Alaskan Way Viaduct & Seawall Replacement Project

and

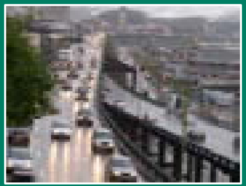
SR 520 Bridge Replacement and HOV Project

Cost & Schedule Estimating - WSDOT's CEVP Process

John Reilly

Washington State Department of Transportation

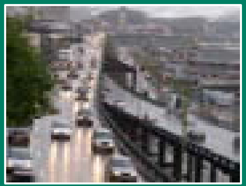
Background - discussions since 1997



– Vienna, Basel, Melbourne, New York, Oslo, Frankfurt, Mexico City, Seattle, Beijing, Milan, Ferrara, Bern, Durban, Boston, Salzburg, Sydney, Amsterdam, Singapore, Istanbul, Beijing, Washington DC……

– Resulting in input to (examples):
  – Beijing Symposium - TBM Joint Cooperation, 2000 & 2001
  – American Underground Construction Association, 2000-2002
  – Swedish Swedish Road Authority - 2001
  – ITA Working Groups 13 & 20, 1997-2004
  – **WSDOT - 2002**
    – WSDOT committed to develop better cost estimating and risk management to deliver complex transportation projects

Key Project Goals



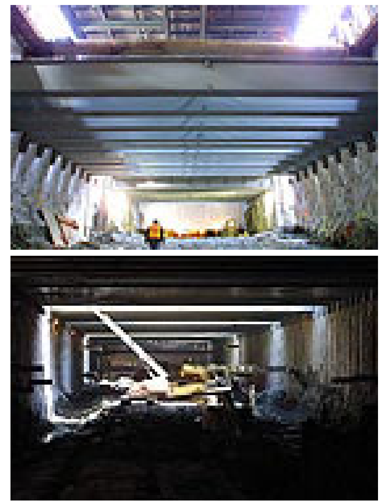
- Meeting cost and schedule goals is essential.
  - Cost is a prime focus - we must meet our budget!
  - A project's final (future) cost is difficult to estimate in the beginning - many mistakes made
  - Management needs information about what events and factors can influence and increase cost, early in the project, in order to manage to budget
- This Presentation will cover:
  - Cost and cost estimation
  - How to better estimate future costs and
  - How to use this data to reduce risk and cost growth

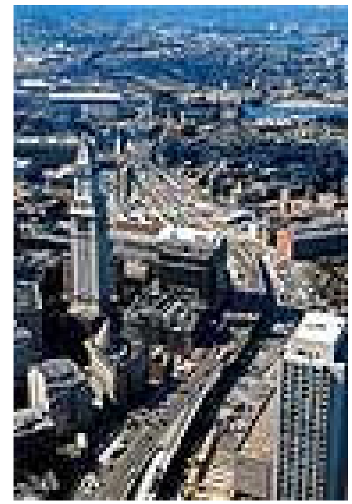
Cost and Budget problems

- Many large, complex transportation projects have exceeded their budgets and schedules - no surprise!
- Examples in the following slides

London Jubilee Line Metro

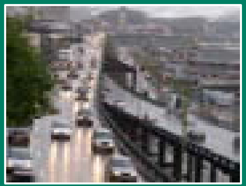
Channel Tunnel





Boston Central Artery / Tunnel

Channel Tunnel, UK- France Cost + 80%



Budget - £2,600m

Cost - £4,650m

Finance Cost +145%

- serious financial problems continue for the Agency

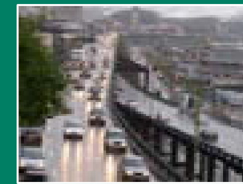
London Jubilee Line, Metro Transit Cost +67% (*)

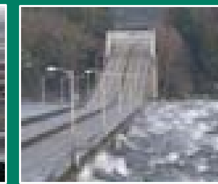
- Project was:
  - 2 years late (74 vs. 53 months + 40%)
  - £1.4 billion over budget (£3.5 vs. £2.1 +67%)

- Recommendations - Arup Report (Advisors to Government):
  - "Safe achievement, bringing significant benefits…"
  - But - "Time and cost overruns could have been minimized with <u>a more established strategy at the beginning of the project</u>".

(*) Reference: T&T, October 2000, p19

Boston Central Artery/Tunnel, Cost +60-100% (tbd)

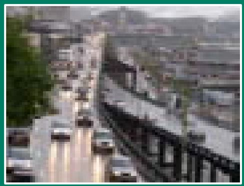




- Complex tunneling and urban road project in the heart of Boston
- Difficult management task
- Long time period involved, many political changes
- Very significant “mitigation” requirements (new scope)
- History and causes of cost & schedule increases only partly defined at this point
- See Fred Salvucci’s paper, ITA Amsterdam, 2003 & T&T NA May 2003

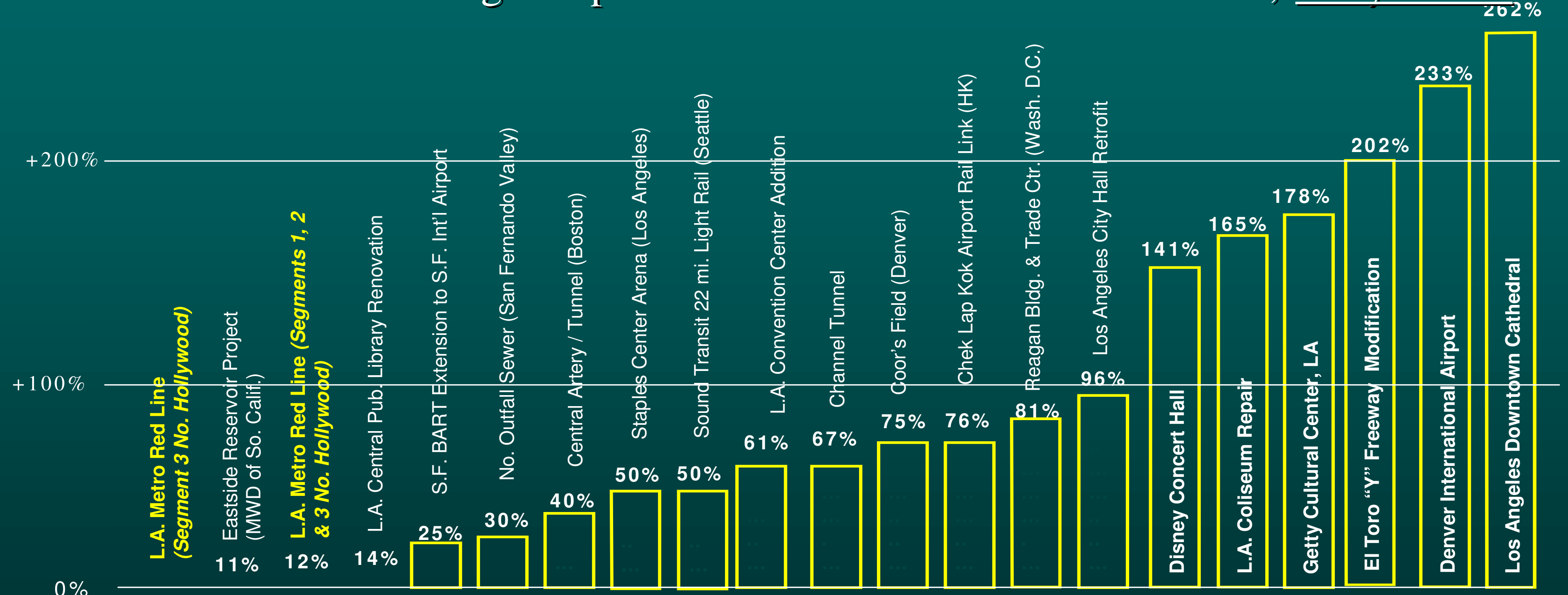
Are these unique examples?

- No, many projects exceed their budgets!



Examples of Project Cost Growth, US(*)

Percent Over Budget - presented at AUA Conf. Seattle, May 2001



Reference	M 1-31-01	E 1-11-99	M 7-1-98	D 9-6-94	E 3-1-99	D 9-6-94	I 4-3-98	L 3-19-99	E 1-8-01	A 10-12-93	E 1-3-94	X 5-92	U 2-14-96	L 1-25-98	L 12-8-99	L 12-16-94	L 12-97	E 4-24-95	O 6-7-91	E 10-19-98	L 3-5-98
Orig. Est. (in $mil.)	1311	1970	4007	109	1200	19	8000	250	2400	310	9210	123	1560	362	153	110	35	360	55	1500	45
Current Est. or Actual (in $mil.)	1311	2190	4502	125	1500	25	11200	375	3600	500	15350	215	2750	656	300	274	93	1000	166	5000	163

(*) Similar examples exist world-wide

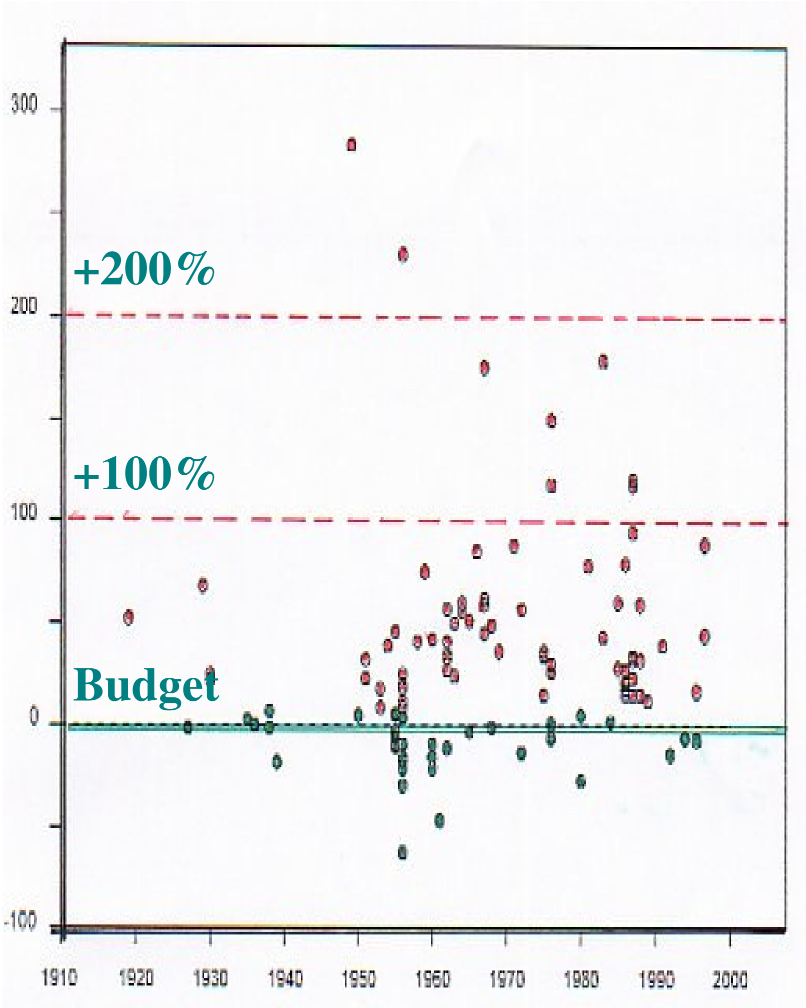
Prepared 2-26-01 by LACMTA Construction Div. Program Mgmt.

