Outline

- Probabilistic, Risk-Based Integrated Cost and Schedule RA/RM Concepts
- Project Examples
- Summary

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Uncertainty in Project Cost and Schedule

- Cost & schedule estimates for large or unique projects are often significantly inaccurate, with corresponding consequences (e.g., Flyvbjerg et. al. 2002)
- A project can be affected by a number of technical and policy variables
- These variables cause uncertainty in cost and schedule:
  - Variations in project *conditions* assumed for estimates (e.g., in average unit rates, progress rates, escalation rates)
  - Uncertain impacts from unplanned *events* (deviations from assumptions)
- During project development, information on these variables is typically limited

Probabilistic Cost and Schedule RA / RM: Objectives

Help mitigate these problems by:

- Quantifying project cost and schedule uncertainty
- Identifying and prioritizing critical risks and key opportunities
- Increasing confidence in the cost and schedule estimates
- Increasing project team understanding and communication
- Enabling Risk Management and Value Engineering studies

Probabilistic Cost and Schedule RA / RM: Philosophy

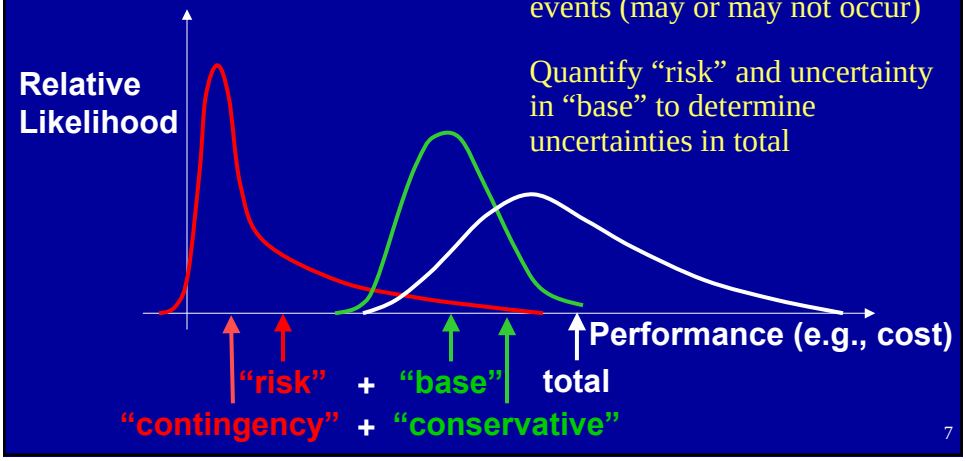
- Take a comprehensive look at the project (i.e., not just construction)
- Quantify uncertainty in key project assumptions
- Utilize independent perspective (for validation)
- Employ a collaborative, team approach
- Achieve consensus (and reduce controversy)
- Focus on the key issues
- Identify and evaluate risk-management strategies to improve project performance
- Update as the project changes significantly

Probabilistic Cost and Schedule RA / RM: Concept

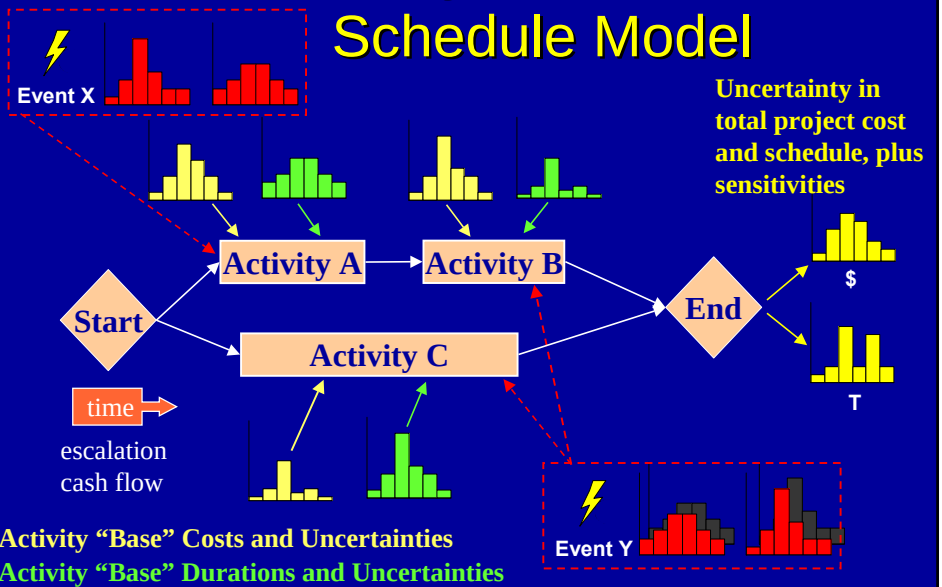
Total ≈ "Base" + "Risk"

