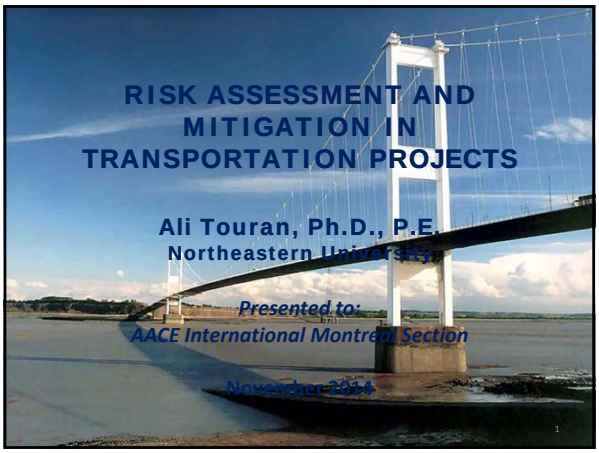

Objectives

- **Risk Assessment and Risk Management Offer a Systematic Approach to Understanding Uncertainties Surrounding Projects**
- **Objectives of Risk Management are to:**
  - Identify strategies to mitigate risks
  - Take advantage of opportunities
  - Have sufficient funds (activity durations) to cover situations when things do not proceed as planned [establish sufficient contingencies]

2

Benefits of Risk Analysis

- A carefully planned risk analysis leads to:
  - Improved communication within project team
  - Improved external communication; helps to educate public and other parties
  - Better understanding of the project delivery process (timeline, phasing, obstacles)
  - More realistic estimates of project costs and durations

3

FTA's First Report on Risk Analysis

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Causes of Cost Overrun (TCRP G-07 Study 2005)

- ***Scope creep***
- **Time required to achieve consensus among stakeholders and start construction**
- **Items left out of the estimate**
- **Uncertainty of real estate costs**
- **Inflation**
- **Project complexity**
- **Length of project development**

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Motivation

- In order to cope with cost overrun and delays, and identify risk factors early on, public transportation agencies have started using formal probabilistic risk assessment for their capital projects.
  - State of Washington D.o.T. (since 2002)
  - FTA (since 2003)
  - FHWA published a guide for risk analysis 2006
  - CALTRANS published a manual in 2007

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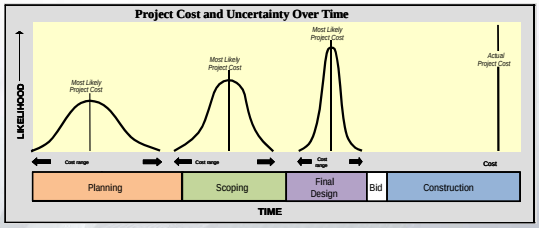
Cost Uncertainty Over Project Life



It is important to realize that the cost estimate is not a single number; realistically it is a range!

Timing of Risk Assessment

Contracting Method	PROJECT PHASE: Conceptual Design*	Preliminary Engineering	Final Design	Construction
Design-Bid-Build	●	●	◍	⊙
Design Build	●	●	⊙	⊙
Design-Build-Operate-Maintain	●	●	⊙	⊙
Construction Manager/General Contractor	●	●	◍	⊙

● Preliminary risk assessment based on conceptual cost and schedule data

● Comprehensive risk assessment based upon all the detailed information collected up to the point of analysis

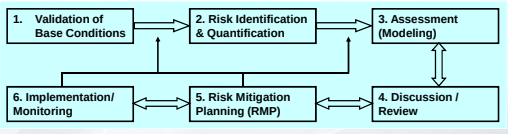
◍ Follow-up / updated risk assessment based upon most current design, cost, and schedule information.

