AACE® International

The Authority for Total Cost Management™

Recommended Practice

This Recommended Practice (RP) is brought to you as public service by AACE International, the Authority for Total Cost Management.

The AACE International Recommended Practices are the main technical foundation of our educational and certification products and services. The RPs are a series of documents that contain valuable reference information that has been subject to a rigorous review process and recommended for use by the AACE International Technical Board.

AACE International is a 501(c)(3) non-profit professional association serving the total cost management community since 1956. AACE International provides its members and stakeholders with the resources they need to enhance their performance and ensure continued growth and success. With over 8,500 members world-wide, AACE International serves total cost management professionals in a variety of disciplines and across all industries. AACE International has members in 87 countries. If you share our mission to "enable organizations around the world to achieve their investment expectations by managing and controlling projects, programs, and portfolios and create value by advancing technical knowledge and professional development", then we invite you to become one of our members.

In addition to this and other *Recommended Practices*, here are just a sample of the products and services that AACE has to offer you:

Total Cost Management® Framework:

Total Cost Management is a systematic approach to managing cost throughout the life cycle of any enterprise, program, facility, project, product or service. AACE's flagship publication, the TCM Framework: An Integrated Approach to Portfolio, Program and Project Management, is a structured, annotated process map that for the first time explains each practice area of the cost engineering field in the context of its relationship to the other practice areas including allied professions.

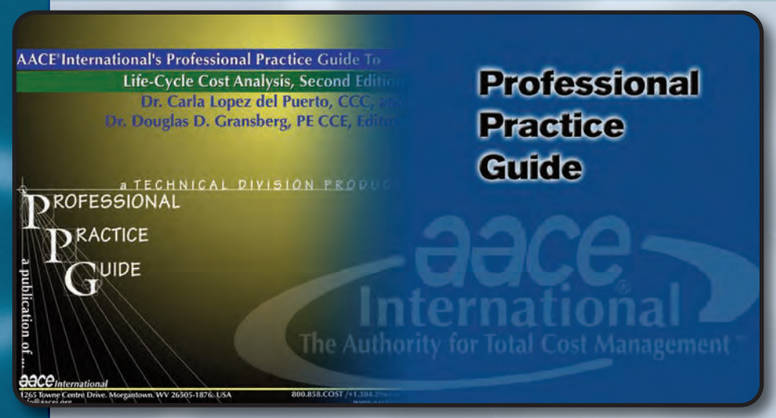
Visual TCM Framework:

Visual TCM graphically demonstrates the integration of the strategic asset management and project controls process maps of the TCM Framework. The Visual TCM application has been designed to provide a dynamic view of the TCM processes, from the overall strategy process maps to the mid-level processes and detailed activities. The processes are hyperlinked, giving the user the ability to move to and from related process maps and reference

material. This allows for the optimal effectiveness of understanding and using the process and sub-process in the context of and relationship to associated sub-processes that share common strategies and objectives. Visual TCM allows the user to view and apply TCM section-by-section, at a sub-process or functional level. Visual TCM is available to members at no extra fee.

Virtual Library:

Members receive free access to the Virtual Library, an online collection of over 5000 complete technical articles on virtually every aspect of cost engineering. Search this extensive database and immediately retrieve the best techniques and potential solutions to the problems confronting you and your organization.



Professional Practice Guides (PPGs):

Professional Practice Guides contain the most worthwhile contributions to the field of total cost

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management. Comprehensive, well organized, and timely, each PPG is a collection of selected articles covering a particular technical topic area or industry segment. The PPGs provide an excellent source of reference material and is a welcome addition to any reference library.

Certification:

Since 1976, AACE has been certifying individuals as Certified Cost Consultants (CCC)/Certified Cost Engineers (CCE); Certified Cost Technicians (CCT); Certified Estimating Professionals (CEP); Certified Forensic Claims Consultants (CFCC); Earned Value Professionals (EVP); and Planning & Scheduling Professionals (PSP). In the midst of staggering business and economic turmoil, you need all the tools at your disposal to help shore up your career prospects. AACE certification can help you and the organizations that rely on you for help!

Online Learning Center:

The Online Learning Center features modules based upon actual technical presentations captured

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at our Annual Meetings. Each recorded unit includes a live audio recording of the speaker synchronized to the slides accompanying the presentation. Each unit includes the technical paper associated with the presentation, and a downloadable audio-only version that you may play on your mobile device or iPod. Completion of each unit earns 0.1 AACE recertification credits (i.e. 0.1 CEUs). An electronic certificate of completion will be attached to your profile.

Conferences:

AACE International's Annual Meeting brings together the industry's leading cost professionals in a forum focused on learning, sharing, and networking. Over 100 hours of technical presentations and an industry tradeshow that will challenge you to better manage, plan, schedule, and implement technology for more effective and efficient business practices.

The International TCM Conference is a similar event that is held outside of North America – complete with technical presentations, seminars and exhibits.

Discussion Forums:

The discussion forums encourage the exchange of thoughts and ideas, through posting questions and discussing topics. They provide a great means for networking and interaction with your peers. Participate anytime at your convenience and receive automatic e-mail notifications on topics that are of interest to you. With several thousand users, if you have questions or concerns about a technical subject, program, or project - the forums are a great resource for you.

Mentoring Program:

Looking to gain more knowledge from an experienced professional or an opportunity to help another professional? Included with your membership, AACE offers a comprehensive mentoring program for individuals interested in sharing knowledge with others or advancing their own careers to the next level.

Career Center:

AACE's career center provides tools and resources for you to progress through your career.

Looking for the next rung on the career ladder or to hire the talent necessary to take your firm to the next level? Job seekers, use our services to find your next job – post your resume, get e-mail notifications of new job-postings, and more. Employers, post your current job-openings and search our extensive resume database to find your next star employee.

Salary and Demographic Survey:

Conducted annually, salary survey is a great resource for employers that want to gain a better understanding of the competitive marketplace for talent and for employees interested in knowing how their compensation compares with their peers in the profession.

Join aace

Periodicals

Members receive a complimentary subscription to the Cost Engineering journal, AACE's bi-monthly professionally peer-reviewed publication. It contains best-in-class technical articles on total cost management related subjects.
It is published as both a print version and an online version.

Our bi-monthly digital publication, Source, focuses on AACE activities and items of interest to the total cost management community, with special features for our members.

Recommended Practice

AACE International Recommended Practice No. 11R-88

REQUIRED SKILLS AND KNOWLEDGE OF COST ENGINEERING

TCM Framework: General Reference
(All Sections)

Rev. June 18, 2013

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

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TCM Framework: General Reference
(All Sections)

June 18, 2013

This recommended practice has the following purposes:

- define what *core* skills and knowledge of cost engineering a person is required to have in order to be considered a professional practitioner, and in doing so,
- establish the emphasis of *core* subjects for AACE International education and certification programs.

It is also hoped that enterprises will find this useful as a reference or guide for developing their own competency models. *Knowledge* is an understanding gained through experience or study, and *skills* are abilities that transform knowledge into use. *Core* subjects are those whose usage is occasional to frequent and are considered by AACE International as being required for professional practitioners of cost engineering to know and be able to use.

