TRANSPORTATION RISK AND UNCERTAINTY EVALUATION

REVIEW OF THE SEATTLE MONORAIL PROJECT

Executive Summary:

The Elevated Transportation Company (ETC) has proposed development, construction and operation of a 14-mile monorail system extending from the Ballard area to the north, through downtown Seattle and extending into West Seattle on the south. Given recent local and national experience with major cost-overruns on large transportation projects, the City of Seattle has engaged a consultant team to review the cost estimates that have been prepared for parts of this project.

The Transportation Risk and Uncertainty Evaluation (TRUE) process provides a risk-based assessment of the cost and schedule estimates for a project. The general approach derives from, and is similar to, the Cost Estimate Validation (CEVP) process that was developed by the Washington Department of Transportation to evaluate the major Projects of the Urban Corridors Program. Specific objectives of both methodologies are to evaluate the quality and completeness, including anticipated risk and variability, of the estimated cost and schedule. The results of an assessment are expressed as a range of expected values for the estimated objective along with characteristic values and attributes of that objective.

The overall cost estimate and Recommended Budget prepared for the Seattle Monorail project were factually-based, appropriate for this level of design development and a valid basis for the TRUE estimating process. Highlights of the statistical characteristics of the cost estimate evaluation, in future (year of expenditure) dollars, include:

Mean Total Project Cost: $1.77 B

Range of Project Cost (10^{th} percentile to 90^{th} percentile): $1.55 B to $2.05 B

Other characteristics of the distribution are:

10% chance that project will cost less than $1.55 B

50% chance that project will cost less than $1.72 B

80% chance that project will cost less than $1.89 B

90% chance that project will cost less than $2.05 B

Among the risks considered in the evaluation are several that represent relatively major consequences but have a low probability of occurrence. The two major risks are Effectiveness of Management Continuity and policy relating to Operational Subsidy. These are attractive opportunities for risk management and may be mitigated early in the development of the Monorail System.

TRANSPORTATION RISK AND UNCERTAINTY EVALUATION

REVIEW OF THE SEATTLE MONORAIL PROJECT

Introduction:

The Elevated Transportation Company (ETC) has proposed to develop, build and operate a 14-mile monorail system extending from the Ballard area to the north, through downtown Seattle and extending into West Seattle on the south. The ETC proposes levying a 1.4% Motor Vehicle Excise Tax (MVET) to pay for the construction and operation of this system, subject to voter approval in November 2002. Given recent local and national experience with major cost-overruns on large transportation projects, the City of Seattle has engaged a consultant team to review the cost estimates that have been prepared for parts of this project and to evaluate the probability that the new monorail entity could build the proposed system with the 1.4% MVET.

The City of Seattle has engaged a combined consultant team with one group of consultants, the TRUE[1] collaborative, addressing the validity of cost estimates, and a second team addressing revenue projections. The members of these two teams are listed in Appendix A. The City also requested that the cost estimating evaluation apply the Cost Estimate and Validation Process (CEVP) principles, an approach that was developed by the Washington Department of Transportation. The TRUE consultants were involved in the CEVP process and have adapted the CEVP methodology for application to the Seattle Monorail Project.

As input to the cost and risk evaluation process, the TRUE team relied upon the work done by others in developing the plan for the Seattle Monorail. In particular, the scope of the project was referenced to the June 2, 2002 publication from ETC entitled Building the Monorail, Seattle Popular Transit Plan. A second critical document was the cost plan report prepared by Davis Langdon Adamson, Feasibility Cost Plan for Seattle Monorail Project, Capital Cost, presented to ETC on June 20, 2002. The results presented in this report depend upon the information contained in these key documents and in the active participation of the consultants who prepared these reports.

This report presents the results of a TRUE evaluation process, as described below, that was carried out in an intense and compressed timeframe during July 2002. The focus of the evaluation was a two-day workshop conducted on July 17 and 18. The participants in this workshop are listed in Appendix A. The valuable and constructive contributions from all these participants is acknowledged as an essential ingredient in the final output of this process.

[1] The Transportation Risk and Uncertainty Evaluation (TRUE) Collaborative operated through a contract to Golder Associates Inc. as the prime contractor.

The TRUE Evaluation Process

The Transportation Risk and Uncertainty Evaluation (TRUE) process provides a risk-based assessment of the cost and schedule estimates for a project. The basic approach is to perform a peer-level review or "due diligence" analysis on the scope, schedule and cost estimate for a project and then to frame this analysis to incorporate uncertainty and "risk". The general approach derives from, and is similar to, the CEVP process that was developed by the Washington Department of Transportation to evaluate the major Projects of the Urban Corridors Program. Specific objectives of both methodologies are to evaluate the quality and completeness, including risk and uncertainty, of the estimated cost and schedule. The results of an assessment are expressed as a range of values for the estimated objective (e.g., total cost; schedule to completion; probability of meeting a certain milestone) along with appropriate characteristic values and attributes of that objective.

The TRUE process is based on an analysis of two fundamental components of any project estimate objective (such as cost): the Base component and the Risk component. This approach can be applied to cost, schedule or other project estimate objectives. For estimates of cost, the following definitions illustrate the differences between these two fundamental parts:

1. Base Cost – The most probable cost for a unit or element of the project. The Base Cost represents the cost, which can most reasonably be expected if no significant problems occur, with typically small uncertainty or variance. However, when significant uncertainties exist in the base cost and schedule, uncertainty in and correlation among these components may be included. The Base Cost is usually not a lower bound or minimum cost estimate because some risk elements are always present.
2. Risk Events – Potential adverse (or opportunity) events that affect the project resulting in impacts to cost, schedule, safety, performance or other characteristics, but do not include the minor variance inherent in the Base. Correlation among risk events can also be included.

The TRUE process is organized in five major steps as outlined below:

I. Although the TRUE process can address any of the estimating objectives, the methodology is focused on cost. The process requires that the Project Team prepare plans, exhibits and project documents to describe the scope, character and timeframe of the project. The conventional cost estimates will include the base project costs plus allowances and contingencies. The initial step in the TRUE process is for the cost team members to evaluate the Project Team estimate with four primary objectives:

1. Establish the project scope and major assumptions for the TRUE evaluation. If multiple project scenarios or alternatives are to be

evaluated, the scope and assumptions for each scenario must be clearly defined.

