Naval Facilities Engineering Command
200 Stovall Street
Alexandria, Virginia 22332-2300

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Economic Analysis Handbook

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Foreword

The requirement to make economical resource decisions within the Department of Defense has never been greater. Typical questions facing us are: *What are the alternative solutions to meet the requirement? Which alternative is the most economical? What is the payback period?*

This handbook is designed to assist with your facilities investment decision-making through application of economic analysis and to provide consistent guidance for documentation of your decision for Department of the Navy and Congressional approvals. It provides economic analysis policy and procedures and should be used by all Navy commands and field offices who prepare economic analyses.

This 5th edition, like previous editions, is built around the concepts of engineering economics. The "life cycle cost" approach to cost/benefit analysis, using a six-step process, is emphasized. This edition contains the following important changes:

1. **Discount Factors**: Revised tables to reflect the lower range of discount rates anticipated over the next several years (vice the 10% end-of-year factors of the 4th edition);
2. **Feasible Alternatives**: Added guidance about the "status quo," renovation, and lease alternatives to new construction alternatives;
3. **Documentation**: Added guidance about computer software enhancements (PC ECONPACK) vice Formats A, A-1, and B;
4. **Revised Examples**: Using lower discount factors;
5. **Focus Areas**: Revised appendices, including updated guidance for projects involving Energy, Family Housing, and Automated Data Processing (ADP) procurement;
6. **Reorganized chapters** to flow in a pattern similar to the sequence taught in Naval School, Civil Engineer Corps Officers (CECOS) sponsored courses.

We invite your comments on this handbook. Please complete a copy of the "Customer Feedback" form and send it to: Commander, Naval Facilities Engineering Command (Attn: Code 90ZTW), Operations Research Division, 200 Stovall Street, Alexandria, VA. 22332-2300.

This publication is certified as an official Navy publication and has been reviewed and approved per SECNAVINST 5600.16.

JACK E. BUFFINGTON
Rear Admiral, CEC U.S. Navy

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Naval Facilities Engineering Command Headquarters, Alexandria, VA

Project Team

Operations Research Division, Directorate of Corporate Management
Mr. Timothy Wireman, Project Manager
Ms. Michelle A. Minus, Operations Research Analyst
Ms. Marie A. Mitchum, Management Assistant
Mr. Terry L. Ulsh, R.A.; Associate Director
Mr. Bernard F. White, Jr.; Associate Director
Mr. Tony D. Hinson, P.E.; Director

Contributing Consultants

Mr. James J. Carberry, Information Systems
Mr. Stephen Keating, Housing
Ms. Ollie V. King, Utilities
Mr. John W. Thurber, Programming and Construction
Mr. Joseph J. Lane, Operations Research Analyst
Mr. Steven A. Coppedge, Computer Applications
Mr. William E. Brack, Graphic Arts

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ATTN: Code 90ZTW (P-442 Handbook)
200 Stovall Street
Alexandria, VA 22332-2300

Points of contact are Tim Wireman, Terry Ulsh, or Bernie White at DSN 221-7354/7355/7356, Commercial (703) 325-7354. Call or send additional copies of this form if you have other questions or comments.

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INTRODUCTION

Chapter 1

1.1 WHY THIS HANDBOOK IS FOR YOU

Analysts, Reviewers, Decision-Makers: This book is for those who prepare, review, and approve economic analyses. It is also for those who defend them (along with other project submittals) to higher authorities.

a. Analyst: Who prepares economic analyses? Until recently, a common assumption was that this is tasked to personnel labeled the "experts." In reality, economic analysis preparation is assigned as a "collateral" duty to individuals who have minimal economic analysis (EA) training or none at all. Even with training, economic analysis preparation might be done so infrequently that it is difficult to retain the knowledge. This handbook provides you with basic tools and "number-crunching" techniques to prepare economic analyses.

b. Reviewer: Whether you are a supervisor or project manager, the methodologies described in this handbook are applicable to comprehensive and continuous management review of the costs and benefits of both proposed and ongoing projects.

c. Decision-Maker: Economic analysis is not in itself a decision-making process; it is only a tool in the decision-making process. As a decision-maker, you must still interpret the results of the economic analysis along with other intangible factors such as safety, health, morale, environmental impacts and other constraints involved in the total process. This handbook provides an explanation of Department of Defense (DoD) policy and procedures on economic analysis. It also explains concepts used in comparing life-cycle costs and benefits of the various alternatives under consideration.

Experienced, as Well as Inexperienced, Practitioners: Regardless of experience level, we all have different perspectives, depending on our role in the naval shore facilities acquisition process. This handbook, with its straightforward approach, will be a useful reference source to the novice as well as the experienced practitioner.

1.2 HANDBOOK'S PURPOSE

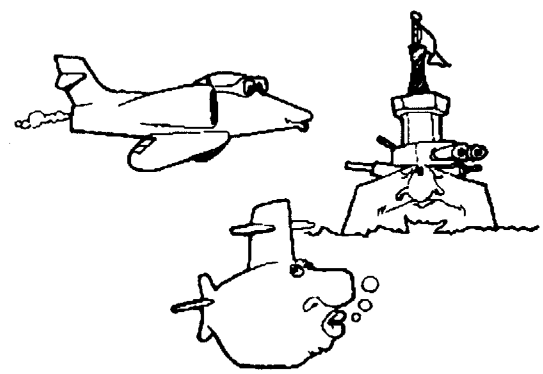
The purpose of this handbook is to provide official Navy and Naval Facilities Engineering Command guidance on the preparation of:

a. Economic analyses for proposed programs, projects and activities, and;
b. Program evaluations of ongoing activities.

It is important to point out that economic analyses and program evaluations serve very different purposes. **Economic analyses** are "pre-expenditure" analyses designed to assist a decision-maker in identifying the best new projects or programs to adopt. **Program evaluations** are "post expenditure" analyses designed to evaluate ongoing approved projects/programs to ensure that objectives will be attained in a cost effective manner. The analyses are based on actual performance.

1.3 HOW THE HANDBOOK IS ARRANGED

Emphasis on Facilities Applications: Although the methods of analysis are applicable to a wide variety of engineering and economic decisions, the primary focus is on economic analyses of Navy facilities which support our fleet.



A Practical Guide, not Theoretical: This handbook provides guidance for personnel who have little or no experience with economic analysis, as well as the more experienced practitioner. It is a practical, "how to do it" guide rather than a theoretical one. Step-by-step guidance is provided, along with a broad range of information organized:

- From policy to process to techniques and tools,
- From general to specific, with plenty of examples, and
- With definition of terms explained in the text, and a more comprehensive glossary in Appendix G.

1.4 WHAT IS ECONOMIC ANALYSIS?

Economic analysis (often referred to as **cost/benefit analysis**) is:

"a systematic approach to the problem of choosing how to employ scarce resources to achieve a given objective(s) in an effective and efficient manner."

A systematic approach...

Economic analysis is an analytical tool by which the factors affecting a decision may be qualified and quantified to assist in the decision-making process. It is not the end to the decision-making process; it is only an input to sound management or operational judgment. By systematically quantifying factors involved in the analysis, economic analysis:

a. Allows the decision-maker to focus his judgment more sharply on the economic aspects of a decision.

b. Serves as documentation and visible evidence to authorities that economic factors bearing on the decision have been adequately considered.

... to achieve a given objective(s) ...

There are alternative ways of reaching an objective(s) and each alternative requires resources to produce certain results. An economic analysis systematically investigates and relates all life cycle cost and benefit implications in achieving an objective(s). In general, it assists in determining the most benefits or outputs for the least resources or inputs to be expended.

...in an effective and efficient manner

This comprehensive presentation of alternatives is not merely a method for determining the least cost solution regardless of effectiveness, but rather, it serves as a guide to identify the most cost effective alternative. Economic analysis decisions involve major capital investments with long term future implications over their expected useful lives. Each decision will deal with a choice among alternatives and all alternatives involve a number of economic considerations.

1.5 WHY ECONOMIC ANALYSIS IS NEEDED

To Maximize the Use of Available Resources: In the present atmosphere of reduced government budgets, decisions still involve complex issues frequently requiring high investment and recurring operations costs with varying uncertainties. Good, quantifiable data and analyses are needed to assure decisions maximize the use of available resources.

To Ensure Qualitative Values are Considered: Analysis of alternatives reveal the innermost complexities of a decision. Each alternative has a unique combination of life cycle costs, benefits, and uncertainties with its political, social and economic implications. This burdens the analyst to consider the total life cycle consequences of a decision. To prepare an accurate appraisal of a project's worthiness, value is required for each cost and benefit over time. In an economic analysis, a quantitative framework is defined to ensure qualitative values are appropriately considered. The impacts of alternative actions can be clarified by:

a. Exploring all reasonable means to satisfy an objective,
b. Documenting all costs and benefits, and
c. Testing the uncertainties.

To Implement DoD and NAVFAC Policy: The concepts of economic analysis and program evaluation constitute an integral part of the Planning, Programming, and Budgeting System of the Department of Defense (DoD), including Navy facilities decisions. Economic implications must be considered at all levels of authority, i.e., Headquarters, Commands and Installations. Economic analysis provides an evaluation and documentation process.

1.6 POLICY AND GUIDANCE

Guidance from "Higher Authorities": Appendix A lists the latest economic analysis policy instructions. This handbook:

a. Is consistent with the current version of the DoD Instruction (DODINST) 7041.3 series, "Economic Analysis for Decision Making," and the corresponding implementing Navy instructions, SECNAVINST 7000.14 series.

b. Adheres to the directions of (OMB Circular) A-94, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Program."

Submission Requirements: The requirements and responsibilities for submission of economic analyses are prescribed in Appendix A guidance per direction of Congress, the Office of Management and Budget (OMB), the Government Accounting Office (GAO), or the Department of Treasury. In general, project officers and managers should be prepared to:

- Demonstrate the costs and benefits of recommended projects and programs, and
- Submit detailed support analysis documentation, when required.

1.7 BASIC PRINCIPLES

Decisions involving economic choice are everywhere. The essence of economic analysis is a straightforward approach to the very real problem of efficiently allocating scarce resources. Economic analysis is consistent with three, sound principles:

a. *All reasonable alternative methods of satisfying a given program objective must be investigated.*

b. *Each alternative must be considered in terms of its life cycle costs (funding implications) and benefits.*

c. *Money has value over time as expressed by the price it commands.* This is included in the analysis by expressing life cycle costs and benefits in terms of their "present value." (See Chapter 3 for an explanation of present value.)

These concepts seem intuitively acknowledged by all of us in our day to day decisions. Whether consciously or unconsciously, we consider them when we decide to buy or lease a car, rent an apartment versus buy a house, or evaluate other investment options. The Department of Defense economic analysis policy is merely a formalization of these three concepts; and if you keep this in mind, you can better understand the spirit and form of DoD economic analysis policy.

1.8 SUMMARY

Economic analysis is an effective tool in the decision-making process. It assists the analyst, reviewers, and decision-makers to:

a. Focus thinking (both formal and informal),

b. Surface assumptions (both hidden and presumed), and classify their logical implications and sensitivities, and

c. Provide an effective communications vehicle for considerations in support of the decision.

To apply economic analysis techniques, it is important to be aware of the following considerations:

a. Understand economic realities that influence and restrict economic decisions,

b. Understand how the economic analysis process and techniques are utilized in actual applications,

c. Link computational methods and supporting economic principles to the assumptions upon which they are based, and

d. Evaluate current concerns and non-economic factors when faced with uncertainties of the future.

This handbook will discuss these considerations and more. The economic analysis process described in Chapter 2, is a successful step-by-step approach for developing a complete economic analysis.

THE ECONOMIC ANALYSIS PROCESS

Chapter 2

2.1. THE SIX STEP APPROACH

The Economic Analysis process is an iterative procedure for evaluating and ranking alternatives that meet an objective. Proper performance of this process requires each of the following six key steps be done to completion:

a. Define the Objective.
b. Generate Alternatives.
c. Formulate Assumptions.
d. Determine Costs and Benefits.
e. Compare Costs and Benefits and Rank Alternatives.
f. Perform Sensitivity Analysis.

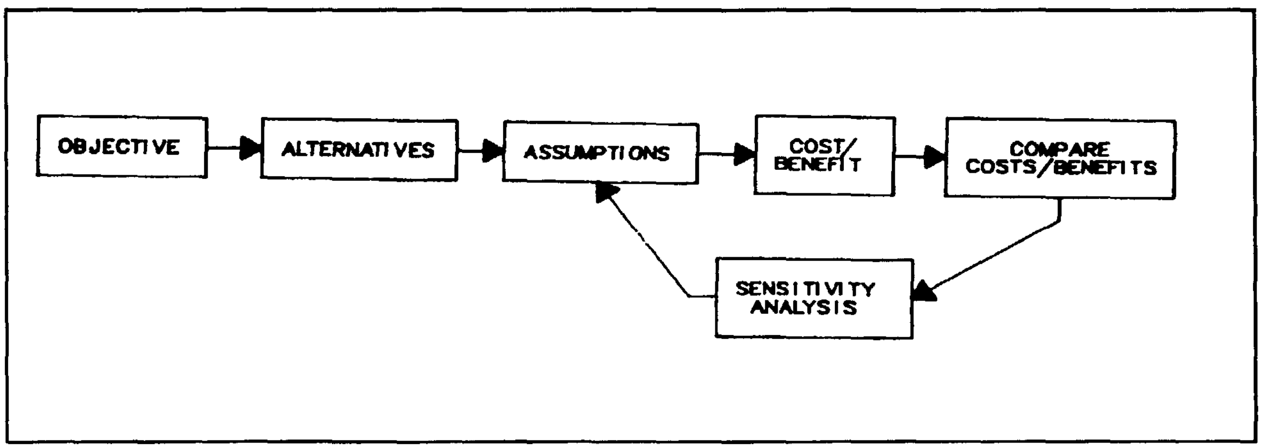


Figure 2A
The Economic Analysis Process

Figure 2A depicts these steps as a sequential process with feedback provided by the sensitivity analysis step to reiterate the process.

These six steps outlined comprise the essential elements of any economic analysis. This orderly, comprehensive process for evaluating alternatives allows the decision-maker to select the most cost effective alternative. The following sections describe the analytical considerations involved in each of these steps.

2.1.1 DEFINE THE OBJECTIVE (STEP 1)

Defining the objective is the single most important step in the analysis. Without a succinct statement of what is to be investigated, you cannot possibly proceed in a meaningful way. This seemingly trivial step sets the tone and the level of objectivity for the whole analysis. As Aristotle wrote, *"Well begun is half done."*

For example, consider the case of major Military Construction (MILCON) project procurement. What is the purpose of the facility/system being considered? Is it to be permanent or temporary? What level of support should it provide? To what future growth/contingencies should it be capable of responding? It should be clear that until you address the answers to these and other basic questions, the economic analysis cannot proceed (or even be conceived).

Fortunately, the problem of defining the objective usually lends itself to a straight forward solution in the area of facilities procurement. Typical facilities planning objectives might be to:

a. Provide 1,000 square meters of administrative space,
b. Meet Environmental Protection Agency (EPA) pollution abatement requirements at a Naval activity, and
c. Provide housing for unaccompanied visiting officers.

Therefore, a well defined objective statement should incorporate, either explicitly or implicitly, an easily measurable standard of accomplishment. **Note** that objective (a) above explicitly states a measurable standard (1,000 square meters); objectives (b) and (c) incorporate implicit standards.

The actual wording of the objective is very critical. It should reflect a totally unbiased point of view concerning methods of meeting the objective. Here is a quick example:

- Provide housing for unaccompanied visiting officers.
- Construct Unaccompanied Officer Personnel Housing (UOPH) for 200 persons.

The preferred statement is the first because it is not in the form of a solution (construct). Sometimes, the establishment of the objective is beyond your individual responsibility for the EA. If so, you still need to recognize the significance of this step in the economic analysis process. Unbiased statements of objective should always be used. This is a key point to remember throughout your analysis.

2.1.2 GENERATE ALTERNATIVES (STEP 2)

After formulating an unbiased statement of objective, the next step is to determine all feasible alternative methods of meeting that objective. Since the ultimate purpose of the economic analysis process is to help in making resource allocation decisions, it is essential to consider all realistic alternatives. Good decisions are extremely difficult to make unless they are made with a full understanding of all the relevant options.

Occasionally, there will exist presumptive notions concerning the desirability of one or more options. There are also some administrative constraints (such as a limit on personnel, facilities, or funding) that tend to exclude certain alternatives. Such conditions should in no way hinder the necessity for you to do a complete job. Take care to avoid arbitrary constraints that would unduly limit the number of alternatives available. All reasonable alternatives must be considered; otherwise, the value of the analysis is seriously undermined.

When you generate alternatives for your analysis, economic analysis becomes more of an art form than a science. Challenge current paradigms. Don't assume old benchmarks fit your particular scenario. How often did you consider other Department of Defense (DoD) services beyond those of the Navy in meeting your objective? Permanently changed funding for the DoD requires new ways of looking at old problems. Furthermore, the consideration of all feasible alternatives may provide useful information about "impossible" alternatives. Sometimes, the obvious choice is not so obvious once you have looked at the alternatives more closely.

For example, consider the case where only the first two of the three feasible alternatives were evaluated.

Alt (A) : MILCON Option #1
Alt (B) : Private Lease
Alt (C) : MILCON Option #2

Alternative (A), MILCON Option #l was recommended as the lowest net present value cost alternative. However, Alternative (C), MILCON Option #2 was not evaluated because its initial construction cost seemed too high. Further investigation showed that due to unique design features, Alt (C)'s operations and maintenance costs were small. So much so that Alt (C) was really the **lowest life cycle cost** (present value) option. Should this alternative have been brought to the management's attention?

The answer, of course, is YES! All feasible alternatives should be considered. Your role is to develop the facts relating to every feasible alternative. By not considering all the feasible alternatives, you are preempting part of the final decision function. You may still want Alt (1), MILCON Option #1; but this should be done with the knowledge that it is not the most cost effective solution. The final decision- maker should know and be willing to pay a life cycle cost premium to choose an alternative that requires a smaller MILCON funding appropriation.

Alternatives which at first appear to be infeasible may, in fact, be feasible. Provisions for military family housing overseas is a good example. Formerly, the law limited foreign leases to five years. The economic analysis showed that a ten year leasing period increased the present value of life cycle costs by only about 10%.

Furthermore, renewing a five year lease to cover ten years results in a 70% greater life cycle cost than if the lease was originally written for ten years! Because of this economic analysis, a successful petition of the U.S. Congress changed the law to allow ten year leasing in overseas areas. Today, additional extended term leases may be available.

Remember, the list of alternatives compiled at the beginning of the study should not be regarded as the final list. As you proceed into the analysis, new and better alternatives may surface while those not feasible within the constraints may be eliminated.

2.1.3 FORMULATE ASSUMPTIONS (STEP 3)

Economic analysis deals with future oriented benefit and cost decisions that address elements of uncertainty. To the extent possible, your EAs should be based upon objective **"facts."** A complete factual picture of an alternative under consideration may be impossible to construct and certain assumptions may be necessary to proceed with the analysis.

The economic analysis bases itself upon **assumptions** that are explicit statements used to describe the present and future environment. It is important not to confuse assumptions with facts or attempt to simplify the analysis through utilization of assumptions when, with summary research, factual data could be presented. The purpose of assumptions is not to limit the analysis, but to reduce complex situations to problems that are manageable. Undocumented assumptions detract from the credibility of an analysis. Despite the degree of impact on the analysis, assumptions should be clearly identified and should be accompanied by a statement of their rationale.

Some rules that may help in making assumptions are:

a. Don't confuse assumptions with facts. Make assumptions only when they are absolutely necessary to bridge gaps in the essential information that cannot be obtained - after diligently attempting summary research.

b. Be certain the assumptions are realistic.

c. State assumptions positively, using the word "will." For example:

- "The facility **will** have an economic life of twenty-five years and a physical life of fifty years."
- "MILCON funds **will** be available in FY 9X."

d. Ask yourself if the conclusions would be valid if an assumption did not hold. If the answer is yes, then eliminate the assumption, because it is not a requirement that must be met.

Examples of assumptions include:

- the discount rate,
- the functional life of an asset,
- the level or extent of future requirements for a particular function, and
- after the present objective is fulfilled, the usefulness of a facility.

It is possible to base these assumptions (or "estimates") on historical or technical information. If possible, an estimate of their validity should be included.

Frequently, you must formulate assumptions before reasonable alternatives can be generated. This may be a reiterative process while preparing the analysis. The sensitivity of the assumptions should be tested during the sensitivity analysis (step 6).

Besides assumptions, another restriction is the constraint. **Constraints** are factors external to the relevant environment which limit alternatives to problem solutions. They may be:

- **physical**, as with a fixed amount of space,
- **time-related**, as with a fixed deadline,
- **financial**, as with a fixed or limited amount of resources, or
- **institutional**, as with organizational or defense policy/regulations.

Whatever their particular characteristics, these external constraints or barriers are beyond your control and *provide boundary limitations for alternative solutions to a particular problem.*

Exercise caution in deciding assumptions and constraints. An alternative is feasible only when it satisfies all the restrictions. Use of unduly restrictive assumptions and constraints will bias an analysis, precluding investigation of feasible alternatives. Conversely, failure to consider pertinent assumptions and constraints can cause the recommendation of a technically or institutionally infeasible alternative.

2.1.4 DETERMINE COSTS AND BENEFITS (STEP 4)

This is another time consuming step. The exact information needed will depend to some extent on the size and nature of your problem. You must decide what is the needed data, how relevant data is to be collected and documented, and when the data in-hand is sufficiently reliable to be used in the EA.

Emphasis should be placed on the costs and benefits of the alternatives. The principal benefit from a military project is the completion of a stated objective. Since this is a benefit common to all the alternatives, its inclusion in the calculations will not affect the ranking of the alternatives. Consequently, quantification of the principal benefit is unnecessary. It is only the **differences** in costs between alternatives that are important to making sound economic based decisions. Costs which would not be affected under any of the alternatives may be omitted from the analysis. It is still a good idea to note these exclusions under the list of assumptions.

You must investigate each alternative to find all the costs and benefits occurring during the entire project life cycle. This is **life cycle costing**. Timing is important in investment decision making. Estimates need to be for the year in which a cost is to be incurred or a benefit is to be received.

Costs, although often difficult to estimate in the future, are at least easier to measure in terms of dollars spent. Chapter 4 includes a detailed discussion of relevant costs and estimating methods.

Benefits, on the other hand, are often difficult to measure. Despite this inherent difficulty, it is incumbent upon you to assess quantitatively the benefits associated with each alternative under consideration to the maximum extent possible. You should treat the dollar quantifiable benefits (other than meeting the stated objective) of **each** alternative as "cost offsets" for that alternative.

Nontangible benefits are more difficult to evaluate and quantify. "Increased morale" or "increased safety" should be identified as nontangible benefits and included in the analysis with a narrative description. Chapter 5 has a detailed discussion of the suggested techniques for benefit analysis.

It is important that you make every effort to have obtained the best available cost and benefit estimates. Because the validity of the analysis is dependent upon the credibility of the estimates, it is essential to document sources and derivations of cost and benefit data. A thorough "audit trail" planned and carried out now will save immeasurable time and effort later if audited by higher authorities.

2.1.5 COMPARE COSTS AND BENEFITS AND RANK ALTERNATIVES (STEP 5)

This step is the essence of justification in cost effectiveness studies and economic analysis because it provides the tool for better management decision-making. When you compare and rank your alternatives, normally there are three criteria to distinguish between alternatives:

1. **Least cost** for a given level of effectiveness,
2. **Most effectiveness** for a given constraint, and
3. **Largest ratio** of effectiveness to cost.

Generally, there are four possible configurations into which alternatives may fall:

1. Equal Costs/Equal Benefits: This is the **least likely** to happen. Because the cost and benefits cancel each other out, *the recommendation would be determined by **noneconomic factors**.*

2. Equal Costs/Unequal Benefits: Here, the costs cancel each other out so *the recommendation would be determined by the alternative that has the **most benefits**.*

3. Unequal Costs/Equal Benefits: In the facilities acquisition process, this form rarely occurs in pure form. However, this configuration is frequently acceptable when the benefit of one facility over another is marginal. When you make this assumption, employ the techniques developed in Chapter 5. *The recommendation for this configuration would be based upon the alternative having the **least costs**.* In cases where you consider the benefits to be substantial, the next form would be the best choice.

4. Unequal Costs/Unequal Benefits: Frequently, however, the only valid assumption you can make is that both the costs and benefits of alternatives are unequal. When this is the case, you must address both sides of the

benefit/cost equation, employing the techniques described in Chapters 5 and 7. *The basis for recommendation for this configuration would be based upon the* ***highest benefit to cost ratio.***

2.1.6 PERFORM SENSITIVITY ANALYSIS (STEP 6)

Because uncertainties are always present, it is necessary to test their effects and influences on the sensitivity of the analysis. Cost factors and assumptions need to be analyzed to portray a complete picture. Chapter 7 discusses the techniques of sensitivity analysis.

Sensitivity analysis provides feedback within the economic analysis process by indicating that alternatives, estimates and assumptions are in need of further refinement. Conduct the investigation to decide how the economic analysis results may change with respect to changes in the system's original parameters and basic assumptions. *If a change in a parameter or an assumption results in a significant change in the results, then the results are* ***sensitive*** *to that parameter or assumption.*

Include the results of the sensitivity analysis in the final economic analysis presentation. In this way, you assure the reviewers that you have considered and tested the impact of the uncertainties on the analysis.

The review of different parameters and assumptions under varying conditions shows that the economic analysis process is iterative. Figure 2A illustrates the entire six step process. When you document the analysis before submission, ensure that you addressed **each** step in the process adequately.

2.2 TWO CLASSES OF NAVY ECONOMIC ANALYSES

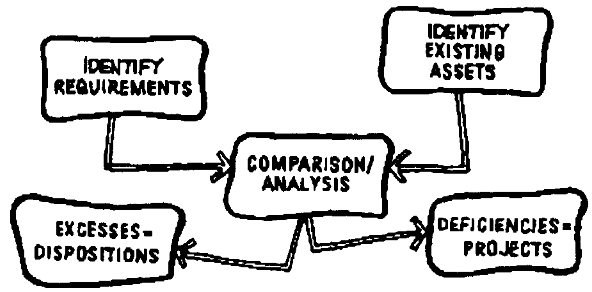
Within the realm of the Naval Facilities Engineering Command facilities acquisition process, there are two distinct classes to which the process of economic analysis may be applied. It is convenient to define two classes of analyses. The classes are:

- Fundamental Planning Analysis (FPA)
- Design Analysis (DA)

2.2.1 FUNDAMENTAL PLANNING ANALYSIS

In Fundamental Planning Analysis (FPA), you adopt the broadest possible perspective of the Navy activity's facilities planning objectives for your situation. You must then develop an unbiased definition of the precise planning objective and identify all the feasible methods to accomplish the objective.

In general, these alternative methods will include MILCON and non-MILCON funding options. The FPA is the appropriate forum for their evaluation.



The MILCON is not the cure to all facility problems. It is important that you exhaust all possibilities before recommending a MILCON. If the MILCON alternative still seems to be the most cost effective option available to the Navy, you must then provide further information. You need to provide formal economic justification and substantiation for a Navy request to Congress for MILCON project funds.

Only One Alternative: All projects are assumed to have two or more alternatives (minimum, the status quo and the proposed solution); therefore, the recommended alternative should be supported by an economic analysis, and the results of this analysis included in the DD 1391. *Exceptions to this assumption should only occur in a few safety, health, pollution, and security projects in which the status quo is unacceptable.*

If the analysis suggests that only one alternative is feasible, then you must document the thought process that led to this conclusion. In essence, a list of the alternatives that would fulfill the objective and proof of their infeasibility must be submitted as part of the facility study in place of an economic analysis. Only after this will there be support for the idea that there is only one feasible solution to a facility's deficiencies.

The FPA is important and should be prepared carefully and completely. There are two broad categories into which Navy investment proposals fall; so, it is useful to define the two types of analyses:

a. **Type I:** A Type I economic analysis (also called a **primary** economic analysis) helps to decide whether an **existing** situation should be changed to take advantage of dollar savings available through another alternative.

   This type of analysis addresses the basic need and economic justification for a change to present conditions.

A Type I analysis deals with the economics of projected dollar savings, since the operational requirement is already being met. This analysis would justify a project that is economically advantageous because it permits the requirement to be met at a lower life cycle cost.

The classic Type I analysis case is for an alternative investment to be made to achieve a reduction in annual recurring cost(s). Investments supported by Type I economic analyses must promise **absolute cost savings** over the present method of meeting a requirement. The reduced cost(s) would be over the life cycle of the alternative relative to the status quo, or present condition. Some examples of Type I (primary) economic analyses are:

- Investment in additional insulation for existing buildings to lower heating and cooling costs.
- Expansion of utility systems at berthing piers to allow in-port ships to secure internal power plants.
- Modernization of Naval Air Rework Facility (NARF) overhaul facilities to speed overhaul work, by that decreasing the aircraft "pipeline" inventory requirements.
- Replacement of existing high maintenance cost facilities or equipment with new facilities that have lower maintenance costs.

b. **Type II:** A Type II economic analysis (also called a **secondary** economic analysis) helps once a deficient, changed, or new requirement has been identified. This type of analysis determines which of several **planning** alternatives (for example, new construction versus commercial lease) would most economically satisfy the unmet need.

In the Type II analysis, the requirement exists and is not currently being fulfilled.

This type of analysis **does not** concern itself with the justification for the requirement. It is concerned with the selection of the best alternatives to satisfy a need or deficiency.

A Type II analysis justifies projects in which economic considerations are secondary to military operational requirements. Because the military has a currently unmet requirement, a Type II analysis is appropriate. Examples of Type II (secondary) situations are:

- Acquisition of land for a new communication center, either through lease or outright purchase.

- Correction of facility deficiencies through new construction versus rehabilitation of existing facilities versus conversion of other existing unused facilities.

- Providing housing for unaccompanied personnel by the construction of new Unaccompanied Enlisted Personnel Housing (UEPH), payment of Basic Allowance for Quarters (BAQ), or by lease construction of housing.

c. **Differences between Type I and Type II:** Additional discussion of the differences between Type I (primary) and Type II (secondary) economic analyses needs to be stressed to assure that budget submissions reflect those differences.

Type I economic analyses are those that involve proposed savings over an already existing mode of operation. Investments supported by Type I economic analyses must promise absolute cost savings over the present method of meeting a requirement to justify changing from the status quo.

On the other hand, a Type II economic analysis investigates the selection of an alternative to satisfy a mission requirement that is not currently being met. That is, there is **no status quo**, or existing mode of operation.

Another important distinction for the Type II analysis is that the selection of the most economical alternative is not justified on the basis of dollar savings but rather on the least life cycle cost. For example, an additional facility requirement may be justified due to an expanded mission of an activity. The methods of satisfying the **additional** requirement are investigated through the Type II economic analysis. Here, the economically preferable alternative does not result in an absolute cost saving; it represents the least cost alternative relative to the other possible alternatives.

Type I analyses always address a status quo among the alternatives they consider - Type II analyses do not.

Another difference between these two methods is the cash flows. A Type I economic analysis justifies investments intended to reduce an already existent cash flow. Type II economic analyses justify investments that initiate an expense stream. Projects resulting in cost savings (Type I - primary) and those resulting in increased costs but less costly solutions to new requirements (Type II - secondary) are significant to the Navy budgeting system.

2.2.2 DESIGN ANALYSIS

The second class of economic analysis comes into play once a decision has been made to procure a given facility via the MILCON funding route (generally influenced by the results of a Fundamental Planning Analysis). After awardment of funding, it may be necessary to do an economic analysis (usually Type II) examining the MILCON design alternatives. Some examples of Design Analyses (DA) are:

- One-level versus multi-level construction,
- Wood siding versus concrete masonry units,
- Steel versus concrete,
- Double-glazed glass versus single-glazed glass windows,
- Alternative physical orientations of a proposed structure,
- Alternate heating and cooling systems for a building, and
- R-19 versus R-30 insulation.

The procedures for the preparation of the Design Analysis (DA) are identical with those of the Fundamental Planning Analysis (FPA). The only difference between the DA and FPA is the nature of the alternatives considered (Design vs. Planning). The remainder of this handbook will address the procedures for the preparation of the FPA unless stated otherwise. Keep in mind that, except for the nature of the alternatives considered, all the procedures that apply to the FPA apply to the DA as well.

2.3 SPECIAL CASES

Certain military construction projects can qualify for Unspecified Minor MILCON (UMM) funding if the project investment cost will be amortized by savings within a three year period. These projects must be supported by Type I economic analyses.

Due to the special nature of UMM project documentation requirements, these analyses must follow special guidelines. A discussion of economic analyses and caveats supporting UMM projects appear in Appendix D.

Special guidelines also apply to economic analyses in which energy costs are important. An example is the documentation for Energy Conservation Investment Program (ECIP) projects. A discussion of these guidelines appears in Appendix E.

2.4 PREPARATION AND REVIEW RESPONSIBILITIES

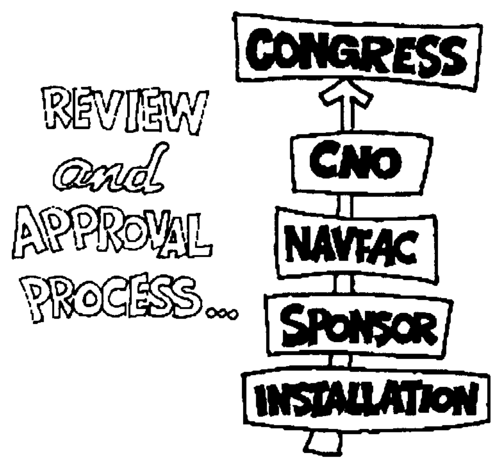
2.4.1: Players, Submittals, and Directives: Specific economic analysis (EA) preparation requirements, as mentioned above, may vary from time to time as the needs of the Navy change. Below is a general list of players, submittal requirements, and specific directives for both EA classes. (A comprehensive list of EA policy instructions appears in Appendix A.)

a. **Fundamental Planning Analysis (FPA)**

Preparer: The Navy activity requesting funds for a given project

Submittal: Part of the Facility Study (DD Form 1391C) to the updated Military Construction Project Data (DD Form 1391) when required.

Reviewers: The cognizant NAVFAC Engineering Field Division (EFD) and Major Claimant. Ultimately available as part of the project data when reviewed by:



- NAVFACENGCOM (Code 30),
- The Shore Facilities Programming Board (SFPB),
- Office of the Comptroller,Department of the Navy (NAVCOMPT),
- Office of the Secretry of Defense (OSD),
- Congressional Armed Services, and Appropriations Committees

Reference:

NAVFACINST 11010.44 series, "Shore Facilities Planning Manual." (Note: Updates of this reference will not be available in hard copy. Efforts are currently under way to have updates of this document available on computer software, titled "Installation Planning and Management Guide" - also known as "Electronic Version or E-1.")

b. **Design Analysis (DA)**

Preparer:	Either the cognizant Engineering Field Division (EFD) or a private architect/engineer (A&E) firm for a given project
Submittal:	Part of the project design documentation
Reviewers:	Ultimately available as part of the project design data for appropriate authority review
Reference:	NAVFACINST 11010.14 series, "Project Engineering Documentation (PED) for Proposed Military Construction Projects"

2.4.2 "LESSONS LEARNED" FROM THE PROCESS

Some Navy projects have not received funding because economic analyses were not submitted or were incomplete. Whether a project is in the early development stages (Project Data Sheet submission) or later stages (DD Form 1391/Facility Study submission) consider the following "lessons learned":

a. **EA's are needed for most projects**: Misconceptions have existed based on the following "bad" assumption: My MCON project is justified on the basis of operational requirements so an economic analysis isn't needed. This is not true. Economic justification is required for all MCON projects, regardless of project cost or mission. All MCON projects, with few exceptions, have a minimum of two viable alternatives - the way mission requirements are currently being met ("status quo" alternative) and the proposed alternative. Therefore, every project requires an economic analysis to support its economic justification.

Exceptions: The status quo alternative may be unacceptable and eliminated as a viable alternative in projects which correct:

1. Fire, safety, or health deficiencies
2. Pollution or environmental compliance problems
3. Security problems

b. **Prepare EA'S as Early as Possible**: A preliminary EA is recommended at the earliest possible stage of project development to be included (if possible) with the Project Data Sheet submission. Prepare a more detailed EA as part of the the DD Form 1391/Facility Study submission.

c. **Consider viable alternatives**: Each EA should document feasible alternatives, if applicable, from the following categories:

1. Status Quo
2. Modification of Existing Assets: Renovation, Conversion, Upgrade, Expansion, or other forms of improvement. *Consider facilities at other DOD bases nearby, as well as on the Navy base.*
3. Leasing
4. New Acquisition

d. **Update EA's**: The economic analysis must be reviewed, re-evaluated, and updated each time the project cost is revised, to ensure the alternative selected has the lowest life cycle costs. Also consider changes in project scope/size and EA assumptions regarding economic factors which may be outdated. This is especially true for an EA that was part of a DD Form 1391/Facility Study submittal for a project in a previous year's program.

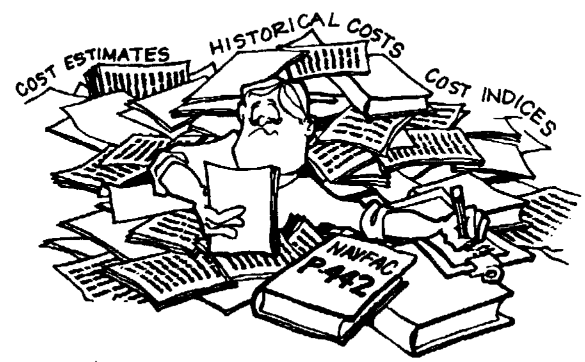
2.4.3 IMPACT OF NO EA SUBMITTAL

Economic implications must be considered at all levels of authority, i.e., Headquarters, Commands and Installations. Any construction project may be excluded from consideration for the Program Objectives Memorandum if the economic analysis/economic justification (or DD Forms 1391/1391c) have not been prepared when the project is presented to the second Shore Facilities Programming Board. On an exception basis, due to circumstances that were unforeseen in the normal planning process (such as weapons system changes), the documentation may be prepared after the second Shore Facilities Programming Board.

BASIC ECONOMIC ANALYSIS TECHNIQUES

Chapter 3

Chapter 2 discussed the 6 step economic analysis process. Step 4 is "Determine Costs and Benefits." Step 5 is "Compare Costs and Benefits/Rank Alternatives." The following techniques are needed to complete these steps.



ANALYST AT WORK

3.1 CASH FLOW DIAGRAMS

The cash flow diagram is a graphic technique for representing the magnitudes and timing of all costs and benefits associated with a given economic alternative. It is customary to draw a cash flow diagram for each alternative being considered in an economic analysis. Estimating the correct timing of the costs or benefit is very important to the net present value results.

Figure 3A shows a generalized cash flow diagram with a typical pattern of life cycle costs. The horizontal line represents a time axis. The choice of time unit is usually graduated in years. Costs are represented by vertical arrows whose lengths are proportional to the cost magnitudes, and whose locations on the time line indicate the end of the year when they occur.

In Figure 3A, the long arrow on the left (Time Zero) represents the acquisition or start-up cost; the shorter downward arrows (Years 1-7) represent costs incurred from year to year, as, e.g., annual recurring operating costs, maintenance costs, and isolated one-time costs. The upward arrow at the right (Year 7) represents the terminal or residual value of assets on hand at that time. Because terminal value is to be netted against the total life cycle cost, it acts to offset other costs, and is drawn upward.

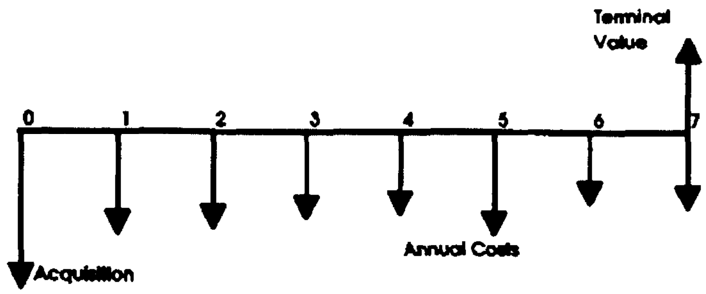


Figure 3A
Cash Flow Diagram

3.2 DETERMINING THE ECONOMIC LIFE

The seven year time frame in figure 3A is referred to as the **economic life of the alternative**. In general, the economic life of a proposal (i.e., alternative) is the period of time during which it provides a positive benefit. The specific factors limiting the duration of economic life are:

a. The mission life, or period over which a need for the asset(s) is anticipated. DoD mission objectives are about 25 years.

b. The physical life, or period over which the asset(s) may be expected to last physically. Usually, physical life can be approximated to 50 years for salvage value estimates for new permanent construction.

c. The technological life, or period before obsolescence would dictate replacement of the existing (or prospective) asset(s).

Generally, the economic life of an alternative should be taken as the least of the above three time parameters. The mission life is often the greatest constraint in the analyses. Economic decisions must be justified within mission planning guidelines.

It should be noted that there may be a significant period (i.e., lead time) between the initial investment expenditure and the beginning of the economic life. Economic life starts only when the alternative begins to yield tangible benefits to the Navy.

For example, the beginning of economic life coincides with the date of beneficial occupancy. Figure 3B demonstrates a cash flow diagram for a project with a 2 year lead time and a 25 year economic life. Notice that the project life is a total of 27 years and that the economic life does not begin until year 2. These important considerations will be explained in this and other chapters.

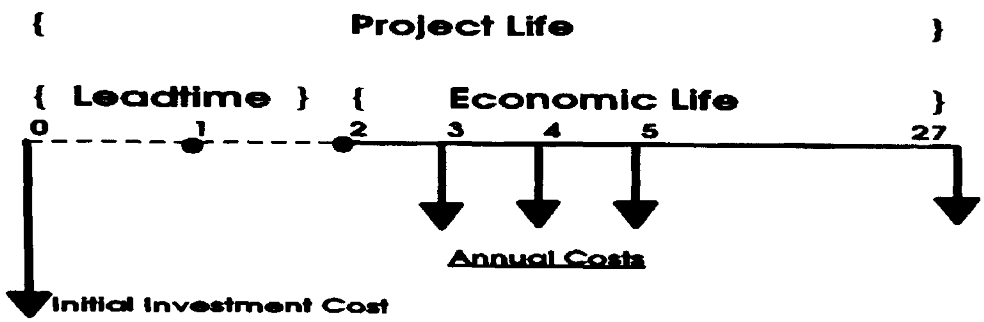


Figure 3B
Cash Flow Diagram with Lead Time

The economic lives of the various possible project alternatives will govern the time period to be covered by the economic analysis. In general, the economic lives of all alternatives should be set so that they start in the same year and, where possible, extend over the same period of time. The case of unequal economic lives requires special analytical treatment and will be discussed in section 3.8.2.

3.3 ECONOMIC LIFE GUIDELINES

To provide a basis for comparison between competing projects, economic lives are established for the general investment classifications listed below. These guidelines should be used in the absence of better information. The term of use of government property often exceeds that of the private sector. The economic life should not exceed the figures below since economic decisions must be justified within the DoD mission time frame. If a shorter life is selected, the reasons for the choice should be documented. Defense economic life time frames are constrained by the mission. This usually requires facility decisions to be economically justified within these economic guidelines. Also, discounting longer than these guidelines for facilities has very little or no effect on a military decision.

a. ADP Equipment	8 years[1]
b. Buildings	
1. Permanent	25 years
2. Semi-Permanent, non-wood	25 years
Semi-Permanent, wood	20 years
3. Temporary or Rehabilitated	15 years
c. Operating Equipment	10 years[2]
d. Utilities, Plants, and Utility Distribution Systems	15-25 years[3]
e. Energy Conserving Assets	
1. Insulation, solar screens, heat recovery systems, and solar energy installations	25 years
2. Energy Monitoring and Control Systems	15 years
3. Controls (e.g., thermostats, limit switches, automatic ignition devices. clocks, photocells, flow controls, temperature sensors,etc.)	15 years
4. Refrigeration compressors	15 years

[1] NOTE First refer to the Manufacturers guidance.
[2] NOTE More guidance in the MIL-HDB 1190, "Facility Planning and Design Guide"and MIL-HDBK 1001/2 "Materials & Building Components."
[3] NOTE Refer to OASD (L/MRM) DEPPM, 3 March 1993.

3.4 UNDERSTANDING COMPOUND INTEREST AND FUTURE VALUES

Money is a productive commodity, and as such it commands a price for its use. This price is called interest. Interest is customarily expressed as a percent or decimal, representing the fractional amount the borrower must pay the lender over a specified time period, usually one year; for the use of the money.

Interest rates for the Department of Defense (DOD) are based on an annual estimate of the government's costs of borrowing for the appropriate period of analysis.

The Department of Defense recognizes the effect that time has on investment

The Department of Defense recognizes the effect that time has on investment decisions and uses an appropriate discount rate to calculate the net present value of competing alternatives in an economic analysis. The rates and guidance follow the Office of Management and Budget (OMB) rates prescribed annually within the President's budget submission to Congress each February. The criteria to judge desirability of competing Government projects is based on comparing alternatives' total life cycle costs (Including the government cost of capital). Appendix C provides representative discount factors for various interest rates.

3.4.1 COMPOUND INTEREST, ONE YEAR

If an amount of money P is lent today at an annual interest rate i. The original amount P is called the **principal** or **Present Value** (Worth). Further, suppose that the loan is subject to it being repaid at the end of one year. At that time, the borrower has to return not only the original amount P, but an interest charge (P x i). This surcharge, (Pi) is the cost the borrower must pay for the use of the lender's money. The total amount (F) returned to the lender is thus:

$$\text{Future Value } (FV_1) = P + Pi = P(1 + i) \qquad (3.1)$$

3.4.2 COMPOUND INTEREST, TWO YEARS

Suppose the above loan is to be repaid at the end of two years instead of one. The amount which would have been paid at the end of Year 1 is P(1 + i), as we have just seen. This becomes the principal during the second year, i.e., the interest has been compounded at the end of Year 1. (Throughout the remainder of this discussion, it is assumed that interest is compounded every year). The amount repaid at the end of Year 2 is:

$$FV_2 = (P(1 + i))\ (1 + i) = P\ (1 + i)^2 \qquad (3.2)$$

(In equation (3.2), P(1 + i) takes the place of P in equation (3.1).)

*** EXAMPLE 3A COMPOUND INTEREST ***

Mr. B. White opens a savings account at the Ninth National Bank with an initial deposit of $500. If the bank pays interest on savings at the rate of 5% per year, calculate the balance in Mr. White's account in two years' time? (Assume no deposits or withdrawals are made in the interim.)

Solution 3A: Note that this is in fact a loan transaction; the bank pays Mr. White interest for the two years it has the use of his money. Let: P = \$500, i = 0.05. and F(2) = the total future amount paid to Mr. Bernie White.

So by equation (3.2). we have:

$$FV_2 = \$500(1.05)(1.05) = \$500(1.1025)$$

$$\text{Total future amount} = \$551.25$$

*** EXAMPLE 3A END ***

3.4.3 COMPOUND INTEREST, "N" YEARS

By successive repetition of the reasoning used in the two year case, if an amount (P) is lent today at an annual interest rate (i), the total amount repaid to the lender by the borrower at the end of (n) years is:

$$\text{Future Value, } FV_n = P(1 + i)^n \qquad (3.3)$$

In the money market, with prevailing interest rate (i), the lender is willing to exchange (or, more precisely, to forego) a present amount (P) today in return for $P(1+i)^n$ dollars (n) years from today. That is, the future worth to the lender of (P) dollars today is $P(1 + i)^n$ dollars (n) years from today. The borrower, on the other hand, is willing to secure the use of (P) dollars today by agreeing to pay $P(1 + i)^n$ dollars (n) years from today. In this situation, the lender and borrower complement one another, but to each, (P) dollars today and $P(1 + i)^n$ dollars (n) years from today are equivalent.

3.4.4 PRESENT VALUE AND CUMULATIVE PRESENT VALUE FACTORS

The discounting process can most easily be understood by first examining its opposite, the compounding process (see section 3.4.1 above).

Compounding is the process of converting present values to future values.

Discounting is the process of converting future values to present values.

The present value of a given future amount at a specific future date is equal to a present amount that would accumulate to that future amount by that date given a particular interest rate.

For example, the present value of $10,000 to be received two years from now is $8,734 if the interest rate is 7%. The formula for the calculation of present value (the Navy uses the end-of-year ((E-O-Y) convention) can easily be derived from the formula for the future value calculation (equation 3.3 above).

Since, Future Value, $FV_n = PV (1 + i)^n$ (3.3 shown above)
it follows:

Present Value, $$PV = (FV_n)\left(\frac{1}{(1+i)^n}\right) \qquad (3.4)$$

the interest rate (i) in this formula is also known as the "Discount Rate."
The ratio **$(1/1+i)^n$** *is called the single present value factor*, often also called the **"Discount Factor."** See Appendix C tables for all the factors at various interest rates.

The cumulative present value factors for finding the present value of future amounts recurring annually, such as routine operations and maintenance costs; is the cumulative sum of appropriate single present value factors. The formula for finding the present value (PV) of an annually recurring uniform amount (A) is the following:

$$PV = \left[A \times \frac{(1+i)^n - 1}{i(1+i)^n}\right] = A \times b_n \qquad (3.5)$$

where b_n is the cumulative (CUM) or Uniform Present Value factor (See Appendix C).

*** EXAMPLE 3B : COMPOUND INTEREST, "N" YEARS ***

Mr.& Mrs. White plan to take a cruise in 3 years. The fare charged by the cruise line is $11,000/couple. To finance the trip, they plan to open a passbook account at American Savings and Loan, which pays interest at the rate of 6% per year.

How much must they deposit today if the balance in their account is to cover the cost of a trip 3 years from today? (Assume that no other deposits or withdrawals will be made, and that the fare will still be $11,000/couple in 3 years' time.)

Solution 3B: Equation (3.3) still applies, but here it is necessary to solve for the unknown P:

F_3 = $11,000, i = 0.06, n = 3 years;
$F_3 = P(1 + i)^3$ yields: $\$11,000 = P(1.06)^3 = P(1.191)$

yields $$P = \frac{\$11,000}{1.191} = \$9,235.94$$

In this example, a service costing $11,000 three years from today could be secured by setting aside $9,235.94 today. In this sense, $9,235.94 today is equivalent to $11,000 three years from today. Another way of stating it is that, relative to an interest rate of 6%, the present value of $11,000 three years from today is $9,235.94.

*** EXAMPLE 3B END ***

The concepts developed in this subsection culminate in two general observations:

1. Because of its productivity, there is a time value associated with money. A dollar ten years from today is not the same as a dollar five years from today or a dollar today. An investor needs to take this time value of money into account when analyzing an investment proposal involving expenditures and receipts at varying points in time. Specifically, in order for a meaningful comparison to be made, such costs and benefits should be converted into equivalent costs and benefits occurring at a single point in time. The point in time usually chosen is the present, and the mechanism of conversion is equation (3.4) with an appropriate interest rate i.

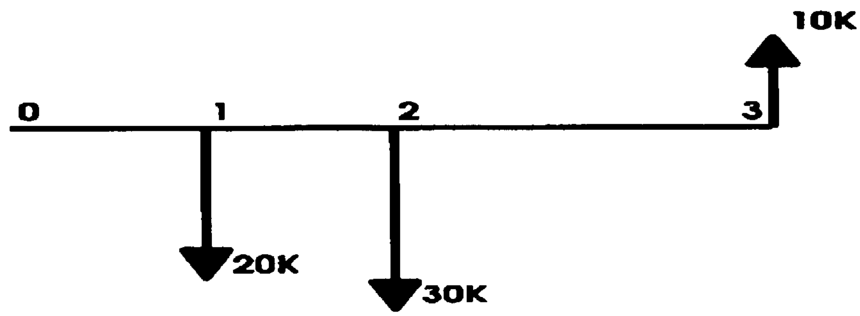
2. Equations (3.3) and (3.4) apply in a much broader context than a simple monetary transaction between borrower and lender. The most general interpretation of (i) is that of a rate of return confronting the investor (or borrower, as the case may be), whether that investor be an individual, a corporation, or the government.

To streamline the computational task of preparing economic analyses, a table of single and cumulative present value factors, using various discount rates, is given for years 1 through 30 (Appendix C). These factors were derived by taking the appropriate interest rate, i, and using equation (3.4) for n equals 1 through 30 years. Previous editions of the P-442 presented continuous compounding factors which differed slightly from the end-of-year factors. However, since the financial community at large as well as education and government all use the end-of-year factors, NAVFAC endorses the end-of-year convention to derive our discount factors.

The following set of examples illustrate some typical problems in determining Net Present Values (NPV).

*** EXAMPLE 3C: CALCULATING THE PRESENT VALUE OF A SINGLE AMOUNT ***

Compute the total net present value cost of the following cash flow diagram using the interest rate, i = 5%:



Solution 3C:

Application of the first, second and third year discount factors from Appendix C yields:

Total NPV Cost = NPV (YR1) + NPV (YR2) - NPV (YR3)
= $20K (.952) + $30K (.907) - $10K (.864)
= $19.04K + $27.21K - $8.63K
= $37.62K

$37.62K represents the equivalent in today's dollars of $20K flowing out next year plus $30K flowing out the following year plus $10K flowing in the year after.

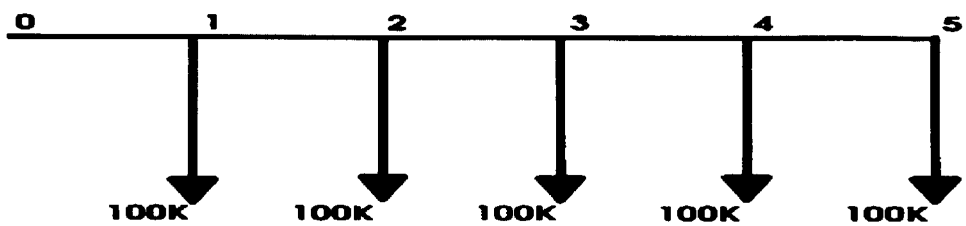
*** EXAMPLE 3C END ***

*** EXAMPLE 3D : CALCULATING THE PRESENT VALUE OF AN ANNUITY ***

Compute the NPV cost of the following cash flow diagram using i = 5%.

Solution 3D:

Application of the Table A discount factors for years 1- 5 yields:



Solution 3D:

Total NPV Cost = NPV (YR1) + NPV (YR2) + NPV (YR3) + NPV (YR4)
+ NPV (YR5)
= \$100K (.952) + \$100K (.907) + 100K (.864) + 100K (.823)
+ \$100K(.784)
= \$100K (.952 + .907 + .864 + .823 + .784)
= \$100K (4.330)
= \$433K

As you can see, the annual cost of \$100K was multiplied by the sum of the Table A factors. The computations would have been easier if the sum of the Table A factors had already been calculated. This is precisely what has been done in Table B of Appendix C. For any number n, the sum of the factors from Year 1 to the nth Year in Table A equals the n^{th} year Table B factors.

Using the Table B discount factor for year 5 yields a NPV Cost for the cash flow diagram of \$100K (4.329) = \$432.9K. Clearly, the use of Appendix C factors are far more easier, quicker, and simpler to use. The discrepancy between the NPV calculations (\$433.0K vs \$432.9K) is due to the fact that the Appendix C factors have been derived from a mathematical formula rather than summing the Table A factors. This results in occasional differences in the third decimal place, which is considered negligible for these kind of economic analyses.

Appendix C, Table B factors are useful because most annual costs can be assumed to be uniform recurring costs in constant dollar terms. The general rule for applying Table B factors is:

Rule 1: To find the total net present value of a series of uniform recurring cash flows beginning in Year 1 and continuing through Year n:

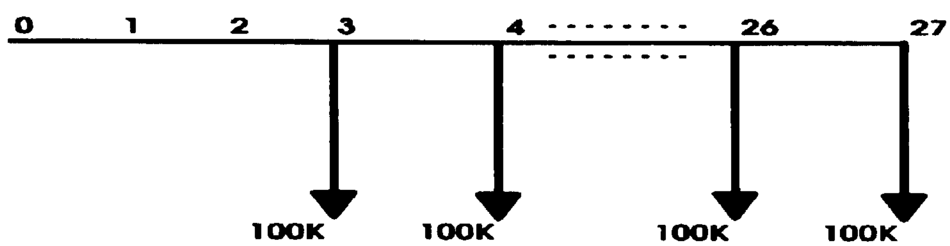
Multiply the amount of the annual payment by the nth year factor from the correct interest rate in Appendix C.

Total NPV Cost = (annual payment) (n^{th} Year Factor)

*** EXAMPLE 3D END ***

*** EXAMPLE 3E: Calculating the Present Value of a Deferred Annuity ***

Compute the total net present value cost of the following cash flow diagram where the interest rate, i = 10%:



Solution 3E:

This problem can be solved by applying the Table A factors from year 3 to year 27. Clearly, this would be too tedious and time consuming. Unfortunately it is not possible to use Rule 1 from Example 3B because the cash flow does not begin in Year 1. However, Table B factors can be applied by considering the cash flow diagram to be the difference between a twenty-seven year uniform recurring series and a two year recurring series, both starting in Year 1. Invoking Rule 1 twice, we have

Total NPV Cost = NPV (Yrs. 0-27) - NPV (Yrs. 0-2)
= $100K (9.237) - $100K (1.736)
= $100K (7.501)
= $750.1K

This method leads us to a second general rule:

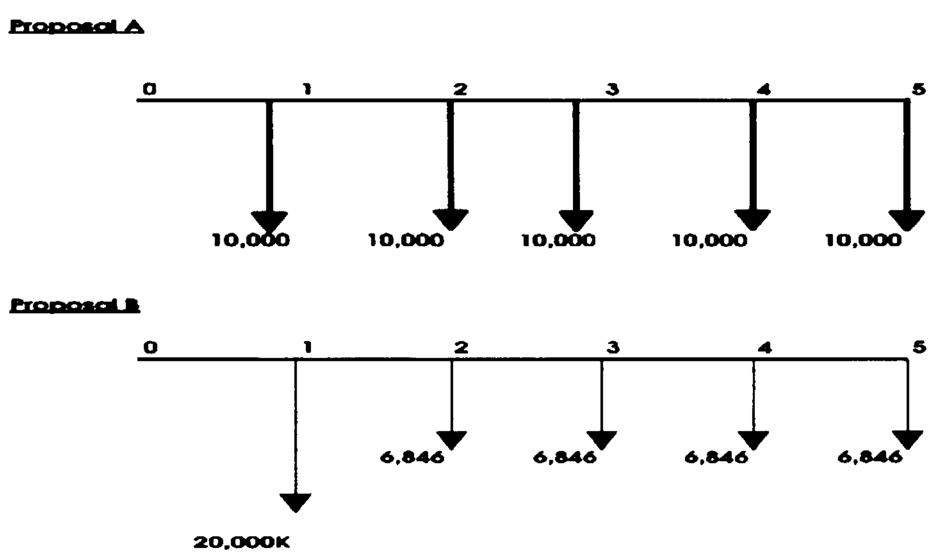
> **Rule 2:** To find the total net present value of a series of uniform recurring cash flows beginning in Year m and continuing through Year n, multiply the amount of the annual payment by the difference between the n^{th} and $(m-1)^{th}$ year factors from Table B, Appendix C.
>
> Total NPV Cost = (annual payment) (n^{th} Yr Factor - $(m-1)^{th}$ Yr Factor)

This type of calculation is very common in "real world" problems. It represents, for example, a project with a three year lead time, an economic life of 25 years with benefits and recurring annual costs starting in year three and ending in year twenty seven. Note, in this example, there is no initial investment or start-up cost to "get the project going."

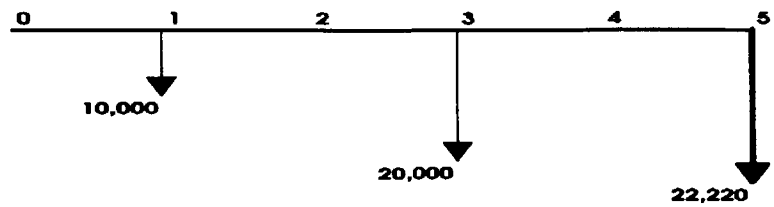
*** EXAMPLE 3E END ***

3.6 EQUIVALENCE

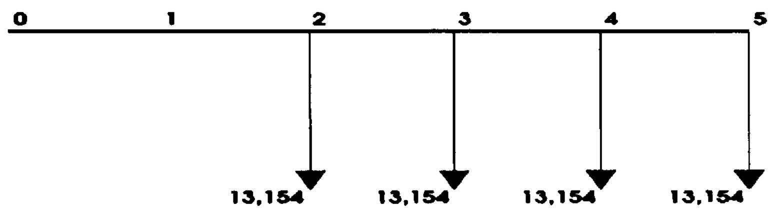
Assume the following cash flow diagrams represent four proposals to provide an engineering service to NAS, East Coast. By visual inspection, which proposal do you feel is most cost effective?



