Cost-Effectiveness Specification for Computer-Based Training Systems

Volume III

OPERATION AND MAINTENANCE

by

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September 1977

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19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The purpose of this cost-effectiveness specification is to facilitate the purchase, monitor, and evaluation of computer-based training systems. This standardized structure for deriving and communicating training system costs and effectiveness is presented in three volumes, corresponding to the life cycle of a computer-based training system: (1) development, (2) procurement, and (3) operation and maintenance. The cost methodology focuses on identifying and quantifying total inputs required by the system over its life cycle. Effectiveness dimensions include objectives-based achievement and time measures for within-

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course and end-of-course criteria. Other measures, such as attrition rates, instructor ratings, and attitude scales, are also discussed.

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PREFACE

This is Volume III of the Cost-Effectiveness Specification for Computer-Based Training Systems. It is part of a three-volume set which corresponds to the three phases of a training system's life cycle (Volume I - Development; Volume II - Procurement; Volume III - Operation and Maintenance). An Executive Summary document is included which provides the reader with general guidance and instructions on how to go through and respond to the various parts of the specification. This Cost-Effectiveness Specification was developed for DARPA as part of Contract #MDA903-76-C-0210. Dr. Harold F. O'Neil was the Technical Monitor.

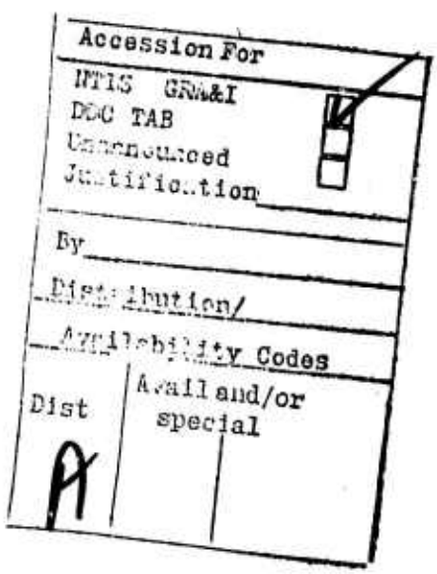

TABLE OF CONTENTS

Part A

SYSTEM DESCRIPTION

INSTRUCTIONS

The purpose of Part A is to describe some of the characteristics of the computer-based training system and to identify the individuals who are using this specification.

(1) Print the name or descriptive title of the computer-based training system.

(2) Enter the year which represents the system's current life cycle status. Indicate which year of the Operation and Maintenance Phase you are in by entering the date in the appropriate space.

(3) Check the type of hardware configuration supporting the system.

(4) Enter the maximum number of time-sharing students per system.

(5) List the courses taught or supported by the computer-based training system.

(6) Enter the number of students who are served by the system in each course, and in all courses per year.

(7) Print your name, job title, and organization.

SYSTEM DESCRIPTION

① **Computer-Based Training System** _____

② **System Life Cycle**

	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	7th Year	8th Year
Phase III - Operations and Maintenance	19__	19__	19__	19__	19__	19__	19__	19__

③ **Configuration**

☐ Stand-Alone ☐ Remote ☐ Combination Stand-Alone and Remote

④ **Time-Sharing Capacity** _____

⑤ **Courses Supported by System** (Specify)

⑥ **No. of Students Per Year**

_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
Total	_____

⑦

Your Name	Job Title	Organization
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

Part B

GENERAL COSTING ASSUMPTIONS AND DEFINITIONS

Part B

GENERAL COSTING ASSUMPTIONS AND DEFINITIONS

OPERATION AND MAINTENANCE PHASE

Activities related to the daily operation and maintenance of the computer-based training system over its projected life after its official acceptance. Operation and Maintenance costs are all costs (in-house and contractor), irrespective of how funded, including replacement training for site personnel, administration, instructional delivery, etc. These costs include the following components:

- Equipment. The costs associated with operating and maintaining the hardware (all parts and equipment necessary for the system), including the acquisition of replacement spares and repair test equipment.

- Facilities. The costs of operating and maintaining the facilities which house the operational computer-based training system.

- Software. The costs of operating, maintaining, and modifying computer programs which support the training system.

- Instructional System Development (ISD) Activities. The costs of performing all activities in the last two phases of the ISD process except revision of instructional material and tests.

- Instructional Methods/Materials. The costs of maintaining, reproducing, and modifying the testing and training materials required by the operational system.

- System Management. The costs of managing the day-to-day operation of the computer-based training system. This element includes the costs associated with any official alteration made to a system by accomplishing a Modification Work Order (MWO), retrofit, conversion, remanufacture, or engineering change after official acceptance of the system.

- Other Direct Costs. Any direct operation and maintenance costs not included in the previous components.

COMPUTER-BASED TRAINING SYSTEM

The application focus of this costing specification is *formal, school-based* training. The specification is oriented toward training which is administered, aided, or managed by computer (hence, *computer-based*). The system component costs are distributed across the training system's life cycle which consists of three phases: Development, Procurement, Operation and Maintenance.

CONSTANT DOLLARS

In order to make valid comparisons between alternatives, the cost for each alternative must be stated in the same terms. In Part D of the specification all costs are to be adjusted so that they are expressed in constant year dollars. Constant year dollars express all the costs expended in various years in terms of the general purchasing power of the dollar for a given base year. An estimate is said to be in constant dollars if costs for all work, both prior, current, and future, are adjusted so that they reflect the level of prices of the base year. *For purposes of this specification, the base year is the calendar year in which the costing analysis is performed.*

If cost data or estimates are available in other than constant year dollars, constant year dollars are arrived at by applying the appropriate adjustment factors. Current dollars reflect purchasing power current to the year in which they are expended. Prior costs stated in current dollars are the actual amounts paid out in these years. Future costs stated in current dollars are the projected actual amounts which will be paid. Care should be exercised to preclude the mixing of current dollars with constant dollars in a single display of costs. *Any cost figures provided in current dollars are to be clearly identified as such.*

DISCOUNTED RATES

Discounting is a technique for converting various cash flows occurring over time to equivalent amounts at a common point in time, considering the time value of money to facilitate a valid comparison. The appropriate interest rate is used to discount or calculate future costs and benefits so as to arrive at their present values. Each year's expected yearly cost is multiplied by its discount factor and then summed over all years. (The current discount rate specified by OSD is 10 percent.)

INDIRECT COSTS

An overhead or indirect cost factor is attached or "burdened" atop direct costs by each contractor to account for general support and administrative expenses. At each Government or sponsor site used during the life cycle of the training system, an indirect cost factor needs to be established. If no specific indirect factor, per site, can be determined, a "standard" service or DoD rate will be used.

INHERITED ASSETS

The use of assets already available (inherited assets) requires careful evaluation when preparing a cost estimate. The fact that a given system component is already available does not automatically equate to zero cost to the computer-based training system. Each inherited asset must be evaluated on its own merit and in terms of whether its use in connection with the system being costed will cause some future expense. If so, that expense must be included in some cost element in the system's life cycle. If there will be no future expense, the cost of the item will be included in the

total life cycle cost but will be highlighted as a sunk cost. Such existing assets will be included at their fair market value (as measured by market price, scrap value, or alternative use) and the basis for arriving at the estimate will be documented.

INSTRUCTION

An organized, open information-exchange process in which the student and instructional agent (human, programmed text, or intelligent machine) continually interact. The purpose of the interaction is to enable the student to reach some criterion of understanding or skill proficiency called mastery of a given set of objectives. A computer can aid this process directly by reducing all or portions of a strategy for interaction to an explicit algorithm or set of algorithms. The computer can also help by providing accurate, reliable massive storage and retrieval for records of student progress.

INSTRUCTIONAL SYSTEM DEVELOPMENT (ISD)

"A systematic procedure for assuring application of instructional technology to course planning and development."[1] The five phases of ISD are treated in detail in the five volumes of:

Air Force--"Handbook for Designers of Instructional Systems"[2]
Army--"Interservice Procedures for Instructional Systems Development"[3]
Navy/Marines--"Interservice Procedures for Instructional Systems Development"[4]

There is some disagreement between the Services on how the Phases are numbered. In this specification, we will adopt the Army's terminology of: Analyze, Design, Develop, Implement and Control to represent Phases I-V, respectively.

An issue to consider in working with this specification is that the instructional development process does not coincide with the computer-based training system life cycle for hardware and software. The ISD Phases do not fit the Development, Procurement, and Operation and Maintenance Phases of the system's life cycle unless it is a completely new course of instruction. For most training, sections of the course will be designed, developed, tested, revised, adapted, and integrated throughout the entire life cycle of the computer-based training system. (For example, one-third of Air Force instructional hours are revised each year on the average.)

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[1] "Instructional System Development," Department of the Air Force, AFM 50-2, 31 July 1975, p. 1.1.

[2] AFP 50-58, 15 July 1973.

[3] TRADOC PAM 350-30, 1 August 1975.

[4] NAVEDTRA106-A, August 1975.

One problem in obtaining cost data for ISD activities is that functionally related cost data are generally not available from existing records. That is, information regarding personnel time and non-personnel costs related to such functions as job analysis, media selection, or preparation of learning objectives, are generally not recorded. Thus, such data must be collected during these activities or projected by the analyst who is complying with this specification. One approach would be to designate an individual with the responsibility of maintaining a detailed log of on-going instructional system development.

For purposes of this specification, the costs associated with all activities related to the first three ISD Phases (Analyze, Design, and Develop) will be documented as part of the Development Phase of the system life cycle. The costs associated with the ISD activities of Phases IV and V (Implement and Control) will be accounted for in the Operation and Maintenance Phase. No ISD activities will be shown as part of the Procurement Phase--but rather, this Phase will involve only the cost of purchasing the completed instructional products, materials and programs.

LIFE CYCLE/LIFE CYCLE COSTS

The life-cycle cost is the total cost of an item or system over its full life. The computer-based training system life cycle is encompassed in three phases: Development, Procurement, and Operation and Maintenance. These three phases are of variable lengths depending upon each specific system. Although the three phases overlap, for purposes of this specification, they will be considered to occur sequentially. The Development Phase can take up to 6 years, the Procurement Phase is shown as one year, and the Operation and Maintenance Phase can be up to 8 years. Although Procurement can take more than one year, this specification requires an assumption of all Procurement activities occurring within the year following development of a tested prototype system. Also, although such systems are usually phased in, it is assumed in this specification that Procurement will be followed by instantaneous operation of all systems acquired.

