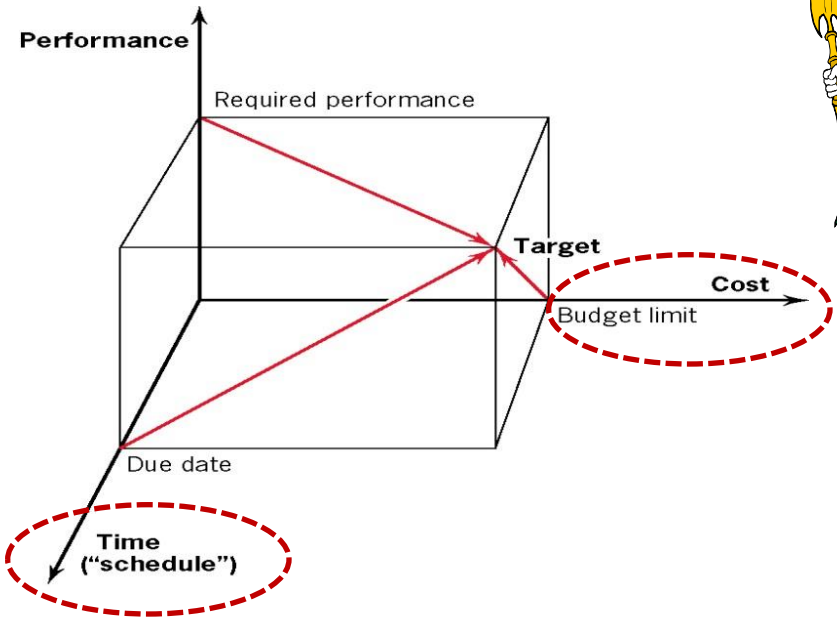
Cost Risk and Uncertainty Analysis

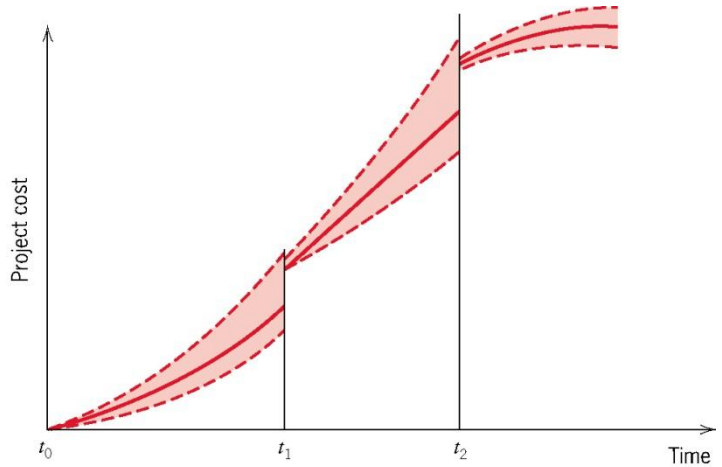
Risk, Trade Space & Analytics in Aquisition

MORS Special Meeting | 19-22 September 2011
Sheraton Premiere at Tysons Corner, Vienna, VA



DASA Cost & Economics

Mort Anvari
Mort.Anvari@us.army.mil



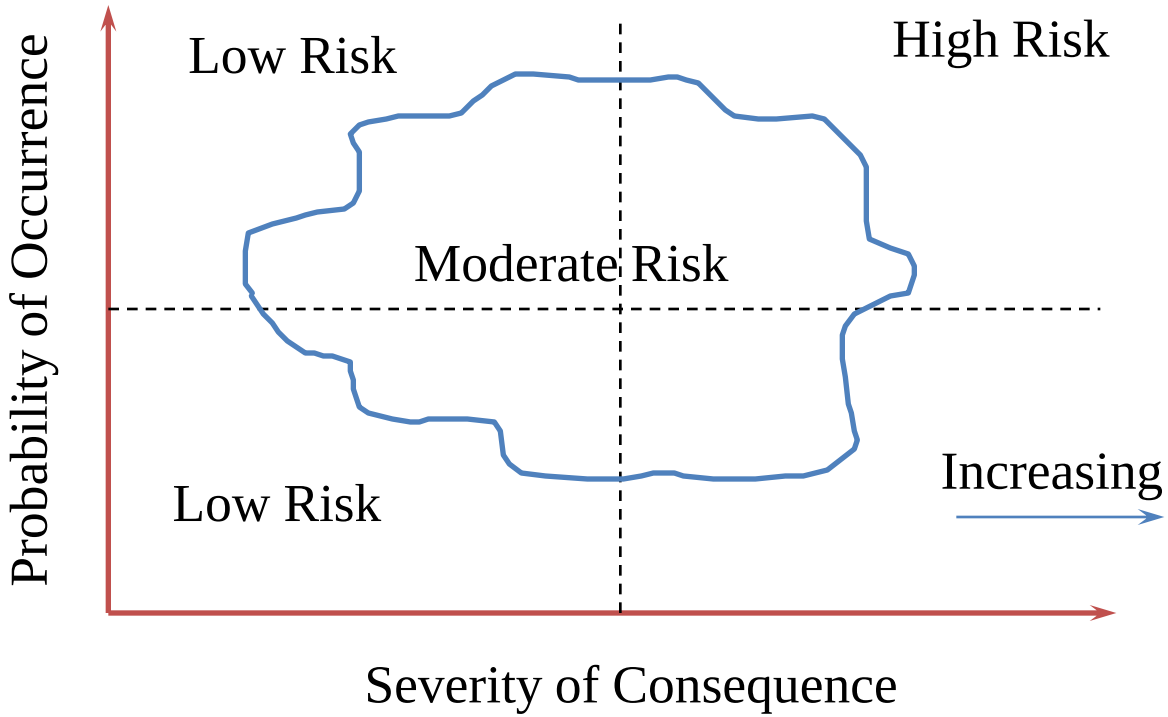
Cost Risk and Uncertainty Analysis

- **The Need For:**
  - Without risk analysis, a cost estimate will usually be a point estimate, which may not account for all of the uncertainties inherent in the effort
  - Not accounting for potential uncertainties may lead to underfunding, cost overruns, and the potential for a program to be reduced in scope in the future
- **Definitions:**
  - *Cost risk and uncertainty analysis* identifies the cost, in terms of dollars, time, and materials that should be added to a point estimate to increase the probability of meeting the desired outcome
  - *Risk* is the occurrence of an outcome subject to a known pattern of random variation (i.e., Known-Unknown). Changes in those technical parameters that are captured in the estimating methodology
  - *Uncertainty* is the occurrence of an outcome subject to an unknown random fluctuations (i.e., Unknown-Unknown). Changes in those parameters that are not part of the estimating methodology
- **Analysis Methodology:**
  1. Identify Areas of Uncertainty
  2. Address the Uncertainty within the Cost Estimate
  3. Quantify the Risk within the Cost Estimate
  4. Presentation of Results

