

## **COST ESTIMATING BODY OF KNOWLEDGE (CEBoK®) SYLLABUS**

<b><u>Module</u></b>	<b><u>Title</u></b>
1.	Cost Estimating Basics
2.	Costing Techniques
3.	Parametric Estimating
4.	Data Collection & Normalization
5.	Inflation & Index Numbers
6.	Basic Data Analysis
7.	Learning Curve Analysis
8.	Regression Analysis
9.	Cost & Schedule Risk Analysis
10.	Probability & Statistics
11.	Manufacturing Cost Estimating
12.	Software Cost Estimating
13.	Economic Analysis
14.	Contract Pricing
15.	Earned Value Management
16.	Cost Management (TOC/CAIV/Tgt. Cost/ABC)

### **MODULE 1 – COST ESTIMATING BASICS**

The Cost Estimating Basics module introduces the most elemental framework of cost estimating and analysis and the reasons for doing cost estimates. The context for needing estimates is discussed; the specific types of cost products that may be created, resulting uses of the cost estimate, why and how it is used, and an overview of challenges and issues are presented. The types of cost estimating products are outlined, including life cycle, independent, budget support, contracting, and cost management. This module also includes a general overview of the processes and methods used, although the detailed analytical techniques behind these processes and methods are presented in later modules.

### **MODULE 2 – COSTING TECHNIQUES**

The Costing Techniques module introduces the essential knowledge needed and methods used when analysts are developing estimates, explains how to use these costing techniques, and compares the different approaches and their results. The basic techniques of analogy, engineering build-up, and parametric are covered, with

an emphasis on the latter. Extrapolation from actual costs and expert opinion are also discussed. Examples are presented, and the strengths, weaknesses, and considerations of each technique are discussed. There is an additional emphasis on the concepts of uncertainty and risk and how these manifest in the application of each technique.

### MODULE 3 – PARAMETRIC ESTIMATING

This module provides an overview of parametrics. It covers the process of building parametric models and describes how those models are used. The module discusses cost estimating relationships (CERs) and introduces the topics of data use, CER development, and development of complex models. The proper development and application of CERs depends on understanding the associated mathematical and statistical techniques. This module provides general guidance for use in developing and employing valid CERs, including differences between simple and complex CERs, techniques for developing and implementing CERs, including linear regression ordinary least squares (OLS) “best-fit” models. It also examines current “Off the Shelf” models and development tools such as PRICE, SEER, COCOMO II, and ACE-IT and their particular applications.

### MODULE 4 – DATA COLLECTION & NORMALIZATION

All estimating techniques require credible data before they can be used effectively. The Data Collection and Normalization module discusses data types and considerations necessary to its collection as well as sources, including contractor reports, the processes needed to collect and analyze it, and adjustment techniques to put it on a common basis (i.e., data normalization). It also discusses complex data collection, management, and analysis systems such as Earned Value Management (EVM), and other contractual and governmental cost reporting data structures.

### MODULE 5 – INFLATION & INDEX NUMBERS

This module investigates the concept of inflation, or the increase in the general level of prices in the economy. Applied to a systems development and acquisition program context, the module investigates the construction and application of inflation indices, which are of importance in assuring that investment and sustainment budget accounts keep pace with the rise of prices in the economy. The module discusses definitions such as inflation, discounting, escalation, indexing, base year and then year. It presents the mechanics of generating and manipulating inflation indices as well as the application of raw and weighted inflation indices in estimating tasks.

## MODULE 6 – BASIC DATA ANALYSIS

This module discusses the first analytical steps to take after obtaining a set of cost data, with a particular emphasis on mathematical techniques and displaying and analyzing data graphically. It addresses univariate, bivariate, and multivariate data sets, with a focus on statistical analysis of univariate data sets and graphical analysis of bivariate data sets via scatter plots. It introduces measures of central tendency, such as mean, median, and mode; measures of variability, such as standard deviation, variance, and coefficient of variation (CV); and measures of uncertainty, such as confidence and prediction intervals.

## MODULE 7 – LEARNING CURVE ANALYSIS

This module explains the theory and practice of the learning curve and presents the origins, equations, and accompanying steps of the two types of learning curve theory: cumulative average (or CUMAV) theory, and unit learning curve (or ULC) theory. The learning curve (cost improvement curve or experience curve) is a standard estimating methodology commonly used in the hardware production phases of both commercial and defense industries. The material is accompanied by sample problems to demonstrate the concepts and math involved. These problems help illustrate how to choose between the two theories when fitting historical lot data and how to derive learning curves based on lot data and their midpoints. The module also discusses various applications of learning curve theory, and addresses how to deal with issues such as production gaps and the application of major configuration changes.

## MODULE 8 – REGRESSION ANALYSIS

This module covers the linear, non-linear, and multivariate subsets of Regression. It demonstrates how to determine the linear regression equation for a bivariate data set using ordinary least squares (OLS), calculate appropriate statistics related to the linear regression, use them to determine goodness of fit and statistical significance of the model, and create Cost Estimating Relationships (CERs) from normalized data. The module will apply logarithmic transformations to enable the determination of best fit using OLS for data exhibiting power, exponential, or logarithmic functional forms. There is discussion of regression techniques as found in the Microsoft Excel computer program.

## MODULE 9 – COST & SCHEDULE RISK ANALYSIS

This module introduces the basic types and uses of risk determination and analysis. It focuses on the practical execution of the general risk analysis process, which involves technical, schedule and cost risk potential, applied to a point cost estimate

by identifying the risk areas in the point estimate. The module identifies how to define the uncertainty around the point estimate, identify and properly apply correlation between uncertainty distributions, run the Monte Carlo simulation, assess the reasonableness of results, and determine a risk dollar distribution throughout the program. While the emphasis is on an Input-Based approach, Outputs-Based and Scenario-Based approaches are also presented, and the pros and cons discussed.