Proposal C



Proposal D



Even though the cash outlays are different, the proposals are equivalent; i.e., they have the same present value cost ($37,910). Budgetary constraints may lead to a preference, but the employing of a 10% interest rate causes the proposals to be equally attractive. The importance of the concept of equivalence is to emphasize that different cash outlays among alternatives may yield equal present value costs. Alternatives can not be selected solely on the basis of expenditures; the time value of money must be incorporated into the analysis to make the correct decision.

3.7 METHODS OF COMPARISON FOR TYPE I ECONOMIC ANALYSES

This section presents the two techniques used to compare Type I analyses.

- Savings to Investment Ratio (SIR)

- Discount Payback Period

3.7.1 SAVINGS TO INVESTMENT RATIO (SIR)

The first step in comparing a proposed alternative against the status quo is to calculate the SIR. The SIR is the amount of savings generated by each dollar of investment. Since all government economic analyses must take the time value of money into account, the SIR is mathematically determined as:

3.7.1 SAVINGS TO INVESTMENT RATIO (SIR)

The first step in comparing a proposed alternative against the status quo is to calculate the SIR. The SIR is the amount of savings generated by each dollar of investment. Since all government economic analyses must take the time value of money into account, the SIR is mathematically determined as:

$$SIR = \frac{NPV(Savings)}{NPV(Investment)} \qquad (3.5)$$

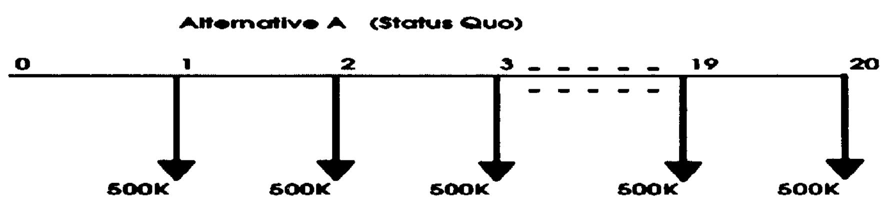
where NPV (Savings) means the present value of the reduced amount of annual expenditures from replacement of the status quo by the proposed alternative and NPV (Investment) means the present value of the initial investment for the proposed alternative less the present value of any terminal value.

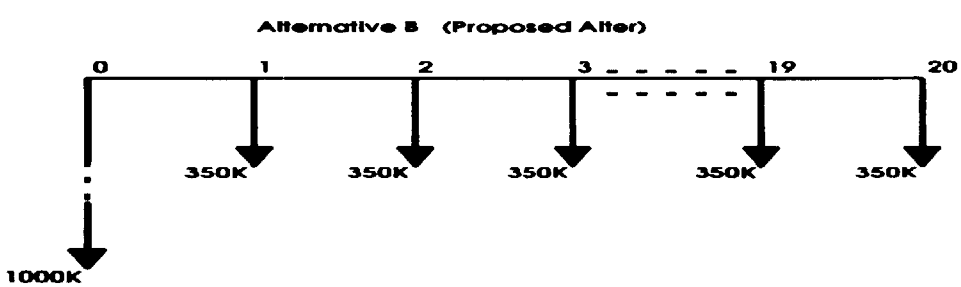
The SIR should be greater than 1 in order for the proposed project to be considered cost effective. That is, the proposed alternative should generate more savings than it costs to implement.

To see how SIRs are calculated, see Examples 3F and 3G.

***EXAMPLE 3F: OPERATION ALTER: SIR Calculations ***

The following cash flow diagrams represent the operations and maintenance costs for an existing facility and the costs for a proposed alteration of the building. Using the cost information shown, calculate the SIR and determine if the proposed project is cost effective. Use an interest rate of 10% for this example.





Project Year(s)	Recurring Costs Present	Proposed	Differential Cost	Discount Factor	Disc./Diff. Cost
1 - 20	500K	350K	150K	8.514	1277.1K

Solution 3F: NPV (Savings) = 1277.1K and PV (Investment) = 1000K

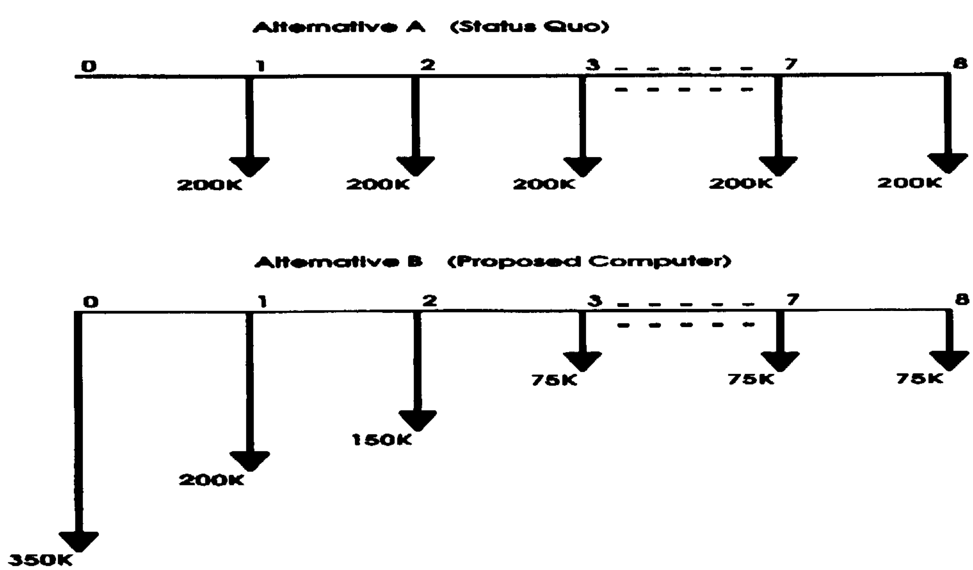
$$SIR = \frac{NPV\ (Savings)}{NPV\ (Investment)} = \frac{1277.1K}{1000K} = 1.28$$

Since the proposed rehab project generates more savings than the required investment (i.e., the SIR 1), it is cost effective and should be undertaken.

*** EXAMPLE 3F END ***

*** EXAMPLE 3G: OPERATION AUTOMATE: SIR Calculations ***

The following cash flow diagrams represent the present costs to operate a manual record keeping system and the costs for a proposed computer system that will maintain the records. Using the cost information shown, calculate the SIR and determine if



the proposed system is cost effective. Use an interest rate of 10% for this example.

Solution 3G:

Project Year(s)	**Recurring** Present	**Costs** Proposed	Differential Cost	Discount Factor	Disc./Diff. Cost
1	200K	200K	0	.909	0
2	200K	150K	50K	.826	41.3K
3 - 8	200K	75K	125K	3.599	449.9K

NPV (Savings) = 491.2K

NPV (Investment) = 350K

$$SIR = \frac{NPV\ (Savings)}{NPV\ (Investment)} = \frac{\$491.2K}{350.0K} = 1.40$$

The proposed computer system is more cost effective than the manual system (SIR 1) and should be undertaken.

*** EXAMPLE 3G END ***

3.7.2 THE DISCOUNTED PAYBACK PERIOD

In addition to the SIR, the discounted payback period should be calculated for all Type I economic analyses. Unlike the SIR which describes the amount of the savings that are accrued, the payback period describes how quickly the savings accrue. Payback is achieved when the total accumulated present valve savings are sufficient to offset the discounted investment cost of a proposed alternative. Simply put, the payback period is the length of time it takes the cumulative value of the savings to be equal to the investment.

Unlike the SIR, which has only one method of computation, the discounted payback period can be determined many different ways. Four recommended ways are:

1. Calculate the Savings Year-by-Year and Payback Occurs When the Cumulative Savings Equals the Initial Investment

This straight forward approach will determine the payback period for any possible situation. The main disadvantage is that the calculations can be tedious and time consuming.

2. Determine When the SIR = 1

This method is most advantageous to use when the annual savings are uniform and the proposed alternative has lead time. It is not effective when there are many one time costs.

3. Use the SIR to Payback Conversion Table (Appendix C)

This method is by far the easiest and simplest to use. How ever, there are some restrictions. Savings must accumulate in equal amounts and there cannot be any lead time for the proposed alternative.

4. Use the Payback Period Formulae in Appendix C

The formula on page C-6 can be used for the same conditions as in subsection 3.7.2 above. The formula on page C-7 can be used for situations with lead time and uniform annually recurring savings.

Examples 3H and 3I describe the calculations needed to determine the payback periods for Operations ALTER and AUTOMATE by each of the methods.

*** EXAMPLE 3H : OPERATION ALTER: Payback Calculations ***

Determine the discounted payback period for Operation ALTER by each of the three recommended methods. Use a 10% interest rate for this problem.

Method 3.7.2.1: Calculate the savings year-by-year and see when the cumulative savings equals the initial investment.

Solution 3H: (Continued on next page)

Year	Savings	Discount Factor	Discounted Savings	Cumm Discounted Savings	Investment
1	150K	.909	136.4K	136.4K	1000K
2	150K	.826	123.9K	260.3K	1000K
3	150K	.751	112.7K	373.0K	1000K
4	150K	.683	93.2K	475.5K	1000K
5	150K	.621	84.8K	568.7K	1000K
6	150K	.564	77.0K	653.5K	1000K
7	150K	.513	70.1K	730.5K	1000K
8	150K	.467	63.6K	800.6K	1000K
9	150K	.424	57.9K	864.2K	1000K
10	150K	.386	63.6K	922.1K	1000K
11	150K	.350	52.7K	974.8K	1000K
12	150K	.319	47.9K	1022.7K	1000K

Solution 3H :

After 12 years the Cumulative discounted savings exceed the investment. Therefore, payback occurs in the 11th year. You may interpolate to determine the exact payback period, but stating payback as occurring in 11 + years will suffice.

Method 3.7.2.2: Determine When the SIR = 1.

$$SIR = \frac{PV(Savings)}{Investment} \times b_n = 1$$

$$\frac{150}{1000}\,(\,b_n\,) = 1$$

$$150b_n = 1000$$

$$b_n = 6.67$$

6.67 is the cumulative uniform series discount factor required to make the SIR = 1. The payback period is therefore the year in which the cumulative discount factor equals 6.67. Table B, Page C-2 shows that the 11 year factor is 6.495 and the 12 year factor is 6.814. Payback thus occurs in 11+ years.

year factor is 6.814. Payback thus occurs in 11+ years.

Method 3.7.2.3: Use the SIR to Payback Conversion Table

We know that:

1. The SIR is 1.28
2. The savings accumulate in equal amounts each year.
3. There is no lead time for the proposed project.
4. The economic life is 20 years.

Therefore, we can use the SIR to Payback Conversion Table on Page C-4. From the table we see that the payback period for a SIR of 1.2 and an economic life of 20 years is 12.97 years and the payback period for a SIR of 1.3 and an economic life of 20 years is 11.16 years. Because of the significant difference in payback, we must interpolate in this case.

$$\text{Payback} = 11.16 + \frac{(1.30-1.28)}{(1.30-1.20)}(12.97-11.16) = 11.16+.36 = 11.52$$

The payback is therefore 11+ years.

Method 3.7.2.4: Use the Payback Period Formula on page C-13

$$n = \frac{-\ln\left(1 - R\frac{I}{S}\right)}{\ln(1+R)} = \frac{-\ln\left(1 - (.1)\frac{100K}{150K}\right)}{0.09531018}$$

n = 11.53

Payback is therefore 11 + years.

*** EXAMPLE 3H END ***

*** EXAMPLE 3I : OPERATION AUTOMATE: Payback Calculations ***

Determine the discounted payback period for Operation AUTOMATE by each of the four recommended methods. Use 10% for the interest rate in this example.

Solutions 3I:

Method 3.7.2.1: Calculate the savings year-by-year and see when the cumulative savings equals the initial investment.

Year	Savings	Discount Factor	Discounted Savings	Cumm. Discounted Savings	Investment
1	0	.909	0	0	350K
2	50K	.826	41.3K	41.3K	350K
3	125K	.751	93.9K	135.2K	350K
4	125K	.683	85.4K	220.6K	350K
5	125K	.621	77.6K	298.2K	350K
6	125K	.564	70.6K	368.8K	350K

After 6 years the cumulative discounted savings exceed the investment. Therefore, payback occurs in 5 + years.

Method 3.7.2.2: Determine When the SIR = 1

$$SIR = \frac{PV\ (Savings)}{(Investment)}$$

$$\frac{41.3 + 125\ (x - .736)^{**}}{350} = 1$$

$41.3 + 125\ (x - 1.736) = 350$; $125X - 217.0 = 308.7$

$125X = 525.7$; and therefore, $X = 4.21$

4.21 is the cumulative uniform series discount factor required to make the SIR=1. Table B, page C-2 shows that the 5 year factor is 3.791 and the 6 year factor is 4.355.

Payback therefore occurs in 5 + years.

**The reason (X - 1.736) is used instead of X is that the 125K savings begin in year 3.

Method 3.7.2.3 & Method 3.7.2.4: These methods cannot be used because the savings are not uniform.

*** EXAMPLE 3I END ***

3.8 METHODS OF COMPARISON FOR TYPE II ECONOMIC ANALYSES

There are three available methods of comparison to use when performing Type II economic analyses: Net Present Value (NPV) Comparison, Uniform Annual cost (UAC), and Slippage. The appropriate method is dependent upon whether (1) at least one of the alternatives has unequal lead time* (1 year or more) or (2) the alternatives have different economic lives. Table 3A shows the appropriate method to use for each situation.

Table 3A
Appropriate Methods of Comparison

If the Alternatives Have:	Equal Economic Lives	Unequal Economic Lives
Unequal Lead Time	Slippage	UAC
Equal or No Lead Time	NPV Comparison	UAC

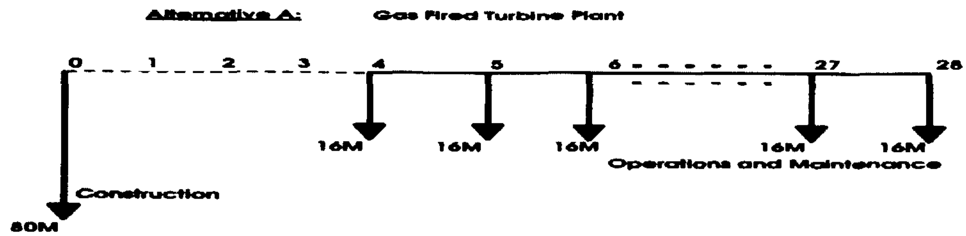
* Lead time is the period between the initial investment for a project and the time it becomes operational. For example, it may take up to three years of construction for a hospital to become operational.

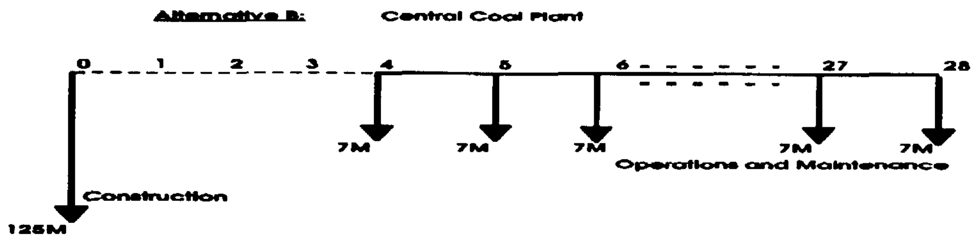
3.8.1 NET PRESENT VALUE (NPV) COMPARISON

When the alternatives to satisfy a deficiency or new requirement have the same economic life and equal or no lead time, a net present value comparison is employed to determine the most cost effective alternative. In a NPV comparison, the cost streams are discounted as they occur. Example 3J presents a NPV Comparison example.

*** EXAMPLE 3J : OPERATION POWER PLANT: NPV Comparison ***

The cash flow diagrams on the next page represent two feasible alternatives to be undertaken in Operation Power Plant. Using the cost in information shown, calculate the total NPV cost for each alternative and make a recommendation on the basis of your results. Use an interest rate of 10% for this problem.





Solution 3J: Alternative A: Gas Fired Turbine Plant

Project Year(s)	Cost Element	Amount	Discount Factor	Discount Cost
0	Construction	$80M	1.000	$ 80.0M
4 - 28	O&M	$16M	6.820	$109.1M

TOTAL NPV COST $189.1M

Alternative B: Central Coal Plant

Project Year(s)	Cost Element	Amount	Discount Factor	Discount Cost
0	Construction	$125M	1.000	$125.0M
4 - 28	O&M	$ 7M	6.820	$ 47.7M

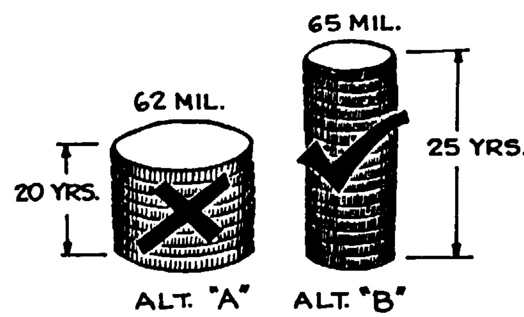
TOTAL NPV COST $172.7M

Alternative B is preferred because of its lower NPV Cost ($172.7M vs $189.1M)

*** EXAMPLE 3J END ***

*** EXAMPLE 3J END ***

3.8.2 UNIFORM ANNUAL COST



When alternatives have different economic lives, a comparison of Net Present Value costs may yield incorrect results. Consider two alternatives to fulfill the same requirement; the first has a NPV cost of $62 million over a life of 20 years whereas the second has a NPV cost of $65 million over a life of 25 years. On the basis of a NPV cost comparison, the first alternative would be preferred. However, due to its shorter economic life it may not be more economical. For cases like this, it is recommended that the Uniform Annual Cost (UAC) be calculated for each alternative. The UAC provides the average discounted cost per year for each alternative. The alternative with the smallest average cost per year is considered to be the most economical. The UAC is calculated by dividing the NPV cost by the sum of the present value factors of the years benefits accrue to the Navy.

For alternatives **without** lead time the formula for UAC is:

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

Where: UAC = The Uniform Annual Cost
NPV = The Net Present Value Cost for the Alternative
b_n = The N^{th} year Table B factor; N is the length of the economic life.

For alternatives **with** lead time the formula for the UAC becomes:

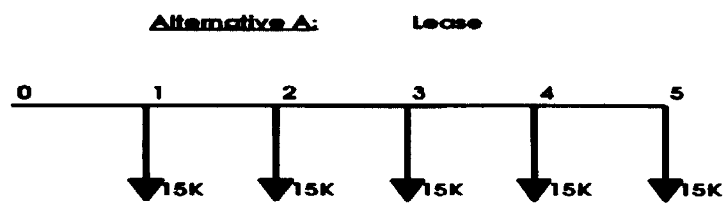
$$UAC = \frac{NPV}{bx - by}$$

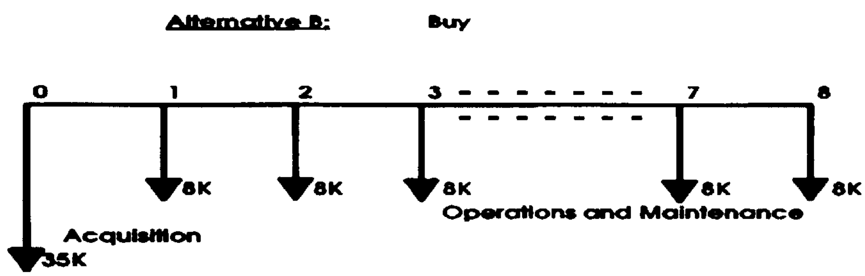
Where: UAC = The Uniform Annual Cost
NPV = The Net Present Value Cost for the Alternative
bx = The year Table B factor where X is the length of the project life
by = The year Table B factor where Y is the length of the lead time

See Examples 3K and 3L for examples of UAC comparisons.

*** EXAMPLE 3K :Operation COMPUTER: UAC Comparison ***
(Without Lead Time)

The following cash flow diagrams represent the feasible alternatives to be undertaken in Operation Computer. Using the cost information shown, calculate the Uniform Annual Cost for each alternative and make a recommendation on the basis of your results. Use 10% as the interest rate in this example.





Solution 3K:

Alternative A: Lease

Project Year(s)	Cost Element	Amount	Discount Factor	Discounted Cost
1 - 5	Lease	$15K	3.791	$56.9K

Uniform Annual Cost = $\frac{\$56.9K}{3.791}$ = $15K

Alternative B is on the next page.

Alternative B: Buy

Project Year(s)	Cost Element	Amount	Discount Factor	Discounted Cost
0	Acquisition	$35K	1.000	$35.0K
1 - 8	O&M	$ 8K	5.335	$42.7K

TOTAL NPV Cost: $77.7K

$$\text{Uniform Annual Cost} = \frac{\$77.7K}{5.335} = \$14.6K$$

Based on Uniform Annual Cost. Alternative B is preferred ($14.6K vs $15K).

*** EXAMPLE 3K END ***

*** EXAMPLE 3L : Operation REPLACE: UAC Comparison ***
(With Lead Time)

The following cash flow diagrams represent the feasible alternatives to be undertaken in Operation Replace. Using the cost information shown, calculate the Uniform Annual Cost for each alternative and make a recommendation on the basis of your results. Use a 10% interest rate for this example.

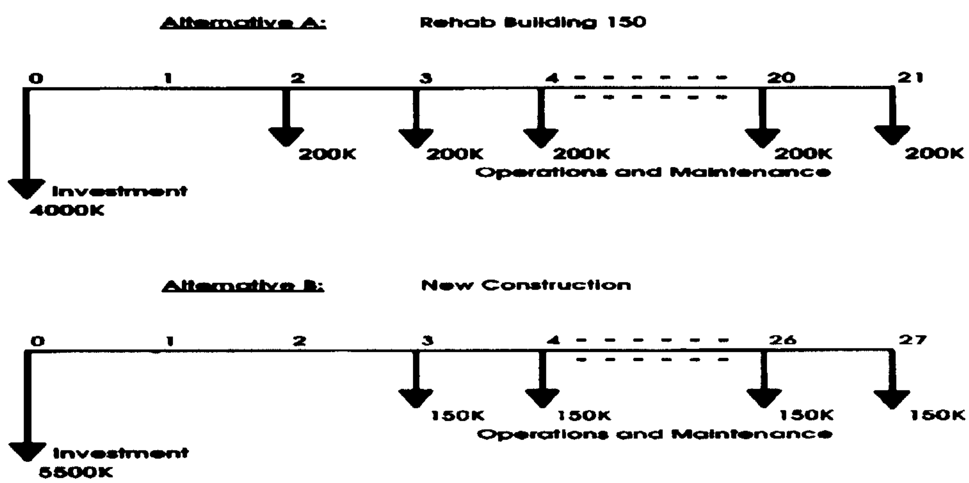
Solution 3L:

Alternative A: Rehab Building 150

Project Year(s)	Cost Element	Amount	Discount Factor	Discounted Cost
0	Investment	$4000K	1.000	$4000K
2 - 21	O&M	$ 200K	7.74	$1548K

TOTAL NPV COST = $5548K

Uniform Annual Cost = $\frac{\$5548K}{7.74}$ = \$717K



Alternative B: New Construction

Project Year(s)	Cost Element	Amount	Discount Factor	Discounted Cost
0	Investment	\$5500K	1.000	\$5500K
3 - 27	O&M	\$ 150K	7.501	\$1125K

TOTAL NPV COST = \$6625K

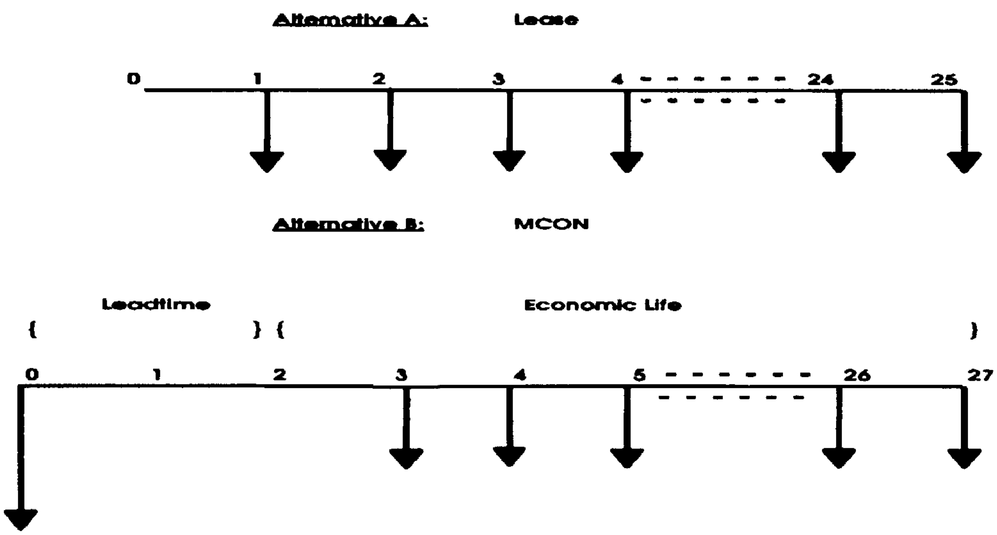
Uniform Annual Cost = $\frac{\$6625K}{7.501}$ = \$883K

Based on Uniform Annual Cost. Alternative A is preferred ($717K vs $883K)

*** EXAMPLE 3L END ***

3.8.3 SLIPPAGE

Consider the following cash flow diagrams which represent two feasible alternatives to meet a new facility requirement.



We see that:

a. Both alternatives have the same economic life (25 years).

b. Alternative A has no lead time. Therefore to discount its cash flow diagram, the annual costs should be multiplied by 9.077 (the Table B, 25 year discount factor).

c. Alternative B has a lead time of 2 years. Therefore, to discount its cash flow diagram, the annual costs should be multiplied by 7.501 (the Table B, 27 year discount factor minus the Table B, 2 year discount factor).

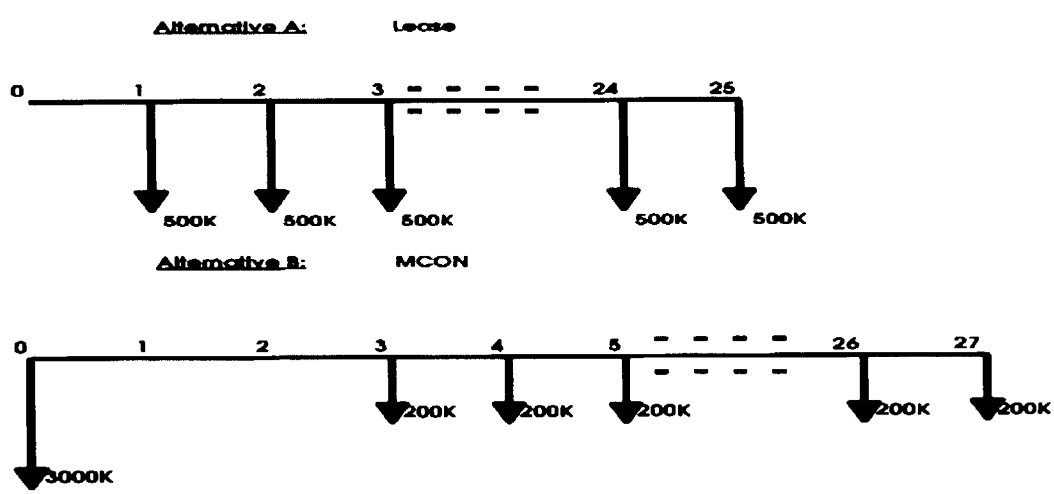
The difference in the discount factors leads to the following question. "Why should Alternative A be penalized by using a larger discount factor (which leads to a higher NPV cost) when it can immediately fulfill the requirement? The recommended approach is that when alternatives have equal economic lives but different lead times, the annual cost for the alternative with the shorter time should be "slipped" to coincide with the beginning of the economic life for the alternative with the longer lead time. The alternatives are then compared by an NPV Cost Comparison.

It should be noted that slippage is purely an analytical device. If the alternative that is "slipped" is found to be cost effective, it should be implemented.

Example 3M provides an example of slippage.

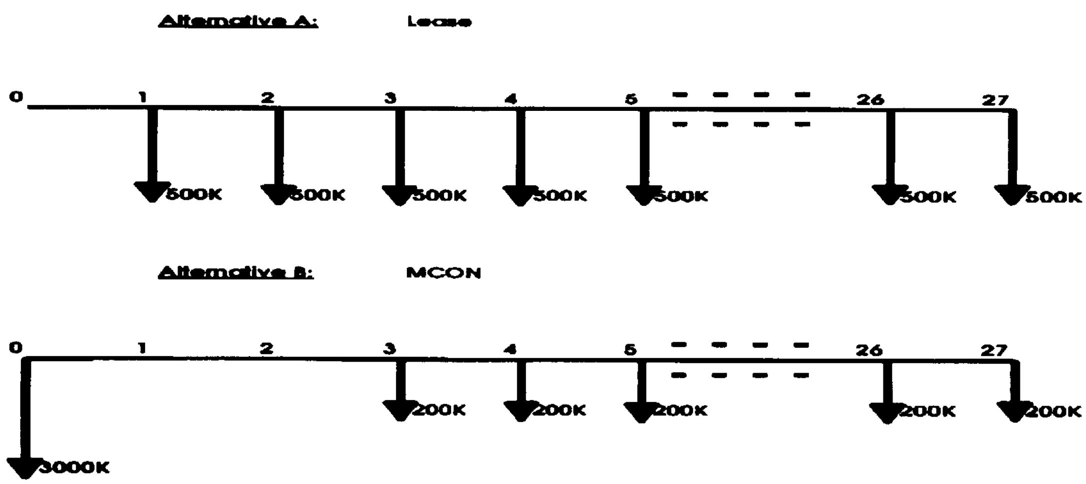
*** EXAMPLE 3M : Operation ADMIN: Use of Slippage ***

The following cash flow diagrams represent the feasible alternatives to be undertaken in Operation ADMIN. Using the concept of slippage and the cost information shown, calculate the NPV cost for each alternative and make a recommendation on the basis of your results. Use 10% interest rate for this problem.



Solution 3M:

The first step is to "slip" the costs for Alternative A back two years.



Alternative A: Lease

Project Year(s)	Cost Element	Amount	Discount Factor	Discounted Cost
3 - 27	Lease	$500K	7.501	$3750.5K

Alternative B: MCON

Project Year(s)	Cost Element	Amount	Discount Factor	Discounted Cost
0	Investment	$3000K	1.000	$3000.0K
3 - 27	O&M	$ 200K	7.501	$1500.2K

TOTAL NPV Cost $4500.2K

Alternative A has a lower NPV Cost ($3750.5K vs $4500.2K) and therefore is preferable and should be undertaken in year 1.

*** EXAMPLE 3M END ***

3.9 EFFICIENCY/PRODUCTIVITY TO INVESTMENT RATIO (EPIR) FOR TYPE I ECONOMIC ANALYSES

Projects for modernization, rehabilitation, consolidation, and other related goals often generate an increase in efficiency of operations or productivity. Such increases are extremely beneficial and should be included in a benefit/cost analysis when they exist.

Benefits of this type are frequently confused with direct cost savings because they are easily quantified in dollar terms. However, they are not equivalent, and you should understand the fundamental difference.

An **increase in efficiency or productivity** implies only one thing--the ability to do more work within the existing manpower/funding level. The only way to translate an efficiency/productivity increase into **direct cost savings** is to effect a reduction in force (RIF) which lowers the required funding level. However, a RIF is not usually intended as the mandated result of a MILCON project, and thus some other means of quantifying efficiency/productivity benefits must be used.

The solution to the problem is really a simple matter of semantics. An efficiency/productivity increase which translates into a labor time saving of two man-years is a benefit whose value may be defined as what it would cost the Government to buy an additional two man-years of labor. This cost should be accelerated by the appropriate rate for leave and fringe benefits because the value of the benefit should reflect the actual **total cost** to the Government of providing two man-years of work.

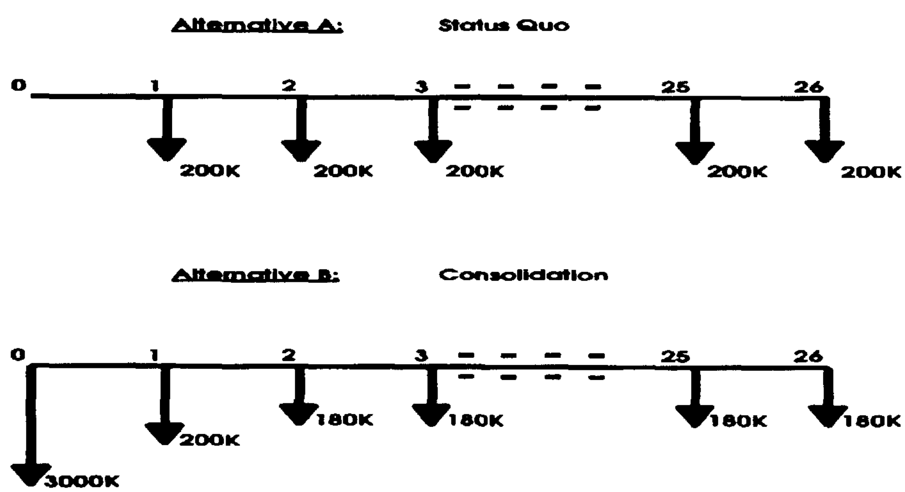
One very important caveat must be mentioned. In order to claim an efficiency/productivity increase as a valid benefit, there **must be a documented need** for the increased workload capacity. In other words, there must be an alternative use to which the "new" manpower resources can be put, such as reducing a backlog of maintenance. Lacking this, there is no **quantifiable** benefit -- derived from the project. Documentation of this fact must be complete and explicit in the benefit/cost analysis.

The measure for efficiency/productivity increases is called the Efficiency/Productivity to Investment Ratio (EPIR). The EPIR is derived by dividing the present value of the benefits by the investment. The EPIR is then added to the SIR to produce the

Example 3N presents an example of SIR, EPIR, and BCR computations.

*** EXAMPLE 3N : Operation CONSOLIDATE: EPIR Calculations ***

Naval Base, Anywhere, presently houses its administrative functions in three different buildings. A proposal has been made that will consolidate the admin functions into one central facility. It is anticipated that due to improved operational efficiencies resulting from the consolidation, ten people, at an average cost of $28,000/year, will be reassigned to other functions at the base. Using this information and the cash flow diagrams shown below, calculate the SIR, EPIR, and BCR and make a recommendation on the basis of your results. Assume the interest rate for this example is 10%.



Note: No savings occur in the first year due to the construction time for Alt. B.

Solution 3N:

(1) Calculate the SIR

Project Year(s)	Recurring Costs Present	Recurring Costs Proposed	Differential Cost	Discount Factor	Disc./Diff. Cost
2 - 26	$2000K	$1800K	$200K	8.252	$1650K

Investment = \$3000K

$$SIR = \frac{\$1650K}{\$3000K} = .55$$

(2) Calculate the EPIR

Annual Benefits = 10 personnel x \$28,000 per yr x 1.53 (escalation factor for fringe benefits) = \$428,400 per yr

Discounted Annual Benefits = \$428,400 x 8.252 = \$3,535.157 say \$3535K

$$EPIR = \frac{\$3535K}{3000K} = 1.18$$

(3) Calculate the BCR

$$\begin{aligned} BCR &= SIR + EPIR \\ &= .55 + 1.18 = 1.73 \end{aligned}$$

The consolidation project should be undertaken because 1.73 dollars of savings and benefits are generated for each dollar invested.

NOTE: Without the Efficiency/Productivity benefits the SIR was not sufficient to justify the alternative.

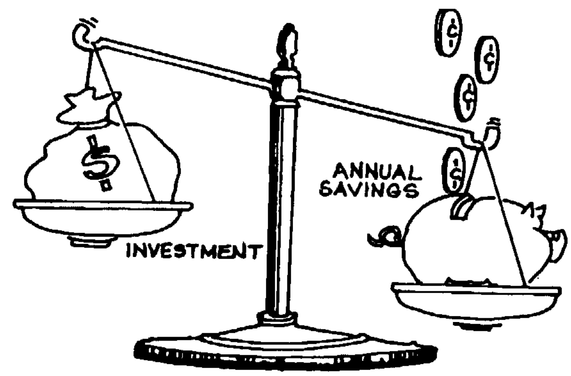
*** EXAMPLE 3N END ***

LIFE CYCLE COST ANALYSIS

Chapter 4

4.1 WHAT IS LIFE CYCLE COST ANALYSIS?

Life cycle cost analysis is a method of determining the total cost to the Government of acquisition and ownership of an alternative over its full useful life. Economic analysis provides a tool for effective resource allocation only when all the resource implications associated with **each** alternative are included. In facility decisions, it would include estimates of the **direct** and **indirect** expenditures required to acquire, operate, maintain and, where applicable, salvage facilities. Development, production, operation, support, and disposal costs may be required. This would require identifying all the costs associated with labor, capital (funds), and raw materials necessary to produce a good or service.



A decision to undertake an investment implies the allocation of many different resources and tapping into several different "pots" of money. The construction of a Navy Public Works Maintenance Shop, for example, involves not only the construction investment cost, but also the allocation of Navy land resources, the commitment of Navy funds for personnel, operations, routine maintenance, other recurring expenditures, and other resoruce allocations throughout the facility's economic life. Your analysis will be incomplete if you attempt to evaluate an investment option without due consideration to all of the resource implications.

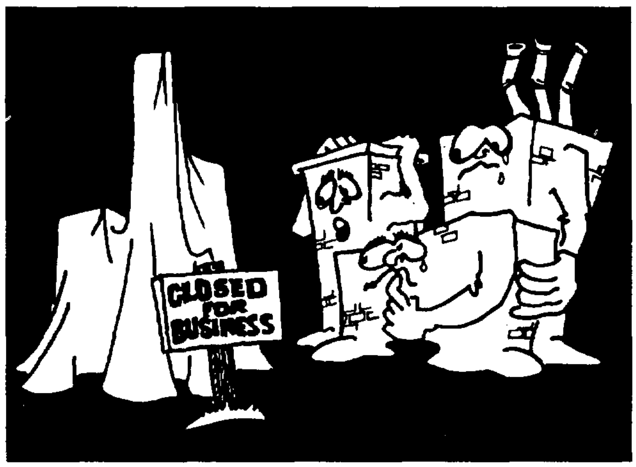
The ultimate purpose of an economic analysis is to provide one document which presents an unbiased picture of the life cycle resource/benefit implications of each alternative considered. Only when you have such an unbiased presentation is it possible to achieve the most beneficial resource allocation within the constraints of the

Navy budget.

4.1.1 POINT OF VIEW

When compiling life cycle costs, you must take the appropriate vantage point to ensure that all relevant costs are included. The correct vantage point is that of the United States Government, not just the Navy. This view provides for the maximum effectiveness of national defense resource allocation by Congress and the President. The Congress is naturally interested when a program or project of one Federal agency has impacts on the costs incurred by another Federal agency. If a Navy investment results in another Government agency incurring additional costs, then those costs must be included in the analysis even though the Navy does not pay them.

An example may help to clarify this point: Expansion, consolidation or re-alignment of a Navy base may force a non-Navy tenant occupying Navy space to find suitable space elsewhere. You need to include the relocation costs of the non-Navy tenant in the Navy analysis. This allows the highest levels of approval (from the Department of Defense and Congress) to make the decision by considering all of the pertinent information.



4.2 THE COSTS OF CAPITAL IN GOVERNMENT DECISIONS

The cost of capital is a function of the time value of money, that is, the value of money at different points of expenditure. This is because a dollar spent next year has a different value today as compared to a dollar spent five years from today. Therefore, future expenditures must be adjusted to a common point (usually the present value) for an accurate comparison. The adjustment is accomplished by **discounting**. An example is the situation in which one alternative may seem more cost effective than another because it has a smaller initial investment cost; but may be, in fact, more costly to maintain over its entire life. The Government recognizes the effect that the time value of money has in life cycle cost analysis by using a predetermined interest rate for discounting (see a copy of the OMB Circular A-94 in Appendix A).

4.3 SUNK COSTS AND DEPRECIATION ARE EXCLUDED IN THE EA

Life cycle cost analysis applies to all costs and benefits which occur after the decision point. So, the economic analysis should include only those cash flows which the decision can affect. Costs which occur prior to the time at which the economic analysis is prepared are sunk and cannot be changed or recaptured.

For example, if an alternative is linked to a $300,000 research cost undertaken prior to the decision point; the research cost is sunk and should not be included in the analysis. The $300,000 is spent and can not be recaptured no matter which alternative is selected. *Sunk costs are never included in the economic analysis, although their mention as supplemental information may be of interest to budget reviewers.*

Depreciation is an accounting convention which impacts on cash flows only when an income tax structure exists. In the private sector, depreciation is an accounting expense which neither requires nor generates cash and therefore has no effect on the firm's cash balance before taxes. However, a firm can deduct its depreciation allowance from its net income before paying taxes and thus reduce its tax expense.

Because the Navy is part of the Government and does not pay taxes, depreciation is not applicable in Navy owned alternatives and should not be included in an economic analysis of Government investments.

4.3.1 GOOD DATA MEANS GOOD ANALYSIS

Cost refers to the value of inputs such as materials, operating labor, maintenance, supplies, and capital expended in producing a good or service. To be realistic, cost estimates must refer to all ramifications of alternatives being analyzed. Well developed cost analysis of an operation requires detailed investigation into where money comes from, where it goes, and what it buys.

Throughout this handbook, the process of economic analysis is described in various ways. Central to all the alternative definitions for economic analysis is the notion that economic analysis is a **process** which operates on certain input data and provides an output. It provides a measure of cost effectiveness to aid in the decision-making process. The best and most complete of process can yield output only as good as the input data supplied. Economic Analysis is no exception to this important rule. Well-documented cost data provide the foundation for the analysis and are absolutely essential to it. Meaningful conclusions can only be drawn from meaningful cost data.

4.4 WHAT COSTS SHOULD BE INCLUDED?

The next two sections list typical cost elements included in many alternatives considered in an economic analysis. The cost elements are divided into two general categories: **one-time costs** and **recurring costs**. This distinction is necessary because the timing and annual rate of costs incurred are important factors in an analysis. This point will be more evident in Chapter 6.

The list of typical costs is intentionally broad and it is unlikely that any one analysis will include all the cost elements described in the next two sections. However, it is a checklist against which each alternative should be measured. Conversely, this list may not be broad enough to meet the requirements of all analyses, and you should augment the list as necessary.

4.5 ONE-TIME COSTS

The following is a list of one-time investment costs to consider in making a complete analysis. Also see the checklist for analysts and reviewers in Section 8.4 of this handbook.

a. **Research and Development (R&D)** - all costs for research and development (R&D) incurred after the decision point (i.e., no sunk costs included). Each cost should be identified by year.

b. **Facility Investment Costs** - are all the costs associated with the acquisition of equipment, real property, nonrecurring services, nonrecurring operations, maintenance (startup) costs. and other one-time investment costs estimated by the year of approval. Investment costs are usually not spread over several years since funding is rarely approved in increments. Typical investment costs are:

- land acquisition or easements
- new construction
- rehabilitation or modification
- collateral equipment
- plant rearrangement and tooling
- demolition and site restoration
- one-time personnel costs (recruitment, separation, or training costs, etc.)
- relocation costs
- nonrecurring services

c. **Working Capital Changes (Plus or Minus)** - money tied up in liquid funds, assets on hand, or on order. Generally, working capital is some form of inventory of consumables or similar resources held in readiness for use or in stock. Working capital changes can be **positive** (representing additional funding requirements) or **negative** (representing a reduction in funding requirements).

   Remember, negative change figures should be enclosed by parentheses so that the reduction in funds will be subtracted from other investment costs for the alternative.

   Most military construction projects will have little or no effect on the working capital. Some examples of possible working capital changes are as follows:

   1. Construct a supplemental Navy Exchange gasoline filling station due to overcrowding and congestion at the existing service station. This will require increased capital investment to produce the initial stock of gasoline in the new storage tanks (Plus - working capital cost).

   2. Convert a utility plant from coal or oil to natural gas. This may allow a reduction in fuel stocks (Minus - Working Capital Cost).

   3. Modernize a repair shop with new production equipment. This will increase the capacity of the shop, reducing the working capital of end items stocks necessary in an "under repair" status (Minus - "reduced pipeline" of working capital).

d. **Value of Existing Assets Employed (Plus)** - the value of assets already on hand which are to be used with the new project. The value or cost to the Navy for consuming part of the asset with the new project is an opportunity cost since, once the action is taken, the opportunity to use this asset (resource) for some other purpose is foregone. The value of such existing assets shall be included in the investment costs only when one of the two following conditions is met:

   1. The existing asset will result in a cash outlay on some other project which would otherwise not be incurred; i.e., when the existing asset is currently in use (or has an alternative planned use) on some other project.

   2. The existing asset will deprive the Government of cash planned to be realized by sale.

In all other cases, the value of existing assets to be used will be treated as a sunk cost. If there is no alternative use for the eliminated asset, then a cost to dismantle or perform minimal maintenance will be incurred by the Navy and should be included in the analysis.

When the value of existing assets employed is included, the existing assets should be included at their *fair market value* (as measured by market price, scrap value, or alternative use value) and the basis for the arrived estimate should be fully documented.

e. **Value of Existing Assets to be Replaced or Eliminated (Minus)** - the value of assets or property already on hand; the current need which is **eliminated** by the proposed project. If this property is sold, the proceeds benefit the Government. They are included in Miscellaneous Receipts by the U. S. Treasury Department.

If the property is redistributed to some other federal or state agency, that agency is benefited even though there is never any reimbursement or cash flow to the Navy or the other agency which controlled the property initially. The fair market value of these replaced assets (as measured by sale price, scrap value, or alternative use value) should be treated as a **reduction** in the investment required for the U.S. Government for decision-making in the economc analysis if (and only if) there is a documented alternative use for the assets.

NOTE: The documentation of the alternative use is necessary for both the value of existing assets employed and/or eliminated. When no documentation is available, you should assume that the assets are of no value and therefore irrelevant to the economic analysis.

f. **Residual or Terminal Value** - is an estimate of the value of the proposed investment at the end of its economic life. Terminal value is impacted by the probability of the continued Government need for the asset and by its resale value in the private sector. The effect of these factors normally cannot be estimated with any measurable degree of certainty. Moreover, any salvage value estimate frequently must be offset by removal, dismantling, or disposal costs.

Residual values should be calculated for alternatives which have assets (buildings, equipment, structures, etc.) which will still have useful value at the end of the period of analysis. This value should reflect the remaining worth of the asset(s) in question at the end of the period of analysis. Market appraisal for similarly aged assets, appraisal guidelines, and depreciation schedules are all acceptable techniques for estimating the terminal value.

The value of buildings and other structures are assumed to decline, due to decay or obsolescence, over their physical life. Most facilities can assume a *physical life* of 50 or 60 years.

Use the rate of 2.0% annual decay for 50 year facilities and 1.7% annual decay for 60 year facilities to estimate the terminal values in the absense of market appraisals.

For example, the terminal value of a 50 year physical life is estimated as 50 percent of the original investment cost in the 25th year of economic life.

On the other hand, land is an asset which is expected to appreciate, rather than depreciate, over time. Terminal value estimates for land can be based on a market study. If this is not feasible, then assume land will appreciate at a real rate of 1.5% per annum.

Any adjustment of the present value calculation is likely to make the impact of the terminal value cost very insignificant. Good cost documentation of the terminal value should be included in the analysis, accompanied by rationale and assumptions of the need for the facility beyond the economic life.

NOTE: The net total investment is the sum of the present value dollar amounts of a, b, c, d, e, and f above. The terminal value, f, is adjusted against all the initial investment costs.

4.6 RECURRING ANNUAL COSTS

The following is a list of recurring costs to consider in making a complete analysis. Also see the checklist in section 8.4 of this handbook.

Recurring Operating Costs - all costs to operate and maintain (O&M) the alternative being considered (other than labor).

1. **Materials. Supplies, Utilities, and Other Services** - The cost to the Government of supplies and materials used in providing a product or service.

   Included in this figure are the cost of base transportation which can be directly identified with the function, costs for handling, storage, custody and protection of property, and the cost of utility services, including electric power, gas, water, and communications related to the function. Material costs and supplies should include consideration for reasonable overruns, spoilage or defective work.

2. **Maintenance and Repair** - The cost of maintenance and repair to buildings, structures, grounds, and equipment utilized by the function involved in the production of goods or services. (Capital improvements. however. should be included with one-time investment costs rather than here).

3. **Support Costs (Including Overhead)** - The costs of local procurement, accounting, legal fees, medical, police, fire and other services, and the storage and issue of supplies. Also, consider any costs for terminating or cancelling existing contracts or arrangements which will become due as a result of changing alternatives. When estimating support costs associated with an alternative, you must take care to itemize **only** those support costs which will change as a result of the investment proposal.

   For example, construction of a new UEPH will probably not affect the size of the base fire department, but the costs of operating the fire department may be included in the general base overhead.

   Thus, only the variable components (with respect to the alternative under consideration) and **not** the fixed components of support cost should be included. (When a change in cost is due to the change of a single unit of output, it is referred to as **marginal cost**).

Recurring Personnel Costs - Include the total costs to the government of military and civilian personnel including their benefits, travel per diem, moving expense and training as appropriate.

1. **Civilian** - The method to be used for calculation of personnel costs depends upon whether the requirements are expressed in numbers of people or in man-hours of work. In either case the base pay for civilian personnel services involved directly in the work to be performed is computed based upon current General Schedule (GS) or Wage Board (WB) pay tables, which are available at the appropriate personnel office. (Step 5 is used as a representative average within a GS grade level; Step 3 is used as a representative average within a WB grade level). Methods for the two cases are:

CASE 1 - (Number of Personnel) - When the civilian personnel services are specified in terms of the number of personnel required, the base pay should be accelerated by a figure to account for the Government's contribution for civilian retirement, disability, health and life insurance, and, where applicable, social security programs.

NOTE: The acceleration rates for your activity should be available from your comptroller. For example, appropriate acceleration rates previously recommended by OMB Guidance were:

• Retirement and Disability (for employees under Civil Service Retirement)	20.4%
• Health and Life Insurance	3.7%
• Medicare	3.7%
• Other Benefits (including work disability, unemployment programs, bonuses and awards, etc.)	1.9%
TOTAL	27.3%

Therefore, for employees under the Civil Service Retirement System base pay should be accelerated by 27.3% to account for Government furnished fringe benefits. If comptroller data are unavailable, use current OMB rates.

CASE 2 (Man-years of work) - When civilian personnel requirements are specified in terms of the number of man years of work required, the base pay must be accelerated both for Government furnished fringe benefits (usually 27.3% as above), formal training, annual leave, sick leave, and other classifiable absences. This is necessary since, due to such absences, more than one person is required to perform one man- year of work. (**One man- year** is defined as 2080 hours, or 260 days of 8 hours each, or 52 weeks of 40 hours each). In the Continental United States (CONUS) the usual acceleration rate for leave and other absences is 20%. This figure should be used when local data is not obtainable from the activity comptroller.

NOTE: Fringe benefits are accrued by government employees whether on leave or at work, so, the net acceleration rate is a multiplication of the two factors 1.273 X 1.20 = 1.528 or approximately 53% times the man-year costs.

For example, to accomplish X man-years of work per year, a civilian on board strength of 1.2X would actually be required. Due to the cost of fringe benfits, each of these 1.2X people costs the Government 127.3% of the annual salary each year. Therefore, the total annual personnel cost of X man-years of work is approximately (1.2X)(1.273) = 1.53X times the annual salary.

2. **Military** - Complete military personnel costs for services involved directly in the work performed, computed as described in NAVCOMPT Manual 035750. The standard work period for computing military personnel costs is also based on an established 2080 hours/year. Composite standard military rates prescribed in Volume 3 of NAVCOMPT Manual 035750 should be used for estimating costs of military personnel services. These rates should be accelerated for military retirement, other personnel costs, and leave by using the rates in the manual.

Other Recurring Costs - any other recurring annual costs which do not fit easily into the categories mentioned above. All such costs should be itemized. A discussion of cost documentation is included in Chapter 8.

4.7 STATE COSTS IN CONSTANT DOLLARS OF THE BASE YEAR

The effects of inflation during the planning period covered by an economic analysis may impact the decision to recommend one alternative over other alternatives being considered. In this case, the analysis should include an explicit treatment of inflation.

It is useful at this point to define two terms related to the measurement of costs:

Constant dollars - Dollars of constant purchasing power. Constant dollars are always associated with a base year (e.g., Fiscal Year 1995 constant dollars). An estimate is said to be in constant dollars if all costs are adjusted so that they reflect the level of prices of the **base year.**

Current dollars - Dollars that are current to the year of their expenditure (also called **outlay dollars**). When past costs are stated in current dollars, the figures given are the actual amounts paid out. When future costs are stated in current dollars, the figures given are the amounts which will be paid including any amount due to projected future price changes (i.e., including inflation).

Economic analysis requires measuring the **value** of costs and benefits. The unit of measure is the dollar. To avoid distortions due to changes in the value of the dollar over time (when the general price level changes), all estimates of costs and benefits should be made initially in terms of constant dollar values. That is, it should be made in terms of the general purchasing power of the dollar in the base year (Year 0) . This is referred to as a **base case** or "**baseline**" analysis.

In a baseline analysis cost estimates are all made in the base year dollars. Projected annual costs should vary only to the extent that the required level of procured goods and services is expected to vary during the project life.

For example. it would be legitimate for annual costs to reflect an increase in the anticipated amount of repairs needed, as measured by prices at the beginning of the project life, since this represents a real cost increase and not an inflationary one. Because constant dollar estimates are used in economic analyses, the costs given generally are not budget estimates, which should reflect anticipated inflation.

However, if one or more cost elements are expected to undergo abnormal escalation in the long term, and such sustained anomalous escalation is potentially important to the conclusion of the analysis, then, it should be explicitly addressed. Because uncertainties are involved, inflation is best treated by sensitivity analysis. The general subject of sensitivity analysis is developed in Chapter 7.

4.8 COST-ESTIMATING METHODS

This section has stressed the principle of full life cycle costing and developed a representative checklist of cost elements to be considered in such a procedure. With experience, the identification of appropriate cost elements should become routine.

The actual estimation of costs, however, may be a more difficult problem. Historically, this has proven to be true in the procurement of weapon systems and in analyses of large and complex programs. In many cases, the system or program to be costed simply has not had any precedent. Under such circumstances, prior cost estimating experience may not keep the task at hand from becoming formidable.

To help meet the practical problems of cost estimation, a number of unique methodologies have been developed. Currently, some of these techniques are less often applied to the facilities area than others. However, since a treatment of cost analysis would not be complete without at least identifying the most important cost-estimating procedures, three basic approaches are briefly described below.

1. INDUSTRIAL ENGINEERING METHOD

This approach consists of a consolidation of estimates from various separate work segments into a total project estimate. For example, the estimated cost of producing a new model "widget," which will entail work contributions from 10 separate work divisions in a plant, could well be an aggregation of 10 separate and detailed estimates, each of which might itself be composed of several sub-estimates.

A more familiar example is that of an architect estimating the cost of a new house. He may estimate the construction cost as being equal to the sum of the structural, electrical, plumbing, heating, finish and other costs. Each sub-estimate may have numerous labor, materials, and equipment components.

This method is sometimes called **the "bottom-up" process** because it separates the total end product into simple parts for which detailed estimates can be established. The detailed estimate for each of the work contribution areas is developed by one or more of the following:

1. Examination of historical data for similar items.

2. Establishment of new standards by reviewing current operations (using industrial engineering techniques such as work measurement, sampling, etc.)

3. Engineering simulation of operations required to produce the item.

The end result is the consolidation of the individual estimates into a total projected cost for the system or product.

An adavantage of this method is that it separates the parts of the system on which little data are available and permits them to receive special treatment. The industrial engineering approach can result in extremely detailed and complete estimates of item/system costs. Where detailed data exist, the industrial engineering method is the best method for estimating costs.

2. PARAMETRIC COST ESTIMATING

When adequate data are unavailable for using the industrial engineering approach, you may use the parametric cost estimating technique. The total cost of an alternative is based upon ascribed physical and performance characteristics and their relationships to highly aggregated component costs. In other words, a functional relationship must be established between the total cost of an alternative and the various characteristics or *parameters* of that alternative. **Parameter** is formally defined as a cost related explanatory attribute which may assume various values during actual calculations.

You can derive a parametric cost estimate of an alternative if there is the following:

1. Historical cost/parameter information on similar systems.

2. The ability to predict with some degree of likelihood the expected parameters of the future alternative.

The primary limitation of parametric costing lies in the cost data that are available. Also, as the variation of new systems from previous systems increases, the credibility of the estimate decreases. Parametric cost estimating is the preferred procedure to use in deriving a cost estimate at the concept formulation stage. At this point, system costs can only be based on expected physical and performance characteristics and their direct relationship to costs.

As an example, the family contemplating the purchase of a new house might consider the following parameters (among others):

- number of bedrooms
- number of baths
- capacity of the garage
- size of the property lot
- age of the house
- location

If a house price for any particular combination of these parameters is known (say, the expected selling price of the house currently occupied by the family), then prices for other parameter mixes may be estimated relative to this **baseline** (perhaps, in this case, with the assistance of a real estate agent).

The greater the number of actual combinations for which the prices are known, the easier it is to estimate the effects of a particular parameter on the total cost. Your aim is to develop a valid Cost Estimating Relationship (CER). CERs are frequently derived through **regression analysis**, which relates cost as a dependent variable to physical and performance characteristics, which are independent variables.

Figure 4A illustrates the use of regression analysis to develop a CER for UEPH project construction cost. Historical UEPH project construction costs were escalated to 1991 constant dollars. The scattered points in Figure 4A show the combinations of square meters of area and construction cost in 1991 dollars. The line shown is the "best fit" of a linear relationship between area (the independent variable) and construction cost (the dependent variable). It allows you to estimate the construction cost for a new UEPH project given that the gross area to be constructed is known. The distances between the line and the points give a visual impression of the statistical confidence of the estimate. (Of course, you might wish to develop a CER that uses, in addition to the gross area of the project, other independent variables such as number of buildings, number of stories, capacity of air conditioning system, etc. Multiple re gression analysis could be applied for this purpose).

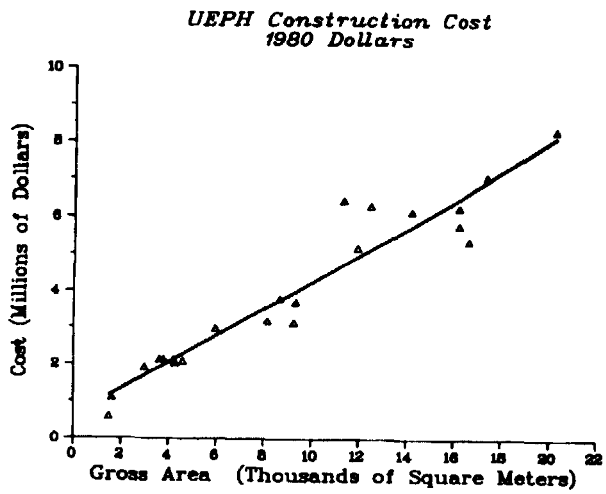


Figure 4A
Linear Regression Graph

3. ANALOGY METHOD

If more formal techniques cannot be applied, a specialized method of judgment, called the **analogy method**, may be used to estimate costs by making direct comparisons with historical information on similar existing alternatives or their components. It is *probably the most widely used method of cost analysis to date.*

The major caution of the analogy method is that it is basically a judgment process; and, as a consequence, requires a considerable amount of experience and expertise if it is to be done successfully. Moreover, judgment should always be recognized for what it is, namely a guess, albeit an educated guess.

There are two types of analogies:

1. Similiar Products

2. Similar Concepts

Similar products can be represented by the use of commercial airplane costs to estimate costs of military aircraft. An example of **similar concepts** is the use of aircraft costs to estimate missile costs.

Estimation of facilities acquisition costs may place heavy reliance on the analogy method. At the activity level, the process will obviously be influenced by the recent history of construction costs for that region. Even if cost estimates are available from an "expert" source such as a local architect and engineering firm, these estimates will essentially be extrapolations of the firm's recent experience in labor, materials, and overhead costs.

