

A Scenario-Based Method (SBM) for Cost Risk Analysis

Cost Risk Analysis



Without Statistics!!

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Paul R Garvey
Chief Scientist,
Center for Acquisition and Systems Analysis

Introduction

This talk presents an approach for performing an analysis of a program's cost risk
The approach is referred to as the scenario-based method (SBM)

This method provides an assessment of the amount of cost reserve needed to protect a program from cost overruns due to risk

The approach can be applied without the use of advanced statistical concepts, or Monte Carlo simulations, yet is flexible in that confidence measures for various possible program costs can be derived

This method emphasizes the development of written scenarios as the basis for deriving and defending a program's cost and cost reserve recommendations



Introduction

The SBM grew from a question posed by a government agency

Can a valid cost risk analysis (that is traceable and defensible) be conducted with minimal (to no) reliance on Monte Carlo simulation or other statistical methods?

The question was motivated by unsatisfactory experiences in developing and implementing Monte Carlo simulations to derive “risk-adjusted” costs of future systems

SBM was formally developed and completed for the US Air Force Cost Analysis Agency in 2005

It has since been published in the *Cost Risk Analysis Handbook* (US AFCAA) and in the *Journal of Cost Analysis and Parametrics*



animated



What is a Scenario?

By definition, a scenario is a sequence of events – especially when imagined; an account or synopsis of a possible course of action or events (Merriam-Webster)

SBM (in either mode) operates on specified scenarios that, if they occurred, would result in costs higher than the level planned or budgeted

These scenarios do not have to represent worst cases; rather, they should reflect a set of conditions a program manager or decision-maker would want to have budget to guard against, should any or all of them occur

What is a Scenario?

The Scenario-Based Method derives from what could be called “sensitivity analysis”, but with one difference

Instead of arbitrarily varying one or more variables to measure the sensitivity (or change) in cost, the Scenario-Based Method involves specifying a well-defined set of technical and programmatic conditions that collectively affect a number of cost-related variables and associated work breakdown structure (WBS) elements in a way that increase cost beyond what was planned

Defining these conditions and integrating them into a coherent risk “story” for the program is what is meant by the term “scenario”

Scenario Development: A Best Practice!

The process of defining scenarios is a good practice

It builds the supportive rationale and provides a traceable and defensible analytical basis behind a “derived” measure of cost risk

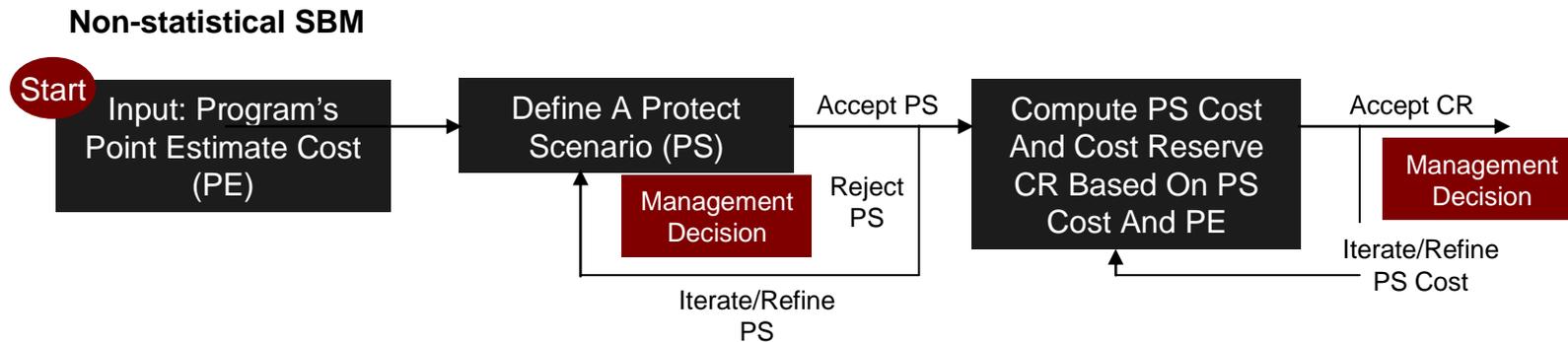
This is often lacking in traditional simulation approaches