Reasons for Risk

Technical	Programmatic	Cost	Schedule
Physical Properties	Material Availability	Sensitivity to Assumptions	Degree of Concurrency
Material properties	Skill Requirement	Sensitivity to Technical Risk	Sensitivity to Technical Risk
Software Complexity	Environmental Impact	Sensitivity to Programmatic Risk	Sensitivity to Programmatic Risk
Integration Interface	Contractors Stability	Sensitivity to Schedule Risk	Sensitivity to Schedule Risk
Requirement Changes	Funding Profile	Estimating Errors	Number of Critical Path
Operational Environment	Political Advocacy		Estimating Errors

Risk Concepts



Risk Analysis Methods

- **Qualitative** Methods (e.g., subjective assessments of Low, Medium, or High Risk) are of most use when there is little or no historical data available or firm requirements have not yet been established
- **Quantitative** Methods are considered where probability distribution on cost elements or drivers can be estimated from historical data or deduced from expert opinion
  - **Analytical** Method involves the mathematical determination of a total cost distribution from its components cost distributions
  - **Simulation** Method involves the computer generation of random costs from component distributions and aggregation into a total cost distribution

1. Identify Areas of Uncertainty:

- Objective is to identify areas where variance may have an impact on future costs
  - Potential areas of uncertainty include:
    - *Cost Estimating:* Variability inherent in cost estimating data and methodologies used
    - *Technical:* Variability in the range of technical options possible to meet requirements
    - *Schedule:* Variability due to potential fluctuations in duration of activities
    - *Requirements:* Variability due to potential changes in system performance
    - *Programmatic:* Variability due to changes in the program's acquisition strategy
  - Potential data sources include:
    - Historical data / trends
      - Cost growth reports
    - Programmatic documents
      - Initial Capabilities Document (ICD), Capability Development Document (CDD), Capability Production Document (CPD)
    - Discussions with Subject Matter Experts (SMEs)
    - Analogous system data

Cost Risk and Uncertainty Analysis

2. Address the Uncertainty within the Cost Estimate:

- Need to determine which identified uncertainties to model (i.e., which are cost-sensitive)
- Cost methodology highly dependant, reliant upon data available
- Application of uncertainty dependant upon cost methodology
  - Uncertainty assessment is best done at the lowest-level variables possible
  - Important to identify uncertainty associated with cost drivers at a minimum
- Selection of appropriate probability distribution for each risk element is critical

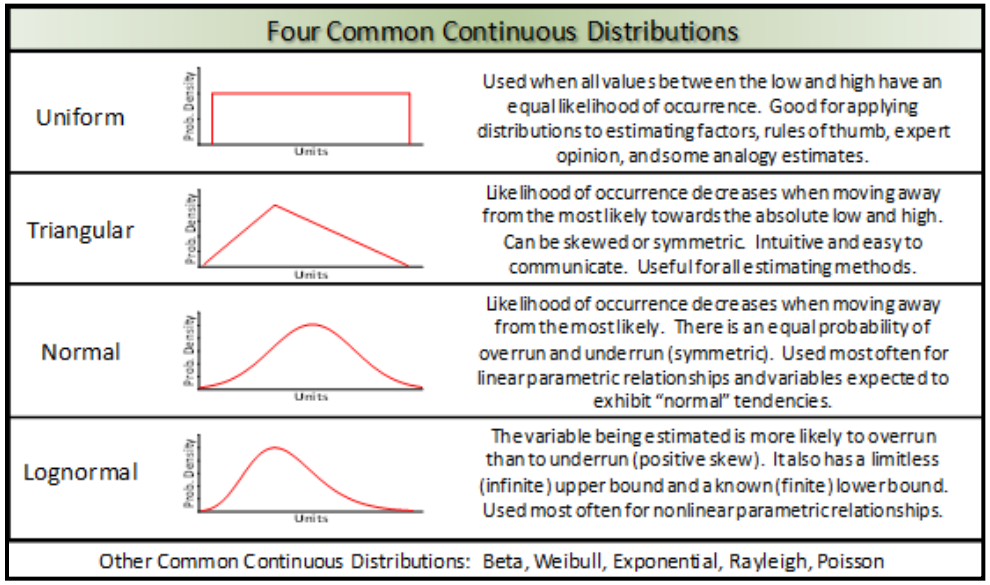


Figure 1: Common Risk Distributions

Cost Risk and Uncertainty Analysis

3. Quantify the Risk within the Cost Estimate:

- ODASA-CE utilizes the Automated Cost Estimating Integrated Tools (ACEIT)
  - Integrated within ACEIT is a simulation-based risk analysis capability (RI$K) that allows the analyst to perform cost, schedule, and technical risk and uncertainty analysis
  - Provides the capability to calculate risk results for various confidence levels using Latin-Hypercube sampling
  - *Input:* Specification of risk within ACEIT

WBS/CES Description	Point Estimate	Equation / Throughput	RI$K Specification	Distribution Form	PE Position in	Low (% of PE)	High (% of PE)
5.10 SYSTEMS ENGINEERING/MGMT	$ 40.452 (50%) *						
5.101 Project Mgmt Admin (PM Civil)	$ 40.452 (50%) *	SEPM_CIV_FACT	Form=Triangula	Triangular	Mode	90	110

Figure 2: Specifying a Risk Distribution within ACEIT

  - *Output:* ACEIT risk statistics report
    - Displays statistical results in Base Year (BY) dollars for each WBS element at the specified confidence level