Those engaged in the review of cost estimates should find a useful guide in:

- NAVFAC P-438, "Historical Military Construction Cost Engineering Data"

This provides for individual category codes, unit costs with adjustments for area, size, Supervisory Inspection and Overhead (SIOH) and contingencies, and short term cost escalation projections. Brief but specific physical descriptions of facilities are also included.

Estimates of facilities related recurring annual costs also lend themselves to the analogy method. Such estimates will necessarily depend heavily on expert judgment, seasoned by experience as documented in public works (O&M) cost records.

In summary, *providing good cost data is often the most demanding and time consuming task required for the preparation of an economic analysis. Even with the application of one or more of the techniques outlined above, the results are by no means certain. Consequently, the cost estimates of an investment proposal are a major focal point of Chapter 7, sensitivity analysis.*

4.9 LEAVE A CLEAR AUDIT TRAIL OF THE COST ESTIMATES

Just as important as the quality of the cost data, and an essential complement to it, is sound and defensible data documentation. Always bear in mind that your work is subject to many different levels of review in the Navy budget formulation process.

The most detailed review should occur at the cognizant Engineering Field Division (EFD), but this is by no means the only one. Personnel at NAVFAC Headquarters, on Major Claimant staffs, in the offices of both the Navy Comptroller and the Secretary of Defense, and at the Shore Facilities Programming Board review the analyses with appropriate scrutiny.

Finally, when a MILCON project is reviewed by Congressional committees for inclusion in the budget, everything about it is subject to detailed inquiry, including the economic analysis and its cost data. The analysis may be reviewed by the committee staff or by General Accounting Office (GAO) auditors.

None of these budget reviewers is as familiar with the economic analysis as you are, and yet each of the reviewers must review the analysis critically and pass judgment upon its validity and adequacy. This state of affairs demands that you provide complete documentation of your economic analysis.

The economic analysis should be complete in itself. The reviewer should not have to search other documents for information necessary for comprehension and support of the analysis. For **each** cost element included in the analysis, the documentation should address, at a minimum, the following points:

- Specific data source
- Method of data derivation, if applicable
- An assessment of the accuracy of the cost estimate

This requirement is nothing more than what is dictated by good professional practice, and you should exercise prudent judgment in determining the appropriate level of documentation necessary. In making this determination, the following general suggestions are offered:

1. Identify the **dominant cost element**. These are costs whose present value equivalents have a significant impact on the total present value cost of the alternative under investigation. In other words, these are the **driving** factors of the total present value cost. Accordingly, dominant cost factors should be supported with detailed documentation.

2. Identify any cost factors which are sensitive, politically or otherwise. Such costs are subject to more careful review that might otherwise be required, and thus demand complete documentation. This guideline applies to "sensitive" assumptions inherent in the analysis as well.

3. Provide documentation for all other cost data proportional to their impact on the analysis.

When providing cost data documentation, you should bear in mind the ultimate purpose for which the analysis is intended to help determine the most cost effective allocation of Navy resources. Furthermore, you should remember that economic analysis is one of the pieces of information used to support the MILCON program before Congress. Both of these purposes will be better served if the documentation guidelines suggested above are used.

It is important to remember that a **thorough summary** of the construction cost estimates, like those described on the completed NAVFAC Form 11013/7, **Cost Estimate**, should be included in the economic analysis. Example 4A provides an illustration of an audit trail for Operation and Maintenance (O&M) costs.

*** EXAMPLE 4A: DOCUMENTATION OF O&M COSTS ***

An engineer in the Public Works Department at NAS Anywhere was tasked (in FY-92) to derive the annual O&M costs for an economic analysis to decide whether to lease or construct a 50,000 SF facility in FY-94.

The documentation and derivation of costs are demonstrated below. (Note: The cost estimates and methods used in this example are for illustrative purposes only.)

ELECTRICAL/HEATING COSTS

A similar type and sized facility at the Air Station presently uses 375,000 KWH of electricity and 2,500 MBTU of steam heat per year. Executive Order 12003 mandates that new construction must result in a 45% reduction in energy consumption. Therefore it is estimated that the new facility will require 206,250 KWH (375,000 x .55) of electricity and 1,375 MBTU (2,500 x .55) of steam heat per year. Our EFD advises that electricity will cost $.135/KWH for electricity and $8.90/MBTU for heat in FY-94.

FY-94 Annual Electric Costs: 206,250 KWH X $.135 = $27,844
FY-94 Annual Heating Costs: 1,375 MBTU X $8.90 = $12,237
FY-94 Total Electric/Heating Costs: $27,840 + $12,237 = $40,081 say $40,000

JANITORIAL COSTS

A janitorial contract for a similar type and sized facility at the Air Station presently costs $.90/SF/YR. Inflation is assumed to be 5% per year between FY-92 and FY-94. (OSD Price Indices provided by the NAS Anywhere Comptroller).

FY-92 Annual Janitorial Costs: 50,000 SF x $.90/SF/YR = $45,000
FY-94 Annual Janitorial Costs: $45,000 X $(1+.05)^2$ $49,612 say $50,000

MAINTENANCE COSTS

Historical data at the Air Station shows the average maintenance cost for a facility over its life to be $1.00/SF.

FY-92 Annual Maintenance Costs = 50,000/SF X $1.00 = $50,000
FY-94 Annual Maintenance Costs = $50,000 X $(1.05)^2$ = $68,906 say $69,000

WATER/SEWAGE COSTS

Water/Sewage costs are presently $1.00/1000 gal. Past experience shows that 50 gallons is used per person per day.

FY-92 Annual Water/Sewage Usage:

400 people x 50 gal/day x 260 days/yr = 5,2000,000/gal/yr.

FY-92 Annual Water/Sewage Cost = 5,200,000/gal/yr x $1.00/1000 gal = $5,200

FY-94 Annual Water/Sewage Cost = $5,200 x $(1.05)^2$= $5,733 say $6,000

OTHER COSTS

Personnel and other support costs are assumed to be the same for both alternatives and therefore "wash" and are not included.

TOTAL FY94 ANNUAL O&M COSTS

Electric/Cooling	$ 40,000
Janitorial	50,000
Maintenance	69,000
Water/Sewage	6,000
Total O&M per year	$ 165,000

*** EXAMPLE 4A END ***

BENEFIT ANALYSIS

Chapter 5

5.1 WHAT IS BENEFIT ANALYSIS?

The essential aspects of an economic analysis are the identification of all the relevant **inputs** and **outputs** and the quantification of these as **costs** and **benefits** to facilitate evaluation. Any economic analysis will involve considerations of both costs and returns expected for each alternative. For purposes of this handbook, the term "**benefits**" is used as the overall term for returns (outputs, products or yields). The benefits of each alternative should be expressed so that you are able to compare various alternatives. This is usually done by the benefit/cost ratio. Generally, the **benefit/cost ratio (BCR)** is defined as benefits divided by costs for each alternative considered:

$$BCR = \frac{Benefits}{Costs} \qquad (5.1)$$

So far, this handbook has considered only the frequently occurring case, in which the benefits associated with all alternatives are roughly comparable. The comparison of costs and benefits correctly focused mostly on the costs.

However, there are many instances in which the assumption of equivalent benefits is a poor one. As you might expect, *benefits are more difficult to quantify.* Costs can be more readily quantified than benefits because they normally have dollar amounts attached to them. Benefits are difficult because they often tend to have more **intangibles**. In analyses, benefits are just as important as costs and deserve to be brought to decision makers' attention. Although difficult, it is advisable to describe your project in terms of benefit with a **quantifiable** output measure whenever possible.

One example of direct comparison of costs and benefits has been treated already. This is the savings/investment ratio (SIR) developed for use in a Type I economic analysis for projects justified on the basis of projected cost savings relative to the status quo (see section 3.7.1). In other words, a Type I economic analysis applies to a project whose measurable benefits include expected recurring cost savings, relative to the current situation, which have a total life cycle present value in excess of the project investment cost.

Most Navy investments do not fit nicely into the domain of a Type I economic analysis, but this is to be expected. After all, the Navy's main concern is not in making money, but rather in providing national defense. Consequently, the benefits of Navy investments are more likely to be stated in other terms. Economic analysis is the logical vehicle for the presentation of this type of benefit/cost information.

5.2 THERE ARE FOUR TYPES OF BENEFITS

There are, in general, four types of benefits potentially associated with Navy MILCON projects, and each will be considered in turn. While the four benefit categories are by no means mutually exclusive, it is useful to consider them separately. The four categories are as follows:

a. Direct Cost Savings

b. Efficiency/Productivity Increases

c. Other Quantifiable Outputs

d. Non-Quantifiable Outputs

5.2.1 Direct Cost Savings:

a. A Reduced Budget

Projects for modernization or rehabilitation of existing facilities sometimes generate real cost savings when compared to the status quo of operations. These savings, usually in the form of a reduction of recurring operations and maintenance expenses during the projected economic life, represent a literal reduction in the funding level required to support an operation after some initial investment has been made.

When the present value of these recurring saving **exceeds** the present value of the investment, the project is said to "pay for itself" over the economic life. Stated another way, the investment is **self-amortizing**.

b. Using the SIR

1. Self-Amortization Investment

For these projects, the preparation of a Type I economic analysis is prescribed. The self-amortizing quality is demonstrated by a savings/investment ratio (SIR) greater than unity, calculated according to formulae as equations (3-6), (3-6a), or (3-6b) in section 3-E. More generally, the SIR may be calculated simply by executing in sequence step 7 through 22 of Format A-1, Appendix B.

2. Partial Self-Amortization Investment

Not all projects generating recurring cost savings relative to the status quo can support a SIR greater than unity, but a partial self-amortization may nevertheless be of interest to you, other decision-makers, or other budget reviewers; and it should be brought to their attention. Consider the following:

EXAMPLE 5A: DIRECT SAVINGS GIVES PARTIAL PAYBACK

U.S. Naval Station, Anywhere, has been plagued over the last several years by repeated power blackouts due to an outmoded and overloaded transformer substation. the Public Works Officer (PWO) has investigated the situation and determined that the only alternative is to upgrade the power substation. (The local power company is unable to provide the power required and operational needs mandate an on-base source, whose present location is ideal and fully consistent with the station master plan).

NOTE: A defensible statement indicating the other alternatives investigated and the reasons for their infeasibility **is** required when only one alternative is considered to be feasible.

However, the PWO recognized certain benefits potentially accruing from this project and has decided to portray them to the decision-makers in a benefit/cost analysis.

The public works planners have generated the following cost data for this project:

Investment	$500,000

Reduction in Recurring Annual Expenses

1.	Personnel (Maintenance)	$ 20,000
2.	Operations	$ 10,000
	TOTAL:	$ 30,000

Economic Life	25 years

This data translates into the following computation:

Total Recurring Annual Savings	$ 30,000
25 Year (Table B) 10% Discount Factor	(9.524)
Investment	$500,000
Savings/Investment Ratio (SIR)	0.57

This demonstrates that the project amortized 57% of its investment into cash savings relative to current operations over the anticipated economic life. This information is important to the Navy and the taxpayer. It should be included in the project data, even though there exists only **one** solution to this critical deficiency.

EXAMPLE 5A END

5.2.2 Efficiency/Productivity Increases:

Occurs when there is an increase in productivity that can be measured in dollars but does not result in a reduction of the budget. The Efficiency/Productivity Investment Ratio (EPIR) and the Benefit/Cost Ratio (BCR) are the appropriate techniques to measure increases in productivity. The method used to determine the (EPIR) is shown in Chapter 3.

EXAMPLE 5B: EFFICIENCY/PRODUCTIVITY BENEFITS

The public works planners at NAVSTA, ANYWHERE, have identified additional efficiency/productivity benefits accruing from the transformer project of EXAMPLE 5-1. Since the existing substation serves the industrial area of the base, every time a power blackout occurs most of the base industrial functions come to a standstill.

The Assistant PWO (APWO) has conducted an extensive time and motion study to determine the impact of the power blackouts on industrial output. His detailed study revealed that over the past four years, total industrial downtime due to blackouts averaged 2.1 man-years per year. (This figure was deemed to be conservative in that it did not include an estimate of restart time necessary to resume interrupted project work after a power loss). Average present annual salary of the personnel involved in the work interruptions is $14,820. Existing work backlog is more than sufficient to justify the need for full capacity operations.

The proposed project is expected to completely solve the current power problem, and thus provide an additional 2.1 man-years of industrial capacity *with no increase in personnel.* The value of this benefit is the cost the Navy would incur if it had to hire enough additional workers to provide 2.1 man-years of labor per year. Thus, the figure must be accelerated to account for both leave and fringe benefits:

Annual Benefits = (2.1 man-years) x ($14,820/yr) x (1.51) = $47,000

This does not represent a direct savings, but a *benefit whose value is $47,000 per year.* Using this information, the APWO calculated an efficiency - production/investment ratio (EPIR) according to the following formula:

$$EPIR = \frac{P.V.\ of\ Efficiency/Productivity\ Benefits\ Generated}{P.V.\ of\ Investment\ Required} \qquad (5.2)$$

The computation follows:

Total Recurring Annual Benefits	$ 47,000
25 Year (Table B) 10% Discount Factor	9.524
Total Discounted Benefits	$447,600

P.V. of Investment Required (See EXAMPLE 5-1)	$500,000
Efficiency - Productivity/Investment Ratio (EPIR)	0.90

In this particular case, the SIR and EPIR may be added together to obtain the total benefit/cost ratio (BCR). Thus:

SIR	0.57
EPIR	0.90
BCR	1.47

EXAMPLE 5B END

It should be noted that the benefit/cost ratio (BCR) was defined in the most general terms as the following:

$$BCR = \frac{Benefits}{Costs}$$ see equation (5.1)

It may be either dimensional or nondimensional, depending upon the terms in which the benefits are described. In the example above, the BCR was obtained as the sum of the SIR and the EPIR **only** because of two reasons:

a. The cost savings, efficiency/productivity increases, and project investment costs were all stated in terms of dollars, thereby, yielding a consistent dimensionality between the two benefit measures.

b. The two benefit measures (namely life cycle cost savings and increased efficiency/productivity) were distinct and nonoverlapping. This situation occurs frequently in MILCON projects whose goals are savings and productivity

5.2.3 OTHER QUANTIFIABLE OUTPUT MEASURES

Many investment decisions, especially in industrial areas, have a stated goal defined in terms of required output produced. The goal is not always quantified, but it is often is susceptible to quantification and thus provides a potential measure of benefits associated with the investment. Military Construction Project justification provides a definition of objectives and speaks to these goals, but, too frequently in general, rather than a specific manner. To be of real use to you, decision-makers, and budget reviewers, project backup data should relate goals to **quantifiable** levels of output where possible. These output measures may be used as a measure of benefits accruing from the project since, by definition, the justification (expected benefit) for a project **is**, in fact, some product or service (output) required to fulfill a mission requirement of the Navy.

A. ANNUAL BENEFIT/OUTPUT MEASURE:

This category of benefits applies most frequently to projects requiring a Type II economic analysis, in which alternative methods of satisfying a validated facility deficiency are compared. This comparison is facilitated by the computation of a form of benefit/cost ratio (BCR) for **each** alternative. The appropriate formulation of the BCR is as follows:

$$BCR = \frac{Annual\ Benefit/Output\ Measure}{Uniform\ Annual\ Cost} \qquad (5.3)$$

In this expression, the **Uniform Annual Cost** (UAC) is calculated as described in section 3.8 and the Annual Benefit/Output Measure (ABOM) is merely a quantified statement of expected yearly output for the alternative under investigation.

Some examples of ABOM's follow:

- number of aircraft overhauled per year
- number of liberty-man-days generated per year (Cold Iron Project)
- cubic meters of sewage treated per year
- number of sailors trained per year
- kilowatt-hours of electricity produced per year
- antennas overhauled and tested per year

This list is by no means exhaustive, but it should provide you with a good perception of what a **benefit measure** is. It should assist you in formulating specific benefit measures tailored to your particular analysis. The next example illustrates the methodology employed for such benefit measures.

*** EXAMPLE 5C : OPERATION NARF: BENEFIT COST RATIO CALCULATION ***

Due to a Chief of Naval Operations (CNO) sponsored regional consolidation, the Naval Air Rework Facility at Naval Air Station, Elsewhere, has been assigned the responsibility of providing all the corrosion control maintenance for Atlantic Fleet P-3 Orions in the Northeast. The public works planners have undertaken a detailed feasibility/concept study and have determined that there exist only two reasonable alternative methods of satisfying this operational requirement:

1. Modify existing unused hangar space to accommodate the corrosion control function. Expected economic life: 25 years.

2. Demolish old hangar space and construct a new, highly efficient. semi-automated corrosion control facility. Expected economic life: 25 years.

The planning staff investigated all the relevant data for these alternatives and provided the following analysis with the interest rate, i = 10%:

ITEM	MODIFY	NEW-CONSTRUCT
Recurring Annual Expenses (Personnel. O&M, etc.)	$100,000	$ 80,000
25 Year Discount Factor (10%)	9.077	9.07
P.V. of Recurring Cost	$908,000	$ 726,000
Investment (Time Zero)	$2,000,000	$2,600,000
Total P.V. Cost	$2,908,000	$3,326,000
Uniform Annual Cost (UAC) (Discount Factor 9.077)	$320,000	$ 366,000
Benefit (Output) (Maintenance Jobs Performed		

in terms of aircraft per year)	300/yr	375/yr
Benefit/Cost Ratio (BCR) (Completed Aircraft Maintenance Jobs per year per $1000)	0.94	1.02

Thus, although the new facility is more expensive. the benefit (output) per equivalent annual dollar expended is 8.5% higher than for the modification option, since:

$$1.02 / 0.94 = 1.085$$

*** EXAMPLE 5C END ***

The planning staff noted that the new construction alternative of Example 5-3 is likely to have a more favorable effect on increasing aircraft life. The total number of P-3 aircraft (A/C) in the Northeast fleet is 200. With new construction, a plane can undergo corrosion control about every 6.4 months. If it had modification, 8 months would be the minimum time between corrosion controls.

$$\text{NEW: } \frac{200\ A/C}{375\ A/C/Yr} = 0.533 \text{ Yr./Maint.} = 6.4 \text{ Months/Maint.}$$

$$\text{MODIFY: } \frac{200\ A/C}{300\ A/C/Yr} = 0.667 \text{ Yr./Maint.} = 8.0 \text{ Months/Maint.}$$

Although both maintenance cycles are acceptable to COMNAVAIRLANT, it was acknowledges that a more frequent corrosion control would be preferable due to the cumulative impact of salt air corrosion on airframes.

No significance should be attached to the fact that the computed BCR for the modification alternative is less than unity and the BCR for new construction exceeds unity. This is due entirely to the dimensional quality of the BCR and the arbitrarily chosen baseline (completed maintenance jobs per year per $1000). The only valid comparison is between the two ratio measures. Their relationship to unity is insignificant. (You should not confuse this situation with that of a non-dimensional BCR, such as the savings/investment ratio, in which the significance of unity is pivotal). Additionally, it should be noted that the various benefit/cost ratio techniques should be employed only when the order of magnitude of benefits and costs for alternatives under consideration is the same. If this is not the case, the BCR, like any other ratio measure, will obscure important information and can prove to be definitely misleading.

Other quantifiable output measure expected of an alternative may fall into various areas depending on the kind of operation, program, or system being analyzed. Some potential areas for quantifiable output measures are listed below. This list is not intended to be all inclusive. It is merely an effort to include all relevant benefits related to an alternative. Some of the areas where these other benefits appear are:

Acceptability: Consider the alternative in terms of whether it may interfere with the operation of parallel organizations or the prerogatives of higher echelon organization (consider customer satisfaction).

Accuracy: What is the error rate? Measure errors per operating time period, number of errors per card punched, errors per hundred records, errors per 100 items produced, etc.

Availability: When can each system be delivered/implemented; when is it need ed to meet proposed output schedules? What is the lead time for spare parts?

Environmental and Community Impact: (Refer to Subsection 5-3, Externalities.)

Integrability: Consider how the workload and product of the organization will be affected by the changes necessitated by modification of existing facilities or equipment, technical data requirements, initial personnel training, warehouse space for raw goods or parts storage, etc.

Maintainability/Controllability: Has adequate human factors engineering been performed? When the system does fail, is it difficult to repair because of poor accessibility? A useful measure could be based on the average man-hours necessary for repairs over a given time period, i.e., downtime, or the crew rate necessary to control and maintain the system.

Manageability: Consider how the workload of the organization will be affected by increased or decreased supervision or inspection time as a result of the system. Man-days could be used as a measure; differences in kind of personnel might be a factor as well as availability of type needed.

Morale: Employee morale - this could be measured by an opinion sample survey or by other indicators.

Operating Efficiency: At what rate does the system consume resources to achieve its outputs? For example, miles per gallon, copies per kilowatt-hour, mean days per shipment.

Production or Productivity: Number of commodities or items produced; or volume of output related to man-hours (i.e., number of components manufactured, hours flown or meals served; or number of items per man-hour).

Quality: Will a better quality product/service be obtained? Could quality be graded, thus measurable? If not, a description of improvement could be given. What is the impact of the varied quality?

Reliability: This describes the system in terms of its probable failure rate. Use ful measures may be mean-time-between-failure, the number of service calls per year, percent refusals per warehouse requests.

Safety: Number of accidents, hazards involved.

Security: Is security built in? Will more precautions be needed? More guards? Are thefts more likely?

5.2.4 Non-quantifiable Outputs:

Despite your best efforts to develop quantitative measures of benefits, you are sometimes faced with a situation which simply does not lend itself to such an analysis. Certain projects may provide benefits such as increased retention rates, improved morale, better troop habitability, and other similar qualitative advantages. Although they are most difficult to assess, these benefits should be documented and portrayed in the economic analysis.

In such instances, you must resort to written **qualitative** benefit descriptions. This is the least preferred method of analyzing benefits due to its inherent lack of precision. However, under certain conditions, this method must suffice; and, if the following guidelines are observed, qualitative statements can make a positive contribution to the analysis.

1. Identify all benefits associated with each alternative under consideration. Give complete details.

2. Identify the benefits common in kind but not in extend or degree among the

alternatives. Explain all the differences in detail.

3. Avoid platitudes. All prospective projects are worthwhile in that they support national defense, and statements to this effect are unnecessary. Platitudinous statements serve only to cloud the entire decision-making environment.

Following these general guidelines faithfully will help to enhance the difficult task of documenting these intangibles that are measured in non-economic terms like goodness, safety, or morale to enhance the value of benefit/cost analyses and make the final job of decision-making easier.

5.3 EXTERNALITIES

Usually, it is adequate to perform an economic analysis of a Navy decision solely from the viewpoint of the U.S. Government (as discussed in Subsection 4-9). The basic output of Navy investments, that is, national defense, is public good. Once it is provided to someone, it is provided to everyone in the country. However, other types of outputs may result from Navy investments. When computing the benefit/cost ratio, costs are usually regarded as the resources or **inputs** necessary to implement an alternative while benefits are regarded as results or **outputs** from implementing that alternative, so the BCR may be equivalently formulated as:

$$BCR = \frac{Benefits}{Costs} \qquad (5.4)$$

[Strictly speaking, a savings is not an output; it is a difference in inputs. However, a savings may be the result or yield of an investment, and it is useful to consider the SIR as a special case of the BCR as formulated in equation 5-4.] It should be obvious that outputs may be negative - they may be **disbenefits** rather than benefits.

Externalities (also referred to as external effects or spillovers) are an important class of outputs that may be benefits or disbenefits. Externalities are outputs involuntarily received or imposed on a person or group as a result of an action by another and over which the recipient has no control.

Air pollution is an example of an externality that is a disbenefit. The recipients accrue health, aesthetic, etc., disbenefits from a polluter for which they receive no compensation. For most facilities investment decisions, it is not necessary to analyze in depth externalities such as environmental impacts and community economic impacts as part of the economic analysis; these aspects of the alternatives are usually treated in detail as part of the Environmental Impact Assessment/Environmental Impact Statement process. However, the mention of anticipated impacts (both quantified and unquantified) in the economic analysis documentation is appropriate.

An example of an externality that should be fully treated in a facilities related economic analysis occurs in the comparison of providing medical care using a Government facility versus through Civilian Health and Medical Program of the Uniformed Services (CHAMPUS) payments. If the CHAMPUS alternative is chosen, the eligible people involved must pay the difference between the bill for the medical care and the (lower) CHAMPUS reimbursement provided. In this case, the differential cost which must be picked up by military personnel and their families should be estimated and provided as supplemental information in the economic analysis documentation. Similarly, in the comparison of MILCON versus BAQ for provision of housing, if BAQ payments are inadequate to obtain rental housing on the local market, the impact on the personnel involved should be estimated and provided separately from the NPV of costs to the Government. Such impacts are important to the Navy since they affect the effective compensation of military personnel.

5.4 BENEFIT DOCUMENTATION

There is no specific format prescribed for documentation of benefit analysis information. Format B, in Appendix B, for all intents and purposes, is a "blank page" on which you may enumerate any and all information you deem important. What is important is the content; and, in the case of benefits, content is critical.

No economic analysis is truly complete unless it addresses benefits attending all the alternatives considered.

One other simple documentation format suggested for summarizing benefits is a matrix of benefits versus alternatives. A list of all benefits can be made and easily compared among alternatives. This matrix is recommended as an additional summary of the outputs listed on Format B, paragraph 8. Format B is a good starting point for summarizing benefits. Whether you leave your analysis in the handwritten economic analysis format or use an economic analysis package (Such as PC-Econpack), writing down the summary first can aid in preparing your final version.

In addition to benefits, you should also include information concerning any negative aspects of alternatives, quantified where possible. This information is important to decision-makers and possibly to the community at large; and may be a determining factor in deciding between possible investment alternatives.

5.5 SUMMARY

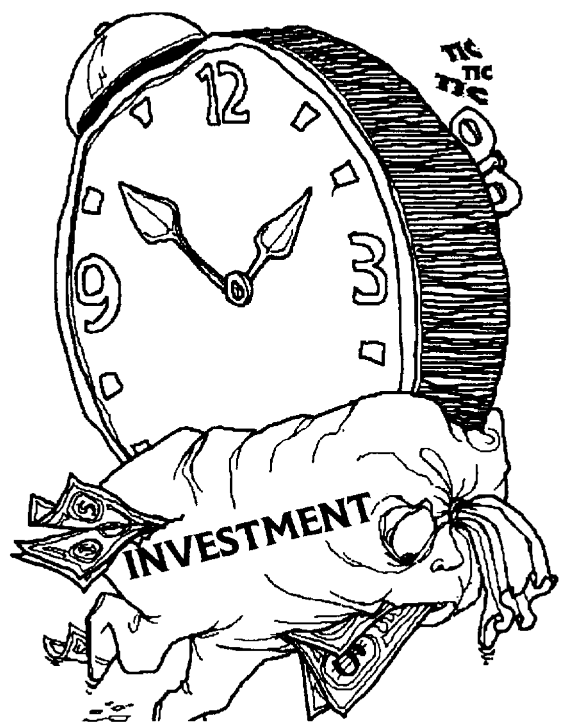
This section has outlined a number of techniques for evaluating and portraying benefits in a benefit/cost analysis framework. The techniques mentioned here are by no means exhaustive in their scope, but rather are suggestive of the approach you should follow in evaluating alternatives under consideration. You are encouraged to use not only the techniques mentioned, but also any others you may feel appropriate. If a unique methodology is employed, you should explain and justify your work thoroughly. Whatever methodology you employ, you are required to document your source data adequately. This mandate has been mentioned before with respect to costs, and it is just as fundamentally true for benefits.

TREATMENT OF INFLATION

Chapter 6

6.1 INTRODUCTION

The problem caused by inflation is not simply that future acquisitions are likely to cost more than today's estimates. There is also uncertainty as to how much more they will cost. It is this uncertainty which complicates economic analysis and financial planning. Cost estimation is complicated by a combination of two circumstances:



1. There is a time lag between cost estimation and actual expenditure.

2. Costs and prices change over time.

When a period of a continuing rise in general price levels is meant, this condition is referred to as **inflation**. When a period of falling price levels is meant, it is referred to as **deflation**. The term **cost escalation** is used to mean a rise in the price of a commodity or service in excess of inflation increases.

This chapter explores the nature of inflation-associated problems, outlines current policy guidance for addressing such problems in economic analysis, and develops analytical procedures consistent with this policy guidance. In practice, the treatment of inflation must be carefully addressed in two separate time periods:

a. The interval between the preparation time of the cost estimates and the "zero point" or **base year** of the analysis for the alternatives being considered.

b. The interval between the "zero point" and the endpoint of use (i.e the end of the project life of the alternatives).

As will be seen, a clear identification of these two distinct time periods is necessary, because discount factors, which incorporate a real opportunity cost of capital, are often applied to the cost projections over the entire project life.

6.2 MEASURING INFLATION AND COST ESCALATION

Changes in prices over time may be measured by a series of index numbers. An **index number** is a measure of relative value compared with a base figure for the same series. Most price indices consist of a number of components which are combined according to a set of weights. For example, a construction cost index might consist of various materials, equipment, and labor components. The prices of these components would be combined using weights which reflect the relative contribution of each component to total the construction cost. *The base period index value is usually set at 100.*

Figure 6A, on page 6-3, illustrates a type of price index - the Gross Domestic Product (GDP) Implicit Price Deflator. The GDP is the market value of the output of all goods and services produced by the nation's economy. The GDP Price Deflator is used to make comparisons of the GDP for different years; the index value is the weighted average of many price indices that relate to the components of GDP. The weights used to combine these indices are the relative expenditures in each component category in the current period. (Therefore, the weights are different for each period). Because it is so comprehensive, the GDP Price Deflator is widely regarded as the best single measure of changes in the general price level of the United States.

The most widely known index is probably the **Consumer Price Index** (CPI). It is changes in this index that are usually reported in the news media as changes in the "cost of living." *The CPI represents prices paid by urban wage earners for a "market basket" of consumer items.*

Many other indices are compiled and published by the U.S. Government and by private organizations for various purposes. Therefore, indices are available for measuring both trends in escalation for specific types of costs and trends in inflation on the general purchasing power of the dollar.

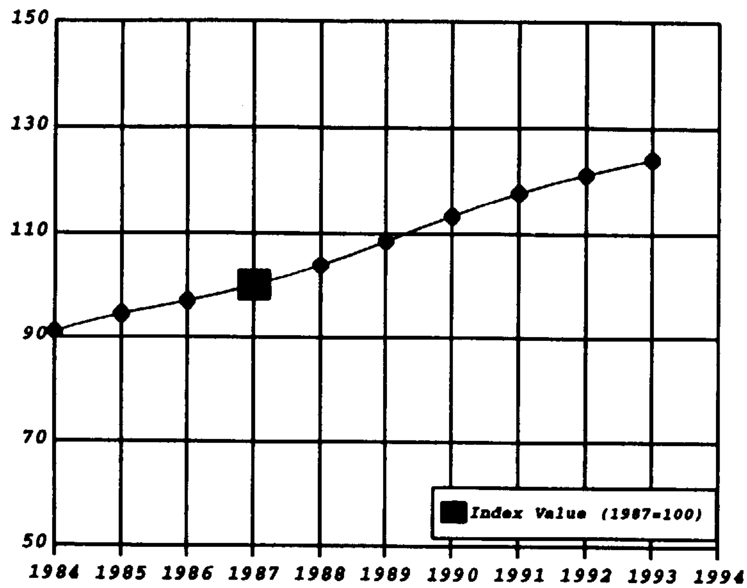


Figure 6A
Gross Domestic Product (GDP) Price Deflator Graph

6.3 NEAR TERM VERSUS LONG TERM ESCALATION

The expectation that costs will escalate applies not only to the near future, but to the indefinite future as well. In economic analysis, however, treatment of the two situations (near-term vs. long-term future) differs, as will be explained below. First, a definition of terms:

a. For the purpose of this discussion, **preliminary period** means the period from the estimate date to the analysis base year (zero point) inclusive. During this period, the project or program must be approved and funding must be authorized and appropriated. This must be done prior to the initial investment expenditure. Escalation from past or present estimates to the base year is discussed in this subsection.

b. The **long-term** future extends beyond the analysis base year through the final project year. It includes any necessary **lead-time period** (e.g., for a facility, the time between initial investment expenditure and the date of beneficial occupancy) and the **economic life** immediately following. The lead time and economic life together make up the **project life**, during which are incurred all recurring annual costs and any one-time cash-flows after the base year. Escalation of these costs is discussed in Section 6.4.

The time periods defined above are diagrammed in the illustrative time profile of Figure 6B. The figure shows a preliminary period of 4 years, a project lead time of 2 years (Project Years 1 and 2), and an economic life of 25 years (Project Years 3 through 27).

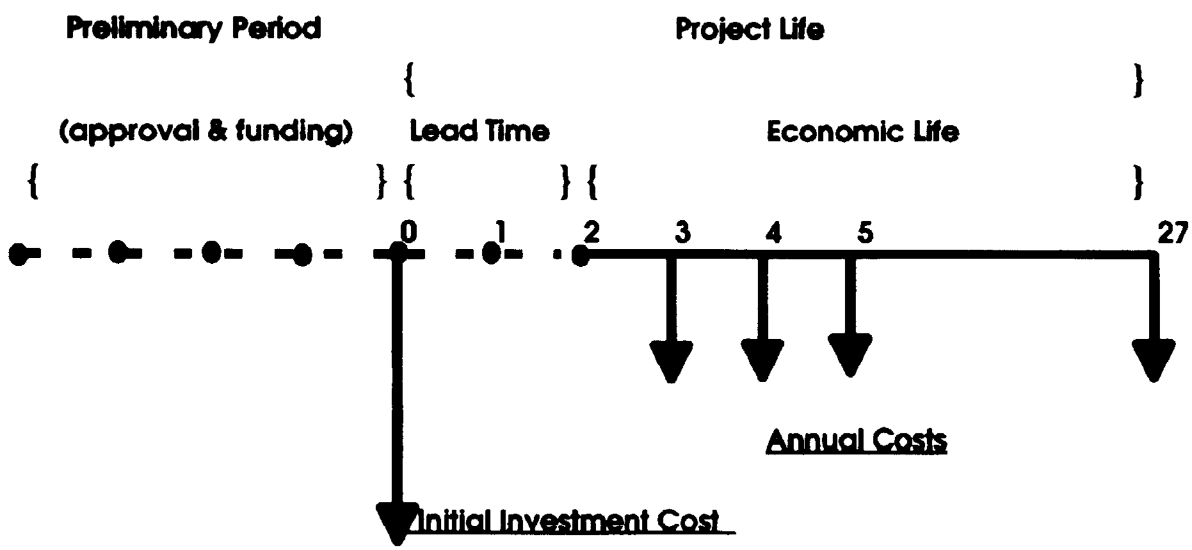


Figure 6B
General Cash Flow Diagram

The first task confronting you in the treatment of inflation is the escalation of costs from the time of their estimation point to the zero point or base year. For most economic analyses, the base year is the point in time of initial investment.

Choosing the initial investment year to be the base year has the useful aspect that the investment cost estimate can also serve as the budget request for that investment. However, for certain energy conservation proposals, the base year used for conducting the economic analysis has been directed in the Federal Energy Management Program (FEMP). Please refer to *Appendix E.*

For proposed military construction projects, the lag between time of preparation of an analysis and the obligation of initial funds can range up to three years or more. Over such periods, the question is usually not **whether** costs will escalate, but **how much** they will escalate. Furthermore, you may need to use historical cost information in the economic analysis. Estimates derived from historical data must be adjusted for any escalation that has already occurred, as well as for near-term future escalation.

Attempts are made to answer the "how much" question at various levels. The Office of the Secretary of Defense, Program Analysis and Evaluation (OSD, PA&E) regularly disseminates different short term cost escalation projections. They do this for military construction, family housing, research, development, test, and evaluation (RDT&E) investments as well as other major areas of procurement.

Within the Department of the Navy, this information is forwarded to all major commands from the Office of the Comptroller, Department of the Navy (NAVCOMPT). Its intended purpose is to provide escalation guidance for the preparation of the Program Objectives Memorandum (POM). The Naval Facilities Engineering Command Headquarters, (NAVFACENGCOMHQ), periodically disseminates construction cost escalation guidance to its Engineering Field Divisions (EFD's). The EFD's may further refine these estimates by factoring in changes in construction costs within their respective geographical areas.

Current general trends in construction costs are also monitored by such sources as the "Engineering News-Record," which publishes cost indices compiled on a monthly basis, and by "Construction Review," published by the Department of Commerce.

Officially disseminated cost projections should not be construed as anything more than a guideline. Where available, specific local data may be used for a more realistic cost model. All sources should be explicitly documented (see Chapter 4).

Projections of cost escalation may take the form of either percentages or cost indices. Table 6A shows some hypothetical projections with examples to illustrate how to treat each case.

Table 6A

Hypothetical Near-Term Escalation Guidance

(19x1-19x4 Historical, 19x4-19x8 Projected)

Escalation Indices

FY	RDT&E	MILCON	O&M	SHIPS
19x1	78.65	77.15	78.22	78.23
19x2	85.41	84.56	85.34	85.89
19x3	92.42	92.34	92.25	92.94
19x4	100.00	100.00	100.00	100.00
19x5	107.70	107.60	107.80	107.30
19x6	115.45	115.35	115.36	116.10
19x7	122.96	122.96	122.84	124.11
19x8	129.72	130.34	129.60	132.67

Annual Rates (Percentages)

19x1 - 19x2	8.4	9.6	9.1	9.8
19x2 - 19x3	8.2	9.2	8.1	8.2
19x3 - 19x4	8.2	8.3	8.4	7.6
19x4 - 19x5	7.7	7.6	7.8	7.3
19x5 -19x6	7.2	7.2	7.0	8.2
19x6 - 19x7	6.5	6.6	6.4	6.9
19x7 - 19x8	5.5	6.0	5.5	6.9

*** EXAMPLE 6A ***

Take FY 19x4 to be the present. Given the cost escalation percentage projections shown in Table 6A, escalate a construction cost estimate of $1.20M (FY 19x4 dollars) to the amount we would expect to have to fund in FY 19x8.

Solution: Using the Military Construction escalation percentage projection, the FY 19x4 estimate must be escalated 7.6% to produce a FY 19x5 estimate. which in turn must be escalated 7.2% to yield a FY 19x6 estimate, and so on. The final estimate is:

$$\text{FY 19x8 estimate} = (\$1.20\text{M})(1.076)(1.072)(1.066)(1.06) = \$1.56\text{M}$$

This calculation yields the escalated cost that is actually expected to occur. A simplistic approach of adding each year's percentage escalation is an error. It produces a four-year percentage escalation of 27.4% (i.e. = 7.6% + 7.2% + 6.6% + 6%) understates the final result of $1.56M. The following calculation shows the difference:

$$(\$1.20\text{M})(1.274) = \$1.53\text{M}$$

*** EXAMPLE 6A END ***

The higher the yearly escalation figures, or the longer the overall escalation period, the greater the distortion will be that is introduced by adding each year's percentage escalation to produce an aggregate figure. (This effect notwithstanding, when monthly escalation projections are given as percentages, they are usually understood to be summable to yearly projections. Thus 1% per month is equivalent to 12% per year).

In the special case for which the future escalation rate is expected to be a constant fraction, X percent per year, a cost estimate, C_o, is escalated for n years as follows:

$$C_n = C_o(1+X)^n \qquad (6.1)$$

Therefore, as shown above, yearly escalation factors must be multiplied in respect to each other, not just simply added together.

*** EXAMPLE 6B ***

Use the Table 6A Military Construction index to escalate a FY 19x4 construction cost estimate of $1.20M to the anticipated amount which will have to be paid in FY 19x7.

Discussion: Price or cost indices are numbers which are proportional to prices (or costs) in the stated periods. The Military Construction index suggests that a structure which costs $10.000 to build in FY 19x4 will cost $12.296 to build in FY 19x7. The difference is due solely to expected construction cost escalation between FY 19x4 and FY 19x7.

Solution: The FY 19x7 construction cost estimate is:

$$\$1.20M \times \frac{122.96}{100.00} = \$1.48M$$

The index values of 122.96 for FY 19x7 and 100.00 for FY 19x4 correspond to the percentage projections of Table 6A, since:

$$(100)(1.076)(1.072)(1.066) = 122.96$$

*** EXAMPLE 6B END ***

The next example illustrates the use of an index to escalate an estimate from prior year dollars to today's dollars.

*** EXAMPLE 6C ***

Again, taking FY 19x4 as the present, escalate a ship acquisition estimate of $250M in FY 19x2 dollars to the current budget year.

Solution 6C: Using the Ships index of Table 6A,

$$\$250M \times \frac{100.00}{85.89} = \$291.1M$$

*** EXAMPLE 6C END ***

In general, the following relationship can be used to determine costs using escalation indices:

$$\frac{C_1}{C_2} = \frac{X_1}{X_2}$$

Where: C_1, C_2 are costs based on any 2 years, and X_1, X_2 are their respective indices.

The previous techniques described must be applied to recurring annual costs as well as to investment costs for the period between the estimate date and the analysis base year. **All** cost estimates must be escalated to **constant dollars** of the analysis base year. The escalation of costs to be incurred **after** the analysis base year must be treated differently and are discussed in the next section.

6.4 TREATMENT OF INFLATION DURING THE PROJECT LIFE

The straightforward escalation techniques described in Section 6.3 cannot be directly applied to costs during the entire project life. The reasons are twofold:

1. Inflation guidance cited in Section 6.3 typically extends only a few years into the future. The Office of Management OMB Circular A-94 instruction (29 October 1992), provides new inflation rate guidance for economic analyses. The general inflation rate can be approximated by subracting the real interest rate from the nominal interest rate. You can do this because the nominal interest rate equals the estimated inflation rate plus the real rate.

2. Costs incurred during the project life of an economic analysis (i.e., from project year one onward to project year end) are discounted to their "present- value" (i.e.. Year Zero equivalents) using either a real discount rate for constant dollar estimates or a nominal discount rate for outlay or current dollar estimates.

Care should be taken in using the appropriate rates from OMB Circular A-94, Appendix C, revised annually (i.e., in February).

Nominal Discount Rates (also called Market Rates) should be used for discounting current dollars cash flows which includes inflation, as found in lease purchase alternatives.

Real Discount Rates should be used for discounting real or constant-dollar cash flows as in most defense cost-effectiveness studies. A Real interest rate is one that has been *adjusted* to remove the effect of expected inflation. The real rate can be approximated by subtracting the inflation rate from the nominal rate.

Either approach should give consistant equivalent results and ranking of alternatives. *Do not mix* nominal rate discounting on current dollars cash flows with real rate discounting on constant dollar cash flow in the same economic analysis study. If any alternative has current dollar cash flows, convert all other alternatives to current dollars by applying an inflation factor and solve each net present value by using the nominal discount rate.

*** EXAMPLE 6D ***

Consider a proposed project with the costs shown in Figure 6D. The $1M and $100K are costs estimated in constant dollars, but the annual recurring maintenance cost is estimated to inflate at 3% each year. Use 1995 as the zero base year.

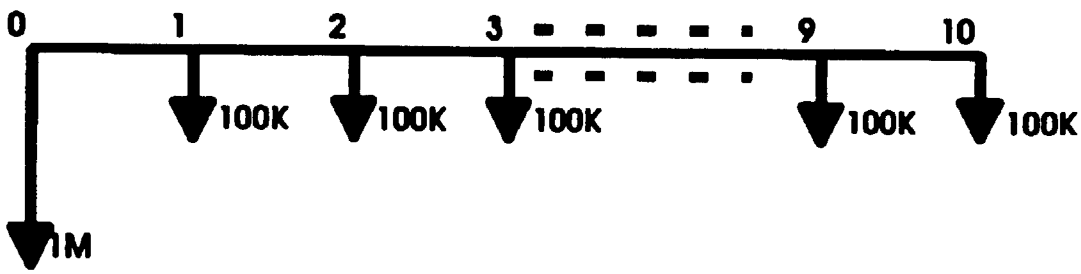


Figure 6D
Cash Flow Diagram

Outlay Dollar Analysis:

Since the recurring maintenance costs are given in outlay dollars with a 3% projected inflation rate during project years (1-10); then an **outlay dollar analysis** must be completed. Therefore, as shown in Table 6B below, the annual recurring cost first have to be inflated to outlay dollar cash flows and then discounted at the 6.8% nominal discount rate currently prescribed by OMB Circular A-94.

ASIDE NOTE: This 6.8% rate has an expected inflation estimate of 2.25% compounded within it. Also, it should be noted that if linear interpolation of the OMB rates is taken, the nominal rate would be 6.7% rather than 6.8% for 10 years. For Navy analyses, rounding to the higher rate is preferred for consistancy, simplicity, and assured confidence in the results.

Table 6B
Outlay Dollar Cash Flow

NMBR OF YRS	FISCAL YEAR	INFLAT FCTR	TOTAL INVEST	MAINT CST RECUR	TOTAL OUTLAY	DISC FCTR 6.80%	PRESENT VALUE	CUMULATIVE NPV
0	1995	1.0000	$1,000,000	$100,000	$1,100,000	1.0000	$1,100,000	$1,100,000
1	1996	1.0300		103,000	$103,000	0.9363	96,442	$1,196,442
2	1997	1.0609		106,090	$106,090	0.8767	93,010	$1,289,452
3	1998	1.0927		109,270	$109,270	0.8209	89,699	$1,379,151
4	1999	1.1255		112,550	$112,550	0.7686	86,509	$1,465,660
5	2000	1.1593		115,930	$115,930	0.7197	83,433	$1,549,094
6	2001	1.1941		119,410	$119,410	0.6739	80,466	$1,629,560
7	2002	1.2299		122,990	$122,990	0.6310	77,602	$1,707,161
8	2003	1.2668		126,680	$126,680	0.5908	74,841	$1,782,002
9	2004	1.3048		130,480	$130,480	0.5532	72,178	$1,854,180
10	2005	1.3439		134,390	$134,390	0.5179	69,607	$1,923,787

If the projected inflation rate of 2.25% (which is the prescribed 1993 OMB estimate) was allowed here instead of 3%, the results would be slightly different. Using constant dollar estimates at the 1993 prescribed discount rate of 4.5% could be used and the total net present value (TNPV) would be calculated in constant dollars as:

$$TNPV = \$1M + 100 (7.913) = 1.791$$

This (except for rounding) would be the same asnwer when substituted in Column 3 of Table 6B a 2.25% inflation rate factor instead of 3%.

*** EXAMPLE 6D END ***

NOTE: The pattern of annual costs can be non-uniform for reasons other than inflation. Maintenance costs may increase with age, for example, or periodic future investment outlays may be necessary for repair or replacement of physical assets. A "learning curve" effect may reduce costs for a new type of operation, or, growth in a requirement for services may increase real costs over time. To the extent that these circumstances can be foreseen and justified, they should be reflected in basic annual cost estimates and cash-flow diagrams.

6.5 OUTLAY DOLLAR ANALYSES

As seen from example 6D, an outlay dollar analysis should be completed when cost estimates of cash flows are estimated in current (or outlay) dollars and/or when inflation is used in the economic analysis. These type of analyses must be discounted at the nominal (or Market) discount rate as projected in OMB circular A-94 for the appropriate time frame. Navy economic analyses will use OMB prescribed 30 year term nominal or real discount rates only for a more responsible comparison between alternatives. The current nominal discount rate is 6.8 % and the real rate is 4.5% until February 1994, per OMB curricular A-94.

6.6 INFLATION RATES AND THE DISCOUNT FACTOR

The nominal discount factors (prescribed in OMB Circular A-94) adjusts only for the expected general inflation rate. If an annual cost (or cost component) is not expected to escalate at or near the general inflation rate or much higher, all cost estimates should be converted to outlay dollar estimates and the nominal discount rate should be used.

Often, long-term general price changes cannot be predicted with significant degree of reliability, the best estimate of long term inflation is from the OMB Circular A-94.

The term "real rate of return" means that the decreasing purchasing power of money (due to inflation) has been taken into account. If, in fact, such a stability exists, then there is a reasonable assurance that the real discount factors do adjust for general price increases, even though future general inflation rates are not specifically known. A more complete explanation is difficult without considering the derivation of the officially prescribed discount rate.

The OMB Circular A-94 has listed different rates of inflation for nominal and real rates of return. The **nominal** rate of return is basically the market rate of return including inflation. If you subtract the effect of inflation away from the market rate, the remainder is the real rate of return. The **real** rate of return is the nominal rate of return **minus** inflation. The formula for calculating the nominal rate of return is:

$$\text{Nominal Rate} = [(1 + i) \times (1+n) - 1] \qquad (6.2)$$

Where: i = the real rate of return
n = the general inflation rate

For example: The current 1993 OMB Circular A-94, the rates at a 30 year term

$$i = 4.5\% \quad \text{and} \quad n = 2.25\%$$

Then:

$$\text{Nominal Rate, } n = [(1 + 0.045) \times (1 + 0.0225) - 1] = (1.045)(1.0225) - 1$$

$$= 0.0685 \text{ or } 6.85\%$$

NOTE: Example 6D showed that discounting constant dollar cash flows with a real rate of return gives the same result as discounting current dollar cash flows with a nominal rate of return if the costs escalate at the same rate as the general economy.

6.7 SUMMARY AND COMMENTS

Use of the real discount rate simplifies the treatment of inflation in an economic analysis because the discount factors implicitly adjust for the general inflation rate, "whatever it may be". The **key points** for you to keep in mind are:

1. The economic analysis should be performed in terms of constant dollars of the analysis base year unless outlay dollar cash flows are estimated.

2. When the base year is the same as the year of initial investment, current cost estimates must be escalated to the base year. Such escalation must **include both** general inflation and real cost increases.

3. If it is expected that a particular annual cost element will experience long-term escalation behavior different from the OMB prescribed general inflation rate, current or outlay dollar comparison should be performed.

4. Differential inflation may be handled computationally in two steps, first by inflating or escalating costs to current dollars and then second by discounting at the nominal rate. It should be remembered that escalating and discounting of costs work at cross purposes. Costs are discounted because money commands a price for its use. Discount factors reduce future cash flows to present value equivalents in spite of inflation, not because of it. The higher the rate at which a cost is escalated, the less the impact of discounting.

5. The pattern of annual costs can be non-uniform for reasons other than inflation; i.e. maintenance costs may increase with the age of a physical asset or periodic maintenance costs may be incurred. Real cost variations should be reflected in the year-by-year cost estimates used in an outlay dollar analysis and discount at the prescribed nominal rate.

6. Because projections of future cost trends are very uncertain, you should perform a base-line analysis without assumptions of general inflation and another with outlay dollars using your best projections of any cost changes.

7. The fact that the effects of general inflation are incorporated in the real discount rate simplifies your work. It makes it unnecessary to project long term inflation rates as long as it can be assumed that all costs will escalate at about the general inflation rate.

8. For analyses with leases on lease-purchase alternatives with outlay dollar or nominal cash flows, always use nominal discount rates in accordance with the current OMB Circular A-94 guidance.

9. The use of escalation for energy costs is described in *Appendix E.*

SENSITIVITY ANALYSIS

Chapter 7

7.1 DEALING WITH PROBLEMS OF UNCERTAINTY

> *"If a man will begin with certainties, he shall end in doubts; but if he will be content to begin with doubts he shall end in certainties."*
> - Sir Francis Bacon

This quotation reflects the problem that analysts face dealing with real world problems of uncertainty. Economic analyses are built from data as a house is built of bricks, but an accumulation of data is no more an analysis than a pile of bricks is a house. Regardless of the care devoted to data collection, there is always a distinct possibility that the data will be misleading. Estimates and forecasts may be inaccurate. Data may be accurate but descriptive of a different situation. When data is in doubt, as is often the case, you must consider the consequences of its use.

Data analysis and forecasts represent your best judgment on the way in which events will occur in the future. While there are always uncertainties about the future, you should still make your best estimate and base conclusions upon them. Nevertheless, a decision among alternatives often can be made more confidently if the final reviewer can see whether the conclusion is sensitive to moderate changes in data forecasts. Sensitivity analysis provides this extra dimension to an economic analysis.

7.2 WHAT IS SENSITIVITY ANALYSIS?

Since uncertainty is almost universally present in economic decision-making, some type of sensitivity analysis should always be considered when performing an economic analysis. When doubts and uncertainties enter an analysis, it is necessary to test the sensitivity of the results to the cost estimates or other assumptions in order to portray a complete picture. The sensitivity of a decision is investigated by inserting a range of estimates for critical elements; a sensitivity analysis measures the relative magnitude of change in one or more elements of an economic comparison that will re-order the ranking of alternatives.

In preceding sections, examples involved choosing among alternatives in which a single set of cost estimates were specified. When conducting an economic analysis, the stated cost estimates represent someone's best judgment on the way in which expected future cash-flows will occur.

Future costs, salvage value, economic life and other data are estimates based on reasonable expectations. However, these are rarely known with complete certainty, and the degree of uncertainty generally increases with the time interval between the estimate and the occurrence. In addition to recognizing uncertainty during the estimating process, it is prudent to examine how one or more of the variables will affect the choice of alternatives if values for these variables would be higher or lower than the baseline estimate (best estimate).

It is obvious that if some cost elements were sufficiently different, the ranking of alternatives would be different. On the other hand. radical changes could be made to other elements without changing the decision. For example, if one particular element can be varied over a wide range of values without affecting the decision, then the decision is said to be **insensitive** to uncertainties regarding that particular element. However, if a small change in the estimate of one element will alter the decision, the decision is said to be very **sensitive** to changes in the estimate of that element.

An established semantic tradition partitions sensitivity analysis into two branches, risk analysis and uncertainty analysis. **Risk analysis** addresses variables which have a known (or estimated) probability distribution of occurrence; here applied probability and statistics techniques may be used to great advantage. **Uncertainty analysis** concerns itself with situations in which there is not enough information to determine probability or frequency distributions for the variables involved.

When contemplating a sensitivity analysis, you should begin by asking yourself the following questions:

1. Which input(s) should be tested?

2. Once the test variables have been selected and a sensitivity analysis has been performed, how should the results be formatted for submission?

The watchword in sensitivity analysis is **sensibility**. If the preference ranking of alternatives establishes one option as markedly superior to the rest, you should not be overly concerned about the sensitivity of this choice to nominal variations in the values of input parameters. It is when an economic choice is not the clear "put in front" decision that further investigation is most appropriate.

The application of sensitivity analysis is recommended as an iterative process to refine the analysis. Rather than developing a formal theory, the remainder of this chapter illustrates the rationale and basic techniques most commonly applied in sensitivity analysis through a series of examples.

7.3 ONE VARIABLE UNCERTAINTY TESTS

First, sensitivity analysis should be applied to the dominant cost factors (i.e.. those having the greatest impact on the total net present value (NPV) costs and/ or benefits of a given alternative). Many of the input cost factors are linear. Using the best estimate (or expected value) as a starting point, it is easy to derive another point or points and to graph the relationships between each input factor and the total NPV, as shown in Example 7A below.

*** EXAMPLE 7A OPERATION POWER PLANT ***

Uncertainty Analysis - Alternative B: (c.f. Example 5J) is plotted as a function of varying levels of inputs. The inputs specifically considered are initial construction (acquisition) cost, recurring annual cost, and project life, for which the original values were $125M, $7M, and 28 years, respectively: As can be seen, within a given percentage range, fluctuations in construction cost induce correspondingly greater changes in the total NPV cost than do fluctuations in recurring annual cost or economic life. In this sense, construction cost dominates the other two input variables.

Discussion 7A:

1. Note that the NPV cost, when plotted in figure 7A as a function of construction cost, yields the steepest of the three curves (see Figure 7A). It is true in general that the steeper the curve, the more dominant is the corresponding input variable. (As you gain experience, you should find that in many cases you will be able to identify the most dominant variables without actually plotting curves.)

2. Nonetheless, construction cost is not necessarily the most critical input variable in this example. Suppose. e.g., that the actual construction cost is expected to be within 10% of the $125M estimate but that the range of uncertainty in the $7M recurring annual (O&M) cost estimate is ± 50%. Scrutiny of Figure 7A indicates that, under these conditions, the potential impact of recurring annual cost on total PV life cycle cost is actually greater. Thus, the choice of input variable(s) for sensitivity testing may depend not only upon relative dominance, but also upon the degree of confidence which can be placed in the estimate(s).

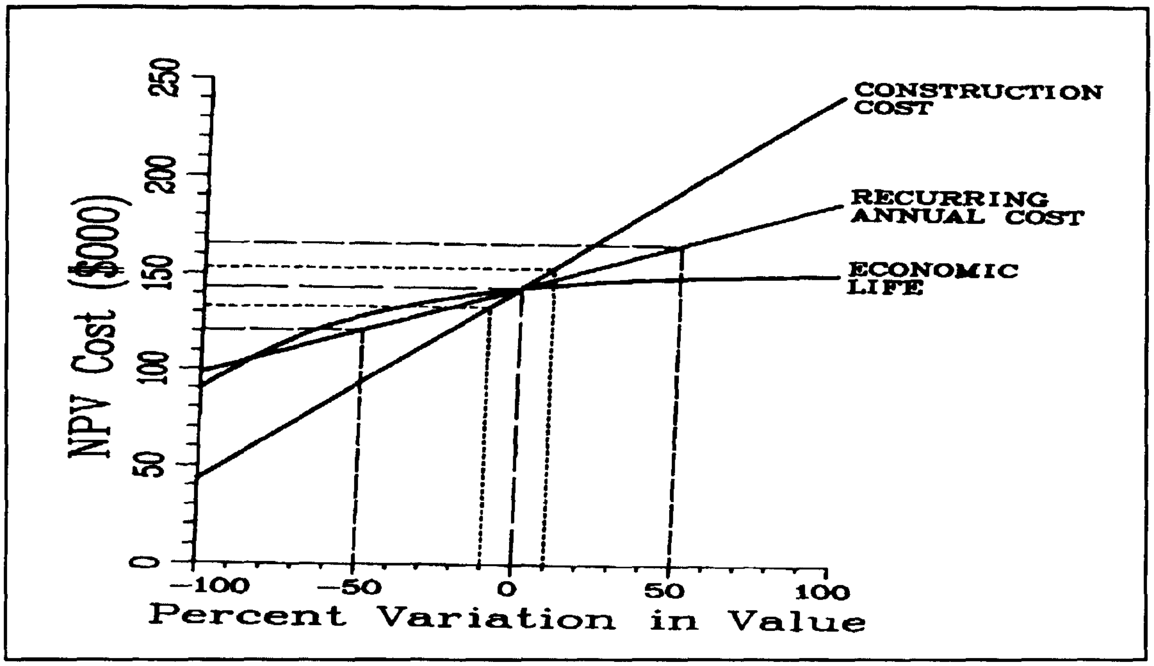


Figure 7A
Example 7A Graph

You should observe that while total PV life cycle cost is a linear function of construction cost and annual cost, it is a nonlinear function of project life. This is because of the diminishing trend of Table A discount factors as we proceed further into the future. Due to the slope of the curve, project life is more dominant than annual recurring cost in the approximate range -100% to -50% (0-10 years), and less dominant thereafter (because the curve is less steep). In fact, the curve tends to a horizontal asymptote as it proceeds to the right, as can be seen in Figure 7A.

It should be further noted from Figure 7A that increasing the project life has but a slight impact on the total PV life cycle cost. This situation is in fact typical, and it bears implications for project-life guidelines. The contention is sometimes made that a new permanent building should have a project life of 40 or 50 years instead of the 25 years prescribed earlier. Such an assertion fails to acknowledge the constraint of mission life on project life - it is simply unrealistic to project a requirement much more than 25 years into the future. Due to obsolescence or changing criteria, technological life may be a constraining factor also.

Quite apart from this consideration, Figure 7A suggests that the sheer mathemat-

Quite apart from this consideration, Figure 7A suggests that the sheer mathematics of discounting makes 25 years a practical choice for the maximum project life allowable. Relative to a conservative interest rate the difference between total present-value life cycle costs computed for 25-year life and costs computed over any longer period is not significant.

*** EXAMPLE 7A END ***

Another example of a one variable uncertainty analysis is discussed in Example 7B (below), which portrays a range of **Savings to Investment Ratio** (SIR) values over the range of uncertainty.

*** EXAMPLE 7B: OPERATION ALTER Sensitivity Analysis ***

This is an uncertainty analysis of Example 3F OPERATION ALTER SIR Calculations. Determine how high the annual costs of the proposed alternative (B) can be before it becomes "unprofitable" to undertake the project. Use a 10% for the interest rate, i.