This recommended practice lists these core subjects and provides general *performance statements* (i.e., "be able to" describe, perform, etc.) to represent the level of proficiency expected in each subject area. These statements are representative or guiding examples only

This text is an outline that is intended to be the structural foundation for products and services developed by the Educational and Certification Boards. It will continue to be modified as current practice changes.

BACKGROUND AND SCOPE UPDATE

The original recommend practice *Required Skills and Knowledge of a Cost Engineer* was developed by the AACE International Education Board and published in 1988 based on their evaluations of a membership survey. Until that time, AACE International lacked a formal definition of professional cost engineering in terms of skills and knowledge. Based on the recommended practice findings, the Education Board then published the first *Skills and Knowledge of Cost Engineering* text to provide an educational product to elaborate on the core skills and knowledge subjects. The earlier text has been regularly updated by the Education Board.

Since the original publication, the AACE Technical Board was given the charter to define the technology of cost engineering and total cost management. In 2005, the Technical Board completed development of the *Total Cost Management Framework* which describes a systematic process (i.e., TCM process) through which the skills and knowledge of cost engineering are applied. It also provides an integrated structure upon which the Technical Board can organize its development of recommended practices, including this one.

This update of the *Required Skills and Knowledge of a Cost Engineer* retains most of the content of the earlier versions while incorporating those elements of the TCM process that the AACE associate boards (Technical, Education and Certification) determined are required for a professional practitioner of cost engineering to know. It also incorporates a more systematic organization of the subjects, based on TCM developments, to better differentiate between general *supporting knowledge* used in more than one practice or process (e.g., statistics, elements of cost, etc.), and specific *practice knowledge* used in particular functions or processes (e.g., cost estimating, planning and scheduling, etc.)

INTRODUCTION

A professional cost engineering practitioner must first be able to articulate the meaning of the terms *cost engineering* and *total cost management (TCM)*. Practitioners will frequently be asked these questions. Given the

importance of this first knowledge requirement to the understanding this recommended practice, the questions are answered here. Elaboration of all other skills and knowledge requirements is left for subsequent Education Board products.

What are Cost Engineering and TCM?

The AACE International *Constitution and Bylaws* defines cost engineering and total cost management as follows:

> **Section 2.** The Association is dedicated to the tenets of furthering the concepts of *Total Cost Management* and *Cost Engineering*. Total Cost Management is the effective application of professional and technical expertise to plan and control resources, costs, profitability and risk. 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.
>
> **Section 3.** 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.

In summary, the list of practice areas in Section 3 are collectively called *cost engineering*; while the "process" through which these practices are applied is called *total cost management* or TCM.

How is cost and schedule management an "engineering" function?

Most people would agree that "engineers" and engineering (or more generally, the "application of scientific principles and techniques") are most often responsible for creating functional things (or *strategic assets* as we call them in TCM). However, engineering has multiple dimensions. The most obvious is the dimension of physical design and the calculation and analysis tasks done to support that design (e.g., design a bridge or develop software). However, beyond the physical dimension of design (e.g., the bridge structure), there are other important dimensions of *money, time*, and other *resources* that are invested in the creation of the designed asset. We refer to these investments collectively as *costs.* Using the above example, someone must estimate what the bridge might cost, determine the activities needed to design and build it, estimate how long these activities will take, and so on. Furthermore, someone needs to monitor and assess the progress of the bridge design and construction (in relation to the expenditure of money and time) to ensure that the completed bridge meets the owner's and other stakeholder's requirements. Someone must also monitor and assess the cost of operating and maintaining the bridge during its life cycle.

Returning to the *Constitution and Bylaws* definition, understanding and managing the cost dimensions requires skills and knowledge in "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." No significant asset has ever been built without dealing with these cost dimensions in some way, and the more systematically and professionally these dimensions are addressed, the more successful the asset performance is likely to be. Therefore, cost *engineering* recognizes that cost is a necessary extension of traditional engineering (and other creative functions such as systems analysis, etc.), and that there is an intimate connection between the physical and cost dimensions of the asset.

Do cost engineering practitioners need to have a traditional "engineering" background?

The skills and knowledge required to deal with *costs* (i.e., cost estimating, planning and scheduling, etc.) are quite different from those required to deal with the physical design dimension. From that difference, the field of *cost engineering* was born. Cost engineering practitioners work alongside of and are peers with engineers, software analysts, play producers, architects, and other creative career fields to handle the cost dimension, but they do not necessarily have the same background. Whether they have technical, operations, finance and accounting, or other backgrounds, cost engineering practitioners need to share a common understanding, based on "scientific principles and techniques", with the engineering or other creative career functions.

Do cost engineering practitioners all have the same function?

Cost engineering practitioners tend to be: a) specialized in function (e.g., cost estimating, planning and scheduling, etc.); b) focused on either the asset management or project control side of the TCM process; and c) focused on a particular industry (e.g., engineering and construction, manufacturing, information technology, etc) or asset type (e.g., chemical process, buildings, software, etc.). They may have titles such as cost estimator, quantity surveyor, parametric analyst, strategic planner, planner/scheduler, value engineer, cost/schedule engineer, claims consultant, project manager, or project control lead. They may work for the business that owns and operates the asset (emphasis on economics and analysis), or they may work for the contractor that executes the projects (emphasis on planning and control). But, no matter what their job title or business environment, a general knowledge of, and skills in, all areas of cost engineering are required to perform their job effectively. In summary, the purpose of this document is to define these *required skills and knowledge of professional cost engineering.*

THIS DOCUMENT'S OUTLINE STRUCTURE AND ITS RELATIONSHIP TO PARTICULAR FUNCTIONS AND AACE INTERNATIONAL CERTIFICATIONS

Figure 1 illustrates the hierarchical structure of the Required Skills and Knowledge of Cost Engineering. 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.

On the process and functional side, the structure is organized in accordance with the plan, do, check, (or measure), and assess (PDCA) process model that serves as the basis for the TCM process through which all the skills and knowledge of cost engineering are applied. It 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. Their particular function's required skills and knowledge will include elements of supporting knowledge, as well as elements of planning, measuring, and assessing that are appropriate to their function.

This document includes the required skills and knowledge that certified cost engineers and consultants (CCE/CCCs) must have. Its scope is broad and represents the comprehensive skills and knowledge that business management may expect someone with overarching responsibilities in an organization to have (e.g., supporting overall capital program or project system management).

For specialty certifications [e.g., planning and scheduling professionals (PSP)], the Certification Board will document appropriate skills and knowledge requirements. These will include elements from this overall outline as they apply to the scope of the particular function. They may also include more detailed skills and knowledge than

included here. The scope of those requirements will not be as broad, but will be deeper, representing the skills and knowledge that business management may expect from a manager of or expert in the particular function.

