

**LIFE
CYCLE
ASSET
MANAGEMENT**

Good Practice Guide
GPG-FM-032A

Life-Cycle Cost

May 1997

Department of Energy
Office of Field Management
Office of Project and Fixed Asset Management

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Economic Analysis: Description and Methods, Department of the Army, Pamphlet 415-3	

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1. INTRODUCTION

This Guide is intended to clarify and supplement the standard methods used to estimate life-cycle costs (LCCs). This Guide will assist in accomplishing the goals and requirements of DOE O 430.1, LIFE-CYCLE ASSET MANAGEMENT.

LCCs equal acquisition costs [total project cost (TPC)] plus ownership costs (ownership includes operating, maintenance, and support of an asset throughout its life and through disposition), less revenues. LCC estimates must be included in the cost and funding information presented for a proposed DOE project. These estimates are used to justify the following types of activities:

- tradeoffs and other decisions for DOE projects when an Energy System Acquisition Advisory Board meeting is at level 0, 1, or 2 [see also *Critical Decision Criteria Guide*, GPG-FM-002, and *Project Management Overview Guide*, GPG-FM-001];
- equivalent environmental actions and planning; and
- Congressional budget requests.

The project manager and director are responsible for including LCC estimates in the project decision-making process and ensuring that downstream ownership costs are not neglected. Program offices also are responsible for ensuring that LCC estimates are properly balanced in decisions.

In general, LCC estimates have greater leverage in tradeoffs and alternative comparison and selection when they are included early in the project. For example, design decisions affect operations, maintenance, and disposal, which are the major drivers of ownership costs. The earlier the tradeoffs are made, the fewer resources are used to explore inferior alternatives and the more flexibility remains as to the alternatives considered, particularly in view of sunk costs that might be avoided.

It is tempting to neglect full LCC considerations because they tend to increase up-front costs: for example, more expensive equipment may be necessary to reduce maintenance costs; also just estimating LCCs increases design costs. Nevertheless, LCC estimates should not be neglected because potential leverage could be lost. LCC estimates should be prepared for the following purposes:

- Key Decision-1 (KD-1): Approval of New Start;
- preparations for negotiating compliance agreements;
- support of Environmental Impact Statements and site treatment plans;
- support of feasibility studies and remediation measures;
- budget submissions for fixed assets; and
- comparison of alternatives.

The Department of the Army, Pamphlet 415-3, Economic Analysis: Description and Methods (Appendix A) is a detailed document on how to develop Life Cycle Costs based on the Department of Defense methods. Note: all of the information in Appendix A may not be applicable to Department of Energy project.

2. REQUIREMENTS

The following documents contain requirements for LCC estimates:

- Office of Management and Budget (OMB) Circular A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis*;
- OMB Circular A-109, *Major System Acquisitions*;
- OMB Bulletin 95-03, *Planning and Budgeting for the Acquisition of Fixed Assets*; and
- 10 CFR 436 Subpart A, "Methodology and Procedures for Life-Cycle Cost Analysis."

LCC estimates are required for the preferred alternative and all other alternative courses of action for projects whose TPC is \$20M or more to aid in decisions such as alternatives selection or to avoid unreasonable out-year mortgages.

Including LCC estimates in the decision-making process ensures that future costs will be reasonable and can be provided for in budgets and plans. Thus, the funds to operate a facility should be available as required, and no intolerable budget burdens will emerge in the out-years, either for operations, maintenance, or disposal.

Requirements Documents

Document	Summary of Relevant Sections
OMB Circular A-94, Guidelines and Discount Rates for Benefit-Cost Analysis	¶13.c: Requires that determination of least expensive alternatives include consideration of LCC estimate.
OMB Circular A-109, Major System Acquisitions	¶5.j: Defines LCCs. ¶7: Requires tradeoff and LCC methods. ¶11.f: Requires that selection of alternatives include consideration of ownership costs.
OMB Bulletin 95-03, Planning and Budgeting for the Acquisition of Fixed Assets	page A-5: Requires that decisions be based on the present value of expected LCCs.
10 CFR 436, Subpart A, "Methodology and Procedures for Life-Cycle Cost Analysis"	Applies to energy and water conservation projects and renewable energy resource projects for new and existing buildings and facilities owned or leased by the Federal Government.

3. PRINCIPLES AND PROCESSES

Customary cost estimating methods are used to estimate the budget elements; these methods are discussed in the *DOE Cost Guide* and elsewhere (see section 5, Suggested Reading). Sections 3.1 through 3.3 provide guidance on three aspects of LCC estimating methods, analysis, and assumptions that are often misunderstood: time frame, present value, and alternatives.

3.1 Time Frame

The LCC time frame should extend from project inception through disposal of the proposed facility, or in the case of an environmental restoration project, through verification of adherence to applicable cleanup standards.

Sometimes the mission a project is to serve, or the period when the services of the asset will be needed, extends beyond the expected or design life of one or more of the alternatives. For each such option, the LCCs should also include the costs of fulfilling the mission or need beyond the expected or design life; otherwise, an inexpensive, short-lived project might be favored erroneously.

3.2 Present Value

To compare alternatives, the LCCs are reduced to present value, which is obtained by discounting the time-phased costs (regardless of type of appropriations or source of funds). Standard methods for discounting and calculating present value may be used (e.g., Chapter VI, *DOE Cost Guide*, Volume 1, January 1982, or OMB Circular A-94). OMB Circular A-94 prescribes discount rates. If other rates are used, for other than sensitivity analysis (which is encouraged in Circular A-94, page 13, ¶9.c), justification should be provided. However, the same rates must be used for all alternatives.

3.3 Alternatives

The LCC estimate should include the costs of all budget elements that would be affected by the preferred alternative and all other alternatives, even when such costs are not integral to the project and regardless of funding sources. However, sunk costs should be excluded from the totals used to compare alternatives because they are not changed by, and should not affect selection of, the alternatives.

As an example, consider a hypothetical proposed new building (the first alternative) to replace a deteriorated old building. The old building is assumed to be laden with friable asbestos and would therefore need substantial environmental work and renovation if its use were continued (a second alternative) instead of constructing the new building. The asbestos hazard must be addressed under either alternative, so D&D costs must be included in both alternatives to ensure that the comparison doesn't inappropriately include the unavoidable D&D costs in only one alternative. Therefore, the new building alternative would also include costs for D&D of the old building.

4. MEASURING FOR RESULTS

The following criteria can be used to judge whether LCC estimates are being used effectively. The first criterion measures extent of use; the second shows benefits from its use.

- Proportion of project proposals and budget elements for which appropriate and reliable LCC estimates are used.
- Budgetary savings resulting from the use of LCC estimates compared with commitments made without the benefit of LCC estimates.

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5. SELECTED DOCUMENTS

- OMB Circular A-109, *Major System Acquisition*, April 5, 1976.
- OMB Circular A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, October 1992.
- OMB Bulletin 95-03, *Planning and Budgeting for the Acquisition of Fixed Assets*, June 27, 1995.
- American Society for Testing and Materials, *Standard Practice for Measuring Life-Cycle Costs of Buildings and Building Systems*, ASTM E 917-93, March 1993.
- GPG-FM-002, *Critical Decision Criteria*, August 21, 1995.
- *DOE Cost Estimating Guide*, Volume 6, November 1994, chapters 9 and 23.
- *DOE Cost Estimating Guide*, Volume 1, June 1982.
- National Institute of Standards and Technology, *Life-Cycle Costing Manual for the Federal Energy Management Program*, Sieglinde K. Fuller & Stephen R. Petersen, NIST Handbook 135, prepared for DOE, October 1995.
- Fuller, Sieglinde K. and Petersen, Stephen R., *Life-Cycle Costing Workshop for Energy Conservation in Buildings: Student Manual*, Prepared for the DOE Federal Energy Management Program by the U.S. Department of Commerce Technology Administration National Institute of Standards & Technology, Gaithersburg, Maryland, October 1993; NISTIR5165.
- *Department of Defense Operating and Support Cost-Estimating Guide*, Prepared by the Office of the Secretary of Defense (OSD) Cost Analysis Improvement Group (CAIG), May 1992.
- Dhillon, B.S., *Life Cycle Costing*, Gordon & Breach Science Publishers, New York, New York (and others), 1989.
- Fabrycky, Wolter J. and Blanchard, Benjamin S., *Life Cycle Cost and Economic Analysis*, Prentice Hall, Englewood Cliffs, New Jersey, 1991.

6. DEFINITIONS

Life-cycle cost (LCC) includes the direct, indirect, recurring, nonrecurring, and other related costs incurred or estimated to be incurred in the design, development, production, operation, maintenance, and support of an asset throughout its anticipated useful life span and through final disposition. Revenues such as user fees, salvage receipts, or power revenues should be included as an offset to cost, if this is incidental to the project's mission (for example, a production reactor might incidentally produce and sell electric power).

Useful life is the period during which the services of the asset will be needed to support a DOE mission. If LCCs are estimated solely to support budgeting, the period of time covered by the LCC estimate need only extend to the budget out-years. If the useful life exceeds the design life of a proposed asset, the LCC estimate should include costs of means to meet the mission after the design life.

Typical elements of LCC. LCC equals acquisition plus ownership costs. Typically, acquisition cost is represented by the TPC as defined in Volume 6 of the *DOE Cost Guide*. Ownership costs are typified by elements such as the following:

- maintenance and routine facility upgrades (including related program capital and construction);
- user (program) costs such as (1) the salaries of scientists performing experiments, utilities; (2) the material costs for weapons production when those expenses will be borne by the Federal Government; (3) operations expenses (operators, lab technicians, engineers, etc.); and (4) nonrecurring costs such as equipment replacement and spare parts inventory;
- revenues (an offset to cost) such as user fees, sale of scrap, or power revenues, when incidental to the project or program mission;
- disposal of trash and contaminants during use;
- standby or surveillance;
- D&D at the end of use (in some cases, this is at the beginning also, such as when a site is already occupied and must be cleared before construction or a hazard must be addressed when use of the related asset is replaced by the new asset);

- demolition and disposal of demolished facilities;
- restoration, such as site landscaping, if appropriate; and
- termination costs, if contract termination is affected by an alternative.

7. ASSISTANCE AND POINTS OF CONTACT

For further information, contact one of the following:

- Juan Castro, FM-20, 202-586-9706
- Jerry L. Cook, LLNL, 510-423-2153 (CCMD)
- Ann Morimizu, EM-24, 202-586-0381 (CCMD)

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8. RELATED TRAINING

Refer to list of available Departmental training courses on project management through the Office of Human Resources.

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9. EXAMPLES

Sections 9.1 and 9.2 are examples of LCC estimates for several hypothetical situations, including:

- a budget submission for a fixed asset using the format of the Congressional Budget Request with corresponding paragraph numbering.
- in preparation for Key Decision-1 or negotiating compliance agreements, a concept development report or equivalent, showing the comparative costs of options considered.
- Environmental Impact Statements, site treatment plans, feasibility studies, etc.

Because the text format would probably be similar, the narrative in section 9.2 can be used as an example for both the second and third hypothetical situations.

9.1 Example 1: Budget Submission

Sections 9.1.1 and 9.1.2 are examples of information that would comprise paragraphs 12 and 13 in the Congressional Budget Request.

9.1.1 Paragraph 12.b of the Congressional Budget Request

Annual Costs (in FY 1995 thousand dollars)

	Item	Annual Cost
1	Facility operation	830
2	Facility maintenance and repair	190
3	Related program operations	9,500
4	Related program capital equipment	600
5	Related program construction	0
6	Utilities	1,000
7	Incidental revenues (an offset to cost)	-500
8	Standby or surveillance	500
9	Decommissioning, decontamination, demolition, salvage, disposal, restoration, etc.*	10,500
10	Termination costs	0

*Not annual, rather nonrecurring at the end of the program.

9.1.2 Paragraph 13.b.(1) of the Congressional Budget Request

1. Facility operation: Landlord costs (such as cafeteria operation, janitorial, and other miscellaneous support), including salaries, supplies, utilities, and disposal of trash and contaminants during use.

This facility requires an equivalent staff of seven persons (two less than now required in the facility to be replaced). Trash and other fees have been reduced because the modernized facilities are more efficient. Supplies and materials continue at their previous annual cost of \$50,000.

2. Facility maintenance and repair.

Facility maintenance and repair (maintenance and routine facility upgrades) have been costing \$1M. Based on experience with comparable past replacements, this cost is expected to decrease by half.

3. Related program operations.

Related program operations costs include user (program) costs such as the salaries of 150 scientists performing experiments and their supporting staff. These expenses are borne by the Federal Government and are based on current expenses.

4. Related program capital equipment.

The conduct of modern world-class research requires periodic purchases of scientific equipment, typically \$600 thousand per year.

5. Related program construction.

New facilities should require no foreseeable construction.

6. Utilities.

Costs are based on costs of existing buildings and efficiency is to be designed into the new building.

7. Incidental revenues.

Incidental revenues include user fees or power revenues that are an offset to cost.

8. Standby or surveillance.

Standby or surveillance costs are included if use is suspended or halted.

9. D&D.

D&D costs at the end of facility use include demolition, salvage, and disposal of demolished facilities and restoration (such as site landscaping), if appropriate.

10. Termination costs.

Termination costs are included if contract termination is affected by an alternative.

9.2 Example 2: Concept Development Report or Equivalent

This example comprises paragraphs from a hypothetical concept development report. It could also illustrate an Environmental Impact Statement, etc., if reformatted appropriately. This example is not intended to illustrate the overall document structure (e.g., how the material is summarized in the executive summary or supported in detailed backups or appendices). It does not include a summary cost backup or narrative cost explanation, but these would be similar to the narrative above.

SUMMARY OF ALTERNATIVES

The following three alternatives were evaluated to determine the best approach to supporting the mission of the X program:

- remain in the existing facility and continue to renovate as needed;
- build a new facility to house the equipment and staff; or
- lease a facility for the equipment and staff.

Other alternatives that were considered but rejected after preliminary screening include...

Life-cycle benefits and costs, as well as intangible and unquantifiable factors, were considered as part of the evaluation of the three remaining alternatives. The life-cycle duration was set at 40 years, which corresponds to the design life of the facility and the

typical life of other laboratory facilities. Costs and benefits were discounted at both 2.8 and 4.9 percent per year (the 30-year rates in OMB Circular A-94, February 1994 and 1995, respectively) to show insensitivity in the relative ranking.

Renovation costs are included in the LCC estimate because the lives of many components of the current building are near an end. Costs for decontamination of those areas that pose increasing threats to staff, the public, and the ecology have been added. Also, in view of the advanced age of the building,

Because the lives of many components in the current building are near an end, renovation costs are included. Also costs have been added to decontaminate those areas that are posing increasing threats to staff, the public and the ecology. Also in view of the advanced age of the building, annual capital expenditures continue, compared to such expenditures for the leased or new facility. Such expenditures for the leased and new facilities reflect recent experience of the laboratory.

Many operating costs for the old facility continue at traditional rates, whereas, costs for modern and better facilities have been reduced in accordance with laboratory experience and industry guidelines.

Constructing a new facility or leasing would allow evacuation of the old facility, thereby avoiding continued exposure of staff to its hazards. However, evacuation would also advance the time of final disposition of the aging facility, and so lease or construction costs must be added to the early LCC estimate, so the decision can be based on an accurate comparison.

At the end of the time frame, the costs for the various alternatives are considerably different. The old facility would require expensive D&D, demolition, etc. The costs reflect current in-house estimates and experience. The new facility, which was designed with the environment in mind, would be much easier to dispose of, and costs reflect design goals. Finally, since responsibility for disposition of the leased building would be with the owner, not DOE, there would be no cost.

In this case, the ranking is the same for both undiscounted and discounted (present value) costs, though the spread is reduced for the discounted totals (both in dollars and percent).

Cost (in FY 1995 million dollars)

Year	Item	Alternatives		
		As-Is	Build	Lease
1995	Design and build		5.0	
1995	Operations, etc.*	18.3	18.3	18.3 ^f
1995	Decontamination and renovation	15.0		
1995	Move equipment and staff			1.0
1996	Lease			2.5 ^e
1996	Design and build		12.0	
1996	Operations, etc.	18.3	18.3	12.9 ^b
1996	Decommissioning and decontamination			20.0 ^f
1997	Demolition, salvage, disposal			10.0
1996	Lease			2.5
1997	Complete build		8.0	
1997	Move equipment and staff	0	1.0	
1997	Operations, etc.	18.3	11.6 ^e	12.9
1997	Decommissioning and decontamination		20.0 ^f	
1998	Demolition, salvage, disposal		10.0	
1998-2037	Facility operation	1.15	0.83	1.0
	Lease			2.5 ^e
	Facility maintenance and repair	0.75	0.19	0.1
	Related program operations	10.0	9.5	9.7
	Related program capital equipment	1.6	0.6	0.7
	Related program construction	2.5	0	0
	Utilities	2.25	1.0	1.4
	Revenues (e.g., user fees)	0	-0.5	0

Year	Item	Alternatives		
		As-Is	Build	Lease
2038	Standby or surveillance	0.5	0.5	0
	Termination costs			1.0
2039	Decommissioning and decontamination	15.0	6.5	0
2040	Demolition, salvage, disposal	5.0	1.0	0
2041	Demolition, salvage, disposal	5.0	1.0	0
2042	Restoration	2.0	2.0	0
	TOTAL	827.2	579.9	697.1
	Present Value (2.8%/year:2/94 circ)	488.7	366.1	426.0
	Present Value (4.9%.year:2/95 circ)	359.0	282.1	319.7

Notes:

- ^a Operating costs totaled from the As-Is 199-2037 tabulation.
- ^b Operating costs are from the Lease 1998-2037 tabulation.
- ^c Operating costs are from the Build 1998-2037 tabulation.
- ^d Includes asbestos removal.
- ^e Lease annual cost is at \$25/ft² for 100,000 ft².
- ^f Illustrates that costs for an alternative may appear to be for some other facility (see section 3.3).

Appendix A

**Economic Analysis: Description and Methods
Department of the Army, Pamphlet 415-3**

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Department of the Army
Pamphlet 415-3

Construction

Economic Analysis: Description and Methods

Headquarters
Department of the Army
Washington, DC
10 August 1992

UNCLASSIFIED

SUMMARY of CHANGE

DA PAM 415-3

Economic Analysis: Description and Methods

This new pamphlet presents guidance for performing economic analysis as part of the resource allocation process for Military Construction, Army, Base Realignment and Closure, Army, Commercially Financed Facilities, Army Reserve and Army National Guard projects. Specifically, this pamphlet--

- o Clarifies the Army policy on economic analysis set by AR 11-18.
- o Describes procedures to--
 - Conduct an economic analysis within the confines of DODI 7041.3, OMB A-104, OMBA-94, and AR 11-18 (chap 2-7).
 - Report economic analysis results in a comprehensive manner (chap8).
- o Incorporates information about ECONPACK, a computer program that is available to perform economic analysis calculations. Econpack is available on PAX, and floppy disk for IBM-compatible microcomputers.

Construction

Economic Analysis: Description and Methods

By Order of the Secretary of the Army:

GORDON R. SULLIVAN
General, United States Army
Chief of Staff

Official:



MILTON H. HAMILTON
Administrative Assistant to the
Secretary of the Army

Construction, Army (MCA); Base Realignment and Closure, Army (BCA); Commercially Financed Facilities (CFF); Army Reserve; and Army National Guard projects. This information clarifies the Army policy on economic analysis set by AR 11-18 and OMB Circular A-104. Results of an economic analysis provides valuable input in deciding which projects to fund for the most cost-effective use of tax dollars. In addition to providing instructions for conducting an economic analysis, this pamphlet contains guidance for reporting.

Applicability. This pamphlet applies to all active Army installations, subinstallations, assigned activities, the Army National Guard, and the U.S. Army Reserve.

Interim changes. Interim changes to this pamphlet are not official unless they are authenticated by The Adjutant General. Users

will destroy interim changes on their expiration date unless sooner superseded or rescinded.

Suggested improvements. The proponent of this pamphlet is the U.S. Army Corps of Engineers (CEMP-P). Users are invited to send comments and suggested improvements on DA Form 2028 (Recommended Changes to Publications and Blank Forms) directly to Commander, U.S. Army Corps of Engineers, ATTN: CEMP-P, WASH DC 20314-1000.

Distribution. Distribution of this publication is made in accordance with the requirement on DA Form 12-09-E, block number 5357, intended for command levels C, D, and E for Active Army, and D and E for the Army National Guard and the U.S. Army Reserve.

History. This UPDATE printing publishes a new DA pamphlet.

Summary. This pamphlet presents guidance for performing economic analyses as part of the resource allocation process for Military

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Chapter 1 Introduction

1-1. Purpose

a. This pamphlet assists installation analysts in understanding and developing economic analyses (EAs). It explains how to conduct EAs in support of Military Construction, Army (MCA), Base Realignment, and Closure, Army (BCA), commercially Financed Facilities (CFF), Army Reserve, and Army National Guard projects and how to report results. (It does not apply to Productivity Capital Improvement Program or Energy Conservation Investment Program analyses.)

b. This pamphlet provides enough information that a beginning analyst will be able to use it as a reference to perform simple EAs for the Military Construction, Army (MCA); Base Realignment and Closure, Army (BCA); Military Construction, Army Reserve (MCAR); Military Construction, Army National Guard; and CFF projects. (In this document, MCA and BCA is denoted by MILCON.) It describes the complete EA process and the analytical tools needed to perform EAs, as well as essential data and reporting requirements. It will be useful for all persons involved in EAs, from those who assist in providing data to those who make decisions using results of the EAs. Entry-level persons may need close supervision for their part in the analysis whereas journeymen and supervisors should be formally trained in EA.

c. All methods required to perform an EA for the MILCON process are provided in this document. It is self-contained in that the complete process of performing an EA is described in detail with explanations of terminology, equations, and reporting elements. Although the report is directed toward the MILCON process, the basic EA procedures can be used for any EA.

1-2. References

Required and related publications and referenced forms are listed in appendix A.

1-3. Explanation of abbreviations and terms

Abbreviations and special terms used in this pamphlet are explained in the glossary.

1-4. Requirement for an economic analysis in the MCA process

Every Army project is required to be supported by an EA *if* feasible option to a proposed project exists. If *no* feasible options exist to meet a requirement (mission objective), a comparison of life-cycle costs and benefits is not possible. In special cases, some projects will not have any viable alternatives. However, it is a rare case when a proposed project does not have any feasible alternatives. In *all* cases, the mission objective must be determined, and possible alternatives to meet the mission objective must be investigated.

a. It is necessary to view the EA in the context of the MILCON project approval process since, ultimately, the EA serves as part of the project justification. In fact, the EA is a key element of the justification required to obtain MILCON funding.

b. The requirement for a project is normally identified by the user at the installation. This requirement is documented on a project justification forms DD Form 1391 (FY , Military Construction Project Data), and submitted to higher command levels for approval. Project justifications are reviewed at the major Army command (MACOM), Headquarters, U.S. Army Corps of Engineers (HQUSACE), Office of the Secretary of Defense (OSD), and Congressional levels (fig 1-1).

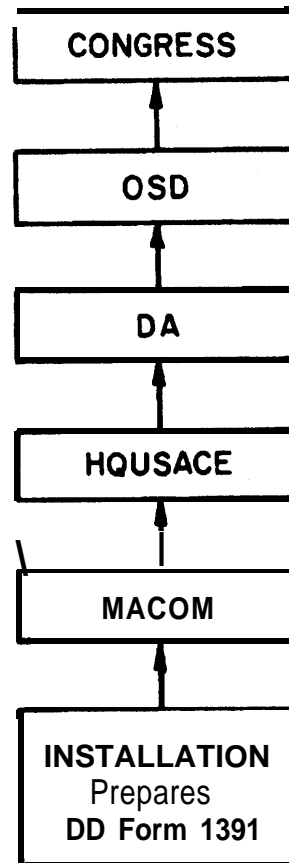


Figure 1-1. Project review process

c. Lack of a proper EA in support of projects can result in deferral or elimination of the projects from the MILCON program.

d. On the DD Form 1391, EA justification is to be documented in section 11 (Economic Analysis). (See AR 415-15 for additional information on DD Form 1391 project submission.)

1-5. Exceptions to the requirement

a. In addition to projects where only one method exists to meet the mission objective, DODI 7041.3 and AR 11-18 both provide three standard exemptions from the requirement for a formal life cycle cost analysis. From DODI 7041.3—

(1) 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.

(2) In case 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.

(3) 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. Except for these three exemptions, a formal EA is required for any MCA or BCA project if at least one feasible option to a proposed project exists.

b. It is important to note that if an EA is not provided, reasons (1) through (3) above, as specified by AR 11-18, must be documented on the DD Form 1391, Section 11D for the project.

Chapter 2 Concepts, Goals, and Steps of Economic Analysis

2-1. Description of economic analysis

a. The Army never has adequate funding resources for obtaining facilities to meet new mission requirements, replace aging or functionally obsolete structures, and renovate existing ones. Decisionmakers need economic evaluations to help them choose projects. They must be confident that the most economical and beneficial alternatives to meet Army needs are considered in the decisionmaking process. The best solution among many alternatives is identified and selected by doing an EA.

b. EA is a systematic method for studying problems of choice. Alternative ways to satisfy a goal (requirement) are studied by evaluating the quantifiable costs and benefits of each alternative. These costs are assessed objectively using economic and statistical techniques so that alternatives can be compared through a numerical ranking. The principle of life-cycle costing is used in EA (all resources required during the analysis period are considered).

c. EA is a common sense approach for allocating scarce resources efficiently. The Army EA policy is simply a formal directive that describes EA processes.

d. An Army EA relies on three sound economic principles-

(1) All reasonable alternative methods of meeting an objective must be considered.

(2) Each alternative must be evaluated in terms of its total life-time effects (life-cycle costs).

(3) The value of money changes over time. Adjustments must be made for this change so that the costs of alternatives can be compared at a common point in time.

e. An EA analyst uses a standard method to organize and present elements of an economic study so that—

(1) Informal thinking is focused and clarified.

(2) Hidden assumptions are found, discussed, and their impacts studied.

(3) Information is reported in simple, concise terms for use in recommendations and project funding decisions.

2-2. Goal of economic analysis

The goal of EA is to compare quantitative cost and benefit information for alternative solutions to a problem or requirement. Proper use of this information will lead to efficient allocation of scarce funding resources in the MILCON process. An EA is one of several decision criteria; it is not the only factor used by the decisionmaker.

a. An EA promotes a clear understanding of the stated need, possible solutions, and cost implications. It allows the analyst to compare options on an equal basis (in time).

b. The EA approach results in an objective assessment of all costs, benefits, and uncertainties. Once identified, uncertainties can be evaluated through sensitivity analyses.

c. The ultimate goal is that tax dollars are spent most economically.

2-3. General guidelines for performing economic analysis

EA development consists of seven basic elements. An overview of these elements is given below. Chapter 3 contains a detailed discussion of each step.

a. *Objective.* State the purpose of the analysis clearly and concisely and, if possible, in quantitative terms. This is done so that a reviewer understands the project requirement to be met.

b. *Develop a complete list of alternative solutions to the requirement.* This list will include feasible and nonfeasible alternatives. If any alternative is left off of this list the validity of the EA may be questioned. Not including all alternatives biases the EA.

c. *Document any assumptions.* The impact of assumptions can be tested later in sensitivity analyses.

d. *Collect cost and benefit data.* Sources of data and the data calculations must be documented as they are very important in determining accuracy.

e. *Perform the EA calculations accurately.* Nothing can cause a reviewer to return an EA more quickly than to find mathematical errors. Most errors can be avoided by using one of the standard computer programs (para 2-8 below).

f. *Perform sensitivity analysis.* Test uncertainties in cost or benefit data—their values or the times they occur—to determine their impact on the results of the EA. Sensitivity analyses must be performed when large uncertainties exist.

g. *Report the EA results and recommendations.* This is essential to show management and decisionmakers that the best alternative has been selected and recommended for funding.

24. Guidelines for ranking alternatives

For most EAs, the best alternative is the one that is least cost to the Government over the period of time for which the requirement is to be met. The appropriate ranking method for a specific type of EA must be used. Specific techniques for ranking alternatives are given in chapter 4.

2-5. Determining the scope of an economic analysis

The scope (alternatives considered) of an EA is defined in terms of the requirement, time period for the analysis, and the effort needed to perform it.

a. The scope of an EA will depend on the requirement being addressed. Normally the alternatives considered will be confined to the installation or community and the immediate surrounding area. Space to house the installation commanding officer would be on the installation. However, facilities to house visiting officers could be provided in the adjacent community. Alternatives may be limited by the mission requirement. For example, vehicle maintenance may be limited to on post options for security.

b. The scope of the EA in terms of time will usually be well defined in the statement of the requirement. For example, the number of years a central heating plant is needed would be stated in the requirement or would be understood to be the length of time that the installation would be active.

c. The scope in terms of level of effort required depends on the project. For example, if a range improvement costs \$2M with annual out year costs of \$ 100K and the only alternative is to send troops to another base for training at an annual cost of \$7M, no further data research is warranted. In this case, little effort will be spent developing costs used in the EA. However, a complete life-cycle comparison must still be done.

2-6. Applicability of economic analysis techniques and processes

a. EA can be applied to all decisions for which there are at least two possible ways of meeting a requirement. The EA provides the decisionmaker with the relative ranking of options with respect to cost over the life of the project.

b. EA can be applied to very small problems such as replacing versus leasing a duplicating machine, as well as very large ones such as base consolidations.

c. EA is an indispensable tool to management in planning for the future. In the normal funding environment, the Army never has enough funds to complete all its goals. EA can assist management in allocating these scarce funding resources in the most efficient way.

2-7. Guidance for overseas commands and installations

Overseas commands and installations face several issues different from those in the continental United States (CONUS), Hawaii and Alaska.

a. The options may be very limited due to host country restrictions, status of force agreements (SOFA) and U.S. laws may limit MILCON or leasing opportunities.

b. Exchange rates for foreign currencies fluctuate greatly and their future values are difficult to estimate. The assumption is made that the selected exchange rate will remain constant over the analysis period,

c. Foreign inflation rates are much different than those in the United States.

2-8. Computer programs for economic analysis

a. Proper preparation of an EA requires a major effort to gather data do mathematical calculations, and summarize results into required report formats. Use of currently available computer programs can reduce the time required, ensure correct calculations, and produce results that comply with DOD guidance. A word of caution: results from computer runs are only as good as the data input—valid data must be used.

b. The ECONPACK program is available on the MILCON Programming, Administration, and Execution (PAX) System. A microcomputer version (PC ECONPACK) is available that allows the computer input file to be uploaded to the mainframe system. This allows analysts to run EAs on a personal computer until a final result is achieved. The mainframe version allows automatic copying of the EA results to the DD Form 1391 which is required before the DD 1391 is submitted for higher level review. Information on these programs can be obtained from HQUSACE (CEMP-P). See appendix E for sample computer outputs.

Chapter 3 Principles of Economic Analysis

3-1. The economic analysis process

The seven steps in the EA process are shown in figure 3-1 and discussed in detail below.

