

# “Cost Estimating and Risk - Management for Tunneling and Infrastructure Projects”

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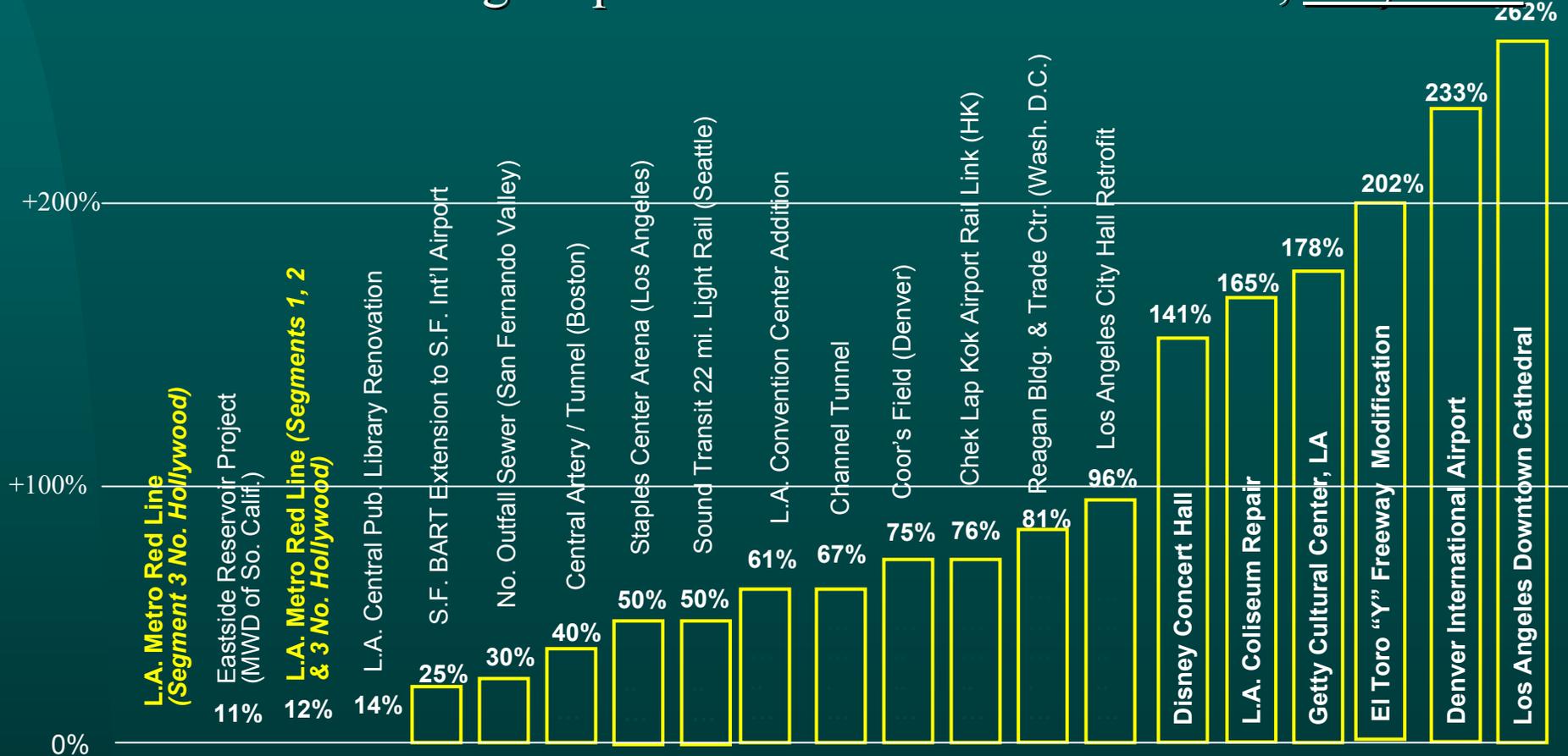
Sydney Harbor Bridge +200% \*