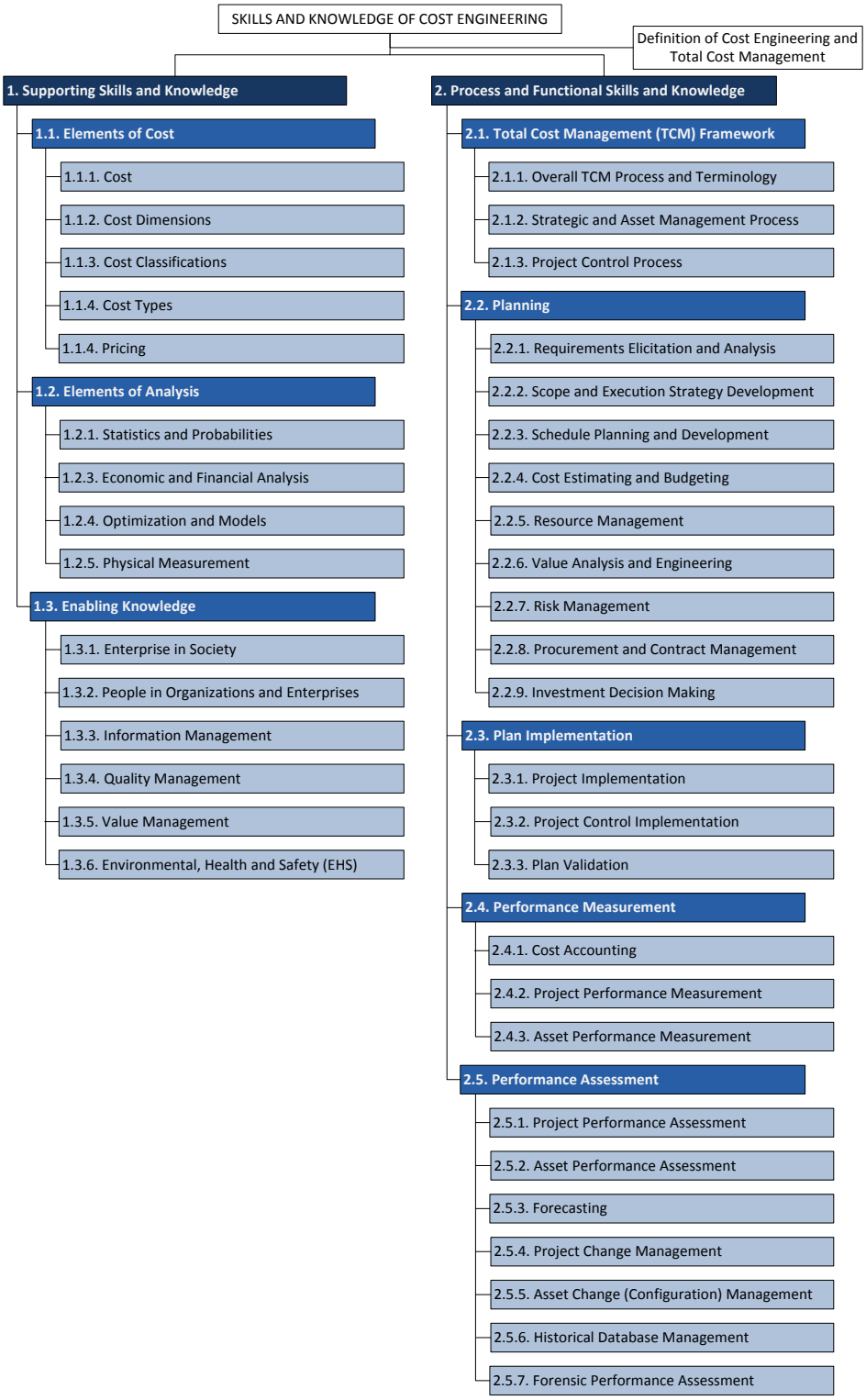

Figure 1. High Level Outline of the *Skills and Knowledge of Cost Engineering*

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Note: The outline that follows signifies key concepts and performance statements for which the practitioner should have at least a basic understanding.

1. Supporting Skills and Knowledge
1.1. Elements of Cost
1.1.1. Costs: be able to define/explain these general concepts in relation to each other and to assets and/or activities.
1.1.1.1. Resources
1.1.1.2. Time
1.1.1.3. Cost
1.1.2. Cost Dimensions:
1.1.2.1. Lifecycle: be able to describe this term and differentiate the life cycle of an asset and a project
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.
1.1.2.2.1. Be able to distinguish among products, co-products, and byproducts.
1.1.2.3. Responsibility: be able to describe and differentiate the cost perspectives of an owner and a contractor/supplier
1.1.2.4. Valuation: be able to describe and differentiate cost from cash/monetary versus economic/opportunity costs (also see economic analysis) perspectives.
1.1.2.5. Influence: be able to explain the concept of the cost influence curve
1.1.2.6. Legal:
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.
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)
1.1.3. Cost Classifications: for the following classifications, be able to:
1.1.3.1. Explain the general differences between the ways costs are classified for various cost management purposes
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.
1.1.3.2.1. Operating (Production, Manufacturing, Maintenance, etc.) vs. Capital
1.1.3.2.2. Capital vs. Expense
1.1.3.2.2.1. Depreciation
1.1.3.2.2.2. Amortization
1.1.3.2.2.3. Accrual
1.1.3.2.3. Fixed vs. Variable
1.1.3.2.4. Direct vs. Indirect
1.1.3.2.4.1. Activity-Based Costing (ABC)
1.1.3.2.4.2. Job Costing
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)
1.1.4.1. Materials:
1.1.4.1.1. Materials types: be able to describe the types and their cost drivers:
1.1.4.1.1.1. Raw
1.1.4.1.1.2. Bulk
1.1.4.1.1.3. Fabricated
1.1.4.1.1.4. Engineered or designed

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

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

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.
1.2.1.2.3. Non-Normal Distributions: be able to describe the following concepts:
1.2.1.2.3.1. Skewness (symmetry)
1.2.1.2.3.2. Kurtosis (central tendency relative to normal).
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
1.2.1.3. Inferential Statistics
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.
1.2.1.3.2. Regression Analysis: be able to describe the concept of the methodology as well as diagnostic statistics (R2, root mean square error (RMSE), and t)
1.2.1.3.3. Statistical Significance:
1.2.1.3.3.1. Be able to describe the purpose and use of chi-squared and t-tests
1.2.1.3.3.2. Be able to interpret the t-statistic for comparing two sets of normally distributed data.
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.
1.2.2. Economic and Financial Analysis
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.
1.2.2.2. Cash Flow Analysis:
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.
1.2.2.2.2. Given a set of cost and revenue forecasts calculate a cash flow for an asset investment option
1.2.2.3. Internal Rate of Return: be able to determine discounted rate of return of a cash flow series.
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.
1.2.3. Optimization
1.2.3.1. Model:
1.2.3.1.1. Be able to describe the concept of a quantitative representational models and parameters.
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.
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).
1.2.3.3. Simulation: be able to describe the use of a model for analysis of a cost problem.
1.2.3.4. Sensitivity Analysis: be able to perform a sensitivity analysis of a modeled problem.
1.2.4. Physical Measurements: be able to convert basic metric and imperial weight and dimensional measurements.
1.3. Enabling Knowledge
1.3.1. Enterprise in Society
1.3.1.1. Societal Values: be able to generally describe societal concerns and needs that should be considered in asset and project planning.
1.3.1.2. Decision Policy: be able to describe how to translate societal values to policy so that an enterprise can consistently address societal values in everyday practice.

