Hope is Not a Method

Using Uncertainty Analysis to Better Predict the Costs of Your Program

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A Better Method Is…

- *Data-driven research leading to a systematic approach that is consistently and rigorously applied through regulation*

- *Although everyone complains, mandates can serve a critical forcing function that leads to success*

Improving Program Cost Outcomes

- Cost is the driving consideration in decisions that determine how and if a system is developed, produced, and sustained
- Unfortunately the unknowns about costs associated with any building project are many

- *My hardware store problem*

Improving Program Cost Outcomes

- How do we improve cost outcomes?
  - Envision scenarios
  - Forecast costs
  - Improve planning

When we still have overruns - what do we do?

- We evolve our techniques

This presentation focuses on how the US DoD cost estimating community evolved their approach to improve the overall outcomes of their cost estimates

What is Cost Uncertainty Analysis?

- A cost estimate is a forecast with many possible outcomes
- The purpose of uncertainty analysis is to:
  - **Understand** the **range** of possible cost outcomes
  - **Determine** the program **most likely cost** within the range
  - **Use** this information to **inform** the program **budget**

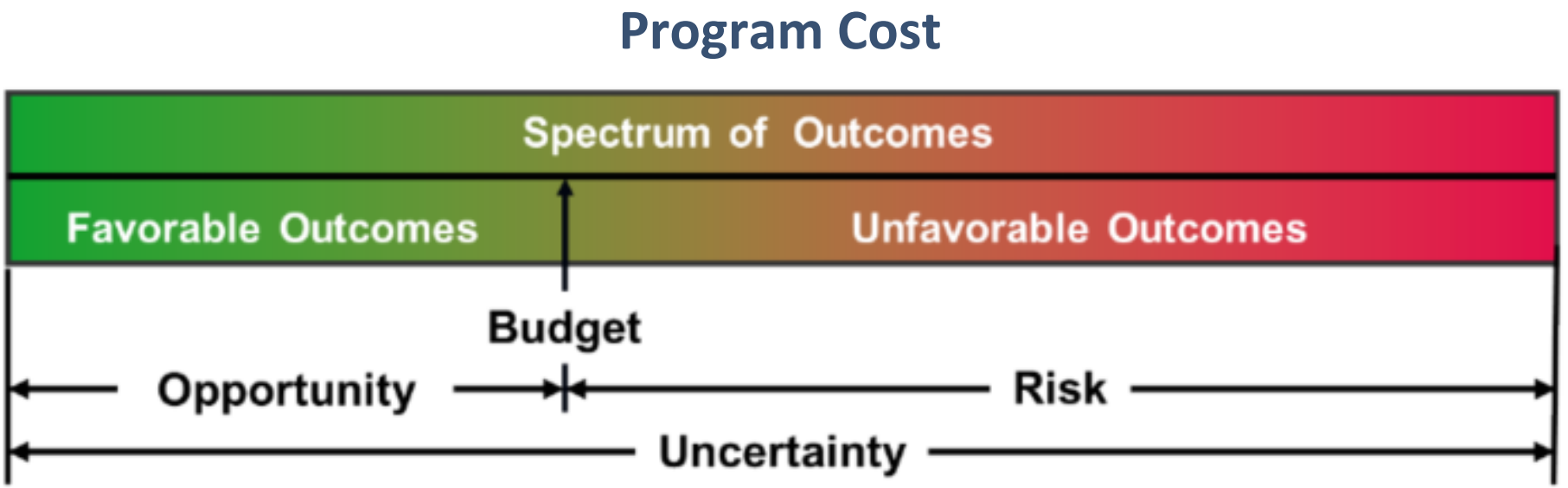


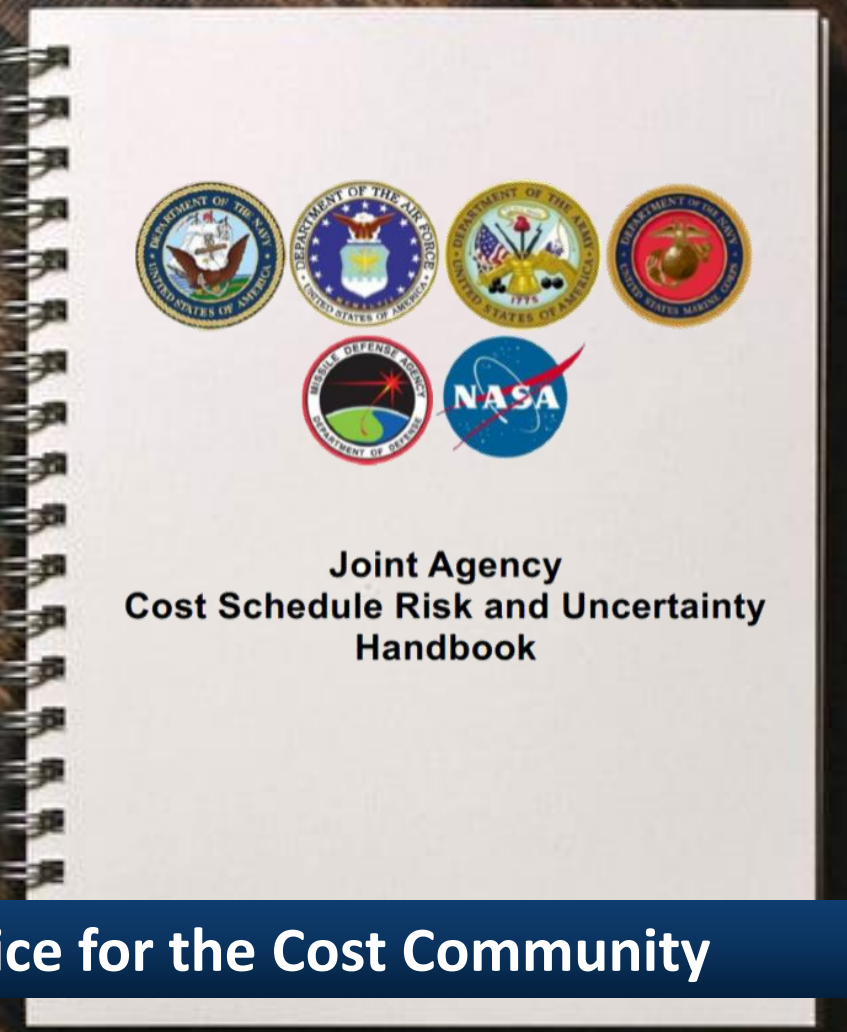
Image reference: Figure 1-3 from the JA-CSRUH March 2014

JA CSRUH

Joint Agency Cost Schedule Risk and Uncertainty Handbook

JA CSRUH:
The **Authoritative Document** of Cost Schedule Risk and Uncertainty for the US DoD and NASA

Goal: Define and clearly present simple, well-defined cost risk and uncertainty analysis processes that are repeatable, defendable, and easily understood



