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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 provide guidance for preparing economic analyses used to guide facilities investment decisions. It provides economic analysis policy and procedures to be used by Navy commands and field offices that prepare and review facility economic analyses. The handbook utilizes policy provided in Office of Management and Budget (OMB) Circular A-94 and Department of Defense Instructions.

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

- Graphics and Tables were updated to modern standards including include new CPI graphs and formulas for discount factors.
- A Non-Monetary Considerations (NMCs) chapter was developed and the Energy Appendix was streamlined by including effective references.
- A section Synopsis of Economic Factors Affecting Lease versus Buy Analysis was written as well as a section on Discount Rates for Facility and Energy Economic Analyses.
- An Economic Indicator Relationships chapter was developed to show the relationships between indicators and how they are calculated, the variables they are dependent on, and how they are used to compare alternatives.
- A DON Economic Analysis Guide chapter was written to explain how the guide may be used by completing the MS Word document DON EA Guide Benefit and Risk Analysis Non-Monetary Considerations.
- A Default Economic Life Guidelines section was written using the Useful Lives in the DOD Facility Pricing Guide.
- A Primer Appendix designed to provide highlights of the economic analysis principals and process.
- A Chapter about Business Case Analysis (BCA) as well as a BCA Statement of Work Appendix.
- An ECONPACK Chapter providing guidance on the economic analysis software.

Assistant Commander for Asset Management

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1. INTRODUCTION

Chapter one provides an overview of economic analysis concepts. The chapter includes the purpose of the handbook, the reason for economic analyses, guidance and legal authority for economic analyses upon which the handbook is based, and the content of the handbook. A few basic principles are touched upon like considering all reasonable alternatives from a life cycle cost perspective and that money has value over time. The NAVFAC Economic Analysis Handbook:

- Adheres to the directions of OMB Circular A-94, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs."
- Is consistent with DOD Instruction (DODI) 7041.3, "Economic Analysis for Decision Making," and the corresponding implementing DOD instruction, DODI 7000.14, "Department of Defense Financial Management Policy and Procedures."

Project Officers and Managers to meet the requirements and responsibilities for submission of economic analyses should be prepared to:

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

Guidance from "Higher Authorities": Appendix B lists the latest economic analysis policy, instructions, and guidance.

1.1 PURPOSE AND SCOPE

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 facility programs, projects and activities, and;

b. Program evaluations of ongoing facility activities and proposed plans.

It is important to point out 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, based on actual performance.

The NAVFAC Economic Analysis Handbook is designed for analysts, reviewers, decision-makers 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? Economic analysis preparation is often assigned as a "collateral" duty to individuals who have limited economic analysis (EA) training or experience. Even with training, economic analysis preparation might be done so

infrequently that it is difficult to retain the knowledge. This handbook provides basic tools and "number-crunching" techniques to prepare economic analyses.

b. Reviewer: 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. Decision-makers 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.

Inexperienced and Experienced Practitioners regardless of experience level, have different perspectives depending on their 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 References and Legal Requirements

Economic analyses are required to improve the economy and efficiency of the United States Government.

The foundation for DOD economic analyses is Office of Management and Budget Circular A-94, Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs. Circular A-94 is issued under the authority of 31 U.S.C. § Section 1111 as well as the Budget and Accounting Act of 1921, as amended. The focus of 31 U.S.C. § 1111 is to improve economy and efficiency in the United States Government while the Budget and Accounting Act of 1921, as codified in Title 31 of the United States Code, requires the President to submit a proposed budget to Congress for the federal government, establishes the Office of Management and Budget to assist the President, and establishes the General Accounting Office as the principal auditing agency of the federal government.

DOD Instruction 7041.3, Economic Analysis for Decision Making, implements policy, responsibilities, and procedures for conducting cost-effectiveness economic analysis for evaluating the costs and benefits of investment alternatives under the Office of Management and Budget Circular A-94, Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs.

1.3 General Policy

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, ensuring 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.

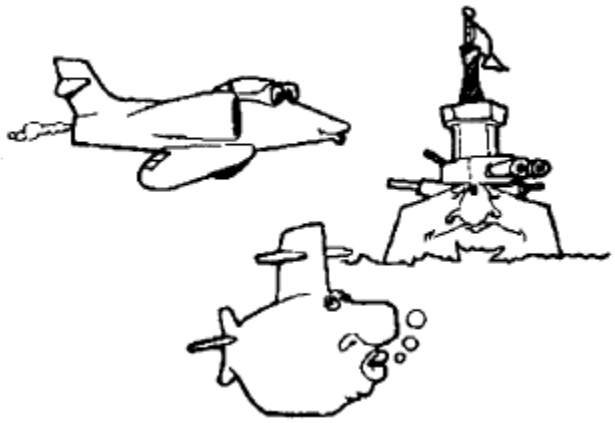
…In an effective and efficient manner

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.

1.4 Role of Naval Facilities Engineering Command (NAVFAC)

NAVFAC is the Shore Facilities Execution Agent for the U.S. Navy, providing Facility Management, Construction Management and Project Management for all real property. NAVFAC roles are discussed further in OPNAV Instruction 5450.348 Mission, Functions, and Tasks of Naval Facilities Engineering Command.

Although the methods of analysis are applicable to a wide variety of engineering and economic decisions, the primary focus of this handbook is on economic analyses of Navy facilities which support the fleet and Navy families worldwide.



This is a Practical Guide, not Theoretical:
This handbook provides guidance for NAVFAC 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, including plenty of examples, guidance on the use of ECONPACK, and recommendations on developing a business case analysis.

1.5 GENERAL AUTHORITY

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

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: An analysis of alternatives reveals 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 frame-work is defined that also ensures qualitative values are appropriately considered. The impacts of alternative actions can be clarified by:

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

1.6 GENERAL RESPONSIBILITIES

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:

- All reasonable alternative methods of satisfying a given program objective must be investigated.
- Each alternative must be considered in terms of its life cycle costs (funding implications) and benefits.
- Money has value over time as expressed by the price it commands (which is Interest. OMB uses the relatively safe US Treasury Interest Rates for Different Maturities.) 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 are intuitively acknowledged by our day to day decisions. Whether consciously or unconsciously, we consider the economic consequences 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 meaning and character of DOD economic analysis policy.

1.7 SUMMARY

Economic analysis is an important and effective tool in the decision-making process. It must be reasonable and defendable to the highest levels of the Navy. Economic analysis assists the analyst, reviewers, and decision-makers to:

- Focus on the alternatives (both formal and informal).
- Surface assumptions (both hidden and presumed), and classify their logical implications and sensitivities.
- Provide an effective communications vehicle for considerations in support of the investment decision.

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

- Understand economic realities that influence and restrict economic decisions.
- Understand how the economic analysis process and techniques are utilized in actual applications.
- Link computational methods and supporting economic principles to the assumptions upon which they are based.
- 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.

2. THE ECONOMIC ANALYSIS PROCESS

Economic Analysis fundamentals include the process, types, preparation and responsibilities. The NAVFAC Economic Analysis Process follows a seven step approach which is used to ensure all possible alternatives are considered. There are several types of economic analysis and this publication covers those used by the DON. Finally the responsibilities for preparation and review of economic analysis are also defined.

2.1. Economic Analysis Process.
The Economic Analysis process is an iterative procedure for evaluating and ranking alternatives that meet an objective. These steps are used to formulate the objective, develop alternatives, make assumptions, derive costs & benefits, conduct sensitivity analyses, and make recommendations. Figure 2A depicts these steps as a sequential process with feedback provided by the sensitivity analysis step to reiterate the process. Proper performance of this process requires each of the following seven key steps be done to completion:

- Define the Objective based on planning actions and project scope.
- Generate Alternatives.
- Formulate Assumptions.
- Determine Costs and Benefits.
- Compare Costs and Benefits and Rank Alternatives.
- Perform Sensitivity Analysis.
- Results and Recommendations

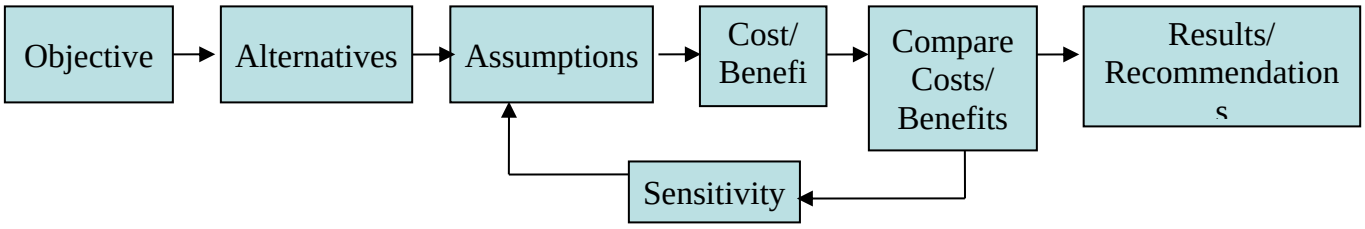


Figure 2A
Economic Analysis Process

The seven 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 concise statement of what is to be investigated, a meaningful analysis cannot be pursued. This step establishes the level of objectivity for the whole analysis.

For example, consider the process for recommending a major Military Construction (MILCON) project procurement. The objective begins with the analysis of the requirement. Refer to the Shore Facility Planning System Processes for defining requirements for a new facility. However, key questions for any project must be addressed to define the objective of a project. The following provides a few examples of key questions that should be answered prior to developing an objective:

- What are the purpose, mission, and function of the facility/system being considered?
- When and why is it needed?
- Is it a permanent or temporary requirement?
- Can the requirement be solved by non-facility solutions?
- Are there facilities elsewhere that should be considered?
- To what future growth/contingencies should it be capable of responding?

It should be clear that addressing the answers to the questions shown above along with any other pertinent questions is essential before proceeding with the economic analysis. If after all options are considered and a facility solution is the only viable alternative defining the objective is the first step in preparing the economic analysis. The Objective must define why the requirement is needed and what that requirement is based on. Typical facility objectives resemble the following:

- Provide 1,000 square meters of administrative space to satisfy the current deficit of x within region Y
- Meet Environmental Protection Agency (EPA) pollution abatement requirements at a naval activity, to ensure compliance with...
- Provide housing for unaccompanied visiting officers
- Consolidate a function into one place and eliminate excess infrastructure
- Reconfigure the building to accommodate a new function, eliminating a need for a new facility
- Restore existing building, extending the functional life and eliminating need for new facility
- Renovate historic facility to consolidate ship depot maintenance space near the waterfront in support of X

A well-defined objective statement should incorporate, either explicitly or implicitly, an easily measurable standard of accomplishment. Note that the first example objective above explicitly states a measurable standard (1,000 square meters) while the other objectives 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. The objective should allow for many alternatives to be considered. It may be helpful to review the original planning action that initiated the project or the planning actions for an installation or region. Do not use: "Recommend preferred option," as an objective statement. That does not provide any information as to why the project is being considered. 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

Economic Analysis. If so, an understanding and recognition of the significance of this step is still required in the economic analysis process. Unbiased statements of objective should always be used. This is a key point to remember throughout the analysis.

2.1.2 GENERATE ALTERNATIVES - STEP 2

After formulating an unbiased statement of objective, the next step is to determine all viable 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 be 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 a thorough analysis. 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 generating alternatives for consideration, economic analysis becomes more of an art form than a science. Challenge current paradigms. Don't assume old benchmarks fit the proposed scenario. Consider other Department of Defense (DOD) services beyond those of the Navy in meeting the objective? Department of Defense (DOD) constrained funding requires new ways of looking at old problems. Furthermore, the consideration of all viable alternatives may provide useful information about "impossible" alternatives. Sometimes, the obvious choice is not so obvious once all the alternatives have been looked at more closely. For example, consider the case where only the first two of the three viable alternatives were evaluated.

Alt (A) Renovate Facility
Alt (B) Private Lease
Alt (C) Construct New Facility

Alternative (A) Renovate Facility was recommended as the lowest net present value cost alternative. However, Alternative (C) Construct New Facility 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 so small 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 viable alternatives should be considered. The role of the EA is to develop the facts relating to every viable alternative. Leadership must be provided all options and the best economical decision should be recommended. Alternative (A) may still be selected but this would be done with the knowledge that it is not the most cost effective solution, but the best solution at the present time. The final decision maker should know and be willing to pay a life cycle cost premium to choose an alternative that requires a smaller funding appropriation but higher life cycle costs.

Alternatives which at first appear to be nonviable may, in fact, be viable. 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 viable 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, Economic Analysis 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:

- 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.
- Be certain the assumptions are realistic.
- State the information source from which assumptions are based.
- Include calculations and other information pertinent to the assumptions as attachments to the final package and follow existing process to maintain documents.
- Be certain the assumptions are realistic.
- 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 XX."
- If the ranking of the alternatives is not significantly affected by an assumption, then the assumption can be down played, explained away, or removed from the analysis because it is not a requirement that must be met.

Examples of assumptions include:

- The discount rate.
- Base year projected for project funding.
- Construction duration.
- The functional life of an asset.
- The level or extent of future requirements for a particular function, include timelines.
- The usefulness of a facility after the present need is fulfilled.
- Workload – Base assumptions on a credible source such as the WARR report.
- Execution/Performance - Base upon relevant and credible documentation.

- Facilities Deficiencies/Backlog - Have realistic plans for correction of maintenance deficiencies/backlog.
- Utilities and Service Contract Costs - Ensure that current and future utility costs are based upon realistic and credible documentation. Where utilities and service contracts are consolidated for base operations, use a pro-rata share of costs.
- Frequency of Process Delays - Sometimes delays impact work performance. Include these in the EA if significant and base calculations upon relevant and credible documentation such as previously recorded delay events.
- Process Improvements - Explain assumptions on functional changes to operations (i.e., process labor, work site travel, material movements, overtime, etc.).
- Wash Costs - A cost that is identical in all alternatives and would increase the net present value of all alternatives by the same amount during the same period. Wash Costs are also referred to as Common Costs.
- 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 the validity of this information should be included.

Frequently, assumptions need to be formulated before reasonable alternatives can be generated. This may be a reiterative process while preparing the analysis. The sensitivity of the assumptions can be tested during the sensitivity analysis (step 6). Besides assumptions, another key factor is constraints. 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 not controllable and *provide boundary limitations for alternative solutions to a particular problem.*

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

2.1.4 DETERMINE COSTS AND BENEFITS - STEP 4

This step requires the collection of information needed, determining how relevant the data is and if the in-hand data is sufficiently reliable to be used in the economic analysis. The DOD usually conducts cost effectiveness economic analyses where each alternative is designed to be as equivalent as possible. Consequently, quantification of benefits need only be where the alternatives differ, rather than the total benefit provided by each alternative. Likewise, it is only the differences in costs between alternatives that are important to making sound economic based

decisions. Costs which are equivalent and would not be affected under any of the alternatives may be omitted from the analysis. Exclusions should be noted under the list of assumptions.

Each alternative should be investigated to find all the costs and benefit that are projected to occur 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 measured in terms of dollars spent. Chapter 4 includes a detailed discussion of relevant costs and estimating methods.

Benefits are often difficult to measure. Despite this inherent difficulty, it is important to assess quantitatively the benefits associated with each alternative under consideration to the maximum extent possible. The dollar quantifiable benefits (other than meeting the stated objective) of each alternative should be treated as "cost offsets" for that alternative.

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

It is important to obtain 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 valuable time and effort when the project is 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 comparing and ranking alternatives, there are normally three criteria to distinguish between alternatives and four possible configurations into which alternatives fall. The following provides the three criteria and four configurations:

Three criteria:

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

Four possible configurations:

1. Equal Costs/Equal Benefits: This is the least likely to happen. In this case, cost and benefits cancel each other out. The recommendation would be determined by non-economic 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, because benefits are not always exactly equal. However, this configuration is frequently acceptable when the benefit of one facility over another is marginal. When you make the assumption benefits are equal (or nearly equal), employ the techniques developed in Chapter 5. The recommendation for this configuration would be the least cost alternative.

4. Unequal Costs/Unequal Benefits: Frequently, 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 6. 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 the effects and influences of assumptions made for the alternatives considered. Sensitivity analysis is very useful when attempting to determine the impact the actual outcome of a particular assumption or alternative will have if it differs from what was previously assumed. By creating a given set of scenarios, the analyst can determine how changes in one or more assumptions/ alternatives can impact the final decision. Chapter 8 is dedicated to explaining the sensitivity analysis process.

If a change in an assumption results in a significant change in the results, then the results are sensitive to that assumption. Include the results of the sensitivity analysis in the final economic analysis report. This shows the reviewers that uncertainties associated with assumptions have been tested and considered prior to recommending a final solution.

The sensitivity analysis may lead to changing assumptions and choosing different final alternatives, as this is an iterative process. Figure 2A illustrates the entire seven step process. Ensure each step in the process is addressed before submission of an economic analysis.

2.1.7 RESULTS AND RECOMMENDATIONS - STEP 7

The results and recommendations is an important part of the economic analysis. A well reasoned conclusion provides the rationale for the final results or recommendation. It must be logical and defendable to the highest levels of the Navy. It should state both facility and mission costs, and savings. An example would state the project results in NPV facility savings of $8M and depot maintenance savings of $99M.

2.2 NAVY ECONOMIC ANALYSES TYPES

Within the realm of the Naval Facilities Engineering Command (NAVFAC) facilities acquisition process, there are two distinct classes to which the process of economic analysis may be applied. The two classes are Fundamental Planning Analysis prepared for proposed projects and Value Engineering used to evaluate design alternatives for an active MCON.

2.2.1 FUNDAMENTAL PLANNING ANALYSIS

The Fundamental Planning Analysis (FPA), process starts with the broadest possible objective for the situation. An unbiased definition of the planning objective with viable methods to accomplish the objective must then be developed. Figure 2.1 depicts a high level view of the process.

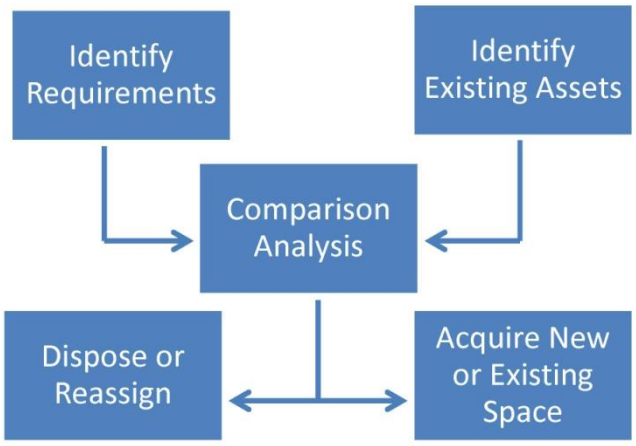


Figure 2.1

There are several types of FPA's used by NAVFAC and Commander Navy Installations Command (CNIC). Two include Return on Investment (ROI) and Mission Requirement (MR) economic analyses. There is also the energy decision model, electronic Return on Investment (eROI) that includes an economic analysis spreadsheet and complements the Energy Life Cycle Cost Analysis (LCCA) workbook that is used to initially screen projects. Another FPA being considered is the consolidation Return on Investment (cROI) model.

In general, these alternative methods may include MILCON and non-MILCON funding options. The FPA is the appropriate forum for the evaluation of alternatives to solve the overall objective.

MILCON projects are not the cure to all facility problems. It is important that all possibilities be exhausted before recommending a MILCON. If the MILCON alternative is the most cost effective option available to the Navy, formal economic justification and substantiation for the Navy request to Congress must be provided before the MILCON is programmed.

Sometimes only "one" Alternative to the Status Quo is considered. If this is the case, ensure there is a discussion about why other alternatives are not possible and consider the status quo as the second alternative. The recommended alternative should still be supported by an economic analysis, and the results of this analysis included in the project documentation, a DD 1391 for most facility projects. Exceptions may occur for some life, safety, health, pollution and security, projects in which the status quo is unacceptable.

If the analysis suggests that only one alternative is viable, the documentation must provide all alternatives considered and proof that they are nonviable. This should be rare as most projects should have more than one alternative available for consideration.

The main types of FPA are generalized below. Specifics can be found later in this document:

a. Return on Investment (ROI) economic analysis helps to decide whether an existing situation (i.e. status quo) should be changed to take advantage of dollar savings available through other alternatives. This type of analysis addresses the basic need and economic justification for a change to present conditions. A ROI economic analysis is an evaluation of alternatives, including the status quo, to determine which option is the most economical over the established life cycle. A classic ROI economic analysis reviews potential investments that will reduce annual recurring cost(s) against current operational costs. Investments supported by ROI economic analyses must promise absolute cost savings over the present method of meeting a requirement. Some examples of ROI 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 aircraft overhaul facilities to speed overhaul work by decreasing the aircraft "pipeline" inventory requirements.
- Replacement of existing high maintenance cost facilities or equipment with new facilities that have lower maintenance costs.

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

- Acquisition of land (over $750K) to create a buffer for aircraft operations for safety.
- Construction of a Naval Operations Support Center (NOSC) to support reserve operations where none exists.
- Providing housing for unaccompanied personnel in remote areas such as San Clemente Island off the coast of Los Angeles, where no other options are available.

Consider the differences between ROI and MR economic analyses. Many projects deal with a situation of preventing a total facility failure (i.e., a pier is deteriorating and will eventually collapse). The project should be developed with engineering data stating the estimated remaining life until failure. Activities should not attempt to raise the priority of the project by making it sound like an emergency and utilizing the MR economic analysis method stating there is no current option, when the function is currently being done. If the Status Quo meets the requirement and will not result in an unsafe environment over the period of analysis, then it should be included in the economic analysis. As a side note a ROI economic analysis has more economic indicators than a Mission Requirement economic analysis and thereby provides more information to compare alternatives. One way that more economic indicators could be generated in a MR economic analysis is to do the analysis as a ROI economic analysis and make one of the alternatives the Status Quo alternative. This provides a more thorough review of the alternatives.

2.2.2 VALUE ENGINEERING

The second class of economic analysis is used once a decision has been made to procure a given facility via the MILCON funding route (usually determined by the results of a Fundamental

Planning Analysis). This type of analysis is used during the design phase of the project to analyze design alternatives. The design alternatives to be analyzed vary, and are project specific.

- One-level versus multi-level construction,
- Wood siding versus concrete masonry exterior,
- Steel versus concrete frame,
- 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 process for the developing a Value Engineering (VE) economic analysis is very similar to those of the Fundamental Planning Analysis (FPA). The main differences between the VE and FPA are the nature of the alternatives considered (Design vs. Planning) and the length of the period of analysis due to relatively recent federal energy management law.

Value Engineering is a user advocate process with the goal to meet the users functional requirements at the lowest life cycle cost; assure design is within scope and budget; expose project issues at the RFP stage; assure the use of sustainable design solutions; with buy-in by all project stakeholders. Benefits include improved project performance, reduced cost, improved confidence in project success, improved public relations, and better design performance. Synonymous with Design Analysis or Value Analysis, it is the systematic application of recognized techniques by a multi-disciplined team which identifies the functions of a product or project, establishes a worth for those functions, generates alternatives through the use of creative thinking, and provides the needed project functions at the lowest overall cost.

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 VE as well.

2.3 Special Cases

Certain military construction projects can qualify for Unspecified Minor Construction (UMC) funding if the project investment cost will be amortized by savings within a three year period. These projects must be supported by Return on Investment economic analyses. Due to the special nature of UMC project documentation requirements these analyses must follow special guidelines. A discussion of economic analyses and caveats supporting UMC projects appear in Appendix D.

2.4 Preparation and Review Responsibilities

2.4.1 Players, Submittals, and Directives

Specific economic analysis (EA) preparation requirements 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.

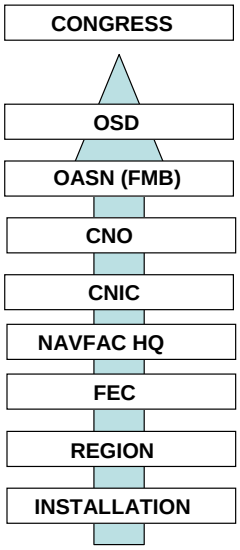


Figure 2.2 Project Review and Approval Process

a. Fundamental Planning Analysis (FPA). Figure 2.2 depicts the project review and approval process for project documentation. The Installation requesting funds for the project prepares the project for the Project Review and Approval Process. Project Reviewers Include:

- Installation supported by Cognizant Facility Engineering Command
- Navy Region
- Commander, Navy Installations Command (CNIC).
- NAVFAC
- Office of the Assistant Secretary of the Navy, Financial Management and Budget OASN (FMB)
- Office of the Secretary of Defense (OSD),
- Congressional Armed Services, and Appropriations Committees

b. Value Engineering (VE) Either the Cognizant NAVFAC Facility Engineering Command (FEC) or a private architect/engineer (A&E) firm for a given project may be assigned to conduct a Value Engineering Economic Analysis that is submitted as part of the project design documentation. The VE Analysis is reviewed with the project design, and suitable alternatives are selected for incorporation into the project by the appropriate project reviewing authority.

2.4.2 "LESSONS LEARNED"

Some Navy projects have not received funding because economic analyses were not submitted or were incomplete. No matter what stage a project is in, consider the following "lessons learned":

a. An economic analysis is needed for the majority of projects. Misconceptions have resulted

in rejected projects because there was a belief that an operational requirement justified the project. This "bad assumption" is not true. Economic justification is required for all MILCON projects, regardless of project cost or mission. All MILCON projects that are not satisfying an unmet need must have a minimum of two viable alternatives - the way mission requirements are currently being met ("status quo" alternative) and the proposed alternative. For a new mission requirement, all viable alternatives need to be considered. Alternatives may not be deemed nonviable because they are expected to be expensive. If there is only one viable alternative then a Partial Mission Requirement EA may be conducted. For the special case that a Public Law has mandated the project and there is only one solution to the problem then a Nominal Mission Requirement EA may be conducted. The Status Quo alternative may be unacceptable and eliminated as a viable alternative in projects which correct 1)Documented fire, safety, or health deficiencies, 2)Documented pollution or environmental compliance problems, 3)Documented security problems, and 4)New mission or equipment platform requirements, not replacements.

b. Prepare the EA as early as possible: A preliminary EA is recommended at the initial stage of project development and should be included with the Project Data Sheet submission. Prepare a more detailed EA as part of the FEC Team 1391 submission.