1.3.1.3. Ethics:
1.3.1.3.1. 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.
1.3.1.3.2. Be familiar with AACE International's ethics policy (Canons of Ethics).
1.3.2. People and Organizations in Enterprises
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.
1.3.2.1.1. Leadership Roles:
1.3.2.1.1.1. Be able to explain why the need for leading, managing, facilitating, and mentoring roles may vary by situation.
1.3.2.1.1.2. Discuss the meaning and provide examples of "participative management."
1.3.2.1.2. Motivation/Incentives (Behavioral Science):
1.3.2.1.2.1. Be able to discuss motivator/demotivator affects on labor attitude and performance
1.3.2.1.2.2. Given a list, be able to describe the basic themes of two or more generally accepted behavioral science theories:
1.3.2.1.2.2.1. McGregor- Theory X and Y
1.3.2.1.2.2.2. Herzberg-Motivation-Hygiene
1.3.2.1.2.2.3. Argyris-Effects of organization like on individuals
1.3.2.1.2.2.4. Likert-Four model systems
1.3.2.1.2.2.5. Mouton-Managerial grid
1.3.2.1.2.2.6. Other current theories
1.3.2.1.3. Performance/Productivity Management:
1.3.2.1.3.1. Be able to describe the concept of productivity (and its difference from the term production).
1.3.2.1.3.2. 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.):
1.3.2.1.3.2.1. Individual worker skills
1.3.2.1.3.2.2. Crew balance of skills
1.3.2.1.3.2.3. Immediate supervision competence
1.3.2.1.3.2.4. Overall supervision competence
1.3.2.1.3.2.5. Worker and supervision attitudes
1.3.2.1.3.2.6. Work force sociological, cultural and demographic characteristics
1.3.2.1.3.2.7. Absenteeism and turnover
1.3.2.1.3.2.8. Overtime
1.3.2.1.3.2.9. Level of technology used
1.3.2.1.3.2.10. Learning curve
1.3.2.1.3.2.11. Work area environment
1.3.2.1.3.2.12. Weather
1.3.2.1.3.2.13. Geographic location
1.3.2.1.3.2.14. Proximity to other work and contractors
1.3.2.1.3.2.15. Job layout
1.3.2.1.3.2.16. Work rules
1.3.2.1.3.2.17. Safety practices
1.3.2.1.3.2.18. Quality control practices (including quality circles)
1.3.2.1.3.2.19. Materials and tools availability
1.3.2.1.3.2.20. Wages, salaries and benefits.
1.3.2.2. Organization Structure

1.3.2.2.1. Organizational Design: be able to describe the issues that organizations must address (division of labor, unity of command, unity of directions, and span of control) and how each may affect performance.
1.3.2.2.2. Basic Structures:
1.3.2.2.2.1. Be able to draw and example chart and explain the differences between, and advantages/disadvantages of traditional functional, divisional, and matrix structures
1.3.2.2.3. Teams:
1.3.2.2.3.1. Be able to explain how and why teams are used in enterprises and why they are typically used to manage projects.
1.3.2.2.3.2. Be able to describe typical team organization (i.e., matrix) and operation and the roles, responsibilities, and methods for its successful performance.
1.3.2.2.4. Typical Organizations in TCM: be able to generally describe the typical roles of capital investment management (business planning), operations management, and project management in TCM (i.e., where cost engineers usually work).
1.3.3. Information Management
1.3.3.1. Data, Information, and Knowledge: be able to explain the difference between these three types of "information"
1.3.3.2. Databases and Database Management. Be able to define and explain the following concepts:
1.3.3.2.1. History: the importance of historical and empirical information to most cost engineering practice
1.3.3.2.2. Reference Data: the need that specific methods and tools for specific processed data
1.3.3.2.3. Lessons Learned: the need for data that is qualitative in nature.
1.3.3.2.4. Metric: the need that benchmarking or validation methods have for specific processed quantitative data
1.3.3.2.5. Validation: the need to assure the reliability and sometimes competitiveness of data
1.3.3.2.6. Basis: the need to understand the basis of all data and information in a database
1.3.3.2.7. Normalization: be able to adjust data to a common basis in currency, time, location, etc.
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).
1.3.3.3.1. Enterprise Resource Planning/Management (ERP/ERM): be able to describe the goal of these types of systems (support efficient business processes, including project management, through shared or common databases)
1.3.4. Quality Management: be able to explain the following concepts:
1.3.4.1. Quality: be able to define this as conformance to requirements (which are based on customer needs).
1.3.4.2. Requirements: (see Requirements Elicitation and Analysis practices)
1.3.4.3. Quality Planning: be able to describe this as an integrated way of planning directed towards satisfying customer needs.
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.
1.3.4.5. Quality Assurance: be able to describe this as actions that provide confidence that the requirements will be fulfilled.
1.3.4.6. Quality Control: be able to describe this as actions focused on fulfilling requirements
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).
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.

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.
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
1.3.4.11. Quality Standards: be able to describe these imposed requirements.
1.3.4.11.1. ISO 9000 standard quality management series
1.3.4.11.2. ISO 10006 quality in project management
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
1.3.4.12.1. Benchmarking
1.3.4.12.2. Cost of Quality
1.3.4.12.3. Value Analysis/Engineering
1.3.4.12.4. Change Management
1.3.5. Value Management:
1.3.5.1. Be able to explain the following general concepts (i.e., not in the context of Value Analysis and Engineering practice):
1.3.5.1.1. Value (i.e., a measure of the worth of a thing in terms of usefulness, desirability, importance, money)
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.)
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”.)
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):
1.3.5.2.1. Manufacturability Analysis
1.3.5.2.2. Constructability Analysis
1.3.5.2.3. Reliability, Availability and Maintainability (RAM) Analysis
1.3.6. Environment, Health, Safety, and Security (EHS): be able to explain the following concepts:
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).
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.
1.3.6.3. EHS Standards/Compliance. be able to explain why compliance with minimum standards and regulations should be the minimum expected.
1.3.6.3.1. ISO 14000: management systems that an organization employs to manage environmental matters.
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.
2. Process and Functional Skills and Knowledge
2.1. Total Cost Management (TCM) Process
2.1.1. Overall TCM Process and Terminology
2.1.1.1. Basic Terminology: be able to explain the following:
2.1.1.1.1. Plan-Do-Check-Assess (PDCA):
2.1.1.1.2. Strategic asset
2.1.1.1.3. Project

2.1.1.1.4. Portfolios and Programs
2.1.1.2. TCM Processes: be able to sketch the TCM, strategic asset management, and project control processes in basic PDCA format and explain the following:
2.1.1.2.1. The cost management purpose of the overall processes
2.1.1.2.2. How the two component subprocesses differ, but are related to each other
2.1.1.2.3. The benefits of an integrated, systematic cost management approach over the life cycle of assets and projects
2.1.2. Strategic Asset Management Process
2.1.2.1. 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.
2.1.3. Project Control Process
2.1.3.1. 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.
2.1.3.2. 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)
2.2. Planning
2.2.1. Requirements Elicitation and Analysis: be able to describe the following concepts
2.2.1.1. Stakeholders/Customers: be able to describe how to identify these in relation to various business problems
2.2.1.2. Needs, wants, or expectations of stakeholders: be able describe challenges of eliciting this information from various stakeholders
2.2.1.3. Requirements: be able to describe the characteristics of a good requirement for use in asset or project control planning
2.2.1.4. Cost requirements: be able to describe the following asset planning methodologies for which cost may be a requirement
2.2.1.4.1. Target costing (including design-to-cost, and cost as an independent variable)
2.2.1.4.2. Quality-function deployment
2.2.1.5. Other Concepts:
2.2.1.5.1. Asset vs. Project: be able to explain how requirements for an asset or product might differ from those for a project.
2.2.2. Scope and Execution Strategy Development: be able to describe the following concepts
2.2.2.1. Asset scope: be able to describe this as the physical, functional and quality characteristics or design basis of the selected asset investment
2.2.2.1.1. Functional decomposition
2.2.2.2. Project scope: be able to describe this as the scope of work to deliver the asset
2.2.2.2.1. Project scope breakdown (work decomposition)
2.2.2.3. Work Breakdown Structure (WBS): be able to diagram a WBS for a basic scope provided in narrative form
2.2.2.4. Organization Breakdown Structure (OBS): be able to diagram an OBS for a basic scope provided in narrative form
2.2.2.5. Work package
2.2.2.6. Deliverables
2.2.2.7. Execution strategy
2.2.3. Schedule Planning and Development: be able to describe the following concepts:
2.2.3.1. Schedule Planning
2.2.3.1.1. Activities
2.2.3.1.2. Activity Logic and Logic Diagramming:
2.2.3.1.2.1. Given a series of logic statements, be able to draw a logic diagram.

