



AAACE International Recommended Practice No. 46R-11

REQUIRED SKILLS AND KNOWLEDGE OF PROJECT COST ESTIMATING
TCM Framework: General Reference

Rev. January 16, 2013

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

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INTRODUCTION

This recommended practice (RP) is intended to serve as a guideline, not a standard. As a recommended practice of AACE International, the intent of the guideline is to define the required skills and knowledge to perform project cost estimating. It serves as the foundation of the skills and knowledge of an AACE Certified Estimating Professional™ (CEP™).

Project cost estimating requires knowledge of all elements of cost from project conception to completion. This includes: direct material and labor costs, indirect costs, general administration costs, profit, finance cost, owner's costs and startup costs. This may also include operations and maintenance costs for selection of project alternatives.

Purpose

The RP highlights the necessary skills and knowledge of a cost estimator from a high level viewpoint. It identifies competencies for a project cost estimator. Detailed skills, knowledge and methodology, are excluded from this recommended practice. These skills and knowledge are applicable to the cost estimating profession across all industries and types of projects.

This RP is aligned with RP 11R-88, *Required Skills and Knowledge of a Cost Engineer* and the *Total Cost Management Framework*.

RECOMMENDED PRACTICE

A cost estimate is a compilation of all the probable costs of the elements of a project or effort included within an agreed upon scope.

Cost estimating is the predictive process used to quantify, cost, and price the resources required by the scope of an investment option, activity, or project. Cost estimating is a process used to predict uncertain future costs. In that regard, a goal of cost estimating is to minimize the uncertainty of the estimate given the level and quality of scope definition. The outcome of cost estimating ideally includes both an expected cost and a probabilistic cost distribution. As a predictive process, historical reference cost data (where applicable) improve the reliability of cost estimating. Cost estimating, by providing the basis for budgets, also shares a goal with cost control of maximizing the probability of the actual cost outcome being the same as predicted.

The cost estimating process is generally applied during each phase of the asset or project life cycle as the asset or project scope is defined, modified, and refined. As the level of scope definition increases, the estimating methods used become more definitive and produce estimates with increasingly narrow probabilistic cost distributions. The specific estimating tools and techniques used vary widely depending upon the industry, organization, the life cycle phase, the type of asset or project, and the level of definition of scope information available. The analysis, development, and maintenance of estimating tools and techniques are steps that are considered part of the estimating process.

The cost estimating process is typically performed concurrent to or iteratively with the asset and project planning and evaluation processes described in the *TCM Framework*. Because costs are often dependent on time duration,

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while resource requirements identified in cost estimating may affect the schedule, the estimation of the time duration of activities must be considered concurrently with costs. Iterative approaches are used to enable the team to remain current with cost as the project/product scope matures. This is a direct input into the organization's decision process which systematically evaluates and refines a scope until it satisfies all of the organization's requirements.

Estimating is a predictive process which requires judgment and experience although some aspects of estimating lend themselves to semi-automation (e.g., quantity take-off tools, estimating software tools, determinations of quantities by computer-aided design tools, and so on). While these tools increase efficiency they are not a substitute for experience and judgment.

Effective cost estimating requires an understanding of the work being planned. In some industries, such as engineering and construction, cost estimating is a recognized discipline because of the specialized knowledge required. In all industries, many individuals contribute to the performance of the estimating process.

The cost estimating process includes: planning for the estimate, quantifying scope, applying cost to the scope, pricing of the project, reviewing, validating, and documenting the estimate.

Project cost estimators predict the cost of a project for a defined scope, to be completed at a defined location and point of time in the future. Cost estimators assist in the economic evaluation of potential projects by supporting the development of project budgets, project resource requirements, and value engineering. They also support project control by providing input to the cost control baseline. Estimators collect and analyze data on all of the factors that can affect project costs such as: materials, equipment, labor, location, duration of the project, and other project requirements. A professional cost estimator practitioner must be able to articulate the meaning of the terms cost estimating and total cost management (TCM).

Cost estimators may have different perspectives depending on their particular situation. The following are two possible scenarios:

1. When working for an owner organization, cost estimators are involved directly in supporting the economic evaluation of a potential program or project. They will establish the baseline estimate for budgetary purposes and financing. This includes not only the scope of work to be completed by various contractors, but also the costs for all other portions of the project that may be the owner's responsibility. The owner estimator reviews and validates contractor estimates; prepares conceptual estimates in early phases (before contractors are involved); validates estimates prepared by joint venture (JV) partners; and prepares operating and abandonment cost estimates.
2. When working for a contracting organization, cost estimators determine the probable cost of the contractor's defined scope of work plus the contractor's profit. This typically constitutes the contractor's bid, tender or proposal. The owner will typically compare various contractor bids for possible project award.

What is the career progression for a cost estimator?

Typically, most cost estimators begin as junior estimator with a limited focus depending upon the industry they are employed in. For example, in construction, they may develop their skills around a specific trade or discipline of work (e.g., civil, structural, architectural, mechanical, electrical, etc.). As the estimator practitioner develops their skills, they progress to a senior estimator position and may be considered subject matter experts (SME's) in multiple areas of estimating (e.g., multiple disciplines of work, quantity takeoff, pricing, bidding and analysis, change orders, life cycle analysis, value engineering, etc.). After mastering many areas within the estimating fields, the seasoned estimator may become the chief estimator of the estimating department or organization. Chief estimators may

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have company management duties such as: developing estimating standards and guidelines, training, and other management roles.

What are the differences between an owner estimator, engineering consultant estimator and a construction contractor estimator?

The roles and duties of the owner, engineering consultant, and construction contractor estimators may vary throughout the phases of a project. We will use facilities projects to describe the differences, but similar variations will exist for other industries.

Owner Estimator

The owner estimator typically has the duty to develop and oversee an owner's full cost portfolio for a given year of spending requirements. The owner's estimating staff may include a full discipline of estimator support (civil, structural, architectural, mechanical, and electrical, etc.) but may depend on the size of the owner organization. The owner estimator position typically requires experience in multiple disciplines. The owner estimator may be involved in planning phases of programs or projects consisting of conceptual, budget and definitive estimating, as well as, value engineering, change control, claims avoidance/reconciliation and risk modeling/management.

During the bidding cycle of construction projects, the owner estimator will be called upon to update the owner's estimate with addenda details, collect and evaluate contractor bids, assess the lowest responsive bidder, evaluate bids, and support owner decision making. During construction implementation activity, the owner estimator will be engaged in change control, change order processing, negotiations, claims avoidance and cost trending. After construction is completed the owner estimator will be asked to reconcile definitive estimates to actual construction costs and provide lessons learned to the owner organization.

After the project is complete the owner estimator collects project data and develops historical databases that can support estimating for future projects. The goal of the owner estimator is to determine the appropriate capital budget for the project to be successful. Typically, bids will only comprise a portion of the overall owner's estimate. The owner's estimate forms the basis for project funding requirements, and includes both project capital and expense costs.

Engineering Consultant Estimator

The engineering consultant estimator may have similar duties and responsibilities as the owner estimator because they are often tasked with preparing the facility estimate on behalf of the owner. Typically, the cost estimate prepared by the engineering consultant estimator will exclude owner costs associated with the overall project funding. If the owner contracts with an engineering firm to prepare the facility estimate, the owner has ultimate responsibility to condition the engineer's estimate and include all owner related costs and expenses to support full project funding.