The specific years in which each Phase occurs are to be noted, the information coming either from the contractor or service monitor. The respondent needs to enter the years in which the system is operational.

Life cycles are different for various system components. These life times established by the *Economic Analysis Handbook, 2nd edition*, Department of Defense, are as follows:

ADP Equipment	8 years
Buildings	25 "
Operating Equipment	10 "
Utilities, Plants & Utility Distribution Systems	25 "
Weapon/Support Systems	Variable

PAY AND ALLOWANCES

The cost of civilian and military personnel paid at annual rates will be gross pay in current pay tables, plus the Government's contribution for civilian retirement, disability, health, life insurance, and, where applicable, social security programs. Factors to weight the base pay of civilian and military personnel will be based on guidance from the Office of the Assistant Secretary of Defense (Comptroller), "Economic Cost of Military and Civilian Personnel," and recent policies of the Office of Management and Budget regarding civilian personnel pay. The latter will be used to weight the pay of civilian Government personnel who are directly involved in the life cycle of the computer-based training system. The following percentages of base pay will be used in computing the costs of civilian personnel services:

Retirement	24.7%
Health Insurance	3.5%
Life Insurance	.5%

The military and civilian pay rates, as weighted, do not include special pay, such as flying pay or hazardous duty pay. These costs must be added to the rates whenever they are required by the job or location. If appropriate, pay should be increased to cover leave and other benefits such as the average cost of sick leave taken and annual, holiday and other paid leave accruals, plus the average Government contributions for other benefits.

SUNK COST

A cost which is *irrevocably* committed to a project. Each cost analysis will make explicit any cost which is sunk at the time the analysis is prepared. All costs which reflect irreversible decisions will be treated as sunk.

Part C

COMPUTER-BASED TRAINING SYSTEM ELEMENTS: DEFINITIONS AND COSTS

Part C

COMPUTER-BASED TRAINING SYSTEM ELEMENTS: DEFINITIONS AND COSTS

In this section you are to provide costing information for each element on the computer-based training system. For Equipment or Facilities, four items of information are required for accurate costing: the type of device or unit, the unit cost, the number of units or the proportion of one unit allocated to the system, and whether or not the units are to be supplied, operated, and maintained by the government (e.g., GFE) or by the contractor. If you are a contractor and the units are to be provided by the government, check the GFE space; otherwise, give the unit cost. Maintenance costs should be included wherever applicable. All costs should be presented in the year expended. You should make a copy of the Part C worksheets for each year covered in the Operation and Maintenance Phase. You can then easily transfer the yearly costs to the matrix in Part D.

Definitions of all system elements are provided on the left-hand pages, with examples of how these items are to be costed. For Software, Instructional System Development (ISD) Activities, Instructional Methods/Materials, and System Management, units are hard to define and unit costs are difficult to obtain or are not applicable. In these cases, you are to provide as meaningful a description of the item and its characteristics as possible, and delineate the personnel and non-personnel costs which were incurred. If items were purchased, and only total costs are available, enter them in the appropriate column. To assist you in identifying total personnel costs, Personnel Cost Worksheets accompany this specification.

EQUIPMENT

Included in this category are all the components of equipment related to a computer-based training system (e.g., the computer and its associated auxiliary memory requirements, terminals, carrels, auxiliary audiovisual devices). Also included are local interface hardware, telephone lines, special lines, satellites, receivers, power generating equipment, associated test and checkout equipment, etc. Replacement spares and repair test equipment are included in the Operation and Maintenance Phase. Maintenance costs, derived from factors such as mean time before failure and mean time or cost to repair, should be included in the costs of every piece of equipment maintained.

EXAMPLE

1. EQUIPMENT

1.3 Auxiliary Audiovisual Devices

	Description	No Units	x	Unit Cost	=	Total Cost	GFE (✓)
a.	Singer Caramate 35 mm slide/tape units	9		$ 285		$ 2565	
b.	" " " " " master	1		343		343	
c.	Bell & Howell Film-O-Sonic 8 mm projector	1		400		400	
d.							
e.							
						$ 3,308	

Computer(s): This refers to the hardware, either contractor or in-house, required to produce the automatic data processing capability of the system. It includes the installed machine or group of inter-connected machines consisting of input, storage, computing, control and output devices which use circuitry in the main computing element to automatically perform arithmetic and/or logical operations by means of internally stored or externally controlled programed instructions. This element includes, for example, a central processor, large capacity storage data channels, and input/output.

Terminal(s): Refers to the hardware required to produce the data display portion of the system. It includes the equipment necessary to provide visual presentation of processed data or instruction by means of specifically designed electronic or electromechanical devices interconnected with the computing/processing subsystem, such as flat panel displays, projection screens, image data storage and retrieval equipment.

Auxiliary Audiovisual Devices: This subcategory consists of equipment which presents audiovisual instructional material. Included are such devices as: slide projectors, slide/tape units, film strip and overhead projectors, various movie film projectors, videotape recorders/players, etc.

1. EQUIPMENT

Year

1.1 Computer(s)

19 _____

Description	No. Units	x	Unit Cost	=	Total Cost	GFE (√)
a.			$		$	
b.						
c.						
d.						
e.						
					$	

(To Part D p. 63)

1.2 Terminal(s)

a.			$		$	
b.						
c.						
d.						
e.						
					$	

(To Part D p. 63)

1.3 Auxiliary Audiovisual Devices

a.			$		$	
b.						
c.						
d.						
e.						
					$	

(To Part D p. 63)

Auxiliary Memory: Storage capability designed to extend the core memory of a computer. It may consist of serial access devices (e.g., magnetic tape) or random access (e.g., disc or drum) or possibly extended core storage (ECS) or shift registers added to the main memory. The medium is electro-magnetic although paper tape could be used.

Local Interfaces: Direct transmission connectors linking various peripheral devices (disc, tape drivers, CRTs, etc.) with the computer or in some cases with each other.

Telephone Lines: Standard public commercial voice grade channels (generally up to 3000 cps) usable in computer-based training systems.

Year

1.4 Auxiliary Memory

19 _____

Description	No. Units	x	Unit Cost	=	Total Cost	GFE (✓)
a.			$		$	
b.						
c.						
d.						
e.						

$ _____

(To Part D p. 63)

1.5 Local Interfaces

a.		$	$		
b.					
c.					
d.					
e.					

$ _____

(To Part D p. 63)

1.6 Telephone Lines

a.		$	$		
b.					
c.					
d.					
e.					

$ _____

(To Part D p. 63)

Special Lines: Electrical communication channels designed to handle computer data transmission between two or more points. The circuits are constructed to transmit baud rates (or bits per second) relevant to various grades of transmission; e.g., 300-3000 cps for voice grade channels or up to 50,000 baud (or higher) for high-speed, wide-band digital transmission.

Satellites: Earth orbiting electronic transmitters designed as high altitude means to cover a large geographic area and to reduce signal interference caused by high natural or man-made structures. Satellite transmission is typically at higher frequencies than is standard for receivers and therefore requires frequency converters at reception points.

Receivers: Devices at the instructional site designed to capture the transmitted signals to convert them to instructor/student usable form as a basis for training materials. These include, for example, radios, TV monitors, ground receiving equipment relevant to satellite signals, etc., along with related equipment such as antenna, mount, amplifiers, converter, batteries and cable.

Power Generating Equipment: Where non-electrified areas (or minimal power areas) are used as reception sites electrical generating equipment, or batteries are required to activate receivers (or amplify) transmittal signals over appropriate receivers.

1.7 Special Lines

Year 19 ____

Description	No. Units	×	Unit Cost	=	Total Cost	GFE (✓)
a.			$		$	
b.						
c.						
d.						
e.						

$ _____
(To Part D p. 63)

1.8 Satellites

a.			$	$	
b.					
c.					
d.					
e.					

$ _____
(To Part D p. 63)

1.9 Receivers

a.			$	$	
b.					
c.					
d.					
e.					

$ _____
(To Part D p. 63)

1.10 Power Generating Equipment

a.			$	$	
b.					
c.					
d.					
e.					

$ _____
(To Part D p. 63)

Carrels: Small enclosures for individual study that are moveable. If firmly fixed or built into the structure of the building, they would be categorized under Facilities.

Replacement Spares and Repair Test Equipment: This subcategory includes cost of replacement spare components, subassemblies and repair parts used for replacement purposes in major end items of equipment during the operational phase of the system's life. It also includes test equipment such as meters required for troubleshooting and repair of other equipment components.

Year

19 _____

1.11 Carrels

Description	No. Units	x	Unit Cost	=	Total Cost	GFE (✓)
a.			$		$	
b.						
c.						
d.						
e.						
					$	

(To Part D p. 63)

1.12 Replacement Spares and Repair Test Equipment

a.			$		$	
b.						
c.						
d.						
e.						
					$	

(To Part D p. 63)

1.13 Other Equipment

a.			$		$	
b.						
c.						
d.						
e.						
					$	

(To Part D p. 63)

FACILITIES

Included in this category are all the physical facilities required for housing the equipment components, administrators, and users of the computer-based training system. This category includes classrooms, laboratories, large group instruction spaces, offices, individual learning spaces, libraries and other information resource centers, etc. Units should be specified as the number of square feet required to house all components of the computer-based training system.

EXAMPLE

2. FACILITIES

2.4 Offices

	Description	No. Units	x	Unit Cost	=	Total Cost	GFE (✓)
a.	Administrative Personnel	450 sqft		$ 3.80		$ 1710	—
b.	Instructor Cadre	1440 "		3.80		5472	—
c.	Contractor Personnel	150 "		3.80		570	—
d.							—
e.							—
						$ 7752/yr	

Classrooms: Places within buildings in which training is administered to students.

Laboratories: Places providing opportunity for observation, practice, or experimentation. Included in this category are simulated job settings which can be room-size or as large as warehouses, depending upon the particular training situation.

Large Group Instruction Spaces: Included in this element are such places as auditoria, study halls, demonstration rooms, etc., where large numbers of can be trained.

Offices: Places in which the personnel who develop, manage, administer, and support the computer-based training system perform their functions.

2. FACILITIES

Year 19 ____

2.1 Classrooms

Description	No. Units	x	Unit Cost	=	Total Cost	GFE (√)
a.			$		$	
b.						
c.						
d.						
e.						
					$	

(To Part D p. 64)

2.2 Laboratories

a.			$		$	
b.						
c.						
d.						
e.						
					$	

(To Part D p. 64)

2.3 Large Group Instruction Spaces

a.			$		$	
b.						
c.						
d.						
e.						
					$	

(To Part D p. 64)

2.4 Offices

a.			$		$	
b.						
c.						
d.						
e.						
					$	

(To Part D p. 64)

Individual Learning Spaces: This category includes built-in carrels and small cubicles which serve as spaces for individuals to study or work by themselves. If such carrels are moveable, they would be classified as Equipment.

