Being Certain about Uncertainty
(Part 1)

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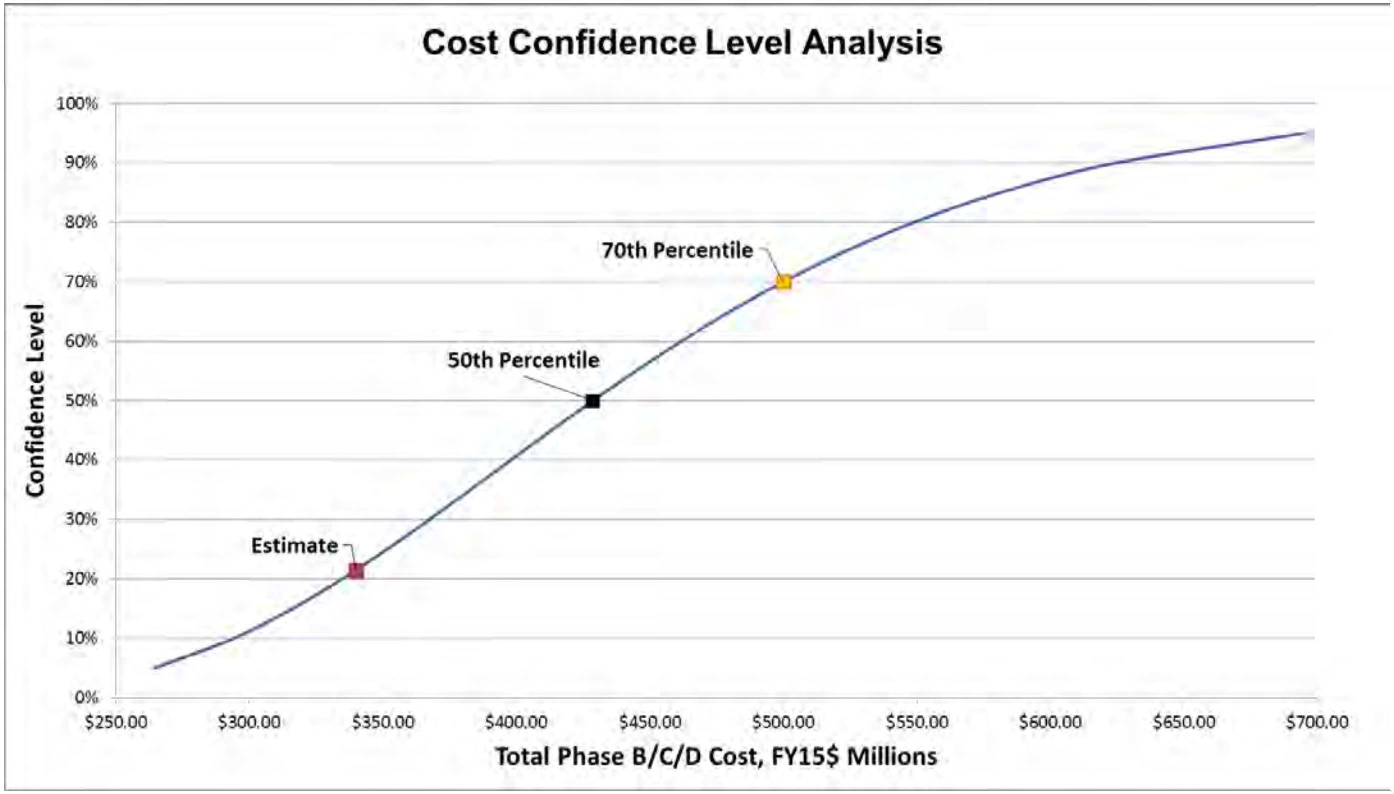
Outline