Construction Contractor Estimator

The construction contractor's estimating roles and duties traditionally cover the "hard bidding" aspects of cost estimating. A prime construction contractor estimator typically provides the estimate for the portion of construction activity that they will self-perform. They may receive bids from their preferred subcontractors for the remaining portion of the work. The construction contractor estimator's duties often consist of compiling the multiple bids into a one overall bid package that will ultimately be considered by the project owner. This may

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include responsibility to review subcontractor quotes, ascertain their compliance with scope, and incorporate prime contractor carrying charges and profit markups. These estimators also keep estimates (bids) for historical purposes to potentially be used for conceptual pricing on future prospect work or to use as competitive data on future bid proposals.

COST ESTIMATING PROCESS MAP

TCM Framework Fig 7.3.1 (Figure 1) illustrates the process map for cost estimating and budgeting that shows the basic work flow process of the development of a cost estimate. This includes: planning for the estimate, quantifying scope, applying cost to the scope, pricing of the project, reviewing, validating, and documenting the estimate.

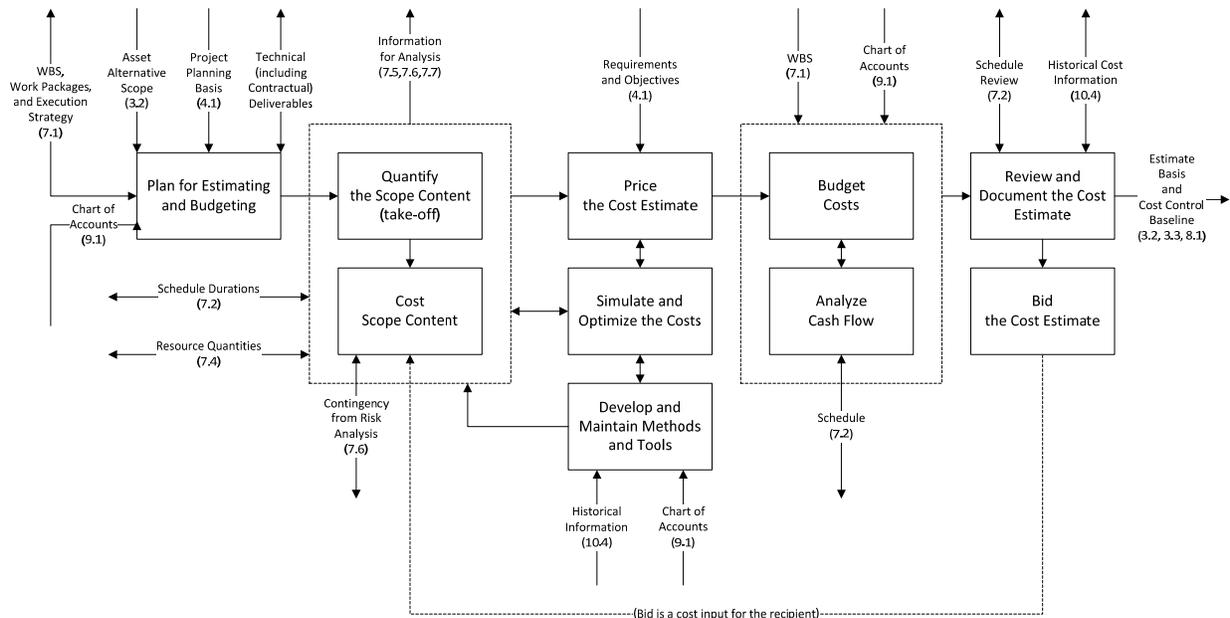


Figure 1 – Process Map for Cost Estimating and Budgeting (TCM 7.3.1)

COMPETENCY MODEL

Figure 2 illustrates the hierarchical structure of the skills and knowledge competency model for a cost estimator. The first level of the structure differentiates between general supporting knowledge used in more than one practice or process, and specific practice knowledge used in particular functions or process steps. Succeeding levels further break down the content to whatever level is appropriate for each skills and knowledge area. The location of a skill or knowledge element in the level of the outline does not reflect on its relative importance.

The structure is organized in accordance with the plan, do, check, and assess (PDCA) process model that serves as the basis for the *TCM Framework* through which all the skills and knowledge of cost engineering are applied. TCM is not structured by a practitioner's work function. For example, cost estimators will not find all of their required skills and knowledge under one heading. The required skills and knowledge of a cost estimator will include elements of supporting knowledge, as well as elements of planning, measuring, and assessing that are appropriate to the estimating function.

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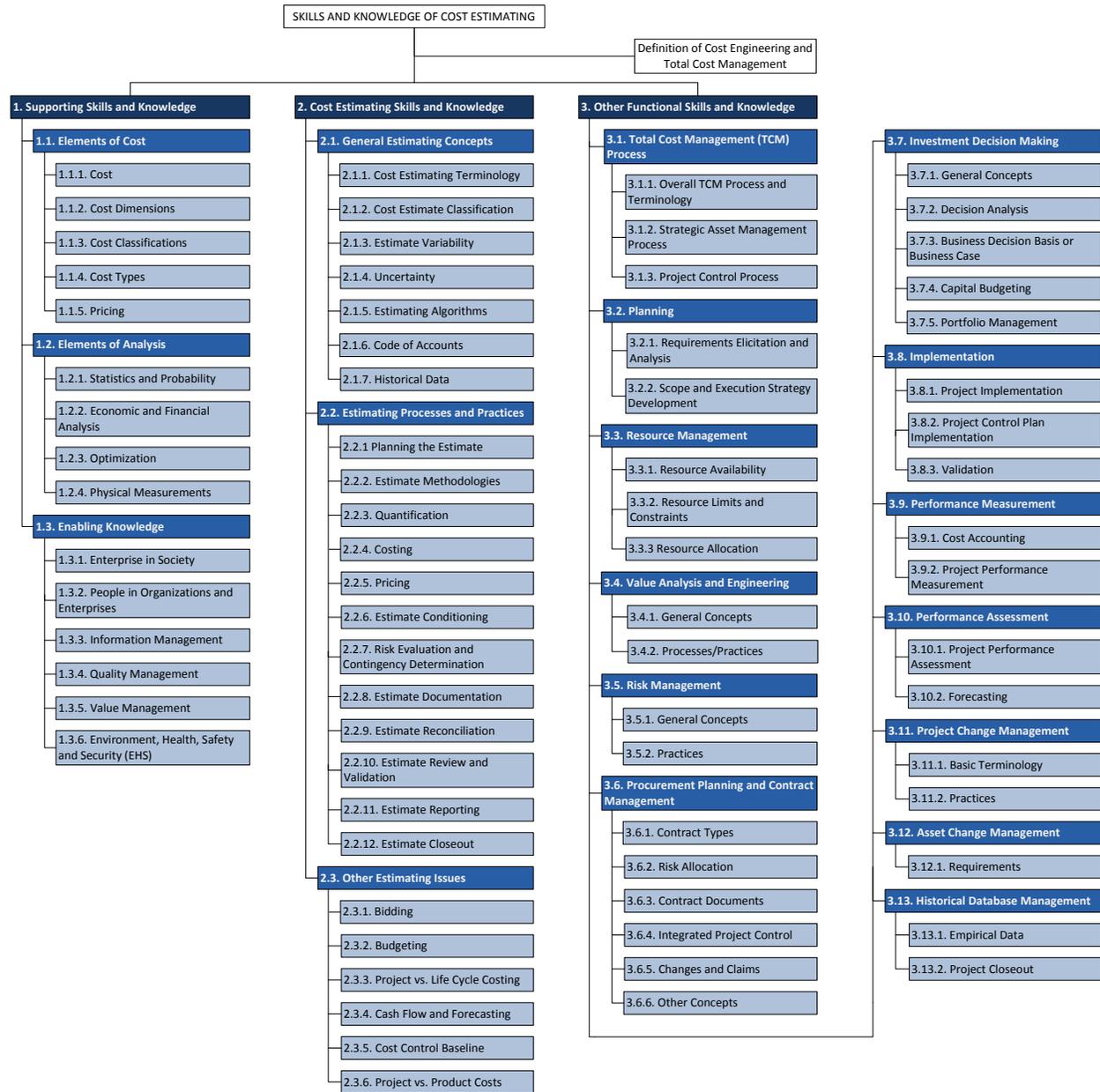


