Programmatic Risk Analysis and the Joint Confidence Level

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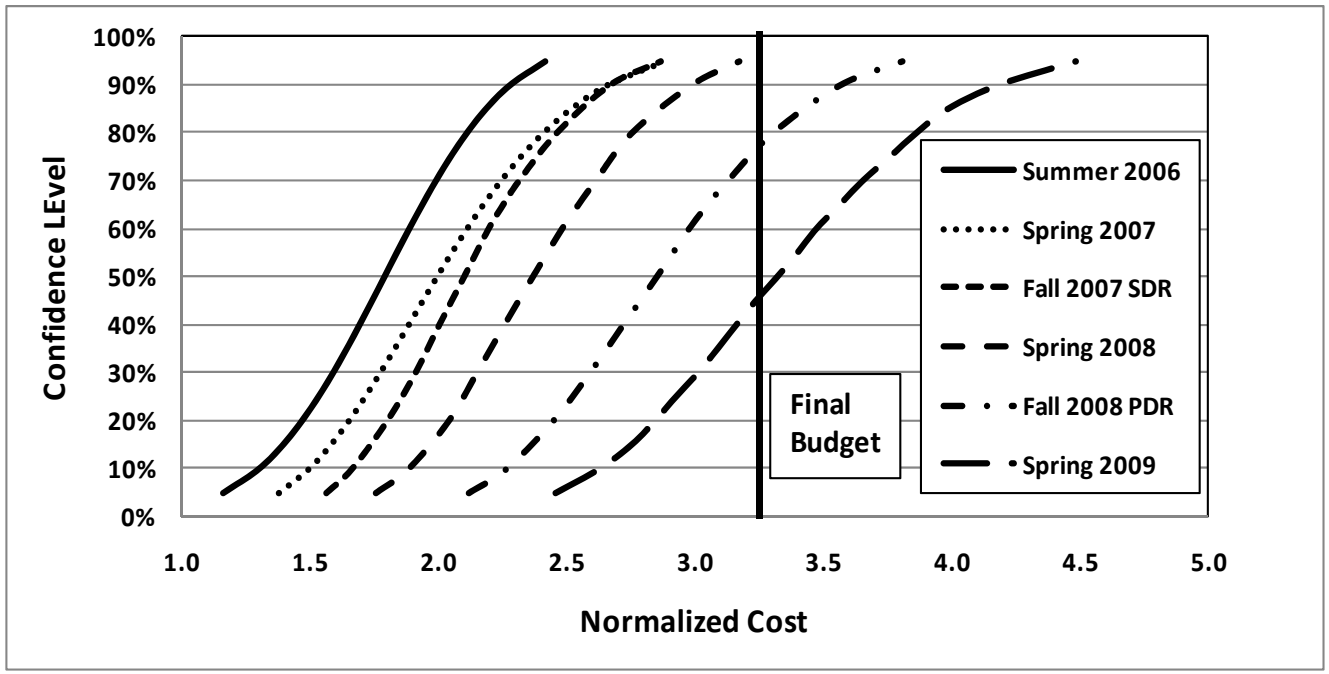
MARSHALL SPACE FLIGHT CENTER

Outline

- The Challenge of Good Programmatic Risk Analysis
- The Human Failure to Understand Risk and Uncertainty
- The Joint Cost Schedule Confidence Level Analysis
- Evaluating Your Results
- Summary and Conclusions



From “Covered with Oil” by Christian Smart, this graph shows the sad history of a NASA project’s cost risk analysis.

The Challenge of Programmatic Risk Analysis

- **Programmatic Risk Analysis is an Abstract Concept**
- **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**

We harbor a crippling dislike for the abstract.

Nassim Taleb, “The Black Swan”

Our very human biases make it impossible for us to be purely dispassionate and logical.

