The Case for Quantitative Project Risk Analysis

Tenth Annual Conference on
Quality in the Space and Defense Industries
March 4-5, 2002
Cape Canaveral, Florida

John P. Kindinger

Decision Applications Division
Probabilistic Risk Analysis Group (D-11)
Los Alamos National Laboratory

LA-UR-02-63

Presentation Topics

- The Need for Project Risk Analysis
- Expectations for Project Risk Analysis
- Advantages of a Quantitative Approach
- Performing a Project Risk Analysis
- LANL Experience and Example Results

The Need for Project Risk Analysis

Research Results for Project Failure Likelihood

Project Outcome Categories	Likelihood (%) Nuclear Power after TMI (3)	Information Technologies (7)	Process Industries (1)	Your Business?
1 Success	0%	26%	33%	
2 Completed but one or more major objectives not met	60%	46%	67%	
3 Total failure / not completed	40%	28%	N/A	

How Can Risk Analysis Aid Project Management?

- Provide better information to support decisions regarding project direction and the setting of schedule & cost targets and contingencies
- Identify actions that can be taken to help improve technical, schedule and cost performance
- Address known causes of poor project performance
- Assist in monitoring the status of the program as it proceeds
- Demonstrate compliance with procedural requirements for project risk management

Project Risk Analysis - Expected Results

- Quantitative results, including uncertainty, for tasks and the total project
- Identification of the important contributors to uncertainty by task and total project
- Identification of potential risk reduction actions
- Identification of key boundary conditions
- Satisfaction of project risk management requirements

Project Risk Analysis - Expected Features/Capabilities

- A systematic and consistent methodology
- Quantitative bases for establishing project cost and schedule targets and contingencies
- Costs/benefits assessments for potential risk reduction actions (“What if” cases)
- Results that include project wide“ripple” effects
- Corrections for common errors inherent in deterministic scheduling and cost estimating methods
- Ability to upgrade results with actual data

Available Project Risk Analysis Methods

- Project risk analysis (PRA), particularly quantitative analysis, is in an early state of development.
- I see PRA developing along two tracks or approaches:
  - The first evolves from the safety analysis world, in particular, process hazards analysis.
  - The second is derived from the discipline of system analysis.
- I will argue that the systems analysis approach has clear advantages over the hazards analysis approach and describe the systems approach that is being applied at Los Alamos.

Hazards Analysis Approach to Project Risk Analysis

- Has its origins in chemical/petroleum or other hazardous processes safety analysis
- Is performed by walking through the steps of a batch or continuous process to identify the undesired events that could occur
- The identified events are then categorized, qualitatively or quantitatively, using a frequency and consequence risk matrix.

Project Risk Analysis
Risk Matrix

Likelihood			1 Minor	2 Moderate	3 Major	4 Serious	5 Extremely Serious
L	Very Likely	5	5	10	15	20	25
i k	Somewhat Likely	4	4	8	12	16	20
l i	Unlikely	3	3	6	9	12	15
h o	Very Unlikely	2	2	4	6	8	10
o d	Extremely Unlikely	1	1	2	3	4	5

High

Mod.

Low

Risk Rating

Consequence

Systems Analysis Approach to Project Risk Analysis

- Has its origins in the discipline of system analysis or system dynamics
- Is performed by building a mathematical model of the "system" to predict results for important performance measures
- Ranks risk events by their potential impact on performance