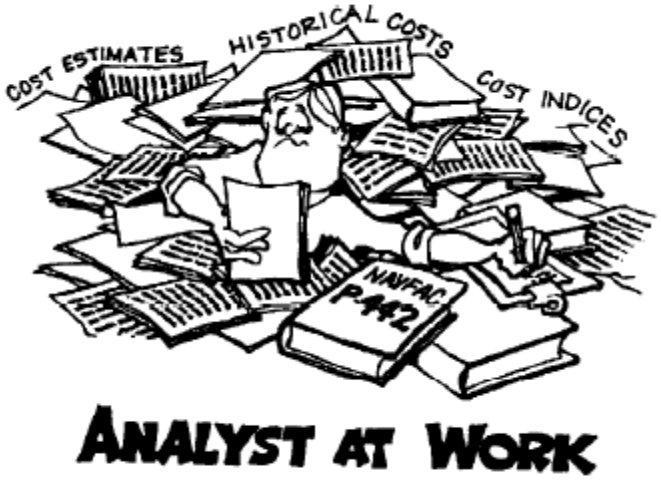
c. Consider viable alternatives: Each EA should document viable alternatives, if applicable, from the following categories:

- Status Quo
- Modification of Existing Assets: Renovation, Conversion, Upgrade, Expansion, or other forms of improvement. Consider facilities at other DOD bases nearby, as well as on base. Go beyond the activity and installation, considering what exists within the region or other regions and taking into the account the enterprise and warfare provider objectives as presented in the latest Global Shore Infrastructure Plans (GSIPs), Strategic Lay Down efforts or force structure changes.
- Leasing
- New Acquisition

d. Update the EA: The economic analysis must be reviewed, re-evaluated, and updated each time the project cost is revised to ensure the alternative selected is still the preferred alternative. This is especially true for an EA that was part of a FEC Team 1391 submittal for a project in a previous year's program.

3. ECONOMIC ANALYSIS TECHNIQUES

Chapter 2 discussed the seven step economic analysis process. Chapter 3 covers Step 4 "Determine Costs and Benefits" and Step 5 "Compare Costs and Benefits and Rank Alternatives."
The essential concepts of determining the period of analysis, understanding compound interest, discounting, equivalence, types of economic analysis, and slippage are discussed. The important economic indicators of savings to investment ratio, discounted payback period, net present value, uniform annual cost, and efficiency/productivity to investment ratio are also covered.



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 3.1 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 an end of the year cash flow (not necessarily when the cost occurs). No matter when a cost or benefit occurs during the year, it is shown as one cash flow in the beginning, middle, or end of the year. For simplicity, all cash flows are shown at the end of the year in this handbook.

In Figure 3-1, the long arrow on the left (Time Zero) represents the acquisition or start-up cost; the shorter downward arrows (Years 1-9) 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 9) 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.

Cash Flow Diagram

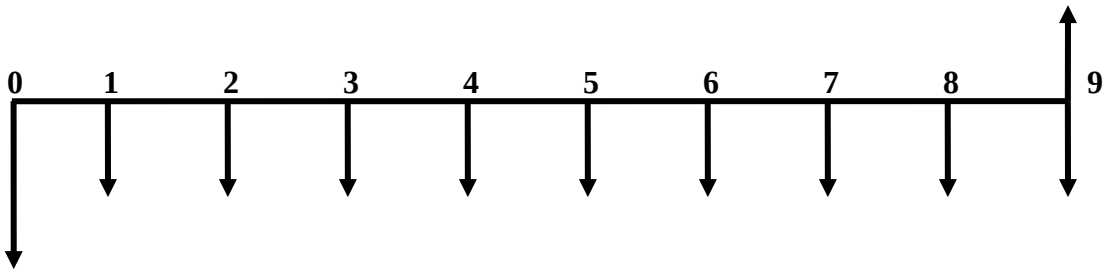


Figure 3.1

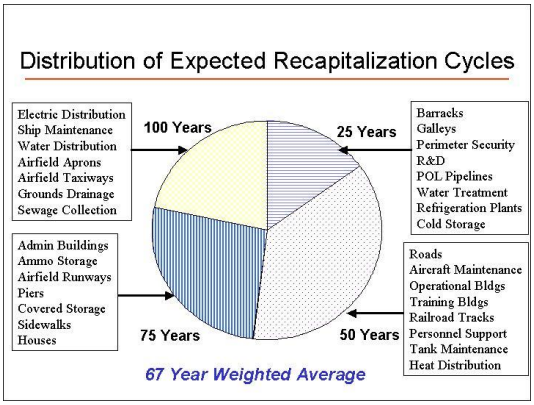
3.2 DETERMINING THE ECONOMIC LIFE

The nine year time frame in figure 3-1 is referred to as the economic life of the alternative. In general, the economic life of an alternative is the period of time during which it provides a positive benefit. The specific factors limiting the duration of economic life are:

For energy projects and the design of new buildings, the United States Code (Fully Amended) Title 42 - The Public Health and Welfare, Chapter 91 - National Energy Conservation Policy, Subchapter III - Federal Energy Initiative, Part B - Federal Energy Management, Section 8254 - Establishment and use of life cycle cost methods and procedures established an increase in the Period Of Analysis (POA) for energy projects and the design of new federal buildings from 25 to 40 years unless the expected life of the energy system is less than 40 years where the POA would then equal the life of the energy system.

For special projects economic analyses that have an alternative with significant improvements in energy efficiency, it is important to do a sensitivity analysis on the POA and if the results are sensitive, highlight this finding in the Executive Summary. Furthermore, if increasing the POA to 40 years changes the least cost alternative to the one that has the most energy efficiency, then emphasize this feature of the economic analysis and consider increasing the POA to 40 years. CNIC in the eROI scoring model for energy projects allows economic lives up to 40 years or the life of the system whichever is shorter.

There are three specific lives for buildings, physical life, technical life and mission life. The following provides the definition for each type of life:



- The physical life is the period of time the asset(s) is expected to last. The average physical life estimate for new facility construction is 67 years. 67 years is the PRV weighted average estimate. For greater accuracy the age categories on the Distribution of Expected Recapialization Cycles chart may be used for Special Projects. MILCON policy uses 67 years for all facilities. Note that Recapitalization Cycles are the amount of time before the facility or structure is demolished and then replaced. Longer Recapitalization Cycles indicate either the facility has low maintenance requirements or has maintenance requirements that allow the facility to avoid demolition and subsequent replacement.

- <u>MILCON EA Example</u>
  At the end of the 67 years salvage value is considered. For Existing Facilities reduce the 67 year physical life by the age of the facility. For Renovated Facilities prorate the 67 years by the age of the facility and the renovation cost using PRV. For example for a 30 year economic life, if the renovation cost is 25% of PRV, the physical life of the renovation alternative is 20 years, and the age of the facility is 25 years then the Physical Life estimate would be 25% x (30-20) years + 75% x (67 years – 25 years) = 2.5 years + 31.5 years = 34 years.
- The technological life is the period of time before obsolescence would dictate replacement of the existing (or prospective) asset(s).
- The mission life is the period of time in which a need for the asset(s) is anticipated.

Generally, the economic life of an alternative should be taken as the least of the above three time parameters. The mission life might be 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 aka the beneficial occupancy date (BOD). Figure 3.2 demonstrates a cash flow diagram for a project with a 2 year lead time and a 30 year economic life. Notice that the project life is a total of 32 years and that the economic life does not begin until year 2. These important considerations will be explained in this and other chapters.

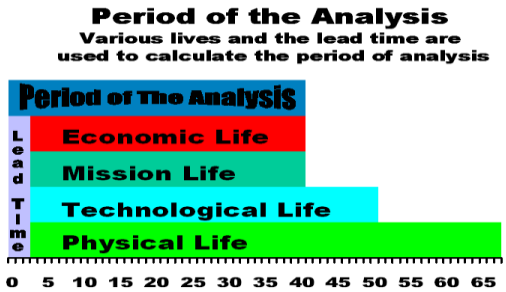
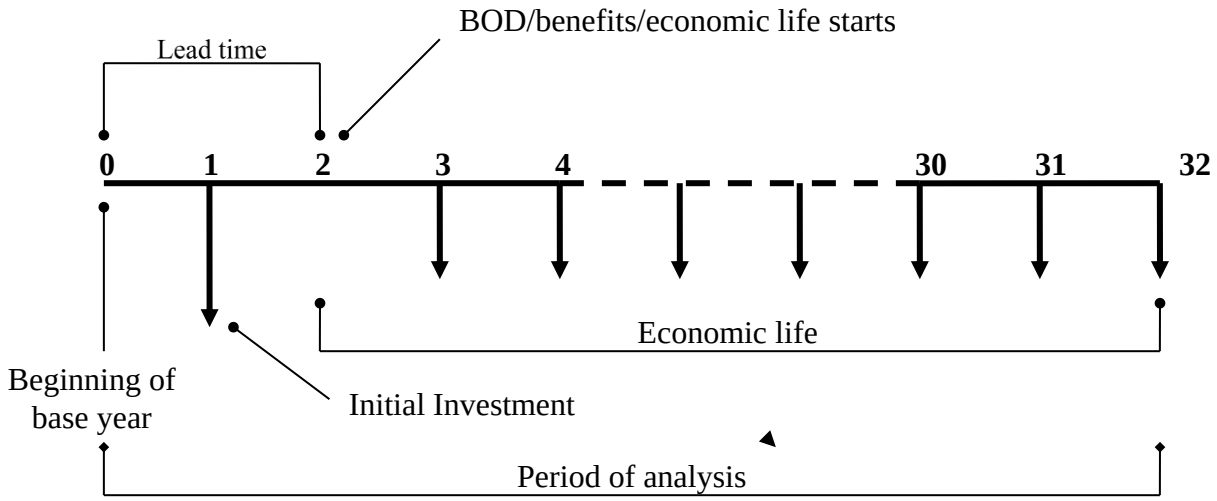


Figure 3.2
Cash Flow Diagram with Lead Time



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 3.7.

3.3 Period of Analysis 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.

Period of Analysis Caveats to Consider

- Default Period of Analysis (POAs) established here are to be used for special project economic analyses when better information is not available. MILCON guidance is 32 years except for "pure" energy projects where the POA is 42 years. Shown as the ECONPACK POAs in the upcoming table, there default POAs are derived from the DOD Facility Pricing Guide Useful Service Lives (USL). The USL estimate is derived in essence from the physical and technological live of the facility type. However, USL does not include mission life. If the mission life is shorter than the USL then the mission life becomes the economic life of the asset. For example, the USL for a Recreation Center is 50 years. Suppose however the mission for that area is only expected to be 15 years. In that case the economic life is the mission life is 15 years. If the lead time needed to build the building is the standard lead time for MILCON projects of 2 years then the Period of Analysis (POA) = Economic Life + Lead Time = 15 years + 2 years = 17 years.

- The FPG useful life is considered to include the technological life as well as the physical life.

- This data evaluates the period of analysis (POA) for Facility Types considered in the Facility Unit Costs for Military Construction AKA Table 2 of the DOD FPG.

- ECONPACK period of analysis (POA) maximum is 60 years.

How to Use Table

- For example for an Aircraft Machine Shop the default POA is the ECONPACK POA equal to 42 years.

- Likewise, the default POA for an Indoor Firing Range is 47 years.

Table 3.1
Default Period of Analysis (POA) Recommendations by Facility Type
For Mission Stable Locations

Acronyms: FAC – Facility Analysis Category, ESL – Expected Service Life, ECONPACK MAX – Maximum POA allowed by ECONPACK equal to 60 years, ESL POA – ESL plus 2 years of lead time, ECONPACK POA – ESL POA with cap at 60 years, MILCON POA is an economic life of 30 years plus a lead time of 2 years equal to 32 years.

Facility Type Name	FAC	ESL	ECONPACK MAX	ESL POA	ECONPACK POA	MILCON POA
COMMUNICATIONS FACILITY	1311	50	60	52	52	32
SATELLITE COMMUNICATIONS CENTER	1312	50	60	52	52	32
(CENTRAL FIRE ALARM SYSTEM NOT INCLUDED)	1411	45	60	47	47	32
AIRCRAFT OPS FACILITY WITHOUT TOWER	1412	50	60	52	52	32
AIR CONTROL TOWER (STAND-ALONE)	1413	35	60	37	37	32
KENNEL - MILITARY WORKING DOG	1445	40	60	42	42	32
GENERAL INSTRUCTION (LECTURE CLASSROOM)	1711	50	60	52	52	32
APPLIED INSTRUCTIONS (HANDS ON TRAINING)	1712	50	60	52	52	32
ARMED FORCES RESERVE CENTER	1714	55	60	57	57	32

INDOOR FIRING RANGE	1718	45	60	47	47	32
HIGH BAY W/ SIMULATION TRAINING	1721/1724	50	60	52	52	32
GENERAL PURPOSE, LOW-MID BAY, UPTO 40 FT HIGH	2111	40	60	42	42	32
AIRCRAFT AVIONICS	2112	40	60	42	42	32
AIRCRAFT CORROSION CONTROL MAINTENANCE	2113	40	60	42	42	32
HIGH BAY MAINTENANCE, OVER 40 FT HIGH	2115	40	60	42	42	32
AIRCRAFT MACHINE SHOP	2116	40	60	42	42	32
MILITARY VEHICLE MAINTENANCE, LARGE (>21,000 SF)	2141	50	60	52	52	32
MILITARY VEHICLE MAINTENANCE, SMALL (<21,000 SF)	2141	50	60	52	52	32

Facility Type Name	**FAC**	**ESL**	**ECONPACK MAX**	**ESL POA**	**ECONPACK POA**	**MILCON POA**
ELECTRONICS SHOP, DEPOT LEVEL	2172	50	60	52	52	32
INSTALLATION MAINTENANCE, GENERAL PURPOSE	2182	50	60	52	52	32
PARACHUTE AND DINGHY MAINTENANCE	2184	50	60	52	52	32
ARMORY/ WEAPONS STORAGE FACILITY	4211	55	60	57	57	32
GENERAL PURPOSE MAGAZINE W/O CRANE	4221	55	60	57	57	32
HIGH EXPLOSIVE MAGAZINE	4221	55	60	57	57	32
HAZARDOUS/ FLAMMABLE STORAGE, > 1,000 SF	4413	45	60	47	47	32
HAZARDOUS/ FLAMMABLE STORAGE, < 1,000 SF	4423	45	60	47	47	32
INPATIENT HOSPITAL / MED CENTER	5100	30	60	32	32	32
DENTAL CLINIC	5400	30	60	32	32	32
MED CLINIC (SMALL, FREE STANDING<60,000 SF)	5500	30	60	32	32	32
MENTAL/BEHAVIORAL HEALTH CLINIC	5500	30	60	32	32	32
MED CLINIC (attached to HOSPITAL / MED CENTER)	5501	30	60	32	32	32
MED CLINIC (LARGE, FREE STANDING, >60,000 SF)	5501	30	60	32	32	32

SQUADRON/ BATTALION HQS (MID LEVEL)	6100	55	60	57	57	32
MULTI-PURPOSE ADMINISTRATION	6100	55	60	57	57	32
COMPANY LEVEL (LOWEST LEVEL)	6101	55	60	57	57	32
COMMAND HEADQUARTERS BUILDING	6101/6102	55	60	57	57	32
BRIGADE/DIVISION WING HQS (UPPER LEVEL)	6102	55	60	57	57	32
DATA PROCESSING AREA FACILITY (includes admin and storage)	6104	45	60	47	47	32
ENLISTED FAMILY HOUSING - CONUS	7110	60	60	62	60	32
OFFICERS FAMILY HOUSING - CONUS	7110	60	60	62	60	32
ENLISTED FAMILY HOUSING - OCONUS	7110	60	60	62	60	32
BARRACKS / DORMITORY (does not include kitchenette equipment)	7210	55	60	57	57	32
BARRACKS - STUDENT DORMS, ADVANCE TRAINING	7213	55	60	57	57	32
BARRACKS - OPEN BAY, TRAINING	7214	41	60	43	43	32
ENLISTED DINING, <15,000 SF	7220	40	60	42	42	32
ENLISTED DINING, 15,000 to 39,999 SF	7220	40	60	42	42	32
ENLISTED DINING, >40,000 SF	7220	40	60	42	42	32
OFFICERS QUARTERS (does not include kitchenette equipment)	7240	55	60	57	57	32
FIRE STATION, COMMUNITY	7311	45	60	47	47	32
CONFINEMENT FACILITY	7312	45	60	47	47	32
MAIN EXCHANGE (w/ mall service shops)	7331/7345/7346/7387/7388	45	60	47	47	32
EDUCATION CENTER	7351	50	60	52	52	32
ELEMENTARY SCHOOL - CONUS	7352	45	60	47	47	32
CHAPEL CENTER	7361	50	60	52	52	32

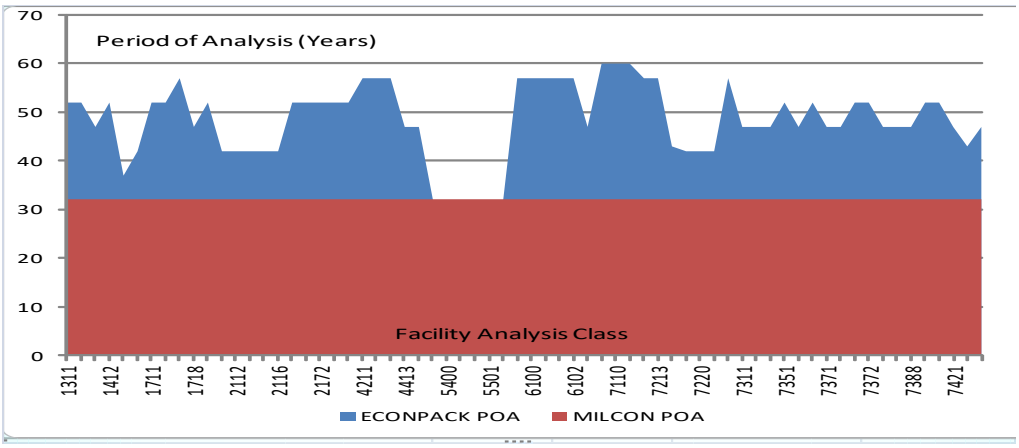
CHILD DEVELOPMENT CTR (under 6 years old)	7371	45	60	47	47	32
CHILD DEVELOPMENT CTR (school age)	7371	45	60	47	47	32
FAMILY SERVICE CENTER, <10,000 SF	7372	50	60	52	52	32
FAMILY SERVICE CENTER, > 10,000 SF	7372	50	60	52	52	32
GENERAL PURPOSE - SMALL (<15,000 SF), LOW BAY (STACK HEIGHT <16 FT)	7388	45	60	47	47	32
GENERAL PURPOSE - LARGE (>15,000 SF), LOW BAY (STACK HEIGHT <16 FT)	7388	45	60	47	47	32
GENERAL PURPOSE - LARGE (>15,000 SF), HIGH BAY (STACK HEIGHT >16 FT)	7388	45	60	47	47	32
YOUTH CENTER	7417	50	60	52	52	32
RECREATION CENTER	7417	50	60	52	52	32

Facility Type Name	**FAC**	**ESL**	**ECONPACK MAX**	**ESL POA**	**ECONPACK POA**	**MILCON POA**
PHYSICAL FITNESS TRAINING CENTER	7421	45	60	47	47	32
TRANSIENT LODGING FACILITY	7441	41	60	43	43	32
PARKING GARAGE / BUILDING (450 SF/vehicle includes turning space and ramps)	8531	45	60	47	47	32

Special Project ECONPACK POA versus MILCON POA

- The plot of the Special Project ECONPACK POA with the MILCON POA shows the very significant difference in the two approaches. For example the difference varies from zero for medical type facilities to almost double for family housing facilities.

Figure 3.3
Comparison of Special Project ECONPACK POA with MILCON POA



3.4 Understanding Compound Interest, Future Values, and Discounting

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 decisions and uses a 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 within the President's annual 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. The discount rate is available to NAVFAC by clicking on the Discount Rate (%) link on the Alternatives Tab in ECONPACK. This link takes you OMB Circular A-94 Appendix C web page that is updated annually with new discount rates around the beginning of every year. Use the 30-year Real Discount Rate.

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). Suppose that the loan is subject to 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 or Future Value (FV) returned to the lender is thus:

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

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 (l + i), as we have just seen. This becomes the principal during the second year, and thereby the interest is compounded during the second year. (Throughout the remainder of this discussion, it is assumed that interest is compounded every year). The amount repaid, or FV at the end of Year 2 is:

$$FV = (P (1 + i)) (1 + i) = P (1 + i)^2 \quad (3.2)$$

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

********** EXAMPLE 3A Compound Interest BEGIN**********
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 FV_2 = the total future amount paid to Mr. Bernie White. So, by equation (3.2) we have:

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

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:

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

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 valued as being 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 (MOY) convention) can easily be derived from the formula for the future value calculation (equation 3.3 above).

Since, Future Value, $FV_n = PV\ (1 + i)^{n-1}$ (3.3 shown above adjusted to MOY)

It follows that …

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

The interest rate (i) in this formula is also known as the "Discount Rate." The ratio $(1/1+i)^{n-1}$ 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) using EOY discounting is the following:

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

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

********** EXAMPLE 3B: Compound Interest, "N" Years BEGIN**********

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: $\$11{,}000 = P(1.06)^3 = P(1.191)$

$$\text{Yields: } P = \frac{\$11{,}000}{1.191} = \$9{,}235.94$$

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:

a) Time Value of money. Because of its productivity including its capacity to earn interest, 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.

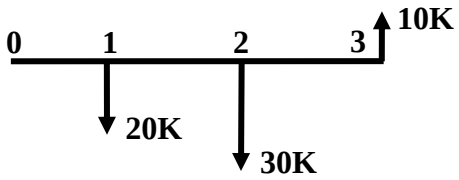
b) Rate of return for each alternative considered. Equations (3.3) and (3.4) apply in a much broader context than a simple monetary transaction between borrower and lender. The most general interpretation of (i) is that of a rate of return confronting the investor (or borrower, as the case may be), whether 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. NAVFAC endorses and recommends the middle-of-year convention except for terminal values that occur at the end of the period of analysis and for some formulas that are simplified by using EOY discounting. It should be noted that the Army Corps of Engineers uses middle-of-year factors.

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

********** EXAMPLE 3C: PRESENT VALUE OF A SINGLE AMOUNT BEGIN********

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) - $l0K (.864)
= $19.04K + $27.21 K - $8.63K
= $37.62K

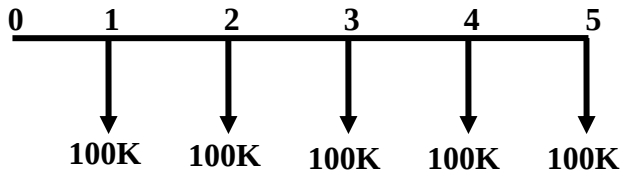
$37.62K represents the equivalent in today's dollars of $20K being invested or spent (flowing out) a year from the present time (zero) plus $30K flowing out the following year plus $l0K being received (flowing in) the year after.
********** EXAMPLE 3C END **********

********** EXAMPLE 3D: PRESENT VALUE OF AN ANNUITY BEGIN**********

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

Solution 3D:

Application of Table A discount factors for years 1 - 5 to the Cash Flow (CF) yields:



Solution 3D:

Total NPV Cost = CF (YR1) + CF (YR2) + CF (YR3) + CF (YR4)
+ CF (YR5) = $l00K (.952) + $l00K (.907) + 100K (.864) + 100K (.823) + $100K (.784) = $l00K (.952 + .907 + .864 + .823 + .784) = $l00K (4.330) = $433K

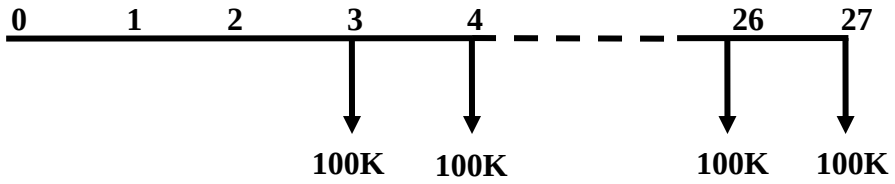
As is demonstrated, the annual cost of $l00K was multiplied by the sum of the Table A factors. The computations would have been easier if the sum of the Table A factors had already been calculated. This is precisely what has been done in Table B of Appendix C. For any number n, the sum of the factors from Year 1 to the nth Year in Table A equals the nth year Table B factors.

Using the Table B discount factor for year 5 yields a NPV Cost for the cash flow diagram of $l00K (4.329) = $432.9K. Clearly, the Appendix C factors are 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 resulting in rounding error. This results in occasional differences in the third decimal place, which is considered negligible for these kinds 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 column in Table B of Appendix C. Total NPV Cost = (annual payment) (nth Year Factor)

********** EXAMPLE 3D END **********

**********EXAMPLE 3E: PRESENT VALUE of a Deferred Annuity BEGIN**********
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 3D 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)
= $l00K (9.237) -$l00K (1.736)
= $l00K (7.501)
= $750.1 K

This method leads 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 nth and (m-1)th year factors from Table B, Appendix C. Total NPV Cost = (annual payment) (nth 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 **********

3.4.5 DISCOUNT RATES FOR FACILITY AND ENERGY ECONOMIC ANALYSES

Discount Rates for Facility Economic Analyses

For facility projects, the guidance is located in Appendix C of OMB Circular A-94 that is updated annually around the beginning of the calendar year.

https://www.whitehouse.gov/omb/information-for-agencies/circulars/

2019 Discount Rates for OMB Circular No. A-94

Nominal Interest Rates on Treasury Notes and Bonds of Specified Maturities (in percent)

3-Year	5-Year	7-Year	10-Year	20-Year	30-Year
1.6	1.7	1.8	2.0	2.3	2.4

Real Interest Rates on Treasury Notes and Bonds of Specified Maturities (in percent)

3-Year	5-Year	7-Year	10-Year	20-Year	30-Year
-0.4	-0.3	-0.2	0.0	0.3	0.4

Real rates are used in a constant dollar analysis and nominal rates are used when all the numbers for each year have been escalated for inflation. The 30-Year rate is used for period of analyses greater than 30 years. Linear interpolation may be used for period of analyses that fall between published rates. For example the 25-Year rate would be (20-Year rate + 30-Year rate)/2 = (0.3 + 0.4)/2 = 0.35.

We usually do a constant dollar analysis to avoid extra use of inflation indices.

Discount Rates for Energy Economic Analyses

The Department of Energy sets the discount rates for projects related to energy conservation, renewable energy resources, and water conservation while the Office of Management and Budget (OMB) distributes discount rates using Appendix C of OMB Circular A-94 for use with most other capital investment projects in federal facilities. They also provide projected fuel price indices (excluding general inflation), by end-use sector and fuel type. These may be used to adjust utility cost especially in energy related economic analyses.