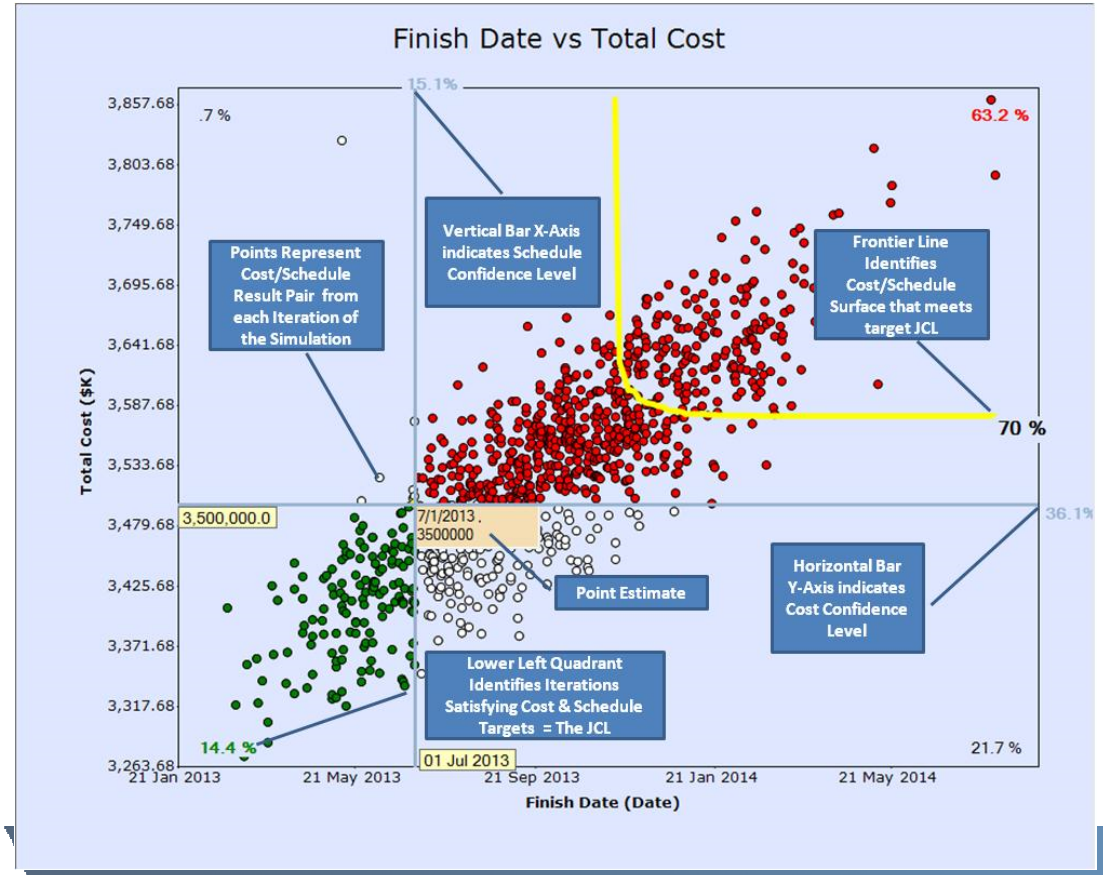
The Human Condition

- **NASA has implemented a technique called Joint Cost Schedule Confidence Level Analysis (JCL)**
- **JCL incorporates cost uncertainties, schedule uncertainties, and risks in an analytical framework**
- **JCL enables project managers and senior Agency leaders to understand how the level of uncertainty and risk drive probable outcomes**

DOE has begun to use JCL analyses for highly complex projects and those with firm completion dates

JCL = Joint Cost and Schedule Confidence Level

Identifies the probability that a given project's or program's cost will be equal or less than the targeted cost AND the schedule will be equal or less than the targeted schedule date.



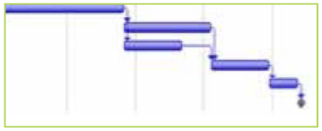
- **Each dot in the scatter plot represents a result from the simulation calculation (Cost, Schedule).**
- **Scatter plot shows iterations of cost and schedule risk analysis.**
  - Cross-hairs can be moved to a date and cost to obtain their joint confidence.
- **Analysis results valid only for plan the inputs are based on, and represents a snapshot in time.**

What is a JCL?

The Four Key JCL Inputs

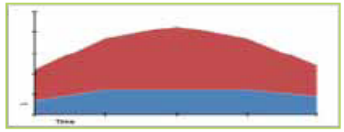
Schedule

The network schedule of activities is the foundation of the JCL analysis.



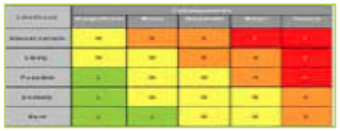
Cost

Project cost data by element is linked to the schedule and mapped to activities.



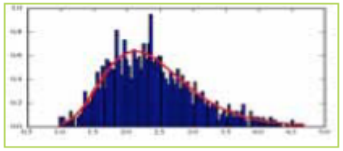
Risk

An itemized list of risks with likelihood and impact is included in the JCL.



Uncertainty

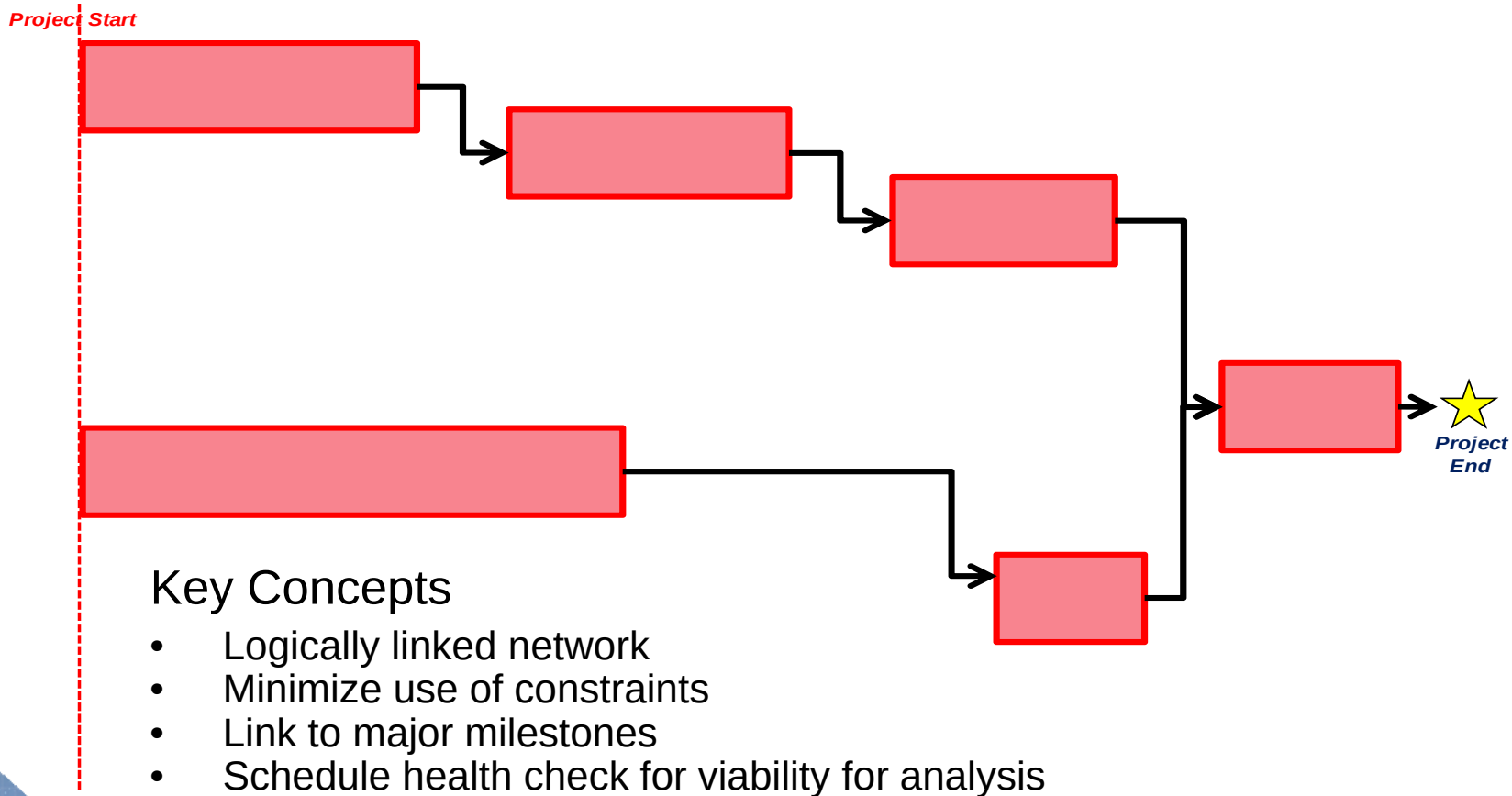
Uncertainty in the cost and duration can capture additional unknown risk.



