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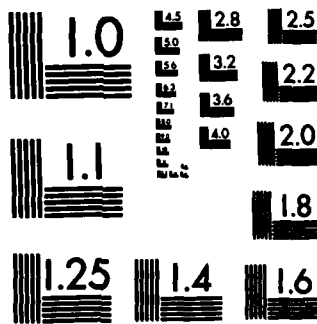
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RESEARCH REPORT 84-15

ECONOMIC
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HANDBOOK

JUNE 1984



U.S. ARMY MISSILE COMMAND

Redstone Arsenal, Alabama 35898

COST ANALYSIS DIVISION
COMPTROLLER

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ECONOMIC ANALYSIS HANDBOOK

BY

JAMES L. GOSSETT

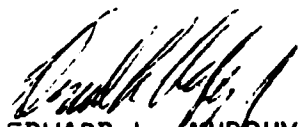
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US ARMY MISSILE COMMAND

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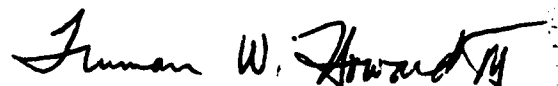
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CHAPTER 1

INTRODUCTION

Economic analysis is a systematic approach to the problem of choosing how to employ scarce resources and an investigation of the full implications of achieving a given objective in the most efficient and effective manner. The determination of efficiency and effectiveness is implicit in the assessment of the cost effectiveness of alternative approaches and is accomplished by:

Systematically identifying the benefits (and other outputs) and costs (inputs) associated with alternative programs, missions, and functions, and/or of alternative ways for accomplishing a given program (usually referred to as projects and activities).

Highlighting the sensitivity of a decision to the values of the key variables and assumptions on which decisions are based, including technical, operational, schedule, resource availability (e.g., energy sources), environmental requirement, and other performance considerations.

Evaluating alternative methods of financing investments, such as lease or buy.

Using benefits and costs to compare the relative merits of alternatives as an aid in:

- Making trade-offs between alternatives

- Recommending the cost-effective alternative

- Establishing or changing priorities

Program evaluation is economic analysis of ongoing actions to determine how best to improve an approved program/project based on actual performance. Program evaluation studies entail a comparison of actual performance with the approved program/project.

The key elements of an economic analysis are: (1) Establishing and defining the goal or objective desired, (2) Searching out hypothetical alternatives for accomplishing the objective, (3) Formulating appropriate assumptions, (4) Determining the cost (inputs) and benefits (outputs) of each alternative, (5) Comparing costs and benefits of all alternatives and ranking the alternatives, (6) Testing the sensitivity of major uncertainties on the outcome of the analysis, and (7) Making the decision.

The most important step in analysis is the first step, the definition of the objective. Most simply stated, an objective is some fixed standard of accomplishment. In establishing an objective, we concurrently and implicitly establish the criteria by which we will measure the relative benefits and costs of each alternative.

THE
ECONOMIC ANALYSIS
PROCESS

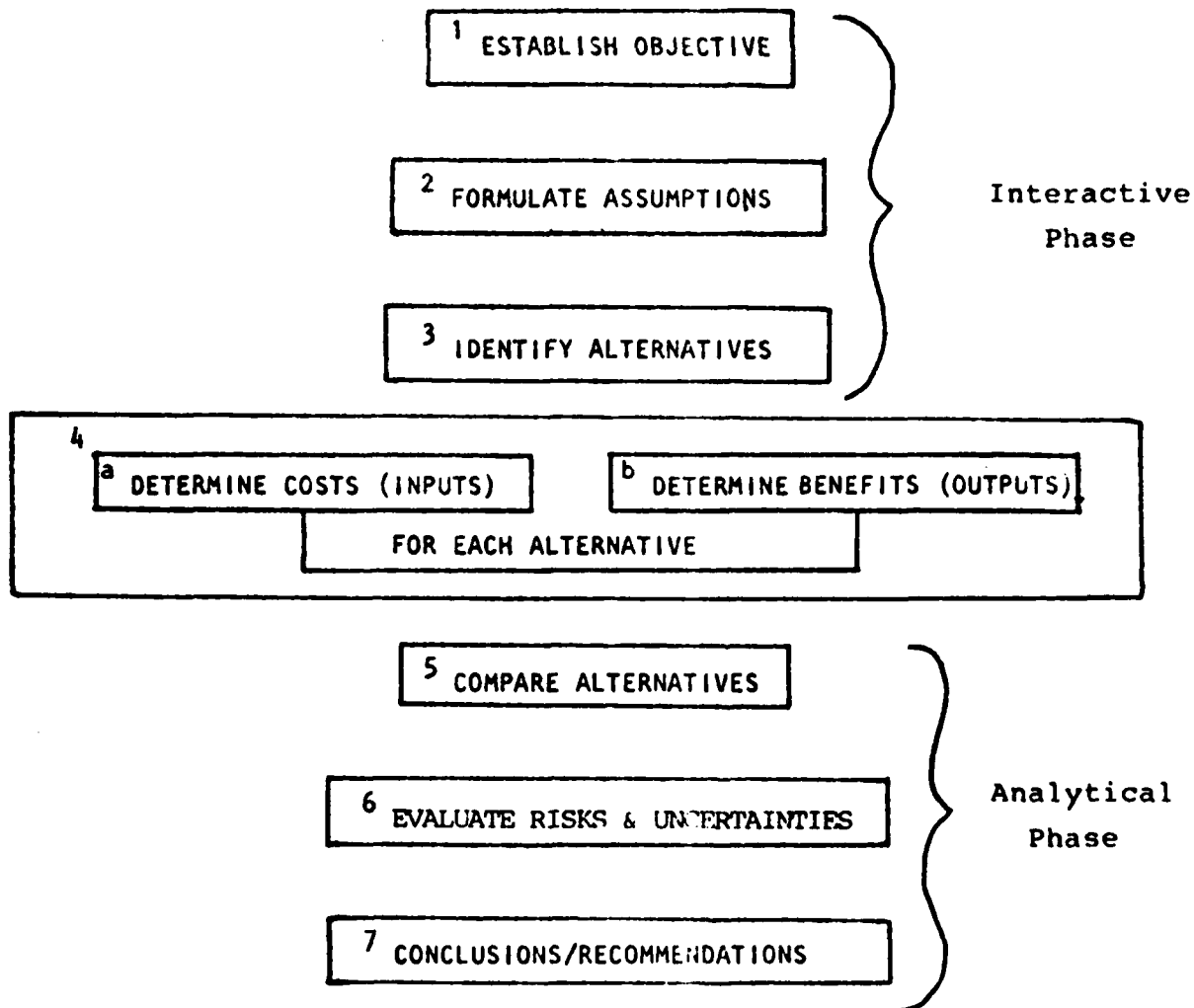


Figure 1. The Process

Once the objective of an economic analysis has been clearly established, the next step is to determine the feasible solutions or means to meet the objective. In an economic analysis, these solutions or means are referred to as the alternatives. Alternatives need not be identical in function, so long as they meet the objective or goal.

Once the alternatives have been established and cost and benefit information gathered, the alternatives should be ranked by one of three cost/benefit relationships:

Most effective for a given cost constraint

Least cost for a given effectiveness limitation

Largest ratio of effectiveness to cost

The first two relationships are easier to handle than the third relationship. In the third relationship there is a danger that we may accept an alternative that is highly effective at a high cost rather than an adequate alternative at much lower cost.

Assumptions are statements made to support and reasonably limit the scope of a study. Because an assumption is a "given" as opposed to a "fact" and relates to a future occurrence, it involves a degree of uncertainty. For this reason, regardless of the degree of impact they might have on the analysis, it is strongly recommended that all assumptions pertinent to its preparation be so identified, for the use of undocumented assumptions detracts from the credibility of an analysis.

Additionally, it is important that we do not confuse assumptions with facts, or attempt to ease our role by utilizing assumptions when, with research, factual data could be presented. For example, if we are considering landfill as an alternative to solving a disposal problem stemming from increased waste, we might include in the study the assumption that sufficient land for this operation is available within a 20 mile radius of the installation. However, in this particular instance, there may have been no obstacle preventing us from the research necessary to present this element of data as a fact rather than as an assumption.

Two very significant assumptions that must be made in all economic analyses concern the "economic life" of each alternative and the period over which we will compare the alternatives.

Important decisions involve elements of risk or uncertainty. The economic analysis should ideally address the areas of uncertainty and provide for their treatment.

An economic analysis is required, subject to exceptions, for all proposals which involve a choice of trade-off between alternatives.

An economic analysis will be updated when evaluation of programs or projects reveals that:

The assumptions of the original study have become invalid

The projected performance or predicted costs in the original estimate are sufficiently different from current estimates to invalidate the benefit (output) to cost (input) relationship on which previous decisions were made.

New alternatives are available

An economic analysis is not required:

When it can be shown that the minimum level of effort required to do the analysis would not be worth the benefits to be gained from such an analysis.

In cases where other DoD Instructions and issuances prescribe equipment age or condition replacement criteria, labor and equipment trade-off standards, or requirements computations which in turn have been based on an analysis as called for herein.

When proposed actions are specifically directed by legislation or prior irrevocable management decisions which preclude any choice or trade-off among alternatives including alternative ways to accomplish a program/project.

Before attempting to imply that an economic analysis is not required for a proposal because it does not involve a choice or comparison between two or more options, it must be recognized that continuing the present course of action, or inaction, may be a feasible alternative. The identification of alternative courses of action is an important element of economic analysis and it often requires deliberate effort to examine the situation from innovative points of view. Consequently, the mere presumption without investigation that no alternatives exist is not sufficient. Such a determination must be supported and documented.

Documentation will be specific enough to facilitate ready reference to authority for non-performance by interested parties. If the authority is other than a statute, regulation, directive, or instruction available through normal publication channels, a copy thereof will be attached to the justification for non-performance.

Discounting is a technique for converting various cash flows (cost streams) to economically comparable amounts at a common point in time, considering the time value of money. Once cost estimates have been generated, they must be time phased to reflect alternative expenditure patterns. The time value of money is considered by computing present value costs.

