AACE International Recommended Practice No. 40R-08

CONTINGENCY ESTIMATING – GENERAL PRINCIPLES

TCM Framework: 7.6 – Risk Management

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INTRODUCTION

Scope

This Recommended Practice (RP) of AACE International defines the expectations, requirements, and general principles of practice for estimating contingency, reserves and similar risk funds (as defined in RP 10S-90) and time allowances for project cost and schedule as part of the overall risk management process (as defined in TCM Framework Section 7.6). The RP provides a categorization framework and provides a foundation for, but does not define specific contingency estimating methods that will be covered by other RPs.

This RP does not address the general risk management "quantification" steps as might be used for screening or ranking risks in terms of their probability or impact. While the quantification methods of contingency estimating may be similar to those used for screening, the application often differs.

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 broad range of contingency estimating methodologies; this RP will help guide practitioners in developing or selecting appropriate methods for their situation.

Background

This RP is new. It is based on discussions of the AACE Decision and Risk Management committee. There is no one best way to quantify risks or to estimate contingency; each method has its advocates. However, there is general agreement that any recommended practice should be in accordance with first principles of decision and risk management as described here.

RECOMMENDED PRACTICE

Contingency versus Risk Impact

This RP covers more than just the estimation of traditional "contingency" for cost or schedule. It also refers to the estimation of risk values in general (excluding escalation, currency, and other primarily monetary or financial risks). For example, management may want to know not only what traditional contingency to include in a project cost control budget or float to include in a schedule, but what reserves or insurance it may want to establish for catastrophic risks for the project or its capital portfolio as a whole, what ranges of impacts to consider in business case sensitivity analysis, and so on. From here forward, we will refer to the product of the estimation as quantitative risk impact.

General Principles of Estimating Quantitative Risk Impact

Any methodology developed or selected for quantifying risk impact should address these general principles:

- Meet client objectives, expectations and requirements
- Part of and facilitates an effective decision or risk management process (e.g., TCM)
- Fit-for-use
- Starts with identifying the risk drivers with input from all appropriate parties

- Methods clearly link risk drivers and cost/schedule outcomes
- Avoids iatrogenic (self-inflicted) risks
- Employs empiricism
- Employs experience/competency
- Provides probabilistic estimating results in a way the supports effective decision making and risk management

These principles are further described below.

Objectives, Expectations and Requirements

Management (or other customer of the estimate) may require traditional contingency or float values, reserves, ranges, and other information. They may also have constraints in terms of time and resource availability, and so on, or they may need quantification methods to be enhanced or validated before beginning the effort. It may also be advantageous to integrate the effort with other practices (e.g., value engineering). Therefore, a first principle is that the client's objectives, expectations and requirements must be determined.

This determination includes agreeing on the meaning of the terms "risk" and "contingency"[1]; definitions may vary somewhat among organizations and applications (e.g., does risk include both opportunities and threats?). During this discussion, the client's level of risk tolerance should be gauged. For example, is it the client's desire that the budget or schedule represent the most likely result, or a more conservative or aggressive outcome?

Decision or Risk Management Process

Estimating quantitative risk impacts is not an end in itself; it should be part of some process. Therefore, the practitioner must identify the decision or risk management process that the estimating practices are supporting, and make sure that the estimating practices and their outcomes facilitate that process (TCM being a generic model for such a process). If there is no such process in place, the practitioner should recommend that one be established as appropriate for the objectives and requirements of the customer.

Fit-for-Use

In addition to considering the general requirements of the client and the process, the practitioner must also consider any other significant contextual characteristics that may or may not affect the estimating practices selected and how they are managed and/or performed. These include, but are not limited to the following:

- Portfolio, Program or Project Type: Scope, size, complexity, level of technology
- Risk Type: Strategic versus tactical, systemic versus project-specific.
- Project Phase: Estimate/Schedule Class
- Base Estimate/Schedule Methodologies: Methods, tools, and data used to develop the estimate or schedule (without risk cost/time included)
- Skills and Knowledge: Of both the practitioner and other participants

Identifying Risk Drivers

The risk management process starts with identifying risks, and therefore, any risk estimating method must begin likewise (e.g., do not quantify ranges on a cost or activity, without first determining what is driving the range). This process needs to consider both inherent estimate uncertainty (as a result of level of definition available, methodologies employed and other systemic risks) and risk events (including both project specific and external risks that may impact the project).

