AACE INTERNATIONAL RECOMMENDED PRACTICE

104R-19

COMMUNICATING EXPECTED ESTIMATE ACCURACY

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COMMUNICATING EXPECTED ESTIMATE ACCURACY

TCM Framework: 7.3 – Cost Estimating and Budgeting

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Any terms found in AACE Recommended Practice 10S-90, *Cost Engineering Terminology*, supersede terms defined in other AACE work products, including but not limited to, other recommended practices, the *Total Cost Management Framework*, and *Skills & Knowledge of Cost Engineering*.

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Disclaimer: The opinions expressed by the authors and contributors to this recommended practice are their own and do not necessarily reflect those of their employers, unless otherwise stated.

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1. INTRODUCTION

This recommended practice (RP) of AACE International defines expected estimate accuracy; and describes how the concept of estimate accuracy should be communicated to a stakeholder or decision maker that is interested in understanding the potential variability or predictability that is associated with a particular estimate.

The results of the estimating process are often conveyed as a single value of cost or time. However, since estimates are predictions of an uncertain future, it is recommended that all estimate results should be presented as a probabilistic distribution of possible outcomes in consideration of risk. However, because probabilistic methods are difficult to communicate, its concepts are reduced to an expression called *expected estimate accuracy* that is a simplified means of communicating uncertainty as a single expression. Discussions of expected estimate accuracy often describe estimate accuracy in terms of +/- percentages that bound the published single estimate value, but too often fail to convey other significant information that is required by an estimate stakeholder to truly assess what the +/- percentages indicate. Worse, *rule-of-thumb* percentages often fail to reflect the true risk and uncertainty at all.

This RP applies to estimates of both cost and time (duration). Its subject matter deals with the integration of the disciplines of decision and risk management, cost estimating and planning and scheduling within the AACE International community. Where a discussion in the RP focuses on either cost or time specifically, it is noted as appropriate.

This RP is intended to provide guidelines (i.e., not a standard) to be used in conveying the expected accuracy level of an estimate to a stakeholder that are considered to be good practices that can be relied on and that would be recommended for use where applicable. This RP will present an estimate as a probabilistic range of potential values in consideration of risk, discuss the typical shapes of the probability distribution associated with the range of potential values, discuss the concept of estimate contingency and identify the elements required to convey information about expected estimate accuracy to stakeholders. When referring to cost or duration estimating, this RP focuses on cost or duration estimating for a project or dedicated effort to accomplish a scope of work or activities.

This RP does not discuss the calculation or determination of the variability of the indicated accuracy of an estimate after completion of the associated project or effort (a comparison of an estimate with actual results). When the term *estimate accuracy* is used in this RP, it is intended to convey *expected estimate accuracy*.

2. RECOMMENDED PRACTICE

2.1. Definition of Uncertainty and Risk

This RP addresses practices for communicating the probabilistic nature of estimates. As such, its subject matter requires basic understanding of statistical and risk analysis concepts and terms. In particular, the following terms are important to understand and will be discussed further in the RP:

- Error: where this term is used, it refers to its statistical meaning of *error of prediction* and does not mean a mistake by the team or estimator unless so stated (although mistakes can be a contributing factor to error).
- Uncertainty: in respect to this RP, the term has two possible meanings. It can be used as a general synonym for what the accuracy +/- range represents regardless of the cause of that range; or it may reflect the analyst view that distinguishes between risk types wherein uncertainties are variability risks with 100 percent probability of occurrence (i.e., not risk conditions and events).
- Risks: in respect to this RP, the term has two possible meanings. It can be used as a general synonym for uncertainty and what the accuracy +/- range represents regardless of the cause of that range. Or, it may

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reflect the analyst's view that distinguishes between risk types wherein risks are identifiable conditions or events with less than 100 probability of occurrence but contribute to error.

The fact that alternate definitions of uncertainty and risk are used and valid implies that those who communicate about estimate accuracy must also communicate the meaning and context of these supporting terms.

2.2. Definition of an Estimate

AACE International defines an estimate as: A prediction or forecast of the resources (i.e., time, cost, materials, etc.) required to achieve or obtain an agreed upon scope (i.e., for an investment, activity, project, etc.). [1] It applies to both cost and time (duration).

AACE International defines a cost estimate as: The prediction of the probable costs of a project or effort, for a given and documented scope, including a defined location and point of time in the future. [1] The results of a cost estimate are expressed in a currency value.

In respect to cost, estimating is the predictive process used to quantify, cost, and price all of the resources required by the scope of an investment option, activity, or project. [2] The output of the estimating process, the cost estimate, is typically used to establish a project budget, but may also be used for other purposes, such as:

- Determining the economic feasibility of a project.
- Evaluating between project alternatives.
- Providing a basis for project and schedule control.

Activity duration estimating is defined as: Estimation of the number of work periods that will be needed to complete the activity. [1] For duration (activity or project), the periods can be expressed in hours, days, months or any defined time segment.