Present value costs are computed by applying a discount rate to each year's cost in a cost stream. The current discount rate specified by OSD is 10 percent. The present value cost is the sum of the discounted costs over time.

The purpose of discounting is to determine if the time value of money is, in any given case, sufficiently great to change the ranking of alternatives--a ranking that has been established on the basis of all other considerations, i.e., relative cost and relative effectiveness. In formulating cost estimates, priority will be given to developing the best possible estimate of undiscounted costs.

PROJECT YEAR DISCOUNT FACTORS

TABLE A

Present Value of \$1 (Single Amount---To be used when cash-flows accrue in different amounts each year).

Project Year

10%

1	0.954
2	0.867
3	0.788
4	0.717
5	0.652
6	0.592
7	0.538
8	0.489
9	0.445
10	0.405
11	0.363
12	0.334
13	0.304
14	0.276
15	0.251
16	0.228
17	0.208
18	0.189
19	0.172
20	0.156
21	0.142
22	0.129
23	0.117
24	0.107
25	0.097
26	0.088
27	0.081
28	0.073
29	0.066
30	0.060
31	0.055
32	0.050
33	0.045
34	0.041
35	0.037

TABLE B

Present Value of \$1 (Cumulative Uniform Series--To be used when cash-flows accrue in the same amount each year).

10%

0.954
1.821
2.609
3.326
3.977
4.570
5.108
5.597
6.042
6.447
6.815
7.149
7.453
7.729
7.980
8.209
8.416
8.605
8.777
8.933
9.074
9.203
9.320
9.427
9.524
9.612
9.693
9.766
9.832
9.892
9.947
9.997
10.042
10.083
10.120

Note: Table factors represent an arithmetic average of beginning and end of the year single amount factors found in standard present value tables. Table B factors represent the cumulative sum of the factors contained in Table A through any given project year.

Figure 2. Project Year Discount Factors

Assure validation of all economic analyses by the Cost Estimate Control Data Center (CECDC) where such centers have been established. This validation will include methodology and rationale applied as well as completeness and accuracy of the analyses.

Establish and maintain an annual schedule of on-going projects and activities to be subjected to economic analysis. To the extent not directed by higher authority, projects and/or activities selected for analysis, and their respective priorities will be determined locally, based on preliminary evaluation of relative effectiveness and efficiency of current performance, alternatives that may be available to improve mission accomplishment, and anticipated analysis payoff.

Use economic analysis as a basis for establishing and recommending priorities for application of resources.

Maintain documentation of economic analyses for audit purposes.

As a minimum, each economic analysis will contain the following components.

Mission related objectives of the actions being considered.

Specification of assumptions and constraints underlying the analysis.

Identification of alternatives.

Listing of benefits (outputs) for all feasible alternatives.

Cost estimate for each feasible alternative.

The relationship of benefits to cost of alternatives considered, in order of their respective economic performance.

An economic analysis should be considered as only one of the inputs required to make a proper decision concerning the use of resources, and not the decision-making process itself.

Economic analysis is an integral part of the planning, programing, and budgeting system of the Department of the Army, and has implications at all levels of authority.

Economic analysis will be used as an aid to management decision-making at all organizational levels within Department of the Army. Normally, analyses will be prepared at the organizational level at which a request for resources originates.

Benefit/Output analysis. An analysis will identify the outputs of each alternative: benefits, effectiveness, performance.

Specifically exempted from the requirement to use discounting are:

Decisions concerning water resource projects, under the jurisdiction of the Corps of Engineers.

Comparative cost analyses conducted in accordance with commercial activities.

Proposed programs or projects, which, if adopted, would commit the Department of Defense to a series of measurable costs which in aggregate would not extend over 3 years, or which result in a series of cash benefits that do not extend over 3 years from the inception date.

Treatment of Inflation. Estimates for inflation in future years may be important in conducting time-phased trade-off studies. When this is the case, analyses will specifically consider inflation.

To assure consistency in comparative studies, all estimates of monetary costs for each year of the planning period will first be made in terms of constant dollars. Constant dollars are always associated with a base year and reflect the dollar "purchasing power" for that year. These estimates should not include any forecasted change in the general price level during the planning period.

When inflation is a factor that should be in a decision between alternatives, a second computation will be made in terms of current (inflated) dollars. Inflation indices promulgated by the Office of the Comptroller of the Army for use in escalating cost estimates in life cycle costing should be used. The source of the inflation factors and the rates used will be included as part of the assumptions underlying the analysis.

Sample formats for display of costs.

The format to be used in summarizing the costs should be tailored to display these costs in the most meaningful manner. However, the choice of format is left to the discretion of the person directing the analysis.

Often it is critical for an analysis to focus on the differential costs between the present alternative and proposed alternatives. Format A-1 is designed for use in such instances.

The commander/director of each DARCOM major subordinate command, depot, and separate installation and activity reporting directly to Headquarters, DARCOM, will:

Establish and maintain a capability for centralized staff direction and monitorship of economic analysis which assures performance commensurate with requirements.

Accomplish economic analysis, and submit documentation thereof, to higher authority.

Mission related output of the respective alternatives considered must be identified and analyzed. It is desirable to express benefits in terms of a quantified common denominator, e.g., dollars; in some cases, this is difficult to do. However, output indicators should be expressed quantitatively whenever possible, e.g., number of patients treated, number of students trained, number of personnel records processed, number of items inspected, number of engines overhauled. Inability to express outputs quantitatively should not be justification for disregarding output analysis. Benefit (output) analysis cannot be overemphasized! Outputs are indicators of objective achievement, i.e., indicators of the degree to which a manager will accomplish his mission. Therefore, outputs should be in terms that are meaningful to the decisionmaker. When practical, this information shall be capable of historical accumulation, and must be auditable and relatable to significant organizational missions and functions, to relevant environmental impacts, and to resources consumed or required. The period of time during which these benefits accrue is a function of the economic life of the project in question.

Important non-quantifiable benefits, e.g., health, safety, or security, will also be specifically identified in the analysis, if pertinent to a decision.

Benefits should be stated positively in sufficient detail to indicate what an alternative will contribute to mission accomplishment, if approved. It must also be recognized that the benefits identified also indicate what won't be accomplished if the proposal is disapproved.

The following step-by-step procedure can be used when dealing with an output measurement problem.

Step 1 - Identify all relevant outputs. Government programs or projects often have two or more objectives. These objectives may be prescribed by law, established by policy, or may be based on historical practice. There should be a causative relationship between activity, as measured by the output indicator, and the resources consumed. An increase or decrease in output (mission accomplishment or goal attainment) once fixed costs have been taken into account, should be reflected by a change in input, or resources consumed (costs). A restatement of resources consumed is not a way to measure output. For example, a statement of the man-hours required to do a job is just another way of accounting for resources consumed and tells little about what is accomplished. (The difference between costs of competing alternatives, i.e., differential costs/savings, is not an "output.")

Step II - Establish data sources. Do a literature search. Avoid generating unnecessary work by determining if adequate information is already available in some form. Consider sources such as established reports, opinions, and judgements of experts, observations and tabulations of steps in a work process, outside organization and information centers.

Step III - Collect, summarize, evaluate, validate, and display or present output data. Select a technique for summarizing the data in a tabular, graphic, or other format, as appropriate. The exact methods employed and techniques are left to the discretion of the analysts.

Step IV - Compare output data and costs associated with a particular alternative or activity. By constructing a graphical relationship of output to cost, it may be possible to observe trends developing or detect evidence of possible substandard performance. Use of such very basic analysis is essential to making informed judgements about cost effectiveness. To the extent not quantifiable, outputs should be identified in precise terms and compared to the required resources so that the decisionmaker can identify what he considers to be the most cost-effective alternative.

Units of output and factors, such as production per employee, will be included. As a minimum requirement for measurable output, standards based on statistical procedures will be developed to permit analysis of productivity trends.

Performance measurement and productivity indexes will be used to the maximum extent practicable in analyzing resource requirements and the capabilities of the various alternatives.

Productivity indexes are to be based on the ratio of total output to resource input.

Output measures are to be based on the volume of product or services produced and should take into account the relative importance of any differences in the products or services.

Whenever trends are significantly different than original estimates, the analysis shall deal with the reasons for the change.

Summary of output. The purpose of the output summary is to identify and describe the benefit, output, or effectiveness implications of resource allocation decisions. This information will be provided in sufficient detail to permit a comparison of alternatives. The format of the summary of outputs should be tailored to display the outputs of each alternative in the most meaningful manner. The choice of format is left to the discretion of the personnel directing the analysis.

Cost estimate.

General.

Each economic analysis must contain an estimate of all anticipated inputs (costs) directly or indirectly associated with each alternative. These costs will be displayed by fiscal year. The analyst must show all resources required to achieve the stated objectives. Inputs will be stated in dollar terms when possible. Non-quantitative costs will be identified in as specific terms as possible.

It is difficult to specify which cost elements should be included in an economic analysis, because of the diversity of programs encountered. However, the cost of each alternative will be examined in detail, and cost categories will be mutually exclusive to avoid double-counting.

Cost estimates will be --

Included for research and development, investment, operating and support, and disposal for all alternatives, when applicable.

Time-phased, i.e., displayed on a fiscal year by year basis.

Expressed in constant year dollars. (Estimates may also be stated in current year dollars.)

Sunk costs will not be included in the comparison of alternatives.

Research and Development. All costs for research and development.

Investment. Costs associated with the acquisition of equipment, real property (including leaseholds), nonrecurring services, nonrecurring production (start-up) costs, and other one-time investment costs. Investment costs need not all occur in a single year. They include --

The cost of rehabilitation, modification, or addition of land, buildings, machinery, and equipment.

The costs of plant rearrangement and tooling associated with the project.

The value of nonrecurring services received from others, both internal and external to the Department of the Army.

Treatment of existing assets to be employed on the project.

The investment for a given project may consist of assets to be acquired plus existing assets, i.e., assets already on hand. However, the value of such existing assets will be included in the investment costs only when the existing asset is currently in use (or has an alternative, planned use) on some other project or is intended for sale. When such alternative use of the existing asset will result in a cash outlay for some other project which would otherwise not be incurred, or will deprive the Government of the cash planned to be realized by sale, the value will be included in the analysis. (If there is no alternative use of the asset, it will be treated as a sunk cost.)

