

SCAV-CSVA 2009

Developing Project Budgets Based on a Risk-Adjusted Estimate

Risk-Based Estimating in Application



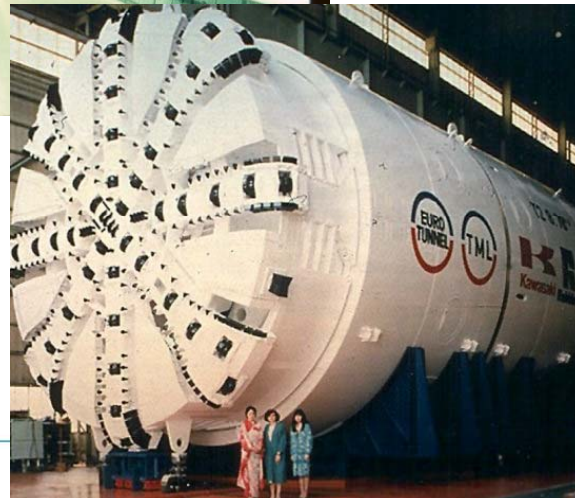


Final Cost versus “Budget”

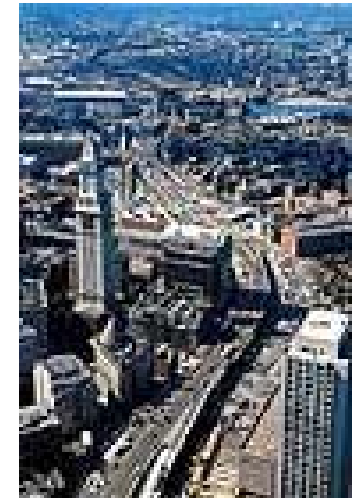
- Many large, complex projects have exceeded budgets and schedules
- Examples include these major projects.....



London Jubilee
Line Metro
+67%



Channel Tunnel
+80%



Boston Central
Artery / Tunnel
>>400% (tbd)



Final Cost versus “Budget”

- “MTA projects likely to face budget cuts.” Fulton St. Transit Center, NYC: “Nobody anticipated this kind of increase,” MTA Board Chairman Dale Hemmerdinger said. “This is just a reality of doing business in 2008. You just have to get used to it.” Ramifications of soaring prices have been felt worldwide, he added. (NY Times, NY Daily News)
- Brightwater Sewer System, Seattle: When the current, \$1.8 billion cost estimate for Brightwater is mentioned, Sheadel deadpans, “You’re an optimist. Do you want to bet lunch on \$3 billion?” (Seattle Times)
- 90% of estimates for transportation infrastructure projects have been low
- On average, cost estimates for transportation projects have been 25% short of final costs



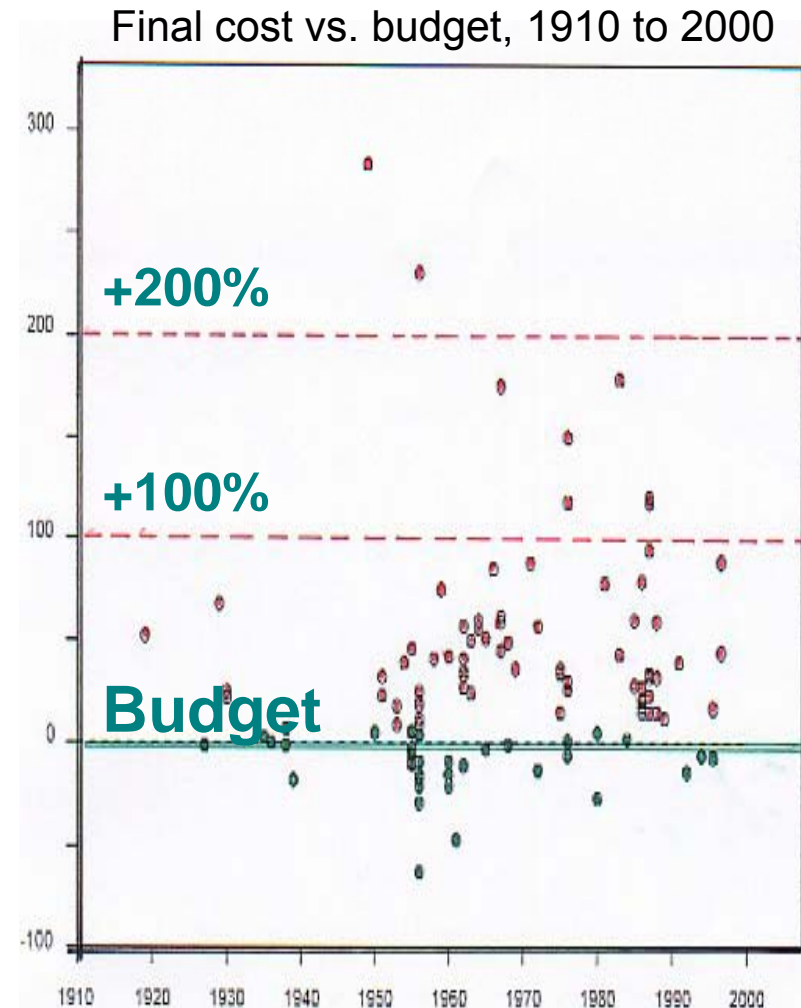
Final Cost versus “Budget”

- Pickering Beach/Salem Road cost > 190% of 1998 estimate
- Lakeridge Road cost > 150% of 1998 estimate
- Stevenson Road Oshawa cost > 450% of 1998 estimate
- Front Street Extension cost growth > 145% so far
- Highway Widening in SW Ontario, Bid Price \approx 200% of preliminary engineering budget
- New Highway Twinning, preliminary engineering estimate \$135M, risk-adjusted estimate, \$250M expected value (current value)
- New Highway Twinning, preliminary engineering estimate \$105M, risk-adjusted estimate, \$136M expected value



Final Cost versus “Budget”

- 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
- Flyvberg suggested this was best explained by “strategic misrepresentation” or dishonestly optimistic representation to “push” project ahead for political/financial gain



** at time of decision to implement



Final Cost versus “Budget”

- MTO – Unknown Subsurface Conditions
- Typical geotechnical exploration and consulting cost 1% to 2% of total construction cost
- Over-runs, Under-runs, or Extras on earth or rock excavation estimates led to:
 - average 14.3% cost escalation
 - range of cost escalation 0% to >50%
 - standard deviation of cost escalation of 15%
- Interpretation – who is at “fault”? Geotechnical Engineer, Design Engineer, Contractor?