2. Separate the Project Team estimate into a base component and other components that represent the risk and other uncertainties,
3. Evaluate the quality of the Project Team cost estimate. The detail of this evaluation can range from a comprehensive audit of the cost estimate, through a "valuation" (this was the level of the CEVP evaluation) to a "reasonableness" assessment of the base cost component. The ultimate quality of the results of a TRUE process will be influenced by the detail of the cost evaluation. However, different levels of cost-estimate quality can be addressed by quantifying uncertainty and bias in the base-cost elements.
4. Distribute the base costs among the major activities in the project flow chart (see II below).

II. The Project Team should provide a detailed description of the expected project plan and schedule. From this information, the TRUE process develops a project flow chart that represents the sequence of major activities to be performed in the project. Major decision points (e.g., funding decisions) and project milestones, as described by the Project Team, are explicitly represented in the flow chart. The base costs and durations (as well as any related major uncertainties or correlations; see III below) for each activity are entered on the flow chart using values as confirmed or defined by the TRUE cost team.

III. The third major part of the TRUE process is to address risk and uncertainty. Risk is captured by identifying and characterizing a group of significant risk issues or "risk events". A risk event is a discrete event in time that causes significant impacts to cost, schedule, or other project measure. Risk events can include adverse impacts (i.e., risks) or positive impacts (i.e. opportunities). Relationships among risk events can also be addressed if appropriate. Example risk events include the potential for additional requirements to meet environmental regulations, adverse geotechnical conditions in constructing high retaining walls, or the discovery of unexpected utilities. Experts from the Project Team and other independent experts who have a valued perspective on the risk issues develop the list of risks (also known as a risk register), in a workshop setting. Uncertainty and correlations in the base costs and durations can also be assessed when they are significant. These assessments are also made during the workshop, but typically require additional time and effort. The workshop is chaired and facilitated by a member of the TRUE team.

The starting point for the TRUE risk workshop is the Project Team estimate that has been reviewed and evaluated by the cost team. This initial estimate provides a "point estimate," or single project cost, usually including allowances and/or contingencies, but without regard to significant uncertainties or risk events. However, the true cost of the project is subject to uncertain variables and potential future risk and opportunity events. These variables and events are not all directly

controllable or absolutely quantifiable early in project design. Therefore, cost estimates should rationally be expressed as a range of values (with associated likelihoods) to acknowledge this uncertainty and risk. This range in estimated cost is developed using a recognized, logical, and tested process, so that reasonable conclusions can be drawn for the most probable range of cost and schedule for the evaluated project alternative. In the TRUE process, the range of the cost estimate at any stage in a design will be composed of a base cost, that will evolve as the design matures, and a risk component that will also evolve. For well-managed projects, it is typical for the risk component to decrease as the design matures. However, there will always be some residual risk component in the total cost estimate until the project is completed.

An essential objective of the workshop is to identify missing items and appropriate modifications to the Project Team plan, especially those that were identified during the cost evaluation activity. Another quality assurance activity during the workshop is to assure that the risk items and base cost items are coordinated during the evaluation process to assure that no gaps or overlaps exist.

IV. The next step in the TRUE process is to develop and implement a probabilistic model for analyzing the stated project measures (e.g., risk and uncertainty in project cost and schedule to completion). Both escalated and non-escalated (current dollars) costs are modeled, usually by entering a rate of inflation (or different rates for different components, if required). The analysis is typically done using Monte Carlo simulation techniques. At least 1,000 equally-likely project realizations (or outcomes) are simulated . These realizations are a sample set from the true population of project outcomes. This sample set is used to develop distributions, ranges and characteristics for the stated project measures.

V. The TRUE process is concluded by interpreting, documenting, and reporting the results. The specific form of the reported results can vary depending upon the client needs.

Seattle Monorail Project

The TRUE evaluation of the Seattle Monorail Project was conducted following the methodology described in the previous section. The scope of the project addressed the plans from the Elevated Transportation Company (ETC) to develop, build and operate a 14-mile monorail system extending from the Ballard area to the north, through downtown Seattle and extending into West Seattle on the south. The TRUE process also considered the ETC plan to fund the Monorail Project by levying a 1.4% Motor Vehicle Excise Tax to pay for the construction and operation of this system. The evaluation was focused on obtaining information that would be used to support an ETC proposal that would be presented for voter approval in November 2002.

Certain assumptions were made as a basis for the TRUE evaluation, as follows:

- The monorail guideway and stations are assumed to be built in public ROW,
- The route for the Seattle Monorail is assumed to be essentially fixed; only minor variations in alignment are assumed to be possible. If the route ultimately deviates significantly from the assumed route, then additional costs and schedule impacts could result (but are not addressed by this risk assessment);
- The capital cost estimate for the project is represented by the Feasibility Cost Plan for Seattle Monorail Project, Capital Cost prepared by Davis Langdon Adamson, dated June 20, 2002;
- Estimates of other, non-capital, cost items for the total project were provided by Joel Horn. These costs included estimates for 1) Agency costs for pre-construction planning and design and program management, 2) Project reserves for sales tax, cost escalation and agency reserves, 3) Provision for Park and Ride facilities;
- The schedule for the project was provided by Joel Horn in a Project Flow Chart dated 7/16/02. The project team has defined this schedule to be consistent with their strategy of pursuing an aggressive project timeline;
- The risk analysis is a first-order approximation of uncertainty and considers primarily the uncertainty in the event occurrence. Some risk issues were modeled with more complex expressions of risk consequences to address participant input;
- The "point of time" for the Seattle Monorail evaluation is the present, July 17, 2002.

Cost Review

The cost team conducted a review of the June 20, 2002 Feasibility Cost Plan for the Seattle Monorail Project as prepared by Davis Langdon Adamson (DLA). The TRUE consultants understood that certain cost information was considered to be proprietary to the Design Build teams and qualified David McCracken to work with this information in a restricted mode. The cost team confirmed the process and the reasonableness of the cost information and identified some cost items that were subsequently considered for review during the risk workshop.

