

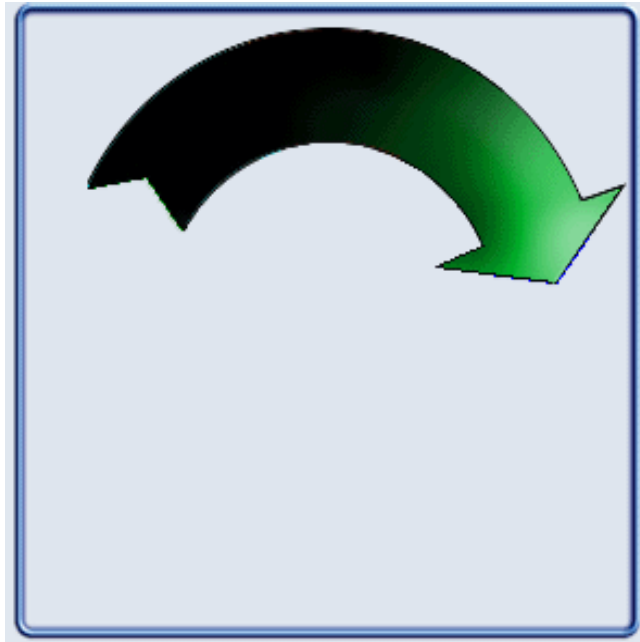
Cost Analysis

Introduction to Cost Analysis

Introduction to Cost Analysis

Introduction to Cost Analysis Terms and Concepts

Page 1 of 2



Approximate Length: 2 hour, 20 minutes

Welcome to the Cost Analysis Module. This module will present you with information on the cost estimating and review process and cost estimating methods. Learning curve theory is also covered in the module. The following topics are part of this module:

- Affordability
- Cost as an Independent Variable
- Cost Estimating and Review
- Cost Estimating Methods
- Learning Curve Theory
- Lesson Summary

Located throughout and at the end of this module are Knowledge Reviews, which are not graded but enable you to measure your comprehension of the module material.

Long Description

Image of Acquisition life-cycle in the form of a circle. Arrows point in a clockwise direction showing the cycle from development to testing to production to operation and support to disposal. A stack of money is in the middle.

Learning Objectives

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By completing this lesson you should be able to:

- Describe the basic concepts of affordability.
- Describe the philosophy of Cost as an Independent Variable (CAIV).
- **Recall when, how, and why an Analysis of Alternatives is prepared for a defense acquisition program.**
- **Identify when and why each of the following documents is required for ACAT I and ACAT IA acquisition programs: Life-Cycle Cost Estimate, Economic Analysis, Component Cost Estimate, Independent Cost Estimate, and Cost Analysis Requirements Description.**
- **Define the roles, responsibilities and perspectives of the organizations that participate in the cost estimating and review process.**
- **Define each of the following cost estimating methods: analogy, parametric, engineering, and actual costs.**
- **Determine the cost estimating method most appropriate for use in a given situation.**
- **Given appropriate data, estimate the learning curve for a production process and the number of labor hours required for a future production unit.**

This page completes the Module Introduction. Select a lesson from the Table of Contents to continue.

Affordability

Affordability

Affordability (1 of 4)

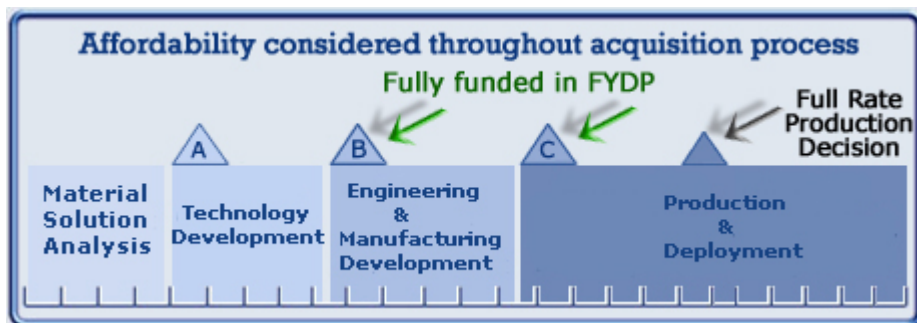
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Affordability is the degree to which the life-cycle cost of an acquisition program fits into the long-range investment and force structure plans of DoD and its individual components. From a cost perspective, program plans should be based on realistic projections of funding availability. Such planning improves the likelihood that program funding will remain stable, enabling the program manager to execute the program as intended.

Affordability (2 of 4)

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DoD acquisition policy requires that affordability be considered throughout the acquisition process, beginning with the Initial Capabilities Document, which should address cost as a system parameter.

In addition, the Milestone Decision Authority (MDA) must assess affordability at program initiation and each subsequent milestone, ensuring that sufficient funding exists in the Future Years Defense Program (FYDP) to execute the program as presented (that is, the program should be "fully funded").

If the program is not fully funded in the FYDP, the DoD Component Head responsible for the program must commit to incorporate appropriate funding in the next FYDP update in order to receive milestone approval.

Long Description

Program affordability timeline. Affordability is considered throughout the acquisition process. Material Solution Analysis is at the beginning of the process. Milestone A is followed by Technology Development, Milestone B by Engineering & Manufacturing Development, Milestone C by Production & Deployment by Full Rate Production Decision. Milestones B and C are fully funded in the FYDP.

Affordability (3 of 4)

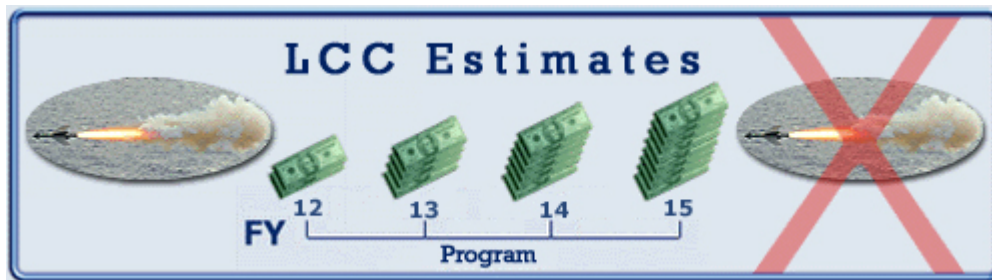
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DoD Instruction 5000.02, Office of Management and Budget (OMB) Circular A-11 and Public Law 104-106 prohibit a major defense acquisition program from proceeding into Engineering & Manufacturing Development (EMD) unless sufficient resources are programmed in the most recently approved FYDP, or will be programmed in the next FYDP update.

Affordability (4 of 4)

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In the past, programs have often tended to underestimate their costs initially to meet affordability considerations at program initiation, leading to later cost overruns and budget shortfalls. As a result, DoD is now placing greater emphasis on realistic cost estimates in the acquisition decision process, and in most cases is directing that programs be programmed and budgeted to the level of the independent cost estimate rather than the program office's life-cycle cost estimate.

This page concludes our discussion of affordability; the knowledge review on the next page will help you measure your comprehension.

Knowledge Review

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After you have completed the following question, select another topic from the Table of Contents to continue, as this page completes the topic. The following Knowledge Review allows for multiple correct answers. Select all of the answers that are correct, then select the Submit button and feedback will appear.

Which of the following statements concerning the affordability of an acquisition program are true?

- a. A program that is not fully funded in the FYDP at program initiation may be considered affordable if the component head agrees to add sufficient resources to fully fund the program in the next FYDP update.**
- b. Program affordability should be assessed at every milestone beginning with program initiation by the MDA.**
- c. Affordability is the degree to which the program's life-cycle cost fits into DoD's short-term investment and force structure plans.**
- d. Affordability is an acquisition community concern and need not be considered in establishing a program's operational requirement.**

Correct! A program that is not fully funded in the FYDP at program initiation may be considered affordable if the component head agrees to add sufficient resources to fully fund

the program in the next FYDP update. Also, program affordability should be assessed at every milestone beginning with program initiation by the MDA. However, affordability is the degree to which the program's life-cycle cost fits into DoD's long-term investment and force structure plans. Also, affordability is not merely an acquisition community concern. DoD 5000.02 requires that affordability be considered in establishing a program's operational requirement.

Cost as an Independent Variable

Cost as an Independent Variable (CAIV)

Cost As an Independent Variable (CAIV) (1 of 7)

Page 1 of 10



Acquisition programs must balance three major characteristics:

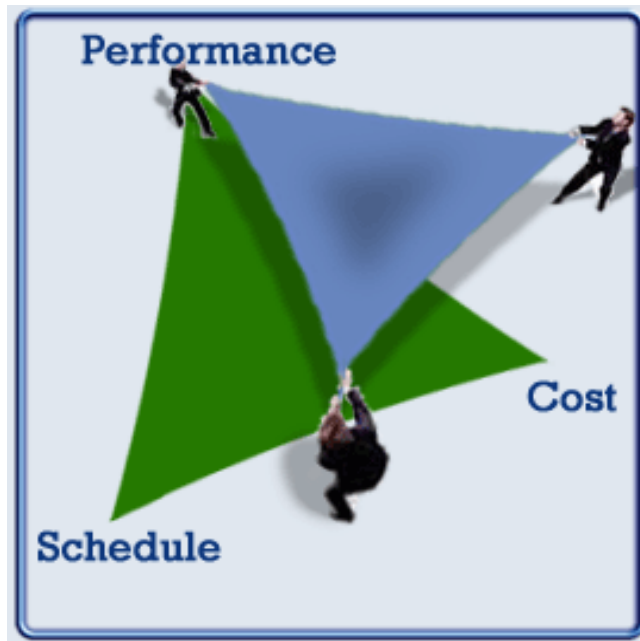
- **Performance** that satisfies operational requirements
- A development and fielding **schedule** that satisfies user needs
- **Cost** that can reasonably be expected to be funded

Each overall characteristic may have multiple system parameters related to it. For example, an aircraft program might have range as a performance parameter, an Initial Operational Capability date as a schedule parameter, and procurement cost as a cost parameter.

The Acquisition Program Baseline (APB) specifies the desired values ("objectives") as well as the minimum acceptable values ("thresholds") of these parameters.

CAIV (2 of 7)

Page 2 of 10



Rarely do sufficient resources exist to achieve the objective levels of all performance, schedule, and cost parameters simultaneously. Something has to give. In keeping with its current emphasis on affordability and reduced cycle time for fielding new systems, DoD requires all acquisition programs to employ the philosophy of Cost As an Independent Variable (CAIV) focusing on controlling Total Ownership Cost (TOC).

This means performance and schedule parameters may be traded off from their objective levels as necessary to reduce TOC while still achieving required system capability.

CAIV (3 of 7)

Page 3 of 10



DoD acquisition policy articulates the requirements for CAIV implementation. Upon approval of the Initial Capabilities Document (ICD), the PM must formulate a CAIV plan as part of the acquisition strategy. Upon program initiation, each ACAT I and ACAT IA PM shall document TOC objectives as part of the APB.

The cost portion of the APB shall include a complete set of TOC objectives: research, development, test and evaluation (RDT&E); procurement; military construction; operating and support; and disposal costs; as well as other indirect costs attributable to the system, and infrastructure costs not directly attributable to the system. The MDA shall re-assess cost objectives, and progress towards achieving them, at each subsequent milestone.

CAIV (4 of 7)

Page 4 of 10



The CAIV philosophy recognizes that the best time to reduce life-cycle costs is early in the acquisition process, since system design decisions tend to drive production and operating and support costs. For example, reducing the top speed or payload of an aircraft can reduce fuel consumption. Spending a few extra dollars early on to design the system to be maintained more easily and less expensively is another example of CAIV at work. Cost/schedule/performance trade-off analyses should be conducted continuously to maximize opportunities for reducing cost and schedule.