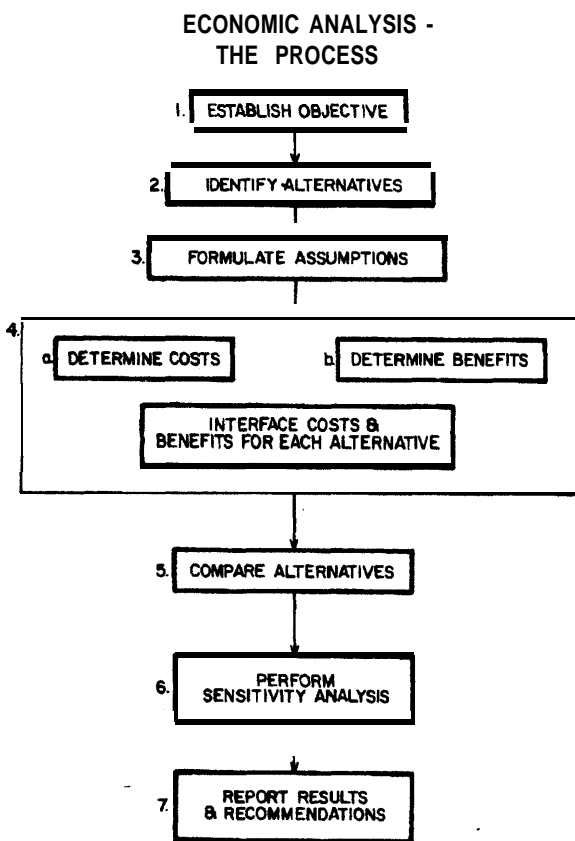


Figure 3-1. Steps of an economic analysis

a. *Step 1: Establish the objective.* The single most important step in an EA is to define the objective. Without a clear, concise statement of what the EA is to evaluate, the EA will not be successful. With this definition, the analyst sets the objectivity of the analysis. An improperly stated objective may indicate that the EA was done to justify a conclusion and not to determine—without bias—the most economical solution for a requirement.

(1) Consider the following two objectives-

(a) Provide 35,000 square feet of general warehouse space for a 15-year period.

(b) Construct a general warehouse building with an area of 35,000 square feet with a 15-year life.

(2) The first states an objective in unbiased terms whereas the second is biased toward constructing a new facility. The *wording is* critical in stating the objective. Not only should it be unbiased, but it should also contain explicit criteria for measuring the results from the proposed concept. In the above, the goal is to provide 35,000 square feet of warehouse space for 15 years and any proposed solution must meet this criterion.

b. *Step 2: Identify alternatives.* The next step is to list alternatives initially considered to meet the objective. Alternatives that are not feasible must be discussed in the documentation but need not be included in the cost comparison. An alternative is said to be feasible if it fully meets the stated objective. It is vital that all realistic options be considered and *documented* for higher levels of review. Common alternatives for requirements in the MILCON program are--

(1) New construction.

(2) Leasing.

(3) Renovation or conversion.

(4) Modification or addition.

(5) Commercially financed.

(6) Status quo.

(7) Other DOD or Federal agency facilities.

(8) Contract for services.

c. *Step 3: Formulate assumptions.* In most EAs, the analysts must make some assumptions. Common assumptions include the estimated useful life of an asset, an estimated requirement, the replacement time for a building component (such as a roof), and the future cost of a required repair action. Often, analysts must formulate assumptions before they can choose alternatives wisely. Assumptions must be stated so that reviewers can assess their impact on the EA. Assumptions should never be used if factual data is available or can be obtained, as they can impact the validity of the analysis.

d. *Step 4: Estimate costs and benefits.* This step is the most difficult and time-consuming part of an analysis. The analyst must consider all costs and benefits associated with each alternative and how to collector estimate them. They must be determined for the entire life of the project to reflect total life-cycle costs. Estimates must be made for the year in which the cost is to be incurred or the benefit is to be received. Each option must be studied separately. This step is critical as the overall accuracy of the EA depends on the accuracies of these estimates. Meaningful conclusions can only be obtained from meaningful data.

e. *Step 5: Compare costs and benefits and rank alternatives.* This step is the heart of the analysis. It is also the easiest, because once the first four steps have been completed, the comparisons and ranking can be done using computer programs. Comparisons give managers the information needed to make informed decisions. Once the costs and benefits for all options are found, one option can be compared with another. The main benefit to be derived from a MILCON project is fulfillment of the stated objective. This is a benefit common to all alternatives in the EA, and its inclusion in the EA calculations would not affect the ranking of the alternatives. So, dollar quantification of the major benefit is unnecessary. Emphasis is, therefore, placed on the costs of the alternatives. Dollar quantifiable benefits (other than meeting the stated objective) of each alternative are treated as cost offsets for that alternative.

- (1) Three general criteria are used to compare and rank them—
 - (a) Least cost for a given level of effectiveness.
 - (b) Highest effectiveness for equivalent cost.
 - (c) The largest ratio of effectiveness to cost.
- (2) These three criteria conform to the three basic types of cost and benefit relationships—
 - (a) Unequal cost and equal effectiveness.
 - (b) Equal cost and unequal effectiveness.
 - (c) Unequal cost and unequal effectiveness.
- (3) At times, alternatives have equal costs and equal benefits. When this happens, an alternative is chosen based on noneconomic factors. In most MILCON EAs, the first type is applicable — all alternatives would have the same effectiveness such as providing quarters for 100 officers, and the lowest cost option is the one preferred. Table 3-1 shows how to compare the alternatives.

Table 3-1
Comparison of alternatives

Costs	Benefits	Basis for Recommendation
Equal	Unequal	Most benefits
Unequal	Equal	Least costs
Unequal	Unequal	Highest benefit-to-cost ratio
Equal	Equal	Other factors

f. Step 6: Perform sensitivity analysis. A sensitivity analysis is a “what-if” exercise. It tests whether the conclusion of an EA will change if some variable such as a cost, benefit, or assumed inflation rate changes.

- (1) Sensitivity analyses should always be performed when—
 - (a) The results of the EA do not clearly favor any one alternative.
 - (b) There is a great deal of uncertainty about a cost, benefit, or assumption in the EA.
- (2) If a change in a variable or assumption causes a change in the ranking of alternatives, the EA is said to be “sensitive” to that variable or assumption. By performing a sensitivity analysis and including its results in the report, the analyst ensures the decisionmaker that uncertainties in the EA have been tested and the results documented.

g. Step 7: Report results and recommendations. The EA report should be detailed and include data sources. It is important to state the recommendation because the cost comparison alone may not determine which alternative best meets the objective. A detailed outline for reporting is given in chapter 8.

3-2. Classes of economic analyses

There are two types of economic analyses—secondary and primary. A secondary analysis is for a situation in which a new requirement is to be met, or when the current method of meeting a requirement is no longer suitable to meet that requirement. A primary analysis is performed when a better, *less costly* way to meet an existing requirement is proposed; that is, although the requirement is being met by the current method, a better method is available.

a. Secondary analysis. In a secondary economic analysis, the most economical option is selected from a group of options, all of which will perform a function or satisfy a mission which is not justified on the basis of dollar savings. For example, an additional facility requirement may be justified due to the expanded mission of an installation. The economically preferred alternative does not result in an absolute savings; rather it represents the least-cost alternate relative to other possible alternatives. Examples are a requirement to

house 1,000 more trainees, a requirement to maintain an extra 100 tanks, and the need to provide a facility to meet current demands of the users.

b. Primary analysis. In this type of analysis, the purpose of comparing alternatives with a present method of operation for meeting a requirement is to minimize costs to the Government. Investments supported by primary EAs must predict absolute cost savings over the present method of meeting the requirement. An example is constructing a new automated maintenance facility to increase productivity.

c. Impact. Results of these two types of analyses have different impacts on the Army’s cash flow. Secondary EAs justify investments that start an expense stream. Primary EAs justify investments intended to reduce an existing cash flow.

3-3. Present value and discounting

EA alternatives are compared and ranked using present values of costs and benefits. The concept of time value of money is fundamental to EA and must be understood before other aspects of the analysis can be discussed. The value of \$1,000 today is not the same as \$1,000 5 years from now. Money is a productive commodity and there is a price for its use. This price is called interest. Interest is expressed as a percent or decimal representing the fractional amount of a loan the borrower must pay the lender within a specified interval of time.

a. Compound interest. Suppose an amount of money, P, is borrowed today at an annual interest rate, i. The amount of money, P, is called the principal. Assume that the money is to be repaid at the end of 1 year. At that time, the borrower will have to pay the lender not only the principal, P, but an additional amount, P x i. This surcharge, P(i), is the price (interest) the borrower must pay for the use of the money for the year that the loan is outstanding. So, the total future amount, F₁, paid to the lender is—

$$F_1 = P + Pi = P(1 + i)$$

Equation 3-1

(1) Now suppose the above loan is to be repaid at the end of 2 years instead of 1 year. The amount which would have been repaid at the end of year 1 is P(1 + i), as shown in equation 3-1. This becomes the principal during the second year; that is, the interest has been compounded at the end of year 1. The amount repaid at the end of year 2 is—

$$F_2 = P(1 + i) + [P(1 + i)]i \\ = p(1 + i)(1 + i) = p(1 + i)^2$$

Equation 3-2

(2) In equation 3-2, P(1 + i) takes the place of P in equation 3-1. An example of computing compound interest is shown in figure 3-2. To compute compound interest for, n, years, the same reasoning is used. The general equation for the total amount to be repaid to a lender at the end of, n, years for an amount, P, loaned today at an annual rate of interest, i, is—

$$F_n = p(1 + i)^n$$

Equation 3-3

Problem: A savings account is opened at a bank with an initial deposit of \$10,000. If the bank pays interest on savings at the rate of 10 percent per year, what will be the balance after 3 years? (Assume no deposits or withdrawals in the 3 years.)

Solution: This is the same as a loan by you to the bank. Here, $P = \$10,000$, $i = 0.10$, $n = 3$, and by equation 3-3--

$$\begin{aligned} F_3 &= \$10,000(1 + 0.10)(1 + 0.10)(1 + 0.10) \\ &= \$10,000(1.10)^3 \\ &= \$10,000(1.331) \\ &= \$13,331 \end{aligned}$$

Figure 3-2. Example of computing compound interest

(3) Another way of viewing this loan is that the future value to the lender of, P , dollars today is $P(1 + i)^n$ dollars, n , years from today. The borrower, in order to secure, P , dollars today, is willing to pay $P(1 + i)^n$ dollars n years from today. The lender and borrower complement each other as, P , dollars today and $P(1 + i)^n$ dollars n years from now are equivalent. Using equation 3-3, any principal amount can be converted to a future value. The reverse is also true. Rearranging the equation, any future amount can be converted to its present value. If the principal, P , in equation 3-3 is viewed as the present value (PV) of the future amount F_n , the relationship can be expressed as--

$$PV = F_n \frac{1}{(1 + i)^n}$$

Equation 3-4

(4) In equation 3-4, F_n represents the dollar amount value, n , years in the future of an investment today at an interest rate, i . The PV represents a cash equivalent in today's dollars (that is, a present value or present worth). The quantity $1/(1 + i)^n$, which is a number less than unity, reduces the future cash amount, F_n , to its equivalent PV, and is called a discount factor. Figures 3-3 and 3-4 show examples of computing the present value rather than the future value.

Problem: A parent wishes to establish a college account for a newborn child. The parent estimates the education will cost \$40,000 18 years from now. If the interest rate on the account is guaranteed at 8 percent indefinitely, how much must be invested today to have \$40,000 on the child's 18th birthday?

Solution:

Here, $F_n = \$40,000$, $i = 0.08$, and $n = 18$.

The formula is--

$$\begin{aligned} PV &= F_n \frac{1}{(1+i)^n} \\ PV &= \$40,000 \frac{1}{(1.08)^{18}} = \$40,000(0.2502) \\ &= \$10,008 \end{aligned}$$

Figure 3-3. Example of computing present value for investment purposes

Problem: An installation needs to reroof a large building. Roof material A will last 15 years and cost \$2M to replace at that time. Material B will last 22 years with a replacement cost of \$2.8M. An interest rate of 10 percent is used to compare the materials. Which is the least cost with respect to replacement cost?

Solution:

$$\text{Material A: } PV = \frac{\$2M}{(1.10)^{15}} = \$2M(0.2394) = \$478,800$$

$$\text{Material B: } PV = \frac{\$2.8M}{(1.10)^{22}} = \$2.8M(0.1228) = \$343,840$$

Material B is least cost. In today's dollars, its replacement cost is less than that of Material A.

Figure 3-4. Example of computing present value for a least-cost comparison

b. Investment. The Army is no different from a private investor in that it seeks the best return on its investments. Thus, in Army economic analyses, future costs and benefits are brought to a common point in time so that valid comparisons can be made.

(1) In equation 3-4 the value of i is called the *discount rate*. This rate is established by the Office of Management and Budget (OMB). Currently, two methods are used to determine the discount rate for DOD capital investments. The first, used since 1972, is described in OMB Circular A-94. OMB A-94 mandates a 10 percent discount rate for evaluating capital investments. The second in OMB Circular A-104 (1986), proposes that the discount rate for government investment analysis be tied to the rate at which the Federal Government is willing to borrow money.

(2) Figure 3-5 shows the difference between using and not using discounting in comparing three alternatives. Appendix B gives tables of discount factors for 10 percent. Both end-of-year and mid-year rates are given. End-of-year means that the cost or benefit occurs at the end of a year whereas mid-year factors are used for costs and benefits occurring in the middle of the year. If they occur evenly during the year, it is customary to use the total for the year and use a mid-year factor. Equation 3-4 is used to calculate both end-of-year and mid-year factors. As an example, to calculate the end-of-year factor for 10 years, simply use 1 for, F_n , and 10 for the value of n ; to calculate the mid-year for 10 years, use 9.5 for the value of, n .

(3) There is a relationship between mid-year and end-of-year discounting. A present value calculated using end-of-year discounting can be converted to mid-year by *multiplying* by $(1 + i)0.5$ and, conversely, a present value computed using mid-year discounting can be converted to end-of-year by *dividing* by $(1 + i)0.5$.

(4) Each table has a column of single-year present worth factors to be used for cost(s) in one year. Each also has a column of cumulative factors for use when the cost(s) occurs in every year. For example, to discount a \$10,000 cost occurring in years 1, 2, and 3 (end-of-year), use table B-1. The present value can be calculated by either equation 3-5 or equation 3-6.

$$\$10,000(0.909) + \$10,000(0.826) + \$10,000(0.751) = \$24,660$$

Equation 3-5

$$\$10,000(2.487) = \$24,870$$

Equation 3-6

(5) The \$10 difference in equations 3-5 and 3-6 is due to rounding.

c. Summary. Money is a productive commodity and as such commands a premium, called interest, for its use. Because of this, there is a time value associated with money. A dollar today is worth more than a dollar 5 or 10 years from now. (A dollar today can be invested and earn interest.) Investors take this fact into account when analyzing an investment proposal involving expenditures and

receipts at varying points in time. To make meaningful comparisons, costs and returns must be converted into equivalent costs and returns occurring at a single point in time. This point is usually the present or the time of analysis. Equation 3-4 is used to convert future values to that time.

3-4. Economic analysis period

The economic analysis period begins with the year to which costs are discounted. Figure 3-6 shows the relationships between key dates in a typical analysis period for a construction project in the MILCON program. These key dates are defined below.

a. Base year of an economic analysis is the year to which all costs and benefits will be discounted. This year can be either before, after, or the same year that costs/benefits begin to occur for any alternative. Normally, the base year will be the year in which the EA is performed or the same year as the start year (defined below). From a purely mathematical viewpoint, the choice of a base year will not affect the rankings of alternatives, only the magnitude of difference between them.

b. Start year is the first year in which initial investments are made (first year in which costs occur) and often is the first year of the period of analysis.

c. Lead time is the time from the beginning of the start year to the beginning of the economic life of the asset. There may be a significant lead time between the initial investment expenditure and the beginning of the economic life of the asset. Economic life of an asset starts only when the Army begins to receive tangible benefits. Usually this is the date of beneficial occupancy of a facility.

d. Analysis period is normally the time from the start year to the end of the mission requirement (period of time over which comparisons are made). The mission requirement may be indefinite, but in MILCON EAs, long-range planning is usually 25 years.

e. Economic life of an asset is the period during which it provides a positive benefit to the Government.

(1) The economic life of an asset in an analysis is limited by—

(a) The mission life (period over which the asset is needed).

(b) The physical life (period over which the asset is expected to function).

(c) The technological life (period of technological usefulness).

(2) Usually, the economic life of an alternative will be the shortest of the three lives above. Table 3-2 gives guidelines for estimating economic lives. If shorter ones are used, reasons should be documented in the report. These guides can be interpreted as maximum lives. Local data or conditions may dictate shorter times to be used in the analysis.

Table 3-2
Economic life guidelines

	Years
Automated data processing (ADP) equipment	8
Buildings	
Permanent	25
Semipermanent, nonwood	25
Semipermanent, wood	20
Temporary or rehabilitated	25
(with extra maintenance at 15 years)	
Operating Equipment	10
Utilities, plants and utility distribution systems	25
(including investment projects for electricity, water, gas, telephone, and similar utilities)	
Energy-conserving assets	
Insulation, solar screens, heat recovery systems, and solar energy installations	25
Energy monitoring and control systems	15
Controls (e.g., thermostats, limit switches, automatic ignition devices, clocks, controls, photocells, flow controls, temperature sensors)	15
Refrigeration compressors	15

3-5. Developing cash-flow diagrams

a. One of the first steps in organizing cost/benefit data in an EA is to list, for each alternative, all costs, benefits and their timing. Often a cash-flow diagram is used to depict this information. A cash-flow diagram displays, in graphic form, the timing and magnitudes of all costs associated with a given alternative. Usually a diagram is drawn for each alternative in an analysis. Figure 3-7 is a cash-flow diagram for an alternative with a 10-year life, with an investment cost of \$5000 at the beginning of year 1, mid-year annual costs of \$300, one-time costs (mid-year) in years 4 and 8 of \$500, and a salvage value of \$2000. In a cash-flow diagram, costs are depicted with a downward arrow whereas benefits (such as savings) are shown as upward arrows.

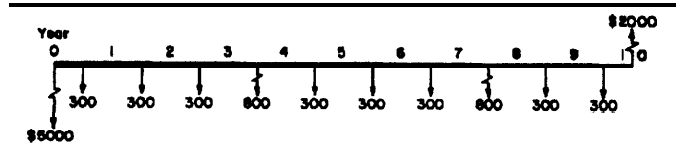


Figure 3-7. Example cash-flow diagram

b. It is important to place a cost at the proper point in time because its discounted value depends directly on the time it occurs. Once a cash-flow diagram is developed, the data can then be easily input into a computer program that will do the calculations.

3-6. inflation

a. Inflation is a consistent rise in costs (prices) of goods and services over time. In EA, inflation is treated differently, depending on the OMB guidance being used to perform the analysis. Inflation guidance is provided below when using either OMB A-104 or OMB A-94 guidance.

b. To discuss inflation concepts it is necessary to understand the concepts of constant and current dollars.

(1) Constant dollars indicate constant purchasing power, in terms of the dollar value in the base year of the EA. An EA is said to be in constant dollars if all costs are adjusted to reflect the level of prices for the base year. For example, if the annual maintenance cost is \$20K in the base year, it will be \$20K in each year of the analysis.

(2) Current dollars are expressed in the value of their year of occurrence. Past costs are simply expressed as the actual amounts paid out. Future costs are expressed in amounts expected to be paid in their year of occurrence. These costs include any amount due to inflation or deflation at a level different from the general inflation rate.

c. OMB Circular A-104 requires that all costs in the analysis be inflated. (Note that the interest rate on U.S. Treasury Securities is used as the discount rate for OMB A-104 analyses. The U.S. Treasury Security rate includes inflation and thus all costs must be inflated.) OMB A-104 also suggests that a sensitivity analysis be done to evaluate the impact of changes in the inflation rate.

d. When OMB A-94 guidance is followed, inflation is not considered in the EA since the 10 percent discount rate specified excludes the effect of any general inflation. As documented in OMB Circular A-94, the rate of 10 percent represents an estimate of the average rate of return on private investment, before taxes and after inflation. Thus, all costs are expressed in terms of constant dollars in the base year. For example, if the maintenance cost is \$10,000 in the first year, it will have the same value for future years unless the maintenance workload increases.

e. When OMB A-94 guidance is followed, and some costs are increasing faster than the general rate of inflation, the value of those costs must be inflated before discounting. Suppose one of the costs is maintenance of a complex electronics station and the cost of labor is increasing 3 percent per year *faster* than the overall inflation rate. The cost at the beginning of the second year would be the cost at the start of the first year increased by 3 percent, the cost in the third year

would be the cost in the second year increased by 3 percent (cost at the end of third year = first-year cost x 1.03 x 1.03 x 1.03), and so on. Once all inflated values are computed for this cost, they are discounted along with the other costs in the EA. Note: deflation is the opposite of inflation—a cost increase at a rate less than the general rise in prices. Deflation for a specific cost should be performed just as inflation is done.

f. There is usually a time gap between the present (when the EA is performed) and the start year (when costs are first incurred). This means that costs estimated at the present time may have to be inflated to the start year. For example, if the period of analysis begins in 1993, but cost estimates from 1989 are obtained, these costs must be inflated from 1989 to 1993.

3-7. Life-cycle costing

EA helps the decisionmaker allocate resources effectively only when all direct and indirect resource implications associated with each alternative are considered. The EA must analyze the impact of all costs incurred during the life span of the project. This step is important because initial investment costs can be misleading. For example, renovation may require less of an initial capital investment, but its annual operations and major repair costs may be much higher than similar costs with other alternatives.

a. An investment decision commits many different resources for future allocation and various sources of funds. Construction of a maintenance shop, for example, involves not only the construction cost, but also-

- (1) The allocation of land.
- (2) The commitment of funds for personnel, operations, and routine maintenance.
- (3) Other recurring and nonrecurring costs during the facility life.
- (4) Possibly a cost to demolish the shop at a future point in time.

b. The goal of an EA is to give the decisionmaker an essential piece of information for use in the resource allocation process. It gives an unbiased picture of the full life-cycle resource and benefit implications of each alternative. Once this information is available, a decision can be made to achieve the best level of national defense possible within the constraints of the Army budget.

3-8. Depreciation

The Government does not use depreciation as it has no impact on the cash flow. The only costs to be used in an EA for MILCON alternatives are for elements such as labor, materials, supplies and utilities.

a. In the private sector, depreciation write-off of a long-term asset is an accounting expense. The benefit is that a firm can deduct its depreciation allowance from net income before paying taxes.

b. In summary, depreciation write-off is used only when an income tax structure exists. The Government does not pay income taxes, and therefore depreciation write-offs must not be included in analyzing Government investments. However, the concept of depreciation can be used to help estimate the residual value of an asset.

3-9. Economic analysis versus budgeting

Economic analysis and budgeting are completely separate processes. EA is used to help determine the best alternative to meet an Army requirement. Data presented in the EA may not be useful in a future budget process. An EA may contain costs over several organizations, making it difficult to use them in the budgeting process for a single element. Some costs may be omitted from the EA because they are “wash” costs (the same for all alternatives). Also, the time basis of EA costs may differ from that of the budgeting process.

Projects A, B, and C each require equal investments, but the occurrence of costs varies by years as shown below.

<u>Year</u>	<u>A</u>	<u>B</u>	<u>C</u>
1	\$7,500	\$0	\$5,000
2	7,500	0	12,000
3	7,500	0	16,000
4	7,500	0	3,000
5	7,500	37,500	1,500
Total (Nondiscounted)	\$37,500	\$37,500	\$37,500

Alternative A:

<u>Year</u>	<u>Cost (\$)</u>	<u>10% Discount factor</u>	<u>Present value (\$)</u>
1	7,500	0.909	6,818
2	7,500	0.826	6,195
3	7,500	0.751	5,632
4	7,500	0.683	5,122
5	7,500	0.621	4,658
Total (Discounted)			28,425

Alternative B:

<u>Year</u>	<u>Cost (\$)</u>	<u>10% Discount factor</u>	<u>Present value (\$)</u>
1	0	-	-
2	0	-	-
3	0	-	-
4	0	-	-
5	37,500	0.621	23,288
Total (Discounted)			23,288

Alternative C:

<u>Year</u>	<u>Cost (\$)</u>	<u>10% Discount factor</u>	<u>Present value (\$)</u>
1	5,000	0.909	4,545
2	12,000	0.826	9,912
3	16,000	0.751	12,016
4	3,000	0.683	2,049
5	1,500	0.621	932
Total (Discounted)			29,454

Disregarding the time value of money, the alternatives are equal in cost. But, incorporating the time value of money and using a 10 percent discount rate shows that alternative B is preferable to either of the others.

Figure 3-5. Example showing impact of the time value of money

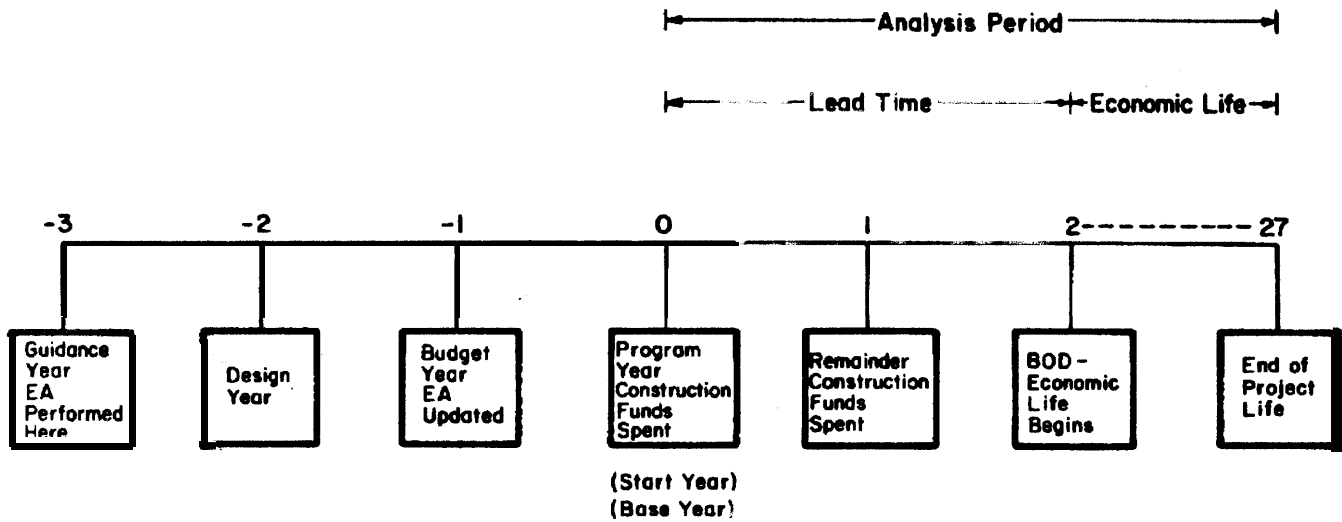


Diagram showing the relationships among key dates in an analysis period for a typical MILCON project. EA preparation usually is in the first part of the guidance year. (See AR 415-15 for more details on the design and budget process.)

Figure 3-6. Relationships among key dates in an analysis period for a typical MILCON project

Chapter 4 Methods of Economic Analysis

4-1. General

This chapter describes five EA methods used to compare alternatives. Each method includes examples of how and when to use it. One or a combination of these methods can be used for all EAs done for MILCON and CFF projects. Net present value or equivalent uniform annual cost must always be calculated, regardless of the type of analysis performed.

4-2. Net present value (NPV)

a. This method is used when all alternatives meet the mission requirement over the same period of analysis. This method is the "standard" way to compare alternatives in the MILCON process. It is the only method recognized by OMB Circular A-104 for EAs performed when one alternative is a lease.

b. NPV is calculated for each alternative. The alternatives are ranked and the one with the lowest NPV is the preferred option. The NPV is calculated for an alternative by discounting the value of the costs minus the benefits for each year and summing over the years for a total or net value.

c. Consider the two cash-flow diagrams in figure 4-1. The renovation alternative has an initial cost, annual maintenance costs, and a reroofing cost. The new construction alternative has a construction cost and an annual maintenance cost. It also has a large residual value. Figure 4-1 also shows the calculations needed to discount all costs and the residual value to the base year of the analysis—1990. Note that cumulative factors are used for a cost that occurs every year and single amount factors for a one-time cost.

(1) The NPVs calculated for each alternative are-

(a) New construction: \$7,209,100.

(b) Renovation: 7,231,700.

(2) The difference of \$22,600 shows that new construction is the most economical alternative. Because the NPVs are very close, further (sensitivity) analysis would normally be done and nonquantifiable factors considered before a recommendation could be made. This example shows that all life-cycle costs need to be considered: initial costs alone do not provide enough information to support a decision.

4-3. Savings/investment ratio (SIR)

EA finds the most economical way to meet a requirement, given that there is more than one alternative. As explained earlier, a secondary analysis addresses a requirement that is not adequately satisfied when the EA is performed. There is another possibility y: a given requirement may already be met at the present time, but a better solution could be found. In the context of EA, "better" specifically means that the total NPV cost of an alternative is lower than that of the existing alternative (the status quo) over the same period (economic life). In such a case, the justification for implementing another alternative is economic; the analysis supporting the proposal is called a primary EA.

a. In addition to comparing a proposed alternative with the status quo by examining the total NPV costs, another method is used for primary analyses—the savings/investment ratio (SIR). SIRs compare the profit potentials of the alternatives. SIR means exactly what it states—the ratio of savings resulting from an alternative (to the present method) to the investment required for implementing the new alternative. An SIR value of 1.0 means that the savings NPV equals the investment cost NPV required to effect those savings. Thus, for an investment to be economically feasible, the SIR must be greater than 1. If there are several alternative(s), their SIRs can be compared (ranked). However, the analyst must assess other implications of the analysis such as amount of the investment and the savings. For example, one alternative might have an SIR of 5.0 while another has an SIR of only 2.0. Normally, the one with the

higher SIR would be preferred. But if the total savings over the analysis period for the option with the higher SIR is very small in total discounted dollars compared with the savings from the other option, the one with the smaller SIR may be preferred.

b. The SIR is used only to compare investment costs to savings to determine if the investment costs can be recovered through savings.

c. When computing an SIR, total annual maintenance and operations are not discounted—only the difference between annual costs for the two alternatives. Thus, the crucial question is: “Are the recurring savings of the alternative relative to the status quo large enough to justify the investment costs needed to implement the alternative”.

(1) For an alternative A to a status quo Q, the total PV savings of A relative to Q can be calculated as shown in equation 4-1.

$$PV(S) = PV(A1-Q1) + PV(A2-Q2) + \dots + PV(An-Qn)$$

Equation 4-1

where S is savings, PV is “present value of,” and Ai and Qi are yearly costs. Thus, the SIR is as shown in equation 4-2.

$$SIR = \frac{PV(S)}{I}$$

Equation 4-2

(2) If the investment extends over more than 1 year, it should also be discounted as in equation 4-3.

$$SIR = \frac{PV(S)}{PV(I)}$$

Equation 4-3

d. Figure 4-2 shows an example of a primary analysis for existing and proposed methods of maintaining shelters.

4-4. Discounted payback period (DPP)

An easily understood method of comparing alternative investments or for evaluating a single investment is “payback” analysis. Payback period is the time required for the total accumulated savings or benefits of a project to offset investment costs. So, if a project cost \$100 and yielded annual savings of \$25, its undiscounted payback period would be 4 years. DPP is often used in conjunction with the SIR. If the SIR is greater than 1.0, indicating the project pays for itself, the question then becomes “How long does it take to recoup the investment costs.” (A rule of thumb for an acceptable DPP is 10 years or less.) DPP, like SIR, is used with the NPV as an aid in selecting the best alternative.

a. The duration of project life has no effect on the payback period. For example, a payback period of 10 years has the same meaning whether the economic life is 15 or 25 years. Thus, the payback period can be used to help rank alternatives. Options with quick payback are generally preferred.

b. The time value of money must be considered in payback computations. So, all costs must be discounted to compute a DPP. Payback is achieved when the total accumulated PV savings are enough to offset the total PV costs of an alternative. The payback period is simply the total elapsed time between the point when savings begin to accrue and the point at which payback will occur. Figure 4-2 also shows DPP calculations.

c. A simple example is shown in figure 4-3. If an installation purchases a \$5,000 machine, it can save \$1,500 annually in operating costs. During its fifth year, the machine will need a \$3,000 major overhaul. At the end of its 8-year life, the machine will have no value. The total PV savings over the life cycle of the machine is \$8,392. It is not until after year 6 that the cumulative PV(S) =

PV(I). At that point, all discounted investment costs are recovered. The exact point of payback can be found through interpolation.