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. Each inherited asset must be evaluated on its own merits and in terms of whether its use in connection with the alternative being costed will cause future expense to the Government.

The terminal or residual value of assets should be treated as a reduction in the cost of the particular alternatives to which they are related.

In computing terminal value consideration must be given to costs connected with removal, dismantling or disposal of assets.

The explicit assumptions used in the derivation of all terminal or residual values must be provided.

Personnel training and retraining costs should be included for each alternative.

Operations.

Personnel. This category includes personnel costs (civilian and military) and employee benefits for all employees who can be identified with the work to be performed.

Civilian personnel services.

The cost of civilian 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.

Other personnel costs. The sum of personnel costs which pertain to performance of the function under consideration, and which are not included above, e.g., travel, per diem, moving expenses, personnel training.

Materials, supplies, utilities, and other services. The costs to the Government for supplies and materials used to provide a product or service. Include in this figure the cost of base transportation which can be directly identified with the function; costs for handling, storage, custody and protection of property; and the cost of utility services including, specifically, electric power, gas, water; and communications related to the function. Cost of material and supplies will include allowances for reasonable overruns, spoilage or defective work.

Maintenance and repair. The cost of maintenance and repair to buildings, structures, grounds and equipment utilized by the function involved in producing goods or services. (Capital improvements should not be included here, but should be included with investment costs). Include only those maintenance and repair expenses directly attributable to the project under analysis.

Overhead costs. Include estimates of overhead costs attributable to the project in question, particularly those costs that will change as a result of the proposal. These may be costs for accounting, personnel, legal, local procurement, medical services, receipt, storage and issue of supplies, police, fire and other services. Include also the costs of terminating or cancelling any existing arrangements which will become due as a result of undertaking the project in question.

Other costs. Includes the operating costs of the status quo to the extent that the status quo will be required to operate while the proposed alternative is being phased in.

CHAPTER 2

DOCUMENTATION

The method of documentation used to record and summarize cost and output information will usually vary from one study to another. However, guidelines for documenting the required information are provided in this enclosure to insure completeness and consistency. Formats A, A-1, and B may be useful for organizing the results of an economic analysis or program evaluation, but are not intended as required forms. Formats A and A-1 focus on the same kind of basic cost information. However, Format A-1 highlights differences in costs between alternatives. It is derived from Format A, and the same guidance for compiling cost data applies to both formats.

Format A - Total life-cycle costs should be compiled for each alternative under consideration, including any approved project. Life-cycle costs associated with an alternative provide a relatively complete picture of the overall resource implications of the acquisition of goods and services.

Format A-1 - Often it is critical for an analysis to focus on the amount of difference in those costs affected by alternatives (differential costs). In cost reduction proposals particularly, only those costs, direct and indirect which could be affected by one of the alternatives, are relevant for making comparisons to identify the least costly of several project alternatives.

Format B - The purpose of Format B is to identify and describe the benefit, output, or effectiveness implications of resource allocation decisions. This information will be provided in sufficient detail to permit a comparison of alternatives. Format B need not be prepared for alternatives which are to be evaluated on the basis of cost only. Format B will be devoted entirely to information which will set benefits and other outputs completely apart from the cost or input implications of a particular alternative. If one or more of the alternatives being considered produces a different level of benefits than any other alternative, or is more effective, then the analysis will identify these benefits and other outputs on Format B. Nonquantifiable benefits such as health, safety, and morale would be documented on Format B.

SUMMARY OF COSTS FOR ECONOMIC ANALYSIS

FORMAT A

1. Submitting Organization: _____
2. Date of Submission: _____
3. Project Title: _____
4. Description of Project Objective: _____
5. Alternative: _____
6. Economic Life: _____

7. Project Year	8. Appropriation Identification	9. Program (if OMA)	10. Program/Project Costs					
			a. R&D	b. Investment	c. Operations	d. Annual Cost (a+b+c)	e. Discount Factor From Fig. 2-4	f. Present Value Annual Cost (d x e)
1.								
2.								
3.								
.								
.								
etc.								
11. TOTALS								

- 12a. Total Project Cost, Discounted (11f)
- 12b. Uniform Annual Cost (Before Allowance for Terminal Value)
13. Less Terminal Value, Discounted
- 14a. Net Total Project Cost, Discounted (12a-13)
- 14b. Uniform Annual Cost (After Allowance for Terminal Value)

Figure 3. Format A.

SUMMARY OF COSTS FOR ECONOMIC ANALYSIS

FORMAT A

15. Source/Derivation of Cost Estimates: (use as much space as required)

a. Research and Development:

b. Investment:

c. Operations:

d. Net Terminal Value:

e. Other Considerations:

16. Name & Title of Principal Action Officer Telephone Number:	Date
17. Name & Title of Approving Authority	Date

Figure 3. (Continued)

SUMMARY OF COSTS FOR ECONOMIC ANALYSIS

FORMAT A-1

1. Submitting Organization: _____
2. Date of Submission: _____
3. Project Title: _____
4. Description of Project Objective: _____
- 5a. Present Alternative: _____
- 5b. Proposed Alternative: _____
- 6a. Economic Life: _____
- 6b. Economic Life: _____

7. Project Year	8. Appropriation Identification	9. Program (if DMA)	10. Operations		11. Differ- ential Cost (10a - 10b)	12. Discount Factor From Fig. 2-4	13. Present Value Differ- ential Cost (11X12)
			a. Present Alternative	b. Proposed Alternative			
1.							
2.							
3.							
...							
etc.							
14.							
TOTALS							

Figure 4. Format A-1.

SUMMARY OF COSTS FOR ECONOMIC ANALYSIS

FORMAT A-1

15. Present Value of New Investment:	
a. Land and Buildings	_____
b. Equipment	_____
c. Other (identify nature)	_____
d. Working Capital (change-plus or minus)	_____
16. Total Present Value of New Investment	_____
17. Plus: Value of existing assets to be employed on the project	_____
18. Less: Value of existing assets replaced	_____
19. Less: Discounted terminal value of new investment	_____
20. Total New Present Value of Investment	\$ <u>_____</u>
21. Present Value of Cost Savings from Operations (Col 13)	_____
22. Plus: Present Value of the Cost of Refurbishment or Modifications Eliminated	_____
23. Total Present Value of Savings	\$ <u>_____</u>
24. Savings/Investment Ratio (Line 23 divided by Line 20)	_____
25. Rate of Return on Investment	_____

Figure 4. (Continued)

SUMMARY OF COSTS FOR ECONOMIC ANALYSIS

FORMAT A-1

26. Source/Derivation of Cost Estimates: (use as much space as required)

a. Investment:

(1) Costs

(2) Net Terminal Value

b. Operations:

(1) Personnel

(2) Operating

(3) Overhead Costs

(4) Other Costs

c. Other Considerations:

27. Name & Title of Principal Action Officer Telephone Number:	Date
28. Name & Title of Approving Authority	Date

Figure 4. (Continued)

SUMMARY OF BENEFITS/OUTPUTS FOR ECONOMIC ANALYSIS

FORMAT B

1. Submitting Organization: _____
2. Date of Submission: _____
3. Project Title: _____
4. Description of Project Objective: _____
5. Alternative: _____ 6. Economic Life: _____
7. Outputs:
 - a. Dollar Quantifiable Outputs: (describe and justify)
 - b. Other Quantifiable Outputs: (describe and justify)
 - c. Non-quantifiable Outputs: (describe and justify)

Figure 5. Format B.

SUMMARY OF BENEFITS/OUTPUTS FOR ECONOMIC ANALYSIS

FORMAT B

8. Source/Derivation of Outputs: (use as much space as required)

a. Dollar Quantifiable Outputs:

b. Other Quantifiable Outputs:

c. Non-quantifiable Outputs:

9. Name & Title of Principal Action Officer Telephone Number:	Date
10. Name & Title of Approving Authority	Date

Figure 5. (Continued)

USE OF FORMATS

Format A should be used to compare two or more alternatives and/or when total life cycle costs should be shown. This format is particularly useful in the comparison of alternatives when a present alternative does not exist. It is also useful for Product Improvement Proposals when the cost of the improvement is greater than the basic system. The uniform annual costs should be computed for the basic system and also for each alternative. The benefits derived from the proposed improvement for each alternative should be compared to the increase in uniform annual cost to determine the cost effectiveness as compared to the basic system and to other alternatives.

The specific year in which costs will be incurred should be established. Then costs should be collected for each alternative from the beginning of the project until the end of its useful life. The comparison should be made using the same base year for all alternatives. The first year in which expenditures are made for any one of the alternatives will be considered the base or year "1" for all alternatives. An exception to this principle is the immediate payment of non-recurring investment costs when time value of money is not involved.

It is difficult to determine what costs should be included in each economic analysis because of the diversity of projects and problems. In general, life cycle costs (excluding sunk costs) for both direct and indirect costs will be included. All cost estimates will be in constant (year) dollars.

Annual costs are the sum by years of the non-recurring and recurring costs of the alternative under analysis.

The discount factors to be used are listed in Table A and Table B, AR 11-28. Time value of money factors are based on interest costs and payments occurring at the end of some time period. In economic analysis situations, expenditures are made at various times of the year. To allow for this, the discount factors are an arithmetic average of beginning and end of year single amount factors found in standard percent value tables. We all know that it is possible to compute discounts for any number of days desired in a given year. But it is difficult enough to forecast expenditures ten to fifteen years in the future, for the year in which the expenditure will occur, without trying to refine these forecasts to days. That is the reason for the discount factors to be computed in the manner of Table A and Table B, AR 11-28.

The uniform annual cost is computed by dividing the total Discounted Annual Cost by the total of the discount factors. Care should be exercised here because only the total of discount factors applicable to the years of operation of the alternative under investigation should be used in the computation. Uniform annual cost is a computed constant amount that, if paid annually throughout the economic life of a project, would equal the total present value costs for the project. This computation allows comparison of projects having unequal lives, by using a common denominator.

FORMAT A-1

The Format A-1 is to be used when the purpose of the economic analysis is to compare the "differential costs" of the present alternative to a proposed alternative rather than comparison of life cycle costs. "Differential Costs" are the costs of differences in the recurring costs between the proposed alternative and the present alternative.