[1] These terms are defined in AACE's terminology RP 10S-90 in which the "risk" definition is based on the following reference: "AACE International's Risk Management Dictionary", AACE International Risk Management Committee, Cost Engineering, Vol. 37, No. 10, AACE International, Morgantown, WV, 1995

Linking Risk Drivers and Outputs
A comprehensive risk management process requires clear understanding of each risk and its potential impact. Risks are continually reassessed throughout a project's life cycle. If management cannot explicitly see the connection between a given risk and the potential impact, then management of the risk during execution will be difficult. Therefore, it should be clear in the estimation practice how each identified risk is linked to the estimated impact.

Avoid Iatrogenic (Self-Inflicted) Risks
The estimation process itself should not introduce new risks. For example, if too many risks are considered, or too many cost items are included in range estimating, important risk drivers may not get sufficient attention, and in some cases, the cost analysis may become corrupted or obscured. If the risk impact estimate is too low, it will distort the project control process as teams try to work around inadequate plans. If the risk impact estimate is too high, history shows the excess funds or time will be consumed to the detriment of profitability or other project success measures.

Empiricism
Estimation as a general practice is based on taking experience from the past and applying it to the present and future. Any method must be informed by past experience. Empiricism implies objectively capturing experience through measurement and analysis of past practices and outcomes. For example, empirical research has shown that there are systemic risks that have fairly predictable impacts. Empiricism can be brought to bear directly through parametric quantification methods (e.g., regression based) or less directly through the use of lessons learned and/or benchmarking, or validating analysis results against historical data.

Experience/Competency
Empirically based or not, no estimating algorithm or routine will provide reliable estimates without the input of an experienced and competent estimator (in this case, a risk analyst). The probability of iatrogenic risks increases with inexperience and/or incompetence of the practitioners. The less empiricism incorporated in the methodology itself, the more critical the experience, skills and knowledge of the analyst and team become. Optimally, the risk analyst's experience and competency in risk management and quantification methods will be seasoned with relevant asset and project management experience. Competency is best obtained through both training and hands-on practice.

Probabilistic
The quantitative risk impact estimate is always part of the basis of a management decision. The client may use the risk estimate values in a business case simulation supporting an investment decision, or they may simply be deciding how much risk impact to include in a project budget or schedule (or to insure, or establish as a reserve, etc.). Probabilistic estimate outputs (i.e., distributions or ranges) help ensure that the client understands the potential consequences of their decision; point estimate values do not do this. If the risk impact estimating method does not directly generate a distribution or range (e.g., through simulation), then the analyst and team is obliged to otherwise communicate equivalent information through other means, preferably based on empirical data and experience.

General Categories and Characteristics of Methods in Practice

The definition of contingency and how to estimate it are among the most controversial topics in cost engineering. While there is consensus among cost engineers on what contingency is, there is much less consensus on how to estimate it. In general, there are four classes of methods used to estimate risk cost/time that can respect the basic principles. These include:

- Expert Judgment
- Predetermined Guidelines (with varying degrees of judgment and empiricism used)
- Simulation Analysis (primarily expert judgment incorporated in a simulation)
  - Range Estimating
  - Expected Value

- Parametric Modeling (empirically-based algorithm, usually derived through regression analysis, with varying degrees of judgment used)

Hybrid methods that combine several or all of the above classes are also common.

Methods that do not respect the general principles are never appropriate. Common examples of inappropriate methods includes the "Remainder" method; i.e., setting contingency as the difference between the base cost estimate or schedule duration and some pre-determined budget or duration (e.g., "We have $100M for this project; the base estimate is $98M; therefore the contingency is $2M). Also, judgment or predetermined guidelines that disregard risks and/or have no basis in empiricism or experience are inappropriate.