Key Concepts - Root Issues for “Budgets”

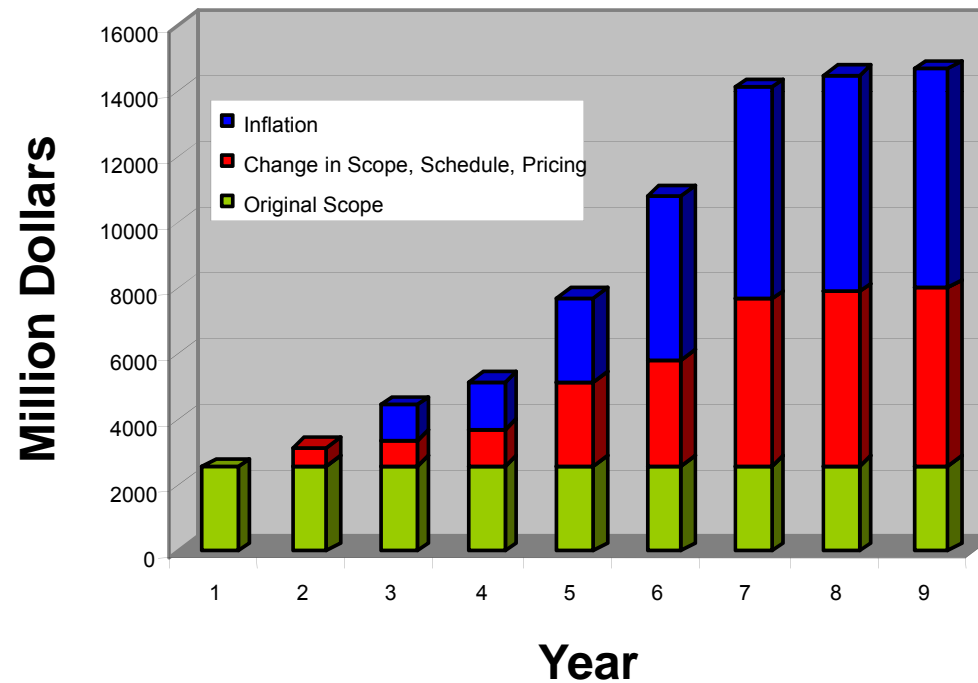
Project “Budgets” are often set very early in life of a project:

- Changes for environmental assessment/permitting needs
- Uncertain design – budgets developed prior to preliminary or detailed engineering
- Uncertain functional goals
- Project “add-ons” - scope creep (death by a thousand pin pricks)
- Economic changes - inflation, market conditions
- Alignment changes forced by property issues
- Unknown subsurface conditions (geotechnical, archeological, environmental)
- Materials performance and costs
- Third parties (neighbours, railroads, etc.)
- Errors & Omissions in planning or design
- Procurement method (low-bid, bid-averaging, design-build, etc.)



Key Concepts - Root Issues for “Budgets”

- Example of breakdown in underlying changes to project cost: Boston “Big Dig”, Central Artery/Tunnel

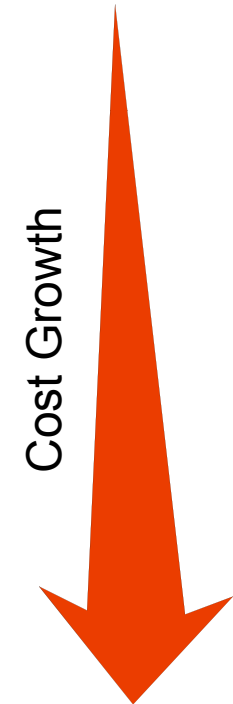
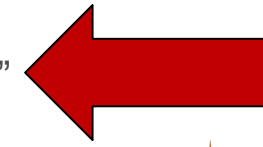




Key Concepts - Root Issues for “Budgets”

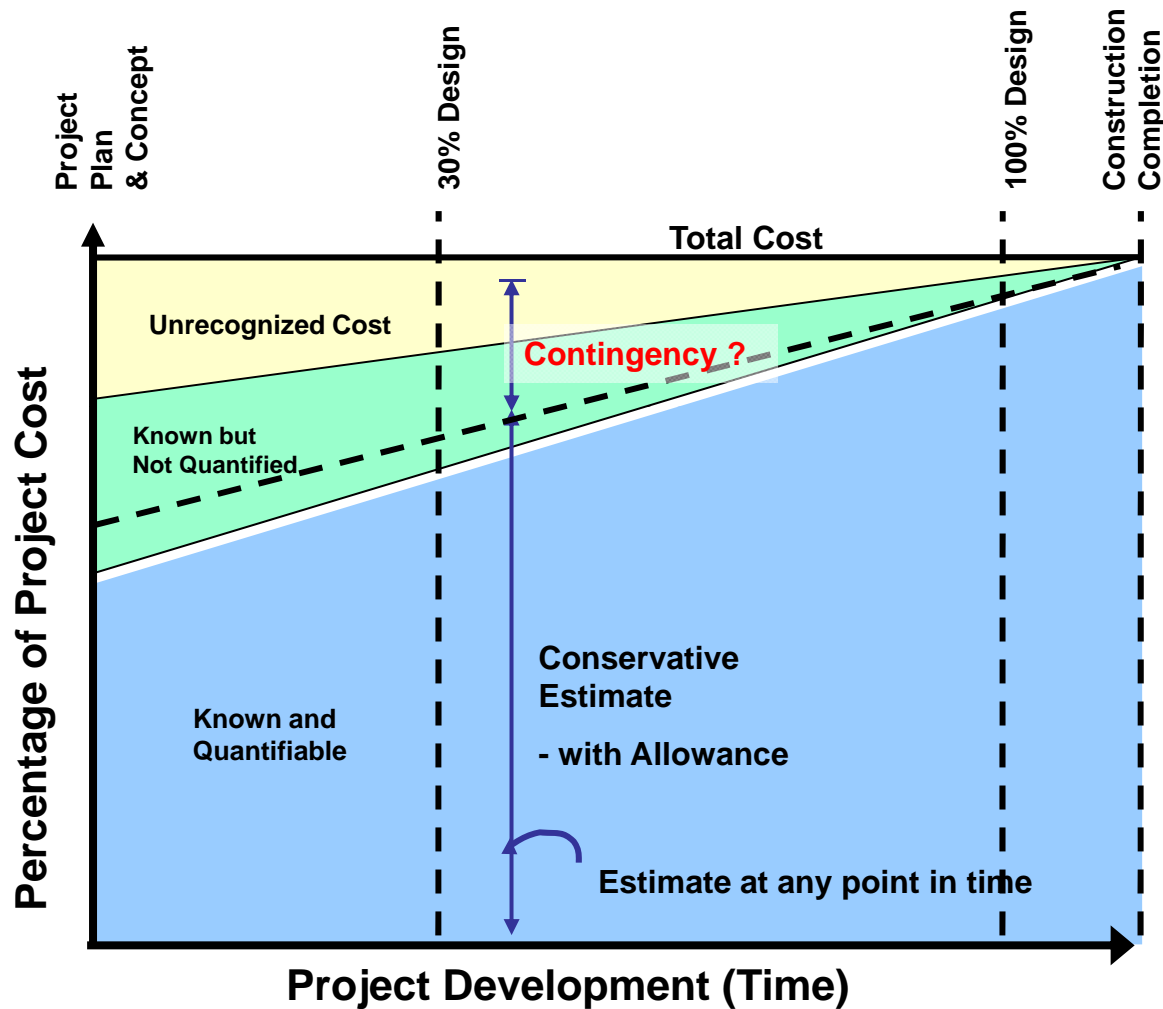
- Conceptual Planning/Environmental Assessment:
 - “It’s too early to develop a realistic budget”
 - Conceptual design, needs/feasibility/alternatives
 - Parametric estimating + “contingency” + inflation(?) = “budget #1”
 - Long delivery timeline (for major projects, 5 to 10 years out)
- Preliminary Engineering:
 - “It’s too early to develop a realistic budget”
 - Geometrics, basic layout
 - Parametric estimating + “contingency” + inflation(?) = “budget #2”
 - Delivery timeline better known
- Detailed Engineering:
 - Unit cost estimating + “contingency” + inflation(?) = “budget #3”
 - Delivery time and method known
- Construction
 - Bid cost + “extras” = final construction price
 - Additional engineering + legal fees + final construction price = total