Sydney Opera House +1,400% \*

**ITA World Tunneling Conference, Istanbul**  
**May 11th, 2005**

# Examples of Project Cost Growth, US(\*)

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



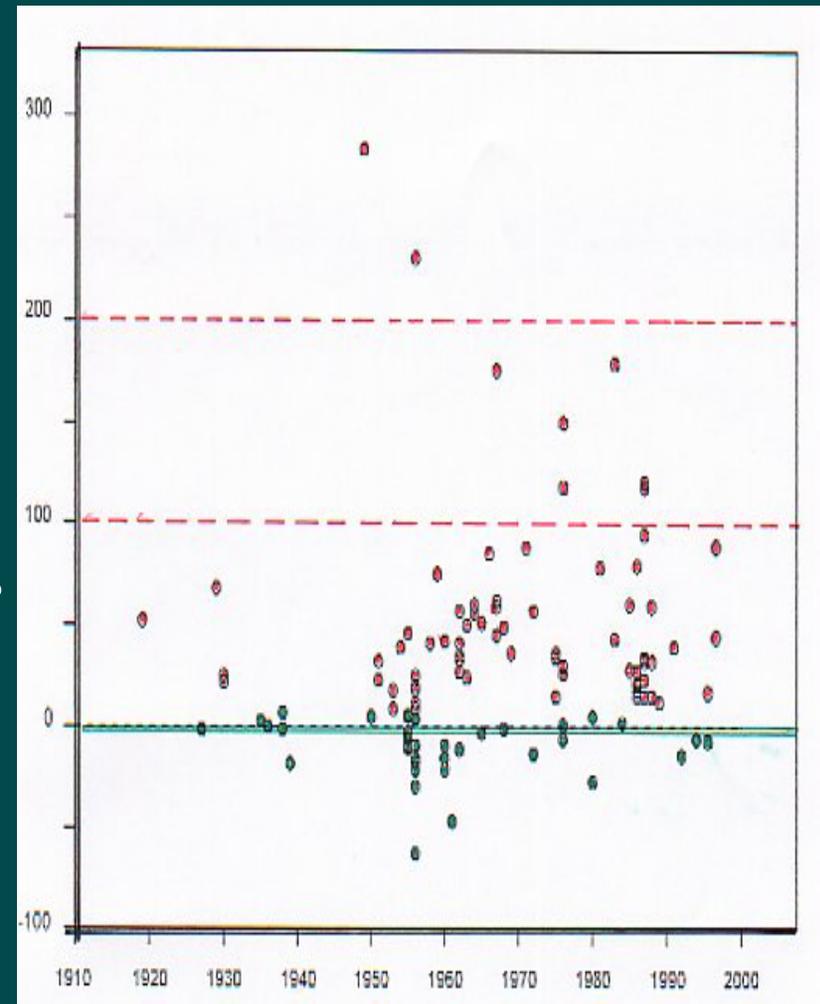
Reference	M	E	M	D	E	D	I	L	E	A	E	X	U	L	L	L	L	E	O	E	L
Orig. Est. (in \$mil.)	1-31-01	1-11-99	7-1-98	9-6-94	3-1-99	9-6-94	4-3-98	3-19-99	1-8-01	10-12-93	1-3-94	5-92	2-14-96	1-25-98	12-8-99	12-16-94	12-97	4-24-95	6-7-91	10-19-98	3-5-98
Current Est. or Actual (in \$mil.)	1311	1970	4007	109	1200	19	8000	250	2400	310	9210	123	1560	362	153	110	35	360	55	1500	45
	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

# The Flyvbjerg Study (June 2002)

- 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”
- What’s the real story?