CAIV (5 of 7)

Page 5 of 10



For ACAT I and ACAT IA programs, a Cost/Performance Integrated Product Team led by the Program Manager (PM) or PM's representative is assembled to conduct trade-off analyses. The Cost/Performance Integrated Product Team should include representatives of the user, cost estimating, analysis, and budgeting communities, at minimum, with others participating as required.

Cost, schedule, and performance may be traded within the "trade space" between the objective and the threshold without obtaining MDA approval. If proposed trades require changes to threshold values in the APB or Capabilities Document, the PM shall notify the OSD Overarching IPT leader and quickly bring such proposals to the appropriate approval authorities for decision.

CAIV (6 of 7)

Page 6 of 10



One of the keys to making CAIV work is to provide incentives (and remove disincentives) to both government and contractor personnel. Contracts should be structured to incentivize the contractor, for example, by equitably sharing CAIV savings between the government and the contractor.

Government PMs can be incentivized by permitting the PM to retain at least some internally generated savings within the program, perhaps for use on program enhancements, further cost reduction efforts, or to improve operations of the program office. For government personnel (both civilian and military), there should be provisions for awards to individuals and groups for notable contributions to achieving cost reductions.

CAIV (7 of 7)

Page 7 of 10



An example of removing disincentives to cost savings efforts concerns perception of "failed" efforts. The chain of command should be willing to accept risk-taking when the potential for future payoff is high. Managers who take the risk and work in that risky environment should not be penalized for their less-successful attempts at cost savings if their efforts fail for reasons beyond their control.

This page concludes our discussion of CAIV; the knowledge reviews on the following pages will help you measure your comprehension.

Knowledge Review

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The following Knowledge Review allows for multiple correct answers. Select one or more answers that best correspond, then select the Check Answers button and feedback will appear.

In accordance with the philosophy of Cost as an Independent Variable, acquisition programs must balance:

- a. Performance that satisfies operational requirements**
- b. A development and fielding schedule that satisfies user needs**
- c. Cost that can reasonably be expected to be funded**
- d. Technology that is at or near the 'cutting edge'**

Correct

In accordance with the philosophy of Cost as an Independent Variable, acquisition programs must balance performance that satisfies operational requirements, a development and fielding schedule that satisfies user needs, and cost that can reasonably be expected to be funded.

Knowledge Review

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The following Knowledge Review is a True or False question. Select the best answer and feedback will immediately appear.

The best time to reduce life-cycle costs is early in the acquisition process.

True

False

Correct!

The best time to reduce life-cycle costs is early in the acquisition process.

Knowledge Review

Page 10 of 10

After you have completed the following question, select another topic from the Table of Contents to continue, as this page completes the topic. The following Knowledge Review allows for multiple correct answers. Select all of the answers that are correct, then select the Submit button and feedback will appear.

Which of the following would help to improve the chances of a successful CAIV implementation for an acquisition program?

- a. Sharing savings with program contractors**
- b. Distributing savings to other programs experiencing cost overruns.**
- c. Providing awards to government personnel for their contributions**
- d. Accepting occasional failures when risks are taken to achieve potentially large savings**

Correct! Sharing savings with program contractors, providing awards to government personnel for their contributions, and accepting occasional failures when risks are taken to achieve potentially large savings would all help to improve the chances of a successful CAIV implementation for an acquisition program. However, distributing savings to other programs experiencing cost overruns would not provide any incentive for a program office to reduce program costs.

Cost Estimating and Review Process

Cost Estimating and Review

Cost Estimating Documentation Requirements Overview

Page 1 of 27



The DoD 5000 series provide guidance for preparing program documentation, including program cost-related documents. These include the Analysis of Alternatives, Cost Analysis Requirements Description, Life-Cycle Cost Estimate or Economic Analysis, Component Cost Estimate, and Independent Cost Estimate. Recommended content for these documents vary, primarily based on program acquisition category (ACAT).

The most comprehensive content recommendations, applying to ACAT I Major Defense Acquisition Programs (MDAPs) and ACAT IA Major Automated Information System (MAIS) programs, will be discussed on the following pages, beginning with the Analysis of Alternatives.

Analysis of Alternatives (1 of 6)

Page 2 of 27



An Analysis of Alternatives (AoA) is a study of the operational effectiveness, life-cycle costs, concepts of operations, and overall risk associated with each of the various alternatives that may be able to meet a mission area need. It answers the question, "What is the most cost-effective way to meet this mission need?"

- The analysis should help decision-makers judge whether or not any of the proposed alternatives offer sufficient military and/or economic benefit to be worth the cost. It also may recommend a specific alternative.
- The analysis is intended to foster joint ownership and afford a better understanding of subsequent decisions by early identification and discussion of reasonable alternatives among decision-makers and staffs at all levels. The analysis should be quantitatively based, producing discussion on key assumptions and variables.

Analysis of Alternatives (2 of 6)

Page 3 of 27



The user responsible for the affected mission area is responsible for determining the independent activity that will perform the AoA. For weapon systems, this determination is made by the DoD Component Head; for ACAT IA automated information system programs, it is made by the OSD Principal Staff Assistant (PSA) for the affected functional area. For example, the Director of Defense Procurement was the PSA designated to conduct the AoA for the ACAT IA Standard Procurement System program. For joint programs, the lead DoD component is responsible for ensuring a comprehensive analysis and coordinating any supplementary analysis from other components.

Analysis of Alternatives (3 of 6)

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An Integrated Product Team (IPT) may be formed to prepare the AoA. If a Program Manager (PM) has been designated at this point in the acquisition process, the PM may participate as a member of the IPT, but may not be designated as the IPT leader. If it has already been established, the Program Office usually provides support to the AoA preparation effort.

Analysis of Alternatives (4 of 6)

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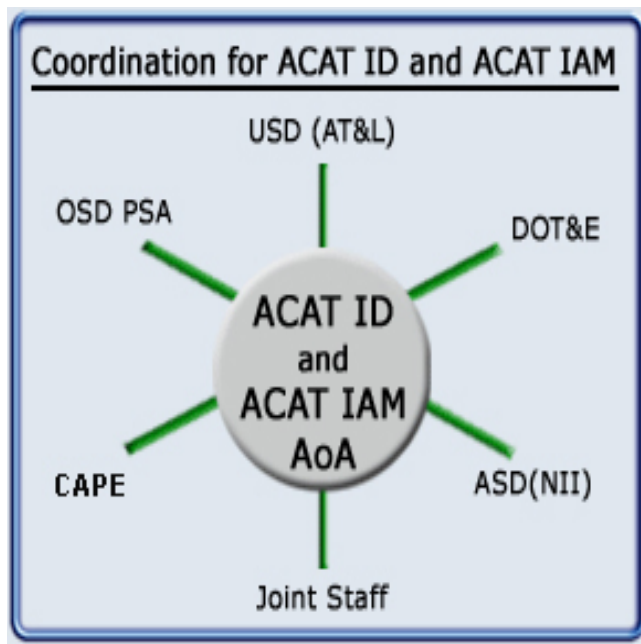


For ACAT ID and ACAT IAM programs (where the milestone decision is made at the DoD-level), the Component Head or PSA (as applicable) is required to coordinate with key OSD officials and staffs early in the AoA process.

This coordination is required to help ensure that a full range of alternatives is considered; that plans for the alternatives are consistent with U.S. military strategy; and that joint-service issues such as interoperability, security, and common use are addressed in the AoA.

Analysis of Alternatives (5 of 6)

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The staffs of the Undersecretary of Defense (Acquisition, Technology and Logistics) (USD(AT&L)), the Assistant Secretary of Defense (Networks & Information Integration) (ASD(NII)), the Joint Staff, the OSD PSA, the Director for Operational Test and Evaluation (DOT&E), and the Director of Cost Assessment & Program Evaluation (Director of CAPE), are included in this ACAT ID and ACAT IAM AoA coordination, as applicable. The Director of CAPE is responsible for preparing guidance for the AoA, which is issued by USD(AT&L) or ASD(NII) as appropriate.

Analysis of Alternatives (6 of 6)

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The AoA is normally completed and documented during the Material Solution Analysis phase prior to Milestone A. For ACAT IA programs, the PM is required to incorporate the analysis of alternatives into the program's Economic Analysis.

The MDA may direct updates to the analysis for subsequent decision points, if conditions warrant, such as significant changes to the program or its underlying assumptions.

DoDI 5000.02 articulates guidance and requirements for developing an AoA to support milestone and decision reviews.

Knowledge Review

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The following Knowledge Review is a multiple choice question. Only one answer is correct; select the best answer and feedback will immediately appear.

Which one of the following is responsible for designating an independent activity to perform the AoA for an ACAT IA program?

- a. DoD component head responsible for the affected mission area**
- b. OSD Principal Staff Assistant responsible for the affected functional area**

c. Director, Cost Assessment & Program Evaluation

d. Assistant Secretary of Defense (Network & Information Integration)

Correct!

The OSD Principal Staff Assistant responsible for the affected functional area is responsible for designating an independent activity to perform the AoA for an ACAT IA program.

Knowledge Review

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The following Knowledge Review is a True or False question. Select the best answer and feedback will immediately appear.

DoD Instruction 5000.4-M articulates the requirements for preparing acquisition program documentation, including program cost-related documents, such as the Analysis of Alternatives.

True

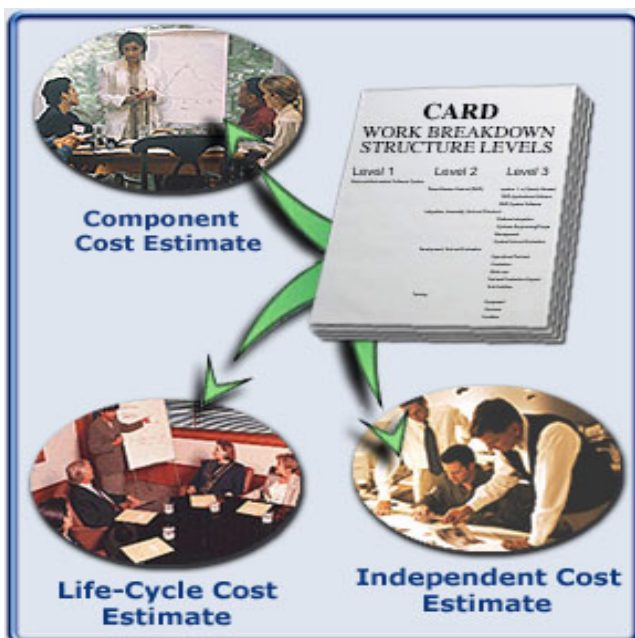
False

Correct!

DoD Instruction 5000.02 articulates the requirements for preparing acquisition program documentation, including program cost-related documents. DoD 5000.4-M provides guidance for performing cost analyses.

Cost Analysis Requirement Description (CARD)(1 of 3)

Page 10 of 27



The Cost Analysis Requirements Description (CARD) provides a complete description of the system whose costs are to be estimated. This document helps ensure that all major acquisition program cost estimates are based on common and accurate information and provide the amount of detail required by decision-makers. DoD 5000.4-M provides guidance regarding CARD preparation.