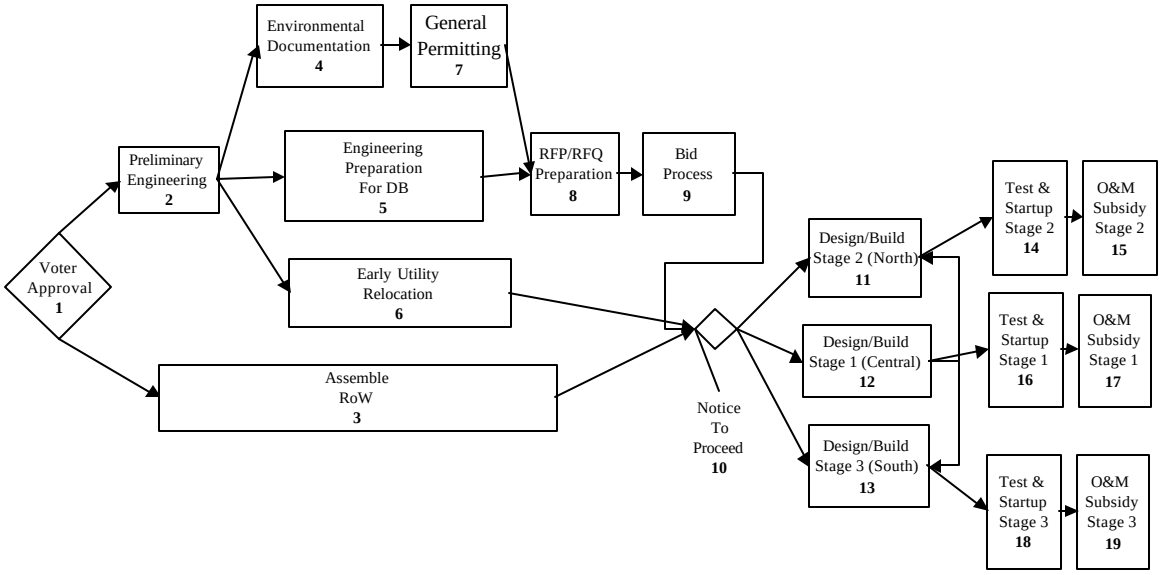
During the cost review, it was noted and confirmed that certain cost items appropriate for the total Seattle Monorail Project had been excluded from the scope of the DLA estimate. As noted in their report of June 20, 2002, the DLA Recommended Budget (see DLA Report, p5) did not include:

- Agency costs for pre-construction planning, design and program management
- Project reserves for sales taxes, cost escalation and agency reserves
- Provision for park and ride facilities.

Estimates of the costs for these items were subsequently provided by ETC staff and they were considered during the risk workshop. The full scope of the estimated base budget, which includes the items in the Recommended Budget plus the items listed above, was included in the model used to estimate the range and characteristics of the Seattle Monorail Project cost.

In cooperation with DLA, the cost data from the June 20 report, as modified during the workshop, were distributed to conform to the principal activities of the Project Flow Chart (Figure1) and were separated into components representing base cost for each activity. The estimating contingency that was included in each component of the DLA cost estimate was identified as a candidate for replacement with explicit risk issues during the risk workshop. However, it was the conclusion of the cost team that the overall cost estimate and Recommended Budget were factually-based, appropriate for this level of design development, and a valid basis for the TRUE estimating process.

Figure 1 Project Flow Chart for the Seattle Monorail Project



The following assumptions are implicit in the project flowchart:

- The funding and route, but not necessarily the final alignment, will be established at the time of the public vote;
- The maintenance facility and station locations will not necessarily be finalized at the time of the public vote. It is assumed that the maintenance facility will be located in the central segment;
- An aggressive schedule approach is assumed in the activity precedence relationships, base cost, and base duration;
- The Engineering Preparation for Design/Build activity will produce the utility and Right-of-Way plans;
- The Right-of-Way acquisition and utility relocations will be conducted on the assumed alignment prior to construction of each segment. The contractor will receive assurances that this will be done in such a manner that his activity is not on the critical construction path;
- Each stage can be tested and operated independently when completed, if necessary;

- Some additional permitting will be conducted after the notice to proceed, but will be coordinated with the construction so that this activity is not on the critical path;
- Funding-related activities (e.g., bonding) are not reflected on the activity diagram.

Table 1 lists base costs and durations (i.e., without contingency or risk) for each major project activity shown in Figure 1. These values are the result of the cost review, as modified by discussions during the risk workshop. Along with the relationships between activities shown in Figure 1, these values form the basis for the schedule risk model.

Table 1 Summary of Base Costs and Activity Durations

Project Activity	Base Cost (current $M)	Base Duration (months) [1]	Annual Inflation Rate (%/yr)	Annual Discount Rate (%/yr)
1. Voter Approval Milestone	--	--	--	--
2. Preliminary Engineering	6.4	--	3	4.4
3. Assemble Right-of-Way (ROW)	25.0	24	3	4.4
4. Environmental Documentation	5.0	--	3	4.4
5. Engineering Preparation for Design-Build	4.0	--	3	4.4
6. Early Utility Relocation	7.0	--	3	4.4
7. General Permitting	10.4	--	3	4.4
8. RFP/RFQ Preparation	2.0	--	3	4.4
9. Bid Process	2.0	--	3	4.4
10. Notice to Proceed Milestone[2]	--	--	--	--
11. Design/Build Stage 2 (North)	204.0	48	3	4.4
12. Design/Build Stage 1 (Central)	796.0	48	3	4.4
13. Design/Build Stage 3 (South)	217.0	48	3	4.4
14. Test & Startup Stage 2	--	--	--	--
15. O&M Subsidy Stage 2	--	--	--	--
16. Test & Startup Stage 1	--	--	--	--
17. O&M Startup Stage 1	--	--	--	--
18. Test & Startup Stage 3	--	--	--	--
19. O&M Startup Stage 3	--	--	--	--
Total	**1278.8**	**78**		

Notes:

1. Assumed project start date is January 2003. The duration results will be presented relative to the present time (July 2002).
2. Notice to Proceed is scheduled to occur in January 2005. Because a detailed work schedule was not available for the pre-construction activities, the Right-of-Way activity was assigned a 24-month duration to enforce this timeline. The other pre-construction activities are assumed to take place concurrently with ROW acquisition. The ROW activity has the highest base cost and,

thus, would be most impacted by escalation. All risk items causing pre-construction delays were assigned to the Notice to Proceed milestone

Risk Review

The Seattle Monorail Project risk workshop participants identified approximately 30 independent and comprehensive potential risk issues that could be defined as major risk or opportunity events. Some risk issues had been identified in several earlier reviews, including the cost review, and others resulted from the discussions during the workshop. A screening criterion was used to separate major issues having a cost impact of 1 million dollars or more, or a schedule delay of 1 month or more from minor issues. The impact of minor risk elements, those below the screening criteria, was included within several of the major risk categories, specifically those relating to project scope, and a category called Other Minor Risks.