Visibility, traceability, defensibility, and the cost impacts of specifically identified risks is a principal strength of the Scenario-Based Method



animated

Non-Statistical SBM



The first step (see Start) is input to the process

It is the program's point estimate cost (PE)

For purposes of this paper, the point estimate cost is defined as the cost that does not include an allowance for cost reserve

It is the sum of the cost element costs summed across the program's work breakdown structure without adjustments for uncertainty

Often, the point estimate is developed from the program's cost analysis requirements description (CARD)

Non-Statistical SBM

Next, is the effort to define a protect scenario (PS)

The key to a “good PS” is one that identifies, not an extreme worst case, but a scenario that captures the impacts of the major known risks to the program – those events the program manager or decision-maker must monitor and guard the costs of the program against

Thus, the PS is not arbitrary

It should reflect the above, as well as provide a possible program cost that, in the opinion of the engineering and analysis team, has an acceptable chance of not being exceeded

Define Protect Scenario



Non-Statistical SBM

In practice, it is envisioned that management will converge on a protect scenario after a series of discussions, refinements, and iterations from the initially defined scenario

This part of the process, if executed, is to ensure all parties reach a consensus understanding of the risks the program faces and how they are best represented by the protect scenario

Once the protect scenario has been defined and agreed to its cost is then determined

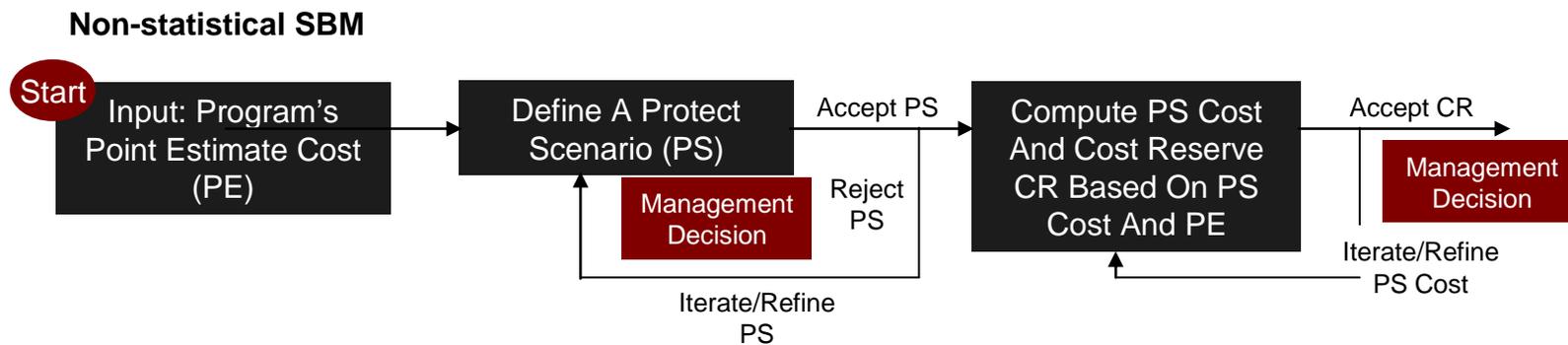
The next step is computing the amount of cost reserve dollars (CR) needed to protect the program's cost against identified risk

This step of the process defines cost reserve as the difference between the PS cost and the point estimate cost, PE

Non-Statistical SBM

Shown below, there may be additional refinements to the cost estimated for the protect scenario, based on management reviews and considerations

This too may be an iterative process until the reasonableness of the magnitude of this figure is accepted by the management team



Non-Statistical SBM

A Valid Cost Risk Analysis

This approach, though simple in appearance, is a valid cost risk analysis; why?