Replace contingency with explicit risk and opportunity events (may or may not occur)

Quantify "risk" and uncertainty in "base" to determine uncertainties in total



Integrated Cost and Schedule Model



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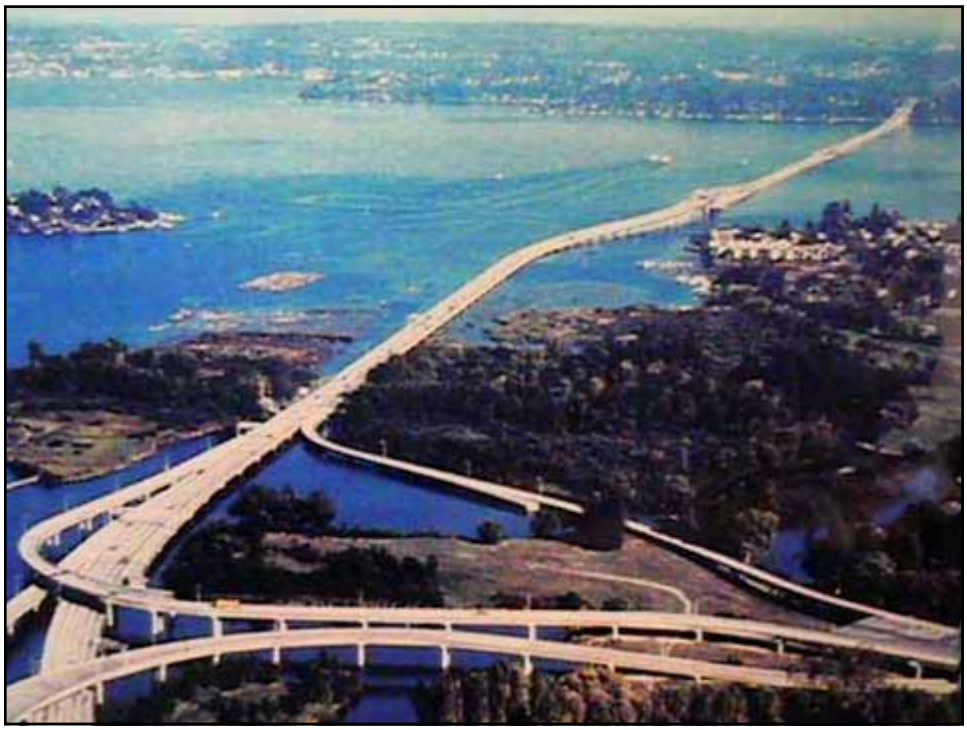
Example Applications

- Transportation:
  - Highways (WSDOT)
  - Bridges (WSDOT)
  - Rapid transit (Pittsburgh, NY PATH, Dallas)
  - Rail (Pittsburgh Maglev, Denmark-Storebaelt)
  - Ports / Airports (SeaTac, Transbay)
  - Tunnels (San Vicente, Caldecott)
- Other Infrastructure:
  - Water supply (San Diego Co)
  - Sewer systems (King Co WA, Hong Kong)
  - Electrical substations (SEPTA)
  - Buildings (NY PATH)
  - Mines / LNG plant (Freeport, Trinidad)
  - Landfills (Cleanaway, RDOS)