Flyvbjerg Study, June 2002 - 258 International Projects

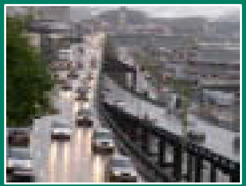
- Cost estimates** have been "systematically misleading"
- A wide range of projects have this problem
- This condition has existed for a very long time (70 years)
- This cannot be explained by normal errors / random results
- Best explained by "strategic misrepresentation"
- How to correct this problem?

** - at time of decision to implement

Final cost vs. budget, 1910 to 2000

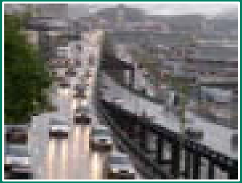


Areas for Study :
AUA Conference Seattle, May 2001



- A survey of 1400 international projects (Reilly & Thompson 2000) found significant cost and schedule overruns suggestive of poor management in at least 30%, and probably more than 50%, of projects (but, specific data was not reliable)
- It appears that the factors that most commonly influence the success or failure of projects were:
  - Expertise, capability and policies of the Owner
  - Political changes in the middle of projects
  - Poor decision making and lack of continuity
  - Inappropriate contracting procedures
  - Inadequate agreement about requirements and impacts
  - Lack of understanding and control of external events

Projects not exceeding budget:
MBTA Southwest Corridor, 1977-1987



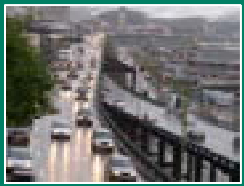
- Budget for Management, Outreach, Design & Construction (+): $750 million US
- Final Project Cost: $743 million US
- Initial Project Schedule (1977): November 1986
- Actual Project Operations: May, 1987 (+6 months)

Project included rapid transit system (facilities, vehicle-retrofit, signals, electrification); civil, structural and tunnels, arterial roadway, 3 high-speed rail lines, urban development, community outreach, educational training, park and parklands + political changes

Boston Harbor Project '91-'02 delivered close to budget

– The 1987 Facilities Plan for the Boston Harbor Cleanup Project presented a range of costs from $4 to $4.9 billion.
– In 1992 a thorough review of cost resulted in an estimate of $3.65 billion.
– Cost at project completion - $3.8 b
– What factors contributed to this success?
  • Constrained Schedule (Court Order)
  • Competent strategy and,
  • Competent Managers

Need for Better Cost Estimation




- Doug MacDonald asked Mike McBride & John Reilly to help Dave Dye to develop better cost estimating for WSDOT

Questions that we asked:

- How are estimates usually done?
- What do we need to do to get a good estimate?
- How can we include risk and "validate" costs?

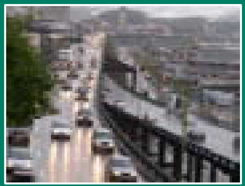
Worksession early 2002:

- We developed a process that (we thought) had potential to better estimate and validate costs
- It was called CEVP® (Cost Estimate Validation Process)

Key Conclusions:

- We need to examine cost assumptions using independent experts to "validate" the base cost estimate
- We need to include uncertainty (risk) using statistical risk and decision analysis methods

Different Cost Estimates




Planning

- "Top Down"
- Cost per Km
- ID "Order of Magnitude"

Environmental

- "Top Down" or mix of "Top Down" & "Bottom Up"
- Cost per Km unit costs, quantities
- Comparison Purposes

Engineering

- "Bottom Up"
- Unit cost & quantities
- Basis for bid comparison & analysis
- Based on specific schedule & construction phasing
- Risks identified & assigned (contingency)

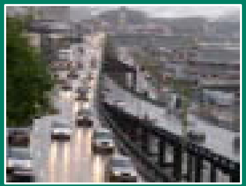
These estimates have:

- Different levels of detail
- Used for different purposes at different phases

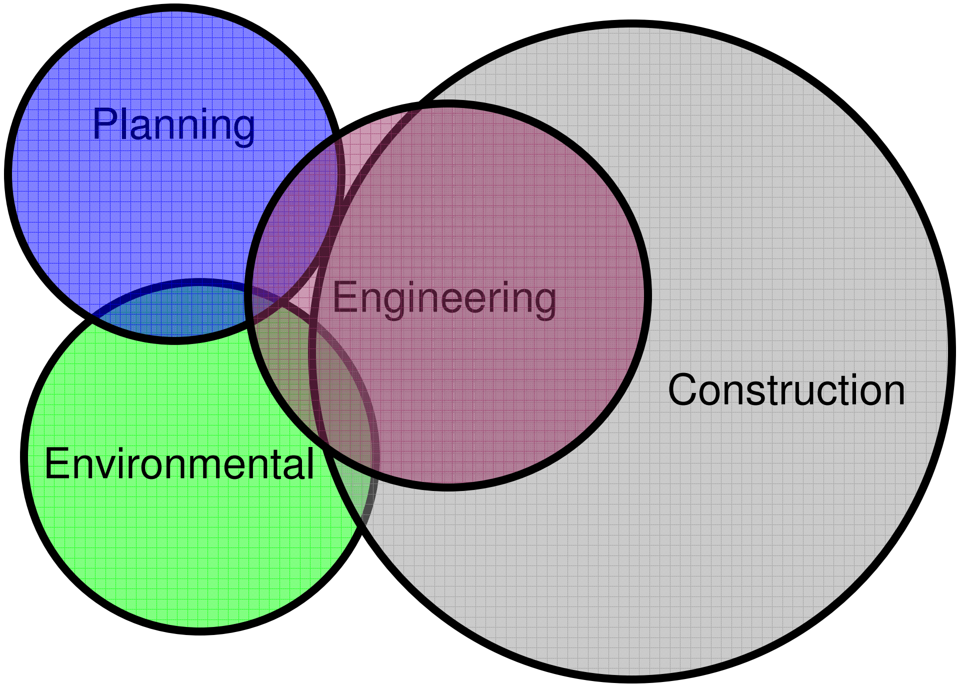
Construction

- "Hard Money bid"

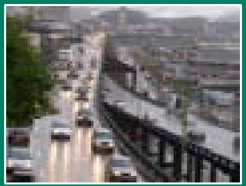
A “Good” Cost Estimate:



1. Integrate planning, environmental, engineering & construction
2. Consider history (escalation) and local circumstances
3. Identify and characterize risk & opportunity
4. Identify & quantify items that have a major affect :
   - Politics
   - Environmental
   - ROW
   - Escalation
   - Schedule/Phasing
5. Consider & incorporate uncertainty, variability & risk



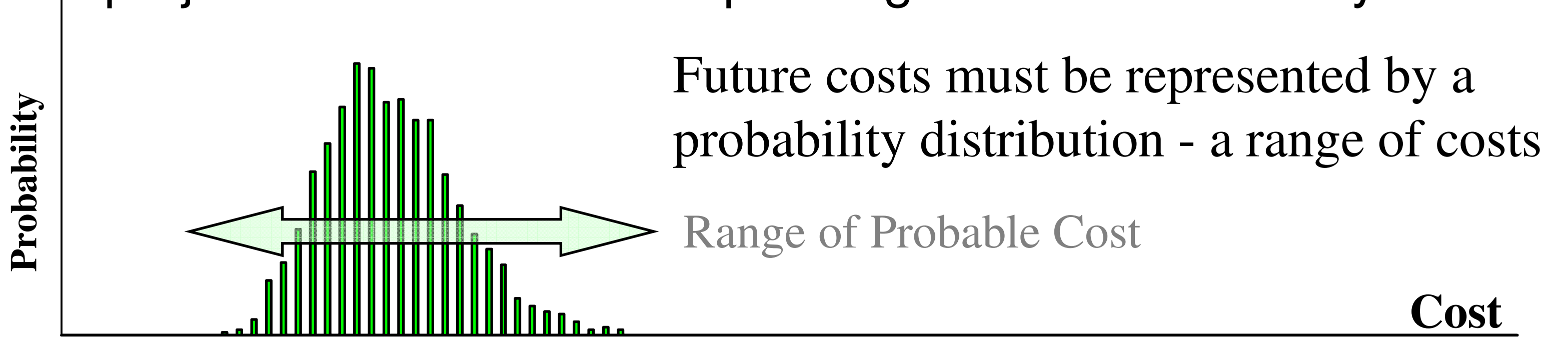
An Estimate is not "a number"




- The ultimate cost of a project is subject to many variables which can, and will, significantly influence the range of probable projected cost.
- Any one cost number represents only one possible result of the multiple variables.
- These variables are not all directly controllable or absolutely quantifiable.
- Therefore, cost estimating and the cost validation process must consider probabilities in assessing cost, using a recognized, logical and tested process