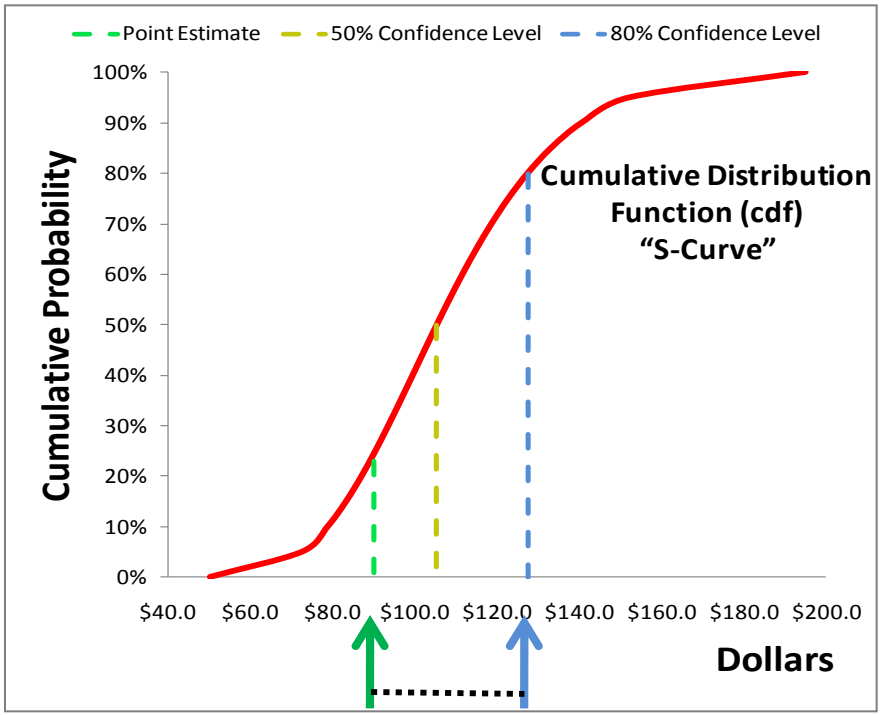
WBS/CES	Point Estimate	Mean	Std Dev	CV	5.0% Level	10.0% Level	15.0% Level	20.0% Level
5.10 SYSTEMS ENGINEERING/MGMT	$ 40.452 (50%)	$ 40.451	$ 3.657	0.090	$ 34.343	$ 35.515	$ 36.404	$ 37.166
5.101 Project Mgmt Admin (PM Civil)	$ 40.452 (50%)	$ 40.451	$ 3.657	0.090	$ 34.343	$ 35.515	$ 36.404	$ 37.166
5.102 Other								

Figure 3: Example Statistics Report within ACEIT

Cost Risk and Uncertainty Analysis

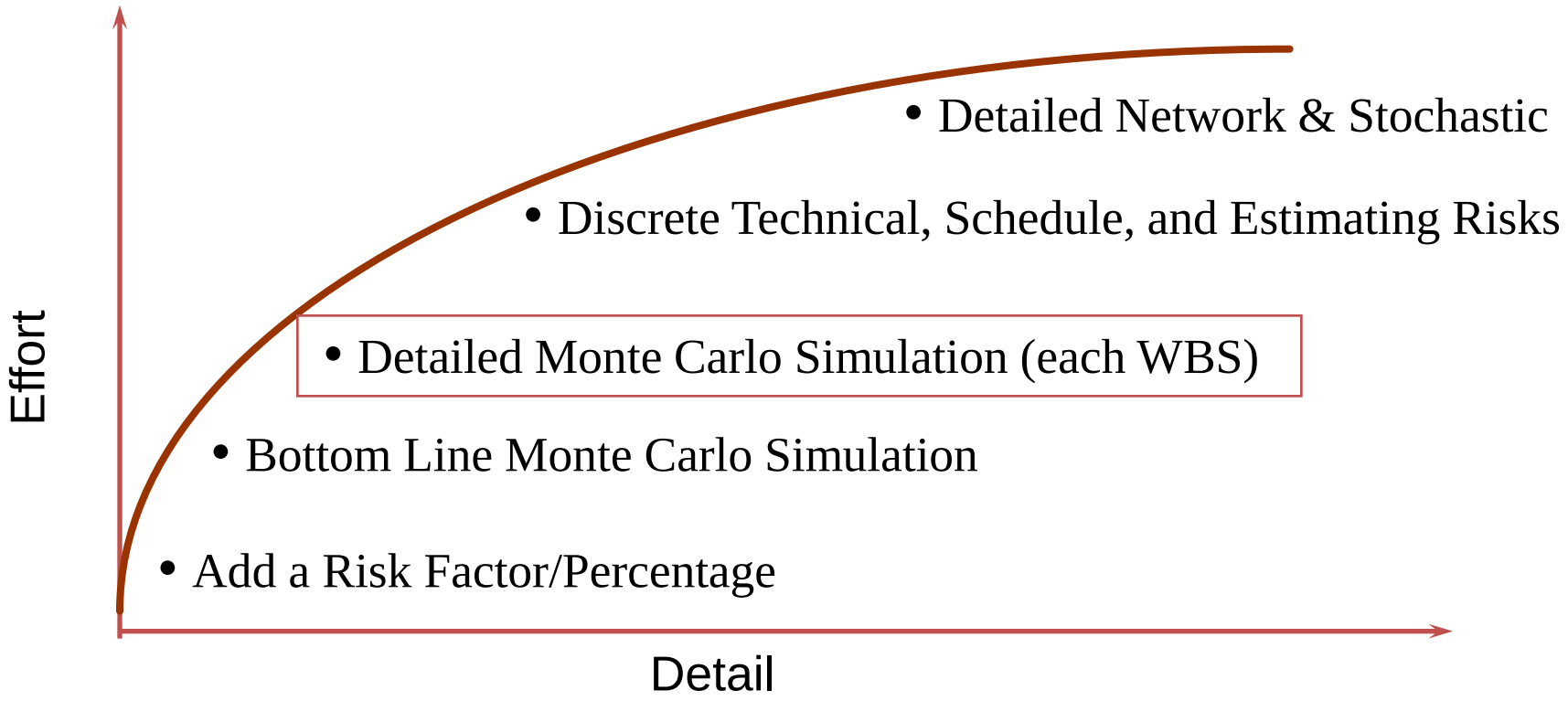
4. Presentation of Results:

- ACEIT can also be used to formulate a Cumulative Density Function (CDF) or S-Curve
  - Each point on the S-Curve identifies the cumulative probability that the associated cost on the x-axis will not be exceeded. This is referred to as the level of confidence in a particular estimate.