Cost Analysis Requirement Description (CARD)(2 of 3)

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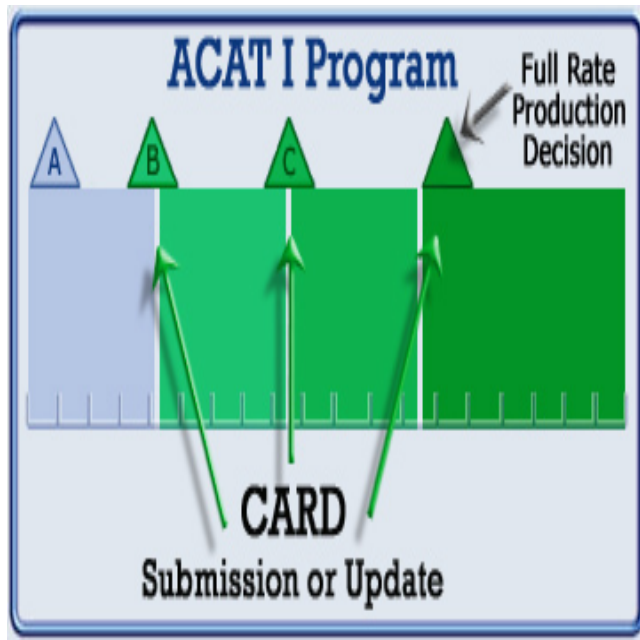


Per DoD 5000.02 guidance, a CARD will be prepared for all ACAT I and ACAT IA programs. For ACAT I programs, the DoD Component sponsoring the acquisition program is responsible for establishing the CARD. Generally, engineers and others in the ACAT I Program Management Office (PMO) prepare the CARD, which must be approved by an authority no lower than a Component Program Executive Office.

For ACAT IA programs, the Program Manager is responsible for preparation of the CARD, in coordination with appropriate IPT members. Per DoD 5000.4-M, the CARD should be considered a "living document" to be updated periodically, but particularly in preparation for all milestone and program decision reviews to reflect any changes that have occurred, or new data that have become available, since the previous version.

Cost Analysis Requirement Description (CARD)(3 of 3)

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Enclosure 4 to DoD Instruction 5000.02 specifies that ACAT I programs must prepare or update the CARD in support of Milestone B, Milestone C, and the Full Rate Production Decision Review. DoD Instruction 5000.02 also specifies that ACAT IA programs must prepare or update the CARD whenever an initial or updated Economic Analysis is required.

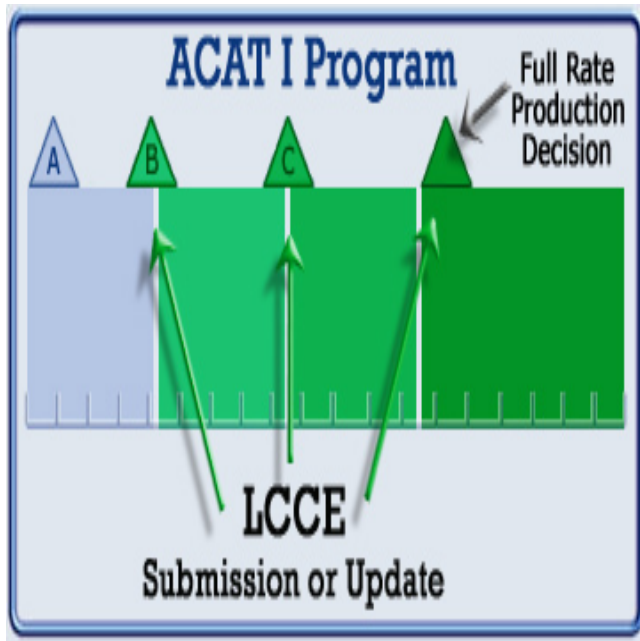
All teams preparing life-cycle cost estimates must generally be provided with a draft CARD at least 180 days prior, and the final CARD 45 days prior, to a planned DoD Overarching IPT or DoD Component review.

Long Description

ACAT I Program timeline. Milestones A, B, C and the Full Rate Production Review Decision points are indicated. Arrows point to Milestones B, C, and the Full Rate Production Review Decision from the words "CARD Submission or Update."

Life-Cycle Cost Estimate (LCCE)

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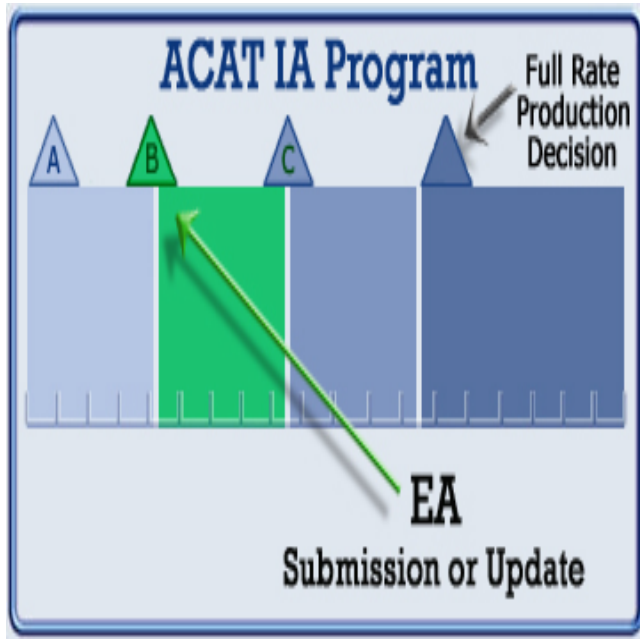
Every ACAT I acquisition program office is required to prepare a Life-Cycle Cost Estimate (LCCE) (sometimes referred to as a Program Office Estimate) for the program initiation decision and at all subsequent program decision points. The LCCE serves as the source of the cost information included in the program's Acquisition Program Baseline (APB) and should also be used as the basis for budget requests.

Long Description

ACAT I Program timeline. Milestones A, B, C and the Full Rate Production Review Decision points are indicated. Arrows point to Milestones B, C, and the Full Rate Production Review Decision from the words "LCCE Submission or Update."

Economic Analysis (EA)

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The Economic Analysis (EA) is prepared by the program office for ACAT IA (Major Automated Information System) programs at program initiation (usually Milestone B). It includes estimates of both life-cycle costs and benefits, as required by Title 44, United States Code, Section 3506 and the Clinger-Cohen Act of 1996, Section 5122.

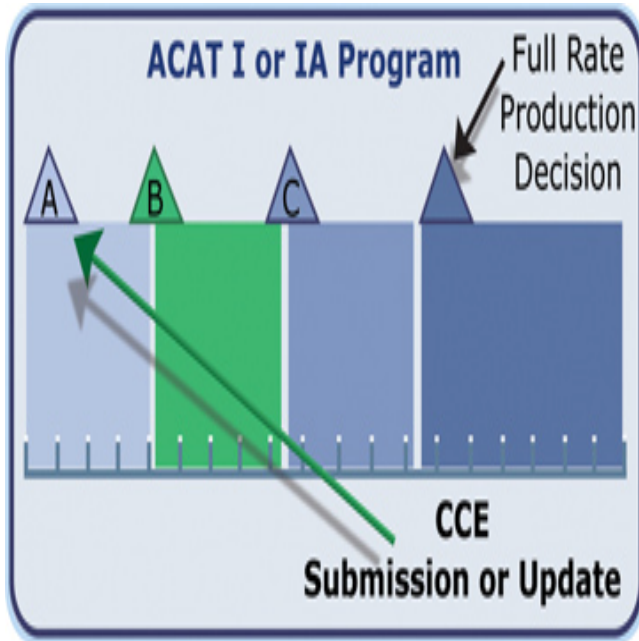
The EA is updated whenever directed by the Milestone Decision Authority, usually whenever program cost, schedule, or performance parameters significantly deviate from the approved Acquisition Program Baseline (APB). The EA serves as the source of the cost information included in the program's APB and should also be used as the basis for budget requests.

Long Descriptions

ACAT IA Program timeline. Milestones A, B, C and the Full Rate Production Review Decision points are indicated. Arrow points to Milestone B from the words "EA Submission or Update."

Component Cost Estimate (CCE)

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The Component Cost Estimate (CCE) is a life-cycle cost estimate representing the component's "corporate cost position." The estimate is also referred to as the "Component Cost Position." Each component has latitude in how it develops the CCE. This process may involve the component cost agency simply evaluating and recommending adjustments to the POE, the result being the CCE. Or, it could involve the component cost agency developing its own independent estimate (sometimes called the Component Cost Analysis (CCA)) followed by a formal reconciliation between this estimate and the POE to arrive at the final CCE.

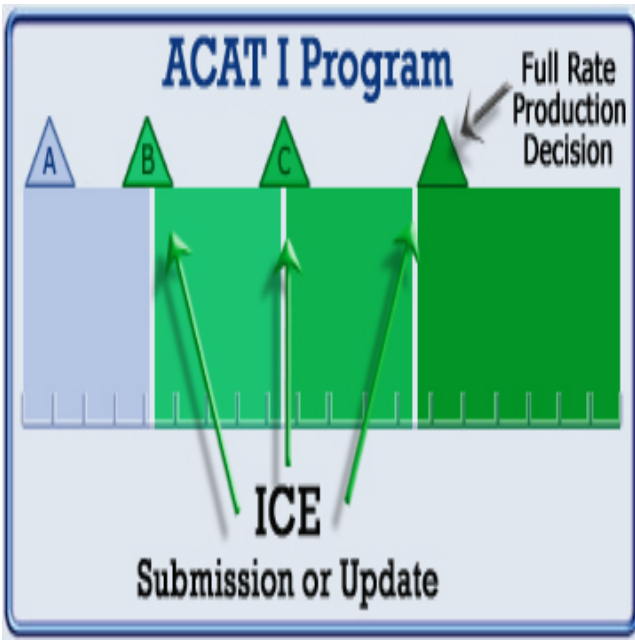
A CCE is required for all ACAT I programs at Milestone A, B, C and the Full Rate Production Decision Review (FRP DR) (per DoDI 5000.02, Enclosure 4). A CCE is required for all ACAT IA programs at Milestone A and whenever an economic analysis is required.

Long Description

ACAT I or IA Program timeline. Milestones A, B, C and the Full Rate Production Review Decision points are indicated. Arrow points to Milestone B from the words "CCE Submission or Update."

Independent Cost Estimate (ICE)

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Title 10, United States Code, Section 2434, requires that the Secretary of Defense consider an independent estimate of the life-cycle cost of a Major Defense Acquisition Program (ACAT I) prior to granting Milestone B and Milestone C. (Per DoDI 5000.02, an ICE is also considered at the Full Rate Production decision review, at the discretion of the Milestone Decision Authority (MDA)). This Independent Cost Estimate (ICE) must be produced by an entity outside the development and acquisition chain(s) of command. For ACAT ID programs, the ICE is prepared by the OSD Directorate of Cost Analysis and Program Evaluation (CAPE).

For ACAT IC programs, the Component cost agency prepares an independent estimate (sometimes called the CCA) that serves as the ICE, unless the Undersecretary of Defense (Acquisition, Technology & Logistics) requests that the ICE be prepared by the OSD CAPE.

Long Description

ACAT I Program timeline. Milestones A, B, C and the Full Rate Production Review Decision points are indicated. Arrows point to Milestones B, C, and the Full Rate Production Review Decision from the words "ICE Submission or Update."

Knowledge Review

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The following Knowledge Review is a multiple choice question. Only one answer is correct; select the best answer and feedback will immediately appear.

Which of the following organizations is most often responsible for preparing the CARD?

- a. DoD component staff
- b. Program Management Office
- c. DoD contractor
- d. OSD CAPE

Correct!

The Program Management Office is most often responsible for preparing the CARD.

Knowledge Review

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The following Knowledge Review is a True or False question. Select the best answer and feedback will immediately appear.

For ACAT ID programs, the ICE is prepared by the OSD CAPE.

True

False

Correct!

For ACAT ID programs, the ICE is prepared by the OSD CAPE.