Figure 2 – High Level Outline of Skills and Knowledge of Cost Estimating derived from RP 11R-88, *Required Skills and Knowledge of Cost Engineering*.

In the following detailed outline, a “P” in the leftmost column indicates key concepts that form the major emphasis for the AACE International Certified Estimating Professional (CEP) certification examination; while an “S” identifies concepts with less emphasis in the examination (although not necessarily of less importance).

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OUTLINE OF THE SKILLS AND KNOWLEDGE OF PROJECT COST ESTIMATING [P = Primary, S = Secondary]

P	1. Supporting Skills and Knowledge
P	1.1. Elements of Cost
P	1.1.1. Cost: be able to define/explain these general concepts in relation to each other and to assets and/or activities.
P	1.1.1.1. Resources
P	1.1.1.2. Time
P	1.1.1.3. Cost
P	1.1.2. Cost Dimensions:
P	1.1.2.1. Lifecycle: be able to describe this term and differentiate the life cycle of an asset and a project
P	1.1.2.2. Process (product vs. project): be able to describe and differentiate the cost characteristics and types (see cost types below) that make up product and project costs.
P	1.1.2.2.1. Be able to distinguish among products, co-products, and byproducts.
P	1.1.2.3. Responsibility: be able to describe and differentiate the cost perspectives of an owner and a contractor/supplier
P	1.1.2.4. Valuation: be able to describe and differentiate cost from cash/monetary versus economic/opportunity costs (also see economic analysis) perspectives.
P	1.1.2.5. Influence: be able to explain the concept of the cost influence curve
P	1.1.2.6. Legal:
S	1.1.2.6.1. Be able to explain how cost and schedule analysis practices might differ when applied for forensic versus traditional planning and control purposes.
S	1.1.2.6.2. Be able to describe some potential legal consequences that may result from using poor or unethical cost management practices (e.g., anti-trust, claims, Sarbanes-Oxley, etc)
P	1.1.3. Cost Classifications: for the following classifications, be able to:
P	1.1.3.1. Explain the general differences between the ways costs are classified for various cost management purposes
P	1.1.3.2. Given a problem with appropriate cost classification inputs (e.g., indirect cost using ABC classification method), be able to calculate how the cost would be accounted for in a project or product estimate.
P	1.1.3.2.1. Operating (Production, Manufacturing, Maintenance, etc.) vs. Capital
P	1.1.3.2.2. Capital vs. Expense
P	1.1.3.2.2.1. Depreciation
P	1.1.3.2.2.2. Amortization
P	1.1.3.2.2.3. Accrual
P	1.1.3.2.3. Fixed vs. Variable
P	1.1.3.2.4. Direct vs. Indirect
P	1.1.3.2.4.1. Activity-Based Costing (ABC)
P	1.1.3.2.4.2. Job Costing
P	1.1.4. Cost Types: for the following cost types, given cost type and classification inputs, be able to apply them in a project or manufacturing estimating application (i.e., for project or product cost)
P	1.1.4.1. Materials:
P	1.1.4.1.1. Materials types: be able to describe the types and their cost drivers:
P	1.1.4.1.1.1. Raw
P	1.1.4.1.1.2. Bulk
P	1.1.4.1.1.3. Fabricated
P	1.1.4.1.1.4. Engineered or designed
P	1.1.4.1.1.5. Consumables

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P	1.1.4.1.2. Purchase costs: be able to describe these terms/concepts and their influence on the cost of materials:
P	1.1.4.1.2.1. Market pricing (pre-negotiated vs. competitively bid, etc.)
P	1.1.4.1.2.2. Order quantity
P	1.1.4.1.2.3. Taxes and duties
P	1.1.4.1.2.4. Carrying charges
P	1.1.4.1.2.5. Cancellation charges
P	1.1.4.1.2.6. Demurrage
P	1.1.4.1.2.7. Hazardous material regulations
P	1.1.4.1.2.8. Warranties, maintenance and service
P	1.1.4.1.3. Materials management costs: be able to describe these terms/concepts and their influence on the cost of materials:
P	1.1.4.1.3.1. Delivery schedule
P	1.1.4.1.3.2. Packing
P	1.1.4.1.3.3. Shipping and freight
P	1.1.4.1.3.4. Freight forwarding
P	1.1.4.1.3.5. Handling
P	1.1.4.1.3.6. Storage and inventory
P	1.1.4.1.3.7. Agent cost
P	1.1.4.1.3.8. Surveillance or inspection
P	1.1.4.1.3.9. Expediting
P	1.1.4.1.3.10. Losses (shrinkage, waste, theft, damage)
P	1.1.4.1.3.11. Spare parts (inventory or start-up)
P	1.1.4.1.3.12. Surplus materials
P	1.1.4.1.4. Capital Equipment: (i.e., fabricated or engineered items)
P	1.1.4.1.4.1. Rent vs. lease vs. purchase:
P	1.1.4.1.4.1.1. Be able to explain the mechanics and cost considerations.
P	1.1.4.1.4.1.2. Given a problem with useful life, fixed and operating cost, credits, depreciation, taxes, etc., be able to determine the most economical option
P	1.1.4.1.4.2. Valuation: be able to explain these concepts:
P	1.1.4.1.4.2.1. Reproduction costs
P	1.1.4.1.4.2.2. Replacement costs
P	1.1.4.1.4.2.3. Fair value
P	1.1.4.1.4.2.4. Market value
P	1.1.4.1.4.2.5. Book value
P	1.1.4.1.4.2.6. Residual or economic value
P	1.1.4.1.4.2.7. Operating vs. economic life
P	1.1.4.1.5. Temporary Equipment: (expensed items for construction, maintenance, etc) be able to explain the cost implications of rent, operators, maintenance, scheduling, etc.
P	1.1.4.2. Labor
P	1.1.4.2.1. Labor Wage Rate or Salary:
P	1.1.4.2.1.1. Be able to describe the differences in mechanics of compensation for wage and salaried employees including the meaning of exempt and non-exempt.
P	1.1.4.2.1.2. Be able to calculate an effective wage rate allowing for:
P	1.1.4.2.1.2.1. Overtime premium
P	1.1.4.2.1.2.2. Other premium pays
P	1.1.4.2.1.2.3. Shortened shift time
P	1.1.4.2.1.2.4. Travel time