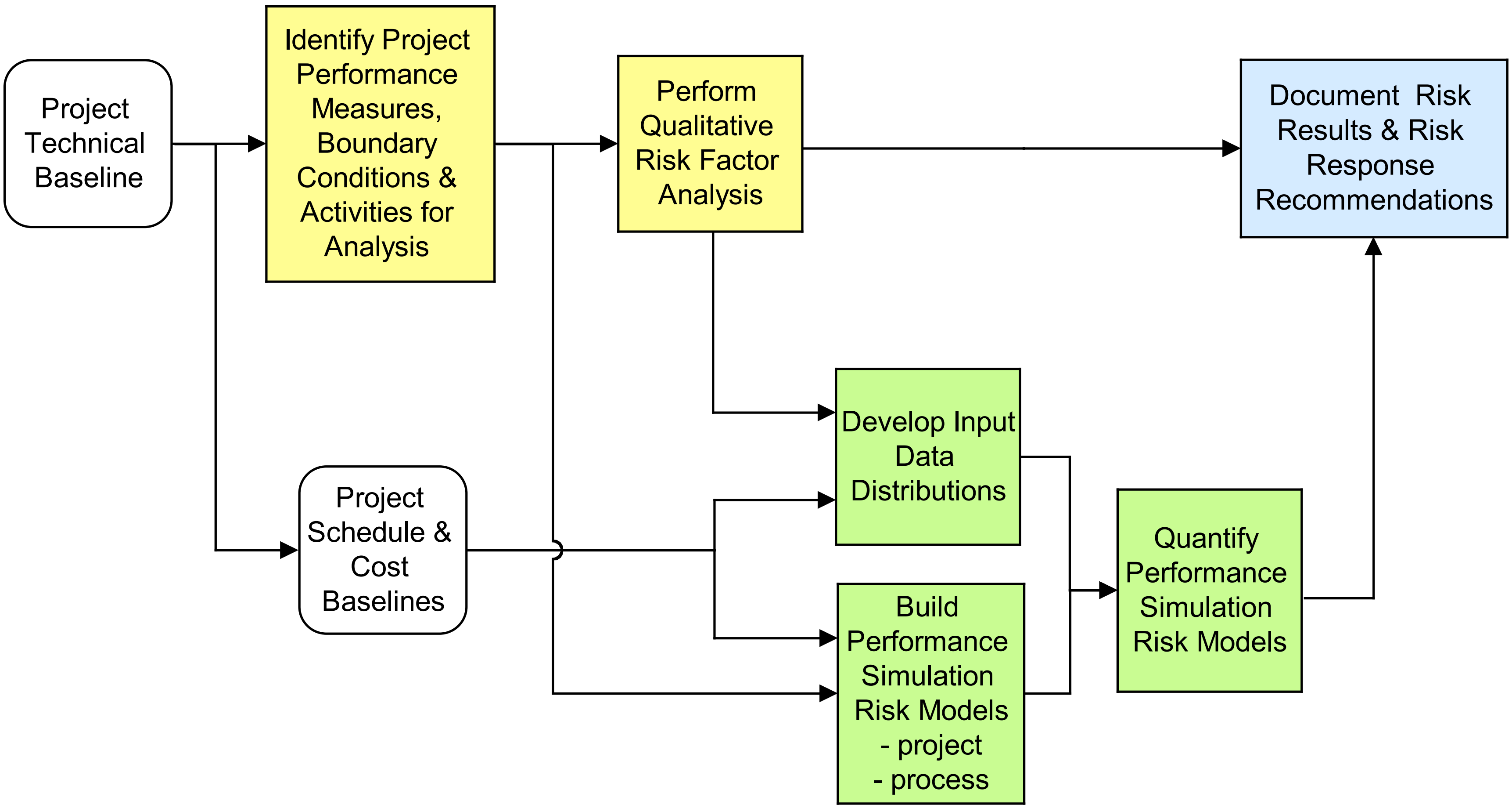
How the Approaches Satisfy Expectations

Expectations for Project Risk Analysis	Expectations Met by: Risk Matrix Approach	Expectations Met by: Systems Approach
Outputs		
1) Quantitative results, including uncertainty, for tasks and the total project	**No**	**Yes**
2) Identification of the important contributors to uncertainty by task and total project	**No**	**Yes**
3) Identification of potential risk reduction actions	**Partially**	**Yes**
4) Identification of key boundary conditions	**Yes**	**Yes**
5) Satisfaction of project risk management requirements	**Yes**	**Yes**
Analysis Features and Capabilities		
1) A systematic and consistent methodology	**Partially**	**Yes**
2) Quantitative bases for establishing project cost and schedule targets and contingencies	**No**	**Yes**
3) Costs/benefits assessments for potential risk reduction actions ("What if" cases)	**Partially**	**Yes**
4) Results that include project wide“ripple” effects	**No**	**Yes**
5) Corrections for common errors inherent in deterministic scheduling and cost estimating methods	**No**	**Yes**
6) Ability to upgrade results with actual data	**Partially**	**Yes**

Using the Systems Analysis Method at LANL

- Project Risk Analysis Tasks
  - Performance measure selection
  - Activity definition
  - Boundary condition specification
  - Risk Factor Analysis
  - Input distribution development
  - Dependency analysis
  - Risk Model simulation
- Risk based goal setting & contingency analysis
- Risk Response Development
- Risk Monitoring