Solution 7B: The data from Example 3F is redisplayed below:

Economic Life . . . . 20 years

Alternative A (Status Quo):

Investment Cost . . . . .none
Recurring Annual Cost . . . $500K

Alternative B (Proposed):

Investment Cost $1000K
Recurring Annual Cost . . . $350K

Annual savings of B relative to A were thus $500K - $350K = $150K, and the discounted savings/investment ratio over the 20 year economic life was computed as follows:

$$\text{SIR} = \frac{\$150\text{K}(8.514)}{\$1000\text{K}} = \frac{\$1277.1\text{K}}{\$1000\text{K}} = 1.28$$

In order to test the sensitivity of the savings/investment ratio to the annual cost in Alternative B, we represent that cost as a variable (say X) and rewrite the SIR equation as follows:

$$SIR = \frac{(\$500K - x)(8.514)}{\$1000K}$$

The minimal SIR necessary for "profitability" of the proposed alternative (B) is SIR = 1.0. Solving for X, when SIR = 1.0 gives:

$$1 = \frac{(\$500K - x)(8.514)}{\$1000K}$$

$$(\$500K - x)(8.514) = \$1000K$$

$$\$500K - x = \frac{\$1000K}{8.514} = \$117.5K$$

$$x = \$382.6K$$

Thus the proposed alternative is economically worth undertaking so long as its annual costs does not exceed $382.6K.

Discussion 7B : The above sensitivity analysis may easily be expanded into a graphical portrayal of the SIR function over the entire range of possible Alternative B annual costs.

The rewritten SIR equation is a linear equation, and two points on its graph are already known:

X = $350.0 K, SIR = 1.28

X = $382.6 K, SIR = 1.0

A plot of SIR and the annual cost of Alt B is shown in Figure 7B.

The minimal level of profitability (SIR=1) is shown by the dashed horizontal line. The SIR's below this line (i.e., in the shaded region) do not warrant funding of the project. This type of graphical presentation is often a very effective way to communicate sensitivity analysis information to the decision-maker.

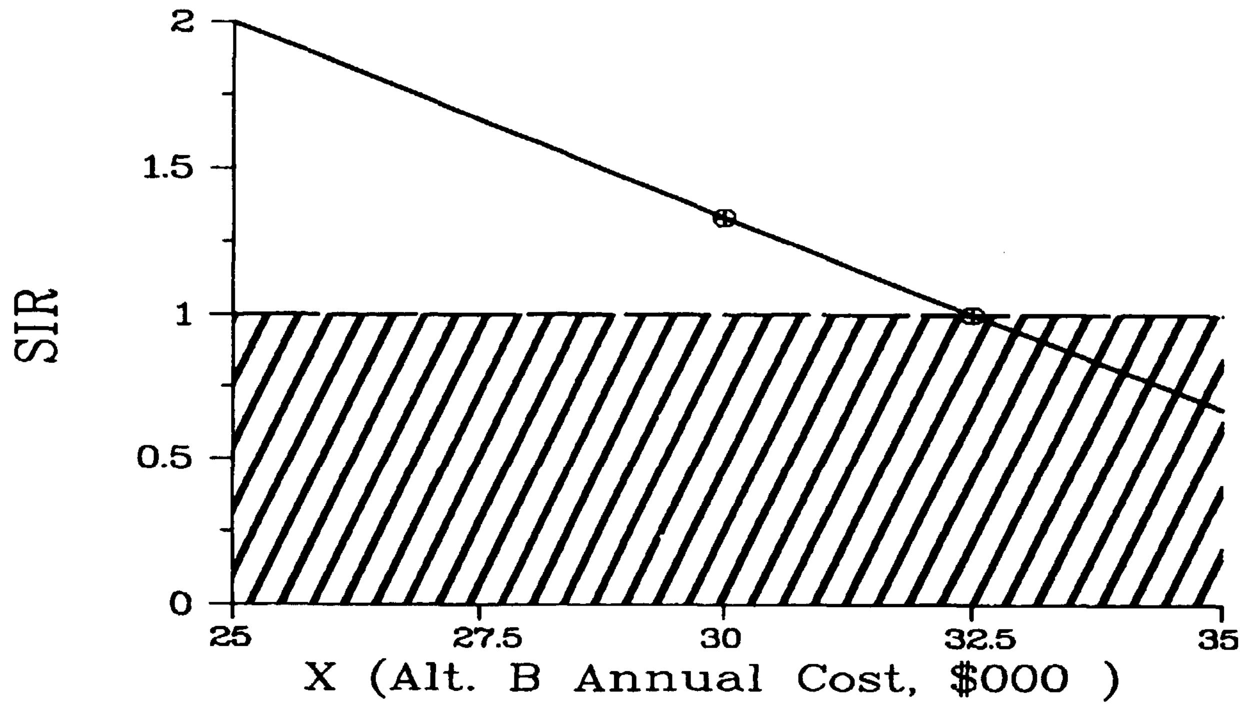


Figure 7B
Example 7B Graph

*** EXAMPLE 7B END ***

7.4 BREAK-EVEN ANALYSIS

The break-even type of analysis is useful in economic analysis when uncertainty is concentrated in only one of the aspects which must be forecast. When a large change in the value of a factor will not change the choice of alternative, the decision is not sensitive to variations in the value of this factor. Break-even calculations may then be a simple means of verifying the ranking of alternatives.

A break-even calculation is made by equating the costs of alternative courses of action, keeping the uncertain factor as an unknown in the equation, and solving for the value of the unknown factor which will make the alternatives equal.

If the expected range of the unknown factor is definitely larger or smaller than the break-even value, the ranking of alternatives is insensitive to that factor and the lower cost alternative can be selected with a high degree of confidence and without carefully estimating values for the insensitive factor. The wide applicability of break-even analysis can be seen in the following three examples.

*** EXAMPLE 7C: THE ACME TESTING COMPANY ***

The Acme Testing Company requires a new testing device. It is considering a semi-automatic device (A) or a fully automatic model, device (B).

Device (A) will cost $8,000, will have an expected life of 15 years with no salvage value, and will have maintenance and operating costs of $2,000 a year, plus testing use costs of $0.20 per item tested.

Device (B) will cost $20,000, will have an expected life of 10 years with no salvage value, and will have maintenance and operating costs of $3,000 a year, plus testing use costs of $0.08 per item tested.

NOTE: The R & D Testing Department is very uncertain as to the annual number of tests that will be made. Furthermore, use 10% for the interest rate, i.

Solution 7C: An equal cost analysis may be helpful in this case. At what testing volume will the annual costs be the same, regardless of whether the semi-automatic or fully automatic device is purchased?

Let N represent the number of tests made. Equivalent uniform annual cost (UAC) for using device (A) is:

$$UAC_A = \frac{\$8{,}000}{B15} + \$2{,}000 + \$0.20N$$

Where: B_{15} is the Table B factor for 15 yrs.

The annual cost for (UAC_B) using device (B) is:

$$UACB = \frac{\$20{,}000}{B_{10}} + \$3{,}000 + \$0.08N$$

Where: B_{10} is the Table B factor for 10 years.

Equating the annual costs gives:

Annual Cost of Device (A) = Annual Cost of Device (B)

$$\frac{\$8.000}{7.606} + \$2000 + \$.20N = \frac{\$20.000}{6.145} + \$3.000 + \$.OBN$$

$$N = 26,691$$

Discussion 7C: Equivalent uniform annual cost will be the same using the semi-automatic or the fully automatic testing device if the number of tests performed per year is 26,691. If more than 26,691 tests are expected, the fully automatic device is more economical. If less than 26,691 tests are expected, the semi-automatic device is more economical.

The headquarters' best estimate of future annual testing requirements is between 60,000 and 120,000 items per year. Therefore, despite the uncertainty and wide range of estimates, the more economical alternative is device (B) for fully automatic testing.

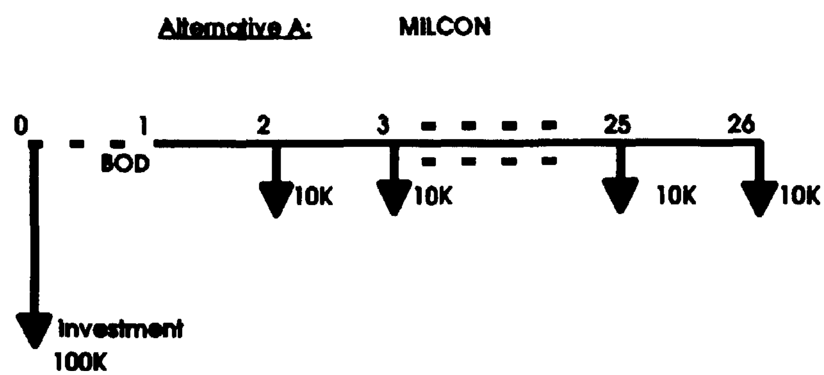
*** EXAMPLE 7C END ***

*** EXAMPLE 7D : Operation COMPARE ***

Problem: For the MILCON and LEASE options diagrammed in Figure 7C determine:

a. which alternative has the lesser total NPV cost over the indicated economic life of 25 years;

b. the break-even economic life. i.e., the period over which total NPV costs for the two alternatives would be the same.



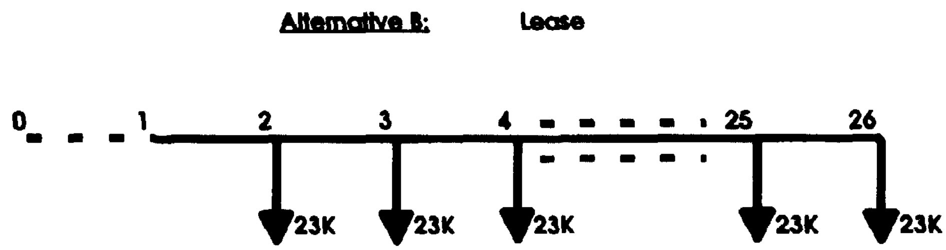


Figure 7C
Cash Flow Diagrams for Example 7D

Discussion 7D: The cash-flow diagrams of Figure 7C reflect an increasingly accepted treatment of lead time. The presumption here is that in the MILCON alternative, at least a year will elapse between obligation of construction funds and the facility's beneficial occupancy date (BOD). Accordingly, the **baseline** is taken as the time of obligation, and a full year intervenes before recurring annual costs begin. (i = 10%)

NOTE (For Example 7D): The economic life of the LEASE has been slipped back a year to coincide with the delayed economic life of the MILCON alternative. This does not necessarily represent the actual situation - it might well be possible to negotiate a lease for occupancy during the first year. The slippage is purely an analytical device which indirectly penalizes that alternative having the longer lead time (in this case MILCON) but will make the analysis more equitable. The penalty is exacted by the application of smaller discount factors to the LEASE costs (Years 2-26 instead of Years 1-25), thereby making the LEASE alternative appear relatively more favorable.

Solution 7D: Total NPV costs for the two alternatives are as follows:

$$\begin{aligned} \text{NPV (MILCON)} &= \$100K(1.000) + \$10K(9.161 - 0.909) \\ &= \$182.5K \end{aligned}$$

$$\begin{aligned} \text{NPV (LEASE)} &= \$23K(9.161 - 0.909) = \$23K(8.252) \\ &= \$189.8K \end{aligned}$$

(Here 9.161 and 0.909 are the 26th and 1st-year cumulative discount factors, respectively, taken from Table B, Appendix C.)

One method of estimating the break-even economic life is to adopt a graphical approach. Some additional sample NPV calculations are presented below:

20-YEAR ECONOMIC LIFE

$$\begin{aligned} \text{NPV (MILCON)} &= \$IOOK(1.000) + \$10K(8.649 - 0.909) \\ &= \$177.4K \end{aligned}$$

$$\begin{aligned} \text{NPV (LEASE)} &= \$23K(8.649 - 0.909) = \$23K(7.740) \\ &= \$178.OK \end{aligned}$$

15-YEAR ECONOMIC LIFE

$$\begin{aligned} \text{NPV (MILCON)} &= \$100K(1.000) + \$10K(7.824 - 0.909) \\ &= \$169.2K \end{aligned}$$

$$\begin{aligned} \text{NPV (LEASE)} &= \$23K(7.824 - 0.909) = \$23K(6.915) \\ &= \$159.OK \end{aligned}$$

10 - YEAR ECONOMIC LIFE

$$\begin{aligned} \text{NPV (MILCON)} &= \$100K(1.000) + \$10K(6.495 - 0.909) \\ &= \$155.9K \end{aligned}$$

$$\begin{aligned} \text{NPV (LEASE)} &= \$23K(6.495 - 0.909) = \$23K(5.586) \\ &= \$128.5K \end{aligned}$$

Observe that the economic decision changes (e.g., break-even point occurs) somewhere between 15 and 20 years. The results of these NPV calculations are plotted in Figure 7D. When the cost points for each alternative are joined by smooth curves, the impact of economic life can readily be diagnosed. It is apparent from the figure that the break-even period is approximately 19.6 years.

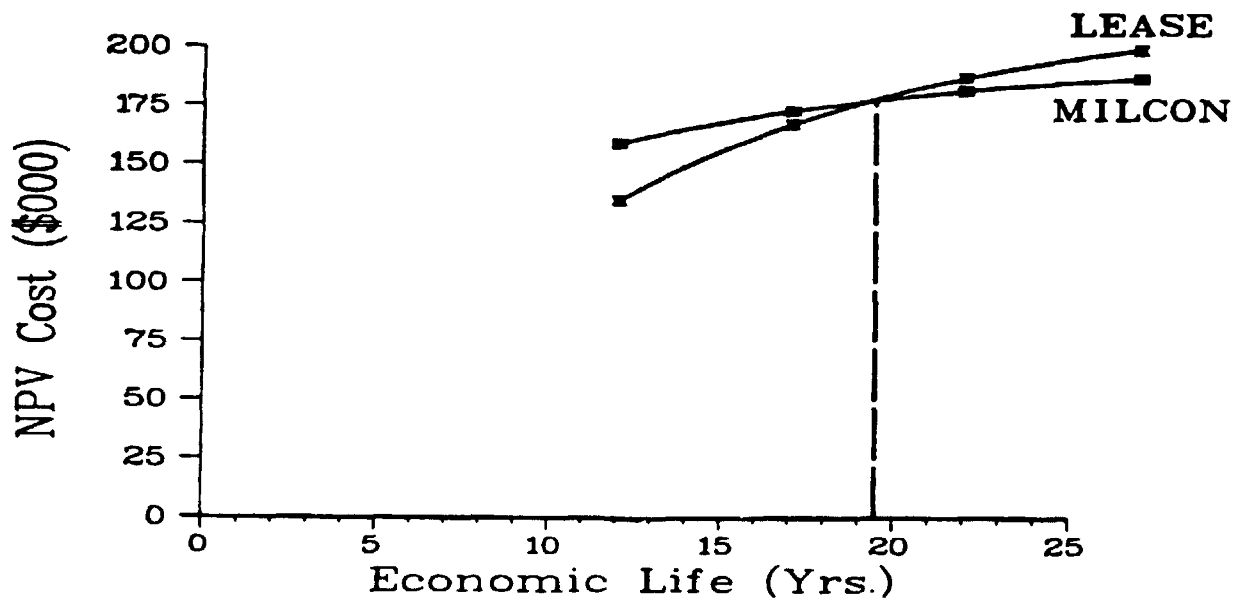


Figure 7D
Graph for Example 7D

Remarks 7D: An algebraic approach could also be employed to determine the break-even economic life. If N denotes the duration of project life in years, then for break-even we must have equivalence of present-value life cycle costs as expressed in the following equation:

NPV (MILCON) = NPV (LEASE)

$$\$100K + \$10K(B_N - B_1) = \$23K(B_N - B_1)$$

Here B_1 and B_N are the 1st and Nth-year Table B factors (Appendix C), respectively.

Substituting $B_1 = 0.909$ and solving for B_N yields

$$(\$23K - \$10K)(B_N - 0.909) = \$100K$$

$$(\$13K)(B_N - 0.909) = \$100K$$

$$B_N - 0.909 = \frac{\$100K}{\$13K} = 7.692$$

$$B_N = 7.692 + 0.909 = 8.601$$

Now from Table B, Appendix C,

$$B_{20} = 8.514. \qquad B_{21} = 8.649$$

so the project life N is between 20 and 21 years. On the basis of a linear interpolation between these two factors, we arrive at the approximation:

$$N = 20.6 \text{ years.}$$

Subtracting the one-year lead time from this figure gives 19.6 years, which is in good agreement with the graphical estimate of economic life in Figure 7D.

*** EXAMPLE 7D END ***

7.4 BREAK-EVEN ANALYSIS (CONTINUED)

The portrayal in Figure 7D is a logical sequel to a dominance test such as that shown in Figure 7A. Figure 7A examines the sensitivity of a single alternative to variations in several inputs. In Figure 7D, one input has been selected (either because of its dominance or extreme uncertainty in its estimate, or perhaps both), and the sensitivities of both alternatives to this input are plotted on the same graph. The intersection of the two curves in Figure 7D is known as a **decision point** or **break-even point**. The same type of graphical approach is often used in cost/volume/profit analysis for a private firm.

If the economic life is to be 25 years, as originally assumed in Example 7D, then MILCON is preferable to the LEASE alternative. It might be, however, that a general climate of base closures and troop strength reductions would raise some doubt about the validity of a 25-year facility requirement.

If there is a possibility that the economic life will be appreciably less than 25 years, then, on the basis of the information portrayed in Figure 7D, one might seriously consider leasing or something other than MILCON. Another application of break- even analysis, to verify a benefit/cost ratio with uncertain annual cost, is shown in Example 7E.

*** EXAMPLE 7E : Operation NARF: Break-Even Analysis ***

Problem: Perform a sensitivity analysis of the recurring-annual cost total for the NEW-CONSTRUCT Alternative of Example 5C, and determine the break-even point.

Solution 7E: The benefit/cost ratio (BCR) for the MODIFY alternative was found to be 0.94. The essential data for the NEW-CONSTRUCT alternative is reproduced below:

Economic Life	25 years
Investment Cost (Year 0)	$2,600K
Recurring Annual Expense	$ 80K
Benefit/Output (Maint. Jobs)	375/year

For the required sensitivity analysis, the recurring annual cost will be treated as a variable (say Y). The uniform annual cost of the NEW-CONSTRUCT alternative is:

$$UAC_{NC} = \frac{\$2600K + 9.077}{9.077} = \$286.4K + Y,$$

which leads to the following benefit/cost ratio (see Equation 4.2):

$$BCR_{NC} = \frac{ABOM_{NC}}{UAC} = \frac{375}{286.4K + Y}$$ (Maint. Jobs/yr/$1000 UAC).

Table 7A

Y	$UAC_{NC} = 286 + Y$	$BCR_{NC} = 375/UAC_{NC}$
$ 80K	$366K	1.025
$ 95K	$381K	0.984
$110K	$396K	0.947
$125K	$411K	0.912

A plot of these points appears in Figure 7E.

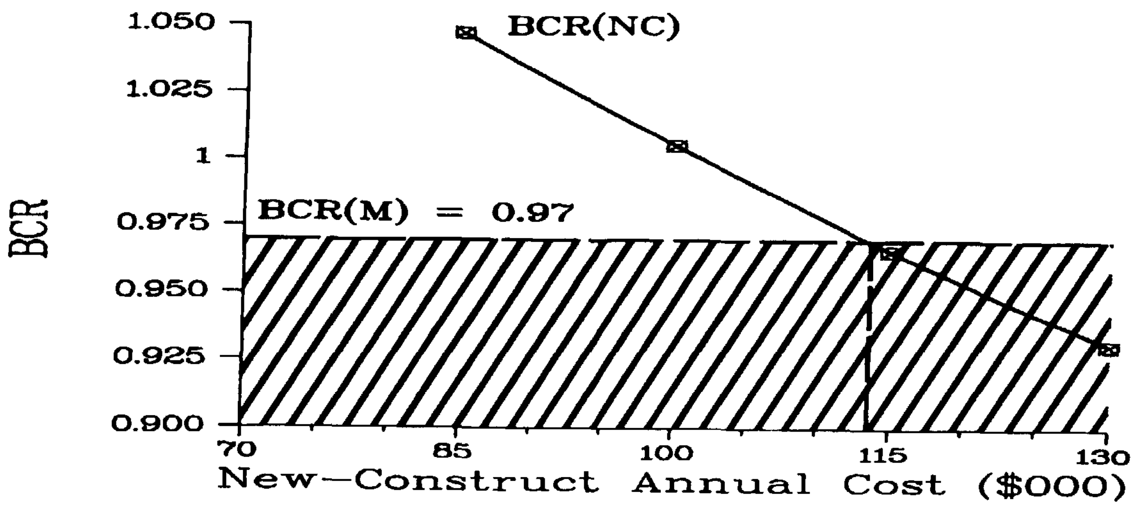


Figure 7E
Example 7E Graph

It can be seen that the annual expenses associated with the NEW-CONSTRUCT alternative can range past $110K before it becomes less cost-effective than the MODIFY alternative.

A precise determination of **break-even** NEW-CONSTRUCT annual recurring costs can be made by equating the BCR expression of the (BCR) equation to 0.94 (the benefit/cost ratio for the MODIFY alternative) and solving for the unknown Y. As you may verify, the upper threshold is $112.5K.

*** EXAMPLE 7E END ***

7.5 TWO-VARIABLE UNCERTAINTY TESTS

The outcome of an economic analysis is frequently sensitive to more than one input or assumption. The graphical techniques developed in the previous subsection may be extended to treat two variables simultaneously. Three illustrations follow:

*** EXAMPLE 7F : Operation ALTER: Testing SIR Sensitivity ***

Problem: Test the sensitivity of the SIR in Operation ALTER (Example 3F) to simultaneous variations in the Alternative B annual costs and the economic life. (i = 10%)

Solution 7F: Here Example 7B serves as a point of departure. The SIR calculations of that example may be repeated for several prospective economic life periods. The following set of economic lives might be construed as representative of reasonable fluctuations about the "best guess" of 20 years (the economic life assumed in the original study):

14 years
17 years
20 years
23 years
26 years

With the Alternative B annual cost treated as a variable (X), the SIR equations for these economic lives are as follows:

14 years: $$\text{SIR} = \frac{(\$500K - X)(7.367)}{\$1000K}$$

17 years: $$\text{SIR} = \frac{(\$500K - X)(8.022)}{\$1000K}$$

20 years: $$\text{SIR} = \frac{(\$500K - X)(8.514)}{\$1000K}$$

23 years: $$\text{SIR} = \frac{(\$500K - X)(8.883)}{\$1000K}$$

26 years: $$\text{SIR} = \frac{(\$500K - X)(9.161)}{\$1000K}$$

These equations are derived in the same way as the SIR equation in Example 7B.

Each of the above equations may be graphed in the same fashion as was the SIR equation in Figure 7B. Figure 7F below shows a plot of all five equations on the same set of axes. Each curve is a straight line which, for the indicated economic life, represents the SIR as a function of the Alternative B annual cost. In the figure, vertical lines are plotted for each annual cost in the critical $375K - $395K range. The intersection of these reference lines with the various SIR plots determines a lattice of SIR points.

For a given economic life and annual cost, one can tell by inspection whether or not Alternative B is economically justified - it is **if and only** if the SIR point lies above the SIR = 1.0 threshold. Moreover, visual interpolation between designated economic lives and annual costs is possible. For example, if the actual economic life were to be 25 years and the Alternative B annual cost, $377K, then the SIR would be approximately 1.12 (see point A in Figure 7F).

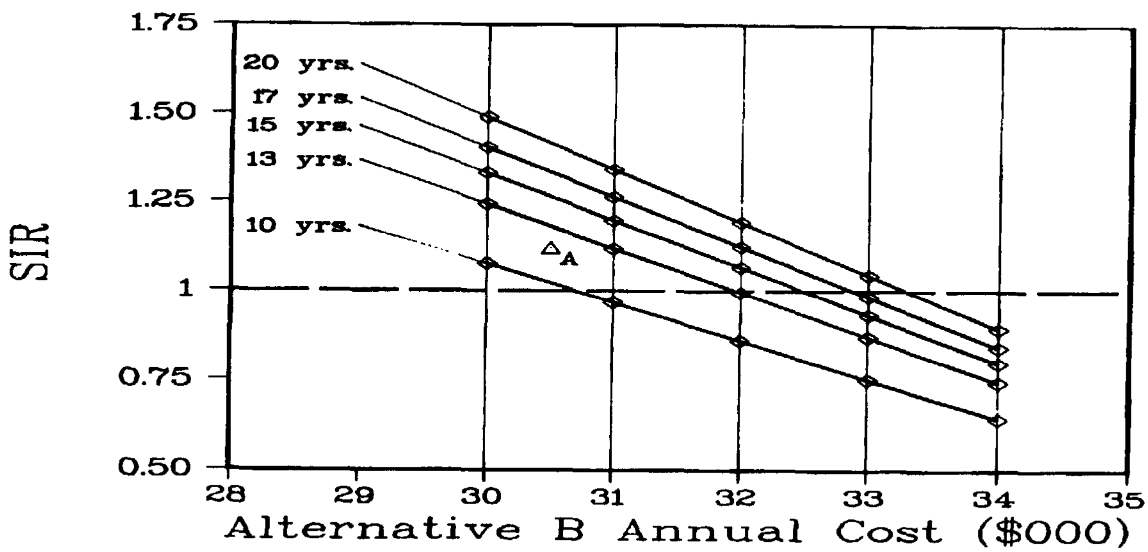


Figure 7F
Graph Example 7F

*** EXAMPLE 7F END ***

EXAMPLE 7G : Operation COMPARE: Testing PV Life cycle Cost

Problem: Test the sensitivity of the PV life cycle MILCON cost of Example 7D. to simultaneous variations in annual O&M costs and acquisition cost.

Solution 7G: If we denote the acquisition (MILCON) cost by A and the recurring annual (O & M) expense by R, total NPV life-cycle MILCON cost is given by:

$$NPV = A + (8.252)R$$

(Refer to the computations in the solution to Example 7D). Figure 7G shows plots of total NPV life-cycle MILCON cost for various combinations of acquisition and recurring costs. Here the annual O&M cost is plotted on the horizontal axis and the acquisition cost A is shown at increments of $10K from $80K to $120K. The lattice of PV life-cycle costs points readily indicates for which combinations of acquisition cost and annual cost MILCON is economically preferable to leasing. The encircled point represents the "best guesses" (A = $100K, R = $10K) used in the original analysis.

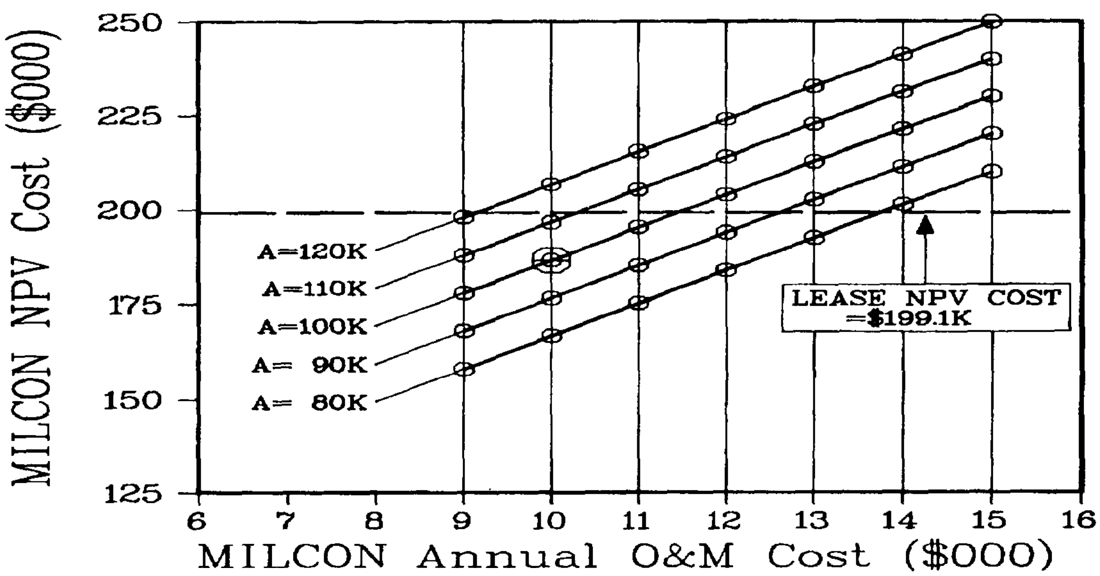


Figure 7G
Graph Example 7G

*** EXAMPLE 7G END ***

* EXAMPLE 7H : Operation COMPARE: Bivariate Break-even Analysis *

Problem: In Example 7D we determined which combinations of economic life and MILCON annual costs equate total NPV life-cycle costs of the MILCON and LEASE alternatives. Use 10% as the interest rate, i.

Solution 7H: The calculations in Example 7D serve as an appropriate point of departure. Denote the recurring annual (O&M) cost of the MILCON alternative by R. Then, we have the following:

25-YEAR ECONOMIC LIFE

NPV(LEASE) = $189.8K

NPV(MILCON) = $100K + 8.252R

NPV(LEASE) = NPV(MILCON); yields R = $10.9K (break-even)

20-YEAR ECONOMIC LIFE

NPV(LEASE) = $178.0K

NPV(MILCON) = $100K + 7.740R

NPV(LEASE) = NPV(MILCON); yields R = $10.1K (break-even)

15-YEAR ECONOMIC LIFE

NPV(LEASE) = $159.0K

NPV(MILCON) = $100K + 6.915R

NPV(LEASE) = NPV(MILCON); yields R = $8.5K (break-even)

10-YEAR ECONOMIC LIFE

NPV(LEASE) = $128.7K

NPV(MILCON) = $100K 5.586R

NPV(MILCON) = \$100K 5.586R
NPV(LEASE) = NPV(MILCON); yields R = \$5.1K
(break-even)

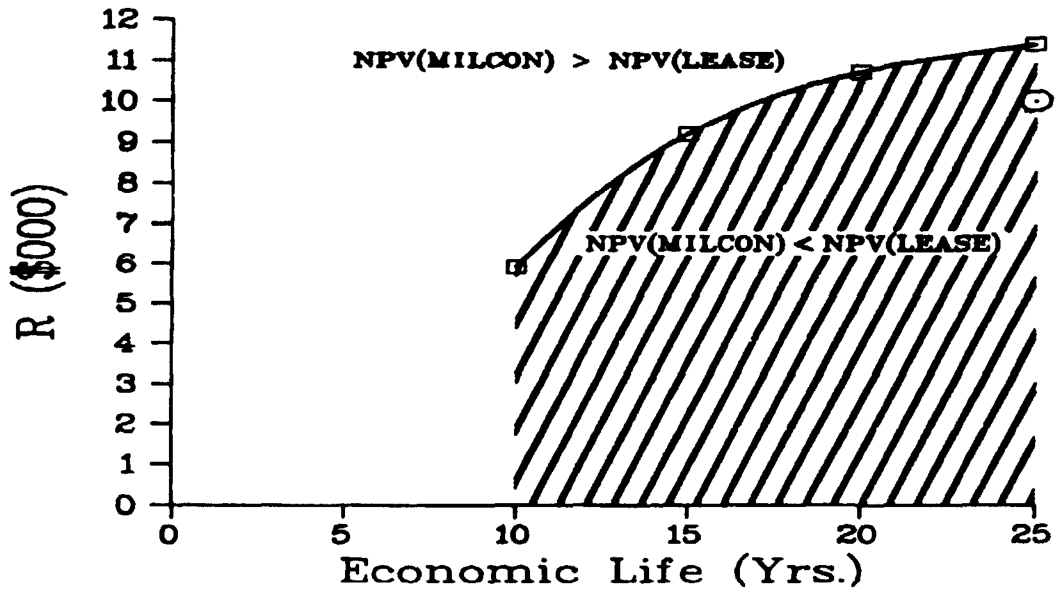


Figure 7H
Graph for Example 7H

Discussion 7H : These break-even combinations are graphed in Figure 7H, which plot economic life against the recurring annual cost, R, of the MILCON alternative. The smooth curve joining these points is a **break-even curve**. Any point on this curve represents an economic-life/MILCON-annual-cost combination for which total PV life- cycle costs of the MILCON and LEASE alternatives are the same. Because of this characteristic, the break-even curve is a two-dimensional (bivariate) analogue of the break-even point (such as the one plotted in Figure 7D).

The break-even curve of Figure 7H partitions economic-life/MILCON annual-cost space into two regions. All points in the shaded region represent economic-life/ annual-cost combinations for which PV life-cycle MILCON cost is less than PV life-cycle lease cost. (The encircled point in this region corresponds to values taken in the original comparison in Example 7D: economic life 25 years and R = \$10K). In the clear region, the LEASE alternative is economically preferable to the MILCON alternative. The more remote a given point is from the indifference curve the greater the economic advantage enjoyed by the one alternative over the other (for the indicated economic life and MILCON annual cost).

7.6 EXPECTED VALUE

In some cases, you have quantitative information about the probabilities of various possible outcomes of an alternative; that is, there is enough information to make an estimate of what the relative frequency of an outcome would be if numerous trials were made. While the theories of probability and statistical inference are outside the scope of this handbook, probabilistic methods are often applicable in economic analyses. One simple technique that is frequently useful is **expected value**. An **expected value** characterizes a random variable and its probability distribution. The expected value is simply a weighted average that represents the average outcome that would be realized if the alternative was implemented many times. For a set of possible outcomes:

P_i is the probability of outcome i, and

W_i is the worth or value of outcome i.

The expected value E is given by the summation of the products of the probabilities and their worth, or

$$E = P_1w_1 + P_2w_2 + P_3w_3 + ... + P_nW_n \qquad (7.1)$$

This equation may be equivalently written, using summation notation, as:

$$E = \left[\sum_{i=1}^{n}\right] P_i W_i \qquad (7.2)$$

*** EXAMPLE 7I : Operation WIDGET: Expected Value Analysis ***

Problem: In a Proposed automated widget system with an eight year economic life, there is a critical component with a shorter physical life. Replacement of this component will be required in project year 5. Costs experienced for replacement and for production during replacement will vary depending upon skill of the personnel, the number of widgets in process at the time of replacement. and many other factors. While the cost of component replacement in the actual system cannot be known beforehand, there is some experience with similar components installed in previous systems. Out of 20 replacements of these components,

10 cost $10,000 each,

6 cost $15.000 each, and
4 cost $20,000 each.

If the present value of all other costs associated with the system (including the original installation of the component) is $50,000, and experience with previous systems is considered representative, what is the expected NPV of costs for the system?

Solution 7I:

For this system, NPV = $50,000 + (E)(0.621)

where E is the expected cost of component replacement. The probability (relative frequency) that this cost will be $10,000 is 10/20 or 0.5; the probability that it will be $15,000 is 6/20 or 0.3; and the probability that it will be $20,000 is 4/20 or 0.2.

(Note that the probabilities of occurrence must sum to 1.0.)

The expected value of the replacement cost is then computed using Equation 7.1 as:

$$E = (0.5)(\$10{,}000) + (0.3)(\$15{,}000) + (0.2)(\$20{,}000)$$

$$= \$5{,}000 + \$4{,}500 + \$4{,}000$$

$$= \$13{,}500$$

The expected NPV is then

$$NPV = \$50{,}000 + (\$13{,}500)(0.621)$$

$$= \$50{,}000 + \$8.384$$

$$= \$58{,}384$$

The above example is rather simplistic, but, it is intended merely to show how risk may be integrated into the present value calculations of an economic analysis. In an actual case, many more than three discrete outcomes would be considered. In many cases, empirical data will be unavailable and probability estimates must be based upon limited information. While the use of a single expected value incorporates and describes risk, more information about risk may be desired for decision-making. The following section deals with a more complete analysis of risk.

NOTE: THE NEXT SECTION IS **ADVANCED ANALYSIS TECHNIQUES**. BEGINNERS MAY WISH TO SKIP THIS SECTION FOR NOW AND COME BACK TO IT AT A LATER TIME.

*** EXAMPLE 7I END ***

7.7 RISK ANALYSIS AND MONTE CARLO SIMULATION

Frequently, you will desire information about the distribution of possible outcomes and their probabilities, in addition to the expected value of the outcome. For Example 7I of the previous section, the probability distribution of NPV outcomes is illustrated in the histogram of Figure 7I below.

(Note: 0.5 x $56,210 + 0.3 x $59,315 + 0.2 x $62,420 = $58,384, the expected value)

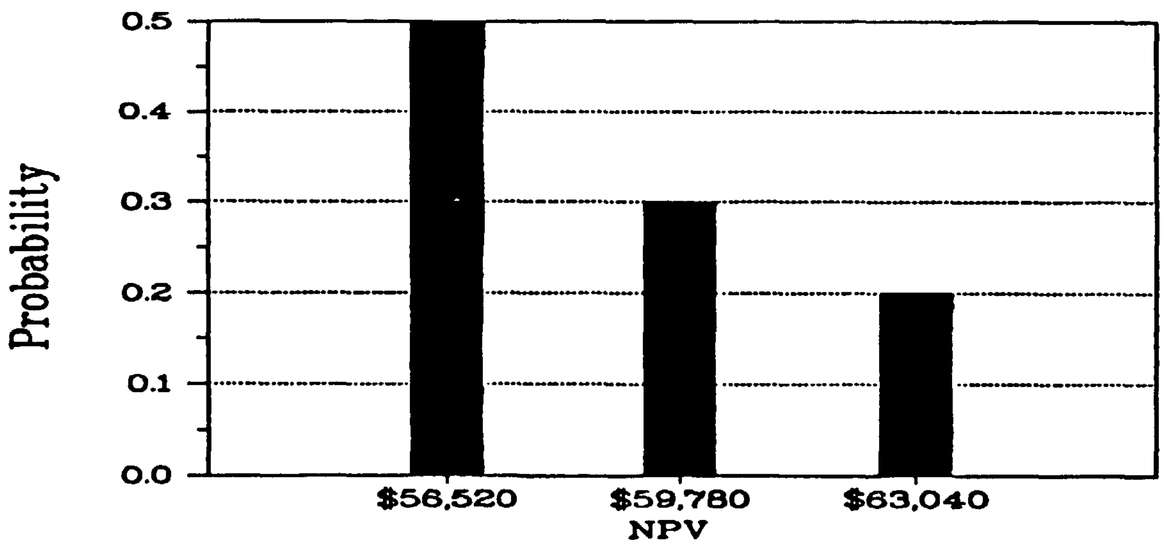


Figure 7I
Histogram Graph

By developing the outcome probability distribution for each alternative under consideration, it is possible to portray the risk involved in each alternative and to compare the relative riskiness of the alternatives. In the case Shown in Figure 7I, developing the distribution was simple because only one probabilistic factor was involved. However, you typically must deal with situations in which almost all of the variables have associated probability distributions.

you typically must deal with situations in which almost all of the variables have associated probability distributions.

*** EXAMPLE 7J : Operation WIDGET: Tree Diagram Analysis ***

Problem: Suppose that in Example 7I of the previous section it is not certain that the component replacement will occur in Project Year 5, but rather that there is:

a 0.20 probability that it will occur in Project Year 4;

a 0.45 probability that it will occur in Project Year 5; and

a 0.35 probability that it will occur in Project Year 6.

Further, assume that the cost to replace the component (in base year constant dollars) is **independent** of the project year in which it occurs.

Solution 7J: Since year of replacement and replacement cost are independent of each other, the probability of any particular combination of replacement year and replacement cost can be computed by multiplying the individual probabilities. One way to array the data for clarity and convenience in calculating the expected value and generating the probability distribution of outcomes is by a tree diagram such as that shown in Figure 7J, which illustrates the nine possible outcome combinations of replacement years and replacement costs.

Discussion 7J: It is apparent that as the number of probabilistic variables becomes greater and as the number of values that each variable can assume becomes greater, the techniques discussed in the above examples become more unwieldy and burdensome. It is usually impractical and economically infeasible to perform numerous experiments to gain experience from real world situations. However, performing experiments on a model of the real world can be done through the process of simulation. For risk analysis, the technique of **Monte Carlo Simulation** is usually employed.

To perform a Monte Carlo Simulation, it is necessary to have a set of random numbers, such as those shown in Table 7B. By choosing probabilistic variable values based on these numbers, numerous trials may be simulated to develop an NPV distribution as in Example 7K.

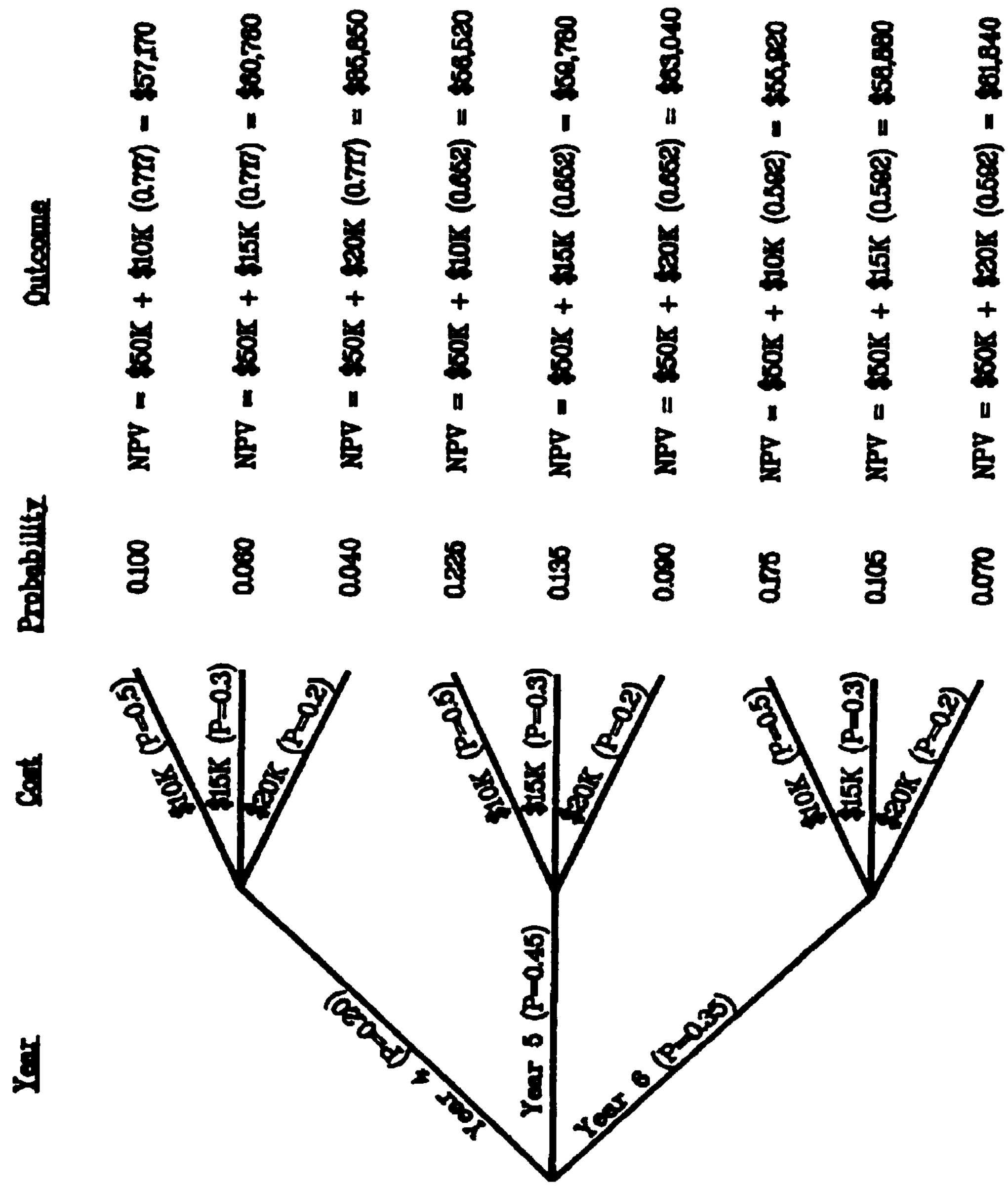


Figure 7J
7J Solution Tree Diagram

*** EXAMPLE 7J END ***

*** EXAMPLE 7K : Operation WIDGET: Monte Carlo Simulation ***

A Monte Carlo Simulation may be performed for the problem of the previous example as follows:

1. Values for the variables (Replacement Year, Replacement Cost) may be chosen based upon random numbers between zero and one. This is done by setting intervals, between zero and one, which correspond to the probabilities of the respective variables. Then a value for one of the variables is determined based upon the interval the random number fell between. For the year of component replacement, one might select:

Year 4 (P = 0.2) when the random number is in the interval 0-0 to 0.2;

Year 5 (P = 0.45) when the random number is greater than 0.2 and less than or equal to 0.65;

Year 6 (P = 0.35) when the random number is greater than 0.65 and less than or equal to 1.0.

Thus, for any simulated case, a replacement year is selected based on a random number; since the intervals are in proportion to the probabilities, the distribution of a large number of simulated cases will approximate the assumed probability distribution.

Similarly, for the cost of component replacement the next random number might be used to select:

$10,000 replacement cost (P = 0.5) when the random number, is in the interval 0-0 to 0.5;

$15.000 replacement cost (P = 0.3) when the random number is greater than 0.5 and less than or equal to 0.8;

$20.000 replacement cost (P = 0.2) when the random number is greater than 0.8 and less than or equal to 1.0.

2. Using the selection rules developed above, many simulated cases are performed as in Table 7C. From these numerous cases, the expected NPV and the probability distribution of NPV can be derived.

*** EXAMPLE 7K CONTINUED ***

.975078	.659518	.181406	.152768
.283958	.328833	.417378	.544767
.512201	.170302	.411998	.939272
.927648	.112442	.325820	.942946
.725291	.865235	.663791	.195627
.199643	.437218	.826516	.024134
.706160	.019756	.763094	.400762
.536728	.613510	.850510	.581468
.834217	.772092	.124594	.798741
.671094	.837898	.987540	.384159
.417096	.045141	.516985	.695639
.520970	.865065	.501659	.224368
.831275	.968344	.328587	.256421
.581244	.179677	.846862	.464077
.162709	.799559	.332974	.801810
.814090	.668254	.682709	.081972
.347447	.346938	.954601	.605167
.039592	.791046	.389954	.220309
.812263	.890798	.034425	.189366
.826367	.253911	.086166	.231795
.615267	.605503	.095533	.123665
.882195	.180185	.141354	.226462
.944640	.782560	.193596	.118540
.968870	.746361	.758340	.832789
.171677	.534959	.664667	.173333
.058054	.788328	.207482	.149942
.032314	.844410	.775632	.054095
.343896	.576517	.364043	.995601
.697222	.222922	.062533	.368905
.650629	.583632	.646129	.624085
.929354	.959358	.391961	.717539
.777586	.207666	.247724	.617350
.474577	.291315	.476697	.238349
.139820	.693784	.904319	.181860
.952289	.076991	.891342	.655135
.908735	.556190	.158531	.945471
.246051	.967067	.587937	.824023
.652703	.500010	.125731	.254297
.394209	.076579	.911591	.780336

Table 7B, Random Numbers
Uniformly Distributed Between Zero and One

Case No.	Random Number	Repl. Year	Random Number	Repl. Cost ($)	Disc. Factor	Disc. Cost ($)	NPV ($)
1	.975078	6	.659518	15,000	0.564	8,460	58,460
2	.181406	4	.152768	10,000	0.683	6,830	56,830
3	.283958	5	.328833	10,000	0.621	6,210	56,210
4	.417378	5	.544767	15,000	0.621	9,315	59,315
5	.512201	5	.170302	10,000	0.621	6,210	56,210
6	.411998	5	.939272	20,000	0.621	12,420	62,420
7	.927648	6	.112442	10,000	0.564	5,640	55,640
8	.325820	5	.942946	20,000	0.621	12,420	62,420
9	.725291	6	.865235	20,000	0.564	11,280	61,280
10	.663791	6	.195627	10,000	0.564	5,640	55,640
11	.199643	4	.437218	10,000	0.683	6,830	58,830
12	.826516	6	.024134	10,000	0.564	5,640	56,640
13	.706160	6	.019756	10,000	0.564	5,640	55,640
14	.763094	6	.400762	10,000	0.564	5,640	55,640
15	.536728	5	.613510	15,000	0.621	9,315	59,315
16	.850510	6	.581468	15,000	0.564	8,460	58,460
17	.834217	6	.772092	15,000	0.564	8,460	58,460
18	.124594	4	.798741	15,000	0.683	10,245	60,245
19	.671094	6	.837898	20,000	0.564	11,280	61,280
20	.987540	6	.384159	10,000	0.564	5,640	55,640
21	.417096	5	.045141	10,000	0.621	6,210	56,210
22	.516985	5	.695639	15,000	0.621	9,315	59,315
23	.520970	5	.865065	20,000	0.621	12,420	62,420
24	.501659	5	.224368	10,000	0.621	6,210	56,210
25	.831275	6	.968344	20,000	0.564	11,280	61,280
26	.328587	5	.256421	10,000	0.621	6,210	56,210
27	.581244	5	.179677	10,000	0.621	6,210	56,210
28	.846862	6	.464077	10,000	0.564	5,640	55,640
29	.162709	4	.799559	15,000	0.683	10,245	60,245
30	.332974	5	.801810	20,000	0.621	12,420	62,420
31	.814090	6	.668254	15,000	0.564	8,460	58,460
32	.682709	6	.081972	10,000	0.564	5,640	55,640
33	.347447	5	.346938	10,000	0.621	6,210	56,210
34	.945601	6	.604167	15,000	0.564	8,460	58,460
35	.039592	4	.791046	15,000	0.683	10,245	60,245
36	.389954	5	.220309	10,000	0.621	6,210	56,210
37	.812263	6	.890798	20,000	0.564	11,280	61,280
38	.034425	4	.189366	10,000	0.683	6,830	56,830
39	.826367	6	.253911	10,000	0.564	5,640	55,640
40	.086166	4	.231795	10,000	0.683	6,830	56,830

Average simulated NPV is $58,074

Table 7C
MonteCarlo Simulation (Example 7K)

** EXAMPLE 7K CONTINUED ***

Because the Monte Carlo risk analysis method involves numerous repetitions of a procedure, it is more appropriate to perform it on a computer than to accomplish it by manual computations. This is especially true when more variables and more complicated distributions than those in the example above are used.

So far, the assumed probability distributions and the resulting NPV distribution that we have examined have all been **discrete**; they consist of a finite set of values.

For some variables, it is reasonable to assume a continuous distribution, that is, a distribution consisting of an infinite set of values on a continuum. In a **continuous distribution**, the probability of any particular value occurring is extremely small, so the graph of a continuous distribution shows **probability density** instead of probability. The probability that the variable will take on a value in any interval is the area under the density curve in that interval; the area under the total curve is, by definition, one.

An example of a continuous distribution is shown in Figure 7K below. This is a probability density graph for a cost with an assumed **normal** (Gaussian) **distribution**, with a **mean** (i.e.. expected value) of $2,000, and a **standard deviation** (a measure of dispersion) of $200.

NOTE: The area under the normal curve between the mean and one standard deviation above the mean is approximately one third of the area under the whole curve.

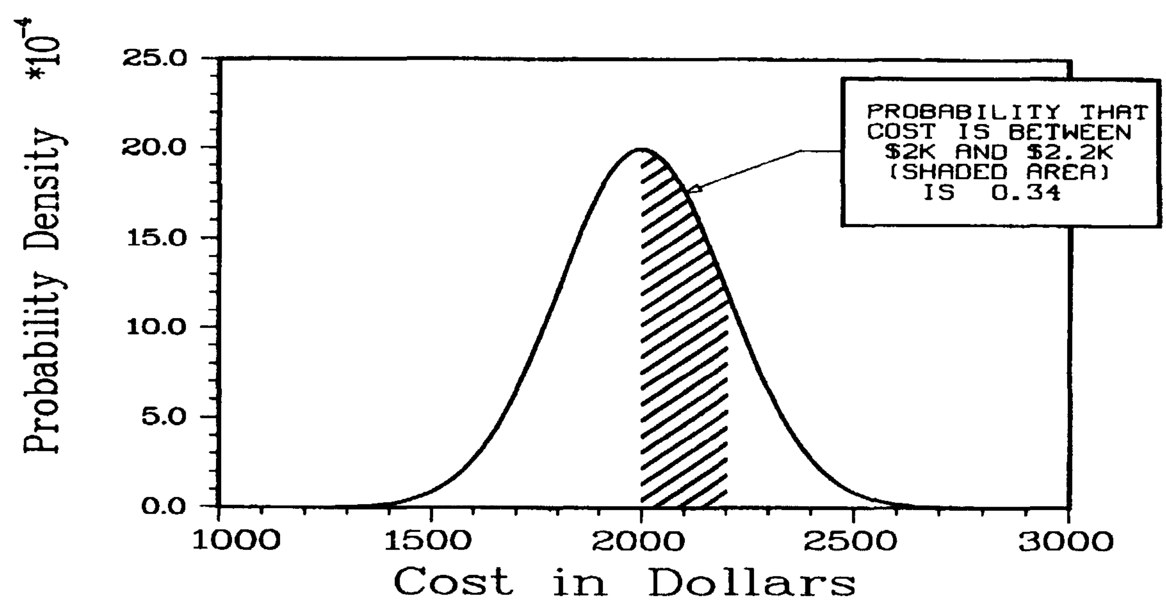


Figure 7K
Graph for Example 7K

Once a NPV probability distribution has been developed for each alternative by Monte Carlo simulation, the results should be appropriately displayed. How this information is used for decisions will depend upon the decision-maker's aversion to risk.

For example, in the comparison shown in Figure 7L below, Alternative A has an expected NPV cost that is lower than that of Alternative B, but it also has a wider range of possible outcomes; in fact, there is a significant probability that Alternative A will cost more than the highest cost of Alternative B.

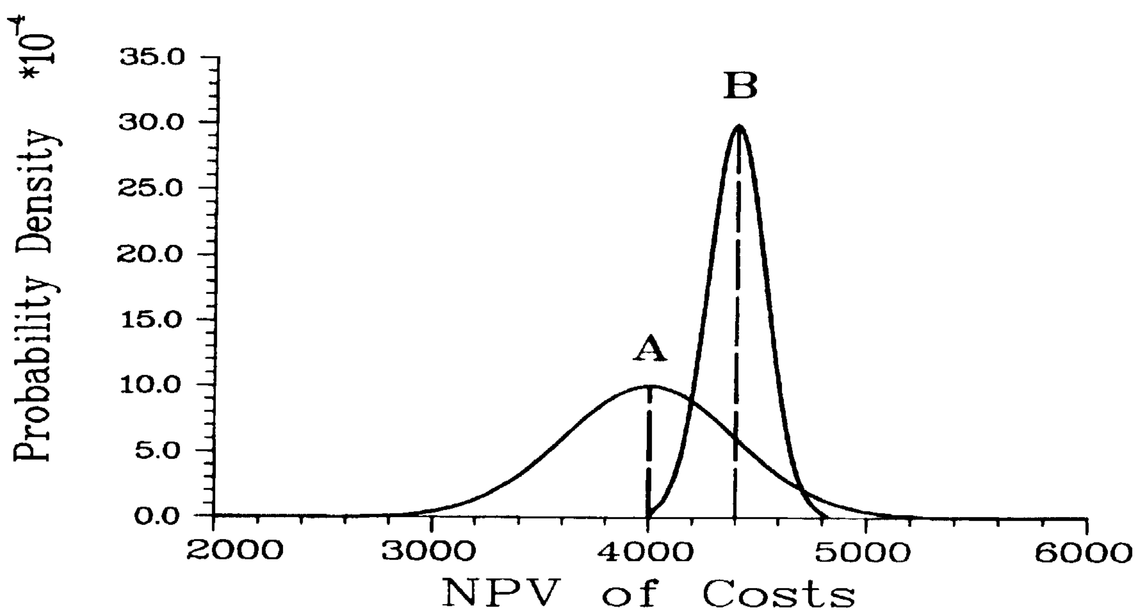


Figure 7L
Graph for Example 7K

Another display technique for the results of a Monte Carlo risk analysis is to graph the cumulative probability distributions of the alternatives. The cumulative NPV probability distribution displays the probability that the NPV will be less than or equal to any particular amount. Figure 7M indicates that there is a 40% probability that the Alternative A NPV will be less than or equal to $3,900.

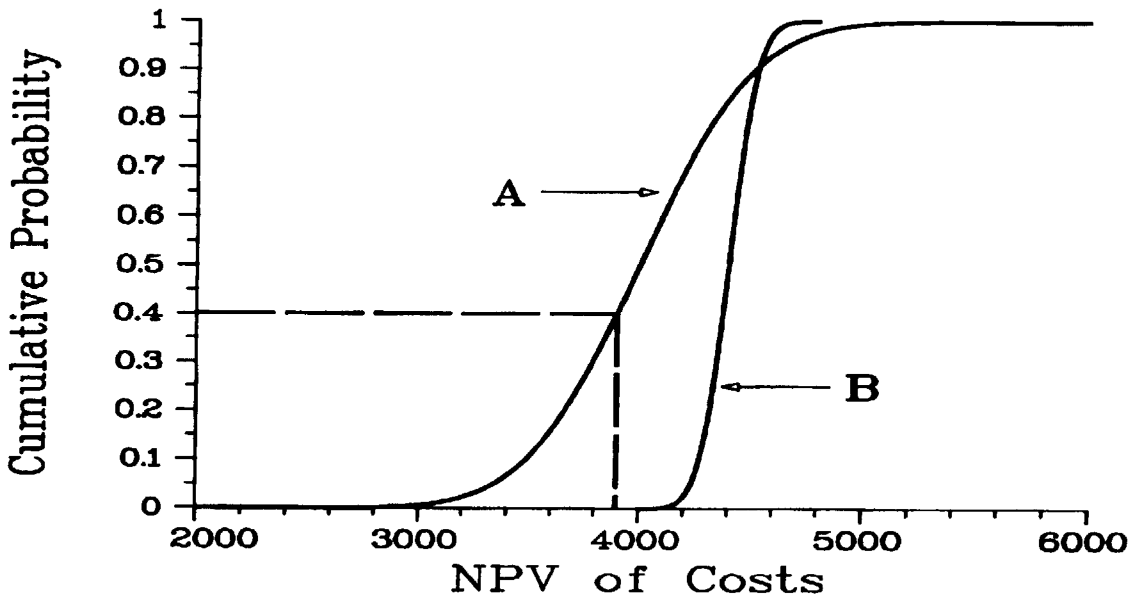


Figure 7M
Graph for Example 7K

The narrative here is intended to acquaint you with basic concepts and convey the basic elements of risk analysis. For in-depth information, you should refer to the reference works on probability, statistics, and risk analysis listed in Appendix H, the bibliography.

*** EXAMPLE 7K END ***

DOCUMENTATION STANDARDS

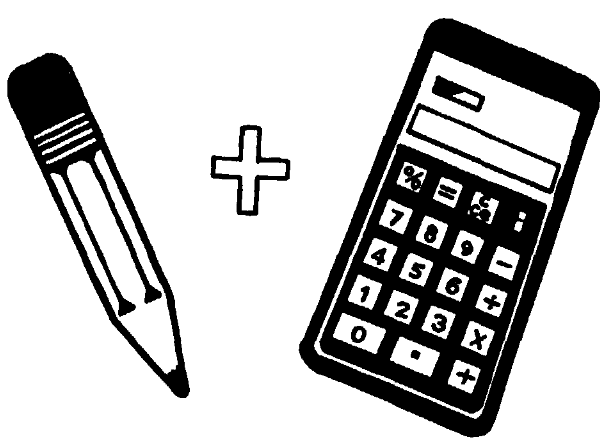
Chapter 8

8.1 INTRODUCTION

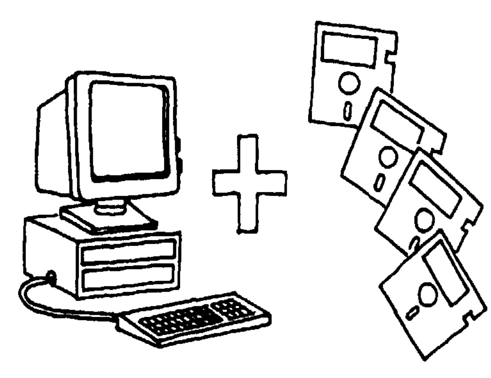
Throughout this handbook, the importance of adequate documentation has been stressed. Even the best analysis is of no use to the Navy if it is not properly communicated. There must be confidence that the analysis is complete and credible so that credible decisions can be based upon it. Lastly, good economic analysis documentation is invaluable for the future program evaluation or for analysis of related programs.