Cost Estimating Review Process

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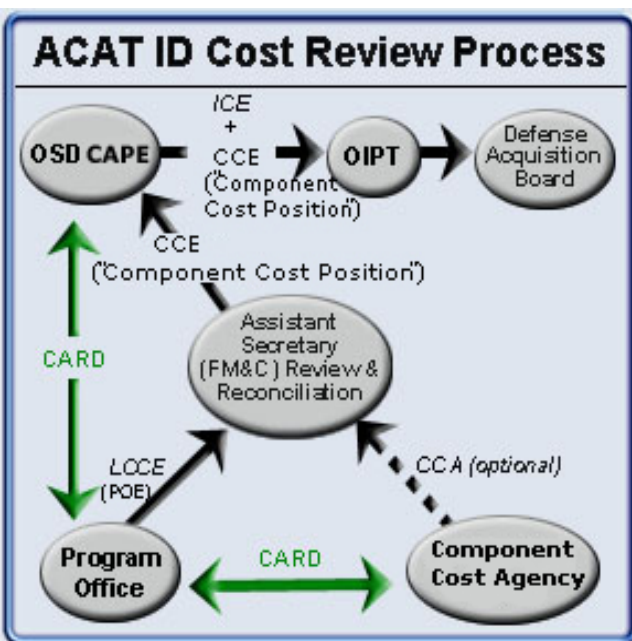
The cost estimating review process for major acquisition programs involves various players and requires documentation depending on the acquisition category of the program for which the analysis is being conducted.

The following pages describe the cost estimating review process for ACAT I programs. ACAT II and below programs follow similar processes. Descriptions of the different ACATs can be found in DoDI 5000.02, Enclosure 3, Table 1 on page 33.

<http://www.dtic.mil/whs/directives/corres/pdf/500002p.pdf>

ACAT ID Cost Review Process

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Up to three cost estimates may be prepared for an ACAT ID program approaching a major milestone: the program life-cycle cost estimate (LCCE) (otherwise known as the Program Office Estimate (POE)), an optional Component Cost Analysis (CCA), and an Independent Cost Estimate (ICE). All of the offices preparing estimates use the Cost Analysis Requirements Description (CARD) to ensure that the estimates are comparable. The LCCE (POE) and CCA (if prepared) are reviewed by the Service's Assistant Secretary (Financial Management & Comptroller) and reconciled if necessary into a "Component Cost Position" (officially referred to as the Component Cost Estimate (CCE), discussed earlier).

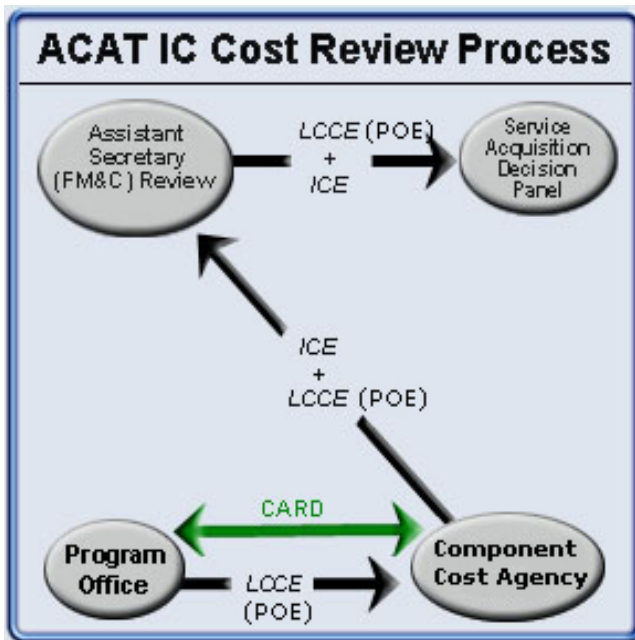
The OSD Cost Analysis and Program Evaluation (CAPE) directorate prepares the ICE, compares the CCE to the ICE and analyzes the differences between the estimates in a report to the appropriate OSD Overarching Integrated Product Team (OIPT). The OIPT considers the program's affordability using the LCCE (POE), ICE, and the CAPE analysis. Any affordability issues that cannot be resolved at the OIPT level are referred to the Defense Acquisition Board (DAB) for resolution. The DAB makes final recommendations to the Milestone Decision Authority (Defense Acquisition Executive).

Long Description

The diagram shows 6 oval shaped circles titled OSD CAPE, OIPT, Defense Acquisition Board, Assistant Secretary (FM&C) Review and Reconciliation, Program Office, and Component Cost Agency, respectively. A two-way arrow labeled CARD runs between the OSD CAPE and the Program Office, and another two-way CARD arrow runs between the Program Office and the Component Cost Agency. An arrow labeled LCCE (POE) runs from the Program Office to the Assistant Secretary (FM&C) Review & Reconciliation. An arrow labeled CCA (optional) runs from the Component Cost Agency to the Assistant Secretary (FM&C) Review & Reconciliation. An arrow labeled CCE ("Component Cost Position") runs from the Assistant Secretary (FM&C) to the OSD CAPE. An arrow labeled ICE & CCE ("Component Cost Position") runs from the OSD CAPE to the OIPT. Finally, an arrow runs from the OIPT to the Defense Acquisition Board.

ACAT IC Cost Review Process

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ACAT IC programs approaching a major milestone require a program LCCE (POE) and an ICE prepared by the Component Cost Agency (may be referred to as the CCA). Use of the CARD ensures that the estimates are comparable. The Component Cost Agency prepares the ICE (unless the MDA requests an OSD CAPE ICE), compares the LCCE (POE) and ICE and analyzes the differences between the estimates in a report.

The LCCE (POE), ICE, and Component Cost Agency report are reviewed by the Service's Assistant Secretary (Financial Management & Comptroller) and forwarded to the Service Acquisition Decision Panel for use in evaluating the program's affordability before making recommendations to the Milestone Decision Authority (Service Secretary or Component Acquisition Executive).

Select the hyperlink to access a list of the [Service Acquisition Decision Panels](#).

Long Description

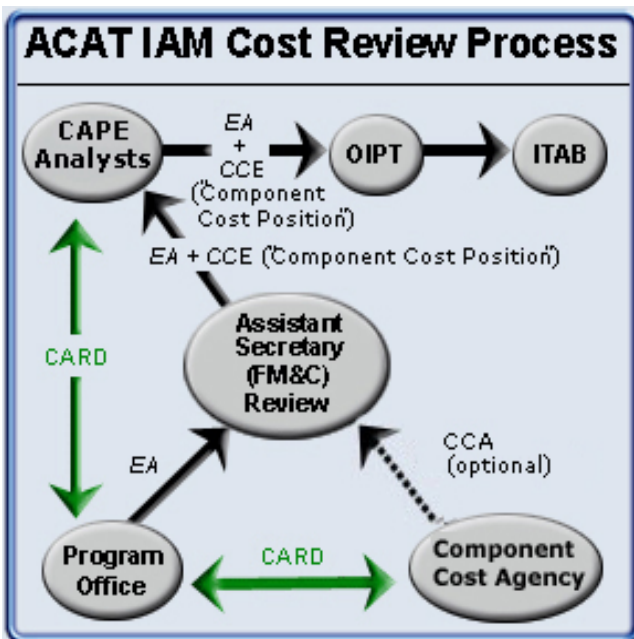
The diagram shows 4 oval shaped circles titled Assistant Secretary (FM&C) Review, Service Acquisition Decision Panel, Program Office, and Component Cost Agency, respectively. Each title represents the name of the office or person responsible for preparing estimates or analysis throughout the review process. An arrow labeled LCCE (POE) runs from the Program Office to the Component Cost Agency. A two-way arrow labeled CARD runs between those last two offices as well. An arrow labeled ICE & LCCE (POE) runs from the Component Cost Agency to the Assistant Secretary (FM&C). Finally, an arrow labeled LCCE (POE) & ICE runs from the Assistant Secretary (FM&C) to the Service Acquisition Decision Panel.

Service Acquisition Decision Panels

The Service Acquisition Decision Panels are variously the Army Systems Acquisition Review Council (ASARC); the Air Force OIPT; the Navy Program Decision Meeting (NPDM); and the Marine Corps Program Decision Meeting (MCPDM).

ACAT IAM Cost Review Process

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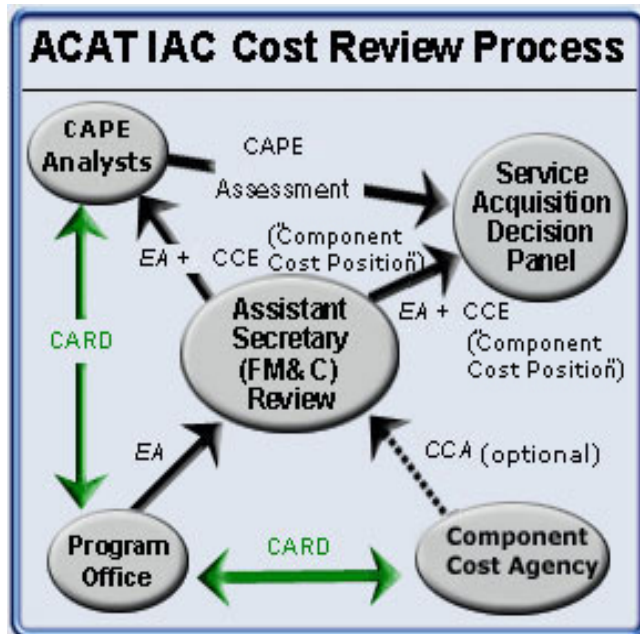
An Economic Analysis (EA) and the Component Cost Estimate (CCE) are prepared for an ACAT IAM program approaching a major milestone. Both documents are based on the program's CARD to ensure that they are comparable.

As discussed earlier, each component has latitude in how they develop the CCE. This may involve the component cost agency developing an “independent” estimate (may be called the CCA) to then be reconciled with the LCCE (or POE) to arrive at the CCE (otherwise known as the “component cost position”). Regardless of how the CCE is developed, the component’s Assistant Secretary (Financial Management & Comptroller) will then forward the EA and the CCE to OSD CAPE for evaluation. CAPE will compare the two documents and provide its assessment to the OIPT overseeing Information Technology.

Long Description

The ACAT IAM Cost Review Process consists of six parts, represented in this diagram by six ovals of varying sizes. The ovals are titled CAPE Analysts, OIPT, ITAB, Assistant Secretary (FM&C) Review, Program Office, and Component Cost Agency, respectively. A two-way arrow labeled CARD runs between the CAPE Analysts and the Program Office, and another two-way CARD arrow runs between the Program Office and the Component Cost Agency. An arrow labeled EA runs from the Program Office to the Assistant Secretary (FM&C). An arrow labeled CCA (optional) runs from the Component Cost Agency to the Assistant Secretary (FM&C). An arrow labeled EA & CCE (“Component Cost Position”) runs from the Assistant Secretary (FM&C) to the CAPE Analysts. An arrow labeled EA & CCE (“Component Cost Position”) runs from the CAPE Analysts to the OIPT. Finally, an arrow runs from the OIPT to the ITAB.

ACAT IAC Cost Review Process



The cost review process for an ACAT IAC program approaching a major milestone is very similar to that for an ACAT IAM program except that the component’s Assistant Secretary (Financial Management & Comptroller) will forward the EA and CCE to both CAPE and the Service Acquisition Decision Panel. CAPE will then provide its assessment of the EA and CCE to the Service Acquisition Decision Panel. This panel considers the program’s affordability

using the EA, CCE and the CAPE assessment before making final recommendations to the Milestone Decision Authority (Component Chief Information Officer).

Select the hyperlink to access a list of the [Service Acquisition Decision Panels](#).