Defines Uncertainty Best Practice for the Cost Community

My Cost Estimating Story

TECOLOTE RESEARCH

ACEIT
Automated Cost Estimating Integrated Tools

Practitioner

Educator

Manager

I was a member of the JA CSRUH writing team

From Problem to Mandate

- Mobilizing a community
  - Adopting new approaches requires investment in three elements

RESEARCH

Develop the approach and techniques

TOOLS

Build tools that support the techniques

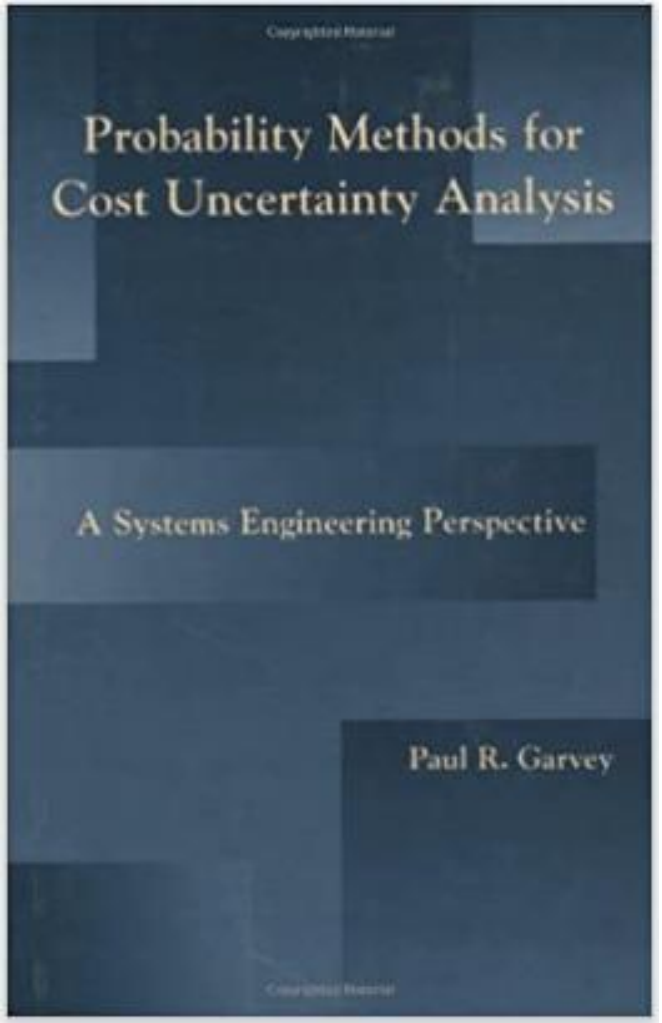
GUIDANCE

Train the analytic core to apply the techniques

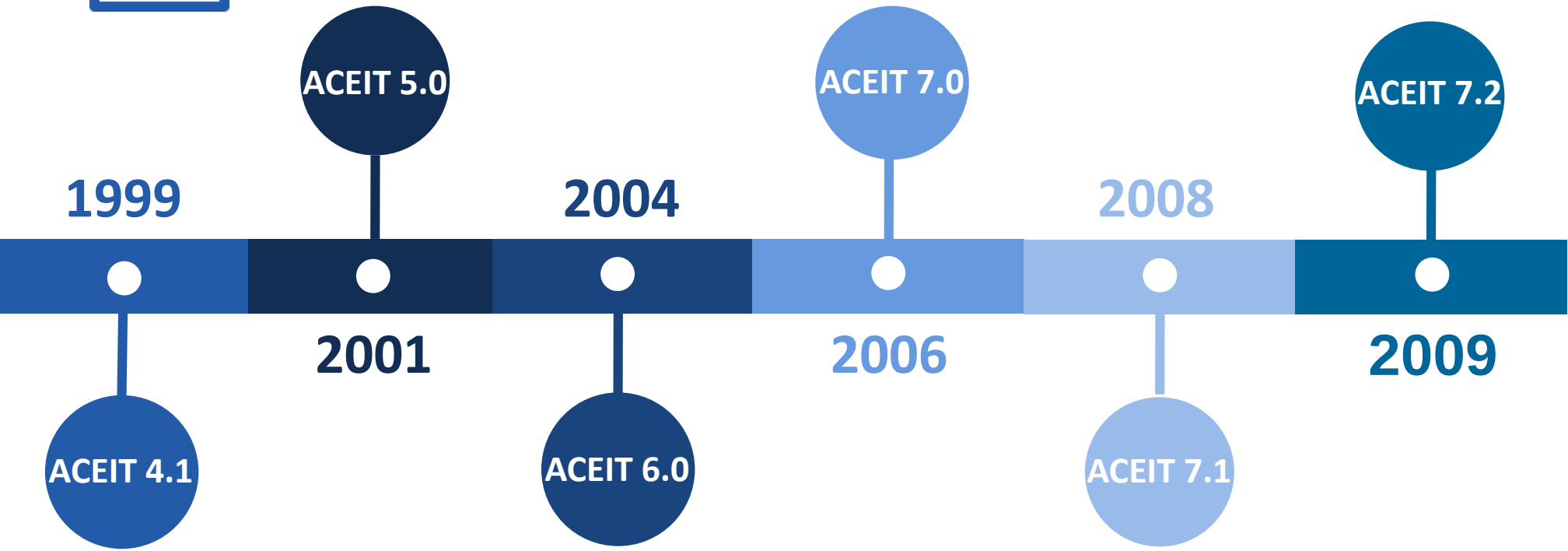
Research: **Probabilistic Approach to Cost Uncertainty Analysis**

- Probabilistic theory is applied to model, measure, and manage risk in cost of a systems engineering project

- Beginning research on probabilistic theory dates back to the 1960s
- Formalized research textbook published by Paul Garvey in 2000



Tools: **Early Uncertainty and Risk in ACEIT**



ACEIT 4.1: Integrated RI$K Analysis

ACEIT 5.0: Incorporated RI$K Allocation

ACEIT 6.0: Improvements to RI$K calculation and added RI$K to POST

ACEIT 7.0: Expanded RI$K distributions, added RI$K input options, and RI$K functions

ACEIT 7.1: Added Custom CDFs, Help updated to align with Cost Risk Uncertainty Handbook