Main Steps in Building a JCL

1. **Build a JCL schedule/logic network**
2. **Cost load the schedule**
3. **Implement risk list**
4. **Conduct uncertainty analysis**
5. **View results & plot**

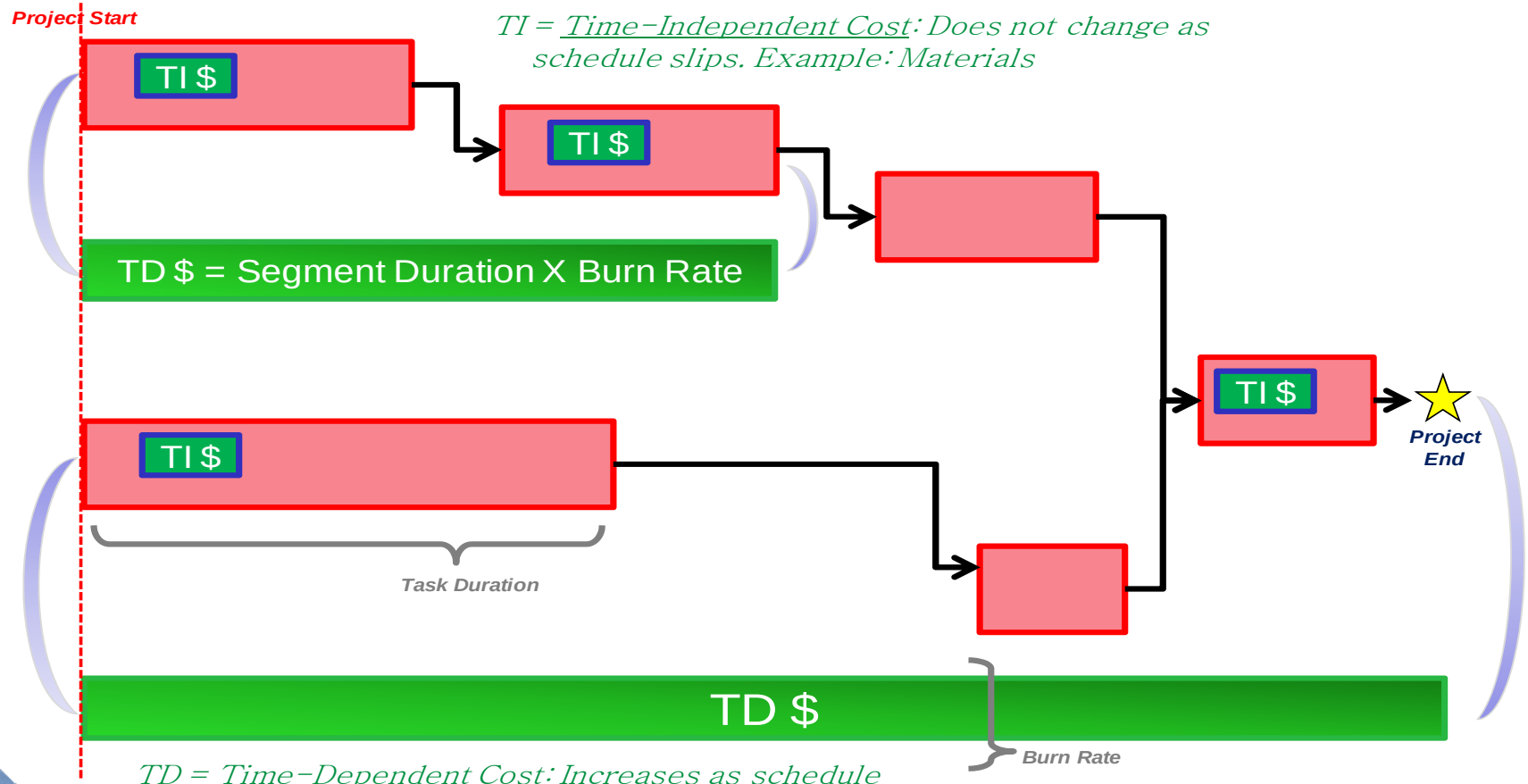
Important to Remember: Analyze results and refine steps 1-5 as necessary