Political/Public Focus





Key Concepts – Uncertainty Changes





Key Concepts – Uncertainty Changes

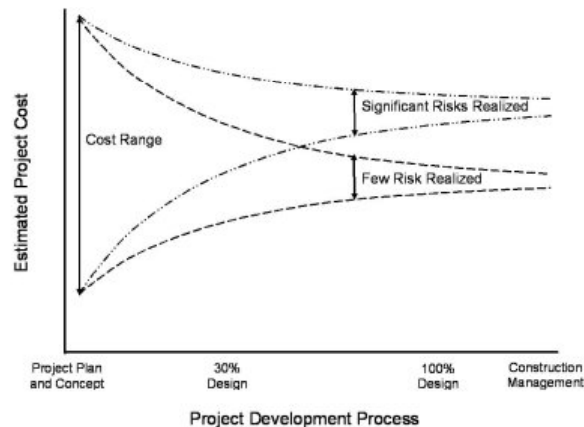
AACEI Generic Cost Estimate Classification Matrix (from AACEI, 1997)			
Estimate Class	Level of Project Definition (typical)	Purpose of the Estimate	Expected Accuracy - %
Class 5	0 to 2%	Screening or Feasibility	+100 to -50
Class 4	1% to 15%	Conceptual Studies or Feasibility	+75 to -40
Class 3	10% to 40%	Budget Authorization Design (Control)	+40 to -20
Class 2	30% to 70%	Design or Bid/Tender	+20 to -10
Class 1	50% to 100%	Check Estimate or Bid/Tender	+10 to -5

Adapted from *Association for the Advancement of Cost Engineering International* by Anderson (2003)



Key Concepts – Uncertainty Changes

- “Contingency” = Top Down Approach
 - Applies a deterministic (single value) estimate (guess) to deal with all uncertainty
 - Database for choosing appropriate contingency usually very limited because of complicating factors with unique civil engineering projects
 - For example: for a Class 5 estimate (early) range is +100% to -50%, what is the “budget”
 - For Class 3 estimate (decision point?) range is +40% to -20%, what is the “budget”





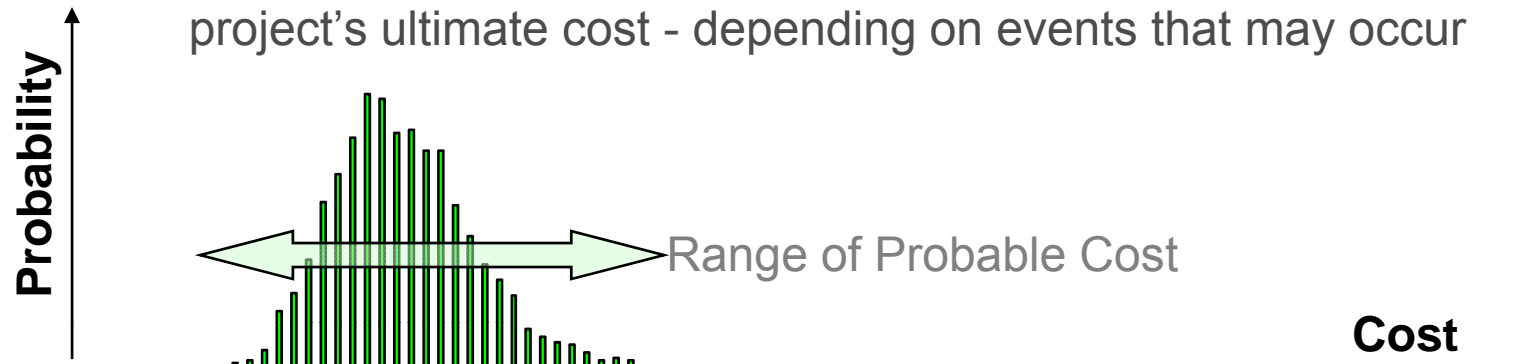
Deterministic “Budgets” – Consequences

- Challenges for industry and public policy:
 - Initial estimates (conceptual/preliminary) are viewed/published/acted-upon as “fixed price” for “project” in spite of “qualifiers” often included with estimates
 - Political “budgets” often neglect time-value of money & construction cost escalation
 - Cost-sharing funding agreements are often based on budgets set early in the project
 - For shared funding arrangements, the senior levels of government may fix the level of funding based on current dollar values for a project delivered at some indeterminate future date
 - Junior funding partners may be inexperienced with risk management and become financially overwhelmed
 - Recrimination, political fall-out, damaging for industry



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

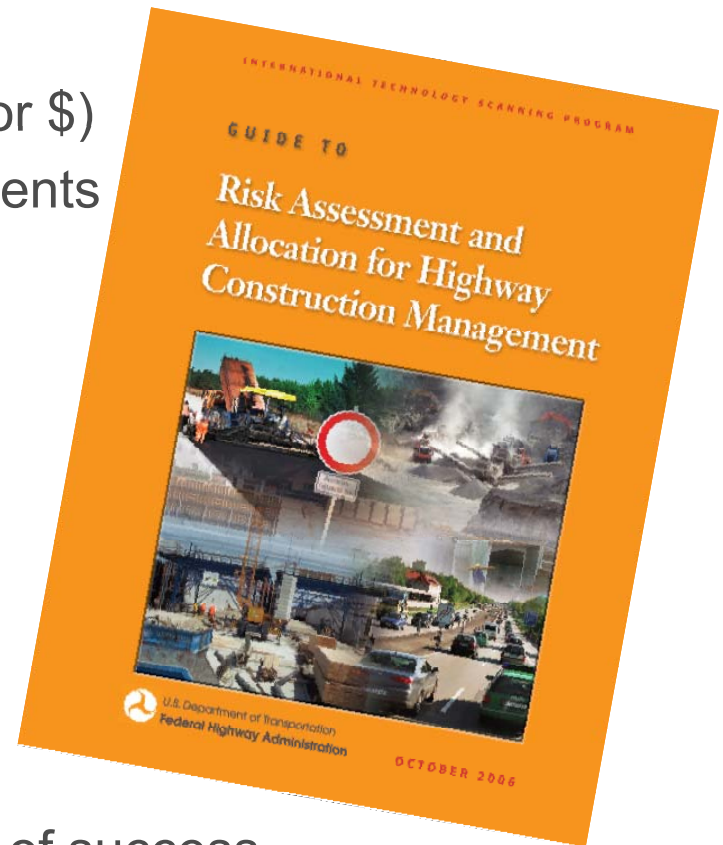


- A single cost number represents only one possible result, depending on circumstances and risk events that affect cost
- These circumstances and risk events are not directly controllable or absolutely quantifiable
- The risk events, if they occur, produce impacts which add cost or time to the project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