ACEIT 7.2: Added RI$K phasing and more RI$K distributions

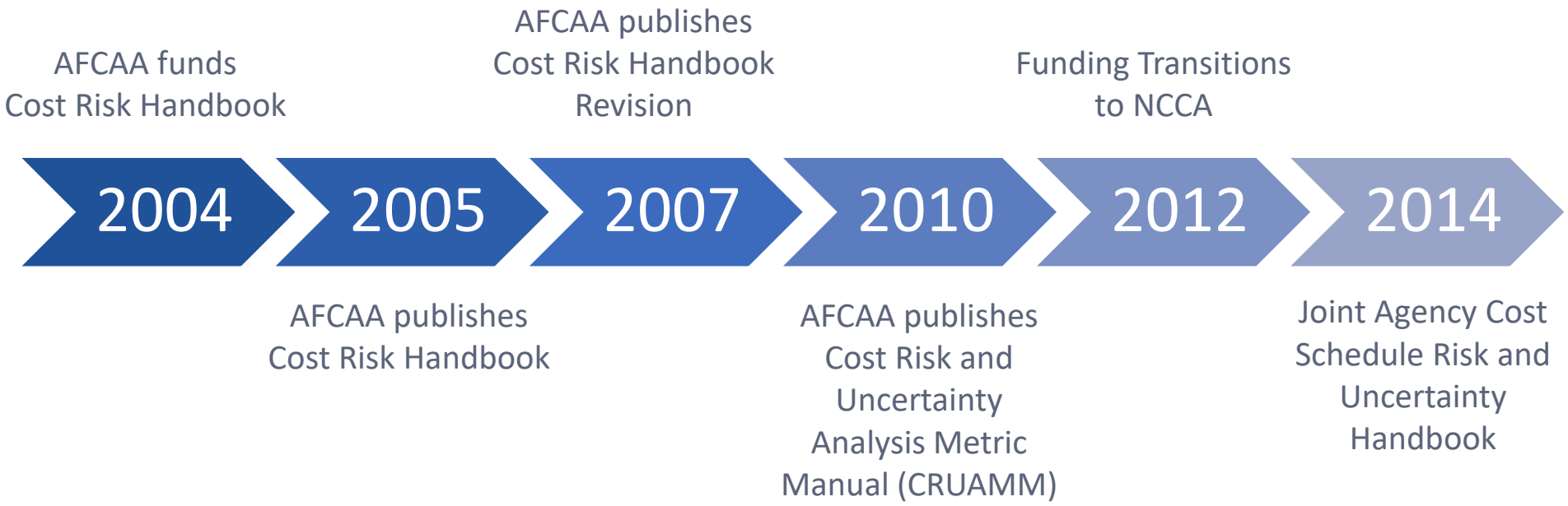
RI$K is the risk calculation engine of ACEIT

Guidance: **Uncertainty Handbooks**

- Handbooks serve as a reference for approved methods, practices, and reporting requirements