The process of defining scenarios is a valuable exercise in identifying technical and cost estimation risks inherent to the program

Without the need to define scenarios, cost risk analyses can be superficial with its basis not well-defined or carefully thought through

Scenario definition encourages a discourse on program risks that otherwise might not be held

It allows risks to become fully visible, traceable, and “costable” to program managers and decision-makers

Non-Statistical SBM

A Valid Cost Risk Analysis

Defining, iterating, and converging on a protect scenario is valuable for understanding the “elasticity” in program costs and identifying those sets of risks (eg, weight growth, software size increases, schedule slippages, etc) the program must guard its costs against

Defining scenarios, in general, builds the supportive rationale and provides a traceable and defensible analytical basis behind a “derived” measure of cost risk; this is often lacking in traditional simulation approaches

Visibility, traceability, defensibility, and the cost impacts of specifically identified risks is a principal strength of the Scenario-Based Method



Non-Statistical SBM (concluded)

The non-statistical SBM described above does come with limits

Remember, cost risk, by definition, is a measure of the chance that, due to unfavorable events, the planned or budgeted cost of a program will be exceeded

A non-statistical SBM does not produce confidence measures, in a probabilistically measured way

The chance that the cost of the protect scenario, or the cost of any defined scenario, will not be exceeded is not explicitly determined

The question is Can the design of the SBM be modified to produce confidence measures while maintaining its simplicity and analytical features?

The answer is yes

Statistical SBM

The following introduces (only) a statistical, non-Monte Carlo simulation, implementation of the SBM; it is an optional augmentation to the basic SBM methodology

It can be implemented with lookup tables, a few algebraic equations, and some appropriate technical assumptions and guidance

There are many reasons to implement a statistical SBM

These include

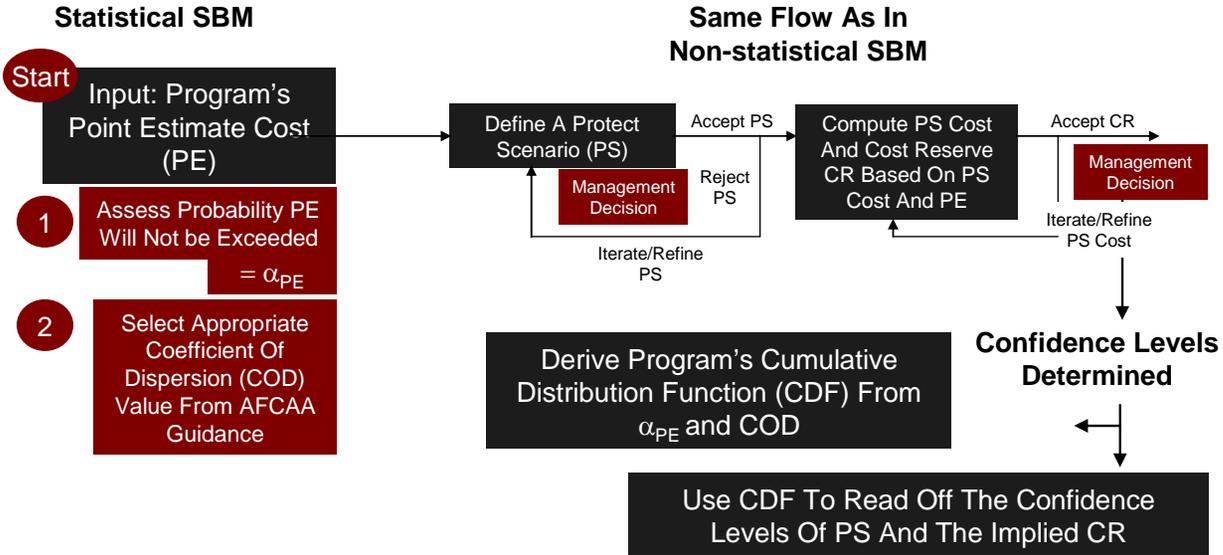
- (1) a way to develop confidence measures; specifically, confidence measures on the dollars to plan so the program's cost has an acceptable chance of not being exceeded
- (2) a means where management can examine changes in confidence measures, as a function of how much reserve to "buy" to ensure program success from a cost control perspective and
- (3) a way to assess where costs of other scenarios of interest different than the protect scenario fall on the probability distribution of the program's total cost