8.2 DOCUMENTATION FORMATS AND TOOLS

Methods used at our field commands and activities to prepare economic analyses are quite diverse.



At one extreme is the "stubby pencil and calculator method."



At the other extreme are computer - supported methods.

It is NAVFACENGCOM policy for Economic Analyses documentation to be complete and credible. NAVFACENGCOM has allowed "flexibility" in economic analysis format to allow for the wide range of training, experience, and capabilities of field personnel who are tasked with the preparation of economic analyses. The following formats are acceptable, for EA preparation:

a. FORMAT A-1 FOR TYPE I ECONOMIC ANALYSES

To promote uniformity and consistency throughout NAVFAC, use of the Format A-1 (shown in Appendix B) was recommended for the preparation of all Type I economic analyses. The format leads the analyst to the correct SIR via a logical, step by step procedure which is valid in all cases . Following this will generate valid results, however using the PC-ECONPACK computer model produces a more detailed presentation of results.

b. FORMAT A FOR TYPE II ECONOMIC ANALYSES

Use of the Format A (shown in Appendix B) is recommended for the preparation of all Type II economic analyses. A complete Format A should be prepared for each alternative of a Type II economic analysis. Also, following this will generate valid results, however using the PC-ECONPACK computer model produces a more detailed presentation of results.

c. FORMAT B FOR RESOURCE ALLOCATION DECISIONS

Format B (shown in Appendix B) is recommended to identify and describe the benefits, output, or effectiveness implications of resource allocation decisions.

d. LOTUS 1-2-3 SPREADSHEET TEMPLATES

In August 1987, NAVFACENGCOM released a user manual and diskettes for spreadsheet templates (worksheets) to prepare economic analyses via microcomputer. The user enters data for Type I or Type II analyses, the worksheets then perform the computations and display the results through graphics and in an economic analysis summary. By using these worksheets, computation time is drastically reduced. Graphs and result tables are readily generated and sensitivity analysis can be easily performed by altering data and viewing the changes in the results.

e. THE FUTURE OF ECONOMIC ANALYSIS

In current DoD environment of shrinking budgets and manpower reductions, there are dynamic changes to automate the office.

Working "slowly, but surely" is no longer practical.

New EA focus is to "WORK SMARTER, NOT HARDER."

The preferred format is PC-ECONPACK.

PC-ECONPACK is a computer application program and documentation which includes capabilities for economic analysis calculations, documentation of analysis, and report generation. It is a "user-friendly" program that assists non-economist users with preparing complete, properly documented economic analyses (both primary and secondary). PC-ECONPACK's format is menu-driven and contains interactive display screens to select analysis parameters and specify functions.

It was developed by the Army's Construction Engineering Research Laboratory (CERL) under the sponsorship of Headquarters, U.S. Army Corps of Engineers (HQUSACE). PC-ECONPACK was initially distributed in November 1987, primarily to Army users.

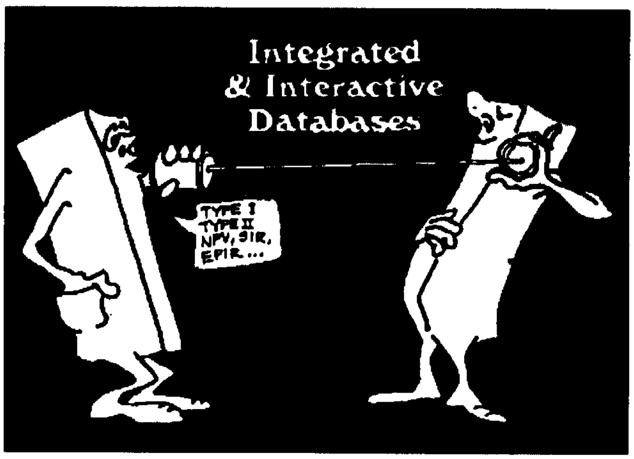
Current copies of the computer diskettes and User's Guide may be ordered by contacting:

Naval Facilities Engineering Command
200 Stovall Street, CODE: 90ZTW
Alexandria, VA 22332-2300

Commercial = (703) 325 - 7355 , DSN = 221-7355
(Fax Machine = 221 - 2261)

As you will see, PC-ECONPACK addresses the same information (input and output data) as the previously mentioned "accepted" formats. In addition, however, PC-ECONPACK has additional capabilities for saving you time by being able to generate various reports and perform sensitivity analysis.

In the future, there will be increased use of integrated and interactive data bases to assist with the preparation of economic analyses. NAVFACENGCOM continuously revises and updates policy guidance. These policies will address acceptable EA formats. At some point in the future, current formats that are now "acceptable, but not preferred" may become unacceptable. While Formats A, A-1, B, provided in Appendix B, and the LOTUS 1-2-3 not are yet "extinct," their days are limited.



In recent years, economic analyses have been reviewed with close scrutiny at all levels. With declining DoD budgets, there will be continued focus centered on a projects's economic merits. It is a necessity to use the most thorough and helpful analysis packages available to increase a project's chances in the review process. At the preparing activity level, emphasis must be placed on **complete and credible economic analyses**.

8.3 ECONOMIC ANALYSIS SUBMISSION OUTLINE

Regardless of which aforementioned method you use, most economic analysis submissions will require more comprehensive documentation. The following outline is suggested as a guide for economic analysis submissions. The outline reflects the view that an economic analysis submission should be complete in itself - you should not have to search other sources for information necessary to support and/or understand the analysis.

1. Summary

This section should briefly summarize the entire analysis, with emphasis on the objective, alternatives, ranking of alternatives, conclusions, and recommendations.

2. Background/Objective/Requirements

This section should include a succinct and unbiased objective statement as well as sufficient information to allow a reviewer, who may be unfamiliar with the situation, to understand the basis for the requirements.

3. Alternatives

All alternatives considered in the analysis should be listed and defined.

4. Assumptions

List and explain all assumptions used in the analysis.

5. Costs, Benefits, and Present Value Summaries

This section should include the information presented on Formats A or A-1, and Format B (Appendix B of this Handbook). Although this information is covered here so that everyone may manually fill out the information, it is strongly recommended that this task be put into PC-ECONPACK so that **all** economic analysis material may be managed and submitted together in one complete harmoneous packet.

6. Sensitivity Analysis

Uncertainty and/or risk analyses performed on dominant cost elements, economic life. discount rate, differential escalation rates, and other major assumptions.

7. Other Considerations

Any decision considerations which have not been treated in the preceding sections should be included here (e.g. non-quantifiable variables).

8. Conclusions/Recommendations

Ranking of alternatives with appropriate conclusions and recommendations based upon Sections 1-7.

9. Appendices

Detailed information supporting all cost and benefit estimates, including data sources, equations, projections, and calculations.

8.4 CHECKLIST FOR ANALYSTS AND REVIEWERS

The following checklist is provided to aid economic analysts and reviewers in insuring that economic analyses are correct, complete, and well-documented.

a. CHECKLIST

1. THE OBJECTIVE, ASSUMPTIONS AND ALTERNATIVES

   a. Is the problem stated the real problem?

   b. Is the objective, as stated. unbiased as to the means of meeting the stated objective?

   c. Are all reasonable assumptions identified and explained?

   d. Are assumptions too restrictive? Too broad?

   e. Are intuitive judgments identified as such? Are uncertainties treated as facts? Can the facts be verified?

   f. Are potential mission change constraints to the economic life of an alternative given due consideration? Has the impact of technological change been fully considered?

   g. If a scenario has been used, is it realistic?

   h. Are the alternatives well defined and discrete? Do they overlap?

2. THE COST ESTIMATES

   a. What cost estimating methods were used? Are they appropriate?

   b. Are all relevant costs (including directly related support and training costs) included?

   c. Are sunk costs properly excluded?

   d. Are the sources of cost data indicated? Are these sources accurate and appropriate?

   e. Have all cost estimates been made in base year constant dollars? What escalation projections were used?

   f. If parametric cost estimating was used, are the Cost Estimating Relationships statistically valid? Are the estimates interpolated within the range of historical data or has extrapolation been used?

   g. Was an average cost used where a marginal cost is appropriate?

   h. Are cost factors current and supportable?

3. THE BENEFIT DETERMINATION

   a. Does the analysis ignore some portion of total output?

   b. Were criteria used to measure benefits justified by the context of the study?

   c. Was the benefit, in fact, unmeasurable? Has there been a rational assessment of non-quantifiable factors?

   d. Was expert opinion used? Were these experts properly qualified?

   e. If savings have been claimed, will a budget actually be reduced?

   f. Have all advantages and disadvantages of the alternatives been identified? Are there any important externalities?

   g. If an efficiency/productivity increase is projected, is there a documented need for greater output?

4. TIME-DEPENDENT CONSIDERATIONS

a. Was lead time between the investment and the start of economic life accounted for?

b. Was present value analysis properly performed?

c. Are the economic lives used reasonable? Are they based upon guidelines?

d. Is terminal value important in this analysis?

e. If differential escalation has been assumed for a particular cost element, has the expectation that long-term cost escalation, different from general inflation, been adequately documented?

f. If lead time differs between alternatives, have the economic lives been aligned?

g. Have any relevant growth, "learning curve" and technological change predictions been incorporated in the analysis? Are they realistic?

5. THE SENSITIVITY ANALYSIS

a. If differential escalation was assumed, has a base case analysis with no assumption of differential escalation been performed?

b. Has sensitivity analysis of the results to changes in dominant cost elements, economic life, etc., been performed? If not, why not?

c. Has break-even analysis been performed?

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

e. Have graphs been used to display sensitivity analysis information?

f. If a risk analysis has been performed, how were the probability estimates derived?

g. What do the sensitivity analysis results imply about the relative ranking of alternatives?

6. SELECTING FROM ALTERNATIVES

   a. Are the recommendations logically derived from the material?

   b. Is interference from co-extensive or parallel operations ignored?

   c. Are the recommendations feasible in the real world of political, cultural, or policy considerations?

   d. Are the recommendations based upon significant differences between the alternatives?

   e. Do benefits exceed costs for alternatives considered?

b. LESSONS LEARNED FROM PROGRAM BUDGET REVIEWS

Budget reviews of the FY 94/95 MCON Programs indicated a renewed interest and emphasis on a project's economic merits. Following is a summary of economic lessons learned from these reviews:

1. Review and consider known "Force Reductions" and "Base Closure Actions" which could create cost effective opportunities (either elsewhere on Base, on other DoD installations, or on private or public property) for:

   a. Surplus facilities that would meet mission requirements;

   b. Conversion/Additions of existing facilities currently used for other operations;

   c. Joint use and/or consolidated facilities.

2. Avoid repricing/funding adjustments by:

   a. Using the OSD (P&L) - published area cost factors and unit prices, and providing sufficient justification when adjusting to reflect local conditions;

   b. Adjusting the unit costs to reflect economies of scale for larger projects.

3. For multi-phased projects where consolidation and/or integration of functions is important, ensure that documentation addresses:

a. OMB Circular A-11, which currently directs that each segment of a phased construction project must satisfy a fully definable mission objective (complete and usable facility), without subsequent funding:

b. Cost savings of phasing versus separate projects (like design efficiencies, construction efficiencies, and/or reduction in average cost per square foot).

4. Alteration projects should not exceed 70% of new construction costs.

5. In projects containing items that might be perceived as "excessive" costs (for items like rock excavation and demolition of existing structures for supporting facilities), fully document these costs in DD Form 1391 justification.

6. Document operational delays and associated costs caused by the status quo, and fully explain their impact.

7. When new construction replaces an existing facility, include demolition of the old facility. If the old facility will not be demolished but converted to a different function, provide detailed justification.

EA POLICY INSTRUCTIONS

APPENDIX A

This appendix lists relevant economic analysis instructions in effect as of the date of publication of this handbook. It is the responsibility of the analyst to ensure that current guidance is followed in the preparation of economic analyses.

APPENDIX A

A. BASIC ECONOMIC ANALYSIS INSTRUCTIONS

1. OMB Circular No. A-94 (Revised) (29 October 1992). Subj: "Guidelines and Discount Rates for Benefit-Cost Analysis of federal Programs" -- prescribes current discount rates for general use in the economic evaluation of U. S. Government programs and projects; cites general policy for the treatment of inflation in such economic evaluations; does not apply to the evaluation of decisions regarding acquisition of commercial-type services by Government or contractor operation (guidance for which is OMB Circular No. A-76 (Revised)).

2. DODINST 7041.3 (18 October 1972, revision anticipated for FY 93). Subj: "Economic Analysis and Program Evaluation for Resource Management" establishes policy and procedural guidance for:

a) economic analysis of proposed DOD programs, projects, and activities, and
b) program evaluation of ongoing DOD activities;

(NOTE: DODINST 7041.3 revsion is anticipated in late FY 93 or early FY 94, titled "Economic Analysis for Decision Making.")

3. SECNAVINST 7000.14B (18 June 1975). Subj: "Economic Analysis and Program Evaluation for Navy Resource Management" implements the DODINST 7041.3 within the Department of the Navy; outlines specific area of action responsibility for the Secretary of the Navy (Financial Management), the Comptroller of the Navy (NAVCOMPT), the Chief of Naval Operations (CNO), and the Commandant of the Marine Corps (CMC).

4. MIL-HDBK 1190 (1 September 1987). Subj: "Facility Planning and Design Guide" requires that life cycle costs be considered in engineering economic studies which are requisite to the design of military facilities.

B. LEASE VS. PURCHASE FOR THIRD PARTY ANALYSES

1. OMB Circular No. A-94 (Revised) (29 October 1992). Subj: "Guidelines and discount Rates for Benefit-Cost Analysis of Federal Programs" establishes specialized procedures for the economic analysis of general purpose real property buy vs. lease analyses of Third Party options. These procedures replace the rescinded guidance of OMB Circular No. 104 of 1 June 1986.

2. DODINST 4165.6 (1 September 1987). Subj: "Prior Approval of Real Property Actions" requires an economic analysis in accordance with DODINST 7041.3 when a proposed leasehold is in lieu of new construction. (Replaces guidance of canceled DODINST 4165.12 of 23 July 1973, with Change 1 of 28 December 1976).

C. MILITARY CONSTRUCTION SUBMITTAL PROCEDURE

1. NAVFACINST 11010.14Q (4 MAY 88). Subj: "Project Engineering Documentation (PED) for Proposed Military Construction (MILCON) Projects" -- provides procedures for submission of engineering data and documents to support Military Construction Projects.

2. NAVFACINST 11010.44E (12 December 1987). Subj: "Shore Facilities Planning Manual: A System for the Planning of Shore Facilities" -- provides procedures and guidance for the Shore Facilities Planning System. (NOTE: Update of this reference will not be available in hard copy. Efforts are currently underway to have updates of this document availble on computer software, titled "Installation Planning Management Guide" - also known as "Electronic version No. 4" or "E-1".)

D. ENERGY POLICY DIRECTIVES

The following directives and instructions establish policy for energy related economic analysis. Submittals of MILCON energy projects must also meet the requirements for MILCON projects discussed in Subsection A of this appendix.

1. Executive Order 12759 (17 July 1991). Establishes energy conservation goals and requires an economic analysis based on present value techniques.

2. Federal Register, Vol. 55, No. 224 (20 November 1990). Subj: "Federal Energy Management and Planning Programs, Life Cycle Cost Methodology, and Procedures" -- provides guidance for evaluating the cost effectiveness of energy conservation and renewable energy projects for new and existingfederally owned and leased buildings and facilities.

3. OPNAVINST 4100.5C (8 July 1986, revision underway) replaces: NAVFACINST 4101.4 (19 OCT 84). Subj: "Energy Engineering Program (EEP)" and , NAVFACINST 4101.5 (19 OCT 84). Subj: "Energy Conservation Investment Program (ECIP) Guidance" - provides criteria and guidance for candidate ECIP MILCON projects.

4. NAVFACENGCOM ltr 11101 082A (11 May 1992). OPNAVINST 11101.9D Subj: "Economic Analysis Guidance for Family Housing Revitalization/ replacement Projects" - provides guidance for the preparation of economic analyses for family housing revitalization and replacement projects.

5. OASD (L/MRM) (memorandum of 17 March 1993). Subj: "Energy Conservation Investment Program (ECIP) Guidance.

6. NAVFACINST 11300.37 (12 June 1989, revision underway). Subj: "Energy and Utilities Policy.

E. COMMERCIAL/INDUSTRIAL POLICY DIRECTIVES

The following chain of instructions establishes policy regarding the acquisition of commercial or industrial products for Government/ DOD/Navy use. Where applicable, economic evaluation procedures are prescribed. These procedures are self-contained; they do not conform to the economic analysis guidance of this handbook (i.e., the guidance prescribed by the OMB Circular No. A-94/DODINST 7041.3 chain cited in Part A. but are under the OMB Circular No. A-76 policy.

1. OMB Circular No. A-76 (Revised) (August 1983). Subj: "Performance of Commercial Activities" - this reaffirms the Government's general policy of reliance on the private sector for goods and services.

2. Cost Comparison Handbook: Supplement No. 1 to OMB Circular A-76 (March 1979) provides detailed instruction for developing comprehensive cost comparisons for acquiring a product or service by contract vs. providing it with in-house Government resources.

3. DOD Directive 4100.15 (10 March 1989). Subj: "Commercial or Industrial Activities" -- prescribes Department of Defense policy governing the establishment and operation of DOD commercial or industrial activities by DOD components.

4. DODINST 4100.33 (9 September 1985). Subj: "Commercial or Industrial Activities - Operation of" - implements criteria for use by the Military Departments and Defense Agencies in regard to the commercial or industrial activities which they operate and manage.

5. SECNAVINST 4860.44F (29 September 1989). Subj: "Commercial and Industrial Activities Program" - assigns responsibility for implementing the Commercial or Industrial Activities Program within the Department of the Navy.

F. INFORMATION SYSTEMS (IS) POLICY

There are numerous regulations, directives, and instructions providing guidance on acquisition of IS hardware, software, maintenance, and services. Note that information systems include communications as well as computing. Listed below are a few key documents that provide essential guidance related to information systems acquisition.

1. OMB Circular No. A-109 (5 April 1976). Subj: "Major System Acquisition." - establishes policies to be followed by executive branch agencies in the acquisition of major systems.

2 DOD Directive 8120.1 (14 January 1993). Subj: "Life Cycle Management of Automated Information Systems (AISs)." - applies to the life-cycle management of DoD programs, projects, and activities on the design, development, deployment, operation, support, and/or termination and disposal of all AISs.

3. DODINST 8120.2 (14 January 1993). Subj: "Automated Information System (AIS) Life-Cycle Management (LCM) Process, Review, and Milestone Approval Proceedures." - updates uniform procedures for conducting AIS Life Cycle Management (LCM) activities and provide guidelines for preparing AIS LCM documentation.

4. SECNAVINST 5231.1C (10 July 1992). Subj: "Life-Cycle Management of Automated Information Systems within the Department of the Navy" - establishes policies and approval requirements to be followed in performing information systems projects.

5. SECNAVINST 5230.6B (21 June 1983). Subj: "Delegation of ADP Approval Authority and Acquisition/Development Thresholds."

6. SECNAVINST 5236.1B (15 October 1980). Subj: "Contracting for Automatic Data Processing (ADP) Resources."

7. SECNAVNOTE 5200 (20 MAY 1993). Subj: " Acquisition Management Policies and Procedures for Computer Resources."

8. SECNAVNOTE 5231 (20 August 1993). Subj: "Oversight of Federal Information Processing Resource Acquisition Contracts."

9. NAVFACINST 5231.1 (DRAFT September 1993). Subj: "Life Cycle Management (LCM) Policy and Approval Requirements for Information System Projects."

10. Federal Information Resources Management Regulation (FIRMR), General Services Administration.

G. COMPUTER APPLICATION INSTRUCTION

1. PC-ECONPACK USERS MANUAL (Version 3.01 November 1991) Subj: "Automated Economic Analysis Package" - this is the manual which has instructions for PC-ECONPACK. It is a computer application program and documentation package which is menu driven. PC-ECONPACK includes the capability for economic analysis calculations.

FORMATS FOR EA SUBMISSIONS

APPENDIX B

TYPE II ECONOMIC ANALYSIS
SUMMARY OF COSTS
FORMAT A

1. Submitting Department of the Navy: ____________________

2. Date of Submission: ____________________

3. Project Title: ____________________

4. Description of Project Objective: ____________________

____

5. Alternative: ____________________

6. Economic Life: ____________________

8. Program/Project Costs

7. Project Year(s)	a. Cost/Benefit Element	b. Non-Recurring Cost: R&D, Investment	c. Recurring Annual Cost	d. Discount Factor	e. Discounted Cost
9. TOTALS					

10a. Total Project Cost (discounted) ____________
10b. Uniform Annual Cost (without terminal value) ____________

11. Less Terminal Value (discounted) ____________
12a. Net Total Project Cost (discounted) ____________
12b. Uniform Annual Cost (with terminal value) ____________

TYPE II ECONOMIC ANALYSIS
SUMMARY OF COSTS
FORMAT A

13. Source/Derivation of Cost Estimates: (Use as much space as required) All cost estimates are in FY 19__ constant dollars.

a. Non-Recurring Costs:

(1) Research & Development:

(2) Investment:

b. Recurring Cost(s):

c. Net Terminal Value:

d. Other Considerations:

14. Name & Title of Principal Action Officer Date

TYPE I ECONOMIC ANALYSIS
SUMMARY OF COSTS
FORMAT A-1

1. Submitting Department of the Navy: ______________________

2. Date of Submission: ______________________

3. Project Title: ______________________

4. Description of Project Objective: ______________________

____

5a. Present Alternative: ____________ 6a. Economic Life: ________
b. Proposed Alternative: ____________ b. Economic Life: ________

7.	8. Recurring Annual (Operations) Costs		9.	10.	11.
a. Project Year(s)	b. Present Alternative	Discounted Proposed Alternative	Differential Cost	Discount Factor	Differential Cost
12. TOTALS					

TYPE I ECONOMIC ANALYSIS
SUMMARY OF COSTS
FORMAT A-1

13. Present Value of New Investment:

    a. Land and buildings ________
    b. Equipment ________
    c. Other (identify nature) ________
    d. Working Capital (Change: plus or minus) ________

14. Total Present Value of New Investment (i.e., Funding Requirements). ________

15. Plus: Present Value of Existing Assets to be Employed on the Project. ________

16. Less: Present Value of Existing Assets Replaced. ________

17. Less: Present Value of Terminal Value of New Investment. ________

18. Total Present Value of Net Investment: $________

19. Present Value of Life Cycle Cost Savings from Operations (Col. 11) ________

20. Plus: Present Value of the Cost of Refurbishment or Modifications Eliminated. ________

21. Total Present Value of Savings. $________

22. Savings/Investment Ratio (Line 21 divided by Line 18) ________

23. Discounted Payback Period. ________

TYPE I ECONOMIC ANALYSIS
SUMMARY OF COSTS
FORMAT A-1

24. Source/Derivation of Cost Estimates: (Use as much space as required). All cost estimates are in FY 19__ constant dollars.

a. Investment Costs: (Itemize Project Costs)

(1) Changes in Working Capital

(2) Net Terminal Value

b. Recurring Costs (Operations):

(1) Personnel

(2) O&M

(3) Overhead Costs

c. Other Considerations:

---

25. Name & Title of Principal Action Officer Date

SUMMARY OF OUTPUTS FOR ECONOMIC ANALYSIS
FORMAT B

1. Submitting Department of the Navy: ____________

2. Date of Submission: ____________

3. Project Title: ____________

4. Description of Project Objective: ____________

____

5. Alternative: ____________

6. Economic Life: ____________

7. Outputs:

   a. Expected Benefits, Outputs, and Indicators of Effectiveness: (Describe and justify)

   b. Nonquantifiable Benefits: (Describe and justify)

   c. Present Value of Revenues: (Describe and justify)

SUMMARY OF OUTPUTS FOR ECONOMIC ANALYSIS
FORMAT B

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

a. Benefits, Performance and Indicators of Effectiveness:

b. Nonquantifiable Benefits:

c. Revenues:

9. Name & Title of Principal Action Officer Date

INFEASIBLE ALTERNATIVES
FORMAT C

(This format is provided as a guide to the type of documentation that the submitting Navy activity should provide as part of a facility study in the rare situation in which only one method of satisfying a facilities deficiency exists, as required by NAVFACINST 11010.32.)

1. Submitting Department of the Navy: ____________________

2. Date of Submission: ____________________

3. Project Title: ____________________

4. Description of Project Objective: ____________________

____

5. Respective Alternative is infeasible because:

   a. ____________________

   ____

   b. ____________________

   ____

   c. ____________________

   ____

   d. ____________________

   ____

   e. ____________________

   ____

____

6. Name & Title of Principal Action Officer Date

____

MEMORANDUM

CONTROL#________
DATE: __________

From:
To:

Subj: ECONOMIC ANALYSIS REVIEW

Encl: (1)

1. In accordance with your request, the subject review of enclosure (1) has been completed and it is returned for your appropriate action.

2. Following comments are provided for your assistance:

A. Summary/Background: ____

____

B. Objectives: ____

____

C. Alternatives: ____

____

D. Format (Type I or II): ____

E. Assumptions:
   1. Economic Life: ____
   2. Lead Time: ____
   3. Terminal Value: ____
   4. Comments: ____

   ____

F. Costs:
   1. Data: ____
   2. Documentation: ____
   3. Comments: ____

   ____

G. Benefits:
   1. Data: ____
   2. Documentation: ____
   C. Comments: ____

   ____

H. Present Value Calculations: ____

____

I. Sensitivity Analysis: ____
   A. Decision Variable(s): ____
   B. Breakeven Point(s): ____
   C. Comments: ____

   ____

J. Conclusions/Recommendations: ____

____

____

3. The project for this review (is/is not) supported by the subject economic analysis. The point of contact is ______________________.

PV TABLES AND FORMULAE

APPENDIX C

Single and Cumulative Present Value Factors

4.00%

	Table A	Table B
YR (n)	a(n)*	b(n)**
1	.9615	.9615
2	.9246	1.8861
3	.8890	2.7751
4	.8548	3.6299
5	.8219	4.4518
6	.7903	5.2421
7	.7599	6.0021
8	.7307	6.7327
9	.7026	7.4353
10	.6756	8.1109
11	.6496	8.7605
12	.6246	9.3851
13	.6006	9.9856
14	.5775	10.5631
15	.5553	11.1184
16	.5339	11.6523
17	.5134	12.1657
18	.4936	12.6593
19	.4746	13.1339
20	.4564	13.5903
21	.4388	14.0292
22	.4220	14.4511
23	.4057	14.8568
24	.3901	15.2470
25	.3751	15.6221
26	.3607	15.9828
27	.3468	16.3296
28	.3335	16.6631
29	.3207	16.9837
30	.3083	17.2920

4.50%

	Table A	Table B
YR (n)	a(n)*	b(n)**
1	.9569	.9569
2	.9157	1.8727
3	.8763	2.7490
4	.8386	3.5875
5	.8025	4.3900
6	.7679	5.1579
7	.7348	5.8927
8	.7032	6.5959
9	.6729	7.2688
10	.6439	7.9127
11	.6162	8.5289
12	.5897	9.1186
13	.5643	9.6829
14	.5400	10.2228
15	.5167	10.7395
16	.4945	11.2340
17	.4732	11.7072
18	.4528	12.1600
19	.4333	12.5933
20	.4146	13.0079
21	.3968	13.4047
22	.3797	13.7844
23	.3634	14.1478
24	.3477	14.4955
25	.3327	14.8282
26	.3184	15.1466
27	.3047	15.4513
28	.2916	15.7429
29	.2790	16.0219
30	.2670	16.2889

* NOTE: The a(n) (single present value) factors are based on End-of-Year compounding using the equation 1/(1+i)^n.

**NOTE: The b(n) (cummulative uniform series) factors represent the cummulative sum of PV factors in the a(n) column.

Single and Cumulative Present Value Factors

5.00%

	Table A	Table B
YR (n)	a(n)*	b(n)**
1	.9524	.9524
2	.9070	1.8594
3	.8638	2.7232
4	.8227	3.5460
5	.7835	4.3295
6	.7462	5.0757
7	.7107	5.7864
8	.6768	6.4632
9	.6446	7.1078
10	.6139	7.7217
11	.5847	8.3064
12	.5568	8.8633
13	.5303	9.3936
14	.5051	9.8986
15	.4810	10.3797
16	.4581	10.8378
17	.4363	11.2741
18	.4155	11.6896
19	.3957	12.0853
20	.3769	12.4622
21	.3589	12.8212
22	.3418	13.1630
23	.3256	13.4886
24	.3101	13.7986
25	.2953	14.0939
26	.2812	14.3752
27	.2678	14.6430
28	.2551	14.8981
29	.2429	15.1411
30	.2314	15.3725

5.50%

	Table A	Table B
YR (n)	a(n)*	b(n)**
1	.9479	.9479
2	.8985	1.8463
3	.8516	2.6979
4	.8072	3.5052
5	.7651	4.2703
6	.7252	4.9955
7	.6874	5.6830
8	.6516	6.3346
9	.6176	6.9522
10	.5854	7.5376
11	.5549	8.0925
12	.5260	8.6185
13	.4986	9.1171
14	.4726	9.5896
15	.4479	10.0376
16	.4246	10.4622
17	.4024	10.8646
18	.3815	11.2461
19	.3616	11.6077
20	.3427	11.9504
21	.3249	12.2752
22	.3079	12.5832
23	.2919	12.8750
24	.2767	13.1517
25	.2622	13.4139
26	.2486	13.6625
27	.2356	13.8981
28	.2233	14.1214
29	.2117	14.3331
30	.2006	14.5337

* NOTE: The a(n) (single present value) factors are based on End-of-Year compounding using the equation 1/(1+i)^n.

**NOTE: The b(n) (cummulative uniform series) factors represent the cummulative sum of PV factors in the a(n) column.

Single and Cumulative Present Value Factors

6.00%

Table A Table B

YR (n)	a(n)*	b(n)**
1	.9434	.9434
2	.8900	1.8334
3	.8396	2.6730
4	.7921	3.4651
5	.7473	4.2124
6	.7050	4.9173
7	.6651	5.5824
8	.6274	6.2098
9	.5919	6.8017
10	.5584	7.3601
11	.5268	7.8869
12	.4970	8.3838
13	.4688	8.8527
14	.4423	9.2950
15	.4173	9.7122
16	.3936	10.1059
17	.3714	10.4773
18	.3503	10.8276
19	.3305	11.1581
20	.3118	11.4699
21	.2942	11.7641
22	.2775	12.0416
23	.2618	12.3034
24	.2470	12.5504
25	.2330	12.7834
26	.2198	13.0032
27	.2074	13.2105
28	.1956	13.4062
29	.1846	13.5907
30	.1741	13.7648

6.50%

Table A Table B

YR (n)	a(n)*	b(n)**
1	.9390	.9390
2	.8817	1.8206
3	.8278	2.6485
4	.7773	3.4258
5	.7299	4.1557
6	.6853	4.8410
7	.6435	5.4845
8	.6042	6.0888
9	.5674	6.6561
10	.5327	7.1888
11	.5002	7.6890
12	.4697	8.1587
13	.4410	8.5997
14	.4141	9.0138
15	.3888	9.4027
16	.3651	9.7678
17	.3428	10.1106
18	.3219	10.4325
19	.3022	10.7347
20	.2838	11.0185
21	.2665	11.2850
22	.2502	11.5352
23	.2349	11.7701
24	.2206	11.9907
25	.2071	12.1979
26	.1945	12.3924
27	.1826	12.5750
28	.1715	12.7465
29	.1610	12.9075
30	.1512	13.0587

* NOTE: The a(n) (single present value) factors are based on End-of-Year compounding using the equation 1/(1+i)^n.

**NOTE: The b(n) (cummulative uniform series) factors represent the cummulative sum of PV factors in the a(n) column.

Single and Cumulative Present Value Factors

7.00%

YR (n)	Table A a(n)*	Table B b(n)**
1	.9346	.9346
2	.8734	1.8080
3	.8163	2.6243
4	.7629	3.3872
5	.7130	4.1002
6	.6663	4.7665
7	.6227	5.3893
8	.5820	5.9713
9	.5439	6.5152
10	.5083	7.0236
11	.4751	7.4987
12	.4440	7.9427
13	.4150	8.3577
14	.3878	8.7455
15	.3624	9.1079
16	.3387	9.4466
17	.3166	9.7632
18	.2959	10.0591
19	.2765	10.3356
20	.2584	10.5940
21	.2415	10.8355
22	.2257	11.0612
23	.2109	11.2722
24	.1971	11.4693
25	.1842	11.6536
26	.1722	11.8258
27	.1609	11.9867
28	.1504	12.1371
29	.1406	12.2777
30	.1314	12.4090

7.50%

YR (n)	Table A a(n)*	Table B b(n)**
1	.9302	.9302
2	.8653	1.7956
3	.8050	2.6005
4	.7488	3.3493
5	.6966	4.0459
6	.6480	4.6938
7	.6028	5.2966
8	.5607	5.8573
9	.5216	6.3789
10	.4852	6.8641
11	.4513	7.3154
12	.4199	7.7353
13	.3906	8.1258
14	.3633	8.4892
15	.3380	8.8271
16	.3144	9.1415
17	.2925	9.4340
18	.2720	9.7060
19	.2531	9.9591
20	.2354	10.1945
21	.2190	10.4135
22	.2037	10.6172
23	.1895	10.8067
24	.1763	10.9830
25	.1640	11.1469
26	.1525	11.2995
27	.1419	11.4414
28	.1320	11.5734
29	.1228	11.6962
30	.1142	11.8104

* NOTE: The a(n) (single present value) factors are based on End-of-Year compounding using the equation 1/(1+i)^n.

**NOTE: The b(n) (cummulative uniform series) factors represent the cummulative sum of PV factors in the a(n) column.

Single and Cumulative Present Value Factors

8.00%

Table A Table B

YR (n)	a(n)*	b(n)**
1	.9259	.9259
2	.8573	1.7833
3	.7938	2.5771
4	.7350	3.3121
5	.6806	3.9927
6	.6302	4.6229
7	.5835	5.2064
8	.5403	5.7466
9	.5002	6.2469
10	.4632	6.7101
11	.4289	7.1390
12	.3971	7.5361
13	.3677	7.9038
14	.3405	8.2442
15	.3152	8.5595
16	.2919	8.8514
17	.2703	9.1216
18	.2502	9.3719
19	.2317	9.6036
20	.2145	9.8181
21	.1987	10.0168
22	.1839	10.2007
23	.1703	10.3711
24	.1577	10.5288
25	.1460	10.6748
26	.1352	10.8100
27	.1252	10.9352
28	.1159	11.0511
29	.1073	11.1584
30	.0994	11.2578

8.50%

Table A Table B

YR (n)	a(n)*	b(n)**
1	.9217	.9217
2	.8495	1.7711
3	.7829	2.5540
4	.7216	3.2756
5	.6650	3.9406
6	.6129	4.5536
7	.5649	5.1185
8	.5207	5.6392
9	.4799	6.1191
10	.4423	6.5613
11	.4076	6.9690
12	.3757	7.3447
13	.3463	7.6910
14	.3191	8.0101
15	.2941	8.3042
16	.2711	8.5753
17	.2499	8.8252
18	.2303	9.0555
19	.2122	9.2677
20	.1956	9.4633
21	.1803	9.6436
22	.1662	9.8098
23	.1531	9.9629
24	.1412	10.1041
25	.1301	10.2342
26	.1199	10.3541
27	.1105	10.4646
28	.1019	10.5665
29	.0939	10.6603
30	.0865	10.7468

* NOTE: The a(n) (single present value) factors are based on End-of-Year compounding using the equation 1/(1+i)^n.

**NOTE: The b(n) (cummulative uniform series) factors represent the cummulative sum of PV factors in the a(n) column.

Single and Cumulative Present Value Factors

9.00%

Table A Table B

YR (n)	a(n)*	b(n)**
1	.9174	.9174
2	.8417	1.7591
3	.7722	2.5313
4	.7084	3.2397
5	.6499	3.8897
6	.5963	4.4859
7	.5470	5.0330
8	.5019	5.5348
9	.4604	5.9952
10	.4224	6.4177
11	.3875	6.8052
12	.3555	7.1607
13	.3262	7.4869
14	.2992	7.7862
15	.2745	8.0607
16	.2519	8.3126
17	.2311	8.5436
18	.2120	8.7556
19	.1945	8.9501
20	.1784	9.1285
21	.1637	9.2922
22	.1502	9.4424
23	.1378	9.5802
24	.1264	9.7066
25	.1160	9.8226
26	.1064	9.9290
27	.0976	10.0266
28	.0895	10.1161
29	.0822	10.1983
30	.0754	10.2737

9.50%

Table A Table B

YR (n)	a(n)*	b(n)**
1	.9132	.9132
2	.8340	1.7473
3	.7617	2.5089
4	.6956	3.2045
5	.6352	3.8397
6	.5801	4.4198
7	.5298	4.9496
8	.4838	5.4334
9	.4418	5.8753
10	.4035	6.2788
11	.3685	6.6473
12	.3365	6.9838
13	.3073	7.2912
14	.2807	7.5719
15	.2563	7.8282
16	.2341	8.0623
17	.2138	8.2760
18	.1952	8.4713
19	.1783	8.6496
20	.1628	8.8124
21	.1487	8.9611
22	.1358	9.0969
23	.1240	9.2209
24	.1133	9.3341
25	.1034	9.4376
26	.0945	9.5320
27	.0863	9.6183
28	.0788	9.6971
29	.0719	9.7690
30	.0657	9.8347

* NOTE: The a(n) (single present value) factors are based on End-of-Year compounding using the equation 1/(1+i)^n.

**NOTE: The b(n) (cummulative uniform series) factors represent the cummulative sum of PV factors in the a(n) column.

Single and Cumulative Present Value Factors

10.00%

Table A   Table B

YR (n)	a(n)*	b(n)**
1	.9091	.9091
2	.8264	1.7355
3	.7513	2.4869
4	.6830	3.1699
5	.6209	3.7908
6	.5645	4.3553
7	.5132	4.8684
8	.4665	5.3349
9	.4241	5.7590
10	.3855	6.1446
11	.3505	6.4951
12	.3186	6.8137
13	.2897	7.1034
14	.2633	7.3667
15	.2394	7.6061
16	.2176	7.8237
17	.1978	8.0216
18	.1799	8.2014
19	.1635	8.3649
20	.1486	8.5136
21	.1351	8.6487
22	.1228	8.7715
23	.1117	8.8832
24	.1015	8.9847
25	.0923	9.0770
26	.0839	9.1609
27	.0763	9.2372
28	.0693	9.3066
29	.0630	9.3696
30	.0573	9.4269

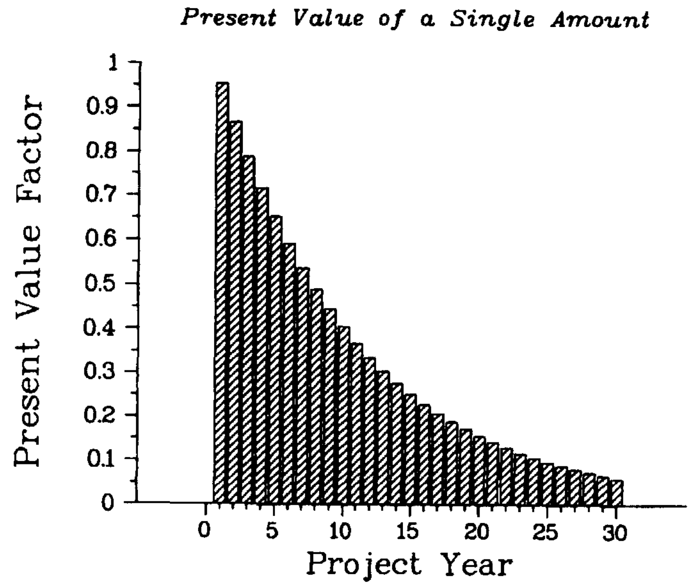
10.50%

Table A   Table B

YR (n)	a(n)*	b(n)**
1	.9050	.9050
2	.8190	1.7240
3	.7412	2.4651
4	.6707	3.1359
5	.6070	3.7429
6	.5493	4.2922
7	.4971	4.7893
8	.4499	5.2392
9	.4071	5.6463
10	.3684	6.0148
11	.3334	6.3482
12	.3018	6.6500
13	.2731	6.9230
14	.2471	7.1702
15	.2236	7.3938
16	.2024	7.5962
17	.1832	7.7794
18	.1658	7.9451
19	.1500	8.0952
20	.1358	8.2309
21	.1229	8.3538
22	.1112	8.4649
23	.1006	8.5656
24	.0911	8.6566
25	.0824	8.7390
26	.0746	8.8136
27	.0675	8.8811
28	.0611	8.9422
29	.0553	8.9974
30	.0500	9.0474

* NOTE: The a(n) (single present value) factors are based on End-of-Year compounding using the equation 1/(1+i)^n.

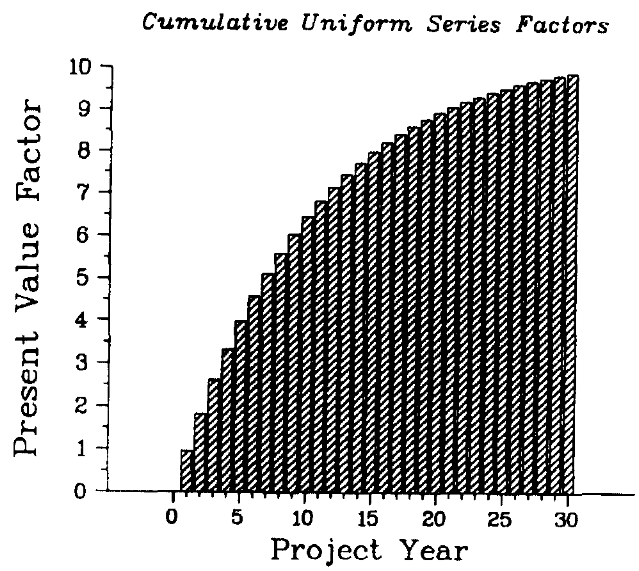
**NOTE: The b(n) (cummulative uniform series) factors represent the cummulative sum of PV factors in the a(n) column.



Graph of Table A
Single Amount Discount Factors

Table A factors are graphed in the bar chart above. Note that costs or benefits occurring many years from today are heavily discounted. It is for this reason that the results of economic analyses of facilities are usually insensitive to assumptions about terminal value.

Table B factors are graphed in the bar chart on the next page. Note that the cumulative present value of a uniform series of costs gradually levels off as the number of years becomes large. Due to this effect of discounting at 10%, assumption of an economic life in excess of 25 years generally does not have a significant impact on the present value of life cycle costs.



Graph of Table B
Cumulative Series Discount Factors

Table C

Conversion Table
Savings/Investment Ratio To Discounted Payback Period

NOTE: This table should be used only when savings accumulate in equal amounts each year and there is no significant lead time between the initial investment and the beginning of the savings stream. This table was calculated at 10% discount rate, however it is not dependent on discount factors and applies for any discount rate.

Discounted Payback Period (Yrs.) For Economic Life Shown

SIR	5	10	15	20	25
1.0	5.00	10.00	15.00	20.00	25.00
1.1	4.43	8.58	12.34	15.60	18.30
1.2	3.98	7.53	10.54	12.97	14.82
1.3	3.62	6.71	9.23	11.16	12.57
1.4	3.31	6.06	8.22	9.83	10.97

1.5	3.06	5.53	7.42	8.80	9.75
1.6	2.84	5.08	6.77	7.97	8.79
1.7	2.65	4.71	6.22	7.29	8.01
1.8	2.48	4.38	5.76	6.72	7.36
1.9	2.33	4.10	5.37	6.24	6.82
2.0	2.20	3.85	5.02	5.82	6.35
2.1	2.09	3.63	4.72	5.45	5.94
2.2	1.98	3.44	4.45	5.13	5.58
2.3	1.89	3.26	4.21	4.85	5.27
2.4	1.80	3.10	4.00	4.60	4.99
2.5	1.73	2.96	3.81	4.37	4.73
2.6	1.66	2.83	3.63	4.16	4.51
2.7	1.59	3.71	3.47	3.97	4.30
2.8	1.53	2.60	3.33	3.80	4.11
2.9	1.47	2.50	3.19	3.65	3.94
3.0	1.42	2.40	3.07	3.50	3.78
3.1	1.37	2.32	2.95	3.37	3.63
3.2	1.32	2.24	2.85	3.24	3.50
3.3	1.28	2.16	2.75	3.13	3.37
3.4	1.24	2.09	2.66	3.02	3.26
3.5	1.20	2.03	2.57	2.92	3.15
3.6	1.17	1.96	2.49	2.83	3.05
3.7	1.13	1.91	2.41	2.74	2.95
3.8	1.10	1.85	2.34	2.66	2.86
3.9	1.07	1.80	2.28	2.58	2.78
4.0	1.04	1.75	2.21	2.51	2.70
4.5	.92	1.54	1.92	2.20	2.36
5.0	.83	1.38	1.73	1.96	2.10
5.5	.75	1.24	1.56	1.76	1.89
6.0	.68	1.13	1.42	1.61	1.72
6.5	.63	1.04	1.31	1.47	1.58
7.0	.58	.96	1.21	1.36	1.46
7.5	.54	.90	1.12	1.26	1.35
8.0	.51	.84	1.05	1.18	1.26

PRESENT VALUE FORMULAE

Project Year Discount Factors:

Table A Single Amount Factor:

$$a_n = \frac{1}{(1+R)^n}$$

Table B Cumulative Uniform Series Factor:

$$b_n = \frac{(1+R)^n - 1}{R(1+R)^n}$$

where:

n = the number of years

R = is the effective annual discount rate

Payback Period

Discounted payback occurs when the present value of accumulated savings equal the present value of the investment. For an investment at time point zero which produces uniform annually recurring savings with no significant lead time between investment and the start of savings, this occurs when:

$$I = S \times b_n$$

where:

I = the investment

S= the annual savings

b_n = the TableB factor forn years

n = the number of years to discounted payback

Substituting the expression for the Table B factor from the previous subsection gives:

$$I = S\left[\frac{(1+R)^{n}-1}{R(1+R)^{n}}\right]$$

Rearranging terms leads to:

$$R\frac{I}{S} = R\frac{(1+R)-1}{(1+R)^{n}} = \frac{(1+R)^{n}}{(1+R)^{n}} - \frac{1^{n}}{(1+R)^{n}} = 1 - \frac{1}{(1+R)^{n}}$$

or

$$\frac{1}{(1+R)^{n}} = 1 - R\frac{I}{S}$$

Then, taking the natural logarithm of both sides of the equation, we have:

$$\ln(1+R)^{n} = \ln\left[1 - R\frac{I}{S}\right]$$

$$-n\ln(1+R) = \ln\left[1 - R\frac{I}{S}\right]$$

$$n = \frac{-\ln\left[1 - R\frac{I}{S}\right]}{\ln(1+R)}$$

You would then insert into the denominator the annual discount rate for the current year. For example, the discount rate for 1993 is 4.5%, so you would have the natural log of (1 + 0.045), or, ln(1.045) in the denominator.

Payback Period - With Lead Time

By a process similar to that in the preceding subsection, the formula for discounted payback with lead time may be derived, starting from

$$I = S(b_n - b_m)$$

where m is the number of years between the investment and the start of savings. The resulting formula is:

$$n = \frac{-\ln\left[\frac{1}{(1+R)^{n}} - R\frac{I}{S}\right]}{\ln(1+R)}$$

Payback Period - As a Function of SIR and Economic Life

The discounted payback period as a function of savings/investment ratio and economic life may be computed, for the case in which there is no significant lead time and uniform annually recurring savings are produced, by using the relationship

$$SIR = \frac{S \times b_e}{I}$$

where b_e is the Table B factor for the economic life. S and I were defined above.

Rearranging terms leads to:

$$\frac{I}{S} = \frac{b_e}{SIR}$$

The right hand side of this equation may be substituted for the I/S term in the formula for discounted payback with no lead time in order to duplicate, or extend Table C.

EA FOR SELF-AMORTIZING UNSPECIFIED MINOR MILCON PROJECTS

APPENDIX D

INTRODUCTION

Unspecified Minor MILCON (UMM) projects represent a special class of MILCON funded projects and are therefore accorded special treatment. As explained below, UMM projects may in some cases be justified on the basis of economics. Such projects must be supported by Type I economic analyses (see Subsection 5.1). Because of the special nature of Unspecified Minor MILCON projects, economic analyses supporting these projects are also somewhat specialized. It is for this reason that a discussion of UMM economic analyses has been reserved for this appendix.

UMM PROJECTS -- GENERAL BACKGROUND

Unspecified Minor MILCON projects are accomplished by authority of 10 U.S.C. 2805. To qualify for UMM funding, a project must satisfy urgent in the sense that:

a) it relates to operations essential to the support of primary missions and tasks or to conditions hazardous to life and property;

b) because of an existing or developing condition, the project cannot be deferred for inclusion in future military construction legislation, and there is no other alternative; and

c) the project addresses a requirement which was not foreseeable.

The project may be considered for UMM funding if it reduces current expenditures sufficiently to amortize the investment cost within a three year period. It is unlikely, however, in this period of funding constraints that economies alone will be sufficient justification for UMM funding. The funded project cost must not exceed $1,500,000.

For additional details concerning statutory guidelines and limitations, funding authority, approval chains, and actual UMM project preparation and submission procedures, the reader is referred to OPNAVINST 11010.20 (current issue), "Facilities Projects Manual," Chapter 2. The remainder of this appendix will discuss the economic analyses associated with those construction projects costing between $300,000 and $1,500,000 which are to be justified under the UMM three year payback approval criteria.

ECONOMIC ANALYSES IN SUPPORT OF UMM PROJECTS

The importance of self-amortizing projects is evident. The significance of the three year payback criterion is tied to the normal MILCON cycle. For projects in the regular military construction program, an average of three years elapses between preparation of the DD Form 1391 and the date of contract award. By contrast, the approval process for UMM projects is expeditious, usually requiring only a few months. Thus, UMM projects with amortization periods of three years or less will essentially have "paid for themselves" during the time it would have taken merely to get them approved as part of a regular military construction program.

Economic analyses supporting self-amortizing projects are Type I in the sense discussed in Subsection 5.2 -- they must of necessity be comparing a status quo (existing situation) against a proposed alternative. Examples of self-amortizing UMM projects might include the following:

- Construction of a short section of pipeline thereby eliminating trucking costs
- Connection of two steam plants, permitting shutdown of one plant and enabling the other to carry the whole load
- Extension of a primary station power distribution system to radar units, thereby eliminating the need for electrical generators at these locations

Because of the special requirements for economic UMM projects, supporting economic analyses do not conform to normal guidelines as set forth in the main text of this handbook. Although UMM economic analyses are Type I analyses, no savings/ investment ratio computation is necessary. Economic projects qualify for Unspecified Minor funding *if, and only if,* the discounted savings in costs will amortize the investment cost within a three year period. Accordingly, the economic analysis need only establish a discounted payback period of three years or less.

Again, with depressed funding levels for UMM projects through the next six years, it is unlikely a project justified solely on economic payback will be considered for funding.

Example D-1: Suppose Alternative A represents the status quo and Alternative B represents an alternate proposal (i.e., a proposed UMM project), with the following cost data:

ALTERNATIVE A:

Project Year	Recurring Cost
1	$245K
2	$245K
3	$245K

ALTERNATIVE B:

Project Year	Investment Cost	Recurring Cost
0	$300K	--
1	--	$160K
2	--	$145K
3	--	$145K

Then cumulative present value savings may be computed:

Project Year	Alt A Cost	Alt B Cost	Savings	Discount Factor	P.V. Savings	Cumm Savings
1	$245K	$160K	$ 85K	.909	$77.3K	$ 77.3K
2	$245K	$145K	$100K	.826	$82.6K	$159.9K
3	$245K	$145K	$100K	.757	$75.1K	$235.0K

Note that the cumulative present value of savings for three years, $235.0K, is greater than the investment cost of $300K for Alternative B, so Alternative B meets the three year discounted payback criterion. Since the cumulative present value of savings after two years, $159.9K, is not sufficient to amortize the investment, the discounted payback period must be between two and three years. The discounted payback period may be estimated via linear interpolation as follows:

Let x = Discounted payback period (yrs.)

$$\frac{x-2}{3-2} = \frac{Investment\ Cost - 2nd\ Yr.\ Cum.\ P.V.\ Savings}{3rd\ Yr.\ Cum.\ P.V.\ Savings - 2nd\ Yr.\ Cum.\ P.V.\ Savings}$$

$$\frac{x-2}{3-2} = \frac{\$300K - \$159.9K}{\$235.0K - \$159.9K}$$

$$\frac{x-2}{1} = 0.93$$

$$x = 0.93 + 2 = 2.93$$

The discounted payback period is estimated to be 2.79 years.

For a formatted example of an economic analysis supporting an Unspecified Minor MILCON project, see Example D-2.

CAVEAT

The economic guidelines set down in the OPNAVINST 11010.20 series are explicit. To be acceptable for UMM funding, a "self-amortizing" project must cause an existing function to be less expensive as a result of the capital investment. Justification must be based strictly on HARD DOLLAR SAVINGS. Vague savings attributed to depreciation, increased productivity, or cost avoidance do not qualify. The government must be actually paying the costs claimed in Alternative A.

Personnel savings are very difficult to successfully claim. Civilian labor savings can only be claimed if: (1) the civilian positions are totally eliminated by a reduction in force (RIF); or (2) the involved civilians fill other billets that are open and authorized to be filled at the activity. "Auditable" savings must actually accrue as a result of the proposed Unspecified Minor MILCON project. If the personnel remain in the same billets, doing other work such as working at a backlog of maintenance, no reduction in the activity operating costs occurs as a result of the project. (This would be a productivity increase.) Even though the personnel are working to reduce the backlog of maintenance, their salaries and fringe benefits are still paid, resulting in no "auditable" savings. However, if these personnel fill other open billets on station that need to be filled and for which funding is already available, and their old billets are eliminated, this elimination is considered justifiable savings in three year payback submissions. It must also be pointed out that only appropriated funds can be claimed as savings. If personnel are paid out of nonappropriated dollars, no savings can be claimed. Military personnel savings can be claimed only if the activity involved reduces its military billets as a result of construction.

The emphasis on hard dollar accountability applies to investment costs as well as savings. Terminal or assets replaced values should not be netted against investment costs unless direct cash receipts will accrue to the Government from the sale of assets. This policy is more restrictive than that applying to Type I economic analyses supporting regular military construction projects, in which properly documented continuing use value or alternative use value is allowable. (See Example D-2, Section IV.) All investment items connected with the project must be shown in the total cost to be amortized within the three years. Items to be included along with the construction project are associated repair, collateral equipment, transportation, equipment installation, demolition and civilian relocation costs. All such items must be considered when investigating the economy of the project.

Finally, it is to be stressed that the documentation of source/derivation of cost estimates and assumptions, if important to regular economic analyses, is crucial to those supporting self-amortizing UMM projects. Such projects are funded solely on an economic basis. If documentation is insufficient to establish credibility of costs and savings, chances for approval are extremely remote.

Example D-2: Following is an example adapted from an actual UMM analysis submission. It is intended to serve as a model for general format. The reader will note that a separate Format A is used to document costs for each alternative. This practice has become standard at NAVFAC Headquarters, despite the general use of Format A-1 for Type I economic analyses. The Format A is here considered more appropriate because, as discussed above, the general imputations allowed on the Format A-1 do not apply to UMM analyses unless a literal cash flow is involved. (For a complete display of formats, see Appendix B.)

COST ANALYSIS FOR
UNSPECIFIED MINOR MILCON PROJECT P-999
DIVER TRAINING FACILITIES
NAVAL TRAINING CENTER, SAN FLORA, ECOTOPIA

I. Background, Objective, and Alternatives

This analysis investigates the economy of replacing an existing barge and three small buildings at the Naval Station, San Flora, used for conducting underwater diver training, with new and existing facilities at the nearby Naval Amphibious Base, San Flora. Present facilities are in need of extensive repair and are within the waterfront operations area of the Naval Station. Existing facilities are also located within an Explosives Safety Quantity-Distance (ESQD) arc.

The objective is to continue the Second Class Diver Training mission in the most economical manner. The alternatives are:

Alternative A - Continue at Naval Station ("Status Quo")

The Second Class Diving School is currently housed in three small buildings, which are in need of extensive repairs, and one barge. The barge is overdue for a complete overhaul which has been scheduled for FY 19x0 and budgeted at $750,000. The barge is a 25 year old vessel used for instructions in diving. The barge contains classrooms and is used tied up to a pier; it is not towed to deep water.

Alternative B - Relocate to Naval Amphibious Base (NAB)

It is proposed to build (through Project P-999) a 6,375 square foot addition to Building 107 at NAB which will contain classrooms, offices, storage and shop areas and to construct a new diving float adjacent to Pier 5 to house various diving apparatus. The estimated construction cost is $480,000; collateral equipment required is estimated at $53,200. The barge will be retired to salvage.

II. Discount

The costs for Alternatives A and B are discussed in Attachments "A" and "B", respectively. The following is a summary of Present Value (PV) costs for three years:

	Alternative A	Alternative B
Investment	0	$533,200
PV 3 year O&M	$733,398	45,822

Cumulative Present Value Savings are:

Project Year	Alt A Cost	Alt B Cost	Savings	Discount Factor	P.V. Savings	Cumm Savings
1	$786,000	$40,000	$746,000	.909	$678,114	$678,114
2	$ 12,000	$ 6,000	$ 6,000	.826	$ 4,956	$683,070
3	$ 12,000	$ 6,000	$ 6,000	.751	$ 4,956	$687,576

Payback occurs within the first year. The discounted payback period is estimated, using linear interpolation, as:

x = Discounted Payback Period in years

$$\frac{x - 0}{1 - 0} = \frac{\$533,200 - 0}{\$678,114 - 0} = 0.79$$

The discounted payback period is 0.79 year, within the three year payback criterion.

III. Assumptions

1. Utilities consumption will be approximately equal for both alternatives and is not included in the cost summaries of this analysis. Electrically-operated equipment will be the same. Total area of new facilities will be approximately the same as the area of existing facilities.

2. Personnel needed for training operations and non-facility costs directly related to the training function will be the same for either alternative.

3. The Naval Station will have to repair Buildings 191, 425, and 470, either for continuation of the Diver Training School or for any new occupant. Although a new occupant of the repaired buildings would perform a function different than diver training, the budgetary impact is the same. Therefore, repair costs for these

occupant of the repaired buildings would perform a function different than diver training, the budgetary impact is the same. Therefore, repair costs for these buildings are included for both alternatives.

IV. Cost and Present Value Summaries

Costs for Alternatives A and B are summarized on the attached Format A's; cost estimates and sources are detailed in Attachments "A" and "B".

V. Other Considerations

An Environmental Impact Assessment has been made and it has been determined that the proposed project will not have a significant impact on the environment and is not highly controversial. If the project is not implemented, the School will continue to operate within the waterfront operations area of the Naval Station encumbered by an ESQD arc. If Alternative B is implemented, training can continue uninterrupted during project accomplishment; however, if Alternative A is chosen training will be interrupted by the barge overhaul and building repairs.

VI. Conclusion and Recommendation

Implementation of Alternative B will provide a rapid payback, primarily through saving FY 19x0 funds from the small craft overhaul budget. This conclusion is not sensitive to the assumptions and estimates made in this analysis. Therefore, it is recommended that Project P-999, Diver Training Facilities, be funded through the Unspecified Minor MILCON program.

ECONOMIC ANALYSIS - DEPARTMENT OF THE NAVY INVESTMENTS
SUMMARY OF PROJECT COSTS

FORMAT A

1. Submitting DOD Component: Department of the Navy

2. Date of Submission: 1 Jan 19x0

3. Project Title: Diver Training Facilities P-999

4. Description of Project Objective: Continue Second Class Diver Training mission

5. Alternative: A · Continue at NS 6. Economic Life: Three Year Payback Criterion

8. Project Costs

7. Project Year(s)	a. Nonrecurring R&D	a. Nonrecurring Investment	b. Recurring Operations	c. Annual Cost	d. Discount Factor	e. Discounted Cost
1	0	0	$786,000	$786,000	.909	$714,474
2	0	0	12,000	12,000	.826	9,912
3	0	0	12,000	12,000	.751	9,012
9. TOTALS			$810,000	$810,000		$733,398

10a. Total Project Cost (discounted) $733,398

10b. Uniform Annual Cost (without terminal value) ______

11. Less Terminal Value (discounted) ______

12a. Net Total Project Cost (discounted) $733,398

12b. Uniform Annual Cost (with terminal value) ______

ECONOMIC ANALYSIS - DEPARTMENT OF THE NAVY INVESTMENTS
SUMMARY OF PROJECT COSTS
FORMAT A

13. Source/Derivation of Cost Estimates:

All Cost estimates are in FY 19x0 constant dollars.