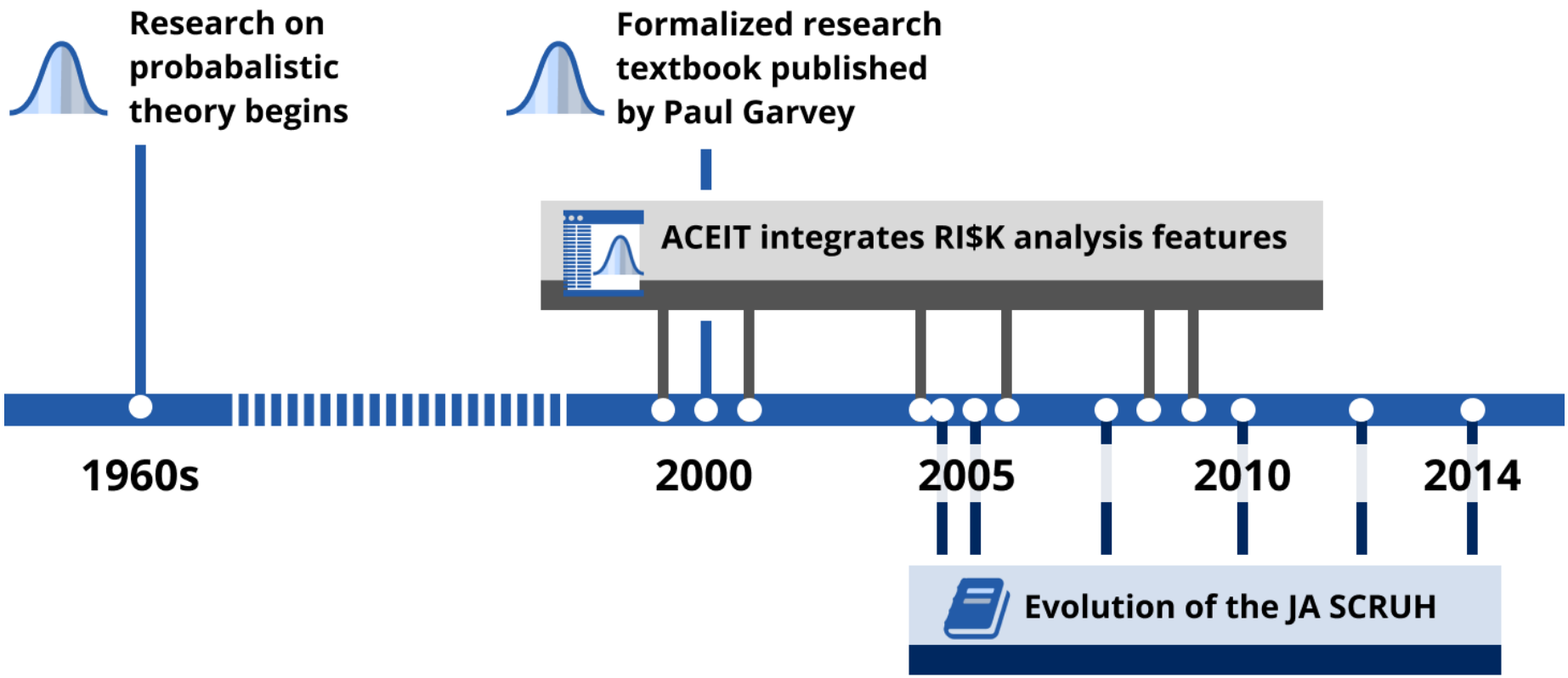
TECOLOTE RESEARCH

Cost Agencies of the US DoD contracted Tecolote Research to write the JA CSRUH



The JA CSRUH guidance from 2014 is the current DoD handbook

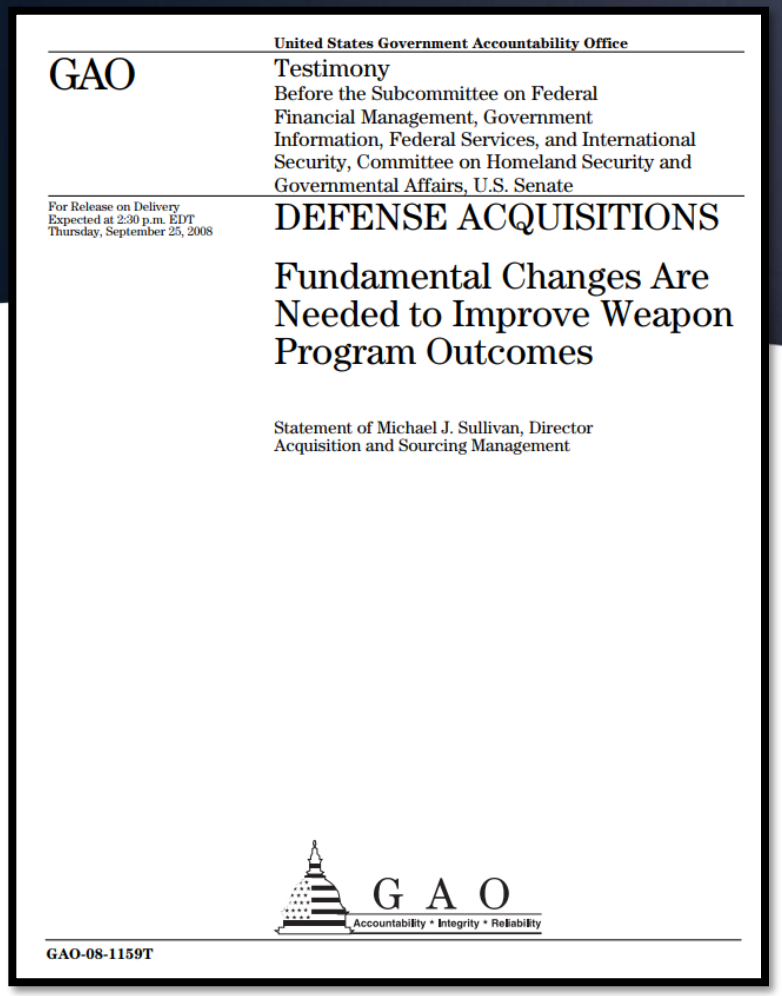
Pathway to Implementation



- Problem Solved, Right?

US DoD Experiences Major Acquisition Problems

GAO Publishes countless studies on DoD Cost Overruns



United States Government Accountability Office

GAO

Testimony
Before the Subcommittee on Federal Financial Management, Government Information, Federal Services, and International Security, Committee on Homeland Security and Governmental Affairs, U.S. Senate

For Release on Delivery
Expected at 2:30 p.m. EDT
Thursday, September 25, 2008

DEFENSE ACQUISITIONS

Fundamental Changes Are Needed to Improve Weapon Program Outcomes

Statement of Michael J. Sullivan, Director
Acquisition and Sourcing Management

G A O
Accountability * Integrity * Reliability

GAO-08-1159T

Table 1: Analysis of DOD Major Defense Acquisition Program Portfolios

Fiscal year 2008 dollars

	Fiscal year		
	2000 portfolio	2005 portfolio	2007 portfolio
Portfolio size			
Number of programs	75	91	95
Total planned commitments	$790 Billion	$1.5 Trillion	$1.6 Trillion
Commitments outstanding	$380 Billion	$887 Billion	$858 Billion
Portfolio performance			
Change to total RDT&E costs from first estimate	27 percent	33 percent	40 percent
Change in total acquisition cost from first estimate	6 percent	18 percent	26 percent
Estimated total acquisition cost growth	$42 Billion	$202 Billion	$295 Billion
Share of programs with 25 percent or more increase in program acquisition unit cost	37 percent	44 percent	44 percent
Average schedule delay in delivering initial capabilities	16 months	17 months	21 months

Source: GAO analysis of DOD data.

In 2008 GAO reports nearly 70% of the DoDs 96 biggest programs were over budget

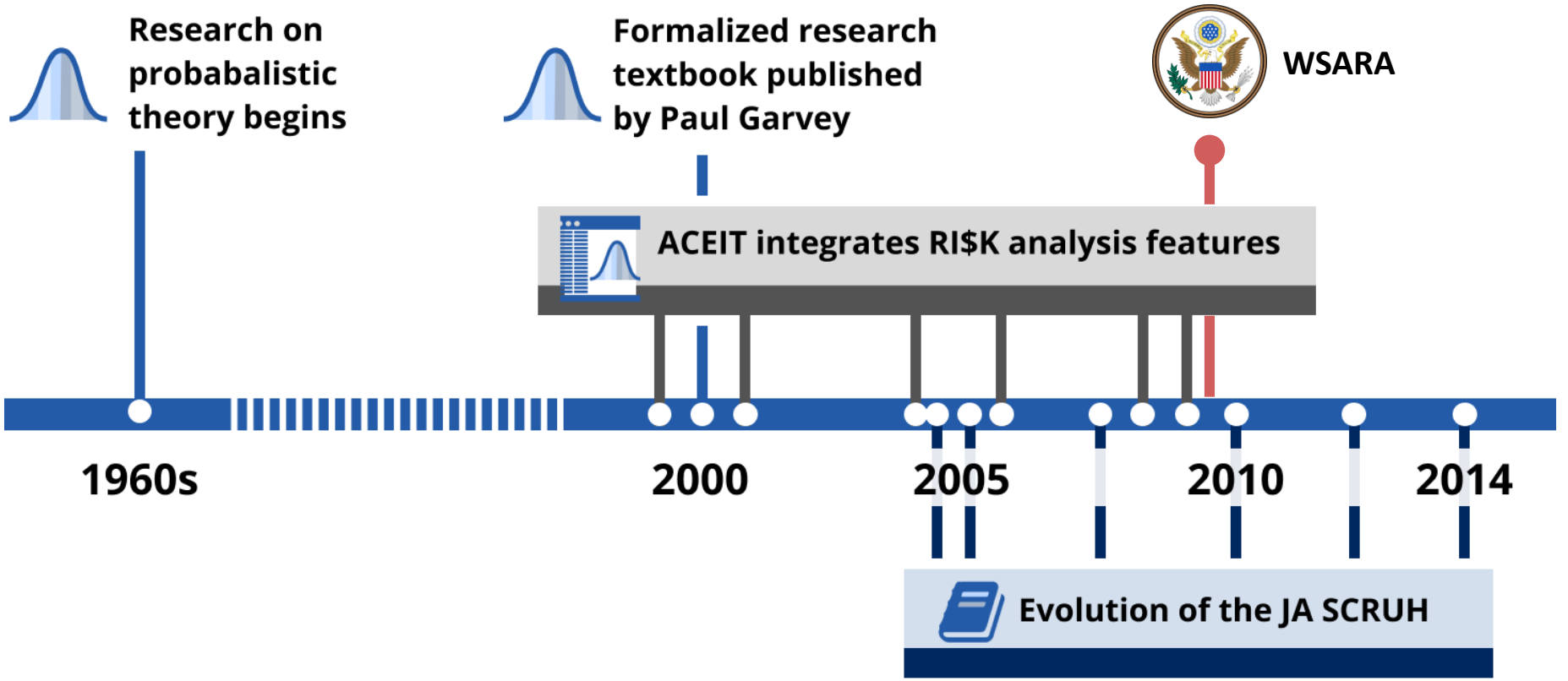
Weapon Systems Acquisition Reform Act: WSARA 2009