Statistical SBM

Approach & Assumptions

Below illustrates the basic approach involved in implementing a statistical SBM
 Observe that parts of the approach include the same steps required in the non-statistical SBM

So, the statistical SBM is really an augmentation to the non-statistical SBM The following explains the approach, discusses key technical assumptions, and highlights selected steps with computational examples



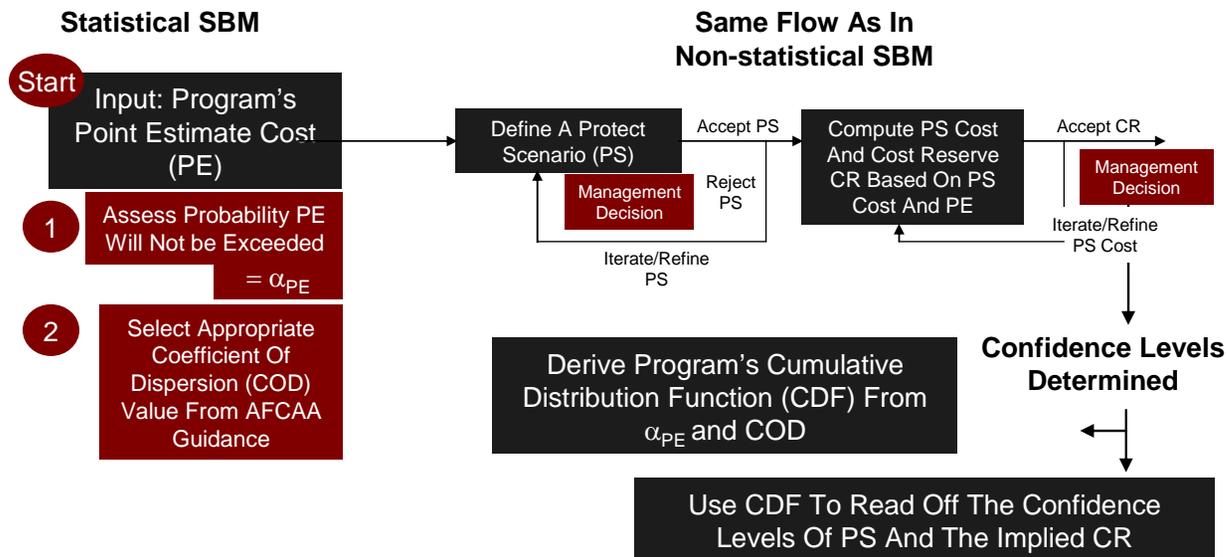
Statistical SBM

Approach & Assumptions

Mentioned above, the statistical SBM follows a set of steps similar to the non-statistical SBM

Below, the top three activities are essentially the same as described in the non-statistical SBM, with the following exception

Two statistical inputs are needed; they are the probability the point estimate cost (PE) will not be exceeded and the coefficient of dispersion (COD)



