A LIFE-CYCLE COST STRUCTURE FOR DEFENSE TRAINING PROGRAMS

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ABSTRACT

The subject of this paper is a cost-element structure (CES) that identifies, defines and structures a list of cost elements that is intended to describe fully the life-cycle cost of any formal program, course, or device for individual training of military personnel. It was developed to satisfy a widely-recognized need for consistent and credible evaluation of cost in cost-effectiveness analyses of alternative methods of training. The cost-element structure is based upon authoritative and widely used cost guides promulgated by the Services and the Office of the Secretary of Defense, and many potential users contributed to its development. Accordingly, the general use of a comprehensive CES such as this offers the following advantages. It should (1) ensure that all elements of life-cycle costs are accounted for, (2) reveal gaps in essential data, (3) permit making credible and equitable comparisons among training alternatives, (4) identify "cost drivers" for trade-off analysis or cost reduction, (5) enable resource specialists to focus on elements of interest, while observing the impact of those resources in a total-program context, (6) disclose significant variables for the development of cost-estimating relationships and, (7) improve communication and understanding among officials at various levels in the Services and the Office of the Secretary of Defense whose decisions affect the conduct of military training.

PURPOSE

This paper describes the development, use, and potential advantages of a comprehensive cost element structure that is intended to characterize fully the life-cycle cost of any formal program, course, or device for individual training of personnel in the Department of Defense, regardless of the conditions or assumptions imposed by the particular application or problem of interest.* The focus on formal individual training (also referred to as institutional training) omits consideration of training in operational mission units, field training detachments, on-the-job training, institutions not managed by the Department of Defense, and non-resident and correspondence programs.

The main need for a definitive cost element structure (CES) is to enable consistent and credible evaluations of the costs of alternative means to satisfy a specific training requirement.

This paper is part of an effort to satisfy a recognized need for a general method that can be used by acquisition and manpower planners, and developers of weapon and support systems in and for the military Services, to estimate the cost-effectiveness of alternative ways to train operational and maintenance personnel. The general use of such a method should assist policymakers and decisionmakers at various levels in the Services and the Office of the Secretary of Defense (OSD) to make better informed judgments concerning the efficient allocation of resources available for military training. This CES might also be used to analyze the costs of institutional training in other departments of the government; however, no attempt has been made to evaluate its usefulness outside of the Department of Defense.

Since it is in an early stage of development, it is anticipated that this cost element structure will be modified and improved on the basis of experience with its use.

BACKGROUND

Training is a necessary and expensive activity needed to maintain military readiness. In fiscal year 1985, for

*This paper is abstracted from Knapp and Orlansky, 1983(1). That paper identifies, defines and structures a list of 42 principal elements and 120 sub-elements that encompass life-cycle cost. Space limitations preclude presentation of the complete structure and the explicit definitions of elements and sub-elements in this paper. The complete paper has been distributed and is available to the public.

example, individual training at Service schools is estimated to cost $17.9 billion and to account for about 12 percent of all military man-years in the active and reserve components [Office of the Assistant Secretary of Defense (Manpower, Installations and Logistics, 1984)][(2)]. Both the cost and effectiveness of formal, individual military training are examined by the Congress, the OSD, and the individual Services (e.g., Defense Science Board 1982[(3)], Orlansky and String 1979 and 1981[(4)], String and Orlansky 1977[(5)]). Attention has been directed towards the cost and effectiveness of flight simulators, computer-based instruction, unit training, and field exercises.

Our review of the cost analyses in well over 100 studies of training in the last six years reveals some fundamental deficiencies that limit meaningful cost-effectiveness comparisons among alternatives:

1. The use of formal cost models is not documented in most studies on the cost-effectiveness of military training systems; yet a formal cost model is essential to credible cost-effectiveness analysis. Without explicit identification of all relevant costs and assumptions, one cannot be certain that alternatives are compared in a consistent manner.

