INTERNATIONAL

TOTAL COST MANAGEMENT FRAMEWORK®

An Integrated Approach to Portfolio, Program, and Project Management

SECOND EDITION

H. Lance Stephenson, CCP FAACE, Editor

Total Cost Management Framework

An Integrated Approach to Portfolio, Program, and Project Management

Second Edition

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Total Cost Management Framework
Second Edition

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Total Cost Management Framework

An Integrated Approach to Portfolio, Program, and Project Management

Second Edition

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PREFACE

What Is the Total Cost Management (TCM) Framework?

Total cost management (TCM) is the effective application of professional and technical expertise to plan and control resources, costs, profitability and risk. Simply stated, TCM is a systematic approach to managing cost throughout the life cycle of any enterprise, program, facility, project, product or service. The *TCM Framework* is a representation of that systematic approach.

The *TCM Framework* is a structured, annotated process map that explains each practice area of the cost engineering field in the context of its relationship to the other practice areas including allied professions. It provides a process for applying the skills and knowledge of cost engineering. A key feature of the *TCM Framework* is that it highlights and differentiates the main cost management application areas: *project control* and *strategic asset management*.

Those working in the project management field will find similarities with the Project Management Institute's (PMI) *A Guide to the Project Management Body of Knowledge (PMBOK Guide)* as project control is a subset of the field of project management. With a greater focus on project control, the *TCM Framework* enhances many of the processes. More importantly, the *TCM Framework* addresses *strategic asset cost management* practices in business and capital planning, operations and maintenance, and product cost management, both upstream and downstream of the project processes. Asset owner companies will particularly appreciate the enhanced coverage of areas such as historical data management, cost modeling, economic and decision analysis, and value analysis.

The *TCM Framework* is a significant contribution to the cost management profession applicable to all industries. It is an AACE cornerstone technical document that joins the current body of knowledge for related fields such as project management, operations management, and management accounting. It is also consistent with organizational and portfolio thinking which ties all practices and processes back to overall business strategies and objectives.

As a framework, this document is a conceptual representation that provides a structured, integrated overview of cost engineering. It will guide AACE International's development of more detailed technical products including the following:

- *Recommended Practices (RPs)*: original, peer-reviewed documents that define the specifics of particular methods or procedures outlined in the *TCM Framework*,
- *Professional Practice Guides (PPGs):* a set of structured, edited compilations of selected AACE publications on specific areas of cost engineering,
- *Cost Engineer's Notebook* (*CEN*): a single structured, edited compilation of selected AACE publications that provides an overview of all the key fundamental areas of cost engineering.

The *TCM Framework's* structure provides consistency and supports development of AACE Education Board (e.g., *Skills and Knowledge of Cost Engineering* and certification study guides) and Certification Board (e.g., certification examinations) products.

The intent is that the *TCM Framework* will be studied, applied, and continuously improved by a worldwide audience from all industries, thereby advancing the profession of cost engineering and cost management.

The Value of the TCM Framework for Industry

Companies are continually looking for ways to tie everything they do to their strategic missions and objectives. As they strive for better strategic performance, they are frequently re-engineering their organizations. To find efficiencies and improve quality, they are documenting, benchmarking, analyzing and improving business and work processes. For the many enterprises seeking ISO certification a process focus is required.[1] TCM provides a strategic model that can help an organization design its own processes related to cost management.

Likewise, re-engineering increases the challenges for individual professionals as employers break down functional silos and increasingly expect staff and leaders to be competent in many different practices, while also being more knowledgeable of business processes. For individuals, the *TCM Framework* provides a map to help them understand all the practice areas while also helping guide their career planning.

In the academic arena, the *TCM Framework* provides a model for developing cost engineering education and training products and curricula that will serve those individuals and enterprises in need of a broader, more integrated perspective.

How to Use the TCM Framework

Because the *TCM Framework* process is based on broadly accepted first principles (i.e., the Deming/Shewhart cycle) and it applies to all industries. It can be used by all levels of practitioners and in all business, academic, and institutional environments (customers, subcontractors, government, prime contractors, construction managers, design-build, etc.) worldwide. It also applies to the entire life cycle of asset and project portfolios.

It is a *generic reference* process model or guideline. It is not intended to be used directly out-of-the-box in any specific application. Managers, practitioners, educators, and others will need to build their own processes and improve practices in the context of their business, and their organization, culture, project systems, etc. As a generic reference model, the *TCM Framework* has been successfully tested in reengineering consulting and training.

The *TCM Framework* can be read and applied section-by-section at a sub-process or functional level. However, optimal effectiveness of a sub-process requires that it be developed in the context of and in relationship to associated sub-processes that share common strategies and objectives. In that respect, all readers with limited interest or time should understand the *Part 1* overview sections before focusing on the sections and sub-processes of interest.

TCM Online

An enhanced online edition of the TCM Framework incorporates additional key AACE resources such as recommended practices (RPs). In each section of the TCM Framework, there will be links to RPs that are applicable to that particular section. RPs provide additional detail that supplement key TCM concepts and processes. The online version is a living document that will change each time a new or revised RP is published.

The online edition of TCM is a product of the AACE Technical Board and is available on the AACE website at web.aacei.org.

[1] International Organization for Standardization ISO 9000 and its family of related standards is focused on an enterprise having, maintaining, and following documented process and procedures.

Introduction to the First Edition

The *TCM Framework* had its beginnings in 1994 as an effort to develop a professional handbook to be called *AACE International's Total Cost Management Guide for the 21st Century* with Wes Querns as the editor. A significant and successful effort was made to enlist recognized leading professionals in their respective fields as contributing authors and a publisher was lined up.[2] However, as the *Guide's* scope was defined, it became apparent that a book with independent experts covering the traditional cost engineering topics in their own ways would not provide the required *systematic approach*. Therefore, in 1995, the *Guide* project was re-scoped as the *Framework* project.

In 1996, the high level TCM process was published in an article in *Cost Engineering* journal entitled "A New Look at Total Cost Management", authored by John Hollmann. At this time John became the lead author and editor for the Framework working in association with the Technical Board. The Technical Board solicited member comment via a special survey and we drafted the introductory chapters (now Part I). These overview chapters were subjected to considerable review and consensus building (during what may be called phase one) until 2002 when the introductory chapters were formally published.[3]

Completing the remaining 30 sections was not so much a traditional writing process as a process reengineering project for the editor and contributors. The effort consisted of taking common practice knowledge about cost engineering and allied fields, breaking it down into steps, connecting the steps based on a time honored management process model, and finishing it with consistent narrative using a *single voice*. Once again, the support of leading professionals was sought to assist in the development. The value of the resulting product is in *integration and structure,* not new practices, how-tos, or narratives.

The product was then reviewed by AACE's Technical Committees, the main and associate AACE Boards, and other subject matter experts. Comment was sought from related associations as well. The review and approval process used was the same stringent approach that AACE uses for its recommended practices. This multi-stage process requires formal requests for comment, documented comment disposition, and Technical Board approval to ensure that general consensus is achieved.

Introduction to the First Edition Revised

This revision included two completely rewritten sections; *3.3 Investment Decision Making* and *7.6 Risk Management*. These resulted from work to improve AACE's technical foundation for the Decision and Risk Management Professional (DRMP) Certification.

Introduction to the Second Edition

The second edition enhanced the process maps through the use of color to emphasize the plan-do-check-act (PDCA) steps integral to TCM. In addition, it incorporates minor edits to the process maps and associated narrative.

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[2] Many of these experts provided early outlines or draft chapters for the cancelled *Guide.* They are listed in the Contributors section. Some of these experts are also acknowledged as author/key contributors for *Framework*.

[3] Individuals that commented at that time are included among the contributors listed in the Contributors section.

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The Technical Board acknowledges the significant efforts by John Hollmann to guide the development of the *TCM Framework* from its inception in 1994 through completion in 2006. John served as lead editor and primary author for the First Edition. He contributed a substantial amount of his personal time and resources toward this very important effort.

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I. INTRODUCTION TO TOTAL COST MANAGEMENT

CHAPTER 1 - INTRODUCTION

1.1 Definition of Total Cost Management

1.1.1 Total Cost Management and Related Terminology

The Constitution of AACE International provides the following definition of total cost management (TCM):

"Total cost management is the effective application of professional and technical expertise to plan and control resources, costs, profitability and risks. Simply stated, it is a systematic approach to managing cost throughout the life cycle of any enterprise, program, facility, project, product, or service. This is accomplished through the application of cost engineering and cost management principles, proven methodologies and the latest technology in support of the management process."

Put another way, total cost management is the sum of the practices and processes that an enterprise uses to manage the total life cycle cost investment in its portfolio of strategic assets.

For example, a real estate developer may build, maintain, renovate, and then demolish an office building during its life cycle—at each phase of the building life cycle the developer makes significant investments. To manage these investments, the building developer monitors building operating costs and profitability; evaluates alternative investment opportunities; and initiates, plans, and controls improvement projects. These activities are all within the scope of the TCM process.

Costs in TCM include any investment of resources in the enterprise's assets including time, monetary, human, and physical resources. *Total* refers to TCM's comprehensive approach to managing the total resource investment during the life cycle of the enterprise's strategic assets. The enterprise can be any endeavor, business, government, group, individual, or other entity that owns, controls, or operates strategic assets.

Strategic asset is shorthand for any unique physical or intellectual property that is of long term or ongoing value to the enterprise. For most cost engineers, strategic assets equate to capital assets; however, the term strategic asset is more inclusive (e.g., may include things that are considered expenses). The asset may be a building, an industrial plant, a software program, or a stage production. Strategic asset investments are made through the execution of projects or programs. Projects are temporary endeavors for creating, modifying, maintaining, or retiring strategic assets. Products and services may be considered strategic assets in that before a product can be made or a service performed, many investments must be made through the execution of projects for research, development, design, and so on.

As an example of where TCM fits within a company's undertakings, consider a company that designs and manufactures integrated circuits. The chip's design is a strategic asset of the company created through the execution of research and design projects. In order to fabricate a new chip, the company develops a unique manufacturing process or layout—that process design or layout is also a strategic asset developed through the execution of projects. Next, a project is performed to design, procure, and build the plant for fabricating the microchips—the physical plant is another strategic asset. Finally, workers are hired and trained to operate the plant. Worker skill and knowledge are strategic assets and their initial training and plant start-up are executed as projects. The new plant must be maintained and eventually decommissioned. Each component of the chip maker's strategic asset portfolio requires investments realized through the execution of projects whose cost must be managed. Each component of the company's asset portfolio has its own life cycle with cost investments to integrate over time. The complex interaction of the asset portfolio component costs over their various life cycles and during operations calls for a total cost management process.

One way that TCM adds value to the body of cost engineering knowledge is that it integrates areas of cost management that are too often treated as separate entities or fields. While AACE is not the subject-matter caretaker or custodian of all that is covered in the *TCM Framework*, it is important that cost engineers understand the relationships between the various fields of practice with which they are likely to interact or in which they may be expected to perform.

1.1.2 Total Cost Management's Relationship to Other Fields

TCM is an integrating process that not only maps the fields of practice of cost engineering, but it also provides links to the fields of project management, resource management, and management accounting practice.[4] TCM provides a unique technical perspective that is often missing from financially focused approaches (hence the term cost engineering). Figure 1.1-1 illustrates how TCM, with roots and emphasis in project management and project control, has a balanced focus on product and capital costs, project and operational work processes, and resources of all types. In other words, it covers the total costs of the business.

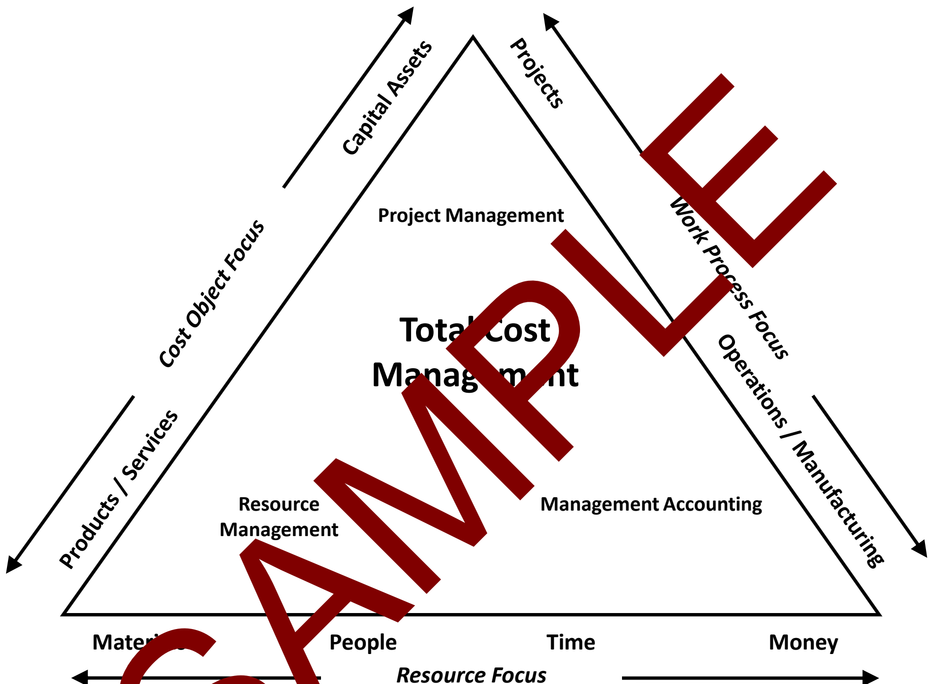

Figure 1.1-1 TCM's Place in the Cost Management Spectrum

Recently, project management models have been enhanced to better address pre-project processes, project portfolios, and consideration of overall business organization strategies. An example is the *Project Management Institute's Organizational Project Management Maturity Model (OPM3)*. However, these models still do not cover production and operation management and costs to the extent addressed by TCM.

Product and operations costs have been the focus of the resource management and management accounting fields. Resource management's developments in enterprise resource management (ERP) and management accounting's developments in activity-based-costing (ABC) are significant advancements that are incorporated in TCM. However, unlike TCM, those fields have focused on product costs and typically address capital project costs as an incidental cost (i.e., depreciation) as it affects products.