100 projects, totaling US $70B capital cost

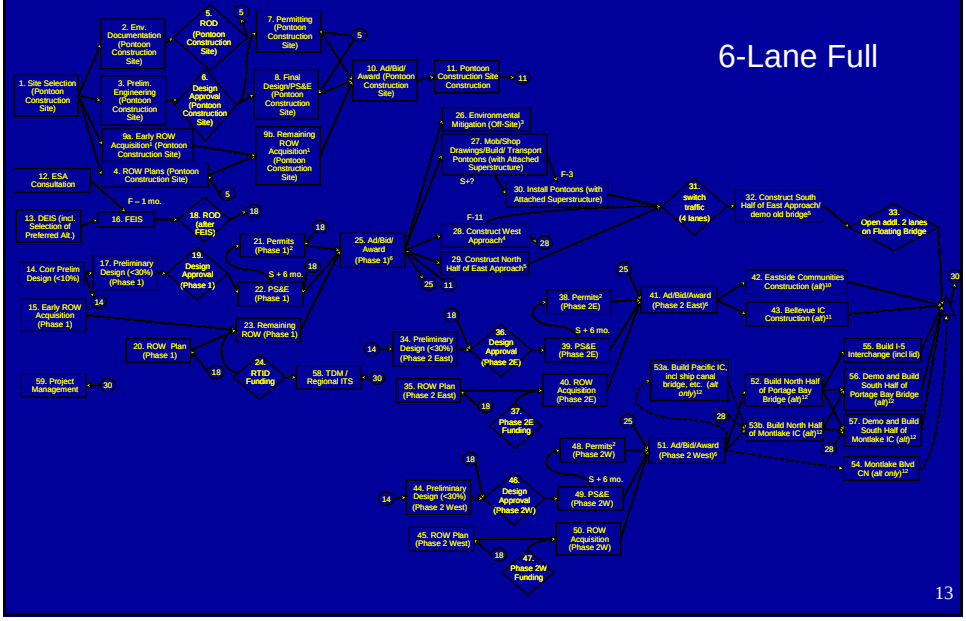
Floating Highway Bridge

- Old bridge with multiple fixed spans and long floating span
- Carries 115,000 vehicles per day
- Owner considering 3 bridge re-build alternatives, two with additional improvements beyond the ends of the bridge:
  - 4 lanes with “full” improvements (bridge and beyond)
  - 6 lanes with “full” improvements
  - 6 lanes with bridge improvements only (“6 lane partial”)
- Owner wanted to compare cost and schedule for the alternatives, considering uncertainties and risks
- Policy dictates budgeting for the 80th percentile