Libraries and Other Information Resource Centers: Places in which printed and other forms of mediated information is stored and arranged for use. Included in this element are learning resource centers, dial-in TV and other information retrieval systems, etc.

2.5 Individual Learning Spaces

Year 19____

Description	No. Units	x	Unit Cost	=	Total Cost	GSE (✓)
a.			$		$	
b.						
c.						
d.						
e.						

$ _____

(To Part D p. 64)

2.6 Libraries and Other Information Resource Centers

a.			$		$	
b.						
c.						
d.						
e.						

$ _____

(To Part D p. 64)

2.7 Other Facilities

a.			$		$	
b.						
c.						
d.						
e.						

$ _____

(To Part D p. 64)

SOFTWARE

This category of the computer-based training system includes systems programming support, general applications programs, diagnostic and checkout software, utility programs, etc.

EXAMPLE

3. SOFTWARE

3.1 Systems Programs

Description	Personnel Hours	Personnel Costs	Non Personnel Costs	Total Costs	GFE (Y/N)
a. Executive System	310	$7185	$900	$8085	
b. System Error Routine	70	1630	150	1780	
c. System Initialization	114	2806	312	3118	
d. Keyboard Handler	106	2468	450	2918	
e.					
				$15,901	

Systems Programs: The underlying software necessary for the control of a computer system, including operating systems, monitors, executives, peripheral device interfaces, etc.

General Applications Programs: Those computer programs which are dependent on data bases for their use but which can be run on various machines and have usefulness independent of a specific course of instruction (e.g., SPSS, BioMed Statistical Packages, Compilers, Assemblers and Interpreters such as FORTRAN, BASIC, COURSEWRITER, or certain interactive CAI functions).

Diagnostic/Test Programs: Special purpose programs used primarily to test the operation of computer system hardware components. Examples include diagnostics to locate damaged tape or disk surfaces, faulty sections of computer memory, transmission errors on telecommunication links. Diagnostic programs often operate independently of a computer's operating system software.

3. SOFTWARE

Year 19____

3.1 Systems Programs

Description	Personnel Hours	Personnel Costs +	Non-Personnel Costs =	Total Costs	GFE (✓)
a.		$	$	$	
b.					
c.					
d.					
e.					

$ _____

(To Part D p. 64)

3.2 General Applications Programs

a.		$	$	$	
b.					
c.					
d.					
e.					

$ _____

(To Part D p. 64)

3.3 Diagnostic/Test Programs

a.		$	$	$	
b.					
c.					
d.					
e.					

$ _____

(To Part D p. 64)

Utility Programs: Generalized data and file manipulation software used to create, copy, modify or delete machine-readable data. Such utilities include programs to copy tapes, print tape and disk files, convert files from one data representation (e.g., ASCII) to another, etc.

3.4 Utility Programs

Year 19____

Description	Personnel Hours	Personnel Costs +	Non-Personnel Costs =	Total Costs	GFE (✓)
a.		$	$	$	
b.					
c.					
d.					
e.					

$ _____

(To Part D p. 64)

3.5 Other Computer Programs

a.		$	$	$	
b.					
c.					
d.					
e.					

$ _____

(To Part D p. 64)

INSTRUCTIONAL SYSTEM DEVLLOPMENT (ISD) ACTIVITIES

This category includes the costs incurred during the process of implementing and controlling the quality of the instruction. The activities covered in this category are described in ISD Phases IV and IV (Implement and Control). However, for purposes of this specification, this category does not include the costs of actually revising the test items and instructional materials (see Category 5--Instructional Methods/Materials).

EXAMPLE

4. INSTRUCTIONAL SYSTEM DEVELOPMENT (ISD) ACTIVITIES

4.1 Implement (Phase IV)

4.1.1 Replacement Training of Site Personnel

Description	Personnel Hours	Personnel Costs	Non Personnel Costs	Total Costs	GFE (Y/N)
a. On site Instructor Training	160	$ 4067	$ 870	$ 4937	
b. On site Maintenance Training	160	3820	1800	5,620	
c.					
d.					
e.					
				$ 10,557	

Implement (Phase IV): Staff training is required for the implementation of the instructional management plan and the instruction. Some key personnel must be trained to be managers in the specified management plan. The instructional staff must be trained to conduct the instruction and collect evaluative data on all of the instructional components. At the completion of each instructional cycle, management staff should be able to use the collected information to improve the instructional system. The outcomes of this phase are:

- Documents containing information on time, space, student and instructional resources, and staff trained to conduct the instruction.
- A completed cycle of instruction with information needed to improve it for the succeeding cycle.

Replacement Training of Site Personnel: This element refers to all the training services, courses, devices, accessories, aids, equipment, facilities, and parts used to facilitate instruction through which replacement personnel will acquire the skills necessary to operate and maintain the computer-based training system.

Instructor Pay and Allowances: The cost of civilian and military personnel involved directly in the administration of the training program(s).

4. INSTRUCTIONAL SYSTEM DEVELOPMENT (ISD) ACTIVITIES

4.1 Implement (Phase IV)

4.1.1 Replacement Training of Site Personnel

Year

19___

Description	Personnel Hours	Personnel Costs	+ Non Personnel Costs	= Total Costs	GFE (*)
a.		$	$	$	
b.					
c.					
d.					
e.					
				$	

(To p. 38)

4.1.2 Instructor Pay and Allowances

a.		$	$	$	
b.					
c.					
d.					
e.					
				$	

(To p. 38)

Student Pay and Allowances: The cost of civilian and military personnel who are in a training status while participating in the course(s) administered as part of the computer-based training system.

Total Implementation Costs: Enter total costs obtained in subcategories 4.1.1 thru 4.1.4 in the spaces provided. Sum these costs to arrive at a total cost of the 4.1 subcategory. Transfer this sum to the appropriate line of the TCBS Matrix (Part D).

4.1.3 Student Pay and Allowances

Year 19____

Description	Personnel Hours	Personnel Costs +	Non-Personnel Costs =	Total Costs	GFE (*)
a.		$	$	$	
b.					
c.					
d.					
e.					
				$ (below)	

4.1.4 Other Costs of Implementing Instruction

a.		$	$	$	
b.					
c.					
d.					
e.					
				$ (below)	

Total Implementation Costs (4.1)

Replacement Training of Site Personnel (4.1.1)	$
Instructor Pay and Allowances (4.1.2)	
Student Pay and Allowances (4.1.3)	
Other Costs of Implementing Instruction (4.1.4)	
Total 4.1	$ (To Part D p. 65)

Control (Phase V): The first activity in this Phase (internal evaluation) is the analysis of learner performance in the course to determine instances of deficient or irrelevant instruction. The evaluation team then suggests solutions for the problems. In the external evaluation, personnel assess job task performance on the job to determine the actual performance of course graduates and other job incumbents. All collected data, internal and external, can be used as quality control of instruction and as input to any phase of the system for revision. *For purposes of this specification, revision of instructional materials and tests will not be costed in this subcategory. Rather subcategories 5.1 - 5.11 are to be entered with that information.* The outcomes of this phase are:

- Data on instructional effectiveness.
- Data on job performance in the field.
- Instructional system revision plans based on empirical data.

Year

19_____

4.2 Control (Phase V)

Description	Personnel Hours	Personnel Costs	+ Non-Personnel Costs	= Total Costs	GFE (✓)
a.		$	$	$	
b.					
c.					
d.					
e.					
				$	

(To Part D p. 65)

4.3 Other Instructional System Development (ISD) Activities

a.		$	$	$	
b.					
c.					
d.					
e.					
				$	

(To Part D p. 65)

INSTRUCTIONAL METHODS/MATERIALS

Included here are all forms of instructional methods, materials, and tests in the computer-based training program. All print and mediated instruction is included, as well as specific applications computer programs when appropriate. Printed materials would include such items as training manuals, instructor guides, printouts, books, programmed texts, etc. Other mediated forms of instruction include film, audio, audiovisual, video and computer displays, etc. Indicate the estimated number of course hours for each element of instruction revised or added to the system.

EXAMPLE

5. INSTRUCTIONAL METHODS MATERIALS

5.9 Computer Administered Instructional Materials

5.9.2 Simulation

	Description	Est Course Hours	Hours to Revise/Prepare	Personnel Costs	Non Personnel Costs	Total Costs	GFE (*)
a.	Repair of Simulated Equipment failures	38	1400	$33,138	$7,333	$40,471	
b.	Troubleshooting Diagnostics	100	5461	107,529	19,667	127,196	
c.							
d.							
e.							
						$167,667	

Audio: In this subcategory are included instructional materials in forms presented only for listening. Tape recordings, phonograph records, radio broadcasts, etc., comprise this subcategory.

Audiovisual: Mediated instructional materials which are to be seen and heard in an integrated fashion. Included in this subcategory are slide/tape programs, sound filmstrips, sound motion pictures, videotape and other television programs, etc.

Film/Text/Visual: Mediated instructional materials on film designed to be viewed only. Included in this subcategory are slides, overhead transparencies, film strips, silent motion pictures, etc., in which text as well as pictures are presented.

Lecture/Demonstration: A portion of instruction in which facts or concepts to be learned are presented by the instructor, or a skill to be mastered may be introduced. Active student participation may be elicited at critical points with (1) questions or (2) by directing attention to certain features demonstrated.

5. INSTRUCTIONAL METHODS/MATERIALS

Year 19____

5.1 Audio

Description	Est. Course Hours	Hours to Revise/ Prepare	Personnel Costs	+ Non-Personnel Costs	= Total Cost	GFE (✓)
a.			$	$	$	
b.						
c.						
d.						
e.						
					$	

(To Part D p. 65)

5.2 Audiovisual

a.			$	$	$	
b.						
c.						
d.						
e.						
					$	

(To Part D p. 65)

5.3 Film/Text/Visual

a.			$	$	$	
b.						
c.						
d.						
e.						
					$	

(To Part D p. 65)

5.4 Lecture/Demonstration

a.			$	$	$	
b.						
c.						
d.						
e.						
					$	

(To Part D p. 65)

Group Discussion/Seminar: A small number of students engaged in interactive exchange of information about a given topic. The instructor may or may not participate.