For energy projects, the guidance is located in the Introduction of the Annual Supplement to NIST Handbook 135, Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis – 2020 that is updated each year.

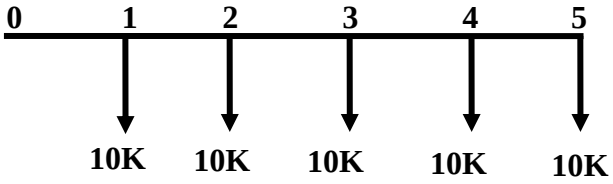
The DOE discount and inflation rates for 2020 are as follows:

Real rate (excluding general price inflation): 3.0 %
Nominal rate (including general price inflation): 2.5 %
Implied long-term average rate of inflation: -0.5 %

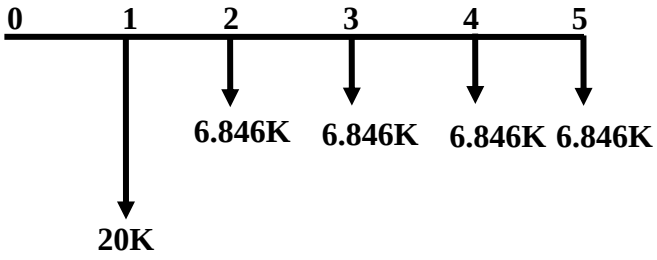
3.5 EQUIVALENCE

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

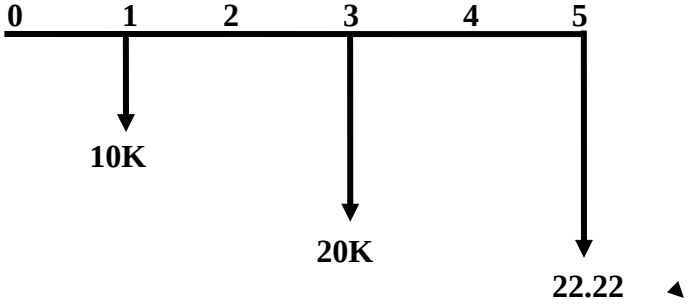
Proposal A



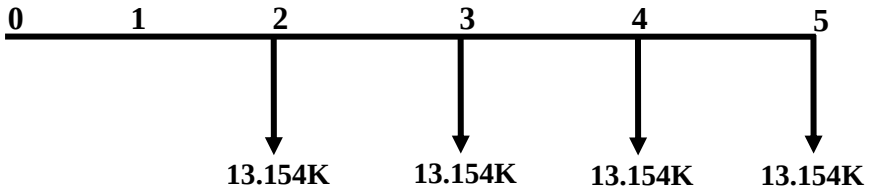
Proposal B



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 cannot be selected solely on the basis of expenditures; the time value of money must be incorporated into the analysis to make the correct decision.

3.6 METHODS OF COMPARISON FOR RETURN ON INVESTMENT (ROI) ANALYSES

This section presents the two techniques used to compare ROI analyses:

- Savings to Investment Ratio (SIR)
- Discount Payback Period

3.6.1 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:

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

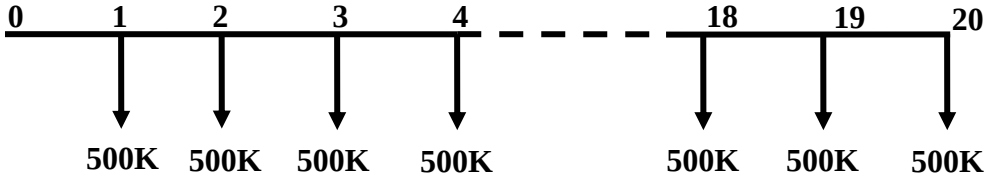
Where NPV (Savings) means the present value of the reduced amount of annual expenditures from replacement of the status quo by the proposed alternative and NPV (Investment) means the present value of the initial investment for the proposed alternative less the present value of any terminal value.

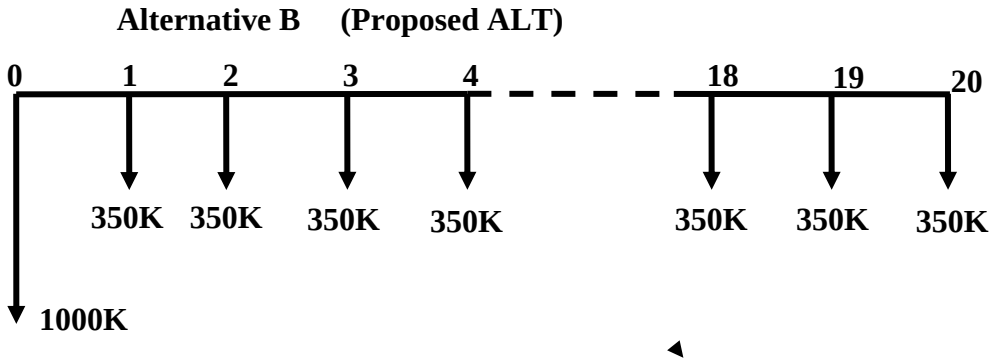
The SIR should be greater than 1 in order for the proposed project to be considered cost effective. That is, the proposed alternative should generate more savings than it costs to implement. To see how SIRS are calculated, see Examples 3F and 3G which show the SIR and not the NPV calculations. Refer to the previous formulas to calculate the NPV numbers.

********** 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.

Alternative A (Status Quo)





Use an interest rate of 10% for this example.

Project Year (s)	Recurring Costs		Differential Costs	Discount	Discounted Differential Cost
	Present	Proposed			
1 - 20	500K	350K	150K	8.514	1277.1K

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

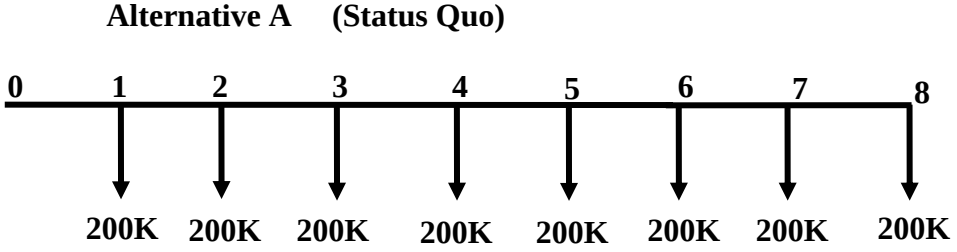
$$SIR = \frac{NPV(Savings)}{NPV(Investment)} = \frac{1277.1K}{1000K} = 1.28$$

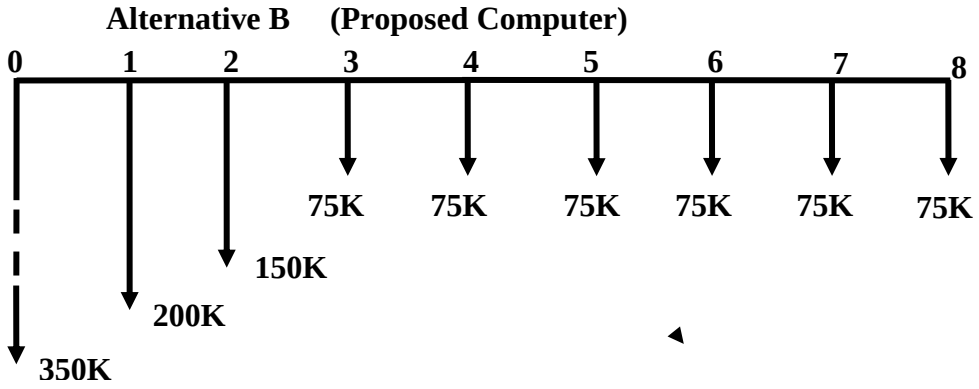
Since the proposed rehab project generates more savings than the required investment (i.e., the SIR greater than 1), it is cost effective and should be undertaken.

********** 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 Costs		Differential Costs	Discount	Discounted Differential Cost
	Present	Proposed			
1	200K	200K	0	0.909	0
2	200K	150K	50K	0.826	41.3K
3 - 8	200K	75K	125K	3.599	449.9K

NPV (Savings) = 491.2K

NPV (Investment) = 350K

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

The proposed computer system generates a SIR of 1.4 which is greater than 1.0 which means the computer system is more cost effective than the manual system is a good investment.

********** EXAMPLE 3G END**********

3.6.2 THE DISCOUNTED PAYBACK PERIOD

In addition to the SIR, the discounted payback period should be calculated for all Return on Investment (ROI) economic analyses. Unlike the SIR which describes the amount of the savings that are accrued, the payback period describes how quickly the savings accrue. Pay-back is achieved when the total accumulated present value savings are sufficient to offset the discounted investment cost of a proposed alternative. Simply put, the pay- back 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 pay-back 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 onetime costs.

3. Use the SIR to Payback Conversion Table (Appendix C):
This method is by far the easiest and simplest to use. However, 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 31 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 BEGIN *********

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

Method 3.6.2.1: Calculate the savings year-by-year and see when the cumulative savings equals the initial investment.

Solution 3H:

			Cumulative		
Discount				Discounted	
Year	Savings	Factor	Savings	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

After 12 years the Cumulative discounted savings exceed the investment. Therefore, payback occurs in the 12th year. Interpolate to determine the exact payback period, stating payback as occurring in 11+ years is close enough for these analyses.

Method 3.6.2.2: Determine When the SIR = 1.

$SIR = \frac{Savings}{Investment} x b_n = 1 = \frac{150K}{1000K}(b_n) = 1$. Thereby, $b_n = 6.67$.

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.

Method 3.6.2.3: Use the SIR to Payback Conversion Table. In this example:

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, use the SIR to Payback Conversion Table on Page C-4. The table gives the results for a payback period for a SIR of 1.2 and an economic life of 20 years as 12.97 years and the payback period for a SIR of 1.3 and an economic life of 20 years as 11.16 years. Because of the significant difference in payback, an interpolation must be done for this case:

Payback = 11.16 + [(1.30 - 1.28) / (1.30-1.20)] (12.97 – 11.16) = 11.16 + 0.36 = 11.52

The payback is therefore 11 + years.

Method 3.5.2.4: Use the Payback Period Formula on page C-13

$$n = \frac{-\ln\left(1 - R\frac{I}{S}\right)}{\ln(1+R)} = \frac{-\ln\left(1-(.1)\frac{1000K}{150K}\right)}{0.09531018}$$

n = 11.53

Payback is therefore 11 + years.

********** EXAMPLE 3H END **********

********** EXAMPLE 3I: Operation Automate: Payback Calculations BEGIN*********

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

Year	Savings	Discount Factor	Discounted Savings	Cumulative Discounted Savings	Investment
1	0	0.909	0	0	350K
2	50K	0.826	41.3K	41.3K	350K
3	125K	0.751	93.9K	135.2K	350K
4	125K	0.683	85.4K	220.6K	350K
5	125K	0.621	77.6K	298.2K	350K
6	125K	0.564	70.6K	368.8K	350K

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

Method 3.5.2.2: Determine When the SIR = 1

$$SIR = \frac{PV(Savings)}{(Investment)} = \frac{41.3 + 125(x - 1.736)^{**}}{350} = 1$$

41.3 + 125(x – 1.736) = 350 => 125x -217.0 = 308.7 => 125x = 525.7 and solving for x,
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 3.5.2.3 & Method 3.5.2.4: These methods cannot be used because the savings are not uniform.

********** EXAMPLE 3I END **********

3.7 METHODS OF COMPARISON FOR MISSION REQUIREMENT (MR) ECONOMIC ANALYSES

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

Table 3A - Appropriate Methods of Comparison

	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.

3.7.1 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 BEGIN ***

The below cash flow diagrams represent two viable alternatives to be undertaken in Operation Power Plant. Using the cost 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	Discounted Cost
1	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	Discounted Cost
1	Construction	$125M	1.000	$125.0M
4 – 28	O&M	$ 7M	6.820	$ 47.7M

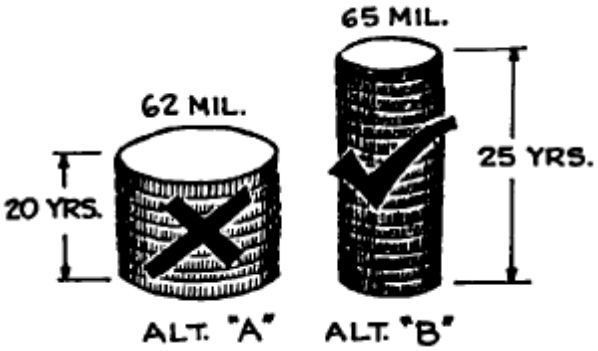
TOTAL NPV COST $172.7M

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

********** EXAMPLE 3J END **********

3.7.2 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 of 65 million over a life of 25 years.



On the basis of a NPV 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:

$UAC = NPV/b_n$ where: UAC = Uniform Annual Cost

NPV = Net Present Value Cost for the Alternative and b_n = the nth year Table B factor; n is the length of the economic life.

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

$UAC = NPV / (b_x - b_y)$

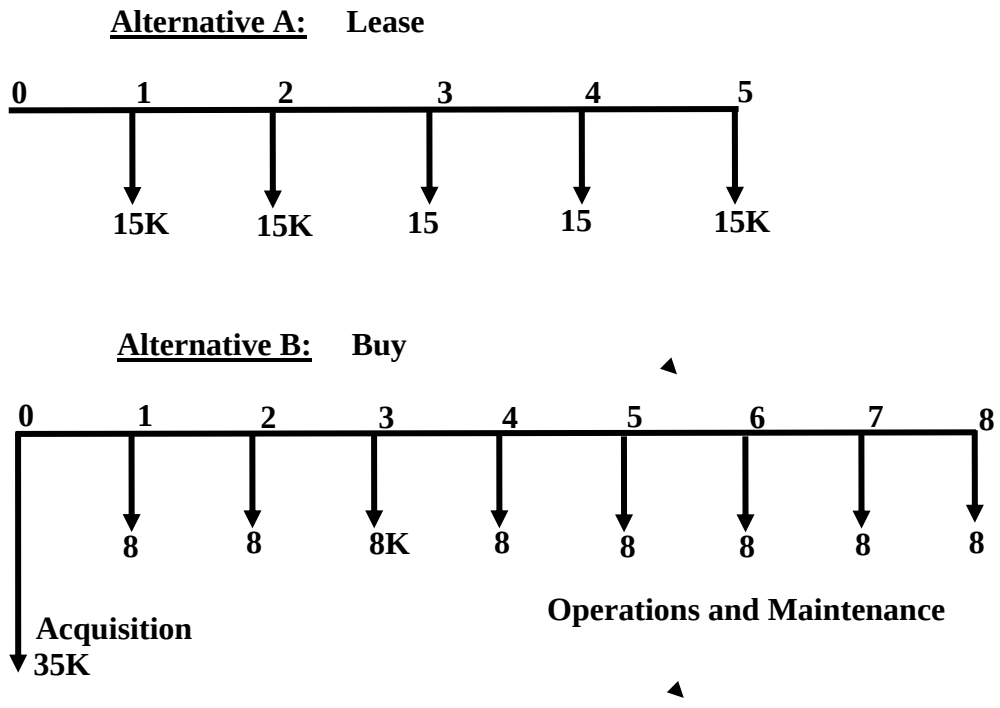
Where:

UAC = Uniform Annual Cost, NPV = Net Present Value Cost for the Alternative, b_x = the year Table B factor where X is the length of the project life, b_y = 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 BEGIN **********
(Without Lead Time)

The following cash flow diagrams represent the viable alternatives to be undertaken in Operation Computer. Using the cost information shown, calculate the UAC 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	$15M	3.791	$56.9K

TOTAL NPV Cost: $56.9K

Uniform Annual Cost = $56.9K / 3.791 = $15K

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

Uniform Annual Cost = $77.7K / 5.335 = $14.6K

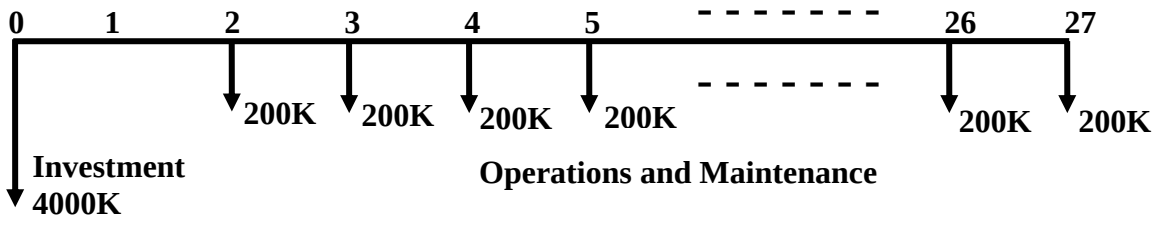
Based on Uniform Annual Cost, Alternative B is preferred ($14.6K versus $15K).

********** EXAMPLE 3K END **********

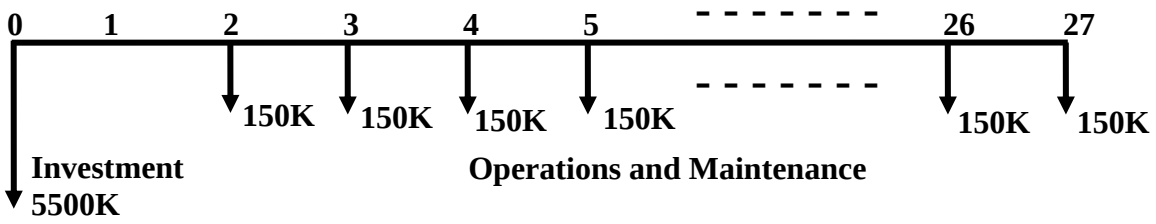
********** EXAMPLE 3L: Operation REPLACE: UAC Comparison BEGIN**********
(With Lead Time)

The following cash flow diagrams represent the viable 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.

Alternative A – Rehab Building 150



Alternative B – New Construction



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	7.740	$1548K

TOTAL NPV COST = $5548K

Uniform Annual Cost = $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 = $6625K / 7.501 = $883K

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

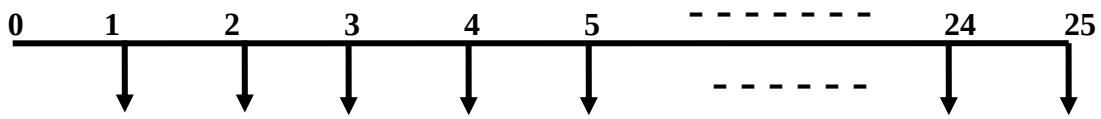
********** EXAMPLE 3L END **********

3.7.3 SLIPPAGE

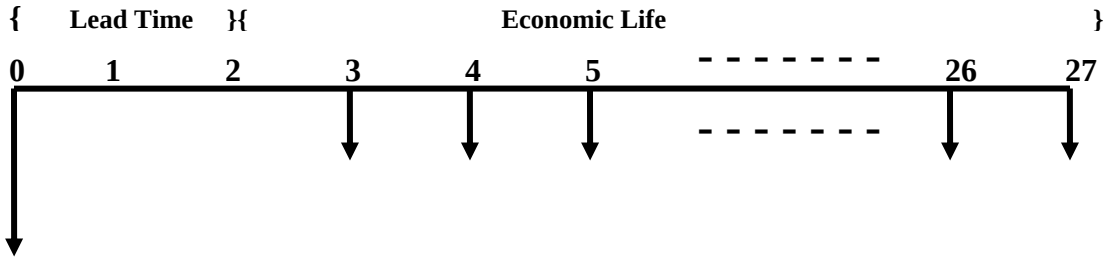
The concept of equivalence requires that each alterative provide the same benefit over the POA. Slippage is used to slip the POA of one alternative so that both alternatives provide an equivalent benefit over an equivalent period of analysis. In a Lease versus Buy analysis, the Lease can be slipped to begin at the BOD of the Buy alternative. Another way to provide equivalent benefits is to add a short term lease to the Buy alternative to cover the lead time. Note that the rent in a shorter term lease if available is likely to have a higher annual cost.

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

Alternative A – Lease



Alternative B – MCON



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.

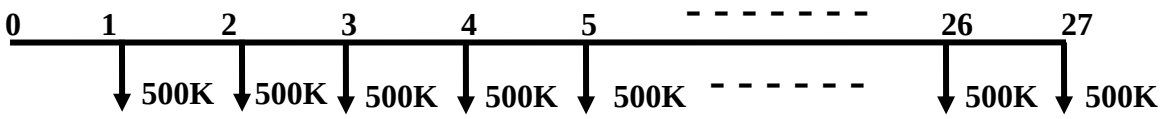
It should be noted that slippage is purely an analytical device. If the alternative that is "slipped" is found to be cost effective, it should be implemented.

Example 3M provides an example of slippage.

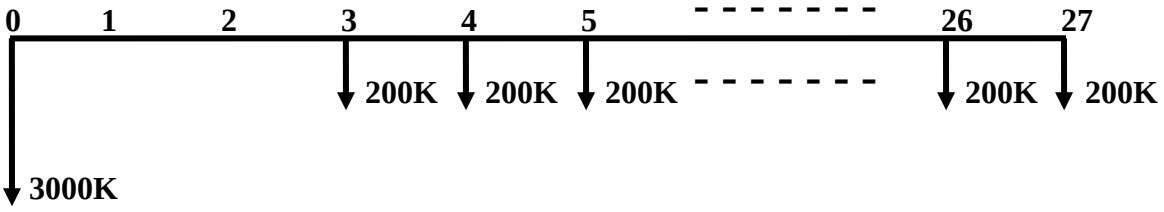
********** EXAMPLE 3M: Operation ADMIN: Use of Slippage BEGIN **********

The following cash flow diagrams represent the viable alternatives that could 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.

Alternative A – Lease

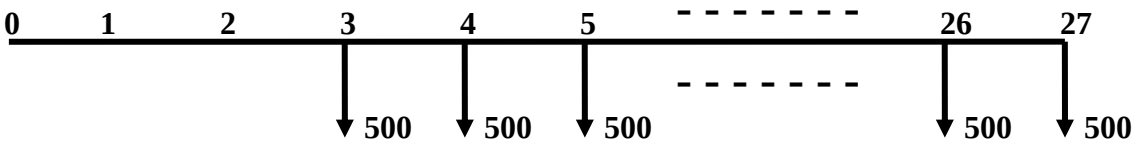


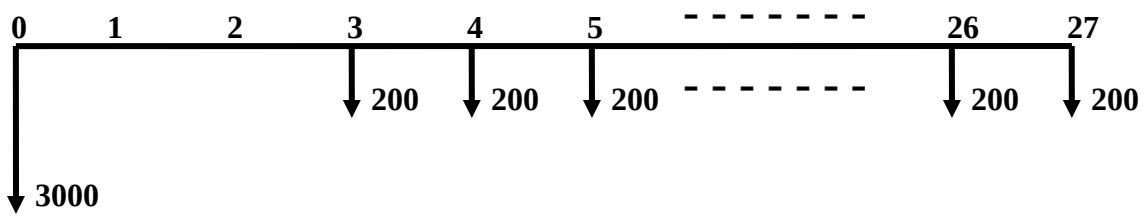
Alternative B – MCON



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 A: 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 for Alternative A is $3750.5K and for Alternative B is $4500.2K. Alternative A has a lower NPV and is therefore preferable and should be undertaken in year 1.

********** EXAMPLE 3M END **********

3.8 EFFICIENCY/PRODUCTIVITY TO INVESTMENT RATIO (EPIR) FOR RETURN ON INVESTMENT (ROI) 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 need to be evaluated to assess the fundamental differences. Double counting of savings is not allowed. The life cycle cost savings and increased efficiency/productivity need to be distinct or prorated if overlapping.

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.

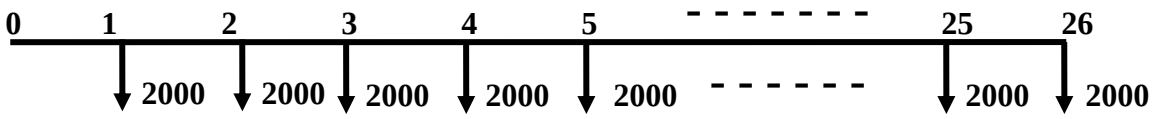
One very important caveat must be mentioned. In order to claim an efficiency/productivity increase as a valid benefit, there must be a documented need for the increased workload capacity. In other words, there must be an alternative use to which the "new" manpower resources can be put, such as reducing 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 Benefit Cost Ratio (BCR).

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

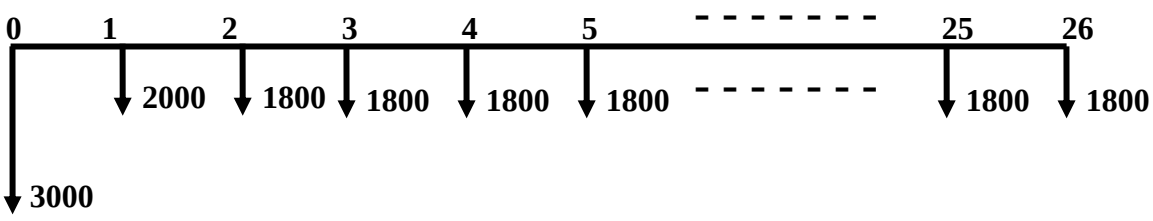
********** EXAMPLE 3N: Operation Consolidate: EPIR Calculations BEGIN **********

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%.

Alternative A – Status Quo



Alternative B – Consolidation



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

Solution 3N:

(1) Calculate the SIR

Project Years(s)	Recurring Present	Costs Proposed	Differential Cost	Discount Factor	Disc/Diff Cost
2-26	$2000K	$1800K	20K	8.252	1650K

Investment = $3000K

SIR = $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=$3535K/3000K=1.18

(3) Calculate the BCR

BCR = SIR + EPIR
= .55 + 1.18 = 1.73

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 **********

3.9 SYNOPSIS OF ECONOMIC FACTORS AFFECTING LEASE VERSUS BUY ANALYSIS

Lease or Status Quo options tend to spread payments over time whereas a Repair or MILCON option has high upfront costs that reduce recurring costs. When interest rates and thereby discount rates are high, this favors the Lease and Status Quo options because higher costs in the future will be reduced when discounted. It looks like interest rates have reversed their long term trend and are in general are gradually headed higher.

There is also supply and demand. If there is not much lease space available this will tend to raise the cost and to thereby favor the other options like Repair, MILCON, and Status Quo.