Long Description

A diagram title "ACAT IAC Cost Review Process." The diagram consist of a pattern of 5 oval shaped circles. Inside the circles are the titles: CAPE Analysts; Assistant Secretary (FM&C) Review; Service Acquisition Decision Panel; Program Office; and Component Cost Agency. Each title represents the name of the office or person responsible for preparing estimates or analysis throughout the review process. A two-way arrow labeled CARD runs between the Program Office and the CAPE Analysts. Another two-way CARD arrow runs between the Program Office and the Component Cost Agency. An arrow labeled EA runs from the Program Office to the Assistant Secretary (FM&C) Review. An arrow labeled CCA (optional) runs from the Component Cost Agency to the Assistant Secretary (FM&C) Review. An arrow labeled EA & CCE ("Component Cost Position") runs from the Assistant Secretary (FM&C) Review to the CAPE Analysts. Another arrow labeled EA & CCE ("Component Cost Position") runs from Assistant Secretary (FM&C) Review to Service Acquisition Decision Panel. Finally, and arrow labeled CAPE Assessment runs from the CAPE Analysts to the Service Acquisition Decision Panel.

Service Acquisition Decision Panels

The Service Acquisition Decision Panels are variously the Army Systems Acquisition Review Council (ASARC); the Air Force OIPT; the Navy Program Decision Meeting (NPDM); and the Marine Corps Program Decision Meeting (MCPDM).

Participants

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This is a list of the major players and organizations involved in the cost estimating and review process. Select each hyperlinked participant to access their roles, responsibilities, and perspectives.

- [Program Management Office](#)
- [Component Cost Agency](#)
- [Service Assistant Secretary \(Financial Management & Comptroller\)](#)
- [OSD Directorate of Cost Assessment and Program Evaluation \(CAPE\)](#)
- [Users](#)
- [DoD Component Head](#)
- [OSD Principal Staff Assistant \(PSA\)](#)
- [DoD Contractors](#)

This page concludes our discussion of the Cost Estimating and Review Process; the knowledge reviews on the following pages will help you measure your comprehension.

Program Management Office (PMO)

The PMO prepares the Life-Cycle Cost Estimate (LCCE) (also known as the Program Office Estimate (POE)) or Economic Analysis (EA), as well as the Cost Analysis Requirements Description (CARD). The PMO must ensure that costs are estimated as accurately as possible for budgeting purposes.

Component Cost Agency

The DoD Components have established their own agencies to serve as their lead organization for cost analysis and cost estimating actions and to act as liaison between the Component and the OSD Cost Assessment and Program Evaluation (CAPE) directorate. These Component Cost Agencies exist in the Component's Financial Management chain of command to maintain their independence from the acquisition decision chain. They prepare independent cost analyses for ACAT IA programs (Component Cost Analysis, or CCA) and most ACAT IC programs (Independent Cost Estimate, or ICE).

They may also prepare a CCA on ACAT ID programs as part of the component's process of developing the regulatory required Component Cost Estimate (CCE). The Component Cost Agency works closely with the Program Office to understand the various aspects of the program relevant to cost but must also maintain an independent perspective. The Component Cost Agency can also provide program offices with advice regarding cost estimating methodologies.

Service Assistant Secretary (Financial Management & Comptroller)

The Service's Assistant Secretary (Financial Management & Comptroller) reviews the program life-cycle cost estimate (or POE) (ACAT I), Economic Analysis (ACAT IA), and Component Cost Analysis (CCA) (as applicable) for early identification of program funding issues. When the Component Acquisition Executive requests that a CCA be prepared for an ACAT ID program, the Assistant Secretary (FM&C) will typically reconcile the CCA with the program office's life-cycle cost estimate to create the CCE (or a "Component Cost Position") to be forwarded for consideration by the OSD CAPE, OIPT, and Defense Acquisition Board.

OSD Cost Analysis Improvement Group (OSD CAIG)

The OSD CAIG acts as the principal advisory body to the Defense Acquisition Board (DAB) and the Secretary of Defense on matters relating to cost. The Deputy Director for Resource Analysis, Program Analysis & Evaluation (DD/PA&E(RA)) is dual-hatted as the CAIG chair. The CAIG membership consists of the CAIG Chair, one member appointed by each permanent DAB member, and ad hoc representatives as appointed by the CAIG Chair. Members of the CAIG represent their functional areas. DoD Directive 5000.4 specifies the functions of the OSD CAIG, which include preparing independent life-cycle cost estimates for ACAT ID and some ACAT IC programs, analyzing the Program LCCE and the CCA as applicable, and establishing guidance on preparing cost estimates.

OSD Directorate of Cost Assessment and Program Evaluation (CAPE)

CAPE is responsible for assessing Analyses of Alternatives (AoAs) for comprehensiveness, objectivity, and compliance with applicable laws; and providing these assessments to the responsible DoD Component Head or OSD Principal Staff Assistant. CAPE is also responsible for assessing the Economic Analysis prepared for an ACAT IA program for: reasonableness of cost and benefits estimates; realism of cost; schedule and performance goals; reliability of the return on investment calculation; and traceability of estimated benefits. This assessment is provided to both the Program Manager and the Milestone Decision Authority. The "Cost Assessment element" in CAPE acts as the principal advisory body to the Defense Acquisition Board (DAB) and the Secretary of Defense on matters related to cost and is responsible for preparing independent life-cycle cost estimates (ICE) on ACAT ID and selected ACAT IC programs.

Users

The prospective users of a major system typically participate in the preparation of the Analysis of Alternatives.

DoD Component Head

The DoD Component Head who is responsible for the mission area affected by a proposed ACAT I program designates an independent activity (not the program office) to perform the Analysis of Alternatives.

OSD Principal Staff Assistant (PSA)

The OSD Principal Staff Assistant who is responsible for the functional area affected by a proposed ACAT IA program designates an independent activity (not the program office) to perform the Analysis of Alternatives (AoA).

DoD Contractors

Contractors participate in acquisition program cost estimating in various ways. Support contractors may assist program offices or components in producing life-cycle cost estimates or analyses of alternatives when the government office lacks the internal resources to perform the analysis itself. Prime contractors prepare their own program cost estimates to support their bids.

Knowledge Review

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The following Knowledge Review allows for multiple correct answers. Select all of the answers that are correct, then select the Submit button and feedback will appear.

The Secretary of Defense is required to consider an independent estimate of the life-cycle cost of a Major Defense Acquisition Program (ACAT I) prior to granting approval of which of the following?

- a. Milestone A**
- b. Milestone B**
- c. Milestone C**
- d. Full-Rate Production**

Correct!

The Secretary of Defense is required to consider an independent estimate of the life-cycle cost of a Major Defense Acquisition Program (ACAT I) prior to the granting of Milestone B and Milestone C. The independent estimate is again considered at the Full-Rate Production decision review, at the discretion of the Milestone Decision Authority (MDA).

Knowledge Review

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The following Knowledge Review is a multiple choice question. Only one answer is correct; select the best answer and feedback will immediately appear.

Which of the following is a function of the Cost Assessment element within the OSD Directorate of Cost Assessment and Program Evaluation (CAPE)?

- a. Assesses Analysis of Alternatives for comprehensiveness, objectivity, and compliance with the Clinger-Cohen Act**
- b. Designates an independent activity to perform the Analysis of Alternatives for ACAT I programs**
- c. Prepares the Independent Cost Estimate for all ACAT ID programs**
- d. Prepares the Economic Analysis and Cost Analysis Requirements Description (CARD) for all ACAT IA programs**

Correct!

The Cost Assessment element within the OSD CAPE prepares the Independent Cost Estimate for all ACAT ID programs. OSD CAPE is responsible for assessing the Analysis of Alternatives for comprehensiveness, objectivity, and compliance with the Clinger-Cohen Act. The DoD Component Head for the affected mission area designates an independent activity to perform the Analysis of Alternatives for ACAT I programs. The Program Office prepares the Economic Analysis and Cost Analysis Requirements Description (CARD) for all ACAT IA programs.

Knowledge Review

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After you have completed the following question, select another topic from the Table of Contents to continue, as this page completes the topic. The following Knowledge Review allows for multiple correct answers. Select all of the answers that are correct, then select the Submit button and feedback will appear.

Which of the following are major participants in the cost estimating and review process for acquisition programs?

- a. Program Management Office**
- b. DoD Component Head**
- c. OSD Cost Assessment & Program Evaluation (CAPE)**
- d. Component Cost Agencies**

Correct!

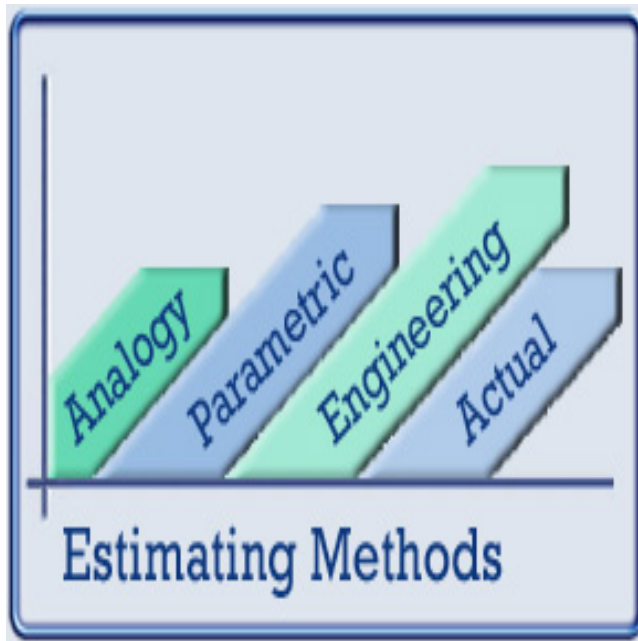
All four of the parties listed are major participants in the cost estimating and review process for acquisition programs.

Cost Estimating Methods

Cost Estimating Methods

Cost Estimating Methods

Page 1 of 16



DoD 5000.4-M, Cost Analysis Guidance and Procedures, identifies four major analytical methods or cost estimating techniques used to develop cost estimates for acquisition programs: Analogy, Parametric (Statistical), Engineering (Bottoms Up), and Actual Costs.

Analogy Method (1 of 3)

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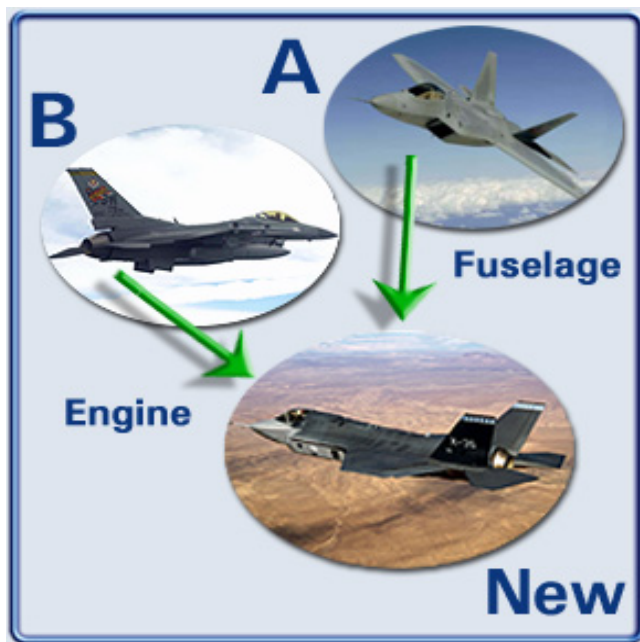


In the analogy method, the cost of a new item is estimated by starting with the cost of one or more similar existing items, then adjusting this cost to take into account the differences between the existing item and the new item. For example, we could estimate the cost of a new air superiority fighter aircraft based on the cost of the aircraft model it will replace.