An Act to improve the organization and procedures of the DoD for acquisition of major weapon systems

- Key Provisions for the Cost Community
  - Appointment of a Director of Cost Assessment and Program Evaluation (CAPE), who will issue policies and **establish guidance on cost estimating and developing confidence levels for such cost estimates**;
  - Appointment of a Director of Developmental Test and Evaluation, who will develop DoD-wide policies and guidance for conducting developmental testing and evaluation;
  - Changes to the Nunn–McCurdy Amendment, such as rescinding the most recent "Milestone" approval for any program that has experienced "critical cost growth”

WSARA made uncertainty analysis a requirement

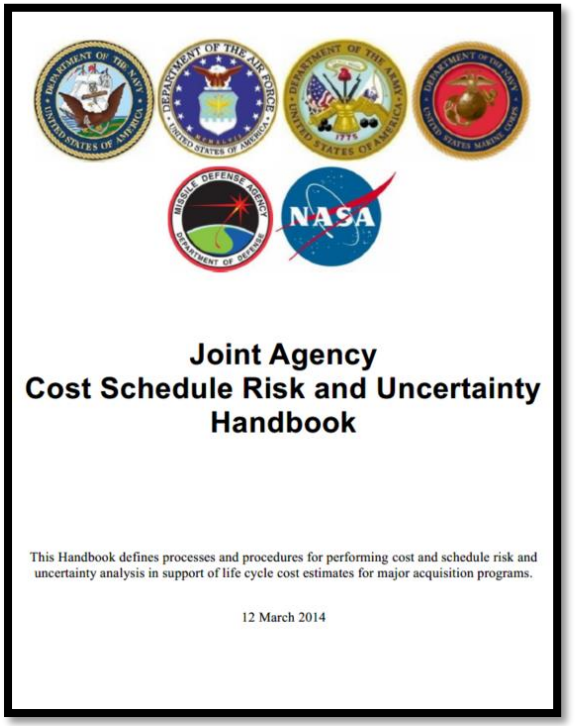
Pathway to Implementation



- While analysts had learned the methods, DoD leadership hadn't prioritized uncertainty analysis into their Program Management mitigation approach
- WSARA was the **forcing function** for full community adaptation

JA CSRUH Guidance

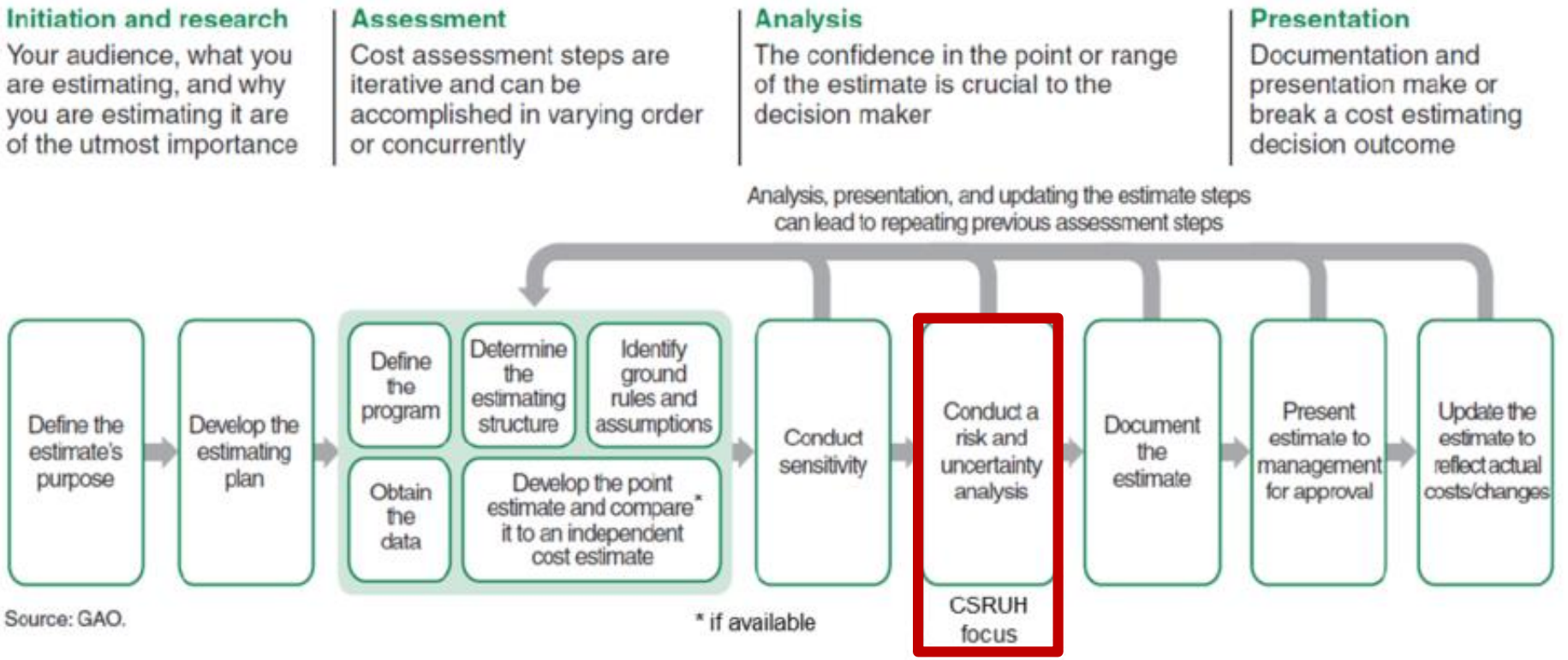
- Practical Guide for Cost Professionals
  - Introduction: Purpose, Sources of Uncertainty
  - Cost Informed by Schedule Method Model
  - Finish and Assess the CISM Model
  - How to Present the CISM Risk and Uncertainty Story
  - Alternative to the CISM Approach
  - Portfolio level considerations
  - CSRUH Utilities and Support Files
  - References