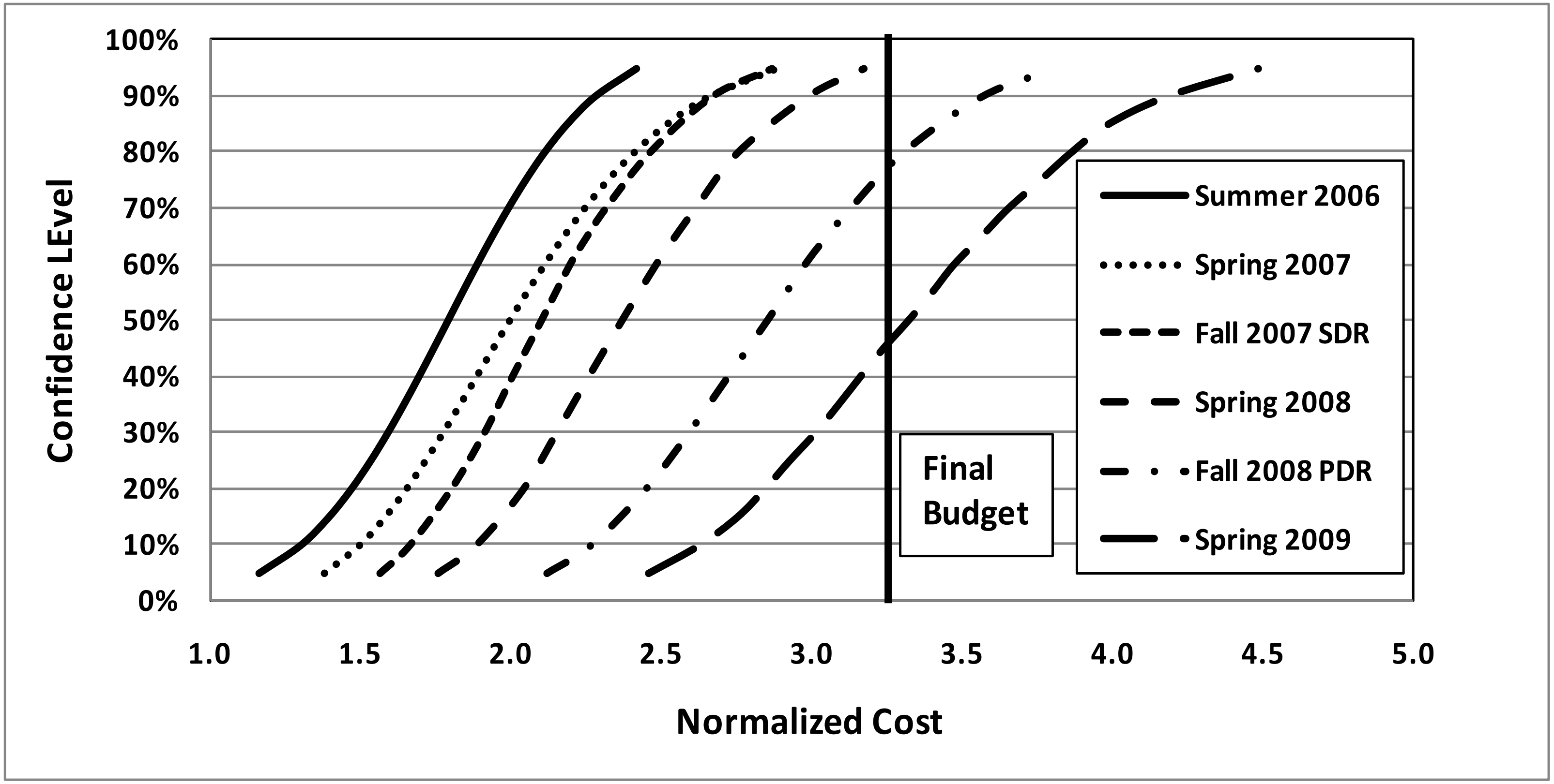
- The Big Question
- The Big Miss
- Cost Risk Analysis is Hard
- Validation
- Learning from History
- A Fly in the Ointment
- The Failure of History
- What's Next

The Big Question

How do I judge the quality of my cost risk analysis?



The Big Miss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Normalized Cost
Final Budget
Summer 2006
Spring 2007
Fall 2007 SDR
Spring 2008
Fall 2008 PDR
Spring 2009

Cost Risk Analysis is Hard

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Cost Risk is an abstract concept. Our brains don't like abstract concepts, therefore; we diligently pursue ways to give it context and meaning through rigorous processes and methodologies. Yet understanding cost risk is as much art as it is science.

- ***Highly Subjective***
- **No Consensus on the "Best" Method**
- **Requires Math, and Even Worse, *Statistics and Probability Theory***
- **Not Sure how to Interpret the Results**

We harbor a crippling dislike for the abstract.
Nassim Taleb, "The Black Swan"

Common Problems

- **Confusion between Risk and Uncertainty**
  - **Risk**: Chance of Loss, Chance Something could go Wrong
  - **Uncertainty**: Indefiniteness about the Outcome
- **Probability: Yes – No – Maybe**
- **The World Makes Sense Looking Backwards**
- **We are Overconfident and Optimistic**
- **Our Preconceived Ideas Define the Data We Look For and the Data We See**

The elephant in the room: there is uncertainty in our uncertainty analyses.

Validating the Analysis

- **Process**
  - GAO Cost Estimating and Assessment Guide
- **Coefficient of Variation (CV)**
  - Air Force: "…early in the project 35-45% is typical for space systems and software intensive projects; 25-35% is typical for aircraft and similar complexity hardware; and 10-20% is typical of large electronic system procurements"
  - Joint Cost Schedule Risk Uncertainty Handbook: table of CV's based on NCCA cost growth experience
- **Historical Experience**
  - Using historical data to determine an expected level of cost growth, approach favored by MDA