After obtaining a technical evaluation of the differences between the systems (for example, increased speed and stealth characteristics for the new aircraft) from engineers or other experts, we would assess the cost impact of these technical differences as well as any other factors that may have changed since the existing model was designed and produced (for example, increased use of computer aided design and manufacturing).

Analogy Method (2 of 3)

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While the previous example shows an analogy estimate performed at the system level, the analogy method may also be applied at a subsystem or component level, such as propulsion or fuselage.

The analogy method may also be applied to processes, such as training, that are part of the cost element structure for the program.

Each individual application of the analogy method at these lower levels need not use the same system as its basis; rather, we should choose the most similar item in each case. For example, while the fuselage for our newer fighter aircraft might most resemble that of Aircraft A, its engine might be more analogous to that of Aircraft B.

Analogy Method (3 of 3)

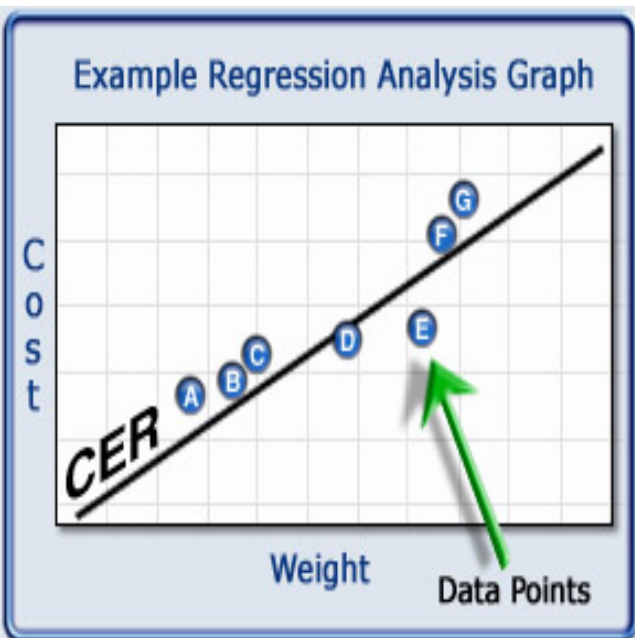
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A key disadvantage of the analogy method is the subjectivity inherent in quantifying the cost of the technical and other differences between the historical item and the new item. For example, one technical expert may believe that fuselage differences will lead to a 30% increase in costs for the new item compared to the old, while another may think that costs will only increase by 10%. However, the analogy method tends to be a relatively fast and inexpensive way of estimating program costs and can be done at a high level of the Work Breakdown Structure with relatively little technical detail about the new system.

Parametric Method (1 of 2)

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The parametric, or statistical, method uses regression analysis of a database of several similar systems to develop a mathematical equation describing a line or curve that fits as closely as possible to the data. The resulting equation, known as a cost estimating relationship (CER), estimates cost based on the value(s) of one or more system performance or design characteristics (for example, speed, weight, number of parts, etc.).

Key advantages of the parametric method are its objectivity and the fact that CERs can easily be used to evaluate the cost effects of changes in design, performance, and program characteristics.

Long Description

Example regression analysis graph. Vertical axis is labeled "Cost." Horizontal axis is labeled "Weight." Seven data points are graphed. Line derived from these points moves up as it goes to the right across the graph. Line is labelled "CER." No specific numerical data is associated with this graph.

Parametric Method (2 of 2)

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In some cases it is either not possible or not appropriate to use the Parametric method. Select each of the following questions to learn more:

- [How many data points exist for comparison?](#)
- [How similar are the items in the underlying database to each other and to the item being estimated?](#)
- [How homogeneous is the data? Are data element entries for all items consistent with each other?](#)
- [How accurately does the CER fit the sample data points as measured by the CER's regression statistics?](#)

- [Do the new system's parameters fall within the range of parameter values for the existing systems in the database?](#)

Data points

How many data points exist for comparison?

A rule of thumb is that at least four data points are required for a valid statistical analysis.

Similarity

How similar are the items in the underlying database to each other and to the item being estimated?

A good parametric database should be timely and accurate, containing the latest available data reflecting technology similar to that of the system of interest. For example, in developing a CER to estimate the cost of a new fighter aircraft fuselage that makes extensive use of composite materials, you would want to try to avoid using data pertaining to historical aircraft that did not use composite materials.

Homogeneity and Consistency

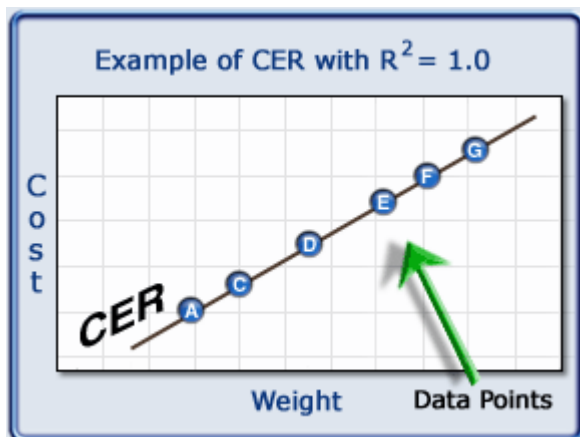
How homogeneous is the data? Are data element entries for all items consistent with each other?

For example, if a data element called "maximum speed" appears in an aircraft database, then all entries for all systems should be expressed in the same units, such as nautical miles per hour (knots) or kilometers per hour (kph). If some systems report speed in knots while others report speed in kph, then the database is not homogeneous in this regard and CERs relating speed to cost that are developed from the database may not be valid.

Accuracy of Fit (R²)

How accurately does the CER fit the sample data points as measured by the CER's regression statistics?

The most commonly used regression statistic is the coefficient of determination (R² or r-squared). A CER that perfectly predicted each sample point in the database (that is, each data point falls on the curve) would have an R² of 1.0. An R² value of .9 or better is desirable, although in practice, CER's with R² values of .8 or better are usually accepted for use in a cost estimate.



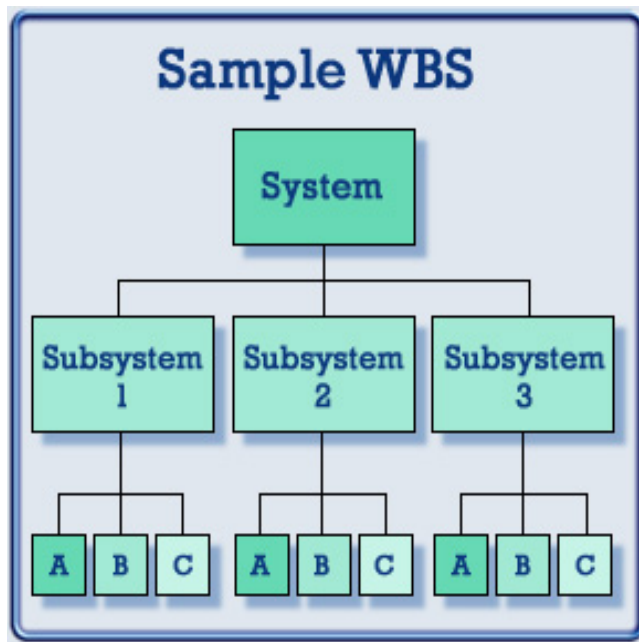
Parameters

Do the new system's parameters fall within the range of parameter values for the existing systems in the database?

A CER which meets the criteria of data homogeneity and good regression statistics may still be unsuitable for use in a particular system's cost estimate if the value of the new system's parameters falls outside the database range. For example, a CER based on speed developed from data on aircraft that travel at less than the speed of sound might not predict costs well for a system that is to travel at supersonic speeds.

Engineering Method (1 of 3)

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The engineering method builds an estimate from the "bottom up" by analyzing the individual elements of the work breakdown structure (WBS) for the direct costs of accomplishing the work then adding appropriate amounts for indirect costs (for example, plant overhead, company overhead, etc.). This method is often used by contractors and usually involves industrial engineers, price analysts, and cost accountants.

Long Description

Sample Work Breakdown Structure. Top level is a box labeled "System." There are three boxes at second level of the structure labeled "Subsystem 1," "Subsystem 2," and "Subsystem 3." For each of these boxes at the second level, there are three boxes at the third level labeled A, B and C.

Engineering Method (2 of 3)

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Based on the system's specifications, engineers estimate the direct labor and material costs of a work package. In calculating labor costs, company or industry standards are often used to estimate what labor categories are required and how many hours will be required for the task. The remaining elements of the work package cost, such as tooling, quality control, other direct costs, and various overhead charges are calculated using factors based on the estimated direct labor and/or material content of the work. Therefore, the actual portion of the cost estimated directly is a fraction of the overall cost of the system.

Engineering Method (3 of 3)

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Engineering cost estimates can be quite accurate since they are usually exhaustive in covering the work to be performed by virtue of using the WBS. These estimates also make use of insight into the specific resources and processes used in performing the work.

However, a substantial amount of time and effort is required to produce and document such an estimate, making it impractical to use this method for all elements of an acquisition program's costs. Also, insufficient information may exist to use this method effectively, particularly early in the program when little is known about the details of the item design and production processes. Finally, the factors used to extrapolate other costs from direct labor and materials may not accurately reflect the company's current business base or facilities.

Actual Cost Method

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The technique of using actual cost data (or extrapolating future costs from actual costs) is based on data from earlier/previous units, prototypes, or production lots of the **same** system (not a similar system, as in the analogy method). The actual cost method is probably the most accurate cost estimating method when the data is available. The OSD Directorate of Cost Assessment and Program Evaluation (CAPE) prefers this method since it uses actual or near actual data for the system of interest.

The uncertainty associated with this method is based, as with the analogy method, on the technical assessment of the differences between an earlier version of the system, such as a prototype, and the current model under consideration. Obviously, the more the two versions are alike, and the further along the system is in the acquisition process, the more easily an accurate estimate can be made.

Choosing a Cost Estimating Method (1 of 2)

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Few acquisition program cost estimates employ the same estimating method for every element of cost. In general, programs lack the time, money, and personnel required to apply the most accurate method to all cost elements. Rather, estimators choose the technique to be used for each cost element based on whether the element "drives" or significantly influences either the magnitude or the uncertainty of the program's life-cycle cost. The more the cost element influences the magnitude of the estimate, the more accurate a method should be chosen. In addition, no matter what method the estimator would prefer to use, they must consider whether sufficient data is available to use that method.

Choosing a Cost Estimating Method (2 of 2)

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At the beginning of a program, analogy or very high level parametric estimates may be used for most of the program's cost elements, since little is known about the system's design, production requirements, support concept, etc. As the program matures, more details are fleshed out, the work breakdown structure is better defined, and actual costs are accumulated. Then the more accurate estimating methods of engineering and actual costs can be used as appropriate. OSD prefers that extrapolation from actual costs be used to the maximum extent possible in preparing estimates for the Full-Rate Production Decision Review and any subsequent actions.

This page concludes our discussion of cost estimating methods; the knowledge reviews on the following pages will help you measure your comprehension.

Long Description

Preferred Estimating Methods. Vertical axis is titled "Program Information." Horizontal axis is titled "Time." An arrow labeled Analogy, Parametric, Engineering, and Actual Cost, stretches across the graph from the left corner to the right moving upward.

Knowledge Review

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The following Knowledge Review is a multiple choice question. Only one answer is correct; select the best answer and feedback will immediately appear.

The cost of the full-rate production item constitutes a significant portion of the life-cycle cost of the ACORN program, which is approaching its Full-Rate Production decision review. Ten Low Rate Initial Production ACORN units have been built, and cost information about their production cost is available. What is the most appropriate estimating method to use in estimating the cost of ACORN's full-rate production items?

