AACE INTERNATIONAL RECOMMENDED PRACTICE

113R-20

INTEGRATED COST AND SCHEDULE RISK ANALYSIS AND CONTINGENCY DETERMINATION USING COMBINED PARAMETRIC AND EXPECTED VALUE

SAMPLE

AACE INTERNATIONAL

AACE
INTERNATIONAL

AACE® International Recommended Practice No. 113R-20

INTEGRATED COST AND SCHEDULE RISK ANALYSIS AND CONTINGENCY DETERMINATION USING COMBINED PARAMETRIC AND EXPECTED VALUE

TCM Framework: 7.6 – Risk Management

SAMPLE

Rev. May 27, 2021

Note: As AACE International Recommended Practices evolve over time, please refer to web.aacei.org for the latest revisions.

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*.

Contributors:

Disclaimer: The content provided by the contributors to this recommended practice is their own and does not necessarily reflect that of their employers, unless otherwise stated.

John K. Hollmann, PE CCP CEP DRMP FAACE Hon. Life
(Primary Contributor)
Colin H. Cropley
Francisco Cruz, PE
Dr. David T. Hulett, FAACE
Martin Snyman, DRMP

Copyright © AACE® International   AACE® International Recommended Practices
Single user license only. Copying and networking prohibited.

This document is copyrighted by AACE International and may not be reproduced without permission. Organizations may obtain permission to reproduce a limited number of copies by entering into a license agreement. For information please contact editor@aacei.org

AACE® International Recommended Practice No. 113R-20

INTEGRATED COST AND SCHEDULE RISK ANALYSIS AND CONTINGENCY DETERMINATION USING COMBINED PARAMETRIC AND EXPECTED VALUE

TCM Framework: 7.6 – Risk Management

May 27, 2021

TABLE OF CONTENTS

SAMPLE

Single user license only. Copying and networking prohibited.

May 27, 2021

1. INTRODUCTION

1.1. Scope

This recommended practice (RP) of AACE International (AACE) defines general practices and considerations for integrated cost and schedule risk analysis and estimating contingency using a combination or hybrid of parametric risk modeling and integrated cost and schedule expected value analysis with Monte Carlo Simulation methods. P+EV is used as a shorthand designation for the combination. In this RP, *EV* always refers to expected value (not earned value). The base methods are covered separately in RP 42R-08 (*Risk Analysis and Contingency Determination Using Parametric Estimating*), RP 44R-08 (*Risk Analysis and Contingency Determination Using Expected Value*) and RP 65R-11 (*Integrated Cost and Schedule Risk Analysis and Contingency Determination using Expected Value*) respectively 1,2,3]. Those RPs should be reviewed for details of the respective methods; this RP is focused on how to use them in combination. Descriptions of other recommended risk quantification practices can be found in AACE Professional Guidance Document PGD-02, Guide to Quantitative Risk Analysis [4].

The P+EV method is a fit-for-use, practical, risk-driven method intended to support management's need for integrated distributions of potential project cost and schedule outcomes to support investment decision making and from which contingency and reserves can be established. It is focused on the bottom-line cost and completion date. This is not an ideal method for understanding risk at a more detailed level such as what the risk impact might be on an intermediate schedule milestone, or an estimate WBS element. For such in-depth analysis and understanding, the hybrid combination of the parametric method with the risk-driven critical path schedule method is recommended (i.e., P+CPM) (117R-21 [5]).

1.2. Purpose

This RP is intended to provide guidelines, 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 range of useful risk analysis and contingency estimating methodologies; this RP will help guide practitioners in developing or selecting appropriate methods for their situation.

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%. The expected value method is focused on critical project-specific risks that includes both threats and opportunities and may either be uncertainties (as described above) or risk events (i.e., contingent risks) for which the probability of occurrence is less than 100%.