⊙ Targeted risk assessment on special problems based upon all available information

Source: Parsons (2004)

Key Elements of Risk Analysis

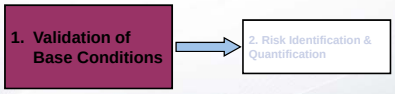
- **View the Process as 6 Steps**



- First four steps are the process of *risk assessment*
- Last two are the process of *risk management*
- Risk analysis is not a static process; a feedback loop can alter the results
- Risk Management is a process of ongoing monitoring → reassessment → new mitigation efforts

Risk Assessment Process

Step 1. Validation of Base Conditions



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- **Objective:**
  Verify the Reasonableness and Accuracy of the Base Project Scope, Schedule and Budget
  - Validation is a precondition for proceeding with risk analysis
  - Establishes the foundation for risk identification (Step 2)

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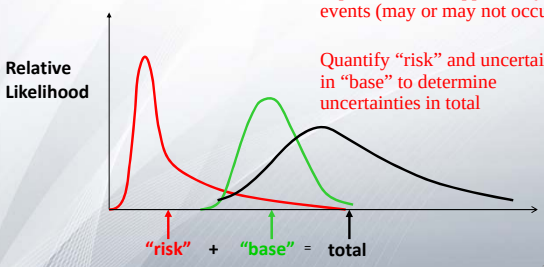
Risk Assessment Fundamentals: Traditional vs. Risk-Based

$Total \approx$ "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



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Step 2. Risk Identification & Quantification

- **Objective:**
  Identify Significant Project Risks and Estimate Individual Risk Impacts
- Specific Tasks Include
  - Prepare long list of potential risks for each major project component
  - Estimate impacts in terms of cost, delay
  - Screen significant risks
  - Document in risk register

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RISK REGISTER

(Step 2. Risk Identification & Quantification)

Example of Risk Register Detail

ID	Risk/Opportunity	Description of Issue	Affected Project Component	Correlation Among Dependent Components	Probability of Risk Occurring	Risk Cost		Risk Duration	
						Distribution	Expected Value of Cost	Distribution	Expected Value of Delay
1	**Permitting and Interagency Agreements:**	Permits required from approval agencies could be delayed; agreements between grantee and other agencies might not be concluded on schedule.	**A. Design & Permitting** **D. Construction**	Positive between Cost & Schedule of Both A & D	25% (0.25)	**Triangular** **A. Design** $1.0 m = 10% $2.5 m = Mode $4.0 m = 90% **D. Construction** $10.0 m = 10% $30.0 m = Mode $50.0 m = 90%	**A.** $ 1.8 m **D.** $21.0 m	**Discrete** **A. Design** 1 mos.= 25% 2 mos.= 50% 3 mos.= 25% **D. Construction** 2 mos.= 50% 5 mos.= 40% 10 mos.= 10%	**A.** 2 mos. **D.** 4 mos.
2	**Utility Relocations:**	Locations of certain utilities are unknown and their relocation could be required.	**D. Construction**		20%	**Lognormal**	$5.0 m	**Uniform** 1-5 mos.=20%	6 mos.
3	**Excess Ground-Water inflow**	Estimated ground-water inflow in the tunnel may be too low. Dealing with excess water may increase the cost.	**H. Tunnel**	Positive between Cost & Schedule	50%	**Lognormal**	$5.0 m	**Lognormal**	6 mos.

Expected Cost of Risk = Probability of Occurrence x Estimate of Risk Cost Impact

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Step 3. Assessment (Modeling)

- **Objective:**
  Estimate the Total Impact of Risk Factors on Total Project Cost or Duration
- Specific Tasks:
  - Identify most appropriate assessment method
  - Evaluate impacts on project by non-simulation or simulation methods
  - Verify results
  - Validate adequacy of project contingency

3

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Risk Quantification

- Quantification is Typically a Multi-Step Process
  1. Estimate likelihood of risk occurring (10%? 90%?)
  2. Estimate range of values ($/Time) if risk occurs. Values follow probability distributions.
  3. Establish correlations among risk events
  4. Estimate expected value of risk
  5. Document in Risk Register

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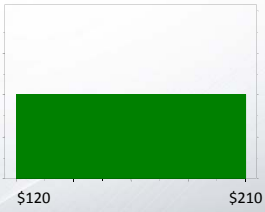
Example of Data Modeling

- Estimator tells us that the cost of a building addition ranges between $120 and $210 per sq. ft. in Boston. This is assuming specific characteristics/ performance criteria for the building.



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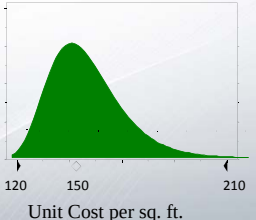
Refinement of Information

- Estimator can further tell us that his best estimate of the unit cost would be $150/sq.ft.
- We know that construction costs are usually unimodal, skewed distributions.