\* Cost estimate at time of decision



Note - Flyvbjerg’s paper was published after WSDOT developed CEVP®

# Early optimism regarding cost estimates

- We are optimistic in understanding and managing scope
  - A PMI study found that the real scope, cost, schedule - for a wide range of project types – was generally about TWICE the initially envisioned scope/cost/schedule
- Results:
  - Low estimate in the beginning – leads to problems:
    - Cost and schedule over-runs, claims and disputes
    - Lack of funding for other projects
    - Media investigation  negative publicity
    - Many more impacts
    - Findings (*Reilly & Thompson, 2000*)

# Reilly & Thompson Study - findings

(presented at AUA Seattle, May 2001)

- There are significant cost and schedule overruns suggestive of poor management in at least 30%, and probably more than 50%, of the projects
- As reported by the Owners, factors that most commonly influence the success or failure of the projects were:
  - Expertise, capability and policies of Owners
  - Local political structures & historical circumstances
  - Local procurement procedures / requirements
  - Management structures / “stakeholder” management
  - Lack of provision for, and control of, external events

# Relationship between risk (uncertainty) and range of potential cost or schedule

- In the beginning there may be a large potential range for a project's ultimate cost or completion.



- We can manage uncertainty (both risks and opportunities) - using logical & reasonable risk identification, quantification and mitigation processes - in order to better manage to deliver the project at the lowest possible cost....

# Boston Central Artery, 1985-2005, \$14+ billion (what % over budget?)

- Cost may turn out to be over twice the initial projections (with new project scope, delays and time cost of money)
- Complex project, difficult management task, long time period involved, many political changes
- Secondary but very significant “mitigation” requirements = new scope
- Many success stories
- See Fred Salvucci’s article (ITA Amsterdam 2003)



# Boston Harbor Project 1991-2002

## 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, in the very early stages of construction, a thorough review of the project cost was performed and the estimate was fine-tuned to \$3.65 billion. When the project was completed a decade later, the final cost was \$3.8 billion.
- The media drew from the early planning another number, \$6.1 billion, that included additional project elements and a very generous inflation factor.
- This number projected large rate increases that created public credibility problems - this drove the cost refinements made in 1992.



# WSDOT's<sup>(\*)</sup> concern - poor cost estimates threaten public confidence. Observations:

- The traditional approaches to early estimating match poorly with the public's intuitive understanding of "*what engineers can tell us.....*"
- The meaning of "*contingency*" in an estimate mystifies ordinary citizens.
- "*Development*" of an estimate is seen by the public as evidence of doubtful engineering competence or, worse, intentional masking of unanticipated cost growth

(\*) Doug MacDonald who was responsible for the Boston Harbor Project's disciplined approach came to the Washington State Department of Transportation (WSDOT) in 2001

# Goal: “WSDOT must build, and maintain, public trust and confidence”

- Problem: Cost Estimating is complex and inexact, but:
  - Current budgeting procedures require that large projects provide “precise” cost numbers to facilitate budget and decision making processes - sometimes at a very early stage.
  - Unfortunately, large projects can, and do, experience large cost changes - usually increases. These changes are not well understood by the public and lead to an erosion of public confidence in the agency.
- Solution: WSDOT decided to develop a more reliable cost estimating procedure and to open the “black box” of estimating - so the public can be better informed and elected officials can make better decisions (“there is no black box”)

# Principle: Avoid single number estimates

- The final cost is subject to many variables
- These variables significantly influence the range of “probable projected cost”
- A single cost number represents only *one possible result* - depending on the many variables, assumptions and conditions
- The variables are not all directly controllable or absolutely quantifiable
- Therefore, cost estimating must consider uncertainty using a logical, structured process

# Key risk and management factors involved

## Basic Technical

- Technical
- Geological
- Environmental
- Funding & budgets
- Organization/Strategy
- Contractual Approach
- People - Capability
- Available Resources



Seattle, I-5

## But, just as important:

- Media & publicity
- Political Changes, Public Requirements
- Historical factors
- Risk & uncertainty must be included

# WSDOT's CEVP<sup>®</sup> Process, January 2002

## “A sophisticated management, engineering & communication process” (Client's statement)

- A compressed peer-level (“due diligence”) type review of scope, schedule and cost of WSDOT Projects using internal project staff and external subject matter experts
- An assessment of the quality, completeness and assumptions of the Project estimate
- Include uncertainty (potential risk and opportunity) to address the potential ranges of cost and schedule
- From the explicit risks identified, develop and implement a Risk Management Plan - reduce risk costs
- Communicate to Decision Makers, Media and Public