The following briefly discusses each of the classes of methods; however, specific methods are intended to be described in other AACE Recommended Practices.

<u>Expert Judgment</u>
This method is largely self explanatory. The term "expert" explicitly means that the judgment must have a strong basis in experience and be backed up by competency in risk management and analysis. The results of all methods are improved to the extent that expertise and good judgment is brought to bear (i.e., most methods are to some extent hybrid combinations employing expert judgment). However, this method is highly subject to imposing iatrogenic risk when the judgment is inconsistent or biased. Bias can be minimized by obtaining the consensus of multiple experts or an experienced team, provided there is varied, independent opinion (i.e., avoid "group-think").

<u>Predetermined Guidelines</u>
This method may be as simple as providing a single contingency or float value (e.g., percentage of base cost or duration) for use on all estimates or schedules of a certain type to complex tables or scoring mechanisms that employ elements of parametric modeling. A common approach is to establish a table of contingency values and ranges for each of AACE's estimate or schedule classes with alternate values and ranges provided for common risks such as the use of new technology[2].

Advantages of the method are that it is simple, understandable, and consistent, and as such, it is easy to get management buy-in. The results of guidelines are improved to the extent that empiricism, expertise and good judgment are brought to bear in development of the guidelines. Because the method is "simple," it is often used by inexperienced people; therefore, the guidelines must be clearly described and documented and supported by training.

A disadvantage is that it cannot effectively address risks that are unique to a specific project, or risks that are common, but may have inordinate impacts on a given project. For that reason it is most useful for early estimates when systemic (i.e., non project-specific) risks such as the level of scope definition are dominant. In all cases, outcomes must be tempered with expert judgment.

<u>Simulation Analysis</u>
This method combines expert judgment with an analytical *model* that is then used in a simulation routine to provide probabilistic output.

An advantage of modeling and simulation analysis is that it facilitates including the analyst's and team's experience and input; this makes is particularly well suited for project-specific risks. It also directly provides probabilistic output.

A disadvantage is the method's complexity which requires expertise in application (which also makes it subject to manipulation), and the outcomes are not highly consistent (being highly dependent on the analyst and team input). Also, because the methods are not empirically-based, they can sometimes be

[2] Research has consistently shown that the level of project scope definition, inherently addressed in AACE's estimate and schedule classifications, is a predominant risk driver and a good starting point for most risk analyses.

more challenging to apply effectively for systemic risks which are predominant for early estimates. Finally, the model requires consideration of alternate estimates or schedules (to estimate the impact if a risk happens) which requires estimating and schedule expertise throughout the exercise.

The most common methods in use are *range estimating* and *expected value*; both of which use Monte-Carlo or similar simulation routines. These methods are described below.

Range Estimating
In range estimating for a cost estimate, the cost model is usually a summary of estimated costs at some level of detail. Simplistic approaches may use a project's work breakdown and cost account structure as it is (e.g., civil construction costs for process unit X). More refined approaches to avoid iatrogenic risk may focus on the cost estimate's critical elements which are identified using a process that considers each cost element's significance to the total project cost. Each cost element in the model is then assessed with a range and distribution that is assigned by the team based on their understanding of the risks. Also, at that time significant correlations amongst cost elements are incorporated into the analysis. Then a Monte-Carlo or similar simulation program is run that uses these cost item ranges and distributions as its input. The simulation's output is a total cost distribution along with other data designed to support the decision making process.

For scheduling, the model is usually a critical path network schedule. For each activity, the duration is replaced by a duration distribution assigned by the team. Then a Monte-Carlo simulation program is run that uses these duration distributions as its input. The simulation's output is a total duration distribution.