Probability (Risk) Based Estimating

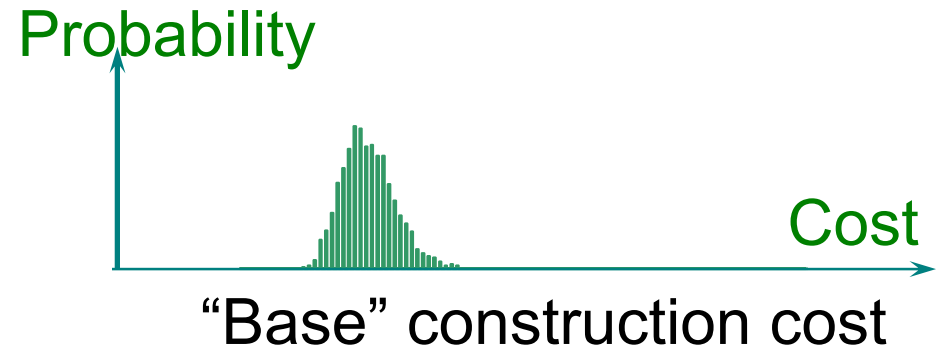
- Structured framework for quantifying uncertainty:
 - Identifies risks (increases in cost, time)
 - Identifies opportunities (savings in time or \$)
 - All uncertainties are QUANTIFIED as events
 - Probability of event occurring
 - Consequence if event occurs
 - Comprehensive uncertainty evaluation
 - Scope (alternatives, “wish lists”, political)
 - External influences/stakeholders
 - Market issues
- Results:
 - Range of cost & probability of success
 - Range of completion dates & probability of success
 - Risks/Opportunities are ranked according to consequence



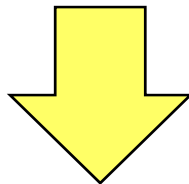


Probability (Risk) Based Estimating

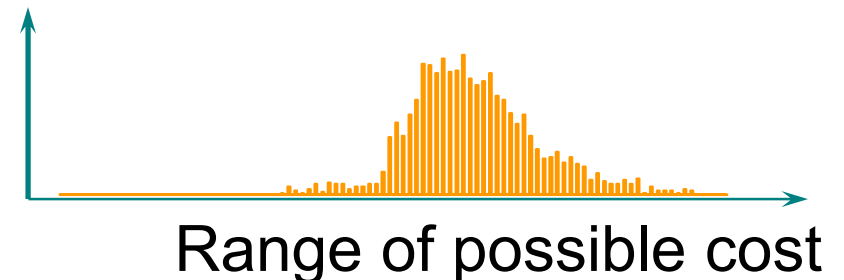
- 1) Determine the “Base cost”
(normal cost with variance)
No Risk/Opportunity
Everything Goes As Planned



- 2) Add Cost for risk events
(risk = probability x consequences)



- 3) Range of possible project cost

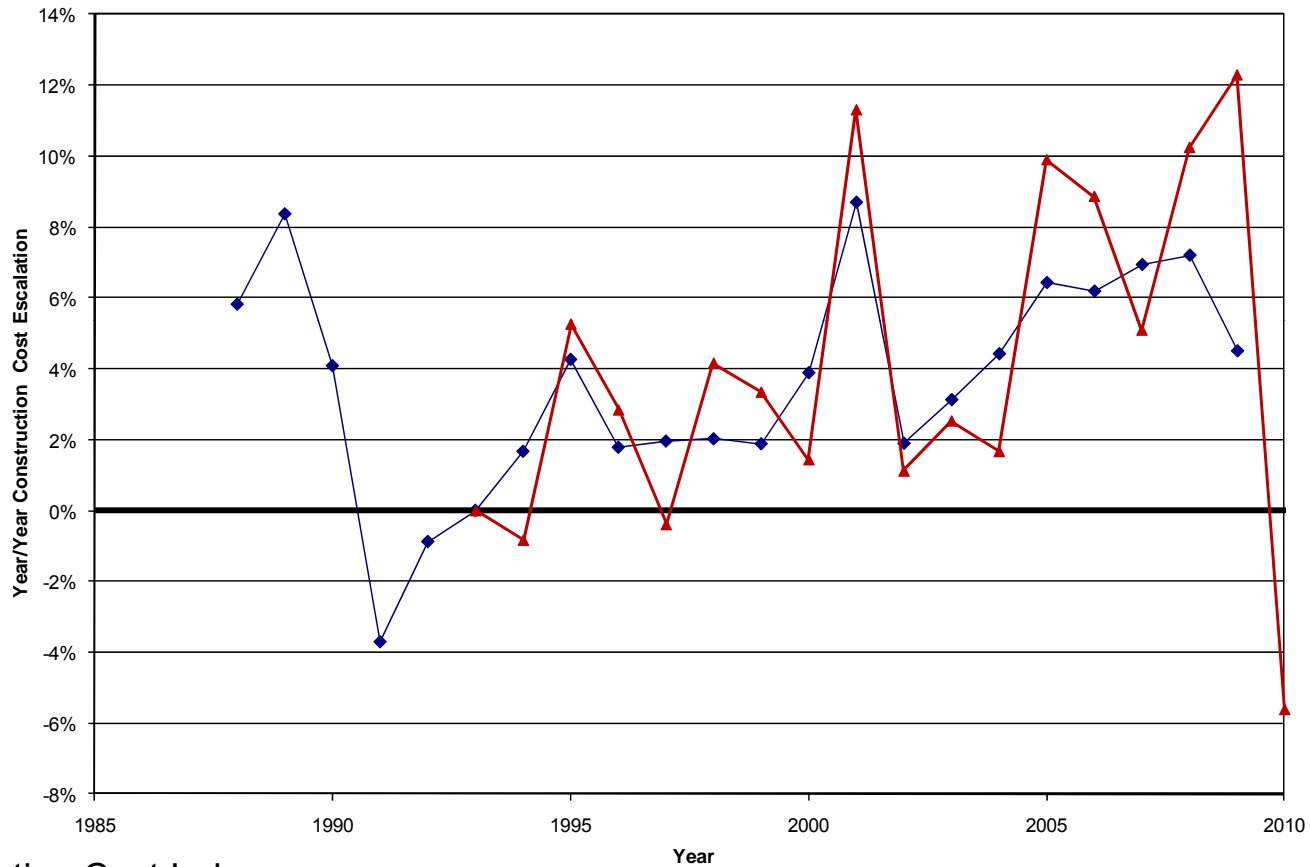


(*) Risk cost is normally called “contingency”