2. Available cost data are fragmentary, are too highly aggregated, and are not always comparable. Reasons for these shortcomings include the following:

   a. The apparent lack of reliance on formal cost models that include standardized definitions of cost elements. Definitions of cost elements *are not given in the majority* of studies of military training costs reviewed to date.

   b. The acquisition costs of many training programs (e.g., computer-based instruction) fall below the threshold of "major" programs for which contractors are required to use prescribed formats in periodic cost reports.

   c. Training equipment is often procured via firm fixed-price incentive-fee (FPIF) contracts. Such contracts provide the Services little leverage in the specification of cost detail. Even when cost-plus-fixed-fee (CPFF) contracts have been employed, the Services' project offices have not always required contractors to furnish cost data in standardized formats.

In general, it appears that no standardized methodology for analysis of training costs has been developed, nor have cost data been acquired in accordance with a common set of definitions.

THE COST ELEMENT STRUCTURE

Approach

A necessary early step in the formulation of any cost-effectiveness model is the delineation and logical organization of the functional elements of cost that constitute life-cycle cost so that alternatives can be compared equitably.

Several criteria and ground rules were adopted to guide development of the cost element structure (CES) discussed in this paper.

Scope of the CES

This CES should be sufficiently comprehensive to capture all elements of the life-cycle cost of any institutional training program, course, or device (p/c/d), regardless of its size, complexity, or cost.* The level of detail should be adequate to identify the cost elements that are the major contributors (i.e., the "cost drivers") to the total cost of a p/c/d.

Principal Use

This CES, and the cost-effectiveness model(s) of which it would become a part, would be used principally in planning for alternative, new training p/c/d's, and in evaluations of substantial modifications to existing p/c/d's.

Definition of "Cost"

In choosing among alternative programs, courses, or devices designed to satisfy a particular training requirement, decisionmakers will be concerned with future expenditures of DoD resources to acquire and/or operate each alternative. In this context, "cost" is defined as *future expenditures of DoD resources* occasioned by the design, development, implementation, and/or operation of a training p/c/d.

Consideration of Service Financial/Cost Accounting Procedures

The Services use various procedures

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*Institutional training is the training of individuals via formal programs and courses at schools in the Department of Defense. As noted above, other types of training are omitted from consideration.

to estimate training costs that are compatible with their financial and cost accounting procedures. While those methods may be adequate for use within the Services, they comprise cost elements that are not always understood or accepted throughout the defense training community, and at the DoD level where final decisions are made on allocations of limited resources among the Services, mission areas, systems, and activities. One criterion observed in the development of this CES was that its adoption should not necessitate changes in existing financial and accounting systems. Accordingly, it was formulated with reference to a number of DoD and Service cost/economic analysis guides and procedures.

Consideration of Work Breakdown Structures

A defense system or item of major equipment is described by its discrete segments (i.e., components or subsystems) to facilitate management planning and control of the research and development and production phases of its life cycle. The procedure is formalized as a work breakdown structure (WBS) that is tailored to the particular system or equipment of interest (Department of Defense, MIL-STD-881, 1968 [6]). Usually, this practice is applied to training p/c/d's of substantial size and complexity (e.g., a trainer aircraft, a weapon system simulator). The CES discussed in this paper is intended to apply to any institutional training p/c/d, regardless of its type, size, complexity, or materiel content. It is impractical, therefore, to anticipate WBS's suitable to all p/c/d's; hence, the cost elements in this CES are function-, activity-, and resource-oriented. It is left to those concerned with analysis of individual p/c/d's to select pertinent cost elements from this structure and to integrate them into the WBS for each p/c/d.

A Proposed Cost Element Structure Applicable to Training

The proposed cost element structure was constructed so that relevant elements can be selected to describe fully the life-cycle cost (or portion thereof) of any training program, course, or device, regardless of the constraints, assumptions, or other conditions imposed by the particular application or problem presented. It is expected that suggestions for improvement would result from experience with its use.*

The cost elements are grouped in three categories: Research and Development, Initial Investment, and Operating and Support. Cost elements in the Research and Development and Initial Investment categories are based on those that have been used throughout the Department of Defense for many years to detail the acquisition costs of weapon systems. The definitions of these cost elements have been modified to accommodate functions, activities, and resources that are typical of military training. Training course cost guidance developed by the Interservice Training Review Organization (ITRO) was instrumental in the generation of the Operating and Support category.