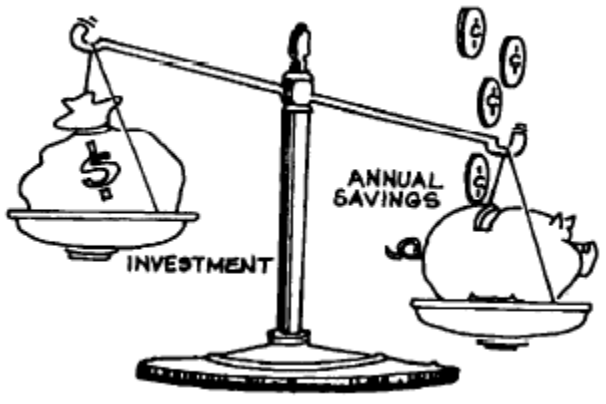
Another factor is land. In an economic analysis comparing an off base lease with on base alternatives, land is imputed to the on base alternatives because if the Navy owned less land then it would be available to society for other uses like parks or factories. Currently, this favors the on base alternative because the differential escalation rate for land that we are currently using is 1.5% which more than offsets the current real discount rate of 1.1% when calculating the land terminal value. Also, in a more practical sense, if the Navy already owns the land then it will not be a direct cost to the Navy. It is also good to note that often the Lease option can be explained away because it does not meet the mission requirement of being on base or in proximity of the base.

4. LIFE CYCLE COST ANALYSIS

The Life Cycle Cost Analysis Method is discussed including the appropriate point of view, costs of capital, sunk costs, depreciation, importance of quality data, what costs and benefits to include, recurring and non-recurring costs, constant dollars with base year purchasing power, and the format for documenting the estimates of costs and benefits. It is useful to note that Life Cycle Cost is a term that is equivalent to the term Total Ownership Cost (TOC).

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 re-sources 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 resource allocations throughout the facility's economic life. Your economic analysis will be incomplete if you attempt to evaluate an investment option without due consideration of all of the resource implications, because the purpose of the 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.

Guidance in this Chapter aligns with the WBDG Life Cycle Cost Analysis resource paper from the National Institute of Standards and Technology, http://www.wbdg.org/resources/lcca.php and with the WBDG Use of Economic Analysis to Evaluate Design Alternatives design guidance, http://www.wbdg.org/design/use_analysis.php.

4.1.1 Scope Analysis and perspective

When compiling life cycle costs, you must take the appropriate vantage point to ensure that all relevant costs are included in the analysis. The correct vantage point is that of the United States, not just the Navy. This view provides for the maximum effectiveness of national defense resource allocation by Congress and the President. 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 or the private sector 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 realignment of a Navy base may force a non-Navy tenant occupying Navy space to find suitable space elsewhere. If DLA is a tenant, their relocation costs must be included as part of the non-Navy tenants 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. The value of a dollar at the point of expenditure will have 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. A 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 set yearly be OMB (see a copy of the OMB Circular A-94 in Appendix A).

4.3 Sunk Costs and Depreciation are Excluded in the Economic Analysis

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 cannot 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 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 a government agency 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. PPV economic analyses may include depreciation depending on whether the private partner will have ownership in the facilities.

4.3.1 DATA IMPORTANCE

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 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 provides the foundation for the analysis and is essential. Meaningful conclusions can only be drawn from accurate cost data.

4.4 INCLUDED COSTS

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.

4.4.1 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 the Documentation Standards chapter.

- Research and Development (R&D) - all costs for research and development (R&D) incurred after the decision point (i.e., sunk costs are excluded). Each cost should be identified by year.

- 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 projected expenditure year. Investment costs are usually not spread over several years since funding is rarely approved in increments. One issue that sometimes comes up is whether to account for the backlog in maintenance in one year or spread out the cost over a number of years. To make the alternatives as equivalent as possible all alternatives need to consider repair and/or constructing being completed and be up and running in the same year the alternative would be available (unless repairs are not part of project scope). Typical investment costs are:

    - Land acquisition or easements
    - New construction
    - Rehabilitation or modification
    - Collateral equipment purchases (personal property / Include when not equivalent in all alternatives)
    - Plant property rearrangement and tooling
    - Demolition and site restoration
    - Onetime personnel cost (recruitment, separation, or training costs, etc.)
    - Relocation costs
    - Nonrecurring services

.

- Working Capital Changes (plus or minus) tied up in liquid funds, assets on hand, or on order need to be considered. Generally, working capital is represented in 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:

    - 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).

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

    - 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 work in process and stock on shelves means less working capital tied up in inventory).

- Value of Existing Assets Employed (Plus) is 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 conditions list below are met. 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. In the case when a facility is temporarily abandoned in place for possible re-use, and the probability of re-use is unknown, then the caretaker costs need to be included in the analysis since it is unclear whether the facility will ever be used. 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. If one of the following applies, the cost should be included in the analysis.

    - 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.

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

- Value of Existing Assets to be replaced or eliminated (Minus) is the value of assets or property already on hand that will be 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 economic 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.

- 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. In a PPV, if the Government would not have an ownership stake in the property, then there would be no terminal value benefit to the Navy. 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 67 years.

Use the rate of 1.5% annual decay for 67 year facilities to estimate the terminal values in the absence of market appraisals. For example, the terminal value of a 67 year physical life is estimated as 50 percent of the original investment cost in the 33rd 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.

4.4.2 RECURRING ANNUAL COSTS

Recurring Operating Costs are those costs to operate and maintain (O&M) the alternative being considered (other than labor). See the checklist in Documentation Chapter of this handbook. The following is a list of recurring costs to consider in making a complete analysis:

- Material, supply, utility and other service costs incurred by the Government used in providing a product or service. Included in this figure is the cost of base transportation for any alternative being considered. Utility costs include all services provided in the alternative and may include electricity, gas, water, and communications related to the function. Material costs and supplies should take into account overruns, spoilage and defective work.

- Maintenance and repair costs incurred by the government to maintenance and repair buildings, structures, grounds, and equipment utilized by the function involved in the production of goods or services. Capital improvements should be included with one-time investment costs because they are one time and not recurring. The Facility Pricing Guide, UFC 3-701-01 refers to recurring costs as sustainment costs. Formulas that include unit costs and adjustment factors for sustainment as well as plant replacement value are found in the guide.

  In the absence of better cost estimating information, sustainment cost for repair versus new construction will be assumed to be equal. For status quo versus new construction or repair,

sustainment costs should be 25% of status quo for new construction or repair in years 1 to 5 50% of Status Quo for years 6 to 10 and 75% of status quo for years 11 to 15 and be equal to status quo for the remaining life of the project. This adjustment is designed to account for the age difference in facility components resulting in differences in sustainment cost. New or repaired facilities tend to be designed to reduce sustainment costs and all or many components are new and therefore require less maintenance than some of the components in the Status Quo alternative.

- Support Costs (Including Overhead) are those costs associated with local procurement, accounting, legal fees, medical, police, fire and other services, and the storage and issuing of supplies. Also included are any costs for terminating, cancelling or modifying existing contracts as the result of an alternative. 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.

  Other Support Costs are those costs that may not be the same for all alternatives. These costs may include custodial, grounds maintenance, IT and other service contracts, furniture rentals, additional security for leasing off base, ATFP requirements, building code requirements associated with conversions and re-use, and the cost of parking or transportation costs if adjacencies and other efficiencies are lost. An example is the construction of a new barracks building which will not affect the size of the base fire department, but the costs of operating the fire department may be included if additional manning is required in the fire department due to student population increases. 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.)

- 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. The following provides information on both civilian and military personnel costs:

- Civilian personnel costs can be expressed in people or 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 Grade (WG) pay tables for that specific area, available via http://www.opm.gov/policy-data-oversight/pay-leave/salaries-wages/. Step 5 is used as a representative average within a GS grade level and Step 3 is used as a representative average within a WG grade level. Methods to calculate personnel costs are:

- Number of People. 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. Acceleration rates are available from the Defense Comptroller, at

  https://comptroller.defense.gov/Portals/45/documents/rates/fy2021/2021_d.pdf

- Civilian personnel fringe benefit rates should be applied to civilian labor costs incurred in support of reimbursable orders, as appropriate. These rates should be used when billing other DOD Components, Federal Agencies, and private parties under the requirements of Chapter 6 of Volume 11A, "Reimbursable Operations Policy and Procedures," of the DOD Financial Management Regulation (DOD 7000.14-R). Billings to the Foreign Military Sales (FMS) Administrative Charge Account and to FMS cases are to be processed under the provisions of Chapter 7, Volume 15, "Security Assistance Policy and Procedures," of the DOD Financial Management Regulation (DOD 7000.14-R).

  Navy Civilian Fringe Benefit Rates

  Funded Benefits Rate 32.2%
  Retirement costs (Unfunded/Health Benefits/Life Insurance Rate) 9.4%
  Public and Private Party Rate 41.6%

  The Funded Benefits Rate is the billing rate to other DOD components and federal agencies while the Public and Private Party Rate is for billings to all others.

  - Man-hours of work are specified in terms of the number of man hours of work required to perform a function. Man-hours are most frequently converted to man-years. The base pay must be accelerated both for Government furnished fringe benefits (41.6% as above), formal training, annual leave, sick leave, and other classifiable absences which impact the performance of one man-year of work. One man-year is defined as 2080 hours, 260 days (8 hour days) or 52 weeks (40 hour work weeks). 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 1.416 X 1.20 = 1.6992 or approximately 70% higher than the base pay 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 benefits, each of these 1.2X people costs the Government 141.6% of the annual salary each year. Therefore, the total annual personnel cost of X man-years of work is approximately (1.2X) (1.416) = 1.6992X times the annual salary.

  - Military personnel costs for services involved directly in the work performed, computed as described in Volume 3 of NAVCOMPT Manual. 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 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 which do not fit easily into the categories mentioned above, should be spelled out, documented and itemized. A discussion of cost documentation is included in the Documentation Standards chapter.

4.5 SETTING THE BASELINE

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 are dollars of constant purchasing power. Constant dollars are always associated with a base year (e.g., Fiscal Year 2013 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 are 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.

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 the Sensitivity Analysis chapter.

4.6 PROVIDE 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 knowledgeable Facility Engineering Command (FEC), but this is by no means the only one. Personnel at NAVFAC Headquarters, on Regional Commander Staffs, and in the offices of both the Navy Comptroller and the Secretary of Defense review the analyses with appropriate scrutiny.

As projects continue to develop or are re-submitted over time, having a detailed economic analysis with well-defined assumptions will allow updates and changes to be made easily by anyone.

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 Accountability Office (GAO) auditors.

The budget reviewers are not as familiar with the economic analysis as the author of the document, and yet each of the reviewers must review the analysis critically and pass judgment upon its validity and adequacy. This requires complete documentation of assumptions and costs as well as a complete economic analysis. 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 data for each element on 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:

- 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.

- 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.

- 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. Identify not only the name and website if available, but also the date and latest version

identification. 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 guide-lines 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, (Microsoft Excel Spreadsheet), see http://www.uscost.net/CostEngineering/documents.htm, The 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-09) 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-09.
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 FEC advises that electricity will cost $.135/KWH for electricity and $8.90/MBTU for heat in FY-09.

FY-09 Annual Electric Costs: 206,250 KWH X $135 = $27,844
FY-09 Annual Heating Costs: 1,375 MBTU X $8.90 = $12,237
FY-09 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-09 and FY-09. (OSD Price Indices provided by the NAS Anywhere Comptroller).

FY-07 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 $l.00/SF.

FY-07 Annual Maintenance Costs = 50,000/SF X $1.00 = $50,000
FY-07 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-07 Annual Water/Sewage Usage: 400 people x 50 gal/day x 260days/yr = 5,200,000/gal/yr. FY-07 Annual Water/Sewage Cost = 5,200,000/gal/yr x $1.00/l 000 gal = $5,200. FY-09 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 a "wash" and are not included.

TOTAL FY09 ANNUAL O&M COSTS

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

********** EXAMPLE 4A END **********

5. COST ESTIMATING

Basic principles of cost estimating are discussed including data analysis, the treatment of inflation, cost estimating methodologies and their hierarchy, risk analysis, and documentation format recommendations. An example of a frequently used cost estimating technique called regression analysis is also provided.

5.1 INTRODUCTION TO COST ESTIMATING

The International Cost Estimating and Analysis Association defines cost estimating as …"The art of approximating the probable Cost or Value of something, based on information available at the time". The U.S. Government Accountability Office has training on this subject. This chapter uses valuable information from that training.

- Cost estimating CANNOT**…**
    - Be applied with cookbook precision, but must be tailored to a particular system,
    - Substitute for sound judgment, management, or control,
    - Produce results that are better than input data, or
    - Make the final decisions.
- Cost estimating CAN**…**
    - Lead to a better understanding of the problem,
    - Improve management insight into resource allocation problems, and
    - Provide an objective baseline to measure progress.

Cost estimates vary over time. The closer you get to the actual completion of a project, the more accurate an estimate tends to become. It is important to repeat the estimating process on a regular basis as more information becomes available.

5.2 DATA ANALYSIS

All cost estimates will need data to support the estimate. Historical cost and non-cost data need to be collected to support various estimating techniques. Technical non-cost data describes the physical, performance, and engineering characteristics of a system such as weight, number of design drawings, source lines of code, function points, number of integrated circuit boards, square footage, etc. It is important to pick data that is a predictor of future cost and to have technical and schedule data because they act as cost drivers.

Both direct and indirect costs need to be identified. Direct costs have direct labor costs that can be called "touch labor" and include direct manufacturing, engineering, quality assurance, material, etc. costs which have a direct bearing on the production of a product. Also included are direct non-wage costs such as training, supplies, and travel. Indirect costs are considered "overhead" and include such things as general & administrative support, rent, utilities, insurance, network charges, and fringe benefits. These expenses are typically charged to a company as a whole. An example of this is sick or annual leave, retirement pay, health insurance, etc.

Some direct costs may be burdened with indirect costs and some may not. For example, labor rate may include sick or annual leave for a salary employee. If this is the case it needs to be known to avoid double-counting and underestimating. It is important to ask when collecting data whether costs are burdened with indirect costs and the amount of burden applied.

Cost of operations may include, direct labor, inter-station movement of materials, travel required for the job and other production costs in each alternative. Generally the trend in generating an Economic Analysis (EA) is to focus on collecting cost data for facilities and infrastructure. Data can be collected in a variety of ways such as contractor site visits, data requests for all relevant cost element structures (CES), documented cost estimates, if available for earlier versions of the current system, and published cost studies. Data collection is a critical and time consuming step in the cost estimating process! Analysis of the data may indicate the need for more suitable data to add credibility to the estimate.

Data Sources

- UFC 3-701-01, Facility Pricing Guide (FPG)
- MAXIMO
- Local estimates and databases
- Current program estimate documentation (if available)
- Contractor proposals (compare to program funding profile)
- Commercial Off-the-Shelf (COTS) catalogs
- Forward Pricing Rate Agreements (FPRA)
- Similar program historical actual costs and estimate documentation
- Engineering drawings/specifications,
- Interviews with technical and program management personnel
- Surveys
- Professional journals and publications
- Industry guides and standards
- Technical manuals

Data Validity and Integrity

- Identifying limitations in the historical data. It's imperative for capturing uncertainty.
- Make appropriate adjustments for differences in new systems versus existing systems when using historical cost data for a similar system.
- Compare previous contractor proposal bids and actual costs for similar programs. Look for trends in underbidding.
- Participate in a fact finding trip to discuss contractor proposal estimates and gather supporting data/evidence.
- Review other projects with similar scope, Electronic Project Generator, EPG is a good resource, but be sure to validate assumptions with the author of projects reviewed. EPG maintains facility project information including EAs that may be attached to the project and sometimes the ECONPACK file.

Data Normalization Involves adjusting data so that it can account for differences in

- Inflation rates,
- Direct/indirect costs,

- Recurring and non-recurring costs,
- Production rate changes or breaks in production,
- Anomalies such as strikes, major test failures, or natural disasters causing data to fluctuate - these types of anomalies including recessions and spikes in gas prices are hard to account for ahead of time and in many cases would have some impact on most of the alternative considered. If one of these anomalies has already occurred and it is deemed to be temporary then the data can be adjusted to account for the anomaly,
- Learning curve (cost improvement) effects due to efficiencies gained from continually repeating a process,
- Constant dollar estimates represent the cost of the resources required to meet each year's workload using resource prices from one reference year, and
- Constant dollars reflect the reference year prices for all time periods allowing analysts to determine the true cost of changes for an item.

5.3 INFLATION REFERENCES

The Department of Defense Facility Pricing Guide (DOD FPG), UFC 3-701-01, has three useful inflation tables.

Table 4-2: Military Construction Escalation Rates is used to bring MILCON Construction costs estimates shown in the DD 1391 to the desired program year purchasing power.

Table 4-3: PRV Escalation Rates is used to escalate replacement unit costs that are made using the PRV formula and replacement unit costs shown in the DOD FPG to bring costs to the desired program year purchasing power.

Table 4-4: Operation and Maintenance Escalation Rates is used to escalate sustainment and energy costs to the base year purchasing power. Note that for constant dollar economic analyses the cost and benefits including the terminal value are estimated in the base year purchasing power. The program year is used for the base year to keep dollars related to the project in a consistent purchasing power. Program year dollars are aligned with the budget to avoid budget shortfalls and be consistent with budget requests.

There are many other inflation indexes out there like the Engineering News Record Index, DOD Selling Price Index (SPI), the RLB Construction Cost Index, Turner Construction Cost Index, the Saylor Subcontracting Index, and escalation rates for the O&M budget authority published by USD Comptroller.

While there are other escalation indices out there that might be more accurate for a particular application, for consistency and simplicity, the DOD FPG escalation rates are used.

See Chapter 7, Treatment of Inflation for more detailed information about inflation.

5.4 COST ESTIMATING METHODOLOGIES & HIERARCHY

Once data has been collected and normalized to constant dollars, there are four general methods used to estimate construction costs per the DOD Facility Pricing Guide UFC 3-701-01, described below in order from least to most accurate and shown in Table 5.4.1. Increased accuracy provides

a greater level of confidence in the estimate but requires more information about specific project requirements and local conditions. Use the most accurate method for the amount of information known when preparing the estimate. Cost estimating accuracy is also addressed by the Association for the Advancement of Cost Engineering (AACE). The organization publishes cost engineering community recommended practices and matrixes of acceptable levels of cost accuracy for various stages of project definition. The matrixes show both positive and negative values for a given project scope and project definition, this range represents the amount of uncertainty that the prepared estimate can be either higher or lower than determined in the market place at the time of contract award. This does not mean that any given estimate is too high and can be reduced. Rather it represents an acceptable variability in cost estimating given various levels of design information, assumptions on the contractor's means and methods to execute the project, and other assumptions about bid competition and market conditions.

The Facility Unit Costs for Military Construction Table 2 found in the DOD Facility Pricing Guide (UFC 3-701-01) supports a Square Foot/Meter Estimating method as described below, and is generally applicable during the planning phase of a project. The unit costs in the table are national average historical costs with a known standard deviation for each facility type. When additional information allows a more detailed estimate using the Parametric or Quantity-Take-Off methods, the unit costs in the DOD Facility Pricing Guide should not govern the estimate. The following are the four methods of construction cost estimating.

1) Project Comparison Estimating is used in early planning stages when little information is known about the project other than overall project parameters. Project comparison estimating uses historical information on total costs from past projects of similar building types. For example, the number of beds in a hospital, or number of spaces in a parking garage, or number personnel in an administration building can form the basis of a project comparison estimate by comparing them to recent projects of similar scope in the same geographic region. Supporting facilities are estimated as a percentage of total facilities cost. This method is considered "preliminary" and is accurate only from -20% to +50% notwithstanding abnormal market conditions (i.e. natural disasters, market volatility, etc).

2) Square Foot/Meter Estimating is another method of developing both preliminary and intermediate budgets based on historical data. This method is effective in preparing fairly accurate estimates if the design provides square footage and heights of space for volume calculations. There are several historical databases such as this UFC 3-701-01, RS Means, and the Tri-Service's Parametric adjusted models (PACES) available to support this method of estimating providing unit costs ($/SF). More accurate estimates made with this method make adjustments and additions for regional cost indices, escalation rates, and size adjustment cost tables. Further adjustments may be made to account for other unique aspects of the design such as special site conditions or design features (reinforced floors for heave equipment loads) being planned. In addition, the estimate can develop overall "core and shell" costs along with build-out costs of different space types, allowing for relative ease of determining the impact of changes to the program. Estimates made with this method can be expected to be accurate between -15% to +25% notwithstanding abnormal market conditions (i.e. natural disasters, market volatility, etc).

3) Parametric Cost Estimating is an intermediate-level estimate performed when design drawings are typically between 10% and 35% complete. Parametric costs are based on assemblies or systems grouping the work of several trades, disciplines and/or work items into a single unit for estimating purposes. For example, a foundation usually requires excavation, formwork, reinforcing, concrete, including placement, finish and backfill. A parametric cost estimate prices all of these elements together by applying engineered values developed in assemblies cost data databases. These databases are based on historical data, typically organized in Uniformat II™. Estimates made with this method can be expected to be accurate between -10% to +15% notwithstanding abnormal market conditions (i.e. natural disasters, market volatility, etc).

4) In Quantity Take-Off (QTO) Estimating (also known as the Industrial Engineering Method), the work is divided into the smallest possible work increments, and a "unit price" is established for each piece. These work increments are typically organized by MasterFormat™. The unit price is then multiplied by the required quantity to find the cost for the increment of work. All costs are summed to obtain the total estimated cost. For example, the cost to erect a masonry wall can be accurately determined by finding the number of bricks required and estimating all costs related to delivering, storing, staging, cutting, installing, and cleaning the brick along with related units of accessories such as reinforcing ties, weep-holes, flashings, and the like. Accuracy is more likely to be affected by supply and demand forces in the current market. A QTO can be based on a site adapted design cost estimate or using the 35% (or more) design. This method provides the most accurate estimate, typically within ±5% of construction costs notwithstanding abnormal market conditions (i.e. natural disasters, market volatility, etc.).

COST ESTIMATING HIERARCHY

Table 5.4.1 Cost Estimating Hierarchy. *Note: See UFC 3-701-01 Facility Pricing Guide and MILCON Team Planning & Programming Process (MTP^3) Process Improvement Report available on the NAVFAC HQ CI MILCON website for more information. As more data becomes available, the accuracy of the estimates improves, and the MILCON Contingency is reduced.*

Estimate Method	Methodology	Typical Accuracy	MTP^3 Stage	MILCON Contingency
Project Comparison Estimating	Estimating from Recent Similar Facility Projects	-20% to +50%	1	20%
Square Foot Estimating	Unit Cost per Facility / Structure	-15% to +25%	1	20%
Parametric Cost Estimating	Applying Engineered Components Estimates	-10% to +15%	2	10%
Quantity Take Off (QTO) Estimating	Sum of Work Increment Estimates By Materials and Labor	-5% to +5%	3	5%

According to the FPG, sustainment provides for maintenance and repair activities necessary to keep a typical inventory of facilities in good working order over a 50-year service life. It includes regularly scheduled adjustments and inspections, including maintenance inspections (fire sprinkler heads, HVAC systems) and regulatory inspections (elevators, bridges), preventive maintenance tasks, emergency response and service calls for minor repairs, major repair or replacement of facility components (usually accomplished by contract) that are expected to occur periodically throughout the facility service life, such as regular roof replacement, refinishing wall surfaces, repairing and replacing electrical, heating, and cooling systems, replacing tile and carpeting.

5.5 RISK ANALYSIS

Risk analysis is a process that uses qualitative and quantitative techniques for analyzing, quantifying, and reducing uncertainty associated with cost goals by estimating probabilities that cost related events will occur. By nature, all cost estimates have some uncertainty. Earlier in cost estimate development the uncertainty is higher. As the project matures these uncertainties decrease due to greater scope and design definition, actual experience, and reduced opportunity for change. Errors can also occur from historical data inconsistencies.

Cost risk analysis aims to identify program level confidence in providing credibility to the target estimate, and to identify technical, schedule, and cost estimating risk drivers for use in risk management.

Risk is defined as a situation in which the outcome is subject to an uncontrollable random event stemming from a known probability distribution. The roll of two dice is an example of an uncontrollable event since the roll can result in one of 11 possible outcomes and has a known probably distribution.

Uncertainty is defined as a situation in which the outcome is subject to an uncontrollable random event stemming from an unknown probability distribution. For example; will it rain two weeks from today?

Cost estimating falls more into the range of uncertainty than risk, but most managers use the term risk analysis. In these cases the risk can be further analyzed to provide information on which factors pose the most risk, by performing sensitivity analysis.

Sensitivity Analysis answers the question; what happens if the assumptions change? Sensitivity analysis highlights the factors that have the strongest impact on the overall cost estimate. Changes to some assumptions can have profound impact, while huge changes to other assumptions have little effect on results. Sensitivity analysis points out to management which factors deserve the most attention and narrows down the number of lower level cost elements that should be examined using risk analysis techniques.

Sources of Cost Risks

- Schedule and Technical risks
    - Unexpected design changes
    - Project team experience
    - Number of business units impacted
    - Requirements changes
    - Integration considerations
    - Technical difficulties or maturity issues
    - Revised project or acquisition plans
    - Quantity changes
    - New labor rates
    - Higher inflation
- Cost estimating risks related to imprecision associated with the estimating techniques used, errors, or oversights

Risk Analysis Techniques

The Risk factor technique identifies a factor to adjust the overall cost estimate to account for risks due to unknown variables of a project. This factor is usually a percentage derived from past data and experience. Often the factor is applied to the estimate as a whole versus lower level cost elements. For example the MILCON cost estimate contains a 5% contingency factor. The Monte Carlo Simulation method can be used to determine the factor. The following describes the Monte Carle Simulation method:

Monte Carlo Simulation automatically analyzes the effect of varying inputs on outputs of a cost model using spreadsheet risk analysis. Randomly selected values for uncertain variables are generated over and over again to simulate normal variation in the uncertain variables.

Monte Carlo Simulation Steps

1) Analyst obtains cost distribution for each element identified as a major cost driver either through experience or sensitivity analysis. The Cost distributions used are often triangular in the form of optimistic (most likely) and pessimistic cost estimates. These cost ranges are often obtained through expert judgment (engineer or technical specialist interviews) or using a Delphi technique. A Delphi technique anonymous questions experts, presents answers to all experts, and repeats the process until a consensus or stability in results is reached or a predetermined number of rounds are completed.

2) After all cost elements have been identified by a distribution, the simulation is run many times (1,000 – 10,000 times). The simulation calculates multiple scenarios of the cost model by repeatedly sampling values from the probability distributions assigned to the various cost elements.