Performance/Practice: Exercises for the student to rehearse a skill (1) with feedback (guided practice), or (2) without feedback (unguided practice) on the student's performance of the skill.

Tutoring (peer or other): A form of instruction involving one-to-one dialogue between instructional agent (teacher, fellow student or other) and student.

Printed Text/Visual: Instructional materials that are printed on paper. Included in this subcategory are books, training manuals, programmed texts, printouts, forms, as well as printed photographs, etc.

5.5 Group Discussion/Seminar

Year 19____

Description	Est. Course Hours	Hours to Revise/ Prepare	Personnel Costs	+ Non-Personnel Costs	= Total Costs	GFE (√)
a.			$	$	$	
b.						
c.						
d.						
e.						
					$	

(To Part D p. 65)

5.6 Performance/Practice

a.			$	$	$	
b.						
c.						
d.						
e.						
					$	

(To Part D p. 65)

5.7 Tutoring (peer or other)

a.			$	$	$	
b.						
c.						
d.						
e.						
					$	

(To Part D p. 65)

5.8 Printed Text/Visual

a.			$	$	$	
b.						
c.						
d.						
e.						
					$	

(To Part D p. 65)

Computer-Administered Instructional Materials. Instructional materials that are prepared for presentation on computer output devices such as cathode ray tubes, plasma panels, teletypes, etc. A variety of instructional strategies can be applied using the computer as described below.

Drill and Practice: Following presentation of a concept and a test of knowledge comprehension, the student interacts with a series of example instances. The purpose of this activity is to strengthen performance skills in the designated concept. Computer-based drill and practice permits repeated presentations of a wide range of randomly generated or specially programmed instances. Acceleration or remediation of instruction can be made contingent on student performance.

Simulation: An instructional situation which allows a participant to interact in a situation closely resembling an actual experience. Depending on the sophistication of the computer system involved, the computer houses the simulation rules and enables complex simulated decision-making, monitors student progress and maintains instructional records for subsequent training use. Justification for simulation: safety in performing dangerous and critical criterial tasks, telescoping real-world time, and permitting abstraction of essential task elements from potentially confusing total criterial environment.

Games: A cooperative or competitive environment in which the student interacts with real or artificial participants to achieve specified goals. Points can be offered for degree of cooperative or competitive achievement. In combination, simulation and games are often used as instructional tools for teaching problem-solving. They are justified as strong motivating forces for learning. In addition to the automated functions ascribed to simulation, the computer can provide the rules for real players to interact; or it also can be the source through artificial intelligence of other simulated players

5.9 Computer-Administered Instructional Materials

Year 19____

5.9.1 Drill and Practice

Description	Est. Course Hours	Hours to Revise/ Prepare	Personnel Costs +	Non-Personnel Costs =	Total Costs	GFE (✓)
a.			$	$	$	
b.						
c.						
d.						
e.						
					$	

(To p. 47)

5.9.2 Simulation

a.			$	$	$	
b.						
c.						
d.						
e.						
					$	

(To p. 47)

5.9.3 Games

a.			$	$	$	
b.						
c.						
d.						
e.						
					$	

(To p. 47)

Tutorial: An instructional situation in which the student interacts with a model of a teacher, the model being resident in the computer. It can encompass all or some of the instructional program, governing (dialogue) sequence of materials, feedback rules, strategies for simulation, games, drill and practice, or other related instructional paradigms. Depending upon computer sophistication, and instructional needs, automation of instructional prescription, resource allocation, and record-keeping can be partial or total.

Problem-Solving: One of the most common instructional forms consists of quantitative problems generated by stored algorithms. The student interacts by inputting step-by-step process solutions at a terminal device or the student solves the problem on paper and inputs his answer.

Inquiry: The student forms questions which he addresses to the computer system. He may use natural language or some easy-to-learn subset of the language. The system processes the questions usually using key words and searching stored algorithms to provide an answer. This activity is often called information retrieval.

Year

19 _____

5.9.4 Tutorial

Description	Est. Course Hours	Hours to Revise/ Prepare	Personnel Costs	+ Non-Personnel Costs	= Total Costs	GFE (✓)
a.			$	$	$	
b.						
c.						
d.						
e.						
					$	

(To p. 47)

5.9.5 Problem-Solving

a.			$	$	$	
b.						
c.						
d.						
e.						
					$	

(To p. 47)

5.9.6 Inquiry

a.			$	$	$	
b.						
c.						
d.						
e.						
					$	

(To p. 47)

Specific Applications Programs: Computer programs written to satisfy a specific instructional logic requirement in a given course. These programs are both data and course dependent (such as unique algorithms written for Physics I problems for a particular instructor). They are usually written in a CAI language although they could also be written in a machine assembly language.

Total Computer-Administered Instructional Materials Costs: Enter total costs obtained in subcategories 5.9.1 thru 5.9.8 in the spaces provided. Sum these costs to arrive at a total cost of the 5.9 subcategory. Transfer this sum to the appropriate lines of the TCBS matrix (Part D).

Year

5.9.7 Specific Applications Programs

19____

Description	Est. Course Hours	Hours to Revise/ Prepare	Personnel Costs	+ Non-Personnel Costs	= Total Costs	GFE (✓)
a.			$	$	$	
b.						
c.						
d.						
e.						
					$ (below)	

5.9.8 Other Computer-Administered Instructional Materials

a.			$	$	$	
b.						
c.						
d.						
e.						
					$ (below)	

Total Computer-Administered Instructional Materials Costs (5.9)

Drill & Practice (5.9.1)	$
Simulation (5.9.2)	
Games (5.9.3)	
Tutorial (5.9.4)	
Problem-Solving (5.9.5)	
Inquiry (5.9.6)	
Specific Applications Programs (5.9.7)	
Other Computer-Administered Instructional Materials (5.9.8)	
Total 5.9	$ (To Part D p. 65)

Tests: In the broadest sense, tests are materials presented to targeted individuals or groups in order to measure their status with respect to a specified domain of behavior. The tests may be direct, the behavior sampled is from the domain, e.g., the student must actually change a tire. On the other hand, the tests may be indirect, e.g., the student describes by paper and pencil how he would change a tire. In instruction, these materials sample student performance during or at the end of a learning sequence. They may be used solely to diagnose current level of achievement or they may be used in addition to prescribe sequences of instruction. If used strictly for diagnosis, the test items are usually presented without feedback of correct answers.

Paper and Pencil: These are verbal materials. Generally these materials form an indirect measure of the student's level of knowledge or comprehension. The student writes answers to an item by choosing from among alternatives, constructs a short answer to complete a sentence, or writes an essay. The inference is made that achievement on these items provides a valid and reliable index for predicting achievement in the criterion environment (e.g., job proficiency).

Performance Tests: Materials are those with which the student has to do something, e.g., non-verbal. They are generally of two types: (1) intermediate or indirect--in which the student manipulates symbols, patterns, or physical items said to be correlated with some desired performance not readily measured in a testing environment; or (2) job-sample (direct)--in which the student is given portions of job-tasks to perform. These tasks are representative, critical to job-performance, or both.

5.10 Other Instructional Methods/Materials

Year 19____

Description	Est. Course Hours	Hours to Revise/ Prepare	Personnel Costs +	Non-Personnel Costs =	Total Costs	GFE (✓)
a.			$	$	$	
b.						
c.						
d.						
e.						
					$	

(To Part D p. 65)

5.11 Tests

5.11.1 Paper and Pencil

a.			$	$	$	
b.						
c.						
d.						
e.						
					$	

(To p. 51)

5.11.2 Performance Tests

a.			$	$	$	
b.						
c.						
d.						
e.						
					$	

(To p. 51)

Computer-Supported Testing: If a test is administered at a display device connected to a computer (a terminal), the test is said to be administered on-line. If it is administered manually by paper and pencil or by performing tasks on devices or equipment not connected to the computer, the test is said to be administered off-line. The support roles of the computer can include any or all of the following: (a) to store and retrieve banks of test items, allowing effecient generation of numerous alternate test forms; (b) to score and print out results of the test administrations; (c) to maintain testing records for purposes of test validation and/or student diagnosis and prescription; and (d) to administer tests on-line.

Total Test Preparation Costs: Enter total costs obtained in subcategories 5.11.1 thru 5.11.4 in the spaces provided. Sum these costs to arrive at a total cost of the 5.11 subcategory. Transfer this sum to the appropriate line of the TCBS matrix (Part D).

5.11.3 Computer-Supported Testing

Year 19____

Description	Est. Course Hours	Hours to Revise/ Prepare	Personnel Costs +	Non-Personnel Costs =	Total Costs	GFE (✓)
a.			$	$	$	
b.						
c.						
d.						
e.						
					$ (below)	

5.11.4 Other Tests

a.			$	$	$	
b.						
c.						
d.						
e.						
					$ (below)	

Total Test Preparation Costs (5.11)

Paper & Pencil (5.11.1)	$
Performance Tests (5.11.2)	
Computer-Supported Testing (5.11.3)	
Other Tests (5.11.4)	
Total 5.11	$ (To Part D p. 65)

SYSTEM MANAGEMENT

This category includes the management effort costs expended in the process of operating, maintaining and supporting the operational computer-based training system. It includes costs associated with program management, etc.

EXAMPLE

6. SYSTEM MANAGEMENT

6.1 Program/Project Management

Description	Personnel Hours	Personnel Costs	Non Personnel Costs	Total Costs	GFE (+)
a. Program Management	160	$5,549	$ -	$5,549	
b. Project Direction	400	12,468	-	12,468	
c.					
d.					
e.					
				$18,017	

Program/Project Management: This subcategory contains costs for planning, directing, and controlling the operation and maintenance of a system and assuring that planning is accomplished by organizations responsible for the complementary functions of logistics and maintenance support, personnel training, operational testing, activation, or deployment of a system.

Year

6. SYSTEM MANAGEMENT

6.1 Program/Project Management

19 _____

Description	Personnel Hours	Personnel Costs	Non-Personnel Costs	Total Costs	GFE (✓)
a.		$	$	$	
b.					
c.					
d.					
e.					
				$	

(To Part D p. 66)

6.2 Other Direct Management Costs

a.		$	$	$	
b.					
c.					
d.					
e.					
				$	

(To Part D p. 66)

OTHER DIRECT COSTS

This category contains elements which are not covered in other categories. Costs related to travel, supplies, consultants, contracts and subcontracts, etc., not identified otherwise are represented here.