The cost element structure (CES) and the associated definitions were derived from the following authoritative and widely-used cost guides: Office of the Assistant Secretary of Defense (Comptroller)[7,8, and 9], Cost Analysis Improvement Group (OSD)[10], Department of the Army [11,12,13,14, and 15], Department of the Navy [16 and 17], Department of the Air Force [18 and 19], and the Logistics Management Institute [20]. The elements in the Operating and Support cost category were adapted, in large part, from the ITRO's proposed joint-Service regulation, Services Standard Training Course Costs [21], and its associated (draft) Services Standard Training Course Cost Procedures Handbook [22]. A Human Resources Research Organization report (Seidel and Wagner, 1977)[23] was used as guidance relevant to computer-based training systems.

Some training p/c/d's are unique to specific weapon systems. Other training course materials and equipment are developed for general types of training at schools. Nevertheless, it is felt that this CES, which reflects cost-estimating procedures of the weapon system and military training communities, can be applied to all types of institutional training programs, courses, and devices.

Table 1 comprises excerpts of the complete CES included in Reference (1). For the purpose of cost-effectiveness (C-E) analysis, this cost structure is meant to capture all relevant costs to the government that may be attributable to a training p/c/d throughout its life cycle. How the costs would be funded (Budget Appropriation, Budget Code, etc.) is incidental to C-E analysis.

The cost elements and their definitions are stated in general terms in order to accommodate differences in terminology among the Services. Differences in nomenclature of cost elements, accounting systems, and data collection procedures among (and within) the Services preclude precise and complete correspondence between financial data and cost elements for all C-E analyses among all Services. Furthermore,

*An early draft of the cost element structure was reviewed by about 30 members of the defense training community and headquarters of the military departments. Many of their comments and recommendations are incorporated in the CES.

TABLE 1. A COMPREHENSIVE COST ELEMENT STRUCTURE FOR MILITARY TRAINING PROGRAMS, COURSES, AND DEVICES*

A. RESEARCH AND DEVELOPMENT
- 1. Design
  - a. Pay and Allowances
    - (1) Military
    - (2) Civilian
  - b. Other Government Personnel Costs
    - (1) Military
    - (2) Civilian
  - c. Other
- 2. Component Development
  - a. Pay and allowances
  - c. Other
- 3. Producibility Engineering and Planning
  - a. Pay and Allowances
- 4. Tooling
  - a. Pay and Allowances
    - (1) Military
    - (2) Civilian
- 7. P/C/D Test and Evaluation
  - a. Pay and Allowances
    - (1) Military
    - (2) Civilian
  - b. Other Government Personnel Costs
    - (1) Military
    - (2) Civilian
  - c. Other
- 8. System/Project Management
  - a. Pay and Allowances

B. INITIAL INVESTMENT
- 1. Production
  - a. Nonrecurring
    - (1) Production Planning
    - (2) Production Tooling and Equipment
    - (3) Industrial Facilities
    - (4) Other
  - b. Recurring
    - (1) Manufacturing
- 5. Data
  - a. Managerial Data
    - (1) Pay and Allowances
  - c. Instructional Materials
    - (1) Pay and Allowances
    - (2) Other Government Personnel Costs
    - (3) Other
- 9. Operational/Site Activation
- 10. Initial Training
  - a. Instructors
  - b. Maintenance Personnel

C. OPERATING AND SUPPORT
- 1. Direct Costs
  - a. Instructional Costs
    - (1) Pay and Allowances
      - (a) Instructors
        - 1 Military
        - 2 Civilian
      - (b) Supervisors, Administrators and Support Personnel
        - 1 Military
        - 2 Civilian
      - (c) Maintenance Personnel
        - 1 Military
        - 2 Civilian
    - (3) Consumption
      - (a) POL
      - (b) Training Munitions
      - (c) Utilities
        - 1 Electric Power
        - 2 Other
      - (d) Instructional Materials
      - (e) Other
  - c. Airfield and Carrier Operations Costs
    - (1) Pay and Allowances
      - (a) Military
  - d. Student Costs
    - (1) Pay and Allowances
      - (a) Military
- 2. Indirect Costs
  - a. Base Operations
    - (1) Pay and Allowances
      - (a) Military
      - (b) Civilian
    - (2) Other Government Personnel Costs
      - (a) Military

*Excerpted from Knapp and Orlansky (1983).