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P	1.1.4.2.1.2.5. Show-up pay
P	1.1.4.2.2. Benefits and Burdens (mandated and fringe):
P	1.1.4.2.2.1. Be able to describe the basic mechanics of benefits and burdens such as:
P	1.1.4.2.2.1.1. Retirement (social security),
P	1.1.4.2.2.1.2. Unemployment insurance
P	1.1.4.2.2.1.3. Workers compensation
P	1.1.4.2.2.1.4. Insurance
P	1.1.4.2.2.1.5. Paid time off (sick, vacation, holiday)
P	1.1.4.2.2.2. Be able to identify typical differences between industrialized and non-industrialized countries and between populated and remote areas.
P	1.1.4.2.3. Overhead and profit: be able to describe the basic mechanics of charging various overhead and profit cost elements to direct labor costs such as:
P	1.1.4.2.3.1. Indirect labor (home office, administrative and similar costs)
P	1.1.4.2.3.2. Small tools
P	1.1.4.2.3.3. Profit
P	1.1.4.2.4. Union: be able to explain the cost differences between union and open shop labor
P	1.1.4.3. Subcontract: be able to explain the cost implications of the following issues:
P	1.1.4.3.1. Reimbursable vs. non-reimbursable costs
P	1.1.4.3.2. Overhead and profit (including contract administration and legal costs)
P	1.1.4.3.3. License, fees or royalties
P	1.1.4.3.4. Bonds (bid, payment, or performance)
P	1.1.4.3.5. Retainage
P	1.1.4.3.6. Performance guarantees
P	1.1.4.3.7. Liquidated damages
P	1.1.4.4. Cost of money: be able to describe these costs:
P	1.1.4.4.1. Escalation
P	1.1.4.4.2. Inflation
P	1.1.4.4.3. Currency exchange rates
P	1.1.4.5. Risk and Uncertainty: be able to describe these costs:
P	1.1.4.5.1. Contingency
P	1.1.4.5.2. Allowance
P	1.1.4.5.3. Reserve
P	1.1.5. Pricing
P	1.1.5.1. Cost vs. Pricing: be able to explain the difference
P	1.1.5.2. Price strategy:
P	1.1.5.2.1. Be able to describe how business strategy and market forces may affect pricing.
P	1.1.5.2.2. Be able to describe from an owner or buyer perspective concerns about pricing (i.e., risks, competitiveness, cash flow, etc).
P	1.1.5.2.3. Be able to describe how profit affects pricing
P	1.1.5.2.4. Be able to describe how profit may be determined how the different types of contracts may influence the amount
S	1.2. Elements of Analysis
S	1.2.1. Statistics and Probability
S	1.2.1.1. Samples and Populations: be able to describe the relationship of the mean of a sample to the mean of a population, and the general affect of sample randomness, bias and size on the reliability of the sample statistics.
S	1.2.1.2. Descriptive Statistics

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S	1.2.1.2.1. Basic Statistics: given a set of data, be able to determine the arithmetic mean, median, mode, standard deviation and variance.
S	1.2.1.2.2. Normal Distribution: be able to provide the percent of observations within one and two standard deviations of the mean for a normally distributed variable.
S	1.2.1.2.3. Non-Normal Distributions: be able to describe the following concepts:
S	1.2.1.2.3.1. Skewness (symmetry)
S	1.2.1.2.3.2. Kurtosis (central tendency relative to normal).
S	1.2.1.2.4. Histograms, Cumulative Frequency: given a tabular distribution for a variable that is other than normal, be able to draw a histogram and resultant cumulative frequency curve (frequency distribution), and determine the percent probability of the variable not being less than or more than a given number
S	1.2.1.3. Inferential Statistics
S	1.2.1.3.1. Probability: given a curve of normal distribution and an accompanying table of areas under the curve, be able to determine the probability of a) the variable being between two given numbers, b) not being higher than a given number, or lower than that number, and c) given a confidence interval or range in terms of percentage probability, give the corresponding low and high number of the interval or range.
S	1.2.1.3.2. Regression Analysis: be able to describe the concept of the methodology as well as diagnostic statistics (R^2 , root mean square error (RMSE), and t)
S	1.2.1.3.3. Statistical Significance:
S	1.2.1.3.3.1. Be able to describe the purpose and use of chi-squared and t-tests
S	1.2.1.3.3.2. Be able to interpret the t-statistic for comparing two sets of normally distributed data.
S	1.2.1.3.3.3. Be able to interpret of the chi-squared statistic for comparing two sets of data that may not be normally distributed.
S	1.2.2. Economic and Financial Analysis
S	1.2.2.1. Economic Cost: be able to define concepts of opportunity cost and assigning monetary value to non-cash values, costs and benefits.
S	1.2.2.2. Cash Flow Analysis:
S	1.2.2.2.1. Be able to calculate simple and compound interest rates and solve interest problems using the basic single payments, uniform series, and gradient formulas.
S	1.2.2.2.2. Given a set of cost and revenue forecasts calculate a cash flow for an asset investment option
S	1.2.2.3. Internal Rate of Return: be able to determine discounted rate of return of a cash flow series.
S	1.2.2.4. Present/Future Value Analysis: be able to calculate present value, future value, and equivalent uniform annual value of a cash flow series.
P/S	1.2.3. Optimization
P	1.2.3.1. Model:
P	1.2.3.1.1. Be able to describe the concept of a quantitative representational models and parameters.
P	1.2.3.1.2. Given an optimization goal involving a result Y which is a function of X, use graphical or incremental methods to determine the optimum value of Y.
S	1.2.3.2. Linear Programming: be able to describe the types of problems amenable to this mathematical optimization technique (i.e., find extreme points of a function given a set of constraints).
S	1.2.3.3. Simulation: be able to describe the use of a model for analysis of a cost problem.
S	1.2.3.4. Sensitivity Analysis: be able to perform a sensitivity analysis of a modeled problem.

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P	1.2.4. Physical Measurements: be able to convert basic metric and imperial weight and dimensional measurements.
S	1.3. Enabling Knowledge
S	1.3.1. Enterprise in Society
S	1.3.1.1. Ethics:
S	1.3.1.1.1. Be able to explain the need to judge the means and the ends of a practice or process against personal and societal values and rules of conduct.
S	1.3.1.1.2. Be familiar with AACE International's ethics policy (Canons of Ethics).
P	1.3.2. People and Organizations in Enterprises
P	1.3.2.1. Leadership: Be able to explain why it is important to obtain team commitment and clearly communicate the purpose of a task or project, and how this might be done.
P	1.3.2.1.1. Performance/Productivity Management:
P	1.3.2.1.1.1. Be able to describe the concept of productivity (and its difference from the term production).
P	1.3.2.1.1.2. Be able to describe the affect on performance of these factors in terms of motivation and waste/inefficiency, and how performance could be improved and at what cost (e.g., leadership role, work process change, etc.):
P	1.3.2.1.1.2.1. Individual worker skills
P	1.3.2.1.1.2.2. Crew balance of skills
P	1.3.2.1.1.2.3. Immediate supervision competence
P	1.3.2.1.1.2.4. Overall supervision competence
P	1.3.2.1.1.2.5. Worker and supervision attitudes
P	1.3.2.1.1.2.6. Work force sociological, cultural and demographic characteristics
P	1.3.2.1.1.2.7. Absenteeism and turnover
P	1.3.2.1.1.2.8. Overtime
P	1.3.2.1.1.2.9. Level of technology used
P	1.3.2.1.1.2.10. Learning curve
P	1.3.2.1.1.2.11. Work area environment
P	1.3.2.1.1.2.12. Weather
P	1.3.2.1.1.2.13. Geographic location
P	1.3.2.1.1.2.14. Proximity to other work and contractors
P	1.3.2.1.1.2.15. Job layout
P	1.3.2.1.1.2.16. Work rules
P	1.3.2.1.1.2.17. Safety practices
P	1.3.2.1.1.2.18. Quality control practices (including quality circles)
P	1.3.2.1.1.2.19. Materials and tools availability
P	1.3.2.1.1.2.20. Wages, salaries and benefits.
P	1.3.3. Information Management
P	1.3.3.1. Data, Information, and Knowledge: be able to explain the difference between these three types of "information"
P	1.3.3.2. Databases and Database Management. Be able to define and explain the following concepts:
P	1.3.3.2.1. History: the importance of historical and empirical information to most cost engineering practice
P	1.3.3.2.2. Reference Data: the need that specific methods and tools for specific processed data
P	1.3.3.2.3. Lessons Learned: the need for data that is qualitative in nature.
P	1.3.3.2.4. Metric: the need that benchmarking or validation methods have for specific processed quantitative data