The risk workshop members assessed these items in terms of their possible impacts if they occur and the corresponding probability of occurrence. There was broad participation from risk workshop participants, including representatives of the project and independent experts, in identifying the consequences of the risk issues and the associated likelihoods. For the purpose of this analysis, the likelihood of occurrence was estimated on a qualitative scale that was then translated to a percentage likelihood using the following general guidelines.

Probability Percentage	Subjective Criteria
50-100%	Very likely
25-50%	Likely
10-25%	Possible
1-10%	Unlikely
>1%	Very unlikely

Using these criteria as a guide, the risk issues for the Seattle Monorail Project were described and the consequences and probabilities were assessed. A detailed description of the assessed risk and opportunity events is contained in the Risk Register included in Appendix B. A summary of the assessed risks is presented in Table 2. The Table contains a listing of the major risk or opportunity events, a notation of the flowchart activities where the risk has an impact, and the probability and consequences (given occurrence) of each risk event.

Table 2 A Summary of the Risk Issues for the Seattle Monorail Project

Risk or Opportunity Event[1]	Project Activity	Probability	Expected Cost ($M)	Expected Delay (months)
1. City Permitting Issues in Design[2,9]	10	19%	-	6
2. City Permitting Issues in Constr.[2,9,10,11]	11,12,13	6%	10	3
3. Guideway Design Uncertainty[5]	12	[50%, 30%, 20%]	[-25, 0, 40]	-
4. Utility Relocation Issues[9,11]	11,12,13	50%	30	-
5. Ballard Bridge Design Cost Risk	11	50%	10	-
6. Ballard Bridge Constr. Schedule Risk	11	25%	2	12
7. West Seattle Bridge Design Risk	13	70%	10	-
8. Not Allowed to Use W. Seattle Bridge	13	1%	100	36
9. Urban Construction Risk[9,11]	11,12,13	50%	10	-
10. Urban Design Risk[3,11]	11,12,13	70%	25	
11. Transportation Systems Cost Uncertainty[4,5]	12	[30%, 50%, 20%] (awarded in 2005) [10%, 50%, 40%] (awarded in 2006) [0%, 50%, 50%] (awarded later)	[-30,0,30]	-
12. Transportation Systems Delivery[4] Risk	12	25% (awarded in 2005) 30% (awarded in 2006) 35% (awarded later)	-	12
13. Maintenance Facility Risk[5]	12	[50%, 40%, 10%]	[0,10,20]	-
14. Power Systems Cost Uncertainty[5]	12	[10%, 40%, 50%]	[-10, 0, 18]	-
15. Foundation Design Risk[9,11]	11,12,13	70%	10	-
16. Hazardous or Contaminated Soils[9,11]	11,12,13	40%	5	-
17. Delays to EIS Process[5]	10	[10%, 40%, 30%, 10%, 10%]	[0, 0, 2, 3, 4]	[-6, 0, 6, 12, 24]
18. Agreements with Other Agencies[5]	10	[70%, 20%, 10%]	-	[0, 6, 12]
19. Right of Way Acquisition Uncertainty[5]	3	[20%, 40%, 40%]	[-5, 0, 5]	-
20. Station Cost Uncertainty[5,12]	12	[20%, 20%, 50%, 10%]	[-24, -14, 0, 24]	-
21. Market Conditions[5,6, 9,11]	11,12,13	50%	-40 (awarded in 2005) 0 (awarded in 2006) 16 (awarded in 2007) 40 (awarded later)	-
22. Additional Parking Required[9,11]	11,12,13	75%	25	
23. Reduction in the Number of Stations[9,11]	11,12,13	50%	-25	-
24. Reduction in Capacity	12	75%	-20	-
25. Other Scope Risk	12	50%	25	-
26. O&M Subsidy Risk[5, 9,11]	15,17,19	[40%, 30%, 10%, 10%, 10%]	[0, 40, 80, 120, 160]	-
27. ETC Governance Transition	10	10%	-	12

Risk or Opportunity Event [1]	Project Activity	Probability	Expected Cost ($M)	Expected Delay (months)
28. Future Monorail Leadership and Management Problems [5,8,11,13]	1-16	[81%, 14%, 5%]	[0%, 20%, 40%]	[0%, 20%, 40%]
29. Contracting Process[9,11]	11,12,13	50%	50	-
30. Acts of God or Terrorism[9,11]	11,12,13	3%	120	-
Other Minor Risks [7]	--	50%	10% of expected cost	10% of expected delay

Notes:

1. Risk or opportunity events with magnitude of less than $1 M and/or 1 month were included in the Other Minor Risks category.
2. City Permitting risks are mutually exclusive (i.e., if permitting problems arise, they will occur in either design or construction but not both). These risks were assessed using an event tree in which a 25% chance of encountering permitting problems was assumed, with the occurrence of these problems divided 75%/25% between design and construction.
3. Urban Design risk cost is allocated 80% to central (downtown) segment, and 10% each to the north and south segments.
4. The probability and consequence of the Transportation Systems Cost and Schedule risk items are represented as a function of the award date, which is simulated in the risk model.
5. Risk item is represented as a discrete distribution with the indicated probabilities and durations. For example, the Guideway Design Uncertainty item is defined such that there is a 50% likelihood of a $25M cost reduction, a 30% likelihood of no cost change, and a 20% likelihood of a $40M cost increase.
6. The cost impact of the Market Conditions risk item is represented as a function of the award date, which is simulated in the risk model.
7. Other minor risk items included adverse geotechnical conditions, community resistance, seismic design criteria changes, railroad coordination, stormwater criteria changes, temporary disruption to local economy, and other miscellaneous items.
8. Future Monorail Leadership and Management risk item consequences are represented as percentage increase for the total cost and schedule of each project activity.
9. Expected cost is allocated across affected project activities.
10. Time risk is allocated only to activity 12.
11. Risk event occurrences are assumed to be perfectly correlated across affected project activities.
12. Station Cost Uncertainty item excludes the potential reduction in the number of stations, as this factor is captured separately.
13. The Future Monorail Leadership & Management risk item was assessed as an event tree in which the likelihood of leadership problems was 10%. Given leadership problems, the likelihood of management problems was assessed at 50%. Given no leadership problems, the likelihood of management problems was assessed at 10%.