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data at the level of detail shown in this CES may not be readily available in the planning stage of a training p/c/d, when C-E analysis should be done. When system-specific data are lacking, generalized factors that represent aggregations of cost elements are often used. These anomalies in Service practices and data availability suggest the use of this CES as a check list to identify gaps in essential data and the need for clear definitions of existing data.

Since this CES was developed to capture all elements of the life-cycle cost of any training p/c/d, regardless of its size, complexity, or cost, it is necessary to include cost elements typical of the largest, most complex, and most costly p/c/d's (e.g., Undergraduate Pilot Training), as well as cost elements of the smallest. The result is a lengthy list of elements, many of which would not be applicable to cost analyses of less extensive training p/c/d's. If, for example, the subject of C-E analysis were computer-based instruction in a schoolhouse environment, the costs of Airfield and Carrier Operations (element C.1.c) and Petroleum, Oil, and Lubricants (POL) and Training Munitions [elements C.1.a.(3)(a) and (b)] would be irrelevant. Obviously, the applicability of each of the cost elements in this CES is dependent upon the nature and types of the alternative p/c/d's under consideration.

While the structure in Table 1 is designed to encompass the life-cycle costs of a training p/c/d, the format permits individuals with narrower interests to focus on specific cost elements or groups of elements. It enables budgeteers, manpower planners, and training and procurement specialists, for example, to identify the resources of primary concern to each of them, and to evaluate the implications of those resources in a total-program context. Operating and Support (O&S) costs, for example, have been the subject of cost containment in recent years. In personnel-intensive programs and courses typified by many types of training (e.g., computer-assisted and conventional group instruction), O&S costs incurred during years of ongoing instruction could exceed substantially the costs of course design and development (R&D) and implementation (Initial Investment). The breakdown of the O&S category provides for the many costs that are associated with personnel who are both directly and indirectly involved in the operations phase of a training p/c/d. In addition to the obvious costs of pay and allowances, the sub-element "Other Government Personnel Costs" (which is correlative to "Pay and Allowances") includes other costs that are properly attributable to the assignment of individuals to a training p/c/d. Among these are Permanent Change of Station (PCS) and Temporary Duty (TDY) costs, which may be estimated based upon program characteristics such as numbers of personnel, frequencies of moves, intensity of program-related business travel, etc. On the other hand, other personnel-related costs [e.g., Personnel Replacement, Health Care, and Base Operations (element C.2.a)] would be allocated, usually on a per capita basis, by each Service. Where equipment costs are dominant in the R&D and Initial Investment phases of a training p/c/d (e.g., an aircraft intended solely as a trainer), the proposed CES provides appropriate cost elements (e.g., Design, Component Development, Tooling, Production) to be applied to each major subsystem in the WBS (e.g., airframe, engine, and avionics). In this way, high-cost subsystems can be identified for possible cost reduction or intra-system trade-off analysis.

ADVANTAGES OF A COMPREHENSIVE COST ELEMENT STRUCTURE

The general use of a comprehensive cost element structure for military training, such as the one proposed in this paper, would offer several advantages for evaluating the costs of training programs, courses, and devices.

1. Used as a guide to estimate costs, it would ensure that all costs incurred during the life-cycle (or period of interest) of a training p/c/d would be accounted for. Gaps in essential data may be identified in this way. Should the level of aggregation of available cost data not provide explicit information on every pertinent cost element, the source(s) of the data could, at least, be queried to determine whether those elements were included in the data that are available. Clearer definitions of such data would make them more useful.