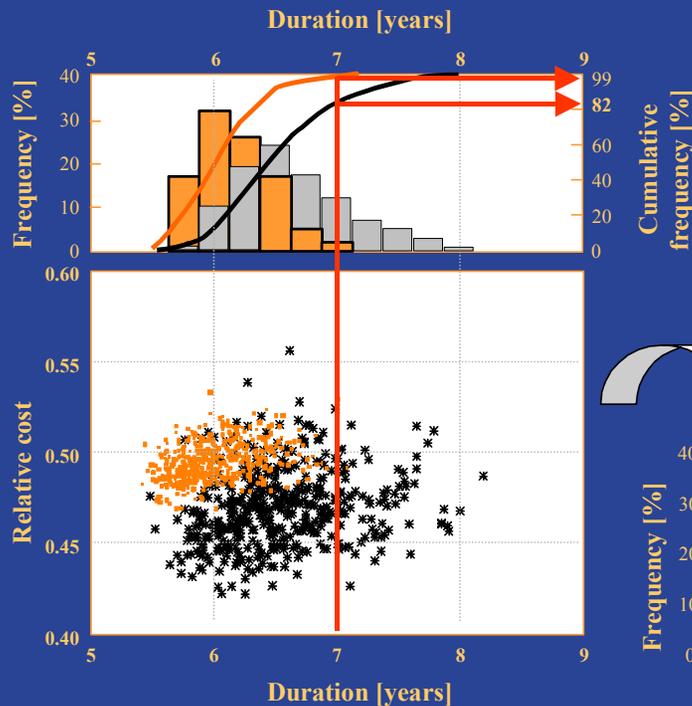
# Risk models have existed for some time (Einstein DAT 1974; Grasso; Roberds.....)



## RMP: Risk quantification - The system DAT

### Scatter plots of a project duration and cost

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

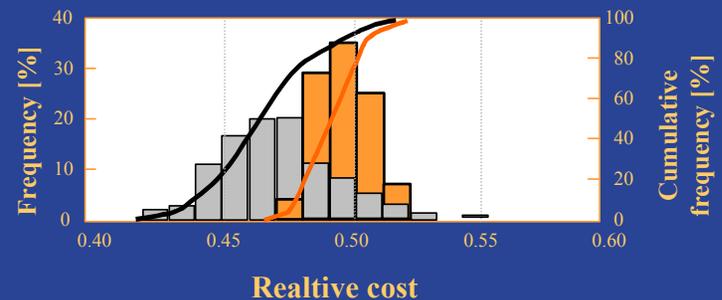


example:

cumulative probability for completing the project within 7 years

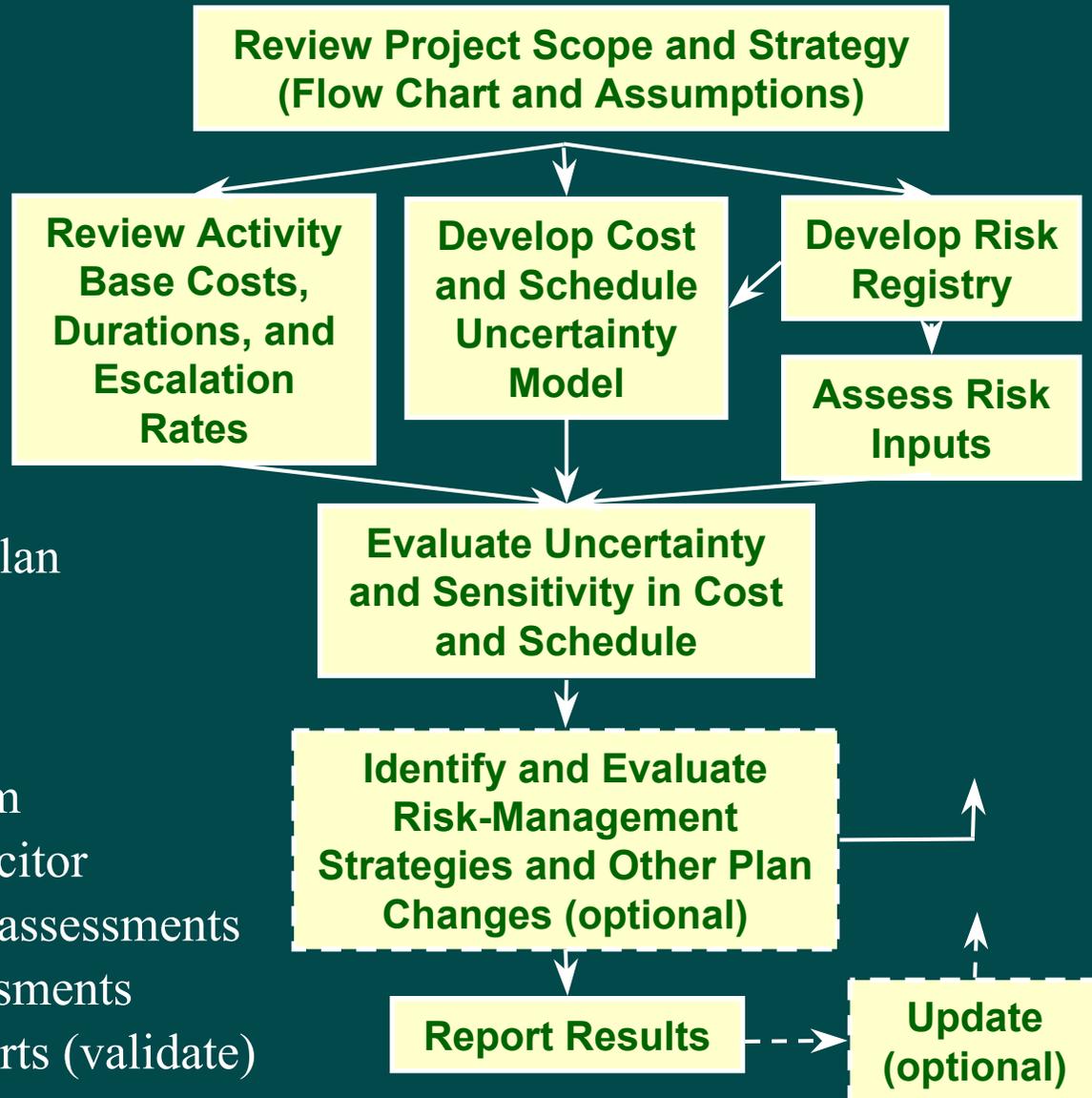
solution A: 82%

solution B: 99%



# CEVP<sup>®</sup> Participants / Process Steps

- Workshops:
  - Preparatory data
  - Base cost & risk identification
  - Risk management, risk management plan
  
- Participants:
  - Project team
  - CEVP review team
    - facilitator / elicitor
      - base cost assessments
      - risk assessments
    - technical experts (validate)
    - modeler



# CEVP<sup>®</sup> - Base Cost Determination

- Determine the “base” costs - the most probable cost that can be expected if the project goes exactly as planned
- Remove all contingency - i.e. provision for unknowns (representing uncertainty = risk + 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)

# Risk workshop - Risk Process

- Identify/list current concerns  
(Examine key issues, causal drivers, relationships)
- Compile list of credible/possible events  
(consequences & and opportunities)
- Estimate the probability of each event
- Estimate the consequence (impact) of each event
- Review the product of consequence (impact) and probability = RISK
- Rank risks - prioritize for attention
- Determine mitigation measures for top ranked risks
- Determine cost/benefit of mitigation measures
- Determine risk management plan for all risks
- Maintain risk management plan, update regularly, keep awareness of other risks (residuals)

# Risk Example - issue, impacts, probability & mitigation action

## EXAMPLE OF RISK IDENTIFICATION AND MITIGATION DETAIL

### **Risk item: T-10 Commercial Property Value**

**Issue:** Project ROW costs were developed by applying a percentage increase to the assessed valuations for each parcel. During review the estimated cost of commercial properties carried in the ROW estimate for the project have been updated, and the multiplier increased to 75% of the assessed value, to better reflect current market conditions. There is a low level of confidence in the updated values and it is estimated that actual market conditions may be as high as 100% of the assessed valuations.