Risk-Assessment Results

Uncertainty and risk in the total project costs and schedule to completion were simulated as described previously. The distributions for total cost and project schedule for the Seattle Monorail Project are presented in Figure 2. The statistical characterization of these results is presented in Table 3. The ranking of the risk for both cost and duration are presented in Table 4.

Figure 2 Probability Mass Functions for the Seattle Monorail Project

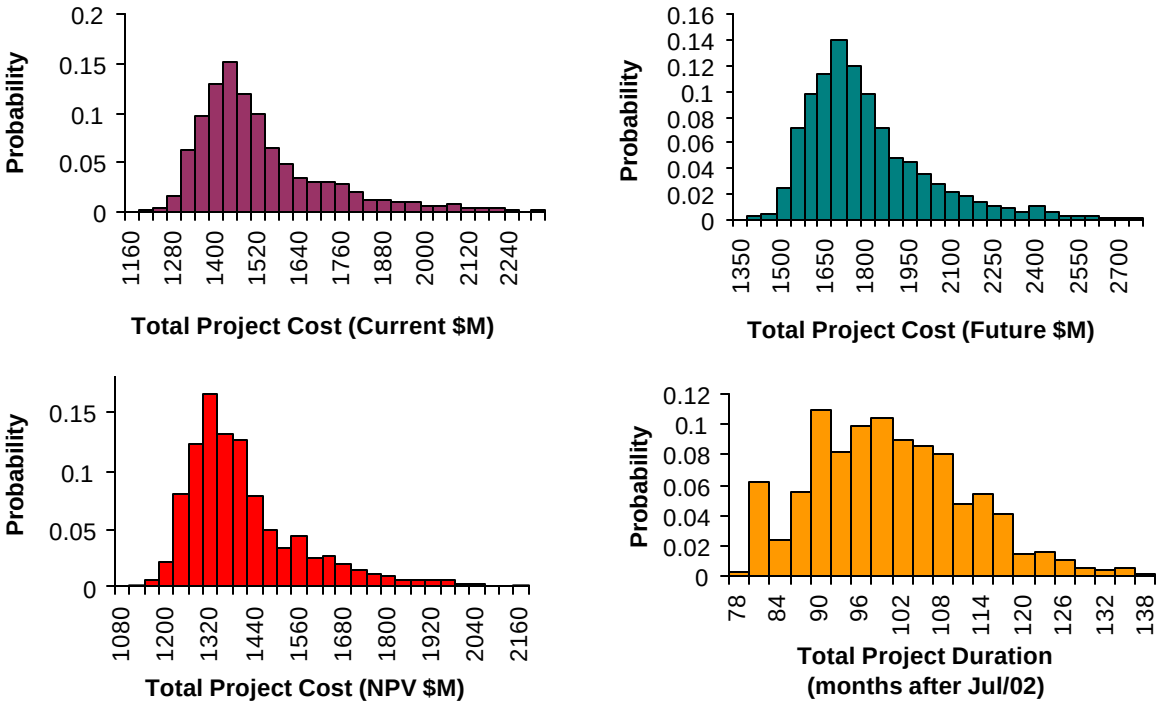


Table 3 Summary of the Statistical Characteristics of the Seattle Monorail Cost and Schedule

	Total Project Cost (Current $M)	Total Project Cost (Future $M)	Total Project Cost (NPV $M)	Total Project Duration (months)
Mean	1500	1766	1393	99
Std Dev	174	212	161	12
Percentiles				
10%	1329	1546	1237	84
20%	1369	1600	1271	89
30%	1398	1646	1298	91
40%	1423	1675	1320	95
50%	1455	1717	1351	97
60%	1488	1763	1379	101
70%	1533	1821	1419	104
80%	1611	1909	1494	108
90%	1741	2054	1615	114

Figure 4 The Ranking of Risks for the Seattle Monorail Project

Rank	Relative Contribution to Risk Cost[1]	Risk or Opportunity Event
1	23%	Future Monorail Leadership & Management
2	18%	O&M Subsidy Risk
3	9%	Contracting Process
4	7%	Additional Parking Required
5	7%	other risk items
6	7%	Urban Design Risk
7	6%	Utility Relocation Issues
8	5%	Other Scope Risk
9	3%	Power Systems Cost Uncertainty
10	3%	Foundation Design Risk
all others	12%	

Rank	Relative Contribution to Risk Delays[1]	Risk or Opportunity Event
1	31%	Future Monorail Leadership & Management
2	18%	Delay to EIS
3	12%	Transportation Systems Delivery Schedule Uncertainty
4	12%	Ballard Bridge Construction Schedule Risk
5	9%	Agreements with Other Agencies
6	7%	other risk items
7	5%	ETC Governance Transition
8	4%	City Permitting Issues in Design
9	1%	Not Allowed to Use W. Seattle Bridge
10	1%	City Permitting Issues in Construction
all others	0%	

1. Delays are to specific activities and are not necessarily on the critical path. Table lists all risk contributors.

Summary and Conclusions:

1. The overall cost estimate and Recommended Budget prepared by Davis Langdon Adamson were factually-based, appropriate for this level of design development and a valid basis for the TRUE estimating process.

2. The risk register prepared for this project is comprehensive.

3. Among the risks considered in the evaluation are several that represent relatively major consequences but have a low probability of occurrence.

4. The two major risks are Effectiveness of Management Continuity and policy relating to Operational Subsidy. These are attractive opportunities for risk management and may be mitigated early in the development of the Monorail System.

5. The results from this evaluation may be combined with revenue projections through compatible assumptions and correlation of variables in the two models.