## MODULE 10 – PROBABILITY & STATISTICS

Module 10 provides a general overview of basic and advanced probability distributions and descriptive and inferential statistics. The intent is to show how probability and statistics are used and their role in cost estimating and analysis, in particular laying the foundation for such crucial tools as regression and cost risk analysis. There is discussion of issues such as covariance and random variable correlation. A section on hypothesis testing explains null and alternative hypothesis, critical values, test statistics, significance level, and p-values, with a focus on its application in the  $t$  and  $F$  tests of regression analysis. The module also provides an explanation of Monte Carlo simulation, and details the process for estimating the parameters of discrete and continuous distributions, given a data set, using Ordinary Least Squares (OLS).

## MODULE 11 – MANUFACTURING COST ESTIMATING

The Manufacturing Cost Estimating module provides a set of techniques used to address issues unique to estimating in the manufacturing environment. It presents the most common general issues, considerations and concerns related to a typical major manufacturing environment, and provides techniques for addressing them. Three costing techniques are explored as a means to estimate the material and labor required for a particular manufacturing product: Analogy, Parametric, and Engineering Build-Up. The module touches on industrial engineering (IE) principles, and introduces standards, time and motion studies, and realization factors. The module focuses on the key concepts of segregating costs into recurring and non-recurring, fixed and variable, and direct and indirect. Learning curve applications and associated concepts such as production breaks and rate adjustments are also examined.

## MODULE 12 – SOFTWARE COST ESTIMATING

Almost every system developed today for commercial or government use involves a significant software component. This module conveys a broad range of information for this critical area of specialized cost estimating. It addresses the basics of

software development and operation, reviews commonly used estimating terminology, and discusses software cost drivers, schedule considerations, creative environment, and methods and metrics for estimating the various types of automated information systems (AIS). Types of AIS that can lead to widely varying development costs include enterprise resource planning, data warehouse, service oriented architecture, management information systems, and mission operations center. The module reviews more common off-the-shelf commercial and government estimating models used, and presents definitions of common terms unique to this estimating area.

### MODULE 13 – ECONOMIC ANALYSIS (EA)

The EA module applies the principles of the EA discipline to identify the “best value” solution from a series of alternatives using a scientific and systematic costing methodology. EA is used to make and justify decisions by invoking the concepts of opportunity costs and time value of money. Terms such as Net Present Value (NPV), Return on Investment (ROI), Internal Rate of Return (IRR), Payback Period, and Cost Benefit Analysis are defined, along with their applications. EA’s use of business case analysis to support milestone decisions and the POM process are discussed. The module reviews the concepts, terminology, and variables, and provides a practitioner’s perspective for conducting economic analyses. This module also introduces practical applications of EA, primarily from a Department of Defense (DoD) perspective, where it is widely used. This includes discussion of EA processes, documents, tools, and case studies derived from real world experience.

The module provides guidance for using EA applications and reviews Congressional, Office of Management and Budget (OMB), DoD, and individual service EA statutes and instructions/manuals/regulations/directives. Types of EAs are reviewed with emphasis on when these types are applicable. The specific methods for computing the cost and benefits of various alternatives are presented.

### MODULE 14 – CONTRACT PRICING

This module takes a holistic view of contracting and contract pricing from a cost estimator's viewpoint, with emphasis on acquisition planning, contract pricing, and cost/price analysis. The discussion of acquisition planning focuses on contract types, specifically how cost risk is shared between parties to the contract and the profit/fee potentials commensurate with that risk. Illustrative examples of each contract type are discussed. The use of cost estimating techniques to establish a basis of estimate (BOE) as the foundation of the cost/price proposal (i.e. cost pricing) are explained in detail. There is discussion of cost/price comparative analysis processes used to evaluate proposals for their reasonableness and to establish an objective basis for comparison and validation of a system's cost.

## MODULE 15 – EARNED VALUE MANAGEMENT (EVM)

The EVM module provides introduction to the basic concepts and components of Earned Value Management (EVM). Basic EVM components include integrated baseline; work breakdown structures (WBS); earned value data elements including budgeted cost of work scheduled (BCWS), budgeted cost of work performed (BCWP), actual cost of work performed (ACWP), budget at completion (BAC), and latest revised estimate (LRE); baseline development; and performance management. Additionally, basic earned value analysis techniques such as analyzing cost variance (CV), schedule variance (SV), cost performance index (CPI), and schedule performance index (SPI) are addressed. Following the definition and calculation of EVM elements, the module focuses on critical analysis of EVM data, including a discussion of how traditional earned value analytical techniques can produce misleading or incomplete indicators of performance. Alternative techniques for assessing program performance are discussed, including heuristic equations and visual displays of information that can provide early indicators of program future performance.

## MODULE 16 – COST MANAGEMENT

Module 16 provides an introduction to cost management as well as the principal tools and techniques, aside from those previously presented in earlier modules, that are in use by both government and industry in conducting performance analysis using cost, and applying it for better oversight of program performance. Some of the Cost Management methods discussed in Module 16 include *Total Ownership Cost* (TOC), which attempts to capture all costs associated with a program, *Cost As an Independent Variable* (CAIV), *Target Costing*, and *Activity Based Costing* (ABC). These and other Cost management techniques generally take a holistic approach, incorporating cost considerations into the overall program management approach, so that together with other measures of performance and control, they will help lead to decisions providing optimal value to the organization.