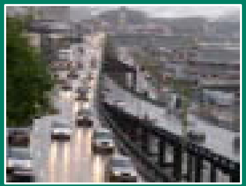
Key Concept - "range of probable cost"

- In the beginning there is a large potential range for a project's ultimate cost - depending on events that may occur

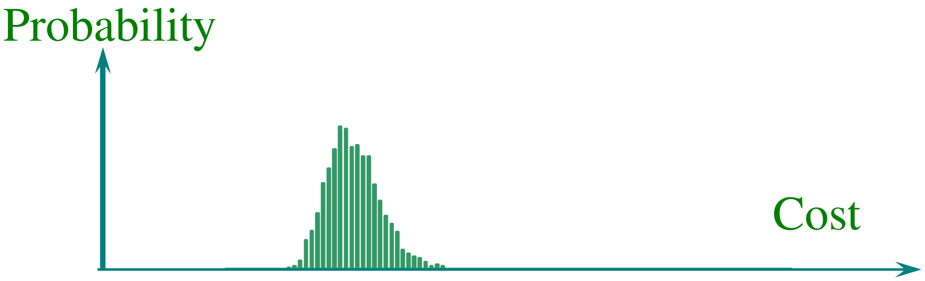


- A single cost number represents only one possible result, depending on circumstances and risk events that affect cost
- These circumstances and risk events are not directly controllable or absolutely quantifiable
- The risk events, if they occur, produce impacts which add cost or time to the project
- Therefore, cost estimation must include risk (i.e. account for uncertainty) using a logical, structured process

Logical Approach: Base+Risk Cost=Range of Cost



1) Determine the "Base cost"
(normal cost with variance)

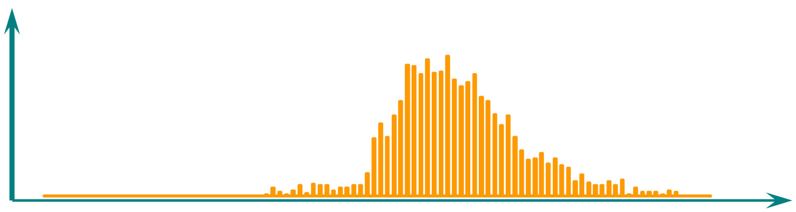


"Base" construction cost

2) Add Cost for risk events
(risk = probability x impacts)

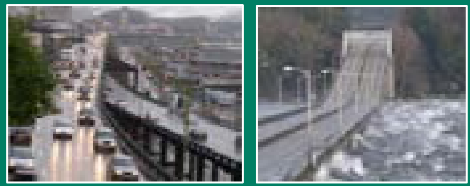

Cost of risk events

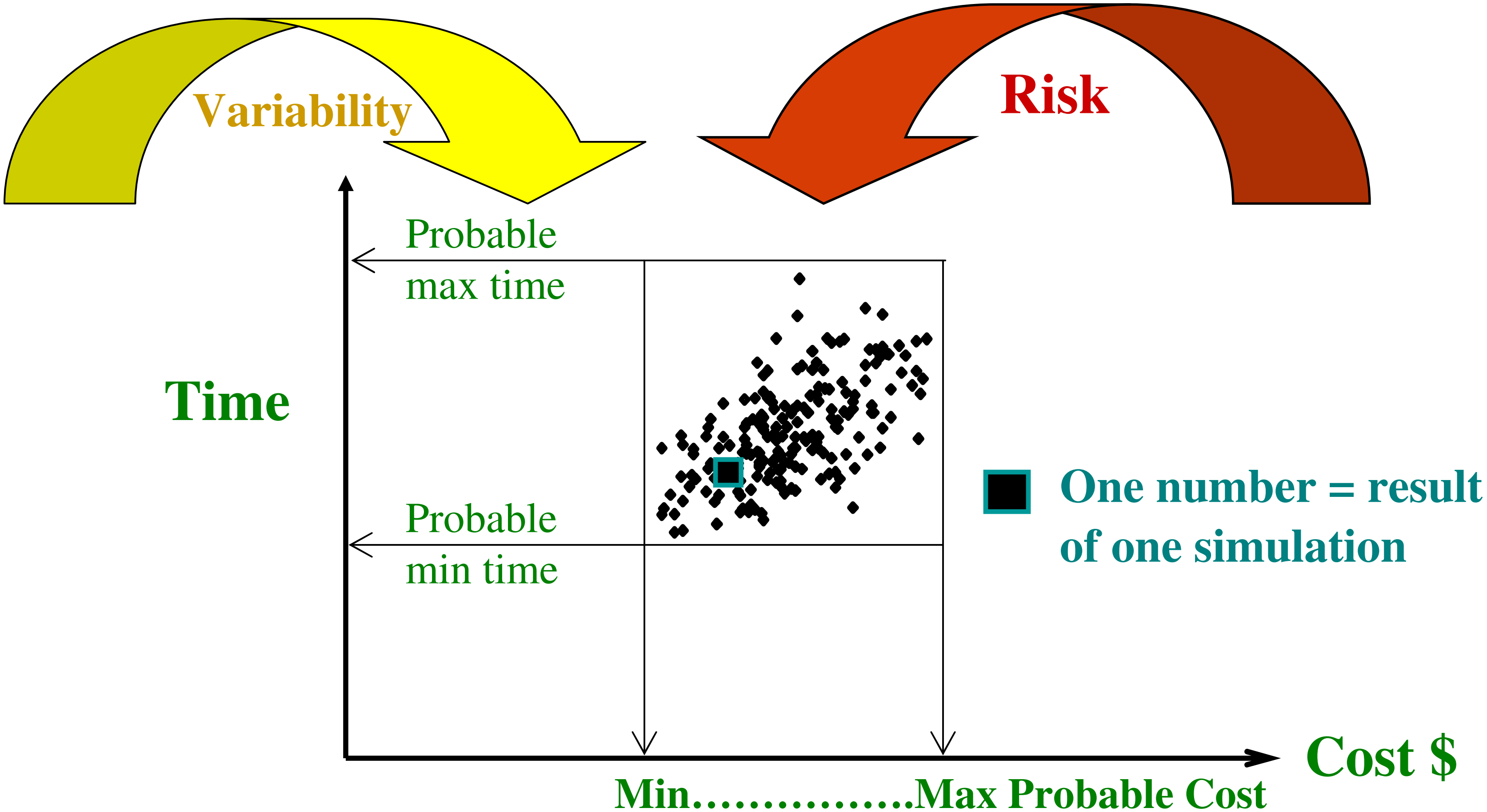
3) Range of probable project cost


Range of probable cost

(*) Risk cost is normally called "contingency"

Combined Variability & Risk

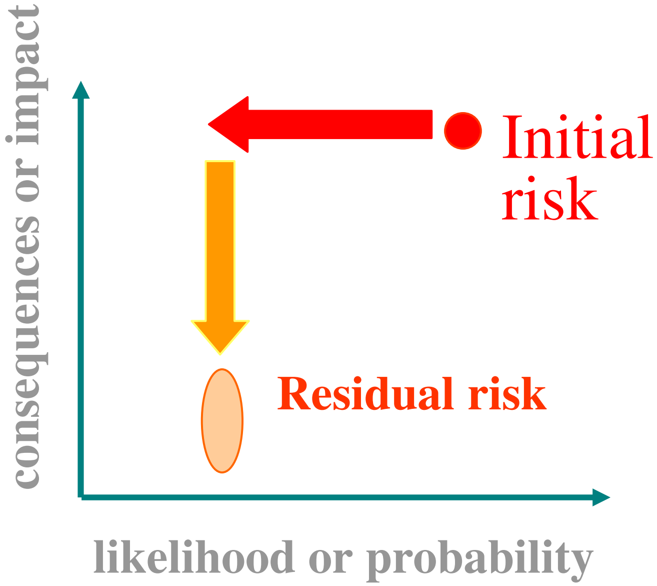




Einstein, Xu, Mahtab, Grasso Model

Risk Management

"Risk can be managed, minimized, shared, transferred, or simply accepted - but it cannot be ignored."



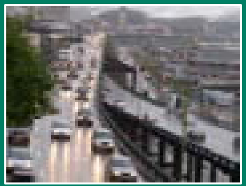
Impact: The effect on the project or its objectives, measured in terms of safety, cost, schedule delay, quality of construction or other requirement.

Probability: Chance of an event occurring

Risk: Combination of impact and probability

Residual risk: risk remaining after primary risks are mitigated

Risks to be considered



<u>We normally address</u>:

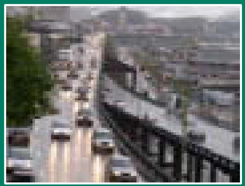
- Engineering uncertainty
- Geological uncertainty
- Construction uncertainty
- Environmental requirements
- Funding uncertainty
- Strategic issues
- Contractual conditions
- Staff Capability
- Management capability
- Management continuity
- Available Resources

Washington ,Metro, Dupont Circle Station

<u>We also need to consider:</u>

- Political Changes
- Public acceptance - if funding by new taxes
- Historical factors
- Cultural factors
- All elements of risk

One Example - WSDOT's 2002+ Cost Estimate Validation Process(*)