3) While the simulation runs, the forecasts stabilize towards a smooth frequency distribution called a cumulative frequency distribution or CDF. After thousands of trials, statistics of the results and the certainty of any outcome can be obtained from the CDF.

Monte Carlo Simulation results reveal not only the values for each forecast, but also the probability of any value occurring. This is helpful to management because it can show the level of certainty of achieving a cost objective. For example, a simulation can show there is a 10% chance of the project finishing for $50 million, a 50% chance of it costing $70 million, and a 90% chance of developing the project for $100 million or less. Decision makers can use these results to decide which projects to fund based on quantifiable risk parameters. US GAO uses Crystal Ball software to perform Monte Carlo Simulations. Crystal Ball is an Oracle simulation program that helps you analyze the risks and uncertainties associated with Microsoft Excel spreadsheet based models. More information about Crystal Ball is available at http://www.decisioneering.com/crystal_ball/

Other Monte Carlo simulation tools are available, such as:
@Risk (http://www.palisade.com/risk/default.asp)
RiskEase (http://www.riskease.com/)
Primavera (http://www.oracle.com/primavera/index.html)

5.6 DOCUMENTATION

An essential part of all cost analyses is the documentation. Documentation is critical for the following reasons:

- Provides detail cost data to support estimated cost. Include copies of vendor quotes, studies used, statistical analysis printouts, cost model input and output reports, assumptions, references, includes dates of reference documents and data, provide source name and phone number, etc.
- Provides information on the level of risk and uncertainty surrounding estimate. Provide disclaimers where applicable. Quantify the uncertainty by using a simulation model that will express the summary estimate in terms of level of confidence:
  - Estimate is presented at the 90% confidence level, or
  - Point estimate of $1 million is bounded by a range of $750,000 to $1,250,000
- Provides references to and for historical data used in refining estimates and for future estimating purposed. To utilize historical data, a database to capture the information is an effective method.
- Validity and uncertainty of data should be documented to give leadership and approval authorities a clear picture of the cost estimate and where there is uncertainty with costs. Ensure everyone is clear where the estimate may have uncertainty and higher risk in the estimate.

5.7 Simple Linear Regression Analysis and High Low Estimates

Simple linear regression is a widely used and effective technique to calculate the relationship between two variables. The High Low Method is a simple approximation of simple linear regression. Both methods can be used to get a more accurate estimate of a true cost when there is historical information that can be obtained to derive estimated costs. The two methods are demonstrated below:

- High Low Method is used to calculate a line defining a relationship between variables x and y. For example if there are five similar projects to the one being estimated then the ones with the highest and lowest cost could be selected. The difference between the costs divided by the difference between the SF defines the slope of the line or the value of A in the formula PRV = $A x SF + $C.

  Example
  Suppose the SF for a new pier project is 30,000 SF and other Pier Project Data is available. Note these example estimates could be refined by adjusting the costs with the Size Adjustment Factors and Area Cost Factors found in the Facility Pricing Guide.

PIER PROJECT DATA PROJECT NAME	YEAR	UM	QUANTITY	EST COST	TOTAL EST COST	INFLATION FACTOR	ADJUSTED ESTIMATED COST	ADJUSTED TOTAL ESTIMATED COST
GENERAL PURPOSE BERTHING PIER REPL	2004	M2	31602	$72,010	$123,720	1.122	$80,800	$138,822
PIER 11 REPLACEMENT (INCREMENT 1)	2004	M2	27328	$75,550	$145,780	1.122	$84,772	$163,574
PIER 6 REPLACEMENT	2005	M2	3020	$7,490	$28,782	1.086	$8,136	$31,265
Sub Drive-in MSF, Beckoning Point Inc	2008	M2	3391	$42,430	$96,400	1.000	$42,430	$96,400
REPLACE PIER (SAN CLEMENTE ISLAND)	2003	M2	1157	$3,350	$6,051	1.237	$4,144	$7,486

  High Cost = $163,574 where SF = 27,328. Low Cost = $7,486 where SF = 1,157.

  A = ($163,574 - $7,486) / (27,328 – 1,157) = 156,088 / 26,171 = 5.9641588.

  Thus PRV = 5.9641588 x SF + C. Using either data point and solving for C = 585.46827.

  For the new pier project of 30,000 SF, the PRV estimate is 5.9641588 x 30,000 + 585.46827 = $178,924.76.

  In comparison, averaging all the data, results in a total quantity of 66,498 and cost of $437,547 for an average cost per SF of $6.579852. For the new pier project of 30,000 SF, PRV estimate is $6.579852 x 30,000 = $197,395.56.

- Simple Linear Regression best fits a straight line on a scatter plot of variables x and y that minimizes the distance between the line and the y variable. For example x could be SF and y could be facility PRV. The Excel Data Analysis module can be added and a regression function used to make this calculation. For example Facility PRV = A*SF + C where C is point where the line crosses the y axis in the scatter plot.

  Using the equation and data shown above, Excel runs a least squares fit analysis of the residuals to determine the best line that will fit the data so that once the line is calculated it represents the best fit for the data in that the sum of the line points minus the dependent variable squared is as small a number as possible. The reason for squaring the data is to treat points above and below the line with the same weight.

The R2 statistic represents the amount of the dependent variable that is explained by the independent variable. Thus an R2 of .75 means that 75% of the independent variable is defined by the dependent variable.

Here are the results of regression analyses using the Pier Project Data that was available.

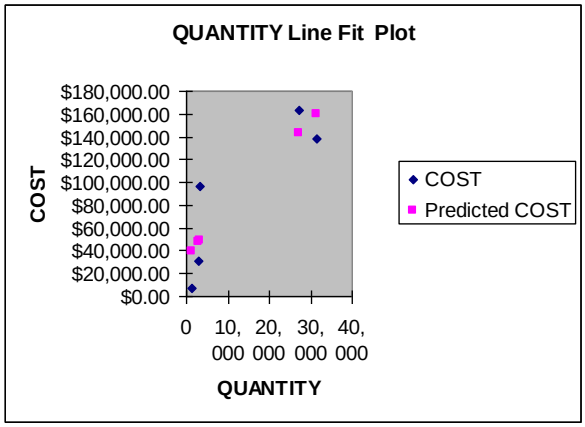
For, the data not normalized by adjusting for inflation adjusted data, the relationship between EST COST and TOTAL EST COST and QUANTITY produced R2 statistics of 0.64 and 0.75 respectively. When the data is normalized to account for inflation the R2 statistics improve significantly to 0.75 and 0.86 respectively. This shows the importance of taking inflation into consideration.

Here is some of the output from the model.

TOTAL EST COST = $3.927193 x QUANTITY + $35,279.36

For the new pier project of 30,000 SF, the PRV estimate is $3.927193 x 30,000 + $35,279.36 = $153,095.15.

SUMMARY OUTPUT	
Regression Statistics	
Multiple R	0.86828
R Square	0.75391
Adjusted R Square	0.67188
Standard Error	38495.17
Observations	5



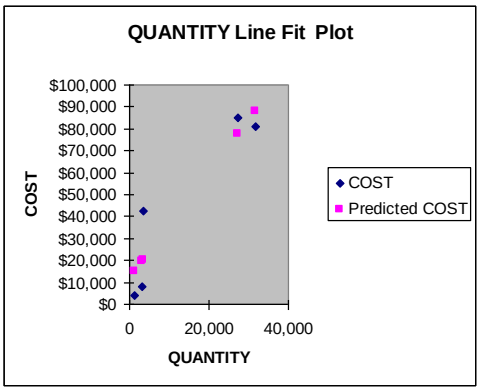
	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	35279.36	24355.64	1.448509	0.2433138
QUANTITY	3.927193	1.295416	3.031607	0.05623938

ADJUSTED TOTAL ESTIMATED COST = $2.393546 x QUANTITY + $12,223.26

For the new pier project of 30,000 SF, the PRV estimate is $2.393546 x 30,000 + $12,223.26 = $84,029.64. Note that this estimate does not include indirect costs. That is why it is lower than the first three estimates.

The ADJUSTED ESTIMATED COST has a better fit than the ADJUSTED TOTAL ESTIMATED COST because it does not have the indirect costs included.

SUMMARY OUTPUT	
Regression Statistics	
Multiple R	0.926498
R Square	0.858399
Adjusted R Square	0.811198
Standard Error	16678.89
Observations	5



	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	12223.26	10552.63	1.158314	0.330571
QUANTITY	2.393546	0.561268	4.264533	0.023656

6. 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 benefit divided by costs for each alternative considered.

$$BCR = Benefits / Costs \qquad (6.1)$$

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. For example, a new power plant might be able to generate an excess supply of energy that can be sold back to the grid.

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 Return on Investment (ROI) 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 ROI 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 ROI 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. Providing an analysis of all the benefits is therefore important.

There are four types of benefits analysis; 1) direct cost savings, 2) efficiency/productivity increases, 3) other monetary output measures, and 4) nonmonetary outputs. This section outlines 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.

Note that 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 6.1. Outputs that are negative are referred to as disbenefits rather than benefits. In this regard, the costs we calculate in an economic analysis could actually be referred to as disbenefits.

Incremental Benefit Cost Ratio (BCR) is discussed in Appendix D – Present Value (PV) Tables and Formulae.

6.1 FOUR TYPES OF BENEFIT ANALYSES

Generally, there are four types of benefits associated with Navy 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:

1) Direct Cost Savings
2) Efficiency/Productivity Increases
3) Other Quantifiable Outputs
4) Non-Quantifiable Outputs

6.1.1 DIRECT COST SAVINGS

- New project results in reduced O&M costs. 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.
- Using the savings/investment ratio (SIR)
  - For self-amortization investments prepare a Return on Investment benefit analysis. The self-amortizing quality is demonstrated by a SIR greater than 1 calculated according to equation 3.5 in section 3.5.1.
  - For partial self-amortization investment, a SIR should be calculated and reviewed. Not all projects generating recurring cost savings relative to the status quo can support a SIR greater than 1, but a partial self-amortization may nevertheless reveal information to decision-makers, or other budget reviewers. Consider Example 6A.

**********EXAMPLE 6A: 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. The present location of the transformer 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 viable. The PWO recognized that there were some benefits accruing from this project and decided to highlight them for decision makers by preparing a benefit/cost analysis. The results show that although the SIR is less than 1 it does have some positive results.

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

Investment	$500,000
Reduction in Recurring Annual Expenses	
Personnel (Maintenance)	$ 20,000
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% Cumulative Discount Factor	(9.524)
Investment ($500K discounted from end of year 1)	$454,545
Savings/Investment Ratio (SIR)	0.63

This demonstrates that the project amortized 63% 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 is only one solution to this critical deficiency.

**********EXAMPLE 6A END**********

6.1.2 EFFICIENCY/PRODUCTIVITY INCREASES

Efficiency/productivity increases occurs when there is an increase in productivity that can be measured in dollars in response to an investment. 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 6B: EFFICIENCY/PRODUCTIVITY BENEFITS BEGIN**********

The public works planners at NAVSTA, Anywhere, have identified additional efficiency/productivity benefits accruing from the transformer project of Example 6A. 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. The detailed study revealed that over the past four years total industrial downtime due to blackouts averaged 1.1 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 $44,820. 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 1.1 man-years of industrial capacity with no increases in personnel. The value of this benefit is the cost the Navy would incur if it had to hire enough additional workers to provide 1.1 man-years of labor per year. Thus, the figure must be accelerated to account for both leave and fringe benefits:

Annual Benefits = (1.1 man-years) x ($44,820/YR) x (1.51) = $74,446

This does not represent a direct savings, but a benefit whose value is $74,446 per year. Using this information, the APWO calculated an efficiency-production/investment ratio (EPIR) according to the following formula:

$$\text{EPIR} = \frac{\text{P.V. of Efficiency/Productivity Benefits Generated}}{\text{P.V. of Investment Required}} \qquad (6.2)$$

The computation follows:

Total Recurring Annual Benefits	$74,446
25 Year (Table B) 10% Discount Factor	9.524
Total Discounted Benefits	$709,024
P.V. of Investment Required (See Example 6A)	$454,545
Efficiency/Productivity/Investment Ratio (EPIR)	1.67

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

SIR	0.63
EPIR	1.67
BCR	2.30

**********EXAMPLE 6B END**********

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

BCR = Benefits / Costs see equation (6.1)

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 non-overlapping. This situation occurs frequently in projects whose goals are savings and productivity

6.1.3 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 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 Mission Requirement (MR) 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:

$$BCR = \frac{\text{Annual Benefits / Output Measure}}{\text{Uniform Annual Cost}}$$

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 ABOMs 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 6C: OPERATION NARF: BENEFIT COST RATIO CALCULATION -BEGIN

Due to a Chief of Naval Operations (CNO) sponsored regional consolidation, the Naval Air Station, Elsewhere, has been assigned the responsibility of providing all the corrosion control maintenance for Atlantic Fleet P-3 Orions in the Southeast. 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:

- Modify existing unused hangar space to accommodate the corrosion control function. Expected economic life: 25 years.
- 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 CONST
Recurring Annual Expenses - (Personnel, O&M, ETC)	$100,000	$ 80,000
25 Year Discount Factor (10%)	9.077	9.077
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)	0.94	1.02

(Completed Aircraft Maintenance Jobs per year per $1000)

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 6C 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 Southeast fleet is 200. With new construction, a plane can undergo corrosion control about every 6.4 months. With the modification alternative, 8 months would be the minimum time between corrosion controls.

$$\text{NEW:} \quad \frac{200 \text{ A/C}}{375 \text{A/C/YR}} = 0.533 \text{ YR/MAINT} = 6.4 \text{ Months/MAINT}$$

$$\text{MODIFY:} \quad \frac{200 \text{ A/C}}{300 \text{A/C/YR}} = 0.667 \text{ YR/MAINT} = 8.0 \text{ Months/MAINT}$$

Although both maintenance cycles are acceptable to COMNAVAIRLANT, it was acknowledged 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 (i.e. 1.00) 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 1000 time cards processed, errors per hundred records, errors per 100 items produced, etc.

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

- Environmental and Community Impact: (Refer to Chapter 7, Non-Monetary Considerations)

- Interoperability: 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 full 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? Are more guards? Are thefts more likely?

6.1.4 NON-QUANTIFIABLE OUTPUT MEASURES

Non-quantifiable Output is not easily quantified in dollars or other quantifiable measures. They can have a very significant effect on the economic analysis even though they are descriptive in nature. A few examples are identified below:

- Funding for a Special Project might be more readily available than a MILCON resulting in more certainty that the project will be funded and a earlier completion or BOD
- New construction floor plans may have a more efficient layout than the renovation alternative
- Morale and quality of life issues
- Historical building may have a better aesthetic value or ambience

6.2 BENEFIT DOCUMENTATION

There is no specific format prescribed for documentation of benefit analysis information. The ECONPACK Expenses module has a Source/Derivation rich text format page for each Benefit that is 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. The matrix should be added to one of the ECONPACK text modules, either the Assumptions module or the Results and Recommendations module.

7. NON-MONETARY CONSIDERATIONS

Non-monetary considerations may play a big role in an economic analysis. This is often the case when the net present values (NPVs) between alternatives are relatively close. Non-monetary considerations include non-monetary benefits as well as some costs. Costs considered are sometimes referred to as disbenefits to show that they are actually a negative benefit. No economic analysis is truly complete unless it addresses non-monetary considerations for each viable alternative considered. The purpose of this chapter is to bring more structure and organization to the non-monetary considerations in an economic analysis.

CNIC programmed projects also are scored for monetary and non-monetary consideration through a scoring model used to prioritize projects submitted to the Shore Mission Integration Group (SMIG) Working Group. The model scores non-monetary considerations as part of the overall scoring process and is made aware of these considerations from a number of sources including the Project Data Sheets, information presented by the Regional Commanders' representatives, the DD 1391, and from the projects' economic analyses.

7.1 TYPES OF NON-MONETARY CONSIDERATIONS

The first criterion of a non-monetary consideration is it cannot be represented in currency such as dollars. The second criterion is the effect must be meaningful and have an impact on the United States Navy or the United States citizens in general.

The following while not a complete list; highlights items to be evaluated when preparing non-monetary considerations of an economic analysis (Note that these non-monetary considerations can be positive benefits as well as negative costs):

- Health: Air, Drinking Water, Ambient Sound, Recreation Opportunities, Healthy Stores and Restaurants
- Safety: Sidewalks, Streetlights, Planned Development, Security Systems
- Environmental: Green Belts, Green Space, Green Structure
- Aesthetics: Appealing Architecture, Landscape Architecture, Pleasant Views
- Morale: Floor Plan Layout, Surface Finishes, Windows, Building Orientation
- Building Systems: Differences in Building Systems Benefits provided by Electrical Wiring, Fire Sprinkler Systems, Ventilation Systems, Elevators, Guard Rails
- Buffer Zones: Demilitarized Zones, Border Zones, AICUZ, Easement Zones (when not purchasing land or easements)
- Externalities: Outputs involuntarily received or imposed.

  EXTERNALITIES DEFINED

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

  Air pollution is an example of an externality that is a disbenefit. The recipients have

potential impacts to health and aesthetic disbenefits from a polluter for which they receive no compensation. The polluter may be gaining monetary benefits from not having to install pollution controls or use more costly methods of achieving the desired output. 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 National Environmental Policy Act (1969) process. However, the anticipated impacts (both quantified and unquantified) should be outlined in the economic analysis documentation.

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 a Civilian Health and Medical Program of the Uniformed Services (TRICARE) payments. If the TRICARE alternative is chosen, the eligible people involved must pay the difference between the bill for the medical care and the (lower) TRICARE 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 comparison of providing housing for military members through MILCON versus providing Basic Allowance for Housing (BAH) to the members. If 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. These examples are a result of policy decisions and thereby are not imputed in the economic analysis. Imputing them would negate the impact of the policy decision.

7.2 Examples of Non-Monetary Considerations

Non-monetary examples are often corrections or improvements to various health, safety, and life codes as well as enhancements to the environment or aesthetics. Be factual; make the discussion strong but not offensive, by relating the all the information known. The following examples are provided for enhanced understanding of non-monetary considerations.

- Unaccompanied Housing (UH) located near a Regional Park offers exceptional recreation opportunities for the sailor residents.
- An on-base MILCON alternative offers better security than renovating USMC barracks located outside the WNY.
- Location near the Anacostia River offers exceptional views. The frequency of flooding has been increasing. The following historical data is available to show the trend. In the 1980's there were no floods, in the 1990's there were two floods, during the 2000's there were five floods, and since 2010 there have been two floods.
- MILCON alternative offers better safety due to adherence to current building codes while renovation may not bring building up to current code.
- Art Deco Architecture of the Repair alternative has classic visual appeal.
- While current electrical requirements would be met by the Repair alternative, due to better configuration and all new materials, the MILCON alterative will have approximately 50% more reserve electrical capacity.

7.3 Quantifying Non-Monetary Considerations

While the Non-Monetary Considerations (NMCs) may not be quantifiable in dollars, the next best option is to quantify in numbers other than dollars. Sometimes, the situation allows you to represent the non-monetary consideration in a more quantifiable form. The following provides ways to quantify non-monetary considerations with examples.

1) Number – An object used to count or measure the magnitude. Numbers are frequently used to represent a historical trend. For example the number of injuries has been increasing.

2005	2006	2007	2008	2009	2010	2011	2012	2013
1	0	3	1	5	3	7	5	9

2) Ratio – A comparison between two things frequently expressed as a fraction. Ratios and Percents frequently are used to compare how one alternative stacks up to another one. For example the MILCON alterative is estimated to provide about ½ (or 50%) less CO_2 emissions than the Repair alternative. Another perhaps more effective way to express this is to use the ratio 2 to 1 or twice and say the Repair alternative CO_2 emissions are expected to be around twice that of the MILCON alternative.

3) Percent – A percent means how much out of 100. It is expressed as a number with the % symbol. It is a ratio that is normalized to have a denominator equal to 100. Example provided in number 2) above.

4) Frequency – Pattern of expected occurrence of a notable benefit or cost. Frequencies are often used to compare expected events. Suppose that the Repair alternative has an asphalt roof that needs to be repaired or replaced every 20 years. The MILCON alternative has a metal roof that is expected to be repaired or replaced every 35 years. Thereby the MILCON roof has the benefit of longer periods of maintenance free service.

5) Probability – Likelihood of the benefit or cost to occur. For example, NOAA estimates that there is a 50% probability of a CAT 2 hurricane or greater in the next five years and the USACE estimates there is a 75% probability that a CAT 2 hurricane will cause the Seawall to be breached.

6) Probability Distribution – Likelihood of a range of outcomes to occur. When frequencies depend on probabilities then they are called Probability Distributions. For example, suppose based on recent data that the Asphalt and Metal roofs have expected probability distributions. Research was summarized by the manufactures using discreet probability distributions to describe expected durability.

ASPHALT	REHAB AT 15 YRS	REHAB AT 20 YRS	REHAB AT 35 YRS	REHAB AT 40 YRS
	0.25	0.45	0.15	0.15

METAL	REHAB AT 30 YRS	REHAB AT 35 YRS	REHAB AT 50 YRS	REHAB AT 55 YRS
	0.25	0.45	0.15	0.15

7) Differential Effects – Differences in maintainability and sustainability over time. For example, to keep the new building energy system optimized public works personnel will need to be trained and monitor the energy system significantly more than the Status Quo energy system.

7.4 ECONPACK NON-MONETARY CONSIDERATIONS INSTRUCTIONS

ECONPACK has a text module for Non-Monetary Considerations. The text module is a "blank page" allowing the user to enumerate all pertinent information. For Navy projects utilize the text module using the following guidance:

The status quo alternative cannot simply be ignored and must be addressed thoroughly. If there are reasons why the status quo does not meet the mission requirement then those reasons can be used to dismiss the status quo. Issues with the status quo facility which significantly impact the health, life and safety of the occupants are appropriate reasons for dismissal of the status quo alternative although this likely means that the status quo is not meeting the mission requirement. There should also be some type of discrepancy report for any health, life or safety issue, such as a Notice of Violation. Use of a non-monetary consideration to dismiss any viable alternative without engaging in life cycle cost analysis of that alternative is not acceptable.

If a viable alternative other than least NPV has been selected as the solution, ensure the reasoning behind the decision is completely explained in this section, including non-monetary benefits which led to choosing the alternative selected. Considerations such as life safety, newly developed mission impacts, or even political requirements that impact the decision to move to a higher costing alternative should be explained. For example if saying a non-monetary benefit 'improves morale', explain specifically how the alternative improves the service members quality of life or service conditions to the point of impacting the mission, such as the Chief of Naval Operations (CNO) decision to move shipboard sailors to barracks on the shore. This was to improve sailor quality of life and is not linked to a monetary savings.

A matrix that summarizes non-monetary considerations may be effective. To begin, a list of all non-monetary considerations can be made and compared among alternatives. Then focus on those considerations that are not common to all alternatives to reduce redundancy. A final recommendation should avoid platitudes. All prospective projects are worthwhile in that they support national defense, and statements to this effect are unnecessary.

7.5 PRESENT VALUE OF NON-MONETARY CONSIDERATIONS

OMB Circular A-94 provides an example where a non-monetary consideration (NMC) is discounted along with the monetary cost. "Other summary effectiveness measures can provide useful supplementary information to net present value, and analysts are encouraged to report them [as well]. Examples include the number of injuries prevented per dollar of cost (both measured in present value terms) or a project's internal rate of return."

Suppose the injuries were expected to occur over a 32 year period of analysis with a 2 year lead

time for new construction. The MILCON alternative is built to current code that resolves the safety issue. Due to the inherent safety design built into the Repair alternative these injuries are expected to occur on a constant frequency of 3 injuries per year. With the 2 year lead time this would be for 30 years beginning in year 3 and ending in year 32 for a total of 3 injuries per year for 30 years or 90 injuries over the period of analysis.

These 90 injuries are expected to occur over 30 years rather than during the Base Year. The Base Year is the year to which all costs and benefits are discounted. In the OMB example above injuries are discounted as well to account for the differences in when the injuries are expected to occur.

ECONPACK can be used to discount the 90 injuries. The essential steps in the process begin by using the current 30 year real discount rate, adding a temporary alternative, making the alternative viable, and adding an injury expense column. Then place the number 3 for 3 injuries in each of the years 3 through 32. The NPV number at the top of the screen is the discounted number of injuries. That is, just ignore the dollar sign. Discounting the injuries in ECONPACK with the very low current real discount rate of 1.1% will result in 75 injuries.

Note that injuries are directly related to medical costs that are expected to rise above the general rate of inflation. So to improve the accuracy of the estimated injury impact differential inflation may be used. If for example the differential inflation for medical costs is estimated at about 1.5% per year, then a differential inflation schedule can be added to the ECONPACK Inflation Schedules module. Afterwards a current dollar analysis can be selected on the Alternatives Tab to allow inflation schedules to be added to expense columns. Then the differential inflation schedule may be added to the injury expense column. Using ECONPACK with these parameters results in 96 injuries.

NMCs may increase or decrease over time. For example, as the landscaping around a MILCON alternative matures the benefits improve like better protection from the sun, lower energy use and costs, and a reduced need for maintenance.

If the NMCs in all the viable alternatives do not have a significant time component then present value is not needed because it will be a wash. Use good judgment in this area, depending on the level of importance of the NMCs in the facility project economic analysis to determine the level of effort needed to adequately address the Non-Monetary Considerations.

8. DON Economic Analysis Guide

The Naval Center for Cost Analysis (NCCA) published three documents in February 2013. The three documents all pertain to performing economic analysis for the DON. The three guides are described below:

1) DON Economic Analysis Guide provides overall guidance on conducting economic analyses. This Guide considers business case analyses an economic analysis and recommends using Net Present Value (NPV) as well as a Weighted Benefit Score and a Risk Analysis Summary Table. The Weighted Benefit Score is a weighted average of each alternatives non-monetary considerations objective score. The Risk Analysis Summary Table uses a Risk Assessment Matrix to assign risk ratings to Threats based on risk probability and severity. The Risk Analysis Matrix is used to address threats of damage, injury, liability, loss, or other negative possibilities.

2) DON Economic Analysis Quick Start Guide provides help for an inexperienced analyst to perform an economic analysis. The Quick Start Guide also discusses the use of the Economic Analysis tool CREATE Version 1.3.5 GENERIC developed by the Air Force Financial Management Center of Expertise.

3) DON Economic Analysis Template provides a structured format to conduct a business case or formal economic analysis. It was developed by NCCA to complement the DoN Economic Analysis Guide.

