AACE INTERNATIONAL RECOMMENDED PRACTICE

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RISK ANALYSIS AND CONTINGENCY DETERMINATION USING PARAMETRIC ESTIMATING

AACE INTERNATIONAL

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RISK ANALYSIS AND CONTINGENCY DETERMINATION USING PARAMETRIC ESTIMATING

TCM Framework: 7.6 – Risk Management

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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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1. INTRODUCTION

1.1. Scope

This recommended practice (RP) of AACE International (AACE) defines general practices and considerations for risk analysis and estimating cost and schedule contingency using parametric methods. Parametric methods are commonly associated with estimating cost based on design parameters (e.g., capacity, weight, etc.) or time duration based on costs; in this case, the method is used to estimate contingency based on systemic risk parameters (e.g., level of scope definition, process complexity, etc.). This RP includes practices for developing parametric models for cost growth and schedule slip (i.e., cost and schedule contingency).

Because most users will not have enough data to develop original models, industry models can be used. AACE RP 43R-08 provides example process industry parametric models for cost growth and schedule slip (including software) [1], but other models are available. If industry models are used, their applicability can be verified and, if need be, the models can be calibrated against company data (in all cases, there must be some data). This RP includes practices for model calibration.

Finally, the RP covers model application. As will be discussed in the RP, the parametric method is optimal for quantifying systemic risks, but not critical project-specific risks (see the Background Risk Types discussion). The parametric method can be used alone to quantify the uncertainty of estimates with a Class 10 or 5 level of scope definition, but as the scope development advances, and critical project-specific risks are identified, it is used in combination with other methods (i.e., as a hybrid application). AACE has developed RPs for how to integrate the parametric method with the expected value method (113R-20 [2]) and the risk-driven critical path schedule method (117R-21 [3]).

1.2. Purpose

This RP is intended to provide guidelines (i.e., not a standard) for contingency estimating that most practitioners would consider to be good practices that can be relied on and that they would recommend be considered for use where applicable. There is a variety of contingency estimating methodologies (see PGD-02; Guide to Quantitative Risk Analysis [4]). This RP will help guide practitioners in developing and/or calibrating parametric risk models. This RP does not address management of contingency once it is determined.

The RP incorporates a lot of information by reference. It references extensive empirical research and addresses somewhat complex statistical practices such as multiple-linear regression of historical data and statistical diagnostic tests for calibration. The RP does not attempt to fully document these methods. It is highly recommended that model builders study and understand the research and statistical basics.

It is an AACE recommendation that whenever the term "risk" is used, that the term's meaning be clearly defined for the purpose of the practice. The parametric modeling method described herein quantifies the impact of systemic risks (defined in this RP) which include both threats and opportunities, and, from a quantitative perspective, are "uncertainties"; i.e., as measures of attributes of or facts about a project system, the probability of occurrence is 100%.

1.3. Background – Research Basis

This RP is based on decades of research, development, and practice. The first known parametric model of systemic risk was published by the late John Hackney (a founding member of AACE) in 1958 [5]. In that year, the draft of an "estimate types" standard based on phased levels of scope definition, and including typical accuracy ranges, was

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also published in the first edition of the AACE Bulletin [6]. The development and use of parametric risk analysis for contingency determination evolved in parallel with industry's increasing recognition that *poor project scope definition* was often the greatest project cost and schedule risk driver. Over the years, other systemic risk drivers were identified by research such as the level of technology and complexity, team development, project controls, and bias (among others). This continuing research since 1958 has led to the near universal use of phase-gate (i.e., front-end loading) or similar scope development processes for capital investment in engineering and construction projects (i.e., it does not apply to agile processes that are more prevalent on information technology and other project types.) It has also led to wide spread application of scope definition measurement and quality assurance schemes such as the AACE RPs for cost estimate and schedule classification [7,8,9].

Notable research and developments following the 1958 work of Mr. Hackney includes the work of Merrow, *et al*. at the Rand Corporation [10], and Trost, *et al*. for the Construction Industry Institute (CII) [11]. A paper by Baccarini provides an extensive survey of these methods (up to 2006 when this RP was first draft) [12]. Work by Myers, *et al.* at Rand and Lee *et al*. at CII extend the research to schedule [13,14]. A text by Hollmann further reviews the history of research behind this method [15]. Still others have reported on the practical use of the parametric method in the workplace by owners, contractors and financiers [16 to 20].

1.4. Background – Parametric Estimating

The AACE RP 10S-90 (Cost Engineering Terminology) defines a "parametric estimate" as one that has "*…estimating algorithms or cost estimating relationships that are highly probabilistic in nature*" [21]. Generally, the relationships of the outcome (e.g., cost growth or schedule slip percentages in this case) and the inputs (e.g., systemic risk drivers) are determined by studying historical data, typically using multi-variable linear regression (MLR) analysis. More advanced analytical methods such as neural networks, machine learning and ultimately artificial intelligence (supported by improved industry data capture) are not covered by this RP, but are likely to become the dominant approach to developing empirically-based risk models in the future.

The following illustrates the typical form of a simple parametric estimating algorithm derived from MLR:

Outcome = Constant + Coefficient 1(Parameter A) + Coefficient 2*(Parameter B) + …*

(Equation 1)

The "outcome" in this case is a measure of cost growth (e.g., contingency as a percentage of base estimate cost) or schedule slip (e.g., contingency as a percentage of base duration), and the parameters are various quantified risk drivers such as a measure of the level of scope definition upon which the estimate or schedule was based (e.g., the AACE estimate classification). The algorithm can use transformed versions of the parameters (e.g., logarithmic, exponential or other); while still linear, this transformation introduces curvature in the predictions (for example, the lognormal distribution is often a good fit for the distribution of cost growth and schedule slip data).

Parametric estimating for risk analysis and contingency determination is aligned with key principles of contingency estimating per AACE RP 40R-08 (Contingency Estimating – General Principles [22]). These include being risk-driven (directly links risks and outcomes) and being inherently empirical in nature (based on actual measured experience). Also, the MLR analysis used to develop the model provides probabilistic information such as the root-mean-square error (RMSE) of the prediction. Once a model is developed, it is also quick and simple to apply which makes it particularly fit-for-use for early phase and small project estimates which have limited time, information and/or budget. Because the method explicitly measures attributes of the project system, it also supports ongoing governance and continuous practice improvement processes. Managers who see the added cost directly resulting from poor team development, immature processes and so on are incentivized to improve them; if not on a given project, then on the project system as a whole.