(1) First, compute the discounted (10 percent rate) dollar value of savings occurring in year 7: \$6,953-\$6,851 = \$102.

(2) Second, divide this amount by the total PV(S) for year 7 to find the proportion of that year during which the investment is being paid back: \$102/\$807 = 0.13.

(3) The result is a discounted payback of 6.1 years.

NPV(Investment) = \$5,000 + \$3,000(0.651) = \$6,953				
Year	Savings	Discount Factor	Cumulative PV(S)	PV(I)
1	\$1,500	0.909	\$1,430	\$1,430
2	1,500	0.807	1,306	2,730
3	1,500	0.709	1,382	3,012
4	1,500	0.710	1,074	4,086
5	1,500	0.651	977	5,063
6	1,500	0.602	898	6,861
7	1,500	0.538	817	7,650
8	1,500	0.489	714	8,392

Figure 4-3. PV cost savings

d. In the case for which annual savings remain constant throughout the entire analysis period, payback can be computed by using the cumulative discount factors in appendix B for a 10 percent discount rate. Discounted payback for the example in figure 4-3 is computed by—

(1) Dividing the PV(I) by the annual savings—

(2) Compare this value with the cumulative discount factors in appendix B for a 10 percent discount rate. The corresponding year will be the point of payback. The value 4.635 falls between the discount factor for years 6 and 7. By interpolation, the exact point of payback is computed as 6.1 years.

e. It is possible for the cumulative PV of savings to pay back the NPV of the investment and then for later investments to occur which show the PV of the savings to be less than the PV of investments. That is, the SIR may be greater than 1.0 for several years and then drop below 1.0 for a few years due to additional investments (replacement, renovation). The last time the SIR exceeds 1.0 is the correct DPP, and ECONPACK calculates this time.

4-5. Equivalent uniform annual cost (EUAC)

Methods considered so far have assumed that all alternatives in an EA have equal lives or lives greater than the period of analysis. However, it is not unusual for the lives of alternatives to differ. When this occurs, all of the alternatives must be compared on a common basis of time in order to make valid comparisons. The EUAC method allows the analyst to make this comparison.

a. The EUAC is an approach for evaluating alternatives with unequal economic lives that are less than the minimum requirement time period. It places all life-cycle costs and benefits for each alternative in terms of an average annual expenditure. Assuming that the alternatives are equally effective over their lives, the one with the lowest EUAC is the most economical choice.

b. Figure 4-4 shows a simple example.

(1) In the figure, it is assumed that—

(a) Each alternative satisfies the requirement.

(b) No end is seen to the requirement.

(c) Technological considerations play no role.

(d) Only the limitation of physical life constrains the alternatives (A to 12 years and B to 8 years).

- (e) The only costs are the uniformly recurring ones shown.
 (f) The annual cost of alternative A exceeds that of alternative B.

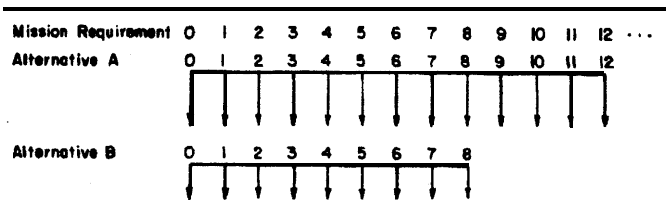


Figure 4-4. Cash-flow diagram for unequal economic lives

(2) Alternative B costs less per year, but A provides benefits over a longer period of time, and the requirement is open-ended. If it is assumed that each alternative can be repeated with the same cash-flow pattern, A can be repeated once and B twice, resulting in the pattern shown in figure 4-5.

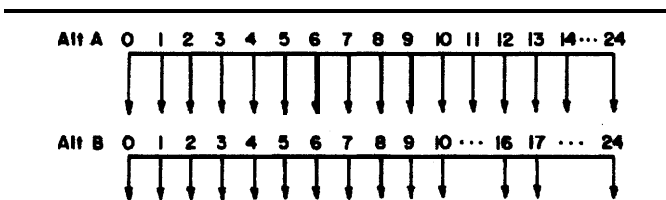


Figure 4-5. Cash-flow diagram for repetitions of lives

(3) Now both alternatives extend to a common point in time. In this case, it is clear that alternative B is the best economic choice.

c. In practice, cash-flow patterns are not so simple. Usually, there are investment costs and other one-time costs. Also, the annual recurring costs may not be uniform over time.

d. The EUAC converts each option into an equivalent, hypothetical alternative having uniform recurring costs. The conversion is such that the total NPV costs of the actual alternative and its hypothetical equivalent are the same. The hypothetical alternatives can then be compared. The best hypothetical alternative corresponds to the best actual alternative, which is the best economic choice for the project.

e. The EUAC calculation method—

(1) The NPV is determined.

(2) The NPV is divided by the sum of the discount factors for the economic life of the alternative. Thus, the formula for finding EUAC is as shown in equation 4-4.

$$EUAC = \frac{NPV}{b_n}$$

Equation 44

where b_n represents the n th year cumulative discount factor.

f. The EUAC represents the amount of money that would pay for the project if it were budgeted in equal yearly installments. This is not the same as taking a simple average. For example, a building with a 25-year life and an acquisition cost of \$ 100M would have a simple average annual cost of \$4M.

(1) Using the EUAC method (equation 4-5) (10 percent discount rate, end-of-year), the annual cost would be about \$11 million since—

$$EUAC = \frac{NPV}{b_n} = \frac{\$100M}{9.077} = \$11.02M$$

Equation 4-5

(2) Using a simple average to find an annual cost for an EA is incorrect because it fails to allow for the time value of money. The EUAC incorporates the time value into its formula. In the example above, the significance of the \$11.02M is that if \$11.02M were spent for each of 25 years, the total NPV of the payments would be \$ 100M, the same as the actual NPV cost of the alternative.

g. Figure 4-6 shows an example of computing the EUAC for two alternatives using a 10 percent discount rate.

h. In most MILCON EAs, the alternatives do have equal economic lives as they all must meet the mission requirement. Thus, the NPV is used to compare alternatives.

4-6. Benefit/cost ratio (BCR)

A complete EA will identify and quantify all relevant costs and benefits of each alternative. Both costs and benefits expected for each alternative will be considered. "Benefits" is an overall term for returns (savings, outputs, products, or yields). The benefits of each alternative must be expressed so that the decisionmaker can make valid comparisons. This step is done using the benefit/cost ratio (BCR) method. In general the BCR is expressed as shown in equation 4-6.

$$BCR = \frac{NPV \text{ of Benefits}}{NPV \text{ of Costs}}$$

Equation 4-6

Benefits are measured in dollars. Total benefits relative to total costs are measured. The larger the BCR, the more cost effective the alternative.

a. *Benefit types.* In general, four types of benefits are potentially associated with MILCON projects. These benefits are not mutually exclusive. They include—

- (1) Direct cost savings.
- (2) Efficiency/productivity increases.
- (3) Other quantifiable output measures.
- (4) Nonquantifiable output measures.

b. *Direct cost savings.* When direct cost savings are the main reason for performing an EA, a primary EA is usually done. These savings can result from a modernization or renovation or from an alternative such as constructing a new facility. The key aspect is that savings will accrue, usually in the form of a reduction in recurring O&M costs. That is, after an initial investment, the funding level needed for the facility and its function will be reduced in future years.

Table 4-1
Sample of recurring O&M costs

Year	Project A Recurring O&M	Project B Recurring O&M	Differential cost (savings)
1	1.5	0.7	0.8
2	1.5	0.7	0.8
3	1.5	0.7	0.8
4	1.5	0.7	0.8
5	1.5	0.7	0.8

(1) In table 4-1, direct cost savings are the net difference between the O&M costs of the two projects. (The BCR is calculated by dividing the total discounted benefits by the total discounted costs.)

(2) When the NPV of these savings exceeds the investment, the project "pays for itself" over its economic life and is self amortizing.

(3) A primary EA is performed for such projects. The self-amortizing is demonstrated by an SIR greater than unity. Sometimes a

project will not produce an SIR greater than 1 but will produce a partial self-amortization of interest to decisionmakers.

(4) An example would be installing new, energy-efficient lighting in parking areas and on streets. Suppose the SIR is 0.70. The fact that the project is mostly self-amortizing, plus the added benefits of increased morale and security/safety, may well justify the project.

c. *Efficiency/productivity increase ratio (EPIR)*. Often projects such as modernization, rehabilitation, and consolidation increase an operation's efficiency or productivity. These increases are very beneficial and should be included in the BCR analysis when they exist. Benefits of this type are often confused with direct cost savings because they are easy to quantify in dollar terms. However, they are not equal, and the analyst should understand the basic difference.

(1) An increase in efficiency or productivity implies only one result: the ability to do more work within the existing manpower and funding levels. One way to translate an efficiency/productivity increase into direct cost savings is to effect a reduction in force (RIF) which lowers the required personnel funding level. The other way is to use the same manpower level to meet an increased workload requirement. A RIF is not usually intended as one of the required results of a MILCON project, and thus some other means of quantifying efficiency/productivity benefits must be used.

(2) An efficiency/productivity increase that translates into a labor/time savings of 2 man years is a benefit whose value can be defined as what it would cost the Army to pay for an additional 2 man years of labor. This cost should be accelerated by the appropriate rates for leave and fringe benefits because the value of the benefit should reflect the actual *total cost* to the Army of providing 2 man years of work.

(3) One very important policy must be mentioned at this point. To claim an efficiency/productivity increase as a valid benefit there must be a documented need for the increased work-load capacity. In other words, there must be an alternative use to which the manpower resources now available can be applied, such as reducing a backlog of maintenance. Without this justification, there is *no benefit-at least no quantifiable benefit-derived from the project.*

d. *Other quantifiable output measures*. Many MILCON projects, especially industrial projects, have a stated goal defined in terms of required outputs. This goal is not always quantified. However, sometimes an analyst can find a way to quantify the goal and thus devise a way to measure the potential benefits associated with the project. This project backup data, to be of use to decisionmakers, should relate goals to quantifiable levels of output when possible. These levels can then be used to measure the benefits of a project.

(1) This comparison is made easier by finding an annual BCR (ABCR) for each alternative -

$$ABCR = \frac{\text{Annual benefit/output measure (ABOM)}}{EUAC}$$

Equation 4-7

(2) In equation 4-7, the EUAC is found as described in paragraph 4-5. The annual benefit/output measure (ABOM) is a quantified statement of expected yearly output for the alternative under investigation. Examples of ABOM are—

- (a) Number of vehicles overhauled per year.
- (b) Number of miles of road resurfaced per year.
- (c) Cubic feet of sewage treated per year.
- (d) Number of soldiers trained per year.
- (e) Kilowatt-hours of electricity produced per year.
- (f) Antennas overhauled and tested per year.

(3) For example, assume that because of a regional consolidation, an Army tank maintenance facility is now responsible for all corrosion-control maintenance for all Army tanks in the northeast United States. Further assume that the facilities engineers have done a detailed feasibility and concept study and decided that there are only two reasonable alternative methods of satisfying this operational requirement—

(a) Modify existing unused space to accommodate the corrosion-control function. Expected life is 25 years.

(b) Demolish the old space and build a new, highly efficient, semiautomated corrosion-control facility. Expected life is 25 years.

(4) Table 4-2 contains the data for this example. The table shows that, although the new facility alternative is more expensive, the benefit (output) per equivalent annual dollar spent is 31 percent higher than that for the modification alternative: $1.67/1.28 = 1.30$.

Table 4-2
Example ABOM data

Item	Modification	New construction
Recurring annual expenses (personnel, O&M, etc.)	\$100,000	\$85,000
26-year cumulative discount factor	9.608	9.608
PV of recurring cost	\$960,800	\$816,680
Investment (year 1)	\$2,000,000	\$2,600,000
Year 1 discount factor	0.953	0.953
PV of investment	\$1,906,000	\$2,477,800
NPV	\$2,866,800	\$3,294,480
EUAC (use end-of-year, 9.161)	\$312,935	\$359,620
Benefit/output (maintenance jobs performed)	400/year	600/year
BCR (completed maintenance jobs per year per \$1,000)	1.28	1.67

(5) The new construction alternative is likely to have a more favorable effect on increasing tank life:

$$\text{New construction: } \frac{2,000 \text{ tanks}}{600 \text{ tanks/year}} = 3.3 \text{ years/maintenance}$$

Equation 4-8

$$\text{Modify space: } \frac{2,000 \text{ tanks}}{400 \text{ tanks/year}} = 5 \text{ years/maintenance}$$

Equation 4-9

(6) Suppose there are 2,000 tanks in the northeast United States. Thus, with new construction, a tank can undergo corrosion control about every 3.3 years as shown in equation E-8. Equation 4-9 shows the modification alternative, there will be at least 5 years between corrosion control measures. Although both maintenance cycles are acceptable, more frequent corrosion control is preferred because of the cumulative effect of corrosion.

(7) No significance should be given to the relation of the ABCR to the number 1. Unlike the SIR, EPIR, and BCR, the absolute size of the ABCR is not important. This is because of the dimensional quality of the ABCR and the arbitrarily chosen baseline (that is, completed maintenance jobs per year per \$1000). Thus, the only valid comparison is between the two ABCR measures. (The reader should not confuse this situation with that of a nondimensional SIR, in which unity has vital significance.)

(8) The various BCR methods should be used only when the unit of measure for the benefits and costs of each alternative is the same. If this is not the case, the BCR, like any other measure, will confuse important information and can be misleading.

e. *Nonquantifiable output measures*. It is not always possible to quantify some benefits such as improved morale, increased retention rates, better troop quarters, and other qualitative benefits. However, they should be documented in the EA report for consideration by the decisionmakers. These written qualitative benefit descriptions can make a positive contribution to the EA. Statements on qualitative benefits should follow these guidelines-

- (1) Identify all benefits associated with each alternative and give complete details.
- (2) Identify benefits common in kind but not in extent or degree among alternatives, and explain the differences.
- (3) Avoid platitudes. For example, all prospective projects are worthwhile because they support national defense, and statements to this effect are not needed.
- (4) Display the benefits in tabular form as shown in table 4-3.

Table 4-3
Matrix of benefits

	increased Morale	Safety	Unit Integrity
Alt A	Yes	Same	Better
Alt B	No	Same	Same

f. Summary. This paragraph has outlined methods that can be used to evaluate and portray benefits in a benefit/cost analysis framework. These methods are not exhaustive, but illustrate approaches the analyst can take to evaluate the benefits of different options. Analysts should use these methods in addition to any others they find appropriate. If a unique method is used, the analyst should clearly and completely explain, justify, and document it for the EA report.

(1) Benefit analysis should be reported in a separate section of the report (see chap 8).

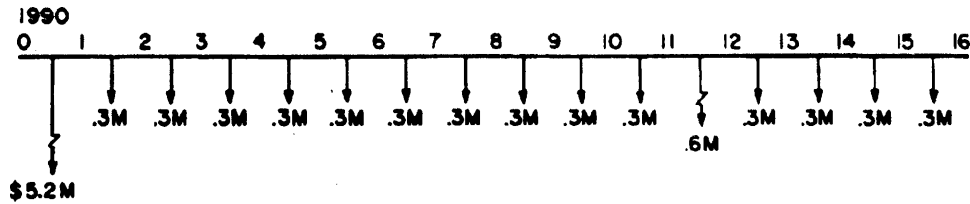
(2) Negative aspects of an alternative should also be reported and quantified when possible. This information is important to the decisionmaker and may be a determining factor in selecting an alternative.

g. Methods. The methods described in this chapter can be used to perform EAs for all MILCON and CFF projects. Some methods work better for certain combinations of costs and lives than others. Once an analyst has done several EAs, selection of the method(s) will become second nature. To assist beginners, figure 4-7 shows combinations of type of analysis, equality of lives, costs, and benefits, and the decision process used to define which technique(s) to use.

This example considers two alternatives: renovation and new construction. Either renovation or new construction would take place in 1990 and require 1 year to complete. There is a 15-year requirement. The analysis base year is 1990.

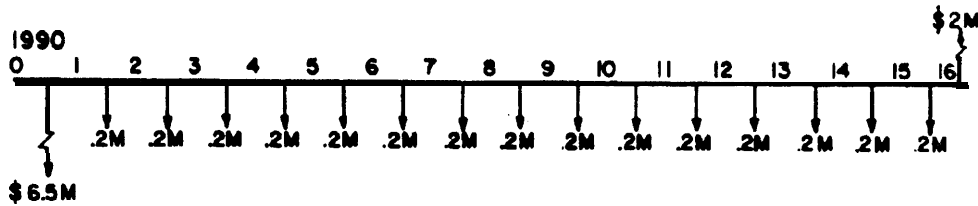
Renovation alternative:

Renovation cost of \$5.2M, annual operation and maintenance (O&M) cost of \$0.3M, and a reroofing cost of \$0.3M in year 12 after BOD. All costs assumed to occur at mid-year. This alternative has no residual value.



New construction alternative:

Construction cost of \$6.5M, annual O&M cost of \$0.2M, and a residual value of \$2M. Costs assumed to occur at mid-year; residual value at end-of-year 16.



Discount rate is 10 percent. All costs are discounted by mid-year except the residual value which is end-of-year.

$$\begin{aligned}
 NPV_{REN} &= \$5.2M(0.953) + \$0.3M(8.206-0.953) + \$0.3M(0.334) \\
 &= \$7,231,700
 \end{aligned}$$

$$\begin{aligned}
 NPV_{NEW} &= \$6.5M(0.953) + \$0.2M(8.206-0.953) - \$2M(0.218) \\
 &= \$7,209,100
 \end{aligned}$$

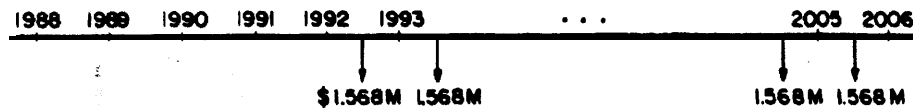
Using NPVs, the new construction is the more economical solution as its NPV is \$22,600 (0.3 percent) less than that of the renovation alternative.

Figure 4-1. Example using NPV to rank alternatives

Shelters are currently maintained in an open-air environment. It is proposed to construct an environmentally controlled maintenance facility to reduce operating costs.

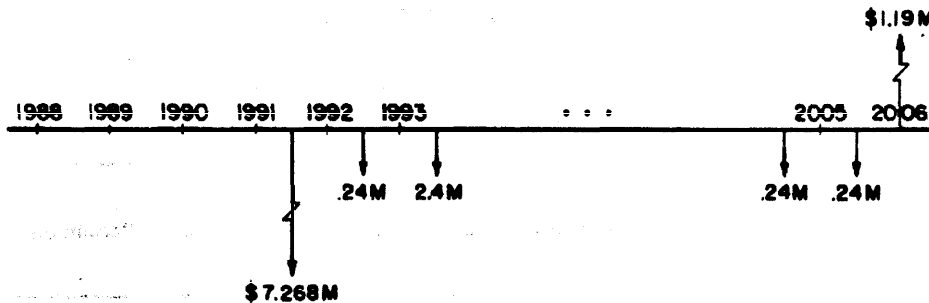
Status quo alternative:

The existing method requires an annual operating cost of \$1.568M.



New facility alternative:

The proposed facility would cost \$5.7M (1991 dollars) to construct, with an annual O&M cost of \$0.24M and a residual value of \$1.19M. The cost of using the existing method during the year of construction is also part of the cost of the proposed alternative (1.568M + 5.7M = \$7.268M).



The analysis is performed in 1988 (base year); start year is 1991 and BOD is 1992. The requirement is for 15 years, so that the period of analysis is 19 years. A 10 percent discount rate is used, with mid-year convention for all costs except the residual, which uses end-of-year.

$$NPV(\text{Savings}) = (\$1.568 - \$0.240)(8.773 - 3.325) = \$7.235M$$

$$NPV(\text{Investment}) = \$7.268M(0.716) - \$1.19M(0.164) = \$5.009M$$

$$SIR = \$7.235M / \$5.009M = 1.44$$

Figure 4-2. Example of a primary economic analysis and DPP calculations

To find the DPP, the cumulative NPV of investment is calculated for each year as well as the cumulative NPV of savings. The point at which they are equal is the DPP.

<u>Year</u>	<u>Cumulative NPV Investment (\$M)</u>	<u>Cumulative NPV Savings (\$M)</u>
1988	0	0
1989	0	0
1990	0	0
1991	0	0
1992	4.081	0.865
1993	4.081	1.651
1994	4.081	2.365
1995	4.081	3.014
1996	4.081	3.605
1997	4.081	4.142

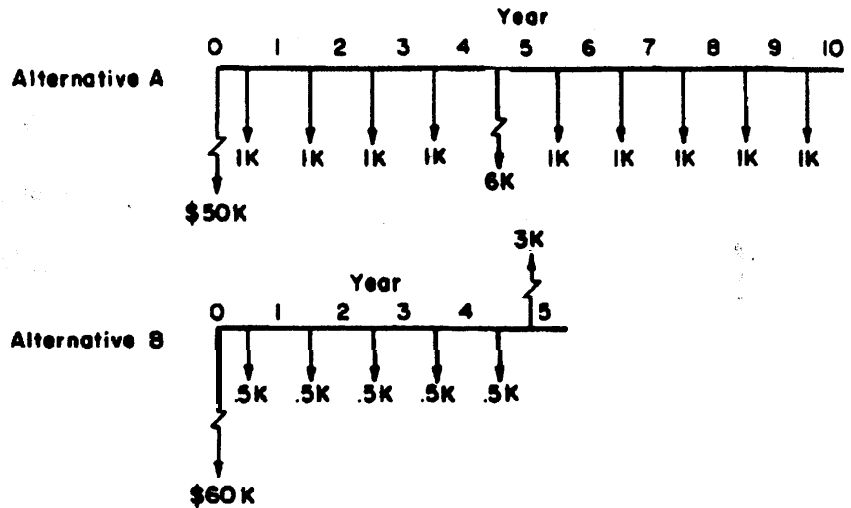
Note that the NPV of investment is not reduced by the discounted value of the residual as that will not occur until 2006.

Calculate the exact DPP by--

$$9 + \frac{4.081 - 3.605}{4.142 - 3.605} = 9.89 \text{ years}$$

Then subtract 4 years--the savings will pay for the investment in 5.9 years after the savings begin to accrue.

Figure 4-2. Example of a primary economic analysis and DPP calculations - Continued



Alternative A has an initial cost of \$50,000 at the beginning of year 1, an annual cost of \$1,000 occurring mid-year, and a one-time cost in year 5 (mid-year) of \$5,000. (Note use of a broken line to show a cost is not to scale.) Using a 10 percent rate (mid-year), the EUAC is calculated:

$$NPV_A = \$50,000 + \$1,000(6.444) + \$5,000(0.651) = \$59,699$$

$$EUAC_A = \frac{NPV_A}{b_{10}} = \frac{\$59,699}{6.145} = \$9,715$$

Note: even though the discounting convention used is mid-year for all costs, the cumulative factor used to calculate the EUAC is end-of-year. This method will also be used in the ECONPACK computer programs.

Alternative B has an initial cost of \$60,000, annual costs of \$500 and a salvage value of \$3,000 occurring at the end of year 5. The EUAC is calculated as follows:

$$NPV_B = \$60,000 + \$500(3.976) - \$3,000(0.621) = \$60,125$$

$$EUAC_B = \frac{NPV_B}{b_5} = \frac{\$60,125}{3.791} = \$15,860$$

Alternative A is preferred because its EUAC is much smaller than that of alternative B.

Figure 4-6. Example of calculating EUAC

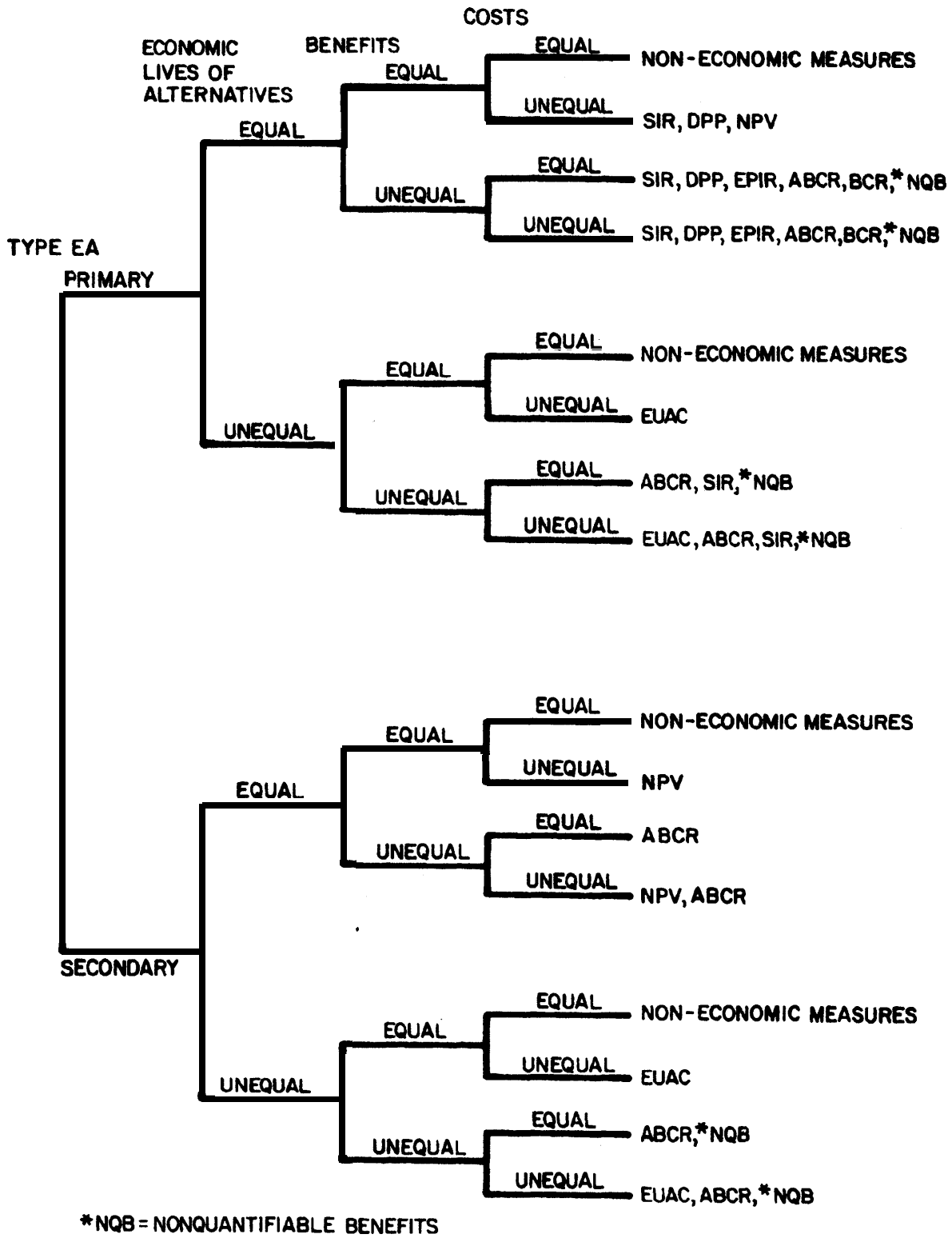


Figure 4-7. General process for determining which EA method to use

Chapter 5

Description and Estimation of Costs

5-1. Definition of costs

a. *A cost represents the value of a resource.* It is the value, measured in dollars, of resources required for an alternative. These costs include materials, labor, maintenance, supplies, and capital spent in producing goods or services. A proper cost analysis of an operation requires that the amount and timing of all costs be determined for each alternative. These costs must be calculated for the entire period of analysis (life-cycle costing).

b. *Costs can be tangible or intangible.* Tangible costs are those related to resources such as labor, material, equipment, and supplies. These costs can be estimated and, in the EA, have a definite dollar value. Intangible costs are those with no dollar value assigned. Costs such as increased or decreased morale, convenience, unit integrity, and satisfaction are all intangible. While these may be listed, discussed, and used to aid in making a decision, they usually have no values that can be quantified.

5-2. Cost elements

a. *General.* Cost elements, if present, that must be addressed in an EA are discussed below. This is a very detailed list—no one EA is ever likely to have all of them. They are listed to ensure that the analysts consider all potential costs. If analysts find a cost not on the list, they will include it in the EA. Analysts perform the EA as representatives of the U.S. Government and the taxpayer, and therefore should include all relevant costs.

(1) *Construction contract costs.* This is usually the major first cost incurred to build the facility. All costs to construct the facility are included: design, construction, contract administration, inspection, supervision, and any other costs associated with the construction process. Sources of data for these costs are AR 415-17, division and district offices, installation Directorates of Engineering and Housing (DEHs) and historical data for similar projects.

(2) *Renovation and rehabilitation.* These are major costs that can occur initially or in outyears to renovate or rehabilitate a facility. Costs and year of occurrence estimates can be obtained from the DEH, district and division offices, and cost-estimating guides.

(3) *Maintenance costs.* These are annual recurring costs of normal maintenance for a facility. They include costs for preventive maintenance and minor repairs. Data for these costs can usually be estimated best by the installation DEH based on historical records.

(4) *Periodic repair and replacement costs.* Costs to replace a roof, the exterior finish, the floor covering, the air conditioner, or heating plant, and to repaint the exterior are typical in this category. Good data sources for these costs are the DEH and cost-estimating guides such as Means and Dodge.

(5) *Utility costs.* Energy source costs such as gas, oil, coal, electricity, and wood are included here. Water and sewer costs are also in this category. Any communications costs can be included. Data can be obtained from the DEH and companies providing the utility.

(6) *Lease cost.* This is the monthly or yearly charge to the government to lease an asset. Estimates for facilities leases can be obtained from district real estate offices, the General Services Administration, and commercial firms in the locale. Equipment lease rates can be obtained from local or national leasing companies.

(7) *Administration costs.* These costs are salaries for the facility management staff (such as the housing office personnel) or for the contract manager in the case of a lease. These costs can be obtained from the DEH.

(8) *Equipment costs.* Equipment includes material handling, production lines, central or domestic laundries and kitchens, nonmedical hospitals, power or heat generation and distribution, fuel handling, utilities distribution and sewage treatment. Data can be obtained from the DEH and Directorate of Logistics (DOL).

(9) *Furnishings costs.* These costs include office and household furnishings. The DEH and DOL are possible sources for cost data.

(10) *Services costs.* These costs are snow removal, trash hauling, security, custodial, and entomological. Data sources are the DEH and DOL.

(11) *Personnel costs.* These costs are for military, civilian and contractor personnel. They are for operating a facility or vehicles associated with the alternative. Salaries can be obtained from Office of Personnel Management (OPM) documents or the local resource management (comptroller's) office.

(a) For civilian personnel, the labor costs are calculated by using the current pay rate as published, plus the Government's contribution for retirement, location differential, disability, health, life insurance and, where applicable, social security. An additional 26 percent for these costs will be added to the basic pay (retirement = 20.4 percent, insurance = 3.7 percent and bonus, compensation, unemployment, and awards = 1.9 percent). In some locations there would be increases to this 26 percent to reflect location adjustments.

(b) The cost of military personnel is calculated by using the standard rates set by DOD for expending military personnel services. These rates include basic, incentive, and special pay, plus certain other expenses and allowances paid from Military Personnel, Army (MPA) appropriations. (See AR 37-100 for more information.) Adjustments must be made to reflect the Government's contribution to retirement and other costs by multiplying by the percentages shown in table 5-1.

Table 5-1

Government contributions for military personnel services (based on percentage of gross pay).

Allowance	Officer (%)	Enlisted (%)
Retirement	26.5	26.5
Other benefits	8.0	23.0
Total	34.5	49.5

(c) Contractor personnel costs should be calculated using Department of Labor general wage determinations published for the trades to be engaged in the project under review. (See FAR 22.404-1 and 22.404-2 for more information on industry wage determinations.)

(d) Costs for pay and employee benefits of host country national or third country national employees must also be included when applicable.