2.2.3.1.2.2. Given a soft-logic work package with no strict activity interrelationships, be able to describe ways to do schedule planning for this work.
2.2.3.1.2.3. Be able to describe how schedule planning differs between a batch and a continuous process.
2.2.3.1.2.4. Be able to describe the concept of linear scheduling
2.2.3.1.3. Activity Duration
2.2.3.1.4. Critical Path: be able to define and identify the critical path(s) in a project schedule
2.2.3.1.5. Float: be able to describe the relationship and significance of total and free float in the scheduling of an activity.
2.2.3.1.6. Schedule Models: Using the PDM method, and given a logic diagram and durations for activities, be able to calculate the early start and finish, late start and finish, and total and free float times for all activities. Identify minimum project completion time.
2.2.3.1.6.1. Precedence Diagram Method (PDM): in using this method include at least on each finish-start, finish-finish, start-finish, and start-start relationships with lags and identify critical path(s)
2.2.3.1.6.2. Bar chart/Gantt chart:
2.2.3.1.6.2.1. Be able to explain the difference between this and a logic diagram
2.2.3.1.6.2.2. Given network activity durations, early and late start and finish times, and total float, be able to draw a bar chart based on early start of all activities, and show total float of activities where applicable.
2.2.3.1.7. Historical Data: be able to describe the importance of historical, empirical data and databases to schedule planning and schedule development
2.2.3.2. Schedule Development: describe difference from schedule planning
2.2.3.2.1. Milestones
2.2.3.2.2. Resource Loading
2.2.3.2.3. Resource Leveling or Balancing: for a simple PDM network with resource inputs, be able to resource level the network within early and late start limits, and draw a histogram of worker-loading for early start, late start, and resource leveled configurations.
2.2.3.3. Schedule Control Basis
2.2.3.3.1. Schedule Control Baseline
2.2.3.3.1.1. Be able to describe the concept of short interval scheduling (SIS) in relation to an overall project schedule control baseline.
2.2.3.3.2. Planned Schedule
2.2.3.3.3. Schedule Basis
2.2.3.4. Other Concepts:
2.2.3.4.1. Programs and Portfolios: be able to explain these concepts and how schedule planning and development might be handled for groups of projects
2.2.3.4.2. Operations/Production: be able to explain how production scheduling differs from project scheduling
2.2.3.4.3. Schedule strategy
2.2.3.4.3.1. Be able to describe the characteristics and risks of a fast track schedule
2.2.3.4.3.2. Be able to describe alternate schedule strategies in regards to potential changes and claims that a contractor may apply in developing a network schedule (e.g., crashing).
2.2.3.4.3.3. Be able describe the characteristics and risks of just-in-time (JIT) scheduling.
2.2.3.4.4. Schedule Development:
2.2.3.4.4.1. Be able to describe the concept of development by schedule level
2.2.3.4.4.2. Be able to describe the concept of rolling wave development.
2.2.3.4.5. Schedule Change Management: be able to describe how schedule changes might be managed.
2.2.3.4.6. Critical Chain: be able to describe the concept

2.2.3.4.7. Linear Scheduling: be able to describe the concept
2.2.3.4.8. Schedule Contingency:
2.2.3.4.8.1. Be able to define the term including what it is supposed to cover
2.2.3.4.8.2. Be able to describe several typical ways that it can be assessed
2.2.4. Cost Estimating Skills and Knowledge: be able to describe the following concepts:
2.2.4.1. General Concepts (must also understand Elements of Cost and Analysis):
2.2.4.1.1. Cost Estimating Terminology
2.2.4.1.2. Cost Estimate Classification. Be able to describe AACE's recommended practice and its basis on scope definition (also see project implementation for discussion of scope development phases).
2.2.4.1.3. Estimate Variability
2.2.4.1.3.1. Be able to describe the elements, conditions, activities, etc. that may affect estimate variability.
2.2.4.1.4. Uncertainty.(also see Risk Management)
2.2.4.1.4.1. 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.
2.2.4.1.4.2. 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.
2.2.4.1.4.3. Contingency:
2.2.4.1.4.3.1. Be able to define the term including what cost it is supposed to cover
2.2.4.1.4.3.2. Be able to describe several typical ways that it can be estimated
2.2.4.1.5. Algorithms and Cost Estimating Relationships (CER).
2.2.4.1.5.1. Algorithm types: Be able to describe the basic characteristics of these algorithm types:
2.2.4.1.5.1.1. Stochastic or parametric
2.2.4.1.5.1.1.1. Given the inputs, be able to perform a "scale of operations" estimate
2.2.4.1.5.1.1.2. Be able to explain why this algorithm type is most often applied in asset planning.
2.2.4.1.5.1.2. Deterministic or definitive: be able to explain why this algorithm type is most often applied in project control planning.
2.2.4.1.5.2. Factors:
2.2.4.1.5.2.1. Be able to describe some typical uses of factors, ratios, and indices in algorithms of various types.
2.2.4.1.5.2.2. 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.
2.2.4.1.6. Chart or Code of Accounts: be able to describe the characteristics of a good code account structure and its benefits for estimating and project control
2.2.4.1.7. Historical Data: be able to describe the importance of historical, empirical data and databases to cost estimating
2.2.4.2. Processes and Practices: be able to describe the basic mechanics of these estimating steps
2.2.4.2.1. Plan for Estimating and Budgeting
2.2.4.2.1.1. Be able to describe practices for assessing estimate requirements
2.2.4.2.1.2. Be able to describe practices for researching, collecting and analyzing information
2.2.4.2.1.3. Be able to describe practices for developing the estimate structure
2.2.4.2.2. Estimate Methodologies
2.2.4.2.2.1. Be able to describe and apply the estimating methodology using Investment Curves
2.2.4.2.2.2. Be able to describe and apply the estimating methodology using Capacity Factoring
2.2.4.2.2.3. Be able to describe and apply the estimating methodology using Analogy
2.2.4.2.2.4. Be able to describe and apply the estimating methodology using Parametric Models
2.2.4.2.2.5. Be able to describe and apply the estimating methodology using Equipment Factoring