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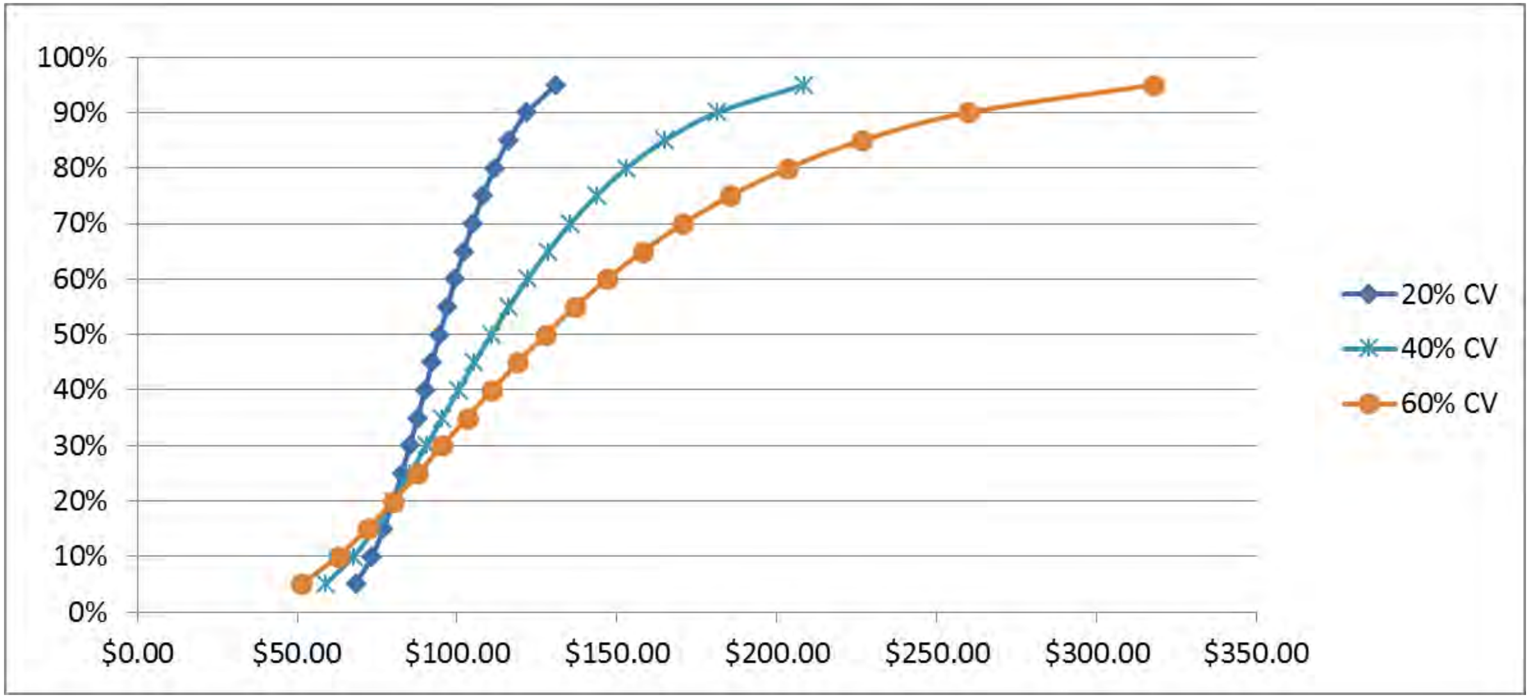
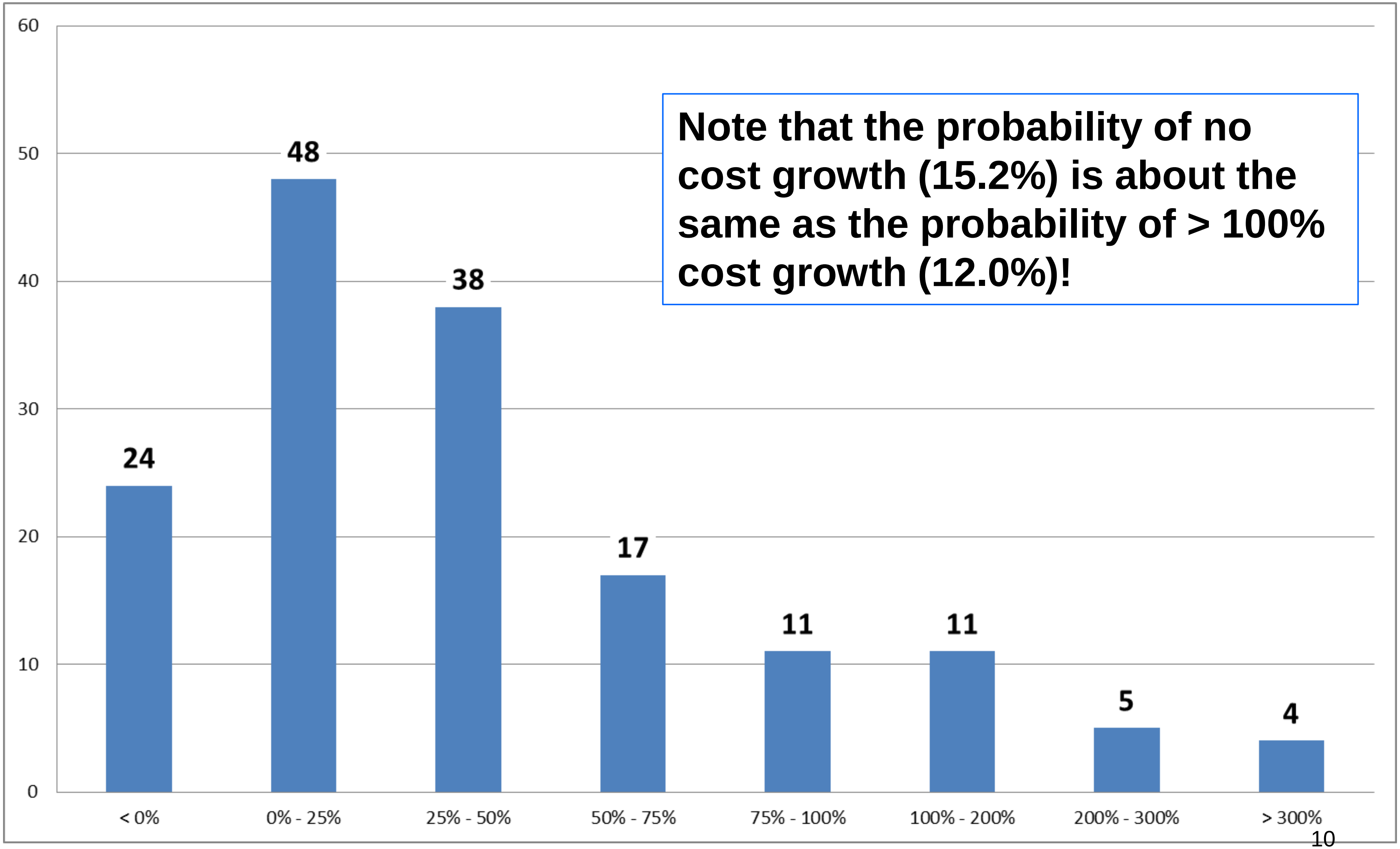
Cost Risk Process*