Every estimate is a prediction of the expected final cost or duration of a proposed project or effort (for a given scope of work). By its nature, an estimate involves assumptions and uncertainties. Performing the work is also subject to risk conditions and events that are often difficult to identify and quantify. Therefore, every estimate presented as a single value of cost or duration will likely deviate from the final outcome (i.e., statistical error). In simple terms, this means that every base estimate value will likely prove to be wrong. Optimally, the estimator will analyze the uncertainty and risks and produce a probabilistic estimate that provides decision makers with the probabilities of over-running or under-running any particular cost or duration value. Given this probabilistic nature of an estimate, it should not be regarded as a single point cost or duration. Instead, an estimate actually reflects a range of potential outcomes, with each value within this range associated with a probability of occurrence.

Typically, a single value (within the range of potential costs or durations) is communicated as the estimate value; however, it is important for the estimator to convey the uncertainty associated with that single point value, to describe the true probabilistic nature of the estimate, and the causes of the uncertainty to the estimate stakeholders. In typical use, the point value represents either a base estimate value or an end use value. The base estimate is the first value the estimator derives before considering and quantifying uncertainty and risks. The end use value includes at least some consideration for uncertainty and risks and represents the estimate value applicable to a decision (e.g., authorization of funds, a bid price, approval of a schedule, etc.). In either case, a point value for an estimate (whether the base or end use value) is in actuality just one point on a probability distribution curve that represents the range of potential cost outcomes.

Most of the end uses of an estimate require a single point value within the range of probable values to be selected. For example, at project sanction the funds to be authorized and acquired are represented by a single monetary value. Likewise, for schedules a completion date representing a single duration value is communicated. When taking into account the uncertainty associated with an estimate (including risk conditions and events), amounts known as contingency and management reserve are added to base estimates to derive a single value suited for the end budget or funding use. Note that depending on a specific organization's polices, management reserve may be added to the value of the base estimate or the value of the base estimate plus contingency. When determined effectively, the end use value addresses uncertainty and risks considering stakeholder risk tolerance and confidence levels; and for their purpose, represents the best single point value to support a project decision.

2.3. Definition of Estimate Accuracy

Accuracy is the degree to which an initial measurement or calculation varies to its final actual value. Accuracy is a distinct and separate concept from precision. Precision is the degree to which a series of calculated values will show similar results. Accuracy can be considered an expression or measure of predictability as well.

AACE International defines expected estimate accuracy as: An indication of the degree to which the value of a cost or duration estimate may vary from the final actual outcome of the completed project or activity. [1]

As indicated above, an estimate should be regarded as a range of potential outcomes, with associated probabilities of occurrence. Estimate accuracy is based on a probabilistic assessment of uncertainties and risks that forecasts how far a project's final cost may potentially vary from the single point value that is selected to represent the estimate, whether a base estimate or end use value. The estimate range (the variability between the potential lowest reasonable value for the estimate and the highest reasonable value) is driven by the uncertainties, and risks associated with the project or activity being estimated.

2.4. Presenting Estimate Accuracy

Individual estimates should always have their accuracy ranges determined by a quantitative risk analysis study that results in an estimate probability distribution when appropriate. The estimate probability distribution is typically skewed. Research shows the skew is typically to the right (positive skewness with a longer tail to the right side of the distribution) for large and complex projects [5]. In part, this is because the impact of risk is often unbounded on the high side. For example, if a base estimate assumed 2 lost days of work per month due to weather based on local historical data, the best would be 0 days, but the worst could be 10 or 20 or more.

High side skewness implies that there is potential for the high range of the estimate to exceed the median value of the probability distribution by a higher absolute value than the difference between the low range of the estimate and the median value of the distribution. When a probability distribution is positively skewed, the median is a higher value than the mode, and the mean is typically higher than the median (see the appendix information on probability distributions). Some complex projects may have bi-modal, long and/or fat tails or other unusual distributions depending on the nature of the risks.

Some skewness may be due to bias in the base estimate. For example, small projects and others with less pressure on cost and more on safety or other objectives are often estimated with a conservative bias to minimize the bureaucratic entanglements that cost overruns may provoke. These may display skewness to the left; a tendency to underrun. On the other hand, as projects become larger and the focus on minimizing costs becomes greater, the base estimate may have an aggressive bias (optimism bias). Bias should be minimized, but one must assume that every base estimate has some bias, and risk analysis must attempt to identify and quantify it (the topics of estimate validation and benchmarking are covered in other RPs).

Figure 1 shows a positively skewed distribution for a sample cost estimate risk analysis that has a base estimate (the value before adding contingency) of $88.5. As illustrated in Figure 1, typically the value of the base estimate before

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contingency is less than the mode, median and mean values of the distribution.[1] Also, note that the tails of the distribution in this example range from $80 to $115, and there would be a temptation to describe the estimate range as between $80 and $115 with 100% certainty. Note: Many of the figures included in this RP were created using Palisade @Risk for Excel, Version 6.3.1 Professional Edition.