In summary, TCM is unique in that it integrates the best approaches from all the major fields that have cost management interests while emphasizing cost engineering's practices and major role in them all.

[4] See the Further Reading and Sources section for references to the organizations that are primary caretakers for the project management, resource management, and management accounting bodies of knowledge.

1.2 Purpose and Uses of the TCM Framework

The purpose of the *TCM Framework* is to provide an integrated and theoretically sound structure upon which AACE recommended practices (RPs) can be developed for those areas of TCM for which AACE is the primary caretaker.[5] The *Framework* achieves this objective by establishing an integrated process map of TCM. The process map helps ensure that RP products are consistent with each other and free of unnecessary duplication. As the structure for RP products, the *Framework,* by extension, also provides a technical framework that all AACE International educational and certification products and services can use.

Having achieved its primary purposes, there are many other possible uses of the *Framework*. For example, the *Framework* defines key concepts and terminology[6], and provides illustrations that can aid communication between cost engineering practitioners. This is particularly important because cost management is practiced in a myriad of enterprises such as construction, manufacturing, software development, real estate development, healthcare delivery, and so on. Also, practitioners striving for functional excellence may lose sight of overall cost management objectives.

In addition, students and newcomers to the cost management field can gain a broad understanding of the field from the *Framework.* For educators, the *Framework* can provide the structure for a course that can be enhanced with selected readings. Companies and skilled cost engineering practitioners that are looking for better ways to tie their disparate cost functions and asset management into an effective system will find that the *Framework* adds structure and value to their efforts. The *Framework* also provides a conceptual process model on which professionals can benchmark or pattern cost management work processes and practices within their enterprises.

[5] AACE's Constitution defines the areas of association focus as follows: "Total Cost Management is that area of engineering practice where engineering judgment and experience are utilized in the application of scientific principles and techniques to problems of business and program planning; cost estimating; economic and financial analysis; cost engineering; program and project management; planning and scheduling; and cost and schedule performance measurement and change control." Furthermore, AACE's Recommended Practice 11R-88, "Required Skills and Knowledge of Cost Engineering" specifies cost engineering knowledge that is "core" (i.e., recommended that professional cost engineers know) and identifies skills that are recommended for individuals to put that core knowledge into practice.

[6] Where concept definitions are provided, they are consistent with AACE's primary terminology reference: Recommended Practice 10S-90, "Cost Engineering Terminology."

1.3 Organization of the TCM Framework

1.3.1 The TCM Framework Uses Process Management Conventions

Total cost management is a quality driven process model. As such, the *Framework* employs process management conventions. A process consists of a flow of inputs and outputs with mechanisms that transform the inputs to outputs. The *Framework* maps the process flows of TCM. The transforming mechanisms or activities are referred to as tools, techniques, or sub-processes. The inputs and outputs of TCM consist primarily of data and information.

1.3.2 The TCM Framework Uses a Standard Organization Structure

The *Framework* is organized into parts, chapters, and sections. The chapters correspond to the process elements (i.e., blocks) in the high level TCM process map that is illustrated and described later in Section 2.2. Figure 1.3-1 below illustrates how the chapters and key sections can be grouped by basic, overarching processes, functional or working processes, and enabling and supporting processes.

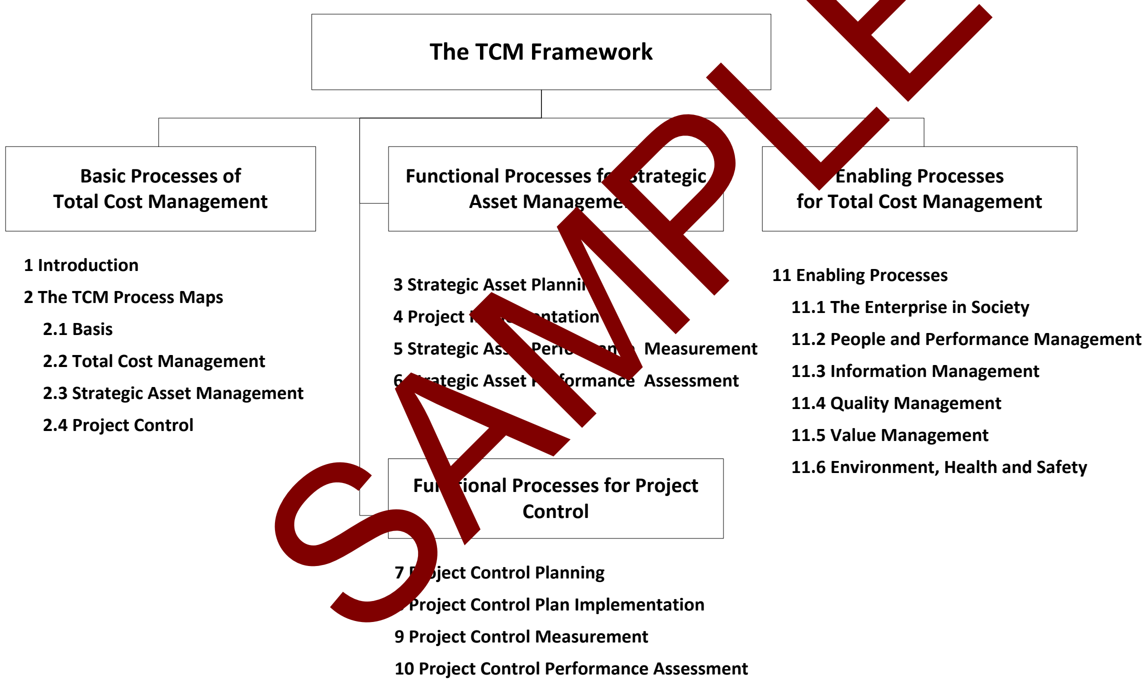

Figure 1.3-1 The Structure of the Framework's Parts and Chapters

The sections in each chapter correspond to the functional level process steps that are illustrated and described later in Sections 2.3 and 2.4. The process sections are organized as follows (for the enabling processes, maps, inputs, and outputs are not applicable and are excluded):

x.x.1 Description of the Process
x.x.2 Process Map
x.x.3 Inputs to the Process
x.x.4 Outputs of the Process
x.x.5 Key Concepts and Terminology for the Process

1.4 Key Introductory Concepts and Terminology for Total Cost Management

1.4.1 *Total Cost Management* - The sum of the practices and processes that an enterprise uses to manage the total life cycle cost investment in its portfolio of strategic assets. Describes the process employed in the profession of cost engineering.

1.4.2 *Resource Management* - (1) The effective planning, scheduling, execution, and control of all organizational resources to produce a good or a service that provides customer satisfaction and supports the organization's competitive edge and, ultimately, organizational goals. (2) An emerging field of study emphasizing the systems perspective, encompassing both the product and process life cycles, and focusing on the integration of organizational resources toward the effective realization of organizational goals. Resources include materials; maintenance, repair, and operating supplies; production and supporting equipment; facilities; direct and indirect employees; and capital.[7]

1.4.3 *Project Management* - The methodical application of management knowledge, skills, and practices to project activities in order to meet project objectives.

1.4.4 *Management Accounting* - The process of identification, measurement, accumulation, analysis, preparation, interpretation, and communication of financial information used by management to plan, evaluate, and control within an organization and to assure appropriate use of and accountability of its resources.

1.4.5 *Costs and Resources* - Any investment of time, money, human effort, or physical objects in the enterprise's products, services, and assets.

1.4.6 *Strategic Asset* - Any unique physical or intellectual property of some scope that is of long term or ongoing value to the enterprise.

1.4.7 *Enterprise* - Any endeavor, business, government entity, group, or individual that owns or controls strategic assets.

1.4.8 *Process* - A flow of inputs and outputs with mechanisms that transform the inputs to outputs.

1.4.9 *Projects* - A temporary endeavor to conceive, create, modify, or terminate a strategic asset.

1.4.10 *Operations* - Ongoing endeavors that use strategic assets.

1.4.11 *Life Cycle* - Describes the stages or phases that occur during the lifetime of an object or endeavor. A life cycle presumes a beginning and an end. The asset life cycle describes the stages of an asset's existence, and the project life cycle describes the phases of a project's endeavors.

1.4.12 *Life Cycle; Asset* - Describes the stages of asset existence from ideation through termination during the lifetime of an asset.

1.4.13 *Life Cycle; Project* - Describes the stages of project progress from ideation through closure during the lifetime of the project.

[7] *APICS Dictionary*, 9th ed., James F. Cox and John H. Blackstone (www.apics.org).

CHAPTER 2 - THE TOTAL COST MANAGEMENT PROCESS MAP

2.1 Basis of Total Cost Management Processes

This section describes the fundamental basis or foundation of the TCM process and defines the process mapping conventions used in the *Framework*. Sections 2.2, 2.3, and 2.4 further describe the respective processes of TCM, strategic asset management, and project control.

2.1.1 TCM Is Based on Process Management Principles

The pursuit of increased productivity and quality has been a driving force of worldwide business management for decades. Process management and process reengineering emphasize the need for enterprises to identify their work processes and continually improve them. Effective processes are needed to support continuous quality improvement while nurturing innovation and change without chaos.

TCM as described in the *Framework* is a process map that supports continuous process improvement while being flexible. It is not intended to be a set of rigid rules or work procedures. While each of the sub-process maps of TCM may look rigid when set on paper, users may chose to emphasize those process steps that are most critical to their situation. Steps can be skipped when they are not applicable and information flows can be modified to suit the needs of the enterprise. If the enterprise or market is growing, the emphasis can be placed on asset creation and scheduling aspects. On the other hand, if the enterprise or market is mature, the emphasis may be put on asset maintenance and cost aspects. In practice, the processes are quite flexible.

In addition, TCM supports cross-functional integration and multi-skilling. Few enterprises in a dynamic environment can afford to have cadres of functional specialists. However, multi-skilling may come at the price of having less experience, skill, and knowledge than desired in any one function. Weaknesses in individual skill and knowledge place a premium on having reliable, integrated processes like TCM.

2.1.2 The Basic TCM Process Model—Plan, Do, Check, and Act (PDCA)

The TCM process model is based upon the PDCA management or control cycle, which is also known as the Deming or Shewhart cycle. The PDCA cycle is a generally accepted, quality driven, continuous improvement management model. PDCA stands for plan, do, check, and act, with the word *check* being generally synonymous with *measure*. *Act* as in *to take corrective action* is sometimes substituted with the word *assess*. The PDCA cycle is the framework for TCM because (1) it is time-proven and widely accepted as a valid management model, (2) it is quality driven, and (3) it is highly applicable to cost management processes, which are cyclical by nature.

The PDCA cycle in TCM includes the following steps:

- **Plan** - plan asset solutions or project activities
- **Do** (i.e., execute) - initiate and perform the project or project activities in accordance with the plan
- **Check** (i.e., measure) - making measurements of asset, project, or activity performance, and
- **Act** (i.e., assess) - assessing performance variances from the plan and taking action to correct or improve performance to bring it in line with the plan or to improve the plan.

Throughout this book, colors are used to indicate the four steps of the PDCA cycle:

PLAN	**DO**	**CHECK (MEASURE)**	**ACT (ASSESS)**

These steps are repeated as activities and time progress until such time as the asset or project life cycle is complete. Figure 2.1-1 illustrates the PDCA process steps.

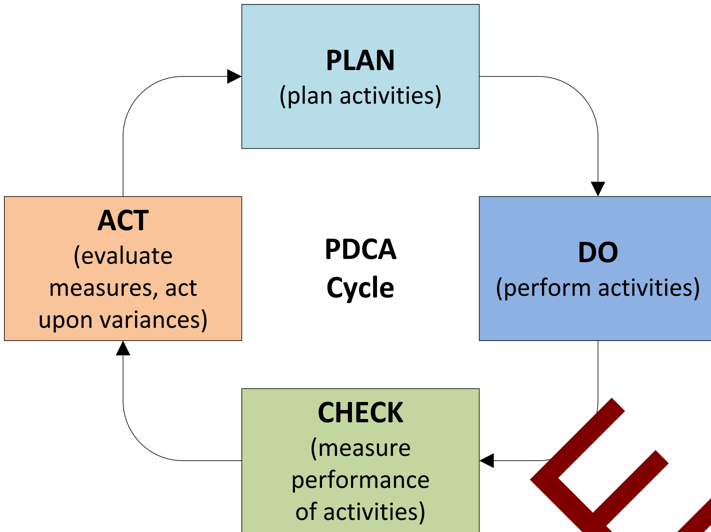

Figure 2.1-1 The Plan, Do, Check, Act Cycle

Two underlying tenets of the PDCA process cycle and process management in general are that:

- you can’t manage what you can’t measure
- whatever you measure tends to improve

Measurement is a key element that is often lacking in management systems that focus on planning. However, use caution in what and how you measure—“playing for score” is not the way to achieve the desired improved outcomes.

A cyclical process model is useful because strategic assets and the projects that create them each have an inherent life cycle. With each stage or phase of the asset or project life cycle, successive iterations of the cost management process are required. Each iteration of the cycle achieves a new or improved level of performance or progress for the asset or project.

2.1.3 The Asset Life Cycle

The PDCA control process takes place within the context of the asset and project life cycles. The life cycle describes the stages or phases that occur during the lifetime of an object or endeavor. The stages or phases are sequential groupings of processes that result in an intermediate deliverable or progress milestone.

While the life cycle for a given asset has a defined beginning and end, the process actions are not a straight line—an asset is usually modified and recycled many times with ongoing ideation leading to changes and improvements. The life cycle of a strategic asset can be summarized in five stages as follows:

1) **Ideation** - recognize an opportunity or need for a new or improved asset; evaluate, research, develop, and define optional asset solutions that address the opportunity; and select an optimum asset solution.
2) **Creation** - create or otherwise implement the asset solution through execution of a project or program.
3) **Operation** - deploy or put the new or modified asset into service, function, production, operation, or other use.
4) **Modification** - improve, modify, or otherwise change or recycle the asset through execution of a project or program.

5) **Termination** - decommission, close, retire, demolish, remove, dispose, or otherwise terminate the asset from the enterprise's portfolio (often through execution of a project or program).