(e) The military pay rate of host country officers shall be increased by 61 percent and for enlisted personnel by 79 percent.

(12) *Allowances.* These costs include Basic Allowances for Quarters (BAQs), Variable Housing Allowance (VHA), Overseas Housing Allowance (OHA), temporary lodging allowance (TLA), and temporary duty (TDY). They are available from the DEH and the Finance and Accounting office.

(13) *Land.* This is the cost to acquire land from the private sector. In CONUS they are available from the district real estate office. OCONUS land costs will be based upon local procedures.

(14) *Residual/terminal value and demolition costs.* The residual (or terminal) value of a facility at the end of the period of analysis represents the market value at that time. The residual/terminal (salvage) value of a facility is usually a negative cost (inflow of funds) and must be accounted for in the EA. The value is discounted and subtracted from the overall costs of the alternative. A demolition cost is incurred if Army funds are used to remove a facility. This cost is added to the overall costs of an alternative.

(a) The residual or terminal value is estimated on the basis of use, obsolescence, rehabilitation possibilities, and market value. Estimates of these costs can be obtained from the DEH, district real estate offices, and commercial real estate firms. Factors for estimating building decay-obsolescence and site appreciation have been developed and are given in table C-1, see appendix C. These can be used in lieu of local estimates.

(b) For projects outside the continental United States (OCONUS), the analysis must include estimates which conform to the terms of the SOFA agreement,

(c) It is common to calculate the terminal value using straight-line depreciation. A residual value can also be recalculated using the declining balance method or the analyst's own depreciation schedule.

(d) As an example of straight-line depreciation, suppose a building has an initial cost of \$1M, with an economic life of 40 years. The period of analysis is 25 years. The value of the building will decrease by \$1M/40 years = \$25 K/year. At the end of 25 years, its terminal value is calculated as shown in equation 5-1.

$$\$1 \text{ M} - (\$25 \text{ K/yr})(25 \text{ yr}) = \$375\text{K}$$

Equation 5-1

(15) *Inherited assets.* When an alternative involves the use of an existing asset, its value may be included in the analysis as a cost. The value at the base year of analysis is estimated. However, if the asset has no other use and is not intended to be sold, its value will not be included in the analysis. A possible data source is the installation real estate office.

(16) *Insurance.* For certain analyses involving leases, the cost of insurance to the contractor is included. Sources for this data are Building Owners and Managers Association (BOMA) and local insurance firms.

(17) *Transportation.* If an alternative includes transporting personnel, goods, or equipment, the cost must be an input to the analysis. Household goods costs are included here. This cost consists of vehicle and operating personnel in addition to any cost for transported personnel such as student trainees. Data sources are the DEH, DOL, and local private transportation firms.

(18) *Communications.* This is the cost for purchasing and installing communications equipment. It includes the annual cost for communications service. A possible data source is the local office of the Information Systems Command.

(19) *Property taxes.* For certain lease analyses, property taxes are included. Tax amounts can be obtained from the district real estate office and the local assessor's office.

b. Not used.

5-3. Cost kinds

a. General. Costs are grouped into 18 kinds. Some of these are composed of several cost elements. Table 5-2 lists the cost elements that may be contained in a cost kind. Note that table 5-2 is a guide; it must be interpreted for each alternative in an analysis. An alternative may not involve military personnel costs, even though this element is listed under personnel costs. Or, there may be no heat-generating equipment as the alternative may use steam from a central plant. Table 5-2 is not all encompassing, but includes most common cost kinds. Each kind is defined below and examples are given. Use of table 5-2 will aid in consistently classifying cost elements into cost kinds, resulting in an EA which is easier to review at higher levels. The 18 cost kinds discussed below are-

- (1) Initial investment.
- (2) Personnel.
- (3) Administration.
- (4) Utilities.
- (5) Periodic repair/replacement.
- (6) Services.
- (7) Travel/transportation.
- (8) Allowances.
- (9) Furnishings.
- (10) Equipment.
- (11) Salvage/demolition.
- (12) Maintenance.
- (13) Land.
- (14) Insurance.
- (15) Property taxes.
- (16) Lease.
- (17) Inherited assets.
- (18) Communications.

b. Initial investment. These are first costs incurred for an alternative. For construction of a new facility or renovation/rehabilitation, they include the design cost, construction contract cost, supervision, and administration of the construction contract, any research and development costs, and site preparation costs.

c. Personnel. These are costs for military and civilian personnel who will be employed to operate or manage a function. For production-type facilities, this cost can be a crucial part of the EA, as different alternatives may allow different production line designs that require different numbers of personnel. These costs can also cover transportation time for occupants in going from one facility to another.

d. Administration. This cost involves the management of the facility or lease costs. It occurs frequently in a housing function where time of managers and assistants is required to manage housing units. It does not include the normal costs of occupants in management of their space.

e. Utilities. This cost kind includes all utilities consumed whether provided by the Government or by contract. Costs are for gas, electricity (purchased or generated), oil, wood, coal, water, and sewer. They do not include construction and maintenance costs of utilities plants or distribution lines.

f. Periodic repair/replacement. These costs are major one time or periodic costs occurring during the life of the project. They include costs such as replacement of a roof, overhaul or repair of an air-conditioning system, remodeling the kitchen of a house, and rewiring a building. Major renovation or rehabilitation expected to occur in the future is included. For any project of 20 years or more, several of these costs should occur.

g. Services. Trash hauling, snow removal, entomological work, grounds maintenance and security are all of this kind.

h. Travel/transportation. One cost kind is concerned with transportation (shuttle service) of personnel using the facility or of bringing equipment and materials to the facility. An example would be if a training facility is leased offpost and trainees must be bused to and from it. Costs would be incurred for the driver's salary and for the vehicle, including maintenance and fuel. Or, it could be the contract cost to obtain bus service. Another cost of this kind is the per diem for personnel awaiting quarters.

i. Allowances. These costs include allowances for quarters. The BAQ is provided to military personnel who live on the economy. VHA, Rent Plus, Family Separation Allowances, and Temporary Living Allowance (after permanent change of station moves) are other costs within this kind.

j. Furnishings. This is the cost of furnishing a facility. For housing, it includes the furnishings and their replacement, maintenance, repair, storage, distribution, security, and all other property management functions. For nonhousing, it may include office furniture if the cost varies between options. Otherwise, it is a wash cost and need not be included in the analysis.

k. *Equipment.* This cost kind is a very broad category and can vary from a refrigerator in a house to a heavy crane in a maintenance shop. It includes kitchen equipment in a dining hall, refrigeration equipment in a hospital, a boiler in a heat generating plant, a gas line and an electrical power line. This kind is often a wash cost as all Alternatives will use the same equipment.

l. *Salvage/demolition.* This cost kind can be either positive or negative. If a facility has a salvage or residual value at the end of the analysis period, then that value represents an inflow (negative cost) of funds to the government. In contrast, if the facility must be removed or demolished, there will be an outflow (positive cost) to the Government. Demolition costs shall include the cost of removal and proper disposal of hazardous material.

m. *Maintenance.* This cost kind contains annual maintenance costs such as those normally done through service orders. It also includes ongoing maintenance such as that done with standing service orders and any periodic maintenance such as a biyearly inspection of a facility. Preventive maintenance also is included. Any maintenance and repair costs not considered a major repair or replacement falls into this cost kind.

n. *Land.* Both land purchases and costs of easements are in this category. In analyzing certain lease options, the imputed cost of land owned by the Government must be estimated.

o. *Insurance.* This is the cost of insuring a privately held asset. The Government is self-insured and insurance costs are used only when leasing is one of the alternatives (chap 7).

p. *Property taxes.* These costs are included in certain types of lease analyses and are imputed for the Government. Estimates of these taxes are based on taxes assessed for comparable private property.

q. *Lease.* This is the annual charge to the Government for leasing a facility or asset in the private sector.

r. *Merited assets.* In some cases, an alternative will use an existing asset. If so, its value at the base year of the analysis will be a cost and must be included in the analysis since the asset could alternately serve another purpose. However, if the asset has no use or value except in the alternative, no cost is included.

s. *Income tax.* Per OMB Circular A-104 the normal payment of income tax by private sector organizations should not be considered in the EA.

5-4. Cost estimation methods

a. Perhaps the most difficult phase of an EA is the estimation of costs. However, this part of the EA is crucial because the results will only be defensible to the extent that the cost estimates are reliable. Estimates can never be 100 percent precise as they are made several years before the costs will actually occur. This implies that inflation will have an impact, but inflation rates vary over time and location. Standards such as level of maintenance for a facility also may vary in the future, which will change the maintenance cost of the facility. Estimates must be as precise as possible given the constraints on the analyst in performing the EA. Precision is usually obtained by acquiring as much detailed data as possible. Most cost estimates are based on historical data.

b. The analyst chooses the proper level of detail and accuracy in the estimates. These must be weighed with the time allowed to obtain the estimates. Detail and accuracy can be of three levels-

(1) *Order-of-magnitude estimates.* The accuracy of these estimates is very low and can differ from the actual cost by as much as 50 percent. These are used when there is not enough time, funds, or both to do a detailed one or when the magnitude of the cost is so small that large inaccuracies will not be a determining factor in the analysis.

(2) *Good estimates.* Good estimates are those for which accuracy is about 10 percent of the actual cost.

(3) *Detailed estimates.* These estimates will normally be within 5 percent of the actual costs. They are often derived from detailed plans and specifications or from accurate historical records. These

estimates should be used when possible to ensure the validity of the analysis.

c. Cost estimates must be made with care and with full knowledge of their limitations. The limitations (assumptions) must be fully documented in the EA report. The accuracy of the estimates must be assessed and tested for impact on the analytical results by use of sensitivity analysis. There are three primary methods of cost estimation:

(1) *Analogy method.* This is perhaps the most widely used method. In some cases, the analyst must make judgments when using this method. If so, they must be documented properly in the EA report.

(a) This method is used often in estimating facility acquisition or renovation costs. Historical construction costs for similar facilities on the installation or in neighboring communities can be used.

(b) Estimates of annual recurring costs are often obtained by this method when the analyst can obtain current, accurate records of costs such as roofing lives and repairs, custodial costs, and energy consumption for similar types of facilities. Application of these cost records requires expert judgment and experience by the analyst and the DEH staff.

(2) *Industrial engineering method.* In this method, estimates from various separate segments of the project are combined into a total project estimate. It is commonly used in projects involving production-type situations such as maintenance shops and ammunition production facilities. However, the principles behind it can be used for any type of analysis.

(a) The analyst must have extensive knowledge of the system, operating processes, and organization. The system is divided into its components and estimates of each component are made. This breakdown allows the analyst to determine which costs are known and thus where effort must be directed to obtain estimates. This process allows an emphasis on estimating costs for which little information is available.

(b) In some cases, industrial engineering techniques such as work measurement and time-and-motion studies may be needed to make the estimates. In other cases, the analogy method maybe used.

(c) Once the costs have been estimated for each lower level component of the system, they are combined to obtain the estimate for the whole system.

(d) Because this method is so detailed, it can result in very accurate estimates. However, it can be very costly to obtain such estimates. When detailed data exist or are easy to obtain, this method is the best one.

(3) *Parametric method.* In this method, the total cost of an alternative or some part thereof is based on specified physical and performance properties and their relationships to component costs. In other words, a functional relationship is established between the total of an alternative (or some part) and the various properties of its parameters. The term "parameter" is defined as a cost-related explanatory attribute that may assume various values during actual calculations.

(a) A parametric estimate depends directly on the ability of the analyst to set up relationships between the attributes that comprise the alternative. The analyst must select and describe the cost-influencing factors of the alternative. For example, the construction of family housing involves (among others): the number of stories, the number of dwelling units in the building the number of bedrooms, baths, dens, and recreation rooms floor area of the various rooms; garage size; and lot size. If house prices are known for various combinations of these parameters, prices for other parameter mixes may be estimated relative to this baseline.

(b) Ease of estimation and accuracy of estimates increase with the increase in number of actual combinations for which prices are known. Given many combinations, the analyst can develop a valid cost estimation relationship. Statistical techniques such as regression analysis can be used to develop equations that describe such relationships.

5-5. Sunk and wash costs.

a. A “sunk” cost is one that will occur before the period of analysis. Sunk costs are past history. They will have no bearing on the future and are therefore disregarded in the EA.

b. A “wash” cost is one that occurs identically for all alternatives. Wash costs can normally be excluded from the EA since they will not affect alternative rankings or the SIR. However, if the EA results will be used to represent total discounted dollars needed or to be spent, wash costs should be included.

Table 5-2
Cost Elements Typical of Cost Kinds

Cost Elements	Cost Kinds																	
	Initial Investment	Personnel	Administration	Utilities	Periodic repair/ replacement	Services	Travel/Transportation	Allowances	Furnishings	Equipment	Salvage/Demolition	Maintenance	Land	Insurance	Property Taxes	Lease	Inherited Assets	Communications
Construction Contract		x																
Renovation		x			x													
Maintenance												x						
Periodic repair/ replacement					x													
Electricity				x														
Gas				x														
Heating/cooling				x														
Water and Sewer				x														
Administration/ Management		x	x															
Equipment procurement				x						x								
Equipment maintenance		x								x	x							
Office furnishings									x									
Household furnishings									x									
Snow Removal						x												
Entomological						x												
Trash Removal						x												
Custodial						x												
Security						x												
Operating Personnel		x	x	x														
Allowances								x										
Land													x					
Lease																x		
Residual											x							
Demolition	x										x							
Inherited Assets																	x	
Insurance														x				
Communications																		x
Property Tax															x			
Travel		x					x											
Transportation		x					x											

6-1. Discussion

Once all costs and benefits have been estimated, the analysis can be performed and the alternatives ranked to show which is economically best. However, the analysis is not complete until it has been examined for areas of uncertainty. Sensitivity analyses are used to evaluate the effect of these uncertainties on the ranking of the alternatives.

a. Some uncertainty is always present in economic decisionmaking and, thus, some type of sensitivity analysis must normally be done in an EA. In an EA, *future costs* are *predicted* and there is an element of uncertainty about these data. Even if actual cost data from past projects are used, it is *assumed* that these data are an accurate estimate of future costs. Thus, all data used in calculating life-cycle costs are actually based on assumptions. The sensitivity of an analysis is tested by evaluating a range of estimates for critical cost elements. The sensitivity analysis measures the percent change in one or more elements of an economic comparison that will reorder the ranking of alternatives.

b. No single criterion can be used to select the most important parameter or factor to be considered in sensitivity analysis. Each analysis has its own set of costs and assumptions.

c. A general rule when considering cost data is to examine the input variables. Variables that significantly impact the total NPV or the benefits of an alternative are good candidates for sensitivity analysis. An easy way to find these variables is to examine the percentage values of the present value of each cost against the net present value of the alternative. A rule of thumb is to examine all costs which are 20 percent or more of the total NPV for an alternative.

d. A sensitivity analysis is developed by asking the question—which input variables should be tested? That is, are there dominant costs with uncertainties concerning their magnitudes or their times of occurrence? Assumptions and constraints must be examined to determine if their variation affects the input variables.

e. As in the entire EA process, the analyst should use common sense in deciding which sensitivity analyses to perform. If the ranking of alternatives shows that one is much less costly than the others, it is probably not necessary to evaluate small changes in costs that have no chance of reversing the ranking. It is when the magnitude or timing of a cost may affect the ranking or when the economic choice is not clear cut that further investigation is needed. There is no formal theory for performing sensitivity analyses. Paragraphs 6-2 and 6-3 discuss the rationale and basic methods used most often in sensitivity analyses.

f. The analyst should not make the sensitivity analysis too complex, as interpretation can be very difficult. A good guide is to study only two alternatives at a time and vary the uncertain costs within each alternative in the same way (an increase or decrease).

g. The analyst should have a range of values of the uncertainty in mind before doing the sensitivity analysis. For example, the uncertainty should be envisioned as ranging from 50 to 150 percent of the estimate or, say, from 70 to 100 percent of the estimate.

6-2. Uncertain cost(s) in one alternative

The simplest case is when there is uncertainty for one or more costs in one alternative. In this case, the analyst can rerun the analysis, inserting the upper (or lower) bound value for the cost(s) in question. (Note: “cost” normally means the magnitude of the cost, but it could also be the timing of a cost.)

a. *Example 1.* Figure 6-1 shows the data, cash flow diagrams, and NPVs. There are two alternatives: new construction and renovation. The facility is required for 25 years, a 1-year construction or renovation time is needed, and a 10 percent discount rate is used. The base year to which all costs are discounted is year one.

(1) The renovation alternative is the best choice from an economical viewpoint as its NPV is \$115,600 less than that of new construction. Suppose that there is a large amount of uncertainty in the

O&M costs for renovation and that it could be as much as 50 percent larger. The NPV is calculated again using \$45,000 as the annual cost. The new value is \$1,115,125 which is \$14,225 higher than the NPV of the new construction alternative. Thus, the results of the original analysis and ranking of the two alternatives are sensitive to the uncertainty in the O&M costs of the renovation alternative. An increase of 50 percent in the renovation O&M costs reverses the ranking of the alternatives.

(2) Equation 6-1 found in figure 6-1, can also be written as-

$$NPV_{REN} = \$725,650 + 8.655(O\&M\$)$$

Equation 6-2

(3) This line can be graphed, showing values for the NPV as a function of the O&M cost. Figure 6-2 shows this relationship.

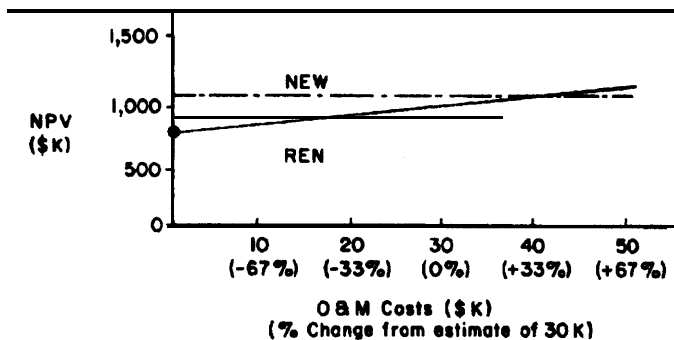


Figure 6-2. Graph of equation 6-2

(4) The intersection of the lines representing NPVs for the new construction and renovation alternatives is at \$43,356 or 44.7 percent. This intersection can be found by solving equation 6-3.

$$\begin{aligned} \$725,650 + 8.655(O\&M\$) &= \$1,100,900 \\ \text{or} \\ O\&M\$ &= \frac{\$1,100,900 - \$725,650}{8.655} = 43,356 \end{aligned}$$

Equation 6-3

b. *Example 2.* Assume there is an existing method of maintaining certain shelters which is done in the open environment. Suppose an alternative method of doing the maintenance in an automated, environmentally controlled building is proposed. Figure 6-3 shows the cash flow diagrams for the primary economic analysis.

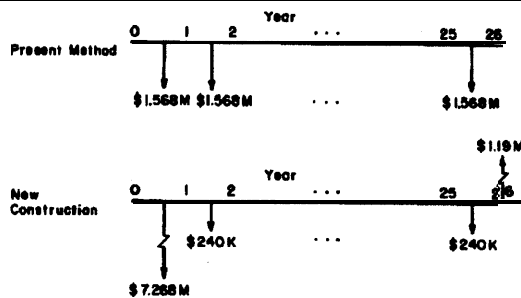


Figure 6-3. Cash-flow diagram for the shelter problem

(1) The present method has only one cost—an annual operating cost of \$1.568 million. The proposed alternative has an initial cost of \$5.7 million, a first-year cost for the present method of operation of \$1.568 million, an annual O&M cost of \$240K, and a salvage value of \$1.19 million. All costs are discounted (10 percent rate) to the beginning of year 1, the construction year. The SIR and DPP are calculated in equation 6-4.

$$\begin{aligned}
 NPV_{SAV} &= (\$1,568,000 - \$240,000) (9.608) \\
 &= \$12,759,424 \\
 NPV_{INV} &= \$5,700,000 (0.953) + \$1,568,000 (0.953) - \\
 &= \$1,190,000 (0.084) \\
 &= \$6,826,444 \\
 SIR &= \frac{\$12,759,424}{6,826,444} = 1.87
 \end{aligned}$$

Equation 6-4

(2) The DPP is calculated by determining when the NPVSAV equals the NPV of the investment cost, \$6,826,444 (the DPP starts after construction is completed) as shown in table 6-1.

Table 6-1
Calculation of DPP

Year	Cumulative NPV investment	Annual NPV savings	Cumulative NPV savings
1	6,833,712	0	0
2	6,833,712	1,265,584	1,265,584
3	6,833,712	1,151,376	2,416,960
4	6,833,712	1,046,464	3,463,424
5	6,833,712	950,848	4,414,272
6	6,833,712	864,528	5,278,800
7	6,833,712	786,176	6,064,976
8	6,833,712	714,464	6,779,440
9	6,833,712	649,392	7,428,832

(3) Payback occurs in the eighth year and can be calculated as shown in equation 6-5.

$$8.0 + \frac{6,826,444 - 6,779,440}{7,428,832 - 6,779,440} = 8.07$$

Equation 6-5

(4) Now the current operating costs are very accurate as is the construction estimate. However, the operating costs of the proposed alternative has a degree of uncertainty. The increase in these costs which would make the SIR = 1.0 (i.e., make the alternative undesirable) can be found by solving the equation 6-6 for these costs-

$$\begin{aligned}
 SIR &= \frac{(\$1,568,000 - O\&M\$) (9.608)}{\$6,826,444} \\
 \text{or—} \\
 O\&M\$ &= 1,568,000 - \frac{\$6,826,444 (SIR)}{9.608} \\
 &= \$1,568,000 - \$710,495 (SIR)
 \end{aligned}$$

Equation 6-6

(5) For an SIR of 1.0, the O&M\$ = \$857,505. That is, the estimate of O&M costs would have to increase as shown in equation 6-7.

$$\frac{\$857,505}{\$240,000} = 3.57 \text{ (357 percent)}$$

Equation 6-7

for the proposed alternative not to save money. Equation 6-3 can be graphed as shown in figure 6-4 to display the relationship and to present the results to management.

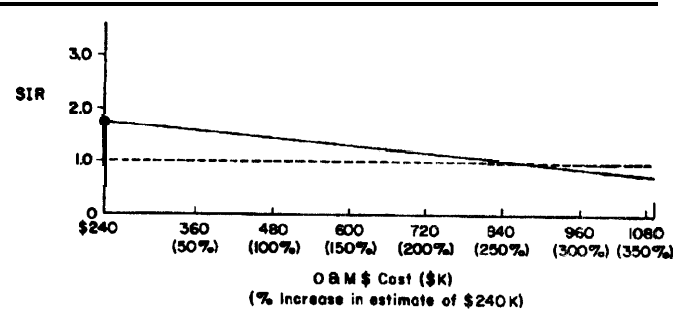


Figure 6-4. Graph of equation 6-6

6-3. General analysis-uncertain cost(s) in two alternatives.

a. The more complex situation is the general one in which one or more costs in each of the two alternatives has uncertainties associated with them. Figure 6-5 depicts the one-variable possibilities as well as the more complex situation.

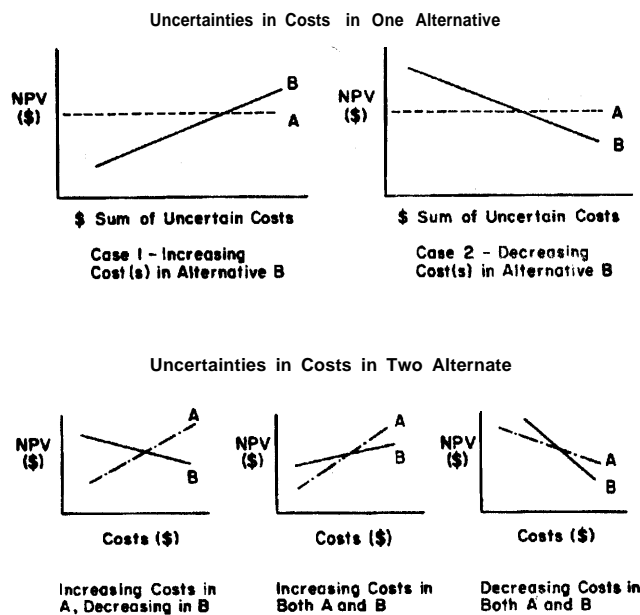


Figure 6-5. Graphs showing relationships between NPVs of alternatives with uncertainties

b. In the simplest case of uncertain cost(s) in only one alternative, the NPV of the alternative containing the uncertain cost(s) will either increase or decrease while the NPV of the other alternative will not change. In the more complex sensitivity analysis, the NPV of one alternative can increase while that of the other decreases as the uncertain costs vary, or both NPVs may increase or decrease at once. In each of the three cases shown, there is a reversal of ranking for the two alternatives.

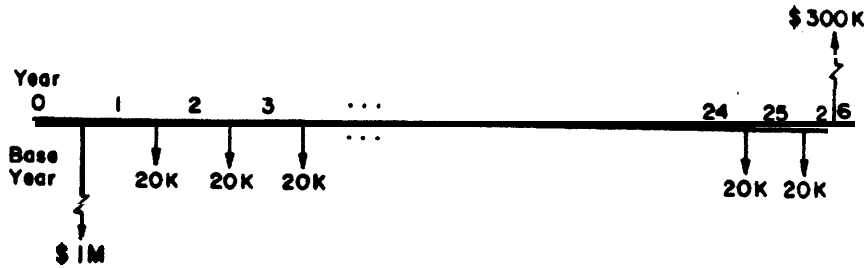
c. The solution to the complex situation is actually very simple. The NPV of each alternative is expressed as a function of the uncertain costs and then the NPVs are set equal to each other. The result is an equation in terms of the percentage change in the costs for each alternative. Figure 6-6 shows an example for this type of problem.

d. ECONPACK has a sensitivity feature that calculates all values within the range of uncertainties specified for which the ranking is reversed.

e. For CFF EAs, a sensitivity analysis of the discount rate used in the analysis is required. This analysis tests the effect of changes in discount rate on the ranking of alternatives. ECONPACK also performs this analysis (see chap 7).

New Construction

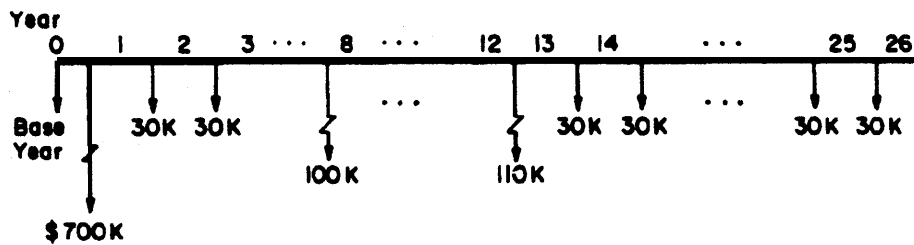
Initial cost is \$1,000,000, annual O&M cost is \$20,000, and residual value is \$300,000.



$$\begin{aligned}
 NPV_{NEW} &= \$1,000,000(0.953) + \$20,000(9.608 - 0.953) \\
 &\quad - \$300,000(0.084) \\
 &= \$1,100,900
 \end{aligned}$$

Renovation:

Initial cost is \$700,000, annual O&M cost is \$30,000, air-conditioner replacement will cost \$70,000 in year 8, and roof replacement will cost \$80,000 in year 13.



$$\begin{aligned}
 NPV_{REN} &= \$700,000(0.953) + \$30,000(9.608 - 0.953) && \text{(eq 6-1)} \\
 &\quad + \$70,000(0.489) + \$80,000(0.304) \\
 &= \$985,300
 \end{aligned}$$

Figure 6-1. Example of uncertainty in cost(s) in one alternative

The data in figure 6-1 are used for this example.

Suppose there is uncertainty in the estimates of O&M costs for both the new construction and renovation alternatives. We want to do a general sensitivity analysis, but will only consider ranking reversals for changes in the cost estimates of 25 to 75 percent.

The method illustrated here is the one used in the ECONPACK program.

First, set up the alternatives' NPV equations with X_N representing the percentage change in the new construction alternative's O&M cost and X_R representing the percentage change in the renovation alternative's O&M cost:

$$\begin{aligned} \text{NPV}_{\text{NEW}} &= \$1,000,000(0.953) + \$20,000(8.655)(1 + X_N) \\ &\quad - \$300,000(0.084) \\ &= \$1,100,900 + \$173,100X_N \\ \text{NPV}_{\text{REN}} &= \$700,000(0.953) + \$30,000(8.655)(1 + X_R) \\ &\quad + \$70,000(0.489) + \$80,000(0.304) \\ &= \$985,300 + \$259,650X_R \end{aligned}$$

Equating these--

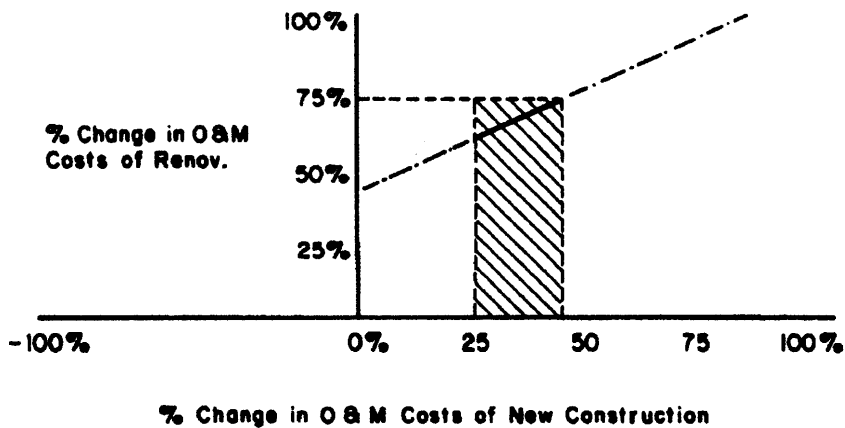
$$\begin{aligned} \$985,300 + \$259,650X_R &= \$1,100,900 + \$173,100X_N \\ \$259,650X_R &= \$115,600 + 173,100X_N \\ X_R &= 0.4452 + 0.6667X_N \end{aligned}$$

This equation represents all values of percentage change in O&M costs of the two alternatives for which the NPVs are equal.

For example, if the new alternative's O&M cost increases 10 percent (i.e., $X_N = 0.10$), then a change of $0.4452 + 0.06667 = 0.512$ or 51.2 percent in X_R would make the NPV of the renovation alternative equal to that of the new construction alternative.

Figure 6-6. Example of sensitivity analysis with uncertainties in cost for both alternatives

The equation is a straight line and can be graphed as shown below:



For the range of uncertainties, 25 to 75 percent, in the O&M costs of each alternative, the points on the line in the shaded area represent the solution to the equation. Values for percentage change in O&M costs for each alternative to make their NPVs equal were calculated by ECONPACK and are:

<u>% Change in O&M costs for renovation</u>	<u>% Change in O&M costs for new constr.</u>	<u>Net present value (\$)</u>
45.9	2.0	1,104,846
47.9	5.0	1,110,039
49.9	8.0	1,115,232
51.9	11.0	1,120,425
53.9	14.0	1,125,617
55.9	17.0	1,130,810
57.9	20.0	1,136,003
59.9	23.0	1,141,196
61.9	26.0	1,146,389
63.9	29.0	1,151,581
65.9	32.0	1,156,774
67.9	35.0	1,161,967
69.9	38.0	1,167,160
71.9	41.0	1,172,353
73.9	44.0	1,177,545
75.9	45.6	1,180,347

Figure 6-6. Example of sensitivity analysis with uncertainties in cost for both alternatives—Continued

Chapter 7

Commercially Financed Facilities: Economic Analysis

7-1. General

a. CFF is an alternate method of providing facilities and services using the private sector as the primary source for financing. The CFF concept is relatively straightforward, although it is becoming more complex with recent OMB policy on "scoring" of lease obligations. CFF is not a feasible alternative to most MILCON projects. This is because of uncertainty surrounding the extension of CFF legislative authorities. Sections 2809, 2812, and 2828 legislation authorities expired 1 Oct 91 and have not been extended.

b. Essentially, the Government enters into a long-term contract for the provision of a facility where the Army is the principal customer for the services provided within that facility. Ultimately, the Army seeks to obtain a package of services from the private sector at a lower cost than through the traditional MILCON acquisition process. The package of services usually includes the financing, design, and construction of a facility. The package maybe structured to include facility maintenance and operation, and provision of primary and ancillary services. The contract usually covers a 20-32 year period (depending upon the specific legislation). The facilities generally do not belong to the Government at the end of the contract term (sections 2812 and 2821 are exceptions to this rule). CFF offers opportunities for the Army to acquire needed facilities/services at a lower overall life-cycle cost than traditional methods.

c. Separate legislative authorities govern different MILCON programs (MCA, AFH, Energy) and allow for CFF initiatives.