1. Determine the program cost drivers and associated risks.
2. Develop probability distributions to model various types of uncertainty.
3. Account for correlation between cost elements.
4. Perform the uncertainty analysis using a Monte Carlo simulation model.
5. Identify the probability level associated with the point estimate.
6. Recommend sufficient contingency reserves to achieve an acceptable level of confidence.
7. Allocate, phase, and convert a risk-adjusted cost estimate to then-year dollars and identify high-risk elements to help in risk mitigation efforts.

The Coefficient of Variation

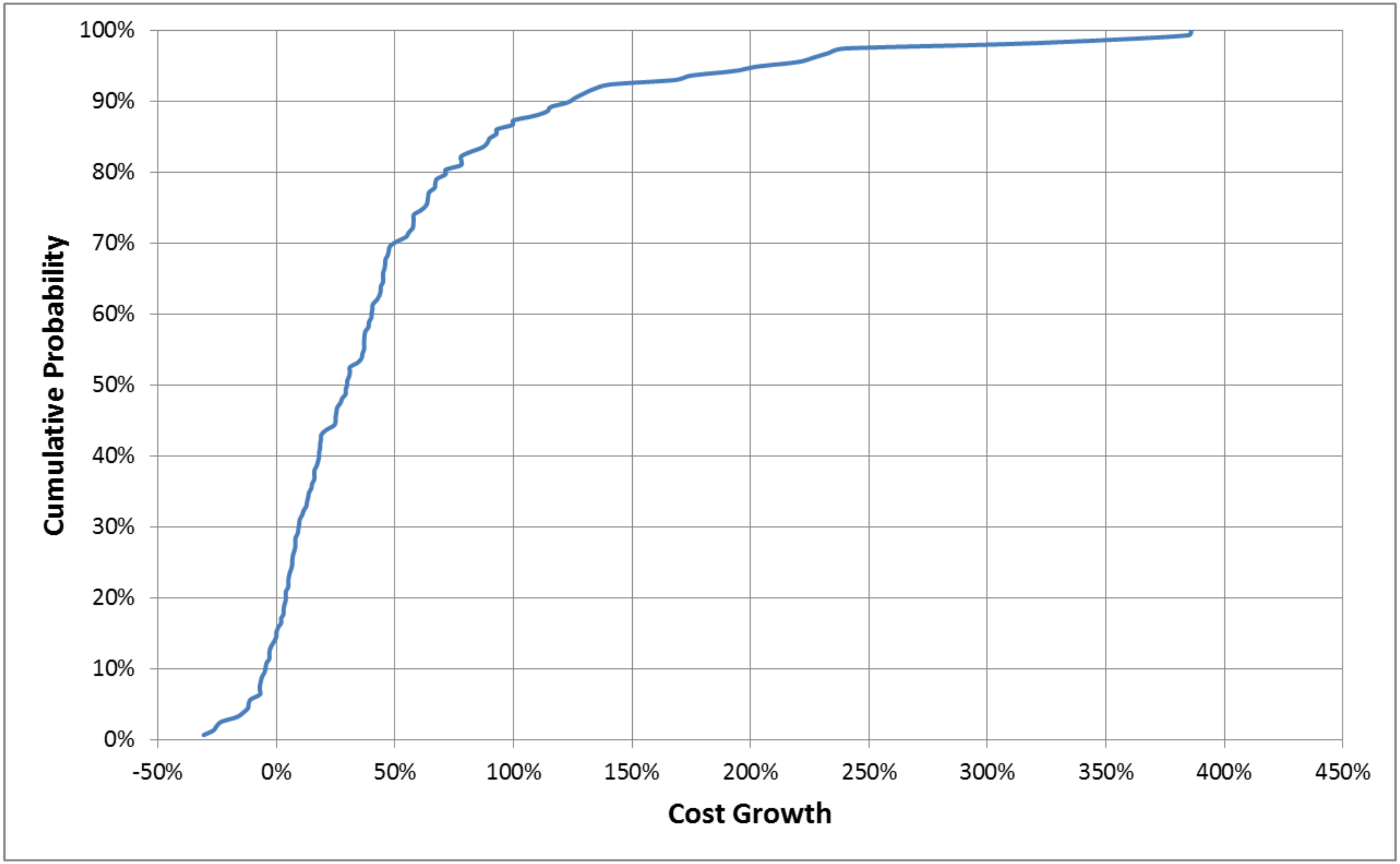
– The greater the CV the greater the relative cost difference between percentile values



