AACE INTERNATIONAL RECOMMENDED PRACTICE

133R-23

USING DECISION ANALYSIS METHODOLOGIES TO ENHANCE DECISION QUALITY

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USING DECISION ANALYSIS METHODOLOGIES TO ENHANCE DECISION QUALITY

TCM Framework: 3.3 – Investment Decision Making
7.6 – Risk Management
11.4 – Quality and Quality 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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July 21, 2025

TABLE OF CONTENTS

July 21, 2025

1. INTRODUCTION

This recommended practice (RP) of AACE International defines the use of the discipline of decision analysis (DA) to structure, analyze, and generate stakeholder decision buy-in and commitment to important organizational decisions, whether made by a team, group or individual. The specific elements of DA are introduced in Section 2.2. This RP illustrates how modern decision analysis methods can be applied broadly to making decisions on projects, programs, and at the enterprise level in the presence of uncertainty.

Application of DA is intended to assure decision quality (DQ). DQ embodies DA concepts and processes that help assure both effectiveness and efficiency in analyzing decision problems, as well as organizational commitment to action around the best expected course of action [1]. This RP encases DA methods in the DQ envelope throughout and provides a specific section giving an overview of DQ processes that can lead to high-quality decisions.

This document is not intended to be a standard. This document is intended to provide a guideline for decision support analysts 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. The document is intended to be a complement to AACE's *Total Cost Management Framework*, Section 3.3 and Chapter 4 [2], which embeds DA within TCM, and which includes helpful further discussion of DA and methods.[1]

The intended audience includes project managers, decision analysts, and decision makers. DA can be applied during each stage of the project life cycle across industries. For example, it is frequently applied during concept selection, before the subject project has been fully defined. These early stage decisions, usually called "analysis of alternatives," deal with the basic structure and strategy space that an ultimate project encompasses. As such, this recommended practice has broad application for decision makers and project managers. DA can also be applied in mid-project to make course corrections or to evaluate newly available alternatives.

When applied successfully in a demonstration project, organizations frequently adopt this decision-making framework organization-wide. Some corporations have created dedicated internal Decision Support organizations to assist in facilitating the process and carrying out the analytics embedded in the DA method. As the organization adopts the process, it frequently empowers the workforce and fosters a sense of responsibility. As it sees more examples and gathers data on outcomes of the process, they are able to compare them to the probabilistic assessments of key uncertainties made by the DA participants. Adjustments in the process can be made for subsequent decisions, fostering a culture of accountability throughout the organization. The goal is to strive for continuous improvement in decision making.

2. RECOMMENDED PRACTICE

This recommended practice introduces the discipline of decision analysis and illustrates how its use improves the likelihood of choosing the best decision from available alternatives. Because it explicitly incorporates uncertainty, it allows for the evaluation of risk alongside expected outcomes arising from different decision alternatives. The uncertainty structure, like the decision structure, can be simple or complex.

The decision to be analyzed can be as straightforward as choosing a pump replacement type, as complex as pursuing alternative technologies, or choosing a company- or organization-wide strategy. This RP includes examples of each.

[1] Further discussion of elements of DA are found in AACE's RP 85R-14, *Use of Decision Trees in Decision Making* [10], RP 57R-09, *Integrated Cost and Schedule Risk Analysis Using Risk Drivers and Monte Carlo Simulation of a CPM Model* [16], RP 41R-08, *Understanding Estimate Ranging* [15], RP 104R-19, *Cost Estimate Accuracy Range and Contingency Determination Using Tables Derived from Parametric Risk Models* [17], and 127R-23, *Choosing Among Strategic Alternatives Using Branching Concepts in Decision Modeling* [33].

July 21, 2025

There are several tools the decision support team can employ to structure and analyze decision alternatives. The simplest decisions require only a few of these. These tools are introduced as they are needed in going from the simple decision example to more complex decision and uncertainty structures. With the help of these tools, decision analysts can enhance their ability to structure and analyze a wide range of decisions, whether simple or complex, that they may encounter in their work.

2.1. Background

The discipline of decision analysis (DA) was developed in the late 1960s and early 1970s by Howard Raiffa at Harvard University [3] and Ron Howard [4] [5] at Stanford University. Much of the methodology and tools development occurred and resided within the business consulting community. Publications such as *Readings on the Principles and Applications of Decision Analysis* [5] and *Foundations of Decision Analysis* [1] provide useful references.[2] [3]

Multiple software packages provide tools for analysts. Many are listed and compared according to their analytic capabilities by INFORMS, an organization for operations research and analytics. [6]

2.2. The Basics

A decision is an allocation of resources to a chosen alternative. A decision is not formal until resources are identified and allocated. DA treats this choice within the context of uncertainty, and both provides numeric analytic methods and a process structure that enables and guides the organizational decision-making apparatus. The mechanics of each are developed in this section. The goal is to identify the best choice among a set of possible alternatives given insights into the strengths, risks and uncertainties of each that meet enterprise-level objectives.