Resource investments are made via the execution of projects during the asset ideation, creation, operation, modification, and termination phases. Figure 2.1-2 illustrates the asset life cycle of a factory as it passes through time.

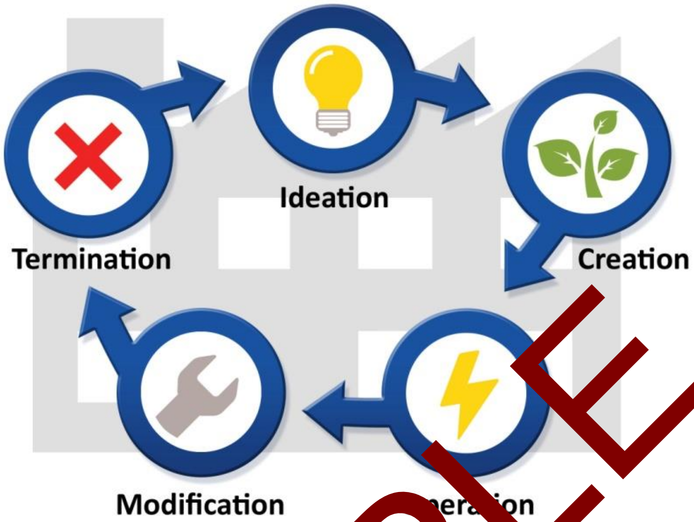

Figure 2.1-2 Asset Life Cycle of a Factory

2.1.4 The Project Life Cycle

Within the life cycle of an asset, projects are temporary endeavors for the ideation, creation, modification, or termination of assets. Projects have a defined beginning and end. In the asset life cycle, only operation is not generally considered a project endeavor. However, there may be many projects within the operation phase of an asset to maintain, relocate, modify, repair, enhance, or otherwise improve the utility of the asset. The elements of the project life cycle are often referred to as phases. Each phase yields one or more deliverables or outputs that become resources or inputs for the following phase. The deliverable may be a requirements document, a plan, a design document, a model, and so on. The life cycle of most projects can be summarized in four sequential phases as follows:

1) **Ideation** - given overall requirements of the project, the project team assesses alternative concepts for performing the project and selects an optimal performance strategy. Strategic performance requirements for the project are established.
2) **Planning -** project plans are developed that address the strategic requirements and selected performance strategy.
3) **Execution** - the plans are implemented through the execution of planned project activities.
4) **Closure** - the asset or deliverable is reviewed, tested, verified, validated, and turned over to the customer. Learnings for future use in ideation are documented.

These phases are recursive; this means that each phase may be a project in itself that produces a deliverable but not the final asset. For instance, the ideation phase has a life cycle including planning for ideation, executing the ideation process, and closure of the ideation phase (e.g., completion of a requirements document). At this recursive level, the closure of a phase usually represents a hand-off of a deliverable and achievement of a project milestone, decision point, or gate. If the deliverable does not pass the phase gate review, it is returned for correction or the project may be killed or terminated.

While the project phases discussed above are performed sequentially, they usually overlap to some extent. Fast tracking, concurrent engineering, and similar terms refer to project strategies that have highly overlapping phases to achieve faster cycle times.

2.1.5 Continuous Improvement During a Life Cycle

The two-dimensional PDCA cycle and traditional asset and project life cycle illustrations, such as Figures 2.2-1 and 2.2-2, do not adequately illustrate the concept of progress through time or continuous improvement. Two-dimensional illustrations infer that one is always returning to the starting point, or that work follows a sequential line from beginning to end. In fact, with each iteration of the PDCA cycle, the asset portfolio or project performance or state is continually improved—it does not return to its original state. An asset's life cycle may include scores of projects to modify the asset. Likewise, a project may go through many iterations of design. In addition, innovation may lead to discontinuous leaps in performance or progress.

There are many ways to illustrate the concept of continuous improvement or progress through time including cyclones, spirals, wheel and axle, and other diagrams. In each of these diagrams, the circular motion aspect illustrates some cyclical process (e.g., PDCA) while the axis or axle represents progress through time or phases. Figure 2.1-3 illustrates the TCM concept for a project life cycle with PDCA shown as a spiral. The axis represents the life cycle phases of a project from ideation through closure. The spiral attempts to show that the plan-do-check-act process is employed continually to achieve various milestones or deliverables at each phase of the project life cycle. The asset life cycle can be represented in the same way by substituting the asset life cycle phases along the axis.

Figure 2.1-3 TCM Applies the PDCA Concept throughout the Project or Asset Life Cycle

2.1.6 General Process Mapping and Diagramming

As was discussed previously, TCM is a quality driven process. Processes represent real work with which to create and deliver value to customers. A process consists of inputs, outputs, and mechanisms that transform the input to meaningful outputs. Outputs of one process may be inputs to another. The transforming mechanisms are referred to in the *Framework* as tools, techniques, or sub-processes.

These processes are illustrated in the *Framework* with block diagrams (i.e., blocks connected with arrows). The blocks represent a transforming mechanism or tool, technique, or sub-process. The TCM processes are governing or directing processes that deal with information rather than physical objects; therefore, the arrows represent the input and output flow of information or information products rather than physical objects. The arrows may be double headed indicating two-way flow or feedback. Groups of blocks surrounded by a dashed outline indicate alternative tools, techniques, or sub-processes or those performed in conjunction with each other using the same inputs and outputs. Input and output arrows that tie to separate diagrams are labeled with the related *Framework* chapter or section numbers that they tie to. Figure 2.1-4 illustrates the basic diagramming conventions used in the *Framework*.

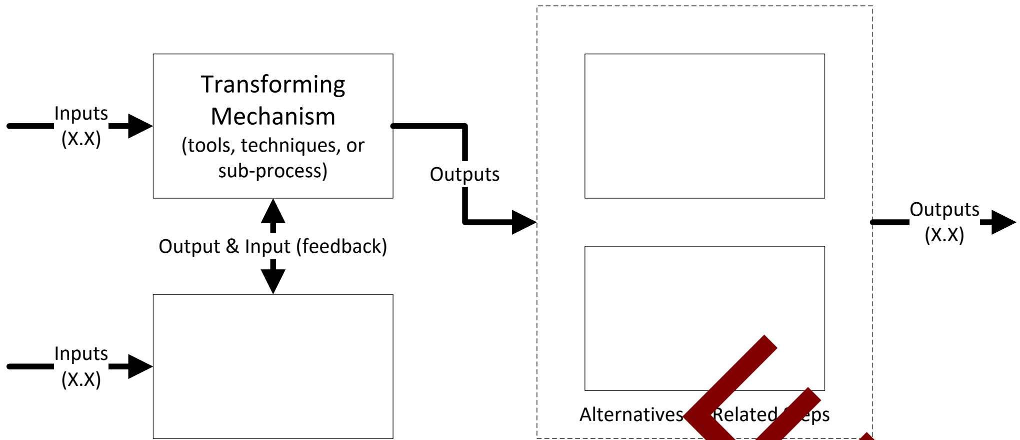

Figure 2.1-4 Process Map Representations as used in the TCM Framework

The *Framework* includes high-level, integrative process maps showing basic inter-relationships and sequencing of processes, and a rudimentary flow of information. The processes are mapped or diagrammed to the highest meaningful level of abstraction. These maps are not intended to be detailed data-flow, flow chart, procedural, logic, or other type of work definition diagrams. A process map does not show the way work is done—it attempts to balance the requirements of communication and content. A single block in a diagram may represent a complex process that would require an entire text to fully explain and document, and a single arrow may represent a large volume and variety of information and data products.

2.1.7 Key Concepts and Terminology for Processes

2.1.7.1 *Process* - A series of actions bringing about a result.

2.1.7.2 *Business Processes* - There are various types of business processes including governing, asset creating, value adding, and enabling. *TCM is a "governing" process*. Governing processes direct or control other processes. A project is an "asset creating" process in that its output is an asset. Value adding processes are those that provide enhanced outputs to the external customer. Enabling processes are those that establish or provide capabilities for the other processes.

2.1.7.3 *Process Map* - A diagram of a process that illustrates high level groupings of sub-processes and their interrelationships. A process map does not illustrate the way work is done at a detailed level.

2.1.7.4 *PDCA Cycle* (Shewhart or Deming cycle) - A basic management process first described in the 1930s. It is conducive to process management and control by inherently incorporating continuous improvement and measurement.

2.1.7.5 *Recursive Process* - A process model that repeats itself when one of the steps of the process is described at a lower level of detail. The project control sub-process of TCM is a recursive application of the PDCA process model (Section 2.2).

2.1.7.6 *Inputs and Outputs* - The inputs to projects are resources and the outputs are assets. An asset may be a resource to a downstream process. Internal to the process maps, inputs and outputs are information and information products that are produced or utilized by tools, techniques, and sub-processes.

2.1.7.7 *Tools, Techniques, and Sub-processes* - These are the transforming mechanisms and technologies that convert the inputs to outputs.

2.2 Total Cost Management Process Map

2.2.1 Description

2.2.1.1 Total Cost Management

This section builds on the information provided in the previous section by illustrating how the generic plan-do-check-act (PDCA) model is implemented in the total cost management process map.

As defined earlier, total cost management is the sum of the practices and processes that an enterprise uses to manage the total life cycle cost investment of resources in its portfolio of strategic assets. Furthermore, the maximum value of TCM can only be realized when the enterprises' practices are applied logically in an integrated process. The TCM process map is a generic outline of that integrated process.

Figure 2.2-1 shows the TCM process map (the numbers in parenthesis correspond to chapters and sections of the *Framework* that cover each step). The figure shows how the PDCA model is applied recursively (i.e., in a nested manner) in TCM—the basic process is applied for each asset and group or portfolio of assets, and then again for each project being performed to create, modify, maintain, or retire those assets.

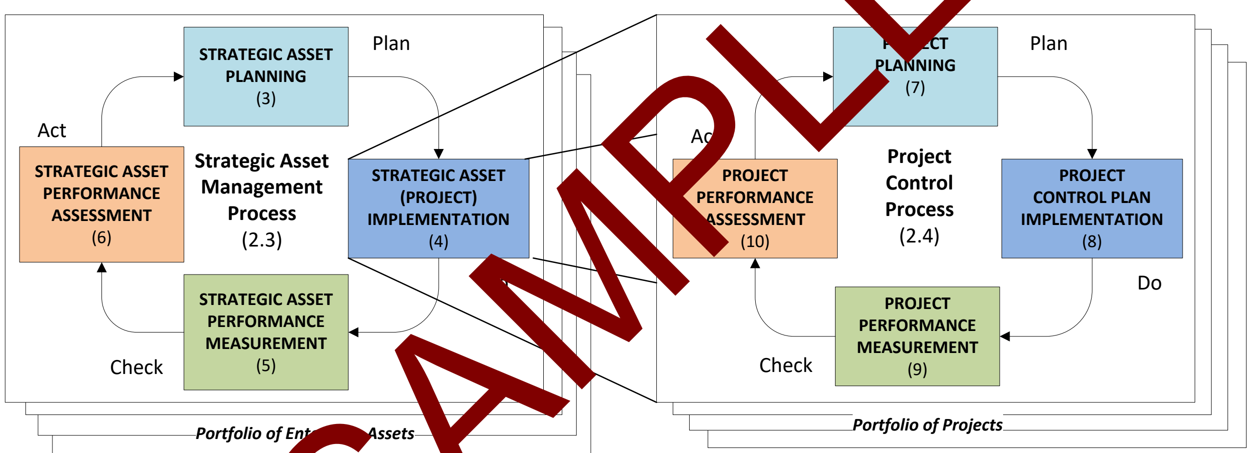

Figure 2.2-1 Total Cost Management Process Map

The two levels of the TCM process in Figure 2.2-1 are referred to respectively as the strategic asset management and project control processes. Project control is a recursive process nested within the "do" or project implementation step of the strategic asset management process. An enterprise will have a portfolio of assets in various stages of their life cycles, and during each asset's life cycle, many projects will be performed to create, modify, or terminate that asset.

2.2.1.2 The Strategic Asset Management Process Cycle

Strategic asset management (SAM) refers to the macro process of managing the total life cycle cost investment of resources in an enterprise's portfolio of strategic assets. The portfolio will contain many assets in various stages of their life cycles (including those assets that are nothing more than ideas). Although investments are made in an asset through the performance of a project or program, SAM is not concerned with day-to-day project tasks; SAM focuses instead on initiating and managing the overall portfolio of projects in a way that addresses the strategic objectives of the enterprise.

The PDCA steps of the strategic asset management process cycle include:

1) Strategic asset planning - converts asset portfolio improvement ideas into plans for investing resources in assets.
2) Project implementation - asset investment plans and requirements are communicated to and executed by project teams. Project teams request resources as needed and report on their performance.
3) Strategic asset performance measurement - includes measurement of both operational asset and project performance.
4) Strategic asset performance assessment – performance measurements are compared to the plan, and corrective, mitigating, or improvement actions are taken as may be determined.

Section 2.3 further defines the SAM process map and the specific steps in its process cycle.

2.2.1.3 The Project Control Process Cycle

Project control is the recursive process cycle nested within the "do" step of the strategic asset management process cycle. A project is a temporary endeavor an enterprise undertakes to create, modify, maintain, or retire an asset. During the life of a project, various resources are invested in the asset by the project team. Ultimately, a usable or operational asset is returned to the enterprise's asset portfolio at the completion of the project.

The PDCA steps of the project control process cycle include:

1) Project planning – converts project requirements or corrective action ideas into plans for investing resources in project activities.
2) Project activity implementation – project plans and requirements are communicated to and executed by project team members.
3) Project performance measurement – includes measurement of project activity progress and performance.
4) Project performance assessment – performance measurements are compared to the plan, and corrective, mitigating, or improvement actions are taken as may be determined.

Section 2.4 further defines the project control process map and the specific steps in its process cycle.