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P	1.3.3.2.5. Validation: the need to assure the reliability and sometimes competitiveness of data
P	1.3.3.2.6. Basis: the need to understand the basis of all data and information in a database
P	1.3.3.2.7. Normalization: be able to adjust data to a common basis in currency, time, location, etc.
S	1.3.3.3. Information Technology (IT) and Systems: be able to explain that information systems are the mechanisms or tools by which knowledge is delivered to the enterprise and those it interacts with (i.e., includes communication).
S	1.3.4. Quality Management: be able to explain the following concepts:
S	1.3.4.1. Quality: be able to define this as conformance to requirements (which are based on customer needs).
S	1.3.4.2. Requirements: (see Requirements Elicitation and Analysis practices)
S	1.3.4.3. Quality Planning: be able to describe this as an integrated way of planning directed towards satisfying customer needs.
S	1.3.4.4. Quality Management: be able to describe this as a process for managing quality and understand that TCM is a quality management process focused on continuous cost performance improvement.
S	1.3.4.5. Quality Assurance: be able to describe this as actions that provide confidence that the requirements will be fulfilled.
S	1.3.4.6. Quality Control: be able to describe this as actions focused on fulfilling requirements
S	1.3.4.7. Continuous Improvement: be able to describe this as a common goal of quality management processes (the traditional result of the PDCA process).
S	1.3.4.8. Plan-Do-Check-Assess (PDCA): be able to describe this as the basis model for TCM and many other management processes.
S	1.3.4.9. Quality Measurement: be able to explain that in some views, cost is the best single quality measurement because so many measures can be expressed in cost terms.
S	1.3.4.10. Quality Policy: be able to explain that this as an imposed requirement that is assumed guided by accepted quality management principles
S	1.3.4.11. Quality Standards: be able to describe these imposed requirements.
S	1.3.4.11.1. ISO 9000 standard quality management series
S	1.3.4.11.2. ISO 10006 quality in project management
S	1.3.4.12. Quality Focused Practices in TCM be aware that these key practices (covered in later sections) have particular importance to quality management
S	1.3.4.12.1. Benchmarking
S	1.3.4.12.2. Cost of Quality
S	1.3.4.12.3. Value Analysis/Engineering
S	1.3.4.12.4. Change Management
P	1.3.5. Value Management:
P	1.3.5.1. Be able to explain the following general concepts (i.e., not in the context of Value Analysis and Engineering practice):
P	1.3.5.1.1. Value (i.e., a measure of the worth of a thing in terms of usefulness, desirability, importance, money)
P	1.3.5.1.2. Value Management (i.e., what an enterprise does to ensure that its assets provide or maintain the usefulness and/or value that the various stakeholders require.)
P	1.3.5.1.3. Value Improving Practices (i.e., practices that have a specific focus and/or significant effect on getting the most value from a process and meet criteria that set the practice apart from “business as usual”.)
P	1.3.5.2. Be able to describe the purposes and general approach of these value improving practices (also see the section on Value Analysis and Engineering):
P	1.3.5.2.1. Manufacturability Analysis

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P	1.3.5.2.2. Constructability Analysis
P	1.3.5.2.3. Reliability, Availability and Maintainability (RAM) Analysis
S	1.3.6. Environment, Health, Safety, and Security (EHS): be able to explain the following concepts:
S	1.3.6.1. Quality Management. Be able to describe why TCM is a quality management process and EHS issues are considered using this process approach (i.e., through establishing EHS requirements and managing to them).
S	1.3.6.2. Non-Conformance/Prevention. Be able to explain why it is important, as in quality management, to focus on preventing non-conformance with EHS requirements and improving performance rather than after the fact appraisal, failure and correction.
S	1.3.6.3. EHS Standards/Compliance. Be able to explain why compliance with minimum standards and regulations should be the minimum expected.
S	1.3.6.3.1. ISO 14000: management systems that an organization employs to manage environmental matters.
S	1.3.6.4. Sustainable Development. be able to explain why enterprises should not use resources in a manner or degree that compromise the ability of future generations to sustain such development.
P	2. Cost Estimating Skills and Knowledge
P	2.1. General Estimating Concepts
P	2.1.1. Cost Estimating Terminology
P	2.1.2. Cost Estimate Classification
P	2.1.3. Estimate Variability
P	2.1.3.1. Be able to describe the elements, conditions, activities, etc. that may affect estimate variability.
P	2.1.4. Uncertainty.(also see Risk Management)
P	2.1.4.1. Probability: Be able to describe the probabilistic nature of cost estimates and the concept of ranges and accuracy, and the importance of communicating these to the project team.
P	2.1.4.2. Accuracy: Be able to describe asset and project characteristics likely to affect the accuracy of cost estimates, and the relationship of estimate classification to accuracy.
P	2.1.4.3. Contingency:
P	2.1.4.3.1. Be able to define the term including what cost it is supposed to cover
P	2.1.4.3.2. Be able to describe several typical ways that it can be estimated
P	2.1.5. Estimating Algorithms
P	2.1.5.1. Algorithm types: Be able to describe the basic characteristics of these algorithm types:
P	2.1.5.1.1. Stochastic or parametric
P	2.1.5.1.1.1. Given the inputs, be able to perform a “scale of operations” estimate
P	2.1.5.1.1.2. Be able to explain why this algorithm type is most often applied in asset planning.
P	2.1.5.1.2. Deterministic or definitive: be able to explain why this algorithm type is most often applied in project control planning.
P	2.1.5.2. Factors:
P	2.1.5.2.1. Be able to describe some typical uses of factors, ratios, and indices in algorithms of various types.
P	2.1.5.2.2. Given a set of project characteristics and associated factors, be able to adjust a cost estimate from one time, location, situation, currency, etc. to another.
P	2.1.6. Code of Accounts
P	2.1.7. Historical Data
P	2.2. Estimating Processes and Practices
P	2.2.1. Planning the Estimate
P	2.2.1.1. Be able to describe practices for assessing estimate requirements
P	2.2.1.2. Be able to describe practices for researching, collecting and analyzing information

