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Assuring Credibility in the Cost Estimate

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Abstract

Credibility can be the most significant attribute of a cost estimate. This paper traces the evolution of quality metrics that assess cost credibility in the words of senior government executives, industry leaders, estimating and engineering handbooks, professional journals, and government auditing manuals. The presentation concludes with recommendations for the estimating professional. [Note that there is more information, with expanded graphics, in the accompanying PowerPoint briefing by the same name.]

The Challenge

In my thirty-five year career as a cost engineer and cost analyst, I have persistently focused on the goodness of my estimates. Good estimates should display key attributes, such as precision, accuracy, relevance, and rough order magnitude. But, the most challenging, and perhaps the most important, is **credibility**. How many estimators, or reviewers of estimates, really can define estimate **credibility** and, and more important, assure the estimate reviewer or customer that an estimate is credible?

In preparing this paper, I asked my peers how they would define "cost estimate credibility." Few could recall an accepted definition of cost **credibility** but several offered: "you will know it when you see it."

I reflected on the beginning of my cost estimating career, when I managed a group of new estimators with engineering backgrounds, dedicated to the new portents of parametric cost estimating. The mantra, then, was "to get a number" derived from the wonder tool of commercial estimating models. Seeing yards of rolled heat-sensitive paper, printed from my Texas Instruments time-share terminal, my boss would infuriate me by asking, "Hank, what does the model say" as if the whole estimating process was about to be automated with little human intervention.

Later, the emphasis seemed to focus on extrapolating "real world" cost data to develop proprietary cost estimating models. The mantra was to derive multi-variable CERs based on ZMPE, MUPE, or GRSQ, depending on how many degrees of freedom we liked. Our goal, then, was to develop estimates based on as many models or CERs as we could find and then defend our most favored estimate.

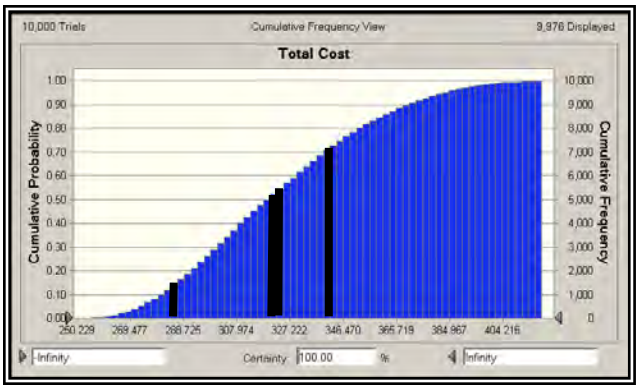


Figure1. What is the confidence level (cumulative probability) that the program can be completed for a budget set to a particular cost estimate?

Ultimately, I strove to challenge the goodness or quality of every estimate as much as its pedigree. And, did it matter if the purpose was to budget, support an engineering trade, or to challenge a contractor's proposal estimate? I wanted to know how to assure my clients that our estimate would be a faithful prediction of their future costs.

My mentor**, Steve Book** convinced me that the answer was rooted in statistics - that the confidence level of the estimate is the right proxy for its **credibility** (figure 1), *providing the input data, groundrules, and assumptions were valid and relevant*. In other words, what is the probability that my client will have enough budget to complete his project?

It is here, also, that we consider Joint Confidence level (JCL) to assess the likelihood that the project can be completed within costt and schedule. NASA applies this metric to their portfolio to establish program level confidence levels.

Estimators and cost model developers consider accuracy, completeness, and reasonableness as fundamental quality metrics. But the final "proof" of the estimate cannot be established until the program is complete and, by then, the estimate is no longer of interest. Perhaps, we should assure the **perception** of the "goodness" of every estimate, by applying the metric "**credibility**."

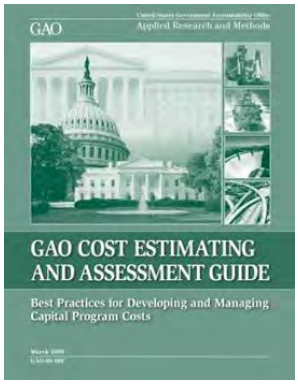
Wisdom of the Crowd

I developed this paper by consulting my peers (clients and team-mates), a process assumed from my reading the 2005 book by James Surowiecki, "The Wisdom of Crowds," which convinced me that "...under the right circumstances, it's the crowd that's wiser than even society's smartest individuals." A sampling of their opinions is deliberated in this paper.