2.2.1.4 Parallels Between Strategic Asset Management and Project Control Process Cycles

Strategic asset management and project control are both recursive PDCA processes. Many of their sub-processes are the same as will be described in Sections 2.3 and 2.4. For example, cost estimating is a planning sub-process in strategic asset management with an emphasis on stochastic estimating methods, while in project control, cost estimating emphasizes deterministic methods. Decision analysis, value analysis and engineering, risk analysis, and resource planning are some other sub-processes that are practiced in both the strategic asset management and project control process cycles. In the *Framework*, these parallel sub-processes are described only one time for brevity (e.g., the value engineering process is grouped with project control processes).

2.2.1.5 Enterprise Organization for Total Cost Management

There is no one best organizational approach to achieve successful TCM implementation. Organizational approaches will be as varied as the strategic objectives of enterprises. However, all organizations should be focused on customer needs and on the entire life cycle of strategic assets rather than on short term functional considerations.

People are every enterprise's most important strategic asset. Organizational or human resource development can be viewed as a portfolio of projects undertaken to continually improve the work life and performance of each person in the enterprise. Narrow functional task training alone does not address the needs of TCM. For instance, a person who understands both stochastic strategic asset management cost estimating methods and deterministic project control estimating methods will be a more valuable asset than a person who understands only one type of cost estimating approach.

2.2.2 Process Maps for Total Cost Management

The process map for total cost management was shown previously in Figure 2.2-1. At a more practical level, TCM is a combination of the process maps for strategic asset management and project control as described in Sections 2.3 and 2.4.

2.2.3 Inputs to Total Cost Management

2.2.3.1 *Investment of Costs or Resources* - Costs refer to any investment of resources in the enterprise's strategic assets. Resources may include time, monetary, human and physical resources. An alternate definition of costs is economic resources used in achieving an objective.

2.2.3.2 *Strategic Objectives and Requirements for Asset and Project Investments* - The TCM process takes place within the overarching context of the enterprise. Enterprise management establishes objectives and performance requirements for its assets and processes. TCM is concerned with the deployment of business strategy, not its formulation.

2.2.3.3 *Working Environment Considerations* - TCM processes are enabled or constrained by technologies such as information and communication management and organizational development management. Also, the enterprise exists and processes take place within society where concerns for culture, environment, health and safety must be addressed (Chapter 11).

2.2.4 Outputs from Total Cost Management

2.2.4.1 *Managed Asset Portfolio* - The end products of the TCM process are new, modified, maintained, or retired assets that achieve the enterprise's strategic performance objectives and requirements.

2.2.4.2 *Managed Project Portfolio* - For larger enterprises, projects will be in progress at all times. While individual projects have a beginning and end, the enterprise must consistently manage the project process to assure that all projects achieve the enterprise's objectives and requirements.

2.2.5 Key Concepts and Terminology for Total Cost Management

2.2.5.1 *Strategic Asset Management* - Refers to the TCM process as applied at an enterprise wide level to manage costs of the enterprise's entire strategic asset portfolio (Section 2.3).

2.2.5.2 *Project Control* - Refers to the TCM process as applied at an individual project level to manage costs of creating, modifying, maintaining, or retiring individual strategic assets (Section 2.4).

2.3 Strategic Asset Management Process Map

2.3.1 Description

2.3.1.1 Definition of Strategic Asset Management (SAM)

Strategic asset management refers to the macro process of managing the total life cycle cost investment of resources in an enterprise's portfolio of strategic assets. The portfolio will contain many assets in various stages of their life cycles (including those assets that are nothing more than ideas). Although investments are made in an asset through the performance of a project or program, SAM is not concerned with day-to-day project tasks; SAM focuses instead on initiating and managing the overall portfolio of projects in a way that addresses the strategic objectives of the enterprise.[8] To paraphrase an old saying, the SAM process is more concerned with doing the right projects than with doing the projects right.

The main financial objective of many enterprises is to maximize the total long-term economic return or profit from its asset investments.[9] The economic performance of existing and proposed assets is often difficult to measure, yet the pressure to improve performance is relentless. Resources available to invest in assets are often limited or scarce while various parts of the enterprise may be in competition for these resources. In addition, the business environment is dynamic and uncertain. The SAM process therefore attempts to balance opportunities and risks against demand and supply for resources in such a way that the enterprise's objectives are met.

As discussed in Section 2.1, SAM is built on the PDCA cycle steps of (1) plan—establishing resource investment plans in assets, (2) do—making measurements of asset and project performance, (3) check—comparing the measurements against the plan, and (4) act/assess—taking corrective, mitigating, or improvement action as may be determined. This section translates those overall steps into sub-processes that will be more generally recognizable by practitioners.

2.3.1.2 The Strategic Asset Management Process Cycle

Figure 2.3-1 in this section illustrates strategic asset management as a process. Each step or sub-process in the figure is covered in a section in the *Framework*. The SAM process starts with the established enterprise business strategy, goals, and objectives. From there, the needs and desires of customers and stakeholders are elicited, analyzed, and translated into asset performance requirements (Section 3.1). Considering the requirements and opportunities from performance assessment, asset investment options are identified and developed (Section 3.2), and then evaluated and decided upon (Section 3.3).[10] Asset investment plans and requirements are communicated to and executed by project teams (Section 4.1).

Asset performance is then measured, including cost accounting measurements (Section 5.1) and non-cost performance measurements such as quality (Section 5.2). Asset performance assessment (Section 6.1) includes techniques for determining if the profitability, cost of quality, and other parameters vary from established plans and benchmarks. Also, adverse or positive trends or changes in performance are evaluated. Benchmarking and other means are used to identify improvement opportunities for new or existing asset performance. If everything is according to plan, the process continues. If there are performance deviations noted in assessments, action should be taken to correct or improve the asset performance trend. If performance corrections or improvements will affect asset portfolio investment plans, or changes to stakeholder needs, requirements, or resource availability occur, then these changes must be managed using a change management process (Section 6.2). Finally, asset and

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[8] The SAM process assumes that the enterprise has developed its strategic objectives through a strategy formation process that is not part of TCM. TCM is focused on business strategy *deployment* in respect to cost management of its assets.

[9] Return on assets (ROA) or return on net assets (RONA) are common financial measures.

[10] Asset planning and investment decision making employ the planning processes covered in Chapter 7.

project performance, history, and lessons learned are captured in a historical database for use in future asset management (Section 6.3).

2.3.1.3 Organization for Strategic Asset Management

In smaller enterprises that have few and/or low value assets, the strategic asset management process may be managed by whoever controls or operates the asset, be it the proprietor, the facility operation manager, the financial manager, or so on. In larger enterprises, there may be a dedicated asset management organization that includes managers, strategic planners, cost estimators, financial and budget analysts, value specialists, cost accountants, and other specialists. In large enterprises, there may be a tiered organizational approach where major investments are managed centrally by a dedicated organization while minor investments are taken care of by the operators of the asset.

The asset management organization may also be responsible for development of project management personnel, processes, and procedures for the enterprise. This organization may also manage relationships with key resource providers.

2.3.2 Process Map for Strategic Asset Management

Figure 2.3-1 below maps the major steps or sub-processes of strategic asset management.

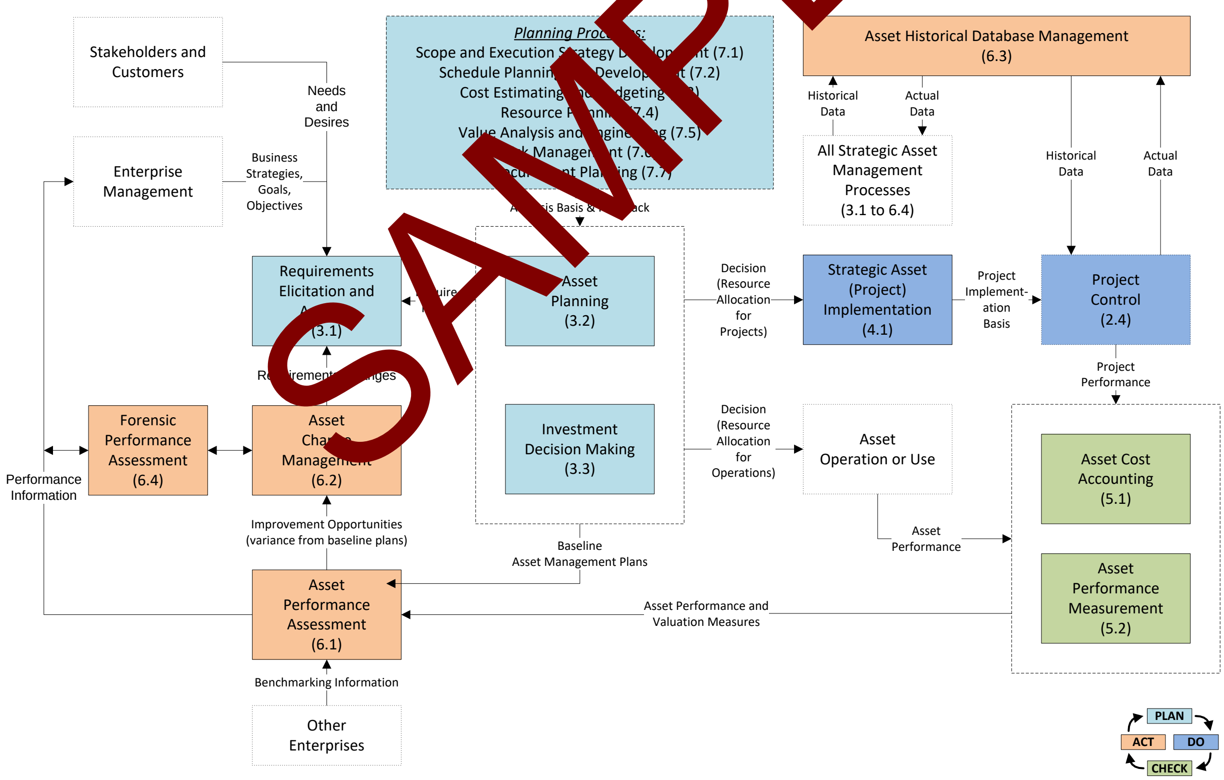


Figure 2.3-1. The Strategic Asset Management Process Map

The processes mapped conceptually above have each been diagrammed at a detail level in the sections noted.

2.3.3 Inputs to Strategic Asset Management

2.3.3.1 *Business Strategies, Goals, and Objectives* - Guiding information, directives, and imposed requirements are elicited for analysis and translation to asset requirements.

2.3.3.2 *Stakeholder and Customer Needs and Desires* - Information is elicited for analysis and translation to asset requirements.

2.3.3.3 *Asset and Project Performance* - Relevant physical and performance characteristics and behavior of each asset and project are described in a timely manner in sufficient detail to support strategic asset management.

2.3.3.4 *External Benchmarking Information* - Performance improvement ideas may be obtained through the benchmarking of practices and results for external enterprises and their assets and projects.

2.3.3.5 *Project Actual Data* - Information and data from projects are captured for use in future asset planning.

2.3.4 Outputs from Strategic Asset Management

2.3.4.1 *Project Implementation Basis* - The scope of asset solutions to be implemented in a project or program is described in sufficient detail to provide a basis for project scope and execution strategy development. The asset performance requirements are also conveyed so that the project team may address them in its project control planning. Cost, schedule, and resource requirements such as target costs, capital and maintenance budgets, schedule milestones, enterprise resource constraints, and other information is included (Section 3.1 and 7.1).

2.3.4.2 *Non-Project Decisions* - The investment decision may select a non-project solution (change to operation practice, expense, etc.) for implementation by the asset operator or user.

2.3.4.3 *Performance Information* - The performance of the enterprise's asset and project portfolio is reported to enterprise management for its consideration in business strategy formulation.

2.3.4.4 *Asset Historical Data* - Information and data from asset management may be used for project control purposes.

2.3.5 Key Concepts and Terminology for Strategic Asset Management

2.3.5.1 *Benchmarking* - A process that compares the processes and performance of an enterprise's endeavors to the processes and performance of the endeavors of a set of peers or competitors selected because they are considered to be the best in whatever endeavor is being assessed.

2.3.5.2 *Planning* - A management or control sub-process that consists of defining scope and establishing baselines or targets against which work performance can be measured. In strategic asset management, integrated asset project plans for cost, schedule, and resourcing are established. All plans should address risks.

2.3.5.3 *Economic Evaluation* - A set of financial analysis techniques that considers all the relevant income and costs associated with an asset or project investment during all or part of the asset or project life-cycle.

2.3.5.4 *Profitability* - A financial measure of the excess income over expenditure during a period of time. In terms of asset management, it is the net economic benefit resulting from an investment in an asset or a project.

2.3.5.5 *Decision Analysis* - A set of analysis techniques that considers all relevant performance and requirements data about a set of asset investment options and produces a decision to pursue or not pursue one or more of the options evaluated.

2.3.5.6 *Resource Allocation* - In terms of asset management, resource allocation is the end result of a decision when actions are taken to invest resources (human, time, or monetary) in an asset investment option to be realized through performance of a project.

AACE International Recommended Practices

The following AACE International recommended practices (RPs) are applicable to this section of the *TCM Framework*. All RPs listed here are published by AACE International, Morgantown, WV. Please be sure to refer to web.aacei.org for the latest revisions and additions.

- 85R-14, *Use of Decision Trees in Decision Making*

2.4 Project Control Process Map

2.4.1 Description

2.4.1.1 Definition of Project Control

Project control is a process for controlling the investment of resources in an asset. In TCM, project control is the recursive process cycle that is nested within the "do" step of the strategic asset management process cycle. A project is a temporary endeavor an enterprise undertakes to create, modify, maintain, or retire a unique asset. Being a temporary and therefore unique endeavor, projects are by nature uncertain and that element of risk puts a premium on control and discipline.

As discussed in Section 2.1, project control (or control of any process for that matter) is built on the PDCA cycle steps of (1) plan—establish a plan, (2) do—make measurements of performance, (3) check—compare the measurements against the plan, and (4) act/assess—take corrective, mitigating, or improvement action as may be determined. As a cycle, steps 2 through 4 are repeated periodically until the project is complete.