1.3. Background

The integrated, hybrid cost and schedule risk quantification method covered by this RP combines parametric modeling of systemic risks (parametric) and expected value with Monte-Carlo simulation (EV w/MCS) modeling of project-specific risks. P+EV is used as a shorthand designation for the combination. The component methods are addressed in RPs 42R-08, 44R-08 and 65R-11 respectively. Two methods are combined because no single method is optimal for quantifying both systemic and project-specific risks. The parametric model offers empirically-based input to risk quantification that is largely missing with pure MCS. MCS is required in this hybrid combination to model the EV portion and to integrate the analyses results. Only the mean values of method outputs are additive (e.g., the overall cost or duration at say p70 confidence level is not the sum of the separate analyses p70 values Figure 1 illustrates the hybrid concept:

SAMPLE

Copyright © AACE® International AACE® International Recommended Practices
Single user license only. Copying and networking prohibited.

May 27, 2021

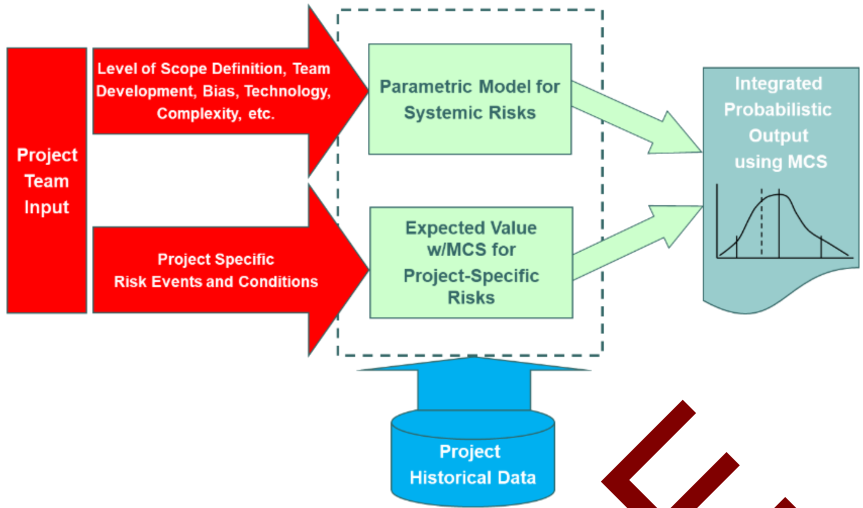

Figure 1 – Hybrid Parametric and EV w/MCS method (P+EV)

SAMPLE

Systemic risks are those that have systematically predictable relationships to overall project cost and schedule growth outcomes [6]. The term systemic implies that the risks are artifacts of the project *system,* i.e., culture, capabilities, competencies, decision making, complexity, level of technology, and so on. This includes estimating and scheduling process uncertainties as well (e.g., rates, quantity takeoff, productivities, production rates, etc.). Some would call these inherent or background risk or general uncertainty. Systemic risks are dominant for poorly defined projects and/or weak project systems; hence the parametric method is ideal for early phase estimates. Systemic risk impacts are best modeled based on empirical research of past projects; i.e., multi-variable linear regression (MLR) or similar analysis (e.g., machine learning) of historical data on risk drivers and their cost and schedule impacts (RP 42R-08 and by extension this RP only address MLR).

Project-specific (P-S) risks are those that do not have predictable, systematic relationships with outcomes, i.e., they are specific to the project. These are most commonly risk events or conditions although they may also include project specific uncertainties (e.g., weather variability). Project-Specific risk assessment is amenable to traditional brainstorming workshops or interviews and can be realistically modeled using EV methods (i.e., probability times impact with MCS). In the EV method, only *critical* project-specific risks are quantified, i.e., those with the potential of material impact on project success. Most risks in a risk register will not meet this criterion. For these critical risks, the quantitative analysis will first assure that the nature of the risk is well understood (e.g., is the cause understood, has too much credit been taken for mitigation efficacy, etc.?), and the probability of occurrence and their impact will be reviewed; i.e., the information in a risk register is never accepted or used verbatim.