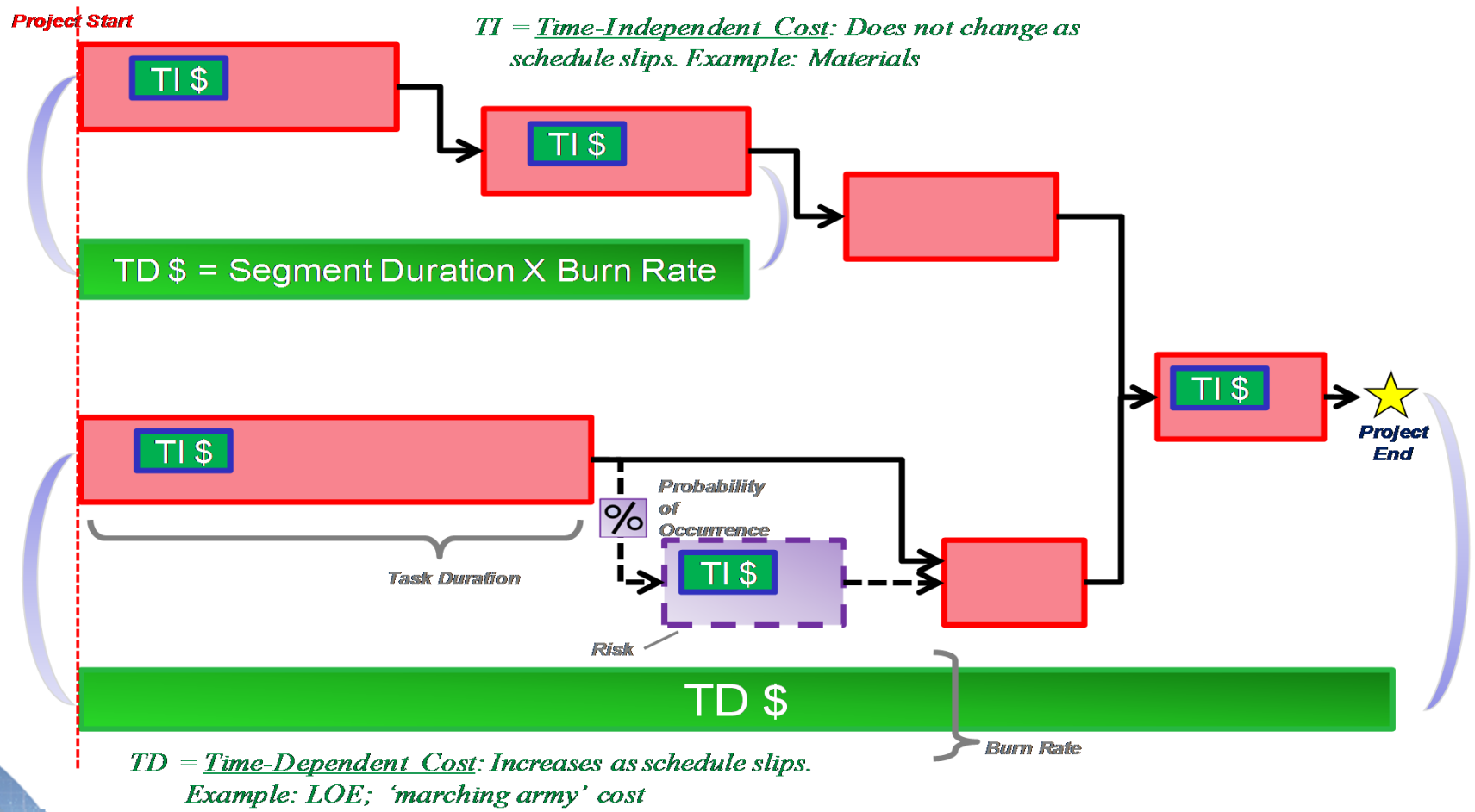
Key Concepts

- Logically linked network
- Minimize use of constraints
- Link to major milestones
- Schedule health check for viability for analysis