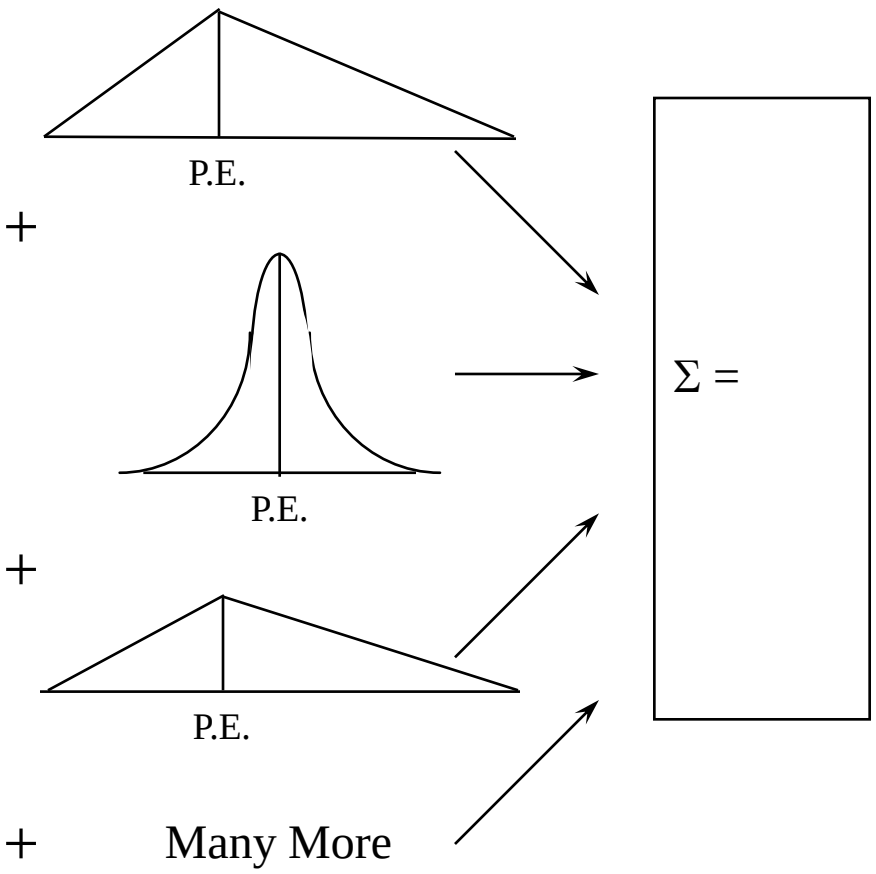


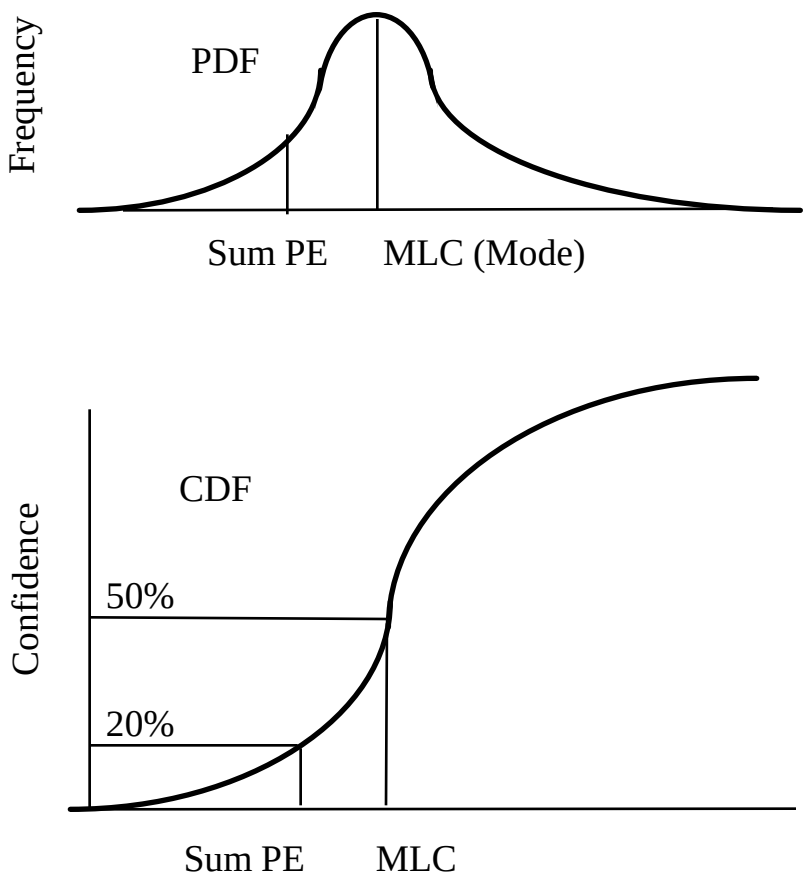
- AoA cost estimates are presented as a point estimate at the 50% confidence level accompanied by a risk-informed cost range (±σ)