Practices demonstrated in several tools to provide examples for analysts

GAO Cost Estimating Process

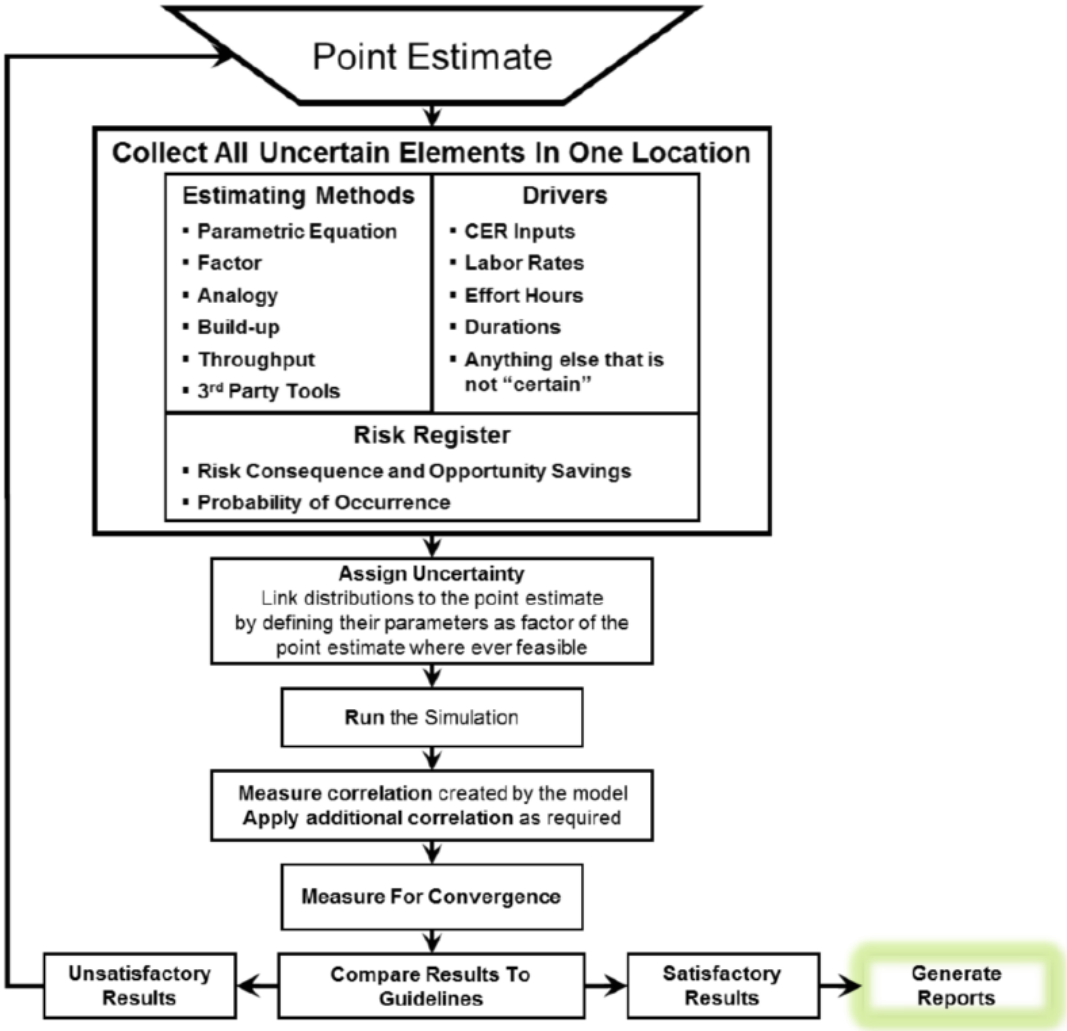
- Conducting a simulation based risk and uncertainty analysis is a major part of the cost estimating process



The goal of the simulation model is to combine all the sources of cost uncertainty in order to estimate the risk of exceeding a given budget

Overview of the CSRUH Simulation Method

- Guidance and best practices outline for all steps in the process



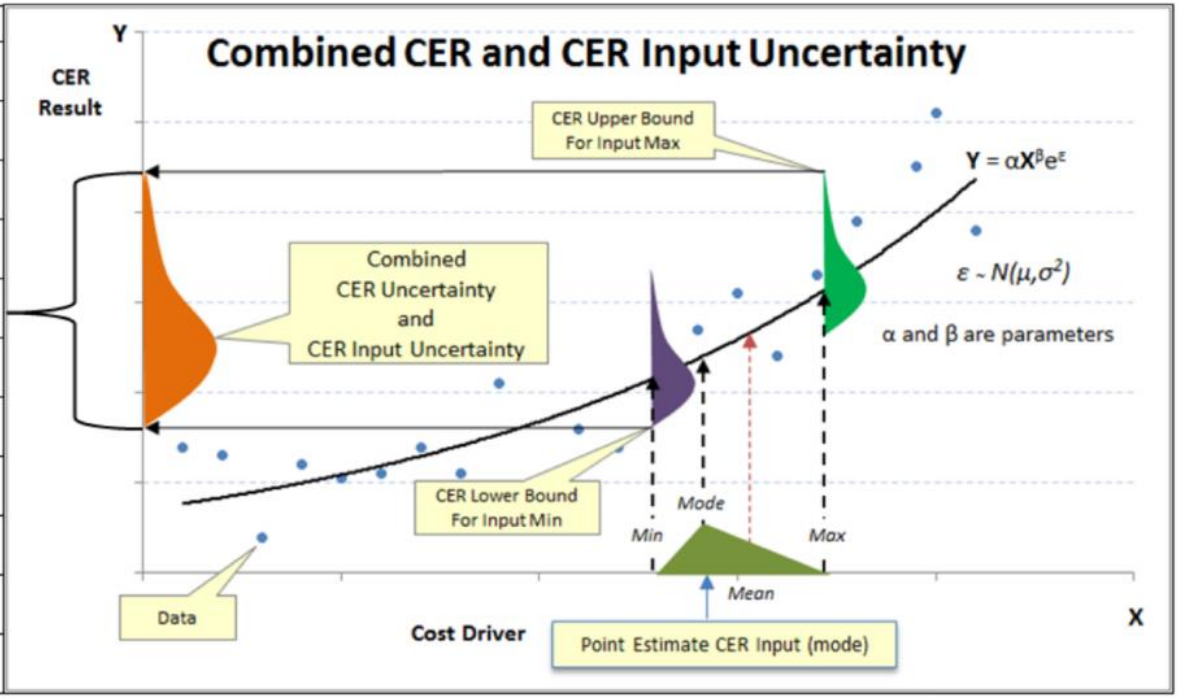
Sources of Uncertainty

- Minimum modeling requirements
  - Parametric CERs including factors and cost improvement curve equations
  - CER inputs, complexity factors for analogies, engineering judgment
  - Other cost drivers: man hours, head counts, rates, ratios, overhead, fee, etc.
  - Planned schedule durations
  - Risk register events, both probability of occurrence and the cost consequence
- Uncertainty that could be modeled
  - Inflation
  - Acquisition strategies
  - Requirements creep
  - Significant changes in planned scope
  - Different contract options or approaches
  - Congressional/Service actions
- Uncertainty that should be left out of the model
  - Natural disasters
  - Unnatural disasters