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P	2.2.1.3. Be able to describe practices for developing the estimate structure
P	2.2.2. Estimate Methodologies
P	2.2.2.1. Be able to describe and apply the estimating methodology using Investment Curves
P	2.2.2.2. Be able to describe and apply the estimating methodology using Capacity Factoring
P	2.2.2.3. Be able to describe and apply the estimating methodology using Analogy
P	2.2.2.4. Be able to describe and apply the estimating methodology using Parametric Models
P	2.2.2.5. Be able to describe and apply the estimating methodology using Equipment Factoring
P	2.2.2.6. Be able to describe and apply the estimating methodology using Detailed Line-Item Estimating
P	2.2.3. Quantification
P	2.2.3.1. Be able to describe how to quantify the project scope in an applicable manner
P	2.2.3.2. Be able to describe ways that this step is sometimes automated, and considerations for using the results of automated take-off
P	2.2.4. Costing
P	2.2.4.1. Be able to describe how to apply baseline costs to the scope quantities
P	2.2.5. Pricing
P	2.2.5.1. Be able to describe how to adjust baseline costs for commercial or other considerations
P	2.2.5.2. Be able to discuss some business considerations for establishing pricing (risk, competition, desired rate of return, current economic conditions, etc.).
P	2.2.5.3. Given a basic set of cost inputs and production plans be able to calculate a break-even product price
P	2.2.6. Estimate Conditioning
P	2.2.6.1. Be able to describe how to apply overall estimating adjustments, such as escalation
P	2.2.7. Risk Evaluation and Contingency Determination
P	2.2.7.1. Be able to describe how to apply risk analysis to an estimate to support contingency determination
P	2.2.8. Estimate Documentation
P	2.2.8.1. Be able to describe the typical content of estimate documentation
P	2.2.8.2. Be able to describe how to document the Basis of Estimate
P	2.2.9. Estimate Reconciliation
P	2.2.9.1. Be able to explain differences between the current estimate with previous versions; and provide resolutions
P	2.2.10. Estimate Review and Validation
P	2.2.10.1. Be able to effectively review and validate the estimate, including providing estimate benchmarking
P	2.2.11. Estimate Reporting
P	2.2.11.1. Be able to summarize and communicate the estimate content to stakeholders
P	2.2.12. Estimate Closeout
P	2.2.12.1. Be able to document, analyze, organize and archive estimate information for future use
P	2.3. Other Estimating Issues
P	2.3.1. Bidding
P	2.3.1.1. Be able to discuss some considerations for using someone else's bid as an input to your cost estimate.
P	2.3.1.2. Be able to describe the purpose and mechanics of unbalancing or front-end loading a bid
P	2.3.2. Budgeting
P	2.3.3. Project vs. Life Cycle Costing
P	2.3.4. Cash Flow and Forecasting:

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P	2.3.4.1. Be able to discuss the importance of integrating estimating and scheduling practices (incorporating the element of timing in quantification and costing)
P	2.3.4.2. Be able to discuss the affects on planning and cost estimating when cash flow is restricted
P	2.3.4.3. Given a schedule and set of cost inputs, be able to develop a cost flow curve.
P	2.3.5. Cost Control Baseline: be able to describe how cost and schedule control baselines can be integrated
P	2.3.6. Project vs. Product Costs
P/S	3. Other Functional Skills and Knowledge
P	3.1. Total Cost Management (TCM) Process
P	3.1.1. Overall TCM Process and Terminology
P	3.1.1.1. Basic Terminology: be able to explain the following:
P	3.1.1.1.1. Plan-Do-Check-Assess (PDCA):
P	3.1.1.1.2. Strategic asset
P	3.1.1.1.3. Project
P	3.1.1.1.4. Portfolios and Programs
P	3.1.1.2. TCM Processes: be able to sketch the TCM, strategic asset management, and project control processes in basic PDCA format and explain the following:
P	3.1.1.2.1. The cost management purpose of the overall processes
P	3.1.1.2.2. How the two component subprocesses differ, but are related to each other
P	3.1.1.2.3. The benefits of an integrated, systematic cost management approach over the life cycle of assets and projects
P	3.1.2. Strategic Asset Management Process
P	3.1.2.1. Given a representation of the strategic asset management process map (or some portion of it), be able to describe the basic purpose of each step and how it relates to the other steps in the map.
P	3.1.3. Project Control Process
P	3.1.3.1. Given a representation of the project control process map (or some portion of it), be able to describe the basic purpose of each step and how it relates to the other steps in the map.
P	3.1.3.2. Be able to describe the Earned Value management process as a specific way of applying the project control process (i.e., in what ways is it specialized)
P	3.2. Planning
P	3.2.1. Requirements Elicitation and Analysis: be able to describe the following concepts
P	3.2.1.1. Stakeholders/Customers: be able to describe how to identify these in relation to various business problems
P	3.2.1.2. Needs, wants, or expectations of stakeholders: be able describe challenges of eliciting this information from various stakeholders
P	3.2.1.3. Requirements: be able to describe the characteristics of a good requirement for use in asset or project control planning
P	3.2.1.4. Cost requirements: be able to describe the following asset planning methodologies for which cost may be a requirement
P	3.2.1.4.1. Target costing (including design-to-cost, and cost as an independent variable)
P	3.2.1.4.2. Quality-function deployment
P	3.2.1.5. Other Concepts:
P	3.2.1.5.1. Asset vs. Project: be able to explain how requirements for an asset or product might differ from those for a project.
P	3.2.2. Scope and Execution Strategy Development: be able to describe the following concepts
P	3.2.2.1. Asset scope: be able to describe this as the physical, functional and quality characteristics or design basis of the selected asset investment
P	3.2.2.1.1. Functional decomposition

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P	3.2.2.2. Project scope: be able to describe this as the scope of work to deliver the asset
P	3.2.2.2.1. Project scope breakdown (work decomposition)
P	3.2.2.3. Work Breakdown Structure (WBS): be able to diagram a WBS for a basic scope provided in narrative form
P	3.2.2.4. Organization Breakdown Structure (OBS): be able to diagram an OBS for a basic scope provided in narrative form
P	3.2.2.5. Work package
P	3.2.2.6. Deliverables
P	3.2.2.7. Execution strategy
P	3.3. Resource Management
P	3.3.1. Resource availability: be able to discuss ways to assess availability and potential consequences of not doing so
P	3.3.1.1. Be able to describe the types of resources and their appropriateness to analysis
P	3.3.1.2. Be able to discuss potential sources for resources
P	3.3.1.3. Be able to discuss methods for validation of initial estimates
P	3.3.2. Resource limits and constraints: be able to discuss typical limits and constraints that may occur or be imposed
P	3.3.2.1. Be able to discuss the role supervision and span of control has on resource limits
P	3.3.2.2. Be able to describe how optimal and maximum crew sizing may play a part
P	3.3.2.3. Be able to discuss the effects of physical workspace limits
P	3.3.3. Resource allocation: be able to describe the mechanics of this step in schedule development
P	3.3.3.1. Forward vs. backward allocation: be able to explain the differences in the methods
P	3.3.3.2. Smoothing vs. maximum limits: be able to explain the difference in the terms
P	3.3.3.3. Maximum vs. over-maximum allocation: be able to explain the differences in the terms
S	3.4. Value Analysis and Engineering
S	3.4.1. General Concepts:
S	3.4.1.1. Purpose:
S	3.4.1.1.1. Be able define the concept (i.e., "the systematic application of recognized techniques which identify the functions of the product or service, establish the worth of those functions, and provide the necessary functions to meet the required performance at the lowest overall cost." Where overall cost is usually life-cycle cost).
S	3.4.1.1.2. Distinguish among the terms "lowest life-cycle cost," "best quality," and "best value."
S	3.4.1.1.3. Be able to describe how value analysis/engineering differs from other cost or scope reduction exercises
S	3.4.1.1.4. Be able to describe how value analysis and engineering differs from other value improving practices such as manufacturability and constructability.
S	3.4.2. Process/Practices; be able to describe the purpose and mechanics of these steps:
S	3.4.2.1. Function Analysis (Value Measurement)
S	3.4.2.1.1. Be able to apportion cost for the entire project by function.
S	3.4.2.1.2. Be able to determine function value in order to support improvement opportunities.
P	3.5. Risk Management
P	3.5.1. General Concepts
P	3.5.1.1. Risk and Uncertainty: be able to define risk in terms of opportunities and threats
P	3.5.1.2. Risk Factors (or drivers) and Risk Factor Properties
P	3.5.1.3. Risk Management Plan
P	3.5.1.4. Contingency (see cost estimating and schedule development)
P	3.5.1.4.1. Be able to describe the appropriate level of authority for managing contingency