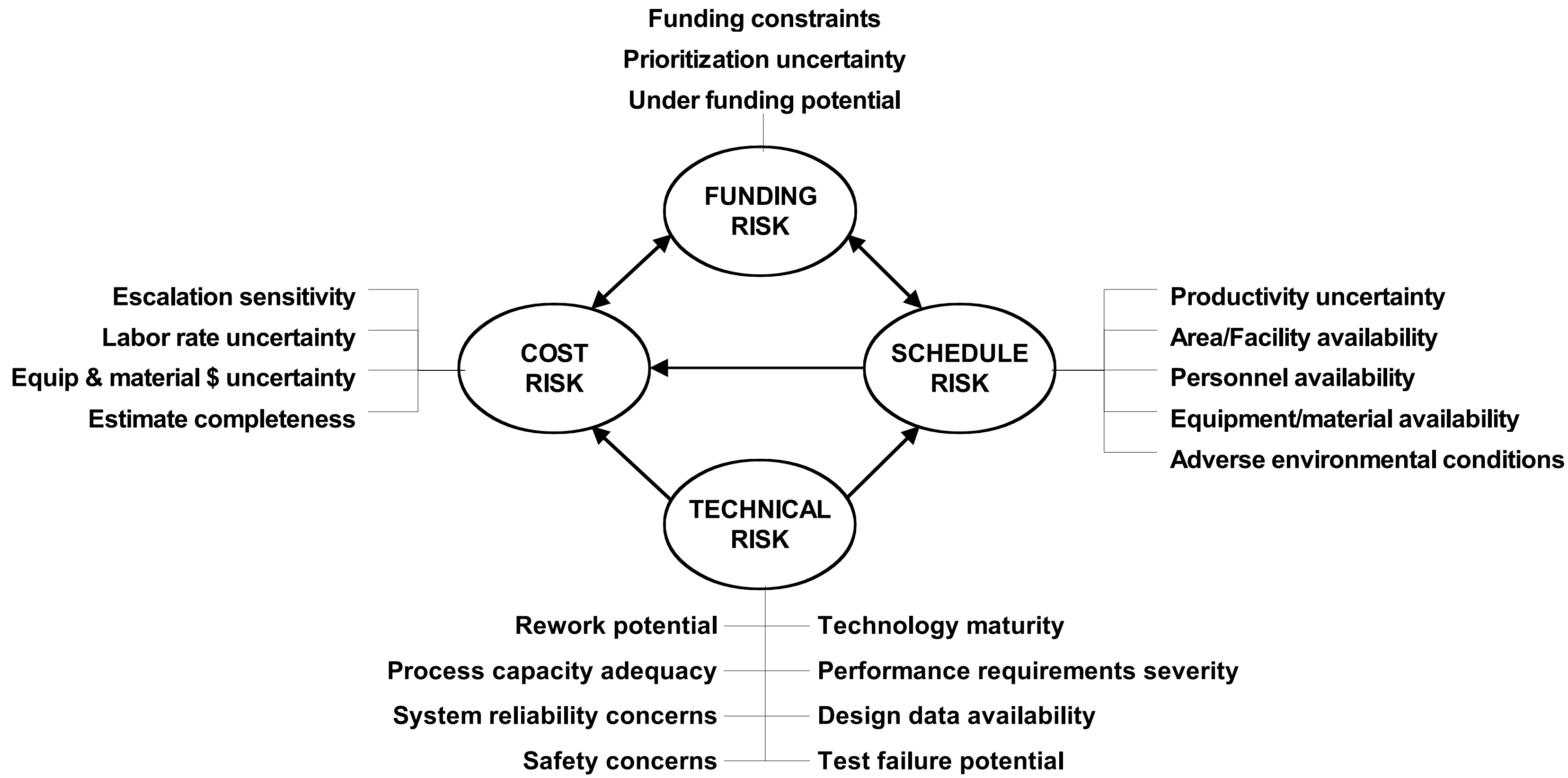
Integrated Qualitative and Quantitative Risk Analysis Tasks