APPENDIX A

PARTICIPANTS IN THE SEATTLE MONORAIL PROJECT TRUE EVALUATION

Dwight Sangrey, Facilitator	Golder Associates Inc.	503-241-9404
John Reilly	John Reilly Associates	508-904-3434
Alan Keizur	Golder Associates Inc.	425-883-0777
Travis McGrath	Golder Associates Inc.	425-883-0777
David McCracken	National Constructor Group	707-253-8707
Ethan Melone	Seattle Dept. of Transportation	206-684-8066
Joel Horn	Elevated Transportation Company	206-310-0891
Daniel Malarkey	DJM Consultants	206-409-9917
David Hudd	Davis Langdon Adamson	206-343-8119
Craig Norsen	Elevated Transportation Company	206-808-7854
Mike Mariano	Elevated Transportation Company	206-262-7634
Bob Griebenau	Berger /ABAM	206-374-9790
Brian Garrett	Berger/ABAM	206-374-9790
David Cotton	Golder Associates Inc.	425-883-0777
Michael Clark	Seattle City Light	
Chris Larsen	Seattle City Light	
Doug Stanley	Seattle Dept. of Transportation	206-684-5167

APPENDIX B
SEATTLE MONORAIL RISK REGISTER

Risk Issue: Permits, City (1,2)

Explanation: Base assumption is that a 20-person dedicated staff is to be used to expedite this process. It is assumed that processing time is constrained by staff availability, not technical issues. Most key decisions will be made by department heads (e.g., SeaTrans, Fire Dept.). Staff will work closely this the decision-makers throughout the process. Permitting is done on a rolling basis over time, with 30-day reviews. Risk is that design/build team develops entire plan based on expectation of these permit agreements, which do not materialize on time. The cause may be due to failure of the permit team to move the process, or the failure of the decision makers to approve the permits in a timely manner. The impact depends on timing of bad news. The risk of a scheduling delay may occur at any time in the process but has been modeled conservatively to impact the Notice to Proceed (activity 10). Reneging subsequent to bid has much more severe cost consequences than an early impact. Cost impact during construction ($10M) includes $3M for total shutdown, with allowance for several partial shutdowns.

Risk Issue: Permits, Water Crossing (5,6,7,8)

Explanation: The risk of costs or delay because of permit requirements for the water crossings was considered. This risk is included in the risk for the specific project activities.

Risk Issue: Guideway Design Uncertainty (3)

Explanation: Cost for beams, columns, and foundations will exceed the budgeted amount. For example, this could result from limited access to the site for the contractors due to traffic maintenance considerations. May also be an opportunity for cost reduction based on a conservative cost estimate. Cost estimate was developed without value engineering attempts to refine the design and reduce costs. Cost estimate assumes 8' shafts, whereas 6' shafts may be possible. Market conditions may be positive based on projected timing relative to other local transportation projects. Opportunity includes the possibility for a lower seismic design than was included in the preliminary approach.

Risk Issue: Utility Relocation (4)

Explanation: It was assumed that half of the relocations will be done by the city, even though most are owned by franchises. There would likely be reimbursement for much of this, but this is not included in the estimates. Estimates ranged between 60 and 100 million, including contingencies. This includes City Light (approximately 75% of the

total) and other utilities. Historical experience holds that the actual costs tend to fall within the range of the estimate. Opportunities exist to coordinate with other transportation projects (e.g., develop "utilidor" for use by other projects). These are also not included in the base cost and are considered to be a Minor Risk.

Private utilities tend to present greater difficulty because of conflict with the elevated structure. The model assumes $65 Million in base and assumes that utilities would be relocated early with the intention that this not be a critical path item. Design assumes that some column adjustments can be made to work around utilities if necessary, but this will not result in additional cost. City Light representatives provided input to this risk item.

Risk Issue: Design of Ballard Crossing (5,6)

Explanation: Assumes cable-stay bridge, which provides enhanced aesthetics but some additional cost. Total length of structure is 3000-3500'. Bridge type would likely be relatively fixed due to EIS and permitting process, but some details (e.g., aesthetics) may be left to the discretion of the design/build contractor. Number of columns in water will be minimized due to ESA considerations, which will largely dictate the design. Uncertainty is largely due to final alignment and placement within a certain corridor, although all potential locations are under the same ownership (Port of Seattle). Risk is not limited to the Port of Seattle. The cost risk combines both the consequence of changing the alignment and the likelihood that the construction cost is underestimated.

Risk Issue: Delays of Ballard Crossing (6)

Explanation: Miscellaneous delays during construction of the Ballard crossing. This can result from a variety of issues, including fish windows, geotechnical problems, and other issues. The base estimate of 36 months for construction assume that permits are obtained during design, the schedule risk includes both permits and actual construction.

Risk Issue: Design of West Seattle Bridge (7)

Explanation: The bridge is considered in three components: two approach structures plus work on existing deck. Base cost contains $11M for each approach plus $18M for work on deck. Major issues are constructability plus uncertainty in the design of the transition structures. Changes to the total amount are likely to be minimal due to transition structure uncertainty because increases would likely be offset by deductions from the deck structure. Primary cost risk is due to constructability. Must maintain 125% safety factor on existing bridge seismic design. Risk is that we have not progressed adequately through the design process to access the necessary retrofitting of the bridge structure. Any delays are unlikely to be on the critical path, and any cost escalation effects will be negated because operating costs and revenues would be delayed together

Risk Issue: Not Allowed to Use West Seattle Bridge (8)

Explanation: The risk to the project is being prohibited from using the existing West. Seattle Bridge for the waterway crossing for any reason. Potential reasons include political or structural. This would require a parallel structure to be constructed. Very unlikely – 1%.

Risk Issue: Maintenance of Traffic (9)

Explanation: Included in Complex Urban construction risk item.

Risk Issue: Construction Staging Area (9)

Explanation: Because of the linear nature of the construction, staging is flexible and does not necessarily need to be along the alignment. Port of Seattle has offered land for a pre-cast yard. ETA would obtain options on this space and offer them to the contractor. The cost for this is included in the base cost. Construction staging is built into the base cost for the various components (e.g., W. Seattle Bridge). In general, this risk is included in the Urban Construction Risk item.