The present alternative identifies the level of costs that would be incurred without the proposed investment project.

The proposed alternative presents the costs that will occur if the proposed project is undertaken.

The amount of cost savings (differential costs) is the difference between the recurring costs of the currently approved project and the recurring costs of each proposed alternative. Recognition of the timing of cash flows for both the investment and operations cost of the alternatives is an integral part of this analysis.

Discount Factor. The discount factors to be used are listed in Table A and Table B, AR 11-28.

Present Value of New Investment. The R&D and investment costs are listed by fiscal year and discounted to present value. The total discounted amount is entered on the lines provided.

Present Value of Existing Assets Replaced. The discounted fair market value, use or disposal value of replaced assets will be treated as a reduction of the investment costs.

Value of Existing Assets to be Employed on the Project. The discounted value of existing assets will be included as a part of the investment cost providing the assets are in use; have a planned use; or are intended for sale. The basis of arriving at these estimates should be documented.

Cost of Refurbishment or Modification Eliminated. All entries included in this line will be documented in the back-up. Include the calculations of the cost basis and rationale used in costing the modification/refurbishment and the time phasing of the costs.

Savings/Investment Ratio. The present value of cost savings is divided by the Net Investment. A savings/investment ratio of one or more is good and indicates that the investment costs are recovered with a 10% return.

Documentation of the economic analysis. Presentation of data is important because much of the effort which goes into the collection and compilation of data will be lost if it is not documented clearly and effectively.

Tables, charts, graphs, mathematical models and other visual aids can frequently be designed to replace lengthy narrative explanations and to emphasize the most significant facts and relationships. Such material should be included when it will assist the presentation of the results of an analysis.

Documentation supporting the results of an analysis should include the computations used to derive total program or project costs and outputs and describe in detail the method for developing estimates. For example, if an estimate is based on statistical data or a mathematical model, show how it was derived, the variables, standard errors, etc.. If factors are used, indicate their source and/or the basic assumptions used in their derivation.

Data sources should be specifically identified.

The principal parties responsible for doing and approving the analysis should be identified along with the date of the analysis was completed.

CHAPTER 3

CONSTANT DOLLARS

To assure consistency in comparative studies, all estimates of costs and financial benefits for each year of the planning period will first be made in terms of constant dollars; that is, in terms of the general purchasing power of the dollar at the time of decision. These estimates should not include any forecasted change in the general price level during the planning period.

Cost projections may be changed over the period of analysis to reflect only real changes in costs due to changes in amounts of services, for example, an increase in the amount of repair, and improvements at prices in effect at the beginning of the period of analysis.

Cost projections may also be changed due to economies or diseconomies of scale resulting from an increase or decrease in the quantity of goods and services purchased.

When inflation is considered important to the conclusion of the study, a second computation will be made in terms of current (inflated) dollars. Using the constant dollar estimates as a baseline, inflation should then be included, either by using price indices, or as a last resort, by application of a uniform inflation rate. When there is reason to believe that price levels, e.g., for Procurement, Research, Development, Test and Engineering (RDT&E), and Family Housing and Construction, will significantly affect the choice between alternatives, factors available for these categories should be used. Indices promulgated by the Office of the Assistant Secretary of Defense (Comptroller) for use in escalating cost estimates in annual budget submissions may be used as appropriate.

To avoid overestimating and double counting for the effects of inflation, consideration will be given to such factors as contract provisions which may already include provision for inflation, labor agreements, productivity and quantity changes, and the extent to which material is already on hand or will be furnished under fixed price contracts.

Whenever practicable, estimates will include forecasts of changes in price levels on the basis of specific data applicable to a given acquisition. The source of the inflation factors and the rates used are to be included as part of the analysis.

The estimates of inflation will be identifiable by fiscal year. Particular care should be taken when including inflation in cost estimates for more than four years beyond the budget year because of the uncertainty in making forecasts of future national economic conditions and the fact that imputed values for inflation are subject to considerable change.

There are three methods which can be used to calculate project costs adjusted for inflation. Method 1, below, is preferred because it portrays changes in real prices exclusive of the effects of discounting.

- 1 Inflate the cost streams first, then introduce the discount rate.
- 2 Discount the cost streams first then introduce inflation.
- 3 Apply a joint discount/inflation rate in a single calculation.

Regardless of the order of introduction of the inflation rate (methods 1, 2, or 3) the result after all calculations will be the same. Therefore, when an inflation rate is employed with a 10 percent discount rate, the order of the calculations is not important.

CHAPTER 4

COST ANALYSIS

Relationship of cost analysis to economic analysis. Cost analysis is an essential element of economic analysis since costs constitute one side of every economic analysis equation, regardless of the title of the study, e.g., cost-benefit analysis, cost effectiveness analysis. The quality of an economic analysis depends in large measure upon the quality of the cost analysis performed.

NON-RECURRING COSTS

Research and Development (R&D) - This category includes those costs resulting from applied research, engineering design, analysis, development, and testing. The effort from which these costs derive includes the conceptual, validation, and full-scale development phases. All costs for Research and Development shall be identified by year.

Investment Non-Recurring - This category includes those costs which generally occur only once in the production cycle, investment, acquisition of equipment, real property, non-recurring services, non-recurring operations and maintenance (start-up) cost and other one-time investment costs. These investment costs need not all occur in a single year. They include:

The cost of rehabilitation, modification or addition of land, buildings, machinery, and equipment.

The costs of rehabilitation, modification or other capital items such as furnishings and fittings required to put the project on a "ready-to-use" basis.

The costs of plant rearrangement and tooling associated with the project.

The value of non-recurring services received from others, both internal and external to DOD.

The costs of freight, foundations, and installations required by the project.

The costs of leaseholds.

The value of existing facilities replaced. In many investments, the proposed purchase of new equipment or facility eliminates the need for existing equipment or facility. If property is sold, the proceeds benefit the Government. If property is redistributed to some other Federal Agency, that agency is benefitted even though there is never any reimbursement or cash-flow to the agency which controlled the property initially. The fair market value of these replaced assets (as measured by sale price, scrap value or alternative use) will be treated as a reduction in the required investment for decision-making purposes only.

The value of existing assets to be employed on the project. The value of such existing assets will be included in the investment costs only when the existing asset is currently in use, or has an alternative planned use.

Include the terminal/residual value of assets expected to be on hand at the end of the economic life as a reduction in total life-cycle cost. Care must be exercised to insure that the residual value of assets is treated as a reduction in the cost of the particular alternative for which the use of these assets is intended.

Terminal values are likely to be so small and occur so far in the future that they may have no significant effect on the decision. Moreover, any salvage values realized may be almost, or completely, offset by removal, dismantling, or disposal costs. Hence, such terminal values will not ordinarily be included in the analysis of a project.

If, however, the terminal or residual value is expected to be significant, this value will be included in the cost analysis. Residual values may be important when considering projects with varying life cycles. The explicit assumptions used in the derivation of all terminal or residual values must also be provided.

Include the terminal value of working capital as an offset to total project costs.

In many DoD Investments, the proposed purchase of a new piece of equipment or facility eliminates the need for an existing piece of equipment or facility. If property is sold, the proceeds benefit the Government because they are included in Miscellaneous Receipts by the Treasury Department. If property is redistributed to some other Federal agency, that agency is benefited even though there is never any reimbursement or cash-flow to the agency which controlled the property initially. The fair market value of these assets may be determined by sale price, scrap value, or alternative use value.

RECURRING COSTS

This category of costs includes personnel costs, material consumed in use cost, operating costs, overhead costs, the costs of support services required on an annual basis and any other recurring costs. Costs that are incurred on a periodic basis are considered as recurring costs.

It is important that you become aware of the significance of these terms. For example, Format A requires that the total nonrecurring and recurring costs, respectively, be included in the year expenditure is expected to be made for each alternative under consideration. Format A-1 is concerned with the amount of cost savings, which is the difference between the discounted recurring cost of the "present" alternative and the discounted recurring costs for each year of each proposed alternative.

How do we determine the costs? This will depend on the individual situation. For the present alternative we have historical records as a guide. But for the proposed alternatives we do not have historical records. History of costs of similar types of equipment can be used as well as consultation with machinery and equipment manufacturers and other sources.

The basis for all costs must be fully documented and the source of the data must be disclosed. All assumptions should be made known and so stated in the economic analysis.

METHODS FOR COST ESTIMATING

For weapon system costing, there are two formal methods for conducting a cost estimate:

Industrial Engineering Method: The industrial engineering approach consists of taking estimates of the various separate work segments and combining them into a total project estimate. Estimating by engineering methods is based on extensive knowledge of the system characteristics. In using the engineering method, the system or item of hardware is broken down into its lower level components and estimates are made for each component. An advantage of this method is that it separates the parts of the system on which little data is available and which may require special treatment. Usually, the type of detail required for this method is not available to a government cost analyst.

Parametric Cost Estimating: In parametric cost estimating, the total cost of an alternative is based upon physical and performance characteristics and their relationships to aggregated component costs. A functional relationship must be set up between the total cost of the alternative and the various characteristics or parameters of the alternative. Cost Estimating Relationships (CERs) are developed between the historical costs of like systems and the parameters of these systems (e.g., weight, maximum speed, load capacity, etc.). The statistical technique usually used to develop Cost Estimating Relationships from historical cost and parametric data is called regression analysis. Regression analysis is primarily concerned with the determination of the equation of a line or curve which will predict how one variable (cost) will vary with respect to a certain parameter (weight, maximum speed, load capacity, etc.).

OTHER COST CONSIDERATIONS

Sunk Costs - is a term for costs that have already been incurred. Since these type costs cannot be changed no matter what action is taken, they are not considered in the decision making process and are therefore disregarded in the economic analysis. There is no point to including costs for decision making, when the decision would have no influence whatsoever on the cost incurred.

For example, say certain advance work was done on one of the alternatives being considered in an economic analysis. Say \$100,000 had been spent. Does this \$100,000 have any part in the economic analysis? No! Or take another example, - in a present alternative \$500,000 had been spent on equipment which has a salvage value of \$50,000 and it is contemplated to replace this equipment. An economic analysis is being performed. The \$500,000 is sunk cost and should not be considered. The salvage value would be used. This value (discounted) would be entered as a reduction of the present value of the new investment.