2. This CES is a synthesis of cost analysis guidance issued for and by the weapon system and training communities of the Services and offices of the Secretary of Defense. As such, its general use should enhance communication and understanding among people concerned with training and those involved with other aspects of weapon system programs on subjects of mutual concern (e.g., cost estimates, trade-offs between cost and effectiveness, and the allocation of resources among mission areas, systems, and programs.)

3. The level of detail should be adequate to identify the cost element(s) that account for the major costs of a training p/c/d. Identification of major costs, i.e., "cost drivers," would permit one to focus attention on areas for significant cost reduction or for trade-off analyses between high-cost items and effectiveness. It should also assist in identifying significant variables for use in the development of cost-estimating relationships.

4. It would permit making comparisons of costs among training options that are reliable and that can be used with confidence.

APPLICATION OF PROPOSED COST ELEMENT STRUCTURE TO TRAINING PROGRAMS, COURSES, AND DEVICES

Table 2 was prepared to illustrate the applicability of each cost element in the CES to three types of training, of various degrees of scope and complexity, that have been evaluated in previous studies, i.e., the cost-effectiveness of flight simulators, computer-based instruction, and maintenance simulators.* The applicability of each cost element to each type of training was estimated as follows:

Applicability of Cost Element	Symbol
Always applicable	+
May be applicable, depending on the context of the problem presented, assumptions, ground rules for the analysis, and characteristics of the training p/c/d of interest.	•
Not Applicable	(blank)

*Discrimination between military and civilian personnel, although an important characteristic of the CES, is omitted from Table 2 because it is not essential to illustrate its general applicability.

TABLE 2. ILLUSTRATIVE APPLICATION OF THE COMPREHENSIVE COST ELEMENT STRUCTURE FOR MILITARY TRAINING PROGRAMS, COURSES, AND DEVICES*

COST CATEGORIES/ELEMENTS	ACADEMIC TRAINING				MAINTENANCE TRAINING		FLIGHT TRAINING		
	CONVENTIONAL (NO COMPUTERS)	INDIVIDUALIZED (NO COMPUTERS)	COMPUTER-BASED[a]		ACTUAL EQUIPMENT	SIMULATOR[a]	AIRCRAFT		SIMULATOR[a]
			COMPUTER-ASSISTED	COMPUTER-MANAGED			TRAINER[b]	OPERATIONAL[c]	
A. RESEARCH AND DEVELOPMENT									
1. Design	+	+	+	+	+	+	+	+	+
2. Component Development	+	+	+	+	+	+	+	•	+
3. Producibility Engineering and Planning			•	•	•	+	+	•	+
4. Tooling			•	•	•	+	+	•	+
5. Prototype Manufacturing			+	+	+	+	+	•	+
6. Data									
a. Managerial	+	+	+	+	+	+	+	+	+
b. Technical	•	•	+	+	+	+	+	+	+
7. P/C/D Test and Evaluation	+	+	+	+	+	+	+	+	+
8. System/Project Management	+	+	+	+	+	+	+	+	+
9. Facilities			•	•	•	•	•	•	•
10. Other	•	•	•	•	•	•	•	•	•
B. INITIAL INVESTMENT									
1. Production									
a. Nonrecurring									
b. Recurring									
(1) Manufacturing			+	+	+	+	+	+	+
(2) Sustaining Engineering			+	+	•	+	+	+	+
(3) Sustaining Tooling			•	•	•	+	+	+	+
(4) Quality Assurance			•	•	+	+	+	+	+
(5) Other			•	•	•	•	•	•	•
c. Initial Spares and Repair Parts			+	+	+	+	+	+	+
5. Data									
a. Managerial	+	+	+	+	+	+	+	+	+
b. Technical	•	•	+	+	+	+	+	+	+
c. Instruction Materials	+	+	+	+	+	+	+	+	+
10. Initial Training									
a. Instructors	+	+	+	+	+	+	+	+	+
b. Maintenance Personnel			+	+	+	+	+	+	+
11. Transportation									
a. First Destination	•	•	•	•	•	+	+	+	+
b. Second Destination	•	•	•	•	•	•	•	•	•
12. Other	•	•	•	•	•	•	•	•	•
C. OPERATING AND SUPPORT									
1. Direct Costs									
a. Instructional Costs									
(1) Pay and Allowances									
(a) Instructors	+	+	+	+	+	+	+	+	+
(b) Supervisors, Administrative and Support Personnel	+	+	+	+	+	+	+	+	+
(c) Maintenance Personnel	•	•	+	+	+	+	+	+	+
(2) Other Government Personnel Costs	+	+	+	+	+	+	+	+	+
(3) Consumption									
(a) POL					•		+	+	
(b) Training Munitions	•	•			•		+	+	
(c) Utilities									
(8) Other	•	•	•	•	•	•	•	•	•
b. Training Activity Costs									
(1) Pay and Allowances	+	+	+	+	+	+	+	+	+