2.4.1.2 The Project Control Process Cycle

Figure 2.4-1 illustrates project control as a process. Each step or sub-process in the figure is covered in a section in the *Framework*. A project starts with project scope and execution strategy development, which translates the project implementation basis, i.e., asset scope, objectives, constraints, and assumptions (Section 4.1), into controllable project scope definition and an execution strategy (Section 7.1). From the work breakdown structure (WBS) and execution strategy, integrated plans for cost, schedule, and resource management are developed (Section 7.2, 7.3, and 7.4). The plans are time-phased baselines against which performance is measured. Value analysis and engineering (Section 7.5) ensures that the scope and plans consider functional importance of scope relative to costs. Risk management (Section 7.6) ensures that the scope and plans address uncertainty at that point in time. Procurement planning (Section 7.7) ensures that information about resources (e.g., labor, material, etc.) as required for project control is identified for, incorporated in, and obtained through the procurement process.

The project control plans are communicated to and implemented by the performing parties (Section 8.1). For work in progress, performance measurements include accounting for cost expenditures and commitments, as well as physical progressing, which include measures of the work and resource quantities that have been completed (Section 9.1 and 9.2.)

Performance assessment includes evaluative techniques for determining if the expenditures and progress vary from the plans (Section 10.1). If everything is according to plan, the control process continues on with more measurements. If there are performance deviations or trends noted in assessments, action should be taken to correct or improve the performance trend. Forecasting techniques (scheduling, estimating, and resource planning) are used to determine if corrective actions will achieve plan targets (Section 10.2). If performance corrections will affect the project scope, or changes to the requirements or scope are initiated by the strategic asset or other stakeholder, the project baseline plans must be managed to incorporate the changes (Section 10.3). Finally, project performance, history, and lessons learned are captured in a historical database for use in future asset management and project control (Section 10.4).

2.4.1.3 Relationship of Project Control to Other Processes

Project control is essentially equivalent to the project management process stripped of its facilitating sub-processes for safety, quality, organizational, behavioral, and communications management. Project control may be considered the quantitative resource control subset of the project management process (or as the AACE International constitution states, where "…engineering judgment and experience are utilized").

Project control is also roughly analogous to the processes of manufacturing and enterprise resource planning (MRP/ERP) with the difference being that MRP/ERP is focused on ongoing operations rather than projects. The enterprise has a portfolio of operations, and MRP/ERP is a recursive process of controlling the investment of resources within those ongoing operations. MRP/ERP and project control processes share many of the same tools and techniques.

As was discussed in Section 2.2, many of the sub-processes in project controls are the same as in strategic asset management.

2.4.1.4 Organization for Project Control

On smaller projects or those with limited types and quantity of resources, the project control process may be managed by the project leader be they a project manager, engineer, architect, systems analyst, cost engineer, or whoever. On larger projects, with many resources to deal with (such as major construction projects), there may be planners, schedulers, estimators, cost/schedule controllers, value specialists, cost accountants, and other specialists involved. Project control on large teams may be coordinated by a lead cost/schedule or resource manager, quantity surveyor, project controls manager, or project manager. For certain techniques, the individual performing the project tasks (i.e., turning the wrench) may be responsible for control tasks such as progress measurement.

A central project management organization may be responsible for development of project personnel, processes, and procedures for all projects in an enterprise (i.e., a project system). That organization may also manage relationships with project resource providers. All of the project control steps require experience and skills in which an enterprise should develop organizational excellence.

2.4.2 Process Map for Project Control

Figure 2.4-1 below maps the major steps or sub-processes of project control.

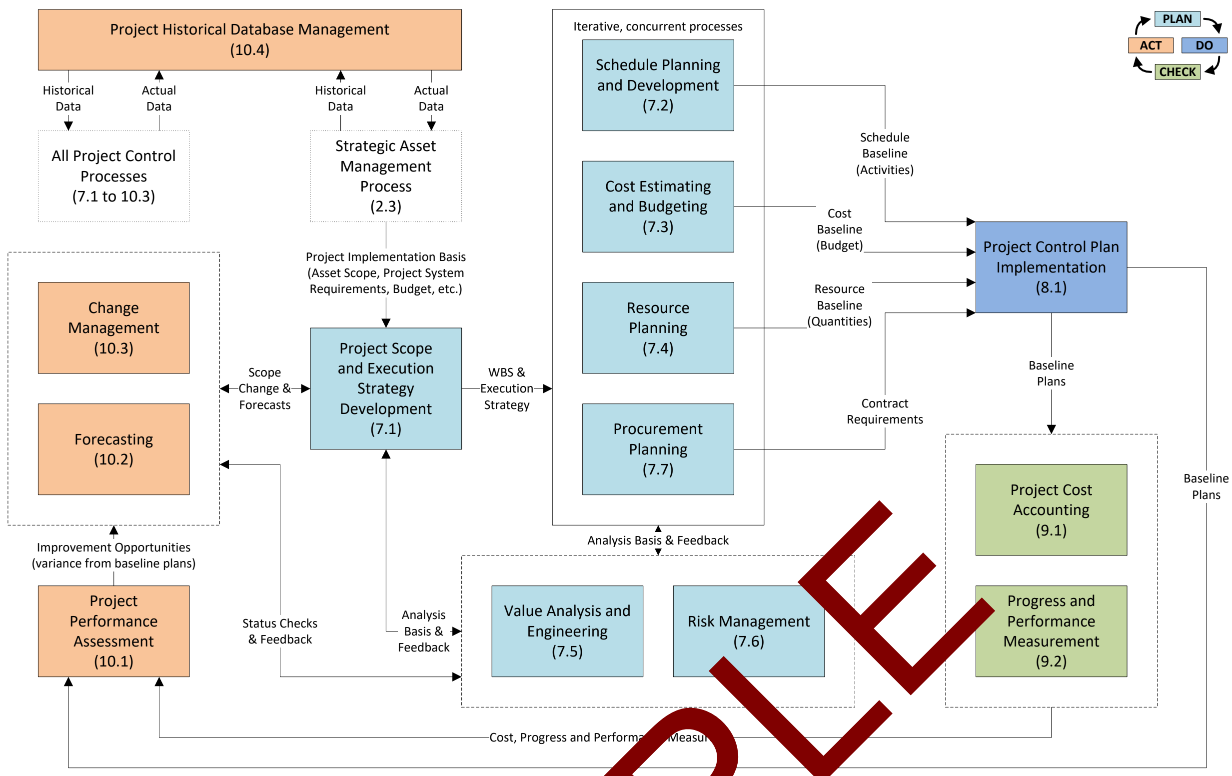


Figure 2.4-1 The Project Control Process Map

The process blocks or steps mapped above have each been diagrammed at a detailed level in the sections noted.

2.4.3 Inputs to Project Control

2.4.3.1 *Project Implementation Basis* - The basis includes objectives, constraints, and assumptions to be addressed in project control planning. The enterprise may establish requirements for schedule planning and development such as completion milestones, constraints, or limitations on the use of resources, and other criteria. The basis also includes the scope description of the asset solution in sufficient detail to provide a basis for planning. (Section 4.1)

2.4.3.2 *Asset Historical Data* - Information and data from strategic asset management (e.g., relevant asset performance metrics) may be useful for project control planning purposes.

2.4.4 Outputs from Project Control

2.4.4.1 *Asset* - The end product of the project process (of which project control is a subset) is the new, modified, maintained, or retired asset along with any information products defining or related to the asset. The overall output of project control is information needed for strategic asset management.

2.4.4.2 *Project Performance Information* - Project performance information is conveyed to the enterprise level for strategic assessment and financial analysis and reporting.

2.4.4.3 *Project Actual Data* - Information and data from projects may be used in strategic asset management.

2.4.5 Key Concepts and Terminology for Project Control

2.4.5.1 *Project* - A temporary endeavor undertaken to create, modify, maintain, or retire a unique asset (product or service). Control of ongoing endeavors producing non-unique assets (e.g., factories) is not covered by project controls but is covered by processes such as manufacturing resource planning. Given their temporary nature, an important characteristic of projects to address is risk and uncertainty.

2.4.5.2 *Planning* - The management or control sub-process of defining scope and establishing baselines or targets against which work performance can be measured. For project control, integrated plans for cost, schedule, and resourcing are established (some refer to planning as the activity definition and sequencing steps in the scheduling process). All plans should address risks.

2.4.5.3 *Control* - A process to ensure that an endeavor produces a desired end result. The process includes identification of the desired end result, measurements and assessment of intermediate results, and identification of actions needed to ensure that the end result is achieved. Project controls then is a control process applied to a project to ensure a desired asset investment result.

2.4.5.4 *Requirements* - An established requisite characteristic of an asset, product, process, or service.

2.4.5.5 *Scope* - The sum or end result of all resources and activities to be invested in an asset or project. Scope definition is a process to decompose the scope into manageable elements.

2.4.5.6 *Scheduling* - A predictive process of estimating and assigning the duration of activities based on available resources and planned means and methods and iteratively refining the planned activity logic in a way that achieves asset investment and project time objectives. A schedule is the output of the planning and scheduling process that documents planned activities and their start and finish times in a way that is logically sequenced; achieves asset investment, operation, project or other time objectives; and addresses available resources, investment objectives, and constraints. A schedule may be used for projects, operations, maintenance, business planning, and other purposes.

2.4.5.7 *Estimating* - A process to predict or approximate the cost of or price for scope. Estimating quantification techniques are also used to predict or approximate resource quantities and schedule durations.

2.4.5.8 *Budgeting* - A process to develop a cost plan by allocating estimated costs or prices to controllable *cost accounts* or activities and time phasing the cost in accordance with the schedule.

2.4.5.9 *Resource Planning* - A process of defining resource types and quantities needed to achieve the scope and time phasing the resourcing in accordance with the schedule.

2.4.5.10 *Cost Accounting* - A process of measuring and reporting actual costs for financial reporting and project control purposes. For control, costs are collected in cost accounts that correspond to the budget accounts.

2.4.5.11 *Baseline* - A plan or target against which performance is measured. Analogous to baseline targets in statistical process control.

2.4.5.12 *Value Analysis and Engineering* - A process to analyze the functional value of a process, asset, product, or service where *value* is defined as the ratio of importance to cost. Increasing value is not synonymous with decreasing cost because value takes into consideration measures of functional importance.

2.4.5.13 *Risk Management* - A process to identify, quantify, manage, and communicate risks or uncertainties that may impact an asset investment or project. Also includes steps to find ways to mitigate risk factors; to continuously monitor the project or asset for the occurrence of risk factors; and to continue to identify, quantify, manage, and close out risks throughout the life cycle of the project or asset.

7.6 Risk Management

7.6.1 Description

Risk management is a systematic and iterative process comprising four steps:

1. **Plan** - *to establish risk management objectives;*
2. **Assess** - *to identify and analyze risk;*
3. **Treat** - *by planning and implementing risk responses; and*
4. **Control** - *by monitoring, communicating and enhancing risk management effectiveness.*

The goal of risk management is to increase the probability that a planned asset, project or portfolio achieves its objectives. In total cost management (TCM), potential deviations from plans are all considered potentially adverse to overall performance. In this sense, perceived opportunities may also pose a threat. However, if properly managed, the project or asset management team may be able to capitalize on opportune uncertainties.

The risk management process is applied in conjunction with the other asset and project control planning processes such as scope development, cost estimating, schedule planning, schedule development, resource planning, procurement planning and financial systems integration. In the context of TCM's strategic asset management process, the term enterprise risk management (ERM) recognizes that the risk management process should be applied to overall enterprise, portfolio and program level objectives, not to just a single business unit, asset or project.

Every organization manages risk but, depending on their level of risk management maturity, this might not be done in a visible, repeatable or consistent way. Risk management is an essential facet of enterprise governance that provides a disciplined environment for proactive decision making.

7.6.1.1 The Definition Debate

Risk is typically recognized as something that is harmful, adverse and negative. This view is supported by a commonplace dictionary definition of risk, however, when reviewing the details of a risk management process or seeking to develop, manage and maintain risk data, some essential concepts must be made clear and readily understood. The commonplace dictionary definitions will not support all the viable risk management processes in use that are evolving, or that which is included in TCM. In recent years risk practitioners and professionals have been actively debating the precise scope of the word.

To be an effective facilitator of the risk management process, professionals should be aware of the two major issues on which this debate centers.

First is the issue of risk versus uncertainty. The controversy here concerns how far we should be trying to manage uncertainty or whether we must restrict our efforts to managing risk. The economist Frank H. Knight in his work *Risk, Uncertainty, and Profit* (1921), made a distinction between risk and uncertainty when he argued that "…measurable uncertainties do not introduce into business any uncertainty whatever." For Knight, measurable uncertainty was not true uncertainty. To describe measurable uncertainty he assigned the term risk.

Knight's view should be balanced against the views held by mathematicians long before him such as Poisson, Bernoulli and Bayes. They referred to uncertainty as measurable in terms of quantified probabilities and did not distinguish between uncertainty and risk. This can help explain why economists may choose to define uncertainty and risk differently from mathematical purists.

Since AACE chooses to frame risk in terms of its effect on business goals or project objectives, we are not concerned with non-quantitative uncertainty but simply risk that matters.

Second is the question of positive or upside risk, commonly called opportunity (as opposed to negative or downside risk, commonly called threats). Traditionally, risk was considered to only have an adverse, harmful or negative impact on objectives (and it still has in many quarters). In the 1960s, risk management began to be recognized as an essential management skill but at that time organizations tended to focus on insurance management, seeking to maintain financial capacity following the negative effects of adverse events. A broader view began to emerge in the 1970s as organizations developed a better understanding of the nature of risks and sought alternatives to insurance, however, the focus remained on overcoming negative effects. In recent years, more and more organizations have spoken of risk management in a broader sense where the intent is to proactively reduce the impact of negative threats and increase the probability of positive opportunities.

When ushering stakeholders through the risk management process, the risk practitioner needs to be aware of and prepared for potential differences in opinion. Listed below is a selection of definitions to help appreciate the differing views currently held by some of the more renowned professional groups who are shaping best practice in this discipline:

1. "*An ambiguous term that can mean any of the following: 1) all uncertainty (threats and opportunities); 2) undesirable outcomes (uncertainty = risks + opportunities); or 3) the net impact or effect of uncertainty (threats - opportunities). The convention used in any work should be clearly stated to avoid misunderstandings*".
   [Ref. AACE Risk Management Dictionary, 1995]

2. "*Combination of the probability of an event and its consequence*."
   Note: 3.1.1-1, The term "risk" is generally used only when there is at least the possibility of negative consequences.
   Note: 3.1.2-2, Consequences can range from positive to negative. However, consequences are always negative for safety aspects.
   [Ref. PD ISO/IEC Guide 73:2002].