4) CREATE Version 1.3.5 GENERIC is an Excel workbook developed by the USAF Financial Management Center of Expertise. To enhance NAVFAC economic analyses, the Benefit and Risk Analysis Matrices presented in the CREATE tool are placed in the document NAVFAC Benefit and Risk Analysis Non-Monetary Considerations as a supplement to the ECONPACK economic analysis. It is recommended for use in Business Case Analyses and in Economic Analysis where the Non-Monetary considerations are thought to be substantial. The Benefit and Risk Analysis Matrices provide additional information that the decision maker can use to weigh the pros and cons of each alternative.

9. ECONOMIC INDICATOR RELATIONSHIPS

This chapter describes the ECONPACK economic indicators and the relationships between how they are calculated and how they are used to make good decisions.

9.1 NET PRESENT VALUE (NPV)

OMB Circular A-94 establishes Net Present Value (NPV) as the standard criterion for economic justification. NPV is dependent on the Period of Analysis (POA) and the real or nominal discount rate used in the economic analysis. POA is the time period over which the economic analysis is conducted. POA is influenced by the economic lives of the alternatives, if they are different, which is determined by how long the mission life is estimated for the location, the perceived technological life of the facilities, and the estimated physical life of the facilities. These estimates are often based on assumptions and may be inaccurate. For example, the mission life could be assumed to be 25 years when in reality it turns out to be 100 years. For a fuller discussion of how to determine the POA, see the DON Economic Analysis Guide, Chapter 6, page 18. The guide can be found at: https://www.ncca.navy.mil/references.cfm

A real discount rate is used when general inflation is removed from the economic analysis. OMB Circular A-94 Appendix C specifies discount rates that are updated annually to reflect interest rates and inflation assumptions in the budget. The 30 year real interest rate has generally declined in last 31 years from a high of 7.9% in 1982 to a low of -0.3% in 2021. Figure 9A shows OMB real 30 year discount rates since 1979.

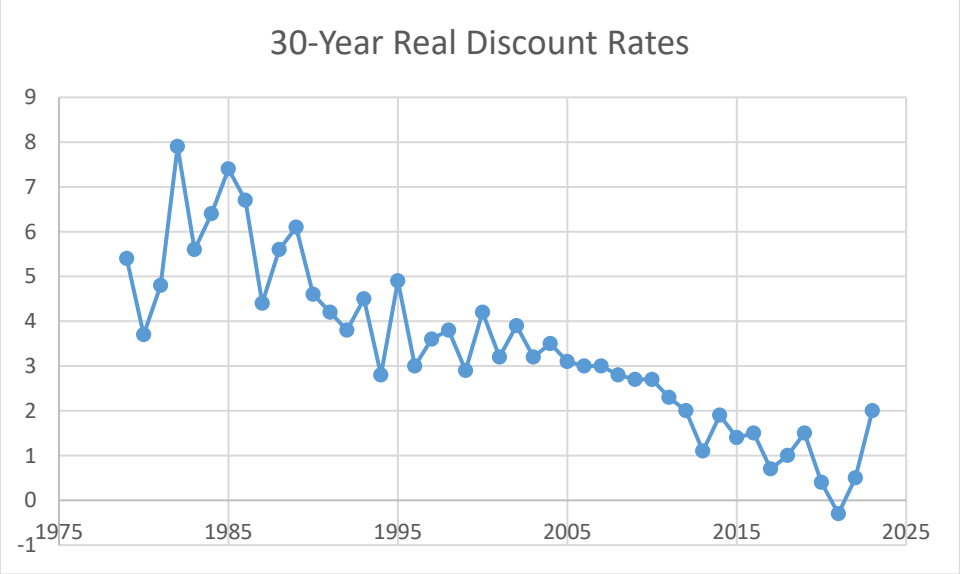


Figure 9A – 30-Year Real Discount Rates

A discount rate sensitivity analysis is automatically calculated by ECONPACK from -10.0% to 10.0%. POA Sensitivity can be accomplished by making a copy of the main analysis in

ECONPACK and adjusting the POA and the benefits and costs of each alternative. Also, the Naval Center for Cost Analysis (NCCA) has a discount rate calculator, which can be found at https://www.ncca.navy.mil/tools/discount.cfm

9.2 DISCOUNTED PAYBACK PERIOD (DPP)

Another economic indicator included in ECONPACK is the Discounted Payback Period (DPP). Net investment costs (initial costs minus benefits and terminal value) are calculated to determine what needs to be paid back by any recurring savings realized by selecting the proposed alternative. A one page Return on Investment (ROI) Economic Analysis (EA) Report is generated by ECONPACK that shows how the Discounted Payback (DPP) is calculated and is helpful in understanding adjustments made to the Investment and Savings in the calculation of the DPP. Once the savings are paid back the payback has occurred. Simple payback, means no discounting was used to calculate the payback. Discounting is used by ECONPACK to account for the time value of money in the calculation of the DPP.

An important relationship to notice is that discounted payback occurs at the point in time when the discounted saving are equal to the discounted investment or in other words the Savings to Investment Ratio (SIR) equals one. ECONPACK automatically generates a SIR economic analysis graph shown in Figure 9B that is useful in visualizing the point in time where SIR = 1.0. The DPP is the number of years including the base year that is takes until SIR = 1.0. The base year is the year that all costs are discounted back to in the economic analysis. For example if the base year is 2013 and the SIR crosses the 1.0 threshold around the middle of year 2017 then the DPP is about 4.5 years. That is it takes 2013, 2014, 2015, 2016, and half of 2017 for the discounted payback to occur.

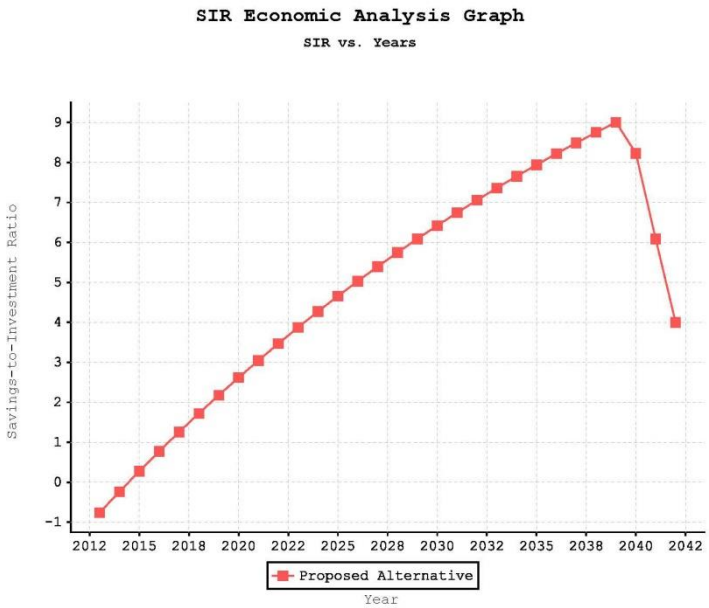


Figure 9B – SIR Economic Analysis Graph

A shorter DPP is better than a longer one. In theory once the initial investment is paid back the funding can be used for other projects or requirements. In the broader economy the money spent

on the initial investment generates income some of which is subsequently spent and that generates more income and so forth. The second investment has this advantage as well. Future investments have the advantage of saving the Navy money than could be used to fund other investments to save even more money.
ECONPACK calculates the DPP as noted previously in the ROI EA report as the time needed to pay back the net investment with the net savings. Net investment is the initial investment of the proposed alternative reduced by proposed alternative benefits and terminal value. Net savings are the proposed alternative recurring savings over the status quo reduced by the status quo benefits and terminal value (lost benefits from choosing the proposed alternative) and increased by the status quo non-recurring costs eliminated (cost avoidance savings by choosing the proposed alternative).

9.3 SAVINGS TO INVESTMENT RATIO (SIR) AND RETURN ON INVESTMENT RATION (ROI)

ECONPACK calculates a Savings to Investment Ratio (SIR) and the Return on Investment (ROI). The SIR is the discounted net savings divided by the discounted net investment. Net investment is calculated by subtracting the benefits and terminal value of the proposed alternative from the proposed alternative investment costs. SIR represents the number of times the net investment is reclaimed thru cost avoidance over the POA.

ROI is being considered in the context of comparing one alternative against another. Usually the comparison is with the status quo alternative that is currently meeting the mission requirement and a proposed alternative. The goal is to see if there is a more cost effective way to meet the mission requirement. ROI represents the return of net investment with net savings after the net investment is reclaimed over the POA. Net savings are calculated by subtracting the status quo benefits and terminal value from the proposed alternative recurring and nonrecurring savings over the status quo.

There are situations when the status quo is no longer viable and the status quo is not considered as an option. If two or more alternatives are being considered, the alternative with the lowest investment cost may be compared against those with higher investment costs to see if the extra investment costs are warranted by potential recurring savings. In either case, the ROI does not have to always be greater than 0%. In some cases the higher costs cannot be avoided such as meeting the monumental architecture at the US Naval Academy. A generic building would not be acceptable.

As previously discussed, the discounted payback occurs at the point in time when enough discounted savings have been generated to make the SIR equal to 1.0. When SIR is equal to 1.0, the investment has been paid for. At the point in time when the SIR equals 1.0 there is no ***return on the investment*** there is only a ***return of the investment***. Any SIR above 1.0 means there is ***a return on the investment***. Thus, 1.0 is subtracted from the SIR in the calculation of the Return on Investment (ROI). For example if the SIR is 5.0, the first step is to subtract 1.0 resulting in 4.0. The 4.0 represents a return of 4 times the investment after the investment expenses have been recovered. The 4.0 is then represented as a percent of the investment by multiplying by 100 or in this case a 400% Return on Investment (ROI).

Thus, ROI = (SIR – 1) x 100%.

9.4 UNIFORM ANNUAL COST ECONOMIC INDICATOR

- UAC is a great economic indicator especially when comparing alternative with different economic lives.

- UAC allows a more accurate comparison of alternatives without the need for residual value estimates as well as accounting for all costs and benefits over each alternative economic life.

- UAC calculations are made by ECONPACK by dividing the NPV by the sum of the discount factors used during the economic life.

- NPV cost is calculated by subtracting the discounted benefits and residuals from the discounted costs.

- UAC is essentially a discount factor weighted average of the costs, benefits, and residuals.

9.4 DISCOUNTED ECONOMIC INDICATORS RELATIONSHIPS

An economic analysis is conducted to determine cost effectiveness. Each alternative developed should meet the mission requirements. Assessing the NPV serves the purpose of measuring comparative costs. The lower the NPV the lower the overall project cost for the period of analysis considered. Overall more projects can be accomplished if the investment costs are lower, the payback is sooner, and the savings (if any) are greater. Including other economic indicators, such as SIR, ROI, and DPP as part of the decision process will ensure the alternative selected is the best possible option for the current situation. These other economic indicators provide valuable information to enhance the effectiveness of the Navy's investment portfolio. The following provides information on how these indicators can be used.

SIR& ROI – Higher is better	DPP - Lower is better
Lower Net Investment	Lower Net Investment
Greater Net Savings or return	Greater Net Savings or return

The theme is greater net savings or return is good, as is lower net investment costs. How much of all this is already covered by Net Present Value (NPV)? As noted above, NPV is calculated by ECONPACK over the POA, where benefits and terminal value are subtracted from total costs resulting in net costs for each alternative that. Total costs include non-recurring investment costs as well as recurring energy and sustainment costs. In general, NPV reflects the overall cost of meeting the mission, for the POA.

SIR and ROI are economic indicators that measure the performance of the investment over the POA. SIR represents the net savings measured in terms of the number of times the investment pays

for itself. ROI represents the return of net investment with net savings after the net investment is reclaimed over the POA.

Unlike the other ECONPACK economic indicators, the ECONPACK DPP does not measure performance over the period of analysis. The DPP provides the length of time it will take to pay for the investment made. It is at the point where the SIR equals one.

In summary, NPV measures the cost to accomplish the mission requirements over the period of analysis. SIR and ROI measure the performance of the investment. DPP measures the length of time it takes for the investment to be "paid back", in either savings or other return.

The DON Economic Analysis Guide has additional metrics, indicators and factors that can be used in your analysis.

10. TREATMENT OF INFLATION

Inflation is a phenomenon that has frequently happened in the history of the United States. It represents a declining purchasing power of the dollar. That is, in the future more dollars likely will be needed to purchase the same product. NAVFAC primarily does constant dollar economic analyses where general inflation is not used nor applied. Differential inflation for special costs or benefits that are expected to vary above or below the general inflation rate are used and applied where appropriate. 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 (or less) they will cost. It is this uncertainty which complicates economic analysis and financial planning.

Cost estimation is complicated by a combination of circumstances. There is a time lag between cost estimation and actual expenditure. Costs and prices change over time.

When a period of increase in general price levels occurs, this condition is referred to as inflation. When a period of failing price levels occurs, 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 general inflation increases. Note that cost escalation is the price change in specific goods over a period of time whereas inflation and deflation are general changes in prices related to the money supply.

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. In practice, the treatment of inflation must be carefully addressed in two separate time periods:

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

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.

Leases

For the special case of a lease that does not adjust over the economic life, a current dollar economic analysis, Also Known As (AKA) an outlay dollar economic analyses, is conducted where inflation is applied as required. If the lease agreement does not adjust for inflation over the life of the lease, then inflation has already been built into the annual lease cost. Therefore, in order to provide a fair comparison, the other alternatives need to include inflation.

Nominal discount rates are larger than real ones because they include inflation. The start year is the first year that costs or benefits occur and is usually the program year. The base year is the year that all costs and benefits are discounted back to and cannot be greater than the start year. Normally all cost and benefits are placed in the start year and thereby the program year dollars. General inflation factors are found in the DOD Facility Pricing Guide, UFC 3-701-01.

10.1 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.

The Gross Domestic Product (GDP) Implicit Price Deflator is an example of a type of price index. 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). The GDP Price Deflator is calculated using the ratio of the nominal to real GDP. 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). Changes in this index are usually reported in the news media as changes to the "cost of living." The CPI represents prices paid by urban wage earners for a "market basket" of consumer items. Figure 10A shows the fluctuation in the annual rate of inflation as measured by the Consumer Price Index (CPI) urban inflation index. Most of the volatility occurred prior to 1983.

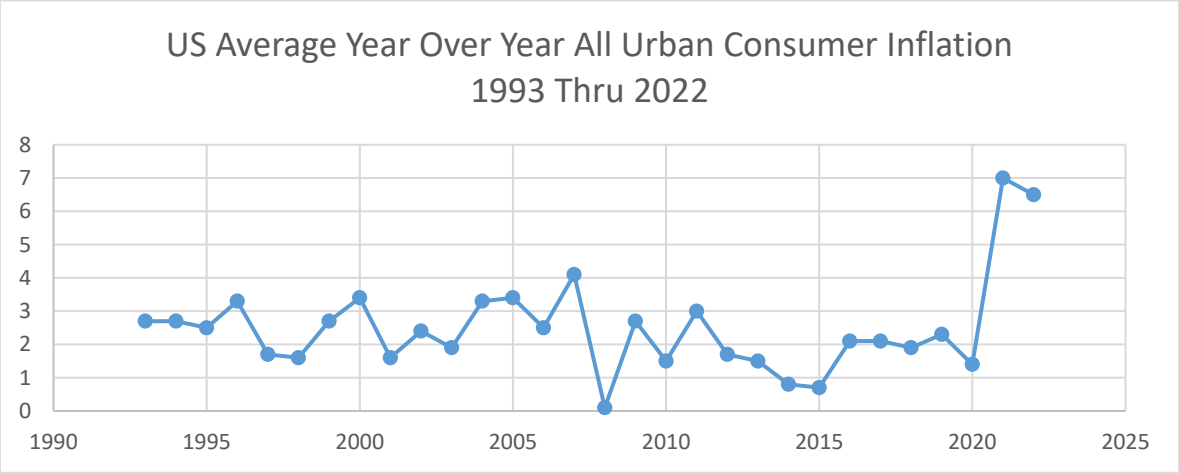


Figure 10A – CPI Urban Inflation

Figure 10B shows cumulative US inflation as measured by the CPI urban inflation index. Most of the increase occurred after the US abandoned the direct convertibility of the United States dollar to gold in 1971.

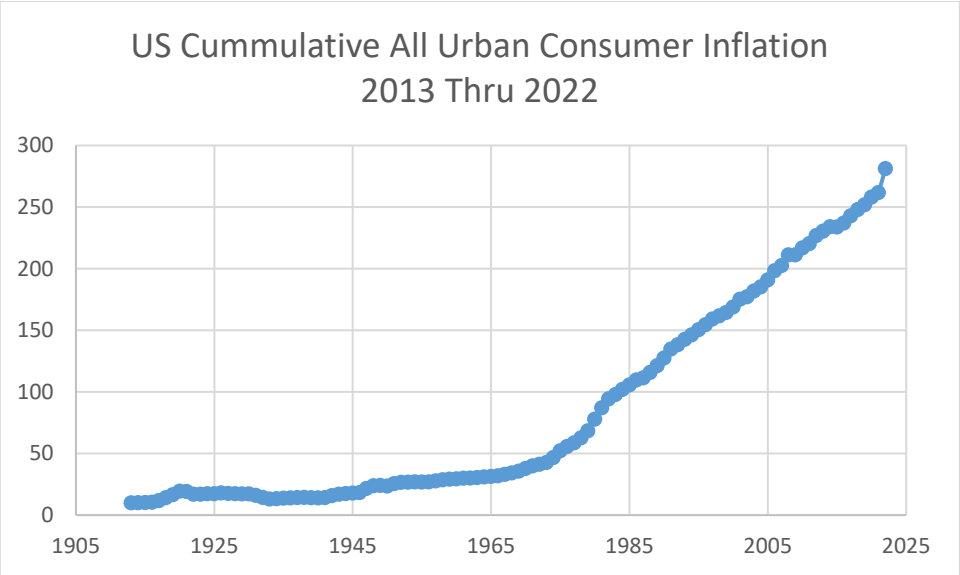


Figure 10B – Cumulative CPI Urban Inflation

Many other indices are compiled and published by the U.S. Government and by private organizations for various purposes. 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. NAVFAC publishes a monthly Construction Cost Index. Office of the Secretary of Defense (OSD) publishes yearly MILCON inflation indices and projected inflation rates.

10.2 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. The following provides the definitions of the two types of escalation and the use of those types in preparing cost estimates:

a. Near-term escalation is 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 before initial investment expenditure.

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.

The time periods defined above are diagrammed in the illustrative time profile of Figure 10C. 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 30 years (Project Years 3 through 32).

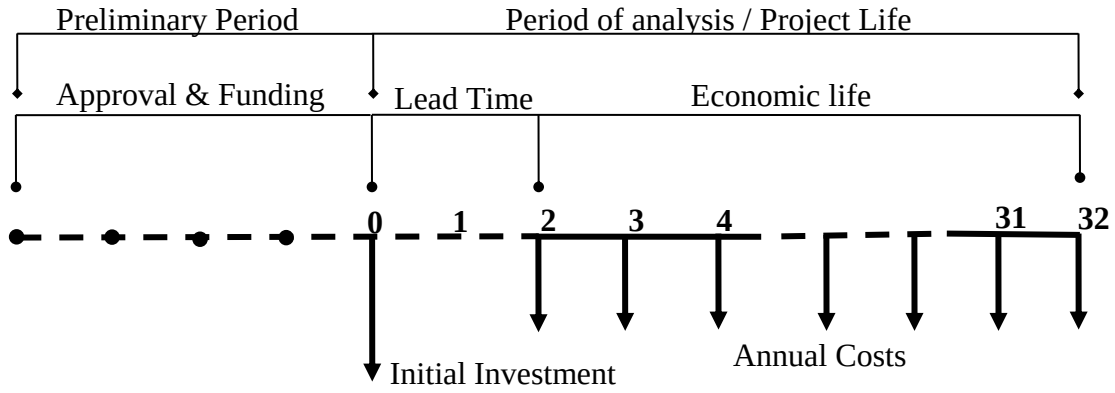


Figure 10C
General Cash Flow Diagram

The first task is to evaluate how inflation impacts escalation of the costs from the time of estimation to the zero point or base year. For most economic analyses, the base year is the point in time of initial investment, which is beneficial in it 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 – guidelines for Energy - Related Analyses.

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. Frequently historical cost data is utilized. 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. OSD CAPE, Cost Assessment and Program Evaluation regularly disseminate 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). The intended purpose is to provide escalation guidance for the preparation of the Program Objectives Memorandum (POM). NAVFAC Headquarters periodically disseminates construction cost escalation guidance to its Facilities Engineering Commands (FECs). The FECs may further refine these estimates by factoring in changes in construction costs within their respective geographical areas. This would be done by the Cost Engineers working in the Capital Improvements Business Line.

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. When available, specific local data may be used for a more realistic cost model. All sources should be explicitly documented.

Projections of cost escalation may take the form of either percentages or cost indices. Table 10A shows some hypothetical projections with examples to illustrate how to treat each case.

Table 10A
Hypothetical Near-Term Escalation Guidance
(20x1-20x4 Historical, 20x4-20x8 Projected)
Escalation Indices

FY	RDT&E	MILCON	O&M	SHIPS
20X1	78.65	77.15	78.22	78.23
20X2	85.41	84.56	85.34	85.89
20X3	92.42	92.34	92.25	92.94
20X4	100.00	100.00	100.00	100.00
20X5	107.70	107.60	107.80	107.30
20X6	115.45	115.35	115.36	116.10
20X7	122.96	122.96	122.84	124.11
20X8	129.72	130.34	129.60	132.67
	ANNUAL RATES (PERCENTAGES)			
20X1-20X2	8.4	9.6	9.1	9.8
20X2-20X3	8.2	9.2	8.1	8.2
20X3-20X4	8.2	8.3	8.4	7.6
20X4-20X5	7.7	7.6	7.8	7.3
20X5-20X6	7.2	7.2	7.0	8.2
20X6-20X7	6.5	6.6	6.4	6.9
20X7-20X8	5.5	6.0	5.5	6.9

********** EXAMPLE 10A BEGIN**********

Take FY 20x4 to be the present. Given the cost escalation percentage projections shown in Table 10A, escalate a construction cost estimate of $1.20M (FY 20x4 dollars) to the amount we would expect to have to fund in FY 19x8.

Solution: Using the Military Construction escalation percentage projection, the FY 20x4 estimate must be escalated 7.6% to produce a FY 20x5 estimate, which in turn must be escalated 7.2% to yield a FY 20x6 estimate, and so on. The final estimate is:

FY 20x8 estimate ($1.20)(1.076)(1.072)(1.066)(1.06) = $1.56.

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%) and understates the final result of $1.56M.The following calculation shows the difference:

($1.20M)(1.274) = $1.53M

********** EXAMPLE 10A 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, is escalated for n years as follows:

$$C_n = C_0 (1 + X)^n \qquad (20.1)$$

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

********** EXAMPLE 10B **********

Use MILCON column of the Table 10A to escalate a FY 20x4 construction cost estimate of $1.20M to the anticipated amount which will have to be paid in FY 20x7.

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 20x4 will cost $12.296 to build in FY 20x7. The difference is due solely to the expected construction cost escalation between FY20x4 and FY20x7.

Solution: The FY 20x7 construction cost estimate is:

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

The index values of 122.96 for FY 20x7 and 100.00 for FY 20x4 correspond to the percentage projections of Table 10A, since:

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

********** EXAMPLE 10B END **********

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

********** EXAMPLE 10C**********

Again, taking FY 20x4 as the present, escalate a ship acquisition estimate of $250M in FY 20x2 dollars to the current budget year.

Solution 6C: Using the Ships index of Table 10A,

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

********** EXAMPLE 10C 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.

10.3 Treatment of Inflation During the Project Life

The straightforward escalation techniques described in Section 10.2 cannot be directly applied to costs during the entire project life. The reasons are twofold:

1. Inflation guidance typically extends only a few years into the future. The UFC 3-701-01, DOD Facilities Pricing Guide provides inflation rate guidance for economic analyses. The general inflation rate can be approximated by subtracting the real interest rate from the nominal interest 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" (value at the beginning of year one) 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 (normally the beginning of each calendar year). The following provides the website for obtaining that information.

http://www.whitehouse.gov/omb/circulars/a094/a094.html

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 consistent 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 10D **********

Consider a proposed project with the costs shown in Figure 10D. The $1M and $100K are costs estimated in constant dollars, but the annual recurring maintenance cost is estimated to inflate at 3% each year. For this analysis, use 2015 as the base year.

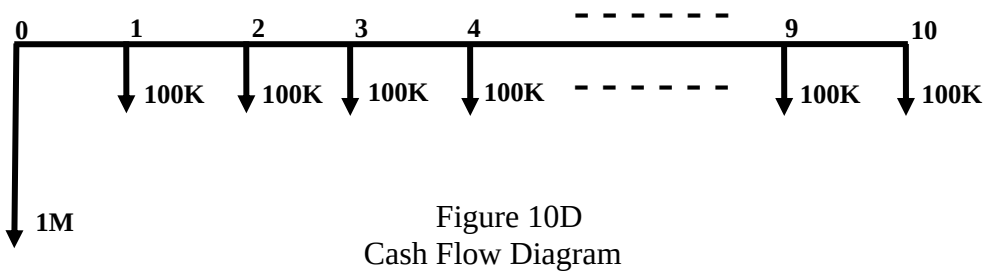


Figure 10D
Cash Flow Diagram

Current Discount Rates:

For a 10-year period analysis the OMB nominal rate is 2.0% and the real discount rate is 0.1% (i.e. one tenth of one percent) resulting in an estimate of inflation over the next 10 years of about 1.02/1.001-1 = 0.018981 or 1.8981%.

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 can be conducted. Therefore, as shown in

Table 10B below, the annual recurring cost first have to be inflated to outlay dollar cash flows and then discounted at the 2.0% nominal discount rate currently prescribed by OMB Circular A-94.