My initial premise was that an estimate is a prediction of a future event – in this case predicting the cost and schedule to deliver a product or execute a program. I wondered, however, how well we can measure the estimate reality (statistics) or should we focus on perception (the right stuff). Would we know it when it when we see it, as a few of my peers suggested?

Rod Stewart, former president of the National Estimating Society and author of the 1982 book, "Cost Estimating" advised that "The credibility, accuracy, and supportability of the cost estimate for any work output will depend to a large degree on the care, knowledge, and time spent on developing a detailed WBS dictionary…every element in the structure must be fully described to allow the specialist to estimate accurately the resources to do the job." And, this was in the day when estimators relied on calculators and printed handbooks.

The **General Accountability Office** (GAO) led the crusade, as early as 1972, in its publication, "Theory and Practice of Cost Estimating for Major Acquisitions," by establishing the following minimum requirements for a **credible** cost estimate in the world of capital programs.



- Clear identification of the task (system description, ground rules, technical characteristics)
- Broad participation in preparing estimates (include all stakeholders)
- Availability of valid data (especially relevant historical data)
- Standardized estimate structure (WBS)
- Provision for program uncertainties (allow for unknowns)
- Recognition of inflation
- Independent review
- Estimate revision as program changes

GAO followed in 2009 with its first Cost Estimating and Assessment Guide for use in conjunction with Government Auditing Standards. The guide establishes a consistent methodology for developing capital program cost estimates and presents its actual survey results of federal agency practice on cost estimating.

The **Missile Defense Agency** (MDA) adapted these same GAO estimate credibility requirements to develop its Cost Estimating and Analysis Handbook in 2012. The MDA Chief of Cost Estimating,

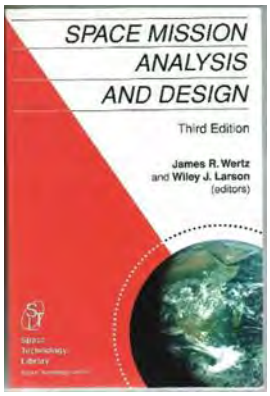
Christian Smart, included in his 2012 Cost Estimating Handbook the following attributes of a credible cost estimate:

- Using a standard estimate structure (work breakdown structure),
- Clearly identifying all estimating inputs (system description, ground rules, technical characteristics),
- Making available valid and relevant historical data,
- Identifying program uncertainties, and
- Conducting an independent review

The **NASA** Cost Estimating Handbook (updated in 2014) suggests that estimates be documented with reasonable description for each line item, along with **risk confidence levels,** such that another estimator could reconstruct the estimate. Their handbook is clear that "Once the estimate has been completed and documented, and before the estimate is presented to decision makers, it is important for the estimator to get an outside review." One stimulus to developing the NASA handbook was the NASA case history in the earlier GAO survey. NASA now relies on peer reviews and sanity checks to verify the reasonableness and **credibility** for its estimates.

Andy Prince, Chief Estimator at Marshall Space Flight Center, in his 2011 ICEAA paper, "The Credibility of NASA Cost Estimators." argues that cost estimate **credibility** is a quality metric (not an accuracy metric) which is dependent upon a sound program baseline, reliable and auditable historical cost data, and a management culture with desire to know the truth. Andy supports his predecessor, **Dr. Joe Hamaker**, then Director of Hq NASA Cost Analysis Division, who wrote in the ISPA Journal (2007) that "… accuracy is important; but we can't know the accuracy until the project is complete…"

Dan Nussbaum, former Director of the Naval Center for Cost Analysis (NCCA) and current Professor at the Naval Post Graduate School (NPS), argues in his 2015 book "Cost Estimation, Methods, and Tools," that a good estimate depends on completeness, reasonableness, and defensibility. His co-author and NPS Cost Analysis Chair, Greg Mislick, expanded on what makes a good estimate in a post-publication review as "So you are not going to prove your estimate is 'correct,' but what you want to prove is that your estimate is reasonable and **credible**. You show this by using sound mathematical techniques and people then understand how you came to these conclusions."



In the Cost Estimating chapter of the 2011 book, "Space Mission Engineering (the new SMAD)," I suggest that cost realism (not accuracy or precision) depends on the perception of the estimate to predict future costs if the estimator used acceptable estimating procedures, calibrated his estimating tools, and scheduled cross-checks.