Risk Issue: Construction in Urban Environment (9)

Explanation: Includes primarily traffic maintenance and construction staging. Estimate is that 2 shafts can be constructed/day. Each block contains 4 shafts. 3 lanes are consumed by the construction, leaving 2 lanes for traffic. There may be traffic limitations during peak hours in certain areas. Noise muffling equipment needs to be employed. Columns would be placed approximately 30 days later. Each block will be shut down 4 times: once for utilities, once for shafts, once for columns, and once for beams (likely done at night). MOT is included in the guideway cost allowance, and is estimated to be roughly $5M. This includes $2M for K-rail, $2M for police, plus some additional. General feeling that this always tends to overrun budget, therefore should be doubled as a risk item. The aggregate total of Urban Construction Risk is $10 million

Risk Issue: Urban Design Requirements (10)

Explanation: Includes construction in Pioneer Square historic district and aesthetics throughout the route. Urban architects will desire an elegant structural design. Urban design cost considerations are included in the base estimates, but the magnitude of the allowances is unclear. Discussed adding $5000/column for design considerations, which represents roughly a 33% increase over the base estimate. This could represent smaller-

diameter columns and/or surface aesthetic enhancements. Different communities (e.g., Pioneer Square, Ballard, West Seattle) may have differing opinions on the aesthetic requirements. Could also include other mitigation measures, such as streetscaping, statuary, areaways, etc. Schedule impactss due to negotiation delays over these issues would be reflected in the Community Opposition risk item. $5M was added to address these considerations. For the visual impairment in the downtown area, $1M/block was added between Lenora and King, resulting in $20M. An additional $5M was included for the North and South segments.

Risk Issue: Trains and Systems Cost and Delivery (11,12)

Explanation: Base cost includes $225M, plus a $30M contingency. Trains themselves comprise approximately $100M of this number (estimates varied from $84M to $128M). Because a very limited number of suppliers exist, and a mass market does not exist, the price is determined by the outcome very sensitive negotiations with the suppliers. This project may represent a strategic opportunity for the suppliers, so they may offer significant concessions. Control systems are more off-the-shelf, so that portion of the cost is more easily estimated. Another consideration is the issue of future considerations for extensions to the proposed line.

Possible factors leading to a delay of delivery of up to 12 months include change requests, and other large contracts coming in prior to this project and competing for the attention of suppliers. Delays and costs are assigned to the Design/Build activities, and are dependent on the timing of the award relative to the assumed schedule. Cost could change upwards or downwards by $30M. The probability of higher costs increases if the award is delayed because of potential manufacturing conflicts with other worldwide projects (e.g., China).

Risk Issue: Maintenance Facility (13)

Explanation: There are several potential areas identified for facility locations, included in Right of Way acquisition costs. This remaining risk item assumes that ETC has a site secured. Base cost includes $20M but estimators considered that there was a $10M contingency requirement. Style and cost of facility depends on the train manufacturer (Bombardier and Hitachi). Examples of differences include paint shop inclusion, electrical test shop inclusion, method of car maintenance (at-grade or on guideway).

Risk Issue: Power Systems (14)

Explanation: Base cost estimates were $80M with recommended contingencies that ranged from $15M to $38M (higher value is not considered to be a legitimate possibility). Power systems include power rails attached to guideway, AC/DC conversion. Assume one unit per mile. Key locations will include downtown and Interbay areas. These

substations may be maximized in about 5 years, but City Light is doing substation planning. An additional substation may be needed downtown, but options are available to tap other capacity. City Light's feeling is that elevated transit alone will not have a major detrimental impact on capacity, but could be significant in conjunction with other projects. Risk value includes uncertainty that the alignment is close enough to the substation.

Risk Issue: Foundation Design Risk (15)

Explanation: Base cost identifies a 10% allowance in foundation cost to remove unexpected obstructions, roughly $6M. An additional $6M expected value is added as a risk item (assuming 10% of 800 shafts encounter a problem, requiring a new shaft). In addition, an additional $1M is added to account for re-fabricating beams to account for the changed shaft locations. .

Risk Issue: Geotechnical Conditions except for Foundation Design Risk (15)

Explanation: Geotechnical uncertainty was included ($4M) in base cost (reserve component) for general geotechnical examination in agency startup budget. An additional $2M is included for utility location. Base numbers are felt to be appropriate with the major risk being to the Guideway foundations (see above).

Risk Issue: Contaminated/Hazardous Soils and Water (16)

Explanation: Base cost includes $5M plus $5M in contingency (breakdown: disposal $3M; Maintenance Base $1M; takes $1M) based on a Level 1 EA study by Shannon & Wilson. State law stipulates that the property owner is responsible, but may sue the party responsible for the contamination. Assumption is that Ballard Bridge foundations will be driven piles constructed within a cofferdam system, and do not involve excavation. This plan reduces the risk of encountering contaminated sediments in this area.

Risk Issue: Environmental Impact Statement and ROD (17)

Explanation: The development of the Environmental Impact Statement, other permits relating to environmental assessment and the decision making process leading to a Record of Decision (ROD) may require studies and documentation that are not currently available. These processes also will be used as a vehicle for opponents to the Seattle Monorail project because of the access to public opinion and the available legal process for delay and review. The base estimate of 24 months to complete this activity is conservative, therefore there is a 6 month opportunity. There also is a potential for delay of up to 24 months.

Risk Issue: Community Resistance (10,17)

Explanation: Includes negotiations related to aesthetics. Strategy is to develop a highly comprehensive EIS and build time allowances for challenges into the base schedule. Risk is covered in Delay to EIS and Urban Design (for concerns about the aesthetics) with the delay impact being in the Other Risks category.

Risk Issue: Agreements with other agencies (stadium authority, Port of Seattle, BNSF Railroad, others) (18)

Explanation: Discussions with other public sector agencies indicate that there should be strong alignment in the interests of these agencies and of the Seattle Monorail Project. However, the specifics of numerous important negotiation issues have not been resolved. There is likelihood that cost and schedule are at risk to negotiating tactics. The impact to the BNSF right of way and schedule is minimal; however, there is little alignment of interests between the Monorail and Railroad interests which may cause delay or require extra costs.

Risk Issue: Right of Way (19)

Explanation: Base cost includes $25M for public take, plus $5M in contingency. Some discussion surrounded assumptions of 25% condemnation at a 20% premium. The ultimate decision was to bracket the base cost to reflect a possibility of increased costs, coupled with general optimism that some cost savings could be realized. Assumption is that R/W acquisition begins immediately.

Risk Issue: Number and Location of Stations (20,23)

Explanation: The base estimate includes 19 stations in the public right-of-way. However, there is some risk that the justification for all of these stations may not materialize for the initial construction. Therefore, there is an opportunity for reduced number of stations and a corresponding reduction in cost.