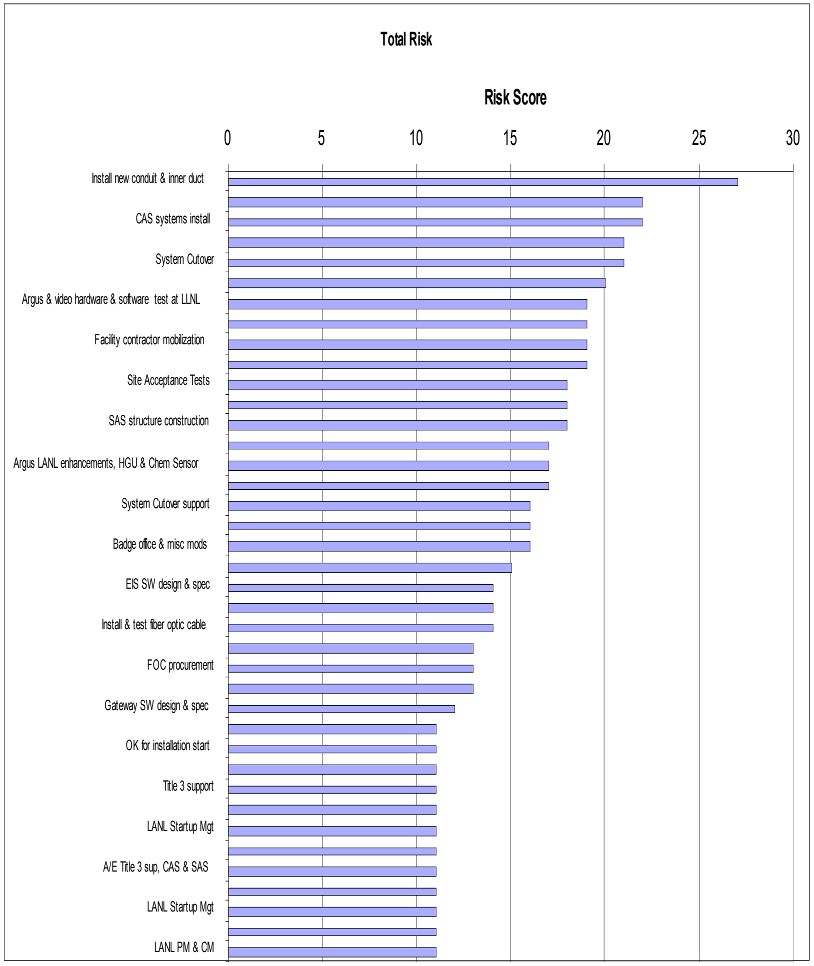
Risk Factor Analysis

- Risk factor analysis is a qualitative risk analysis technique aimed at identifying and assessing the drivers that will determine overall project performance
- RFA is systematic, objective and sufficiently comprehensive to produce meaningful specific insights, yet easy to perform and adaptable to different projects & programs
- See PMI 2000 paper for a detailed description

Example Qualitative Risk Factors



Format of Risk Factor Analysis Results

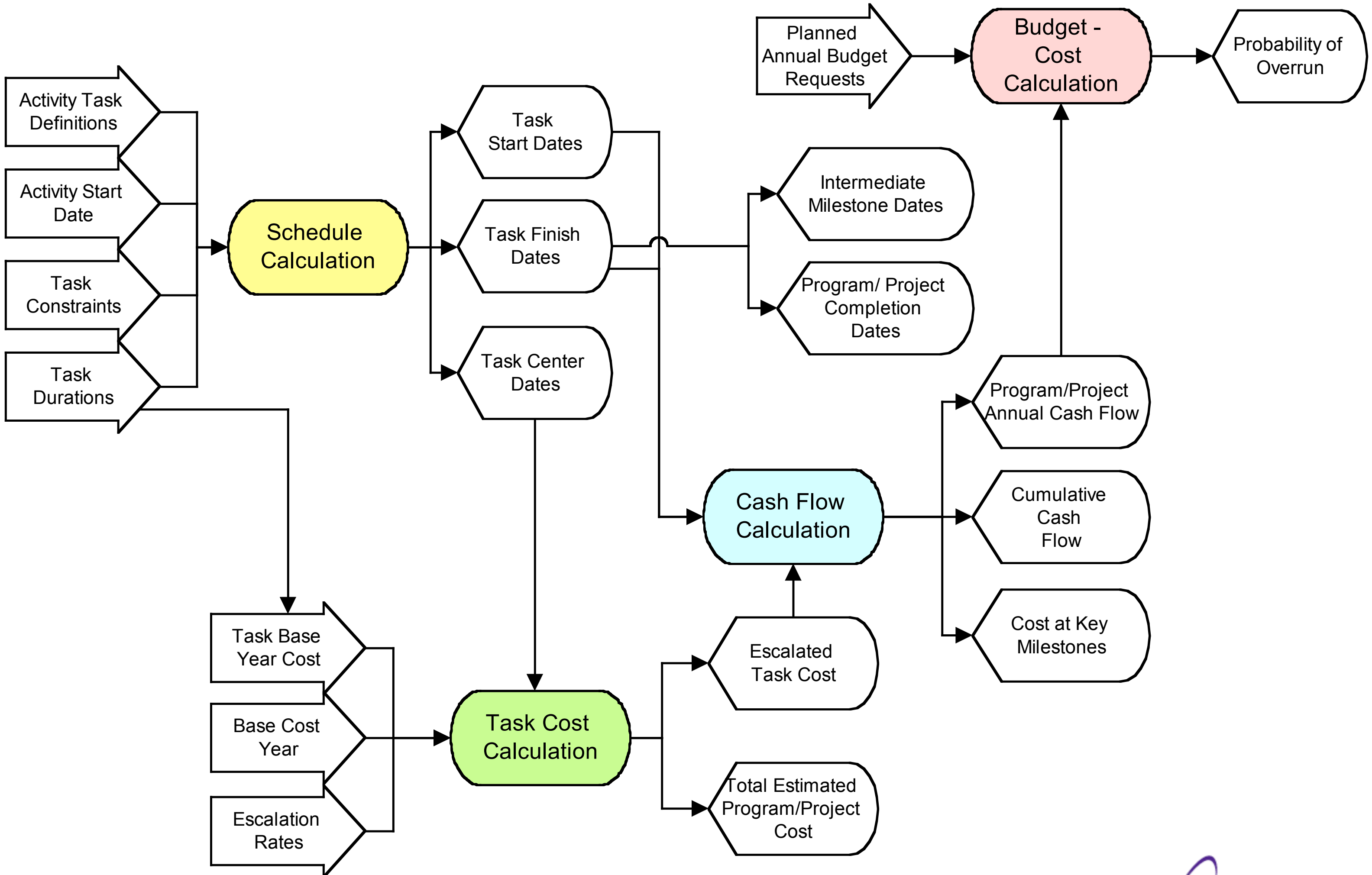


- Risk rankings for each risk factor are documented for each task and summed for technical, schedule, cost and total risk.
- The RFA process identifies possible risk reduction actions and provides the basis for schedule & cost distribution development