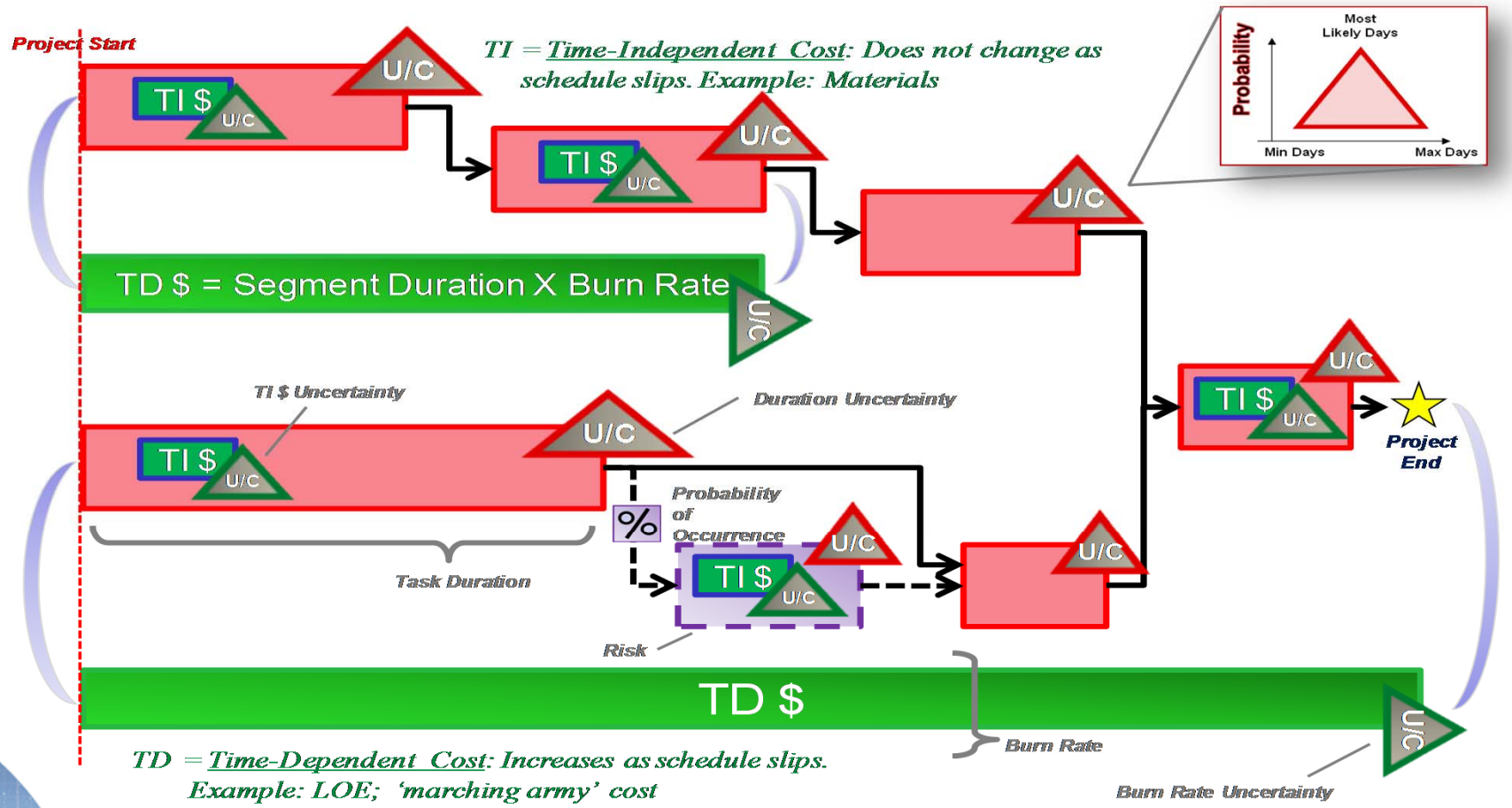
Step One: Schedule Network



Step Two: Cost Loading

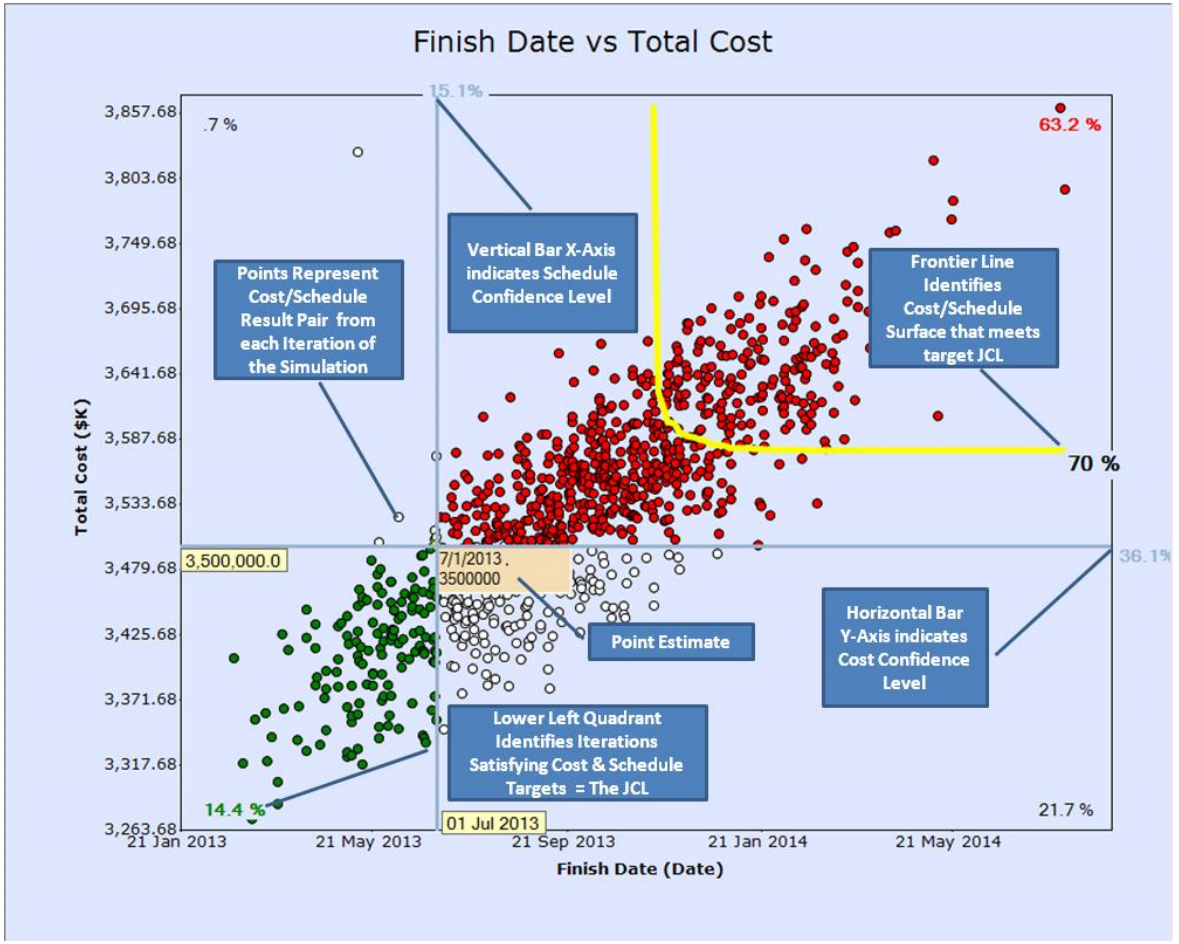


Step Three: Implementation of Risk



Step Four: Implementation of Uncertainty Analysis

- **Finally, after running a simulation, we come back to the end result as seen in scatterplot**
- **Though the scatterplot is most common, there are several additional results that are included with JCL analysis:**
  - Sensitivity Analysis Chart
  - Risk Driver Chart
  - Individual Cost and Schedule S-Curves



Step Five: Visualization of Results

- **Produces a Resource Loaded Schedule**
  - Forces Projects to Plan!
- **Focuses on the Inputs to Project Plans Instead of the Outputs**
  - NASA management resonates with the discussion of specific technical and programmatic inputs
  - Facilitates better communication between the project and the independent review team
- **Reserve Levels are not Dictated by Standards or Rules of Thumb**
  - Derived from the project's unique technical and programmatic characteristics
  - Facilitates better understanding and communication of project health to external stakeholders.
- **Enforces Scheduling Best Practices (i.e., Schedule Health Checks)**
- **Strengthens Risk Management**
  - Quantifies risks in terms of cost and schedule impacts
  - Addresses risk realization instead of only risk mitigation

JCL Benefits

- **Quality Inputs:** The output of the JCL model is no more reliable than the quality of its inputs
  - The **higher the quality** of the project's schedule, cost, and risk **management products**, the **more reliable the JCL analysis**
  - An adequate process can be **rendered ineffective** where:
    - Baseline cost and schedule are incomplete or flawed
    - Risk list is incomplete or under-scoped
    - ***Uncertainty analysis is optimistic***

- **Proper personnel:** Identifying roles and responsibilities early is very important to a successful JCL. There are several key functions to be performed within the project, they are defined below:
  - JCL Leader
  - Scheduler
  - Estimator or Resource Analyst
  - Risk Manager

A JCL requires a significant investment in resources, may not be right for all projects.