There also is opportunity for public/private partnerships to fund some stations. The aggregate potential opportunity or risk is up to $1.25M/station. The weighting of opportunity is based on workshop input by all participants.

Risk Issue: Availability of Labor (21)

Explanation: Included in Market Conditions

Risk Issue: Market Conditions (21)

Explanation: This risk was treated separately for the monorail trains and systems and is included in Risk Event 11. For construction items, it was generally felt that market condition impacts would be generally favorable if the project was awarded on time. As the date slips, it becomes more likely that the market conditions impact would result in higher costs due to conflicts with the WSDOT mega-projects. Cost values were taken as a percentage of the construction cost including the following major items: Bridges, Guideway, Stations, Maintenance Facility, Power, Utilities, Contract Administration. 5% Opportunity if on time to award, no change if 12 months late to award, 2% risk if 24 months late, 5% risk if 36 months late.

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Risk Issue: Change of Scope (22,24,25)

Explanation: Possible changes include adding or reducing the number of stations, adding parking to the stations, capacity of systems, Seattle Center routing (around/across), operating policies and the following issues.

> Eight of the stations are outside the downtown core, and could potentially benefit from increased parking capacity. It is felt that the city council would not permit the parking to be constructed. $25M in base is an amount at risk.
>
> Eliminating a station would save approximately $7M. Four stations could potentially be dropped. This is separate from the Stations opportunity item.
>
> The cost per train is $5M. Assume 4 trains could be dropped, and the maintenance facility is not changed. Could also potentially change the design to support smaller trains. Separate from the Trains opportunity item.
>
> Seattle Center realignment would result in increase of $8 to $10M, plus administrative costs. However, at least half of this would be given back due to mitigation measures required. Could potentially place a central station in the location of the current Seattle Center House; however, costs are very uncertain. It was felt that this may not be an opportunity for significant cost savings due to the inherent risks.

Risk Issue: Financing the O&M Subsidy (26)

Explanation: An O&M subsidy of $21M is included in the capital budget. This could potentially be eliminated due to revenue generation, but could potentially increase. A 30% subsidy was considered to be the high end (based on Metro), which would result in $100M (2002 dollars). Costs are to be applied in the model at the start of operations.

Risk cost values were calculated by Daniel Malarkey by discounting potential O&M costs for various scenarios back to 2002 dollars.

Risk Issue: Future Monorail Leadership and Management (27,28)

Explanation: Issue involves the possibility that the future ETC board will change strategy or degree of effectiveness. Current assumptions hold that the board will continue to be an effective oversight body, and will agree in principle with the current project strategy. Risk is that the board will experience lack of continuity during startup, fail to act in a timely manner, or fail to keep costs in check. Factors influencing this risk include question of whether the board is appointed or elected, and the political makeup of the board. The Design/Build contractor will make an assessment of the effectiveness of the board, and will tailor their bid accordingly. It was felt that a delay could be experienced due to a rough transition to the new board following the general election. An ineffective board could have an ongoing detrimental effect to the project. It was assumed that an ineffective board or ineffective management or staff could increase the overall project cost by 20%, based on experience at other major transportation entities. The result of an ineffective board combined with ineffective management could result in a 40% cost increase.

Risk Issue: Aggressive Schedule Strategy Will be Abandoned (28,29)

Explanation: See Future Leadership and Contracting Process risks

Risk Issue: Contracting Process (29)

Explanation: The base assumption is that the project will be Design/Build because the ETC has been granted the legal authority to use this construction approach. There was discussion of alternative construction approaches, including multiple Design/Build contracts. The conclusion was that these alternatives were very unlikely and that the cost and schedule impacts were too small to include as specific risk issues.

Risk Issue: Acts of God & Terrorism (30)

Explanation: Primary risk is due to a major earthquake. Assume a 10% probability of a severely-damaging earthquake over the next 20 years. Risk window runs from startup through the construction period (because the design standard may change to an elastic 2500-yr criteria if a major earthquake were to occur). Costs would include: $15M for Ballard Bridge (30%), and $90M for the guideway (30%) and $15M for West Seattle Bridge. Acts of terrorism were discussed but deemed to be insignificant due to a very low probability that the monorail would be a target.

Risk Issue: Other Minor Risk

Explanation: To account for other minor risks that were known or unknown, identified or unidentified, a risk to cost or schedule equal to 10% of the aggregate for each simulated project realization was identified as a consequence with a likelihood of 50%.

Risk Issue: Seismic Design

Explanation: All of the structural design for this project was conducted with a base assumption that the 2,500-year seismic event would apply and that plastic design (non-lifeline) would be appropriate. West Seattle Bridge elements are not considered lifeline because the bridge itself is not considered lifeline. Current design is to the proposed AASHTO standards, and allows for structures to be standing following a 2500-year earthquake event. Therefore, no additional cost risk is necessary beyond consideration as a Minor Risk.

Risk Issue: Stormwater Requirements

Explanation: The current level of design has assumed that the current DOE design requirements and guidelines for stormwater control and drainage will be required. There is a relatively small impact area because of the elevated nature of the guideway.

Risk Issue: Public Opposition After Start of Construction

Explanation: The risk that there will be continued opposition to the Monorail Project leading to public opposition after construction is authorized was considered. The conclusion is that this represents a minor risk.

Risk Issue: Disruption to Local Economy (Permanent)

Explanation: There are 3-5 businesses that will be relocated or bought out. Relocation is only necessary if the business owns the property. The Commons project was used as a reference and it averaged $90,000/business for some 100 business (1996 dollars). The base cost was includes $1M to cover this. Other risk is a Minor Risk

Risk Issue: Disruption to Local Economy (Temporary)

Explanation: Some businesses will be disrupted during the construction process, but it is felt that these businesses do not have a legal right to compensation. It was felt that this was not risk item. A second issue pertains to impacts to adjacent property. When operating in the public right-of-way, the adjacent property owners do not have legal recourse. However, when operating outside the pubic right-of-way, issues may arise. Must show economic disadvantage (taking). Studies in other cities indicate that property values increase when in close proximity to a station. Noise is not considered to be an

issue because trains are traveling at a very slow speed near stations. Any other impact is considered to be a Minor Risk.

Risk Issue: Impairment to Adjacent Properties

Explanation: see temporary disruptions