Table 10B
Outlay Dollar Cash Flow

NUMBER OF YEARS	FISCAL YEAR	INFLATION FACTOR	TOTAL INVEST	RECURRING MAINTENANCE	TOTAL OUTLAYS	DISCOUNT FACTOR 2.0%	PRESENT VALUE	CUMMULATIVE NPV
0	2015	1.00000	$1,000,000	$100,000	$1,100,000	1	$1,100,000	$1,100,000
1	2016	1.03000		103,000	$103,000	0.980392157	$100,980	$1,200,980
2	2017	1.06090		106,090	$106,090	0.961168781	$101,970	$1,302,951
3	2018	1.09273		109,273	$109,273	0.942322335	$102,970	$1,405,921
4	2019	1.12551		112,551	$112,551	0.923845426	$103,980	$1,509,901
5	2020	1.15927		115,927	$115,927	0.90573081	$104,999	$1,614,900
6	2021	1.19405		119,405	$119,405	0.887971382	$106,028	$1,720,928
7	2022	1.22987		122,987	$122,987	0.870560179	$107,068	$1,827,996
8	2023	1.26677		126,677	$126,677	0.853490371	$108,118	$1,936,113
9	2024	1.30477		130,477	$130,477	0.836755266	$109,178	$2,045,291
10	2025	1.34392		134,392	$134,392	0.8203483	$110,248	$2,155,539

Constant Dollar Analysis:

Another option that is equally as valid is to conduct a constant dollar analysis and apply real discounting over the period of analysis. The recurring maintenance cost would have a differential inflation factor applied to account for the fact that the rate of increase for recurring maintenance is expected to be different that the 1.8981% 10-year inflation derived from the nominal and real 10-year discount rates. Recurring maintenance differential inflation = 1.03/1.018981 - 1=1.0813744 To verify this result multiply the 10-year derived inflation rate by the new differential escalation rate and the result is the nominal inflation for recurring maintenance or 1.018981 x 1.0108137 – 1 = 1.03-1=.03 or 3%. NPV results are identical except for potential rounding error.

NUMBER OF YEARS	FISCAL YEAR	INFLATION FACTOR	TOTAL INVEST	RECURRING MAINTENANCE	TOTAL OUTLAYS	DISCOUNT FACTOR 0.1%	PRESENT VALUE	CUMMULATIVE NPV
0	2015	1.00000	$1,000,000	$100,000	$1,100,000	1	$1,100,000	$1,100,000
1	2016	1.01081		101,081	$101,081	0.999000999	$100,980	$1,200,980
2	2017	1.02174		102,174	$102,174	0.998002996	$101,970	$1,302,951
3	2018	1.03279		103,279	$103,279	0.99700599	$102,970	$1,405,921
4	2019	1.04396		104,396	$104,396	0.99600998	$103,980	$1,509,900
5	2020	1.05525		105,525	$105,525	0.995014965	$104,999	$1,614,899
6	2021	1.06666		106,666	$106,666	0.994020944	$106,028	$1,720,928
7	2022	1.07820		107,820	$107,820	0.993027916	$107,068	$1,827,996
8	2023	1.08986		108,986	$108,986	0.99203588	$108,118	$1,936,113
9	2024	1.10164		110,164	$110,164	0.991044835	$109,178	$2,045,291
10	2025	1.11355		111,355	$111,355	0.990054781	$110,248	$2,155,539

If the projected inflation rate of 2.2% (used for reference only) was expected instead of 3%, the results would be slightly different. Using constant dollar estimates at the 2015 prescribed discount rate of 4.5% could be used and the net present value (NPV) would be calculated in constant dollars as by using the cumulative uniform series discount factor.

$$NPV = \$1,100,000 + \$100,000\ (7.913) = \$1,891,272$$

This (except for rounding) would result in the same answer when the inflation rate of 2.2% is used in Column 3 of Table 9B instead of using the 3% inflation rate.

********** EXAMPLE 10D 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.

10.4 OUTLAY DOLLAR ANALYSES

As seen from example 10D, 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. This type of analysis 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 over a period of analysis of 30 years or more will use the OMB prescribed 30-year term nominal or real discount rates. The current 30-year nominal discount rate is 3.0 % and the real rate is 1.1% until December 2013, per OMB curricular A-94.

10.5 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. 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 approximately the real rate of return. The real rate of return is approximately the nominal rate of return minus inflation. The formula for calculating the nominal rate of return is:

$$\text{Nominal Rate} = [(1+i) \times (1+n) - 1] \qquad (10.2)$$

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

For example: The 2013 OMB Circular A-94, the real rate for a 30 year term is
i = 1.1% and n = 1.87933% Then:
Nominal Rate, n = [(l + 0.011) x (1 + 0.0187933) -l] = (1.011) x (1.0187933) -1
= 0.03 or 3.0%

NOTE: Example 10D 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.

10.6 INFLATION KEY POINTS

Use of the real discount rate and constant dollars simplifies the treatment of inflation in an economic analysis because inflation is removed from the discount rate as well as the costs and benefits. 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. For reduced effort the base year is set to the year most cost estimates are already in.

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 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; e.g. maintenance costs may increase with the age of a physical asset or periodic maintenance costs may be incurred. Actual 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. Use of 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 or lease-purchase alternatives with outlay dollar or nominal cash flows, always use nominal discount rates in accordance with OMB Circular A-94 guidance.

9. Indexes to adjust energy costs are referenced in Appendix E, Guidelines for Energy – Related Analyses.

11. SENSITIVITY ANALYSIS

> 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.

Since uncertainty is almost universally present in economic decision-making, some type of sensitivity analysis should always be considered when performing an economic analysis. A sensitivity analysis measures the relative magnitude of change in one or more elements of an economic comparison by exploring the impact of variance (sensitivity) of cost estimates and assumptions made to determine whether their variance would impact the selected COA. Note that the lowest cost alternative is not always the recommended COA due to the impact of non-monetary considerations. The sensitivity of a decision is investigated by inserting a range of estimates for critical elements. Additionally a sensitivity analysis may be used to evaluate the impact of the duration of the analysis period on the ranking of alternatives by NPV. The way Sensitivity analysis works is that the estimated value of a benefit, cost, or an assumption is varied to see it has an impact on the ranking of alternatives by net present value (NPV). Period of Analysis (POA) Sensitivity falls under the assumption category.

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.

An example of risk analysis is Monte Carlo simulation. When probability distributions of variables are known or can be easily derived a Monte Carlo simulation is used to simulate real life by using the distributions to replicate naturally occurring variation. If the probabilities of events are not capable of being defined given the limited available resources of time and money then these events are referred to as uncertain events.

In preceding sections, examples involved choosing among alternatives in which a single set of cost estimates were specified based on 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. These costs 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).

This is important because the ranking of alternatives might be different if the element (cost item) being considered is sensitive or may not matter at all if the element is insensitive. 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.

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

1. Which input(s) should be tested?
2. 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, concern about sensitivity of this choice is low. It is when an economic choice is not the clear "put in front" decision that further investigation is most appropriate and sensitivity analysis is strongly recommended.

The application of sensitivity analysis is recommended as an iterative process to refine the analysis. Illustration of the rationale and basic techniques most commonly applied in sensitivity analysis are provided in the below sections.

11.1 ONE VARIABLE UNCERTAINTY TESTS

A one variable uncertainty test is a sensitivity analysis of one of the variables being considered to show the NPV impact on the alternative. Examples of variables that could be considered are alternative expenses, benefits, terminal value, the discount rate used, and the period of analysis used. Good candidates for one variable uncertainty tests are those factors or estimates that have a large impact on NPV as well as those factors or estimates that have uncertainty in their estimated values.

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 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 11A below.

********** EXAMPLE 11A Operation Power Plant BEGIN**********

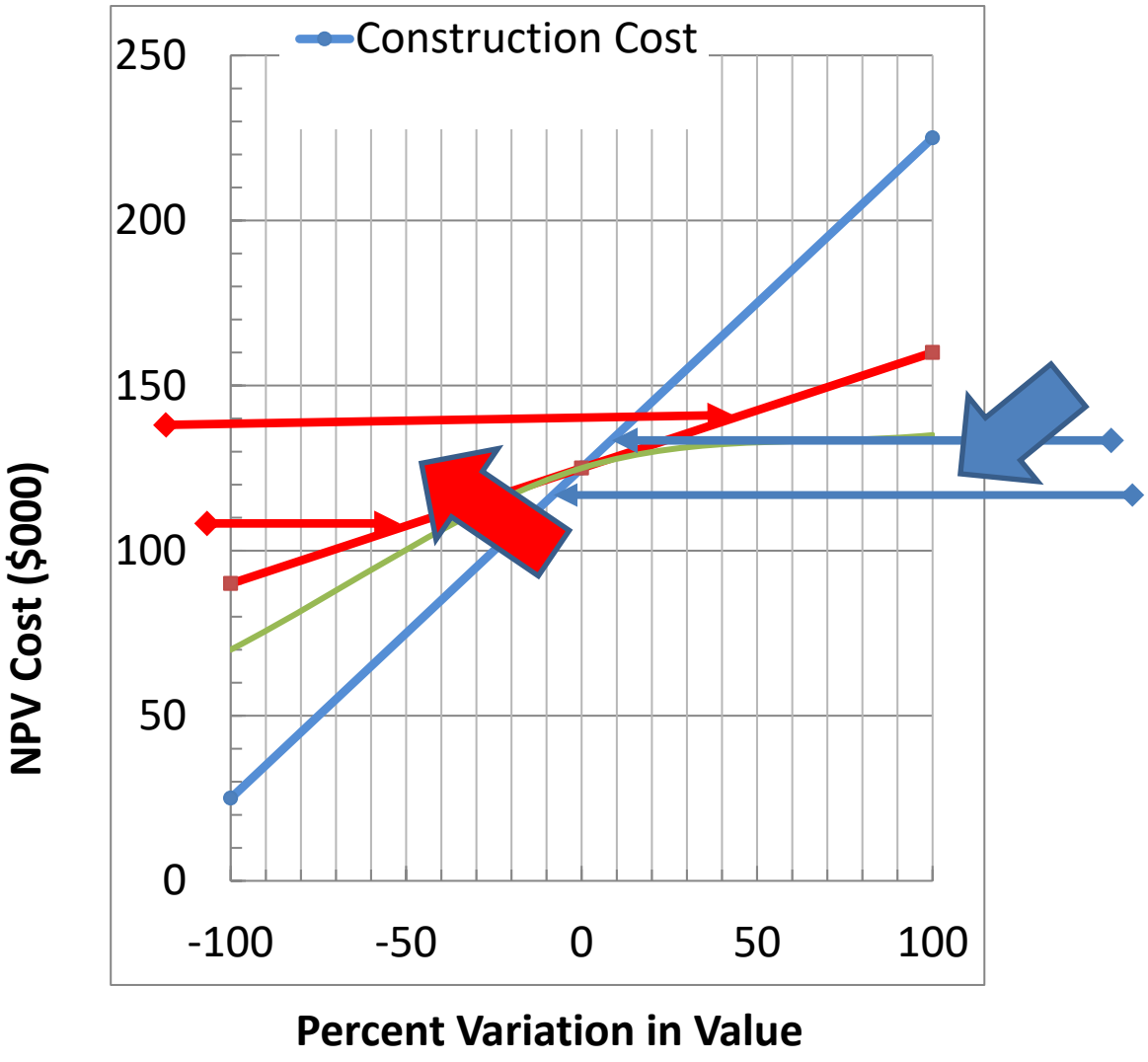
Uncertainty Analysis - Alternative B is plotted as a function of varying levels of inputs, shown in Figure 11A. The inputs specifically considered are initial construction (acquisition) cost, recurring annual cost, and project life, for which the original values were $125M, $7M, and 28 years, respectively. 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 11A:

1. Note that the NPV cost, when plotted in figure 11A as a function of construction cost, yields the steepest of the three curves. In general the steeper the curve, the more dominant the corresponding input variable. Experience with sensitivity analysis will lead to quick identification of the most dominant variables without actually plotting curves.

Construction cost is not necessarily the most critical input variable in this example. Suppose 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 11A 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).



While total NPV life cycle cost is a linear function of construction cost and annual cost, it is a nonlinear function of economic (project) life. This is because of the diminishing trend of discount factors as we proceed further into the future. Due to the slope of the curve, economic life is more dominant than annual recurring cost in the approximate range -100% to -50% (0-14 years), and less dominant thereafter (because the curve is less steep). In fact, the curve tends to a horizontal line as it proceeds to the right, as can be seen in Figure 11A.

It should be further noted from Figure 11A that increasing the economic life has only slight impact on the total NPV life cycle cost. This situation is due to the unusually high interest rate of 10% that was used in this analysis. The most recent real interest rate for 2021 is -0.3%. An interest rate this low would likely cause the length of the period of analysis to have a significant impact on results of analyses when there are significantly different recurring costs or one-time costs in the out years. Enabled by the bond buying program of the Federal Reserve new treasury interest rates fell once again resulting in the 30 year discount rate declining to 1.1% as shown in Figure 11A the same graph shown in Figure 8A, repeated here for continuity.

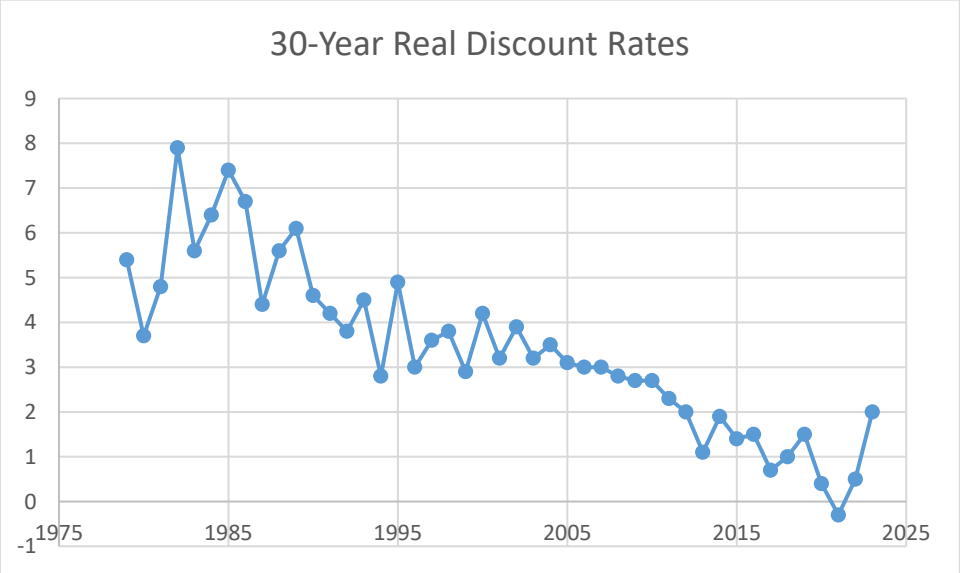


Figure 11A - 30-Year Real Interest Rates

Low interest rates means that the out years count more. At the peak in 1982 when the Federal Reserve was battling inflation the Real 30 Year Discount Rate was 7.9%.

In certain locations the mission life of the asset is the constraining factor and in other cases due to obsolescence or changing criteria, technological life may be a constraining factor also. ECONPACK automatically calculates a discount rate sensitivity analysis from 1% to 10% and has a module for conducting cost sensitivity analyses (CSAs). Note that to conduct a period of analysis sensitivity analysis in ECONPACK a copy of the original economic analysis is saved to a new economic analysis name. Then the period of analysis, costs, and benefits are adjusted. The results of the new period of analysis sensitivity analysis are subsequently added to the original economic

analysis.

********** EXAMPLE 11A END**********

11.2 BREAK-EVEN ANALYSIS

Break-even analysis is useful in economic analysis when uncertainty is concentrated in only one aspect that is forecasted. 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 two alternative courses of action and solving for the unknown variable. Repeat this process if there are more than two alternatives for the ranking of break-even points. In ECONPACK, the cash flow tables can be used to identify the break-even point. ECONPACK does the calculations and provides the results in a table format.

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 11B: Operation COMPARE **********

Problem: For the MILCON and LEASE options diagrammed in Figure 11B 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.

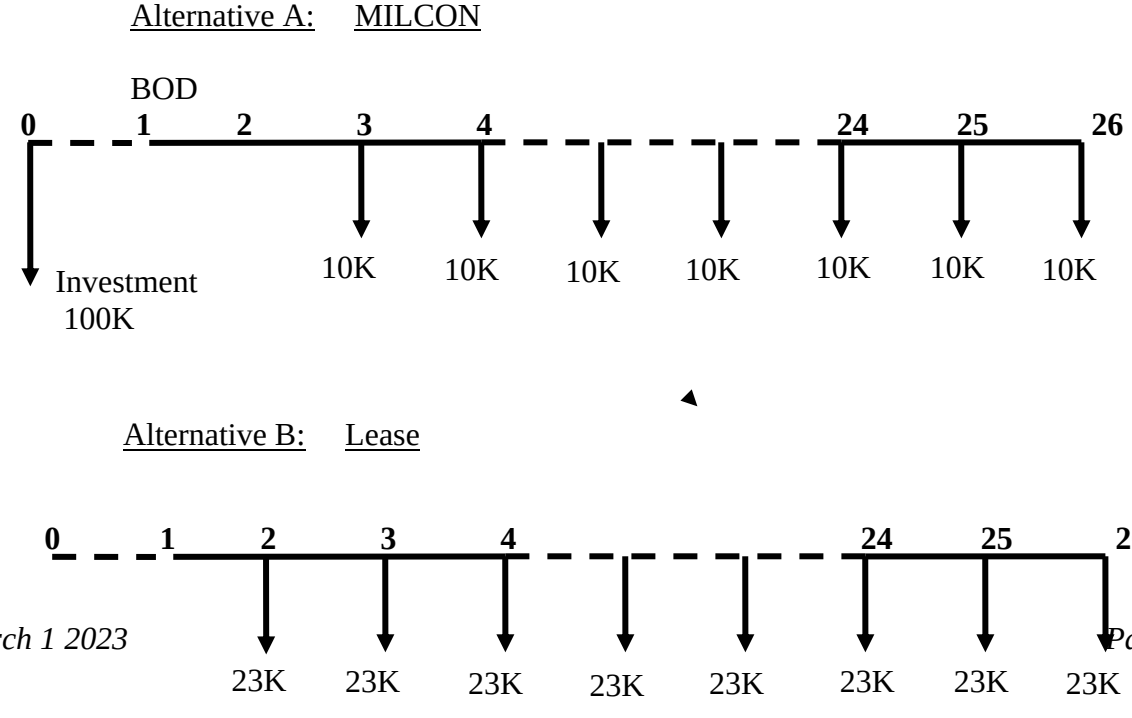


Figure 11B - Cash Flow Diagrams for Example 11B Operation Compare

Discussion for example 11B: The cash-flow diagrams of Figure 11B show the treatment of lead time for both the MILCON and the lease. The presumption in the MILCON alternative is that a year will elapse between obligation of construction funds and the facility's beneficial occupancy date (BOD). Accordingly, the baseline in this case is when the investment dollars are spent and a full year intervenes before recurring annual costs begin (i = 10%). For example 11B, 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. If the facility was needed right away, it might well be possible to negotiate a lease for occupancy during the first year resulting in a lease during the first year in both alternatives. These leases however, would cancel each other out and result in a wash.

Solution 11B: Total NPV costs for the two alternatives are as follows (9.161 and 0.909 are the 26th and 1st-year cumulative discount factors, respectively, taken from Table B, Appendix D):

NPV (MILCON) = $100K (1.000) + $l0K (9.161-0.909) = 1825K
NPV (LEASE) = $23K (9.161 - 0.909) = $23K (8.252) = $189.8K

One method of estimating the break-even economic life is to adopt a graphical approach as shown in figure 11C. To do this, plot the results of solving the NPV equation for multiple economic lives as presented below using different economic lives:

20-YEAR ECONOMIC LIFE
NPV (MILCON) = $100K (1.000) + $10K (8.649 - 0.909) = $177.4K
NPV (LEASE) = $23K (8.649 - 0.909) = $23K (7.740) = $178.0K

15-YEAR ECONOMIC LIFE
NPV (MILCON) = $100K (1.000) + $l0K (7.824 - 0.909) = $169.2K
NPV (LEASE) = $23K (7.824 - 0.909) = $23K (6.915) = $159.0K

10 -YEAR ECONOMIC LIFE
NPV (MILCON) = $100K (1.000) + $10K (6.495 - 0.909) = $155.9K
NPV (LEASE) = $23K (6.495 - 0.909) = $23K (5.586) = $128.5K

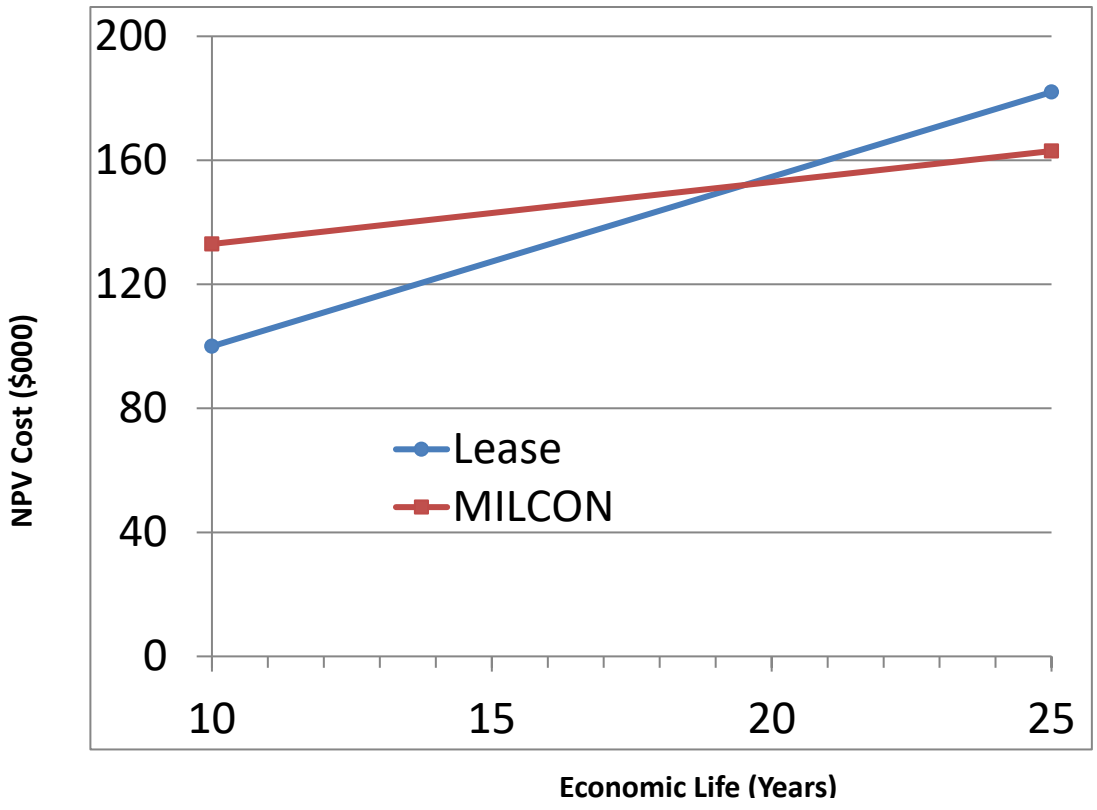


Figure 11C - Graph for Example 11B

Observe that the economic decision changes (i.e., break-even point occurs) somewhere between 15 and 20 years using the equations. When the cost points for each alternative are plotted and a line is drawn, the impact of economic life can readily be diagnosed. The figure shows the break-even period is approximately 19.6 years.

Discussion for example 11B: 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 there must be an 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 D), respectively. Substituting $B_1 = 0.909$ and solving for B_N yields:

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

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

$B_N - 0.909 = \$100K/\$13K = 7.692$

$$B_N = 7.692 + 0.909 = 8.601$$

Now from Table B, Appendix D,

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

Thus, the project life N is between 20 and 21 years. On the basis of a linear interpolation between these two factors, the approximation value of N is 20.6 years:

Subtracting the one-year lead time from 20.6 results in 19.6 years, which aligns with the graphical estimate of economic life in Figure 11C.

********** EXAMPLE 11B END**********

The graph in Figure 11C is a logical sequel to a dominance test represented by the graph shown in Figure 11A. Figure 11A examines the sensitivity of a single alternative to variations in several inputs. In Figure 11C, 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 11C 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 8C, then MILCON is preferable to the Lease alternative. However, the general climate of base closures and troop strength reductions might 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, leasing might be considered a better solution to a MILCON. Another application of break-even analysis, to verify a benefit/cost ratio with uncertain annual cost, is provided in Example 11C, below.

**********EXAMPLE 11C: Operation NAS: Break-Even Analysis BEGIN**********

Problem: Perform a sensitivity analysis of the recurring-annual total cost for the NEW-CONSTRUCT Alternative of Example 6C, and determine the break-even point.

Solution 11C: 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 (Beginning of Year 1) ……..... $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:

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

Which leads to the following benefit/cost ratio:

$$BCR_{NC} = \frac{ABOM_{NC}}{UAC_{NC}} = \frac{\$375}{\$286.4K + Y} \qquad \text{(MAINT Jobs/YR/\$1000 UAC)}$$

Table 11A

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 11D.

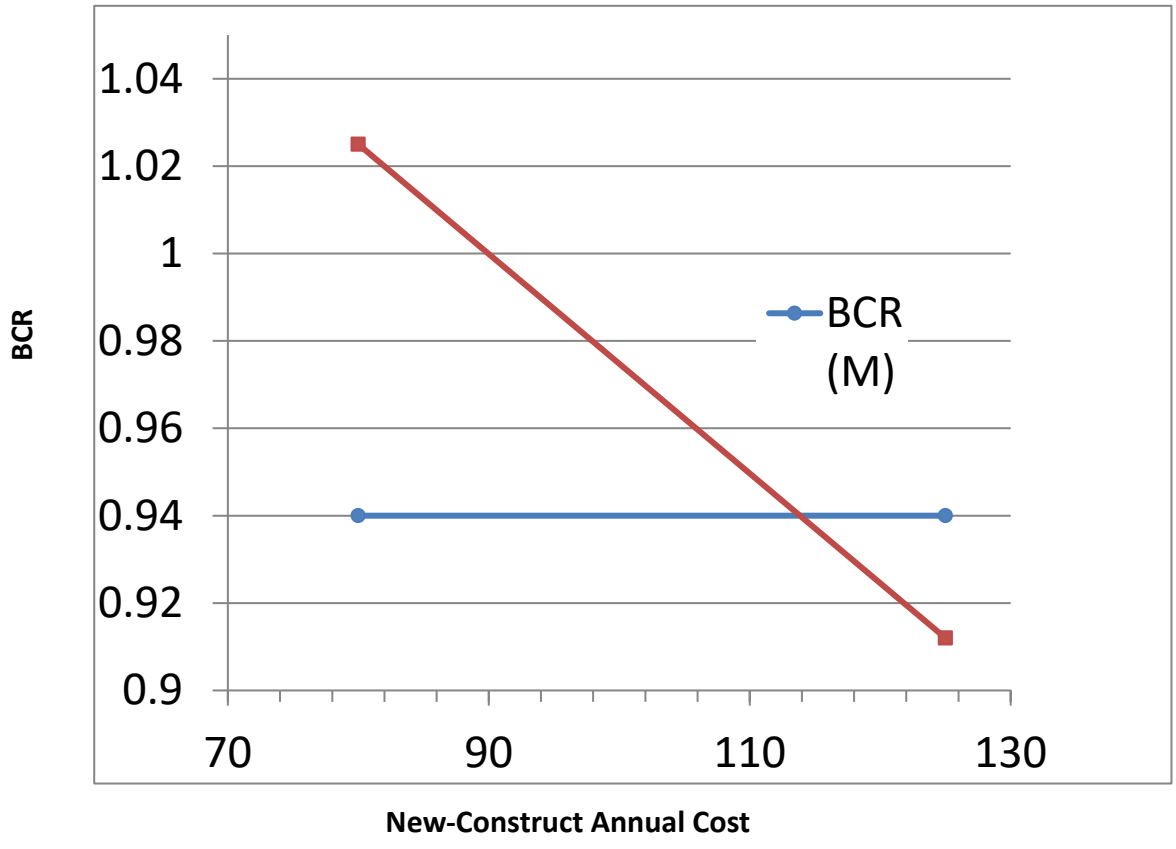


Figure 11D - Example 11C Graph

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 8C END **********

11.3 TWO VARIABLE UNCERTAINTY TESTS

Two variable uncertainty tests are the same as one variable uncertainty tests except that two variables are varied rather than one variable. 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.