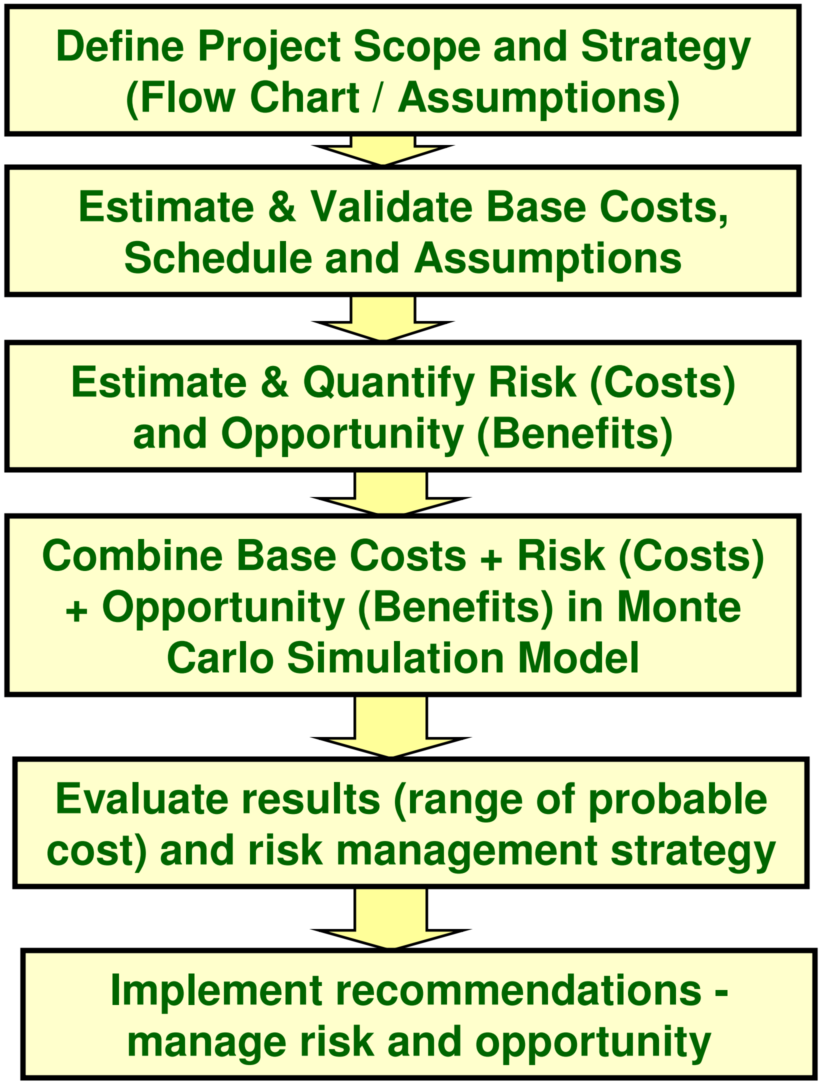


1. Perform a peer-level ("due diligence") review of scope, schedule and cost using project staff working closely with independent (i.e. unbiased) subject matter experts
2. Assess the quality, completeness and assumptions of the project's cost estimate - make contingency explicit and remove it from the estimate to determine the "base cost"
3. Identify and quantify uncertainty (risk and opportunity)
4. Combine base costs and uncertainty costs to determine the "range of probable cost"
5. From the explicit risks identified, develop and implement a Risk Management Plan to eliminate, reduce or minimize risk

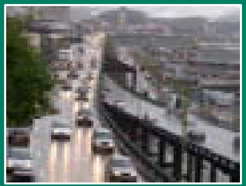
(*) See references

CEVP® Workshop

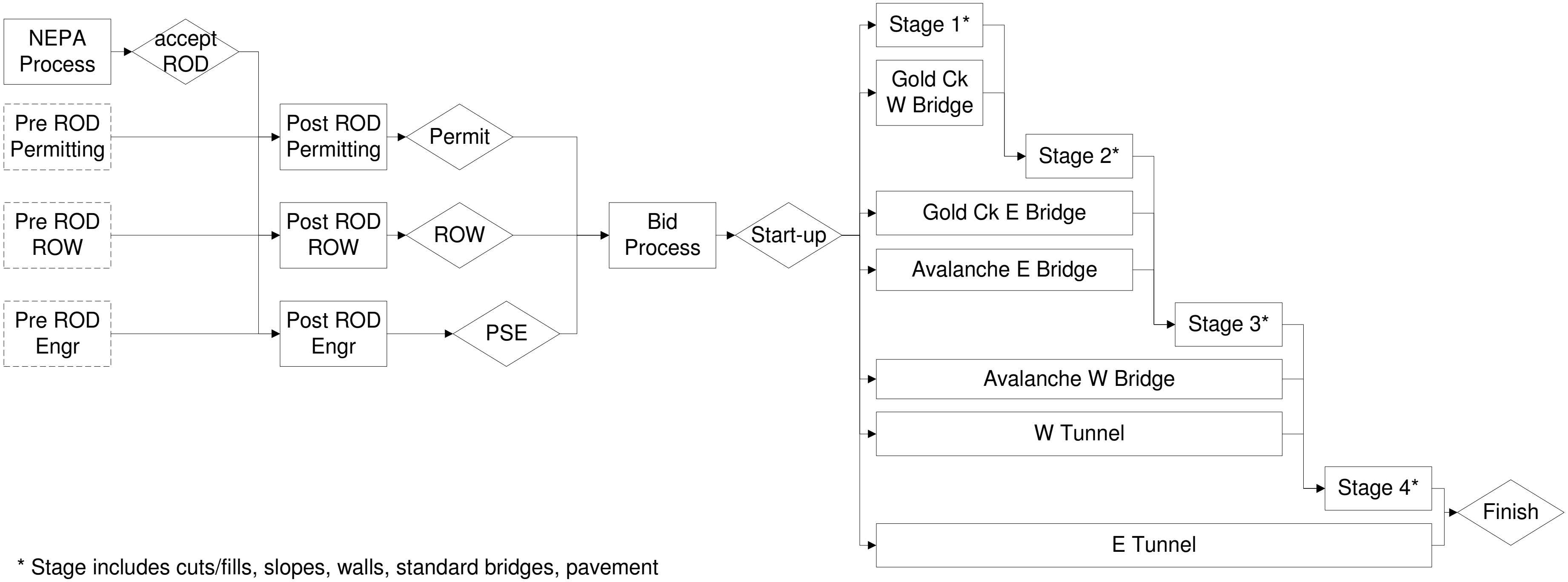

- The CEVP Workshop brings together the Project Team and the independent CEVP team, including external and internal Subject Matter Experts to:
  - Validate base costs,
  - Identify and quantify uncertainty
    (risk and opportunity)
  - Estimate the range of probable cost and schedule



Project Flow Chart

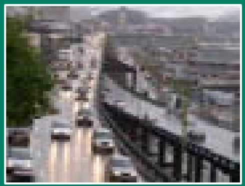


- The project "flow chart" links major activities required for the project. Cost and schedule duration is allocated to each activity.



* Stage includes cuts/fills, slopes, walls, standard bridges, pavement

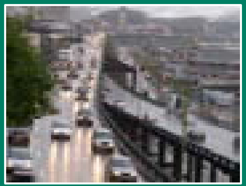
Base Cost Determination



- Determine the "base" costs - the most probable cost that can be expected <u>if the project goes as planned</u>
- Remove all contingency - i.e. provision for unknowns (representing uncertainty = risk and opportunity)
- Consider at the particular stage of the project:
  - What are our assumptions? Where do they come from?
  - How valid are they, how do we know?
  - What do we know we know? (components, units, prices)

  - What do we know but can't quantify? (allowances)
  - What do we know we don't know? (normal uncertainty)
  - What don't we know that we don't know? (gross uncertainty)

Identify Risk & Opportunity

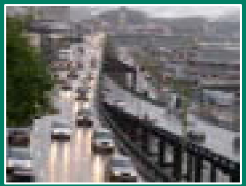


Estimate the impact (to costs & schedule) from risk events + the benefits (to cost & schedule) from opportunity.

Risk Event	Risk Description	Type of Risk	Probability	Cost Impact ($)	Schedule Impact
Construction Resources - people	Currently, the construction market in this part of the state is booming, skilled labor and materials are in short supply. Contractors attracted to higher profit, lower risk projects such as gas pipeline.	Cost and Schedule	75.0%	$25,000,000	6.0
Embankment impacts on permafrost	Permafrost degradation could lead to high O&M. Understanding the variability in load capacity of the subgrade will dictate engineering design parameters.	Cost	50.0%	$28,000,000	0.0

Opportunity Description	Probability	Cost Benefit ($)	Schedule Benefit
Eliminate Access Road	50.0%	$45,000,000	6 mo
Contract Term (Incentives)	40.0%	$40,000,000	8 mo
Change Control from CTC to DTC	20.0%	$13,000,000	2 mo

Examples - risk costs



Construction Staging Cost Uncertainty

Base carries 10% on I-5, ML, Points/Bellevue, 5% on PBB, W/E approaches, 0% on floating bridge. Includes temporary roadway, barriers, retaining walls, etc. Separate from Traffic Control and also separate from the West approach detour bridge, which is carried individually..

% of base construction staging cost, Normal distribution:

10^{th} pct. -25%, 90^{th} pct. 0%

Aesthetic Treatment Cost Uncertainty (excluding Floating Bridge)

Allowance for aesthetic treatments on bridges and walls, which is not included in the base structure costs. Base carries 6% of structures (bridges and retaining walls, noise walls) as an additional line item. 6% covers “bolt-on adornments”. Additional CSS treatments (e.g., planter boxes, etc). would be above and beyond.

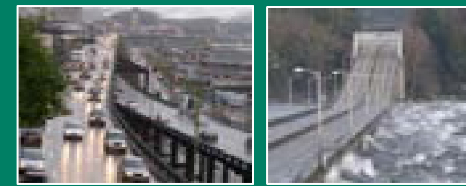
Architectural treatments on the floating bridge are not included in the base cost, and are covered by a separate risk.