Quantitative Simulation Risk Model Construction

- A simplified model of the project activities is developed from the technical, schedule and cost baseline data.
- Modeling is done to a level of detail sufficient to identify important risk contributors and account for key dependencies. The model structure will closely follow the WBS, if available.
- Performance uncertainty is entered for each task based on the results of the RFA and/or quantitative models of performance (e.g. a process production model)
- Integral project level performance/risk results are calculated with a simulation model

Example Simulation Risk Model Data Flow



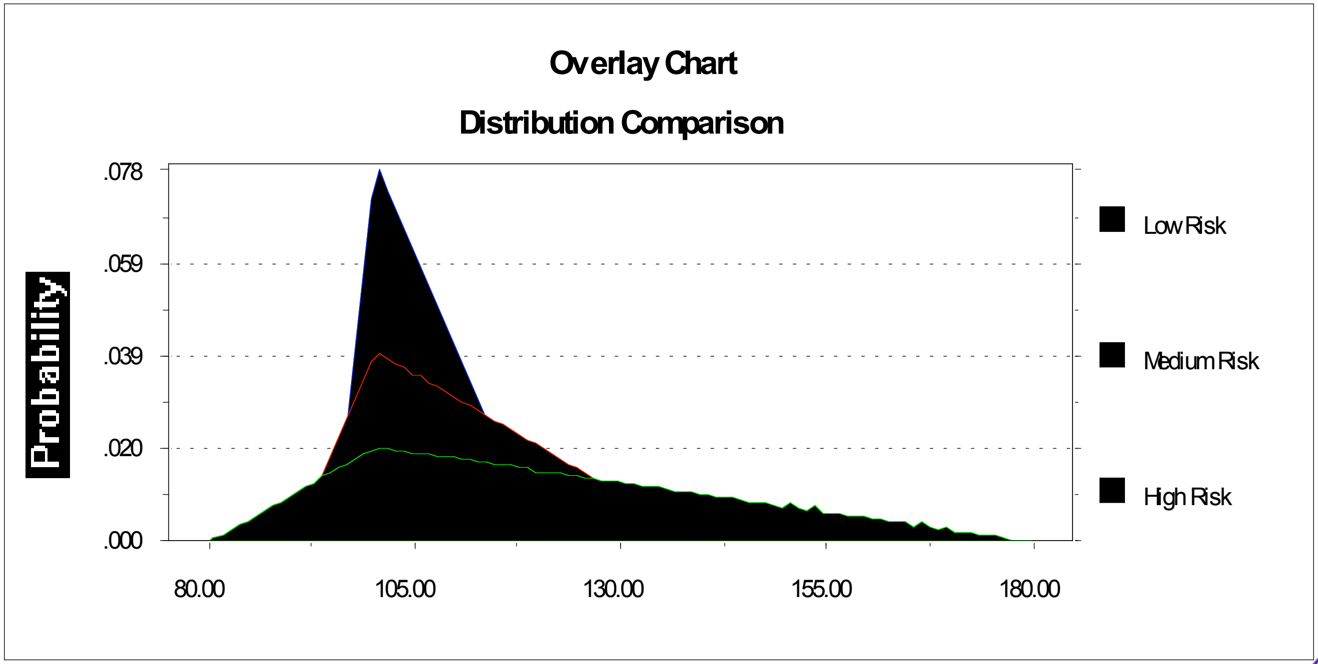
Input Distribution Development from RFA Results

- Risk Factor Analysis results provide a basis for the development of distributions used in the simulation model.