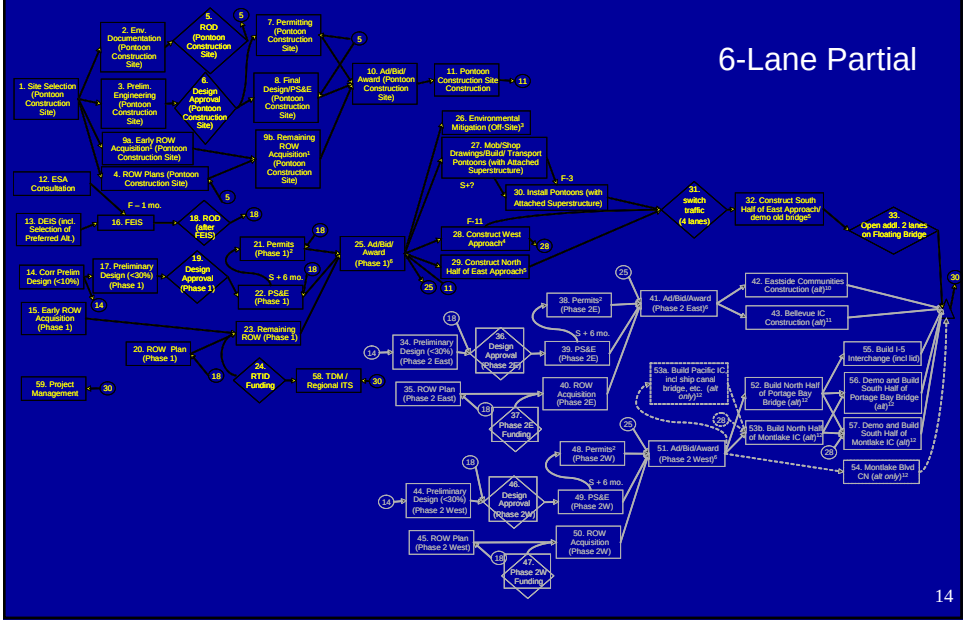
Floating Bridge – Flow chart

6-Lane Full



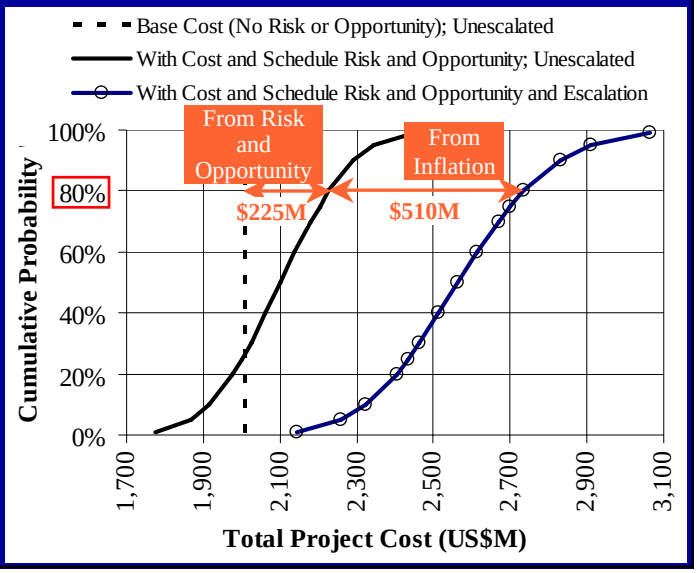
Floating Bridge – Flow chart

6-Lane Partial

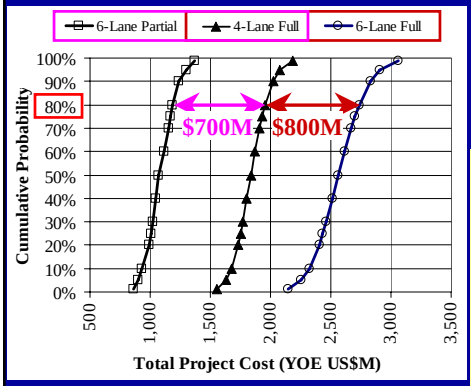


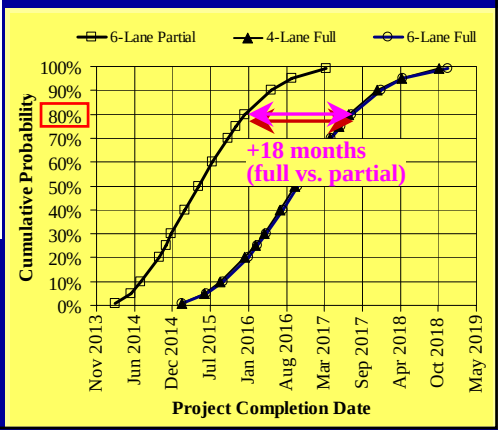
Floating Bridge – Cost Uncertainty (for the 6-Lane Full alternative)

Impacts on Target Confidence Level or Reliability (80th percentile)