Absolute percentage of base construction subtotal, Triangular distribution

10^{th} pct. 5%, ML: 6%, 90^{th} pct. 8%

(i.e., -16%,+0%,+33% of base aesthetic treatment cost)

Run Monte Carlo simulation model

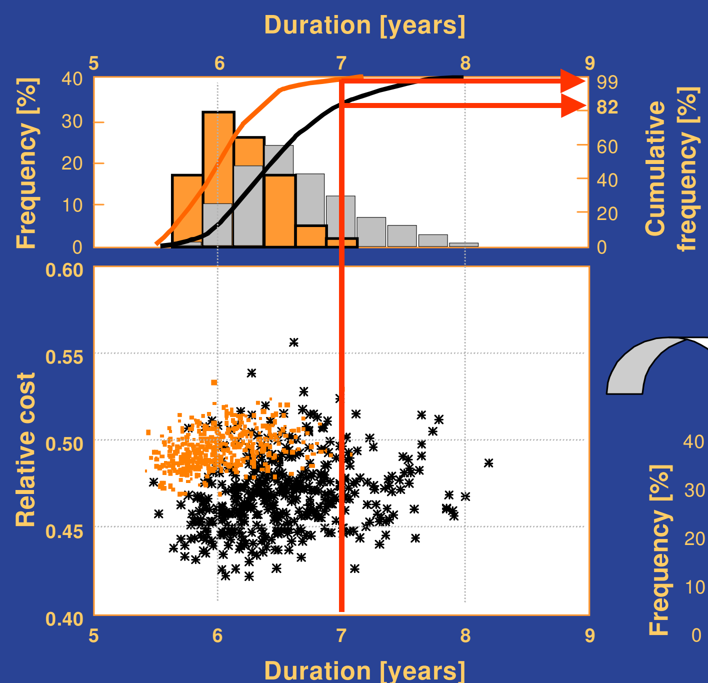


GEODATA

Results [1/5]

Scatter plots of a project duration and cost

Comparison of project solutions with different site investigation extents: partial [A] and complete [B]

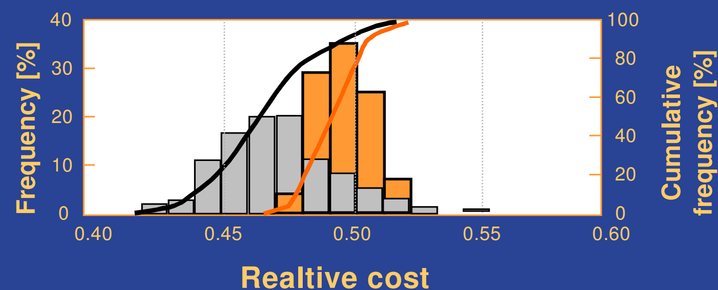


example:

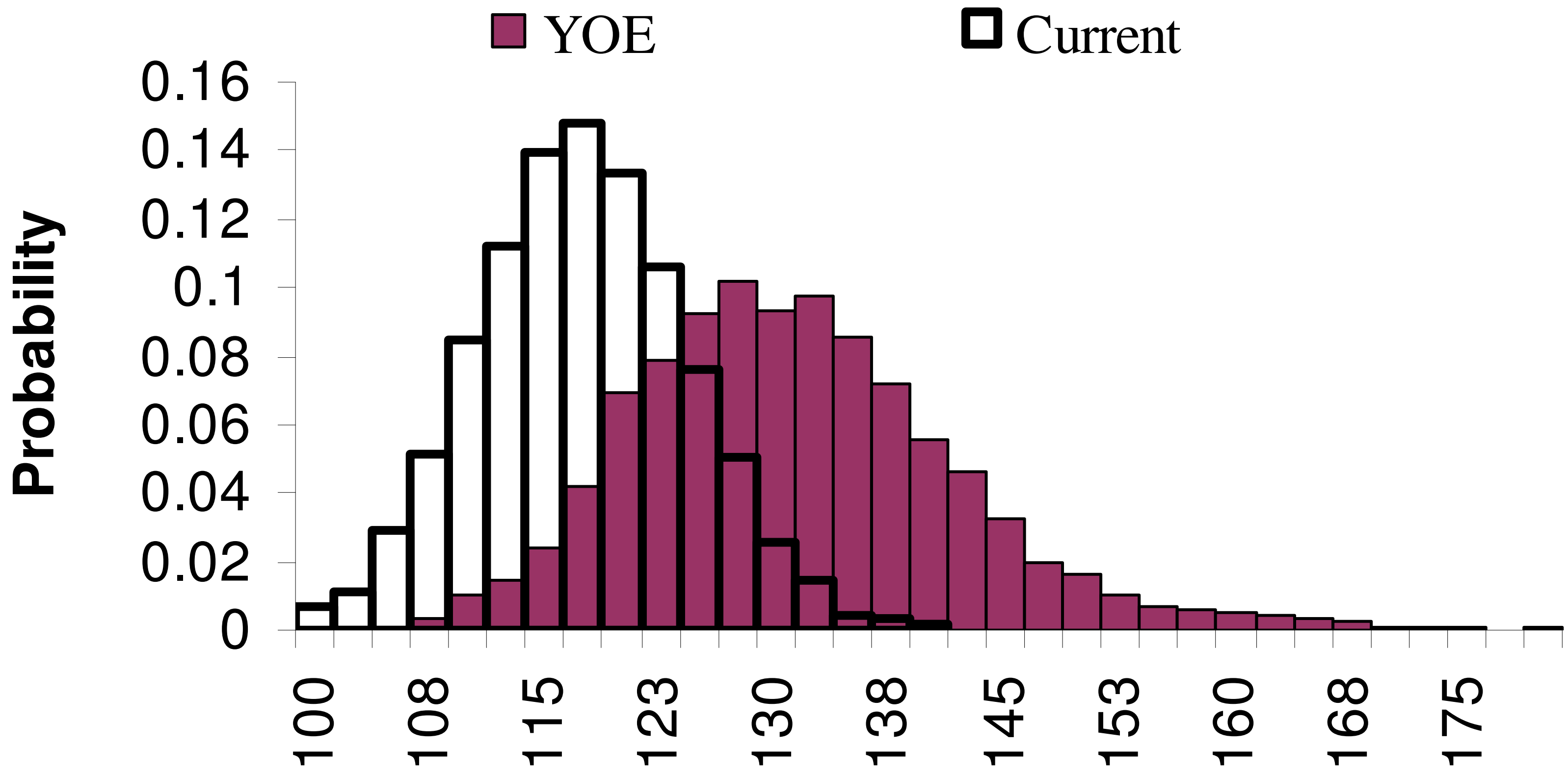
cumulative probability for completing the project within 7 years

solution A: 82%

solution B: 99%

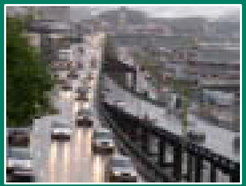


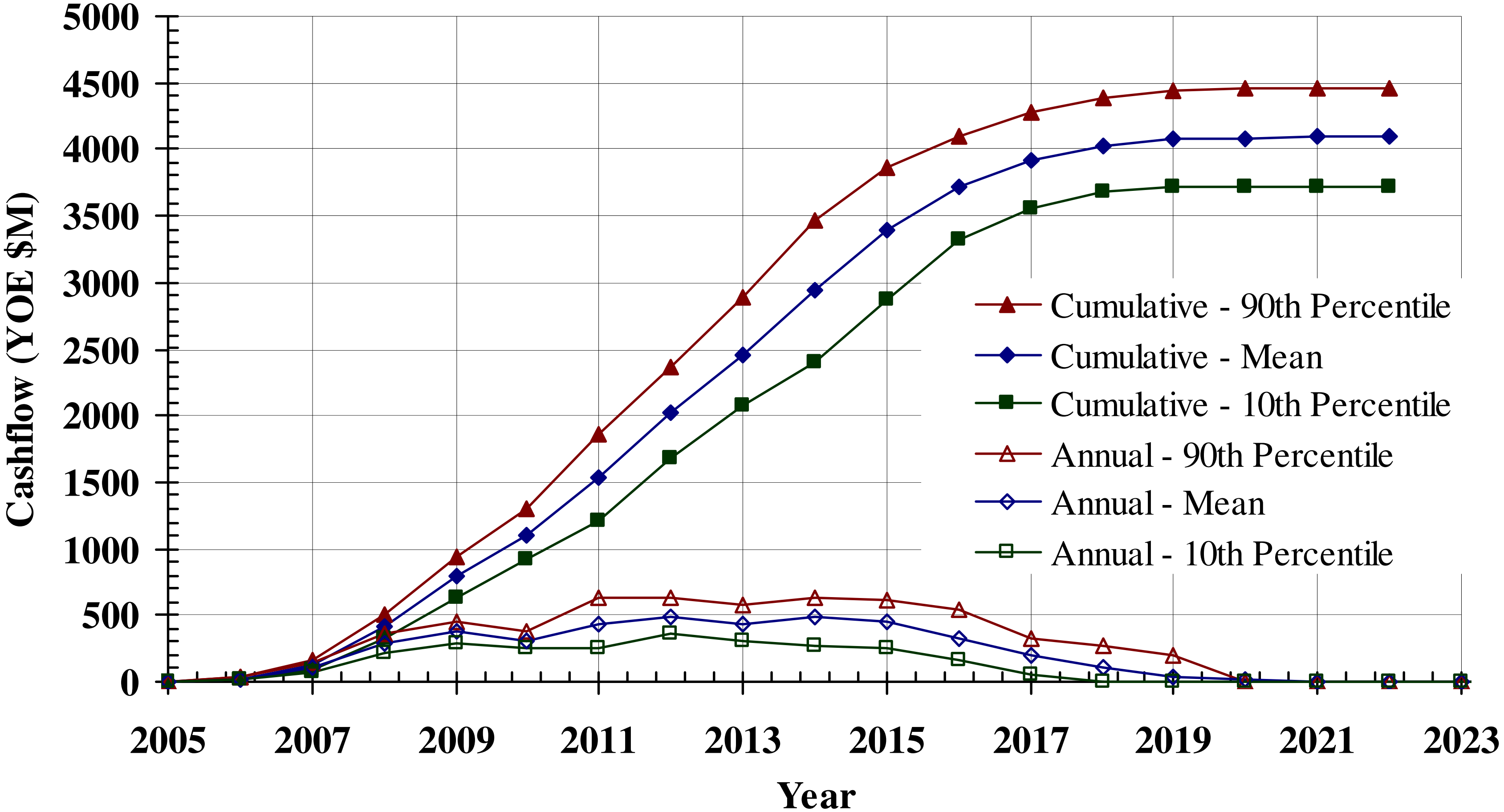
Current & Year-of-Expenditure Costs (2006 CEVP)