3. "*The chance of something happening that will have an impact on objectives*."
   Note 1: A risk is often specified in terms of an event or circumstance and the consequences that may flow from it.
   Note 2: Risk is measured in terms of a combination of the consequences of an event and their likelihood.
   Note 3: Risk may have a positive or negative impact.
   [Ref. AS/NZS 4360:2004]

4. *"Uncertainty inherent in plans and the possibility of something happening (i.e. a contingency) that can affect the prospects of achieving business or project goals."*
   [Ref. BS 6079-3:2000]

5. *"An uncertain event or set of circumstances that, should it occur, will have an effect on achievement of one or more of the project's objectives."*
   [Ref. APM PRAM Guide 2004].

6. *"Uncertainty presents both risk and opportunity, with the potential to erode or enhance value."*
   [Ref. The Committee of Sponsoring Organizations of the Treadway Commission's (COSO's) Enterprise Risk Management - Integrated Framework, 2004].

7. *"An uncertain event or condition that, if it occurs, has a positive or negative effect on a project objective."*
   [Ref. PMI® PMBoK® Third Edition, 2004].

8. *An uncertain event or set of circumstances that, should it occur, will have an effect on achievement of one or more of the project's objectives*.
   [Ref. Management of Risk: Guidance for Practitioners (Published by TSO (The Stationery Office – UK Office of Government Commerce)].

9. *Project risk may be defined simply as the possibility of an unintended future event with potential undesirable consequences*.
   [Ref. National Research Council (US), The Owner's Role in Project Risk Management, The National Academies Press, 2005].

10. *Risk refers to uncertainty of outcome, whether positive opportunity or negative threat, of actions and events. It is the combination of likelihood and impact, including perceived importance.*
    [Ref. Risk: Improving government's capability to handle risk and uncertainty, Strategy Unit Report, November 2002 (UK Cabinet Office)].

11. *A measure of future uncertainties in achieving program performance goals within defined cost and schedule constraints. It has three components: a future root cause, a likelihood assessed at the present time of that future root cause occurring, and the consequence of that future occurrence.*
    [Ref. Risk Management Guide for DOD Acquisition, Sixth Edition (Version 1.0) August, 2006].

12. *Risk = f(hazard, safeguard)*
    [Ref. Project Management: A Systems Approach to Planning, Scheduling, and Controlling, Harold Kerzner, Ph.D., John Wiley and Sons Tenth Edition, 2009].
    Also *"Future events (or outcomes) that are favorable are called opportunities, whereas unfavorable events are called risks."*
    [Ref. Project Management, Harold Kerzner, Ph.D., Fifth Edition 1995, Van Nostrand Reinhold].

13. *The probability and magnitude of a loss, disaster, or other undesirable event.*
    [Ref. The Failure of Risk Management: Why It's Broken and How to Fix It, Douglas W. Hubbard, John Wiley and Sons, 2009].

14. *The chance of things not turning out as expected*.
    [Ref. http://www.economist.com/research 201[illegible]].

15. *The potential for realization of unwanted, adverse consequences to human life, health, property, or the environment.*
    [Ref. The Society for Risk Analysis, www.sra.org].

The AACE definition of risk is provided in Section 7.6.1.2. It may be noted that it is neutral in respect to threat and opportunity. This neutral position embodies a broader concept of risk derived from its Latin root, *risicare* or *to dare*. However, with this in mind, the risk professional should be aware that, although it may be tempting to consider the treatment of threat and opportunity as separate activities, in practice they are seldom independent. The AACE recommended risk management processes adopt a progressive interpretation of this definition by managing both threats and opportunities in parallel.

Hillson and Simon (2007) also acknowledge the increasing popularity of the wider application of risk management. They cite the following benefits to be gained from adopting a process that manages both threats and opportunities:

- *Proactive opportunity management* – a common process reduces the potential for opportunities to be overlooked.
- *Familiar techniques* – only following minor changes to the techniques used for managing threats can organizations deal with opportunities.
- *Minimal additional training* – the common process uses familiar processes, tools and techniques.
- *Maximum efficiency* – no need for a separate opportunity management process.
- *Cost effectiveness* – one process that can both minimize threats and maximize opportunities.

- *More realistic contingency management* – by intrinsically including both potential upside and downside impacts.
- *Increased team motivation* – by encouraging people to come together and think creatively about ways to work better, simpler, faster and more effectively.
- *Improved chances of project success* – by providing a familiar means to realize benefits.

7.6.1.2 Definition of Risk

For the purpose of the risk management process within the TCM process, risk can be defined as follows;

> *An uncertain event or condition that could affect a project objective or business goal.*

In recognition of the "definition debate", some users may choose (during risk planning) to expound this definition so that it expressly underpins their specific stakeholder's needs.

7.6.1.3 Decision and Risk Analysis

The full risk management process, as mapped in this section, is designed for addressing uncertainty in project outcomes (from a project control context). However, the process generally applies and is critical to addressing uncertainty in the outcomes of any decision, including enterprise risk management. As discussed in Section 3.3, a key challenge in strategic asset planning and investment decision-making is bringing an awareness of risk and probability concepts to those processes regardless of whether or not they result in an implemented portfolio or project. If this is not achieved, traditional economic analysis used in investment decision-making may become meaningless when there are significant risks.

7.6.1.4 Risk Management versus Value Management and Value Improving Practices

As defined in Section 11.5, value management in TCM is a process employed by an enterprise to help ensure that its assets provide or maintain the usefulness and/or value required by the stakeholders.

Risk management is considered a value improving practice because it helps increase the probability that a planned asset or project achieves its optimum potential (as stakeholders would require). As discussed in Section 7.6.1.1, it is recommended that risk management processes manage both threats and opportunities in parallel. One way to accomplish this is have separate but integrated risk and value management processes to ensure that both threats and opportunities get all due attention.

7.6.2 Process Map for Risk Management

The risk management process is iterative, centering on steps that establish objectives, identify risk drivers occurring throughout the project or asset life-cycle, and essentially manage that risk by continually seeking to assess, treat and control their impacts. The primary outputs of the risk management process are: the risk management plan; the risk register; risk analyses (including contingency allowances for cost and schedule); risk response plans; and the baseline project scope definition. Figure 7.6-1 is the TCM process map for risk management.

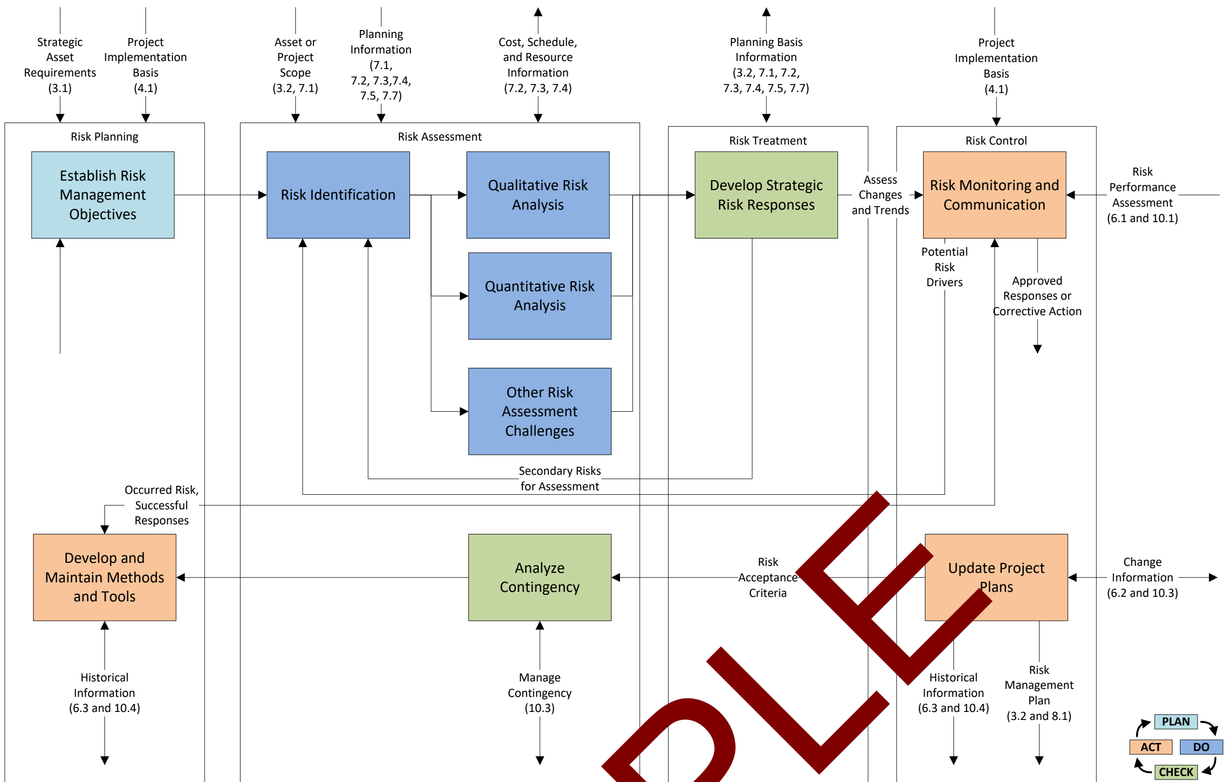


Figure 7.6-1 Process Map for Risk Management

The following sections briefly describe the steps in the risk management process.

7.6.2.1 Risk Planning

At the start of the process, risk management leadership is appointed with the responsibility to plan and prepare for the risk assessment, risk treatment and risk control efforts that will take place throughout the project life-cycle. Depending on the scope, scale and/or complexity of the project, this leadership role may be performed by an individual or group of competent personnel.

Leadership must liaise with stakeholders at all levels and use the risk management plan to establish the scope of risk management. This will help clarify expectations and ensure all parties are aligned. For example:

- Are there any preferred methods or practices?
- Are there preferred metrics and/or report formats?
- Does the operational definition of risk support the specific process and methods being used?
- How frequently will the team be expected to meet and update their qualitative analyses? Each month or at different periodic intervals?
- How frequently are cost and/or schedule risk analyses to be run? Each quarter or at agreed milestones?
- Is there a predetermined budget or an estimated number of hours that can be expended in support of the risk management process?
- Alternatively, is this venture unique requiring special consideration?
- Are there any assumptions that need to be formalized? (E.g. the entire contractual chain may, at some point, be expected to support the implementation of risk response plans).

Roles and responsibilities should also be identified; this may include a risk champion to lead the risk management initiative at project level, a risk study team to complete the initial risk identification and a review committee to complete periodic monitoring and risk control. Such review committees are typically at the project level but, more frequently, organizations are utilizing independent groups to fulfill an additional parallel oversight and/or audit function.

Ultimately, the risk management plan must describe what the project or asset management team recognizes as being the risk management objective so that it may be incorporated within the overall project execution plan and/or project charter. The objective may be expressed in terms of risk appetite and risk tolerance. Risk appetite can be described in terms of a confidence interval or confidence level e.g., percentage confidence of underrun or P value (Section 7.6.2.2). Risk tolerance for example, could be described by using a simple threshold or range of +/- number of days and/or range expressed using the agreed project currency (or currencies). Depending on client needs or expectations it may, for example, be necessary to consider other risk consequences such as a reasonable number of safety and/or environmental incidents.

The scope must be aligned with the strategic asset requirements and project implementation basis (Section 3.1 and 4.1) and with the current asset or project scope definition (Section 3.2 and 7.1).

Planning for risk management is better facilitated when the enterprise has achieved a certain level of risk management maturity. A mature organization will provide a supportive culture and a support structure that offers capabilities for the successful implementation of the risk management process (i.e., methods, tools, and resources). As a consequence, the organization should have in place a policy or procedure document detailing when and how risk management is to be applied. In the context of enterprise risk management, these guidelines will be integrated across the enterprise.

Risk management is applicable to all enterprises and all asset or project life cycle stages. The four iterative steps, planning, assessment, treatment and control are initially applied in a phased manner consistent with the project scope development phases described in Section 7.1.

During planning, it is especially important to understand the synergies between value engineering (Section 7.5) and risk management. Changes to plans to address value issues may affect risk, and vice versa. Therefore, as indicated in the process map in Section 2.4, the value engineering and risk management processes generally need to be revisited together.

Many individuals on the strategic asset or project team may be involved in the risk management process. Diversity of the risk management team is strongly encouraged, with participation by all stakeholders and end users. However, risk management success is so closely linked to the other strategic asset and project processes that it is best facilitated by having experienced management personnel coordinate it.

Essential to effective risk management is experience coupled with good judgment that can be supported by sound historical data. In addition, senior management support of the risk management process is vital to ensure that all the necessary resources are made available, not just initially, but on an ongoing basis that supports periodic review and risk control. An organization's leadership team must convey the need for risk management to be embedded in all business processes. Only then can the risk management process described here be most effective.

7.6.2.2 Risk Assessment

Once the risk management process has been planned and informal agreement or formal approval obtained from all stakeholders, the team can start working through the next step of risk assessment. Risk assessment is typically comprised of three distinct tasks:

1. Risk identification.
2. Qualitative risk analysis.

3. Quantitative risk analysis.

These tasks, as well as other issues concerning the risk assessment process step, are outlined below.

1. Risk Identification

All members of the team should work together to identify asset or project risk drivers for analysis. Risk drivers are events or circumstances that may influence or drive uncertainty in asset or project performance. In this sense, risk drivers can also be considered the 'cause' of risk. They may be inherent characteristics or conditions of the asset or project, perhaps external influences, events, or environmental conditions ranging from climatic to economic.

Checklists or a knowledge base of common risk drivers may be developed and used to facilitate this risk identification step. Checklists and similar tools such as a risk breakdown structure (RBS) are generally based on project historical data and can serve as invaluable prompts during risk identification brainstorming.