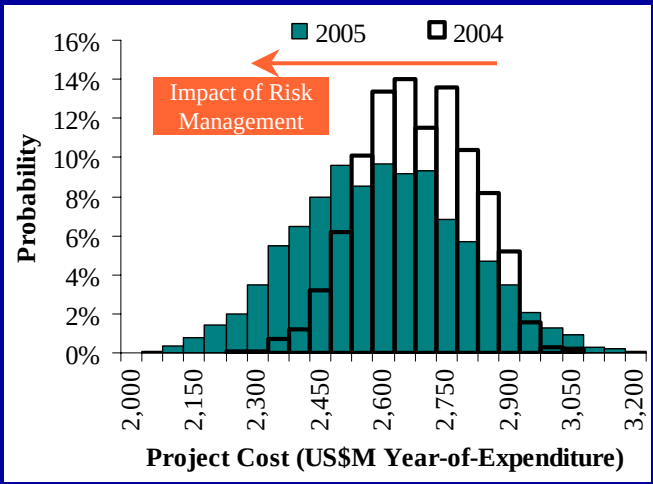


Floating Bridge – Comparison of Alternatives

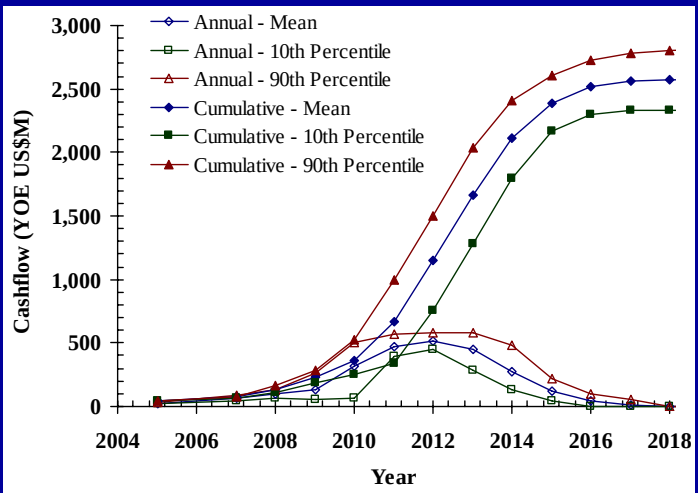




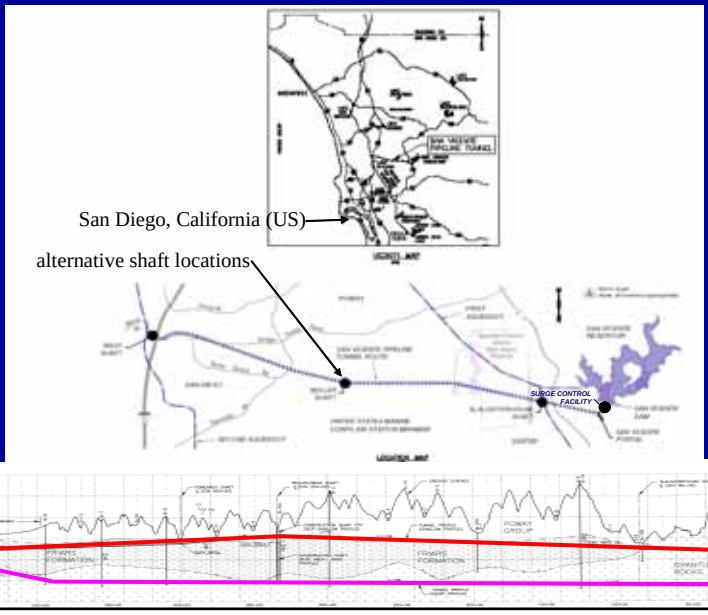
Floating Bridge – Updating and Risk Management