Risk Analysis Approaches

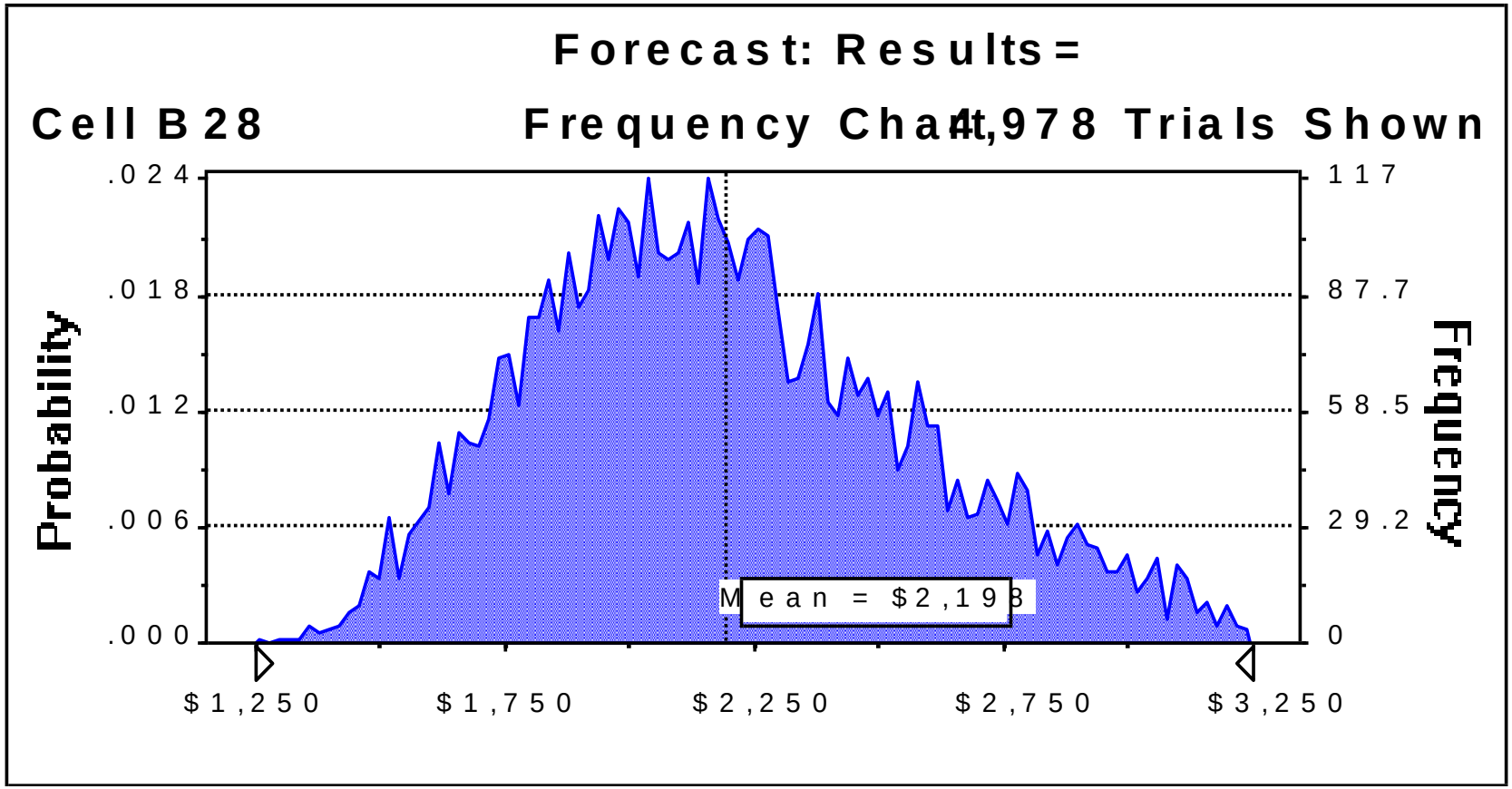


Probability Distributions

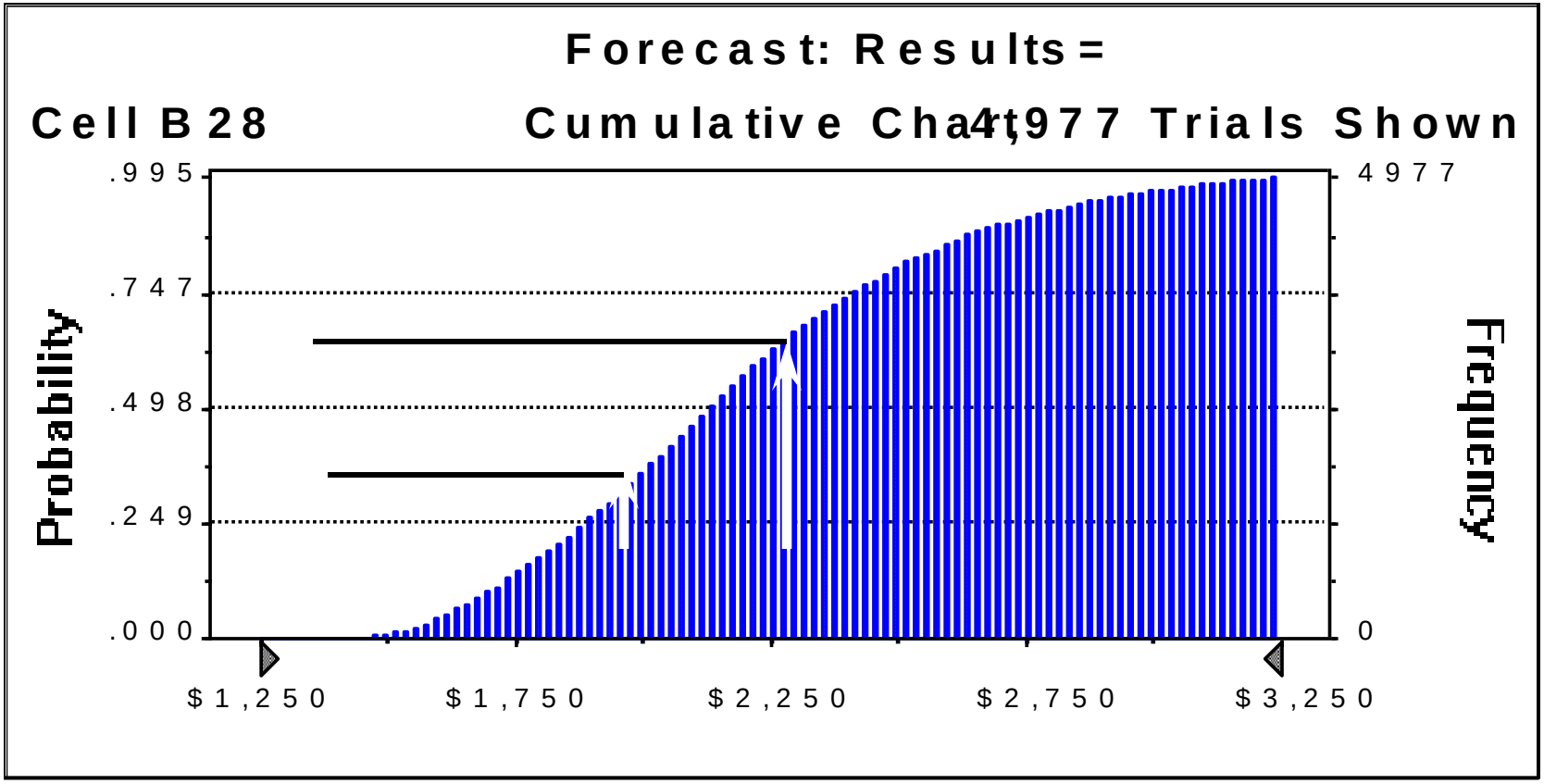




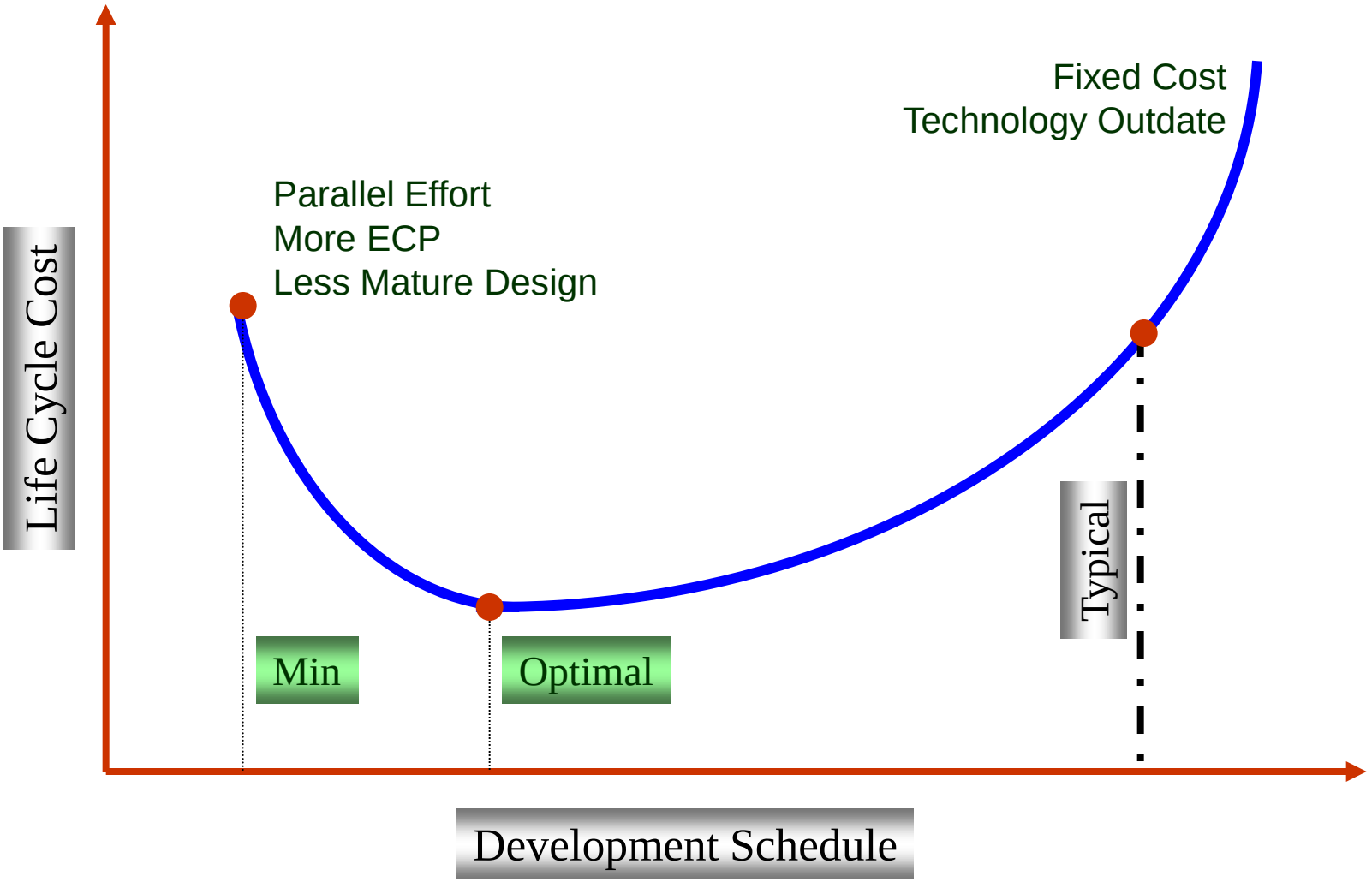
Probability Density Function



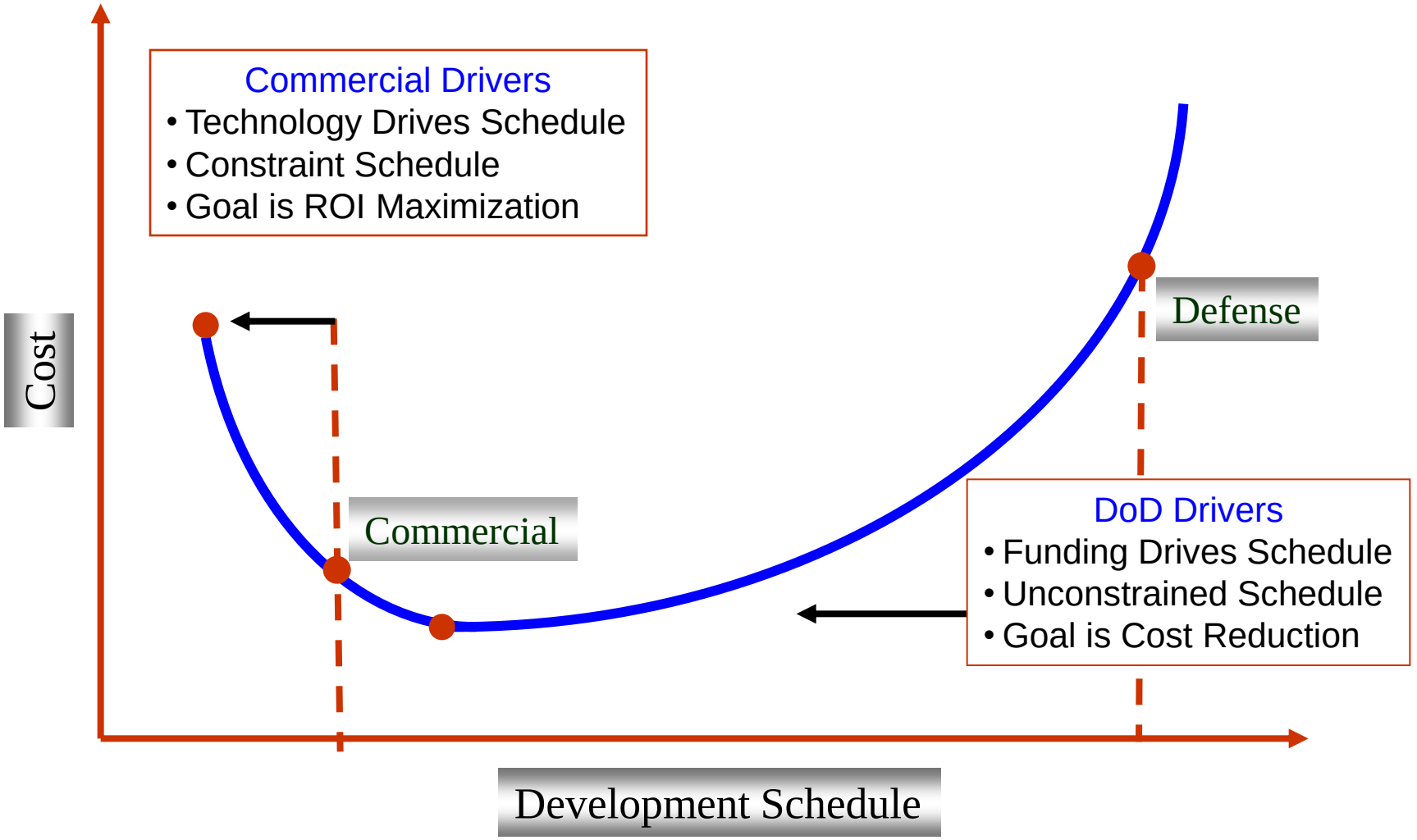
Cumulative Distribution Functions



Cost Schedule Curve

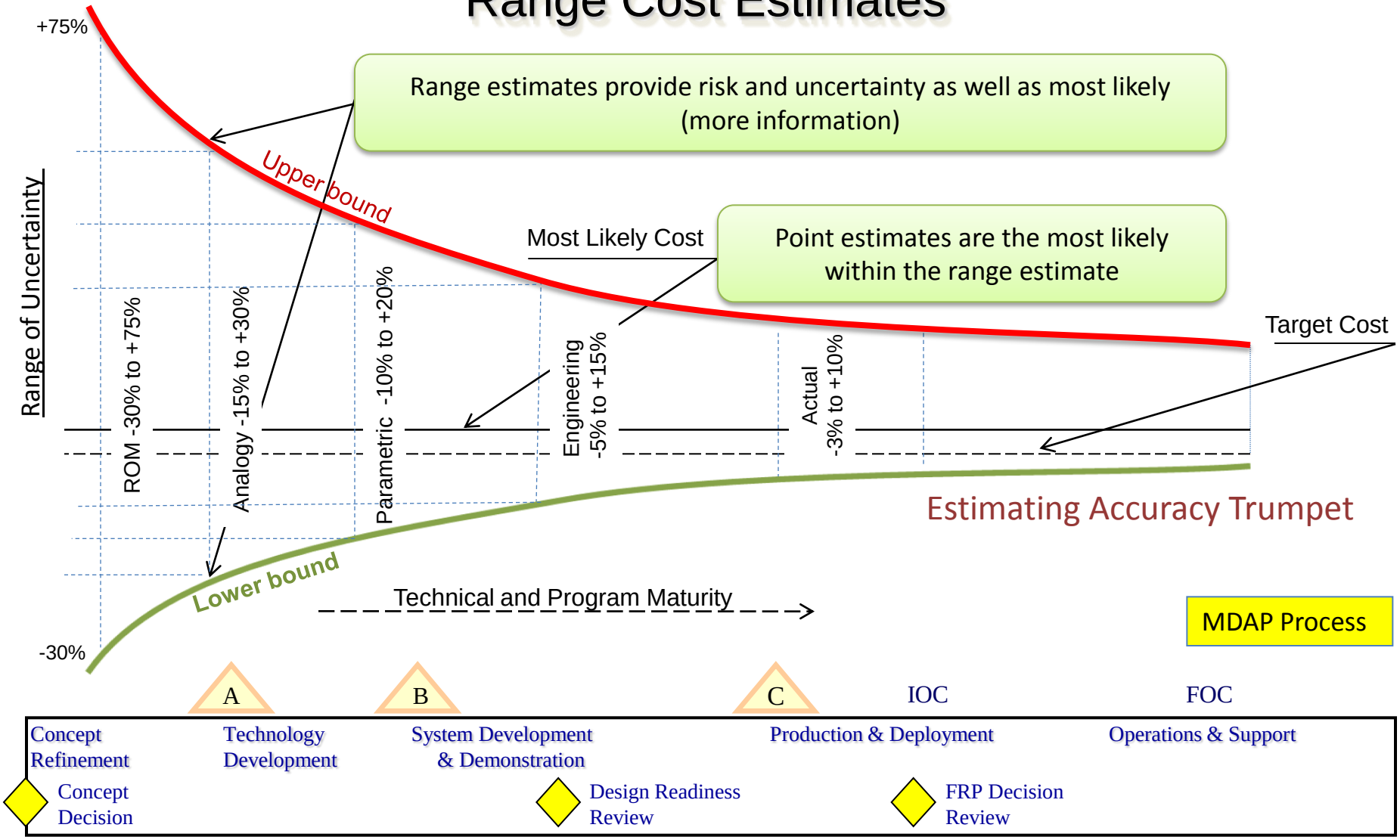


Schedule Goals