2.2.1. Components of a Decision

Every decision has three components: (1) things we control (alternatives we can choose); (2) things we don't control (uncertainties); and (3) things we want (values). Each component can be simple or complex.

2.2.2. Components of the Decision Process

DA is most effectively undertaken in a multi-step decision process: (1) *Frame,* (2) *Analyze,* and (3) *Decide & Commit*. To these is frequently added a fourth, (4) *Execute*. The first three steps are the domain of the decision proper, where it is decided both ***what*** to execute and ***to execute*** it. Without execution the decision's objectives will not be met, therefore step (4) is critical to delivering decision value. For a fuller description of both the decision-making portion of the process and the execution phase, see AACE's Total Cost Management Framework, Section 3.3 and Chapter 4. [2]

To begin with, identify the decision maker (or decision makers if the decision is large and cross-organizational and/or comprises multiple stakeholders). Formally, a decision is a commitment of resources, unless the decision is to do nothing. Therefore, the decision maker controls the execution funding. For a small scale decision (e.g., a pump replacement) the budgetary authority may rest in a single person (e.g., a supervisor). For a large-scale decision (e.g.,

[2] Schuyler describes the use of risk and decision analysis in projects [29]; Leach explains the importance of using uncertainty ranges and resisting the use of single-point forecasts [30]; Hollmann describes how to quantify risk [32].
[3] The Society of Decision Professionals' library provides a rich array of training and other resources for use by decision analyst: https://www.decisionprofessionals.com

involving company-wide strategy) the authority may rest with the CEO joined by their senior executive team, which considers cross-organizational implications. For decisions large enough to have enterprise-defining impacts, the ultimate decision maker may be the Board of Directors.

At any level, organizations find it useful to embed this sequence in a project management structure where decision makers and a decision support team engage in a structured dialogue over a specified period with scheduled periodic check-ins. Figure 1 shows the four-step process, a highly structured interaction between the decision makers and the decision team that assures decision quality:

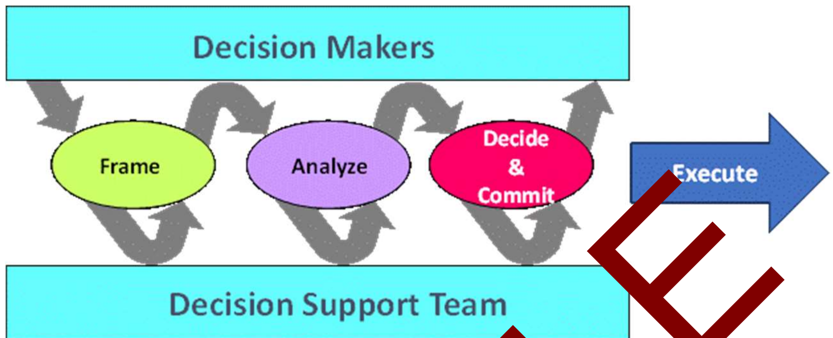

Figure 1. The Four-Step Process to Assure Decision Quality

Decision makers drive the process from the outset and are informed at the beginning that they are accountable to make a decision by a specified future date, even if that decision is "do nothing." They are responsible for designing the decision frame, certifying the analysis, and ultimately making the decision. The decision support team helps the decision makers frame the decision, provides the analytical tools/models/methodologies, assesses uncertainty ranges, and delivers the analytical results.

The *Frame* step is a critical and often short-changed step that occurs before any analysis is undertaken. A frequent mistake is not considering the whole space of potential decision alternatives. This can be summed up in one sentence: *The best way to ensure that you don't choose the best alternative is not to consider it in the first place*. It is worth spending considerable effort to get the frame right.

The *Analyze* step involves a multiplicity of DA tools and methods. This RP describes these, and all the associated process steps, for both simple and complex decisions.

The *Decide & Commit* step combines two seemingly separate elements, but they are a single event. A decision is a commitment of resources – a *commitment* to act and the funding to support that execution. In this step, the decision is to implement the chosen strategy and commit the needed resources. (A decision is not truly made until resources are allocated.) This process assures organizational buy-in and commitment. This action then initiates execution. The execution that follows, depending on its complexity, may itself involve the need for DA methods. For the execution step of the decision, see AACE's Total Cost Management Framework, Chapter 4. [2]

For complex decisions the *Execute* step may include further downstream decisions identified in the *Frame* step, but temporarily set aside as tactical, not strategic. Note that "tactical" does not necessarily mean "small" (e.g., in a refinery modernization strategy, the decisions on the capacity of a hydrocracker and/or the vendor chosen to supply it). The approach to identifying such tactical decisions is described in Section 2.5, which gives further guidance on the overall process. Further, "tactical" must be distinguished from "non-critical." A decision may seem small in monetary outlay terms but it can have a very consequential influence. For instance, it can be the case that failure of an otherwise inexpensive component in a production chain could shut down the operation of an entire enterprise.