EXAMPLE

7. OTHER DIRECT COSTS

7.4 Contracts/Subcontracts

Description	Cost
Technical Advisory Service: Validation of Instruction (Instructional Technology Corporation)	$ 38,481
	$ 38,481

Supplies: This subcategory consists of all expendable supplies directly employed in the operation and maintenance of the computer-based training system.

Travel: Included in this subcategory are all transportation costs, per diem costs, etc., required for system operation and maintenance.

Consultants: This subcategory includes costs associated with unique personal services required in the direct operation and maintenance of the computer-based training system, arranged for by the prime contractor or Government or other sponsor.

7. OTHER DIRECT COSTS

7.1 Supplies

Year 19 ____

Description	No. Units	x	Unit Cost	=	Total Cost	GFE (✓)
a.			$		$	
b.						
c.						
d.						
e.						
					$	

(To Part D p. 66)

7.2 Travel

Description	Cost
	$
	$

(To Part D p. 66)

7.3 Consultants

	$
	$

(To Part D p. 66)

Contracts/Subcontracts: This subcategory includes materials and services to be supplied by private firms/institutions/organizations, for the direct operation and maintenance of the computer-based training system. These are arranged or contracted for by the prime system contractor, or by the Government or other sponsor.

7.4 Contracts/Subcontracts

Description	Year 19 ____ Cost
	$
	$

(To Part D p. 66)

7.5 Other Direct Costs

	$
	$

(To Part D p. 66)

Part D

TRAINING COST BREAKDOWN STRUCTURE (TCBS) MATRIX

Part D

TRAINING COST BREAKDOWN STRUCTURE (TCBS) MATRIX

In this part of the specification, a matrix is provided for entering total yearly costs of operating and maintaining the computer-based training system. For purposes of obtaining total Operation and Maintenance costs, the element costs shown in Part C are to be summed for each subcategory and entered into the appropriate row of the TCBS matrix. All costs should be presented in the year expended. As noted in Part B, General Costing Assumptions and Definitions, all costs should be expressed in constant dollars (using the present year as the base year). Total costs for each category are to be calculated and entered for each year. These total category costs are then to be summed to arrive at total Operation and Maintenance costs for each year covered in this Phase of the system's life cycle.

TRAINING COST BREAKDOWN STRUCTURE (TCBS) MATRIX
OPERATION AND MAINTENANCE PHASE

		YEAR							
		19___	19___	19___	19___	19___	19___	19___	19___
1. Equipment									
1.1	Computer(s)	$	$	$	$	$	$	$	$
1.2	Terminal(s)								
1.3	Auxiliary Audiovisual Devices								
1.4	Auxiliary Memory								
1.5	Local Interfaces								
1.6	Telephone Lines								
1.7	Special Lines								
1.8	Satellites								
1.9	Receivers								
1.10	Power Generating Equipment								
1.11	Carrels								
1.12	Replacement Spares and Repair Test Equipment								
1.13	Other Equipment								
TOTAL EQUIPMENT COSTS		$	$	$	$	$	$	$	$

		YEAR							
		19___	19___	19___	19___	19___	19___	19___	19___
2. Facilities									
2.1	Classrooms	$	$	$	$	$	$	$	$
2.2	Laboratories								
2.3	Large Group Instruction Spaces								
2.4	Offices								
2.5	Individual Learning Spaces								
2.6	Libraries & Other Info. Resource Ctrs.								
2.7	Other Facilities								
	TOTAL FACILITIES COSTS	$	$	$	$	$	$	$	$
3. Software									
3.1	Systems Programs	$	$	$	$	$	$	$	$
3.2	General Applications Programs								
3.3	Diagnostic/Test Programs								
3.4	Utility Programs								
3.5	Other Computer Programs								
	TOTAL SOFTWARE COSTS	$	$	$	$	$	$	$	$

	YEAR							
	19__	19__	19__	19__	19__	19__	19__	19__
4. Instructional System Development (ISD) Activities								
4.1 Implement (Phase IV)	$	$	$	$	$	$	$	$
4.2 Control (Phase V)								
4.3 Other Instructional System Development (ISD) Activities								
TOTAL INSTRUCTIONAL SYSTEM DEVELOPMENT (ISD) ACTIVITIES	$	$	$	$	$	$	$	$
5. Instructional Methods/Materials								
5.1 Audio	$	$	$	$	$	$	$	$
5.2 Audiovisual								
5.3 Film/Text/Visual								
5.4 Lecture/Demonstration								
5.5 Group Discussion/Seminar								
5.6 Performance/Practice								
5.7 Tutoring (peer or other)								
5.8 Printed Text/Visual								
5.9 CAI Materials								
5.10 Other Instructional Methods/Materials								
5.11 Tests								
TOTAL INSTRUCTIONAL METHODS/ MATERIALS COSTS	$	$	$	$	$	$	$	$

	YEAR							
	19 ___	19 ___	19 ___	19 ___	19 ___	19 ___	19 ___	19 ___
6. System Management								
6.1 Program/Project Management	$	$	$	$	$	$	$	$
6.2 Other Direct Management Costs								
TOTAL SYSTEM MANAGEMENT COSTS	$	$	$	$	$	$	$	$
7. Other Direct Costs (Not Included Above)								
7.1 Supplies	$	$	$	$	$	$	$	$
7.2 Travel								
7.3 Consultants								
7.4 Contracts/Subcontracts								
7.5 Other Direct Costs								
TOTAL OTHER DIRECT COSTS	$	$	$	$	$	$	$	$
Total Operation and Maintenance Costs	$	$	$	$	$	$	$	$

Part E

TRAINING EFFECTIVENESS ASSUMPTIONS AND DEFINITIONS

Part E

TRAINING EFFECTIVENESS ASSUMPTIONS AND DEFINITIONS

In this section of the specification, guidance, definitions, and procedures are provided for the measurement of training system effectiveness. A general discussion of evaluation and effectiveness is followed by definitions of terms used in this specification. Effectiveness measures are described and procedures recommended for acquiring this information.

EVALUATION OF TRAINING EFFECTIVENESS

The purpose of evaluating training is two-fold: (1) to continuously improve the program being evaluated; (2) to decide if a given training program is to be continued or adopted. Data needed for both purposes should be related to the two sets of training goals which exist for a given course: end-of-course objectives, and job requirements for which the student is being trained. Training effectiveness information should be collected to determine the degree to which these training goals are achieved.

The first type of information should describe the ability of a course graduate to perform acceptably those tasks which the instructional program claims to teach. In most instances, these training effectiveness assessments can be made at the school or training site. The second type of training effectiveness data deals with the discrepancies between graduate performance and job requirements. This information describes whether or not the instructional program teaches appropriate subjects or tasks, and whether or not the student can transfer these capabilities to the field.

As there are no unequivocal results from delayed types of evaluation, the training effectiveness of a course can be assessed most meaningfully by obtaining the required measurements (e.g., student achievement) immediately following course completion. These measurements reflect the validity or relevancy of the training only to the extent that they are related to job requirements. If training effectiveness measurements cannot be taken immediately following course completion, then they should be obtained as soon as possible from the job or operational setting.

- Evaluation. Evaluation has as its major characteristic the determination of value, worth, or merit. It has a more general meaning than effectiveness. While training effectiveness data can be used as the basis for evaluative decisions, all data gathered for evaluation purposes are not necessarily related to effectiveness.

- Formative Evaluation. When evaluation procedures are used for course improvement, they are categorized as "formative." Therefore, formative evaluation is that process which validates instruction during ongoing initial program development. This formative process may occur during the Development Phase and/or the Operation and Maintenance Phase of the computer-based training system life cycle. Its purpose is to diagnose and correct the weaknesses of a program. The results of this evaluation are acted upon immediately in program modification. One may be concerned with the differential contribution of each of the instructional components to the total effectiveness of the course. The training effectiveness of individual course sections can be examined by the use of measures and techniques designed specifically for this purpose. (For example, achievement or time measures for intermediate, within-course criteria.) These measures may not be, and in many cases, should not be, the same as those needed for judging the effectiveness of the total course.

- Summative Evaluation. This type of evaluation is performed for the purpose of assessing a fully implemented training program with respect to its ability to produce graduates who can perform to minimum standards of performance. In this evaluation, the criteria of effective training may be external to the system. Only after the course has been established as producing successful graduates can the criteria of reenlistment, or transfer to a job or to another course, be applied. In addition, a summative evaluation can determine whether or not efficient and effective use was made of educational resources. Summative evaluation should occur *after* instructional development, improvement, and stabilization of operational and administrative activities. The results of such an evaluation are of primary concern to those who will decide whether or not a program is to be continued or adopted. It, therefore, provides the basis of policy decisions that do not necessarily concern revision of a program or a product. Once the success of the computer-based curriculum is established, comparisons can then legitimately be made between it and other means of producing successful graduates (i.e., conventional lock-step instruction or other means of self-paced instruction). This type of evaluation generally will occur during the Operation and Maintenance Phase.

- Training Effectiveness. This term refers to the specific effects that training has on the students who receive instruction. These effects are usually measured in terms of the time it took students to reach given training goals/objectives, and/or in the levels of achievement reached. Training effectiveness data should be collected to determine the degree to which a training course or system achieves its established goals. This can only be done by evaluating the graduates of the training program. Effectiveness relates to the broader concept of evaluation in that the effects of training are judged as desirable or undesirable by reference to the goals and objectives of the training program.

- Training Efficiency. This term refers to the amount of knowledge or skill gained in relation to the amount of time spent in achieving the gain. Thus, for example, a student who attains mastery within one hour is twice as efficient as the student who reaches mastery in two hours.

Course efficiency refers to the number of students who successfully achieve training goals per unit time or within given training resources.

TRAINING EFFECTIVENESS MEASURES

Several types of measurements for assessing training effectiveness are possible. Foremost among these are direct measures of student achievement which reflect attainment of course goals and learning objectives. These measurements can be in terms of test scores, gain scores, time to achieve mastery, number of objectives mastered, etc. The specific measurements selected should correspond to the requirements as stated in each course's training objectives.

Effectiveness measures may be either short term or long term. Short-term measures can reflect the attainment of intermediate goals within a course, as well as final goals, such as end-of-course achievement. Long-term measures are designed to assess the transfer of the effects of training to other environments.

In the ideal case, the effectiveness of a training program should be evaluated from the viewpoint of long-term as well as short-term criteria measures. However, many intervening factors and events, as well as attitude changes, can take place and effect the long-term measures, totally unrelated to the course of instruction.

As it is usually impractical to account for these intervening factors, the validity of long-term measures decreases the longer these measures are separated in time from the training that is being evaluated.