7-2. Overview of lease contract economic analyses for Army facilities

a. Title 10 of the United States Code authorizes lease contracts for different types of facilities under six sections of the code—

- (1) *Section 2667*. Land Leases.
- (2) *Section 2394*. Energy or Fuel Contracts.
- (3) *Section 2809*. Long Term Facilities Contracts. [Expired 1 Oct 91]
- (4) *Section 2821*. Army Family Housing Rental Guarantee 802 Housing.
- (5) *Section 2828*. Army Family Housing Build to Lease 801 Housing. [Expired 10ct 91]
- (6) *Section 2812*. Lease-Purchase of Facilities. [Expired 1 Oct 91]

b. In addition, special congressional legislation can provide authorizations for specific projects.

c. CFF should not be confused with "Contracting out." The A-76 Program (OMB Circular A-76 as implemented in 1955 and revised in 1983) requires Federal agencies to conduct cost comparisons between an in-housework force or internal supplier and a commercial activity. The A-76 Program is applied to service contracts specifically whereas CFF provides for both facilities and services.

d. Leasing is another method for acquiring facilities distinct from CFF. Leasing is generally used for requirements which have a limited duration or a special, unusual purpose. The General Services Administration (GSA) is responsible for leases of general purpose space under geographic jurisdiction of GSA. Under CFF, the Military Service (Army, Navy, Air Force), not GSA, is responsible for selecting, reviewing and submitting the CFF projects to Congress for approval.

e. CFF should not automatically be considered a feasible alternative in most MILCON EAs. Rather, CFF should only be included if there is significant support for the project as a CFF candidate at the MACOM HQ level or higher. The Office of the Assistant Chief of Engineers, Programming Division (DAEN-ZCP) should be notified immediately (by the MACOM HQ level or higher) if a project is being considered for candidacy as a CFF project.

7-3. Request for Proposal

Obtaining facilities and/or services under lease contract authority involves the formation of a contract. The Request for Proposal (RFP) is the type of contracting document used by the Government to identify the technical requirements, bid schedule, and evaluation process. In response to an RFP, proposals are subsequently submitted by developers with proposed cost, technical data, and management plans. The Government evaluates proposals received from developers, conducts negotiations, and awards a contract. The RFP is a critical component of the CFF process. The RFP defines precisely and clearly the obligations of the Government and the developer with respect to the project. The RFP is the framework from which a comprehensive EA is developed. Cost and contract terms, as specified in the RFP, must be reflected in the EA. For example, the RFP may specify a fixed rental charge to the Government, not subject to price escalation (inflation). The EA should then reflect a fixed rental cost throughout the contract term. The RFP may specify Government responsibility for support services, such as O&M to the facility or Government payment of all tax and insurance increases. The EA and RFP are interrelated documents and a complete and accurate EA cannot be developed in isolation. The provisions of the RFP are the basis for types of costs included in the EA. It is important to develop an EA that reflects the provision of the RFP.

7-4. Application of OMB Circular A-104

OMB Circular A-104 is the regulation for EA when leasing is an option. This document must be used when the assets to be leased have a total fair market value exceeding \$1 million. It is optional for use when lesser dollar values are involved. It does not apply to service contracts. That is, service contracts that involve the use of capital assets by the contractor incidental to the provision of services to the Government are analyzed under OMB Circular A-76. This circular should be used for 801 and 802 Family Housing, 2809 and 2812 projects, and USAR training facilities.

a. The lease-versus-buy analysis required by OMB Circular A-104 is intended to determine if it would costless to lease or to buy a given asset. It is not to be used to determine what kind of asset should be acquired, in what amount, or on what acquisition schedule. For example, when a choice between leasing an asset this year and purchasing it next year is involved, a cost-benefit analysis to determine when to acquire the asset is conducted first, then the lease-versus-buy analysis is performed to determine whether to lease or buy.

b. OMB Circular A-104 may soon be rescinded by OMB and combined with at least one other OMB document. However, the EA methods prescribed by the current OMB A-104 will still be in effect. Specific methodology issues found in OMB A-104 are discussed in paragraphs 7-5 through 7-11 below.

7-5. Analytical perspective

CFF EAs evaluate all costs and benefits from the perspective of the Government as a whole, rather than the DOD, military service, or MACOM. This means that costs and benefits applicable to the Army, installation, or soldier which are not applicable to the Government as a whole are not included in the EA.

7-6. Method of comparing alternatives

The basis for comparing alternatives is the NPV method. Other methods, such as SIR and DPP, are not to be used.

7-7. inflation

All costs are expressed in current ("then year") dollars (taking into account price escalations). costs are discounted back to a common year, usually the year in which the lease will begin. Because all costs are expressed in current year dollars, the analyst must use inflation rates to escalate the costs. The best estimates of inflation rates are the DOD escalation rates given in the Army Program and Budget Committee report. These are also available in "ECON BRIEFS," a

file that can be accessed on the PAX ECONPACK program by use of the Help prompt. These tables provide the price escalation rates by type of appropriation, whether it is MCA or OMA. However, they provide a forecast for only the first 6 years, after which the rate is constant. To provide a more realistic rate for the outyears, a rate from a long-range econometrics firm can be used. A sensitivity test can be performed to evaluate the effects of varying rates.

7-8. Discount rate

The discount rate for a CFF analysis is determined as follows—

a. The discount rate for lease-versus-buy analyses is the current interest rate on new issues of U.S. Treasury securities with maturities most nearly equal to the term of the lease. These rates are given in the Statistical Release (called H-15) published weekly by the Board of Governors of the Federal Reserve Center, Washington, DC. The rate corresponding to an issue with the number of years equal to or greater than the period of analysis is appropriate. Then 1/8 percent is added to this rate to obtain the rate to be used in the analysis. This addition reflects the Treasury charge for agency borrowing.

b. Either mid-year (or continuous) or end-of-year discount factors should be used, as appropriate.

c. Because the Treasury borrowing fluctuates over time, it might change significantly from the time the analysis is performed until the final decision is made. Thus, it is very important to perform a sensitivity analysis with the discount rate varied +25 percent. For example, if the forecast rate from H-15 is 8 percent, the rate to be used in the analysis is 8 1/8 percent and in the sensitivity analysis it should be varied from 0.75 (8.125 percent) to 1.25 (8.125 percent) or 6.1 percent to 10.2 percent. In the report, sensitivity analysis results are reported in a “what-if” sense. That is, they do not invalidate the analysis results, but simply show how results may change if the discount rate changes. The ECONPACK program has a feature to perform this sensitivity analysis.

7-9. Tax implications

The normal payment of taxes refers to the income tax effects on the U.S. Treasury, produced by a given expenditure.

u. Every dollar spent by the Government, regardless of whether it pays for a facility, a service, or some other commodity, and regardless of whether the payment goes to a contractor or to an in-house workforce, becomes the income of some taxable party.

(1) For example, if the Government pays \$100 for a maintenance facility to a contractor (third-party contracting), \$25 might go to a developer to construct the facility, \$30 to the employees the contractor provides, \$15 to pay the contractor's utility expenses to operate the facility, \$15 to purchase supplies, equipment, and other overhead, and \$15 would be counted as profit. Each of these expenses is subject to being taxed (see para b below); employees pay personal income tax, suppliers are taxed on the revenue generated by the purchase of their goods, profits are assessed corporate income taxes, and so on.

(2) Similarly, \$100 paid for a Government-operated/MILCON maintenance facility would be divided among facility costs, in-house employee salaries, overhead, supplies, and other expenses. The entire \$100 that pays for the maintenance facility and its operation becomes some other party's income and, therefore, will be taxed (see para b below). In either situation, third-party or in-house operated MILCON, the \$100 will be fully taxed.

b. The rates of taxation for the various types of income tax are assumed roughly equal to avoid the complexities in trying to determine the actual rate of taxation on all assets and services and at all of the different levels in the spending-income chain. It should be noted that typical Government cost-benefit and economic analyses use pre-tax values of expenditures for the reasons just mentioned.

c. OMB Circular A-104 states correctly: “The normal payment of taxes on income and profits by the lessor (or by other parties to the transaction) should not be included in the lease-versus-buy analysis. Normal income taxes are already taken into account when the

cost of obtaining assets is measured by their market prices; including them explicitly in the analysis would represent double counting.”

7-10. Imputed costs

In an EA governed by OMB Circular A-104, insurance premiums, land costs and real estate taxes must be considered. These are not absolute values like operations or lease payments, but are “opportunity costs” and must be estimated and imputed. They are usually difficult to determine since the Government does not normally pay these costs directly. Since a private developer pays insurance, real estate taxes, and land purchase costs, these costs are reflected in the lease charge to the Government and must therefore be imputed for the Government so the alternatives are comparable.

a. *Imputed cost of land.* This cost is the Government's lost revenue in retaining property that might otherwise be sold on the private market or used for another purpose. This cost represents an “opportunity cost” to the Government which is involved with holding the property. This value would be realized if the land were sold. To estimate the imputed cost and include it in the purchase alternative, an equivalent cost must be found in the private market. However, if the leased facility is to be located on-post, the land cost is a wash and need not be considered.

(1) To obtain a reasonable equivalent cost, the analyst must find the most recent transaction for a piece of property similar to the one being held. This figure should be for a recent sale in the same general area for land with similar attributes, such as nearness to services and population centers. In addition, some consideration should be given to any zoning that would apply if the land were a private holding. This represents the best estimate of the market value of the land and should be imputed to the Government alternative of the EA.

(2) It maybe possible to obtain this information from local real estate dealers or from records of recent transactions. However, the agency that handles the installation real estate transactions is normally the best source. This could be the real estate office on the installation or one at the district office.

b. *Imputed insurance.* The Government is normally “self-insured.” For this analysis, an estimate is needed for the insurance premium against loss of property of the type in the EA. To determine the value of the insured property, the analyst must establish some equivalent commercial value for the building. The approach should be the same as that for the imputed cost of land. The annual imputed cost of insurance can then be computed as a fixed fractional share of the value of the property. The fractional share can be derived from rate schedules of commercial insurers. Per OMB Circular A-104, local estimates of standard commercial coverage for similar property may also be obtained from the Building Owners and Managers Association (BOMA) Regional Exchange reports. In some leases, the Government may pay the insurance costs. The EA must reflect any such special provisions such as this.

c. *Imputed real estate taxes.* Imputed real estate taxes must be added to the Government MILCON alternative. The analyst should consult the city or county office of assessments to obtain the method of assessment (say 30 percent of market value) and the tax rate to be applied (such as 1.5 percent). Then the yearly tax would be calculated and used as the Government's expense for providing community-type services. Normally the cost of real estate taxes is included in the lease charges to the Government. However, the lease contract may specify that the Government will pay any increase in property taxes charged to the private developer. The EA must reflect any such special provision in the lease contract.

7-11. Exchange rates

The use of foreign currency rates is a problem unique to analyses performed on overseas projects where costs are stated in foreign currencies. It is difficult to obtain reliable forecasts of outyear foreign exchange rates. One approach is to apply the concept of “purchasing power parity.” This approach assumes that if local inflation is greater than U.S. inflation, the rise in local currency will be fully

offset by dollar depreciation. Under this approach, it is possible to reflect the long-term dollar costs without resorting to a commercial forecast of the exchange rate and local inflation rate. This process is outlined below.

a. If costs are first expressed in constant terms, note the base year. If costs are first expressed in current terms, deflate by using a compound index on whatever local inflation estimates were used in estimating current costs. The result of this step is costs in the host country's currency expressed in constant terms for a known base year.

b. Since costs from step a are expressed in the host country's currency, multiply the result by the dollar/foreign currency exchange rate for the known base year. The result is the U.S. constant dollar costs.

c. With the constant U.S. dollar costs now established, these values need to be multiplied by the U.S. inflation indexes, resulting in outyear current dollar costs. These costs are then discounted per OMB Circular A-104 procedures.

7-12. Section 2809. Long-Term Facilities Contracts

a. Section 2809 is the CFF authority appropriate for the category of MCA projects. Section 2809 will be described in detail since it is the approved legislation for MCA program application. The six facilities categories eligible for CFF are identified below.

- (1) Child care services.
- (2) Potable and wastewater treatment services.
- (3) Depot supply activities.
- (4) Troop housing.
- (5) Transient quarters.
- (6) Other logistic and administrative services (other than depot maintenance).

b. An explanation of Section 2809 is as follows. "The Secretary concerned may enter into contracts for the construction, management and operation of a facility on or near a military installation for the provision of an activity or service [when] the Secretary concerned has identified the proposed project in the budget proposal to Congress and has determined that the facility can be more economically provided under a long-term contract than by conventional means." The main points are-

(1) It can be on-post or near. "Near" has not been defined quantitatively and depends on the particular project, installation, and operational requirements. A rule of thumb to follow is 200 miles or less.

(2) A contract under this section maybe for "any period not in excess of 32 years, excluding the period of construction."

(3) The contract provides for the "construction, operation, and management of a facility" by a developer. Ownership does not reside with the Government. The 2809 authority allows for the developer to restore the site to its original condition at the end of the 32-year contract or abandon the structures in place. Options to either extend the contract or purchase the facility at fair market value can be included in the Request for Proposal (RFP) but are subject to authority of Congress to allow this.

(4) Construction of a free-standing facility is required. Renovation or an addition to an existing facility is not acceptable.

(5) The Service Secretary, as opposed to the Secretary of Defense (OSD) may select and enter into lease/contracts after Congressional approval. The Assistant Secretary of the Army for Installations, Logistics, and Environment (ASA ILE) is the proponent for 2809 projects. Within Military Programs (CEMP) HQUSACE, the Directorate of Engineering and Construction (E&C) is responsible for the coordination and execution of 2809 candidate projects.

(6) An economic analysis must be submitted to Congress which demonstrates that lease/contract is more economical than nonlease options. The EA plays a central role in this process. It will serve as the basis on which Congress makes its ultimate decision.

c. Section 2809 is a test program. Success of the Services' test projects under this authority will directly influence its extension. [Note: Section 2809 legislative authority has *not* been extended as of 25 Nov91.]

7-13. Section 2828. Army Family Housing Build To Lease 801 Housing

a. Section 801 is based on a traditional "Build to Lease" concept and allows DOD to lease housing and supporting community facilities on or near a military installation in the United States, Guam, or Puerto Rico. Under this program, DOD leases a housing project built specifically for military use for a period not to exceed 20 years, excluding the construction period.

b. Major provisions of the 801 program areas follows-

(1) The Government is responsible for performing the maintenance and paying property tax and insurance increases.

(2) All new 801 projects will be developed on private land. In some cases the Government may take an option on a private land parcel and turn the parcel over to the developer with the best proposal.

(3) Occupants forfeit Basic Allowances for Quarters (BAQ) and Variable Housing Allowances (VHA) in return for assigned quarters.

(4) The Government pays all rent, utilities and administrative costs.

(5) The new housing units are required to be constructed in conformance with DOD specifications.

(6) A validated deficit in military housing must exist in the general area.

(7) Upon termination of the lease agreement, the Government has the first right of refusal to acquire all right, title, and interest in the leased housing facilities.

c. The Section 801 Family Housing legislation requires the submission of an economic analysis to Congress for a 21 day review period showing that the proposed 801 lease is less expensive than military construction. The economic analysis is to be conducted per OMB Circular A-104. The 801 Legislation also requires that all contracts be publicly bid or negotiated. The format for the 801 solicitations is contained in a set of standard Request for Proposals (RFPs) developed by DOD. An example 801 economic analysis and narrative justification in the Congressional/OMB approved arrangement, and a standard RFP package is available from HQU-SACE, CERE-AM.

7-14. Section 2821. Army Family Housing Rental Guarantee 802 Housing

a. Section 802, commonly referred to as the "Rental Guarantee Program" authorizes negotiations with the private sector to provide new rental housing. The Government guarantees 97 percent occupancy. Unlike the 801 Program, the Service member rents housing directly from the developer and continues to receive BAQ and VHA. Major provisions of the 802 Program areas follows-

(1) The Army guarantees 97 percent occupancy with service members leasing directly from the developers.

(2) Occupants continue to receive BAQ and VHA.

(3) Occupants pay for all rent and utilities.

(4) Rental rates may not exceed prevailing existing rates for comparable housing units in the same market area.

(5) New units must be constructed to DOD specifications.

(6) This program may not be applied to existing housing.

(7) The leasing arrangements may not exceed 25 years.

(8) A validated deficit in military housing must exist in the general area.

(9) Use of military controlled housing must have exceeded 97 percent occupancy 18 consecutive months preceding an agreement.

(10) Priority shall be given to military families.

(11) The housing site may be on private or Government-owned land.

b. An economic analysis must be prepared demonstrating that leasing is more cost effective than other means of providing the housing units. The 802 guarantee may not be renewed unless the housing units are located on Government-owned land, in which case the renewal period may not exceed the original contract term.

7-15. Budget scoring rules for commercially financed facilities.

OMB has issued budget "scoring" policies to prevent government agencies from abusing authorities described in this chapter. Economics is only one criteria in determining if CFF is favorable compared to conventional means of acquiring facilities and services. Budget authority and outlay scoring issues must also be considered. These budget "scoring" policies are contained in two OMB documents: OMB Bulletin No. 91-02, 18 Oct 90 and OMB Budget Procedures Memorandum (BPM) No. 768, 15 Nov 90. These policies make CFF alternatives unattractive from a budgeting perspective.

a. Scorekeeping rule. When an agency is authorized to enter into a contract for the purchase, lease-purchase, or lease of a capital asset, budget authority must be scored in the year in which the authority is first made available in the amount of the Government's total estimated legal obligations. Outlays for a purchase (in which the Government is its own contractor) or a lease-purchase in which the Federal Government assumes substantial risk will be spread across the period during which the contractor constructs, manufactures, or purchases the asset. Outlays for a lease or a lease-purchase in which the private sector retains substantial risk will be spread across the lease period, consistent with existing practice.

b. Lease classification. The scorekeeping rule above applies only to purchases, lease-purchases, and capital leases, but not to operating leases. Additionally, the rule only applies when the majority of the risk is to the government. OMB provides the following definitions to help determine CFF budget scoring classifications.

(1) *Lease-purchase.* A type of lease in which ownership of the asset is transferred to the Government at or shortly after the end of the lease period. Such a lease may or may not contain a bargain-price purchase option.

(2) *Capital lease.* Any lease other than a lease-purchase that does not meet the criteria of an operating lease.

(3) *Operating lease.* An operating lease must meet all the criteria listed below. If the criteria are not met, the lease will be considered to be a capital lease or lease purchase, as appropriate.

(a) Ownership of the asset remains with the lessor during the term of the lease and is not transferred to the Government at or shortly after the end of the lease period.

(b) The lease does not contain a bargain-price purchase option.

(c) All risks of ownership of the asset (e.g., financial responsibility for destruction or loss of the asset) remain with the lessor, unless the Government is at fault for such losses.

(d) The lease term does not exceed 75 percent of the estimated economic life of the asset.

(e) The present value of the minimum lease payments over the life of the lease does not exceed 90 percent of the

(f) Fair market value of the asset at the inception of the lease.

(g) The asset is a general purpose asset rather than for special purpose of the Government and is not built to unique specification of the Government as lessee.

(h) There is a private sector market for the asset.

(i) The asset (structure) is not constructed on Government land.

(j) Multi-year service contracts (e.g., grounds maintenance) and multi-year purchase contracts for expendable commodities (e.g., aspirin) will be considered to be operating leases.

(4) *Risk determination.* Another factor in determining the scoring methods to apply to a CFF alternative is the level of risk to the private sector. Lease-purchase agreements are scored as purchases or leases depending on the level of private sector risk. The following types of illustrative criteria will be considered in evaluating the level of private sector risk—

(a) There should be no explicit Government guarantee of third party financing.

(b) All risks incident to ownership of the asset (e.g., financial responsibility for destruction or loss of the asset) should remain with the lessor, unless the Government was at fault for such losses.

(c) The asset should be a general purpose asset rather than be for a special purpose of the Government and should not be built to unique specification of the Government as lessee.

(d) There should be a private-sector market for the asset.

(e) The project should not be constructed on Government land.

Chapter 8 Economic Analysis Reporting

8-1. Purpose of report

Upon completion of the EA, the results must be communicated to the decisionmakers in an easily understood format. The report should contain summary data for the life-cycle cost analysis of each alternative, appropriate graphs, and summaries of any sensitivity analyses. In addition, it should present conclusions and recommendations. A complete report will contain all of these elements. The parts described in paragraphs 8-2 through 8-4 below are currently required in the DD Form 1391.

a. Executive summary. The first section of the report should be an executive summary. This section gives the objective, alternatives considered (feasible and nonfeasible), ranking of alternatives, conclusions, and recommendations. It also lists any assumptions made for the analysis. It gives some details such as the discount rate, period of analysis, and start and base years.

b. Detailed life-cycle cost analysis. This section presents tables of detailed costs for each alternative in each year of the analysis. These tables show the occurrences and patterns of costs over time for each alternative. The sources and derivations for costs are also given in this section.

c. Graph of NPVs. A graph showing cumulative NPV for each alternative over time should be included.

d. Sensitivity analysis. This section should begin with a paragraph discussing which costs need to be examined in sensitivity analyses. Then results of varying these costs-effects on the alternatives' rankings-are given.

8-2. Report review

Appendix D is a guide for reviewing the EA. It can be used as a guideline for both preparers and reviewers of analyses.

8-3. Examples of economic analysis reports generated by ECONPACK

Appendix E shows examples of typical EA reports as generated by ECONPACK. Once these reports are generated on the PAX ECONPACK program, the executive summary, life-cycle cost analysis, and graph can be transferred to the DD Form 1391, Section 11. If an EA is not generated on ECONPACK, results should be reported as described above. Formats for presenting results should be as shown in the reports for the examples of appendix E.

Appendix A
References

Section I
Required Publications

AR 11-18

The Cost and Economic Analysis Program. (Cited in para 1-4)

AR 415-15

Military Construction, Army (MCA) Program Development. (Cited in para 1-4 d)

Section II
Related Publications

A related publication is merely a source of additional information. The user does not have to read it to understand this publication.

AR 1-1

Planning, Programming, and Budgeting Within the Department of the Army

AR 5-4

Department of the Army Productivity Improvement Program

AR 5-20

Commercial Activities Program

AR 37-100

Account/Code Structure

AR 415-17

Cost Estimating for Military Programming

DA Pam 11-5

Standards for Presentation and Documentation of Life Cost Estimates for Army Material Systems

DA Pam 210-6

Economic Analysis of Army Housing Alternatives— Concepts, Guidelines and Formats

Federal Reserve Statistical Release H‐15

NAVFAC P-442

Economic Analysis Handbook

OMB Circular A-76

Policies for Acquiring Commercial or Industrial Products and Services for Government Use

OMB Circular A-94

Discount Rates to be Used in Evaluating Time-Distributed Costs and Benefits

OMB Circular A-104

Evaluating Leases of Capital Assets. (Cited in para 3-6 e)

OMB Circulars maybe obtained from Office of Management and Budget, New Executive Office Building, 725 17th Street, N. W., ROOM 2200, Washington, DC 20503.

Section iii
Prescribed Forms

This section contains no entries.

Section iv
Referenced Forms

DD Form 1391

FY _____, Military Construction Project Data

Appendix B
Discount Factors

6-1. Table B-1 gives end-of-year and mid-year discount factors for a 10 percent discount rate for 30 years. Both the single and cumulative uniform series amounts are given. The formula used for calculating the single amount factors is as shown in equation B- 1 where n = the year.

$$\frac{1}{(1.10)^n}$$

Equation B-1

6-2. For end-of-year factors, n = 1,2, and so on, whereas for mid-year factors, n = 0.5, 1.5, 2.5, for years 1, 2, and 3, respectively.

Table B-1
Discount factors for a 10-percent rate

Year	End-of-Year		Middle-of-Year	
	Single Amount	Cumulative Uniform Series Amount	single Amount	Cumulative Uniform Series Amount
1	0.909	0.909	0.953	0.953
2	0.826	1.736	0.867	1.820
3	0.751	2.467	0.788	2.608
4	0.683	3.170	0.716	3.325
5	0.621	3.791	0.651	3.976
6	0.564	4.355	0.592	4.568
7	0.513	4.868	0.538	5.106
8	0.466	5.335	0.489	5.595
9	0.424	5.759	0.445	6.040
10	0.386	6.145	0.404	6.444
11	0.350	6.495	0.368	6.812
12	0.319	6.814	0.334	7.146
13	0.290	7.103	0.304	7.450
14	0.263	7.367	0.276	7.726
15	0.239	7.606	0.251	7.977
16	0.218	7.824	0.228	8.206
17	0.198	8.022	0.208	8.413
18	0.180	8.201	0.189	8.602
19	0.164	8.365	0.171	8.773
20	0.149	8.514	0.156	8.929
21	0.135	8.649	0.142	9.071
22	0.123	8.772	0.129	9.200
23	0.112	8.883	0.117	9.317
24	0.102	8.985	0.106	9.423
25	0.092	9.077	0.097	9.520
26	0.084	9.161	0.088	9.608
27	0.076	9.237	0.080	9.668
28	0.069	9.307	0.073	9.761
29	0.063	9.370	0.066	9.827
30	0.057	9.427	0.060	9.887

Notes:

1. The single amount is for use with a single cost in 1 year.
2. The uniform series amount is for use when the same cost occurs each year.

Appendix C
Estimating Residual Values

C-1. In new construction and some leasing alternatives, estimates of the residual value for each year of the analysis may be needed. The final residual or terminal value is always required.

C-2. Table C-1 lists building decay-obsolescence, and site appreciation (land) factors that can be used to determine values at any point in time. These factors are for general use. The analyst may develop such factors for a particular analysis applicable to the local situation, but should document the rationale behind them in the report.

Table C-1
Building decay-obsolescence and site appreciation factors

Period of analysis	Building decay-obsolescence factors	Site appreciation factors
1	0.98300	1.01500
2	0.96629	1.03023
3	0.94986	1.04568
4	0.93371	1.06136
5	0.91784	1.07728
6	0.90224	1.09344
7	0.88690	1.10984
8	0.87182	1.12649
9	0.85700	1.14339
10	0.84243	1.16054
11	0.82811	1.17795
12	0.81403	1.19562
13	0.80019	1.21355
14	0.78659	1.23176
15	0.77322	1.25023
16	0.76007	1.26899
17	0.74715	1.28802
18	0.73445	1.30734
19	0.72197	1.32695
20	0.70969	1.34686
21	0.69763	1.36706
22	0.68577	1.38756
23	0.67411	1.40838
24	0.66265	1.42950
25	0.65139	1.45095
26	0.64031	1.47271
27	0.62943	1.49480
28	0.61873	1.51722
29	0.60821	1.53998
30	0.59787	1.56308

Notes

The factors assume end-of-year building decay-obsolescence and site appreciation changes.

Appendix D
Guidelines for Reviewing Economic Analyses

D-1. General

The following checklist will be of use to both analysts and reviewers to ensure that an EA is complete, correct, and well documented. Once the analysis has been reviewed, decisionmakers should be able to accept the results, and-use them in their decision process.

D-2. Objective, assumptions, and alternatives

- a. Is the problem, as stated, the real problem?
- b. Is the objective, as stated, unbiased as to the means of meeting the objective?
- c. Are any reasonable alternatives left out of the analysis without an explanation?

- d. Are assumptions-
 - (1) Too restrictive (e.g., . do not allow an alternative to be considered)?
 - (2) Too broad (e.g., there will always be a requirement for a certain type facility)?
 - (3) Too vague to apply to the problem being studied?
- e. Are uncertainties treated as facts? Can facts be verified?
- f. Are potential mission change constraints on the economic life of an alternative given due consideration? Has the impact of technological change been fully considered?
- g. Are any feasible alternatives omitted and, if so, are the reasons explained?
- h. Are the alternatives well defined, and discrete (do not overlap)?

D-3. Cost estimates

- a. Are the cost-estimating methods used obvious or, if not, explained? Are they appropriate?
- b. Are all relevant costs included?
- c. Are sunk costs properly excluded?
- d. Are the sources of the cost data given? Are these sources accurate, and applicable?
- e. Have all cost estimates been made in the proper type dollars—base year constant dollars for the normal analysis, and current year dollars for an analysis with a lease alternative? Is the source of inflation indices given?
- f. If parametric cost estimating was used, are the cost estimating relationships statistical/mathematically valid? Are the estimates interpolated within the range of historical data or has extrapolation been used?
- g. Have terminal or residual values been included properly? Is the residual schedule appropriate?

D-4. Benefits

- a. Should the analysis consider benefits other than the normal case where all alternatives give comparable benefits? Does the analysis ignore some part of total output?
- b. Are the criteria used to measure a benefit defensible?
- c. Is a benefit, in fact, unmeasurable? Is there a rational assessment of nonquantifiable factors?
- d. If savings have been claimed, will a budget actually be reduced?
- e. Have cost reductions been excluded from the benefit list to avoid double counting'?
- f. Have cost avoidances been considered?
- g. Have all advantages, and disadvantages of the alternatives been identified?
- h. If an efficiency/productivity increase is projected, is there a documented need for greater output? If not, what is the impact on personnel requirements?

D-5. Time-dependent considerations

- a. Was any lead time between the investment, and the start of economic life included?
- b. Was the present value analysis performed correctly? Was the proper discount rate used?
- c. Are the economic lives used reasonable, and sources given?
- d. Is terminal value important in this analysis? If so, is it defensible?
- e. If differential escalation has been assumed for a cost element, is there adequate justification?
- f. If lead time differs among alternatives, have the economic lives been aligned?

D-6. Sensitivity analysis

- a. If differential escalation was assumed, has a baseline analysis with no assumption of differential escalation been performed?
- b. If the analysis includes a lease alternative, was the proper discount rate used (based on treasury securities), and was a sensitivity performed on this rate?

c. Have sensitivity analyses been performed to examine effects of changes in dominant cost elements, economic life, etc.? If not, is the reason correct?

d. Have all relevant "what-if" questions been answered?

e. Have the results of sensitivity analyses been discussed, and incorporated in the report?

D-7. Recommendation of report

a. Is the selected alternative the logical result of the analysis ranking, and sensitivity analyses? If not, are the reasons for its selection justifiable?

b. Is the selected alternative feasible in the real world of political, cultural, and policy consideration?

c. Is the recommendation based on significant differences between the alternatives?

d. Does the selection make sense intuitively?

Appendix E

Computer Outputs From ECONPACK

Section I

MILCON Secondary Analysis called Fort Alice

E-1. Description of Output

a. There is a requirement to provide 95,000 square feet of unaccompanied officer housing for a period of 25 years. This is a new requirement.

b. There are two alternatives, modification to existing space or new construction. The economic lives of the alternatives are 25 years. (Two other alternatives were considered—BAQ/VHA and Lease-but neither was considered feasible.)

c. Beneficial occupancy will be in 1990. The start year and base year is 1988.

d. New construction data—

(1) Construction costs = \$68.42/sf.

(2) Annual maintenance/repair costs = \$.54/sf in FY 86 dollars.

(3) Utility costs = \$.53/sf.

(4) Roof replacement in year 15 with cost = \$9.00/sf.