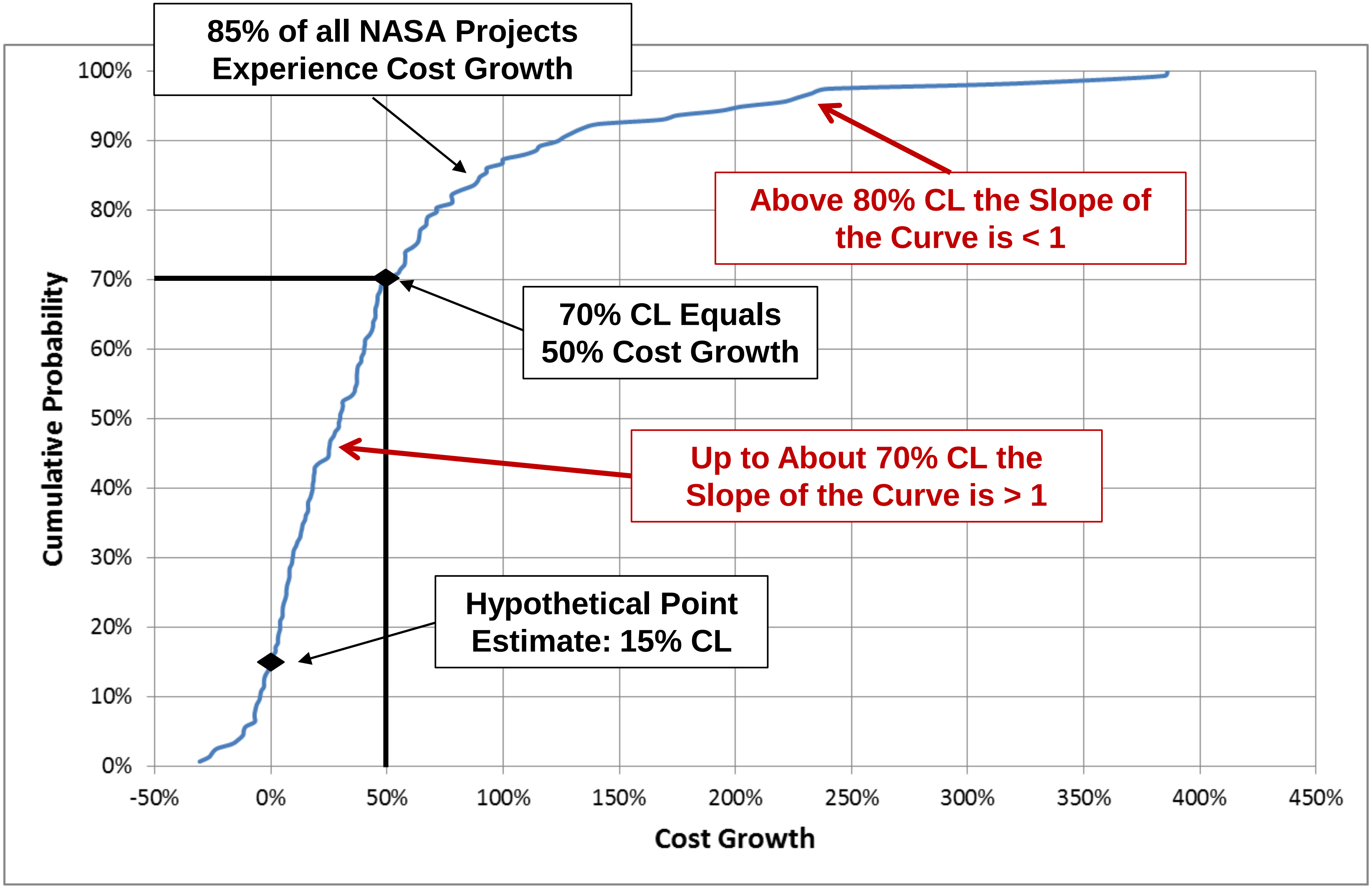


Note that the probability of no cost growth (15.2%) is about the same as the probability of > 100% cost growth (12.0%)!