Combine Effects of Uncertainties

- Simulation process combines the input uncertainty with the CER uncertainty

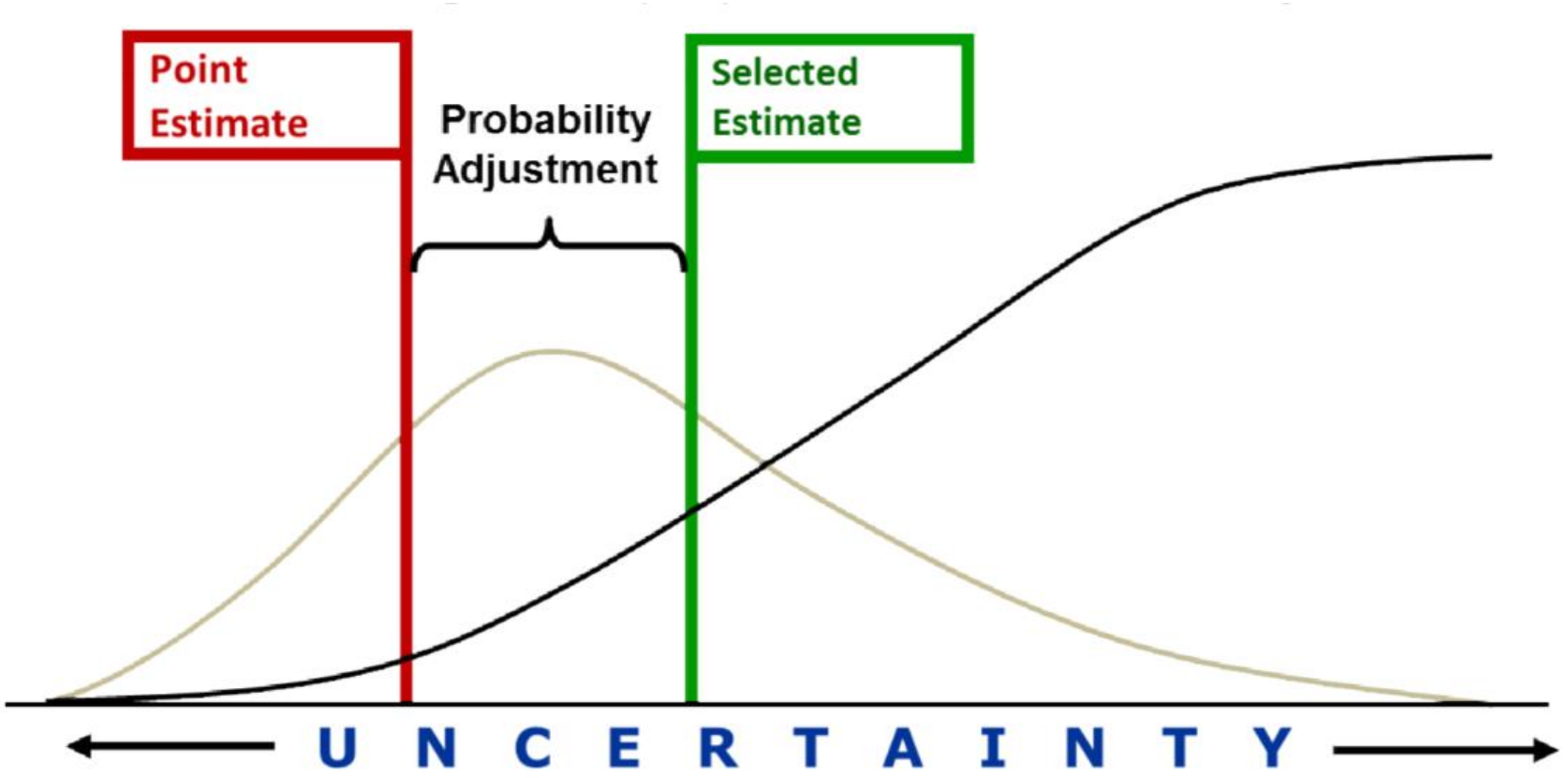
WBS Element	PE	Summing Uncertainty
Engineering and Manufacturing Develop	$83,539	
Air Vehicle	$14,944	
Design & Development	$12,000	
Prototypes	$2,944	
Software	$31,500	
System Engineering	$17,500	
Program Management	$15,000	
System Test and Evaluation	$1,767	
Training	$897	
Data	$1,196	
Peculiar Support Equipment	$736	



Result of each WBS element is summed to develop simulated results at the parent levels

Probability Adjusted Estimate

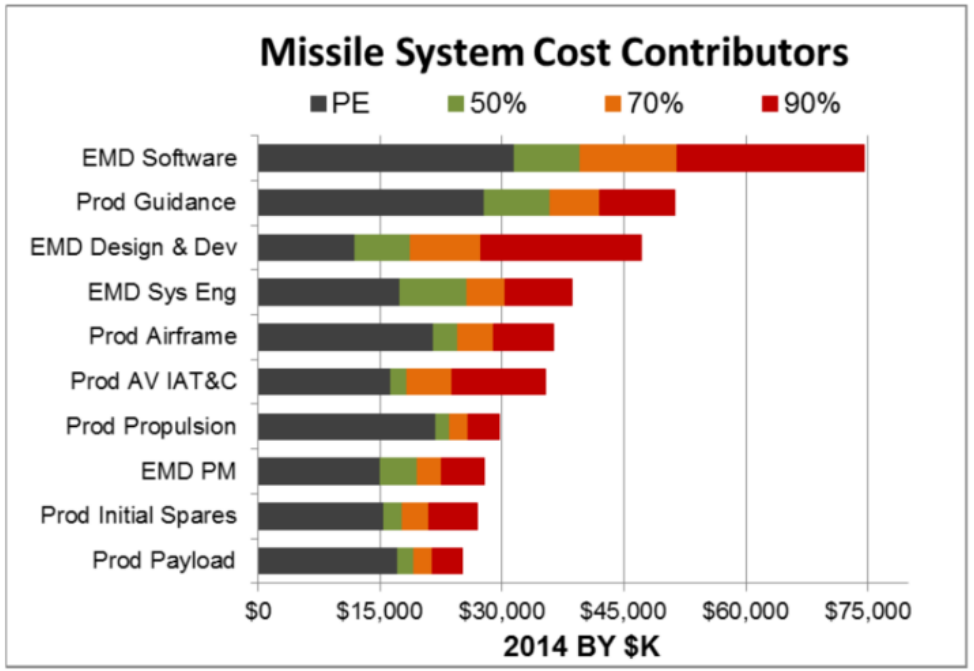
- Probability Adjustment is the amount of funds needed to bring the point estimate value up to a selected probability level