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Example of Risk Modeling

Risk Factors for a Tunnel Project

A hypothetical tunnel project is under study. Three major risk factors are being considered:

#1 – Excessive Groundwater inflow (low, medium, high)

#2 – Total Rock Hardness (Estimated + 10, 20, 25)

#3 – TBM breakdowns (Optimistic, pessimistic)

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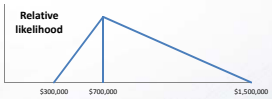
Risk Factors for Tunnel Project

Frequency (likelihood) vs Impact

- Excessive Groundwater
  - Probability of occurrence 40%



- Total Rock Hardness
  - Probability of occurrence 60%

- TBM breakdowns
  - Probability of occurrence 100%

Simulation Model of Risks

	Low	Mode	High	Random Input	Probability	Expected Value
Groundwater	$ 300,000	$ 700,000	$1,500,000	$ 833,333	0.4	$ 333,333
Rock Hardness	$ 1,500,000	$2,500,000	$3,800,000	$ 2,600,000	0.6	$ 1,560,000
TBM Breakdown	$ -		$4,000,000	$ 2,000,000	1	$ 2,000,000
					Total =	$ 3,893,333

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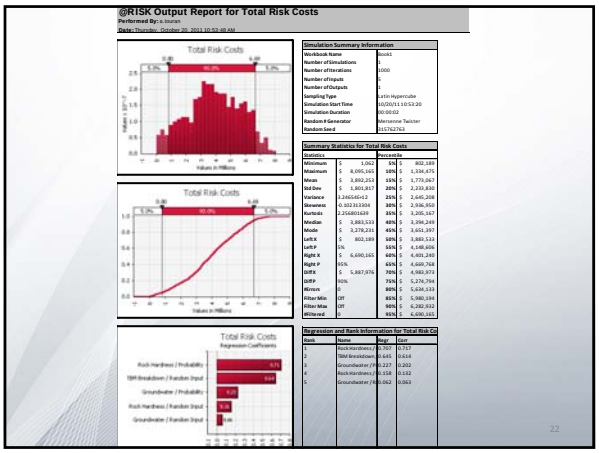
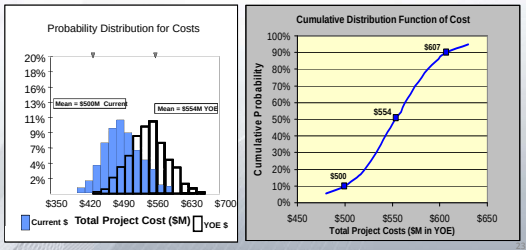
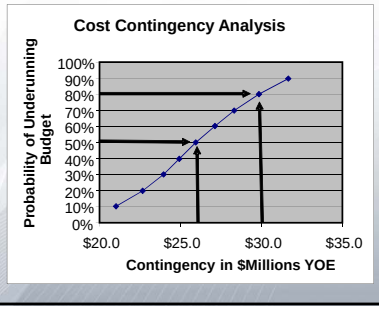


Simulation Results of a Project Cost with Base Cost of $450 M

Step 3. Assessment (Modeling)



Step 3. Assessment (Modeling)



Step 4. Discussion / Review

- **Objective:**

Maintain open lines of communication; ensure that the Transportation Agency and other risk analysis participants agree on findings and on the next steps

4

– Review results of assessment
– Fully document findings

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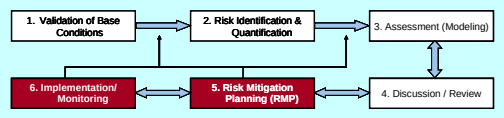
Risk Management



- Risk Management Includes
  - Steps 5 and 6 in the Risk Analysis Process, Covering
    - *Risk Mitigation Planning (Step 5)*
    - *Risk Mitigation Implementation and Monitoring (Step 6)*
  - Both Steps are Primarily Responsibilities of the transportation agency

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Step 5. Risk Mitigation Planning