Probability (Risk) Based Estimating

Example of Uncertainty

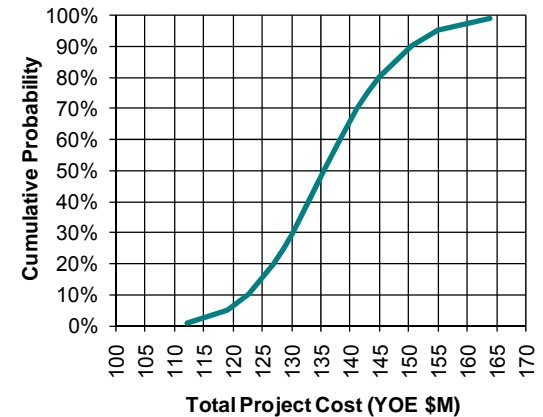
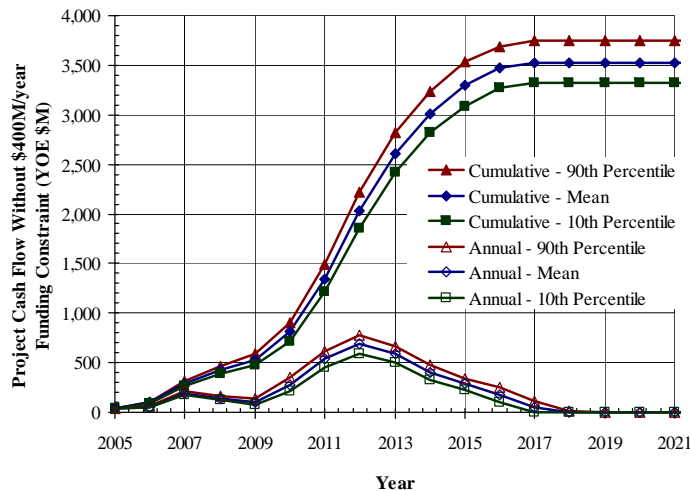
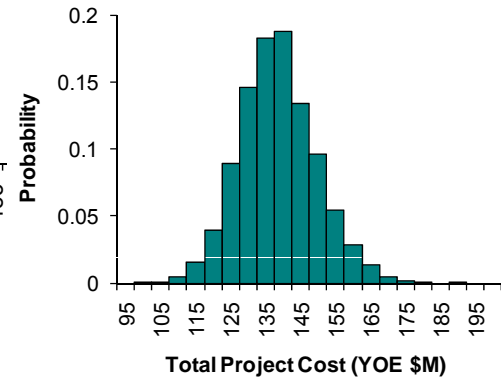
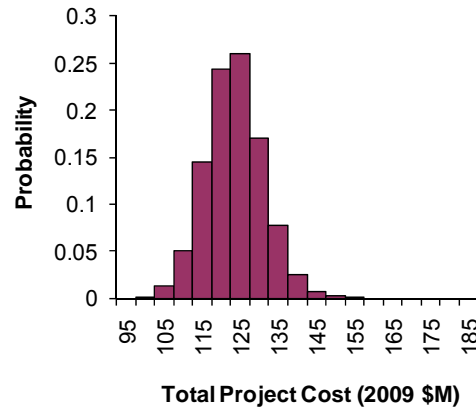


- Construction Cost Index
- MTO Tender Price Index



Probability (Risk) Based Estimating

- Better to be approximately right than precisely wrong
- Expectations more realistic (not a single value)





Probability (Risk) Based Estimating

Item	Risk or Opportunity	Affected Project Activities	Probability of Occurrence	Cost Change (current \$M)	Duration Change (months)
D10	Schematic design time uncertainty (takes longer/shorter time than base). Applied independently to all activities for all packages.	8	70% 30%	0	0 (base) +2
D11	Design development time uncertainty (takes longer/shorter time than base). Applied independently to all activities for all packages.	13	A. 40% (P7, P8) B. 30% (P7, P8) C. 30% (P7, P8) A. 40% (P1-P6) B. 40% (P1-P6) C. 20% (P1-P6)	0	A. 0 (base) B. +2 (P7, P8) C. +4 (P7, P8) A. 0 (base) B. +1 C. +2
D12	Construction documents time uncertainty (takes longer/shorter time than base). Applied independently to all activities for all packages.	19	10%	0	+1
D13	Tender documents time uncertainty (takes longer/shorter time than base)	23	Minor	Minor	Minor
D14	Tender and award process time uncertainty (takes longer/shorter time than base)	24			
D15	Existing seawall requires design and construction modification with increased cost and time. Correlated among activities, but independent for packages.	32, 13	50% (P1-P6)	P1: +\$0.96 P2: +\$0.64 P3: +\$0.60 P4: +\$0.72 P5: +\$6.80 P6: +\$0.96 (\$8k/m) All \$ to 32	+1 to 32 +1 to 13
D16	Design changes to respond to DFO or NWPA reviews. Applied independently to each packages.	13 (P1-P6)	80%	Minor	3
D17	Additional Utility costs (electricity, Bell Telephone, gas, etc.) identified during design QQ: see services for characterization	34, 35, 13	Minor (P1-P6) Minor (P7, P8)	Minor (P1-P6) Minor (P7, P8)	Minor to 13
D18	Design accommodation for free product in groundwater (includes discovery during CN)	34, 35, 13	Minor (P1-P6) Minor (P7, P8)	Minor (P1-P6) Minor (P7, P8)	Minor to 13



Probability (Risk) Based Estimating

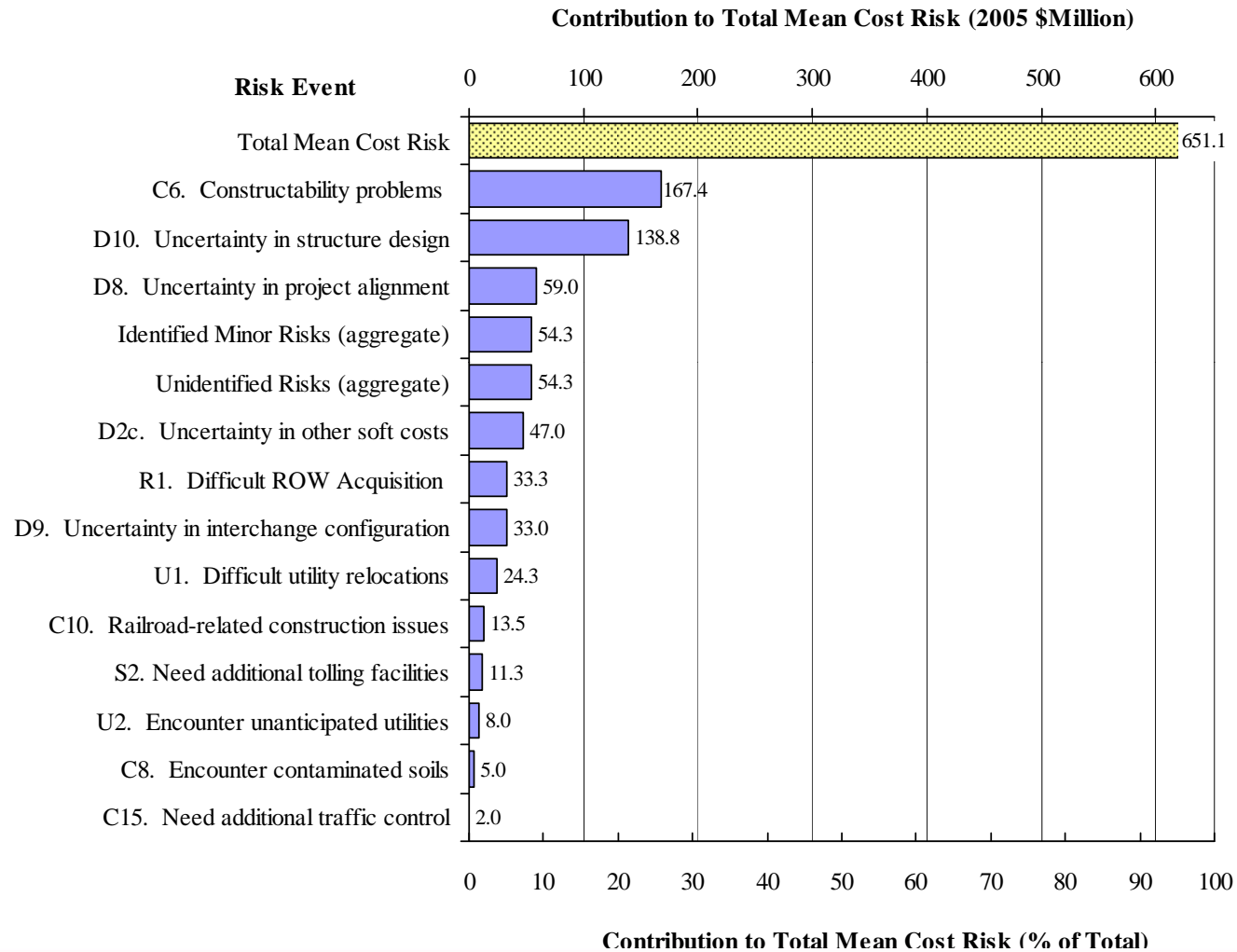
1. Table 3.4.2. Approximate Contribution of Each Major Risk or Base Uncertainty to the 90th Percentile Total Project Cost (in YOE \$M)