JCL Challenges

Mission	Data				Cost Growth		
	SRR	ABC	Actuals		SRR to ABC	SRR to Actuals	ABC to Actuals
NuSTAR	$96.2	$109.9	$104.0		14.2%	8.1%	-5.4%
Landsat 8	$382.1	$587.6	$395.7		53.8%	3.6%	-32.7%
IRIS	$86.2	$140.7	$156.0		63.3%	81.1%	10.9%
LADEE	$117.9	$168.2	$188.3		42.6%	59.6%	11.9%
MAVEN	$488.7	$567.2	$467.9		16.1%	-4.2%	-17.5%
GPM	$660.2	$555.2	$470.5		-15.9%	-28.7%	-15.3%
OCO-2	$225.2	$249.0	$304.6		10.6%	35.3%	22.3%
SMAP	$412.0	$485.7	$469.9		17.9%	14.0%	-3.2%
MMS	$741.0	$857.3	$962.3		15.7%	29.9%	12.2%
Astro-H	$30.0	$44.9	$51.0		49.9%	70.1%	13.5%
OSIRIS-Rex	$515.7	$778.6	$648.7		51.0%	25.8%	-16.7%
CYGNSS	$125.0	$152.8	$90.1		22.2%	-27.9%	-41.0%
SAGE-III	$56.8	$64.6	$81.6		13.7%	43.7%	26.3%
Average					**27.3%**	**23.9%**	**-2.7%**

Average Cost Underrun to Agency Baseline Commitment Indicates that JCL and Independent Assessment Process May be Working

JCL Success

- **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

Validating the Programmatic Risk Analysis

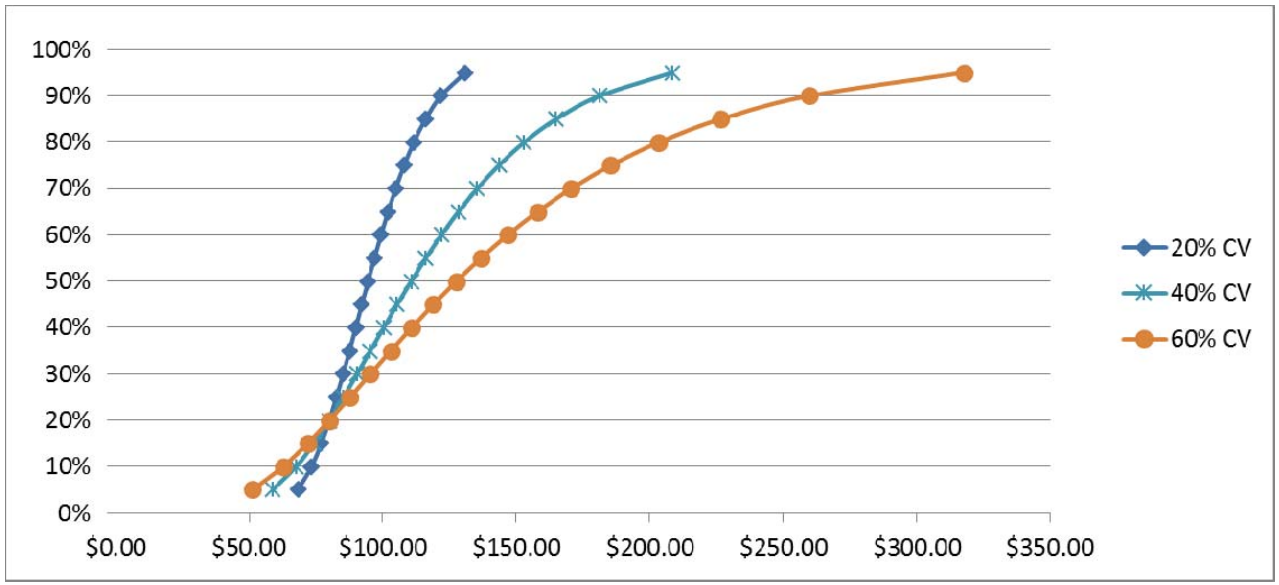
1. Determine the program cost drivers and associated risks.
2. Develop probability distributions to model various types of uncertainty.
3. Account for correlation between cost elements.
4. Perform the uncertainty analysis using a Monte Carlo simulation model.
5. Identify the probability level associated 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.

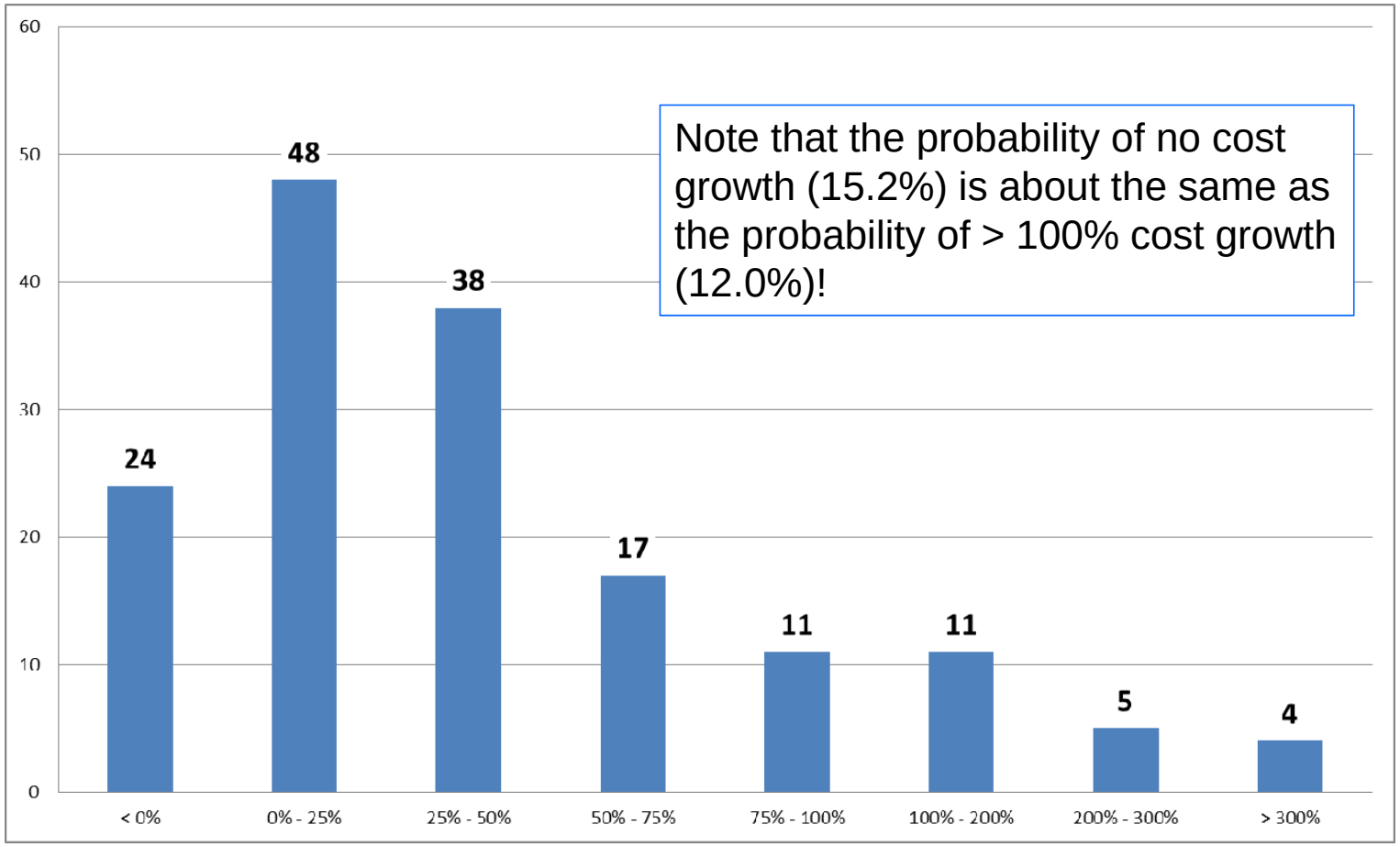
*Seven steps associated with developing a justifiable s-curve from the GAO Cost Estimating and Assessment Guide, GAO-09-3SP (page 159)