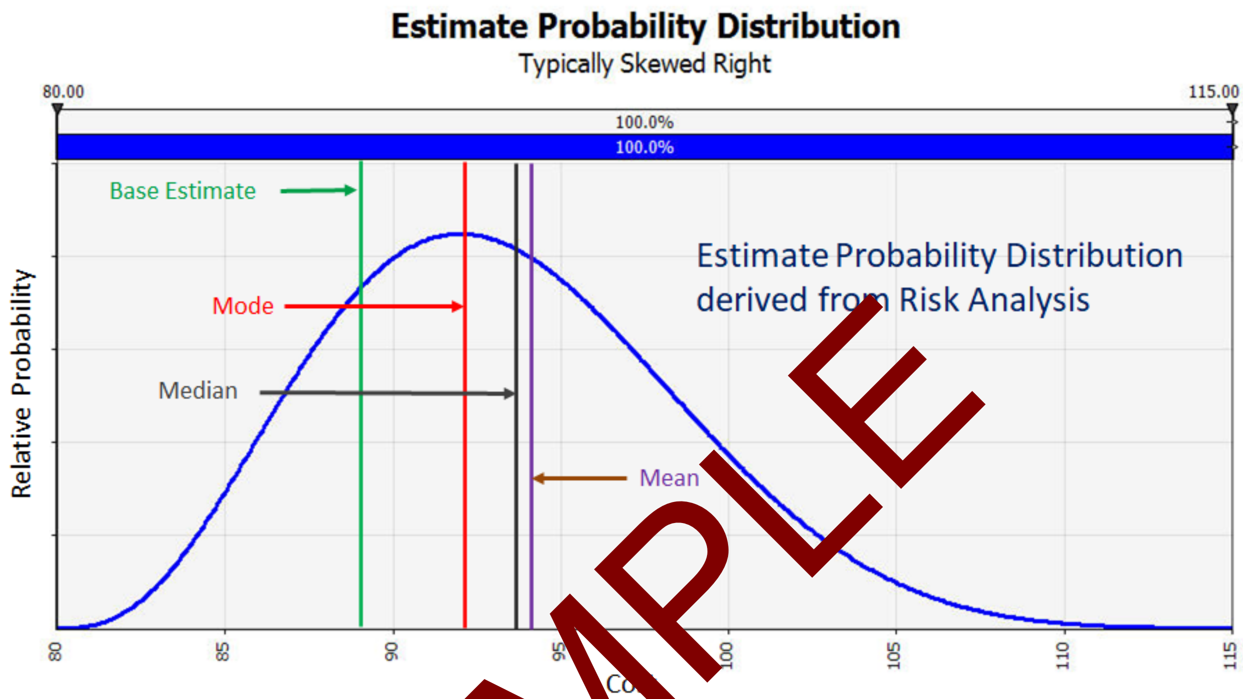

Figure 1 – Sample Estimate Probability Distribution with a Base Estimate before Contingency of $88.5[2]

It is not best practice, however, to express the potential range of the estimate with 100% certainty because it implies specific absolute limits to potential underrun or overrun of the estimate value. Although the calculated probability distribution from the estimate risk analysis may identify absolute lower and upper bounds, it is unrealistic to specify absolute limit to the tails of the estimate probability distribution in actual practice (See Figure 2). This does not imply that the lower and upper bounds of the estimate are indefinite (i.e., that the costs are unbounded); but that the specific lower and upper values of the estimate range are indeterminate for the purposes of risk or uncertainty assessment.

[1] The point value (before consideration of risk and uncertainty for the estimate) will typically lie to the left of the mode of the resulting cost probability distribution from a risk analysis. Although an estimator may (in theory) select a *most-likely* or *mode* value for individual items in an estimate, that value is usually selected without consideration of the estimate-wide systemic and project-specific risks and uncertainties. Thus, a level of contingency is required to achieve the most-likely (mode) value of the estimate total (in consideration of project risks); and since the cost distribution is typically skewed, additional contingency is required to achieve the p50 (median) or the mean value of the cost distribution resulting from risk analysis (to the right of the mode). Also, note that the most-likely (mode) values for individual estimate items comprising the estimate are also typically based on skewed distributions for each of those individual items. One cannot add the mode values of the individual items to obtain the mode value of the overall estimate (only the means of individual cost distributions are additive for anything other than normal or other symmetrical distributions).

[2] Note that the probability distribution graphics in this RP are shown as relative frequency probability distributions, not cumulative probability distributions. The skewness of the distribution is more easily recognized and displayed in a relative frequency distribution, which is important to this discussion of estimate accuracy. In a formal risk analysis report, it may be more prevalent to display risk results as a cumulative probability distribution. The advantage of a cumulative probability distribution in reporting of risk analysis results is that many will find it easier to associate a cost value with a given level of underrun (P value), as the y-axis of a cumulative probability distribution ranges from 0% probability of underrun to 100% probability of underrun. The y-axis of a relative frequency distribution identifies the central tendencies and skewness of the distribution, but the values of the y-axis are not meaningful.