2.2.4.2.2.6. Be able to describe and apply the estimating methodology using Detailed Line-Item Estimating
2.2.4.2.3. Quantification and Take-off:
2.2.4.2.3.1. Be able to describe how to quantify the project scope in an applicable manner
2.2.4.2.3.2. Be able to describe ways that this step is sometimes automated, and considerations for using the results of automated take-off
2.2.4.2.4. Costing:
2.2.4.2.4.1. Be able to describe how to apply baseline costs to the scope quantities
2.2.4.2.5. Pricing:
2.2.4.2.5.1. Be able to describe how to adjust baseline costs for commercial or other considerations
2.2.4.2.5.2. Be able to discuss some business considerations for establishing pricing (risk, competition, desired rate of return, current economic conditions, etc.).
2.2.4.2.5.3. Given a basic set of cost inputs and production plans be able to calculate a break-even product price
2.2.4.2.6. Estimate Conditioning:
2.2.4.2.6.1. Be able to describe how to apply overall estimating adjustments, such as escalation
2.2.4.2.7. Risk Evaluation and Contingency Determination
2.2.4.2.7.1. Be able to describe how to apply risk analysis to an estimate to support contingency determination
2.2.4.2.8. Estimate Documentation:
2.2.4.2.8.1. Be able to describe the typical content of estimate documentation
2.2.4.2.8.2. Be able to describe how to document the Basis of Estimate
2.2.4.2.9. Estimate Reconciliation:
2.2.4.2.9.1. Be able to explain differences between the current estimate with previous versions; and provide resolutions
2.2.4.2.10. Estimate Review and Validation:
2.2.4.2.10.1. Be able to effectively review and validate the estimate, including providing estimate benchmarking
2.2.4.2.11. Estimate Reporting:
2.2.4.2.11.1. Be able to summarize and communicate the estimate content to stakeholders
2.2.4.2.12. Estimate Closeout:
2.2.4.2.12.1. Be able to document, analyze, organize and archive estimate information for future use
2.2.4.3. Other Estimating Issues
2.2.4.3.1. Bidding
2.2.4.3.1.1. Be able to discuss some considerations for using someone else's bid as an input to your cost estimate.
2.2.4.3.1.2. Be able to describe the purpose and mechanics of unbalancing or front-end loading a bid
2.2.4.3.2. Budgeting: be able to describe the mechanics of creating a control budget from a cost estimate
2.2.4.3.3. Costing and Life Cycle Costing (see algorithms); be able to explain the concept of project versus life cycle costing
2.2.4.3.4. Cash Flow and Forecasting:
2.2.4.3.4.1. Be able to discuss the importance of integrating estimating and scheduling practices (incorporating the element of timing in quantification and costing)
2.2.4.3.4.2. Be able to discuss the affects on planning and cost estimating when cash flow is restricted
2.2.4.3.4.3. Given a schedule and set of cost inputs, be able to develop a cost flow curve.
2.2.4.3.5. Cost Control Baseline: be able to describe how cost and schedule control baselines can be integrated

2.2.4.4. Other Concepts:
2.2.4.4.1. Product vs. Project costs: be able to explain how estimating product (i.e., output of manufacturing) cost differs from project cost
2.2.5. Resource Management: be able to describe how this process is tied closely to cost estimating (e.g., quantification) and schedule development (e.g., resource allocation).Also see performance / productivity management considerations
2.2.5.1. Resource availability: be able to discuss ways to assess availability and potential consequences of not doing so
2.2.5.1.1. Be able to describe the types of resources and their appropriateness to analysis
2.2.5.1.2. Be able to discuss potential sources for resources
2.2.5.1.3. Be able to discuss methods for validation of initial estimates
2.2.5.2. Resource limits and constraints: be able to discuss typical limits and constraints that may occur or be imposed
2.2.5.2.1. Be able to discuss the role supervision and span of control has on resource limits
2.2.5.2.2. Be able to describe how optimal and maximum crew sizing may play a part
2.2.5.2.3. Be able to discuss the effects of physical workspace limits
2.2.5.3. Resource allocation: be able to describe the mechanics of this step in schedule development
2.2.5.3.1. Forward vs. backward allocation: be able to explain the differences in the methods
2.2.5.3.2. Smoothing vs. maximum limits: be able to explain the difference in the terms
2.2.5.3.3. Maximum vs. over-maximum allocation: be able to explain the differences in the terms
2.2.6. Value Analysis and Engineering: be able to describe the following concepts:
2.2.6.1. General Concepts:
2.2.6.1.1. Purpose:
2.2.6.1.1.1. 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).
2.2.6.1.1.2. Distinguish among the terms "lowest life-cycle cost," "best quality,” and “best value."
2.2.6.1.1.3. Be able to describe how value analysis/engineering differs from other cost or scope reduction exercises
2.2.6.1.1.4. Be able to describe how value analysis and engineering differs from other value improving practices such as manufacturability and constructability.
2.2.6.1.2. Value: be able to explain the this general concept as well as the meanings, using examples if desired, of these four kinds of value that may be associated with an item:
2.2.6.1.2.1. Use value
2.2.6.1.2.2. Esteem value
2.2.6.1.2.3. Exchange value
2.2.6.1.2.4. Cost value
2.2.6.1.3. Functions
2.2.6.2. Process/Practices; be able to describe the purpose and mechanics of these steps:
2.2.6.2.1. Function Analysis (Value Measurement)
2.2.6.2.1.1. Be able to apportion cost for the entire project by function.
2.2.6.2.1.2. Be able to determine function value in order to support improvement opportunities.
2.2.6.2.2. Creativity
2.2.6.2.2.1. Describe each of the following problem solving techniques:
2.2.6.2.2.1.1. Brainstorming
2.2.6.2.2.1.2. Checklists
2.2.6.2.2.1.3. Morphological analysis
2.2.6.2.2.1.4. Attribute listing

2.2.6.2.3. Value Screening
2.2.7. Risk Management: be able to describe the following concepts:
2.2.7.1. General Concepts
2.2.7.1.1. Risk and Uncertainty: be able to define risk in terms of opportunities and threats
2.2.7.1.2. Risk Factors (or drivers) and Risk Factor Properties
2.2.7.1.3. Risk Management Plan
2.2.7.1.4. Contingency (see cost estimating and schedule development)
2.2.7.1.4.1. Be able to describe the appropriate level of authority for managing contingency
2.2.7.1.4.2. Be able to describe typical criteria for its use (i.e., as opposed to a slush fund).
2.2.7.1.5. Contingency Action Plans
2.2.7.2. Practices: be able to describe the purpose and mechanics of these risk management process steps:
2.2.7.2.1. Risk Assessment
2.2.7.2.2. Risk Analysis
2.2.7.2.3. Risk Factor Screening
2.2.7.2.4. Risk Mitigation or Acceptance
2.2.7.2.5. Risk Control
2.2.8. Procurement Planning and Contract Management
2.2.8.1. Contract types: be able to explain the advantage and disadvantages of these types of contracts from the owner and contractor viewpoints:
2.2.8.1.1. Fixed price (with fixed, incentive, or award fees)
2.2.8.1.2. Unit price
2.2.8.1.3. Cost-plus (with fixed, incentive, or award fees)
2.2.8.1.4. Time and materials (T&M)
2.2.8.2. Risk Allocation: be able to explain how each contract type above allocates risks between the contracting parties.
2.2.8.3. Contract Documents:
2.2.8.3.1. Be able to describe the general contents and purposes of the following elements of bidding and contract documents:
2.2.8.3.1.1. Invitation to bid or request for proposal
2.2.8.3.1.2. Bid form
2.2.8.3.1.3. Agreement
2.2.8.3.1.4. General conditions
2.2.8.3.1.5. Supplementary or special conditions
2.2.8.3.1.6. Technical specifications
2.2.8.3.1.7. Drawings
2.2.8.3.1.8. Addenda
2.2.8.3.1.9. Modifications
2.2.8.3.1.10. Bid bond and contract (performance) bond
2.2.8.3.1.11. Performance guarantee
2.2.8.3.1.12. Warranties
2.2.8.3.2. Be able to explain the role of contract documents in avoiding and resolving disputes, changes and claims (also see Change Management).
2.2.8.3.3. Be able to describe the various types of insurance that may be required as part of a contract
2.2.8.3.4. 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.
2.2.8.3.5. Be able to distinguish between "Job (project) overhead" and "general overhead' and provide examples of each.