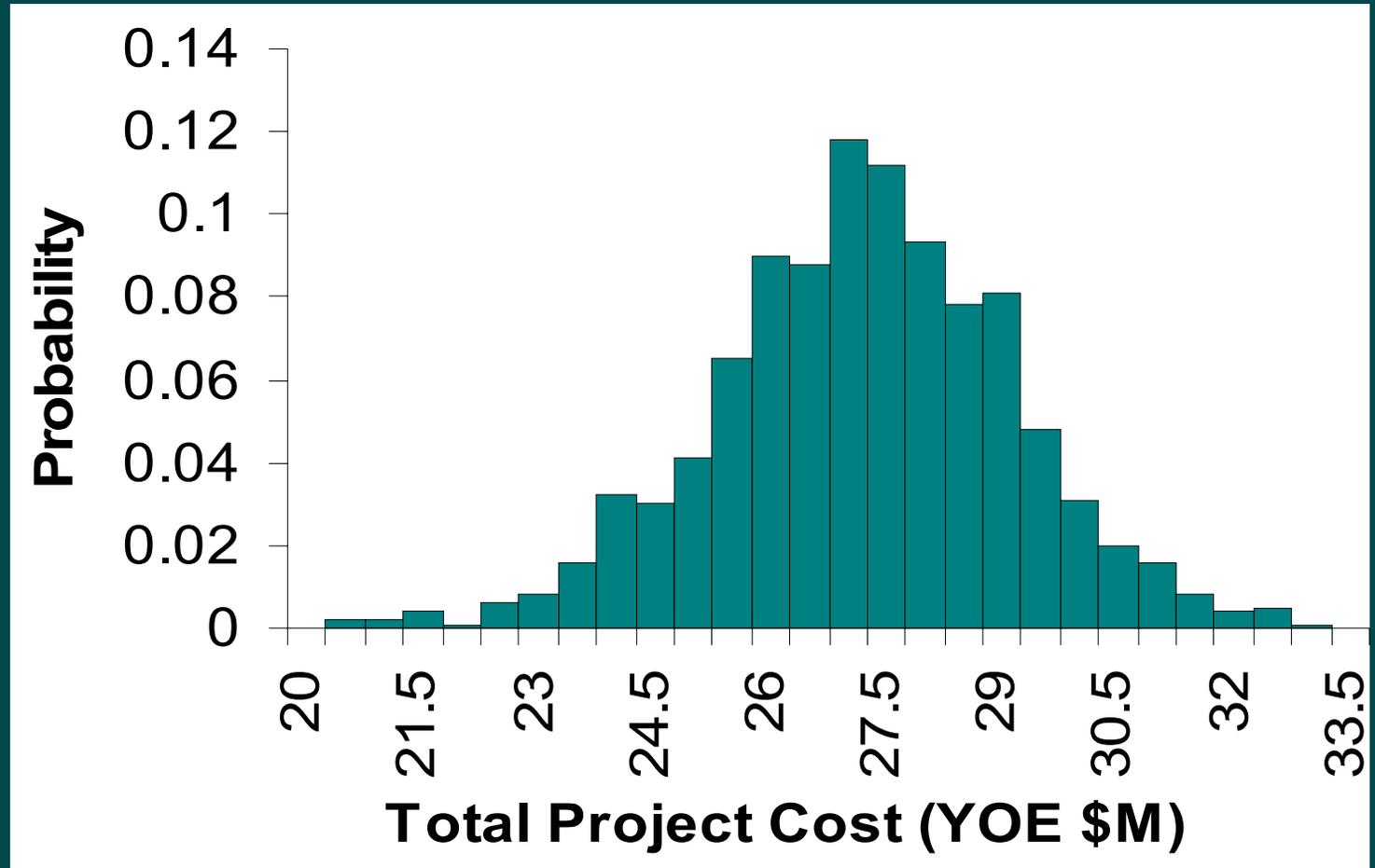
**Impacts:** There is an 85% probability that actual market conditions will increase the cost of acquiring commercial properties by \$25M.