Therefore, for most uses of this specification, the training effectiveness of a course should be assessed immediately upon completion of that course. Tests administered at that time are the most direct and relatively unconfounded measures of training effectiveness.

Other measurements that might be taken which could reflect attainment of training program goals can be categorized as: attitude and other affective measures; ratings of achievement (student and/or instructor); and unanticipated secondary effects. It is important to look at as many meaningful outcomes of a program as possible even if they were not anticipated in the program's stated goals and objectives. It is highly probable that if the course goals and objectives were stated completely, an absence of negative side effects would be desired and, in many cases, insisted upon by the training developers.

To describe the overall training effectiveness of a course or training system, the individual student measurements need to be accumulated and summarized. Measures of central tendency (e.g., means, medians, modes), ranges, frequencies and other descriptive statistical indices can be used for this purpose.

Once measurements have been made and summarized, the resulting data must be compared with standards or criteria which reflect the training

goals. Thus, the units of measurement must correspond to the units of the criterion for each training effectiveness dimension.

- Absentee Rates. This measure refers to the average percentage of students who are not present for training on any given day for each course.

- Accuracy Scores. Accuracy scores indicate the level of achievement reached within certain tolerances on specific scales. These scores reflect the quality or precision of performance. Such scores can be described in terms of the number of positive instances (correct items) or the number of errors made on a given scale.

- Achievement Measures. These measures either reflect student achievement or within-course enabling objectives or assess end-of-course proficiency. In order for this kind of assessment to be possible, the objectives must be explicitly stated and translated into performance or behavioral terms. Examples of such achievement measures would be scores on criterion-referenced tests related to objectives, or gain scores taking into account the initial proficiency level of each student. Additional scores that can be used to describe a student's level of achievement are: number of objectives mastered, skill level attained, etc. All of these would be objective-based achievement scores. Normative (norm-referenced) test scores, or a student's class standing are achievement scores that are used when comparing each student's performance with that of the class as a whole. If achievement scores are used to compare the effectiveness of different training programs, a considerable effort should be undertaken to identify the differences that may exist in training objectives and/or student population characteristics.

Objective achievement or performance tests are the best means of measuring training effectiveness. These tests contain items or tasks which cannot be answered or performed correctly without the benefit of training. Thus, they reflect directly on training effectiveness.

Paper-and-pencil tests can be used to acquire data on achieved level of job knowledge. Such tests are used for obtaining data on student proficiency at recall or recognition of facts, principles, or procedures, and in the application of such knowledges.

Performance tests consist of systematic observation and scoring of the performance of students in test situations which sample actual job operations and requirements. This can occur in either the actual or simulated job environment. Performance tests are most appropriate for evaluating the effectiveness of technical skill training.

Computer-supported tests consist of those tests that are administered by the computer and/or require the student to input responses on-line.

Subjective measures yield data based on opinions about the proficiency of the student/graduate, rather than direct measurements of skill or knowledge. Though not as informative and useful as objective measures,

subjective measures and instruments often provide the only practical means for assessing training effectiveness. *Questionnaires, checklists, rating scales,* and *interviews* are often used when testing is inappropriate or not feasible.

- Attitude Scales. These are subjective, indirect measures of training effectiveness. They are designed to elicit the opinions of students regarding their positive or negative feelings about the course, method of instruction, or other related matters. They can be used as indicators of the emotional states of students, instructors, or others. These measures can point to possible training problems and provide a basis for interpreting the proficiency scores attained in the course.

- Attrition Rates. This measure refers to the percentage of students who fail to meet the within-course or end-of-course criteria and are dropped from the training program. It also includes those students who voluntarily leave the training program for reasons other than academic failure.

- Criteria. Prior to making any cost-effectiveness decision (i.e., prior to a decision that the effectiveness attained in a given course of instruction was worth the investment in dollars), the *decision maker must set effectiveness criteria.* Priorities should be established among the various measures as to their importance in assessing training effectiveness. Whether the measures are objective-related or norm-referenced, the achievement scores of individual students or graduates must be appropriately summarized to describe overall course effectiveness. If means or other measures of central tendency are used to reflect training effectiveness, then similar criterion values need to be established.

- Criterion-Referenced Tests. This type of effectiveness measurement is used when performance by a student is to be evaluated against empirically or rationally established standards. The performance standard is usually derived from an analysis of the job skills for which training is designed. There can be paper-and-pencil, as well as performance-based criterion-referenced tests. Criterion-referenced tests are usually contrasted with norm-referenced measures in which one is interested in how individuals compare with each other. Criterion-referenced tests can indicate the degree of achievement of a student by specifying the number or percentage of objectives attained.

- Gain Scores. These scores refer to the difference between scores on a pre-test taken prior to a course of instruction and scores on an equivalent post-test following a given course of instruction. The gain (difference between pre- and post-tests) is said to be the measure of effectiveness. One weakness in this type of measure stems from the fact that the absolute amount that can be gained by a student is a function of his initial level in the skill being measured. Therefore, it is not a sufficient measure unless students enter the program with relatively low levels of the skill for which they are being trained.

- Mastery. Generally, this term means achievement of all requirements to exhibit expertise in a given course of instruction. In practical terms, it is often used to mean achievement of the required number of objectives at a minimally acceptable level of performance. If instructional decisions are made on a "go/no-go" basis (achievement or not) per course objective, then mastery is defined as meeting the required number of "go" decisions in order to complete the course.

- Norm-Referenced (Normative) Tests. These tests are generally used to indicate relative standing among members of a given student population. They are often set in opposition to criterion-referenced tests which are used to measure individual student achievement against established standards.

- Ratings. Ratings are indirect, subjective measures of effectiveness. While ratings have the advantage of being easily obtained, they often have low reliability and validity. As ratings are indirect measures of performance, they are less valid than direct measures. It is often difficult to obtain consistent ratings over time from the same individual, and from several raters at the same time (inter-rater reliability) without training the raters.

- Recycles (Washbacks). This term refers to the number or percentage of students who are forced to go through all or a portion of a course more than once, based upon failure to achieve that course section's required objectives in a specified amount of time. These students are then recycled through the instruction and given an opportunity to take the criterion test(s) again.

- Reenlistment Rates. This long-term measure refers to the percentage of personnel who voluntarily extend beyond their initial tour of duty for another period of military service. However, reenlistment can be a function of many variables extraneous to the training program.

- Reliability. Measures of training effectiveness should be selected on the basis of their potential for obtaining reliable and valid data. Reliability refers to the consistency, or repleicability of the data that are collected. It is not possible to determine the validity of data unless the data are reliable.

- Speed Scores. This term refers to the rate of acceptable task performance. If time or speed of performance is the standard for certain training objectives, then a measure of training effectiveness must reflect this criterion dimension. If a task must be performed in a given time, a possible effectiveness measure to use could be the number of students who perform acceptably in that time. Another speed score could be the number of steps or activities in a task that are completed by a certain percentage of students by a given time. In either case, the scores used to measure training effectiveness must reflect the training objectives and criteria.

- Throughput. This measure refers to the number of students passing a within-course requirement per unit time, or the number of students completing the course per unit time. In this sense, it is an index of the efficiency of a training program.

- Time Measures

Course Time. This measure refers to the total number of hours, days, weeks or other time units a student spends in a given course in order to reach mastery of the required objectives. It represents the sum of training time and testing time--see below.

Training Time. This measure represents the time actually spent in learning the subject matter and practicing the skills to be acquired. It does not contain time devoted to non-academic subjects, in- and out-processing, and other activities unrelated to the instruction. Training time should include any self-study, remedial or recycle time, even if these times are not officially prescribed.

Testing Time. This measure represents the time spent in taking criterion tests. It includes all the time spent in taking tests that are graded--tests that determine if a student has attained the training objectives of the course. Testing time does not include time spent in skill practice, practical exercises, or quizzes that are part of the instruction or training time.

- Transfer. A transfer measure of effectiveness is any score (time, trials, errors, etc.) obtained on tasks performed subsequent to course completion. The transfer measures are taken after the student attains the required objectives within a course. These measures can be relatively immediate and refer to achievement in another course. Or, they can refer to initial job performance following the completion of a course. One possible index of transfer effects that could be used is:

Percent Transfer. The criterion value (time, trials, errors, etc.) that is reduced as a result of relevant prior training. This is expressed as a percentage of what the criterion value would be without such prior training.

On a longer term basis, transfer can refer to overall job effectiveness in terms of such performance measures as Army SQTs, or the Air Force's ATC Field Follow-Up measures. Other job performance data can include: supervisor ratings, work productivity measures, absenteeism and tardiness rates, etc. Transfer can also refer to the relationship of course achievement to attitudes. For example, it could refer to effects of course success or failure on reenlistment rates, career development pattern, or general attitudes toward the Service.

- Unanticipated Secondary Effects. Sometimes used as training effectiveness measures are serendipitous effects that are not directly related to stated or established training goals. A positive side effect, for example, may be increased independent study by a graduate as a result of his positive experience within a course. An example of a negative

side effect might be an increase in AWOL or disciplinary problems due to the lack of sufficient supervision.

• Validity. Training effectiveness data are valid if they accurately reflect the degree of achievement of course goals. The instruments used to measure effectiveness must be carefully selected in order that validity and reliability of the data are maximized. This is particularly difficult with subjective measures such as attitude scales or ratings. Also, valid data are obtained only if the person being evaluated reacts in a normal manner when tested. Objective data gathering measures (e.g., performance tests) are better at eliciting "normal"and, therefore, valid reactions, than are subjective measures (e.g., ratings).

TRAINING EFFECTIVENESS DATA: WITHIN-COURSE MEASURES

(1) **Course**_____

(2) **Section No.**_____

Time Measures

(3) AVERAGE TRAINING TIME

	Hours	N
Audio		
Audiovisual		
Film/Text/Visual		
Lecture/Demonstration		
Group Discussion/Seminar		
Performance/Practice		
Tutoring		
Printed Text/Visual		
Other		

	Hours	N
CAI: Drill & Practice		
Simulation		
Games		
Tutorial		
Problem-Solving		
Inquiry		
Specific Applications Programs		
Other CAI Materials		
CAI Materials (Total)		

(A) **Average Training Time in Section No.**_____

(To Summary Form) (page 85)

(4) AVERAGE TESTING TIME

	Hours	N
Paper and Pencil Tests		
Performance Tests		
Computer-Supported Tests		
Other Tests		

(B) **Average Testing Time in Section No.**_____

(To Summary Form) (page 85)

(5) AVERAGE SECTION TIME

Make as many copies as required for the number of Sections of the Course.