It should be noted that a project system attribute (i.e., a systemic risk) can change, or be changed, after the risk analysis. However, in the P+EV method, uncertain future states of the system are not rated or credited. Any planned or anticipated change in the project system (i.e., a mitigation) is analyzed as a project-specific risk (an event) that may or may not occur and may or may not be effective. For example, the project control system at the time of analysis may be poor, but a new system is planned for implementation during the project. In this case, the systemic risk is the rating of the current system state, and the new control system implementation is an opportunity with some probability of it being implemented and being effective with some assumed improvement of cost and/or schedule (however, such changes are unlikely to be critical).

Copyright © AACE® International
Single user license only. Copying and networking prohibited.

May 27, 2021

2. RECOMMENDED PRACTICE

2.1. Hybrid Application Steps

As discussed, RPs 42R-08, 44R-08 and 65R-11 must be reviewed for background and details of each of the underlying methods. This is not a stand-alone RP. The steps of applying these methods in a combined or P+EV hybrid approach have been summarized in several AACE International papers, but also a comprehensive text on the method [7,8,9].

The steps of this process assume that tools are in place for 1) parametric analysis of systemic risks and 2) for expected value analysis with MCS for project-specific risks. Most often, the parametric tool will be based upon either the Hackney or Rand models that are documented (and provided in Excel® form) in RP 43R-08, *Risk Analysis and Contingency Determination Using Parametric Estimating – Example Models as Applied for the Process Industries* [10]. The models in RP 43R-08 generate predicted mean cost growth and, for the Rand model, the schedule slip. RP 42R-08 describes how to derive a probabilistic distribution from these mean outcomes. The EV tool with MCS is a fairly basic spreadsheet (no complex or unusual math or functions or macros necessary) with MCS applied. The only connection between the tools is the need to copy the parametric tool's cost and schedule output distributions into the EV tool as will be discussed.

With the tools in place, the steps in applying them as a hybrid application are as follows:

<u>Step 1: Per RP 42R-08; Apply Parametric Model:</u>
Assess and quantify the systemic risks and enter them in an empirically-based parametric cost and schedule contingency estimating model. If the estimate and schedule are AACE® Class 5, the analysis is complete, determine the cost and schedule contingency based on management's risk tolerance and the parametric model's probabilistic output. If the estimate and schedule are AACE® Class 4 or better (i.e., critical project-specific risks can be identified), continue to the EV w/MCS method in step 2.

<u>Step 2: Per RP 44R-08; Screen the Risk Register and Identify Critical Risks:</u>
Optimally, the risk register will already have categorized each risk by quantification method type to be applied (i.e., create a column in the risk register to identify if the risk is systemic, project-specific, escalation or currency). This categorization can be a challenge because risks are often not well titled or described as to their nature and cause. In general, the more ambiguous, or the more the risk is in the nature of a worry or an issue, the greater the likelihood a risk is systemic.

SAMPLE

Further screen the project-specific risks to develop a list of those that are *critical* and refine the descriptions of their nature and cause. The definition of critical risks is included in RP 44R-08, but in general these are risks that have a material impact on the project economics. Risks are selected based on their post treatment, residual status. Check for any risks that were critical pre-treatment, but non-critical after mitigation; assure that the risk reduction credited to the mitigation is realistic. Post treatment, there should typically be no more than 5 to 15 critical risks, keeping in mind that by definition any one critical risk will put the project success at risk. Having too large a number of critical risks implies that the project may not be viable. Note that escalation and currency risks are not covered in this RP (see RP 68R-11, Escalation Estimating Using Indices and Monte Carlo Simulation [12].

<u>Step 3: Per RP 44R-08; Quantify the Probabilities of Occurrence:</u>
Capture the critical risk titles and clear description in the EV tool (do not link to the risk register: start fresh). Assess and input the percent probability of occurrence for each critical risk (again, this is post-treatment residual risk). Probability can be treated as a distribution depending on the team's confidence in their assessment as discussed in RP 44R-08. Establish any dependencies between the risks (or combine risks if they are similar in nature), again as discussed in RP 44R-08 and/or 65R-11.

Copyright © AACE® International
Single user license only. Copying and networking prohibited.