Cost Risk Process*

The Coefficient of Variation

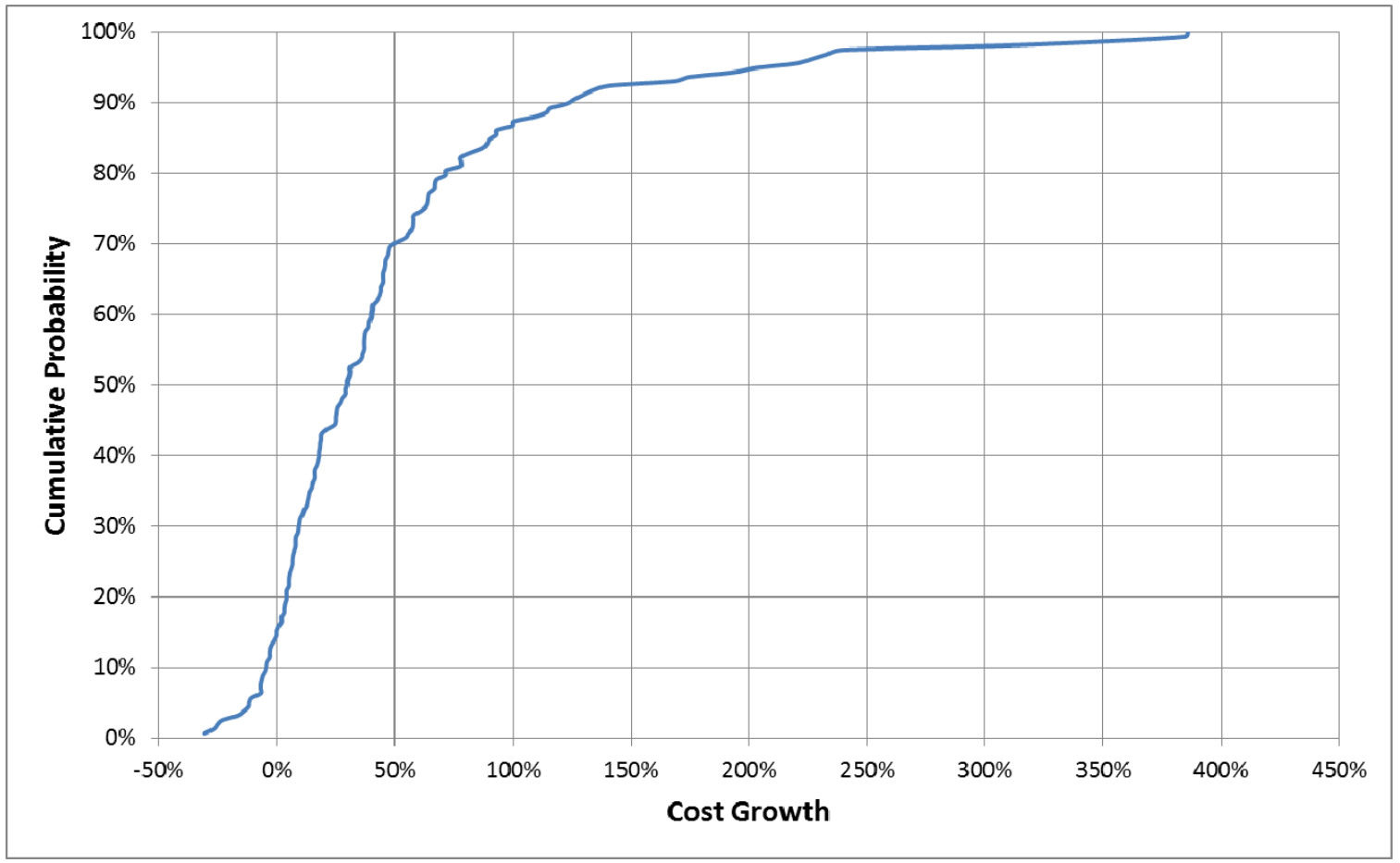
- Coefficient of Variation (CV) is a standardized measure of dispersion for a probability distribution (and thus the amount of uncertainty)
- CV = Standard Deviation/Mean
- CV is an output of most Monte Carlo simulation programs (@Risk, Argo, etc.)
- CV measures the “flatness” of the S-Curve
  - The greater the CV the greater the relative cost difference between percentile values