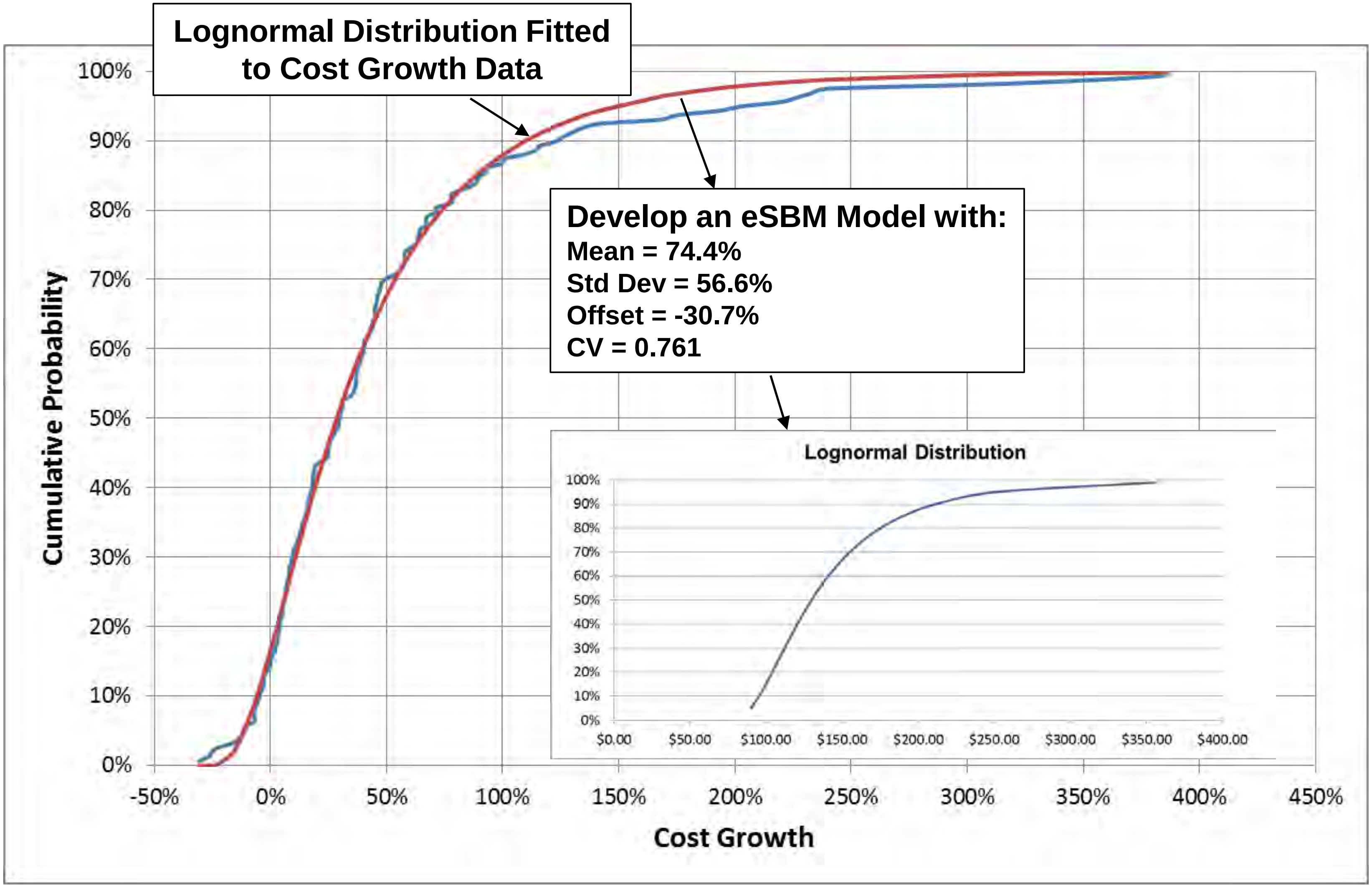
Historical Cost Growth PDF



Learning from the Cost Growth PDF



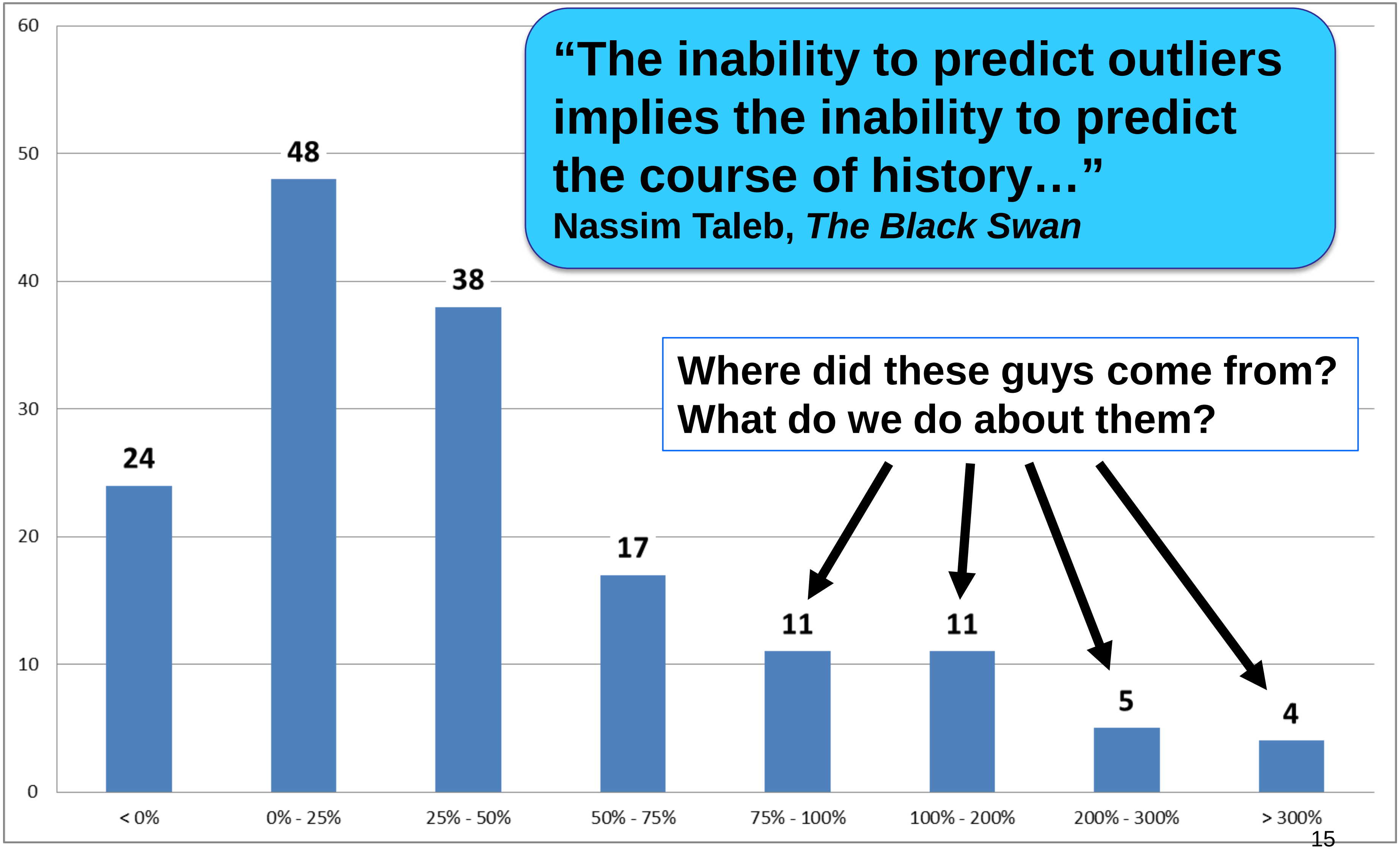
Using the Cost Growth PDF



Validation Summary

- **Process**
  - Are you accounting for correlation?
  - Are all sources of uncertainty adequately addressed?
  - Beware of optimism and overconfidence.
  - Beware the triangle distribution!
- **History and the Coefficient of Variation (CV)**
  - Your CV should be unique to the assumptions in your analysis but within the context of your organization's historical experience.