July 21, 2025

2.2.3. Decision Quality

Ensuring quality in a decision requires both *quality in the elements* of that decision and *quality in the process* of arriving at that decision.

Quality in the elements is best depicted by the Decision Quality Chain developed by Carl Spetzler, Ron Howard and their colleagues at Strategic Decisions Group [7] [8], shown in TCM 3.3.1.2 and reproduced in Figure 2. The quality of the chosen strategy alternative is only as strong as the weakest link in this chain. Each link in the chain is described further in TCM 3.3.1.2.

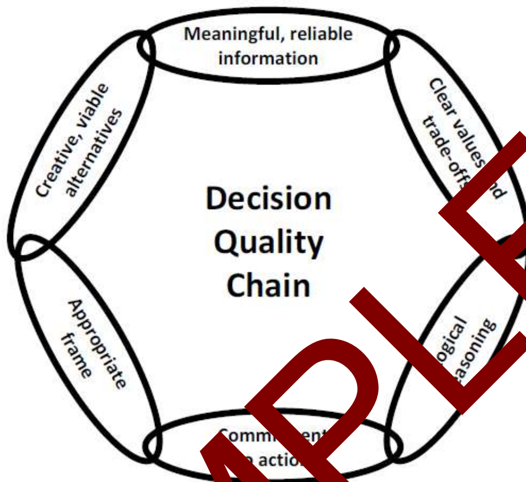

Figure 2. Decision Quality Chain

A key part of *quality in the process* is addressed in the link labeled "Commitment to action." A common mistake is failing to include the final decision maker(s) from the beginning. Frequently, a team starts out with individuals without decision making authority; they go through the process and put forward a recommendation to the higher-level final decision maker(s) for approval. This puts them in the role of trying to "sell" the strategy choice upward. This effectively disenfranchises the final decision maker(s), leaving them only three choices: they can say "yes;" they can say "no," or, as is very often the case, they can say, "go back and do it again." In the worst case, this creates a repetitive loop. Besides harming quality, this is highly inefficient.

To generate organizational buy-in and commitment from the outset, it is best to give the final decision maker(s) the central role in framing, evaluating the analysis, and forming the final strategy choice. This gives them a stake in that strategy choice. Commitment is built along the way.

This approach can be likened to the arguably canonical *process quality* approach put forward by Deming. [9] A key dictum of Deming is to "Cease dependence on inspection to achieve quality." A real-world example of this is the automobile industry, which Deming revolutionized.[4] Rather than have inspectors at the end of the production line culling vehicles with problems for repair (where possible), Deming's process required line workers and production managers to ensure quality at each station of the assembly line.

The above example of the faulty process of leaving final decision maker approval until the final step is akin to trying to achieve decision quality by "inspecting it in" after the recommendation has been developed, rather than having final decision makers build in quality beginning with the first step of the decision process. (Guidance on this quality

[4] Toyota implemented Deming's process after US automakers rejected him. The US automakers belatedly followed, victims of the obvious competitive disadvantage inflicted on them by the Japanese auto industry.

July 21, 2025

imperative is found in section 2.5 detailing specific methods to build in quality at each step of the strategy development process.)

2.2.4. Good Decisions vs. Good Outcomes and Accountability

From its earliest beginnings, DA has promulgated the following principle: *It is important to distinguish between good decisions and good outcomes*. Good decisions do not guarantee good outcomes when uncertainties are involved. One can make a good decision and have a good outcome; one can make a good decision and have a bad outcome; one can make a bad decision and have a good outcome (one gets lucky); or one can make a bad decision and have a bad outcome. Following the DA process correctly increases the *likelihood* of a good outcome but does not guarantee it. This makes instituting organizational accountability a more nuanced proposition. It suggests that it is better to reward good decisions than good outcomes. Accountability would then rest on whether the decision makers have adhered to the Decision Quality Chain of Figure 2 and the DA process and methods. Enterprises sometimes find value in conducting reviews of past decisions given knowledge of the outcomes (lessons learned), to learn what went right or wrong and continuously improve organizational decision making.

2.3. Simple Decisions

A simple decision has few alternatives and few uncertainties. For these, a simple decision tree will suffice for the A*nalyze* phase. A more extensive formal development of decision trees can be found in AACE Recommended Practice 85R-14, *Use of Decision Trees in Decision Making*. [10] The following example illustrates and discusses the tools and methods used.