(A) + (B)

(To Summary Form) (page 85)

(6) Enter the criterion test results used to measure achievement of this Section's instructional objectives. These data should represent the scores and results obtained from students' first attempts at the criterion tests. (Identify the specific tests being reported.)

(a) If accuracy or speed scores are used to measure performance, enter the average scores in the appropriate space.

(b) In those Course Sections where the achievement measure is the number of objectives attained, enter the average number of objectives achieved in the appropriate space.

(c) Enter the percentage of students who pass this Section's criterion tests on their first attempt.

(d) If the measures of achievement used in this Section are gain scores (differences between pre- and post-tests), enter the average gain score in the appropriate space.

(7) Enter the average number of attempts taken to pass the criterion tests on this Course Section.

(8) In this part of the form, enter other data deemed important for describing the training effectiveness of this Section of the Course. Affective data (e.g., student attitudes), indirect measures such as instructor ratings, as well as other measures used, should be described and the findings listed.

TRAINING EFFECTIVENESS DATA: WITHIN-COURSE MEASURES *(Continued)*

Achievement Measures

⑥ SECTION No._____ – AVERAGE CRITERION TEST RESULTS (First Attempt)					⑦
Tests	(a) Accuracy/Speed Scores	(b) No. Objectives Passed	(c) Percent Students Passed	(d) Gain Scores	Number of Attempts
Paper and Pencil:					
Performance:					
Computer-Supported:					
Other:					

(To Summary Form)
(page 85)

⑧

SECTION No._____ – Other Effectiveness Measures

Recycle Rate_____

Instructor Ratings

Student Attitudes

Other

(To Summary Form)
(page 85)

Make as many copies as required for the number of Sections of the Course.

WITHIN-COURSE
TRAINING EFFECTIVENESS DATA SUMMARY

INSTRUCTIONS FOR ENTERING WITHIN-COURSE TRAINING EFFECTIVENESS SUMMARY DATA

In this form you are to summarize the within-course training effectiveness data listed on the preceding forms. If only within-course data are available, these totals can represent the overall effectiveness of this Course.

(1) Print title of Course.

(2) Enter the Section Number in the appropriate space. If you need more than one line to enter the summary data for a given Section, put that number in all the applicable spaces.

(3) Enter the Average Training Time spent in each Section of the Course in the spaces provided. Copy the (A) times from the preceding forms.

(4) Enter the Average Testing Time spent in each Section of the Course in the spaces provided. Copy the (B) times from the preceding forms.

(5) Enter the Average Section Time in the spaces provided. Copy these times (A) + (B) from the preceding forms.

(6) Enter the results from first attempts at the criterion test in each Section of the Course. These data indicate the level of performance achieved in each Section. In some Sections, only one type of achievement test data may be listed. In these cases, copy the data into the spaces provided. If more than one test is used to measure criterion performance, determine each student's grade in the Section by weighting and combining the separate test scores. Enter this weighted average score or Section grade in the summary form. If it is not possible to combine such scores, enter them on separate lines--thereby using more than one line per course Section.

(7) Enter the average number of attempts to pass the criterion test(s) for each Section of the Course.

(8) Enter any other training effectiveness data obtained in each Course Section in the spaces provided.

TRAINING EFFECTIVENESS DATA SUMMARY
WITHIN-COURSE MEASURES

(1) **Course**_____

(2) Course Section (Enter Number)	Time			(6) Achievement					
	(3) Training	(4) Testing	(5) Section Total	Accuracy/ Speed Scores	Number Objectives Passed	Percent Students Passed	Gain Scores	(7) Number of Attempts	Recyc Rat
Overall Course		(Totals)		(Average)	(Total)	(Average)	(Average)	(Average)	

Make as many copies as required for the number of Courses.

NG EFFECTIVENESS DATA SUMMARY
WITHIN-COURSE MEASURES

(6) Achievement				(8) Other			
Number Objectives Passed	Percent Students Passed	Gain Scores	(7) Number of Attempts	Recycle Rate	Instructor Ratings	Student Attitude	Other
(Total)	(Average)	(Average)	(Average)	(Averages)			

Make as many copies as required for the number of Courses.

2

Part G

END-OF-COURSE TRAINING EFFECTIVENESS DATA

INSTRUCTIONS FOR ENTERING END-OF-COURSE TRAINING EFFECTIVENESS DATA

In this part of the specification, recording forms are provided for you to enter data on training effectiveness for the Course as a whole. A Course may be self-paced and achievement criteria fixed, or course time may be fixed, and achievement allowed to vary, or there may be a combination of both situations. End-of-course training effectiveness data can be entered on this form for any of these cases. MAKE A COPY OF THE RECORDING FORM ON PAGES 89, 91, AND 93 FOR EACH COURSE CONSIDERED. If only within-course data (by Section) are available, use the summarized data in the form at the end of Part F and go to Part H for further cost-effectiveness analysis.

(1) Print title of Course.

(2) Enter the average training time spent by students in each instructional method/mode used in this Course. *These time data should be the sums of the time data listed in Part F for each Section of this Course.* This information should represent the time actually spent in learning the subject matter. It should not contain Course time that is unrelated to this function (e.g., non-academic subjects, in- and out-processing, etc.). In the cases where these times are officially prescribed, care should be taken to include additional self-study and recycle time, if relevant. Enter average training times to the nearest tenth of an hour, along with the number of students (N) from whom the data were obtained. Then add these times together to obtain the Average Training Time in this Course (A) .

(3) Enter the average time spent by students taking the criterion tests within this Course. Do not include the time spent in quizzes and practical exercises that are part of the instruction. Rather, that time should be included in (2) above. This entry should include the time spent in tests that are graded--tests which are designed to assess whether or not students have attained the instructional objectives of this Course. These times should include both within-course and end-of-course tests. *The time data should be the sums of the time data listed in Part F for each of the Sections in this Course, PLUS the time spent by the students in the final or end-of-course criterion tests.* Enter the average testing times (to the nearest tenth of an hour) in the space beside the applicable test form category, along with the number of students (N) from whom the data were obtained. Then add these times together to obtain the Average Testing Time in this Course (B) .

(4) Sum the Average Training and Testing Times (A) and (B) to obtain the Average Course Time.

TRAINING EFFECTIVENESS DATA: END-OF-COURSE MEASURES

(1) **Course**_____

Time Measures

(2) AVERAGE TRAINING TIME

	Hours	N
Audio		
Audiovisual		
Film/Text/Visual		
Lecture/Demonstration		
Group Discussion/Seminar		
Performance/Practice		
Tutoring		
Printed Text/Visual		
Other		

	Hours	N
CAI: Drill & Practice		
Simulation		
Games		
Tutorial		
Problem-Solving		
Inquiry		
Specific Applications Programs		
Other CAI Materials		
CAI Materials (Total)		

(A) Average Training Time in Course _____

(3) AVERAGE TESTING TIME

	Hours	N
Paper and Pencil Tests		
Performance Tests		
Computer Supported Tests		
Other Tests		

(B) Average Testing Time in Course _____

(4) AVERAGE COURSE TIME

_____

(A) + (B)

Make as many copies as required for the number of Courses.

(5) Enter the final criterion test results used to measure achievement of this Course's instructional objectives. These data should represent the scores and results obtained from students' first attempts at the end-of-course criterion tests.

(a) If accuracy or speed scores are used to measure performance, enter the average scores in the appropriate spaces.

(b) In those Courses where the achievement measure is the number of objectives attained, enter the average number of objectives achieved in the appropriate space.

(c) Enter the percentage of the students who pass this Course's end-of-course criterion tests on their first attempt.

(d) If the measures of achievement used in this Course are gain scores (differences between pre- and post-tests), enter the average gain score in the appropriate space.

(6) Enter the average number of attempts taken to pass the end-of-course criterion test(s).

(7) In this part of the form, enter other summarized data deemed important for describing the training effectiveness of this Course. Attrition and absentee rates, affective data (e.g., student attitudes) indirect measures such as instructor ratings, as well as other measures used, should be described and the findings listed.

TRAINING EFFECTIVENESS DATA: END-OF-COURSE MEASURES *(Continued)*

Achievement Measures

⑤ FINAL CRITERION TEST RESULTS (First Attempt)					⑥
Tests	(a) Accuracy/Speed Scores	(b) No. Objectives Passed	(c) Percent Students Passed	(d) Gain Scores	Number of Attempts
Paper and Pencil:					
Performance:					
Computer-Supported:					
Other:					

⑦

Other Effectiveness Measures

Absentee Rate _____ Recycle Rate _____

Attrition Rate _____

Instructor Ratings

Student Attitudes

Other

Make as many copies as required for the number of Courses.

⑧ Transfer Measures

Enter actual or estimated data that reflect the transfer effects attributed to the training provided in this Course. In all cases, enter average values. This information can come from subsequent course records, job performance tests, field feedback records, etc.

Try to isolate the influence of training in this Course from other intervening events (e.g., job experience, etc.). Collect these data as soon after Course completion as possible. If data are estimates, place (E) after the entry.

TRAINING EFFECTIVENESS DATA: END-OF-COURSE MEASURES *(Continued)*

⑧ Transfer Measures

Time to Complete Subsequent Course _____

Achievement Score in Subsequent Course _____

Job Performance

Time to be Job Qualified _____

Test Score(s) _____

_____

Work Productivity Measure _____

_____

Ratings – Self _____

_____

Ratings – Supervisor _____

_____

Absentee Rate _____

Attitudes _____

_____

_____

Reenlistment Rate _____

Other _____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Make as many copies as required for the number of Courses.

Part H

COST-EFFECTIVENESS ANALYSIS GUIDANCE

Part H

COST-EFFECTIVENESS ANALYSIS GUIDANCE

In this part of the specification, the approach to be taken in analyzing the cost-effectiveness of computer-based training systems is described. The assumptions which underly this approach are discussed first and general guidance is presented for interpreting and applying the findings of this type of analysis.

When examining alternative systems, a reasonable cost-effectiveness analysis would compare the best estimates of future operation and maintenance costs and not include costs (for development, etc.) that were expended in the past. In the ideal case, one compares the cost-effectiveness of two alternative training systems when they are in their Operation and Maintenance Phase. Although comparisons are made between operational systems and alternatives that are still in their Development Phase, these comparisons can only be treated as hypothetical or "projected." The effectiveness data that are gathered while the system is under development can be influenced by many factors which would not occur in a more stable operational environment. This is particularly important to consider when a prototype hardware/software system is undergoing modification throughout the Development Phase. Thus, projected cost-effectiveness ratios that are calculated during the Development Phase should be treated with caution as they are subject to considerable error.