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TABLE 2. ILLUSTRATIVE APPLICATION OF THE COMPREHENSIVE COST ELEMENT STRUCTURE FOR MILITARY TRAINING PROGRAMS, COURSES, AND DEVICES*

(Cont'd)

COST CATEGORIES/ELEMENTS	ACADEMIC TRAINING				MAINTENANCE TRAINING		FLIGHT TRAINING		
	CONVEN-TIONAL (NO COMPUTERS)	INDIVID-UALIZED (NO COMPUTERS)	COMPUTER-BASED[a] COMPUTER-ASSISTED	COMPUTER-BASED[a] COMPUTER-MANAGED	ACTUAL EQUIP-MENT	SIMU-LATOR[a]	AIRCRAFT TRAINER[b]	AIRCRAFT OPERA-TIONAL[c]	SIMU-LATOR[a]
c. Airfield and Carrier Operations Costs									
(1) Pay and Allowances							•	•	
(2) Other Government Personnel Costs							•	•	
(3) Other							•	•	
d. Student Costs									
(1) Pay and Allowances	+	+	+	+	+	+	+	+	+
(2) Other Student Costs	+	+	+	+	+	+	+	+	+
e. Other Direct Costs	•	•	•	•	•	•	•	•	•
2. *Indirect Costs*									
a. Base Operations									
(1) Pay and Allowances	+	+	+	+	+	+	+	+	+
(2) Other Government Personnel Costs	+	+	+	+	+	+	+	+	+
(3) Other	•	•	•	•	•	•	•	•	•
d. Command Support Costs									
(1) Pay and Allowances	+	+	+	+	+	+	+	+	+
(2) Other Government Personnel Costs	+	+	+	+	+	+	+	+	+
(3) Other	•	•	•	•	•	•	•	•	•
e. Other Indirect Costs	•	•	•	•	•	•	•	•	•

*Excerpted from Knapp and Orlansky (1983).

[a]Assumes new hardware and/or software

[b]Designed, produced, and operated as a trainer.

[c]Essentially operational configuration and performance. May be used in primary mission role but used as trainer.

+ = Applicable

• = May be applicable; dependent upon context of program, assumptions, and system characteristics

(Blank) = Not applicable.

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As should be expected, some functions and resources, and the costs associated with them, are essential to all training systems and, regardless of their size or complexity, certain costs would always be incurred. These include, for example, p/c/d design, test and evaluation, system/project management, instructional materials, initial training of instructors, base operations, students, instructors, and other management and support personnel.

Other functions and resources, however, are required for some, but not all, new training programs, courses, or devices. For example, initial investment costs associated with hardware and software production (e.g., manufacturing, sustaining engineering, tooling, and quality control) apply to simulators and aircraft designed exclusively for training, but are not applicable to conventional and individualized instruction in which computers are not utilized.

This degree of applicability (symbol •), indicating that a cost element may or may not be applicable, is liberally assigned. This is consistent with its definition. For example, the cost of training munitions [element C.1.a(3)(b)] is applicable in individualized markmanship training of combat troops, but may not be applicable in the academic training of zone-of-interior radar operators. Another example applies to several elements in the R&D category for operational aircraft used as trainers. Whether significant costs would be incurred for component development, producibility engineering and planning, tooling, and prototype manufacture would depend upon the degree to which operational aircraft would be modified for training purposes.