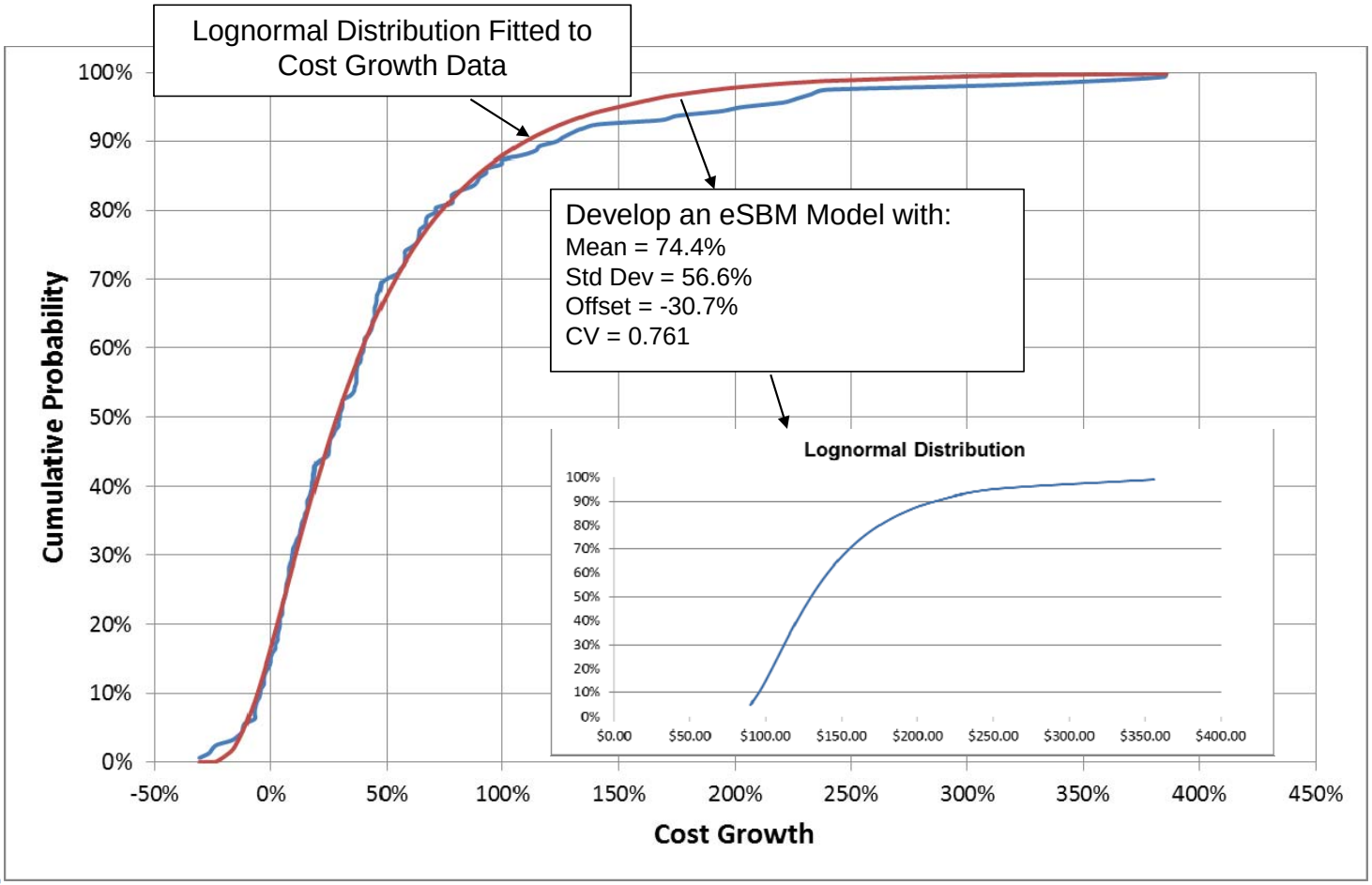


Note that the probability of no cost growth (15.2%) is about the same as the probability of > 100% cost growth (12.0%)!

NASA Cost Growth History



Historical Cost Growth PDF



Modeling the Cost Growth PDF

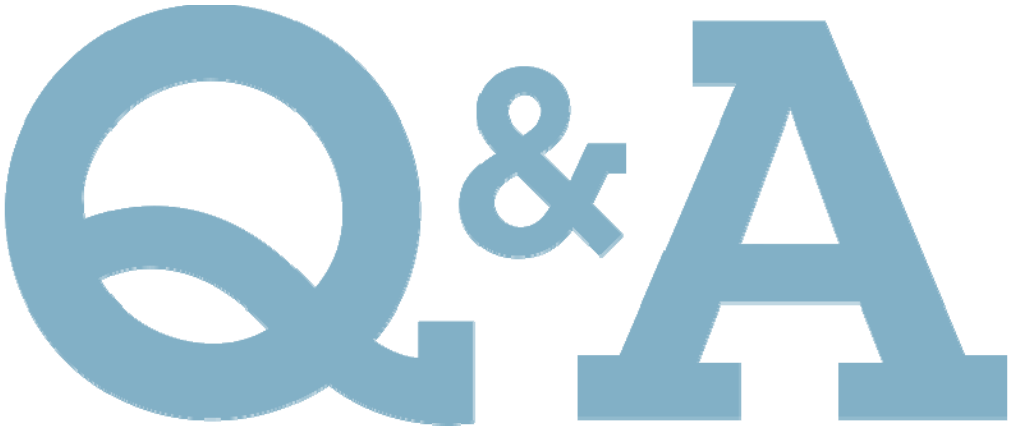
- **Process**
  - Are you accounting for correlation?
  - Are all sources of uncertainty adequately addressed?
  - Beware of optimism and overconfidence.
  - Beware the triangle distribution!
- **History and the Coefficient of Variation (CV)**
  - Your CV should be unique to the assumptions in your analysis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

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

Validation Summary

In Summary

- **Doing good programmatic risk analysis is hard**
- **The CV is an useful measure but it must be consistent with your organization's cost and schedule growth history**
- **DOE has cost risk and JCL experts – *take advantage of them!***
- **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 growth is a reality, be a realist**
- ***Remember: The less you know the greater the uncertainty in your estimate!***


Q&A

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