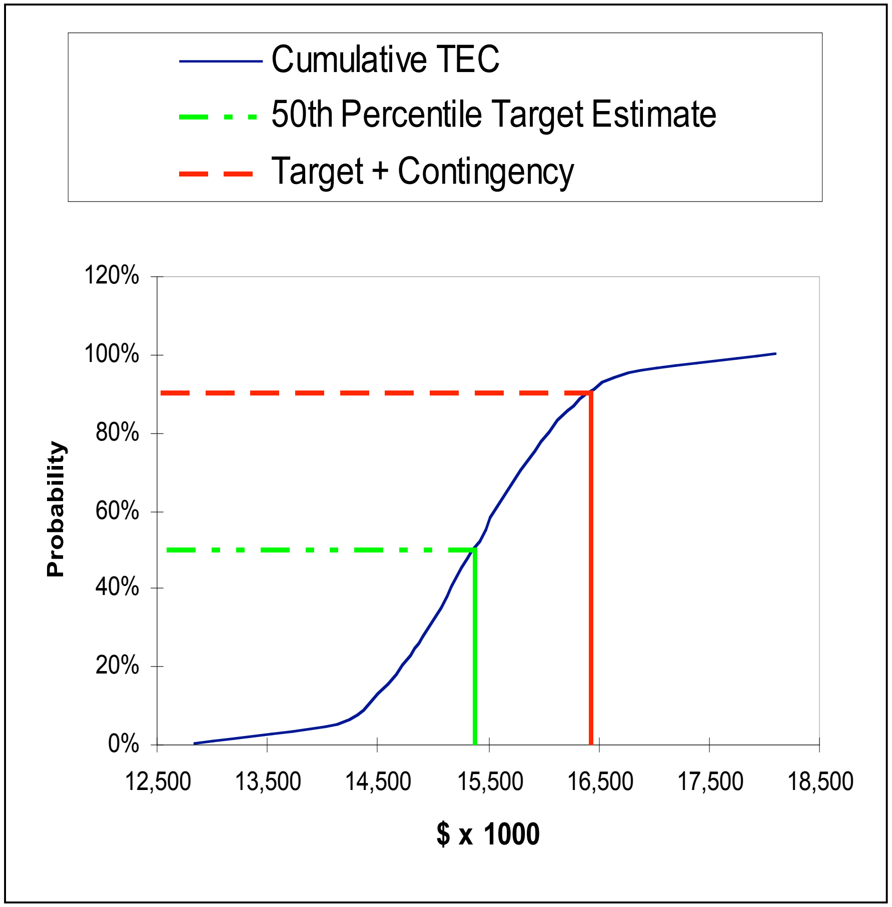
Total Technical, Schedule or Cost Qualitative Risk Score	0 to 6, with no HIGH Risk Factors	6 to 10, with no HIGH Risk Factors	> 10 or HIGH Risk Factors Present
Overall Risk Rank	LOW	MEDIUM	HIGH
Adjustment Factor Guidelines	0% to 10%	10% to 20%	> 20% per specific assessment by the risk analyst
Generally Used Distributions	Triangular, Normal, Uniform, Discrete	Triangular, Normal, Uniform, Custom	Triangular, Lognormal, Custom
Confidence Level (Low/High) Assignment Guidelines	Low Value - 10% High Value - 90%	Low Value - 20% High Value - 80%	Per specific assessment by the risk analyst

Example Risk Distributions

Risk Distributions			
Risk Rank	MIN	Point Estimate	MAX
Low	95	100	120
Medium	90	100	140
High	80	100	180



Format of Simulation Risk Analysis Results

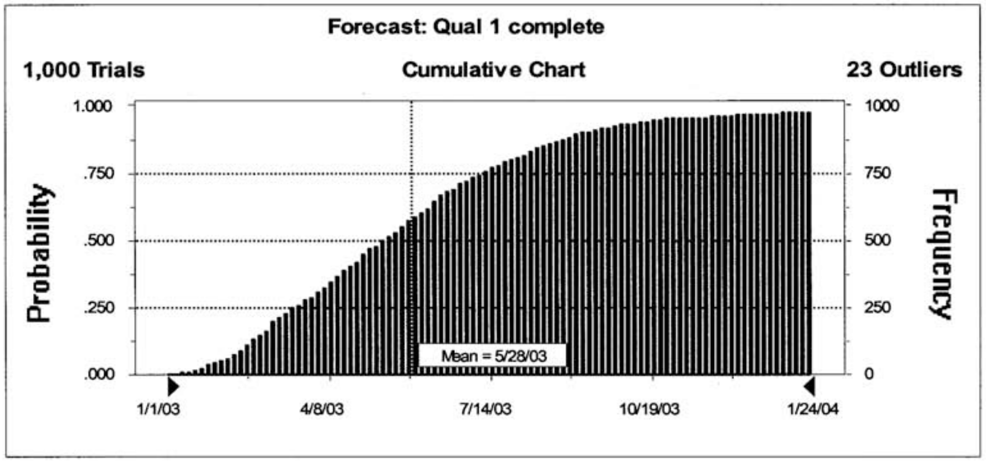


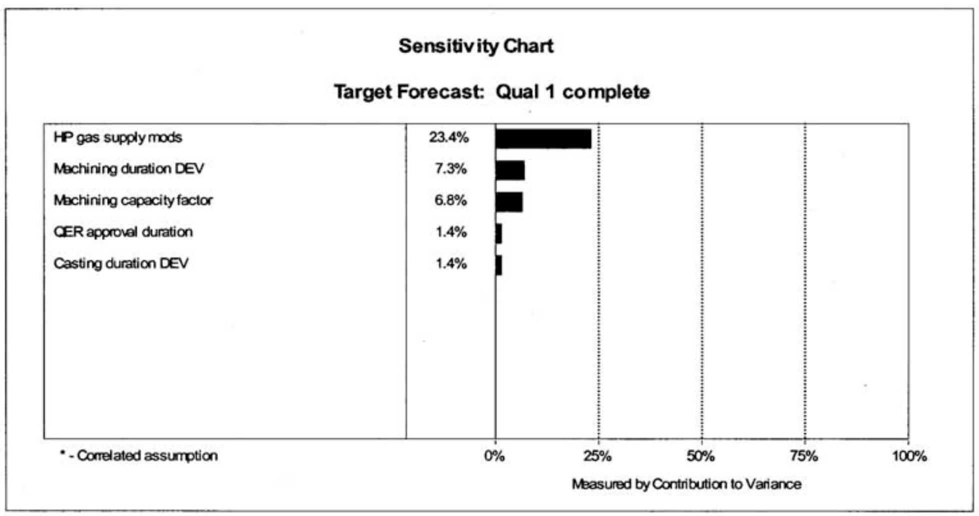
- Cumulative probability distributions provide a complete picture of uncertainty, it is not ignored or assumed to take on extreme values.
- Results provide a basis for setting risk-based performance targets and contingencies.
- Sensitivity analyses identify contributors to risk