Although we acknowledge that the assessment of degree of applicability in Table 2 is, in part, judgmental, the table shows that a common cost element structure can be applied to the broad range of training programs, courses, and devices.

DISCUSSION

The main need for a definitive cost element structure relevant to military training is to enable consistent and credible evaluations of the cost and effectiveness of military training programs, courses, and devices. Once the costs can be specified and effectiveness measured or predicted, cost-effectiveness ratios can be computed for alternative training p/c/d's.

We have already pointed out that the level of detail in this structure permits people with interests in different aspects of training to focus on cost elements of primary concern to them. It must be noted, however, that attempts to optimize among selected cost elements without regard to related cost elements in the same, or other, cost categories can result in misleading conclusions. The following examples illustrate the importance of carefully considering the impact of all costs attributable to a training system, throughout its life cycle, even though it may not appear necessary to do so to answer a particular question.

Consider, for example, two ways of providing images of the outside world in a flight simulator or a tank gunnery simulator. Assuming that both techniques were equally satisfactory and the immediate concern was restraint in procurement costs (i.e., elements of the Initial Investment cost category), a decision might be made in favor of the alternative with the lower purchase price. Over the system's life cycle, however, the alternative that would result in lower procurement cost might prove to be more costly if reliablity were lower,* if electric power consumption were higher and/or occasional modifications were more costly to accomplish.

Another example concerns computer-based instruction and conventional classroom instruction. Computer-based instruction systems generally are characterized by higher acquisition costs (i.e., R&D plus Initial Investment) than are conventional classroom instruction systems. Viewing acquisition cost only, one might favor conventional instruction. Computer-based instruction, however, is self-paced in nature, and can be employed to permit fast learners to complete courses in less time than is needed for conventional instruction; i.e., fast learners are not constrained by a pace set to meet the need of the average student. Considerable data show that computer-based instruction saves, on the average, 25 percent or more of the time students need to complete the same course given by conventional instruction. It follows that if the cost-per-student of alternative computer-based and conventional classroom courses are compared on a life-cycle cost basis, the higher acquisition costs of the computer-based training system might be more than offset in the operational phase. This outcome would not be revealed if the analysis were limited only to consideration of acquisition costs.

The work breakdown structure (WBS) of the training p/c/d components to which the cost element structure will be applied must be carefully detailed. For example, an analysis limited to the cost of computer hardware needed for computer-based instruction might show that acquisition costs have decreased markedly in recent years, and may continue to decrease in future years. It would be incorrect, however, to omit from the WBS the computer programs and course materials (software and courseware) needed for computer-based instruction. These products require highly skilled personnel and their costs have increased as much as, or more than, hardware costs have decreased. Similarly, in comparing computer-based instruction with conventional instruction, one might assume, incorrectly, that the costs of developing course materials would be the same for both methods of instruction and, therefore, could be omitted. A carefully constructed WBS, however, would include software as a component of the computer-based system, but not of conventional instruction, and courseware as a component of both.

Even though this paper is concerned only with the problem of identifying the costs of training p/c/d's, it is necessary to comment on the companion problem of determining the effectiveness of training p/c/d's. It makes little sense to select the least-cost alternative among several systems to satisfy a particular training requirement without regard to differences in effectiveness among the alternatives. Selection of the least-cost alternative in the interest of cost savings or cost avoidance might result in an unacceptably low level of effectiveness. The choice of another of the alternatives might be preferable if much greater effectiveness could be achieved with only slightly higher expenditures. Effectiveness could become the deciding factor, however, if the candidate p/c/d's were of approximately equal cost. This is not the place to discuss the effectiveness of training other than to say that both cost and effectiveness must be considered explicitly in any analysis conducted to enable se-

*Lower reliablity would cause higher maintenance and replenishment spares costs, reflected in elements in the Operating and Support cost category.

lection among alternative training programs, courses, or devices to fulfill a specific need.

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