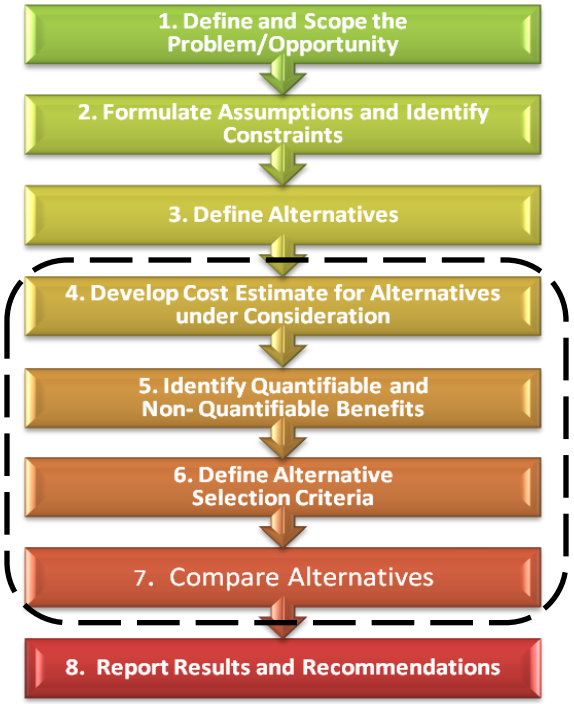
Cost Risk and Uncertainty Analysis

Range Cost Estimates



Cost Risk and Uncertainty Analysis

CBA Steps



	COA-1	COA-2	COA-3
Cost $M in BY-2011	$20	$16	$12

Cost = $ quantifiable cost – $ quantifiable benefit or saving

Decision Matrix		Rating or Ranking		
Benefit Criteria	**Weight**	COA-1	COA-2	COA-3
Lethality	30%	9	6	2
Safety	45%	4	6	6
Survivability	25%	6	5	3