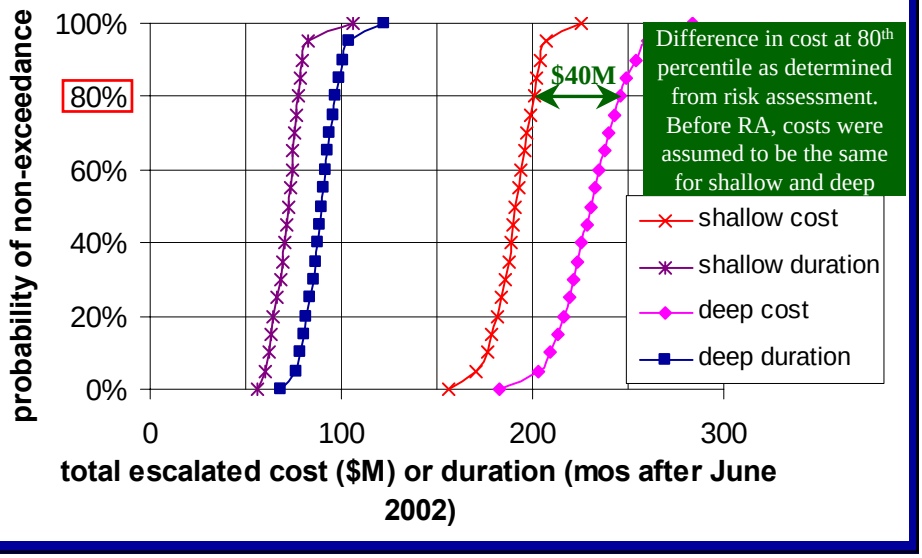
Floating Bridge – Uncertainty in Cash Flow of Expenditures



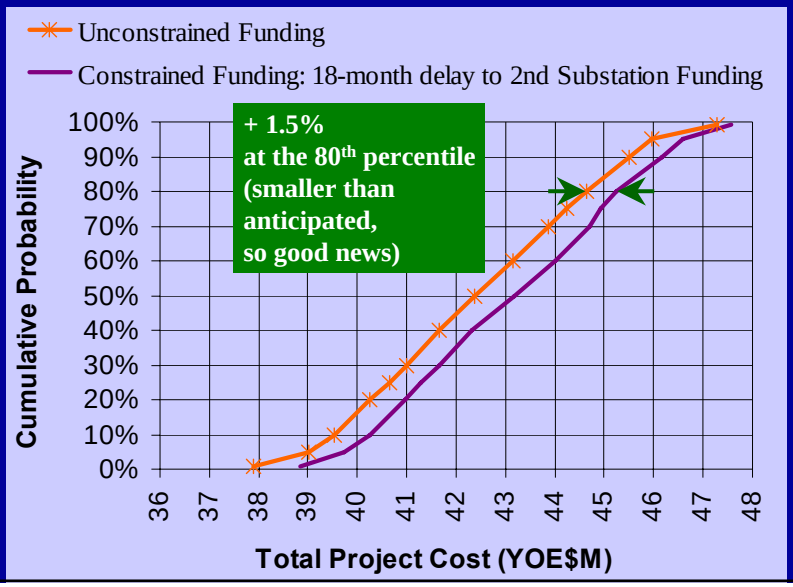
Water-Supply Tunnel



Water-Supply Tunnel – Comparison of Alternatives



Power Substations – Impact of Delayed Funding



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Summary of Benefits

- Clarify and evaluate project delivery strategies
- Validate and improve project estimates
- Quantify uncertainties in project estimates to ensure more realistic expectations
- Quantify key cost and schedule risks and opportunities → provide basis for Risk Management, Value Engineering, and Strategic Planning
- Improve communication (360 degrees)

⇨ **save time and money**

Summary of Challenges

- Interim validation: the approach appears to be performing better (on average) than traditional estimating, but may still be underestimating the uncertainty
- Challenges:
  - Difficulty convincing owner to include all significant uncertainties and risks (excluding them constrains results)
  - Removing optimism and/or "management bias," even when they're known to exist
  - Making results understandable and more useful to owner

⇨ **Careful implementation is required to ensure accurate and defensible results**