(5) HVAC replacement in year 20 with cost = 18% of initial construction costs.

(6) Residual value = 40% of initial construction costs.

(e) *Modification data*—

(1) Renovation costs = \$62.00/sf.

(2) Annual maintenance/repair costs = \$ 1.30/sf.

(3) Utilities costs = \$.87/sf.

(4) Roof replacement in year 15 = \$9.00/sf.

(5) HVAC overhaul in year 20 = 18% of renovation costs.

(6) There is a demolition cost of \$2.66/sf at the end of 25 years occupancy.

E-2. Discussion of output

a. The executive summary (fig E-2) is printed first. It includes a results, and recommendations section.

b. Figure E-3 is a graph of the NPVs of the alternatives.

c. The life cycle cost (LCC) report (fig E-4) is next and lists all costs for each year by alternative. The percent of the total NPV of an alternative for each cost is listed at the end of each cost column. This shows quickly which costs have the most impact on the NPV of the alternative. The source and derivation of costs and benefits are given at the end of the LCC report.

d. The final section (fig E-5) is the sensitivity analysis report.

Section II

Primary Analysis called Tobyhanna

E-3. Description of Output

a. There is a continuing requirement to maintain and store certain type shelters at the depot. Currently this is done in an open air environment, subject to weather conditions. This creates inefficiencies in the work, and also increases deterioration of the shelters while in storage.

b. The work could be done better inside a building and storage in a building would eliminate the deterioration due to storage in an unprotected environment.

c. A primary analysis was performed to evaluate the cost savings resulting from construction of an environmentally controlled warehouse. Current annual operating costs are \$1,568,200.

d. New construction costs are estimated at \$40.99/sf while operating and maintenance costs for a new facility would be \$ 1.69/sf. The new facility would have a salvage value at the end of 25 years while there is none for the current operation.

E-4. Discussion of Output

a. The arrangement for the executive summary (fig E-6) is the same as for a secondary analysis. However, the values of two other measures are also printed (SIR and DPP).

b. The graph arrangement which is also similar to the the secondary analysis is shown in figure E-7.

c. The life cycle cost (LCC) report provides the yearly cost data for each alternative; the arrangement is similar to that in a secondary analysis. However, there is an additional table of comparison in the LCC report unique to a primary analysis (see figure E-8).

d. At the end of the LCC report the source, and derivation of costs and benefits are given.

e. Figure E-9 gives results of the sensitivity analysis.

Section III

Analysis with Lease Option called Panama

E-5. Description of Output

a. Additional housing for 500 families for 15 years was required for an installation in the Panama Canal Zone

b. Five alternatives were considered—

(1) Lease through the Republic of Panama

(2) Build to lease

(3) Rental Guarantee

(4) MCA construction

(5) Purchase trailers/relocatable units

c. Since this secondary analysis has a lease as an option, OMB Circular A-104 guidelines must be followed. The ten year treasury rate was 8.60%. Sensitivity of results to a change in the discount rate must be tested.

E-6. Discussion of output

a. This EA is a secondary analysis and the arrangement of the output is similar to that in section I.

b. First is the executive summary (see fig E-10).

c. The graph of the NPVs (fig E-11) of the alternatives is next.

d. The life cycle cost (LCC) report (fig E-12) is next and shows all costs for each year for each alternative. The source and derivation of costs and benefits are given at the end of the LCC report.

e. The sensitivity analysis report (fig E-13) for varying costs is given next.

f. Since this EA has a lease, a sensitivity analysis on the discount rate was also performed and is given in figure E-14 of the output. Figure E-15 gives a summary of how the rankings changed as the discount rate varied, and figure E- 16 gives a detailed one which lists the NPV for each alternative for each value of the discount rate over the range evaluated.

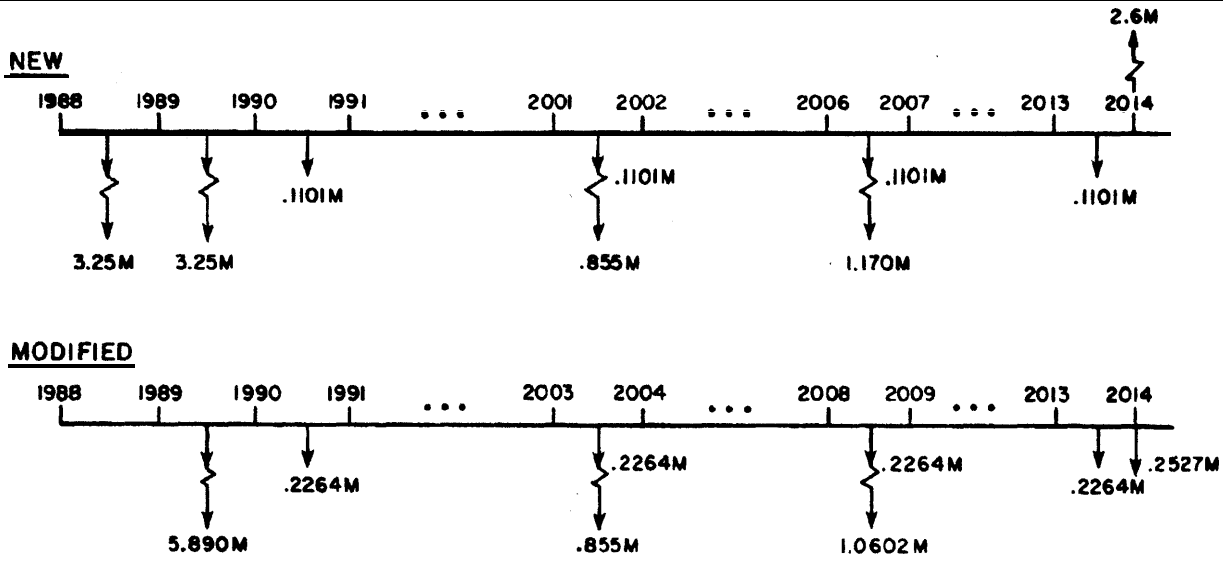


Figure E-1. Cash Flow Diagram

PROJECT TITLE : OFFICERS QUARTERS
 PROJECT OBJECTIVE : PROVIDE 95000 SF OF UNACCOMPANIED OFFICER HOUSNG
 DISCOUNT RATE : 10.00%
 PERIOD OF ANALYSIS: 27 YEARS
 START YEAR : 1988
 BASE YEAR : 1988

ASSUMPTIONS OF THE ANALYSIS:,
 Construction is assumed to take 2 years,

Renovation is expected to take only one year.

The housing is required in 1990.

ALTERNATIVES CONSIDERED FOR THIS ANALYSIS:

New Construction- this alternative will provide the required 95,000 sf of unaccompanied officer housing.

Modification- an existing, unoccupied administrative facility will be renovated to provide the necessary 95,000 sf of housing for unaccompanied officers.

Status Quo Operations- this is a new q ission requirement. There are no facilities available to accommodate this increase in troop strength.

Pay BAQ/VHA- this alternative was eliminated from further evaluation due to the absence of housing available in the vicinity of Fort Alice. The closest town is 87 miles away. Winter conditions preclude commuting from this distance for 4 months of the year. Most importantly, mission requirements, due to the early deployment requirement preclude this unit from being billeted off-post.

Lease- No existing facilities are available for lease within a 100 mile radius of the installation. The mission requirements of this unit (as discussed above) prevent this alternative from being feasible.

ALTERNATIVES COMPARED:

ALTERNATIVE NAME	NPV	EUAC
1 NEW CONSTRUCTION	\$6,911,890	\$748,264
2 MODIFICATION	\$7,416,163	\$802,856

RESULTS AND RECOMMENDATIONS:

The new construction alternative is the least cost alternative. A sensitivity analysis showed that it would take a decrease in the renovation cost of 9.8% or more to make the renovation alternative least cost,

Based on these facts and the other advantages listed below, it is recommended that the new construction alternative be used to fulfill the requirement.

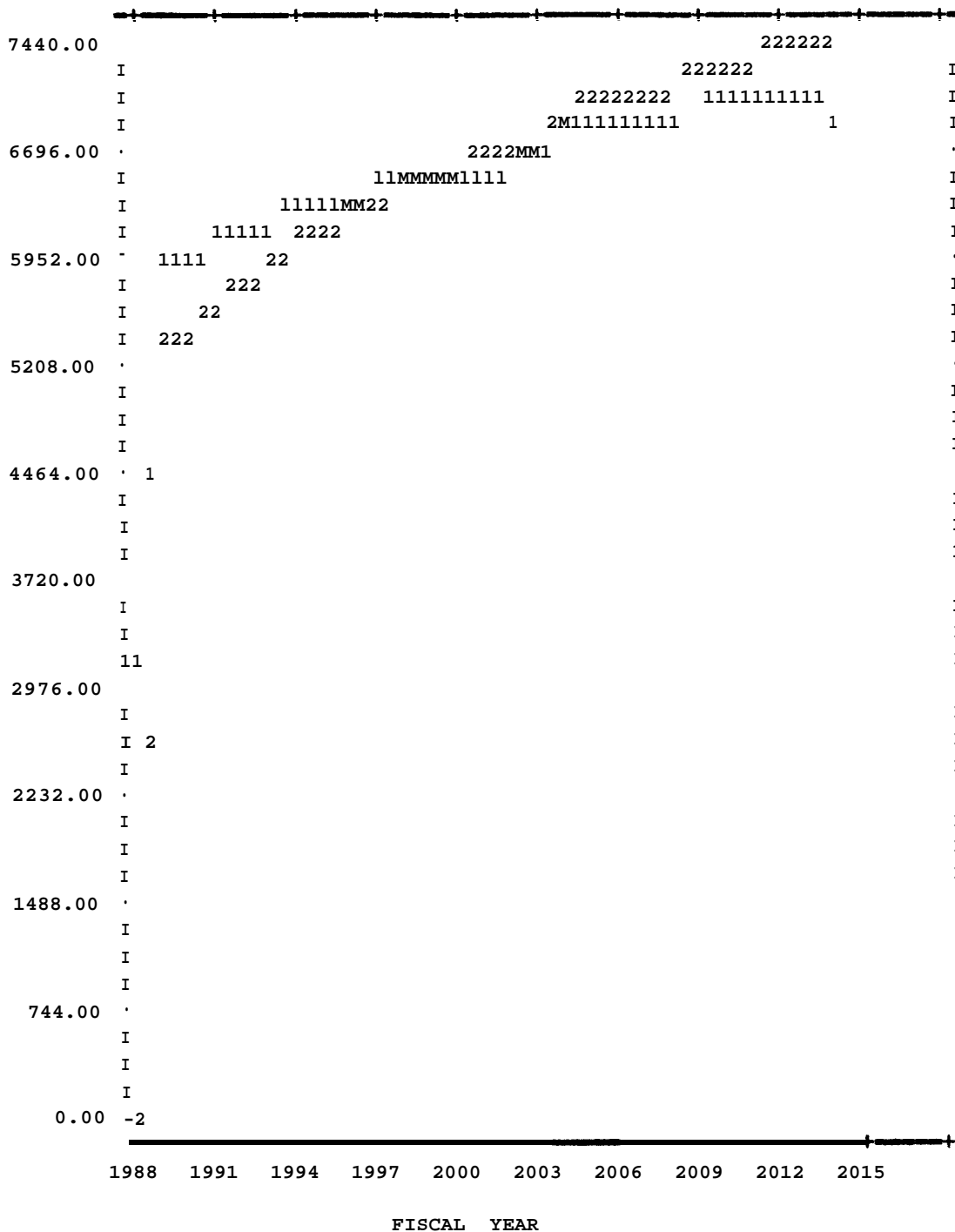
In addition to the quantitative advantages, the new construction alternative offers a higher ranking of non-monetary considerations as follows:

	Modification	New Construction
Morale	Fair	High
Discipline	Fair	Very Good
Re-enlistment	Fair	High
Readiness	Fair	Excellent
Traffic Accidents (lost time)	Fair	Excellent
Community Relations	Fair	Excellent

ACTION OFFICER: James R. SPINDLE
 ORGANIZATION : DEH, FORT ALICE

Figure E-2. Executive Summary Report

CUMULATIVE NET PRESENT VALUE (\$ in thousands)



LEGEND DESCRIPTION

 1 NEW CONSTRUCTION
 2 MODIFICATION
 M MERGING DATA

Figure E-3. Economic Analysis Graph

PROJECT/PROGRAM COSTS

ALTERNATIVE 1: NEW CONSTRUCTION

YEAR	INITIAL CONSTRUCTION COST {Q1}	MAINTENANCE AND REPAIR {Q2}	UTILITIES {Q3}	NEW ROOF IN YR 15 HVAC YR 20 {Q4}	TOTAL ANNUAL OUTLAYS
1988	\$3,250,000	\$0	\$0	\$0	\$3,250,000
1989	\$3,250,000			\$0	\$3,250,000
1990	\$0	\$59,700	\$50,400	\$0	\$110,100
1991	\$0	\$59,700	\$50,400	\$0	\$110,100
1992	\$0	\$59,700	\$50,400	\$0	\$110,100
1993	\$0	\$59,700	\$50,600	\$0	\$110,100
1994	\$0	\$59,700	\$50,400	\$0	\$110,100
1995	\$0	\$59,700	\$50,600	\$0	\$110,100
1996	\$0	\$59,700	\$50,400	\$0	\$110,100
1997	\$0	\$59,700	\$50,400	\$0	\$110,100
1998	\$0	\$59,700	\$50,600	\$0	\$110,100
1999	\$0	\$59,700	\$50,400	\$0	\$110,100
2000	\$0	\$59,700	\$50,400	\$0	\$110,100
2001	\$0	\$59,700	\$50,400	\$0	\$110,100
2002	\$0	\$59,700	\$50,400	\$0	\$110,100
2003	\$0	\$59,700	\$50,400	\$0	\$110,100
2004	\$0	\$59,700	\$50,400	\$855,000	\$965,100
2005	\$0	\$59,700	\$50,400	\$0	\$110,100
2006	\$0	\$59,700	\$50,400	\$0	\$110,100
2007	\$0	\$59,700	\$50,400	\$0	\$110,100
2008	\$0	\$59,700	\$50,400	\$0	\$110,100
2009	\$0	\$59,700	\$50,400	\$1,170,000	\$1,280,100
2010	\$0	\$59,700	\$50,400	\$0	\$110,100
2011	\$0	\$59,700	\$50,400	\$0	\$110,100
2012	\$0	\$59,700	\$50,400	\$0	\$110,100
2013	\$0	\$59,700	\$50,400	\$0	\$110,100
2014	\$0	\$59,700	\$50,400	\$0	\$110,100
NPV	85.59	6.80	5.74	4.75	

PROJECT/PROGRAM COSTS

ALTERNATIVE 1: NEW CONSTRUCTION

YEAR	PRESENT VALUE	CUMULATIVE PRESENT VALUE	PRESENT VALUE RESIDUAL	CUMULATIVE NET PRESENT VALUE
1988	\$3,098,753	\$3,090,753		\$3,098,753
1989	\$2,817,049	\$5,915,802	\$0	\$5,915,802
1990	\$86,757	\$6,002,559	\$0	\$6,002,559
1991	\$78,870	\$6,081,429	\$0	\$6,081,429
1992	\$71,700	\$6,153,129	\$0	\$6,153,129
1993	\$65,182	\$6,218,311	\$0	\$6,218,311
1994	\$59,257	\$6,277,568	\$0	\$6,277,568
1995	\$53,870	\$6,331,438	\$0	\$6,331,438
1996	\$48,972	\$6,380,410	\$0	\$6,380,410
1997	\$44,520	\$6,424,930	\$0	\$6,424,930
1998	\$40,473	\$6,465,403	\$0	\$6,465,403
1999	\$36,796	\$6,502,197	\$0	\$6,502,197
2000	\$33,469	\$6,535,646	\$0	\$6,535,646
2001	\$30,408	\$6,566,054	\$0	\$6,566,054
2002	\$27,643	\$6,593,697	\$0	\$6,593,697
2003	\$25,131	\$6,618,828	\$0	\$6,618,828
2004	\$200,260	\$6,819,088	\$0	\$6,819,088
2005	\$20,769	\$6,839,857	\$0	\$6,839,857
2006	\$18,881	\$6,858,738	\$0	\$6,858,738
2007	\$17,164	\$6,875,902	\$0	\$6,875,902
2008	\$15,604	\$6,891,506	\$0	\$6,891,506
2009	\$164,931	\$7,056,437	\$0	\$7,056,437
2010	\$12,896	\$7,069,333	\$0	\$7,069,333
2011	\$11,724	\$7,081,057	\$0	\$7,081,057
2012	\$10,658	\$7,091,715	\$0	\$7,091,715
2013	\$9,689	\$7,101,404	\$0	\$7,101,404
2014	\$8,808	\$7,110,212	\$198,322	\$6,911,890
NPV			-2.87	

EQUIVALENT UNIFORM ANNUAL COST - \$748,264 (10.00% DISCOUNT RATE, 27 YEARS)

Figure E-4. Life Cycle Cost Report

PROJECT/PROGRAM COSTS

ALTERNATIVE 2: MODIFICATION

YEAR	RENOVATION UPGRADE (01)	UPGRADE IN YEAR 15 ROOF YEAR 20 HVAC (02)	MAINTENANCE AND REPAIR (03)	UTILITIES (04)	TOTAL ANNUAL OUTLAYS
1988	\$0	\$0	\$0	\$0	\$0
1989	\$5,890,000	\$0	\$143,800	\$12,600	\$6,046,400
1990	\$0	\$0	\$143,800	\$12,600	\$26,400
1991	\$0	\$0	\$143,800	\$12,600	\$26,400
1992	\$0	\$0	\$143,800	\$12,600	\$26,400
1993	\$0	\$0	\$143,800	\$12,600	\$26,400
1994	\$0	\$0	\$143,800	\$12,600	\$26,400
1995	\$0	\$0	\$143,800	\$12,600	\$26,400
1996	\$0	\$0	\$143,800	\$12,600	\$26,400
1997	\$0	\$0	\$143,800	\$12,600	\$26,400
1998	\$0	\$0	\$143,800	\$12,600	\$26,400
1999	\$0	\$0	\$143,800	\$12,600	\$26,400
2000	\$0	\$0	\$143,800	\$12,600	\$26,400
2001	\$0	\$0	\$143,800	\$12,600	\$26,400
2002	\$0	\$0	\$143,800	\$12,600	\$26,400
2003	\$0	\$0	\$143,800	\$12,600	\$26,400
2004	\$0	\$855,000	\$143,800	\$12,600	\$1,011,400
2005	\$0	\$0	\$143,800	\$12,600	\$26,400
2006	\$0	\$0	\$143,800	\$12,600	\$26,400
2007	\$0	\$0	\$143,800	\$12,600	\$26,400
2008	\$0	\$0	\$143,800	\$12,600	\$26,400
2009	\$0	\$1,060,200	\$143,800	\$12,600	\$1,216,600
20.0	\$0	\$0	\$143,800	\$12,600	\$26,400
20.1	\$0	\$0	\$143,800	\$12,600	\$26,400
20.2	\$0	\$0	\$143,800	\$12,600	\$26,400
20.3	\$0	\$0	\$143,800	\$12,600	\$26,400
20.4	\$0	\$0	\$143,800	\$12,600	\$26,400
ANAV	68.84	4.23	16.94	9.73	

PROJECT/PROGRAM COSTS

ALTERNATIVE 2: MODIFICATION

YEAR	PRESENT VALUE	CUMULATIVE PRESENT VALUE	PRESENT VALUE RESIDUAL	CUMULATIVE NET PRESENT VALUE
1988	\$0	\$0	\$0	\$0
1989	\$5,301,599	\$5,301,599	\$0	\$5,301,599
1990	\$178,400	\$5,479,999	\$0	\$5,479,999
1991	\$162,182	\$5,642,181	\$0	\$5,642,181
1992	\$147,438	\$5,789,619	\$0	\$5,789,619
1993	\$134,034	\$5,923,653	\$0	\$5,923,653
1994	\$121,850	\$6,045,503	\$0	\$6,045,503
1995	\$110,772	\$6,156,275	\$0	\$6,156,275
1996	\$100,702	\$6,256,977	\$0	\$6,256,977
1997	\$91,547	\$6,348,524	\$0	\$6,348,524
1998	\$83,225	\$6,431,749	\$0	\$6,431,749
1999	\$75,659	\$6,507,408	\$0	\$6,507,408
2000	\$68,781	\$6,576,189	\$0	\$6,576,189
2001	\$62,528	\$6,638,717	\$0	\$6,638,717
2002	\$56,844	\$6,695,561	\$0	\$6,695,561
2003	\$51,677	\$6,747,238	\$0	\$6,747,238
2004	\$224,393	\$6,971,631	\$0	\$6,971,631
2005	\$42,707	\$7,014,338	\$0	\$7,014,338
2006	\$38,825	\$7,053,163	\$0	\$7,053,163
2007	\$35,295	\$7,088,458	\$0	\$7,088,458
2008	\$32,087	\$7,120,545	\$0	\$7,120,545
2009	\$165,767	\$7,286,312	\$0	\$7,286,312
2010	\$26,518	\$7,312,830	\$0	\$7,312,830
2011	\$24,107	\$7,336,937	\$0	\$7,336,937
2012	\$21,916	\$7,358,853	\$0	\$7,358,853
2013	\$19,924	\$7,378,777	\$0	\$7,378,777
2014	\$18,112	\$7,396,889	-\$19,274	\$7,416,163
ANPV			0.26	

EQUIVALENT UNIFORM ANNUAL COST - \$802,856 (10.00% DISCOUNT RATE, 27 YEARS)

Figure E-4. Life Cycle Cost Report—Continued

SOURCE AND DERIVATION OF COSTS AND BENEFITS:

All cost estimates were in 1988 dollars and rounded to the nearest \$100.

NEW CONSTRUCTION

Initial construction cost - \$68.42/sf per AR 415-17.

95,000sf x \$68.42 = \$6,500,000

Maintenance and repair cost estimates were obtained from FY86 Tech Data Reports. These costs were inflated to 1988 by DOD inflation indices as follows: \$.54/sf x 95,000 sf = \$51,300

\$51,300 x 1.164 (Inflation) = \$59,713 = \$59,700.

Utility costs are based on DEH historical records @ \$.53/sf.

\$.53/sf x 95,000 sf = \$50,350 = \$50,400.

Roof replacement and HVAC replacements were included in years 15 and 20 respectively. Roof estimates were developed as follows:

\$9.00/sf x 95,000 sf = \$855,000.

HVAC was assumed to be 18% of initial construction costs.

\$6,500,00 x .18 = \$1,170,000

A residual value for the facility was estimated to be 40% of initial construction costs. \$6,500,000 x .40 = \$2,600,000

MODIFICATION

Renovation costs - \$62.00 per sf. x 95,000sf = \$5,890,000

Maintenance and repair cost estimates were based on FY86 historical records and inflated to 1988: \$1.30/sf x 95,000 sf = \$123,500.

\$123,500 x 1.164 (inflation) = \$143,754 = \$143,800.

Utilities cost estimates were also based on historical records as follows:

\$.87/sf x 95,000 sf = \$82,650 = \$82,600.

A one-time upgrade in year 15 for the roof is estimated to cost

\$9.00/sf x 95,000 sf = \$855,000.

An upgrade of the HVAC system in year 20 is estimated to cost 18% of the renovation costs. \$5,890,000 x .18 = \$1,060,200.

Demolition costs for the facility were estimated to be \$2.66/sf.

\$2.66/sf x 95,000 sf = \$252,700.

Figure E-4. Life Cycle Cost Report - Continued

SENSITIVITY ANALYSIS NUMBER 01
 TITLE TEST SENSITIVITY OF RENOVATION
 COSTS
 ALLOWABLE CHANGE 50.00 PERCENT

THIS SENSITIVITY ANALYSIS CHECKS FOR ALTERNATIVE 2 TO BE RANKED
 FIRST AS A RESULT OF CHANGES IN THE EXPENSE ITEM(S) LISTED BELOW:

ALTERNATIVE	EXPENSE ITEM(S)
1	** NOTHING CHANGED **
2	1

THE SELECTED EXPENSE ITEMS ARE ALLOWED TO VARY FROM A VALUE OF 100%
 LESS THAN THEIR INPUT VALUE TO 50.00% MORE THAN THEIR INPUT VALUE.

ALTERNATIVE	NET PRESENT VALUE
1	\$6,911,890
2	\$7,416,163

FOR ALTERNATIVE 2 TO BE LEAST COST, REDUCE COSTS BY 9.88% OR MORE.

TABLE E-5

Figure E-5. Ranking Sensitivity Analysis

PROJECT TITLE : TOBYHANNA SHELTER MOVING STUDY
 PROJECT OBJECTIVE : EVALUATE COST SAVINGS IN SHELTER MANIPULATIONS
 DISCOUNT RATE : 10.00%
 PERIOD OF ANALYSIS: 26 YEARS
 START YEAR : 1988
 BASE YEAR : 1988

ASSUMPTIONS OF THE ANALYSIS:
 Construction time for a new facility is one year.

ALTERNATIVES CONSIDERED FOR THIS ANALYSIS:
 New construction - construct a new environmentally controlled 140,000sf
 facility.

Status quo - continue to maintain and store the shelters in an open
 environment.

ALTERNATIVES COMPARED:

ALTERNATIVE NAME	NPV	EUAC	SIR	DPP
1 STATUS QUO	\$15,067,389	\$1,644,741		
2 CONSTRUCT NEW FAC	\$8,700,988	\$949,791	1.96	6.9 YEARS

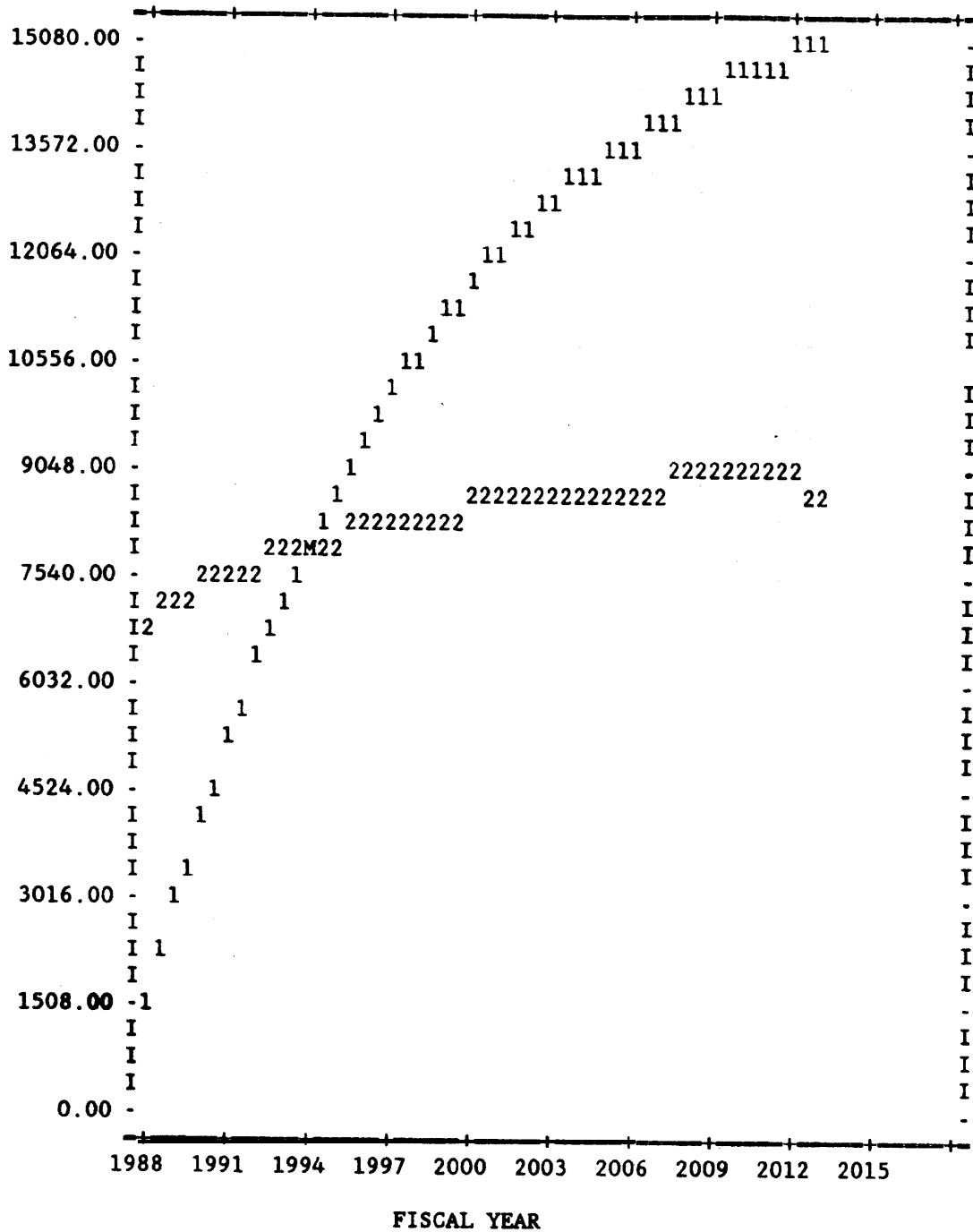
RESULTS AND RECOMMENDATIONS:

The proposed alternative results in a Savings-to-Investment of 2.0 and a
 discounted payback period of 7 years. A sensitivity analysis which allowed
 the operating costs of the proposed alternative to increase 50% was per-
 formed. The proposed alternative was still the least cost. It is recom-
 mended that the new warehouse be built.