Constant Dollars - To assure consistency, all costs used in an economic analysis should be in the same constant year dollar base. Escalation beyond the constant year dollar base should not be included in the economic analysis, as a general rule. If cost figures include escalation, the escalation should be stripped out.

Uniform Annual Cost - This is a constant amount that, if paid annually throughout the useful life of the project, would equal the present value discounted total cost for the project.

As an example, take a total discounted cost of \$5 million for a piece of equipment having a total economic life of ten years. This amount would be divided by the present value discount factor of 6.447, the factor for the 10th year of the project. The total equivalent annual cost would be \$775,555, based on the computation. The uniform annual cost computation allows comparison of projects having unequal lives by using a common denominator. An investment option having the lowest uniform annual cost is judged to be the least costly alternative.

DOCUMENTATION OF COSTS

There should be sufficient documentation of all cost data to enable persons unfamiliar with the project to arrive at essentially the same basic conclusion as the decision maker. A cost trail which would permit validation of all costs should be available. Should someone in the reviewing process be unable to follow the computations and assumptions, because of insufficient documentation, processing will be delayed while clarification is being obtained. If this occurs, the project could be disapproved or deferred to later years.

There are basic principles which should be used to document the cost estimate. If these principles are followed, the economic analysis will meet the test of being properly documented. The following elements should be covered in the documentation:

Cost method used

All relevant costs are included

Directly related support and training costs are included

All sunk costs are excluded

The most accurate sources of cost data available are used. All uncertainties are clearly identified.

The sources of cost data should be identified. The method of arriving at the cost estimates should be explained.

Numerous sources for cost information exist. Some examples are:

Corps of Engineers Estimates. Projects involving construction, building, modification and related construction are covered by cost estimates made by the Corps of Engineers.

Cost Accounting Records. A very valuable source of information is the historical cost accounting records.

Contractor Cost. Another valuable source of information is the contractor costs maintained by the Selected Acquisitions Information and Management System Office of the Comptroller.

Machine specification, engineering data and independent estimates.

Experts in the area of interest.

Manufacturers or their representatives.

Most cost estimates are developed on a combination of these sources. Be careful to assure that all relevant costs are included and all costs which should not be included are properly excluded.

Be consistent in the development of costs. All civilian labor costs, military costs, and other costs are treated equally for all alternatives where applicable.

TIME PHASING OF COST BENEFITS

One of the more important aspects of an economic analysis is the proper time phasing of costs and benefits. If the costs are not properly time phased (by year) the discounted costs or savings will be either overstated or understated. A project may involve a single investment expenditure as soon as the project starts. This type of an investment cost does not require any discounting. But if the expenditure is delayed for several months, then the investment expenditure should be discounted. Any savings realized would be subject to discounting also. For example, assume we are thinking of investing in a machine which will be installed in three weeks. The machine will be paid for upon installation. This expenditure should not be discounted. But, if the expenditure will not occur until two or three months after installation, then the investment cost should be discounted in the economic analysis.

CHAPTER 5

ECONOMIC LIFE

The economic lives of the alternatives govern the time period to be covered by an economic analysis/program evaluation. The period should be set so that the alternatives start yielding the benefits in the same year. The analysis will be made using the same base year for all alternatives. That is, the first year in which expenditures will have to be made for any one of the alternatives should be considered the base year or "project year 1" for all alternatives. For example, it is possible for option A to require investment costs for three years before becoming fully effective, while option B may become operational after only two years of investment. In this case, the base year for A is used as the starting year for both, and option B has zero costs for that year. This imposes an appropriate opportunity cost for the capital required to finance the alternative which requires earlier funding (lead time).

The economic life extends through the period during which an asset performs, or a service is rendered, to accomplish the primary objective of the project.

The economic lives for the alternatives should be set, whenever possible, so that the alternatives yield benefits for the same period of time.

If this is not possible, use the uniform annual cost computation to provide a more complete analysis of alternatives with unequal lives. A second way to treat alternatives with unequal economic lives is to base the time period of the analysis on the economic life of the asset with the shorter time period. In this case, the residual value of the asset with the longer economic life must be considered in the computation of the costs of that alternative.

The economic life will probably differ from physical or technological life and if it is better data, should be used in lieu of depreciation guidelines established by the Internal Revenue Service, the Federal Communications Commission and similar regulatory bodies. Also, if the economic life of a project is expected to differ from the expected physical or technological life, the economic life must be used for purposes of the analysis. Since economic life is a key variable, it is important to make the best possible determination.

Alternatives will be compared on the basis of the time period of stable program use or operation. In the case of lease-purchase or purchase-contract, if such period is greater than the contract term permitted under authority for long-term leasing, the analysis should assume renewal of the lease at the last constant dollar payment.

The economic life will vary by type of weapon or support system. In general, the period of usage will be the basis for determining economic life and will be measured against a stipulated level of threat, or represent the period during which a given mission or function is required or can be supported.

In general, the economic life will be measured against a stipulated level of threat, or represent the period during which a given mission or function is required or can be supported. Also, if the economic life of a system is expected to be less than the specified maximum life, the shorter life must be used for purposes of the analysis.

In the preparation of an economic analysis, the economic life, or the number of years a project will provide benefits, must be ascertained. The following maximum economic lives have been established:

Buildings	25 Years
Utilities, Plant & Distribution Systems	25 Years
Operating Equipment	10 Years
Automatic Data Processing Equipment	8 Years
Weapons/Support Systems	Will Vary by Types of System

Consolidations, base closures and other projects with no significant investment in plant and equipment	5 Years
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The following different methods must be considered in determining the life of a proposal:

Physical Life

Technological Life

Product Life

Physical Life. The number of years that a proposal will be useful until it becomes uneconomically repairable. The physical life will vary depending upon usage.

Technological Life. The number of years that elapse before equipment becomes obsolete. Although the equipment may have physical life left, it is often more economically feasible to replace with more modern equipment. Weapon systems and certain equipment such as ADPE are examples of the state of the art advancing so rapidly that replacement becomes necessary long before the equipment is worn out.

Product Life. If the production or output of the equipment will end before either the technological or physical life is reached, then the product life should be considered in determining the economic life.

Economic Life. The period of time that a project may be used until the marginal costs are greater than the equivalent annual cost of the replacement equipment.

We know that some equipment has been in use for a long period of time and is still operating. It may operate for many more years. Then why do regulations limit the economic life of equipment to 10 years? Why can't we use a longer period of time for computing the economic life? The longer the life, the less the equivalent annual cost and the more favorable the Format A-1 savings/investment ratio.

The maximum economic life permitted by regulations takes into consideration more than just the physical life. Consideration is also given to how long it will be until the equipment becomes technically obsolete. With more modern production methods and procedures coming into use, who knows how long it will be before a system or process will be changed or replaced by a more efficient product? Requirements are subject to drastic change. Rapid changes are occurring in weapon systems, equipment, production, and other processes. Because of the uncertainty connected with ascertaining the economic life of a proposal, the maximum life permitted by regulations is usually used in an economic analysis.

The economic life of an investment project begins in the year in which the investment starts producing benefits.

CHAPTER 6

COMPARISON AND RANKING OF ALTERNATIVES

There are three basic types of cost/benefit relationships that are encountered in the preparation of an economic analysis. The three types are: equal cost/unequal benefit; unequal cost/equal benefit; and unequal cost/unequal benefit.

Equal Cost/Unequal Benefit situation exists when costs are the constraining factor for each of the alternatives, but the benefits vary to a marked degree. For example, say the purchase of new equipment is limited to three million dollars and under both alternative 1 and 2 we have equal cost. However, if alternative 2 has a greater output capacity, and this is desirable then we have unequal benefits. In this case, the alternative which yields the greater benefit would be the preferred choice.

Unequal Cost/Equal Benefit are investment proposals which can be evaluated almost entirely on the basis of discounted cost-flow analysis. Examples are "Lease Versus Buy" and the replacement of an existing asset with a similar model. The alternatives will yield the same benefits but will have unequal costs. Take, for example, the replacement of equipment with similar equipment. The old equipment, because of its age, requires extensive maintenance and repair, but it will still do the job. Say the costs of this present alternative will be three million dollars over recurring cost the next ten years. Alternative 2, a similar machine, can be purchased and its investment and operation and maintenance discounted costs over the ten year period will be only two million. Alternative 2 would be preferred because it would have the lower discounted costs.

Unequal Cost/Unequal Benefit is one of the more complex problems which the decision-maker must face. The problem here is to determine whether the extra effectiveness of a given alternative is worth the additional costs. There is a danger here! We may choose an alternative that is highly effective, but with a much higher cost instead of an adequate alternative at much lower cost. One of the advantages of the discounting technique, where neither the cost nor the effectiveness is equal between alternatives, is to enable the decision-maker to assess the real additional cost of the extra effectiveness.

The Period of Comparison. It is one thing to ascertain the life expectancy of each of our alternatives; it is quite another to appropriately compare these lives within the analysis. When faced with two or more alternatives with different economic lives, the analyst must make an assumption as to when to begin the period of comparison.

The decision-maker may state, early in the analysis, at which point in time he wishes any one or all of the alternatives to begin yielding benefits. Given this point in time, the analyst can then determine the first year in which expenditures must be made to satisfy the "benefit yield date" as set by the decision-maker. If the decision-maker fails to provide this "benefit yield date", the analyst must arrange the expenditures so that the alternatives begin to produce benefits in the same year.

In either case, the first year in which expenditures will have to be made for any one of the alternatives should be considered the base year or year "1" for all alternatives. For example, it is possible for option A to require investment costs for three years before yielding benefit, while option B has zero costs for that year. This imposes an appropriate interest cost for the capital required to finance the alternative which requires a longer lead time.

The period of comparison extends through the time during which an asset will perform, or a service will be rendered, according to some established standard of benefit. When an alternative's benefits fall below this standard, its useful life has ended. The alternative with the longest economic life may determine the end of the comparison period. However, the decision-maker or analyst may shorten this period consistent with the objectives and assumptions of the analysis. Whether the longest or the shortest life is used the residual values of the alternatives with longer lives must be recognized in the cost computation for those alternatives. Should the longest life be used to establish the time period of the analysis, the cost of extending the benefit producing years of those alternatives with a shorter life must be recognized. Care should be exercised to insure that the complete and valid costs for each alternative for the entire length of the analysis are presented to the decision-maker. Another alternative would be to use the Uniform Annual Cost method as a means of comparison.