- An evaluation of cost-effectiveness can only be made following the assignment of value or priority judgments to the various dimensions of training effectiveness. These are to be established by the appropriate decision-maker and should reflect training requirements and goals.

- The specific criteria by which to compare the cost-effectiveness of alternate training systems need to be clearly established. If the efficiency of a computer-based system in aiding the development and revision of training materials is of prime importance, this aspect of the system can be assessed independently of its training effectiveness. Similarly, a system's efficiency in scheduling training resources and equipment, keeping records, etc., can be judged. However, even though these measures are important in determining the value of a computer-based system, they should not be considered the same as analyzing a system's cost-effectiveness when training effectiveness is of utmost concern.

- In the *absence of effectiveness criteria based upon job or training requirements,* indicators such as throughput should not be mistaken for evidence of training system quality. Rather, in these cases, such ratios (e.g., cost per student course hour) should be interpreted as what they are--efficiency measures.

- When comparing alternative training systems, identify a desired level of effectiveness and examine the costs of achieving that level. The cost-effective decision is to select the alternative with the lowest cost.

or

Designate the acceptable costs and determine the level of effectiveness that different training systems might reach assuming those expenditures. The cost-effective decision is to select the alternative which yields the best effects.

- If both costs and effectiveness levels are allowed to vary, one may fallaciously attempt to minimize cost and maximize gain at the same time. Thus, infinite effectiveness at zero cost becomes an ideal which is not tenable and should not guide the cost-effectiveness analysis.

- The problems associated with comparing alternative training systems which differ in costs and effectiveness are numerous. This is of particular importance when there are significant unanticipated benefits elicited by the more costly system (e.g., new skills are taught which can transfer to other training situations). Additional study is then needed to determine the value of such benefits. The higher cost alternative should be rejected if additional benefits do not justify the extra expense.

- In performing a cost-effectiveness analysis of a computer-based training system, one should consider all appropriate costs and benefits during the entire operational life of the system. In this way, "cost avoidance" factors (e.g., fewer instructional personnel or facilities, less training time, etc.) which may accrue over several years will be permitted to surface and balance the large initial capital investment costs of implementing a computer-based training system.

- Although this specification focuses on quantifiable cost-effectiveness data, a thorough analysis should consider these data in light of any effects (both positive and negative) which can only be described in qualitative terms.

- If training system alternatives are to be compared, such a comparison is meaningful only if the systems contain courses with similar objectives, content, testing conditions and criteria.

- If one wants to compare media within a course, cost-effectiveness estimates will be error-prone unless content, objectives, testing conditions, and criteria are equivalent.

- Do not use the cost-effectiveness ratios or relationships established in the analyses as evidence of causality.

- In order to attribute the effectiveness of a computer-based training system to its innovative instructional technology, one must tie the effectiveness measures (e.g., criterion achievement or time scores) to that portion of the course that is supported by this technology. If the portion of a course that is uniquely related to the innovation or method being evaluated cannot be identified, then by definition no conclusions can be drawn related to the efficacy or cost-effectiveness of that innovation or method.

Part I

COST-EFFECTIVENESS ANALYSIS CALCULATIONS

INSTRUCTIONS FOR CALCULATING COST-EFFECTIVENESS RATIOS

In this part of the specification, instructions and worksheets are provided for calculating cost-effectiveness ratios which can be used to evaluate a computer-based training system in its Operation and Maintenance Phase in comparison with alternative system(s). There are many alternative cost-effectiveness ratios which might be considered appropriate for particular applications. It is possible that several ratios will be required in order to make a decision concerning whether one system is better than another. This will require the decision maker to rate the relative importance of one measure of effectiveness over another and make comparisons between systems by calculating only those ratios using the most important measures.

The first two ratios are indices of efficiency and are useful as measures of a training system's cost-effectiveness--PROVIDED that training requirements have been established and graduation signifies attainment of these criteria. Following these ratios is a worksheet upon which to rate the importance of effectiveness measures.

① GRADUATION COST

This index provides the ratio of total dollars expended to produce a graduate for all Courses supported by the system. *If you are going to calculate a ratio for each Course separately, indicate this Course on the worksheet.*

$$\text{Total \# Graduates} = \text{Total \# Students}^{1} - \left[\text{Total \# Students}^{1} \times \text{Attrition Rate}^{2}\right]$$

[1] Total # Students From Part A, p. 3.
[2] Attrition Rate From Part G, p. 91.

$$\text{GRADUATION COST} = \frac{\text{Total Operation \& Maintenance Costs (p. 66)}}{\text{Total Number of Graduates (all Courses)}}$$

This ratio can be calculated by course, but there would need to be an appropriate allocation of Operation & Maintenance Costs to each Course supported by the system.

WORKSHEET FOR COST-EFFECTIVENESS CALCULATIONS

① GRADUATION COST

Check Course(s) Involved in Analysis

- ☐ Course _____
- ☐ Course _____
- ☐ Course _____
- ☐ All Courses

Total Operation & Maintenance Costs = $_____ (From page 66)

Total # Graduates = _____ (Total Students, From page 3) − [_____ (Total Students, From page 3) X _____ (Attrition Rate, From page 91)] = _____ (Total # Graduates)

(O & M Costs)

Graduation Cost = _____ = $_____ **/graduate**

(Total # Graduates)

---

① GRADUATION COST

Check Course(s) Involved in Analysis

- ☐ Course _____
- ☐ Course _____
- ☐ Course _____
- ☐ All Courses .

Total Operation & Maintenance Costs = $_____ (From page 66)

Total # Graduates = _____ (Total Students, From page 3) − [_____ (Total Students, From page 3) X _____ (Attrition Rate, From page 91)] = _____ (Total # Graduates)

(O & M Costs)

Graduation Cost = _____ = $_____ **/graduate**

(Total # Graduates)

② HOURLY COST OF INSTRUCTION

This index provides the ratio of dollars expended for each student hour in the Courses supported by the system. *If you are going to calculate this ratio for each Course or Course Section separately, indicate the specific Course and/or Section on the work sheet.*

To calculate the instruction hours for each Course use the following formula:

Total Course Hours = **Average Course Time**[1] x **# Students/ Course/Year**[2]

[1] Average Course Time From Part G, p. 89; or Part F Summary, p. 85.

[2] # Students/Course/Year From Part A, p. 3.

Total Instructional Hours = **Total Course Hours added together for all Courses supported by the system.**

$$\text{Hourly Cost of Instruction} = \frac{\text{Total Operation \& Maintenance Costs (p. 66)}}{\text{Total Instructional Hours (all Courses)}}$$

If this ratio is calculated by Course, use Total Course Hours in the denominator. However, Operation & Maintenance Costs then would need to be allocated to each Course supported by the system. This ratio can also be calculated by Course Section. Here too, Operation & Maintenance Costs would need to be appropriately allocated by Section. If this ratio is calculated by mode/medium of instruction (e.g., CAI portions only), then there is a need to allocate Operation & Maintenance Costs by type of instruction. This approach is practical only in Courses with Sections using a single mode/medium of instruction.

② HOURLY COST OF INSTRUCTION

- Course_____ Section_____

  Total Course Hours = _____ (Average Course Time) X _____ (Students/Year) = _____hours

- Course_____ Section_____

  Total Course Hours = _____ (Averate Course Time) X _____ (Students/Year) = _____hours

- Course_____ Section_____

  Total Course Hours = _____ (Average Course Time) X _____ (Students/Year) = _____hours

Total Instructional Hours (All Courses) = _____hours

Total Operation & Maintenance Costs (All Courses) = $_____ (From page 66)

(O & M Costs)

Hourly Cost of Instruction = $_____ = $_____

(Total Instructional Hours)

② HOURLY COST OF INSTRUCTION

- Course_____ Section_____

  Total Course Hours = _____ (Average Course Time) X _____ (Students/Year) = _____hours

- Course_____ Section_____

  Total Course Hours = _____ (Average Course Time) X _____ (Students/Year) = _____hours

- Course_____ Section_____

  Total Course Hours = _____ (Average Course Time) X _____ (Students/Year) = _____hours

Total Instructional Hours (All Courses = _____hours

Total Operation & Maintenance Costs (All Courses = $_____ (From page 66)

(O & M Costs)

Hourly Cost of Instruction = $_____ = $_____

(Tutal Instructional Hours)

③ COMPARISON OF EFFECTIVENESS MEASURES

In order to calculate the cost-effectiveness ratios that are most important to your analysis, the effectiveness measures specified in Part G* need to be rated in importance by the decision-maker.

Ⓐ List the end-of-course effectiveness scores to be used in decision-making (from Part G).

Ⓑ Estimate the "value" of each score by rating the importance of each measure based on the system's or Course's training requirements. (Place a rating of 1 to 10 in the space provided—10 being most important.)

Cost-effectiveness ratios can then be calculated for each of the "most important" measures before considering some of the other effectiveness scores.

For example, if the Achievement level attained as reflected by Accuracy Scores is the most important measure of training effectiveness, then it should be the basis for comparing alternative training systems. Cost-effectiveness comparisons can be made using this indicator (assuming costs are held constant); or if achievement scores are held constant, then training systems can be compared with regard to the costs required to reach this level of achievement.

*Part F Summary, if Part G not available.

WORKSHEET FOR COST-EFFECTIVENESS CALCULATIONS

③ Ratings of Effectiveness Measures

Course _____

	(A) End-of-Course Effectiveness Scores (From Part G, pp. 89, 91 & 93)*	(B) Ratings of Importance (1-10, 10 = Most Important)
Time Measures		
Average Course Time		
Achievement Measures		
Accuracy/Speed Scores		
Number Objectives Passed		
Percent Students Passed		
Gain Scores		
# Attempts to Pass Criterion Test		
Other Measures		
Absentee Rates		
Attrition Rates		
Recycle Rates		
Instructor Ratings		
Attitude Scores		
Other		
Transfer Measures		
Subsequent Course Time		
Subsequent Course Achievement		
Job Performance - Time to Qualification		
Job Test Scores		
Work Productivity		
Self-Ratings		
Supervisory Ratings		
Absentee Rates		
Attitudes		
Reenlistment Rate		
Other		

*Part F Summary, if Part G not available

Make as many copies as required for the number of Courses.