ACTION OFFICER: BOB N
 ORGANIZATION : USA-CERL

Figure E-6. Executive Summary

CUMULATIVE NET PRESENT VALUE (\$ in thousands)



LEGEND DESCRIPTION

 1 STATUS QUO
 2 CONSTRUCT NEW FAC
 M MERGING DATA

Figure E-7. Economic Analysis Graph 1

PROJECT/PROGRAM COSTS

ALTERNATIVE 1: STATUS QUO

YEAR	ANNUAL COSTS (01)	TOTAL ANNUAL OUTLAYS	PRESENT VALUE	CUMULATIVE NET PRESENT VALUE
1988	\$1,568,200	\$1,568,200	\$1,495,220	\$1,495,220
1989	\$1,568,200	\$1,568,200	\$1,359,291	\$2,854,511
1990	\$1,568,200	\$1,568,200	\$1,235,719	\$4,090,230
1991	\$1,568,200	\$1,568,200	\$1,123,381	\$5,213,611
1992	\$1,568,200	\$1,568,200	\$1,021,255	\$6,234,866
1993	\$1,568,200	\$1,568,200	\$928,414	\$7,163,280
1994	\$1,568,200	\$1,568,200	\$844,013	\$8,007,293
1995	\$1,568,200	\$1,568,200	\$767,284	\$8,774,577
1996	\$1,568,200	\$1,568,200	\$697,531	\$9,472,108
1997	\$1,568,200	\$1,568,200	\$634,119	\$10,106,227
1998	\$1,568,200	\$1,568,200	\$576,472	\$10,682,699
1999	\$1,568,200	\$1,568,200	\$524,065	\$11,206,764
2000	\$1,568,200	\$1,568,200	\$476,423	\$11,683,187
2001	\$1,568,200	\$1,568,200	\$433,112	\$12,116,299
2002	\$1,568,200	\$1,568,200	\$393,738	\$12,510,037
2003	\$1,568,200	\$1,568,200	\$357,944	\$12,867,981
2004	\$1,568,200	\$1,568,200	\$325,403	\$13,193,384
2005	\$1,568,200	\$1,568,200	\$295,821	\$13,489,205
2006	\$1,568,200	\$1,568,200	\$268,928	\$13,758,133
2007	\$1,568,200	\$1,568,200	\$244,480	\$14,002,613
2008	\$1,568,200	\$1,568,200	\$222,255	\$14,224,868
2009	\$1,568,200	\$1,568,200	\$202,050	\$14,426,918
2010	\$1,568,200	\$1,568,200	\$183,682	\$14,610,600
2011	\$1,568,200	\$1,568,200	\$166,983	\$14,777,583
2012	\$1,568,200	\$1,568,200	\$151,803	\$14,929,386
2013	\$1,568,200	\$1,568,200	\$138,003	\$15,067,389

NPV	100.00			

EQUIVALENT UNIFORM ANNUAL COST - \$1,644,741 (10.00% DISCOUNT RATE, 26 YEARS)

PROJECT/PROGRAM COSTS

ALTERNATIVE 2: CONSTRUCT NEW FAC

YEAR	CONSTRUCTION COSTS (01)	ANNUAL COSTS (02)	COST FOR CURRENT OPER DURING CONST (03)	TOTAL ANNUAL OUTLAYS	PRESENT VALUE
1988	\$5,738,600	\$0	\$1,568,200	\$7,306,800	\$6,966,760
1989	\$0	\$236,600	\$0	\$236,600	\$205,081
1990	\$0	\$236,600	\$0	\$236,600	\$186,437
1991	\$0	\$236,600	\$0	\$236,600	\$169,489
1992	\$0	\$236,600	\$0	\$236,600	\$154,080
1993	\$0	\$236,600	\$0	\$236,600	\$140,073
1994	\$0	\$236,600	\$0	\$236,600	\$127,339
1995	\$0	\$236,600	\$0	\$236,600	\$115,763
1996	\$0	\$236,600	\$0	\$236,600	\$105,239
1997	\$0	\$236,600	\$0	\$236,600	\$95,672
1998	\$0	\$236,600	\$0	\$236,600	\$86,974
1999	\$0	\$236,600	\$0	\$236,600	\$79,068
2000	\$0	\$236,600	\$0	\$236,600	\$71,880
2001	\$0	\$236,600	\$0	\$236,600	\$65,345
2002	\$0	\$236,600	\$0	\$236,600	\$59,405
2003	\$0	\$236,600	\$0	\$236,600	\$54,004
2004	\$0	\$236,600	\$0	\$236,600	\$49,095
2005	\$0	\$236,600	\$0	\$236,600	\$44,632
2006	\$0	\$236,600	\$0	\$236,600	\$40,574
2007	\$0	\$236,600	\$0	\$236,600	\$36,886
2008	\$0	\$236,600	\$0	\$236,600	\$33,532
2009	\$0	\$236,600	\$0	\$236,600	\$30,484
2010	\$0	\$236,600	\$0	\$236,600	\$27,713
2011	\$0	\$236,600	\$0	\$236,600	\$25,193
2012	\$0	\$236,600	\$0	\$236,600	\$22,903
2013	\$0	\$236,600	\$0	\$236,600	\$20,821

NPV	62.88	23.53	17.18		

Figure E-8. Life Cycle Cost Report

PROJECT/PROGRAM COSTS

ALTERNATIVE 2: CONSTRUCT NEW FAC

YEAR	CUMULATIVE PRESENT VALUE	PRESENT VALUE RESIDUAL	CUMULATIVE NET PRESENT VALUE
1988	\$6,966,760	\$0	\$6,966,760
1989	\$7,171,841	\$0	\$7,171,841
1990	\$7,358,276	\$0	\$7,358,278
1991	\$7,527,767	\$0	\$7,527,767
1992	\$7,681,847	\$0	\$7,681,847
1993	\$7,821,920	\$0	\$7,821,920
1994	\$7,949,259	\$0	\$7,949,259
1995	\$8,065,022	\$0	\$8,065,022
1996	\$8,170,261	\$0	\$8,170,261
1997	\$8,265,933	\$0	\$8,265,933
1998	\$8,352,907	\$0	\$8,352,907
1999	\$8,431,975	\$0	\$8,431,975
2000	\$8,503,855	\$0	\$8,503,855
2001	\$8,569,200	\$0	\$8,569,200
2002	\$8,628,605	\$0	\$8,628,605
2003	\$8,682,609	\$0	\$8,682,609
2004	\$8,731,704	\$0	\$8,731,704
2005	\$8,776,336	\$0	\$8,776,336
2006	\$8,816,910	\$0	\$8,816,910
2007	\$8,853,796	\$0	\$8,853,796
2008	\$8,887,328	\$0	\$8,887,328
2009	\$8,917,812	\$0	\$8,917,812
2010	\$8,945,525	\$0	\$8,945,525
2011	\$8,970,718	\$0	\$8,970,718
2012	\$8,993,621	\$0	\$8,993,621
2013	\$9,014,442	\$313,454	\$8,700,988
NPV		-3.60	

EQUIVALENT UNIFORM ANNUAL COST - \$949,791 (10.00% DISCOUNT RATE, 26 YEARS)

PRIMARY ECONOMIC ANALYSIS

PRESENT ALTERNATIVE: STATUS QUO
 PROPOSED ALTERNATIVE: CONSTRUCT NEW FAC
 ECONOMIC LIFE (PRESENT): 25 YEARS
 ECONOMIC LIFE (PROPOSED): 25 YEARS

PROJECT YEAR(S)	RECURRING ANNUAL OPERATING COSTS PRESENT ALTERNATIVE	RECURRING ANNUAL OPERATING COSTS PROPOSED ALTERNATIVE	DIFFERENTIAL COST	PRESENT VALUE FACTOR	PRESENT VALUE OF DIFFERENTIAL COST
1988	\$1,568,200	\$0	\$1,568,200	0.953	\$1,495,220
1989	\$1,568,200	\$236,600	\$1,331,600	0.867	\$1,154,210
1990	\$1,568,200	\$236,600	\$1,331,600	0.788	\$1,049,282
1991	\$1,568,200	\$236,600	\$1,331,600	0.716	\$953,892
1992	\$1,568,200	\$236,600	\$1,331,600	0.651	\$867,175
1993	\$1,568,200	\$236,600	\$1,331,600	0.592	\$788,341
1994	\$1,568,200	\$236,600	\$1,331,600	0.538	\$716,674
1995	\$1,568,200	\$236,600	\$1,331,600	0.489	\$651,521
1996	\$1,568,200	\$236,600	\$1,331,600	0.445	\$592,292
1997	\$1,568,200	\$236,600	\$1,331,600	0.404	\$538,447
1998	\$1,568,200	\$236,600	\$1,331,600	0.368	\$489,498
1999	\$1,568,200	\$236,600	\$1,331,600	0.334	\$444,997
2000	\$1,568,200	\$236,600	\$1,331,600	0.304	\$404,543
2001	\$1,568,200	\$236,600	\$1,331,600	0.276	\$367,767
2002	\$1,568,200	\$236,600	\$1,331,600	0.251	\$334,333
2003	\$1,568,200	\$236,600	\$1,331,600	0.228	\$303,940
2004	\$1,568,200	\$236,600	\$1,331,600	0.208	\$276,308
2005	\$1,568,200	\$236,600	\$1,331,600	0.189	\$251,189
2006	\$1,568,200	\$236,600	\$1,331,600	0.171	\$228,354
2007	\$1,568,200	\$236,600	\$1,331,600	0.156	\$207,594
2008	\$1,568,200	\$236,600	\$1,331,600	0.142	\$188,723
2009	\$1,568,200	\$236,600	\$1,331,600	0.129	\$171,566
2010	\$1,568,200	\$236,600	\$1,331,600	0.117	\$155,969
2011	\$1,568,200	\$236,600	\$1,331,600	0.106	\$141,790
2012	\$1,568,200	\$236,600	\$1,331,600	0.097	\$128,900
2013	\$1,568,200	\$236,600	\$1,331,600	0.088	\$117,182
TOTALS	\$40,773,200	\$5,915,000	\$34,858,200		\$13,019,707

Figure E-8. Life Cycle Cost Report — Continued

PRIMARY ECONOMIC ANALYSIS

TOTAL PRESENT VALUE OF NEW INVESTMENT	\$6,966,760
PLUS: PRESENT VALUE OF EXISTING ASSETS TO BE USED	\$0
LESS: PRESENT VALUE OF EXISTING ASSETS REPLACED	\$0
LESS: PRESENT VALUE OF TERMINAL VALUE OF ALTERNATIVE	\$313,454
TOTAL PRESENT VALUE OF NET INVESTMENT	\$6,653,306
TOTAL PRESENT VALUE OF DIFFERENTIAL COSTS	\$13,019,707
PLUS: PRESENT VALUE OF COST OF REFURBISHMENT OR MODIFICATION ELIMINATED	\$0
LESS: STATUS QUO SALVAGE VALUE	\$0
TOTAL PRESENT VALUE OF SAVINGS	\$13,019,707
SAVINGS/INVESTMENT RATIO	1.96
DISCOUNTED PAYBACK PERIOD	6.9 YEARS

SOURCE AND DERIVATION OF COSTS AND BENEFITS:

NEW CONSTRUCTION

The construction cost for the new facility was obtained from the District office (\$40.99/sf). 140,000 sf x \$40.99/sf = \$5,738,600.

Operating and maintenance costs were estimated at \$1.69/sf based on historical data at the DEH office. 140,000 sf x \$1.69/sf = \$236,600.

Salvage value at the end of 25 years was based on the OMB Circular A-104 obsolescence factor:
\$5,738,600 x .651 = \$3,735,800.

CURRENT METHOD

The annual operating cost of \$1,568,200 of the current method of operation was based on historical records for the past five years.

Figure E-8. Life Cycle Cost Report-Continued

SENSITIVITY ANALYSIS NUMBER 01
TITLE Test of increase of operating
costs of proposed alternative
ALLOWABLE CHANGE 50.00 PERCENT

THIS SENSITIVITY ANALYSIS CHECKS FOR ALTERNATIVE 1 TO BE RANKED FIRST AS A RESULT OF CHANGES IN THE EXPENSE ITEM(S) LISTED BELOW:

ALTERNATIVE	EXPENSE ITEM(S)
1	** NOTHING CHANGED **
2	

THE SELECTED EXPENSE ITEMS ARE ALLOWED TO VARY FROM A VALUE OF 100% LESS THAN THEIR INPUT VALUE TO 50.00% MORE THAN THEIR INPUT VALUE.

ALTERNATIVE	NET PRESENT VALUE
2	\$8,700,988
1	\$15,067,389

INSENSITIVE WITHIN THE ALLOWABLE PERCENT OF CHANGE.

Figure E-9. Ranking Sensitivity Analysis

PROJECT TITLE : PANAMA HOUSING
 PROJECT OBJECTIVE : DETERMINE LEAST COST METHOD OF HOUSING 500 FAM
 DISCOUNT RATE : 8.60%
 PERIOD OF ANALYSIS: 17 YEARS
 START YEAR : 1985
 BASE YEAR : 1985

ASSUMPTIONS OF THE ANALYSIS:

For the conventional MCA construction alternative (#4), it is assumed that there will be no payment made by the Republic of Panama upon the transfer of the property in 1999.

Complete beneficial occupancy for all alternatives will occur in 1987.

Delivery schedules are assumed to be 60/40% for MCA units and 50/50% for trailer/relocatable units.

Lease and rental Guarantee units will be located on privately owned land.

Normally, imputed land and insurance costs and real estate taxes are included in an EA with a lease as an alternative. Because of the location of the installation, these were ignored for this analysis.

The discount rate is 8.60%, based on 10 year treasury securities.

ALTERNATIVES CONSIDERED FOR THIS ANALYSIS:

There are five alternatives analyzed to meet the requirement of housing 500 families. These are:

1. Lease housing through the Republic of Panama - the Army would enter into an agreement to lease 500 units from the ROP.
2. Build to lease - 500 housing units would be constructed by a private developer and leased to the Army.
3. Rental guarantee - the Army would guarantee 97% occupancy of 500 rental housing units. Occupants receive BAQ/VHA and pay for rent & utilities.
4. MCA Construction - 500 housing units would be built on-post through conventional MCA construction.
5. Purchase trailers/relocatable units - the Army would provide housing for 500 families on-post in trailers/locatable housing units.

ALTERNATIVES COMPARED (\$ in thousands):

ALTERNATIVE NAME	NPV	EUAC
1 ROP LEASE	\$89,109	\$10,163
2 BUILD TO LEASE	\$89,909	\$10,254
3 RENT GUARANTEE	\$57,173	\$6,520
4 MCA CONSTRUCTION	\$71,944	\$8,205
5 TRAILER	\$53,623	\$6,115

RESULTS AND RECOMMENDATIONS:

The lowest cost alternative is the trailer/relocatable housing units alternative. It is more than \$3.5 Million less expensive than any other.

A sensitivity analysis which allowed the estimated maintenance costs of the trailer/relocatable alternative to increase by as much as 50% was performed. The rental guarantee became the least cost alternative if the maintenance costs increased by 49.7%.

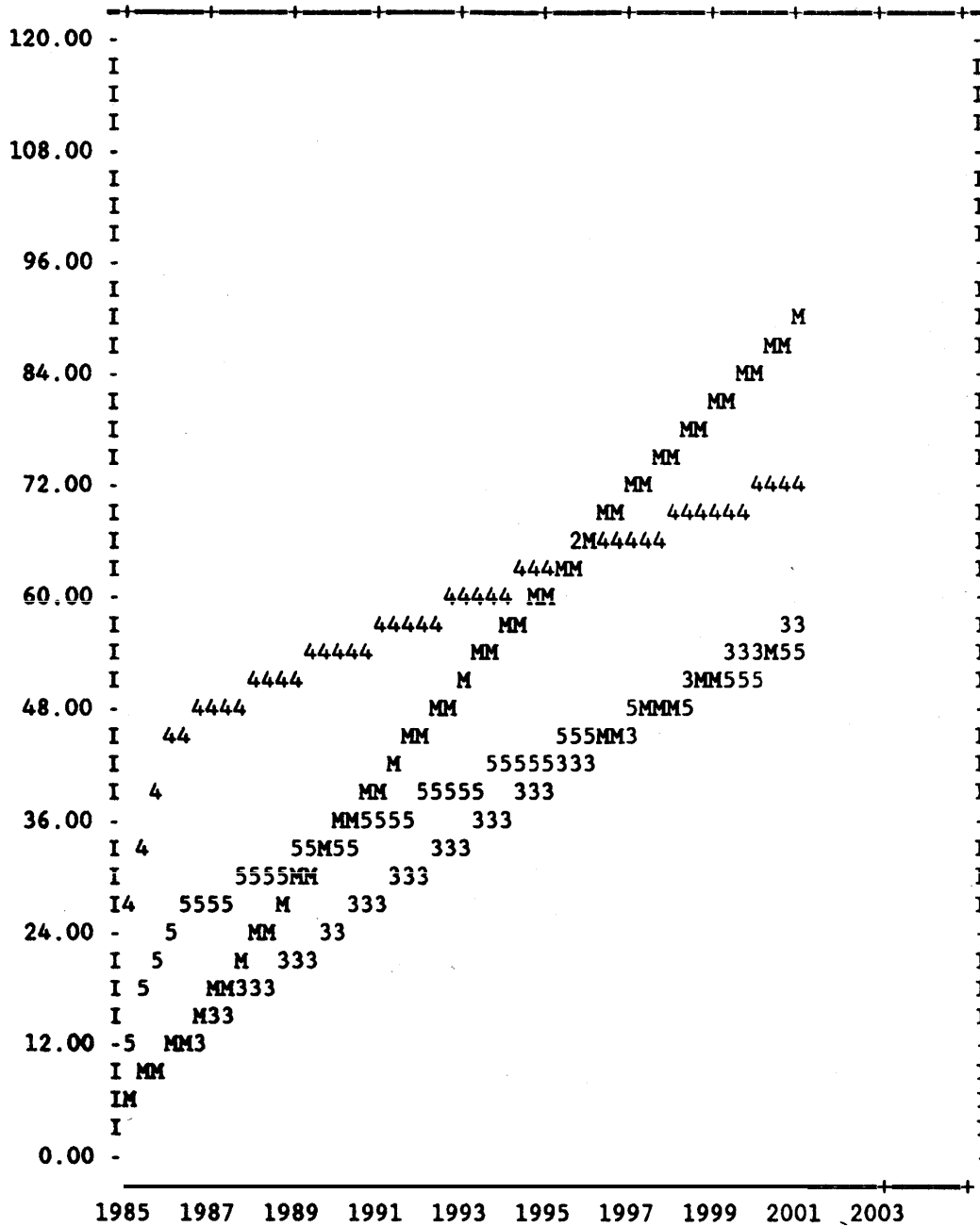
The sensitivity of the results to changes in the discount rate was tested. The analysis is insensitive to +25% change in the 8.60% rate.

It is recommended that the trailer/relocatable alternative be funded.

ACTION OFFICER: BOB N
 ORGANIZATION : USA-CERL

Figure E-10. Executive Summary Report

CUMULATIVE NET PRESENT VALUE (\$ in millions)



FISCAL YEAR

LEGEND	DESCRIPTION	LEGEND	DESCRIPTION
1	ROP LEASE	5	TRAILER
2	BUILD TO LEASE	M	MERGING DATA
3	RENT GUARANTEE		
4	MCA CONSTRUCTION		

Figure E-11. Economic Analysis Graph 1

PROJECT/PROGRAM COSTS (\$ in thousands)

ALTERNATIVE 1: ROP LEASE

YEAR	LEASE RENT (01)	SERVICES (02)	UTILITIES (03)	MAINTENANCE AND REPAIR (04)	ALLOWANCES (05)
1985	\$0	\$0	\$0	\$0	\$5,943
1986	\$0	\$0	\$0	\$0	\$6,240
1987	\$4,263	\$346	\$2,325	\$488	\$13
1988	\$4,562	\$363	\$2,441	\$512	\$14
1989	\$4,881	\$381	\$2,563	\$538	\$14
1990	\$5,223	\$400	\$2,691	\$565	\$15
1991	\$5,589	\$420	\$2,826	\$593	\$16
1992	\$5,980	\$441	\$2,967	\$623	\$17
1993	\$6,398	\$463	\$3,116	\$654	\$17
1994	\$6,846	\$486	\$3,271	\$687	\$18
1995	\$7,325	\$511	\$3,435	\$721	\$19
1996	\$7,838	\$536	\$3,607	\$757	\$20
1997	\$8,387	\$563	\$3,787	\$795	\$21
1998	\$8,974	\$591	\$3,976	\$835	\$22
1999	\$9,602	\$621	\$4,175	\$876	\$23
2000	\$10,274	\$652	\$4,384	\$920	\$24
2001	\$10,993	\$684	\$4,603	\$966	\$26
NPV	52.74	3.78	25.42	5.33	12.73

PROJECT/PROGRAM COSTS (\$ in thousands)

ALTERNATIVE 1: ROP LEASE

YEAR	TOTAL ANNUAL OUTLAYS	PRESENT VALUE	CUMULATIVE NET PRESENT VALUE
1985	\$5,943	\$5,703	\$5,703
1986	\$6,240	\$5,514	\$11,217
1987	\$7,435	\$6,050	\$17,267
1988	\$7,892	\$5,913	\$23,180
1989	\$8,377	\$5,779	\$28,959
1990	\$8,894	\$5,651	\$34,610
1991	\$9,444	\$5,524	\$40,134
1992	\$10,028	\$5,401	\$45,535
1993	\$10,648	\$5,281	\$50,816
1994	\$11,308	\$5,165	\$55,981
1995	\$12,011	\$5,051	\$61,032
1996	\$12,758	\$4,941	\$65,973
1997	\$13,553	\$4,832	\$70,805
1998	\$14,398	\$4,727	\$75,532
1999	\$15,297	\$4,625	\$80,157
2000	\$16,254	\$4,524	\$84,681
2001	\$17,272	\$4,428	\$89,109

EQUIVALENT UNIFORM ANNUAL COST - \$10,163 (8.60% DISCOUNT RATE, 17 YEARS)

EXPENSE ITEM 1 USED INFLATION INDEX 1 - MOBILE PROJECTION.
 EXPENSE ITEMS 2, 3, 4 AND 5 USED INFLATION INDEX 2 - OSD GENERAL.

Figure E-12. Life Cycle Cost Report

PROJECT/PROGRAM COSTS (\$ in thousands)

ALTERNATIVE 2: BUILD TO LEASE

YEAR	ALLOWANCES	LEASE RENT	SERVICES	UTILITIES	MAINTENANCE
	(01)	(02)	(03)	(04)	(05)
1985	\$5,943	\$0	\$0	\$0	\$0
1986	\$6,240	\$0	\$0	\$0	\$0
1987	\$0	\$4,761	\$54	\$2,000	\$637
1988	\$0	\$5,094	\$57	\$2,100	\$669
1989	\$0	\$5,451	\$60	\$2,205	\$702
1990	\$0	\$5,832	\$63	\$2,315	\$738
1991	\$0	\$6,241	\$66	\$2,431	\$774
1992	\$0	\$6,677	\$69	\$2,552	\$813
1993	\$0	\$7,145	\$73	\$2,680	\$854
1994	\$0	\$7,645	\$76	\$2,814	\$897
1995	\$0	\$8,180	\$80	\$2,954	\$941
1996	\$0	\$8,753	\$84	\$3,102	\$988
1997	\$0	\$9,365	\$88	\$3,257	\$1,038
1998	\$0	\$10,021	\$93	\$3,420	\$1,090
1999	\$0	\$10,722	\$97	\$3,591	\$1,144
2000	\$0	\$11,473	\$102	\$3,771	\$1,201
2001	\$0	\$12,276	\$107	\$3,959	\$1,262
NPV	12.48	58.37	0.59	21.67	6.90

PROJECT/PROGRAM COSTS (\$ in thousands)

ALTERNATIVE 2: BUILD TO LEASE

YEAR	TOTAL ANNUAL OUTLAYS	PRESENT VALUE	CUMULATIVE NET PRESENT VALUE
1985	\$5,943	\$5,703	\$5,703
1986	\$6,240	\$5,514	\$11,217
1987	\$7,452	\$6,063	\$17,280
1988	\$7,920	\$5,933	\$23,213
1989	\$8,418	\$5,807	\$29,020
1990	\$8,948	\$5,684	\$34,704
1991	\$9,512	\$5,564	\$40,268
1992	\$10,111	\$5,447	\$45,715
1993	\$10,752	\$5,332	\$51,047
1994	\$11,432	\$5,220	\$56,267
1995	\$12,155	\$5,112	\$61,379
1996	\$12,927	\$5,006	\$66,385
1997	\$13,748	\$4,901	\$71,286
1998	\$14,624	\$4,801	\$76,087
1999	\$15,554	\$4,703	\$80,790
2000	\$16,547	\$4,606	\$85,396
2001	\$17,604	\$4,513	\$89,909

EQUIVALENT UNIFORM ANNUAL COST - \$10,254 (8.60% DISCOUNT RATE, 17 YEARS)

EXPENSE ITEM 2 USED INFLATION INDEX 1 - MOBILE PROJECTION.
 EXPENSE ITEMS 1, 3, 4 AND 5 USED INFLATION INDEX 2 - OSD GENERAL.

Figure E-12. Life Cycle Cost Report - Continued

PROJECT/PROGRAM COSTS (\$ in thousands)

ALTERNATIVE 3: RENT GUARANTEE

YEAR	ALLOWANCES	LEASE RENT	SERVICES	TOTAL ANNUAL OUTLAYS	PRESENT VALUE
	{01}	{02}	{03}		
1985	\$5,943	\$0	\$0	\$5,943	\$5,703
1986	\$6,240	\$0	\$0	\$6,240	\$5,514
1987	\$0	\$4,121	\$54	\$4,175	\$3,397
1988	\$0	\$6,410	\$57	\$4,467	\$3,347
1989	\$0	\$4,719	\$60	\$4,779	\$3,296
1990	\$0	\$5,049	\$63	\$5,112	\$3,247
1991	\$0	\$5,402	\$66	\$5,468	\$3,199
1992	\$0	\$5,780	\$69	\$5,849	\$3,150
1993	\$0	\$6,185	\$73	\$6,258	\$3,104
1994	\$0	\$6,618	\$76	\$6,694	\$3,057
1995	\$0	\$7,081	\$80	\$7,161	\$3,012
1996	\$0	\$7,577	\$84	\$7,661	\$2,967
1997	\$0	\$8,107	\$88	\$8,195	\$2,922
1998	\$0	\$8,675	\$93	\$8,768	\$2,878
1999	\$0	\$9,282	\$97	\$9,379	\$2,835
2000	\$0	\$9,932	\$102	\$10,034	\$2,793
2001	\$0	\$10,627	\$107	\$10,734	\$2,752
NPV	19.62	79.46	0.92		

PROJECT/PROGRAM COSTS (\$ in thousands)

ALTERNATIVE 3: RENT GUARANTEE

YEAR	CUMULATIVE NET PRESENT VALUE
1985	\$5,703
1986	\$11,217
1987	\$14,614
1988	\$17,961
1989	\$21,257
1990	\$24,504
1991	\$27,703
1992	\$30,853
1993	\$33,957
1994	\$37,014
1995	\$40,026
1996	\$42,993
1997	\$45,915
1998	\$48,793
1999	\$51,628
2000	\$54,421
2001	\$57,173

EQUIVALENT UNIFORM ANNUAL COST- \$6,520 (8.60% DISCOUNT RATE, 17 YEARS)

EXPENSE ITEM 2 USED INFLATION INDEX 1 - MOBILE PROJECTION.
 EXPENSE ITEMS 1 AND 3 USED INFLATION INDEX 2 - OSD GENERAL.

Figure E-12. Life Cycle Cost Report - Continued

PROJECT/PROGRAM COSTS (\$ in thousands)

ALTERNATIVE 4: MCA CONSTRUCTION

YEAR	ALLOWANCES (01)	DESIGN AND CONSTRUCTION (02)	UTILITIES (03)	MAINTENANCE AND REPAIR (04)	EQUIPMENT (05)
1985	\$5,943	\$22,308	\$0	\$0	\$429
1986	\$2,496	\$15,913	\$1,135	\$174	\$300
1987	\$0	\$0	\$1,986	\$305	\$13
1988	\$0	\$0	\$2,085	\$320	\$14
1989	\$0	\$0	\$2,190	\$336	\$14
1990	\$0	\$0	\$2,299	\$353	\$15
1991	\$0	\$0	\$2,414	\$371	\$16
1992	\$0	\$0	\$2,535	\$389	\$17
1993	\$0	\$0	\$2,662	\$409	\$17
1994	\$0	\$0	\$2,795	\$429	\$18
1995	\$0	\$0	\$2,934	\$451	\$19
1996	\$0	\$0	\$3,081	\$473	\$20
1997	\$0	\$0	\$3,235	\$497	\$21
1998	\$0	\$0	\$3,397	\$522	\$22
1999	\$0	\$0	\$3,567	\$548	\$23
2000	\$0	\$0	\$3,745	\$575	\$24
2001	\$0	\$0	\$3,932	\$604	\$26
NPV	10.99	49.30	28.28	4.35	1.12

PROJECT/PROGRAM COSTS (\$ in thousands)

ALTERNATIVE 4: MCA CONSTRUCTION

YEAR	SERVICES (06)	TOTAL ANNUAL OUTLAYS	PRESENT VALUE	CUMULATIVE NET PRESENT VALUE
1985	\$0	\$28,680	\$27,521	\$27,521
1986	\$244	\$20,262	\$17,905	\$45,426
1987	\$418	\$2,722	\$2,215	\$47,641
1988	\$439	\$2,858	\$2,141	\$49,782
1989	\$461	\$3,001	\$2,071	\$51,853
1990	\$484	\$3,151	\$2,001	\$53,854
1991	\$508	\$3,309	\$1,935	\$55,789
1992	\$533	\$3,474	\$1,871	\$57,660
1993	\$560	\$3,648	\$1,810	\$59,470
1994	\$588	\$3,830	\$1,749	\$61,219
1995	\$618	\$4,022	\$1,692	\$62,911
1996	\$648	\$4,222	\$1,635	\$64,546
1997	\$681	\$4,434	\$1,581	\$66,127
1998	\$715	\$4,656	\$1,528	\$67,655
1999	\$751	\$4,889	\$1,478	\$69,133
2000	\$788	\$5,132	\$1,429	\$70,562
2001	\$828	\$5,390	\$1,382	\$71,944
%NPV	5.96			

EQUIVALENT UNIFORM ANNUAL COST - \$8,205 (8.60% DISCOUNT RATE, 17 YEARS)

EXPENSE ITEM 2 USED INFLATION INDEX 1 - MOBILE PROJECTION.
EXPENSE ITEMS 1, 3, 4, 5 AND 6 USED INFLATION INDEX 2 - OSD GENERAL.

Figure E-12. Life Cycle Cost Report - Continued

PROJECT/PROGRAM COSTS (\$ in thousands)

ALTERNATIVE 5: TRAILER

YEAR	ALLOWANCES	DESIGN AND CONSTRUCTION	SERVICES	UTILITIES	MAINTENANCE AND REPAIR
	(01),	(02),	(03),	(04),	(05),
1985	\$5,943	\$6,465	\$0	\$0	\$0
1986	\$3,120	\$6,918	\$203	\$865	\$291
1987	\$0	\$0	\$427	\$1,817	\$610
1988	\$0	\$0	\$448	\$1,907	\$641
1989	\$0	\$0	\$471	\$2,003	\$673
1990	\$0	\$0	\$494	\$2,103	\$706
1991	\$0	\$0	\$519	\$2,208	\$742
1992	\$0	\$0	\$545	\$2,318	\$779
1993	\$0	\$0	\$572	\$2,434	\$818
1994	\$0	\$0	\$601	\$2,556	\$858
1995	\$0	\$0	\$631	\$2,684	\$901
1996	\$0	\$0	\$662	\$2,818	\$1,388
1997	\$0	\$0	\$696	\$2,959	\$1,457
1998	\$0	\$0	\$730	\$3,107	\$1,530
1999	\$0	\$0	\$767	\$3,262	\$1,607
2000	\$0	\$0	\$805	\$3,425	\$1,687
2001	\$0	\$0	\$846	\$3,597	\$1,772
%NW	15.78	22.97	8.10	34.43	13.32

PROJECT/PROGRAM COSTS (\$ in thousands)

ALTERNATIVES: TRAILER

YEAR	TRANSPORT	TOTAL ANNUAL OUTLAYS	PRESENT VALUE	CUMULATIVE NET PRESENT VALUE
	(06)			
1985	\$1,537	\$13,945	\$13,382	\$13,382
1986	\$1,614	\$13,011	\$11,496	\$24,878
1987	\$0	\$2,854	\$2,321	\$27,199
1988	\$0	\$2,996	\$2,245	\$29,444
1989	\$0	\$3,147	\$2,171	\$31,615
1990	\$0	\$3,303	\$2,099	\$33,714
1991	\$0	\$3,469	\$2,030	\$35,744
1992	\$0	\$3,642	\$1,962	\$37,706
1993	\$0	\$3,824	\$1,896	\$39,602
1994	\$0	\$4,015	\$1,833	\$41,435
1995	\$0	\$4,216	\$1,773	\$43,208
1996	\$0	\$4,868	\$1,885	\$45,093
1997	\$0	\$5,112	\$1,823	\$46,916
1998	\$0	\$5,367	\$1,762	\$48,678
1999	\$0	\$5,636	\$1,704	\$50,382
2000	\$0	\$5,917	\$1,648	\$52,030
2001	\$0	\$6,215	\$1,593	\$53,623
%NPV	5.41			

EQUIVALENT UNIFORM ANNUAL COST - \$6,115 (8.60% DISCOUNT RATE, 17 YEARS)

EXPENSE ITEM 2 USED INFLATION INDEX 1 - MOBILE PROJECTION.
EXPENSE ITEMS 1, 3, 4, 5 AND 6 USED INFLATION INDEX 2 - OSD GENERAL.

Figure E-12. Life Cycle Cost Report - Continued

SOURCE AND DERIVATION OF COSTS AND BENEFITS:

Cost estimation was performed by the estimators in the District Office. Costs were made in 1985 dollars. Maintenance, repair, utilities, equipment and services costs estimates were made by the DEH staff with the assistance of the district office.