I-405 Bellevue

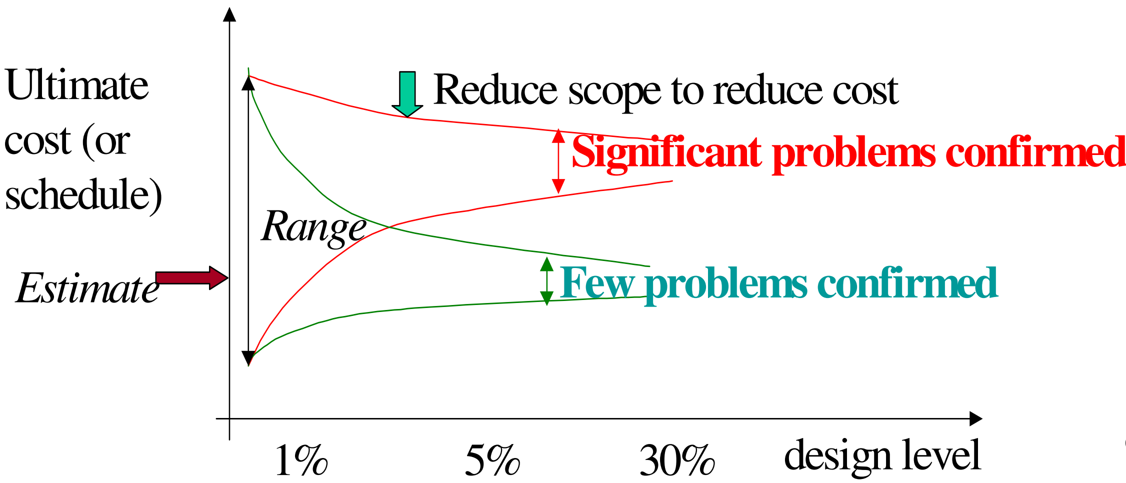
Analytical Results, T-1 Cash Flow

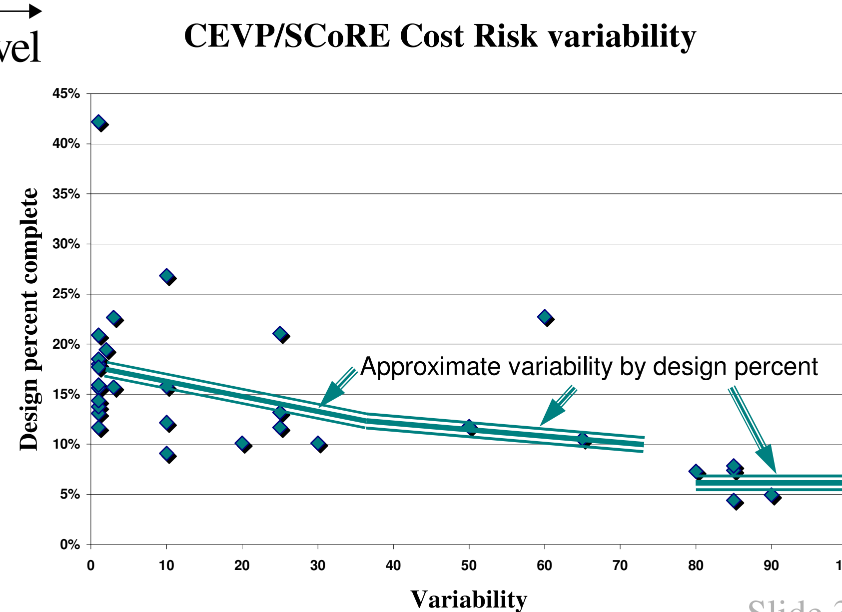




Range and variability

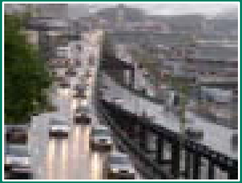
Range - by design %

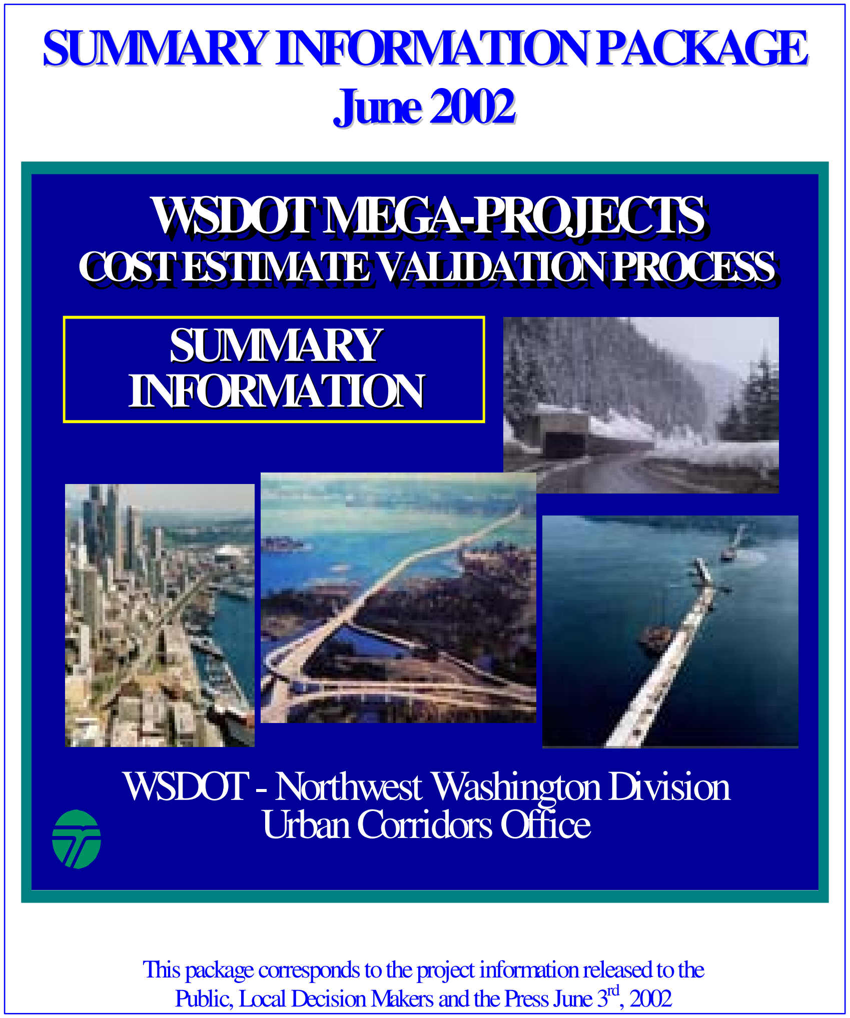


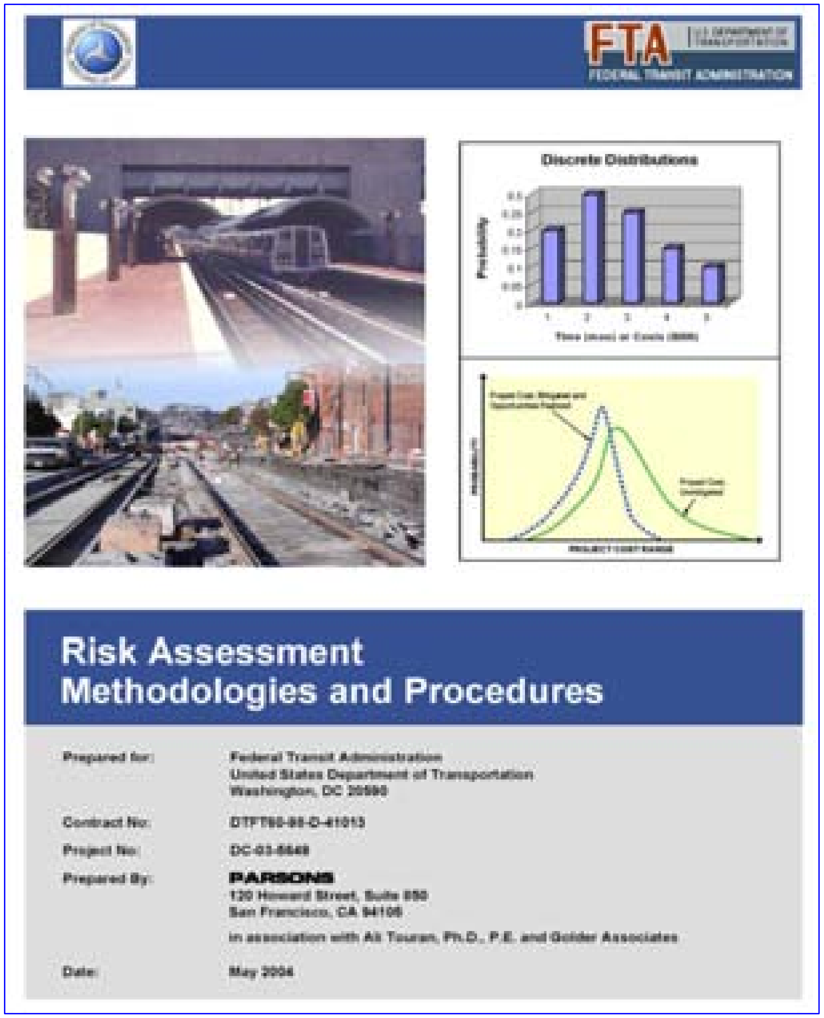


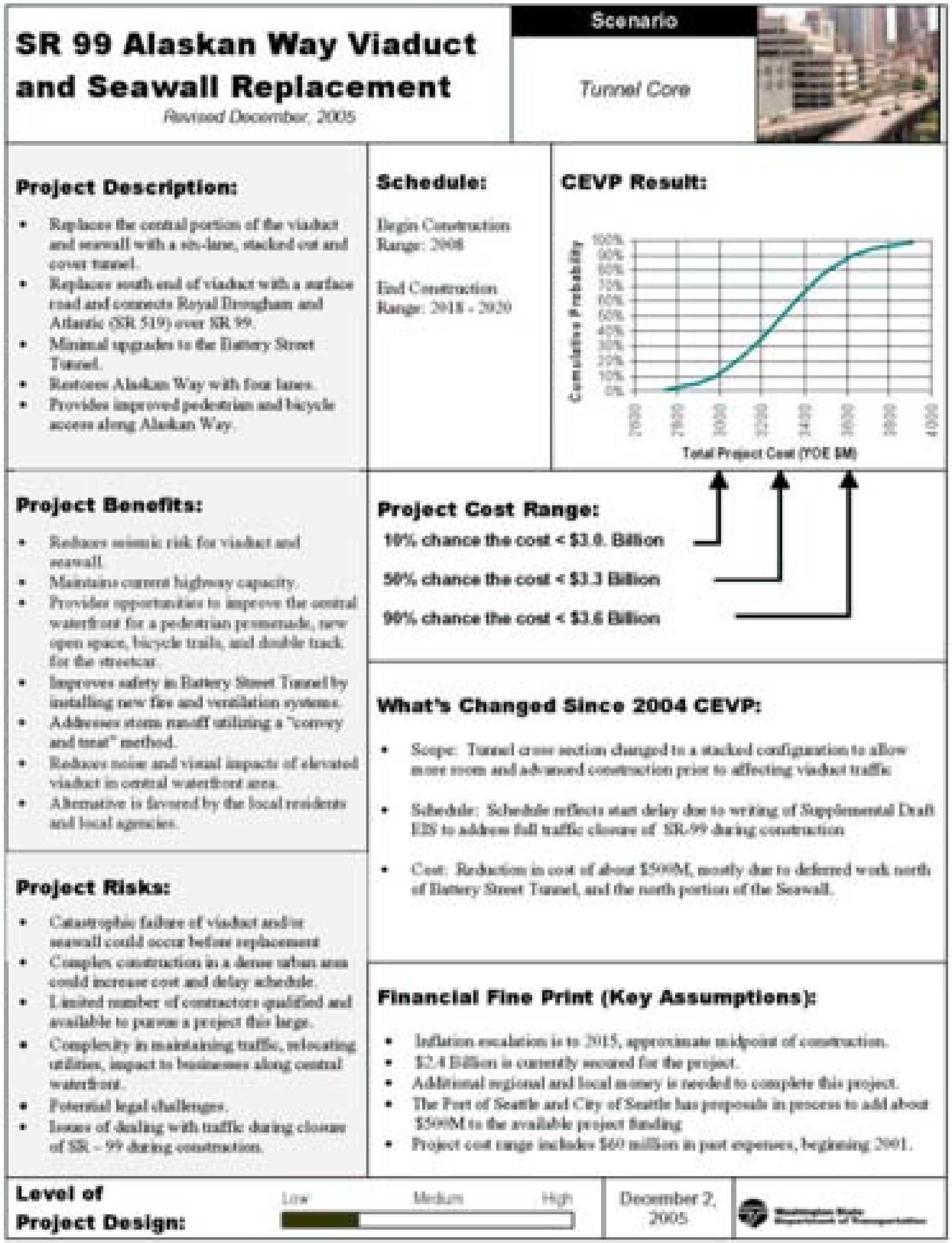
Communicate to the Public

WSDOT / FTA









SR 99 Alaskan Way Viaduct and Seawall Replacement

Revised December, 2005

Scenario

Tunnel Core

Project Description:

- Replaces the central portion of the viaduct and seawall with a six-lane, stacked cut and cover tunnel.
- Replaces south end of viaduct with a surface road and connects Royal Brougham and Atlantic (SR 519) over SR 99.
- Minimal upgrades to the Battery Street Tunnel.
- Restores Alaskan Way with four lanes.
- Provides improved pedestrian and bicycle access along Alaskan Way.

Schedule:

Begin Construction Range: 2008

End Construction Range: 2018 - 2020

CEVP Result:

Project Benefits:

- Reduces seismic risk for viaduct and seawall.
- Maintains current highway capacity.
- Provides opportunities to improve the central waterfront for a pedestrian promenade, new open space, bicycle trails, and double track for the streetcar.
- Improves safety in Battery Street Tunnel by installing new fire and ventilation systems.
- Addresses storm runoff utilizing a "convey and treat" method.
- Reduces noise and visual impacts of elevated viaduct in central waterfront area.
- Alternative is favored by the local residents and local agencies.

Project Cost Range:

10% chance the cost < $3.0 Billion

50% chance the cost < $3.3 Billion

90% chance the cost < $3.6 Billion

What's Changed Since 2004 CEVP:

- Scope: Tunnel cross section changed to a stacked configuration to allow more room and advanced construction prior to affecting viaduct traffic.
- Schedule: Schedule reflects start delay due to writing of Supplemental Draft EIS to address full traffic closure of SR-99 during construction.
- Cost: Reduction in cost of about $500M, mostly due to deferred work north of Battery Street Tunnel, and the north portion of the Seawall.

Project Risks:

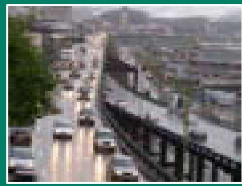
- Catastrophic failure of viaduct and/or seawall could occur before replacement.
- Complex construction in a dense urban area could increase cost and delay schedule.
- Limited number of contractors qualified and available to pursue a project this large.
- Complexity in maintaining traffic, relocating utilities, impact to businesses along central waterfront.
- Potential legal challenges.
- Issues of dealing with traffic during closure of SR – 99 during construction.

Financial Fine Print (Key Assumptions):

- Inflation escalation is to 2015, approximate midpoint of construction.
- $2.4 Billion is currently secured for the project.
- Additional regional and local money is needed to complete this project.
- The Port of Seattle and City of Seattle has proposals in process to add about $500M to the available project funding.
- Project cost range includes $60 million in past expenses, beginning 2001.

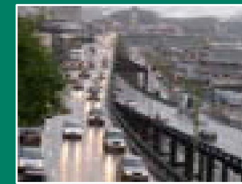
Level of Project Design: Low Medium High

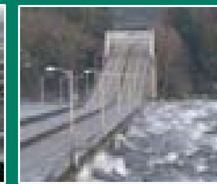
December 2, 2005



- A 1-page summary was used to communicate with the public and decision makers
- The key concepts were understood quickly.

The Public-release effort produced interesting comments





EASTSIDE EDITION

The Seattle Times

TUESDAY

www.seattletimes.com

Sticker shock: Cost estimates for highway projects skyrocket

"Giving citizens a range of costs, including full disclosure of the variables, "is not only politically smart, but it's common sense"…"

John Reilly, reported in the
Seattle Post-Intelligencer, June 9 2002

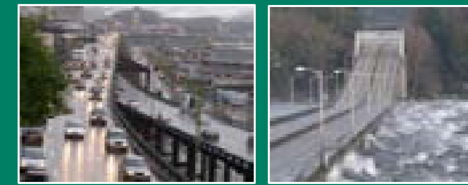
"Shocking or not, the Department of Transportation Has performed an unprecedented public service with these latest cost estimates. It is a much-needed dose of fiscal reality. ***The department offered realistic cost-range estimates"***

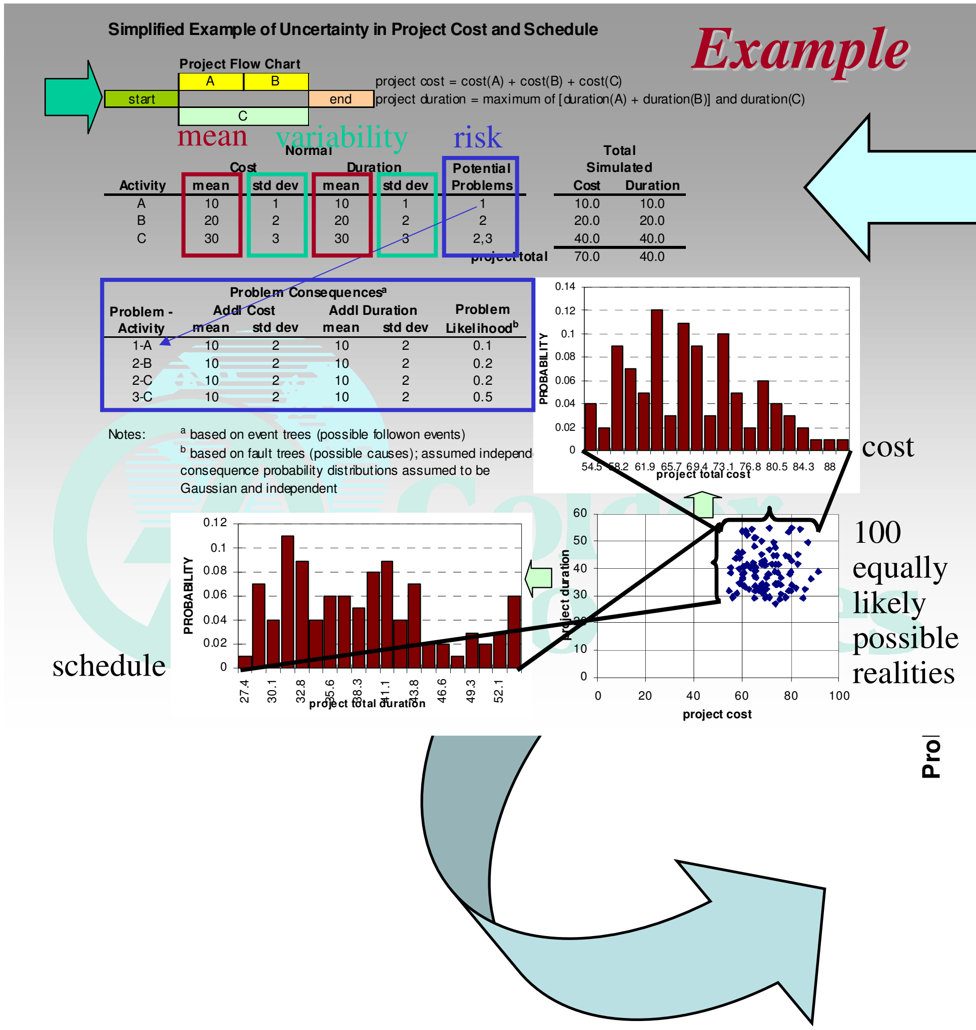
Seattle Post-Intelligencer Editorial

TUESDAY
June 4, 2002

SUNDAY
June 9, 2002

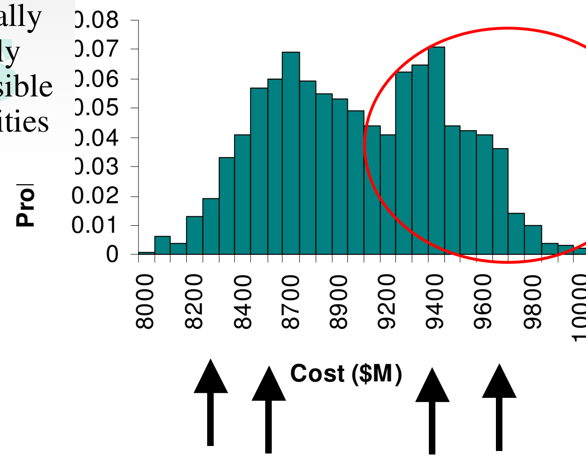
Risk Management





Combine the data to present meaningful management information for comparisons, decisions and risk management