LANL, D-11 Project/Program Risk Assessment Experience

- Over the last 3 years, have completed 11 major projects with 13 more in progress
- Nature of the projects varies from relatively standard construction to highly complex R&D
- Costs range from about $20M to $1B

Example Project Simulation Risk Results





Percentile	Value
0%	1/1/03
5%	2/4/03
10%	2/18/03
15%	2/28/03
20%	3/9/03
25%	3/20/03
30%	4/3/03
35%	4/12/03
40%	4/22/03
baseline	4/24/03
45%	5/2/03
50%	5/13/03
55%	5/25/03
mean	5/28/03
60%	6/5/03
65%	6/14/03
70%	6/26/03
milestone	3qtr'03
75%	7/13/03
80%	7/29/03
85%	8/17/03
90%	9/10/03
95%	11/1/03
100%	1/6/04

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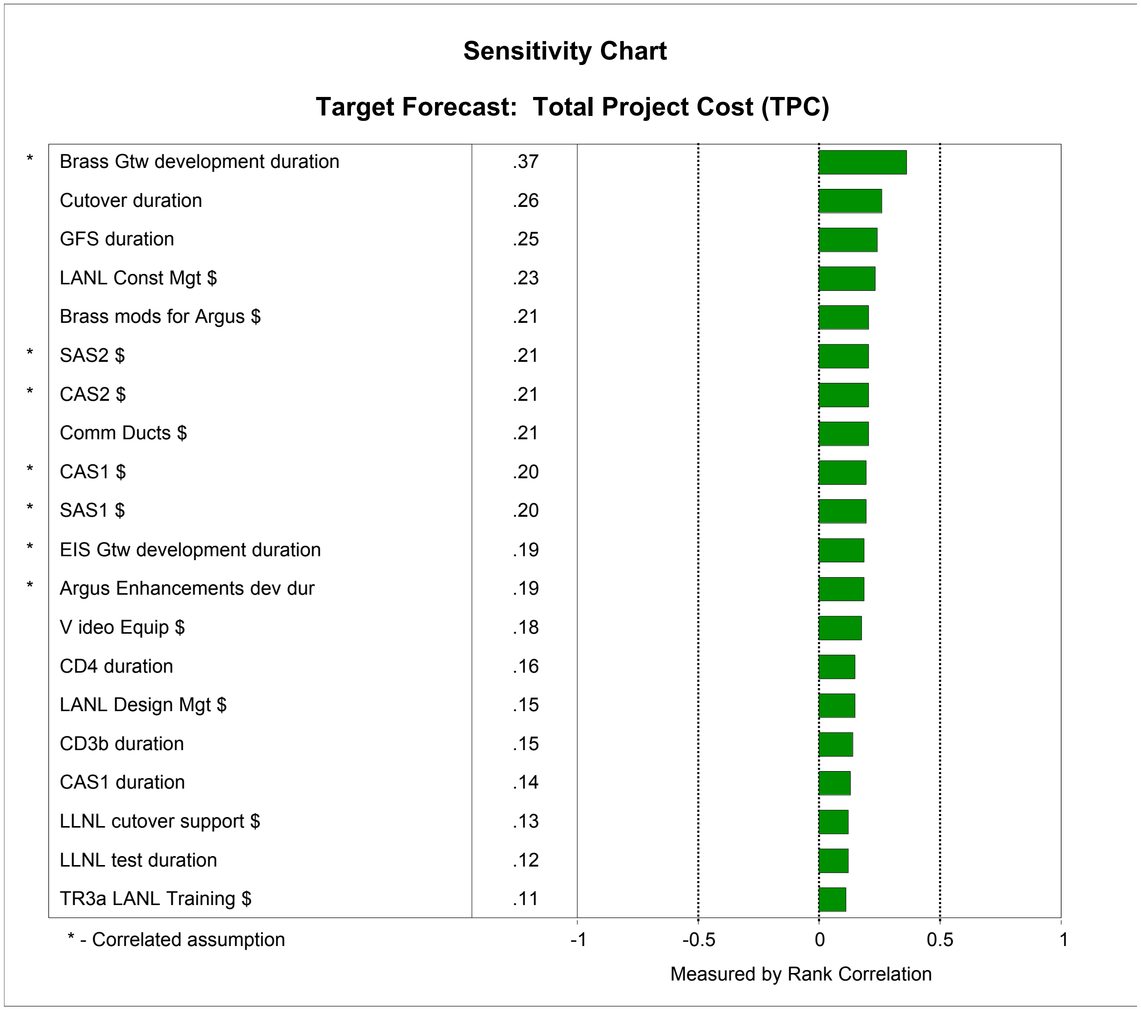