Rank	Approximate Contribution to 90 th Percentile (YOE \$M)	Risk Event or Base Uncertainty (see Appendix E)
1	44.9	S3 - Scope of the works as defined by the Key plan and Managers Report will change
2	21.2	O2. Construction Escalation Uncertainty
3	11.5	C4 - Construction Market Conditions (bidding, competitiveness)
4	11.2	Design/Permitting/Management
5	10.5	Unidentified Risks (aggregate)
6	10.0	Identified Minor Risks (aggregate)
7	9.0	D15 - Existing seawall requires design and construction modification
8	8.7	Existing Conditions/Demolitions/Removals
9	7.2	C8 - Construction Market Conditions (equipment, labor, and materials)



Probability (Risk) Based Estimating

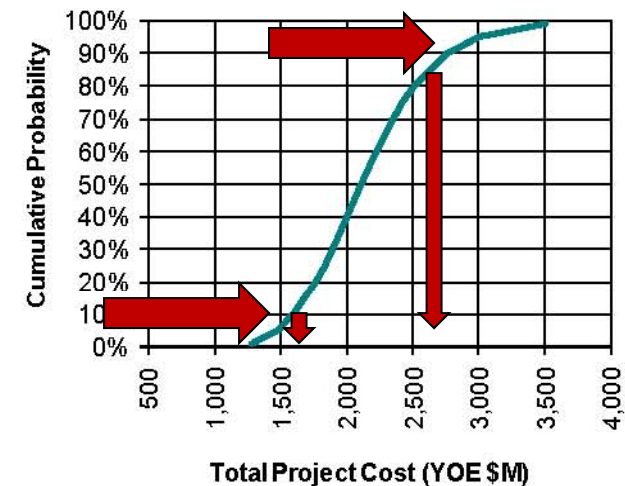
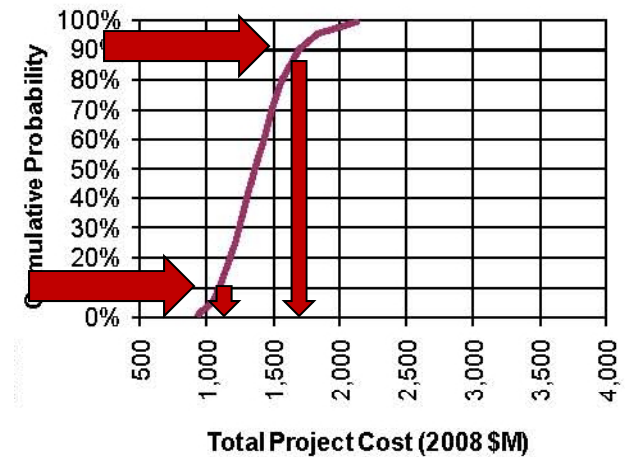
Similar Ranking for Delay Risks





Risk (Probability) Adjusted Budgets

- What number(s) should be used for a target “budget”?
- A “conservative” estimate 90th Percentile – while it avoids “going back to the well” and increases chances of successful delivery “under budget”, can lead to inattention to risks/opportunities
- “Conservative” estimates may cause difficulty with agency-level programming among projects (few projects viable in competition for funds)
- A “tight” estimate 10th Percentile without reserve leaves little ability to manage and only has a 10% chance of success





Risk (Probability) Adjusted Budgets

- Two US States – Informal Policy
 - Establish risk-based estimate
 - Assign project manager budget at 50th Percentile
 - Establish one or more “tiers” of reserve that may be accessed at higher agency levels
 - Require levels of management approval of different difficulty

- US State (unnamed) – Informal Policy
 - Establish risk-based estimate
 - Project manager assigned 60th Percentile
 - 1st Level of Reserve at 70th Percentile – relatively easy to access
 - 2nd Level of Reserve at 80th Percentile – very difficult to access



Risk (Probability) Adjusted Budgets

- Washington State Department of Transportation
 - Most extensive risk-based estimating practice for DOTs
 - Pending Policy Proposal
 - Require Project-Level management to manage to “Base Cost” – adjusted on an annual basis for cost escalation
 - Use 70th Percentile for programming purposes at agency level – cost escalation adjusted
 - Difference between “Base Cost” and 70th Percentile held as “Risk Reserve”
 - Budgeting with “Risk Reserve” proposed to become standard practice



Risk (Probability) Adjusted Budgets

- Develop project or agency policy depending on:
 - Risk tolerance
 - Standing funding policies for projects
 - Legislative controls
 - Agency controls
 - Funding controls
 - Political tolerance for change
 - Communication strategies internally and to public
 - Reserve (or “contingency”) management strategies – reserve balance from individual projects that can be used among many projects (program management) – allows “budgets” to be set at lower percentile values, recognizing that **all** projects will likely not experience **all** risks





Risk (Probability) Adjusted Budgets

Keys to success:

- Start early in project life with risk analysis
- Develop open minded approach to uncertainty of scope and cost of “project”
- Consider “out of the blue” changes to scope – scope changes are perhaps the biggest source of uncertainty at early stages of a project’s life
- Assign responsibility for identified uncertainties to specific individuals (need a “champion” to effectively implement RM strategies)
- Develop clear framework for project management within agency/owner
 - Budget goals at different levels of management responsibility/control
- Develop clear goals – function, social benefit, cost control, etc.
- Develop clear communication & documentation strategies
- Update periodically for long-term projects (particularly influenced by delays and year/year cost escalation)