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P	3.5.1.4.2. Be able to describe typical criteria for its use (i.e., as opposed to a slush fund).
P	3.5.1.5. Contingency Action Plans
P	3.5.2. Practices: be able to describe the purpose and mechanics of these risk management process steps:
P	3.5.2.1. Risk Assessment
P	3.5.2.2. Risk Analysis
P	3.5.2.3. Risk Factor Screening
P	3.5.2.4. Risk Mitigation or Acceptance
P	3.5.2.5. Risk Control
P	3.6. Procurement Planning and Contract Management
P	3.6.1. Contract types: be able to explain the advantage and disadvantages of these types of contracts from the owner and contractor viewpoints:
P	3.6.1.1. Fixed price (with fixed, incentive, or award fees)
P	3.6.1.2. Unit price
P	3.6.1.3. Cost-plus (with fixed, incentive, or award fees)
P	3.6.1.4. Time and materials (T&M)
P	3.6.2. Risk Allocation: be able to explain how each contract type above allocates risks between the contracting parties.
P	3.6.3. Contract Documents:
P	3.6.3.1. Be able to describe the general contents and purposes of the following elements of bidding and contract documents:
P	3.6.3.1.1. Invitation to bid or request for proposal
P	3.6.3.1.2. Bid form
P	3.6.3.1.3. Agreement
P	3.6.3.1.4. General conditions
P	3.6.3.1.5. Supplementary or special conditions
P	3.6.3.1.6. Technical specifications
P	3.6.3.1.7. Drawings
P	3.6.3.1.8. Addenda
P	3.6.3.1.9. Modifications
P	3.6.3.1.10. Bid bond and contract (performance) bond
P	3.6.3.1.11. Performance guarantee
P	3.6.3.1.12. Warranties
P	3.6.3.2. Be able to explain the role of contract documents in avoiding and resolving disputes, changes and claims (also see Change Management).
P	3.6.3.3. Be able to describe the various types of insurance that may be required as part of a contract
P	3.6.3.4. Be able to explain the term "retention" and be able to calculate its effective cost given the terms of the contract and time-value of money.
P	3.6.3.5. Be able to distinguish between "Job (project) overhead" and "general overhead" and provide examples of each.
P	3.6.3.6. Be able to explain what is meant by a contract payment term such as "2/15 net 30", and given a payment timing and time value of money scenario, be able to determine the method of payment that is economically most advantageous under these terms.
P	3.6.4. Integrated Project Control:
P	3.6.4.1. Be able to explain the basic mechanics of how the project control process might be integrated between parties to each type of contract. (e.g., how to measure and report progress, integrate schedules, etc.).

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P	3.6.4.2. Be able to explain the role of contract documents in avoiding and resolving disputes, changes and claims (also see Change Management).
P	3.6.5. Changes and Claims: (see Change Management and Forensic Performance Assessment)
P	3.6.6. Other Concepts:
P	3.6.6.1. Supply chain: be able to explain this concept and how it might affect procurement planning.
P	3.6.6.2. Supplier relationships: be able to explain this concept and how it might affect procurement planning (e.g., initial price versus life cycle cost)
P	3.6.6.3. Schedule of values: be able to explain this concept in regards to contracts, change management, and project control for contracted work.
S	3.7. Investment Decision Making
S	3.7.1. General Concepts:
S	3.7.1.1. Be able explain the concepts and perform the analyses covered previously in the Economic and Financial Analysis section.
S	3.7.1.2. Decision Policy / Criteria:
S	3.7.1.2.1. Be able to describe the role of decision policy in consistent asset investment strategy deployment
S	3.7.1.2.2. Be able to explain why decision policy for most corporations establishes net present value and return on investments (or equivalent) as primary decision criteria.
S	3.7.2. Decision Analysis:
S	3.7.2.1. Decision Model:
S	3.7.2.1.1. Be able to able to explain the benefits of using a cost-based, quantitative decision model that addresses probabilities
S	3.7.2.1.2. Be able to describe the mechanics of addressing non-cash value and risk considerations in a monetary decision model.
S	3.7.2.1.3. Be able to evaluate and select the best alternative from several alternatives using these methods.
S	3.7.2.1.3.1. Net Present Value
S	3.7.2.1.3.2. Decision Tree (probability weighted present value):
S	3.7.2.1.3.3. Discounted Rate of Return (breakeven)
S	3.7.2.1.3.4. Cost/Benefit Ratio
S	3.7.2.2. Sensitivity Analysis and Monte Carlo Simulation: be able to discuss mechanics of using a decision model to assess probable outcomes.
S	3.7.3. Business Decision Basis or Business Case: be able to describe the information (e.g., objectives, assumptions, constraints, etc) that should be communicated to the project team.
S	3.7.4. Capital Budgeting. be able to describe the mechanics of investment decision making in a typical enterprise capital budgeting process.
S	3.7.5. Portfolio Management. be able to describe the affect of portfolio considerations (multiple and often competing assets and projects) on investment decision making and capital budgeting processes.
S	3.8. Implementation
S	3.8.1. Project Implementation: be able to explain the following concepts:
S	3.8.1.1. Phases and Gates Process: be able to describe the typical stages in respect to project planning and funding authorization and the benefits of an established process
S	3.8.1.1.1. Front-end loading (FEL): be able to describe this concept and its benefits in terms of risk management and project control planning
S	3.8.1.2. Project Implementation Basis or Scope Statement: be able to describe the typical information in this deliverable at project initiation and the importance of business and project team agreement and communicating this information to all stakeholders.
S	3.8.2. Project control plan implementation: be able to explain the following concepts:

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S	3.8.2.1. Control Accounts: describe this concept and its content in relation to WBS and earned value application
S	3.8.2.2. Project Control Plan and Basis: be able to describe the typical information in this deliverable at the start of project execution and the importance of integrating, agreeing on and communicating this information to the project team.
S	3.8.3. Validation: be able to describe how the quality and competitiveness of plans might be assessed before implementation and why the process is important. Also explain the value of historical, empirical information.
P/S	3.9. Performance Measurement
P	3.9.1. Cost Accounting: be able to describe the interface of the accounting process with cost engineering practice
P	3.9.1.1. Control and Cost Accounts: be able to discuss the role of the chart or code of accounts with integrating project control
S	3.9.1.2. Capitalization and Depreciation: be able to explain these concepts and the typical role of the cost engineer in working with the finance function to assure it is done effectively
S	3.9.2. Project Performance Measurement
S	3.9.2.1. General Concepts
S	3.9.2.1.1. Earned Value: be able to explain the general concept and the importance of and reliable control basis and objective, quantitative physical progress measures
S	3.9.2.2. Practices
S	3.9.2.2.1. Physical Progress: be able to explain the general concept and the following methods, and, given input information, be able to calculate percent complete.
S	3.9.2.2.1.1. Units completed
S	3.9.2.2.1.2. Incremental milestone
S	3.9.2.2.1.3. Weighted or equivalent units completed
S	3.9.2.2.1.4. Resource expenditure
S	3.9.2.2.1.5. Judgment
S	3.9.2.2.2. Track Resources
S	3.9.2.2.2.1. Labor hours: be able to explain the advantages and disadvantages of tracking labor hours instead of cost as the basis for earned value
S	3.9.2.2.2.2. Material management and fabrication: be able to discuss how material progress/status can be measured
S	3.9.2.2.3. Measure Performance (how work is being done)
S	3.9.2.2.3.1. Be able to discuss why earned value measures alone have limited value in finding ways to improve performance.
S	3.9.2.2.3.2. Be able to discuss the mechanics of the following methods, how they can help find ways to improve performance, and their strengths and weaknesses:
S	3.9.2.2.3.2.1. Work sampling
S	3.9.2.2.3.2.2. Time and motion studies
S	3.9.2.2.3.2.3. Time lapse photography and video monitoring
S	3.9.2.2.3.2.4. Expediting
S	3.9.2.2.3.2.5. Inspection
S	3.9.2.2.4. Status Schedule: be able to discuss the mechanics of statusing and updating a schedule
S	3.10. Performance Assessment
S	3.10.1 Project Performance Assessment: be able to explain the concepts
S	3.10.1.1. General Concepts
S	3.10.1.1.1. Variance: be able to describe this concept as an empirical difference between actual and planned performance for any aspect of the control plan.

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S	3.10.1.1.2. Trends: be able to describe the difference between random and non-random variance and how this might influence subsequent control actions and forecasts
S	3.10.1.2. Practices for control assessment: be able to describe methods for assessing and reporting performance (variances and trends) against the following baseline plans:
S	3.10.1.2.1. Cost:
S	3.10.1.2.1.1. Be able to describe basic earned value methods
S	3.10.1.2.1.2. Be able to describe and prepare tabular and cumulative distribution charts (“s-curves”) for reporting
S	3.10.1.2.2. Schedule:
S	3.10.1.2.2.1. Be able to describe methods to identify variance (e.g., calculate slip, earned value methods, etc), assess critical path and remaining float.
S	3.10.1.2.2.2. Be able to describe performance reporting methods (e.g., schedule plot showing the planned and actual schedule activity status), tables showing a percentage or factor that expresses the extent that the schedule is ahead or behind at given points in time, lists of activities sorted by early start date or total float, etc.).
S	3.10.1.2.3. Resources
S	3.10.1.2.3.1. Labor
S	3.10.1.2.3.1.1. Be able to describe basic earned value methods
S	3.10.1.2.3.1.2. Be able to describe and prepare tabular and cumulative distribution charts (“s-curves”) for reporting
S	3.10.1.2.3.2. Material and fabrication: be able to describe the use earned value, schedule assessment, material management reports, and so on.
S	3.10.1.2.4. Risk: be able to explain the monitoring and assessment of risk factors in accordance with a risk a management plan
S	3.10.1.3. Practices for integrated earned value (Earned Value Management System or EVMS) assessment
S	3.10.1.3.1. Be able to explain and calculate all the basic earned value measures and indices (Planned and/or Budget [was BCWS], Earned [was BCWP], and Actual [was ACWP], SV, CV, SPI, CPI)
S	3.10.1.3.2. Be able to describe the advantages and disadvantages of a fully integrated EVMS assessment using costs
S	3.10.1.4. Practices for work process and productivity improvement
S	3.10.1.4.1. Productivity assessment
S	3.10.1.4.1.1. Labor productivity factor: be able to calculate this using earned value and explain its significance
S	3.10.1.4.2. Work process improvement.
S	3.10.1.4.2.1. Work sampling: be able to describe the mechanics of the method and how it can be used to eliminate wasted effort and improve the work process
S	3.10.1.4.2.2. Be able to describe other methods such as informal sampling, manpower surveys, time card notations, quality circles, inspection observations, etc.
S	3.10.2. Forecasting
S	3.10.2.1. Forecast and Forecasting.
S	3.10.2.1.1. Be able to describe the concepts of forecasts and forecasting
S	3.10.2.1.2. Be able to describe how the project control planning concepts (e.g., estimating, scheduling, etc.) are applied in the context of work in progress, performance assessment findings, change management, and corrective actions.
P	3.11. Project Change Management
P	3.11.1. Basic Terminology: be able to describe the concepts

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P	3.11.1.1. Scope: be able to describe how the meaning of the term “scope” differs in the contexts of owner project funds authorization versus contracting
P	3.11.1.2. Deviations
P	3.11.1.4. Changes: be able to explain the difference between scope and non-scope changes in an owner funding context
P	3.11.1.5. Changes and Contract Types: be able to explain how the change order process may differ with different contract types.
P	3.11.1.6. Disputes and Claims
P	3.11.1.7. Contingency, Allowances, and Reserves (see Risk Management)
S	3.11.2. Practices: be able to describe the concepts
S	3.11.2.1. Variance or trend analysis: be able to describe the difference between performance variance and a trend
S	3.11.2.2. Impact assessment: be able to describe how the project control planning concepts (e.g., estimating, scheduling, etc.) are applied in change management
S	3.11.2.2.1. Be able to describe the concept of time impact analysis related to schedule change
S	3.11.2.3. Make and track disposition
P	3.11.1.3. Trends (also see performance assessment):
S	3.11.2.3.1. Corrective action (also improvement action): be able to describe what these are and why they might be needed.
S	3.11.2.3.2. Be able to describe ways that change management findings and dispositions (actions) are recorded, reported, and incorporated in the project control plans
S	3.11.2.4. Manage contingency and reserves:
S	3.11.2.4.1. Draw down: be able to describe methods for managing contingency
S	3.11.2.4.2. Be able to describe ways to assess the need for contingency for work in progress
S	3.11.2.5. Resolve contract disputes and claims: be able to discuss the concept of changes and change management in respect to contract agreements (also see Forensic Performance Assessment)
P	3.12. Asset Change Management
P	3.12.1. Requirements: Be able to explain how managing the scope of the “asset” in respect to its requirements in strategic asset management differs from managing the scope of “work” in project control.
P	3.12.1.1. Configuration Management: be able to describe the role of this practice area in managing change in information that defines the asset
P	3.13. Historical Database Management
P	3.13.1. Empirical Data: be able to explain why empirical information is the most fundamental planning resource available (why is it critical for asset and project planning?)
P	3.13.2. Project Closeout: be able to describe the mechanics and challenges of closing out a project in respect to project control systems, data and information.

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- AACE International Recommended Practice No. 31R-03 *Reviewing, Validating and Documenting the Estimate*, AACE International, Morgantown, WV, (latest revision).
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