  - Compare the CV of your s-curve to a CV derived from historical cost growth data.
  - By fitting a probability distribution function to your historical data you now have a simple model to use for validation.
  - Use other techniques, such as the enhanced Scenario Based Method (eSBM) to develop alternative models for comparison (and vice versa).

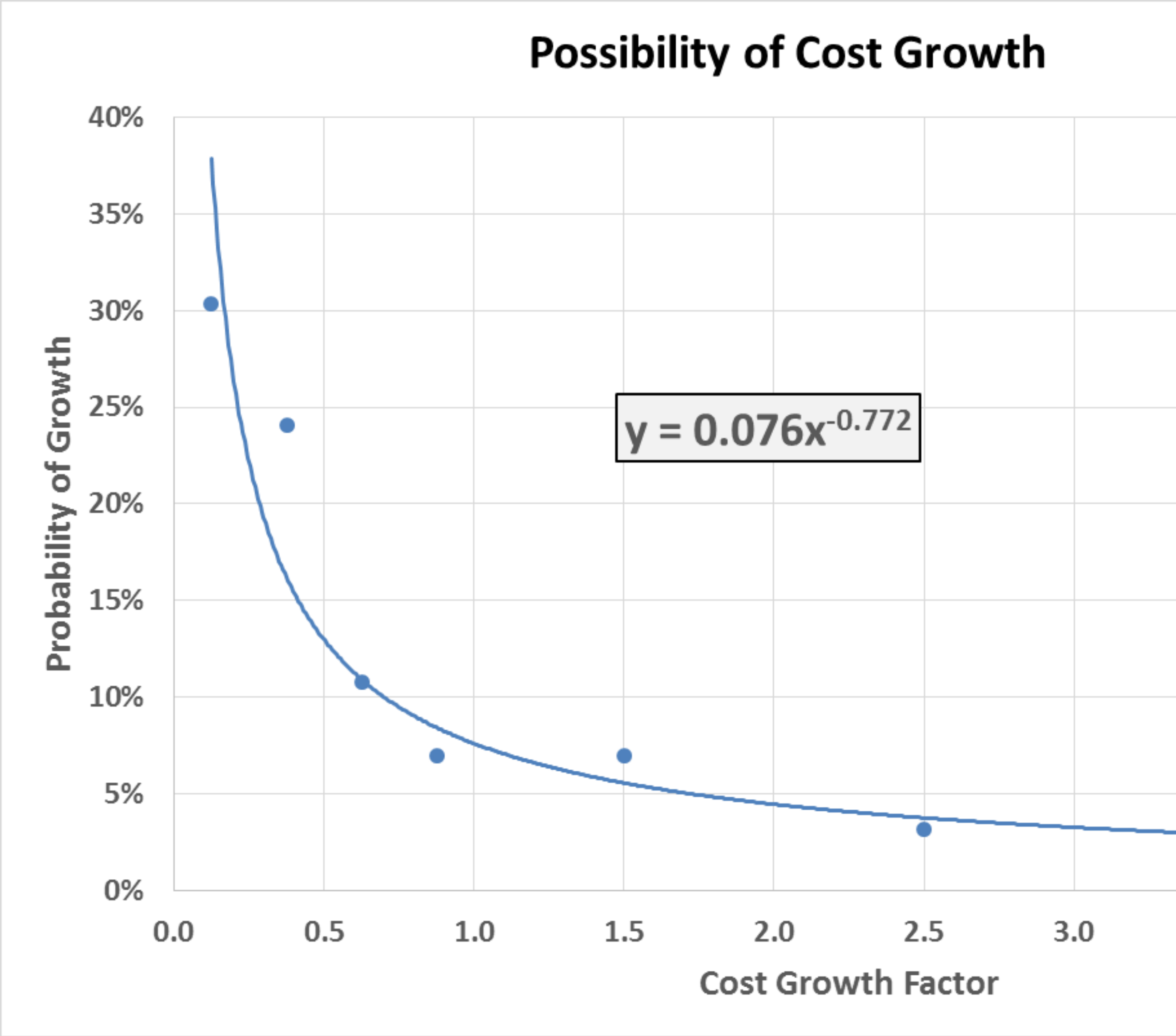
Your Cost Risk Analysis should be a Logical Outcome of all the Evidence