Upon establishment of specific objectives and feasible alternatives for their accomplishment, a decision must be reached on the time-frame in which objective attainment is desired. This provides the basis for determining the time-frame in which benefit (output) accrual should begin.

The economic life of an alternative course of action begins with commencement of benefits, and continues as long as such benefits are greater than or equal to benefits accruing from other courses of future action, cost equivalency being considered. The considerations in establishing economic life are the physical and technological life of capital assets involved, and the life of services provided that contribute substantially to continued objective attainment. Economic life is normally the shortest of physical, technological or service life.

The period of comparison of alternatives should commence with the earliest year in which the initial investment expenditure of the several alternatives being considered will take place. That year is considered "project year 1" for purposes of determining present value of benefits and costs of all alternatives. For example, it is possible for option A to require investment costs for 3 years before becoming fully effective, while option B may become operational after only 2 years of investment. In this case, the base year for A is used as the starting year for both, and option B has zero costs for that year. This imposes an appropriate opportunity cost for the capital required to finance the alternative which requires earlier funding (lead time).

The economic life extends through the time during which an asset will perform, or a service will be rendered, according to some established standard of benefit. When an alternative's benefits fall below this standard, its useful life has ended. The alternative with the longest economic life may determine the end of the comparison period. However, the decision-maker or analyst may shorten this period consistent with the objectives and assumptions of the analysis. Whether the longest or the shortest life is used as a basis, adjustment for unequal life is required. If the shortest life is used, the residual values of the alternatives with longer lives must be recognized in the cost computation for those alternatives. Should the longest life be used to establish the time period of the analysis, the cost of extending the benefit producing years of those alternatives with a shorter life must be recognized. Care should be exercised to insure that the costs for each alternative for the entire period of comparison are presented to the decision-maker. Another alternative would be the use of uniform annual cost methods as a means of comparison. (Uniform annual cost is obtained by dividing the total present value cost by the sum of the present value factors of the years in which an alternative yields benefits. This gives the average cost per year of production).

Uniform annual costs. The amount of money which, if budgeted in equal yearly installments, over the years during which the project produces benefits, would pay for the project. The total present value of these installments would be equal to the total present value computed from the estimated life-cycle costs.

Comparing Costs and Benefits and Ranking the Alternatives The actual comparison of each alternative in terms of its cost and benefit is accomplished in this step. If we can measure cost and benefit on continuous scales we may use a graphical method of comparison. We start by tabulating and then plotting the cost versus the benefit for each alternative with the high benefit for the low cost. If one alternative is strictly dominant over all time periods and for all levels of effectiveness and cost, we have strict dominance and we can rank our alternatives immediately. Unfortunately, this is not usually the case. It is necessary to constrain the problem in a way that one alternative will be preferable to the others. Thus, we select either a fixed cost or fixed benefit schedule and determine how the alternatives will vary over time. Our analysis may then be repeated for inflated (current year) dollars if necessary, and finally a ranking of alternatives can be made.

The analyst may rank alternatives by one of three general criteria. These criteria conform to the three basic types of cost/benefit relationships: Unequal Cost/Equal Effectiveness, Equal Cost/Unequal Effectiveness, and Unequal Cost/Unequal Effectiveness. The three criteria are: (a) Least cost for a given level of effectiveness, (b) Most effectiveness for a given cost constraint, (c) Largest ratio of effectiveness to cost.

The first two criteria are easier to handle than the third. The problem with the third criterion is that it tends to wash out levels of expenditure and relative capabilities of the alternatives. For example, the effectiveness to cost ratio of 1:10 applies to an option whose effectiveness is rated at 1000 and whose cost is \$10,000 and to a much more austere option whose effectiveness is 10 and whose cost is only \$100. The ratio of effectiveness to cost should be used as a criterion only when costs or capabilities are reasonable close for each of the alternatives.

Testing Alternatives Under Uncertainty

Since most important decisions involve elements of uncertainty, an ideal economic analysis should address those areas of uncertainty about the state of the world in the future (technologically, politically, etc.). Techniques that are often used are contingency analysis, sensitivity analysis, and "a fortiori" analysis.

Contingency analysis is the investigation of how the ranking of alternatives holds up when a relevant change in criteria for evaluating the alternatives is postulated, or a major change in the general environment is assumed.

Sensitivity analysis can be applied in a situation where there are a few key parameters about which the analyst is very uncertain. Instead of using expected values for these parameters, the analyst may use several values (say, high, medium, and low) in an attempt to see how sensitive the ranking of the alternatives is to variations in the uncertain parameters.

"A fortiori" analysis is applicable to decision problems where generally accepted intuitive judgment strongly favors one alternative. However, based on preliminary analysis, it appears to the analyst that this alternative might be a poor choice and another may be most advantageous. In performing the analysis of the two, the analyst can deliberately resolve the major uncertainties in favor of the generally favored alternative, and see how the other alternative compares under these adverse conditions. If the latter still looks good, the analyst has a strong case in its favor.

CHAPTER 7

PRESENT VALUE

We all know there is time value to money. For example, if you were offered \$1,000 today or \$1,500 ten years from now, you would not automatically choose the larger amount. You would first determine what each is worth today; you would like to know how much the bank would give you today for the promise of payment of \$1,500 ten years from now so that you could compare this amount to the amount available today.

The Army is concerned with the same sort of problem except that it is usually paying out rather than taking in. The time value of money is therefore a useful technique to be used. It is appropriate to consider not only how much an alternative should cost, but it is also necessary to determine when the expenditures for the alternative will be made. Find out the cash flow. The time value of money is appropriately considered by computing the present value cost of money. The present value of the alternative is the money cost which would be required to finance the alternative when 10% could be earned by investing the funds until required for expenditure. If 10% can be earned, then this represents the "opportunity cost" of capital. Assuming equal benefits, the alternative whose present value cost is least is the better investment because of the more efficient allocation of resources. Fewer current resources are diverted to satisfy the requirement.

PRESENT VALUE OF FUTURE COST FLOW USING TIME VALUE OF MONEY

Recognition must be given to the fact that, before an investment is made, a dollar today is worth more than a dollar a year from now. This is true because of the utility of money related to the investment and the interest return on the dollar today. Therefore, it is a reasonable assumption that a future annual savings has a present value less than its value before discounting. Dollars invested in the present do have more value than dollars invested in the future because of the time value of money.

Discounting is a technique or method of putting investments or savings at different periods of time on an equal basis at a common point in time.

AR 11-28 lists project year discount factors at 10% interest to evaluate investments and savings on the basis of discounting.

NOMINAL AND EFFECTIVE INTEREST RATES

Interest rates are usually quoted as nominal interest rates. Interest at 6% means 6% compounded annually unless otherwise stated. Interest at 6% compounded semiannually converts to 3% compounded every six months. The nominal rate is still 6% but the effective interest rate is 6.09%.

This is arrived at as follows: at the end of the first six month period, the principal has grown to 1.03 or 0.03 times the amount at the beginning. At the end of the second period, the principal has grown to $(1.03)^2$, which equates to 1.0609 effective interest rate.

Similarly, a nominal interest rate of 6% compounded quarterly converts to $1\frac{1}{2}\%$ interest every three months and as effective interest rates $(1.015)^4 - 1$ or 6.14%.

PROJECT YEAR DISCOUNT FACTORS

The discount factors, as shown in Table A and B, AR 11-28, are factors which are an arithmetic average of beginning and end of the year single amount factors found in standard present value tables at the 10% interest rate. For example, in standard present value tables, at 10% interest, the single payment present worth factor for:

$$\text{Year 0} = 1.000000$$

$$\text{Year 1} = \underline{0.909091}$$

$$\text{Total} = 1.909091 \div 2 = .954546$$

$$\text{Year 1} = 0.909091$$

$$\text{Year 2} = \underline{0.826446}$$

$$\text{Total} = 1.735537 \div 2 = .867769$$

As you will note, these factors are the same as the factors shown in Table A for Year 1 and Year 2.

Now if we add the two factors above as follows:

$$\text{Year 1} \quad .954546 \quad \text{or} \quad .954$$

$$\text{Year 2} \quad \underline{.867769} \quad \text{or} \quad \underline{.867}$$

$$1.822315 = 1.821$$

These factors correspond to Table B - Cumulative Uniform Series. A uniform amount each year discounted by using either table, will give the same discounted amount. For Example:

INVESTMENT IN SELECTED PROJECTS

DOLLARS IN THOUSANDS

	A	B	C
Investment Cost	\$40,000	\$40,000	\$40,000
First Year Savings	10,000		7,000
Second Year Savings	10,000		14,000
Third Year Savings	10,000		18,000
Fourth Year Savings	10,000		7,000
Fifth Year Savings	<u>10,000</u>	<u>50,000</u>	<u>4,000</u>
Total Savings	\$50,000	\$50,000	\$50,000

COMPUTATION OF PRESENT VALUE

PROJECT A

(TABLE A)

<u>Project Year</u>	<u>Amt of Savings</u>	<u>10% Factor</u>	<u>Present Value</u>
1	\$10,000	0.954	\$ 9540.
2	10,000	0.867	8670.
3	10,000	0.788	7880.
4	10,000	0.717	7170.
5	<u>10,000</u>	0.652	<u>6520.</u>
	\$50,000	(TABLE B)	\$39,780.
or,	\$10,000	3.978	\$39,780.

Using Table A

<u>Amount</u>	<u>Factor</u>	<u>Discounted Amt</u>
1,000	0.954	\$ 954
1,000	0.867	867
1,000	0.788	788

Using Table B

1,000	2.609	\$2,609
-------	-------	---------

As long as the amount invested or costed each year is a uniform amount, Table B may be used instead of Table A. The use of either table should yield the same results.

To illustrate the significance of the present value of investments and savings, let us take a hypothetical case. We have \$40,000 that we are planning to invest in a project. We have three alternatives, A, B, and C. It is established that each of the three alternatives will do the job equally well.