- a. Engineering**
- b. Actual Cost**
- c. Parametric**
- d. Analogy**

Correct!

Actual Cost is the most appropriate estimating method to use in this case, since cost data for production units is available.

Knowledge Review

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The following Knowledge Review is a multiple choice question. Only one answer is correct; select the best answer and feedback will immediately appear.

The cost of the full-rate production item constitutes a significant portion of the life-cycle cost of the BEETLE program, which is early in its Engineering and Manufacturing Development phase. Only two historical systems resemble BEETLE, and no detailed designs or drawings are available at this time. What is the most appropriate estimating method to use in estimating the cost of BEETLE's full-rate production items?

- a. Engineering**
- b. Actual Cost**
- c. Parametric**
- d. Analogy**

Correct!

Analogy is the most appropriate estimating method to use in this case, since insufficient data is available for using any of the other methods.

Knowledge Review

Page 15 of 16

The following Knowledge Review is a multiple choice question. Only one answer is correct; select the best answer and feedback will immediately appear.

The cost of the full-rate production item constitutes a significant portion of the life-cycle cost of the CICADA program, which is approaching a Milestone C review, having completed most of its design. However, no CICADA prototypes or Low Rate Initial Production units have been built. What is the most appropriate estimating method to use in estimating the cost of CICADA's full-rate production items?

- a. Engineering**
- b. Analogy**
- c. Actual cost**
- d. Parametric**

Correct!

Because the production items are a significant portion of the life-cycle cost, the most accurate estimating method available should be used. Since no actual costs are available for this system, the engineering method is the most accurate estimating method available and is the most appropriate in this case.

Knowledge Review

Page 16 of 16

After you have completed the following question, select another topic from the Table of Contents to continue, as this page completes the topic.

The following Knowledge Review is a multiple choice question. Only one answer is correct; select the best answer and feedback will immediately appear.

The cost of the full-rate production item constitutes a significant portion of the life-cycle cost of the DOGWOOD program, which is in the later portion of the Technology Development phase (prior to MS B). One of the alternatives being explored is an aircraft solution. Cost information exists for at least six historical aircraft that are somewhat similar to the proposed DOGWOOD alternative. What is the most appropriate estimating method to use in estimating the cost of DOGWOOD's full-rate production items for this alternative?

- a. Engineering**
- b. Analogy**
- c. Actual cost**
- d. Parametric**

Correct! Because the production items are a significant portion of the life-cycle cost, the most accurate estimating method available should be used. Since no actual costs are available for this system and system design has not even begun, the actual cost and engineering methods are unavailable. However, sufficient data exists to use the parametric method (at least four data points from similar systems), so this is the most appropriate method to use in this case.

Learning Curve Theory

Learning Curve Theory

Learning Curve Theory

Page 1 of 12



In the early 1930's, aircraft researcher T.P. Wright observed that the average cost to produce a production lot of airplanes decreased at a predictable rate as the size of the production lot increased. He theorized that this primarily occurred because the time required to perform a repetitive task decreases each time the task is repeated. Wright's "Learning Curve" theory has become widely used because it is simple and applicable to a broad range of industries and situations. Subsequent research in the late 1940's by James R. Crawford confirmed Wright's observations and led to the unit theory of the learning curve.

Learning Curve Theory Example (1 of 3)

Page 2 of 12

Widget Company Production Cost Data	
Unit	Recurring Unit Cost
1	\$1000
2	\$800
3	\$702
4	\$640
5	\$596
6	\$562
7	\$535
8	?

Crawford's unit theory of the learning curve states that as the production quantity of an item doubles, the time required to produce each unit decreases at a fixed rate or constant percentage. Although the original learning curve theory only applied to labor hours, it can easily be extended to apply to recurring unit production costs. The graphic on the right represents an example of Crawford's theory as it applies to unit production cost.

Long Description

Table titled Widget Company Production Cost Data showing recurring unit cost for each of the first 7 units produced. Unit 1 cost is \$1000, Unit 2 cost is \$800, Unit 3 cost is \$702, Unit 4 cost is \$640, Unit 5 cost is \$596, Unit 6 cost is \$562, Unit 7 cost is \$535, and Unit 8 cost is unknown.

Learning Curve Theory Example (2 of 3)

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Unit	Recurring Unit Cost
1	\$1000
2	\$800
3	\$702
4	\$640
5	\$596
6	\$562
7	\$535
8	?

From this data, we can see that as production quantity doubled from Unit 1 to Unit 2, the recurring unit cost decreased by \$200, or 20% of the Unit 1 cost of \$1000. Note also that as production quantity doubled from Unit 2 to Unit 4, the recurring unit cost decreased by \$160, which is also a 20% decrease from the previous recurring unit cost of \$800 for Unit 2. Based on this data and the learning curve theory, you can predict that the recurring unit cost for Unit 8 will be 20% less than that of Unit 4, or \$512.

Long Description

Table titled Widget Company Production Cost Data showing recurring unit cost for each of the first 7 units produced. Unit 1 cost is \$1000, Unit 2 cost is \$800, Unit 3 cost is \$702, Unit 4 cost is \$640, Unit 5 cost is \$596, Unit 6 cost is \$562, Unit 7 cost is \$535, and Unit 8 cost is unknown.

Learning Curve Theory Example (3 of 3)

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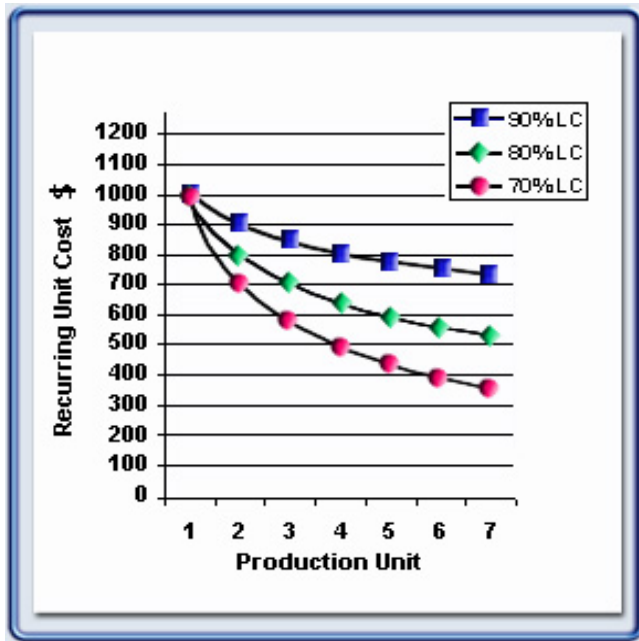
Plotted on an arithmetic graph, this data takes on a curved shape, hence the term "learning curve." The learning curve described in this example is called an "80% learning curve," since the cost of a particular unit of production is 80% of the cost of the unit exactly half-way back in the production sequence. For example, just as Unit 4's cost (\$640) is 80% of Unit 2's cost (\$800), so Unit 8's cost should be 80% of Unit 4's cost, or \$512.

Long Description

Graph of Widget Production Data. Vertical axis shows Recurring Unit Cost in dollars from 0 to 1200 in increments of 100. Horizontal axis shows Production Units from 1 to 8 in increments of 1. Points on the graph correspond to the table on the previous page: 1 is at 1:1000; 2 is at 2:800; 3 is at 3:702; 4 is at 4:640; 5 is at 5:596; 6 is at 6:562; and 7 is at 7:535.

Comparison of Different Learning Curves

Page 5 of 12



This graphic illustrates the relationship between various learning curve values. Compared to the 80% learning curve in the center of the graph, the 90% learning curve shown above it is much flatter, since it represents a slower rate of decreasing costs (that is, less learning). On the other hand, the 70% learning curve that is shown below the 80% learning curve is much steeper, since it represents a faster rate of decreasing costs (that is, more learning).

Long Description

Graph of 90%, 80% and 70% learning curves. Vertical axis shows Recurring Unit Cost in dollars from 0 to 1200 in increments of 100. Horizontal axis shows Production Units from 1 to 7 in increments of 1. All learning curves begin at the same point, with Unit 1 costing \$1000. The 80% learning curve is as described on the previous page, with Unit 7 costing \$535. The 90% learning curve falls less steeply from left to right, with Unit 7 costing over \$700. The 70% learning curve falls more steeply from left to right, with Unit 7 costing less than \$400.

Learning Curve Conditions

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Learning curve theory is most straightforwardly applied in situations where the following conditions exist:

- Uninterrupted serial production (for example, no production breaks)
- Consistent product design
- Management emphasis on productivity improvement

These conditions promote the behaviors displayed on this [hyperlink](#). Note that the Crawford unit learning curve theory is just one of many mathematical models that may be used to project the effect of learning on production costs.

Behaviors Underlying Learning Curve

Behaviors underlying the decline of unit cost with increased production quantities:

Worker familiarization with the required tasks (learning).

Process improvements resulting from experience with the tasks, for example, more efficient layout of assembly line; simplification of methods sheets; reduction of rework, repair, and scrap; improved parts bin accessibility; new or improved tooling.

Applying Learning Curve Theory (1 of 2)

Page 7 of 12



Learning curve theory is only appropriately applied to the production portions of a system's life-cycle cost estimate. The challenge is determining the appropriate learning curve to use for a particular system. Ultimately, the only way to know the "true" learning curve for a particular system is to observe it after the fact. However, this is not useful when resource plans must be submitted years in advance of production. Therefore, most estimators will

use historical data from other similar type systems to estimate the new system's learning curve.

Applying Learning Curve Theory (2 of 2)

Page 8 of 12



Before using a historical learning curve, the analyst should examine how well the historical data reflects the expected production conditions for the new system. If new production conditions differ from the past, the analyst should attempt to quantify the effects of the differences on the historical learning curve. Select the following examples of production conditions to access additional information about how they can affect a system's learning curve:

- [Manufacturing methods and processes](#)
- [Item complexity](#)
- [Workforce stability](#)
- [Production breaks](#)

This page concludes our discussion of learning curve theory; the knowledge reviews on the following pages will help you measure your comprehension.

Manufacturing Methods and Processes

The more automation and less "touch" labor is involved in a production process, the less learning typically occurs. The learning curve will usually be flatter, and the value of the learning curve will tend to be higher. Thus, if the historical learning curve is 85% and the manufacturer intends to automate the production more than in the past, we would expect the learning curve for the new process to be something greater than 85% (for example, 90%).

Item Complexity

The more complex an item is, the steeper the learning curve will usually be. This is because there are more opportunities to improve the production process and more for workers to learn. Thus, if a historical item experienced a 93% learning curve, a new, more complex item of the same type would be expected to have a learning curve of less than 93% (for example, 88%).

Workforce Stability

The higher the turnover rate of the workforce, the flatter the learning curve will usually be, as average worker productivity increases will be inhibited by turnover.

Production Breaks

Interrupting production can lead to changes in the historical learning curve. For example, a significant change in the composition of the workforce following the production break can result in a learning curve that differs from the historical learning curve. In addition, even if a production break does not actually change the learning curve itself, the break will likely change where you are on the learning curve, as the workers tend to have lost some of their skills. Thus, if the production process had a 90% learning curve and 799 units were produced prior to the production break, the first unit after the production break (Unit 800) is unlikely to cost 90% of Unit 400's cost, as would have been expected without the break. Instead, Unit 800 may cost the same as some prior unit, say Unit 700. In this case, we have effectively lost 100 units for the purposes of learning curve effects.

Knowledge Review

Page 9 of 12

The following Knowledge Review allows you to type the best answer or answers into the appropriate spaces. Type carefully and watch your spelling. Then, select the Check Answers button and feedback will appear.