**Likelihood:** 85%.

**Mitigation:** Monitor the commercial real estate market and track the actual cost of recent transactions. Keep the project ROW estimate up to date and reflective of the current commercial property real estate market. Buy early if appropriate.

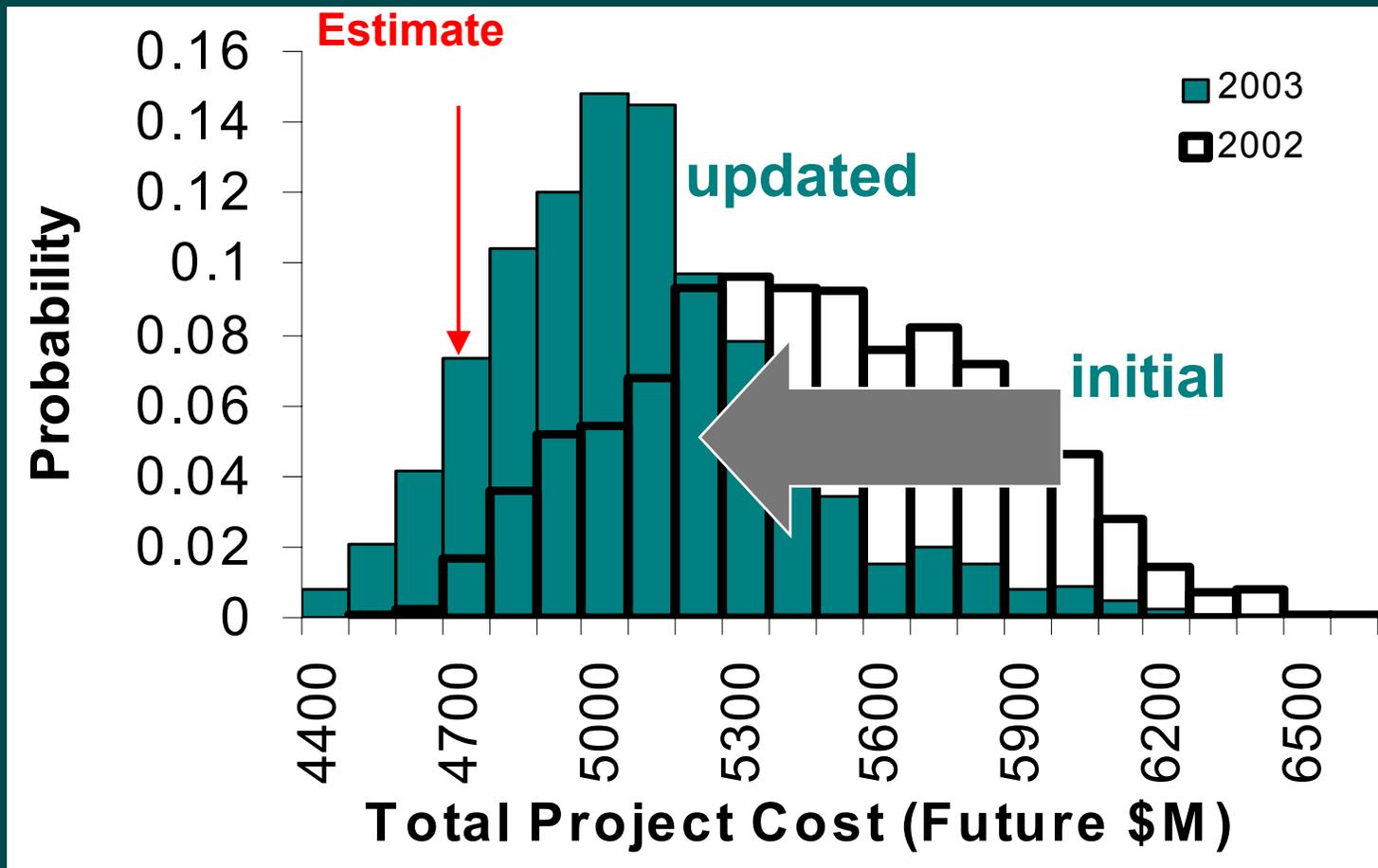
# CEVP<sup>®</sup> - Results

- Combine base costs and uncertainty (risk and opportunity) to create the range of potential cost & schedule



# Risk Reduction & Management Plan

- Risk mitigation actions can be taken, based on the explicit risk events that are causing the higher-range costs



# What does it take to do CEVP®?

- A knowledgeable/committed owner (who wants to know the potential cost)
- A well-shaped project estimate
- Available/involved project team members
- Sufficiently independent subject matter experts
- Skilled risk and cost elicitors (debiasing)
- Risk modeling - technology and experience
- Time / available funding

# The WSDOT Results

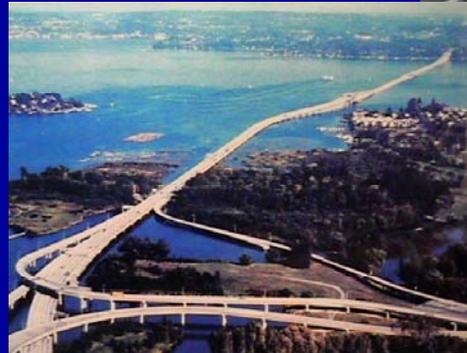
- WSDOT CEVP'd ten projects
- Total cost was \$3 million (approx 0.01% of project costs)
- Hallmark was collaboration of WSDOT's project teams and the CEVP® consulting team
- Formal evaluation reports prepared - presentations made to project staff and WSDOT leadership
- Cost Risk Assessment (CRA) being implemented extensively at WSDOT, including process for small projects
- WA legislature funded a \$5m study to evaluate the results of the CEVP® process - the current results are positive

# SUMMARY INFORMATION PACKAGE

June 2002

## WSDOT MEGA-PROJECTS COST ESTIMATE VALIDATION PROCESS

### SUMMARY INFORMATION



WSDOT - Northwest Washington Division  