Two inflation indices were used. One was developed by the Mobile DO (7%/yr) and the other was published by OSD (5%/yr).

ALTERNATIVE 1 ROP LEASE

Allowances - \$5,800,000 for the first two years of the analysis, and \$11,500 per year for the remaining fifteen years.

Lease rent - \$3,600,000 per year.

Services - \$306,000 per year.

Utilities - \$2,058,000 per year.

M&R - \$432,000 per year.

All were to be specified in the lease. Lease rent was inflated using the DO schedule and all other costs inflated using the OSD schedule.

ALTERNATIVE 2 BUILD TO LEASE

Allowances - \$5,800,000 for the first two years.

Lease rent - \$4,020,000 per year.

Services - \$48,000 per year.

Utilities - \$1,770,000 per year.

M&R costs - \$564,000 per year.

The lease rent cost was inflated using the DO schedule and all other costs inflated using the OSD schedule.

ALTERNATIVE 3 RENTAL GUARANTEE

Allowances - \$5,800,000 for the first two years of the analysis.

Lease cost (reflects BAQ/VHA payments) - \$3,480,000.

Services - \$48,000 per year.

Lease cost used the DO inflation schedule, all others used the OSD schedule.

ALTERNATIVE 4 MCA CONSTRUCTION

MCA construction cost was developed by use of the Tri-Service cost model.

(\$71,888 per unit) x 500 units - \$35,944,000

Utilities - \$1,054,800 the 2nd year of the analysis, \$1,758,000/yr thereafter.

M&R costs - \$162,000 the 2nd year of the analysis, \$270,000/yr thereafter.

Service costs reflect garbage collection and entomological services. This cost is based on current annual costs per unit in Panama - \$226,800

the 2nd year of the analysis, \$370,000 thereafter.

Allowances - \$5,800,000 the 1st year of the analysis, \$2,320,000 the 2nd yr.

Equipment costs reflect	washer/dryer	\$422
	range	\$722
	refrigerator	\$250

\$1,394 per unit

\$1394 X 500 units - \$697,000

Maintenance and repair of equipment was estimated at \$11,500 per year.

Construction cost used the DO inflation schedule, all others the OSD one.

ALTERNATIVE 5 TRAILERS/RELOCATABLE HOUSING UNITS

Design and construction, including furnishings (\$25,000 each) - \$12,500,000.

Transportation costs (shipping) - \$6,000 per unit or \$1,500,000 for 2 years.

Allowances - \$5,800,000 in the 1st year and \$2,900,000 in the second year.

Utilities - \$804,000 for the second year of the analysis, \$1,608,000 for the next 15 years.

Services - \$189,000 in the 2nd year of the analysis and \$378,000 thereafter.

M&R - \$270,000 for the second year of the analysis, \$540,000 for the next nine years and \$792,000 for the remaining six years.

Design and construction costs used the DO inflation schedule, all others the OSD schedule.

Figure E-12 Life Cycle Cost Report - Continued

SENSITIVITY ANALYSIS NUMBER 01
 TITLE Increase of M&R costs for alt
 5 vs next lowest cost alt #3
 ALLOWABLE CHANGE 50.00 PERCENT

THIS SENSITIVITY ANALYSIS CHECKS FOR ALTERNATIVE 3 TO BE RANKED
 FIRST AS A RESULT OF CHANGES IN THE EXPENSE ITEM(S) LISTED BELOW:

ALTERNATIVE	EXPENSE ITEM(S)
-----	-----
3	** NOTHING CHANGED **
5	5

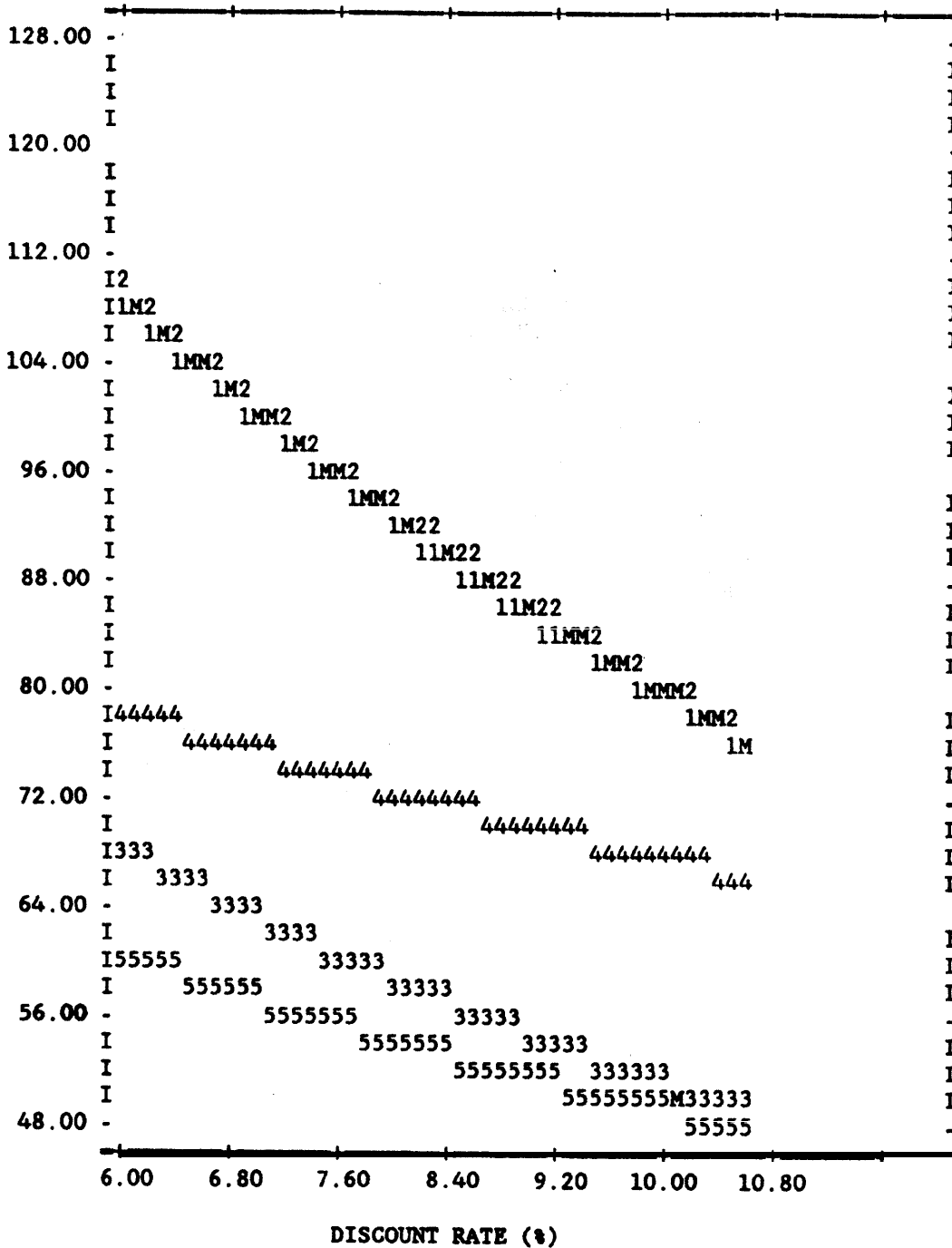
THE SELECTED EXPENSE ITEMS ARE ALLOWED TO VARY FROM A VALUE OF 100%
 LESS THAN THEIR INPUT VALUE TO 50.00% MORE THAN THEIR INPUT VALUE.

ALTERNATIVE	NET PRESENT VALUE
-----	-----
5	\$53,623
3	\$57,173

FOR ALTERNATIVE 3 TO BE LEAST COST, INCREASE COSTS BY 49.69% OR MORE.

Figure E-13. Ranking Sensitivity Analysis (\$ in thousands)

Graph of Net Present Value (\$ in millions) vs. Discount Rate



LEGEND	DESCRIPTION	LEGEND	DESCRIPTION
1	ROP LEASE	5	TRAILER
2	BUILD TO LEASE	M	MERGING DATA
3	RENT GUARANTEE		
4	MCA CONSTRUCTION		

Figure E-14. Discount Rate Sensitivity Analysis

Discount Rate: 8.60 Lower Limit: 6.00 Upper Limit: 10.60

Discount Rate (%)	Alternative Ranking	Discount Rate (%)	Alternative Ranking
6.00	5 3 4 1 2	8.40	5 3 4 1 2
6.10	5 3 4 1 2	8.50	5 3 4 1 2
6.20	5 3 4 1 2	8.60	5 3 4 1 2
6.30	5 3 4 1 2	8.70	5 3 4 1 2
6.40	5 3 4 1 2	8.80	5 3 4 1 2
6.50	5 3 4 1 2	8.90	5 3 4 1 2
6.60	5 3 4 1 2	9.00	5 3 4 1 2
6.70	5 3 4 1 2	9.10	5 3 4 1 2
6.80	5 3 4 1 2	9.20	5 3 4 1 2
6.90	5 3 4 1 2	9.30	5 3 4 1 2
7.00	5 3 4 1 2	9.40	5 3 4 1 2
7.10	5 3 4 1 2	9.50	5 3 4 1 2
7.20	5 3 4 1 2	9.60	5 3 4 1 2
7.30	5 3 4 1 2	9.70	5 3 4 1 2
7.40	5 3 4 1 2	9.80	5 3 4 1 2
7.50	5 3 4 1 2	9.90	5 3 4 1 2
7.60	5 3 4 1 2	10.00	5 3 4 1 2
7.70	5 3 4 1 2	10.10	5 3 4 1 2
7.80*	5 3 4 1 2	10.20	5 3 4 1 2
7.90	5 3 4 1 2	10.30	5 3 4 1 2
8.00	5 3 4 1 2	10.40	5 3 4 1 2
8.10	5 3 4 1 2	10.50	5 3 4 1 2
8.20	5 3 4 1 2	10.60	5 3 4 1 2
8.30	5 3 4 1 2		

* indicates a change in the alternative ranking occurred.

Figure E-15. Summary of Alternative Rankings by Discount Rate

Table of Net Present Value (\$ in thousands) for each Discount Rate

Discount Rate - 6.00%		Discount Rate - 6.10%		Discount Rate - 6.20%	
Alt - NPV		Alt - NPV		Alt - NPV	
5 -	\$61,447	5 -	\$61,102	5 -	\$60,762
3 -	\$69,266	3 -	\$68,730	3 -	\$68,205
4 -	\$79,482	4 -	\$79,151	4 -	\$78,828
1 -	\$109,097	1 -	\$108,212	1 -	\$107,338
2 -	\$110,150	2 -	\$109,258	2 -	\$108,373
-----		-----		-----	
Discount Rate - 6.30%		Discount Rate - 6.40%		Discount Rate - 6.50%	
Alt - NPV		Alt - NPV		Alt - NPV	
5 -	\$60,426	5 -	\$60,097	5 -	\$59,767
3 -	\$67,682	3 -	\$67,163	3 -	\$66,655
4 -	\$78,506	4 -	\$78,186	4 -	\$77,872
1 -	\$106,481	1 -	\$105,621	1 -	\$104,777
2 -	\$107,500	2 -	\$106,635	2 -	\$105,778
-----		-----		-----	
Discount Rate - 6.60%		Discount Rate - 6.70%		Discount Rate - 6.80%	
Alt - NPV		Alt - NPV		Alt - NPV	
5 -	\$59,442	5 -	\$59,121	5 -	\$58,800
3 -	\$66,150	3 -	\$65,650	3 -	\$65,156
4 -	\$77,557	4 -	\$77,251	4 -	\$76,950
1 -	\$103,948	1 -	\$103,121	1 -	\$102,300
2 -	\$104,932	2 -	\$104,099	2 -	\$103,271
-----		-----		-----	
Discount Rate - 6.90%		Discount Rate - 7.00%		Discount Rate - 7.10%	
Alt - NPV		Alt - NPV		Alt - NPV	
5 -	\$58,485	5 -	\$58,175	5 -	\$57,865
3 -	\$64,668	3 -	\$64,188	3 -	\$63,711
4 -	\$76,643	4 -	\$76,344	4 -	\$76,052
1 -	\$101,500	1 -	\$100,699	1 -	\$99,919
2 -	\$102,456	2 -	\$101,650	2 -	\$100,853

Figure E-16. Alternative Ranking of NPV for each Discount Rate

Table of Net Present Value (\$ in thousands) for each Discount Rate

Discount Rate - 7.20%		Discount Rate - 7.30%		Discount Rate - 7.40%	
Alt - NPV		Alt - NPV		Alt - NPV	
5 -	\$57,561	5 -	\$57,260	5 -	\$56,961
3 -	\$63,240	3 -	\$62,776	3 -	\$62,313
4 -	\$75,756	4 -	\$75,466	4 -	\$75,180
1 -	\$99,137	1 -	\$98,367	1 -	\$97,606
2 -	\$100,065	2 -	\$99,288	2 -	\$98,512
Discount Rate - 7.50%		Discount Rate - 7.60%		Discount Rate - 7.70%	
Alt - NPV		Alt - NPV		Alt - NPV	
5 -	\$56,663	5 -	\$56,379	5 -	\$56,088
3 -	\$61,857	3 -	\$61,409	3 -	\$60,965
4 -	\$74,895	4 -	\$74,613	4 -	\$74,337
1 -	\$96,853	1 -	\$96,111	1 -	\$95,374
2 -	\$97,749	2 -	\$96,997	2 -	\$96,252
Discount Rate - 7.80%		Discount Rate - 7.90%		Discount Rate - 8.00%	
Alt - NPV		Alt - NPV		Alt - NPV	
5 -	\$55,804	5 -	\$55,519	5 -	\$55,239
3 -	\$60,522	3 -	\$60,086	3 -	\$59,658
4 -	\$74,056	4 -	\$73,783	4 -	\$73,512
1 -	\$94,642	1 -	\$93,929	1 -	\$93,217
2 -	\$95,513	2 -	\$94,786	2 -	\$94,070
Discount Rate - 8.10%		Discount Rate - 8.20%		Discount Rate - 8.30%	
Alt - NPV		Alt - NPV		Alt - NPV	
5 -	\$54,966	5 -	\$54,690	5 -	\$54,419
3 -	\$59,230	3 -	\$58,811	3 -	\$58,397
4 -	\$73,245	4 -	\$72,979	4 -	\$72,715
1 -	\$92,510	1 -	\$91,813	1 -	\$91,128
2 -	\$93,355	2 -	\$92,647	2 -	\$91,955

Figure E-16. Alternative Ranking of NPV for each Discount Rate—Continued

Table of Net Present Value (\$ in thousands) for each Discount Rate

Discount Rate - 8.40%		Discount Rate - 8.50%		Discount Rate - 8.60%	
Alt - NPV		Alt - NPV		Alt - NPV	
5 -	\$54,148	5 -	\$53,884	5 -	\$53,623
3 -	\$57,981	3 -	\$57,579	3 -	\$57,173
4 -	\$72,454	4 -	\$72,196	4 -	\$71,944
1 -	\$90,445	1 -	\$89,774	1 -	\$89,109
2 -	\$91,260	2 -	\$90,582	2 -	\$89,909

Discount Rate - 8.70%		Discount Rate - 8.80%		Discount Rate - 8.90%	
Alt - NPV		Alt - NPV		Alt - NPV	
5 -	\$53,358	5 -	\$53,104	5 -	\$52,852
3 -	\$56,776	3 -	\$56,383	3 -	\$55,991
4 -	\$71,687	4 -	\$71,440	4 -	\$71,188
1 -	\$88,450	1 -	\$87,797	1 -	\$87,157
2 -	\$89,245	2 -	\$88,586	2 -	\$87,931

Discount Rate - 9.00%		Discount Rate - 9.10%		Discount Rate - 9.20%	
Alt - NPV		Alt - NPV		Alt - NPV	
5 -	\$52,600	5 -	\$52,349	5 -	\$52,104
3 -	\$55,609	3 -	\$55,227	3 -	\$54,846
4 -	\$70,942	4 -	\$70,699	4 -	\$70,462
1 -	\$86,520	1 -	\$85,895	1 -	\$85,266
2 -	\$87,286	2 -	\$86,650	2 -	\$86,018

Discount Rate - 9.30%		Discount Rate - 9.40%		Discount Rate - 9.50%	
Alt - NPV		Alt - NPV		Alt - NPV	
5 -	\$51,857	5 -	\$51,617	5 -	\$51,376
3 -	\$54,476	3 -	\$54,105	3 -	\$53,743
4 -	\$70,226	4 -	\$69,980	4 -	\$69,751
1 -	\$84,651	1 -	\$84,039	1 -	\$83,439
2 -	\$85,394	2 -	\$84,777	2 -	\$84,164

Figure E-16. Alternative Ranking of NPV for each Discount Rate—Continued

Table of Net Present Value (\$ in thousands) for each Discount Rate

Discount Rate - 9.60%		Discount Rate - 9.70%		Discount Rate - 9.80%	
Alt - NPV		Alt - NPV		Alt - NPV	
5 -	\$51,140	5 -	\$50,906	5 -	\$50,675
3 -	\$53,385	3 -	\$53,025	3 -	\$52,670
4 -	\$69,516	4 -	\$69,291	4 -	\$69,060
1 -	\$82,838	1 -	\$82,251	1 -	\$81,665
2 -	\$83,562	2 -	\$82,965	2 -	\$82,375
Discount Rate - 9.90%		Discount Rate - 10.00%		Discount Rate - 10.10%	
Alt - NPV		Alt - NPV		Alt - NPV	
5 -	\$50,443	5 -	\$50,216	5 -	\$49,988
3 -	\$52,320	3 -	\$51,976	3 -	\$51,634
4 -	\$68,835	4 -	\$68,612	4 -	\$68,388
1 -	\$81,087	1 -	\$80,517	1 -	\$79,952
2 -	\$81,792	2 -	\$81,212	2 -	\$80,642
Discount Rate - 10.20%		Discount Rate - 10.30%		Discount Rate - 10.40%	
Alt - NPV		Alt - NPV		Alt - NPV	
5 -	\$49,768	5 -	\$49,545	5 -	\$49,327
3 -	\$51,298	3 -	\$50,960	3 -	\$50,627
4 -	\$68,174	4 -	\$67,953	4 -	\$67,739
1 -	\$79,392	1 -	\$78,843	1 -	\$78,295
2 -	\$80,075	2 -	\$79,510	2 -	\$78,953
Discount Rate - 10.50%		Discount Rate - 10.60%			
Alt - NPV		Alt - NPV			
5 -	\$49,107	5 -	\$48,897		
3 -	\$50,300	3 -	\$49,978		
4 -	\$67,525	4 -	\$67,315		
1 -	\$77,748	1 -	\$77,210		
2 -	\$78,409	2 -	\$77,865		

Figure E-16. Alternative Ranking of NPV for each Discount Rate—Continued

Glossary

Section 1 Abbreviations

ABCR

annual benefit/cost ratio

ABOM

annual benefit/output measure

ADP

automated data processing

AR

Army Regulation

ASA(ILE)

The Assistant Secretary of the Army (Installations, Logistics and Environment)

BAQ

basic allowance for quarters

BCR

benefit/cost ratio

BOD

beneficial occupancy date

BOQ

bachelor officers quarters

CFF

Commercially Financed Facilities

CONUS

continental United States

DA

Department of the Army

DEH

Directorate of Engineering and Housing

DIO

Directorate of Industrial Operations

DOD

Department of Defense

DPP

discounted payback period

EA

economic analysis

ECONPACK

Economic Analysis Computer Package

EPIR

efficiency/productivity increase ratio

EUAC

equivalent uniform annual cost

HHG

household goods

HQDA

Headquarters. Department of Army

MCA

Military Construction, Army (Also called MILCON—Military Construction)

MILCON

Military Construction

MPA

Military Personnel, Army

NPV

net present value

O&M

operation and maintenance

OCONUS

outside Continental United States

OMB

Office of Management and Budget

OPM

Office of Personnel Management

OSD

Office of the Secretary of Defense

PAX

Programming, Administration, and Execution System

RIF

reduction in force

RFP

request for proposal

SIR

savings/investment ratio

SOFA

Status of Forces Agreement

TDY

temporary duty

VHA

variable housing allowance

USACE

U.S. Army Corps of Engineers

Section II Terms

Acquisition Cost

The amount paid to obtain an asset.

Alternative

A course of action, means, or methods by which an objective may be achieved.

Alternative Ranking

The end result of an economic analysis; the rating of options from lowest to highest in terms of dollar value or another indicator.

Analysis

A systematic approach to problem-solving. Complex problems are made simpler by separating them into more understandable elements. Involves identification of purposes and facts, statement of assumptions, and derivation of conclusions. Analyses normally use quantitative methods and are done to support decisionmaking processes.

Appropriation

The most common form of budget authority. Allows Federal agencies to incur obligations and make expenditures for specified purposes and in specified amounts as authorized by the U.S. Congress.

Assets

Real and personal property and other items of monetary value.

Assumption

An explicit statement describing present or future circumstances that may affect the outcome of an analysis.

Base year

The reference year for all present value calculations (costs are converted to present value amounts as of the beginning of the base year).

Benefit

Outputs or effectiveness expected to be received or achieved over time as a result of implementing an alternative. These can be quantifiable in terms of dollar value or some other measure of productivity, or nonquantifiable as in the case of intangible effects such as increased morale.

Benefit/cost ratio

An economic indicator of efficiency defined as the ratio of the value of benefits to costs. When benefits are expressed in dollar terms, both the benefit and cost streams are discounted to reflect the present value of future costs and benefit.

Budget year

Precedes the program year in which funds are made available for construction and follows the design year. The year in which the Army defends the MILCON Program before OSD, OMB, and Congress, and the year final design is to be substantially completed.

Build-to-lease

A program for providing Government facilities through private sector development. The Government contracts with a private developer to have facilities built, with a guarantee that the Government will lease the facilities for a period of time.

capital

Assets of a permanent character having continuing value. Examples are land, buildings, and other facilities, including equipment.

Commercially Financed Facilities (CFF)

Facilities financed by the private sector as an alternative funding method for DOD to procure certain types of service facilities. Different types of construction programs (MILCON, AFH, Energy) derive Authority to pursue CFF from separate laws.

Compound interest

Interest which is computed on both the original principal and its accrued interest.

Constant year dollars

Estimate in which costs reflect the level of prices of a base year. Cost estimates expressed in constant dollars imply the purchasing power of the dollar remains unchanged over the analysis period.

Cost

A resource input to a project, program, or activity expressed in dollar terms.

Cost Analysis

Determines the magnitude, timing and uncertainties of prices for alternatives. A critical part of economic analysis, it translates resource requirements into estimated dollar costs.

Cost/benefit analysis

Technique for assessing the range of costs and benefits associated with a given alternative, usually to determine feasibility. Costs are normally in monetary terms, but benefits need not be.

Cost element

Basic unit of cost, such as labor or material. Related basic units are accumulated to form the total cost of each cost kind. (See cost kind.)

Cost-estimating relationship

A numerical function expressing the relationship between a characteristic, resource, or activity and a particular cost associated with it. The function may be a simple percentage or a complex equation. For example, the annual cost of maintenance for a dwelling unit may be related to the age of the unit.

Cost kind

A group of similar cost elements.

Cumulative net present value

The total of the discounted annual cost for the year in question and all preceding years of the project.

Current dollars

Convention used to show purchasing power in the year spent. Prior costs stated in current dollars are the actual amounts paid out. Future costs stated in current dollars are the actual amounts expected to be paid, including amounts caused by future price changes (inflation).

Data

Numerical information of any kind.

Depreciation

A reduction in the value of an asset estimated to have accrued during an accounting period due to age, wear, usage, obsolescence, or the effects of natural elements such as decay and corrosion.

Design year

The year immediately before the budget year and immediately after the guidance year. It is the year design begins in a construction program.

Differential inflation

The difference in inflation between the rate for the overall economy and the rate for a particular cost which is either greater or less than the general inflation rate.

Disbenefit

An undesirable result; an offset to benefits.

Discount factor

Multiplier calculated using the present value formula and a discount rate. Used to convert a future cost into its present value.

Discount rate

Interest rate used to relate present and future dollars. Expressed as a percentage and used to reduce the value of future dollars in relation to present dollars to account for the time value of money.

Discounting

Technique for converting various cash flows occurring over a period of time to equivalent amounts at a common point in time, considering the time value of money, to allow valid comparisons.

Discounting convention

method of discounting costs, either at beginning-of-year, mid-year, or end-of-year.

Discounted payback period (DPP)

Time required for the accumulated present value of savings of a proposed alternative to equal the total present value of its investment costs.

Economic analysis (EA)

A systematic method for quantifying the costs and benefits of alternative solutions for achieving an objective in order to find the most efficient (economical) solution. Structured method to identify, analyze, and compare costs and benefits of the alternatives.

Economic life

Period of time over which the benefits from an alternative are expected to accrue. The economic life of an alternative starts in the year it begins producing benefits. The economic life is not necessarily the same as physical life or technological life.

Engineering estimate

Predictions of costs based on detailed measurements or experiments and specialized knowledge and judgement. Also called, "engineering method of cost estimating."

Equivalent uniform annual cost (EUAC)

The amount of money which, if paid in equal annual installments over the life of a project, would pay for the project. That is, the discounted value of this hypothetical uniform cost stream is equal to the actual estimated present value of project costs. The alternative with the lowest uniform annual equivalent amount is the least costly alternative.

Externalities

Benefits and costs that affect parties other than ones directly involved. Also called "spillovers" An external economy is a benefit received by one from an economic activity of another for which the beneficiary cannot be charged. An external diseconomy is a cost borne or damage suffered consequent to the economic activities of others for which the injured is not compensated. For example, a city downstream benefits from, but does not pay for, a water pollution control program instituted by a military base upstream.

Guidance year

The year preceding the design year. It begins with the Army guidance documents providing general instruction and the present policies of HQDA. Included are military construction programs and program dollar guidance for each Major Command's MILCON program.

Historical cost

Price based on actual monetary (or equivalent) outlay, determined after the fact. Any method of cost determination can be used, but the sources of costs must be documented in the source derivation part of the EA report.

Imputed cost

Costs that do not involve an actual expenditure of funds. They are not actually incurred but must be included in certain types of EAs.

Index

Statistical device for measuring changes in groups of data, serves as a yardstick of comparative measure, expressed as an index number.

Inflation

A persistent rise in the general level of prices over time which results in a decline in the purchasing power of money. Measured by changes in price indices relative to some base year.

Inherited asset

An existing asset that will be used in an alternative. If the asset could be used for some other purpose or sold, its value is included as a cost in the alternative. If it has no use or

value except in the alternative, no cost is included.

Interest

A price (or rent) charged for the use of money.

Investment costs

Costs associated with acquisition of real property, nonrecurring services, nonrecurring operation, and maintenance (start-up) costs. These are usually one-time costs, although they may be spread over more than 1 year (such as construction costs).

Lead time

The period between initial funding or decision and commencement of the economic life.

Least-cost alternative

The option producing, at less cost, the same or greater quantity of a given output than another alternative.

Life-cycle cost

The total price of an item over its life cycle. Includes initial investment, maintenance and repair, operations, utilities and, where applicable, disposal.

Maintenance and repair cost

Costs incurred to keep buildings and equipment in normal operating condition.

Net present value (NPV)

The cumulative discounted amount that also includes the discounted value of the residual amount.

Nonrecurring cost

Cost that occurs on a one-time basis as compared with annually recurring costs.

Objective

The result to be achieved by the project being studied. It must be stated in unbiased terms.

Operations costs

Utilities, custodial, and other routine costs incurred in operating a facility, not including maintenance and repair.

Optimization

A determination of the best mix of inputs to achieve an objective.

Opportunity cost

Amount of money associated with expending capital resources instead of investing them. If funds are expended, the potential that might be gained from investing them is lost. In the private sector, opportunity costs are equivalent to interest rates adjusted for inflation.

output

Products, functions, tasks, services, or capabilities that an organization exists to produce, accomplish, attain, or maintain.

Period of analysis

Time span over which an EA takes place; that is, the time over which alternatives are compared.

Physical life

Estimated number of years that a piece of equipment or building can physically be used in accomplishing the function for which it was procured or constructed.

Present value (PV)

Monetary expenditure (or savings) multiplied by the discount factor. The resulting figure represents the worth of the future amount in base year dollars.

Present worth

See present value.

Price

Dollar amount for which a good or service is bought or sold.

Primary analysis

An economic analysis performed when the objective is to change the status quo (present method of operation) in order to achieve a financial savings to the Government.

Program year

The year funds are made available for construction. The first year of the execution phase for each military construction program. It follows the budget year and is the current fiscal year.

Project

A major mission-oriented endeavor that fulfills statutory or executive requirements, and that is defined in terms of the principal action required to achieve a significant objective.

Quantification

Measurement in terms of price of the inputs, outputs, or benefits of a program.

Range

The difference between the smallest and largest quantities in a statistical series arrayed according to size.

Real interest rate

Interest rate with inflation removed, which is used to determine the real rate of return on investment. For an EA, real interest rate is calculated by subtracting current rates of inflation from current interest rates for long term U.S. Treasury securities.

Real property

Land, utility plants, distribution systems, buildings, structures and their improvements.

Recurring costs

Expenses for personnel, material consumed, operating overhead, support services, maintenance and other items that are charged annually or repetitively in the execution of a given program or work effort.

Refurbishment costs

The cost of renovation, rehabilitation, or similar items. Applies only to the status quo method.

Regression analysis

Evaluation for determining the relationship between two or more variables. Determines the change in a dependent variable caused by changes in one or more independent variables. The relationship may be linear (straight line) or curvilinear.

Rent

Cost incurred for the use of another entity's tangible assets (land, buildings, equipment, etc.).

Replaced asset

An asset substituted with an alternative. It is made available for other use by the Army or is advertised for sale. Its value is subtracted from the NPV of the alternative.

Residual value

The remaining monetary value, if any, of an alternative at a specified point in time.

Resources

Facilities, personnel, equipment, supplies and other items required for an alternative. Once resources are determined, their value in dollars can then be estimated.

Salvage value

The remaining monetary worth, if any, of an alternative at the end of the project life. The value may be negative (it may cost money to remove the item.)

Savings

Reduction in costs achieved without reduction in performance. Always computed with respect to the existing course of action or status quo in an economic analysis.

Savings-to-investment ratio (SIR)

Ratio of discounted future cost savings (or avoidance) to the discounted investment cost necessary to effect those savings. An SIR of 1 indicates that the present value of savings is equal to the present value of investment.

Secondary analysis

An economic analysis performed when there is a new requirement to be met or the existing facility is not adequate.

Sensitivity Analysis

An examination of how the EA results may change with respect to changes in the costs or

timing of costs in an alternative(s). As a minimum, the effect of changes in high-cost elements and questionable assumptions will be studied.

Start year

The first year in which costs are incurred-often the first year of the analysis period.

Sunk cost

Unrecoverable past costs incurred before the analysis. Has no significance to the analysis and is not included.

Technological life

The number of years a facility or piece of equipment will be used before it becomes obsolete due to changes in technology.

Terminal value

Same as salvage value or residual value at the end of the project.

Time value of money

The concept that use of money costs money; a dollar today is worth more than a dollar tomorrow because of the interest costs.

Total annual outlays

The sum of all costs for a given year

Uncertainty

The state of knowledge about outcomes in a decision which is such that it is not possible to assign probabilities in advance. Doubt or ignorance about the magnitude of cost/benefits or their timing. A technique for assessing the effect of uncertainty on EA results is the sensitivity analysis.

Uniform annual cost

See equivalent uniform annual cost.

Value

The desirability, utility, or importance of an item. The worth of an item in money. Often represented by price. In economic analysis the value of costs and benefits is given in dollars. The value of a good or service is what a consumer is willing to give up to have it.

Wash cost

A cost that is identical for all alternatives. Omitted from an EA because it cannot alter the decision. It would increase the net present value of all alternatives by the same amount during the same time periods.

**Section III
Special Abbreviations and Terms**

There are no entries in this section.

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