You are the cost analyst for the Mega Missile program. Based on historical data and analytical judgment, you have decided that the appropriate learning curve system to use is 82 percent. The expected recurring cost for the first unit to be produced is one million dollars. What is the expected recurring cost of each of the following units? Enter answer in the format: 123999

[Open Calculator](#)

a. Unit 2 \$

b. Unit 4 \$

c. Unit 8 \$

Correct!

Unit 2 should cost **820000** dollars ($\$1 \text{ million} \times .82$)

Unit 4 should cost **672400** dollars ($\$820,000 \times .82$)

Unit 8 should cost **551368** dollars ($\$672,400 \times .82$)

Knowledge Review

Page 10 of 12

The following Knowledge Review is a multiple choice question. Only one answer is correct; select the best answer and feedback will immediately appear.

You have been temporarily detailed to work on the cost estimate for the Complicated Cargo Carrier Program. This system has been in Low Rate Initial Production for 25 months, and the following data has been observed:

- Unit 1 required 5000 labor hours
- Unit 2 required 4250 labor hours
- Unit 4 required 3612.5 labor hours

What is the learning curve for this system based on the above data? [Open Calculator](#)

- a. 75%
- b. 80%
- c. 85%
- d. 90%

Correct!

The learning curve for the Cargo Carrier Program is 85%. This is calculated by dividing the production hours for unit 2 by the production hours for unit 1 ($4250 \text{ divided by } 5000 = 85\%$).

Knowledge Review

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The following Knowledge Review allows you to type the best answer or answers into the appropriate spaces. Type carefully and watch your spelling. Then, select the Submit button and feedback will appear.

You have been temporarily detailed to work on the cost estimate Complicated Cargo Carrier Program. This system has been in Low Rate Initial Production for 25 months, and the following data has been observed:

- Unit 1 required 5000 labor hours
- Unit 2 required 4250 labor hours
- Unit 4 required 3612.5 labor hours

How many labor hours (to the nearest tenth of an hour) would you expect to be required for unit 8?

[Open Calculator](#)

Correct!

The expected labor hours for unit 8 are 3070.6 hours.

Unit 8 hours = Unit 4 hours times Learning Curve

= 3612.5 hours times .85

= 3070.6 hours

Knowledge Review

Page 12 of 12

After you have completed the following question, select another topic from the Table of Contents to continue, as this page completes the topic.

The following Knowledge review is a multiple choice question. Only one answer is correct; select the best answer and feedback will immediately appear.

The following unit learning curve table applies to the production of widgets. This represents a learning curve of:

Unit No.	Production Time
----------	-----------------

1	2000 hours
---	------------

2	1900 hours
---	------------

3	1844 hours
---	------------

4	1805 hours
---	------------

[Open Calculator](#)

a. 80%

b. 90%

c. 85%

d. 95%

Correct!

The learning curve for widgets is 95%. This is calculated by dividing the production hours for unit 2 by the production hours for unit 1 (1900 divided by 2000 = 95%).

Summary of Cost Analysis

Summary of Cost Analysis

Lesson Summary (1 of 7)

Page 1 of 9

Congratulations on completing the Cost Analysis Module. The following topics were presented in this module:

- **Affordability:** This is the degree to which the life-cycle cost of an acquisition program fits into the long-range investment and force structure plans of DoD and its individual components. All programs are assessed for affordability considerations at each major milestone and decision review.
 - **Cost as an Independent Variable (CAIV):** Under this philosophy, acquisition programs seek to balance their program characteristics to achieve performance that satisfies operational requirements, a development and fielding schedule that satisfies user needs, and cost that can reasonably be expected to be funded. Performance and schedule parameters may be traded off within certain limits to keep costs affordable. Since system design decisions tend to drive production and operating and support costs, the best time to implement CAIV and reduce life-cycle costs is early in the system's life-cycle.
-

Lesson Summary (2 of 7)

Page 2 of 9

Other topics presented include:

- **Analysis of Alternatives (AoA):** An AoA is a quantitative analysis of the risks, uncertainty, and relative advantages and disadvantages of various alternatives for meeting a validated mission need. The identification and discussion of alternatives during the AoA process fosters joint ownership of a prospective program among the acquisition and user communities. An AoA is required for all ACAT programs at Milestone A.
- **Cost Analysis Requirements Description (CARD):** The CARD provides a complete description of the system whose costs are to be estimated. This document helps ensure that all major acquisition program cost estimates are based on common and accurate information and provide the amount of detail required by decision-makers. For ACAT I and ACAT IA programs, the CARD is prepared or updated prior to major milestones or decision reviews that require an Independent Cost Estimate or Component Cost Analysis.

Lesson Summary (3 of 7)

Page 3 of 9

Other topics presented include:

- Life-Cycle Cost Estimate (LCCE): The LCCE is prepared for all ACAT programs for the program initiation decision and at all subsequent program decision points. The LCCE serves as the source of the cost information included in the program's Acquisition Program Baseline (APB) and should also be used as the basis for budget requests. The LCCE is also known as the Program Office Estimate (POE).
- Economic Analysis (EA): The EA is the equivalent of the LCCE for Automated Information System (AIS) programs. The EA includes analysis of both program costs and benefits and is prepared at Program Initiation and at other milestones or decision points as directed by the Milestone Decision Authority.
- Component Cost Estimate (CCE): A life-cycle cost estimate representing the component's "corporate cost position." The estimate is sometimes referred to as the "Service or Component Cost Position." Each component has latitude in how it develops the CCE. This process may involve the component cost agency simply evaluating and recommending adjustments to the POE, the result being the CCE. Or, it could involve the component cost agency developing its own independent estimate (sometimes called the Component Cost Analysis (CCA)) followed by a formal reconciliation between this estimate and the POE to arrive at the final CCE.

Lesson Summary (4 of 7)

Page 4 of 9

Other topics presented in this module also include:

- Independent Cost Estimate (ICE): By law, the Secretary of Defense must consider an independent estimate of the life-cycle cost of a Major Defense Acquisition Program (ACAT I) prior to granting Milestone B and Milestone C approval. Consideration of an ICE at the Full-Rate Production Decision Review is at the discretion of the Milestone Decision Authority (MDA).
 - Key players in the cost estimating and review process for acquisition programs:
 - The Program Management Office prepares the Life-Cycle Cost Estimate (LCCE) (also known as POE) or Economic Analysis (EA), as well as the Cost Analysis Requirements Description (CARD).
 - Component Cost Agencies prepare the required independent cost analyses for ACAT IA programs (CCA) and most ACAT IC programs (ICE).
 - The Service's Assistant Secretary (Financial Management & Comptroller) reviews the program LCCE (POE) or EA and the component cost analysis (CCA) (if applicable) and develops the Component Cost Estimate (CCE) (also known as the Component Cost Position) for ACAT I and ACAT IA programs.
 - The cost assessment element with the OSD Directorate of Cost Assessment and Program Evaluation (CAPE) acts as the principal advisory body to the Defense Acquisition Board (DAB) and the Secretary of Defense on matters relating to cost. The cost assessment element in CAPE prepares the ICE for all ACAT ID programs and for certain ACAT IC programs as requested by the Defense Acquisition Executive.
-

Lesson Summary (5 of 7)

Page 5 of 9

Other key players in the cost estimating and review process:

- OSD Cost Assessment and Program Evaluation (CAPE) is responsible for assessing AoAs and providing these assessments to the responsible DoD Component Head or OSD Principal Staff Assistant. CAPE analysts also assess EAs for ACAT IA programs.
- The prospective users of a major system typically participate in the preparation of the Analysis of Alternatives.
- The DoD Component Head who is responsible for the mission area affected by a proposed ACAT I program designates an independent activity (not the program office) to perform the Analysis of Alternatives.
- The OSD Principal Staff Assistant who is responsible for the functional area affected by a proposed ACAT IA program designates an independent activity (not the program office) to perform the AoA.
- Support contractors may assist program offices or components in producing LCCEs or AoAs when the government office lacks the resources to perform the analysis itself. Prime contractors prepare their own program cost estimates.

Lesson Summary (6 of 7)

Page 6 of 9

Other topics presented in this module include:

- Cost estimating methods:
 - The analogy method estimates the cost of a new item by starting with the cost of one or more similar existing items, then modifying this cost to take into account the differences between the old item and the new item.
 - The parametric, or statistical, method uses regression analysis of a database of several similar systems to develop a line or curve described by a mathematical equation that fits as closely as possible to the data.
 - The engineering method builds an estimate from the "bottom up" by analyzing the individual elements of the work breakdown structure (WBS) for the direct costs of accomplishing the work then adding appropriate amounts for indirect costs (for example, plant overhead, company overhead, etc.).
 - The actual cost method uses actual cost data from earlier/previous units, prototypes, or production lots of a system (not a similar system, as in the analogy method) to estimate future costs of the same system.
-

Lesson Summary (7 of 7)

Page 7 of 9

- Determining the cost estimating method most appropriate for use in a given situation:
 - Choose more accurate methods for those cost elements that significantly influence either the magnitude or the uncertainty of the program's life-cycle cost.
 - Choices may be limited by the availability of information, either about the system itself or about costs of similar systems.

- Learning curve: Crawford's unit theory of the learning curve states that as the production quantity of an item doubles, the time required to produce each unit decreases at a fixed rate or constant percentage.
 - The learning curve for a production process can be estimated by the ratio of production hours (or costs) for any pair of units with a doubling relationship, for example, Unit 2 hours divided by Unit 1 hours.
 - The cost of a future production unit can be estimated by multiplying the learning curve percentage by the cost of the unit exactly halfway back in the production sequence, for example, the cost of Unit 4 will be the learning curve percentage multiplied by the cost of Unit 2.

This page completes the module. Select a lesson from the Table of Contents to continue.

Knowledge Review

Page 8 of 9

The following Knowledge Review is a matching question. Select a letter associated with the answers below and type that letter in the space next to the best corresponding phrase or statement. Then, select the Check Answers button and feedback will appear.

Match each of the following cost estimating methods with their definitions:

- a. Analogy method
- b. Parametric method
- c. Engineering method
- d. Actual Cost method

1. Bases estimate on data from earlier/previous units, prototypes, or production lots of the same system.

2. Builds an estimate from the "bottom up" by analyzing the individual elements of the work breakdown structure (WBS) for the direct costs of accomplishing the work then adding appropriate amounts for indirect costs.

3. Uses regression analysis of a database of several similar systems to develop a line or curve described by a mathematical equation that fits as closely as possible to the data.

4. Estimates the cost of a new item by starting with the cost of one or more similar existing items, then modifying this cost to take into account the differences between the old item and the new item.

Correct! The correct answers are: 1 - d., 2 - c., 3 - b., 4 - a. The analogy method estimates the cost of a new item by starting with the cost of a similar existing item, then modifying this cost to take into account the differences between the old item and the new item. The parametric, or statistical, method uses regression analysis of a database of several similar systems to develop cost estimating relationships. The engineering method builds an estimate from the "bottom up" by analyzing the individual elements of the work breakdown structure (WBS). The actual cost method estimates the cost of future system units based on data from earlier/previous units, prototypes, or production lots of that same system (not a similar system).

Knowledge Review

Page 9 of 9

The following Knowledge Review is a multiple choice question. Only one answer is correct; select the best answer and feedback will immediately appear.

As the production quantity of an item doubles, the time required to produce each unit decreases at a fixed rate or constant percentage. This is a description of:

- a. Activity Based Costing**
- b. Learning curve theory**
- c. Parametric method of cost analysis**
- d. Engineering method of cost analysis**

Correct!

Learning curve theory states that as the production quantity of an item doubles, the time required to produce each unit decreases at a fixed rate or constant percentage.