Urban Corridors Office



This package corresponds to the project information released to the  
Public, Local Decision Makers and the Press June 3<sup>rd</sup>, 2002

# The Public-release effort produced interesting results

*“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”***

**SUNDAY  
June 9, 2002**

**TUESDAY  
June 4, 2002**

# WSDOT's current focus: Development of the Process

- Continue to use CEVP consistently
- Scale the process for efficient use with more typical projects & use a simpler shorter process for smaller projects (Cost Risk Assessment)
- WSDOT is building internal expertise
  - Subject Matter Experts
  - Modelers
  - Cost and Risk “Leads”
  - Project Teams
  - Regions/Management

# U.S. Federal Initiatives, 2003/2004

- The U.S. Federal Transit Administration (FTA) has aggressively moved to include cost-risk assessments and risk mitigation for all major capital projects. They now require risk management, linked to the cost-risk process - see FTA's "Risk Assessment Methodologies & Procedures".
- The U.S. Federal Highway Administration (FHWA) is sponsoring CEVP training by WSDOT + CEVP Consultants - the first workshop was held May 19 & 20, 2004 in Seattle.
- Several U.S. State Departments of Transportation are running demonstrations of CEVP to evaluate its use.

**Thank You for your attention.**

**Further Questions - email John Reilly:**

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or go to: [www.JohnReillyAssociates.com](http://www.JohnReillyAssociates.com)

(paper & presentation .pdf available on the website late May)