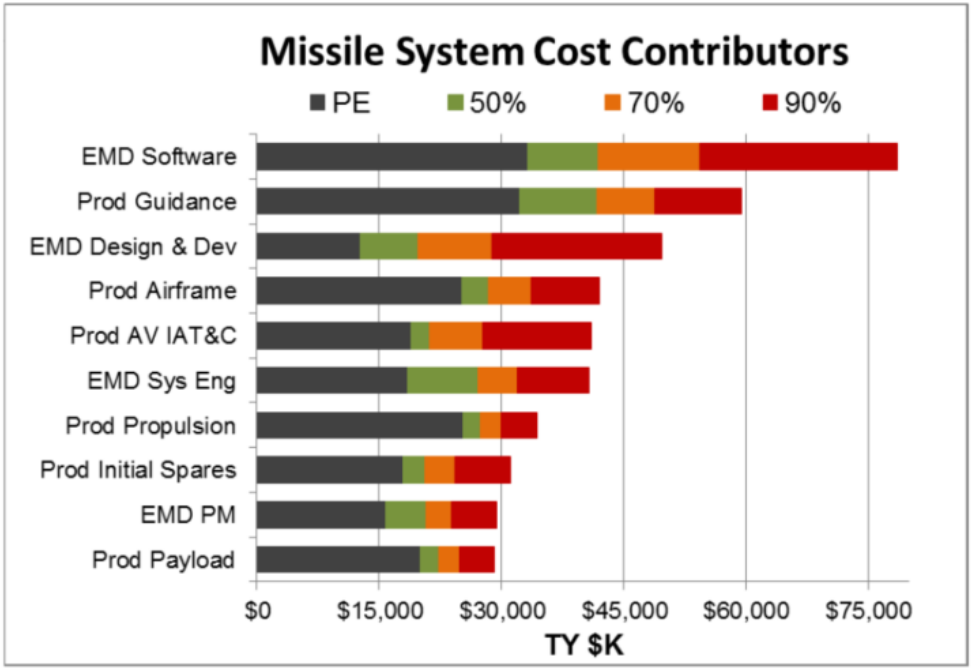


Uncertainty analysis provides an understanding of the PA Adjustment

Identifying Uncertainty Drivers

- Charts report the statistical results for the top contributors to cost uncertainty
  - Summarizes how many dollars are required to move from one probability to another





Uncertainty analysis also informs on project element risks

Empowering Program Management Decisions

- Uncertainty analysis provides Program Managers with valuable program insights that empower their decision making
- Uncertainty analysis can help
  - Understand the true cost range for a project
  - Identify a more realistic budget
  - Understand how adding more funding can increase program success
  - Understand risk dependencies in the program
  - Identify “risky” items for the management team to watch during program execution

JA CSRUH Successes

- Diligent process of creating and refining the handbook contributes to its lasting impact

- JA Cost Estimating Relationship Handbook created following the same judicator method as the JA CSRUH

Authors adjudicated hundreds of comments from the community in updating toward the 2014 guide

US DoD Major Acquisition Improvements

GAO studies DoD Acquisitions each year

Decisions to Increase Quantities Have Led to Increased MDAP Portfolio Costs since Last Year, Although Unit Costs Were Lower

MDAP portfolio total acquisition cost estimates have increased by about 4 percent ($64 billion) over the past year, largely due to quantity increases.[37] Procurement costs, which account for 81 percent of the 2019 portfolio's estimated costs, also increased by 4 percent ($49 billion). Research and development costs, which account for most of the remaining 19 percent of the portfolio's estimated costs, increased by 5 percent. Table 4 details the 1-year change in cost estimates for the 2019 portfolio of 85 programs.

Table 4: Cost Changes to the Department of Defense's 2019 Portfolio of 85 Major Defense Acquisition Programs over the Past Year (Fiscal Year 2020 Dollars in Billions)

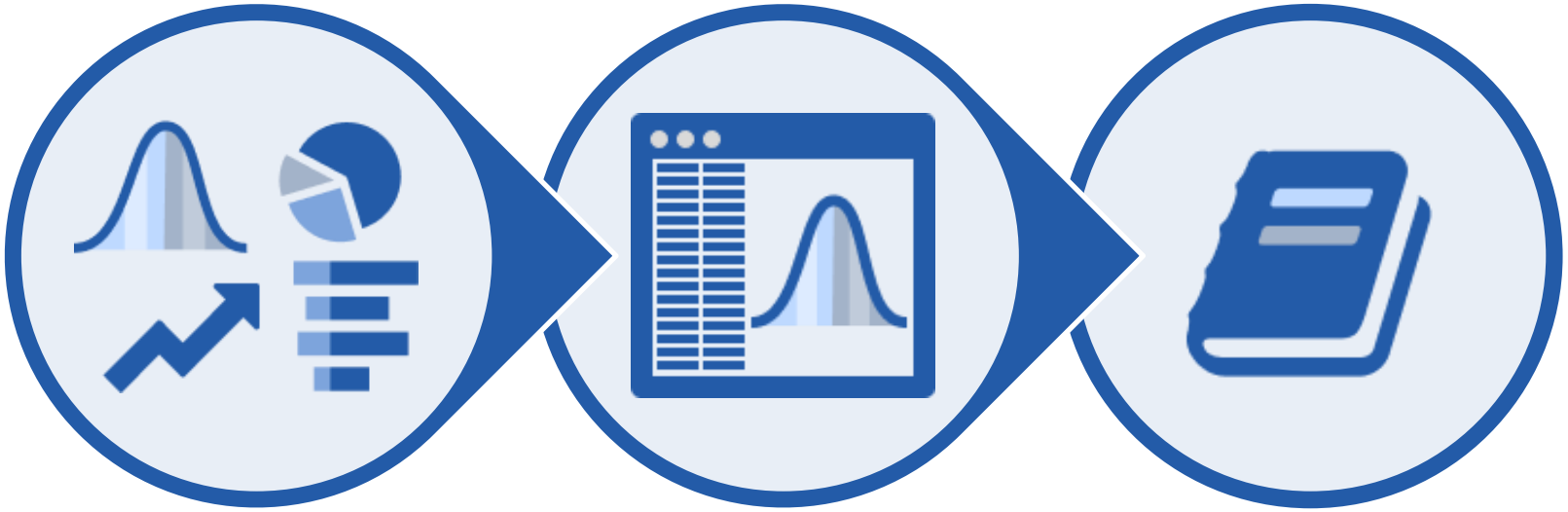
	Estimated portfolio cost in 2018	Estimated portfolio cost in 2019	Estimated portfolio change since 2018	Percentage change since 2018
Total estimated research and development cost	317.38	332.08	14.69	4.6
Total estimated procurement cost	1396.24	1445.56	49.33	3.5
Total estimated other acquisition cost[a]	17.55	17.37	(0.18)	(1.0)
Total estimated acquisition cost	1731.17	1795.01	63.84	3.7

Source: GAO analysis of Department of Defense (DOD) data. | GAO-20-439

In 2020 GAO reports DoD has achieved aggregate procurement-related efficiencies in the 2019 portfolio

Beyond Hope

- Key to improving cost is adopting new methods which requires



RESEARCH **TOOLS** **GUIDANCE**

- Even with these in place, a forcing function may be required to mobilize a community

Mandates and requirements can help to organize a community

Final Thought

Smithsonian

ARTS + INDUSTRIES BUILDING