2.2.8.3.6. 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.
2.2.8.4. Integrated Project Control:
2.2.8.4.1. 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.).
2.2.8.4.2. Be able to explain the role of contract documents in avoiding and resolving disputes, changes and claims (also see Change Management).
2.2.8.5. Changes and Claims: (see Change Management and Forensic Performance Assessment)
2.2.8.6. Other Concepts:
2.2.8.6.1. Supply chain: be able to explain this concept and how it might affect procurement planning.
2.2.8.6.2. Supplier relationships: be able to explain this concept and how it might affect procurement planning (e.g., initial price versus life cycle cost)
2.2.8.6.3. Schedule of values: be able to explain this concept in regards to contracts, change management, and project control for contracted work.
2.2.9. Investment Decision Making
2.2.9.1. General Concepts:
2.2.9.1.1. Be able explain the concepts and perform the analyses covered previously in the Economic and Financial Analysis section.
2.2.9.1.2. Decision Policy / Criteria:
2.2.9.1.2.1. Be able to describe the role of decision policy in consistent asset investment strategy deployment
2.2.9.1.2.2. Be able to explain why decision policy for most corporations establishes net present value and return on investments (or equivalent) as primary decision criteria.
2.2.9.2. Decision Analysis:
2.2.9.2.1. Decision Model:
2.2.9.2.1.1. Be able to able to explain the benefits of using a cost-based, quantitative decision model that addresses probabilities
2.2.9.2.1.2. Be able to describe the mechanics of addressing non-cash value and risk considerations in a monetary decision model.
2.2.9.2.1.3. Be able to evaluate and select the best alternative from several alternatives using these methods.
2.2.9.2.1.3.1. Net Present Value
2.2.9.2.1.3.2. Decision Tree (probability weighted present value):
2.2.9.2.1.3.3. Internal Rate of Return (breakeven)
2.2.9.2.1.3.4. Cost/Benefit Ratio
2.2.9.2.2. Sensitivity Analysis and Monte Carlo Simulation: be able to discuss mechanics of using a decision model to assess probable outcomes.
2.2.9.3. 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.
2.2.9.4. Capital Budgeting. be able to describe the mechanics of investment decision making in a typical enterprise capital budgeting process.
2.2.9.5. 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.
2.3. Implementation
2.3.1. Project Implementation: be able to explain the following concepts:
2.3.1.1. 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

2.3.1.1.1. Front-end loading (FEL): be able to describe this concept and its benefits in terms of risk management and project control planning
2.3.1.2. 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.
2.3.2. Project control plan implementation: be able to explain the following concepts:
2.3.2.1. Control Accounts: describe this concept and its content in relation to WBS and earned value application
2.3.2.2. 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.
2.3.3. 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.
2.4. Performance Measurement
2.4.1. Cost Accounting: be able to describe the interface of the accounting process with cost engineering practice
2.4.1.1. Cash and Accrual Accounting. Be able to describe these concepts
2.4.1.2. Control and Cost Accounts: be able to discuss the role of the chart or code of accounts with integrating project control
2.4.1.2.1. Initiation/closure: be able to discuss the importance of timely management of cost accounts
2.4.1.2.2. Review/correct: be able to discuss ways to deal with and the affects on project control of mischarges.
2.4.1.3. Classify and account: be able to explain the role of the cost engineer in assuring that cost accounting information is accounted for so as to align with the control basis. Be able to describe these cost accounting concepts:
2.4.1.3.1. Expenditures (i.e., cash disbursements)
2.4.1.3.2. Incurred Costs (i.e., expended plus cost of work performed but not paid for yet)
2.4.1.3.3. Commitments (i.e., including expended costs and financial obligations)
2.4.1.3.4. Cost Allocation
2.4.1.3.5. Activity-Based Costing (ABC)
2.4.1.4. 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
2.4.1.5. Asset vs. Project Accounting:
2.4.1.5.1. Be able to describe how traditional asset operation and finance focused accounting differs from that needed for project control
2.4.1.5.2. Be able to describe how legacy or contractor cost accounting system accounts are often not consistent with project control needs, and how the inconsistency may be addressed.
2.4.2. Project Performance Measurement
2.4.2.1. General Concepts
2.4.2.1.1. Earned Value: be able to explain the general concept and the importance of and reliable control basis and objective, quantitative physical progress measures
2.4.2.2. Practices
2.4.2.2.1. Physical Progress: be able to explain the general concept and the following methods, and, given input information, be able to calculate percent complete.
2.4.2.2.1.1. Units completed
2.4.2.2.1.2. Incremental milestone
2.4.2.2.1.3. Weighted or equivalent units completed
2.4.2.2.1.4. Resource expenditure

2.4.2.2.1.5. Judgment
2.4.2.2.2. Track Resources
2.4.2.2.2.1. Labor hours: be able to explain the advantages and disadvantages of tracking labor hours instead of cost as the basis for earned value
2.4.2.2.2.2. Material management and fabrication: be able to discuss how material progress/status can be measured
2.4.2.2.3. Measure Performance (how work is being done)
2.4.2.2.3.1. Be able to discuss why earned value measures alone have limited value in finding ways to improve performance.
2.4.2.2.3.2. Be able to discuss the mechanics of the following methods, how they can help find ways to improve performance, and their strengths and weaknesses:
2.4.2.2.3.2.1. Work sampling
2.4.2.2.3.2.2. Time and motion studies
2.4.2.2.3.2.3. Time lapse photography and video monitoring
2.4.2.2.3.2.4. Expediting
2.4.2.2.3.2.5. Inspection
2.4.2.2.4. Status Schedule: be able to discuss the mechanics of statusing and updating a schedule
2.4.3. Asset Performance Measurement: be able to explain how earned value methods do not apply for operations and performance is measured against metrics established by the requirements.
2.4.3.1. Functional Performance: be able to explain how measures capture what an asset does and how it does it including quality control attributes, cycle time, and so on.
2.4.3.2. Utility measures: be able to discuss ways to capture user or customer perceptions of how well the asset meets their wants and needs.
2.4.3.3. Measure Activity Factors: be able to explain how if ABC/M methods are used, cost assignment network tracing ties expenses to activities whose performance must be measured.
2.4.3.4. Track Resources: be able to explain how ERP systems increasingly handle these measures in operation facilities
2.5. Performance Assessment
2.5.1. Project Performance Assessment: be able to explain the concepts
2.5.1.1. General Concepts
2.5.1.1.1. Variance: be able to describe this concept as an empirical difference between actual and planned performance for any aspect of the control plan.
2.5.1.1.2. Trends: be able to describe the difference between random and non-random variance and how this might influence subsequent control actions and forecasts
2.5.1.2. Practices for control assessment: be able to describe methods for assessing and reporting performance (variances and trends) against the following baseline plans:
2.5.1.2.1. Cost:
2.5.1.2.1.1. Be able to describe basic earned value methods
2.5.1.2.1.2. Be able to describe and prepare tabular and cumulative distribution charts (“s-curves”) for reporting
2.5.1.2.2. Schedule:
2.5.1.2.2.1. Be able to describe methods to identify variance (e.g., calculate slip, earned value methods, etc), assess critical path and remaining float.
2.5.1.2.2.2. 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.).
2.5.1.2.3. Resources
2.5.1.2.3.1. Labor