The 2008 **RAND report** "Guidelines and Metrics for Assessing Space Cost Estimates," suggest that estimate **credibility** depends on completeness (all program elements included), consistency (within the directed program), and reasonableness (using appropriate methods and assumptions). RAND recommends creation of a Cost Analysis Requirements Description (CARD) to document the system architecture, operating scenario, and risk assessment to assure **credibility** of the ultimate estimate.

Defense Contract Audit agency (DCAA) Director **Chuck Starrett**, in his article for issue #1 (October 1979) of the ISPA News (forerunner to the ISPA Journal of Parametrics), identified his five attributes for judging a cost estimating model to be **credible** are:

1. Logical parametric relationships,
2. Verifiable cost and technical data,

3. Significant statistical relationships (high r^2),
4. Reasonably accurate predictions (requires keeping track), and
5. Continuous monitoring and recalibration of the CERs.

These same criteria were later introduced into the DCAA Auditing Manual.

The next DCAA Director, **Bill Reed**, in his keynote address to the 1993 ISPA Conference in San Francisco, stressed that **credible** cost estimates need to:


ispa news
OCTOBER 1979 VOLUME I NUMBER 1
A PUBLICATION OF THE INTERNATIONAL SOCIETY OF PARAMETRIC ANALYSTS
EDITORIALS
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1. Be based on actual cost history,
2. Be stable over time,
3. Result from open communications between estimators and their managers,
4. Be consistent with a company's written policies and procedures, and
5. Be made or reviewed by the person ultimately responsible for performing the work.

In 2006, the Journal of Parametrics initiated a series of five articles on assuring quality in cost estimates. In the first article, **Rich Hartley**, then Deputy Assistant Director of the Air Force for Cost and Economics, identified several areas "to watch out for," some of which are:

- Lack of transparency associated with data sources and estimating methods,
- Unrealistic risk analysis, failure to define risk assumptions, or not linking risks to cost impacts, and
- Excessively detailed briefings to decision makers or dependence on extraneous information.

The second of five articles, this one by **Dr. Joe Hamaker**, then Director of the Hq NASA Cost Analysis Division, offered the following attributes of quality in cost estimates to be:

- Sufficient reserve to cover the "up morphs" [risk adders]that most projects undergo,
- Independent cost estimates performed by non-advocates,
- Top-level sanity checks, and
- A management culture that desires good estimating.

The third of five articles, by **Dick Janda**, Lockheed Martin Vice President of Program Assessment and Evaluation, offered the following check list for a quality estimate:

- Is the estimate based on objective data, not cherry-picked data?
- Is the estimate honest?
- Are the data and analysis relevant?
- Is the basis of the cost estimate logical?

Then, in June 2009, **Stephen Bagby,** Deputy Assistant Secretary of the Army for Cost and Economics and the Director of the Army Cost and Economic Analysis Center (CEAC) entered the debate on estimating quality to describe the Army process to ensure the probable costs of its programs are adequately reflected in a limited budget. He established the Army Cost Review Board (CRB) to combine multiple cost estimates (program office, independent estimate) into a single Army Cost Position (ACP) with several initiatives, since as linking capability with cost.

The final article, by **Herve Joumier,** Chief of Cost Estimating for the European Space Agency (ESA), defined estimate qualities from his perspective as:

- To forget the magic number concept,
- Recognize the dangers of the "initial poor or naïve cost estimate" paradigm, and
- Recognize the value of accountability [who prepared the estimate].

The 2015 ICEAA Conference Overall Best Paper by **Andy Prince** suggested the following estimating "things to look out for:"

- Discarding or ignoring applicable data,
- Placing too much emphasis on a single datapoint or opinion,
- Tenuous analogies or extrapolations,
- An estimate that deviates significantly from the historical trend or reasonable analogs,
- Any estimate that depends on changes in historical business practices (unverified new ways to do business), and
- Falling in love with a subjective assessment.

Consensus

But, where is the consensus of this peer wisdom? My conclusion is that a **credible cost estimate**, *consistent with enough time, qualified tools and resources, and relevant information, should embody the following elements:*

1. A state-of-the-art, transparent, and clearly-defined estimating process,
2. A calibrated cost model or statistically-qualified CERs, derived from relevant and verified cost and technical data,
3. Peer reviews, sensitivity analyses, and independent crosschecks,
4. A defined baseline, sound assumptions, and suitable estimate structure, and
5. Logical, reasonable, and repeatable: cost and schedule predictions with risk assessments.

And, that's how I see credibility as our most significant estimate attribute.