SEE ATTACHMENT "A"

a. Nonrecurring Costs:

(1) Research & Development

(2) Investment

b. Recurring Costs:

c. Net Terminal Value:

d. Other Considerations:

See Section V of this analysis.

14. Name & Title of Principle Action Officer

CDR N. G. Near, PWO San Flora

DATE 1/1/x0

ATTACHMENT "A" FOR ALTERNATIVE A

Present operations are conducted on a barge and in three small buildings. Extensive repairs are needed on all facilities, must be accomplished in the first year, and have already been budgeted to be performed in the first year.

Operation and Maintenance Costs

A. First Year

1. Overhaul and Repairs

a. Barge - This cost estimate is based upon the Small Craft and Boats Accounting Report (SABAR). The YFNX-24 barge is a 25 year old vessel used for instruction in diving and has deteriorated considerably along with original equipment including the basic electrical system. The last drydocking and overhaul was 10 years ago. (The normal cycle is three years.)

Because of the condition of the barge and in accordance with CNO direction, repairs and maintenance as described in the following estimate plus other maintenance or repair items that may become apparent while the barge is in drydock will be funded if P-999 is not approved. The FY 19x0 overhaul budget includes $750,000 earmarked for this purpose.

The single most important feature is the overhaul and repair of the hyperbaric chambers. (This is also the most costly feature.) The chambers (decompression) do not meet current criteria for certification. They continue to be used, however, based on older less restrictive certification criteria. NAVSEA rules require that the chambers be updated to meet new criteria during the next normal maintenance cycle. The hyperbaric chambers will be discarded if P-999 is approved, as existing chambers at the new site are available for this training.

Estimated overhaul costs for YFNX-24:

(1)	Sewage disposal system	$ 37,400
(2)	Repairs to classrooms and head	30,000
(3)	Repair and overhaul hyperbaric chambers	285,000
(4)	Docking/undocking, berthing and services	31,000
(5)	Craft preservation (hull, housing structure)	99,400
(6)	Fendering replacement	47,500
(7)	Electrical system repair	123,200
(8)	Steam and water system repairs (galvanic protection	73,500
(9)	Void preservation	23,000
		$750,000

(Although not included in the three year period addressed by this payback analysis, the barge would also require later expenditures of approximately $115,000 every three years on the normal cycle for routine overhaul which includes craft preservation and void preservation.)

b. Bldgs. 191, 425 and 470

Repairs are needed on these buildings. Work consists of reroofing, repair/replacement of flooring, electrical rewiring, and replacement of light fixtures and painting. Assumed cost is based on Public Works Department estimates.

Estimated Cost = $ 36,000

2. Maintenance - no significant maintenance costs are expected for the first year.

Total First Year Cost = $786,000

B. Annual Cost for the Remaining Two Years

1. Repairs - no further repairs required

2. Maintenance

a. Barge - Work consists of painting the inside of the barge on an annual basis and painting the outside twice a year. Estimated cost for painting is $9,000. A nominal sum of $1,000 is assumed for preventative maintenance and minor repairs. Thus,

$9,000 + $1,000 = $10,000

b. Bldgs. 191, 425 and 470

Annual maintenance for these three buildings is estimated at $2,000, based upon Public Works Dept. records.

$ 2,000

Total Annual Cost = $12,000

ECONOMIC ANALYSIS - DEPARTMENT OF THE NAVY INVESTMENTS
SUMMARY OF PROJECT COSTS

FORMAT A

1. Submitting DOD Components: Department of the Navy

2. Date of Submission: 1 Jan 19x0

3. Project Title: Diver Training Facilities

4. Description of Project Objective: Continue Second Class Diver Training mission

5. Alternative: B - Relocate to NAB 6. Economic Life: Three Year Payback Criterion

8. Project Costs

7. Project Year(s)	a. Nonrecurring R&D	a. Nonrecurring Investment	b. Recurring Operations	c. Annual Cost	d. Discount Factor	e. Discounted Cost
0	0	$533,200	0	$533,200	1.000	$533,200
1	0	0	40,000	40,000	.909	36,360
2	0	0	6,000	6,000	.867	4,956
3	0	0	6,000	6,000	.788	4,506
9. TOTALS		$533,200	$52,000	$585,200		$579,022

10a. Total Project Cost (discounted) $579,022

10b. Uniform Annual Cost (without terminal value) ______

11. Less Terminal Value (discounted) ______

12a. Net total Project Cost (discounted) $579,022

12b. Uniform Annual Cost (with terminal value) ______

ECONOMIC ANALYSIS - DEPARTMENT OF THE NAVY INVESTMENTS
SUMMARY OF PROJECT COSTS
FORMAT A

13. Source/Derivation of Cost Estimates:

All cost estimates are in FY 19x0 constant dollars.

SEE ATTACHMENT "B"

a. Nonrecurring Costs:

(1) Research & Development

(2) Investment:

b. Recurring Costs:

c. Net Terminal Value:

d. Other Considerations:

See Section V of this analysis.

14. Name & Title of Principal Action Officer

CDR N. G. Near, PWO San Flora

DATE 1/1/x0

ATTACHMENT "B" FOR ALTERNATIVE B

Proposed project will relocate the Divers' School from the Naval Station to the Naval Amphibious Base (NAB). The barge will be retired to salvage.

Investment Costs:

Construction: Estimate prepared by A/E firm using industrial engineering method of cost estimating based upon take-off from designs for building extension and float. SIOH included.

$480,000

Collateral Equipment: Based on list of furniture, lockers, equipment, etc., at delivered prices (supplied through GSA).

$ 53,000

Total Investment Cost = $533,000

Operation Costs:

A. First Year

1. Repairs

a. Bldgs. 191, 425, and 470 - The Naval Station will have to repair these buildings for any new occupant. Work will be the same as Alternative A.

Estimated Cost = $36,000

(See Attachment "A")

2. Maintenance

a. NAB Bldg 107, float $ 4,000

Total First Year Cost = $40,000

B. Annual Cost for the Remaining Two Years

1. Maintenance

a. Bldgs. 191, 425, 470 - Continued annual maintenance for these three buildings.

Estimated Cost = $2,000

b. NAB Bldg 107, float $4,000

GUIDELINES FOR ENERGY-RELATED ANALYSES

APPENDIX E

INTRODUCTION

Executive Order 12759 of 17 April 1991 (see attachment 1), specifies certain energy goals for all Federal buildings. The goal is a 20% reduction in the average annual energy required by 2000, when compared to the average annual energy requirement of a building in 1985. Accordingly, when analyzing energy conserving measures economic analysis methods employing life cycle cost techniques shall be used. Generally, all facilities must be designed for minimal energy consumption. This policy is further discussed in NAVFACINST 11010.14Q, "Project Engineering Documentation (PED) for Proposed Military Construction Projects" of 4 May 1988. Additionally, for fuel consuming projects NAVFACINST 11010.14Q describes national policy on utility systems and industrial size plants. In the development of plant projects, an economic analysis is also required to determine the optimum design for power plants and supporting facilities.

The Office of the Assistant Secretary of Defense has implemented policy on the Defense Energy Program (see Attachment (2)). It provides updated policy to meet the current goals of the Energy Policy Act and the continued management of the Energy Conservation Investment Program (ECIP). NAVFAC letter of 20 April 1993, (subject: Energy Conservation Investment Program (ECIP) guidance) (see Attachment (3)) provides NAVFAC guidance on preparing a life cycle cost analysis summary sheet. Further guidance on NAVFAC Energy Cost Avoidance Program (ECAP) projects is provided as Attachment (4).

Energy prices and discount factors for life-cycle cost analysis are provided for the U.S. Department of Energy by the National Institute of Standards and Technology (NIST) in the NISTIR 85-3273-8 (Rev. 10/93) Annual Supplement to NIST Handbook 135. In general, the NISTIR energy prices and discount factors should be used in economic analyses of the following energy project categories for existing faclities:

1. EMCS or HVAC Controls
2. Steam and Condensate Upgrades
3. Boiler Plant Modifications
4. Heating, Ventilation, Air-Conditioning (HVAC) Systems
5. Weatherization
6. Lighting Systems Replacement
7. Energy Recovery Systems
8. Electrical Energy Stystems
9. Renewable Energy Systems
10. Facility Energy Improvements

Attachment 5 contains selected key pages of the current NIST annual supplement to provide the projected average fuel price escalation rates Tables Cb-1 through Cb-5. These key tables consolidate the information provided by the indices in the NIST (Ca-1 to Ca-5 Tables). They are provided herein to assist those who use the PC-

ECONPACK or any other computer program which require escalation rates as inputs.

For further assistance and information on energy training courses and the use of these tables, contact Mr. Bernard F. White Jr., NAVFACENGCOM (Code 90Z), at 703-325-7355 / DSN 221-7356 or Mr. Ed Neidzwiecki, CECOS Port Hueneme, Ca, at 805-982-2891 / DSN 551-5655.

The general guidance for energy related projects is that economics guides the decision among alternatives. Exceptions for solar or other renewable energy investments have been made as a result of the "energy crisis." Special cases for solar related systems should be examined where they appear to have potential economic feasibility. Recent MILCON authorization acts have given solar installations economic preference to stimulate the industry. The FY-80 act requires that all Military Construction projects, including family housing, shall include solar energy systems to the extent that analysis demonstrates it to be cost effective. Solar systems are legislatively defined to be cost effective if the original investment cost differential can be recovered over the expected life of the facility. In conducting the life cycle cost analysis, the solar system O&M cost differential will be considered to be zero and all calculations will be based on undiscounted, escalated dollars. This legislative guidance changes periodically and care should be taken to assure that the latest guidance is being followed.

ECIP AND ETAP

The conservation of energy is an important national goal. Every year, the Navy allocates significant resources to reduce energy consumption at Naval shore activities by retrofitting existing facilities. These energy conservation retrofit projects usually show high energy and cost savings. The submission of energy projects and supporting economic analysis documentation are required in accordance with the guidance of two programs:

1. Energy Conservation Investment Program (ECIP)

2. Energy Technology Application Program (ETAP)

(NOTE: For information about the Energy Cost Avoidance Program (ECAP), see Attachment 4 of this appendix.)

ECIP provides for accomplishment of MILCON projects of more than $100,000 investment cost which retrofit existing facilities. ECIP projects are funded under a dedicated program within the regular MILCON program. Submissions of ECIP projects are in accordance with the guidance of NAVFACINST 11010.44 series and must meet the criteria and formats of OASD Memorandum (L/MRM) of 17 March 1993. Similar guidance for family housing projects is contained in NAVFAC letter 08/MCM of 31 May 1978, "Energy Conservation Investment Program (ECIP) Guidance for Family Housing." ECIP projects must be cost effective based on a savings/investment ratio (SIR) greater than one. As shown by a life cycle cost analysis, ECIP projects may combine similar work in various buildings in order to reduce contract costs. When preparing ECIP life cycle cost analyses, prescribed long-term differential escalation rates are to be used for computing discounted savings.

ETAP provides for accomplishment of smaller energy conservation retrofit projects which cannot be funded under the ECIP program. ETAP is a NAVFAC centrally managed and O&MN funded program for rapid payback facility retrofit projects. Submission of ETAP projects must be in accordance with OPNAVINST 11010.20 Series and must meet the criteria established by claimants. The procedures for ETAP projects are almost identical to ECIP procedures. The ETAP projects must be cost effective, may include multiple category codes, and may group separate small tasks to meet the funding minimums. However, ETAP projects are limited to the correction of deficiencies requiring investment of no more than $300,000 construction cost.

DEPARTMENT OF ENERGY LIFE CYCLE COSTING RULES

Executive Order 12003 directed Federal agencies to consider in their building plans only energy conservation improvements which are life cycle cost effective and to give the highest priority to the most cost effective projects. The Executive Order also required the Department of Energy (DOE) to provide procedures to Federal agencies for estimation of life cycle costs and savings of proposed energy conservation, and for comparison of cost effectiveness in a consistent manner throughout the Federal Government. The National Energy Conservation Policy Act of 1978 also contained provisions for the establishment of life cycle costing procedures by the Department of Energy in consultation with the National Bureau of Standards (NBS) and the General Services Administration (GSA). The basic set of life cycle costing rules included in the Federal Energy Management Program (FEMP) Rules, as established by Part 436, Subpart A, in Title 10 of the U.S. Code of Federal Regulations, was published in the Federal Register, Vol. 45, No. 16, of 23 January 1980. Explanations and procedures for application of these rules are described in the Life-Cycle Costing Manual for the Federal Energy Management Program, which was prepared by NBS for DOE.

The DOE rules apply to consideration of both the cost effects of replacing building systems with energy-saving alternatives in existing Federal buildings, and of selecting among alternative building designs containing different energy-using building systems for new Federal buildings. Those of you who have studied the information in Chapters 1 through 7 of this handbook are well prepared for conducting an analysis as described in the NBS Manual. Key features of the DOE rules and differences from the previously discussed procedures are:

1. DOE establishes energy prices and differential escalation rates to be used in the analysis. Actual prices paid may be used in analyses if they are higher than the DOE energy prices.

   It has been argued that changes in Federal energy use have an impact at the margin and the prices should therefore be based on marginal prices rather than average prices. DOE is considering using marginal prices and is also considering adjusting prices to reflect externalities. (Refer to Section 4.6 of this handbook for a definition of "externalities.")

   Future energy prices and differential escalation rates are forecasted by DOE's Energy Information Administration (EIA). Energy price differential escalation rates are projected for 10 geographic regions for electricity, natural gas, liquid gas, distillate, residual, gasoline and coal. Separate projections are made for the residential, commercial, and industrial sectors. Three differential escalation rates are projected for each combination of region,sector, and fuel type--one for the first 5 years of the study period, one for the next 5 years, and one for the remainder of the study period. Since these projections are periodically updated, the analyst should ensure that the most recent projection is used in the analysis.

   The EIA energy price differential escalation rate projections have been incorporated in tables of "UPW Discount Factors Adjusted for Average Fuel Price Escalation." These factors are analogous to the cumulative uniform series differential escalation-discount factors of Appendix C and are used in a similar manner. The analyst may use these tables or compute factors using the formula provided in the Federal Register and in the NBS Manual.

2. The DOE rules specify that no differential escalation is to be applied to non-fuel costs.

3. The base year (zero point) is the year in which the analysis is performed. Therefore all costs and benefits are estimated in terms of analysis year constant dollars and are discounted to the analysis year "present" in the present value calculations. Usually the initial investment will occur at some point other than the base year and the analysis year constant dollar investment cost will differ from the budget year current dollar investment cost.

(Refer to Chapter 3, Section 5, for a discussion of constant and current dollars.) Because the differential escalation projections mentioned in (2) above apply to specific years, care should be taken to ensure that differential escalation factors are applied properly in relation to the base year.

4. The maximum building life to be used is set at 30 years. The rules state that the useful life of any major building renewal or overhaul may be estimated by the manufacturer, engineer or architect, or other reliable source.

5. Until a more adequate method of accounting for external benefits is developed, DOE requires Federal agencies to assume an investment credit of 10 percent of the initial investment cost of both conservation and renewable energy investments as a proxy for externality adjustments. In other words, each analysis will assume that the initial cost is 90 percent of the actual investment cost. The 10 percent figure is based upon Federal and state tax credits which represent legislative valuations of the external benefits of fossil fuel conserving investments.

6. Ranking measures used in the DOE rules are referred to as "modes of analysis." Replacement of a building system with alternative building system is considered cost effective if:

   a. Total Life Cycle Costs (TLCC) are estimated to be lower. (TLCC is equivalent to net present value (NPV) of life cycle costs discussed in Chapter 3),

   b. Net Savings are estimated to be positive (Net Savings is the difference in TLCC's for the existing and proposed alternatives), or

   c. The Savings-to-Investment Ratio (SIR) is estimated to be greater than one.

   d. As a rough measure, Federal agencies may estimate simple payback time. The estimated simple payback time is the number of years required for the cumulative value of energy cost savings less future nonfuel costs to equal the investment cost required, without consideration of future fuel price increases or discount rates. Alternative building designs for new Federal buildings are to be evaluated on the basis of TLCC. The alternative design which results in the lowest TLCC is deemed the most cost effective.

7. Federal agencies are encouraged to use formats similar to the NBS Manual.

DOE RULES - PRESENT WORTH FORMULA

Single Present Worth Factor (to be applied to non-fuel, non-recurring costs):

$$SPW = \frac{1}{(1+d)^n}$$

where d = the discount rate, and
n = the year the cost occurs

Uniform Present Worth Factor (to be applied to annually recurring uniform amounts of non-fuel costs):

$$UPW = \frac{(1+d)^n - 1}{d(1+d)}$$

where d = the discount rate and the cost occurs in years I through n.

The Uniform Present Worth Factor (UPW) (Adjusted for Energy Price Escalation):

$$UPW = \sum_{j=1}^{n} \left[\frac{1+e}{1+d}\right]^j = \frac{1+e}{1-e}\ 1 - \left[\frac{1+e}{1+d}\right]^n$$

where n_i is the length of the period for a given differential escalation rate in a given period, and the subscript, i, indicates the escalation period for i=1 to k periods and d = the discount rate.

This equation is used to calculate the UPW as noted in NBS Handbook 135, "Life Cycle Costing Manual," issued December 1980 by the National Bureau of Standards.

Executive Order 12759 - Federal Energy Management
April 17, 1991

By the authority vested in me as President by the Constitution and the laws of the United States of America, including the Energy Policy and Conservation Act, as amended (Public Law 94-163, 89 Stat. 871, 42 U.S.C. 6201 et seq.), the Motor Vehicle Information and Cost Savings Act, as amended (15 U.S.C. 1901 et seq.), section 205(a) of the Federal Property and Administrative Services Act, as amended (40 U.S.C. 486 (a)), and section 301 of title 3 of the United States Code, it is hereby ordered as follows:

Section 1. Federal Energy Efficiency Goals for Buildings. Each agency shall develop and implement a plan to meet the 1995 energy management goals of the National Energy Conservation Policy Act, as amended, 42 U.S.C. 8251 et seq., and by the year 2000 reduce overall energy use of Btu's per gross square foot of the Federal buildings it operates, taking into account utilization, by 20 percent from 1985 energy use levels, to the extent that these measures minimize life cycle costs and are cost-effective in accordance with 10 CFR Part 436.

Section 2. Federal Energy Efficiency Goals for Other Facilities. Each agency will prescribe policies under which its industrial facilities in the aggregate increase energy efficiency by a least 20 percent in fiscal year 2000 in comparison to fiscal year 1985, to the extent that these measures minimize life cycle costs and are cost-effective in accordance with 10 CFR Part 436. Each agency shall establish appropriate indicators of energy efficiency to comply with this section.

Section 3. Minimization of Petroleum Use in Federal Facilities. Each agency using petroleum products for facilities operations or building purposes shall seek to minimize such use through switching to an alternative energy source if it is estimated to minimize life cycle costs and which will not violate Federal, State, or local clean air standards. In addition, each agency shall survey its buildings and facilities to determine where the potential for a dual fuel capability exists and shall provide dual fuel capability where practicable.

Section 4. Implementation Strategies. (a) Except as provided by paragraph (b) and (c) of this section, each agency shall adopt an implementation strategy, consistent with the provisions of this order, to achieve the goals established in sections 1, 2, and 3. That strategy should include, but not be limited to, changes in procurement practices, acquisition of real property, participation in demand side management services and shared savings agreements offered by private firms, and investment in energy efficiency measures. The mix and balance among such measures shall be established in a manner most suitable to the available resources and particular circumstances in each agency.

(b) The Secretary of Defense may, if he determines it to be in the national interest, issue regulations exempting from compliance with the requirements of this order, any weapons, equipment, aircraft, vehicles, or other classes or categories of real or personal property which are owned or operated by the Armed Forces of the United States (including the Coast Guard) or by the National Guard of any State and which are uniquely military in nature.

(c) The Secretary of the Treasury and the Attorney General, consistent with their protective and law enforcement responsibilities, shall determine the extent to which the requirements of this order shall apply to the protective and law enforcement activities of their respective agencies.

Section 5. Procurement of Energy Efficient Goods and Products. In order to assure the purchase of energy efficient goods and products, each agency shall select for procurement those energy consuming goods or products which are the most life cycle cost-effective, pursuant to the requirements of the Federal Acquisition Regulation. To the extent practicable, each agency shall require vendors of goods to provide appropriate data that can be used to assess the life cycle costs of each good or product, including building energy system components, lighting systems, office equipment, and other energy using equipment.

Section 6. Participation in Demand Side Management Services. Each agency shall review its procedures used to acquire utility and other related services, and to the extent practicable and consistent with its strategy established pursuant to section 4, remove any impediments to receiving, utilizing, and taking demand side management services, incentives, and rebates offered by utilities and other private sector energy service providers.

Section 7. Energy Efficiency Requirement for Current Federal Building Space. Each agency occupying space in Federal buildings shall implement the applicable rules and regulations regarding Federal property and energy management.

Section 9. Vehicle Fuel Efficiency Outreach Programs. Each agency shall implement outreach programs including, but not limited to, ride sharing and employee awareness programs to reduce the petroleum fuel usage by Federal employees and by contractor employees at Government-owned, contractor-operated facilities.

Section 10. Federal Vehicle Fuel Efficiency. Consistent with its mission requirements, each agency operating 300 or more commercially designed motor vehicles domestically shall develop a plan to reduce motor vehicle gasoline and diesel consumptions by at least 10 percent by 1995 in comparison with fiscal year 1991. The Administrator of General Services, in consultation with the Secretary of Energy, shall issue appropriate guidance to assist agencies in meeting this goal. This guidance shall include guidance concerning vehicles to be covered, the use of alternative/blended fuels, initiatives to improve fuel efficiency of the existing fleet, the use of modified energy life cycle costing consistent with life cycle costing methods in 10 CFR 436, and limitations on vehicle type and engine size to be acquired. Each agency electing to use alternative fuel motor vehicles shall receive credit for such use.

Section 11. Procurement of Alternative Fueled Vehicles. The Secretary f Energy with the cooperation of other appropriate agencies, and consistent with other Federal law, shall ensure that the maximum number practicable of vehicles acquired annually are alternative fuel vehicles as required by the Alternative Motor Fuels Act of 1988 (42 U>S>C> 6374). Subject to availability of appropriations for this purpose, the maximum number practicable of alternative fuel vehicles produced by original equipment vehicle manufacturers shall be acquired by the end of model year 1995.

Section 12. Federal Funding. Within approved agency budget totals, each agency head shall work to achieve the goals set forth in this order. To the extent that available resources fall short of requirements, agency heads shall rank energy efficiency investments in descending order of the savings-to-investment ratios, or their adjusted internal rate of return to establish priority.

Section 13. Annual Reports. The head of each agency shall report annually to the Secretary of Energy, in a format specified by the Secretary of Energy, in a format specified by the Secretary after consultation with the heads of affected agencies, on progress in achieving the goals of this Executive order with respect to Federal buildings, facilities, and vehicles subject to this order. The Secretary of Energy will prepare a consolidated report to the President annually on the implementation of this order.

Section 14. Definition. For the purpose of this order -

(a) the term "energy use" means the energy that is used at a building or facility and measured in terms of energy delivered to the building or facility;

(b) the term "Federal building" means any building in the United States which is controlled by the Federal Government for its use.

George Bush

The White House,
April 17, 1991

(Filed with the Office of the Federal Register, 10:33 a.m., April 18, 1991)

OFF.:E OF THE ASSISTANT SECRETARY OF DEFENSE

WASHINGTON, DC 20301-8000

March 17, 1993

PRODUCTION AND LOGISTICS
(L/MRM)

MEMORANDUM FOR ASSISTANT SECRETARY OF THE ARMY (INSTALLATIONS, LOGISTICS AND ENVIRONMENT)
ASSISTANT SECRETARY OF THE NAVY (INSTALLATIONS AND ENVIRONMENT)
ASSISTANT SECRETARY OF THE AIR FORCE (MANPOWER, RESERVE AFFAIRS, INSTALLATIONS AND ENVIRONMENT)
DIRECTOR, DEFENSE LOGISTICS AGENCY
DIRECTOR, DEFENSE COMMISSARY AGENCY
DIRECTOR, NATIONAL SECURITY AGENCY
DIRECTOR, DEFENSE MAPPING AGENCY
DIRECTOR, WASHINGTON HEADQUARTERS SERVICES

SUBJECT: Energy Conservation Investment Program Guidance

This memorandum replaces Defense Energy Program Policy Memorandum (DEPPM) 92-2. It provides updated policy to meet the goals set by the Energy Policy Act of 1992 (PL 102-486 of October 24, 1992) and for the continued management of the Energy Conservation Investment Program (ECIP).

The ECIP is a Military Construction funded program to improve the energy efficiency of existing Department of Defense facilities. The projects funded through ECIP improve the living and working environment of Defense personnel, enhance mission capabilities, and greatly deceases the negative environmental effects of Defense energy systems. Support of this program must continue to be emphasized at all levels.

Because of increasing emphasis on the program by the Administration and Congress, and the centralized management of funding, it is imperative that this office be kept informed of program execution and results. The attachments contain detailed guidance for program management and execution. Please inform this office of the official point of contact in your office to which all requests for program status should be addressed within sixty days of the date of this memorandum.

Jeffrey A. Jones
Acting Deputy Assistant Secretary
(Logistics)

Attachments

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) GUIDANCE

DEFINITION: ECIP is a subset of the Defense Agencies Military Construction (MILCON) program specifically designated for projects that save energy or reduce Defense energy costs. It includes construction of new, high-efficiency energy systems or the improvement and modernization of existing systems.

SCOPE: The currently projected annual funding level of ECIP is $50.0 million as shown below not to include the cost of design: (Design will be programmed in the Defense Agency design account).

	$Millions					
	FY94	FY95	FY96	FY97	FY98	FY99
Army	12.8	12.8	12.8	12.8		
Navy	19.3	19.3	19.3	19.3	to be	
USMC	2.5	2.5	2.5	2.5	determined	
Air Force	14.9	14.9	14.9	14.9		
Def Agencies	.5	.5	.5	.5		
	50.0	50.0	50.0	50.0		

RESPONSIBILITIES: A list of projects, reviewed for conformance with technical criteria, and comprising the planned execution of the appropriated funds will be forwarded to the Congress upon enactment of the authorization and appropriations acts each year. The list will be prepared by the Office of the Deputy Assistant Secretary of Defense for Logistics in coordination with the DoD Comptroller.

Each Military Service and Defense Agency is responsible to:

- Identify and accomplish all energy conservation measures with a 10 year or less payback.
- Submit project documentation, through the normal Military Construction review and verification process, to the Deputy Assistant Secretary of Defense (Logistics) on the highest priority projects, within the funding levels projected above by February 15 each year for the following Fiscal Year.
- Execute those projects forwarded to Congress and within funds allocated by the OSD Comptroller.
- Ensure that all monies appropriated for ECIP are used for energy conservation purposes.

    The balance of funds accrued through project savings, deferrals, or cancellations within a Service may be used on projects that have experienced cost growth, for design of ECIP projects, to supplement the funding of future or prior year ECIP projects, or for additional projects approved by the Deputy Assistant Secretary of Defense (Logistics) in coordination with the DoD Comptroller.

- Revalidate all projects prior to advertising to ensure that contemplated benefits will still accrue.

  Projects may be considered valid if the Savings-to-Investment ratio remains above 1.25. This will ensure that projects funded within the 25 percent variation allowance still achieve a positive return on investment over the life of the project. However, for programming purposes, ECIP projects with comparatively low savings-to- investment ratios are less likely to be funded than those with high ratios.

  In the event that a project cost estimate changes by more than 25 percent of that furnished to the Congress (the original estimate attached with the DoD funding document) or the scope is reduced by 25 percent to allow award within the original estimate, notify the Deputy Assistant Secretary of Defense (Logistics) and the DoD Comptroller of the circumstances causing the change. Contracts or contract modifications may be awarded 21 days after submission to OSD provided no objections exist. Contracts or contract modifications may be awarded prior to the 21 day period with OSD concurrence.

- Maintain current, auditable documentation on the execution status and the projected and realized savings for each approved ECIP project;

- Provide an annual report on the status of the ECIP to the Office of the Deputy Assistant Secretary of Defense (Logistics) by February 15 of each year in the format of Appendix A for incorporation into the Department of Energy's report to Congress.

  The report also shall include a project status list of all ECIP projects for each of the past five years indicating: original approved costs; current working estimates; the original and current estimated savings, savings-to-investment ratios, and payback periods; and whether or not the project has been awarded, completed, cancelled or deferred. Computer generated reports in Excel or Lotus 123 are preferred--sample provided as Appendix B.

  Projects added will be identified without an original estimate and projects cancelled or deferred without a current working estimate. Projects added, deferred, cancelled, or changed by more than 25 percent, will be identified in the status column.

PROGRAMMING CRITERIA: ECIP projects are to be programmed under the following criteria:

- Priority shall be given to projects that produce the highest savings-to-investment ratio and the shortest payback period.
- Additional consideration can be given to projects that substitute renewable energy for non-renewable energy.
- Since there is uncertainty over future force levels and base structure, a sensitivity analysis must be conducted to determine if there is likelihood that expected changes might alter the economic benefits. Increased risk identified as the result of a sensitivity analysis may be used to lower a project's programming priority.
- Projects must have a saving-to-investment ratio greater than 1.25 and a discounted payback period of 10 years or less.
- Energy Monitoring and Control System projects must have the Installation Commander's certification that appropriate resources will be committed to effectively operate the system over the life cycle of the investment.
- Projects will be classified into one of the ten categories listed on appendix A. Projects will be classified under a category if 75 percent of the scope of the project falls under that category. Projects that do not contain at least 75 percent of any category shall be classified as "Facility Energy Improvement projects".

ECONOMIC ANALYSIS: The savings-to-investment ratios and payback periods shall be arrived at using the following guidance:

- Life Cycle Cost analyses are to be performed on all projects, and discrete elements of the projects using the procedures specified in 10 CFR, Part 436, Subpart A.
- Savings-to-investment ratios and life-cycle cost analyses will be based upon the recommended useful life of the retrofit, as given in Appendix B, or the remaining life of the basic facility being retrofitted, whichever is less.
- Use the actual cost of energy purchased for use at the facility, rather than stock fund prices, as the basis for energy cost analysis. (Stock fund prices might be out of date and include storage and other overhead costs.)

- The following conversion factors are to be used for the calculation of energy savings:

Purchased electricity	3,413 BTU/kWh	3.6 MJ/kWh
Purchased steam	1,340 BTU/lb	1.41MJ/lb
Distillate fuel oil	138,700 BTU/gal	38.6 MJ/L
Natural gas	1,031 BTU/cu. ft.	38.85 MJ/cu. m
LPG, propane, butane	95,000 BTU/gal	24.6 MJ/L
Bituminous coal	24,58~~0,000~~MBTU/ short ton	28,592 MJ/ metric ton
Anthracite coal	25,4~~00~~MBTU/ short ton	29,546 MJ/ metric ton
Residual fuel oil	Average thermal content of oil at each installation	

- Call the Advanced Sciences, Inc., at (703) 243-4900 to obtain copies of the following National Institute of Standards and Technology (NIST) tools which will assist in the economic analysis of candidate ECIP projects:

  (1) *Life-Cycle Costing Manual for the Federal Energy Management Program*, NIST Handbook 135 (current version 1987).

  (2) Present Worth Factors for Life-Cycle Cost Studies in the Department of Defense, NISTIR 4942 (Current version 1993) Included in this document is a *Memorandum of Agreement on Criteria/Standards for Economic Analysis/Life Cycle Costing for MILCON Design* dated March 18, 1991, which includes further information on basic life cycle analysis assumptions and criteria.

  (3) *NIST "Building Life Cycle Cost" (BLCC) Computer Program* Note: Use the most recent version available - Latest version 3.2, October 1, 1992.

These tools along with the Life Cycle Cost in Design (LCCID) program should be used to perform the economic analysis that is submitted with the 1391 project documentation. The LCCID program and application assistance is available from the Building Loads Analysis System Thermodynamics (BLAST) Support Office, Army Construction Engineering Research Laboratory, Champaign, IL, by calling 1-800-842-5278.

PROJECT DOCUMENTATION: Project documentation to be furnished to the Deputy Assistant Secretary of Defense (Logistics) will adhere to the following guidance:

- Projects will be submitted on DD Form 1391 and will include the notation "ECIP" in the title block.

- Projects will be further titled under one of the ten categories listed in Appendix C. A project will be classified in a category if 75 percent of the scope of the projects falls into the category. Projects which do not contain 75 percent on any one category shall be identified as "Facility Energy Improvement."

- Project submittals will include copies of the life-cycle analyses with supporting documentation showing basic assumptions made in arriving at projected savings. Sample format of the analyses and summary sheet are provided in Appendix D. Computer generated summaries are acceptable provided they conform to the above guidance.

- Project descriptions must clearly define the conservation measures from which the energy savings will result and the specific facilities being built or modified by the project.

- Project documentation shall be in metric units in support of the goals established under Executive Order 12770 "Metric Usage in Federal Government Programs" dated July 25, 1991.

- Project documentation shall include a statement regarding whether or not the installation affected by the project is being considered for closure or realignment. If so, an explanation must be provided for why the project is being considered in face of the closure or realignment.

PROGRAM REVIEW: A program review will be conducted mid year to determine the status of the program execution and to verify projected savings. In addition, the Defense Inspector General will make periodic audits of ECIP as part of the overall audit of the Energy Resource Management Program.

ECIP Annual Report Summary 1/

SERVICE ____________________ DATE ____________

FUND SOURCE ______________ 2/

	FY 85	FY 86	FY87	FY88	FY89	FY90	FY91	FY92	FY93	FY94	FY95	FY96	FY97
Number of Projects Authorized													
Millions of Dollars Authorized													
Number of Projects Appropriated													
Millions of Dollars Appropriated													
Number of Projects Completed													
Millions of Dollars Used 3/													
Number of Projects Cancelled													
Millions of Dollars of Cancelled Projects													
Estimated Energy Savings (MBTU) 4/													
Actual Energy Savings (MBTU) 5/													
Estimated Annual Savings ($000) 4/													
Actual Annual Savings ($000) 5/													

1/ A separate project information sheet shall be maintained at the Service Program Management Office for any project cancelled, deferred beyond the Fiscal Year authorized, reduced in scope by more than 25 percent, that exceeds the authorized amount by more than 25 percent, or that fails to save less than 75 percent of the original estimated savings.

2/ Separate Summary Sheets shall be submitted for MILCON Active Forces, Family Housing, Reserve, and Guard.

3/ Actual amounts for program years that have been completed and for those program years not completed, use the total actual expenditures on completed projects and the current working estimates of projects not yet completed.

4/ As originally provided to the Congress.

5/ Actual validated cost savings including current estimates based on the latest scope of those projects not yet completed or validated.

FY 1991 Energy Conservation Investment Program

Installation	State	Project	Approved Estimate	Current Estimate	Original NPV Savings Est.	Current NPV Savings Est.	Design Cost Inhouse	Design Cost Contract	Original SIR	New SIR	Original Payback	New Payback	Status 1/
	ARMY												
Tooele AD	UT	Extend NAG lines	165,000	165,000	34,578,373	34,578,373			209.6	209.6	0.2		
Schofield Barracks	HI	Photovoltaics	100,000	100,000	3,863,232	3,863,232			38.6	38.6	0.2		
Tooele AD	UT	Extend NAG lines	120,000	120,000	3,483,992	3,483,992			29.0	29.0	1.2		
Tooele AD	UT	Extend NAG lines	160,000	160,000	3,302,634	3,302,634			20.6	20.6	1.7		
Ft. Carson	CO	EMCS	1,050,000	1,050,000	4,999,828	4,999,828			4.8	4.8	2.4		
Ft. Hauchuca I	AZ	EMCS	230,000	230,000	690,327	690,327			3.0	3.0	3.3		
Iowa AAP	IA	Insulate Steam lines	630,000	630,000	4,006,656	4,006,656			6.4	6.4	4.1		
Ft. Benning	GA	EMCS for Hospital	1,150,000	1,150,000	2,846,006	2,846,006			2.5	2.5	4.2		
		Design	84,000	84,000									
Army Subtotal for FY 1991			3,689,000	3,689,000	57,771,048	57,771,048	0		15.7	15.7			
	NAVY												
Bangor	WA	Boiler Plant Mods	1,166,000	1,166,000	26,246,984	26,246,984			22.5	22.5	0.7		
Port Hueneme	CA	Fac Energy Mods	310,000	310,000	1,418,821	1,418,821			4.6	4.6	3.3		
		Design	524,000	524,000									
Navy Subtotal for FY 1991			2,000,000	2,000,000	27,665,805	27,665,805	0		13.8	13.8			
	MARINE CORPS												
Camp Lejeune	NC	Replace Pipe Insulation	100,000	100,000	2,561,251	2,561,251			25.6	25.6	0.6		
MCCDC Quantico	VA	Temp Contrl	192,000	192,000	2,392,775	2,392,775			12.5	12.5	0.8		
Camp Lejeune	NC	Replace Pipe Insulation	119,000	119,000	2,289,045	2,289,045			19.2	19.2	0.8		
Camp Lejeune	NC	Replace Pipe Insulation	205,000	205,000	3,124,554	3,124,554			15.2	15.2	1.1		
MCCDC Quantico	VA	Insulate Steam Pipes	172,000	172,000	2,592,913	2,592,913			15.1	15.1	1.3		
MCCDC Quantico	VA	Insulate Steam Pipes	112,000	112,000	1,689,966	1,689,966			15.1	15.1	1.3		
MCCDC Quantico	VA	Insulate Steam Pipes	51,000	51,000	761,707	761,707			14.9	14.9	1.3		
MCCDC Quantico	VA	Various Fac Energy Impr	346,000	346,000	2,716,462	2,716,462			7.9	7.9	1.7		
		Design	114,000	114,000									
Marine Corps Subtotal for FY 1991			1,411,000	1,411,000	18,128,673	18,128,673	0		12.8	12.8			
	AIR FORCE												
Mountain Home AFB	ID	Addition to EMCS	200,000	269,075	1,668,404	1,668,404			6.2	6.2	1.2		
Tyndall AFB	FL	Add EMCS to 16 fac	170,000	170,256	714,349	714,349			4.2	4.2	2.3		
Homestead AFB	FL	Addition to EMCS	190,000	0	716,919				4.2		2.7		cancelled
Tyndall AFB	FL	Hospital Cogen Plant	720,000	840,669	4,692,529	4,692,529			6.5	5.6	2.9		
Columbus AFB	MS	Replace EMCS Basewide	1,400,000	1,400,000	3,126,727	3,126,727			2.2	2.2	4.6		
		Design	220,000	220,000									
Air Force Subtotal for FY 1991			2,900,000	2,900,000	10,920,928	10,204,009	0		3.8	3.5			
Grand total DoD for FY 1991			10,000,000	10,000,000	114,486,454	113,769,535			11.4	11.4			

Status: Awarded, Completed, Deferred, or Cancelled

DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND
200 STOVALL STREET
ALEXANDRIA, VA 22332 2300

IN REPLY REFER TO
4101/10
1652
APR 20 1993

From: Commander, Naval Facilities Engineering Command

Subj: ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) GUIDANCE

Ref: (a) OASD (L/MRM) Memorandum of 17 Mar 93 (NOTAL)
(b) NAVFACINST 11300.37

Encl: (1) ECIP Life Cycle Cost Analysis Guidance

1. Reference (a) updates the ECIP guidance. Enclosure (1) revises Chapter 8107 of reference (b) to reflect changes and provide for the continued management of the ECIP.

2. An ECIP life cycle cost analysis summary sheet, as detailed in enclosure (1), must accompany each ECIP project. ECIP project titles must be one of the ten categories listed in attachment (2) of Enclosure (1) and have an economic analysis life expectancy appropriate for the title. Project submittals will include supporting documentation showing basic assumptions made in arriving at projected savings. The Navy is currently accepting ECIP projects with a Savings Investment Ratio (SIR) of 2.0 or greater; however, projects with the highest SIRs will receive funding priority. Attachment (3) of enclosure (1) contains an example of a completed ECIP life cycle cost analysis summary, which is provided for your guidance.

3. Supporting software for computing the life cycle cost analysis summary sheet is being developed and will be distributed when finalized. The point of contact for ECIP is Mr. Art Spiegel, Code 1652, commercial (703) 325-0363, DSN 221-0363.

Edward A. Krupa

EDWARD A. KRUPA
By direction
Acting

Distribution:
(see next page)

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LIFE CYCLE COST ANALYSIS GUIDANCE

An ECIP Life Cycle Cost Analysis Summary sheet as detailed below, must accompany each ECIP project. Attachment (1) contains an example of a completed ECIP life cycle cost analysis summary, which is provided for your guidance. ECIP project titles must be one of the ten categories listed in attachment (2) and have an economic analysis life expectancy appropriate for the title. Project submittals will include supporting documentation showing basic assumptions made in arriving at projected savings. The Navy is currently accepting ECIP projects with Savings Investment Ration (SIR) of 2.0 or greater; however, projects with the highest SIRs will receive funding priority.

The Forms section of E1 contains an ECIP Life Cycle Cost Analysis Summary form with supporting formulas that perform computations for you. The formulas will need periodic updating.

a. The Life Cycle Cost Analysis Summary form is to be used for determining SIRs for complete ECIP projects and for discrete portions of projects. In using this form, the cost of construction, supervision, inspection, and overhead (SIOH), design costs, salvage value, rebates, unit costs of energy, and recurring and nonrecurring non-energy costs are determined as of the date the analysis is made.

b. Title Block. The project title shall be one of the ten titles listed in attachment (2), and the Title Category shall be put in the accompanying block. The installation region is determined by its location identified in the Annual Supplement to NIST Handbook 135. The economic life shall be for that given in attachment (2) based on the type of project proposed.

c. Item 1 Investment Costs. All investment costs are determined as of the date the analysis is made. Salvage value is the residual value of existing equipment removed as a result of the retrofit project. Rebates are cash or credit incentives provided by the public utility. Investment costs do not include energy audit costs, preliminary design, and analysis costs since these efforts are required by Executive Order, legislation, or Department of Defense (DOD) requirements and are therefore considered sunk costs when the design is completed.

d. Item 2 Energy Savings. ECIP projects must save energy; therefore, there will always be an overall energy cost savings. The overall savings include increases in use of one fuel and decrease in use of another. For each fuel, attach computations to show and substantiate the energy cost/savings (Column 2) claimed. The cost per MBTU (Column 1) is the cost of energy at the activity on the date of the analysis. Care must be taken to use the same conversion factors used in column 2 to develop the appropriate unit cost, e.g., electric cost of ($50.00/MWH) divided by (3.413

MBTU/MWH) = $14.65/MBTU. The source cost per MBTU is used in Column 1 so that the units for annual energy and dollar savings are compatible. The annual savings is the product of Column 1 x Column 2. The discount UPW factor (Column 4) are obtained in the Annual Supplement to NIST Handbook 135. The discounted savings (Column 5) are determined by multiplying Column 3 by Column 4.

e. Item 3 Non-Energy Savings. Annual recurring savings/costs will include items such as operator/maintenance savings (labor and material). Non-recurring savings/costs will include periodic maintenance and integral parts replacement costs. All costs are to be estimated as if they will be incurred on the analysis date. Attach backup data substantiating all costs/savings. For each non-recurring item, enter the analysis year in which it occurs, obtain the discounted (SPW) factor and calculate the discounted savings/cost by multiplying (1) x (3). For annually recurring savings/costs, obtain the Annual Supplement to NIST Handbook 135 (currently at 4% for FY93).

f. Item 4 First Year Dollar Savings. Total of [2G3=3A=(3Bd1/Yrs Economic Life)].

g. Item 5 Simple Payback. Simple payback equals total investment (1G) divided by first year annual savings (line 4).

h. Item 6 Total Net Discounted Savings. Total net discounted savings equals 2G5 + 3C.

i. Item 7 SIR. Project qualifies for inclusion in the program if the SIR in line 7 (line 6/1G) is equal to or greater than 2.0.

j. Attachment (3). This is an example of a completed ECIP life cycle cost analysis summary which is provided for your guidance.

ECIP LIFE CYCLE COST ANALYSIS SUMMARY

LOCATION NAS Anywhere, Nearby VA REGION NO. 1 PROJECT NO. P-001
PROJECT TITLE Weatherization TITLE CAT. 5 FY 1993
ANALYSIS DATE 9/10/92 ECONOMIC LIFE 20YRS PREPARED BY H. Menchen

1. INVESTMENT COSTS:

A. CONSTRUCTION COST	$ 1,200,000	
B. SIOH (6%)	$ 72,000	
C. DESIGN COST (10%)	$ 120,000	
D. ENERGY CREDIT CALC (1A + 1B + 1C)		$ 1,392,000
E. SALVAGE VALUE OF EXISTING EQUIPMENT		$ 3,000
F. PUBLIC UTILITY COMPANY REBATE		$
G. TOTAL INVESTMENT [1D - (1E + 1F)]		$ 1,389,000

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE SAVINGS, UNIT COSTS & DISCOUNTED SAVINGS

FUEL	COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 15.10	3,920	$ 59,192	13.75	$ 813,890
B. DIST	$ 5.00	25,342	$ 126,710	17.92	$ 2,270,643
C. RESID	$		$		$
D. NG	$ 4.00	5,070	$ 20,280	17.18	$ 348,410
E. COAL	$ 2.60	4,500	$ 11,700	16.20	$ 189,540
F. DEMAND SAVINGS			$		$
G. TOTAL			$ 217,882		$ 3,622,483

3. NON ENERGY SAVINGS (+) OR COST (-)

A. ANNUAL RECURRING (+/-)		$ + 5,000
(1) DISCOUNT FACTOR (TABLE 1)	13.59	
(2) DISCOUNTED SAVING/COST (3A X 3A1)		$ + 67,950

B. NON RECURRING SAVINGS (+) OR COST (-)

ITEM	SAVINGS $ (+) COST $ (-)(1)	YEAR OF OCCURRENCE(2)	DISCOUNT FACTOR(3)	DISCOUNTED SAVINGS (+) OR COST (-)(4)
a.	$ - 50,000	10	.68	$ - 34,000
b.	$			$
c.	$			$
d. TOTAL	$ - 50,000			$ - 34,000

C. TOTAL NON ENERGY DISCOUNTED SAVINGS/COST (3A2+3Bd4) $ - 33,950

4. FIRST YEAR $ SAVINGS [2G3+3A+(3Bd1/YRS ECON LIFE)] $ 221,182

5. SIMPLE PAYBACK = 1G/4 6.28 YRS

6. TOTAL NET DISCOUNTED SAVINGS (2G5 + 3C) $ 3,588,533

7. SIR (IF < THAN 2.0 PROJECT DOES NOT QUALIFY)
(SIR) = (6/1G) = 2.58

Attachment (1)

ENERGY CONSERVATION PROJECT TYPES
(Recommended Economic Analysis Life)

Cat:	Title	Description
1.	EMCS or HVAC Controls (10 yrs)	Projects which centrally control energy systems with the ability to automatically adjust temperature, shed electrical loads, control motor speeds or adjust lighting intensities.
2.	Steam and Condensate (15 yrs)	Projects to install condensate lines, cross connect lines, distribution system loops, repair or install insulation and repair or install meters and controls.
3.	Boiler Plant Modifications (20 yrs)	Projects to upgrade or replace central boiler or ancillary equipment to improve overall plant efficiency. This includes fuel switching or dual fuel conversions.
4.	Heating Ventilation, Air Conditioning (HVAC) Systems (20 yrs)	Projects to install more energy efficient heating cooling, ventilation or hot water heating equipment. This includes HVAC distribution systems.
5.	Weatherization (20 yrs)	Projects improving the thermal envelope of a building. This includes insulation, windows, vestibules, earth berms, shading, etc.
6.	Lighting Systems (15 yrs)	Projects to install replacement lighting systems and controls. this would include daylighting, new fixtures, lamps, ballasts, photocells, motion sensors, light wells, etc.
7.	Energy Recovery Systems (20 yrs)	Projects to install heat exchangers, regenerators, heat reclaim units or recapture energy lost to the environment.
8.	Electrical Energy Systems (20 yrs)	Projects that will increase the energy efficiency of an electrical device or system or deduce cost by peak shaving.
9.	Renewable Energy Systems (20 yrs)	Any project utilizing renewable energy. This includes active and passive solar heating, cooling, hot water, industrial process heating, photovoltaic, wind, biomass, and geothermal applications.
10.	Facility Energy Systems (20 yrs)	Multiple category projects or those that do not fall into any other category.

Attachment (2)

ECIP LIFE CYCLE COST ANALYSIS SUMMARY

LOCATION ______________________ REGION NO. __ PROJECT NO.P-___
PROJECT TITLE _________________________TITLE CAT. __ FY ____
ANALYSIS DATE _______ ECONOMIC LIFE ____YRS PREPARED BY _________

1. INVESTMENT COSTS:

A. CONSTRUCTION COST $ ___________
B. SIOH (6%) $ ___________
C. DESIGN COST (10%) $ ___________
D. TOTAL COST (1A + 1B + 1C) $ ___________
E. SALVAGE VALUE OF EXISTING EQUIPMENT $ ___________
F. PUBLIC UTILITY COMPANY REBATE $ ___________
G. TOTAL INVESTMENT [1D - (1E + 1F)] $ ___________

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE SAVINGS, UNIT COSTS & DISCOUNTED SAVINGS

FUEL	COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ _______	_________	$ _______	_______	$ _______
B. DIST	$ _______	_________	$ _______	_______	$ _______
C. RESID	$ _______	_________	$ _______	_______	$ _______
D. NG	$ _______	_________	$ _______	_______	$ _______
E. COAL	$ _______	_________	$ _______	_______	$ _______
F. DEMAND SAVINGS			$ _______	_______	$ _______
G. TOTAL			$ _______		$ _______

3. NON ENERGY SAVINGS (+) OR COST (-)

A. ANNUAL RECURRING (+/-) $ _______
(1) DISCOUNT FACTOR (TABLE 1) _______
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ _______

B. NON RECURRING SAVINGS (+) OR COST (-)

ITEM	SAVINGS $ (+) COST $ (-)(1)	YEAR OF OCCURRENCE(2)	DISCOUNT FACTOR(3)	DISCOUNTED SAVINGS (+) OR COST (-)(4)
a. ____	$ _________	_________	_______	$ _________
b. ____	$ _________	_________	_______	$ _________
c. ____	$ _________	_________	_______	$ _________
d. TOTAL	$ _________			$ _________

C. TOTAL NON ENERGY DISCOUNTED SAVINGS/COST (3A2+3Bd4) $ _______
4. FIRST YEAR $ SAVINGS [2G3+3A+(3Bd1/YRS ECON LIFE)] $ _______

5. SIMPLE PAYBACK = 1G/4 _____YRS

6. TOTAL NET DISCOUNTED SAVINGS (2G5 + 3C) $ _______
7. SIR (IF < THAN 2.0 PROJECT DOES NOT QUALIFY)
(SIR) = (6/1G) = _____

Attachment ( )

FAC 90ZJL
23 SEPT 1993

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) GUIDANCE

To support the Energy Conservation Investment Program Guidance, NAVFAC Code 135 recommends the Lotus 123 spreadsheet file ECIP94.WK1 to automate the ECIP life cycle cost analysis according to the requirements of NISTIR 85-3273-7, Energy Prices and Discount Factors for Life-Cycle Analysis.

Highlights of this spreadsheet are summarized as follows:

a. The directions for data entry have been streamlined by placing them into a table.

b. The defaults for data entry cells contain helpful data entry prompts.

c. Macros are used to automatically convert from English to metric units and vise versa for both the Cost Per Energy Unit and Savings Per Energy Unit columns for various energy types.

d. The economic life and project name are automatically generated when the project category is entered. To simplify data entry, a table is used for the Energy Conservation Project Types by Category, Title, and Description.

e. The appropriate region of the country is automatically generated when a state is entered. A reference table for data entry is used for the list of abbrevations of the states.

f. Macros routines are used for the automatic generation of annual recurring and nonrecurring discount factors which are used to calculate net present values.

g. Macros are used to pull discount factors from the appropriate tables for the energy types, regions of the country, and economic lives that were entered or derived.

The ECIP spreadsheet creates an economic analysis worksheet to assist in the submittal of an ECIP project. The points of contact are Mr. Art Spiegel, NAVFAC 1352 at 703-325-0363/DSN 221-0363 or Mr. Joe Lane, NAVFAC 90ZJL at 703-325-7355/221-7355 for further information or a current copy of the spreadsheet which is updated annually. For E/A policy guidance contact Mr. Bernie White, NAVFAC 90Z1 at 703-325-7354/221-7354.

ENERGY COST AVOIDANCE PROGRAM (ECAP)

The Energy Cost Avoidance Program (ECAP) assists activities and claimants in reducing energy costs and achieving energy goals and energy management standards.

The Naval Facilities Engineering Command (NAVFACENGCOM) provides policy and guidance in managing the ECAP. The ECAP revenues are generated from the third party geothermal development contract at the Naval Air Weapons Station (NAWS) China Lake, California. These revenues will be used to develop additional revenue producing geothermal projects, implement energy saving projects at shore activities, provide cash incentives for winners of the Secretary of the Navy (SECNAV) Energy Awards, and develop additional third party energy projects.

NAVFACENGCOM should:

- Develop and distribute Navy policies and guidelines to implement ECAP.

- Develop Navy-wide ECAP project execution plan.

- Provide centrally managed ECAP funds for implementation of selected projects.

GEOGRAPHIC ENGINEERING FIELD DIVISIONS (EFDs) shall:

- Assist activities in identifying, validating and verifying energy projects on a reimbursable basis.

CLAIMANT EFDs shall:

- Provide technical support to claimants to develop claimant ECAP guidance.

- Assist claimants to manage ECAP project execution.

MAJOR CLAIMANTS shall:

- Provide guidance to shore activities under their command for prioritization of ECAP projects.

- Provide additional funding, if necessary, to supplement ECAP funds to provide complete project funding.

- Submit project list to NAVFACENGCOM (Code 135) by 1 May for the next fiscal year. Submission shall include a summary sheet listing the following for each project:

  - Location
  - Project Title
  - Cost
  - Payback

- Maintain project documentation to facilitate program audit.

SHORE ACTIVITIES shall:

- Prepare and forward ECAP projects to the Claimants via the regional geographic EFD and other command chain specified by the claimant.

- Commit to providing an effective maintenance program for the installed project.

- All ECIP project identification data and annual audit information shall be entered and maintained current in the Energy Project Status System.

CRITERIA:

- ECAP projects shall be prepared as special projects.

- ECAP projects must be cost effective and have a simple payback of 3 years or less.

- Project scope shall be between $50,000 and $200,000 for construction or between $50,000 and $500,000 for repair.

- ECAP projects are usually facility retrofit and are justified by energy or energy cost savings.

SUBMITTAL DOCUMENTATION:

ECAP low-risk project submittal, maintained by the Major Claimant, should include the following documentation:

- Completed Step Two Special Project Request. NAVFAC Form 11014/64 validated by the regional EFD.

- Project Summary Sheet (attached).

- Completed ECAP Economic Analysis For (attached).

COMPLETION DOCUMENTATION:

Project status and savings resulting from projects funded under the ECAP and Navy Reinvestment fund must be documented and maintained by the Major Claimant. Projects will be tracked for five years. The five year period begins upon completion of project.

- Construction Contract. Along with submission documents, the following information and documents verifying that funds were spent on the selected project are required:

1) Milestone Dates

   - Advertisement for Construction
   - Award of Contract
   - Contract Completion

2) Documents

   - Contract Award
   - Contract Final Payment
   - Meter readings and savings calculations provided by the activity and validated by the geographic EFD.

- In-House/Shop Forces. Circumstances may warrant the need to perform the project work by in-house/shop forces. In addition to the above, (modified to in-house work, e.g. funds cited against a job order), funding must be provided to the regional EFD to verify the correctness and completeness of the installation through random sampling of completed work and track and funding through work orders issued against the specified job order funding.

- Post Construction Validation Report. The Post Construction Validation Report is provided as a cover sheet/guide to be maintained by the Major Claimant for completed ECAP projects.

UIC	ACTIVITY	LOCATION	EFD	CLAIMANT
N____	________	________	________	________

PROJECT # ____ PROJECT TYPE ________ PROJECT DESCRIPTION: ________

DESIGN STATUS ____ FY __ __

COSTS	DESIGN	CONSTRUCTION	REPAIR	TOTAL
SCOPE EST.	0	0	0	0
A/E ACTUAL	0	N/A	N/A	
GOVT. EST.	N/A	0	0	0
CONSTR. AWD:	N/A	N/A	N/A	0
ECAP FUNDED:	0	0	0	0

MILESTONE DATES	ESTIMATE	ACTUAL
BEGIN SCOPE	/ /	/ /
COMPLETE SCOPE	/ /	/ /
ADVERTISE FOR DESIGN	/ /	/ /
NEGOTIATE FOR DESIGN	/ /	/ /
AWARD FOR DESIGN	/ /	/ /
COMPLETE DESIGN	/ /	/ /
ADVERTISE FOR CONSTRUCTION	/ /	/ /
AWARD FOR CONSTRUCTION	/ /	/ /
COMPLETE CONSTRUCTION	/ /	/ /

PROJECT JUSTIFICATION:	EST	ACTUAL	METHOD OF VERIFICATION:
DOLLAR SAVINGS/YEAR	0	0	
ELECTRIC	0	0	
FUEL	0	0	
MBTU SAVINGS/YEAR	0	0	
ELEC. (3413 btu/kw)	0	0	
FUEL	0	0	
SIMPLE PAYBACK	0	0	

FY ___	AMOUNT	DATE
AUTHORIZED	0	/ /
OBLIGATED	0	/ /
EXPENDED	0	/ /

CONTACT	TECHNICAL	FINANCIAL
ACTIVITY		
	( ) -	
CLAIMANT		
	( ) -	
EFD		
	( ) -	

COMMENTS: ________

ENERGY COST AVOIDANCE PROGRAM (ECAP)
POST CONSTRUCTION VALIDATION REPORT - SIMPLE ECONOMIC ANALYSIS

Activity ______________________________ Project Number _______
Project Title __________________________ Program Year (FY) ____
Analysis Date ______ Economic Life (yrs) ___ Prepared By _________

1. INVESTMENT (Actual Costs):
   A. Construction Cost $ _________
   B. SIOH (6%) $ _________
   C. Design Cost (10%) $ _________
   D. Salvage Value of Existing Equipment $ _________
   E. Rebate $ _________
   F. Total Investment (1A + 1B + 1C - 1D - 1E) $ _________

2. DIRECT ENERGY SAVINGS (+) OR COST (-) ACHIEVED:

FUEL	COST $/MBTU	SAVINGS MBTU/YR	ANNUAL $ SAVINGS	
A. Elec	$ _______	_______	$ _________	
B. Dist	$ _______	_______	$ _________	
C. Resid	$ _______	_______	$ _________	
D. NG	$ _______	_______	$ _________	
E. Coal	$ _______	_______	$ _________	
F. Demand Charges			$ _________	
G. Total Energy Savings		_______		$ _________

3. ANNUAL RECURRING NON ENERGY SAVINGS (+) OR COST (-):
   A. Operations and Maintenance $ _________
   B. Other (Specify) _______________ $ _________
   C. Total Non Energy Savings (+) or Cost (-) (3A + 3B) $ _________

4. FIRST YEAR DOLLAR SAVINGS (2G + 3C): $ _________

5. SIMPLE (NON-DISCOUNTED) PAYBACK PERIOD (1F/4): $ _________

ENERGY COST AVOIDANCE PROGRAM (ECAP)
POST CONSTRUCTION VALIDATION REPORT

Activity ______________________________ Project Number ________
Project Title __________________________ Program Year (FY) _____
Validation Date ______________ Prepared By ______________________

ORIGINAL PROJECT DESCRIPTION AND SCOPE:

ORIGINAL PROJECT ECONOMICS:

First Year Dollar Savings $ _______ Total Investment $ __________
Simple Payback Period _______ (Years)

AS BUILT PROJECT DESCRIPTION AND SCOPE:

VALIDATION DOCUMENTATION (CONTRACT NUMBERS, PURCHASE ORDER, AND WORK ORDER NUMBERS ETC.):

AS BUILT PROJECT ECONOMICS: [From Enclosure (1)]

First Year Dollar Savings $ _______ Total Investment $ __________

Simple Payback Period _______ (Years)

CERTIFICATION BY RESPONSIBLE OFFICER AT THE ACTIVITY: I am personally cognizant of the scope and requirements of this project and certify that the above information is correct.