Statistical SBM

Point Estimate Probability

For the statistical SBM, we need the probability

$$P(\text{Cost}_{Pgm} \leq x_{PE}) = \alpha_{PE}$$

where Cost_{Pgm} is the true, but unknown, total cost of the program and x_{PE} is the program's point estimate cost (PE) Here, the probability alpha is a judgmental or subjective probability It is assessed by the engineering and analysis team. In practice, alpha often falls in the interval

$$0.10 \leq \alpha_{PE} \leq 0.50$$

Statistical SBM

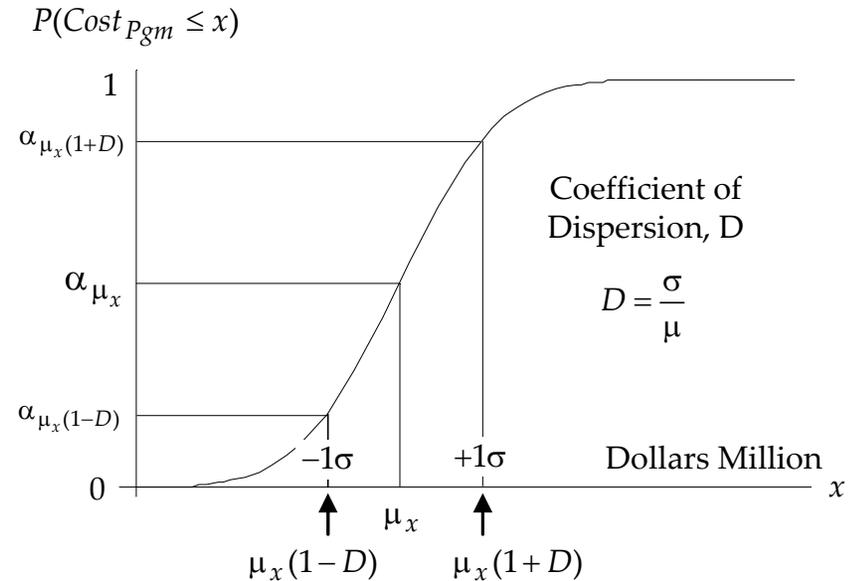
Coefficient of Dispersion (COD)

What is the coefficient of dispersion?

The coefficient of dispersion (COD) is a statistical measure defined as the ratio of distribution's standard deviation to its mean

It is one way to look at the variability of the distribution at one standard deviation around its mean; the general form of the COD is given below

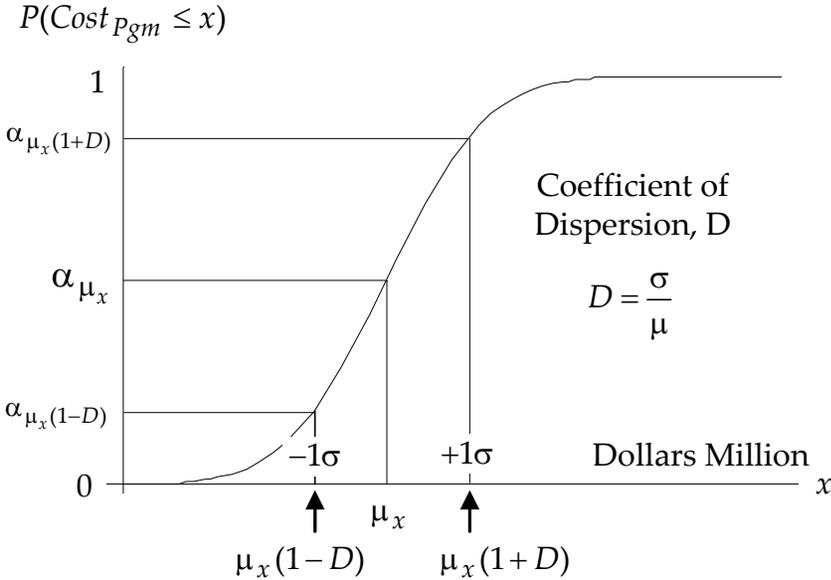
$$D = \frac{\sigma}{\mu}$$



Statistical SBM

Here, the COD statistic is a judgmental value but one guided by Air Force Cost Analysis Agency (AFCAA) and industry experiences with programs in various stages or phases of the acquisition process

As will be discussed in the SBM paper, a sensitivity analysis should be conducted on both statistical inputs to assess where changes in assumed values affect cost risk and needed levels of reserve funds