This example shows the three investments of \$40,000 each. As you can see, Project A will return or save \$10,000 for each of the 5 years, for a total savings of \$50,000. Project B requires an investment of \$40,000 and a savings of \$50,000 is realized in the fifth year.

COMPUTATION OF PRESENT VALUE

PROJECT B

Thousands

<u>Project Year</u>	<u>Amount of Benefit</u>	<u>10% Factor</u>	<u>Present Value</u>
5	\$ 50,000	0.652	\$ 32,600.

COMPUTATION OF PRESENT VALUE

PROJECT C

TABLE A

<u>Project Year</u>	<u>Amount of Savings</u>	<u>10% Factor</u>	<u>Present Value</u>
1	\$ 7,000	0.954	\$ 6,678.
2	14,000	0.867	12,138.
3	18,000	0.788	14,184.
4	7,000	0.717	5,019
5	<u>4,000</u>	0.652	<u>2,608.</u>
	\$50,000		\$ 40,627.

Project C will return or save \$7,000 the first year, \$14,000 the second, \$18,000 the third, \$7,000 the fourth and \$4,000 the fifth. Project C as compared to Project A will return less at the beginning and the end but more in the middle years.

Which of the investments should we choose? Or does it make any difference, since all three will return \$50,000 for the \$40,000 that we plan to invest?

There is a difference - a big difference. Not in the total return but what the return is worth in today's dollars.

As we said, each investment will yield \$50,000 over the five year period. Before we can make a decision on this, the present value of money must be considered.

For Project A, we use the discount factor at 10%, as listed in AR 11-28, for each of the five years. The discounted total is \$39,780.

Since Project A savings are in uniform amounts, we can use Table B factors and get the same result.

For Project B, since the savings did not occur until the fifth year we use the discount factor in Table A for year number five. The total amount discounted is \$32,600.

For Project C, we use the Table A discount factors. The total discounted amount is \$40,627.

Now, after discounting to present value, let us examine the alternatives, since we must have a savings or return of at least 10%, to offset opportunity costs.

Based upon the discounted amount, Project A will not be an economical investment. Project B will not be an economical investment, either. In fact, it is worse than Project A.

Project C is the only one of the returns that is economically feasible. The choice is Project C. This alternative will give us the 10% return, plus an additional \$627.

Let us again re-emphasize that Project C is the choice based on cost. We assumed the benefits to be the same for all three alternatives. It is possible that one of the other projects would be the choice based on greater benefits and cost/effectiveness.

CHAPTER 8

TERMINAL VALUE

Terminal value is the residual value at the end of the economic life of a project. It is the net amount after deduction of costs for removal, dismantling or disposal. Terminal value should not be included in very many economic analyses because of its insignificance cost-wise. However, where the net terminal value is significant (such as ADPE, Precision Machine Tools) it should be included in the economic analysis.

How can we determine the residual value or terminal value at the end of the economic life of a project? This is not an easy question to answer. An important part of the decision depends upon how disposal of the asset is to be accomplished. Is it anticipated that the asset will be sold? Will it be scrapped? Will it be used in another capacity? Each of these situations would probably result in a different terminal value. If the asset is to continue to be used, it will probably be valued at a portion of its value or its depreciated cost. If it is to be scrapped, then the terminal value is the scrap value less cost of disposal. Determining the terminal value of an asset 10 or 25 years in the future is subject to question, no matter what method is used.

Usually, the terminal value will have very little impact upon investment decision. For example, say the terminal value of an asset is established at \$25,000 at the end of ten years. The present value discounted amount value based on the 10% interest rate factor for ten years is only \$10,125. This would not be a big factor in an investment of \$1 million, \$2 million, or more.

How can we obtain and document valid terminal value? The best method is to call on experts in the field. If it is in the construction area, the Post Engineer or other engineering sources may be consulted. In the equipment area, the manufacturer's representative is a good source. Also check to see how terminal value for similar equipment has been handled.

If all avenues have been explored and the information you have is not valid, leave it out of the cost, or reduction of cost, and explain the facts in a statement as a part of the economic analysis.

Be sure to investigate all possibilities. If the terminal value seems to be significant, any reduction in the investment cost will improve the savings/investment ratio or the uniform annual costs.

Be sure to disclose all facts relating to the terminal value where terminal value is included in the economic analysis. The source and the basis of the terminal value should be documented in full.

APPENDIX A
COST COMPARISON PROBLEMS

Payback Method versus Present Value

One method used to determine the feasibility of an investment is the payback method. Using this method, the cost of an investment is compared to the years of payback or savings to amortize the investment.

This is not an attempt to belittle this method but to demonstrate that, for Economic Analysis purposes, it is not adequate.

Let us take as an example an investment we intend to make for a testing machine. We strongly believe that we will be able to save \$90,000 a year by making this investment over our present mode of testing.

**PRESENT VALUE METHOD AS COMPARED TO
PAYBACK METHOD**

<u>YR</u>	<u>SAVINGS</u>	<u>10% DISCOUNT FACTOR</u>	<u>PRESENT VALUE OF SAVINGS</u>
1	\$90,000	.954	\$ 85,860
2	90,000	.867	78,030
3	90,000	.788	70,920
4	90,000	.717	64,530
5	90,000	.652	58,680
6	90,000	.592	53,280
7	90,000	.538	48,420
8	90,000	.489	44,010
9	90,000	.445	40,050
10	\$ 90,000	.405	<u>36,450</u>
			\$580,230

or by using Table B since there is a uniform amount for each year.

$$590,000 \times 6.447 = \$580,230$$

PAYBACK VERSUS PRESENT VALUES

Total cost of the investment: \$630,000

Estimated savings per year \$90,000

Economic Life 10 years.

PAYBACK

<u>Year</u>	<u>Savings</u>
1	\$90,000
2	90,000
3	90,000
4	90,000
5	90,000
6	90,000
7	<u>90,000</u>
	\$630,000

This looks pretty good. We make an investment of \$630,000 that has an economic life of 10 years and we recover these costs in 7 years! This will give us free use of this investment for three years or, if savings continue, a savings of \$270,000 in excess of cost, or a return of 43% of our investment. This is computed by dividing the savings of \$270,000 by the \$630,000 investment.

Now let's look at it through the discounted present value. It looks different now. The discounted present value on a 10% return or savings is less than our investment.

This example clearly demonstrates the importance of taking into consideration the present value of any investment.

EQUIVALENT ANNUAL COSTS (EAC) METHOD

By the use of this method, all costs or savings for each alternative are converted into a uniform annual cost. When household appliances or an automobile are purchased on time, the equivalent monthly cost is figured by the bank or finance company to let you know the amount of each monthly payment and the number of payments required. The payments are not just an average cost per month of the total cost, but include time value of money consideration or interest. So equivalent annual cost is not an average cost of the principal, but is expanded by including interest or is reduced by considering discounting as in the case of economic analysis. In figuring the equivalent annual cost of an alternative, the R&D, investment and operation and maintenance costs are included in the computation. The alternative which has the lowest EAC is considered the more economical choice. The EAC method is particularly useful where the economic lives of the alternatives are not equal, but it is also appropriate when the economic lives of alternatives are equal.

Example. Ice and snow may be removed from the main roads of Redstone Arsenal by hand loading snow and distributing salt to melt the ice, or by using a machine that will remove the snow and distribute the salt in a continuous operation. The hand loading and salt distribution will require 60 people at \$3.00 per hour or \$24 a day per man. The annual cost of equipment, maintenance and storage is \$1,000.

The machine to do this job will cost \$50,000 and will have a \$2,000 salvage value at the end of its economic life of ten years. Three drivers and three operators would be required at \$40 per day, each. Gasoline, oil, lubricants, repairs, etc., would amount to \$150 a day. Storage cost is estimated to be \$300 a year.

Using an average of four snow and/or ice removals per year, which alternative would be the more economical if time value of money is 6%?

HAND LOADING AND SALT DISTRIBUTION COST

\$ 24
60
\$1440 per day
4 per year
5760
1000

\$6,760 Annual Cost

MACHINE LOADING AND SALT DISTRIBUTION COST

50,000 (.1359) 6795
2,000 (.0668) 134
\$6661

40 x 6 x 4 = 960 labor
150 x 4 = 600 fuel
300 storage
\$8,521 Annual Cost

The hand removal method is the more economical in this particular case. Remember, these are only examples. All costs are not included. In the above case, the fringe benefits and support costs are the cost items omitted from this example.

CAPITALIZED COST METHOD

What is the capitalized cost of perpetual service of a structure that has an original cost of \$20,000, a life span of 10 years and annual operations and maintenance cost of \$4,000? The time value of money is 7% and the replacement structure will have the same costs, same economic life and the same operation and maintenance costs as the original structure.

Structure Cost	\$20,000	
Replacement Cost $20,000(.0724) = \frac{1.448}{.07}$	20,686	
Capitalized Cost of O&M $\frac{\$4,000}{.07} =$	57,143	
Total Capitalization Cost	\$97,829	
77,829	20,000	Cost of Bldg
	77,829	
	.07	Percent
	\$ 5,448	

As you will note, after deduction of the original cost of the structure, the interest at 7% will yield \$5,448, which will cover the operation and maintenance cost and the amount necessary for deposit of \$1,488 at 7% to yield \$20,000 in ten years.

BREAK-EVEN ANALYSIS

Example - Time Value of Money Not Considered.

Two motors are under consideration for purchase. Motor A will cost \$800. Motor B will cost \$900. the cost per hour to operate Motor A will be \$0.1315 and \$0.1155 for motor B. Economic life is 5 years and interest rate is 8%. Salvage value of Motor A will be \$200 and for motor B it will be \$250.

$$\text{Motor A} = \frac{800-200}{5} + .1315x$$

$$\text{Motor B} = \frac{900-250}{5} + .1155x$$

$$\text{Motor A} = \frac{650}{5} + .1315X = 120 + .1315x$$

$$\text{Motor B} = \frac{650}{5} + .1155X = 130 + .1155x$$

$$\begin{aligned} 120 + .1315X &= 130 + .1155X \\ .0160X &= 10 \\ X &= 625 \text{ hours} \end{aligned}$$

Same Example - Time Value of Money Considered

$$\text{Motor A} \quad 800(.2505) - 200(.1705) + .1315X \\ 200.40 - 34.10 = 166.30 + .1315X$$

$$\text{Motor B} \quad 900(.2505) - 250(.1705) + .1155X \\ 225.45 - 42.63 = 182.82 + .1155X$$

$$166.30 + .1315X = 182.82 + .1155X \\ .0160X = 16.52 \\ X = 1032.5$$

As you can see, the answer is markedly different where time value of money is considered.