Risk drivers can be general or systemic in nature. Empirical research of past project experience is generally required to understand these drivers. For example, research of historical industry data has shown that one of the most significant project risk drivers is having a poor level of project scope definition and planning. However, other risk drivers may be unique to the asset or project; therefore, input from the entire project team should be obtained using creative processes such as brainstorming workshops or other facilitated risk assessment meetings in order to reveal the full spectrum of risk perception i.e. systemic, project-specific, or varying combinations of both.

Initially, the output of this step is a list of potential risks. Essentially it is the first draft risk register. The list should employ a three part risk metalanguage to describe each risk event.

These structured descriptions will separate cause, risk and effect. An example of a typical risk description using metalanguage follows: "Due to <*cause*>, there is a threat / opportunity that <*risk*> may occur, which may lead to <*effect*>.

Ensuring each risk is explicitly described in this way helps minimize confusion and can aid the identification process. For example, brainstorming may reveal that there are multiple causes behind one risk and vice versa. In addition, having delineated cause and effect, this will aid risk response planning and the assignment of the most competent or qualified risk owner.

It is during the initial risk identification forums that the team may invest their peak level of effort for this step, however, it is important to note that this is an ongoing process. Every team member should be empowered to bring for review a new risk driver, at any stage in the project or asset life-cycle. Periodic risk control meetings can facilitate ongoing risk identification. In addition, it is important to remember that risk identification efforts must focus on risks that matter i.e. those that can influence project objectives, irrespective of their probability of occurrence or severity of impact.

To clarify once more, risks that matter are essentially areas of uncertainty that can be quantified and, if they were to occur, could have a positive or negative impact on business goals or project objectives.

Whenever a risk is identified, care should be exercised to ensure it is assessed in its original state i.e. prior to qualification, mitigation or any other form of treatment.

One last important aspect of risk identification that must be given appropriate consideration, when identifying risk drivers and populating a risk register, the risk practitioner must be careful that the following elements are not mistaken to be risks:

- *Issues or problems*,

- *Causes*,
- *Effects*.

For example, an issue is generally a risk that has already occurred. A proactive risk management process should have permitted the creation of an appropriate risk response ahead of time and a good risk register should acquire a number of occurred risks as the project evolves but, if for some reason this does not happen, it is more appropriate to record and manage such problems in an issue log. Failure to do so will unnecessarily burden the process, curtailing the potential benefits that could have otherwise been enjoyed as a consequence of a more proactive approach.

To further illustrate what a risk is not, let us consider poorly defined scope. This is not a risk per se but a cause. Such a cause will drive numerous risks and effects that, ideally, should be individually isolated, explicitly defined and quantified.

In the case of systemic risks, such as poorly defined scope, it is worth noting that because the resulting risks are unlikely to be individually identifiable, it is likely that the risk(s) may only be defined in general terms, and the subsequent effect only quantifiable at the bottom line.

Finally, late delivery and schedule overrun is not, for example, a risk but an effect. The effect is often what team's have in mind when they enter a workshop so the risk practitioner can perhaps seize on this and use it to their benefit. When brainstorming, it is often useful to build off an effect that is widely appreciated and work backwards by seeking to elicit every potential risk driving the effect in question (e.g. risk of delayed procurement), subsequently asking the team to identify all potential causes of the identified risk (e.g. poorly defined scope).

These examples of what risk is not should further underscore the benefits of employing a metalanguage to describe risk.

2. Qualitative Risk Analysis

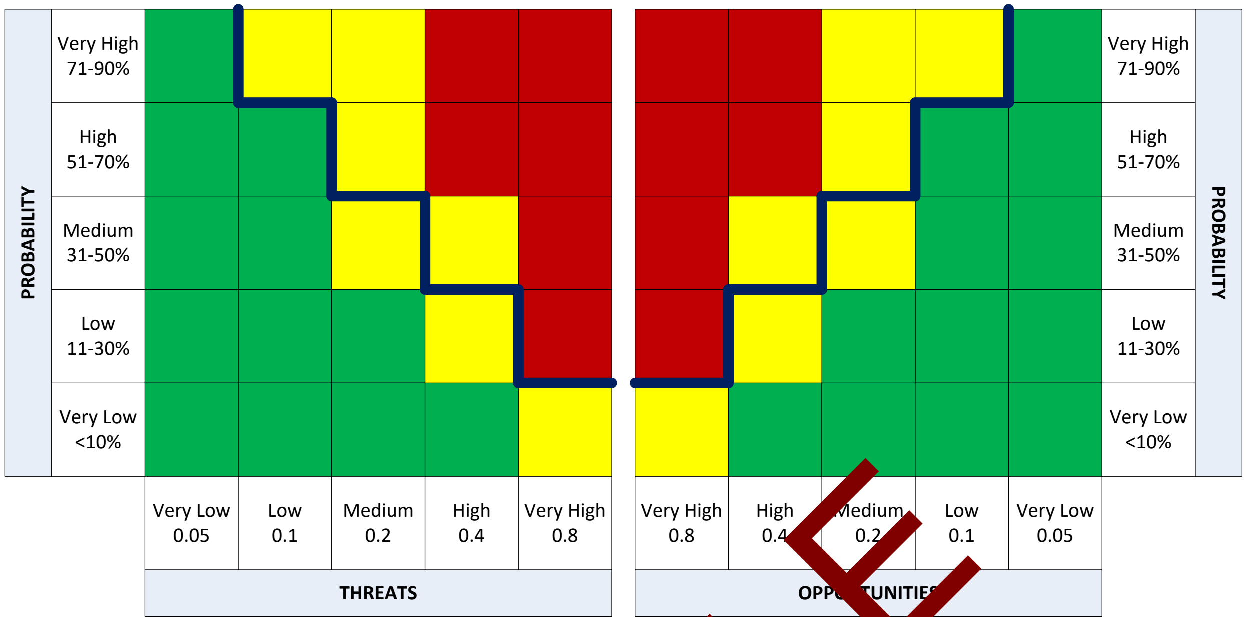
Entries in the risk register are typically classified by their source using the RBS. The team may further categorize or organize their risk data using qualitative methods that help rank risks in terms of criticality and significance to the enterprise objectives. These qualitative methods are subjective in nature and assign, for example, a score from one to five to reflect probability and each identified effect, consequence or impact.

A five point scale is generally preferred. Although a three point scale is common, it can sometimes prevent the desired level of analysis. Conversely, anything beyond a five point qualitative scale (or attempting to provide more quantitative values at this stage) can lead to what is affectionately termed analysis paralysis.

Risks are dynamic. What may appear to be a significant risk at one point in time could later evolve to become one that is critical. Additionally, what may pose a schedule risk at the start of the project may, for example, manifest itself as a safety risk at a later time. For this reason, it is recommended that the team establish a baseline for each risk, scoring them before any responses have been implemented, then periodically reviewing and updating their qualitative risk analysis if necessary, enabling them to monitor for any adverse trends (Section 7.6.2.4).

The content of the scoring matrix used for this exercise should have been agreed with all stakeholders during risk planning.

The output of the qualitative risk analysis is typically reported using a matrix where risk impact or consequence is plotted against probability. An indicative example of a five by five matrix is provided in Figure 7.6-2. An organization that has a mature risk aware culture would, for example, use two matrices to report on both threats and opportunities. The majority of organizations, however, typically focus solely on threats and the left hand matrix is commonly used in isolation.



Legend:

Red zone highlights major risks that require immediate action (in this example, those that score more than 0.2).

Yellow zone highlights moderate risks that require heightened attention (in this example, scoring between 0.08 and 0.2).

Green zone highlights minor risks that are "business as usual" (in this example, scoring less than 0.08).

Risk threshold line

Figure 7.6-2. Double Probability vs. Impact Matrix

3. Quantitative Risk Analysis

Once the risks have been identified and ranked, their quantitative impact on the asset or project plans can, with the support of the project team, be analyzed in an objective way by a professional risk practitioner. This may be a person that is already among the risk management leadership team, it may be someone working from within organization's specialist support services pool or it may be external consultant contracted in especially for this effort.

For each risk selected by the team for quantitative risk analysis, a probabilistic estimate of its impact will be prepared. The chosen methodology will have been specified during the risk planning phase. One of the following three methods or a hybrid of the three is commonly employed: expected value, range estimating, or parametric modeling.

When using the expected value method, estimates of the probability of occurrence and potential impact of the risks are prepared. These probability and impact ranges typically take the form of "three point estimates" and portray the team's optimistic and pessimistic view, where the most likely value frequently, but not always, aligns with the estimated value.

With range estimating, the impacts (usually three points) are estimated while risks and their probabilities are addressed by the team based upon their experience and knowledge as appropriate when determining impact ranges.

With parametric methods, the risk-to-impact estimating relationship is implicit and the probabilistic outcomes are inherent to the algorithm.

Expected value and parametric values are sometimes called risk driver approaches because they start with and focus directly on the risk drivers.

The estimated value is referred to as the base estimate, point estimate or the deterministic value. In expected value and range estimating methods, computer simulations using Monte Carlo, or similar statistical sampling processes, compute thousands of different outcomes or probabilistic values. These probabilistic values can be used for sensitivity analysis (i.e. identifying which variables are most influential) and also to produce a probability distribution for total cost, completion date or other measure of interest.

Parametric models can output distributions directly. The probability distribution is commonly used to derive the confidence level percentage values that support estimation of the appropriate contingency depending on management's risk appetite or tolerance.

Any qualifications, assumptions, or exclusions used in the quantitative risk analysis need to be clearly stated and accepted by all key stakeholders. Done properly, the risk analysis will address cost and schedule risks in an integrated manner. At a minimum, the cost and schedule impacts must reflect consistent assumptions that appropriately account for residual risk.

The first quantitative risk analysis is typically performed to help set an appropriate level of contingency. For the risk management process to be most effective, and resources permitting, it is good practice to repeat this exercise at periodic intervals and/or milestones as agreed in the risk management plan.

<u>Contingency</u>

Contingency is an amount added to an estimate (of cost, time, or other planned resource) to allow for items, conditions, or events for which the state, occurrence, and/or effect is uncertain and that experience shows will likely result, in aggregate, in additional cost.

The change management process (Section 10.3) is used to incorporate changes in the project scope definition and baseline plans. Contingency management is part of that process. In change management, if a project team takes an approved corrective action (within the project scope) that will cost more or less than the amount budgeted for in the affected cost accounts, or will take more or less time than planned for against the affected activities, then budgeted funds or float may be approved for transfer from or to the contingency as appropriate.

Contingency analysis, a sub-step of risk assessment, quantifies the risk impacts after all treatment efforts are complete, also known as residual risk. The team should guard against assumptions that the treatment efforts will be entirely successful, or not successful at all. Following treatment, more often than not, risk cannot be completely eliminated and there will be some degree of residual risk. In addition, many treatment efforts can introduce, inadvertently or knowingly, subsequent variation or secondary risks.

Successful contingency analysis will account for all residual risk and secondary risk that cannot be treated in some way. In this sense, it should be appreciated that appropriate contingency analysis is mutually dependent on the other two iterative process steps: risk treatment and risk control.

The amount of contingency depends in part on an organization's risk appetite or willingness to accept risk or avoid risk. The greater the appetite, the more risk the organization is willing to accept that the project may either exceed or under achieve its objectives.

Since the perception of risk varies from person to person, the risk management plan must document an organization's risk appetite. This will help the team become aligned as to whether their actions are to be risk seeking or risk averse. If modeling techniques that produce probabilistic outcomes are used to quantify risk impacts, then an organization's willingness to accept risk can be expressed simply as organization's desired percentage confidence (a.k.a. percentile or P value) that the project will not overrun its budget or schedule. For example, an aggressive contracting organization with a large risk appetite may choose not to accept a contingency value at a P70 confidence level but instead P50. Here they are fifty percent confident that they will meet their project objectives and have chosen to bid a lower price at the risk of losing their profit if their contingency later proves insufficient.

Contingency is normally controlled by the project manager or equivalent team leader because experience shows that contingency will likely be required by the project. However, the organization may decide that additional funds, time or other values at risk be considered for risks that are beyond the control of the project team. These amounts, typically controlled by senior management, are known as the funded liability or management reserves.

<u>Other Risk Assessment Challenges</u>

There are two additional key challenges for risk analysis. First, the impacts of some risks are difficult to imagine or estimate, even for the most experienced project teams. Second, even if individual risk drivers are understood, it is difficult to understand the interaction of risks. For example, does the occurrence of one risk influence the occurrence or consequence of others? Are the impacts of associated risks added or compounded?

Parametric modeling is one method that helps address interaction and complexity challenges. Parametric models are typically multi-variable regressions of historical, quantified risk drivers versus actual project outcomes. Regression empirically quantifies the impact while allowing the dependency of risks to be examined. Regression models also provide useful probabilistic outputs, and results are replicable. There are also proprietary commercial project risk analysis systems available that help address these risk analysis challenges.

Sensitivity analysis is another way to address risk complexity and interaction. Sensitivity analysis examines risk drivers (or cost or schedule drivers) by developing a model relating the drivers to impacts (can be a parametric or another model type), and then changing the driver variable values to examine the impact of each driver or combination of drivers on the impact. This helps prioritize the risk drivers for later risk treatment.

Not every project may warrant the level of effort required to undertake quantitative modeling. Alternatively, and in terms of their overall life-cycle, some projects may have insufficient data available to support cost and/or schedule analysis because they are in an early stage of implementation. That said, the most robust risk analysis methods tend to combine subjective team judgment and expert objective, empirical based modeling. Here then perhaps lies a paradox; the ability to influence the project outcome is strongest during the earliest stages of the project lifecycle, yet the full extent of inherent risk may not become apparent until the completion of design or commencement of execution.

7.6.2.3 Risk Treatment

As the risk assessment phase draws to a close and the team searches for ways to effectively treat risk, the team must assign risk ownership. It is a good practice for every risk to have a risk owner.

The risk owner is responsible for devising and implementing risk response plans on behalf of the project, monitoring and reporting on both the status of their identified risks and response plan. Such reporting should encompass the identification of secondary risks as response plans are implemented. For clarity, risk response plans simply aim to either maximize opportunities or minimize threats, optimizing the chances of project success. In addition, the risk owner should be one individual and not a department or group. Having a single point of responsibility aids effective communication and helps maintain accountability.