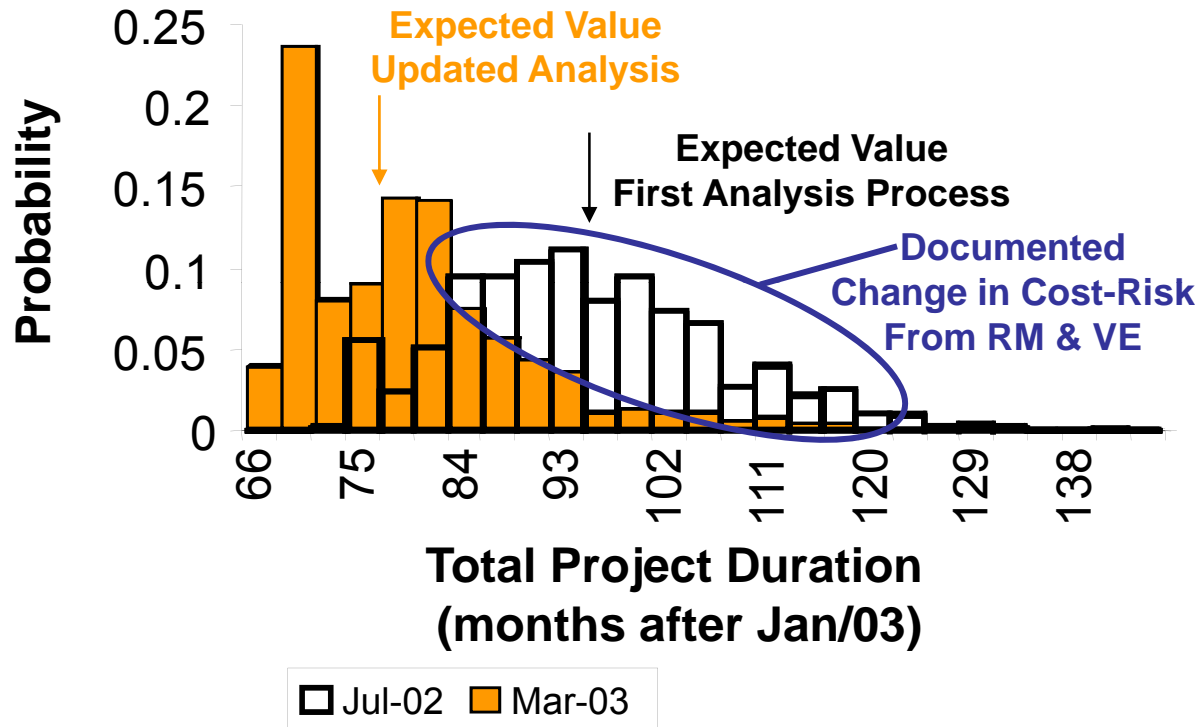
Risk Management – Budget Control

Table 3a: Ranked List of Expected (Mean) Cost Risks (in current \$M)

Risk Rank	Contribution to Expected Cost Risk		Risk Item (see Appendix E)
	%	2008 \$M	
1	17.5%	88.6	C1 Issues related to Project Delivery Strategy/Method, Tender, and Construction Market Conditions
		52.8	D8 Changes to Configuration of Highway Crossings (Tunnel vs. Bridge)
3	9.2%	46.5	C14 Miscellaneous Claims or Other Change Orders
7	6.5%	32.9	D15 Change to Intermodal Station Design - Segments A, C, and F
8	6.2%	31.5	D4 Utilization of Viaduct Structures Rather Than Embankment Fill
9	5.7%	29.0	D1 Changes to Horizontal/Vertical Alignment - Segment F
		17.4	Uncertainty in Stations
11	3.1%	15.6	D11 Might Overbuild Cut & Cover Sections to Provide for Traffic Staging or Future Widening
12	2.4%	12.3	D15 Change to Other Stations Design - Segments B, D, and E