	Score	6.0	5.8	4.1

Benefit = $ non-quantifiable benefit and $ non-quantifiable risk

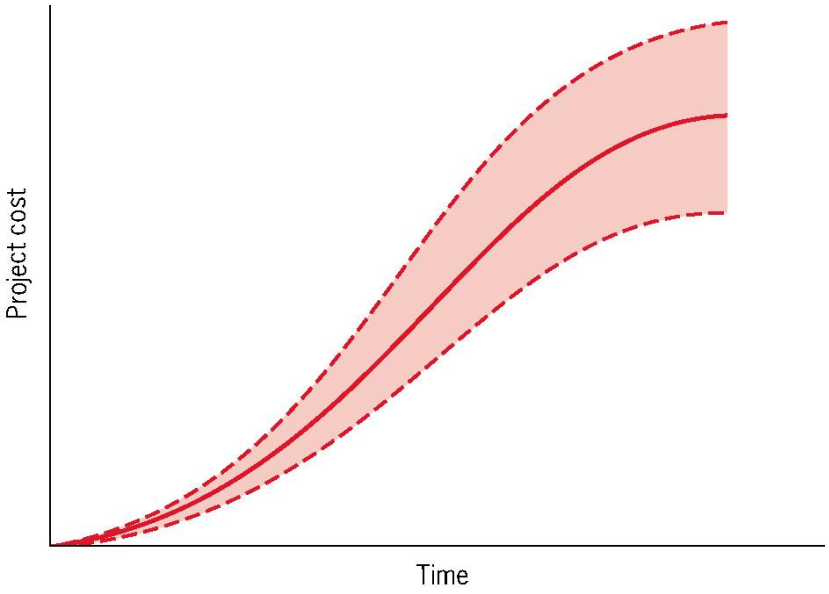
	COA-1	COA-2	COA-3
Cost per Benefit	$3.33	$2.78	$2.96

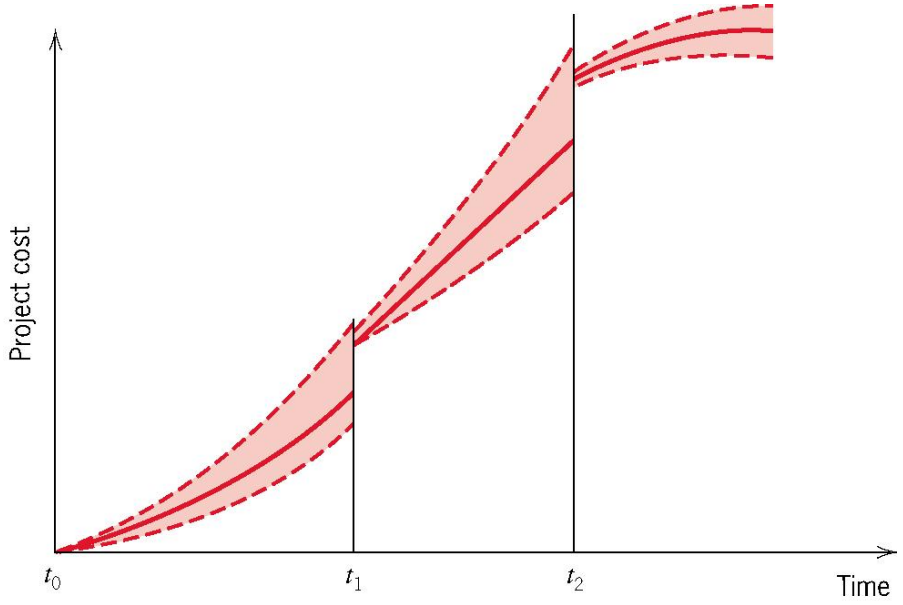
COA-1 highest benefit COA-2 best value COA-3 lowest cost

CBA provide framework for making resource informed decisions

Risk Reduction

- Cost Risk Analysis will not reduce the risk inherent in a program; however it helps PM to understand the nature of the risk involved, and the uncertainty associated with the cost estimates
- More frequent Cost Risk Analysis result in a more realistic assessment of the cost and schedule and the development of effective risk mitigation plan





Risk analysis reduces the uncertainty between requirements and funding