Cost & Schedule Models



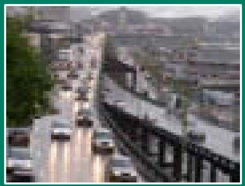
NEXT STEP:

A strategic management plan to reduce the high cost / high schedule risks

Approach:

Drive cost and schedule risk down - reduce impact and probability

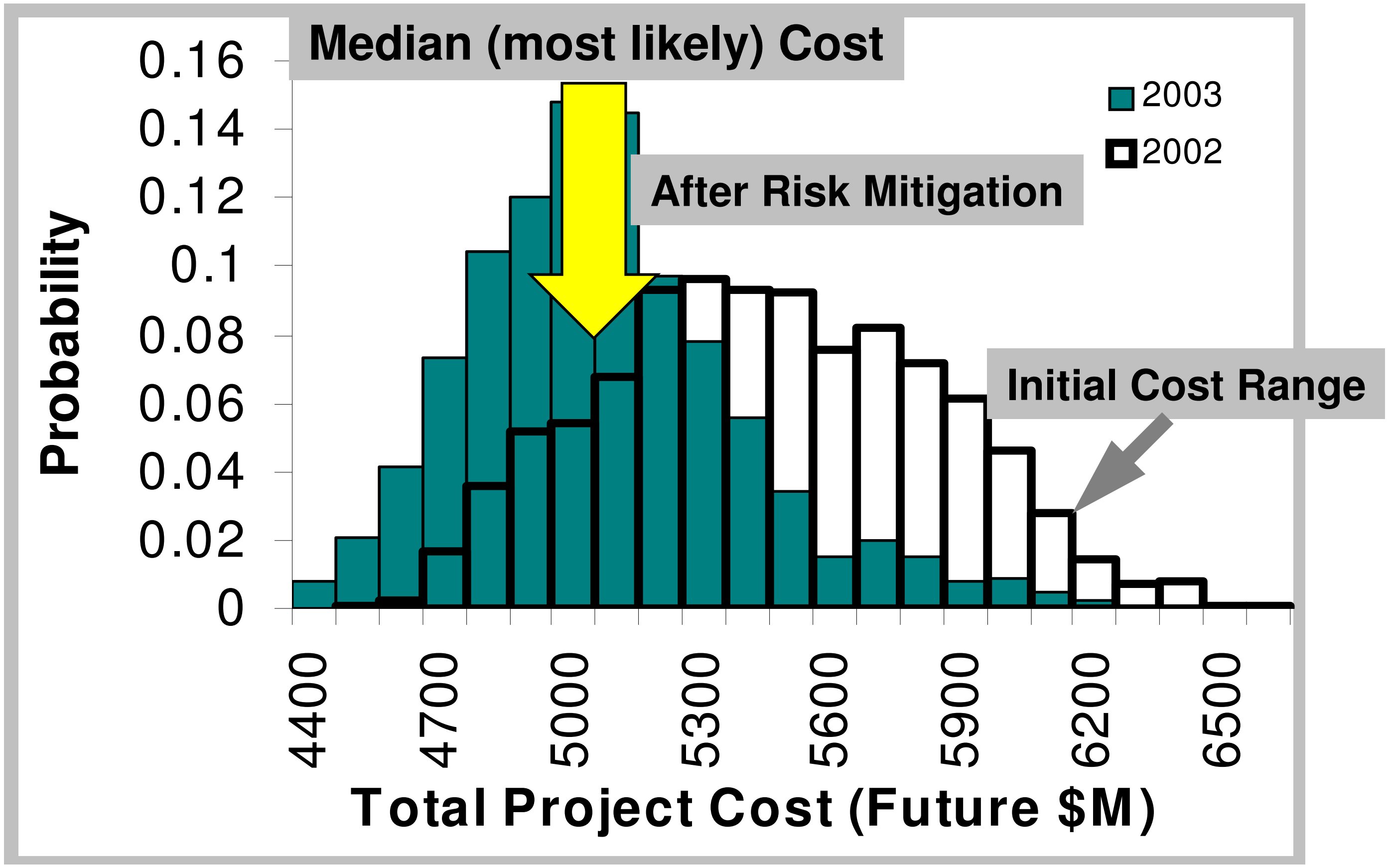
Risk Mitigation - Options



Risk Mitigation Action	How?	Affected Project Component(s)	Probability	Cost Impact	Schedule Impact
Relationship with USCG	Early coordination of communication	Bridge clearance		In the base	
Manage the political process	Work with congressional delegation	Paying for the bridges (major)	0.0%	$100,000,000	
Not able to use eminent domain without approval from governor	Resolve how to have pre-approval for eminent domain				
Relationship with COE	Determine backwater requirements	Bridge length	10.0%	$10,000,000	
Ability to sell tax exempt bonds	Develop MOU to move forward on IRS ruling	Project viability		In the base	
Need right of entry for data acquisition	Contact property owners to begin process immediately	Whole design program data acquisition	10.0%		6.0
Property data	Supplement existing data			In the base	
Military coordination	Agreement with Army for HDR to be ARRC's agent		50.0%		2.0
Early definition of operation requirements	Get first draft of concept operation	Move forward with engineering contract for project in general		In the base	
Relationship with COE/wetland/404	Early coordination with COE on classification /delineation of wetlands	Establish single point of contact		In the base	
Early coordination with federal/state agencies and data collection	Evaluate the large project process and see if that's the appropriate approach			In the base	

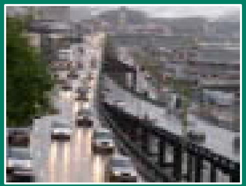
Use results - risk management

- Risk mitigation actions can be taken, based on the explicit risk events that are causing the higher-range costs - thus reducing the "range of probable cost"



Seattle - Alaskan Way Tunnel

Initial results for WSDOT

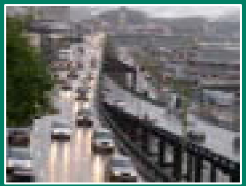


- WSDOT applied the CEVP Cost-Risk process for 10 mega-projects - for approx 0.01% of project costs
- The more realistic cost ranges led to decisions about what could be to built within the available budget
- This allowed better communication with Political decision-makers and Public regarding realistic cost ranges
- Risk mitigation was applied with the explicit risk data
- Scope changes were made to fit projects to budgets
- WSDOT adopted the CEVP process for major projects and a simpler less costly process (CRA) for smaller projects
- FTA and FHWA have used probalistic cost-risk estimating for major projects

What does it take to do CEVP?

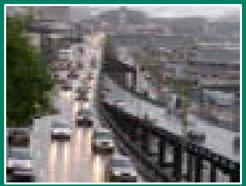

- A knowledgeable/committed owner
  (who wants to know a realistic “potential cost”)
- A well-shaped project estimate (assumptions)
- Committed project team members
- Sufficient independent subject matter experts who can calibrate “the environment” - cost and risk
- Skilled risk and cost elicitators (debiasing)
- Risk modeling - technology and experience
- Time / available funding
- Objective evaluation of the results (ranges)

Cautions



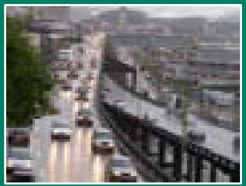
- CEVP is iterative in nature and represents a “snapshot in time” for that project for the known conditions at that point.
- CEVP normally deals with identifiable and quantifiable project-type risks – i.e. those events that can occur in planning, design, bidding, construction and changed conditions.
- CEVP could also consider the larger, more difficult risks – political and management continuity and “acts of God” that can have very high impact in cost and schedule on large programs – but at this point, these risks are not generally included.
  - This is an area for review and development – in particular how to characterize such events in a useful manner for better management of the projects

Current Issues -
future cost escalation rates



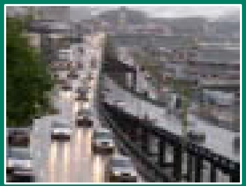
- A major determinant
- Needs to be calibrated to the circumstances of the project and it's timeframe
- How to "read" the current cost environment:
  - Now
  - Next year
  - Next 5 years
  - Next 10 years
  - Next 20 years

Cost Escalation - Preliminary



- Cost escalation (inflation + real escalation) will return to the long term trend - about 3% or less on a long term basis (20 years +)
- Escalation in the next 3 years expected to be about 5.5%
- Variation in specific prices will depend on market conditions and control of inflation (Federal policy)
- Variation may be large in specific years but will average over a long period to historical values
- The political environment is a strong but unknown determinant

Acknowledgements



- Papers and presentations describing the CEVP process can be found at: www.wsdot.wa.gov/projects/projectmgmt/riskassessment