- **Objective:**

5

Develop Cost-Effective Mitigation Strategies to Reduce Risk Impacts to Project Budget and Schedule, Thereby Improving the Probability of Project Success

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Risk Mitigation Process

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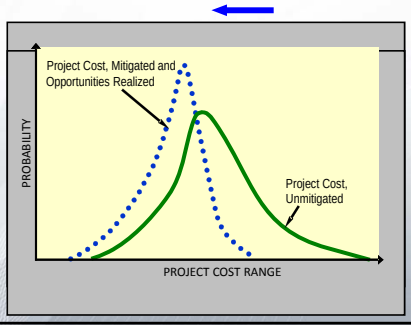
Risk Mitigation Plan

- Expressed Graphically, the Objective is to Shift the Probable Project Cost (or Duration) to the Left



RISK MITIGATION PLAN (RMP)

- End Product of the RMP is a List of Targeted Risks
  - For each risk, establish actions to reduce impacts on total project cost or schedule
- Various Risk Mitigation Strategies Include
  - Avoid the risk
  - Share the risk
  - Reduce the risk
  - Transfer the risk
  - Accept the risk

Step 6. Implementation and Monitoring

- **The Owner Must Implement and Monitor Mitigations**
  - *– Documents risk management program in Risk Management Plan (RMP), to include*
    - Objectives of the plan
    - Prioritized list and description of risks for mitigation
    - Description of risk management responsibilities of each party
    - Performance monitoring program
    - Implementation schedule
    - Plan approval by executive management

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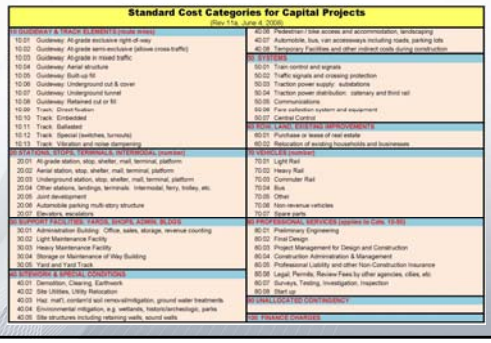
U.S. FTA's Top-down Model

1. Finds Base cost (no contingency and escalation included) for each Standard Cost Category (SCC) of the FTA budget format:



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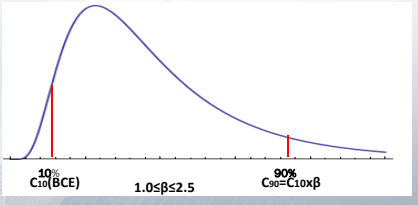
FTA's Top-down Model

2. Assumes that all cost items have Lognormal distributions; these distributions are quantified with two estimates:

   10th Percentile= Base Cost Estimate (BCE); 90th Percentile= BCE*β

3. A set of recommended β values is used (roughly 1.0 <β< 2.5);



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Suggested Values for β

β	Project phase or state of risks
Larger than 2.5	Increasing uncertainty with project requirements. May need to increase the base.
2.0 - 2.5	At 2.0 Design risks have been mitigated.
1.75 – 2.0	At 1.75 all market risks including bidding risks have been mitigated.
1.35 – 1.5	All early construction risks such as geotech/utility/major claims have been mitigated (~20% construction)
1.35 – 1.20	All mid-construction risks inclusive of major claims, delays, impact have been mitigated
1.05 – 1.15	All startup/substantial completion risks, usually associated with 90% construction complete have been mitigated.
1.0	No risk or uncertainty is present.

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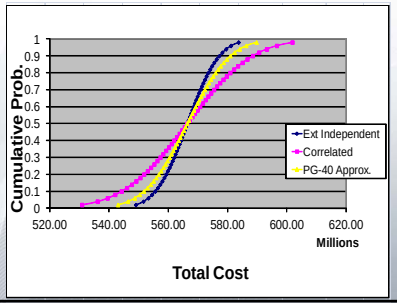
Top-Down Analysis Outcome

4. The final outcome consists of three CDFs!



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To recap…

- A carefully planned risk analysis leads to:
  - Improved communication within project team
  - Improved external communication; helps to educate public and other parties
  - Better understanding of the project delivery process (timeline, phasing, obstacles)
  - More realistic estimates of project costs and durations

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Questions?

Thank you!

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