Same Example - Present Worth Method Used

$$\text{Motor A} = 800 - 200(.6806) + .1315(3.9927)X$$

$$\text{Motor A} = 800 - 136.12 + .5250X$$

$$\text{Motor B} = 900 - 250(.6806) + .1155(3.9927)X$$

$$\text{Motor B} = 900 - 170.15 + 729.85 + .4612X$$

$$663.88 + .5250X = 729.85 + .4612X$$

$$.0638X = 65.97$$

$$X = 1034. \text{ hours}$$

The difference in the Present Worth Method and Time Value of Money Method is due to rounding.

Breakeven Analysis is a method used in the comparison of alternatives where certain variable factors are common to each alternative. Areas to which this method is applicable include:

- a. Replacement of Obsolete Equipment
- b. Make or buy decisions
- c. Expansion of Plant
- d. Other alternatives which have common variable factors.

APPENDIX B

DEFINITIONS

Alternative - An approach or program, among two or more, that is a possible way of fulfilling an objective, mission or requirement.

Assumption - A supposition, hypothesis, premise or conjecture relative to and used throughout the economic analysis study to establish alternatives, and provide a means for treating difficult-to-quantify elements in performing calculations and/or reporting study results. Assumptions should never be confused with facts and should be explicitly identified and explained with supporting rationale.

Benefits - Results expected in return for costs incurred. In this case, the word benefits is used synonymously with performance, results, utility or output.

Expected annual benefit. The dollar value (in constant dollars) of goods and services expected to result from a program or project for each of the years it is in operation.

Expected annual effects. An objective, nonmonetary measure of a program effects expected for each of the years a program or project is in operation. When a dollar value cannot be placed on the effects of comparable programs or projects, an objective measure of the effects may be available and useful to enable the comparison of alternative means of achieving specified objectives on the basis of their relative present value costs. These effects should be estimated for each year of the planning period and are not to be discounted.

Benefit-cost analysis - An analytical approach to solving problems of choice. It requires the definition of objectives, identification of alternative ways of achieving each objective, and the identification, for each objective, of that alternative which yields the required level of benefits at the lowest cost. This same analytical process is often referred to as cost-effectiveness analysis when the benefits or outputs of the alternatives cannot be quantified in terms of dollars. (In either form of analysis qualitative and quantitative factors, foreseeable secondary or side effects, and non-economic benefits are explicitly considered.)

Cost-Effective Alternative - That alternative which:

1. Maximizes benefits and outputs when costs for each alternative are equal (the most effective alternative); or
2. Minimizes costs when benefits and outputs are equal for each alternative (the most efficient alternative); or
3. Maximizes differential output per dollar difference when costs and benefits of all alternatives are unequal.

Constant year dollars - A phrase always associated with a base year and reflecting the dollar "purchasing power" for that 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. When cost estimates are stated in constant dollars, the implicit condition is that the purchasing power of the dollar has remained unchanged over the time period of the program being costed.

Cost and Operational Effectiveness Analysis (COEA) - A documented investigation of:

1. Comparative effectiveness of alternative means of meeting a requirement for eliminating or reducing a force or mission deficiency.
2. The validity of the requirement in a scenario which has the approval of HQ, TRADOC and HQDA.
3. The cost of developing, producing, distributing, and sustaining each alternative in a military environment for a time preceding the combat application.

Contingency analysis - A procedure employed as a result of uncertainty as to major aspects assumed in an analysis. The procedure is to take a worse case approach regarding major aspects of the study, and examine the results of the analysis in light of these changed assumptions. See a fortiori analysis and/or sensitivity analysis.

Current dollars - current year dollars reflect purchasing power current to the year the work is performed. 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.

Defense Economic Analysis Council (DEAC) - Serves in an advisory capacity to the Assistant Secretary of Defense (Comptroller) on matters related to economic analysis and program evaluation. The Council is designed to encourage DoD-wide application of the concepts of economic analysis and program evaluation in the planning, programming, budgeting, and evaluation processes and to strengthen analytical capabilities throughout the Department of Defense.

Differential costs - Differential costs are the increases or decreases in total cost, or the changes or specific elements of cost, that result from any variation in operations.

Depreciation - Depreciation is a reduction in the value of assets, usually because of wear, aging, obsolescence, and so forth. Depreciation accounting is a system of accounting which aims to distribute in a systematic and rational manner the cost or other recorded value of tangible capital assets, less salvage value, over the estimated useful life of the assets. Such accounting is a process of cost allocation, not of asset valuation.

Discount rate - The interest rate used to discount or calculate future costs and benefits so as to arrive at their present values. (See Present Values.)

Economic life - The period of time over which the benefits to be gained from a project may reasonably be expected to accrue to the Department of Defense. (Although economic life is not necessarily the same as physical life or technological life, it is significantly affected by both the obsolescence of the investment itself and the purpose it is designed to achieve.) The economic life of a project begins in the year in which it starts producing benefits. Thus, it is possible that investments may occur several years prior to the time the project starts producing benefits.

Equipment - Machinery, furniture, vehicles, machines used or capable of use in the manufacture of supplies, or in performance of services, or for any administrative or general plant purposes.

Expected annual costs - The expected annual dollar value (in constant dollars) of resources, goods and services required to establish and carry out a program or project.

Extrapolate - Estimate by trend projection the unknown values which lie beyond the range of known values in a series.

Fixed costs - Costs which are constant in total and do not vary with output.

Fortiori analysis - A procedure the purpose of which is to present a convincing comparison of the relevant alternatives being considered in an analysis. This procedure is to handicap the apparently preferable alternative by making assumptions designed to place this alternative at a disadvantage as compared with the other alternatives.

Historical cost - The cost of any objective based upon actual dollar or equivalent outlay ascertained after the fact. May use any one of a number of methods of cost determination.

Incremental costs - Costs which change as a result of changing level or nature of an activity; any cost that changes as a result of a contemplated decision. Incremental costs have the following characteristics:

1. They are limited to those cost items that will change as the result of choosing one alternative instead of another.
2. Their composition will vary, depending upon the nature of the problem under the review and the alternatives.

Investment costs - Costs associated with the acquisition of equipment, real property, non-recurring services, non-recurring production (start-up) costs, and other one-time costs. Investment costs need not all occur in a single year.

Life-cycle costs - The total cost of an item or system over its full life. It includes the cost of development, acquisition, ownership (operation, maintenance, support, etc.), and, where applicable, disposal.

Marginal costs - Change in costs incurred or expected to be incurred in production of one additional unit of output.

Non-recurring costs - One-time costs necessary to the introduction of a system. Examples are R&D and initial investment costs.

Opportunity costs - The measurable sacrifice of rejecting an alternative; the amount foregone by forsaking an alternative. Opportunity costs equal gains given up.

Outlay costs - Costs that involve an expenditure of funds.

Output - The products, functions, tasks, services or capabilities an organization exists to produce, accomplish, attain or maintain. The objectives justifying the existence of the organization and its consumption of resources. (See Benefits.)

Output measures - Useful descriptors of functions, tasks or missions performed by an organization, and of capabilities possessed.

Payback period - The length of time required for the stream of cash proceeds or cost-savings produced by an investment to equal the original cash outlay required by the investment. One of several project evaluation methods generally considered by analysts to be inferior to the present value method, because it ignores project benefits and costs once the cash outlay for the investment has been recovered. Also called payoff period and cash recovered period.

Physical life - The estimated number of years that a machine, piece of equipment or building can physically be used by the Department of Defense in accomplishing the function for which it was procured or constructed.

Present value (discounting) - A computational technique that considers that money to be paid in the future yields investment return until the point in time when it is actually used.

Real property - Land and rights therein, utility generation plants and distribution systems, building, structures, and improvements thereto.

Recurring costs - Expenses for personnel, materiel consumed in use, operating, overhead, support services, and other items incurred on a repetitive basis.

Residual value - The computed value of existing facilities, and other assets or facilities and other assets not in being, at any point in time.

Return on investment - The amount of revenues (savings) received annually from an investment. Usually expressed in percentage.

Risk or measurable uncertainty - In decision theory, the distinction is made that risk is measurable while uncertainty is not. In situations of risk, the probabilities associated with potential outcomes are known. The term may be associated with situations of repeated events, each individually unpredictable but with the average outcome highly predictable. In situations of uncertainty, the probabilities are not known.

Savings/investment ratio - The savings/investment ratio is utilized in comparing a proposed alternative with the present alternative when benefits of the alternatives are equal. The ratio is obtained by dividing the operating cost savings by the cost of the investment required to produce the savings. A savings/investment ratio of more than 1 to 1 indicates that the proposed alternative is cost-effective.

Sensitivity analysis - Investigation of how the optimal decisions and analysis results may change with respect to changes in the system parameters of basic assumptions. If a small change in an assumption results in a proportionate or greater change in the results, then the results are said to be sensitive to that assumption or parameters.

Sunk cost - A cost which is irrevocably committed to a project; such costs have no bearing on the results of comparative cost studies.

Technological life - The estimated number of years before technology will make the existing or proposed equipment or facilities obsolete.

Terminal value - The expected value of either existing facilities, and other assets or facilities and other assets not yet in being, at the end of their useful life.

Uncertainty analysis - This analysis considers the uncertainty in cost estimates. As a minimum, a complete uncertainty analysis will consider the following:

1. Requirements.
2. Program schedule.
3. Technical risk.
4. Cost estimating methodology.

Uniform annual cost - The amount of money which, if budgeted in equal yearly installments, would pay for the project. The total present value of these installments would be equal to the total present value computed from the estimated life-cycle costs.

Variable costs - That portion of total costs which depends upon output and which tends to vary with changes in production.

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