"The inability to predict outliers implies the inability to predict the course of history…"
Nassim Taleb, *The Black Swan*

Where did these guys come from?
What do we do about them?

Extreme Outcomes are a Real Possibility



Some Examples:
- JWST
- A-3 Test Stand
- Ares I
- F-35

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The Failure of History

- **The Problem of Cost Growth has been Studied Since the 1970's**
- **The REDSTAR Library Contains 1,127 Studies, Surveys, Assessments, Recommendations, etc. Concerning Cost Growth**
- **Continued Problems with Cost and Schedule Overruns in Major NASA and DoD Acquisition Programs are Routinely Highlighted by the GAO and Inspector General**
- ***So Why aren't We Doing Better?***

Taleb's Triplet of Opacity*

a. The illusion of understanding, or how everyone thinks he or she knows what is going on in a world that is more complicated (and random) than they realize;

b. The retrospective distortion, or how we can assess matters only after the fact, as if we are looking in a rearview mirror (history seems clearer and more organized in history books than in empirical reality); and

c. The overvaluation of factual information and the handicap of authoritative and learned people, particularly when they create categories – when they "Platonify."

***Nassim Taleb, "The Black Swan" page 8**

A Different Approach to "Analysis"

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- **Much of our analysis is causative – we know the outcome so we look for causes**
- **Causative analysis creates what Douglas Hubbard calls the Expectancy Bias – we see what we want to see**
- **What is needed: an approach to the study of project histories which seeks knowledge without prejudice, observation without judgment**
- **Hypothesis: The environment that surrounds the project creates the conditions for extreme cost growth**

In Summary

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- **Doing good cost risk analysis is hard**
- **The CV is an useful measure but it must be consistent with your organization's cost growth history**
- **Are you ignoring key sources of uncertainty?**
  - **CER uncertainty**
  - **Highly suspect assumptions (i.e. TRL 9, off-the-shelf, etc.)**
  - **Sensitivity analysis**
  - **Historical data**
- **Extreme cost growth is a reality, be a realist**
- ***Remember: The less you know the greater the uncertainty in your estimate!***

Next Step

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Being Certain about Uncertainty, Part 2

– Can We See Extreme Cost Growth Coming?

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Bibliography (2 of 2)

Backup

Another Question

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If unknown unknowns are truly unknown, then how can I credibly bound my cost risk analysis?

- **Ancillary Questions:**
  - If we can't credibly address "unknown unknowns" then how can we credibly address "I forgot's?"
  - If we really don't know what we don't know or what we forgot, then how can we even begin to estimate the magnitude?
  - Is applying a fixed reserved (i.e. 30%) to an estimate anything more than a safety factor based on historical experience?
  - Is there anyway to keep this train of thought from leading us into an ***inability to do cost estimating death spiral***?

Choose Your Weapon!

- **Inputs-Based Methods**
  - Cost Model Input Uncertainty
  - Estimating Method Uncertainty
  - Discrete Project Risks
- **Outputs-Based Methods**
  - Multiple Model
  - Same Model, Multiple Inputs
  - Historical Cost Growth
  - Discrete Project Risks
- **Scenario Based Methods (SBM)**
  - Non-statistical SBM
  - Statistical SBM
  - Enhanced SBM (eSBM)

Explaining

- **Understand Your Analysis**
  - You should be able to support all actions on the basis of facts, data, analysis, sunspots, Ouija Boards, etc.
  - Test yourself: explain it to a co-worker, your boss, your dog (cats won't listen) – don't try to it explain to family members!
- **Develop Your Explanation**
  - Remember: you will be talking to managers and senior government officials, so keep it simple
  - *Avoid deep discussions of probability theory and statistics*
  - Explain the difference between uncertainty and risk
  - Show the relationship between facts, data, analysis, and subjective assessments
  - People understand stories, so use the Narrative Fallacy to your advantage

Goal is for Your Cost Risk Analysis to be a Logical Outcome of the Evidence

Common Mistakes

- Constructing the Narrative before doing the Analysis
- Using Triangular (and other Truncated) Distributions
- Relying on Experts
- Inadequately Addressing Estimating Uncertainty
- Ignoring or Minimizing History
- Failing to Acknowledge the Possibility of Extreme Cost Grow