2.5.1.2.3.1.1. Be able to describe basic earned value methods
2.5.1.2.3.1.2. Be able to describe and prepare tabular and cumulative distribution charts (“s-curves”) for reporting
2.5.1.2.3.2. Material and fabrication: be able to describe the use earned value, schedule assessment, material management reports, and so on.
2.5.1.2.4. Risk: be able to explain the monitoring and assessment of risk factors in accordance with a risk a management plan
2.5.1.3. Practices for integrated earned value (Earned Value Management System or EVMS) assessment
2.5.1.3.1. 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)
2.5.1.3.2. Be able to describe the advantages and disadvantages of a fully integrated EVMS assessment using costs
2.5.1.4. Practices for work process and productivity improvement
2.5.1.4.1. Productivity assessment
2.5.1.4.1.1. Labor productivity factor: be able to calculate this using earned value and explain its significance
2.5.1.4.2. Work process improvement.
2.5.1.4.2.1. 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
2.5.1.4.2.2. Be able to describe other methods such as informal sampling, manpower surveys, time card notations, quality circles, inspection observations, etc.
2.5.2. Asset Performance Assessment: be able to explain how for operations, earned value methods do not apply and performance is measured against metrics established by the requirements.
2.5.2.1. Measurement Basis: be able to describe these concepts for measuring and assessing asset management performance (profitability being the most common metric):
2.5.2.1.1. Balanced Scorecard
2.5.2.1.2. Key Performance Indicators (KPI)
2.5.2.2. Practices
2.5.2.2.1. Profitability: see return on investment
2.5.2.2.2. Cost of Quality:
2.5.2.2.2.1. Be able to describe the mechanics of the method and costs of prevention, appraisal and failure.
2.5.2.2.2.2. Be able to explain how the method can lead to corrective actions
2.5.2.3. Benchmarking: be able to describe the purpose and mechanics of a benchmarking study
2.5.2.4. Lessons Learned. be able to explain the purpose and mechanics of capturing and evaluating lessons learned
2.5.2.5. Risk Assessment: be able to explain the monitoring and assessment of risk factors in accordance with a risk a management plan
2.5.3. Forecasting
2.5.3.1. Forecast and Forecasting.
2.5.3.1.1. Be able to describe the concepts of forecasts and forecasting
2.5.3.1.2. 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.
2.5.3.2. Earned Value Methods:
2.5.3.2.1. Be able to explain and calculate the basic earned value concepts related to forecasting (BAC, EAC, labor productivity factor)
2.5.3.2.2. Be able to explain why earned value measures alone may not be an appropriate basis for a forecast; explain what else must be considered.

2.5.4. Project Change Management
2.5.4.1. Basic Terminology: be able to describe the concepts
2.5.4.1.1. Scope: be able to describe how the meaning of the term “scope” differs in the contexts of owner project funds authorization versus contracting
2.5.4.1.2. Deviations
2.5.4.1.3. Trends (also see performance assessment):
2.5.4.1.4. Changes: be able to explain the difference between scope and non-scope changes in an owner funding context
2.5.4.1.5. Changes and Contract Types: be able to explain how the change order process may differ with different contract types.
2.5.4.1.6. Disputes and Claims
2.5.4.1.7. Contingency, Allowances, and Reserves (see Risk Management)
2.5.4.2. Practices: be able to describe the concepts
2.5.4.2.1. Variance or trend analysis: be able to describe the difference between performance variance and a trend
2.5.4.2.2. Impact assessment: be able to describe how the project control planning concepts (e.g., estimating, scheduling, etc.) are applied in change management
2.5.4.2.2.1. Be able to describe the concept of time impact analysis related to schedule change
2.5.4.2.3. Make and track disposition
2.5.4.2.3.1. Corrective action (also improvement action): be able to describe what these are and why they might be needed.
2.5.4.2.3.2. Be able to describe ways that change management findings and dispositions (actions) are recorded, reported, and incorporated in the project control plans
2.5.4.2.4. Manage contingency and reserves:
2.5.4.2.4.1. Draw down: be able to describe methods for managing contingency
2.5.4.2.4.2. Be able to describe ways to assess the need for contingency for work in progress
2.5.4.2.5. 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)
2.5.5. Asset Change (Configuration) Management
2.5.5.1. 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.
2.5.5.2. Configuration Management: be able to describe the role of this practice area in managing change in information that defines the asset
2.5.6. Historical Database Management (see basic concepts in Information Management)
2.5.6.1. 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?)
2.5.6.2. Project Closeout: be able to describe the mechanics and challenges of closing out a project in respect to project control systems, data and information.
2.5.7. Forensic Performance Assessment
2.5.7.1. Be able to describe how forensic assessment differs from typical project control performance assessments (i.e., the primary purpose is to relate causation and responsibility (or entitlement) to performance to resolve disputes in a legal context and/or to gain knowledge to support long term performance improvement.
2.5.7.2. Be able to describe the difference between changes and claims (for scope, compensation, relief, damages, delay, or other disagreements)
2.5.7.3. Be able to describe major reasons for contract changes including the role of project scope definition
2.5.7.4. Be able to describe various types of schedule delay in respect to contract changes and claims:

2.5.7.4.1. Excusable
2.5.7.4.2. Non-excusable
2.5.7.4.3. Compensatory
2.5.7.4.4. Concurrent
2.5.7.5. Be able to describe the potential affects of disputes on project performance
2.5.7.6. Be able to discuss role of these costs (see Elements of Cost) in context of disputes and claims (bonds, retainage, performance guarantees, liquidated damages, demurrage, legal costs, etc.)
2.5.7.7. Be able to discuss means and methods of resolving disputes and claims through negotiation, mediation, arbitration, and/or litigation (or other forms of alternative dispute resolution) including being able to discuss potential good points and bad points of each forum.
2.5.7.8. Be able to describe the terms discovery process, depositions and interrogatory.
2.5.7.9. Be able to describe why it is import to distinguish between supposition and fact.

REFERENCES

1. Hollmann, John K., Editor. *Total Cost Management Framework: An Integrated Approach to Portfolio, Program, and Project Management, First Edition Revised*, Morgantown, WV: AACE International, 2011.
2. AACE International, Recommended Practice 10S-90, *Cost Engineering Terminology*, AACE International, Morgantown, WV, (latest revision).

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