2.3.1. Pump Replacement Decision – Background

Engineers at an oil refinery notice instrumentation signals indicating a pump will need to be replaced at the next scheduled maintenance outage. The pump services a critical unit supplying intermediate product to other units in the refinery. The current pump is a bottleneck – the downstream unit it feeds can accept a much higher feed rate than the current pump can deliver owing to recent improvements in that unit, which was itself a bottleneck to units downstream of it.

The decision maker is the refinery senior process engineering supervisor, who has the sole authority to approve pump replacement. This person assembles a team of engineers, pump specialists, and the refinery decision support team. The supervisor has the responsibility to ensure downstream units do not suffer unplanned outages. At the outset, she explicitly excludes the option to do nothing; the pump must be replaced. (It is noted that there could potentially be an alternative, *do nothing*; this is an often legitimate and frequently overlooked alternative to consider, though not the case here.)

After a careful situation appraisal, the team secures two bids from suppliers for two different pumps. Pump A has a higher cost than Pump B, but it has a higher nameplate[5] throughput (880 barrels/day or "b/d"). Pump B has a lower nameplate throughput (800 b/d), but it is cheaper. Higher throughput for the pump means higher refinery output through a complex set of downstream units' feed rates, and so will result in higher revenue. However, the higher cost could reduce profitability if not sufficiently offset by such revenue benefits. The cost of Pump A is $650,000 and Pump B is $520,000.[6]

[5] In the process industries, the nameplate identifies the manufacturer's specified design capacity of the pump.
[6] It was determined that the cost of installation, annual energy and maintenance costs, and any other recurring cost were the same for pump A and pump B.

July 21, 2025

2.3.2. Pump Replacement Decision – Alternatives and Uncertainties Structure

The decision alternatives are clear: choose Pump A or Pump B.

There is only one uncertainty to contend with: the throughput of each pump is uncertain – the pump may meet, fall short of, or exceed its nameplate throughput.

The value realized from each alternative comprises two elements. The first is the cost of the particular pump, which is known from each supplier's bid. The second is the value of refinery output lost or gained if the pump realizes either lower or higher throughput than the current pump. Figure 3 constitutes the *frame* of this simple decision problem:

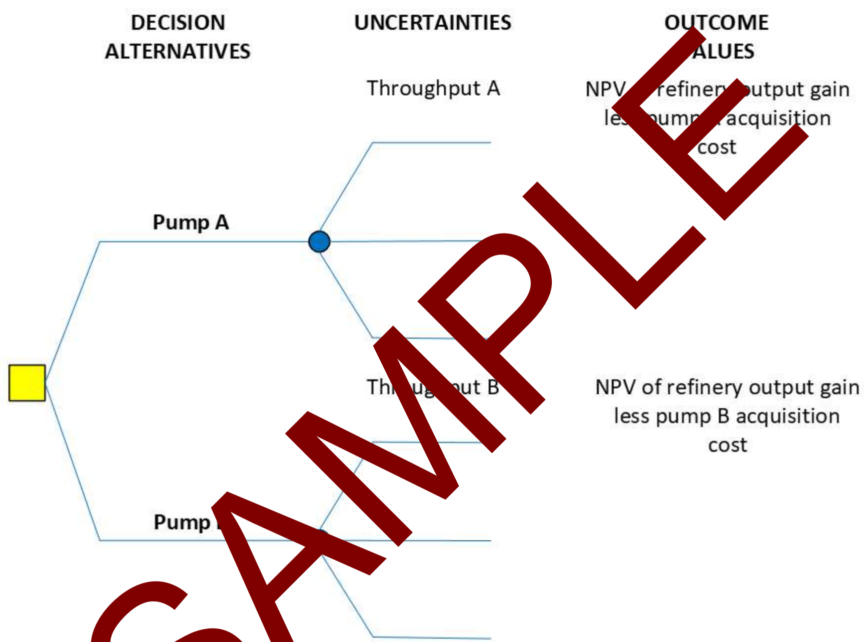

Figure 3. Pump Replacement Decision Tree

The next four sections show the *Analyze* steps.

2.3.3. Pump Replacement Decision – Assessing Uncertainties

Outcome values will in general be different for each of the six branches and may require some modeling to calculate. The uncertainty nodes require some description. They are shown above with three discrete branches, though the uncertainty itself is a continuous distribution (a probability distribution of a variable that does not take on discrete values, but rather any real value over a specific range). It can be shown that the continuous distribution can be represented by discrete counterparts to support mathematical evaluation (discretization[7]) in this way, as discussed in Appendix B.

[7] Discretization is the process of converting continuous data into discrete data. Often used in applied mathematics and machine learning.