SIGNATURE __________________ TITLE __________________ DATE ______

EFD VALIDATION:

SIGNATURE __________________ TITLE __________________ DATE ______

NAVFAC APPROVAL:

SIGNATURE __________________ TITLE __________________ DATE ______

ENCLOSURES:
(1) ECAP Post Construction Validation Simple Economic Analysis.
(2) Photo copy of excerpts from original study indicating original scope and economics.
(3) Photo copy of above listed validation documentation.

ENERGY COST AVOIDANCE PROGRAM (ECAP)
SIMPLE ECONOMIC ANALYSIS

Activity ______________________ Project Number ________
Project Title ______________________ Program Year (FY) _____
Analysis Date ______ Economic Life (yrs) ___ Prepared By ________

1. INVESTMENT (Actual Costs):

A.	Construction Cost	$ ________
B.	SIOH (6%)	$ ________
C.	Design Cost (10%)	$ ________
D.	Salvage Value of Existing Equipment	$ ________
E.	Rebates	$ ________
F.	Total Investment (1A + 1B + 1C - 1D - 1E)	$ ________

2. DIRECT ENERGY SAVINGS (+) OR COST (-) ACHIEVED:

FUEL	COST $/MBTU	SAVINGS MBTU/YR	ANNUAL $ SAVINGS	
A. Elec	$ ______	______	$ ________	
B. Dist	$ ______	______	$ ________	
C. Resid	$ ______	______	$ ________	
D. NG	$ ______	______	$ ________	
E. Coal	$ ______	______	$ ________	
F. Demand Charges			$ ________	
G. Total Energy Savings		______		$ ________

3. ANNUAL RECURRING NON ENERGY SAVINGS (+) OR COST (-):

A.	Operations and Maintenance	$ ________	
B.	Other (Specify) ______________	$ ________	
C.	Total Non Energy Savings (+) or Cost (-) (3A + 3B)		$ ________

4. FIRST YEAR DOLLAR SAVINGS (2G + 3C): $ ________

5. SIMPLE (NON-DISCOUNTED) PAYBACK PERIOD (1F/4): $ ________

NISTIR 85-3273-7
(Rev. 10/92)

ENERGY PRICES AND DISCOUNT FACTORS FOR LIFE-CYCLE COST ANALYSIS 1993

Annual Supplement to
NIST Handbook 135 and
NBS Special Publication 709

Data for the Federal Methodology for Life-Cycle Cost Analysis, Title 10, CFR, Part 436, Subpart A; and for the Energy Conservation Mandatory Performance Standards for New Federal Residential Buildings, Title 10, CFR, Part 435

Barbara C. Lippiatt

Computing and Applied Mathematics Laboratory
Office of Applied Economics
Gaithersburg, MD 20899

October 1992

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Office of the Assistant Secretary for
Conservation and Renewable Energy
Federal Energy Management Program
Washington, DC 20585

U.S. DEPARTMENT OF COMMERCE, Barbara Hackman Franklin, *Secretary*
Technology Administration, Robert M. White, *Under Secretary for Technology*
National Institute of Standards and Technology, John W. Lyons, *Director*

PREFACE

This is the 1993 edition of energy prices and discount factors for life-cycle cost analysis as established by the U.S. Department of Energy (DOE) in Subpart A of Part 436 of Title 10 of the Code of Federal Regulations (10 CFR Part 436, Subpart A), and amplified in the Life-Cycle Costing Manual for the Federal Energy Management Program (NIST Handbook 135). The data are provided as an aid to implementing life-cycle cost evaluations of potential energy conservation and renewable energy investments in existing and new federally owned and leased buildings.

The life-cycle costing methods and procedures as set forth in 10 CFR, Part 436, Subpart A, are to be followed by all Federal agencies, unless specifically exempted, in evaluating the cost effectiveness of potential energy conservation and renewable energy investments in federally owned and leased buildings.

As called for by legislation, the National Institute of Standards and Technology has provided technical assistance to the U.S. Department of Energy in the development and implementation of life-cycle costing methods and procedures. This is the second of a three-volume set which together provide the methods, data, and computational tools for life-cycle cost analysis of Federal energy projects.

Included in the three-volume set for Federal life-cycle cost analysis are the following:

(1) Life-Cycle Costing Manual for the Federal Energy Management Program, National Institute of Standards and Technology, Handbook 135 (revised 1993).

The manual is a guide to understanding life-cycle costing and related methods of economic analysis as they are applied to Federal decisions. It describes the required procedures and assumptions, defines and explains how to apply and interpret economic performance measures, gives examples of Federal decision problems and their solutions, explains how to use the energy price indices and discount factors which are updated annually in the supplement, and provides worksheets and other computational aids and instructions for calculating the required measures.

(2) Energy Prices and Discount Factors for Life-Cycle Cost Analysis, National Institute of Standards and Technology, NISTIR 85-3273 (updated annually).

This report, which is updated annually, gives the energy price and discount factor multipliers needed to estimate the present value of energy and other future costs. The data are based on energy price projections developed by the Energy Information Administration of the U.S. Department of Energy. Request the latest edition when ordering.

(3) NIST "Building Life Cycle Cost" (BLCC) Computer Program (version 3.2), National Institute of Standards and Technology, NISTIR 4481 (January 1991).

The NIST BLCC program, version 3.2, supersedes and incorporates both the Federal Buildings Life-Cycle Cost (FBLCC) and National Bureau of Standards Life-Cycle Cost (NBSLCC) programs. NIST BLCC is designed to run on IBM PC and compatible microcomputers with approximately 512 K of random access memory (RAM). It can be used to calculate the LCC of capital investments in buildings and building systems which are intended to reduce future operating, maintenance, and energy costs. BLCC computes the LCC for each alternative, compares alternatives in order to determine which has the lowest LCC, performs cash flow analyses, and then computes the net savings, savings-to-investment ratio (SIR), and adjusted internal rate of return (AIRR) over the designated study period. BLCC can be used to perform economic analysis of Federal and of private sector projects. BLCC version 3.2 uses the 1993 energy price data in NISTIR 85-3273-7. BLCC in its application to Federal energy conservation and renewable energy projects is consistent with NIST Handbook 135 (see #1 above). In its application to non-energy projects, BLCC is consistent with OMB Circular A-94. In its application to private-sector and non-Federal public-sector projects, BLCC is consistent with ASTM standards for building economics. BLCC is integrated with the DOE ASEAM computer program which performs energy conservation analysis.

Included on the BLCC disk is a stand-alone program called DISCOUNT version 3.2 which can calculate present value, future value, and annual value factors for any discount rate and study period. DISCOUNT can access the DOE energy price projections included on the BLCC disk to compute the UPW* factors needed for Federal LCC analyses of energy projects, consistent with the factors included in this report.

The three-volume set can also be used to perform economic evaluations of Federal building projects which are not primarily for conserving energy or providing renewable energy but which have an energy cost component. Handbook 135 explains both applications.

The U.S. Department of Energy was directed by legislation and executive order to make available to the private sector the methods, procedures, and related aids developed for Federal use. In response to this directive, the National Institute of Standards and Technology, under sponsorship by the U.S. Department of Energy, published a life-cycle costing book for use by the private sector entitled Comprehensive Guide for Least-Cost Energy Decisions, NBS SP 709 (January 1987). The private sector guide is supported by the data provided here, as well as by the BLCC computer program. The BLCC program (version 3.2) supersedes the NBSLCC program which is documented in SP 709. BLCC provides LCC computational support for private sector projects as well as for Federal projects.

To order any of the printed publications contact:

Advanced Sciences, Inc.
2000 North 15th Street
Suite 407
Arlington, VA 22201
Telephone (703) 243-4900

Please request the publications by name and number.

NOTICE

Please note that Federal Methodology for Life-Cycle Cost Analysis, Title 10, CFR, Part 436, Subpart A has been revised to incorporate changes required by the Federal Energy Management Improvement Act of 1988 (P.L. 100-615), and to reflect 10-years experience with the Federal LCC Rule.

The principal change is a discount rate set annually by DOE. The rate for 1993 is equivalent to a market rate of 7.9% and is based on long-term Treasury bond rates averaged over the previous 12 months. The market rate is converted to a "real" discount rate of 4.0%, exclusive of the Administration's assumed rate of general price inflation, to correspond with the constant-dollar analysis approach that is used. The results are identical to those that would be obtained by using the 7.9% market rate as the discount rate and inflating all cash flows at the Administration's assumed rate of inflation. (For further discussion of changes in the Federal life-cycle costing rule see Notice of Final Rulemaking, Federal Register, October 31, 1990. For a more detailed description of how the Federal discount rate is determined, see NIST Handbook 135 (revised 1993).)

The SPW, UPW, and UPW* factors in Part I of this report are given both for the 4.0% discount rate and for a 10% discount rate. The former are for evaluating Federal energy conservation and renewable energy projects. The latter are for evaluating Federal projects subject to OMB Circular A-94, i.e., most Federal capital investment projects other than energy projects and water-resources projects.

An additional change in the Federal methodology that affects the data in this report is the allowance in the analysis of a planning/design/construction period prior to building occupancy. The text that accompanies the "B" series of tables explains how to use the UPW* factors to account for a planning/design/construction period.

Projected average fuel price indices and escalation rates for Federal use (Indices and escalation rates exclude general price inflation)

Table C, "Regional and U.S. average base-year fuel prices by end-use sector and major fuel," has been discontinued. Use your actual energy prices as of the date the analysis is performed as the starting point for estimating present value energy costs.

Tables Ca-1 through Ca-5 present projected average fuel price indices for the 4 Census regions and for the United States. These are multipliers which when applied to today's prices provide estimates of the corresponding future-year prices in constant base-year dollars. The indices reflect end-of-year prices. End-of-year indices are needed because energy prices are discounted from the end of the year in calculating the UPW* factors. Constant dollar prices are needed when discounting is performed with a real discount rate (i.e., one which does not include general price inflation).

Example of How to Use the Indices:

To estimate the price of industrial steam coal at the end of year 2005 in Connecticut, go to table Ca-1, find the year 2005 index for industrial steam coal (1.25), and multiply by the price for industrial steam coal in Connecticut at the beginning of 1993.

Tables Cb-1 through Cb-5 present the projected average fuel price escalation rates (percentage change compounded annually) for seven selected periods from 1992 to 2022 for the 4 Census regions and for the United States. Note that these are "real" rates exclusive of general price inflation. Their use results in prices expressed in constant dollars.

The escalation rates consolidate the information provided by the indices in the Ca tables so that trends in projected price changes can be seen at a glance. They are provided primarily to accommodate those who use computer programs which require escalation rates as inputs.

Unless there is a compelling reason to use escalation rates, it is recommended that you use the indices in the Ca tables when you need estimates of future-year energy prices, since the indices include year-to-year information rather than averages over a number of years.

Example of How to Use the Escalation Rates:

To estimate the price of residential distillate in 1998 (p_{98}) in Wyoming using the escalation rates, go to table Cb-4 and find the 1992-1995 and 1995-2000 escalation rates for residential distillate (1.61% and 2.97% per year, respectively). Enter these values and today's price of residential distillate in Wyoming (p_{92}) into the following formula. Then solve for the 1998 energy price (stated in today's dollars):

$$p_{98} = p_{92} \times (1 + e_1)^{k_1} \times (1 + e_2)^{k_2},$$

$$= p_{92} \times (1 + 0.0161)^3 \times (1 + 0.0297)^3$$

where e_i = Annual compound escalation rate for period i from the Cb tables (in decimal form); and

k_i = Number of years over which escalation rate e_i occurs.

For further explanation of how to use these tables, see NIST Handbook 135.

The data in the tables which follow are reported for the 4 Census regions and the U.S. average. Figure B-1 presents a map showing the states corresponding to the 4 Census regions. The Census regions do not include American Samoa, Canal Zone, Guam, Puerto Rico, Trust Territory of the Pacific Islands, or the Virgin Islands. Analysts of Federal projects in these areas should use data which are "reasonable under the circumstances," and may refer to the tables with U.S. average data for guidance.

Table Cb–1. Projected average fuel price escalation rates exclusive of general price inflation by end–use sector and major fuel (percentage change compounded annually)

Census Region 1 (Connecticut, Maine, Massachusetts, New Hampshire New Jersey, New York, Pennsylvania, Rhode Island, Vermont)

Sector and Fuel	1992 to 1995	1995 to 2000	2000 to 2005	2005 to 2010	2010 to 2015	2015 to 2020*	2020 to 2022*
Residential							
Electricity	–0.44	–0.11	0.21	0.43	0.62	0.60	0.60
Distillate Oil	1.51	2.74	1.67	1.19	1.72	1.40	1.26
Liquefied Petroleum Gas	0.52	2.26	1.44	1.12	1.72	1.40	1.26
Natural Gas	1.51	2.10	2.35	2.16	1.72	1.40	1.26
Commercial							
Electricity	–0.64	–0.34	–0.12	0.38	0.62	0.60	0.60
Distillate Oil	2.01	3.61	2.13	1.45	1.72	1.40	1.26
Residual Oil	4.96	4.74	2.70	1.76	1.72	1.40	1.26
Natural Gas	1.51	2.52	2.78	2.47	1.72	1.40	1.26
Steam Coal	1.58	1.66	1.71	1.71	1.60	1.60	1.60
Industrial							
Electricity	0.63	1.13	0.93	0.78	0.62	0.60	0.60
Distillate Oil	2.10	3.71	2.18	1.47	1.72	1.40	1.26
Residual Oil	5.03	4.84	2.73	1.82	1.72	1.40	1.26
Natural Gas	2.03	3.29	3.50	2.98	1.72	1.40	1.26
Steam Coal	1.77	1.65	1.77	2.14	1.50	1.50	1.50
Transportation							
Motor Gasoline	1.55	2.64	1.71	1.18	1.72	1.40	1.26
Oil Price Assumption	4.06	4.78	2.75	1.82	1.72	1.40	1.26

*Escalation rates are reported for years 2018–2022 to accommodate a planning/construction period of up to 5 years.

Table Cb-2. Projected average fuel price escalation rates exclusive of general price inflation by end-use sector and major fuel (percentage change compounded annually)

Census Region 2 (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin)

Sector and Fuel	1992 to 1995	1995 to 2000	2000 to 2005	2005 to 2010	2010 to 2015	2015 to 2020*	2020 to 2022*
Residential							
Electricity	-0.15	0.36	0.59	0.64	0.62	0.60	0.60
Distillate Oil	1.67	3.08	1.84	1.29	1.72	1.40	1.26
Liquefied Petroleum Gas	0.74	3.18	1.95	1.43	1.72	1.40	1.26
Natural Gas	1.86	2.65	2.91	2.54	1.72	1.40	1.26
Commercial							
Electricity	-0.86	-0.52	0.08	0.27	0.62	0.60	0.60
Distillate Oil	2.29	4.08	2.35	1.57	1.72	1.40	1.26
Residual Oil	5.11	4.86	2.75	1.82	1.72	1.40	1.26
Natural Gas	1.77	2.98	3.20	2.77	1.72	1.40	1.26
Steam Coal	1.96	1.63	1.42	1.86	1.60	1.60	1.60
Industrial							
Electricity	-0.03	0.09	0.67	0.42	0.62	0.60	0.60
Distillate Oil	2.17	3.81	2.23	1.50	1.72	1.40	1.26
Residual Oil	6.09	5.59	3.09	1.99	1.72	1.40	1.26
Natural Gas	2.11	3.48	3.65	3.06	1.72	1.40	1.26
Steam Coal	1.08	0.87	1.41	2.00	1.50	1.50	1.50
Transportation							
Motor Gasoline	1.60	2.71	1.75	1.21	1.72	1.40	1.26
Oil Price Assumption	4.06	4.78	2.75	1.82	1.72	1.40	1.26

*Escalation rates are reported for years 2018-2022 to accommodate a planning/construction period of up to 5 years.

Table Cb-3. Projected average fuel price escalation rates exclusive of general price inflation by end-use sector and major fuel (percentage change compounded annually)

Census Region 3 (Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, West Virginia)

Sector and Fuel	1992 to 1995	1995 to 2000	2000 to 2005	2005 to 2010	2010 to 2015	2015 to 2020*	2020 to 2022*
Residential							
Electricity	-0.04	0.19	0.72	0.47	0.62	0.60	0.60
Distillate Oil	1.53	2.88	1.73	1.23	1.72	1.40	1.26
Liquefied Petroleum Gas	0.65	2.64	1.64	1.26	1.72	1.40	1.26
Natural Gas	1.68	2.35	2.61	2.35	1.72	1.40	1.26
Commercial							
Electricity	-0.12	0.16	0.40	0.39	0.62	0.60	0.60
Distillate Oil	2.36	4.10	2.37	1.58	1.72	1.40	1.26
Residual Oil	6.23	5.63	3.12	2.01	1.72	1.40	1.26
Natural Gas	1.70	2.77	3.01	2.64	1.72	1.40	1.26
Steam Coal	1.69	1.81	2.13	2.20	1.60	1.60	1.60
Industrial							
Electricity	0.51	0.97	1.14	0.63	0.62	0.60	0.60
Distillate Oil	2.18	3.95	2.30	1.54	1.72	1.40	1.26
Residual Oil	5.74	5.39	3.00	1.93	1.72	1.40	1.26
Natural Gas	3.25	4.98	4.88	3.85	1.72	1.40	1.26
Steam Coal	1.88	2.14	1.79	2.09	1.50	1.50	1.50
Transportation							
Motor Gasoline	1.61	2.77	1.79	1.21	1.72	1.40	1.26
Oil Price Assumption	4.06	4.78	2.75	1.82	1.72	1.40	1.26

*Escalation rates are reported for years 2018–2022 to accommodate a planning/construction period of up to 5 years.

Table Cb–4. **Projected average fuel price escalation rates exclusive of general price inflation by end–use sector and major fuel (percentage change compounded annually)**

Census Region 4 (Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming)

Sector and Fuel	1992 to 1995	1995 to 2000	2000 to 2005	2005 to 2010	2010 to 2015	2015 to 2020*	2020 to 2022*
Residential							
Electricity	0.65	0.70	0.60	0.45	0.62	0.60	0.60
Distillate Oil	1.61	2.97	1.79	1.26	1.72	1.40	1.26
Liquefied Petroleum Gas	0.64	2.53	1.59	1.22	1.72	1.40	1.26
Natural Gas	1.75	2.44	2.69	2.38	1.72	1.40	1.26
Commercial							
Electricity	-0.34	0.31	0.49	0.42	0.62	0.60	0.60
Distillate Oil	2.28	4.05	2.33	1.57	1.72	1.40	1.26
Residual Oil	4.46	4.27	2.49	1.68	1.72	1.40	1.26
Natural Gas	1.65	2.76	3.01	2.59	1.72	1.40	1.26
Steam Coal	0.82	0.99	0.14	0.79	1.60	1.60	1.60
Industrial							
Electricity	0.18	1.11	0.87	0.62	0.62	0.60	0.60
Distillate Oil	2.17	3.89	2.23	1.52	1.72	1.40	1.26
Residual Oil	5.59	5.27	2.96	1.88	1.72	1.40	1.26
Natural Gas	2.53	3.69	3.74	3.13	1.72	1.40	1.26
Steam Coal	0.41	0.67	0.71	1.55	1.50	1.50	1.50
Transportation							
Motor Gasoline	1.75	2.62	1.70	1.18	1.72	1.40	1.26
Oil Price Assumption	4.06	4.78	2.75	1.82	1.72	1.40	1.26

*Escalation rates are reported for years 2018-2022 to accommodate a planning/construction period of up to 5 years.

Table Cb–5. Projected average fuel price escalation rates exclusive of general price inflation by end–use sector and major fuel (percentage change compounded annually)
United States Average

Sector and Fuel	1992 to 1995	1995 to 2000	2000 to 2005	2005 to 2010	2010 to 2015	2015 to 2020*	2020 to 2022*
Residential							
Electricity	-0.07	0.23	0.56	0.48	0.62	0.60	0.60
Distillate Oil	1.55	2.81	1.71	1.21	1.72	1.40	1.26
Liquefied Petroleum Gas	0.71	2.81	1.75	1.32	1.72	1.40	1.26
Natural Gas	1.74	2.42	2.66	2.36	1.72	1.40	1.26
Commercial							
Electricity	-0.52	-0.12	0.21	0.35	0.62	0.60	0.60
Distillate Oil	2.18	3.86	2.30	1.51	1.72	1.40	1.26
Residual Oil	5.29	5.04	2.82	1.87	1.72	1.40	1.26
Natural Gas	1.73	2.80	3.00	2.63	1.72	1.40	1.26
Steam Coal	1.70	1.61	1.57	1.76	1.60	1.60	1.60
Industrial							
Electricity	0.29	0.75	0.92	0.59	0.62	0.60	0.60
Distillate Oil	2.14	3.87	2.26	1.52	1.72	1.40	1.26
Residual Oil	5.76	5.30	2.96	1.89	1.72	1.40	1.26
Natural Gas	2.88	4.27	4.26	3.48	1.72	1.40	1.26
Steam Coal	1.50	1.42	1.58	1.81	1.50	1.50	1.50
Transportation							
Motor Gasoline	1.62	2.70	1.74	1.20	1.72	1.40	1.26
Oil Price Assumption	4.06	4.78	2.75	1.82	1.72	1.40	1.26

*Escalation rates are reported for years 2018–2022 to accommodate a planning/construction period of up to 5 years.

Factors for updating appliance label values in compliance with the Energy Conservation Mandatory Performance Standards for New Federal Residential Buildings (10 CFR 435)

Compliance with energy conservation performance standards for new Federal residential buildings requires calculation of a building's energy costs, including appliance costs. For this purpose, label values for gas and electric water heaters are given in the Federal micro-computer program, COSTSAFR, as $176 and $406 per year, respectively, in 1987 dollars, and for refrigerator/freezers, as $61 per year in 1987 dollars. To adjust 1987 prices to today's prices, multiply these 1987 label values by the factors below.

Table D. Factors for updating appliance label values

Fuel	Factor
Gas	1.11
Electricity	1.13

FAMILY HOUSING REVITALIZATION AND REPLACEMENT PROJECTS

APPENDIX F

A. INTRODUCTION

Family housing revitalization and replacement projects must compare the discounted life cycle costs of various alternatives in a complete economic analysis. Any recommendation for selection of other than the lowest net present value alternative must be accompanied by full justification. These economic analyses are subject to close scrutiny by higher authorities and must follow the guidelines prescribed in:

1. NAVFAC ltr 11101 082T/20Z of April 22, 1993 (Attachment 1) and
2. NAVFAC ltr 11101 082A of May 11, 1992 (Attachment 2)

B SUMMARY OF ECONOMIC GUIDELINES

1. Housing economic analyses will follow the guidelines for discounting from OMB Circular A-94, for cost-effectiveness studies. The current 1993 real discount rate is 4.5%. A table of factors is provided in Attachment 1.

2. For consistency, all analyses will use end-of-year (E-O-Y) discount factors.

3. The statutory housing size limitation must be used for the replacement alternative, irrespective of the size of the existing unit.

4. If a lease or lease-purchase alternative is included, then cash flows for all competing alternatives must be analyzed in outlay or current dollars and a nominal discount rate should be applied per guidelines of OMB Circular A-94.

DEPARTMENT OF THE NAVY

NAVAL FACILITIES ENGINEERING COMMAND
200 STOVALL STREET
ALEXANDRIA, VA 22332-2300

IN REPLY REFER TO
11101
082T/20Z
APR 22 1993

From: Commander, Naval Facilities Engineering Command

Subj: ECONOMIC ANALYSIS (EA) GUIDANCE FOR FAMILY HOUSING REVITALIZATION/REPLACEMENT PROJECTS

Ref: (a) COMNAVFACENGCOM ltr 11101 082A of 11 May 92
(b) OPNAVINST 11101.19D

Encl: (1) Economic Analysis Guidance

1. Reference (a) provided guidance for the preparation of economic analyses (EAs) for family housing revitalization and replacement projects. This letter provides updated guidance to reference (a) for use in the development of FY-96/97 programs and for application of reference (a) guidance to other areas.

2. Enclosure (1) contains updated policy and procedural guidance for family housing EAs. This guidance is effective immediately. Milestones for submission of EAs in support of FY-96/97 revitalization and replacement projects have been published separately. Submissions should include both hard copies of the EAs as well as the electronic transfer of the files or submission of diskettes that contain all document and spreadsheet files.

3. Also, effective immediately, the format provided in reference (a) for EA submissions is to be used for EAs in support of:

a. Flag quarters budgets/projects for which EAs are required in accordance with reference (b); and

b. Current or prior year revitalization projects submitted to us for Congressional notification, including projects for the repair of fire damage.

4. During NAVCOMPT/OSD review of our FY-94/95 budget, we were unable to sell revitalization projects where the initial cost exceeded 70% of the initial replacement cost or where the total life cycle cost exceeded 75% of the equivalent cost for new construction, except for historically significant homes.

5. The NAVFAC point of contact for family housing economic analyses is Steve Keating (NAVFAC 082A), DSN 221-7323. NAVFAC points of contact for economic analysis policy are Bernie White or Terry Ulsh (NAVFAC 20Z), DSN 221-7354.

R.G. HOCKER, JR.
By direction

(See next page for distribution)

Subj: ECONOMIC ANALYSIS (EA) GUIDANCE FOR FAMILY HOUSING REVITALIZATION/REPLACEMENT PROJECTS

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ECONOMIC ANALYSIS GUIDANCE

1. In accordance with OMB/OSD guidance, a **4.5%** discount rate will be used. This is the published rate for constant dollar analyses, such as family housing revitalization and replacement EAs. These rates are revised annually. The rate will likely be adjusted in March/April 1994. A sensitivity analysis on discount rates, given the fact that they will change, may be appropriate. For example, to determine if the conclusion is significantly affected by changes in the discount rate, it may be prudent to perform the analysis at plus/minus one percent from the prescribed rate (i.e., at 3.5% and at 5.5%). The results of this sensitivity analysis could be discussed in the narrative.

2. To allow consistency with MILCON analyses, we will use <u>end-of-year</u> discount factors, vice mid-year factors. The revised discount factors, based on a 4.5% discount rate, is provided as Attachment 1 to this enclosure. The appropriate formula for computation of discount factors, per the NAVFAC Economic Analysis Handbook (NAVFAC P-442), is as follows:

$$\text{Discount Factor} = \frac{1}{(1+i)^n}$$

Where:

i= Discount Rate (i.e., 4.5%)
n= Year of analysis (e.g., 1, 2, 3,...25)

Example:

$$\text{Discount Factor (First Year)} = \frac{1}{(1+.045)^1}$$

Discount Factor (First Year) = .9569

3. The latest inflation rates for use in EAs, in accordance with NAVCOMPTNOTE 7111 of 4 March 1993, are provided as Attachment 2 to this enclosure. These rates are to be used in converting prior year costs to program year dollars.

4. Revised unit cost per net square foot (NSF) figures for replacement construction estimates are as follows:

	FY-94	FY-95	FY-96	FY-97	FY-98	FY-99	FY-00	FY-01
CONUS	$53	$55	$57	$59	$61	$63	$65	$67
OCONUS	$55	$57	$59	$61	$63	$65	$67	$69

Enclosure (1)

5. For EAs involving fire damaged units, the "Status Quo" alternative need not be considered. Under "Status Quo," the unit would be left in its fire damaged condition, which would be unacceptable. At a minimum, only the revitalization and replacement alternatives should be considered. If there is a surplus of housing at the location, the direct compensation (i.e., demolition of the unit without replacement) should also be considered, unless there is a determination that the unit is required. If so, the EA should provide detailed justification in support of such a determination.

6. The statutory size limitation must be used for the replacement alternative, irrespective of the size of the existing unit.

7. Ensure that there is consistency in logic among alternatives. A common error noticed in EAs involved oversized units. For example, estimated utilities and maintenance costs for the "Replacement" alternative were based on similar costs for the "Status Quo" alternative. Such an assumption does not take into account the smaller size of the replacement unit. A more acceptable approach, if utilities and maintenance cost data is not available for new construction, would be to convert "Status Quo" costs to a cost per net square foot basis and apply the savings at that level. The adjusted cost per net square foot would then be applied to the total net square footage of the replacement unit. Be sure to fully document the methodology you use in the assumptions section of the EA narrative.

8. In accordance with reference (b), EAs for flag units are required when:

a. Average annual maintenance and repair costs, over a three-year period, exceed $25,000/unit, or;

b. a one-time major repair and/or improvement expenditure is proposed which exceeds $50,000/unit.

9. Neighborhoods of Excellence standards are applicable to both the revitalization and replacement alternatives. These standards should be uniformly applied to both alternatives to ensure both alternatives are approximately equal.

10. To determine if the installation of fire sprinkler systems are required within the scope of a revitalization project, it may be necessary to conduct a preliminary comparison of initial costs of both revitalization and replacement. ("Initial" costs refer to first-year costs of both revitalization and replacement. They do not include recurring utilities and maintenance costs or any other subsequent costs that occur during the 25-year analysis period.) The preliminary comparison should be restricted to the costs associated with revitalizing or constructing a replacement structure (i.e., the "five-foot line"). The revitalization costs in this preliminary comparison

should exclude the costs associated with other real property, such as landscaping, utility distribution systems, parking, etc. Replacement costs should exclude site supporting costs and fire sprinklers. Once the determination is made as to whether fire sprinklers are to be included in the revitalization project scope, the final EA would be prepared which reflects all costs.

FAMILY HOUSING INFLATION RATES

INFLATION/CONVER 3/11/93

	FY-92	FY-93	FY-94	FY-95	FY-96	FY-97
ANNUAL INFL (OPS	2.7%	2.4%	2.4%	2.3%	2.3%	2.2%
ANNUAL INFL (CON	2.4%	2.3%	2.3%	2.2%	2.2%	2.2%

	FY-98	FY-99	FY-00	FY-01
ANNUAL INFL (OPS	2.2%	2.2%	2.2%	2.2%
ANNUAL INFL (CON	2.2%	2.2%	2.2%	2.2%

Attachment 2 to Enclosure (1)

REVISED DISCOUNT FACTOR

4.5%

i = 4.5 %
30-YEARS

YEAR	INDIV	CUMM
0	1.0000	0.0000
1	0.9569	0.9569
2	0.9157	1.8727
3	0.8763	2.7490
4	0.8386	3.5875
5	0.8025	4.3900
6	0.7679	5.1579
7	0.7348	5.8927
8	0.7032	6.5959
9	0.6729	7.2688
10	0.6439	7.9127
11	0.6162	8.5289
12	0.5897	9.1186
13	0.5643	9.6829
14	0.5400	10.2228
15	0.5167	10.7395
16	0.4945	11.2340
17	0.4732	11.7072
18	0.4528	12.1600
19	0.4333	12.5933
20	0.4146	13.0079
21	0.3968	13.4047
22	0.3797	13.7844
23	0.3634	14.1478
24	0.3477	14.4955
25	0.3327	14.8282
26	0.3184	15.1466
27	0.3047	15.4513
28	0.2916	15.7429
29	0.2790	16.0219
30	0.2670	16.2889

Attachment 1 to Enclosure (1)

DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND
200 STOVALL STREET
ALEXANDRIA, VA 22332-2300

IN REPLY REFER TO
11101
082A/SK
MAY 11 1992

From: Commander, Naval Facilities Engineering Command

Subj: ECONOMIC ANALYSIS (EA) GUIDANCE FOR FAMILY HOUSING REVITALIZATION/REPLACEMENT PROJECTS

Ref: (a) COMNAVFACENGCOM ltr 11101 08P of 2 Aug 1985

Encl: (1) Economic Analysis Guidance
(2) Sample Economic Analysis

1. This letter provides guidance for the development of economic analyses (EAs) in support of family housing revitalization and replacement projects. This guidance supersedes reference (a).

2. Enclosure (1) contains both policy and procedural guidance for family housing EAs. A sample EA is provided as enclosure (2). We will provide LOTUS and WORDPERFECT files separately for your use.

3. This guidance is effective immediately. EAs for FY-94/95 revitalization and replacement projects should be submitted to reach us no later than 29 May 1992. Submissions should include both hard copies of the EAs as well as diskettes that contain all document and spreadsheet files.

4. A review of EAs, both in general and specifically with respect to family housing, is on-going. As such, further changes may be necessary at some point in the future. We will keep you advised as these changes occur.

5. The point of contact for this letter is Steve Keating (NAVFAC 082A), autovon 221-7323.

J. R. MOORE
By direction

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FAMILY HOUSING REVITALIZATION/REPLACEMENT PROJECTS ECONOMIC ANALYSES (EAS)

A. Background.

1.Economic analyses for family housing revitalization projects will compare the discounted life cycle costs of various alternatives with respect to providing family housing.

2. Typically, the alternative with lowest present value cost will be selected. Any recommendation which involves selection of other than the lowest cost alternative must be accompanied by full justification.

3. Economic analyses are subject to close scrutiny by higher authorities who review our decisions and budget requests. As such, it is imperative that all economic analyses follow the prescribed format and receive careful review at the EFD and NAVFAC HQ level.

4. General guidance on economic analyses is provided in OMB Circular A-94 and in NAVFAC P-442 (Economic Analysis Handbook).

B. Policy.

1. Economic analyses will be performed and submitted for all family housing revitalization projects (i.e., projects involving major repairs and/or improvements to family housing facilities) which meet at least one of the following conditions:

a. The per unit cost (cost of the most expensive unit rather than the average unit cost of the project exceeds $50,000 per unit as adjusted by the Area Cost Factor (ACF); or

b. The average unit cost of the revitalization project exceeds 60% of the average replacement value per unit, as computed using the OSD tri-service cost model.

2. Economic analyses will also be performed in accordance with this guidance for all projects that propose the replacement of existing housing.

3. The EA will cover a 25-year period. The assumed economic lives of family housing units under the status quo and revitalization alternatives will be 25 years. The assumed economic life of family housing units under the replacement alternative is 45 years. This will result in a residual (terminal) value of family housing, in the replacement alternative, at the end of the 25th year.

4. EA's will be based on discount factors in accordance with OMB Circular A-94.

5. All costs will be in constant dollars. Use the proposed program year for the revitalization project as the baseline. For example, if the analysis is in support of an FY-96 revitalization project, then all costs used in the analysis will be in FY-96 dollars. Use the most current inflation rates provided in POM or budget guidance for family housing.

6. When considering a replacement alternative, the replacement unit will be sized according to statutory size limitations (Title 10, United States Code, Section 2826), regardless of the size of the existing unit.

7. At a minimum, the revitalization and replacement alternatives must yield housing and sites of equal quality. For example, if under the replacement alternative, deficiencies at the existing site would be corrected, then those same deficiencies should be corrected under the revitalization alternative. Amenities and enhancements envisioned under the "Neighborhoods of Excellence" initiative are equally applicable to both the revitalization and replacement alternatives. Any improvement or amenity included in one alternative should be reflected in the other.

8. Economic analyses will reflect all of the units under consideration, vice an analysis of one typical unit.

9. At a minimum, each economic analysis will consider the following alternatives:

a. Status Quo. This is the "do nothing" alternative. This alternative reflects the operation and maintenance of the family housing units "as is," i.e., with no revitalization. However, this alternative does include whatever periodic maintenance and repair is necessary to keep the units habitable for the analysis timeframe.

b. Revitalization. This alternative encompasses the accomplishment of required whole-house revitalization.

c. Replacement. This alternative involves the replacement of the housing under consideration in the EA.

d. Direct Compensation. This alternative involves the disposal or demolition of the housing under consideration and the payment of housing allowances to the displaced families who will then live in private sector housing. If there is a current and projected housing deficit, this alternative does not have to be costed out on the basis that suitable alternative housing is not available in the private sector. If there is a current and/or projected surplus of housing, this alternative must be costed out. The determination of whether or not there is a family housing deficit will be predicated on a family housing requirements survey and a market analysis, if available.

10. Projects where there is less than a 30 percent difference between the net present values of the alternatives receive special scrutiny. Projects where the present value of one alternative exceeds 90 percent of the other are especially vulnerable. There may be myriad considerations (e.g., historical significance, military necessity, etc.) which, although not factored into the EA, may have an impact on a retention versus replacement decision. Such considerations make the establishment of hard and fast repair or replace threshold impossible. Accordingly, the following guidance is offered:

a. For projects where the present value of the proposed alternative exceeds 70 percent of the other alternatives, provide any supporting justification that can be used to support the alternative.

b. For projects where the present value of the proposed alternative exceeds 90 percent of the other alternatives, a sensitivity analysis should be provided which shows the impact of changing key assumptions (such as initial costs, recurring costs, etc.) Additional strong justification that demonstrates why the proposed alternative is in the best interest of the Navy is to be provided.

11. For economic analyses, where the direct compensation alternative is considered applicable and is costed out, the analysis should consider, in addition to other direct costs, imputed costs for land, insurance, and real estate taxes in the Status Quo, Revitalization, and Replacement alternatives.

C. Economic Analysis Format. The following are the major sections of a family housing EA for revitalization or replacement.

1. Executive Summary. An executive summary will be provided with the EA. This summary provides the reader with a description of the proposed project, description of the alternatives, and the results of the economic analysis. The executive summary is extremely important in that it usually is the primary reference point in reviews by higher authorities. The executive summary, as well as other narrative sections of the EA, should be written to an audience who is not familiar with technical jargon associated with the military family housing program. The executive summary will follow the format shown in Attachment 1.

2. Background. This section will identify the nature of project that is under consideration in EA. For example, the background would state that the EA has been prepared in support of a proposed revitalization project involving X units at (activity name). The background should include basic relevant information about the housing units, such as age, paygrade/bedroom designation, etc. The background should also include any other relevant information that a reviewer should be aware of, e.g., a unit is on a historic register.

3. Requirement for the Project. A short narrative is to be provided which describes the nature of the requirement for the project. This narrative can be lifted from the DD 1391 prepared for the project. Although this may appear redundant with the DD 1391, the EA should function as a stand-alone document. The narrative should include an identification of paygrade/bedroom composition of the units involved in the project (e.g., revitalization of 100 units of two-bedroom and 150 three-bedroom junior enlisted (E4-E6) units). In addition to a narrative description of the requirement for the project, current and projected family housing requirements are to be identified. To this extent, each EA will be accompanied by a DD 1523. Guidance on the DD 1523 is contained in annual NAVFAC Notices that address the conduct of the annual family housing requirements survey. If the DD 1523 reflects a current or projected surplus of housing, and retention and revitalization is both the desired and economically preferred alternative, the narrative section should justify continued retention of the units. Examples of reasons why the retention is justified could include shortages in specific paygrade/bedroom compositions that cannot be solved through redesignation, waiting lists, etc.

4. Identification of Alternatives. The EA should identify all alternatives considered (i.e., status quo, revitalization, replacement, direct compensation).

5. Assumptions. All assumptions underlying the EA must be identified. These include assumptions that pertain to all alternatives as well as assumptions that relate to specific alternatives. The assumptions should be provided as an appendix to the EA. Assumptions will, at a minimum, include the following:

a. An identification of the fiscal year assumed for the revitalization and replacement alternatives. Usually, they should be the same.

b. The source of all cost estimates, including recurring expenditures.

c. An explanation of any assumed variances between alternatives. For example, the EA may assume that operations and maintenance costs for the replacement alternative will reflect a reduction from the status quo or the revitalization alternative. Such an assumption must be stated up-front.

6. Cash Flow Analysis of the Alternatives. A cash flow analysis will be performed for each alternative where required. The cash flow analysis displays expected costs over the analysis period (25 years) and applies discount factors to compute the present value. At a minimum, the revitalization and replacement alternatives must be costed out. The format for a display of life cycle costs is provided as Attachment 1.

7. Sensitivity Analysis. A sensitivity analysis shows the effect of various assumptions on the final conclusion. For example, annual recurring maintenance costs could be varied for one alternative, while holding everything else constant, to show the margin of error in the estimate before the conclusion is reversed. A sensitivity analysis should be performed if the difference between alternatives is less than ten percent. If so, the sensitivity analysis should be submitted as an appendix. For EA's where the difference between alternatives is more than ten percent, the performance of a sensitivity analysis is at the discretion of the preparer.

D. Cost Elements of the Economic Analysis. There are a number of cost elements, including recurring as well as one-time, that are associated with the different EA alternatives. These costs elements capture estimated costs during the 25-year analysis timeframe. They are discussed in detail in Attachment 2. A worksheet for one-time maintenance, repair, and replacement costs is provided as Attachment 3. A separate worksheet should be completed and submitted with the EA for each alternative (except demolition/direct compensation if excluded from the cost analysis).

E. Submission Requirements. Economic analyses must be submitted in accordance with requirements established by COMNAVFACENGCOM. These requirements may vary based on the type of program involved (e.g., revitalization or replacement). In addition to hard copies, diskettes should be submitted to allow revisions at the headquarters level. Use LOTUS 1-2-3 for the cash flow analysis and WORD PERFECT or WANG for the EA narrative. The EA must be consistent with the project it supports. For example, if an EA is submitted in support of a replacement project, the replacement cost shown in the analysis of the replacement alternative should be consistent with the proposed project cost. Finally, the EA is a tool to market the proposed project. As such, the importance of its appearance cannot be overstated. Included with the LOTUS worksheet file is an associated ALLWAYS file. Use that file to enhance the appearance of the cash flow analysis.

INSTALLATION: DATE: 07-Apr-92
PROJECT NUMBER:

MILITARY FAMILY HOUSING ANALYSIS

ASSUMPTIONS

PROGRAM YEAR:
DISCOUNT RATE: 10.00%

ALTERNATIVE 1

STATUS QUO:
ANNUAL MAINTENANCE:
ANNUAL UTILITIES:

ALTERNATIVE 2

REVITALIZATION:
1ST YR ANNUAL MAINT.:
ANNUAL UTILITIES:
OFF-BASE HSG - 1 YR: $0
MOVING COSTS: $0

ALTERNATIVE 3

REPLACEMENT CONSTRUCTION:

CONSTRUCTION COST:
CONSTR (BLDG ONLY):
1ST YR ANNUAL MAINT:
ANNUAL UTILITIES:
OFF-BASE HSG - 1 YR: $0
MOVING COSTS: $0

ALTERNATIVE 4

APPLICABLE (YES/NO?):
DIRECT COMPENSATION:
DEMOLITION COSTS:
MOVING COSTS: $0
ANNUAL BAQ/VHA:

MOVING COSTS (TOTAL):
MOVING COSTS (PARTIAL):

SUMMARY OF OPTIONS:

	NET PRESENT VALUE	AS A PERCENT OF REPLACEMENT
STATUS QUO:	$0	ERR
REVITALIZATION:	$0	ERR
REPLACEMENT CONSTRUCTION	$0	ERR
DIRECT COMPENSATION:	N/A	ERR

LIFE-CYCLE: 25 YRS - ALL OPTIONS

ATTACHMENT 1

MILITARY FAMILY HOUSING ANALYSIS									
CASH FLOW ANALYSIS - STATUS QUO									
YR	FY	PERIODIC MAINTENANCE AND REPAIR	RECURRING COSTS			TOTAL RECURRING COSTS	TOTAL ANNUAL COSTS	10.00% MID-YEAR DISCOUNT FACTOR	DISCOUNTED ANNUAL COSTS
			M & R	UTILITIES	OTHER COST				
1	0	$0	0	0		$0	$0	0.9535	$0
2	1	$0	0	0		0	0	0.8668	0
3	2	$0	0	0		0	0	0.7880	0
4	3	$0	0	0		0	0	0.7164	0
5	4	$0	0	0		0	0	0.6512	0
6	5	$0	0	0		0	0	0.5920	0
7	6	$0	0	0		0	0	0.5382	0
8	7	$0	0	0		0	0	0.4893	0
9	8	$0	0	0		0	0	0.4448	0
10	9	$0	0	0		0	0	0.4044	0
11	10	$0	0	0		0	0	0.3676	0
12	11	$0	0	0		0	0	0.3342	0
13	12	$0	0	0		0	0	0.3038	0
14	13	$0	0	0		0	0	0.2762	0
15	14	$0	0	0		0	0	0.2511	0
16	15	$0	0	0		0	0	0.2283	0
17	16	$0	0	0		0	0	0.2075	0
18	17	$0	0	0		0	0	0.1886	0
19	18	$0	0	0		0	0	0.1715	0
20	19	$0	0	0		0	0	0.1559	0
21	20	$0	0	0		0	0	0.1417	0
22	21	$0	0	0		0	0	0.1288	0
23	22	$0	0	0		0	0	0.1171	0
24	23	$0	0	0		0	0	0.1065	0
25	24	$0	0	0		0	0	0.0968	0
26	25	$0	0	0		0	0	0.0880	0
	TOTAL	$0	$0	$0	$0	$0	$0		$0

MILITARY FAMILY HOUSING ANALYSIS

CASH FLOW ANALYSIS - REVITALIZATION

YR	FY	CONSTRUCTION	RECURRING COSTS M & R	RECURRING COSTS UTILITIES	TOTAL RECURRING COSTS	OTHER COSTS	TOTAL ANNUAL COSTS	10.00% MID-YEAR DISCOUNT FACTOR	DISCOUNTED ANNUAL COSTS
1	0	$0	$0	$0	$0	$0	$0	0.9535	$0
2	1	$0	$0	$0	$0		$0	0.8668	0
3	2	$0	$0	$0	$0		$0	0.7880	0
4	3	$0	$0	$0	$0		$0	0.7164	0
5	4	$0	$0	$0	$0		$0	0.6512	0
6	5	$0	$0	$0	$0		$0	0.5920	0
7	6	$0	$0	$0	$0		$0	0.5382	0
8	7	$0	$0	$0	$0		$0	0.4893	0
9	8	$0	$0	$0	$0		$0	0.4448	0
10	9	$0	$0	$0	$0		$0	0.4044	0
11	10	$0	$0	$0	$0		$0	0.3676	0
12	11	$0	$0	$0	$0		$0	0.3342	0
13	12	$0	$0	$0	$0		$0	0.3038	0
14	13	$0	$0	$0	$0		$0	0.2762	0
15	14	$0	$0	$0	$0		$0	0.2511	0
16	15	$0	$0	$0	$0		$0	0.2283	0
17	16	$0	$0	$0	$0		$0	0.2075	0
18	17	$0	$0	$0	$0		$0	0.1886	0
19	18	$0	$0	$0	$0		$0	0.1715	0
20	19	$0	$0	$0	$0		$0	0.1559	0
21	20	$0	$0	$0	$0		$0	0.1417	0
22	21	$0	$0	$0	$0		$0	0.1288	0
23	22	$0	$0	$0	$0		$0	0.1171	0
24	23	$0	$0	$0	$0		$0	0.1065	0
25	24	$0	$0	$0	$0		$0	0.0968	0
26	25	$0	$0	$0	$0		$0	0.0880	0
	TOTAL	$0	$0	$0	$0	$0	$0		$0

MILITARY FAMILY HOUSING ANALYSIS

CASH FLOW ANALYSIS - REPLACEMENT CONSTRUCTION

YR	FY	CONSTRUCTION	RECURRING COSTS M & R	RECURRING COSTS UTILITIES	TOTAL RECURRING COSTS	OTHER COSTS	RESIDUAL VALUE	TOTAL ANNUAL COSTS	10.00% MID-YEAR DISCOUNT FACTOR	DISCOUNTED ANNUAL COSTS
1	0	$0	$0	$0	$0	$0		$0	0.9535	$0
2	1	$0	0	0	0			0	0.8668	0
3	2	$0	0	0	0			0	0.7880	0
4	3	$0	0	0	0			0	0.7164	0
5	4	$0	0	0	0			0	0.6512	0
6	5	$0	0	0	0			0	0.5920	0
7	6	$0	0	0	0			0	0.5382	0
8	7	$0	0	0	0			0	0.4893	0
9	8	$0	0	0	0			0	0.4448	0
10	9	$0	0	0	0			0	0.4044	0
11	10	$0	0	0	0			0	0.3676	0
12	11	$0	0	0	0			0	0.3342	0
13	12	$0	0	0	0			0	0.3038	0
14	13	$0	0	0	0			0	0.2762	0
15	14	$0	0	0	0			0	0.2511	0
16	15	$0	0	0	0			0	0.2283	0
17	16	$0	0	0	0			0	0.2075	0
18	17	$0	0	0	0			0	0.1886	0
19	18	$0	0	0	0			0	0.1715	0
20	19	$0	0	0	0			0	0.1559	0
21	20	$0	0	0	0			0	0.1417	0
22	21	$0	0	0	0			0	0.1288	0
23	22	$0	0	0	0			0	0.1171	0
24	23	$0	0	0	0			0	0.1065	0
25	24	$0	0	0	0			0	0.0968	0
26	25	$0	0	0	0		0	0	0.0880	0
	TOTAL	$0	$0	$0	$0	$0	$0	$0		$0

CASH FLOW ANALYSIS - DIRECT COMPENSATION

YR	FY	DEMOLITION	RECURRING COSTS BAQ/VHA	RECURRING COSTS OTHER UTILITIES	TOTAL RECURRING COSTS	MOVING COSTS	TOTAL ANNUAL COSTS	10.00% MID-YEAR DISCOUNT FACTOR	DISCOUNTED ANNUAL COSTS
1	0	$0	0	$0	0	$0	$0	0.9535	$0
2	1		0		0		$0	0.8668	0
3	2		0		0		$0	0.7880	0
4	3		0		0		$0	0.7164	0
5	4		0		0		$0	0.6512	0
6	5		0		0		$0	0.5920	0
7	6		0		0		$0	0.5382	0
8	7		0		0		$0	0.4893	0
9	8		0		0		$0	0.4448	0
10	9		0		0		$0	0.4044	0
11	10		0		0		$0	0.3676	0
12	11		0		0		$0	0.3342	0
13	12		0		0		$0	0.3038	0
14	13		0		0		$0	0.2762	0
15	14		0		0		$0	0.2511	0
16	15		0		0		$0	0.2283	0
17	16		0		0		$0	0.2075	0
18	17		0		0		$0	0.1886	0
19	18		0		0		$0	0.1715	0
20	19		0		0		$0	0.1559	0
21	20		0		0		$0	0.1417	0
22	21		0		0		$0	0.1288	0
23	22		0		0		$0	0.1171	0
24	23		0		0		$0	0.1065	0
25	24		0		0		$0	0.0968	0
26	25		0		0		$0	0.0880	0
	TOTAL	$0	$0	$0	$0	$0	$0		$0

COST ELEMENTS OF THE ECONOMIC ANALYSIS

A. STATUS QUO ALTERNATIVE. This is the "do nothing" alternative. Under this alternative, neither revitalization or replacement will be considered. Only those maintenance and repair (M&R) requirements necessary to keep the units habitable over the 25-year analysis period will be considered. In recognition of the likely continued deterioration of the unit, in the absence of revitalization, there will be no residual value at the end of the analysis period. Although this may be the cheapest alternative, the analysis must determine whether or not this is an acceptable alternative. If it is expected that the adoption of this alternative would adversely affect the quality of life of the occupants, would result in the accelerated departure of the units from the inventory, and would not represent actions of a prudent landlord, than the EA may conclude that this alternative should be rejected. If so, the rationale for such a rejection should be stated up-front in the assumptions.

1. One-Time or Non-Recurring Costs. The following are examples of one-time costs that are appropriate for consideration under the status quo ("do nothing") alternative:

a. Outyear Renovation Costs. Periodic maintenance and repair (M&R) costs should be reflected in those years where they are expected to occur. These are costs necessary to keep the housing habitable for the 25-year EA period. The costs should be based on local engineering estimates of the work that would be needed on the major systems and components (structural/electrical/mechanical) for these units. Use Attachment 3 to show these estimated costs.

2. Recurring Costs. The following are examples of recurring costs to be included in the EA:

a. Utilities. Use actual historical utility costs for this alternative. Express those costs in program year dollars and hold constant throughout the time period covered by the EA.

b. Recurring Maintenance. Use actual historical maintenance costs for the units under study in the EA. Recurring maintenance includes service calls, routine change of occupancy work, minor repairs, etc.

c. Painting. For purposes of the EA, consider painting to be a recurring cost. (The underlying assumption is that a portion of the units will be painted in any given year.) For purposes of the EA, take actual costs of painting (in program year dollars) and divide by the painting frequency. Assume a painting frequency of every three years for interior painting and every 5 years for exterior painting. (If painting is accomplished at a different frequency at the location involved in the analysis, identify the painting frequencies up-front in the EA assumptions.) For example, if for the housing community under study, the estimated cost for interior painting for all units is $150,000 and the total exterior painting costs is $100,000, then the appropriate annual painting costs for the EA are:

(1) Interior: $150,000 divided by 3 = $50,000;

(2) Exterior: $100,000 divided by 5 = $20,000;

(3) Total Recurring Painting Costs: $70,000

ATTACHMENT 2

3. Imputed Costs. For those economic analyses where the direct compensation alternative is considered and costed out, OMB Circular A-104 requires that imputed costs be factored into the Status Quo, Revitalization, and Replacement alternatives to ensure an equal analysis. Imputed costs include the cost of land, real estate taxes, and insurance. These costs are often difficult to determine and evaluate since the Government does not pay these costs directly. Therefore, they need to be estimated and imputed. Imputed costs, and their derivation, consist of the following:

a. Land. The imputed cost of land reflects the Government's lost revenue in retaining property that might otherwise be sold on the private market. Estimate the market value of the land on which the housing covered in the analysis is sited. If there is no current estimate of market value, to find a reasonable equivalent cost, look for the most recent transaction for a piece of property that closely resembles the Government land.

b. Insurance. The annual imputed cost of insurance can be computed as a fixed fractional share of the value of the property. Apply a factor of .0005 to the current plant value (or other valid estimate of the property value) of the housing in question. Include these annual costs in the "Other Costs" column of the cash flow analysis.

c. Real Estate Taxes. For imputed real estate taxes, an estimate should be obtained from the local office of assessments to establish the tax rate for similar property. The estimated local tax rate is then applied to the value of the property and represents the Government's imputed expense for providing community type services (e.g., snow removal, fire and police protection, etc.). In cases where community type services are provided by the local government or municipality, no imputation is needed.

B. REVITALIZATION ALTERNATIVE. This alternative involves the retention of the existing family housing and a one-time revitalization cost. For purposes of the EA, it is assumed that there will be no residual value associated with these units.

1. One-Time Costs or Non-Recurring Costs. The following are one-time or non-recurring costs for consideration under the revitalization alternative in the EA:

a. Revitalization Project (Program Year). The EA should reflect the proposed revitalization project that prompted the need for an EA. The revitalization cost should match the cost shown on the DD 1391 for the project and should be identified in the correct fiscal year. Do not include any design costs in the analysis.

b. Moving Costs. If the proposed revitalization project will require that families be moved out of Government quarters and/or required to live on the economy, the estimated moving costs and, if applicable, housing allowance costs should be shown. For purposes of the EA, show these costs in the same program year as the revitalization project. Supporting justification should be provided that indicates how these estimates were derived, e.g., BAQ/VHA rates for an E-5 were used since that this is the average paygrade of the occupants. Remember that these costs are to be escalated to the program year of the revitalization project. If this alternative will not require any displacement or moving of occupants, then those costs do not need to be factored in. However, the EA assumptions should state that moving costs will not be incurred.

c. Outyear Renovation Costs. Show estimated one-time renovation costs that are expected to occur during the analysis timeframe. These costs and requirements should take into account life expectancies of major components, the year such components were last repaired or replaced, and the estimated cost (based on historical data, means indices, etc.). These costs should be entered in the year they are expected to occur. Use Attachment 3 to show these estimated costs.

2. Recurring Costs. The following are recurring costs that should, at a minimum, be considered in the EA:

a. Utilities. Use actual historical utility costs for this alternative if the revitalization project does not include any energy conservation features. If the project does include energy conservation features, then the new estimated utility costs should be shown beginning in the year when the project will be complete. The extent of the proposed utility savings resulting from the revitalization project should be stated in the assumptions. Express all costs in program year dollars and hold constant throughout the time period covered by the EA.

b. Recurring Maintenance. Use actual historical maintenance costs for the units under study in the EA. Recurring maintenance includes service calls, routine change of occupancy work, minor repairs, etc. If the revitalization project will result in savings in annual recurring maintenance, state the extent of the savings in the assumptions and show the reduced maintenance expenditures beginning in the estimated year of project completion.

c. Painting. Estimate painting costs for the revitalization alternative in the same manner as the status quo alternative. Add these costs to the annual recurring maintenance and repair costs. If the revitalization project involves the installation of vinyl or aluminum siding over existing wood siding, it is reasonable to expect, and show on the EA, savings in exterior painting costs.

3. Imputed Costs. If the economic analysis considers and costs out the direct compensation alternative, then imputed costs must be estimated for the revitalization alternative. If the direct compensation alternative is not applicable, imputed costs do not need to be estimated. Compute imputed costs in the same manner as described in the Status Quo discussion. These costs should be shown in the "Other Costs" column.

C. REPLACEMENT ALTERNATIVE. This alternative involves the replacement of the units considered in the EA. Replacement could involve demolition or replacement on the same site/same building footprint replacement at a proximate site to the existing housing, or construction of replacement units at a brand new site. Selection of the replacement site is important in determining the extent of site support and infrastructure costs (e.g., utilities, paving, etc.).

1. One-Time Costs or Non-Recurring Costs. The following are one-time or non-recurring costs for consideration under the replacement alternative in the EA:

a. Replacement Project (Program Year). The EA should reflect the replacement cost of the units involved in the proposed action. The program year should be the same as that used for evaluation of the revitalization alternative. The construction costs should include the military construction cost of replacement (including demolition of the existing units, if appropriate). The OSD tri-service cost model (Attachment 4) will be used for the estimate of the replacement cost within the five-foot line and for entry of the estimated supporting/site costs. The narrative assumptions should spell out any factors that are germane to the review of the replacement costs. An example of a factor might be the presence of asbestos that has an impact on the demolition cost. Provision of any supplemental materials as a backup to the EA that would aid in the review is encouraged.

(1) "Five-foot" Line Costs. The first part of the tri-service cost model involves the cost of construction of the building to the five-foot line. Key to the entry of these costs is the paygrade/bedroom composition of the units. The composition used in the replacement analysis should be the same as the composition of the units under consideration for revitalization. Include the identification of the paygrade/bedroom composition in the EA narrative. Another factor in the computation of these costs is the cost per net square foot. These costs are a function of the program year. They are usually updated biannually by OSD. The costs embedded in the spreadsheet are the latest OSD costs.

(2) Supporting Costs. These costs involve site costs associated with the construction of the units. Examples of supporting costs include demolition, landscaping, etc. Supporting costs used in the replacement construction cost estimate should be based on specific engineering estimates that take into account assumed siting, density, etc. Relevant assumptions that underlie the replacement construction cost estimate should be specifically identified in the "Assumptions" appendix of the EA. Any costs in the revitalization alternative that involve "Neighborhoods of Excellence"-type initiatives should also be factored into the supporting costs of the replacement alternative in order to make the two alternatives equal in quality.

b. Moving Costs. If the replacement alternative will require that families be moved out of Government quarters and/or required to live on the economy, the estimated moving costs and, if applicable, housing allowance costs should be shown. For purposes of the EA, show these costs in the same program year as the replacement project. Supporting justification should be provided that indicates how these estimates were derived, e.g., BAQ/VHA rates for an E-5 were used since that this is the average paygrade of the occupants. Remember that these costs are to be escalated to the program year of the revitalization project to ensure consistency in the analysis. If this alternative will not require any displacement or moving of occupants, then those costs do not need to be factored in. However, the EA assumptions should state that moving costs will not be incurred.

c. Outyear Renovation Costs. Show estimated one-time renovation costs that are expected to occur during the analysis timeframe. These costs and requirements should take into account life expectancies of major components, the year such components were last repaired or replaced, and the estimated cost (based on historical data, means indices, etc.). These costs should be entered in the year they are expected to occur. Use Attachment 3 to show these estimated costs.

d. Residual Value. As stated earlier in the guidance, the assumed economic life of the housing under the replacement alternative is 40 years. This means that, at the end of the 25-year analysis period, there will be a residual value of the housing that will be factored into the EA as an offset to costs. A 45-year straight-line depreciation method will be used to compute the residual value. Accordingly, the housing will depreciate at 2.2% per year, or a total of 55.0% over the 25 years covered by the EA. The residual value will be equal to 45.0% of the initial construction cost (excluding demolition, design, etc.). The spreadsheet will automatically calculate the residual value.