Although it is good practice to have in place risk response plans for every risk, it is often prudent to prioritize this effort based on the severity or qualitative ranking of the risks. Figure 7.6-2 illustrates a common type of matrix used for screening identified risks. Depending on the approach cited in the risk management plan, risk treatment may be focused on those risks with both very high impact and probability (i.e. those that are the worst threats and the best opportunities). In this example, the major risks score more than 0.2 and are shown in the central red zone.

Key actions performed during the risk treatment phase include:

- Evaluating all appropriate response strategies.
- Selecting an appropriate risk response plan strategy (or combination of strategies).
- Developing action items in support of the selected response.
- Validating proposed actions with assigned actionees, including dates for implementation.
- Ascertaining post-response targets and gains.
- Ascertaining response plan resource requirements.
- Updating project schedule or budget if the anticipated treatment value gain is positive.
- Identifying any secondary threats or opportunities that may arise from the response.

Response strategies for threats, listed in order of preference are:

- *Avoid* – involves eliminating either the probability or impact. Can be done by either clarifying requirements, acquiring expertise or changing the project management plan.
- *Reduce* – involves mitigating key drivers to reduce probability and/or impact.
- *Transfer* – involves transferring the threat to a competent third party who is better able. Could be through insurance or contractual transfer (via indemnity, exclusion or hold harmless clauses).
- *Accept* – no proactive action is to be taken because cost either outweighs benefit or there is already an adequate contingency provision that will protect the project objectives.

Response strategies for opportunities, listed in order of preference are:

- *Exploit* – involves taking steps that guarantee the opportunity will arise (e.g. changing specification, scope or supplier).
- *Share* – involves sharing the risk with a third party better able to manage it (perhaps by applying a pain/gain formula).
- *Enhance* – involves increasing the probability and/or impact of key risk drivers.
- *Accept* – no proactive action is to be taken because cost either outweighs benefit or there is already an adequate contingency provision that will protect the project objectives.

7.6.2.4 Risk Control

The risk management process will be worth nothing if all that has been discussed and planned during the earlier steps is not implemented. For this reason, monitoring is an essential component of risk control. Each response strategy and any associated actions must be monitored by both the risk owner and review committee to ensure that they are executed in a timely manner, and above all, with the intended effect.

The review committee must decide if response planning must end prematurely and, guided by the risk owners, they must make the final decision as to when it is appropriate to close a risk. Conversely, they must decide if it is appropriate to add any new risks to the register.

After a new risk has been clearly described and coded by RBS, benefit can also be gained by categorizing the affected areas of the project by work breakdown structure (WBS). By comparing the most common causes of risk by RBS, against the most commonly affected areas by WBS, it is possible to identify hot spots. Such information can be invaluable when prioritizing effective risk responses. Visibility of an initiative's hot spots may also influence the overall management of the project.

The probability versus impact matrix (Figure 7.6-2) can also be used to support timely risk control. The bold line in the figure represents a risk tolerance line. It illustrates the overall level of risk that the organization is willing to tolerate in the depicted situation. Risks that are plotted above the line are consequently regarded as unacceptable and require immediate or prompt action. Risks below the tolerance line are considered to be acceptable and should be monitored on a periodic basis.

For there to be tangible risk control after the project control plan has been implemented (Section 8.1), risk owners should, at a minimum, periodically update their qualitative risk analyses. Periodic risk control meetings can facilitate ongoing risk identification and analysis. Using such data, the team can determine if risk treatment is effective or if additional corrective action is required. If an identified risk is shown to have occurred but the original qualitative impact scores are seen to be underestimated, then contingency or fallback plans may be implemented. These changes are managed using the change management process (Section 10.3). In some cases, further risk planning, assessment, treatment, and control may be required to cover these changes, such as when performance trends may worsen, or if new risk drivers arise.

The review committee must be satisfied with the quality of data available to them. Before reporting risk data, they must also be satisfied with the content so there may be occasions where their consensus of opinion differs from that of the individual risk owner. When communicating risk, it is important to remember that, owing to the nature of uncertainty, data is often subjective and circumstantial. Risk perception differs from person to person and, invariably, this can be an emotive subject. For these reasons, it is important that no one individual sanctions a report. A review committee of four to six key stakeholders should ensure that it is their consensus of opinion that is communicated. Reports may take the form of the probability versus impact matrix, they may simply highlight the trends of the 'headline' risks or highlight areas of the scope that give rise for concern or show promise. Reporting requirements are variable so benefit can be gained if these are clearly prescribed in the risk management plan.

Outputs from the risk control process steps will help inform contingency analysis. In contingency analysis, the estimated cost and schedule impacts derived from quantitative risk analysis for residual risks must reflect an assumed contingent response where applicable. For example, if the project has a schedule-driven objective, a delay risk may be responded to by spending money to salvage the schedule; alternatively, a cost-driven project may allow the schedule to slip and incur nominal increases in time-driven costs. Few significant risks are passively accepted so one of the products of the contingency estimate is a list of assumed contingent responses or contingency plans for each risk. There are always cost-schedule tradeoffs associated with responses. It is therefore essential that the project team clearly understand the project objectives captured when risk planning then monitor and control their risk responses to help ensure contingency funds are adequate.

Even with the best risk management infrastructure, the ultimate success of the risk management process is due to the ongoing engagement of the entire team. This will not be a problem for an organization that actively promotes a risk aware culture and operates with a high level of risk management maturity. In other organizations that struggle to recognize the benefits of risk management, or believe that it is nothing more than a cursory bolt-on activity that is solely the preserve of a back-room specialist, there will exist cultural barriers to effective risk control. In these instances, such cultural barriers could be overcome after, for example, training campaigns, incentive programs and risk management audits.

An organization that strives to achieve the highest level of risk management maturity will work towards continual improvement. At the close of the project, one key action will be to capture historical data regarding risk drivers and their impacts in the project database (Section 10.4).

7.6.2.5 Develop and Maintain Methods and Tools

Risk management uses a variety of methods (e.g. parametric or simulation models) and tools (e.g. risk breakdown structures, risk driver checklists, report templates, etc.) that are enterprise specific and must therefore be developed and maintained by each entity. Historical risk occurrence, associated consequences, along with successful risk response plans are all key resources that can be used by an organization to create effective risk management methods and tools.

7.6.3 Inputs to Risk Management

7.6.3.1 *Strategic Asset Requirements and Project Implementation Basis* - These define the basis asset scope, objectives, constraints, and assumptions, including basic assumptions about risks.

7.6.3.2 *Asset or Project Scope* - Deliverables (asset options, work breakdown structure, work packages, and execution strategy) that define the current asset or project scope. Risk factors may be inherent characteristics or conditions of the asset or project scope. Scope changes for which risk assessment and analysis will be applied also channel through the scope development process (Section 3.2, 7.1, and 10.3).

7.6.3.3 *Planning Information* - All planning components may be subject to risk factors that must be assessed. Also, alternate plans may be considered to mitigate risk factor impacts. Results from value engineering are particularly important to assess (Section 3.2, 3.3, 7.1, 7.2, 7.3, 7.4, 7.5, and 7.7).

7.6.3.4 *Cost, Schedule, and Resource Information* - The quantification of risk factor impacts employs the methods and tools of the respective planning processes. Risk analysis is iterative with the other planning processes (Section 7.2, 7.3, and 7.4).

7.6.3.5 *Risk Performance Assessment* - In the performance assessment processes, the asset or project status is monitored for the occurrence of risk factors. New risk factors identified during asset operation or project execution may require updated risk management planning (Section 6.1 and 10.1).

7.6.3.6 *Change Information and Contingency Management* - During project execution, changes to the baseline scope definition and plans are identified in the change management process. In some cases, further risk assessment and analysis may be required for changes and trends. Additional contingency may be required to address changes and performance trends (Section 10.3).

7.6.3.7 *Historical Information* - Past risk factor occurrence and impacts, risk management approaches, and results are key resources for understanding asset and project uncertainty and for creating risk management methods and tools (Section 6.3 and 10.4).

7.6.4 Outputs from Risk Management

7.6.4.1 *Cost, Schedule, and Resource Information* (including contingency) - The quantification of risk factor impacts employs the methods and tools of the respective planning processes. Contingency is incorporated in project plans as appropriate (Section 7.2, 7.3, and 7.4).

7.6.4.2 *Planning Basis Information* - Alternate concepts and plans may be considered to mitigate risk factor impacts. Ultimately, one alternative is selected as the asset or project planning basis. It is particularly important to determine the extent that alternate concepts may affect value (Section 3.2, 3.3, 7.1, 7.2, 7.3, 7.4, 7.5, and 7.7).

7.6.4.3 *Risk Management Plan* - This plan becomes part of the overall project control plan that is implemented. A risk management plan may also be developed for non-project asset investment decision actions. The risk register is a key deliverable of the plan that serves as the bedrock for all subsequent risk management process steps (Section 3.3 and 8.1).

7.6.4.4 *Change Information and Contingency Management* - Findings from risk assessment and analysis may influence the management of changes and contingency (Section 6.2 and 10.3).

7.6.4.5 *Historical Information* - Risk management approaches are key resources for future planning and methods development. Historical risk outcomes are reported from the asset and project performance assessment processes (Section 6.3 and 10.4).

7.6.5 Key Concepts and Terminology for Risk Management

7.6.5.1 *Base or Point Estimate or Deterministic Value* – Section 7.6.2.2
7.6.5.2 *Confidence Level, Percentile or P Value* - Section 7.6.2.2
7.6.5.3 *Contingency* - Section 7.6.2.2
7.6.5.4 *Contingent Response* - Section 7.6.2.2
7.6.5.5 *Enterprise Risk Management (ERM)* - Section 7.6.1
7.6.5.6 *Opportunities* - Section 7.6.1.1
7.6.5.7 *Probabilistic Value* - Section 7.6.2.2
7.6.5.8 *Probability Distribution* - Section 7.6.2.2
7.6.5.9 *Probability vs. Impact Matrix* - Section 7.6.2.2
7.6.5.10 *Qualitative Risk Analysis* - Section 7.6.2.2
7.6.5.11 *Quantitative Risk Analysis* - Section 7.6.2.2
7.6.5.12 *Residual Risk* - Section *7.6.2.2*
7.6.5.13 *Response Strategies* - Section 7.6.2.3
7.6.5.14 *Risk* - Section 7.6.1.1
7.6.5.15 *Risk Assessment* - Section 7.6.2.2
7.6.5.16 *Risk Breakdown Structure* - Section 7.6.2.2
7.6.5.17 *Risk Control* - Section 7.6.2.4
7.6.5.18 *Risk Drivers* - Section 7.6.2.2
7.6.5.19 *Risk Identification* - Section 7.6.2.2
7.6.5.20 *Risk Management Maturity* - Section 7.6.2.[illegible] and 7.6.2.4
7.6.5.21 *Risk Management Plan* - Section 7.6.2.1
7.6.5.22 *Risk Metalanguage* - Section 7.6.2.2
7.6.5.23 *Risk Owner* - Section 7.6.2.[illegible]
7.6.5.24 *Risk Planning* - Section 7.6.2.1
7.6.5.25 *Risk Register* - Section 7.6.2.[illegible]
7.6.5.26 *Risk Response Plan* - Section 7.6.2.3
7.6.5.27 *Risk Screening* - Section 7.6.2.3
7.6.5.28 *Risk Tolerance* - Section 7.6.2.4
7.6.5.29 *Risk Treatment* - Section 7.6.2.3
7.6.5.30 *Secondary Risk* - Section 7.6.2.2
7.6.5.31 *Scenario Analysis* - Section 7.6.2.2
7.6.5.32 *Simulation and Modeling* - Section 7.6.2.2
7.6.5.33 *Stakeholders* - Section 7.6.2.1
7.6.5.34 *Threats* - Section 7.6.1.1

AACE International Recommended Practices

The following AACE International recommended practices (RPs) are applicable to this section of the *TCM Framework*. All RPs listed here are published by AACE International, Morgantown, WV. Please be sure to refer to web.aacei.org for the latest revisions and additions.

- 39R-06, *Project Planning – As Applied in Engineering and Construction for Capital Projects*.
- 40R-08, *Contingency Estimating – General Principles.*
- 41R-08, *Risk Analysis and Contingency Determination Using Range Estimating.*
- 42R-08, *Risk Analysis and Contingency Determination Using Parametric Estimating.*

- 43R-08, *Risk Analysis and Contingency Determination Using Parametric Estimating – Example Models as Applied for the Process Industries.*
- 44R-08, *Risk Analysis and Contingency Determination Using Expected Value.*
- 57R-09, *Integrated Cost and Schedule Risk Analysis Using Monte Carlo Simulation of a CPM Model.*
- 58R-10, *Escalation Estimating Principles and Methods Using Indices.*
- 61R-10, *Schedule Design – As Applied in Engineering, Procurement, and Construction.*
- 62R-11, *Risk Assessment: Identification and Qualitative Analysis.*
- 63R-11, *Risk Treatment.*
- 64R-11, *CPM Schedule Risk Modeling and Analysis: Special Considerations.*
- 65R-11, *Integrated Cost and Schedule Risk Analysis and Contingency Determination Using Expected Value.*
- 66R-11, *Selecting Probability Distribution Functions for use in Cost and Schedule Risk Simulation Models.*
- 67R-11, *Contract Risk Allocation – As Applied in Engineering, Procurement, and Construction.*
- 68R-11, *Escalation Estimating Using Indices and Monte Carlo Simulation*
- 70R-12, *Principles of Schedule Contingency Management – As Applied in Engineering, Procurement and Construction.*
- 72R-12, *Developing a Project Risk Management Plan*
- 75R-13, *Schedule and Cost Reserves within the Framework of ANSI/EIA-748*
- 77R-15, *Quality Assurance/Quality Control for Risk Management*
- 80R-13, *Estimate at Completion (EAC)*
- 82R-13, *Earned Value Management (EVM) Overview and Recommended Practices Consistent with EIA-748-C.*
- 85R-14, *Use of Decision Trees in Decision Making.*