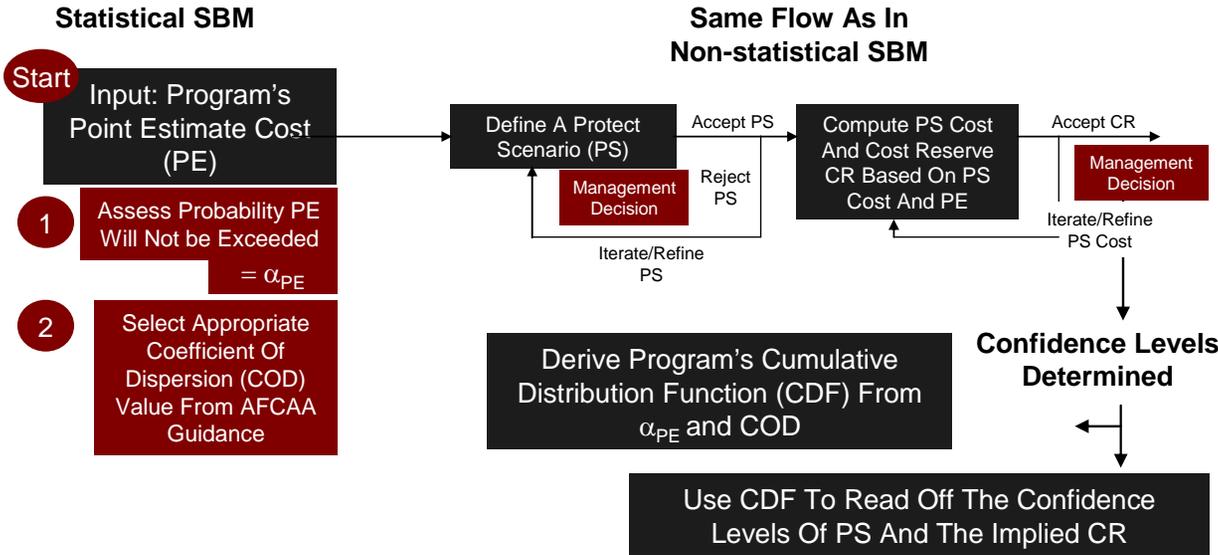


Statistical SBM

The next two steps along the top of the process flow follow the procedures described in the non-statistical SBM

Notice these two steps do not use the two statistical measures

It is not until you reach the last step of this process that these measures come into play



Statistical SBM (concluded)

Shown in the SBM paper (last chart), the distribution function of the program's total cost can be derived from just the three values identified on the far-left side of the process flow

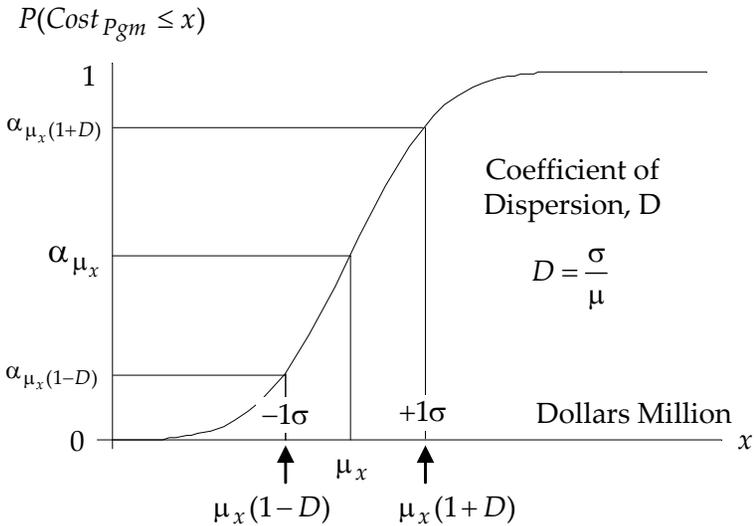
Specifically, with just the point estimate cost PE, and the two statistical measures