2. Recurring Costs. The following are recurring costs that should, at a minimum, be considered in the EA:

a. Utilities. Identify estimated utility costs that would be associated with new units. The estimate should be based on estimated consumption associated with new construction as well as the estimated utility costs that will be in effect at the time of the program year. The basis for the utility cost estimates should be identified in the EA assumptions. Express all costs in program year dollars and hold constant throughout the time period covered by the EA.

b. Recurring Maintenance. Identify estimated maintenance costs that would be associated with new units. Recurring maintenance includes service calls, routine change of occupancy work, minor repairs, etc. If the replacement project will result in savings in annual recurring maintenance, state the extent of the savings in the assumptions and show the reduced maintenance expenditures beginning in the estimated year of project completion. There may be continued occupancy of the existing units until the replacement project is completed. If that is the case, then the EA might reflect maintenance of the existing units (at minimal levels) for the interim period until the new units are occupied. Be careful that the EA is consistent. For example, it would be incorrect to show demolition in year 1 yet show continued occupancy of the existing units until year 3.

c. Painting. Estimate painting costs for the new construction years in the same manner as the status quo alternative. Add these costs to the annual recurring maintenance and repair costs.

3. Imputed Costs. If the economic analysis considers and costs out the direct compensation alternative, then imputed costs must be estimated for the replacement alternative. If the direct compensation alternative is not applicable, imputed costs do not need to be estimated. Compute imputed costs in the same manner as described in the Status Quo discussion. These costs should be shown in the "Other Costs" column.

D. DEMOLITION/DIRECT COMPENSATION. This alternative involves demolition of the existing units, without replacement, and the payment of housing allowances to the displaced families so that they can live on the economy. If there is a current and projected deficit of suitable family housing at the EA location, this alternative need not be priced out. Instead, the EA may dismiss the alternative up-front as not meeting the objective. However, if there is either a current or projected surplus of family housing at the location, this alternative must be priced out.

1. Non-Recurring Costs. The following are one-time or non-recurring costs for the demolition/direct compensation alternative.

d. Demolition. Use the estimated cost of demolition of the existing units. The demolition cost under this alternative should be the same as the demolition cost used in the replacement alternative.

e. Moving Costs. This alternative would involve the displacement, and associated moving cost, involved with putting families on the economy. The moving costs should be estimated in the same fashion as for the revitalization or replacement alternatives. It is conceivable that the moving costs for this alternative are higher than the other alternatives in the sense that where, under the other alternatives, units can be vacated and made available on a phased basis, this alternative would involve the vacating of all units.

2. Recurring Costs. The only recurring costs under this alternative would be the annual payment of housing allowances (Basic Allowance for Quarters (BAQ) and the Variable Housing Allowance (VHA) or Overseas Housing Allowance (OHA)). Use the most current allowance rates in conjunction with the designation or occupancy by paygrade of the units and inflate to the program year in the EA. If the units are designated for occupancy by a paygrade range, select a median paygrade for allowance calculations. Display the allowance calculations in the assumptions.

PERIODIC MAINTENANCE, REPAIR, AND REPLACEMENT COSTS
ALTERNATIVE 1 - STATUS QUO

YEAR	FOUNDATION	ROOF	HVAC	ELECTRICAL	PLUMBING	FLOORING	WINDOWS/ DOORS	KITCHEN	BATHS	OTHER PROPERTY	TOTAL REPAIRS
0											$0
1											$0
2											$0
3											$0
4											$0
5											$0
6											$0
7											$0
8											$0
9											$0
10											$0
11											$0
12											$0
13											$0
14											$0
15											$0
16											$0
17											$0
18											$0
19											$0
20											$0
21											$0
22											$0
23											$0
24											$0
25											$0

PERIODIC MAINTENANCE, REPAIR, AND REPLACEMENT COSTS
ALTERNATIVE 2 - REVITALIZATION

YEAR	FOUNDATION	ROOF	HVAC	ELECTRICAL	PLUMBING	FLOORING	WINDOWS/ DOORS	KITCHEN	BATHS	OTHER PROPERTY	TOTAL REPAIRS
0											$0
1											$0
2											$0
3											$0
4											$0
5											$0
6											$0
7											$0
8											$0
9											$0
10											$0
11											$0
12											$0
13											$0
14											$0
15											$0
16											$0
17											$0
18											$0
19											$0
20											$0
21											$0
22											$0
23											$0
24											$0
25											$0

PERIODIC MAINTENANCE, REPAIR, AND REPLACEMENT COSTS
ALTERNATIVE 3 - REPLACEMENT

YEAR	FOUNDATION	ROOF	HVAC	ELECTRICAL	PLUMBING	FLOORING	WINDOWS/ DOORS	KITCHEN	BATHS	OTHER PROPERTY	TOTAL REPAIRS
0											$0
1											$0
2											$0
3											$0
4											$0
5											$0
6											$0
7											$0
8											$0
9											$0
10											$0
11											$0
12											$0
13											$0
14											$0
15											$0
16											$0
17											$0
18											$0
19											$0
20											$0
21											$0
22											$0
23											$0
24											$0
25											$0

GLOSSARY OF ECONOMIC ANALYSIS RELATED TERMS

APPENDIX G

This appendix provides definitions of terms, in addition to the terms defined in the main body of the text, which the analyst (or reviewer) may encounter in the course of working on an economic analysis. Many of the definitions have been adapted from the Glossary for Economic Analysis, Program Evaluation and Output Measurement, which was prepared by the Defense Economic Analysis Council (DEAC), and which was adapted from a glossary prepared by the American Association for Budget and Program Analysis (AABPA). Other definitions have been adapted from the Glossary for Systems Analysis and Planning-Programming-Budgeting, prepared by the U.S. General Accounting Office (GAO). Terms explained in the main body of the text may be accessed via the Index (Appendix I).

Glossary of Economic Analysis Related Terms

accounting, accrual - Accounting in which revenues and expenditures are recorded as they are earned or occur without regard to when the income is actually received or when payment is made. Accrual accounting contrasts with cash basis accounting in which cash receipts and disbursements are recorded as they occur during a given period.

a fortiori analysis - A procedure for coping with uncertainty by handicapping the preferred alternative by resolving all questions of uncertainty in favor of some other alternative. If the initially preferred alternative remains acceptable, the case for favoring it has been strengthened.

algorithm - A set of ordered procedures, steps, or rules, usually applied to mathematical procedures, and assumed to lead to the solution of a problem in a finite number of steps.

alternatives - Different ways of reaching the objective or goal. In economic analysis and program analysis objectives and goals are defined so that the consideration of different options or alternatives is not precluded.

amortization - The gradual reduction of the balance in an account according to a specified schedule of time and amounts. Usually the provision for extinguishing a debt, including interest, by means of a sinking fund or other form of payment.

analysis - A systematic approach to problem solving. Complex problems are made simpler by separating them into more understandable elements. Involves the identification of purposes and facts, the statement of defensible assumptions, and the derivation of conclusions therefrom. The different types of analyses are distinguishable more in terms of emphasis than in substance. All are concerned with the decision-making process; most of them apply quantitative methods.

appropriation - The most common form of budget authority. Allows agencies to incur obligations and to make expenditures for specified purposes and in specified amounts. At the Federal level, ordinary current appropriations (either no-year or one or more years) are budget authority granted currently by the U.S. Congress. Does not include contract authority to spend debt receipts.

assets - Property, both real and personal, and other items having monetary value.

assumptions - Judgments concerning unknown factors and the future which are made in analyzing alternative courses of action. For instance, in a sewage disposal problem, a possible assumption is that no new technology would be available in the short run.

asymptote - In terms of graph of a function, an asymptote is a straight line which the graph continually approaches and with which it coincides only at an infinite distance. It represents a boundary or limit which the function never crosses.

authorization - Legislation or other action which sets up a program or activity. May set limits on amounts that can be appropriated subsequently but usually does not provide budget authority. In the Federal Government, an authorization is provided by an Act of U.S. Congress; usually emanates from a specific committee of Congress.

average - A quantity or value which is representative of the magnitude of a set (usually a population or a sample) of quantities or values related to a common subject. Popularly refers to arithmetic mean. There are different types of averages and their application varies with the problem involved.

base period - The time period selected to determine the base values of variables (ratios, quantities, or values) for use in current planning and programming. Also, the time period to which index numbers relate. For example, the base year used as the base period of a price index, such as the Consumer Price Index (CPI).

Bayesian statistics - A school of thought within statistics in which estimates of probabilities of events are based on the scientist's or decision-maker's subjective beliefs as modified by empirical data. In classical statistics, probability estimates are based solely on objective data. A consequence of this difference is that Bayesian statistics is considered more decision-oriented than classical statistics since the point of "enough information" for a decision is reached more quickly under Bayesian statistics. An additional aspect of the Bayesian approach which makes it more decision-oriented is that it explicitly takes into account the cost of obtaining additional data.

benefit - Result attainment in terms of the goal or objective of output. For example, if the goal of an educational program is 100 percent literacy for a target group within 10 years, a measure of the benefit attributable to that program would be the increase in the percentage of literacy in the group rather than the number of trainees or any other measure of output.

benefit analysis - Analysis to identify, measure, and evaluate the benefits for each proposed alternative. Sometimes termed benefit determination.

benefit/cost analysis - See: Cost/benefit analysis.

benefit, direct - Result attained which is closely related with the project/program in a cause and effect relationship. For example, increase in literacy as a result of a reading program.

benefit, indirect - Result attainment circuitously related to the program. For example, decrease in crime due to increased literacy arising from a reading program. See: Externalities.

benefit, principal - Result attained toward accomplishing the major goals or objectives of a program. For example, increases in employment rates and income per capita could be the principal benefits derived from an increase in literacy resulting from a reading program.

benefit, secondary - See: Externalities.

benefit, social - Result attained for society as a whole. Benefits which accrue to society as a result of a public program which may or may not be conducted primarily for the benefit of those who are required to act under the program. For example, the reduced cleaning costs to household incident to the installation of an air pollution control system required by Government regulation. Sometimes expressed in terms of aesthetic, recreational, and intellectual benefits. For example, increase in library usage and theater attendance due to increased literacy as a result of a reading program. See: Externalities.

benefit, subsidiary - Result attained toward lower priority objectives or goals of the program. For example, decrease in welfare roles would be a subsidiary benefit as newly literate population becomes employable.

bias - An effect which deprives a statistical result of representativeness by systematically distorting it. Bias may originate from poor design of the sample, from deficiencies in carrying out the sampling process, or from an inherent characteristic of the estimating technique used. Also a survey questionnaire could be biased if it allows only the responses desired by the questioner. Often the degree of bias related to an estimating technique may be so small as to be of no practical importance but in other instances significant enough to invalidate the usefulness of the analysis.

budget estimate - Documentation regarding resources required. The budget estimate represents a plan relating to purpose, size, scope and priorities of operations during the budget period.

budget, program - A budget based on objectives and outputs and coordinated with planning. Focuses upon results of programs by linking resources to purposes for several years ahead, emphasizing policy implications of budgeting. Also, refers to line item in any budget document covering the budget request for a program element.

capital - Assets of a permanent character having continuing value. Examples are land, buildings, and other facilities including equipment. Also, the non-expendable funds used to finance an enterprise or activity. Sometimes refers to the excess of assets over liabilities.

cash flow, discounted - See: Discounted cash flow.

cash recovery period - See: Payback period.

coefficient - A number written before a quantity to indicate multiplication, that is how many times the quantity is to be taken additively. For example, in the expression 5ax the coefficient of the quantity ax is 5 while the coefficient of the quantity x is 5a.

combinations and permutation - In mathematics and statistics, a combination is a group of several things or symbols in which the order of arrangement is immaterial. A permutation is an arrangement reflecting a change in order or sequence, especially the making of all possible changes. Thus, when a problem concerns groups without any reference to order within the group, it is a problem in combinations. When the problem requires that arrangements to be taken into account, it is a problem in permutations. Example: the group of letters ABC make a single combination, whatever their order, but make six permutations, viz. ABC. ACB, BCA, BAC, CAB, CBA.

confidence level - Quantitative statement of the assurance or confidence used in making an estimate from the sample. Usually expressed as a percentage; it is the number of times out of 100 that the true answer would be found within the determined confidence interval. For instance, with a 90% confidence level, we say that we have 90% assurance (or 9 times out of 10) that the estimated expense of $20.000 is within $6000 (the confidence interval) of the true amount allowed for expenses. With increases in the confidence level, the confidence interval must be widened and this decreases information regarding the estimated quantity. Therefore, in selecting the confidence level, much depends on the specific problem as well as judgments about the risks associated with an estimate which misses the true value by more than the amount of the confidence interval.

constant dollars - Computed values which remove the effect of price changes over time. Derived by dividing current dollar values by their corresponding price indexes based on a time period specified as 100. The result is a series as it would presumably exist if prices were the same over time as in the base year; in other words, as if the dollar had constant purchasing power. Thus changes in such a series of price - adjusted output values would reflect only changes in the real volume of output.

constraints - Limitations of any kind to be considered in planning, programming, scheduling, implementing or evaluating programs.

consumer's surplus - In economics, the difference between the price that a consumer pays for a good or a service and the amount that he would be willing to pay rather than be deprived of the good or service.

contingency analysis - A technique for exploring the possible effects of errors in major assumptions. It is designed to cope with significant uncertainties of a quantitative nature. The procedure is to vary the assumptions regarding important aspects of the problem and examine the changes in results of the analysis due to these changes in the assumptions. For example, in an analysis designed to disclose a preferable military strategy among several alternatives, the assumption that one of our major allies becomes allied with our potential enemies might be made to explore the effects of such a contingency. See: Sensitivity analysis.

cost - The value of things used up or expended in producing a good or a service. Also whatever must be given up in order to adopt a course of action.

cost, actual - Cost incurred in fact as opposed to "standard" or projected costs. May include estimates based on necessary assumptions and prorations concerning outlays previously made. Excludes projections of future outlays.

cost allocation - The portion of joint or indirect assets assigned to a particular objective such as a job, a service, a project, or a program.

cost analysis - Determining the actual or estimated costs of relevant spending options. An integral part of economic analysis and program analysis. Its purpose is to translate the real resource requirements (equipment, personnel, etc.) associated with alternatives into estimated dollar costs. The translation produces direct one-dimensional cost comparisons among alternatives.

cost, applied - The value of goods and services used, consumed, given away or lost by an agency during a given period regardless of when ordered, received or paid for. Generally, applied costs are related to program outputs so that such costs become the financial measures of resources consumed or applied in accomplishing a specific purpose. For operating programs, such costs are related to the value of resources consumed or used; for procurement and manufacturing programs. they are related to the value of material received or produced; for capital outlays. they are related to the value of assets put in place; and for loan activities, they are related to assets required.

cost, average - The quotient of total cost divided by corresponding output. Also, the sum of average fixed cost per unit of output plus average variable cost per unit of the same output.

cost/benefit - A criterion for comparing programs and alternatives when benefits can be valued in dollars. Refers to the ratio, dollar value of benefit divided by cost. Provides comparisons between programs as well as alternative methods. Useful in the search for an optimal program mix which produces the greatest number of benefits over costs. See: Cost effective alternative; Present value.

cost/benefit analysis - Comparing present values of all benefits divided by those of related costs, (where benefits can be valued in dollars the same way as costs) in order to identify the alternatives which maximize the present value of the net benefit of the program, and to select the best combination of alternatives using the cost/benefit ratio. See: Cost effective alternative.

cost, direct - Any cost which is identified specifically with a particular final cost objective or goal. Varies with level of operation.

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

cost elements - Cost projected for expected transactions, based upon information available. Does not pertain to estimates of costs already incurred. See: Cost, actual.

cost estimating relationship (CER) - a numerical expression of the link between a characteristic. a resource, or an activity and a particular cost associated with it. The expression may be a simple average, percentage, or complex equation derived by regression analysis which relates cost (dependent variable) to physical and performance characteristics (independent variable). For example, estimated costs of an aircraft airframe (dependent variable) might be determined, using regression analysis, to be a function of airframe weight, delivery rates, and speed (independent variables). The CER shows how the values of such independent variables are converted into estimated costs.

cost growth - Increases in the cost of goods and services in excess of the rate of inflation. See: Inflation.

cost, fixed - Cost incurred whether or not any quantity of an item is produced. Does not fluctuate with variable outputs. For example, the rental cost for a manufacturing facility might be treated as fixed cost because it does not vary with output.

cost, imputed - A cost that does not appear in accounting records and does not entail dollar outlays.

cost, incremental - Increase in costs per unit increase in program activity. Also the additional cost needed to make a change in the level or nature of output. If incremental cost per ton is $100 for an increase in production from 100 to 150 tons per month but only 175 per ton for an increase in input to 200 tons per month, the incremental cost in total operations would be $5000 for adding 50 tons of output and only $7500 for adding 100 tons per month.

cost, indirect - Any cost, incurred for joint objectives, and therefore not usually identified with a single final cost objective. Includes overhead and other fixed costs and categories of resources other than direct costs, required to add up all segments of total cost. For example, the cost of bookkeeping is often not identified with a single type of output.

cost, induced - All uncompensated adverse effects caused by the construction and operation of a project or program, tangible or intangible. For example, deterioration in environmental quality resulting from a water resource project. See: Externalities.

cost, joint - Cost of producing two or more outputs by a single process.

cost, marginal - Change in total cost due to a change in one unit of output. It is a special case of the more general term, incremental cost. Theoretically, a firm will maximize profits (or minimize losses) by increasing output until marginal cost equals marginal revenue. At that point, any additional output will incur a cost greater than the added revenue and any reduction in output will reduce revenue by more than the reduction in costs.

cost, opportunity - The benefits that could have been obtained by the best alternative use of resources which have been committed to a particular use. The measurable sacrifice foregone by forsaking an alternative investment.

cost, social - The total costs of an activity both public and private. For example, health effects of auto pollution are a component of the social cost of automobile transportation.

cost, standard - A predetermined cost criterion. A basis for pricing outputs, evaluating performance, and preparing budgets. May be expressed as unit cost for an item or a component, or total cost for a process, a project, or a program.

cost, sunk - Non-recoverable resource that has been consumed as the result of a prior decision. Sunk costs are not altered by a change in the level or nature of an activity and have no bearing on current investment decisions.

costs, total - Sum of fixed and variable costs at each level of output during a specified time period.

cost, undistributed - Costs incurred but not allocable to specific projects or programs, such as overhead costs for staff personnel working on several projects.

cost, unit - Cost, of any type, per unit of output.

cost, variable - Cost that varies with the quantity of output produced.

criteria - The standards against which evaluations are performed. Measures used should capture or embrace as closely a possible the purposes sought. May consist of proxy measures for dimensions difficult to measure. For example, a school system may seek to develop the maximum potential of all students. Unable to measure potentials, we may use proxy measures such as number of students graduated from high school and the scores made on standardized tests or any other tests that provide a significant basis for the comparison of program results or policies.

critical path method (CPM and PERT) - CPM (Critical Path Method) and PERT (Program Evaluation and Review Technique) are activity network models. In the network representation, the nodes usually depict events (material received, foundation completed, foundation inspected, etc.) and the arcs depict activities (order materials, construct foundation, inspect foundation, etc.). CPM seeks to determine the expected time of completion of the total project and times of completion of the subprojects of which it is composed. PERT goes further and seeks to estimate variances associated with these expected times of completion.

current dollars - Dollars that are current to the year of their expenditure. When past costs are stated in current dollars, the figures given are actual amounts paid out. When future costs are stated in current dollars, the figures given are the amounts due to projected future changes caused by inflation and/or general price escalation.

data - Numeric information or evidence of any kind.

decision theory - A body of knowledge and related mathematical techniques developed from the fields of mathematics, statistics, and logic which are designed to aid in making decisions under conditions of uncertainty. Decision theory is similar to game theory in several respects; however, a major difference between the two is that in game theory the decision is being made vis-a-vis an opponent, whereas in decision theory the only opponent is nature with its related uncertainty. Often decisions are analyzed through construction of a decision tree, analyzing the possibilities at any one time and, if possible, the probability for each. Each node of the decision tree represents an event and each branch represents an alternative course of action. Associated with each alternative course is a result or payoff of some sort.

degree of freedom - Refers to the size of a sample, which is labeled "n," less the number of parameter estimates "used up" in the process of arriving at a given unbiased estimate. For example, to estimate the mean needed to calculate the variance of a population, it is necessary to use the mean of the sample, thus using up one degree of freedom. The estimate of the population variance would thus have n-1 degrees of freedom.

delphi method - Technique for applying the informed judgment of group of experts, using a carefully planned program of sequential individual interrogations, without direct confrontation, and with maximum use of feedback of digested information in the investigation and solution of problems. It is a form of cybernetic arbitration having three features: anonymity, controlled feedback and statistical group response. Usually consists of a series of repeated interrogations by means of questionnaires.

delphi method (con't) - A way of improving the panel or committee approach by subjecting the views of the individual experts to each others' criticism in ways that avoid face to face confrontation, preserving anonymity of opinions and achieving a consensus rather than a compromise. After the initial interrogation of each individual, each subsequent interrogation is supplemented by information from the preceding round of replies. The expert is encouraged to reconsider and, as appropriate, change or defend the previous reply in light of the replies of other members of the group.

demand - Usually means "demand schedule" which is the relationship between price and quantity demanded. The demand schedule expresses how much of the good or service would be bought at various prices at a particular point in time. Sometimes changes in the quantity demanded are confused with changes or shifts in the demand schedule. A shift in the demand schedule may mean, for example. that consumers will demand more of the good or service at all possible prices than they would have previously demanded at the same prices. On the other hand, an increase in the quantity demanded would result only by decreasing the price of the good or service.

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 or corrosion.

diminishing marginal utility - The principle that, as the level of consumption of a good is increased, a point is reached where each additional unit consumed provides less utility than did the preceding unit.

diminishing returns, law of - The economic principle that, as there is an increase in the quantity of any variable input which is combined with a fixed quantity of inputs. The increases in marginal physical product (output) generated by the variable input must eventually decline. For example, an increase in fertilizer on a fixed amount of land will lead to diminishing increases in total output until eventually total will decline.

disbenefit - Undesirable result. An offset against positive benefits.

disbenefit, social - Social diseconomy. Loss of social benefits. For example, problems created by urban renewal projects in dislocating people from their communities. See: Externalities.

disbursements - The dollar amount of checks issued and cash payments made, net of refunds received. Includes all advances of money; excludes transfers involving no expenditures.

discount factor - The multiplier for any specific discount rate which translates expected cost or benefit in any specific future year into its present value.

discounted cash flow - See: Present value.

discount rate - The interest rate used in calculating the present value of expected yearly costs and benefits. Represents the price or opportunity cost of money. See: Present value.

discounting - A computational technique using an interest rate to calculate present value of future benefits and costs. Used in evaluating alternative investment proposals that can be valued in money. Reflects private sector investment opportunity cost as well as preference for current over future dollar incomes.

diseconomy - A damage received as a consequence of the economic activities of another for which the damaged does not receive compensation. See: Disbenefit, social; Externalities.

distributional effects - Impacts on those harmed as well as those benefited by the project/program including the differences in benefits flowing to those receiving them.

econometric model - A set of related equations used to analyze economic data through mathematical and statistical techniques. Depicts quantitative relationships that determine results in terms of economic concepts such as output, income, employment and prices. Such models are used for forecasting, estimating the likely quantitative impact of alternative assumptions, and for testing various propositions about the way the economy works.

econometrics - The mathematical formulation of economic theories and the use of statistical techniques to accept or reject the theories.

economic analysis - A systematic approach to the problem of choosing how to employ scarce resources and an investigation of the full implications of achieving a given objective in the most efficient and effective manner.

economic efficiency - That mix of alternative factors of production which results in maximum outputs, benefits, or utility for a given cost. That mix of productive factors which represents the minimum cost at which a specified level of output can be obtained.

economic good - An object which is both useful, in the sense that it satisfies a want or need, and relatively scarce. For example, food is both useful and scarce. Air, though useful, is not scarce, and is not an economic good. Poison ivy, though relatively scarce, is not useful, and therefore is not an economic good.

economies of scale - Reductions in unit cost of output resulting from the production of additional units. Stems from (1) increased specialization of labor as volume of output increases, (2) decreased unit costs of materials. (3) more efficient utilization of overhead. (4) acquisition of more efficient equipment. and (5) greater use of by-products. For example, the cost of producing a new aircraft, for which the prototype cost $30 million, might be $3 million each for 100 aircraft and only $1 million each for 1,000 aircraft due to economies of scale.

effectiveness - The rate at which progress towards attainment of the goal or objective of a program is achieved. Rate at which the benefits of a program are produced. Effectiveness is not entirely dependent upon the efficiency of a program because program outputs may increase without necessarily increasing effectiveness. Effectiveness is increased by strategies which employ resources to take advantage of changes in unmanageable factors in such a way that the greatest possible advancement of whatever one is seeking is achieved. For example, the effectiveness of an export promotion program may be increased by shifting exhibitions from countries of slow economic growth to countries of more rapid growth to increase the export sales of exhibitors. This improvement might be achieved despite a consequent decrease in efficiency assuming that outputs (number of exhibitions mounted, number of firms exhibiting. number of potential purchasers visiting the shows. etc.) per dollar of costs are reduced due to shifting shows to fewer markets. See: Productivity, Output Measures.

elasticity - A numerical measure of the responsiveness of one variable to changes in another. If greater than one, it indicates that the first variable is relatively elastic to changes in the second (i.e., when the second changes by one percent, the first changes by more than one percent). If the numerical value of elasticity is equal to one (i.e., unitary elasticity) the first variable is said to be elastic to changes in the second (a one percent change in the second variable will cause a one percent change in the first). In economics, elasticity is a measure of the responsiveness of the quantity demanded or supplied to changes in price. For example, the change in number of bus riders in response to change in bus fares.

endogenous variable - A variable the magnitude of which is dependent on and determined by the model being studied. See also: Exogenous variable.

engineering estimate - An estimate of costs or results based on detailed measurements or experiments and specialized knowledge and judgment. Also referred to as engineering method of cost estimating.

evaluation - Appraisal of the effectiveness of a decision made in the past. See: Program evaluation.

exogenous variable - A variable which is wholly independent of the model being studied, that is, a variable determined by outside influences. See also: Endogenous variable.

expected value - The summation of the products obtained by multiplying the probability of the occurrence of an outcome times the value of the outcome if it does occur. A decision criterion for appraising the value of payoffs by applying judgmental or factual evidence concerning the probability of such outcomes. For example, assume that a project has a 60 percent chance of succeeding, wherein the government would, gain $10,000,000, and a 40 percent chance of failing, wherein the government would lose $8,000,000.

The expected value of the project is (.60 x $10,000,000) - (.40 x $8,000,000) = $2,800,000.

expenditures - Generally refers to expenses paid and all other kinds of outlays made during a fiscal period. Sometimes refers to cash disbursements only.

expenditures, accrued - Charges incurred and liabilities established for goods or services received and for other reasons, such as damage claims, benefit payments, and annuities, during a specified period. Expenditures accrue when work is performed or resources delivered regardless of when payment is made or when resources are used. That portion of accrued expenditures which is unpaid at a given time is a liability; that portion of disbursements made for which the expenditures have not accrued (advances and prepayments) is an asset. Federal agencies have implemented reporting of accrued expenditures.

externalities - Benefits and costs (economies or diseconomies) that affect parties other than the ones directly involved. Sometimes referred to as 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 upstream.

fiscal policy - The actions and purpose of the federal government respecting economic goals such as high employment, stable growth and prices, and balance of payments equilibrium through changes in taxes and level of government spending. Distinct from monetary policy.

free good - A good or service that is so abundant, in relation to the demand for it, that it can be obtained without exertion or paying money or exchanging another good. For example, air and, in some localities, rainfall.

frequency distribution - A listing, often appearing in the form of a curve on a graph, of the frequency with which possible values of a variable have occurred. For example, it might show that in a group of 100 persons 50 were within the 10 to 25 year-old category, 30 were within the 26 to 50 year-old category, and 20 were within the 51-80 year-old category. Viewed in another way, this frequency distribution would show that the variable "age" assumed a value from 10 to 25 years, 50 times, a value from 26 to 50, 30 times, and so on.

function - A group of related activities and projects for which an organizational unit is responsible. Part of a system. Also, the principal purpose a program is intended to serve. For example, public safety, health protection, surface transportation. Also, a mathematical statement of a rule or relation between variables. For example, in the expression, $y = f(x)$, the variable is a function of variable x if for every value assigned to x, a specific value of y is determined. Here, x would be the independent variable andy would be the dependent variable.

fund, contingency - Money set aside in a budget to provide for unforeseen requirements.

fund, revolving - A fund established to finance a cycle of operations in which revenues are retained for reuse in a manner that will maintain the principal of the fund. A self-perpetuating or working capital fund.

funding - Providing funds to make payments and/or authority to incur commitments and obligations within established limitations.

game theory - A branch of mathematical analysis developed by von Neumann and Morgenstern to study tactical and decision--making problems in conflict situations. It is a mathematical process of selecting an optimum strategy in the face of an opponent who has a strategy of his own. Optimality may be defined by any of several criteria.

Gross Domestic Product (GDP) - The total national output of final goods and services at market prices for a given period.

heuristic problem solving - Solving problems by the trial and error approach. Frequently involves the act of learning and sometimes leads to further discoveries or conclusions but provides no proof of the correctness or optimality of outcomes.

hypothesis - A theoretical proposition or tentative explanation that is capable of empirical verification.

imputations - Estimates which make possible the inclusion of data for variables which are difficult to measure or do not take measurable monetary form. The general procedure for counting these non-monetary variables is to value them as if they were paid for. For example, the four major imputations made in the U.S. National Income and Product Accounts are for wages and salaries paid in kind (food, clothing, lodging); rental value of owner- occupied houses; food and fuel produced and consumed on farms; and interest payments by financial intermediaries which do not otherwise explicitly enter the accounts.

incommensurables - Consequences of alternatives compared that cannot be translated into the numeric terms being used. For example, the psychological impact on the community of a decision, such as losing a fire station, could not be put into numeric values in the same manner as increases in losses due to fires.

incremental cost - The cost associated with a change in the level of output. For example, if presently the total cost of production is $100,000 and under a planned increase in volume the total cost would be $125,000, the incremental cost would be $25,000.

index - Statistical device for measuring changes in groups of data and serves as a yardstick of comparative measure, expressed as an index number.

index, consumer price - A measure of average change over time in prices of goods and services purchased by city wage-earners and clerical-worker families and individuals. The items priced on a monthly and quarterly basis of the U.S. consumer price index, for example, included some 400 goods and services in a sample of 56 areas. This index is weighted to account for the difference in the importance of the individual items by use of the Laspeyres formula, P_nQ_0/P_0Q_0x100 ,where P_n is the price for each item in the given year. P_0 is the price of each item in the base year and Q_0 is the quantity of each item in the base year.

index number - A number used to measure change by relating a variable in one period to the same variable in another period, known as the base period. The index number is found by dividing the variable by the base period value and multiplying by 100.

indifference curve - A locus of points representing alternative combinations of two variables, often commodities or services to which the consumer is indifferent because each combination is equally as acceptable as another. Each point on the curve yields the same level of total utility to the user. The slope of an indifference curve is known as the marginal rate of substitution (also the substitution ratio and the relative marginal utility ratio) and is significant in analysis of demand.

inflation - Decrease in the value or purchasing power of money due to rising prices in the economy.

input - Resources including personnel, funds, and facilities utilized to obtain a specific output.

interval estimate - An estimate which states, subject to a given confidence level, that the characteristic of interest has a value that is located somewhere within a range or interval of values.

investment - An acquisition of a capability or capacity in the expectation of realizing benefits.

iso-cost curve - An indifference curve showing the different combinations of two outputs that can be obtained for a specific cost. All points on the curve represent a single level of cost. See: Indifference curves

iterative process - A series of computations in a repeating cycle of operations designed to bring the results closer to the desired outcome with each repetition.

learning curve - A curve which describes the set of points conforming to the observed phenomenon that unit cost reductions are a constant percentage decrease for each doubling of the cumulative quantity produced. This means that the cost of manufacturing unit 2 will be a certain percentage less than the cost of manufacturing unit 1; the cost of unit 4 will be the same percentage less than unit 2, and so on.

least-cost alternative - The alternative producing, at less cost, the same or greater quantity of a given output than any other alternative.

life cycle estimates - All anticipated costs, directly and indirectly associated with an alternative during all stages: preoperational, operational, and terminal.

limiting process - As applied to functions in general, it is a basic tool of mathematics that deals with the value approached by a function as its independent variable approaches some fixed value.

linear programming - A mathematical technique which assumes linear relationships (expressible in simultaneous linear equations which may be represented graphically as a straight line) between variables and produces optimal solutions to problems concerning resource allocation and scheduling, subject to one or more limiting constraints. The final output (or cost) to be maximized (or minimized) is called the objective function. In Government agencies, the objective function may be maximization of output or minimization of costs within a time or cost restraint.

macroeconomics - The study of the total or aggregate performance of an economy. It is concerned with concepts such as National Income, Gross National Product, price level, wage increases and level of employment for the economy as a whole.

marginal analysis - Technique for evaluating an added increment. A basis for comparing the added cost to the benefit gained. The term marginal refers to the last increment of whatever is being considered. Profits per unit of cost will be maximized when the additional increment of revenues and additional increment of cost are equal. At any other point, either additional revenue could be obtained at less additional cost, or additional revenue obtained would be less than the additional costs incurred.

marginal cost - In a marginal analysis, the change in total cost due to a one unit change in output. It is a special case of the more general term incremental cost. Theoretically, a purely competitive firm will maximize profits by increasing output until marginal cost equals price, while an imperfectly competitive firm will equate marginal cost to marginal revenue.

marginal revenue - The change in total revenue due to one-unit change in output.

Markov analysis - A method of analyzing the current movement of some variable in an effort to predict the future movement of that same variable. A first-order Markov process is based on the assumption that the probability of the next event depends on the most recent event and not on any other previous event. A second-order Markov process assumes that the next event depends on the past two events, and so on. A simple example of a first-order Markov process would be a baseball team's performance, if it could be shown that the key to determining the probability of a win is the result of the preceding game. That is, if the team won its last game the probability of a win today is .6 but if it lost yesterday the probability of a win is .4.

matrix - A rectangular array of rows and columns. Matrices may be subjected to mathematical operations such as multiplication of one by another, addition of two or more, and others. Matrices may be manipulated in total in a manner similar to the algebraic manipulation of single numbers, but knowledge of special rules, called matrix algebra, is necessary for such manipulation. The development of matrix algebra and of computer solution has made possible the efficient solution of very large systems of simultaneous linear equations.

mean, arithmetic - The sum of all the values of a set of observations divided by the number of observations. Also known as an average, or mean. It is an indication of the typical value for a set of observations. Expressed as:

$$M = \sum_{i=1}^{n} \frac{x_i}{n}$$

where M = mean
X_i = value of the " i^{th} " observation.
n = the total number of observations.

median - The central value of a set of observations, such as incomes, that have been arranged in order of magnitude. It is that value which divides the set so that an equal number of items are on either side of it. For example, if we have five items 4, 7, 9, 12, 15, the median is 9 since there are two items above that value and two items below it. If we have an even number of items, the median is calculated as halfway between the central two items. For example if we have six items, i.e., 4, 7, 9, 12, 15, 20, the median would be calculated:

$$\frac{9+12}{2} = 10.5$$

microeconomics - Economics relating to the study of parts of an economy and how they function rather than to the total economy and its aggregate performance. Individual firms and consumers are analyzed concerning wages, prices, inputs and outputs, supply and demand, among other things. See: Macroeconomics.

mode - The observation which occurs most frequently in a set of observations. It is a measure of central tendency in a frequency distribution. Often used to average weekly sales and purchases. In the distribution: 2, 3, 5, 5, 8, 12, the mode is 5.

model - A representation of the relationships that define a system or situation under study. Its purpose is to predict what will happen when a system becomes operational in terms of performance and output. A model, with its analytical discipline features, may be a set of mathematical equations, a computer program, or any other type of representation, ranging from verbal statements to physical objects.

deterministic model - A model in which the variables take on only definite values, that is, a model that does not permit any risk as to the magnitude of the variables. For example, a set of simultaneous equations for which there is a unique solution.

probabilistic model - A model in which each variable may take on more than one value. Such models are sometimes called stochastic and values are assigned according to probability distributions.

monetary policy - A principle or guideline relative to government actions concerning the availability of money and its impact on employment, prices, and economic growth. Relates to the Federal government economic stabilization policies, primarily executed by the Federal Reserve System, designed to achieve economic goals such as high employment, stable growth and prices, and balance of payments equilibrium, through influence on the money supply, interest rates, and credit availability.

Monte Carlo methods - A catch-all label referring to methods of simulated sampling. When taking a physical sample is either impossible or too expensive, simulated sampling may be employed by replacing the actual universe of items with a universe described by some assumed probability distribution and then sampling from this theoretical population by means of a random number table.

normal (Gaussian) distribution - The most used distribution in statistics because it represents a wide variety of actual distributions in nature and because it simplifies a number of statistical calculations. It is a continous distribution in the form of a bell-shape curve. Its most important feature is that it is completely determined by its mean and standard deviation.

objectives - Statements of what we are trying to accomplish and why, set forth, if possible, in measurable terms. In analysis, objectives are stated in a manner which does not preclude alternative approaches.

obligations - Commitments made by agencies, during a given period, to pay out money for goods, services or other purposes during the same or a future period. Obligations may not be larger than the budget authority apportioned for the period.

operations research (OR) - Systematic effort to provide decisions concerning systems. OR may present a solution to a problem or present the pros and cons of alternatives. Taking an objective as given, OR focuses on ways to optimize realization of that objective in terms of some criterion such as cost, time, distance, speed, etc. A distinctive feature of OR is its application of one or a combination of the scientific disciplines such as mathematics, biology, chemistry, physics, statistics. etc., in addition to subjective methods such as common sense and judgments based on experience. OR might, for example be used by a manufacturer seeking the most efficient method of producing large quantities of electronics equipment on government contract.

optimization - A determination of the best mix of inputs to achieve an objective. An optimum may be derived by differentiating an appropriate function (mathematical equation expressing relationship of input to output) with respect to each variable, setting the resulting equations equal to zero and solving them simultaneously. For example, the optimum frequency for scheduling vehicle maintenance for a number of vehicles is the frequency which equates the costs of maintenance with the consequences of deferred maintenance. If the frequency is too high, you are overspending on maintenance; if too low, the cost of breakdowns will be excessive.

outcomes - The results of operations.

outlays - Checks issued, interest accrued on the public debt, and/or other payments made, net of refunds and reimbursements.

outputs - Program results such as goods produced and services performed expressed in quantities relatable to specific inputs, organizational missions, and functions. Outputs provide a basis for evaluating the productivity and efficiency of an organization or activity. See: Benefits; Effectiveness.

output measures - Quantitative, qualitative, or comparative measures of output such as: 1) gallons of water purified, 2) the oxygen content of water purified, and 3) gallons of water purified per housing unit.

parameter - A numerical characteristic relating to or describing a population, which can be estimated by sampling. Differs from a statistic which is derived from a sample. For example, is the parameter for the mean of population while x is the statistic for the sample, an estimate of. Parameters are frequently denoted by Greek letters to distinguish them from corresponding sample values.

Pareto optimum - A concept in welfare economics that sets the conditions that maximize the economic wealth of given society. The Pareto optimum is said to have been achieved when it is impossible to make one person better off without making another (or others) worse off.

Payback period - The length of time over which an investment outlay will be recovered. Also referred to as payoff period or cash recovery period.

pecuniary spillover - A spillover which is monetary rather than physical in nature and which causes a change in the monetary valuation of a physical input or output, but does not change the relationship between physical inputs and physical outputs. For example, an acceleration of a man-to-Mars program timetable might cause a short run shortage of professionals and technicians thus increasing the costs of similar services to other industries but not necessarily changing the physical productivity of these inputs to the other industries.

point estimate - An estimate which is expressed in terms of a single numerical value rather than a range of values.

policy - A governing principle, pertaining to goals or methods. decision on an issue not resolved on the basis of facts and logic only.

population - The total number of elements within an area of interest. For example, the total number of inhabitants in a country or the total number of vouchers for a program. Also referred to as universe. See: Sample.

precision - Exactness of measurement. For example, a yardstick marked off in units 16 to the inch is more precise than one marked off in eighths. Also, in pointing off a decimal, 5.763 is more precise than 5.8. In statistical sampling, an estimated mean of 10 feet having a standard deviation (3D) of I foot has greater precision than an estimate of 10 feet having an 3D of 2 feet, but has the same precision as another estimate of 20 feet which has an SD of 2 feet. In statistical inference, the measure of precision is the size of the interval within which the value being estimated is predicted to be found with a specified degree of assurance. based upon the results obtained from a sample. There is a tradeoff between the degree of precision of an estimate and the degree of assurance with which it may be made. If a less precise estimate, that is, one with a wider interval, is tolerable, the degree of assurance or confidence level can be increased.

Present value - The present worth of past or future benefits and costs determined by applying discount procedures to make alternative programs and actions comparable regardless of time differences in the money flows. See: Discounting, Discount factor, Discount rate.

present value benefit - Calculation of each year's expected monetary benefit multiplied by its discount factor and then summed over all years of the planning period.

present value cost - Calculation of each year's expected cost multiplied by its discount factor and then summed over all years of the planning period.

price - The amount for which a good or service is bought or sold.

price, equilibrium - The amount of money represented by the intersection of the supply curve and the demand curve.

priority - Ranking of decisions, projects, programs according to urgency with which they are deemed needed. Often involves ranking related to spending budget.

probability - Numeric expression of the likelihood or chance of occurrence of a given event or outcome. Usually expressed as a percentage or proportion computed by dividing the total number of items, values, events, or outcomes of a specific type in a given group or universe by the total of all possible types of items, values, events, outcomes in the same group or universe. For example, in a universe of 1000 vouchers containing 250 receiving vouchers, 700 shipping vouchers, and 50 inventory adjustment vouchers, the probability that a voucher selected at random is an inventory adjustment voucher is .05 (50 divided by 1000).

probability distribution - The listings of possible values of a variable (Y) and their associated probabilities. When summed over all possible values of Y, these probabilities will equal 1.00. In the example in the preceding definition of probability, the probability distribution is:

Shipping vouchers	.70
Receiving vouchers	.25
Inventory adjustment vouchers	.05
	1.00

Some commonly used probability distributions are binomial, hypergeometric and Poisson, which are discrete distributions, and the normal or Gaussian and the F distribution which are continuous distributions. The continuous probability distribution is one in which an infinite number of values of a variable can occur. For example, the amount of time it takes to fix a flat tire is a continuous variable because time can be subdivided into an infinite number of values. A discrete distribution, on the other hand, is one in which only isolated values can occur. For example, the number of tires on a car which have a flat is discrete being either 0, 1, 2, 3, or 4.

program analysis - The generation of options for goals and objectives as well as strategies, procedures and resources by comparing alternatives for proposed and ongoing programs. Embraces the processes involved in program planning, program evaluation, economic analysis, systems analysis, and operations research.

program evaluation - Appraising the efficiency and effectiveness of ongoing or completed programs. Aims at a program improvement through comparisons of existing programs with alternative programs and techniques. Uses actual performance data to gauge progress towards program goals.

programming - Programming is the process of deciding on specific courses of action to be followed in carrying out planning decisions on objectives. It also involves decisions in terms of total costs to be incurred over a period of years as to personnel, material, and financial resources to be applied in carrying out programs.

quantification - The measurement (not valuation) of the inputs, outputs, or benefits of a program. Consists of listing of the magnitudes of all important results, favorable and unfavorable, to which a program will give rise.

queuing techniques - techniques used when a problem involves providing a supply of goods and services in order to satisfy randomly arriving demands for these goods and services. More specifically, the techniques associated with operations research which determine the amount of delay that will occur when operations (such as supplying goods or services) have to be provided in sequences for objects (such as customers) arriving randomly. Queuing theory pay be applied to any operation in which objects arrive at a service facility of limited capacity.

random variable - A variable whose magnitude is determined by chance.

range - The difference between the smallest and largest quantity in a statistical series arrayed according to size. The simplest measure of the dispersion in a set of numbers. For example, the range for series of the four numbers 10, 13, 40, 53, which is 53 - 10 = 43. Also the difference between the largest possible value of a variable (random or not) and its smallest possible value.

receipts, accrued - Revenues earned (less refunds paid or payable) and other receipts due in during the period regardless of dates actually received.

regression analysis - Analysis undertaken to determine the extent to which a change in the value of one variable, the independent variable, tends to be accompanied by a change in the value of another variable (the dependent variable). Where only one independent variable is involved in the analysis, the technique is known as simple regression analysis; where two or more independent variables are involved, the technique is called multiple regression analysis. If the relationship between two variables can be depicted graphically by a straight line, it can be defined mathematically by an equation of the form:

$$y = a + bx$$

where y is the dependent variable and x is the independent variable. Multiple regression analysis can similarly be defined by an equation of the form:

$$y = a + bx_1 + cx_2 + dx_3 \ldots zx_n$$

but in this case graphical representation would have to be multidimensional. If the change in the dependent variable associated with a change in the independent variable does not occur at a constant rate, the regression line takes the form of a curved line and the, analysis is referred to as curvilinear regression analysis. Regression lines are drawn or defined in such a way that the sum of the squared deviations (the squares of the vertical distance of each point from the line) is smaller than would be the sum of the squared deviations from any other line which could be drawn. The relationships identified by means of regression analysis are associative only; causative inferences must be added subjectively by the analyst or obtained by other means.

resources - Assets available and anticipated for operations. Includes items to be converted into cash and intangibles such as bonds authorized but unissued. Includes people, equipment, facilities and other things used to plan, implement and evaluate public programs whether or not paid for directly by public funds.

revenue - Amounts realized from sales of outputs or assets, from collections of taxes and duties, and from contributions and other receipts incidental to operation.

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

salvage value - Estimated value of the asset at the end of the project life.

sample - A subset of the population. Elements selected intentionally as a microcosm representative of the population or universe being studied.

sample, random - A sample selected on basis of probability that each element of the population has an equal chance of being selected. Equal chance of selection for each element in the population may be insured by the sample design. One procedure utilizes a table of random numbers to indicate elements to be included in the sample.

sample, simple random - A random sample of units selected with equal probability and without replacement from a finite population.

sample size - The number of cases (population elements) selected for the sample. Although a number of factors influence the determination of sample size, major factors are the variability of the principal characteristic (in its population) to be estimated, and the confidence level and confidence interval the decision-maker can tolerate. The size of the population or universe is a minor influence. There are many formulae and variations thereto for computing the sample size for any problem.

sample, stratified - A sample consisting of random samples from subgroups, or strata, of the population. The population is stratified for the purpose of sorting out homogeneous groups of elements. This in turn reduces overall sampling error by decreasing the variance between the elements in their respective strata. Stratified proportional samples are often designed to minimize variance by stratifying the population according to some available size criterion.

satisficing - A term, advanced by Herbert Simon, which views decision-making as a process of reaching satisfactory positions (satisfying and sufficing) rather than optimal positions, where the standard of satisfactory is given by complex psychological and sociological considerations.

savings - Reductions in costs.

scalar - A quantity having magnitude but no direction as contrasted with a vector which has both. It is simply a constant or a number. An example would be body temperature.

scenario - A narrative description of the problem or operation under analysis including the sequence of events, environment, scope, purpose and timing of actions. For example, a scenario might be useful for describing the operations involved in operating a branch office to receive and process applications for food stamps. It may or may not include objectives, standards, and guidelines. It should be dated to insure that the need for updating will be recognized.

sensitivity analysis - A procedure employed as a result of uncertainty as to the actual value of a parameter or parameters included in an analysis. The procedure is to vary the value of the parameter or parameters in question and examine the extent to which these changes affect the results of the analysis. For example, if an analysis indicates that program A is preferable to program B, sensitivity analysis might be preformed by increasing a factor such as size of the group to which the programs are directed and then examining the results of the analysis under this change. See also: Contingency analysis.

shadow pricing - Imputing the prices of inputs, outputs, or benefits. Inventing prices for goods or services for which there is no established market. For example, the average hourly value to a person attending a proposed new outdoor recreation facility might be assumed to be more or less than what he now spends to participate in a similar activity.

simulation - An abstraction or simplification of a real world situation. In its broadest sense any model is a simulation, since it is designed to represent the most important features of some existential condition(s). Generally, however, the term simulation is used to refer to a model which is being used to determine results under each of many specific sets of circumstances rather than one which is being used to determine an optimal solution to a problem. Simulations may take the form of either deterministic models or probabilistic models. Man-machine simulation is simulation in which both computing machines and human decision-makers interact in simulating a process or system. Most of these simulations can be legitimately categorized under the heading of "gaming". Reference to those simulations that are carried out solely by machines is called pure-machine simulation. This is in contrast to man-machine or all-man simulation in which human decision-makers serve as part of the model.

spillover - An economy or diseconomy for which no compensation is given (by the beneficiary) or received (by the loser). Spillover is sometimes synonymous with externality and with external economy or external diseconomy.

standard deviation - A measure of dispersion (deviation of each observation from the mean) or degree of spread in a series of numbers. The square root of the average of the squared deviations of the individual values, Y, from their mean, Denoted algebraically:

$$\sigma = \sqrt{\sum_{I=1}^{n} \frac{(Y_I - \mu)^2}{N}}$$

For example, the two sets of values 3, 4, 5, 6, 7 and 1, 4, 3, 15, have the same mean, 5, but standard deviations of 1.4 and 5.1 respectively. This difference reflects the fact that the values in the second set are more widely dispersed around their mean than are the values in the first set.

statistic - A measure, quantity or value, such as an average or proportion, which is calculated from a sample to estimate the corresponding parameter of the population.

sunk costs - Costs which have already been incurred and will not be increased or decreased by any decision made either now or in the future. Therefore, such costs have no relevance to decisions regarding future action. For example, in making a decision as to whether a new plant should be constructed, the construction cost of the existing plant is a sunk cost.

supply - The schedule of quantities of goods and services that producers are willing and able to offer at given prices. Also the function, or process of requisitioning (or ordering), storing, and issuing the materials and supplies required for operations.

systems analysis - The process of investigating, in its broadest sense, the total context within which a problem exists or within which a decision must be made by examining the interacting pieces of a system and applying the methods of science to find out what makes it work. Develops information for the decision-maker that will help select the preferred way of achieving the objective. System analysis has been called the application of enlightened judgment aided by modern analytical methods for decisions concerning systems of broad scope.

technological life - Estimated number of years before the existing or proposed equipment or facilities become obsolete due to technological changes.

terminal value - Estimated value of the asset at the end of the project life.

technological spillover - A spillover which affects the relationship between physical outputs and physical inputs of some external entity which does not pay or receive payment for the spillover. For example, chemical fumes from an industrial plant which reduce (or increase) the yield of crop land.

time series - Observations on a variable at consecutive points in time or during consecutive intervals of time. For example, annual consumer expenditures for each year during the years 1960-90.

trend - The change in a series of data over a period of years, remaining after the data have been adjusted to remove seasonal and cyclical fluctuations. For example, the annual increase in output over a period of several years excluding fluctuations due to the business cycle.

uncertainty - State of knowledge about outcomes in a decision which is such that it is not possible to assign probabilities in advance. Ignorance about the order of things. Some techniques for coping with this problem are a fortiori analysis, contingency analysis and sensitivity analysis.

utility - The real or fancied ability of a good or service to satisfy a human want. Usually synonymous with satisfaction, pleasure. or benefit.

valuation - The process of reducing to a common base (dollars, for example) measurements that are made on different scales. It involves establishing trade-offs, or comparison weights, between multiple objectives. The weights represent policy decisions. The valuation of benefits is not to be confused with the quantitative estimates of benefits. For example, it is one thing to estimate the number of lives saved by a program, but it is another matter to place dollar value on lives saved.

value - The desirability, utility, or importance of a thing or an idea. Usually worth in money. Frequently represented by price. The value of a good or service is what a consumer is willing and able to give up to have it. To have value, a thing must be desired and some degree of scarcity involved. The value of wheat, for example, is expressed in dollars per bushel. Also, the quantity in terms of which a variable may be expressed. The variable x, for example, may represent bushels of wheat produced in the various States and these values may range from 3 million bushels, in one State, to 10 million in another.

variable - A characteristic having magnitudes expressible numerically which may vary from one case or observation to another. Since a variable can take on different values, it must be represented by a symbol instead of a specific number. For example. "x" may represent the height of humans; given a specific human, the variable x would take on a specific numeric value.

variable, dependent - A variable whose value is determined by other variables (or constants) in the structure of an equation or mathematical expression.

variable, predetermined - Variable determined before and independent of any decisions taken by the researcher.

variance - A measure of the dispersion of population elements about the mean of the population. It is calculated by:

$$\sigma^2 = \frac{(Y_i - \mu)^2}{N}$$

where N = size of population
μ = mean of population
i = ranges from 1 to N

vector - A quantity having magnitude and direction. It may be considered to be a matrix of either several columns and one row or several rows and one column. A vector may be contrasted with a scalar which has only magnitude and no direction. It is described by a set of numbers in much the same way as a point on a map is described by its coordinates.

welfare economics - The study of the economic well-being of all persons as consumers and as producers, and possible ways in which that well-being may be improved. It is also known as normative price theory.

zero base budget - A procedure for justifying a budget assuming the base to be zero. Requires a justification for the entire program each year, rather than the incremental amounts by which the budget request exceeds previous year.

zero-sum game - A game in which the sum of the gains (X wins two points) exactly equals the sum of the losses (Y loses two points).

BIBLIOGRAPHY

APPENDIX H

The following references may be useful to the reader looking for background information to expand his/her knowledge of cost/benefit analysis or for the performance of a particular analysis or review. (Nevertheless, where procedures described differ from Navy practice, the Navy analyst should take care to follow guidance listed in Appendix F.)

COST/BENEFIT ANALYSIS, ECONOMIC ANALYSIS, ENGINEERING ECONOMY, AND LIFE CYCLE COSTING:

Barish, Norman N.; and Kaplan, Seymour; *Economic Analysis: For Engineering and Managerial Decision Making,* McGraw-Hill Book Co.. New York. NY. 1978.

Economic Analysis, DLAM 7041.1, Defense Logistics Agency, Cameron Station, VA, March 1978.

Economic Analysis Handbook, 2nd edition, Defense Economic Analysis Council, January 1975.

Engineering Economist (Quarterly), American Institute of Industrial Engineers, Norcross, GA.

Grant, Eugene L.; Ireson, W. Grant; and Leavenworth, Richard S.; *Principles of Enqineering Economy,* John Wiley & Sons, New York NY.

Highway Engineering Economy: A Workbook, Federal Highway Administration, Department of Transportation, July 1976.

Layard, Richard, editor; *Cost-Benefit Analysis,* Penguin, Harmondsworth, England, U.K., 1972.

Life Cycle Cost Analysis: A Guide Architects, American Institute of Architects, 1977.

Life Cycle Costing Procedures (Volume IV of *Life Cycle Budgeting and Costing as an Aid in Decision Making*), Office of Facilities Engineering and Property Management, Dept. of Health, Education, and Welfare, June 1976.

Marks. K. E.; and Massey, H. G.; *Life Cycle Analysis Procedures and Techniques: An Appraisal and Suggestions for Future Research,* P-6031, Rand Corp., Santa Monica, CA, October 1977.

McConnaughey, John S.; *An Economic Analysis of Building Code Impacts: A Suggested Approach,* NBSIR 78-1528, Center for Building Technology, National Bureau of Standards, Washington, DC, October 1978.

Mishan, Edward J.; *Cost-Benefit Analysis,* Praeger Publishers, New York, NY, 1976.

Sassone, Peter G.; and Schaffer, William A.; *Cost-Benefit Analysis: A Handbook,* Academic Press, New York, NY, 1978.

Thaler, Richard; "Why Discounting is Always Right," *Defense Management Journal,* Vol. 15, No. 5, September-October 1979, pp. 2-5.

Thuesen, H. G.; Frabrycky, W. J.; and Thuesen, G. J.; *Engineering Economy,* Prentice-Hall, Inc., Englewood Cliffs, NJ, 1971.

ENERGY:

Peterson, Stephen R.; *Retrofitting Existing Housing for Energy Conservation: An Economic Analysis,* Center for Building Technology, National Bureau of Standards, Washington, DC. December 1974.

Petersen, Stephen R.; *The Role of Economic Analysis in the Development of Energy Standards for New Buildings,* NBSIR 78-1471, Center for Building Technology, National Bureau of Standards, Washington, DC, July 1978.

Ruegg, Rosalie T.; and McConnaughey, John S.; *Life-Cycle Costings Manual for the Federal Energy Management Program,* Center for Building Technology, National Bureau of Standards, Washington, DC, (Draft 1979, final expected 1980).

COSTS AND COST ESCALATION:

Balding, Joe M.; *A U.S. Air Force Cost Analysis Cost-Estimating Model Program for use with the "TI Programmable 59" Handheld Calculator,* P-6130, Rand Corp., Santa Monica, CA, May 1978.

Bibliography of Cost Indexes, American Appraisal Company, Milwaukee, WI, August 1976.

Building Construction Cost Data (Annual), Robert Snow Means Company, Inc., Duxbury, MA.

Construction Review (Monthly), Dept. of Commerce, U. S. Government Printing Office.

Cost and Planning Factors Manual, DCA Circular 600-60-1, Defense Communications Agency, Washington, DC.

CPI Detailed Report (Monthly), U. S. Government Printing Office.

Dodge Building Cost Calculator and Valuation Guide (Quarterly), McGraw-Hill Information Systems Company, New York, NY.

Dodge Construction Systems Costs (Annual), McGraw-Hill Information Systems Co., New York, NY.

Dodge Guide to Public Works and Heavy Construction Costs (Annual), McGraw-Hill Information Systems Co., New York, NY.

Dodge Manual for Building Construction Pricing and Scheduling (Annual), McGraw-Hill Information Systems Co., New York, NY.

Economic Indicators (Monthly), Council of Economic Advisors, U. S. Government Printing Office.

Engineering News-Record (Weekly), McGraw-Hill, Inc., New York, NY.

Halstead, D. Kent; *Higher Education Prices and Price Indexes,* (OE) 75-17005, Dept. of Education, 1975. GPO Stock No.
017-080-014181.

Historical Military Construction Cost Engineering Data, NAVFAC P-438.

National Construction Estimator (Annual), Craftsman Book Company, Solana Beach, CA.

Merrow, Edward W.; Chapel. Stephen W.; and Worthing, Christopher; *A Review of Cost Estimation in New Technologies: Implications for Energy Process Plants,* R-2481-DOE, Rand Corp., Santa Monica, CA, July 1979.

Producer Prices and Price Indexes (Monthly), U. S. Government Printing Office.

Putnam, Lawrence H.; and Fitzsimmons, Ann; "Estimating Software Costs," *Datamation,* September 1979, pp. 189-198, October 1979, pp. 171-178. November 1979, pp. 137-140.

PROBABILITY, STATISTICS, AND RISK ANALYSIS:

Boot, John C. G.; and Cox, Edwin B.; *Statistical Analysis for Managerial Decisions,* McGraw-Hill, New York, NY, 1974.

Chang, Davis L. S; and Liao, Shu S.; "Measuring and Disclosing Forecast Reliability," *The Journal of Accountancy,* May 1977, pp. 76-87.

Fallon, Richard; "Subjective Assessment of Uncertainty," P-5581, Rand Corporation, Santa Monica, CA, January 1976.

Freund, John E.; *Modern Elementary Statistics,* Prentice-Hall, Englewood Cliffs, NJ.

Hertz, David B.; "Risk Analysis in Capital Investment," *Harvard Business Review,* Vol. 57, No. 5, September-October 1979, pp. 169-181.

Mann, Greg A.; "VERT: A Risk Analysis Tool for Program Management," *Defense Management Journal,* Vol. 15, No. 3, May-June 1979, pp. 32-36.

Miller, Irwin; and Freund, John E.; *Probability and Statistics for Engineers,* Prentice-Hall, Englewood Cliffs, NJ, 1965.

Thomas, T. N.; *VERT- A Risk Analysis Technique for Program Managers,* PMC 77-1 Defense Systems Management College, Fort Belvoir, VA, May 1977 (Defense Logistic Studies Information Exchange LD 40483A).

Wilder, J. J.; "An Analytical Method for Cost Risk Analysis," paper presented at 41st Military Operations Research Society Working Session C-2, Fort McNair, Washington, DC, July 1978.

Yame, Taro; *Statistics, An Introduction Analysis,* Harper & Row, New York, NY, 1967.

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