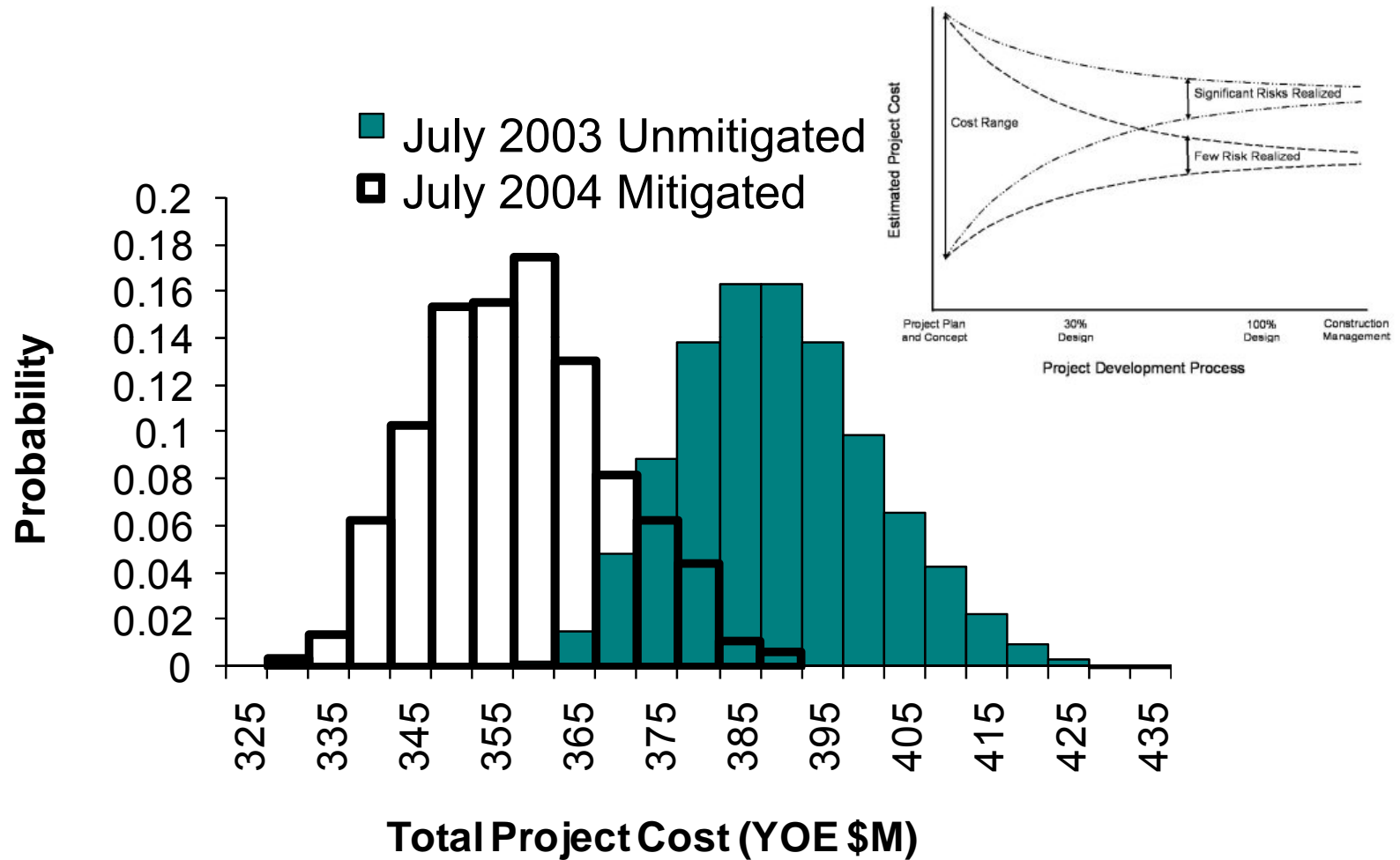


Risk Management – Budget Control





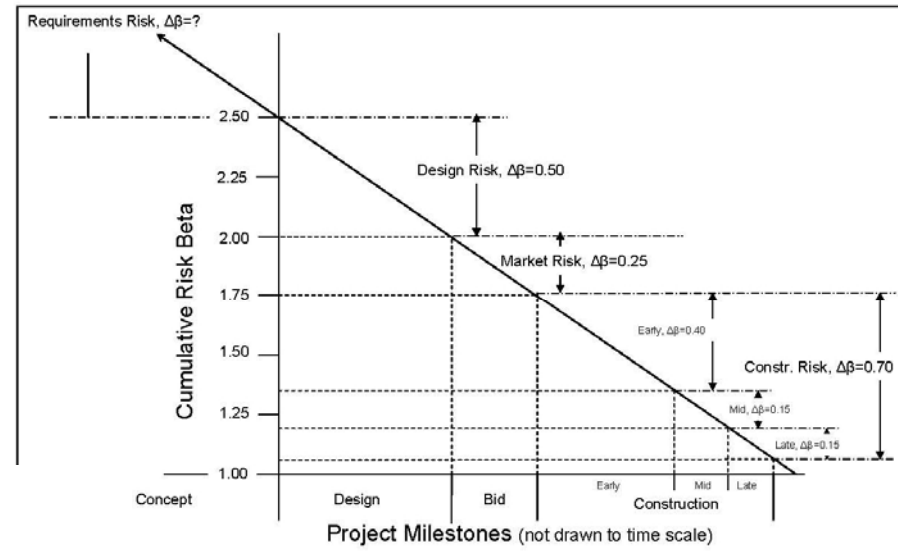
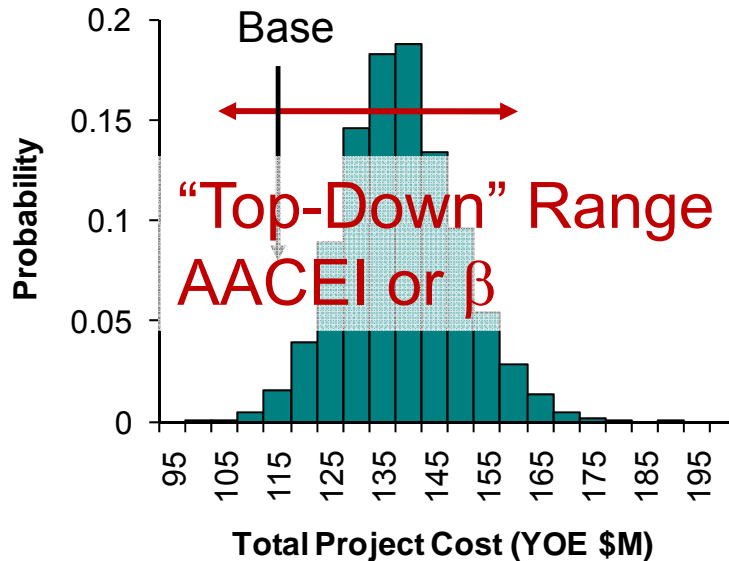
Risk Management – Budget Control





Risk Management – Budget Control

- “Beta Factor” approach to estimating & cost control by the US Federal Transit Administration
- Used as a tool during the funding grant agreement stage
- Risk assignment is made to 10 standard cost categories
- A mult...
- The base...
- The base category equivalent with the by E_{90}



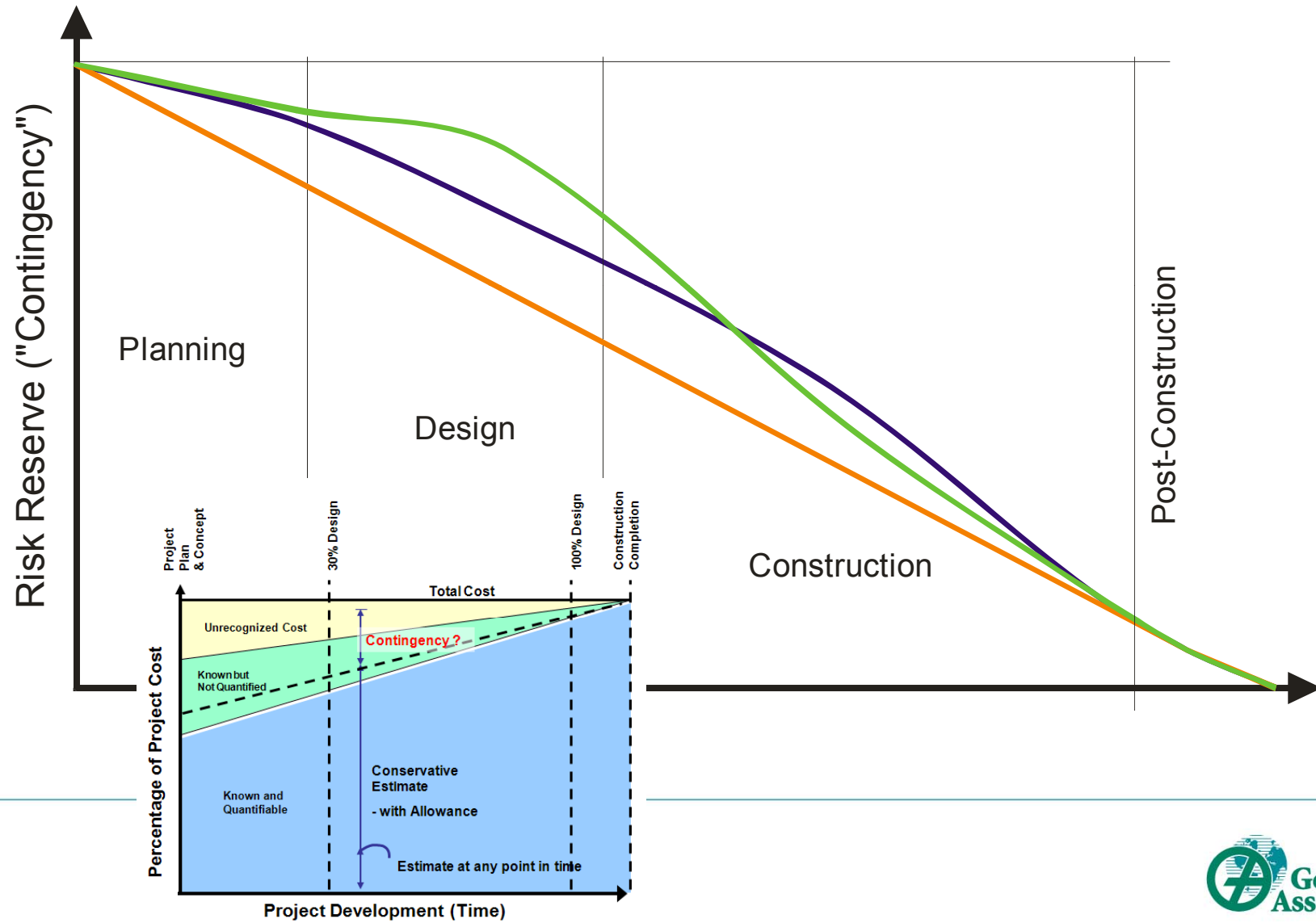
ta Risk Factor by Project Milestone

essence a “top down” method
refining a “contingency”

Risk Assessment and Mitigation Review
10, June 2008 (US Federal Transit Administration)



Risk Management – Budget Control





Risk Management – Budget Control

- Dangers in using or misusing risk-based estimation and budgeting:
 - Updates:
 - “We’ve eliminated that risk” – optimism creeps in and residual risks ignored
 - New risks could remain unidentified – some “mitigation” measures may actually introduce new risks
 - Transfer ≠ Mitigation (risk doesn’t disappear) – contractors/financiers etc. PRICE risk based on assumed thresholds, appropriate & selective transfer = *part* of management strategy
 - Use of high percentile “budgets” without rigorous controls
 - Scope creep
 - Inattention to controlling risks can = risks occurring that could have been avoided or minimized
 - Use of unrealistically low percentile “budgets” = disappointment, etc.
 - Mixing mitigation development & analysis (best left to VE, PM, RM)



Risk Management – Budget Control