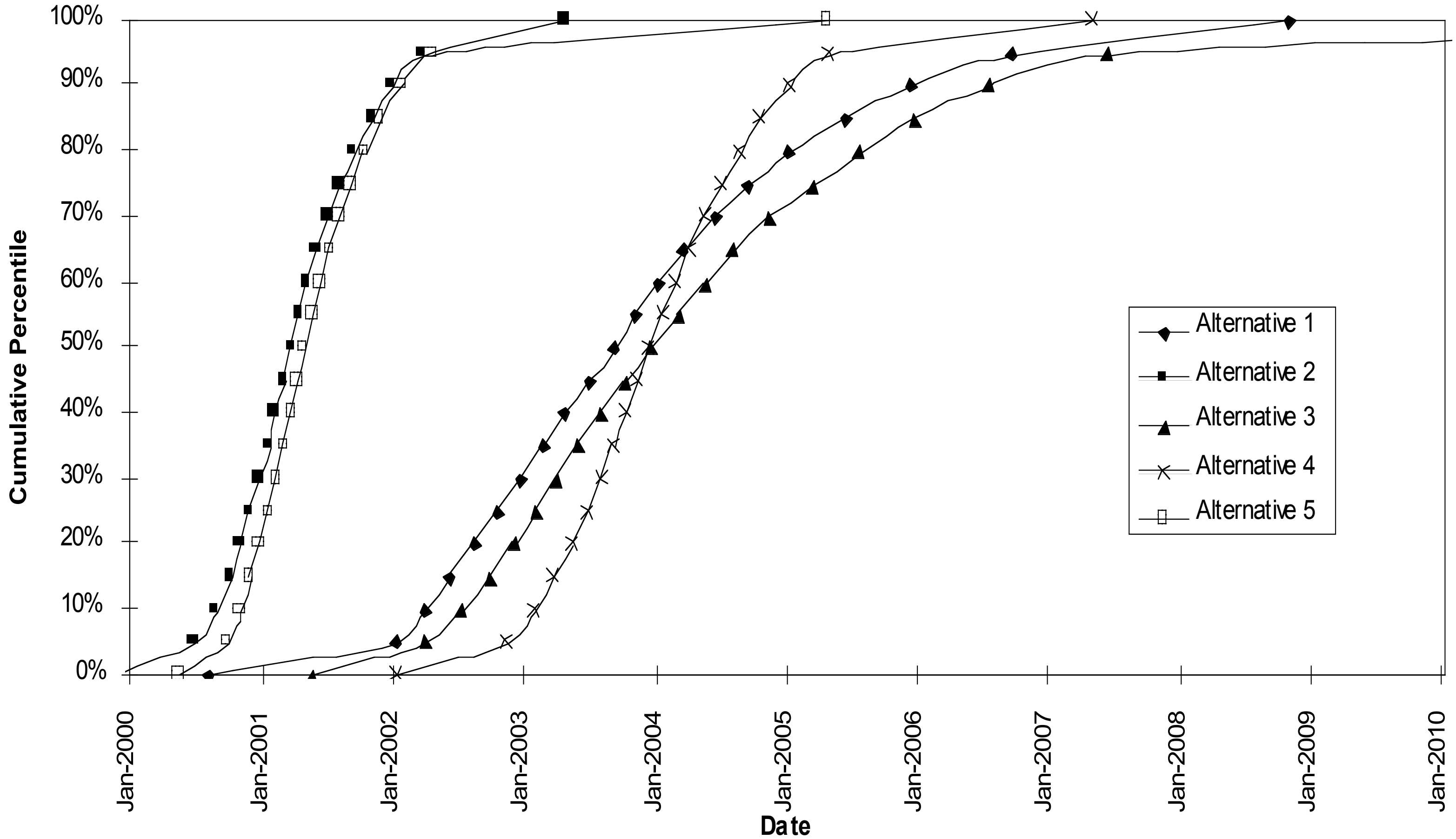
Example of Contributors to Risk



Example Quantitative What-If Analysis Results



Summary

- Two methods have evolved from more established disciplines for performing quantitative project risk analysis:
  - Process hazards analysis method
  - Systems analysis method
- The hazards analysis method is popular because of its apparent simplicity. But, the systems analysis method provides much more complete and comprehensive results
- At Los Alamos National Lab, we have demonstrated the use of the systems analysis method for a wide variety of project types and sizes and hope that our experience will encourage its expanded use by others