Expected Value
The expected value method directly estimates the cost or schedule impact of each significant identified risk. The model starts with a list of risks. The probability of occurrence of each risk is estimated. Then the cost or schedule impact, if the risk happens, is estimated. The cost or schedule duration times the probability of occurrence is the "expected value." The probability and cost or schedule estimates are replaced by distributions that are assigned by the team based on their understanding of the risks. Also, at that time significant correlations amongst risks and cost or schedule activities are incorporated into the analysis. Then a Monte-Carlo or similar simulation program is run that uses these probability and cost distributions as its input. The simulation's output is a total cost or schedule distribution along with other data designed to support the decision making process.

The above are simplistic, generic descriptions for complex methods that if executed poorly can increase iatrogenic risks. This complexity mandates that practitioners refer to the specific Recommended Practices for each of these methods for more information on best practices.

<u>Parametric Modeling</u>
A parametric model is generally an algorithm that is derived from multi-variable regression analysis of quantified risk drivers versus cost growth or schedule slip outcomes for historical projects. For example, a risk driver such as the level of project scope definition can be given a score for each project in a dataset. This score can be regressed against the actual cost growth for those projects. The regression will provide not only an algorithm, but also statistical information about the range.

Advantages of parametric modeling include, like predetermined guidelines, being simple to use, understandable, and consistent. Further, it is empirical by nature.

A disadvantage is the complexity of developing the parametric model which requires statistical skills and historical data with a range of risks and outcomes. Fortunately, industry research of common risks and outcomes is sometimes available for use. The method also cannot effectively address risks that are unique to a specific project, or risks that are common, but may have inordinate or unusual impacts on a given project. For that reason it is most useful for early estimates when systemic (i.e., non project-specific) risks such as the level of scope definition are dominant. In all cases, outcomes must be tempered with expert judgment.

Hybrid Methods

Each of the classes of methods described above has advantages and disadvantages. Therefore, the best approach is sometimes to use two or more methods to estimate risk cost/time. The most common combination is to use expert judgment with any other method. Another combination is to use a parametric model for systemic risks and simulation analysis for project-specific risks. Parametric models may also provide the raw material used to develop pre-determined guidelines.

Summary

Table 1 below provides an overview of the primary classes of risk cost/time estimating methods and consideration for each in regards to the general principles. Practitioners should refer to the AACE RPs describing the specific methods.

	Classes of Contingency Estimating Methods			
First Principles	**Expert Judgment**	**Predetermined Guidelines**	**Simulation Analysis***	**Parametric Modeling**
Meets client objectives, expectations and requirements	Whether a given method or combination of methods best meets the clients objectives, expectation or requirements must be determined prior each application			
Part of a risk and decision management process	Any method can potentially be incorporated in a process.			
Fit-for-use	Any method can potentially be made to address a variety of applications, but typically each method has strengths and weakness. Hybrid approaches can take advantage of the strengths of several methods.			
Starts with identifying risk drivers	Any method can potentially be made to start with identifying risk drivers.			
Links risk drivers and cost/schedule outcomes	Requires that expert(s) make and communicate the linkages	Linkages can be directly incorporated in the guidelines	Linkages are directly used in the *expected value* method	Linkage is inherent to this method
Avoids iatrogenic (self-inflicted) risks	Bias must be tempered, often through consensus	Care must be taken with risks not considered in the guidelines	Complexity of the method increases the need for disciplined approach	Care must be taken with risks not considered in the model
Employs empiricism	Generally requires the use of lessons learned, and/or validation or benchmarking using historical information (not an inherent feature of the method)			Explicitly addressed if regression based
Employs experience /competency	Expertise explicitly required	Expertise employed in development	Expertise employed in analysis	Expertise employed in development
Provides probabilistic estimating results	Can provide subjective ranges	Can provide predetermined ranges	Direct output of most simulations	Can be a direct output of algorithm

***Including range estimating and expected value methodologies**

Table 1 – Classes of Contingency Methods and General Principle Considerations

REFERENCES

Other Industry Practices
The authors were not aware of any other industry standards covering the general principles and classification of contingency estimating methods.

Sources

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