$$\alpha_{PE} \quad D = \frac{\sigma}{\mu}$$

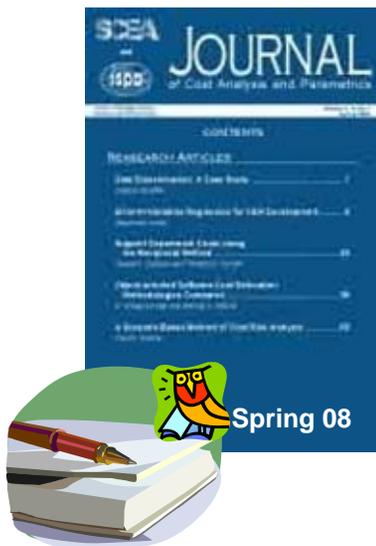
the underlying distribution function of the program's total cost can be determined

With this, other possible program costs, such as the protect scenario cost, can be mapped onto the function

From this, the confidence level of the protect scenario and its implied cost reserve can be seen



SBM Technical Paper



A Scenario-Based Method for Cost Risk Analysis

Paul R. Garvey
The MITRE Corporation
MP 05B0000023, September 2005

Abstract

This paper presents an approach for performing an analysis of a program's cost risk. The approach is referred to as the scenario-based method (SBM). This method provides program managers and decision-makers an assessment of the amount of cost reserve needed to protect a program from cost overruns due to risk. The approach can be applied without the use of advanced statistical concepts, or Monte Carlo simulations, yet is flexible in that confidence measures for various possible program costs can be derived.

1.0 Introduction

This paper introduces an analytical, non-Monte Carlo simulation, approach for quantifying a program's cost risks and deriving recommended levels of cost reserve. The approach is called the Scenario-Based Method (SBM). This method emphasizes the development of written scenarios as the basis for deriving and defending a program's cost and cost reserve recommendations.

The method presented in the paper grew from a question posed by a government agency. The question was *Can a valid cost risk analysis (that is traceable and defensible) be conducted with minimal (to no) reliance on Monte Carlo simulation or other statistical methods?* The question was motivated by the agency's unsatisfactory experiences in developing and implementing Monte Carlo simulations to derive "risk-adjusted" costs of future systems.

This paper presents a method that addresses the question posed by the agency. The method reflects a "minimum acceptable" approach whereby a technically valid measure of cost risk can be derived without Monte Carlo simulations or advanced statistical methods. A "statistically-light" analytical augmentation to

* This paper was written for the United States Air Force Cost Analysis Agency.



SBM Paper

Double-Click (non-
slideshow)

Summary: Features

Provides an analytic argument for deriving the amount of cost reserve needed to guard against well-defined “scenarios”;

Brings the discussion of “scenarios” and their credibility to the decision-makers; this is a more meaningful topic to focus on, instead of statistical abstractions the classical analysis can sometimes create;

Does not require the use of statistical methods to develop a valid measure of cost risk reserve; this is the non-statistical SBM;

Percentiles (confidence measures) can be designed into the approach with a minimum set of statistical assumptions;

Does not require analysts develop probability distribution functions for all the uncertain variables in a WBS, which can be time-consuming and hard to justify;

Correlation is indirectly captured in the analysis by the magnitude of the coefficient of dispersion applied to the analysis;

The approach fully supports traceability and focuses attention on key risk events that have the potential to drive cost higher than expected



Summary

In summary, the Scenario Based Method encourages and emphasizes a careful and deliberative approach to cost risk analysis

It requires the development of scenarios that represent the program's "risk story" rather than debating what percentile to select

Time is best spent building the case arguments for how a confluence of risk events might drive the program to a particular percentile

This is where the debate and the analysis should center

This is how a program manager and decision-maker can rationalize the need for cost reserve levels that may initially exceed expectations

It is also a vehicle for identifying where risk mitigation actions should be implemented to reduce cost risk and the chances of program costs becoming out of control