*********EXAMPLE 11D: Operation COMPARE: Testing PV Life cycle Cost BEGIN *******

Problem: Test the sensitivity of the PV life cycle MILCON cost of Example 11B to simultaneous variations in annual O&M costs and acquisition cost.

Solution 11D: 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 11B). Figure 11D 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 NPV 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.

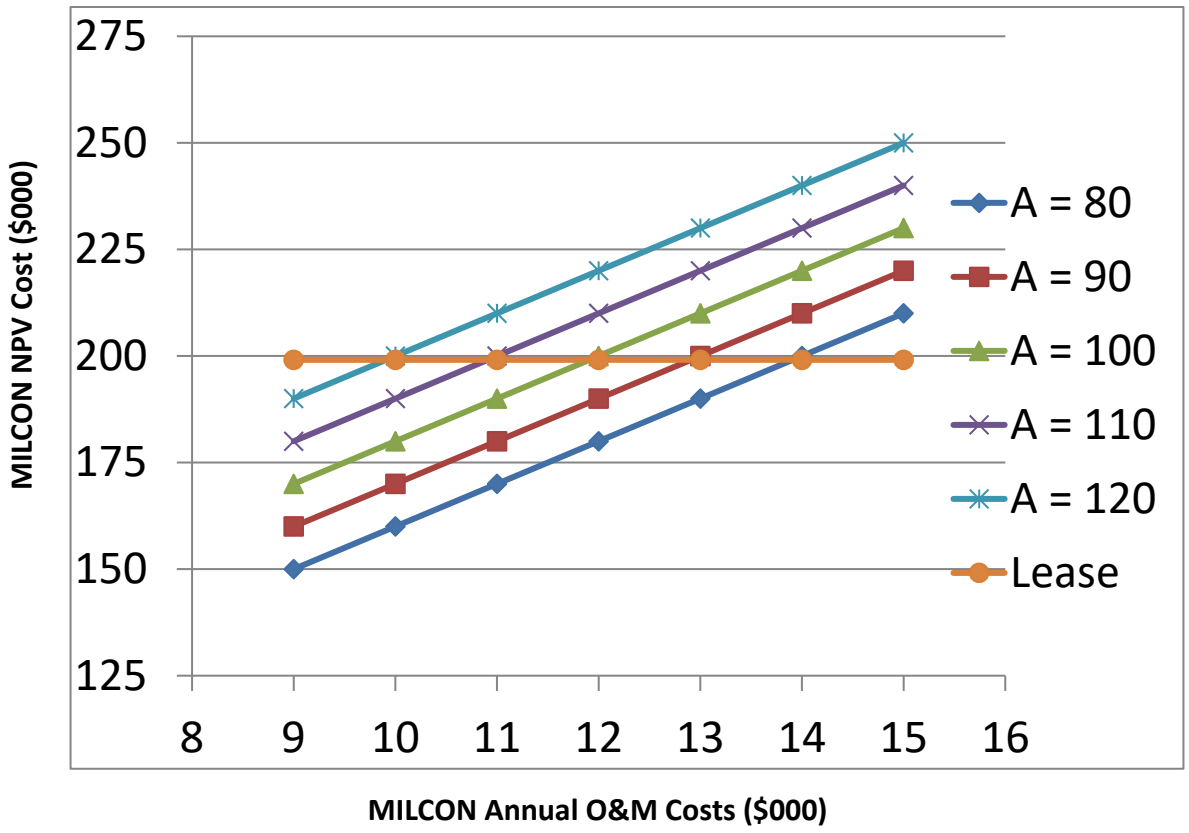


Figure 11E - Graph Example 11D

********** EXAMPLE 11D END**********

****** EXAMPLE 11E: Operation COMPARE: Bivariate Break-even Analysis BEGIN*******

Problem: Recurring O&M breakeven points are calculated for different economic lives to better understand the effect of variation in MILCON O&M and Economic Life on the ranking of alternatives. Determined which combinations of economic life and MILCON annual costs equate total NPV life-cycle costs of the MILCON and LEASE alternatives. Use a 10% interest rate.

Solution 8E: The calculations in Example 11D 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-Y EAR 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 = $5.1 K (break-even)

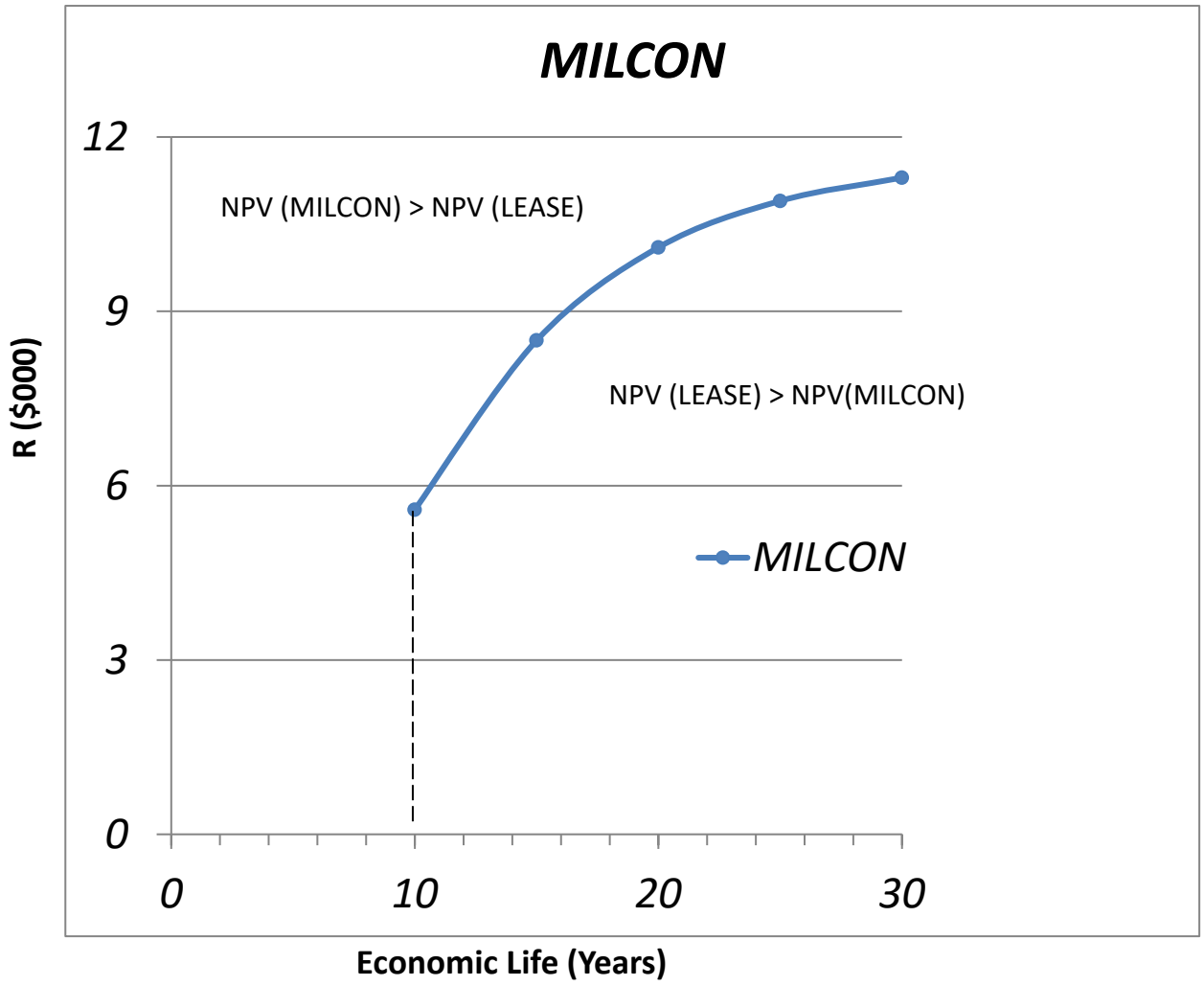


Figure 11F - Graph for Example 11E

Discussion for example 11E: These break-even combinations are graphed in Figure 11E, 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 11D).

The break-even curve of Figure 11E 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 11D: economic life 25 years and R = $10K). In the clear region, the Lease alternative is economically preferable to the MILCON alterative. 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).

********** EXAMPLE 11E END **********

11.4 EXPECTED VALUE

Expected value is a probabilistic technique that can be applied when there is an estimate of the relative frequency of an expected outcome. This happens when quantitative information about the probabilities of various possible outcomes of an alternative is known; 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. 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

$$E= P_1W_1 + P_2W_2 + P_3W_3 + \ldots .+ P_nW_n \qquad (11.1)$$

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

$$E = \sum_{i=1}^{n} P_iW_i \qquad (11.2)$$

********** EXAMPLE 11F: Operation WIDGET: Expected Value Analysis BEGIN *******

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 11F:

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 11.1 as:

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

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

$$= \$13,500$$

The expected NPV is then

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

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

$$= \$58,384$$

The above example is very simplistic, but, it is intended to show how risk may be integrated into the present value calculations of an economic analysis. In an actual case, more than three discrete outcomes might 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.

********** EXAMPLE 11F END **********

11.5 RISK ANALYSIS AND MONTE CARLO SIMULATION

NOTE: This section includes advanced analysis techniques. Beginners my wish to skip this section and come back to it at a later time.

Monte Carlo Simulation assigns probabilities to events like when costs and benefits will occur or the range of expected prices and uses random numbers to simulate numerous outcomes that represent the range of possible price outcomes. Frequently, information is desired about the distribution of possible outcomes and their probabilities, in addition to the expected value of the outcome. For Example 11F of the previous section, the probability distribution of NPV outcomes is illustrated in the histogram of Figure 11F below.

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

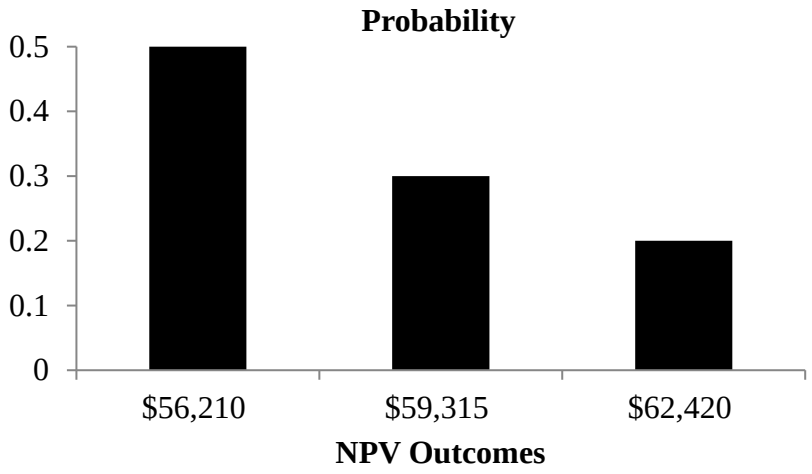


Figure 11G - Histogram

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 8G 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.

******* **EXAMPLE 11G: Operation WIDGET: Tree Diagram Analysis BEGIN**********

Problem: Suppose that in Example 11F 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;
- 0.45 probability that it will occur in Project Year 5; and
- 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 11G: 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. Figure 11G provides an example of a tree diagram and illustrates the nine possible outcome combinations of replacement years and replacement costs.

Discussion example 11G: 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 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 11H. By choosing probabilistic variable values based on these numbers, numerous trials may be simulated to develop an NPV distribution shown in the Figure 11J of Example 11H.

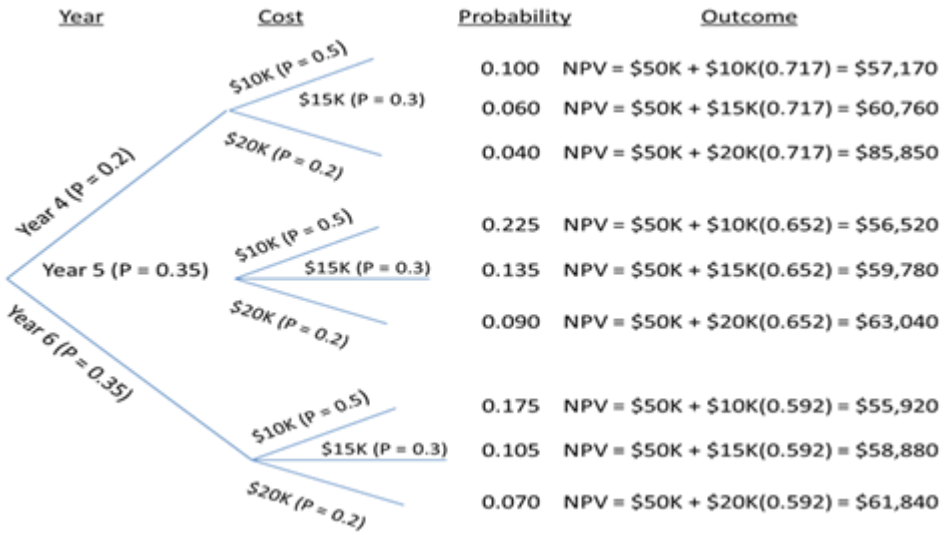


Figure 11H - Solution Tree Diagram

**********EXAMPLE 11G END **********

********** EXAMPLE 11H: Operation WIDGET: Monte Carlo Simulation BEGIN**********

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 11B. From these numerous cases, the expected NPV and the probability distribution of NPV can be derived.

0.6586981	0.2764985	0.5915404	0.8117824
0.9912896	0.2662945	0.350274	0.9901294
0.1044488	0.5353827	0.1681695	0.9889206
0.1209406	0.4005491	0.4326702	0.9063801
0.4909244	0.3301436	0.9970039	0.8068309
0.6286292	0.2874193	0.8983667	0.4329718
0.826918	0.1889196	0.3961346	0.0249106
0.5041863	0.189748	0.8332781	0.4957992
0.7226741	0.3652897	0.7059854	0.6669547
0.9033188	0.1486475	0.9588762	0.3975829
0.5659607	0.0004983	0.4920538	0.5669817
0.0417322	0.2402017	0.2494107	0.4128566
0.5844272	0.2450516	0.3609458	0.0499052
0.4883661	0.9017122	0.453679	0.0125333
0.1080165	0.8412387	0.358884	0.9740202
0.2673369	0.3114369	0.6508867	0.6500631
0.4963877	0.105826	0.4251126	0.8801052

Table 11B - Random Numbers
Uniformly Distributed Between Zero and One

Monte Carlo risk analysis involves numerous repetitions of a procedure. Due to the repetitive nature of this analysis it is more appropriate to perform on a computer rather than 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 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 11H 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.

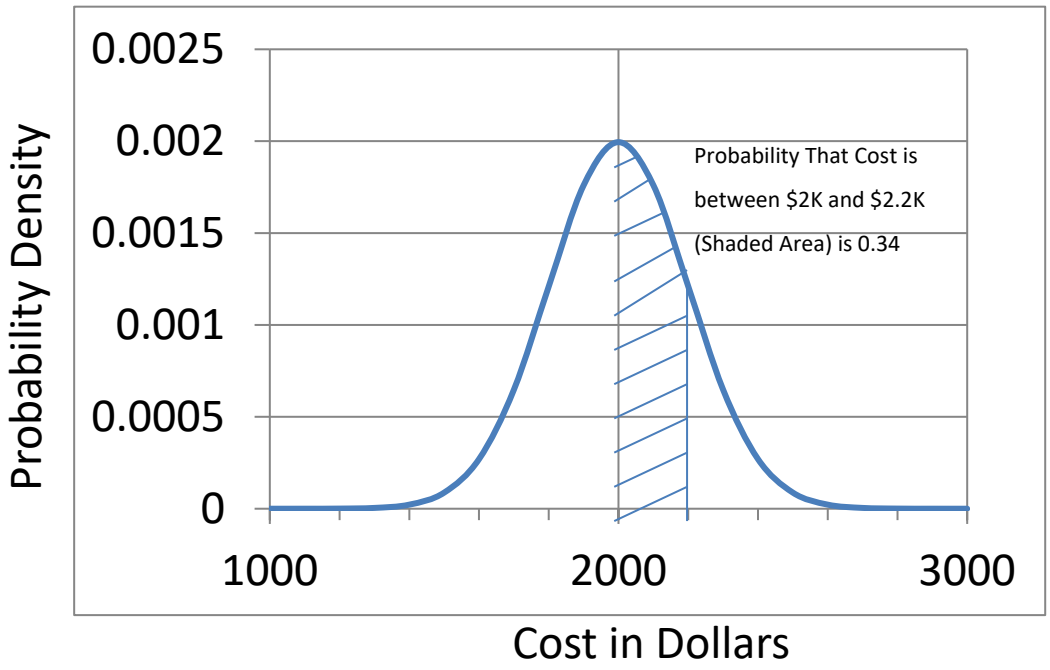


Figure 11I - Graph for Example 11H

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 11I 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.

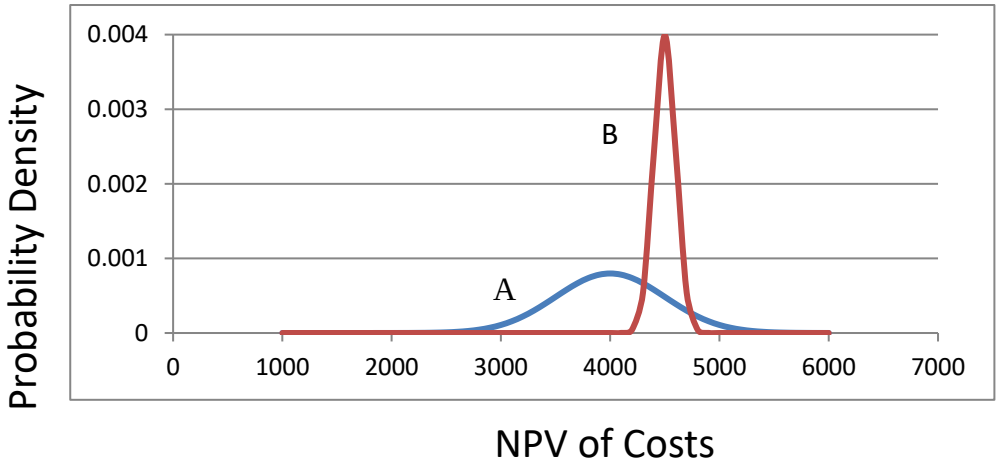


Figure 11J, Graph for Example 11H

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 11J indicates that there is a 40% probability that the Alternative A NPV will be less than or equal to $3,900.

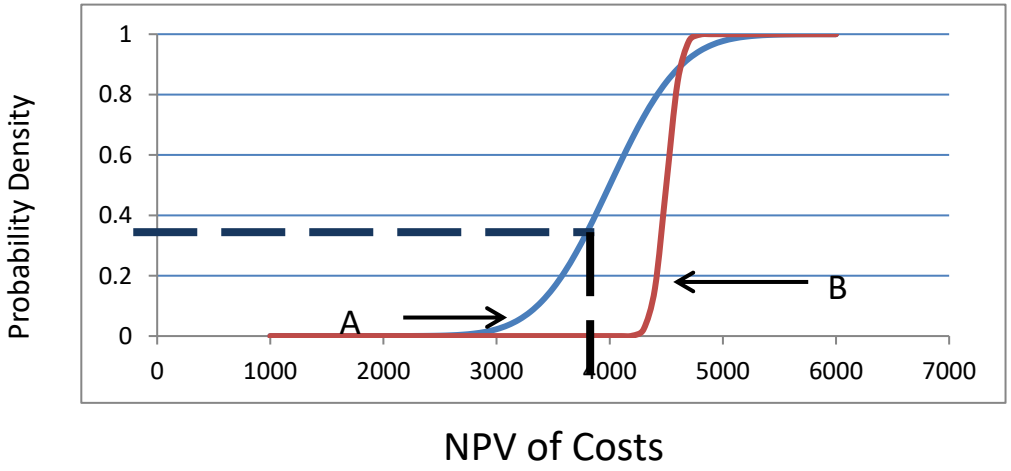


Figure 11K - Graph for Example 11H

The narrative here is intended to acquaint you with basic concepts and convey the basic elements of risk analysis. For in-depth information, refer to the reference works on probability, statistics, and risk analysis listed in Appendix H, the bibliography.

********** EXAMPLE 8H END **********

11.6 Period of Analysis Sensitivity

The last sensitivity analysis that should be considered is the Period of Analysis (POA). What happens if the POA is lengthened or shortened? If it were possible to extend recurring savings over a longer period of time, it might impact the selection of the least cost alternative. In the following example, the period of the analysis was increased to 50 years from 30 years. When using ECONPACK, an analysis can be copied to preserve the original to allow for POA sensitivity by increasing or reducing the POA. The results can then be presented as a comparison in the final economic analysis.

Table 11C shows the impact of extending the period of analysis to 50 years. Ongoing costs and benefits are accrued beyond the initial 30 year period. Underestimating the economic life is a problem as well as overestimating the economic life. The POA is an estimate. Variations in the estimate may have a significant impact on the ranking of alternatives based on NPV. Table 11C is an example POA sensitivity analysis where the recurring savings of one alternative over another is allowed to continue for another 20 years because the estimate of a 30 year economic life may be understating the actual economic life that will be occurring in the future.

Economic Analysis A				Economic Analysis B		
Discount Rate =	1.1%					
	Differential				Differential	
	Recurring	Discounted			Recurring	Discounted
Year	Cost	Cost		Year	Cost	Cost
1	100,000	98,912		1	100,000	98,912
2	100,000	97,836		2	100,000	97,836
3	100,000	96,771		3	100,000	96,771
4	100,000	95,718		4	100,000	95,718
5	100,000	94,677		5	100,000	94,677
	Break	Break			Break	Break
29	100,000	72,814		29	100,000	72,814
30	100,000	72,022		30	100,000	72,022
31	100,000	71,238			Total	$2,543,452
32	100,000	70,463				
33	100,000	69,697				
	Break	Break				
48	100,000	59,149				
49	100,000	58,505	Net Increase in Differential Costs			$1,286,684
50	100,000	57,868				
	Total	$3,830,136				

Table 11C – Period of Analysis Sensitivity Analysis

12. Navy ECONPACK Guide

ECONPACK is the economic analysis software standard for conducting facility related economic analyses by the Navy, Army, and NASA. It is a self-contained package that includes modules for entering text as well as economic analysis data such as costs, benefits and residual values. There are fields for entering parameters as well as general information related to the project being evaluated. The ECONPACK output consists of a well-organized report with economic indicators, charts, costs, benefits, and sensitivity analyses.

12.1 **ECONPACK Java Version**

The Java software platform allows applications like ECONPACK to be installed and run on computer operating systems without requiring administrative rights.

Computer Requirements

Typical Navy computers have the minimum computer requirements for ECONPACK to run. Administrative privileges are usually not required to install the Java version of ECONPACK.

ECONPACK Installation

ECONPACK can be installed in the default location on the C drive under Users / first name dot last name /1391 APPS / ECONPACK. Another good location is C:\ECON4.nn. For example, for the 4.0.55 version, the directory would be C:\ECON4.0.55.

ECONPACK Installation Process

Step I – Acquire ECONPACK Installer Jar file @ https://pax.csd.disa.mil Click on DD1391 Apps. On computers connected to OneDrive – US Navy Flank Speed cloud better to download installer and ECONPACK shortcut on C drive under your Users directory.

Step II – If Step I does not work try Economic Analysis URL.
Economic Analysis (sharepoint-mil.us)

Step III – If Step I & II do not work then send email to joseph.lane@navy.mil requesting ECONPACK Installer by DOD SAFE.

Step IV – After saving Jar file to Desktop or computer folder then double click to open.

Step V – For default installation proceed by selecting all defaults.

Step VI – Occasionally there may be a problem installing in the default location. If so try creating folder C:\ECON4.0.nn before installation and use during the installation.

Step VII – If upgrading in the default location ECONPACK installer is designed to keep your current economic analyses. If installing in a new folder location the DATABASE and text folders from the previous version may be copied over the new version folders. Alternatively, the pervious economic analyses can be exported one by one and imported into the new version of ECONPACK.

Step VIII – After installation place or establish an ECONPACK icon shortcut on your C drive Users directory and then double click on the ECONPACK icon and call the number on the screen to get the unlock code. Desktop ECONPACK icon name may be adjusted the name to ECONPACK 4.0.nn to manage your ECONPACK icons.

Please email or call Joe Lane at joseph.lane@navy.mil or 703-477-5947 for ECONPACK or Economic Analysis questions.

Economic Analysis Website

Economic Analysis (sharepoint-mil.us)

12.2 ECONPACK Features

Economic Analysis Tree

ECONPACK has an economic analysis tree that may be used to quickly navigate available economic analyses by expanding the tree. Navigation can also be accomplished using the pull down menu. Select File, Open and a dialog box pops up with the Analysis Name, Project Title, Date Created, and Date Last Modified. To create a new analysis select the new file Icon or selected New from the File pull down menu.

Save Default General Information

This feature is used to save time and effort by saving Action Officer, Commercial Phone Number, Email Address, and Organization as default values for these fields. The defaults will then be used each time a new economic analysis is created.

Viable / Nonviable

When a new economic analysis is created it automatically has default economic analysis alternatives marked nonviable listed in the Alternatives Tab. In order to enter data into an alternative, it must be first marked viable.

Versatile Copy Features

Copy Alternative Button – Copies highlighted Alternative to end of Alternative List.

Economic Analysis Tree – An Alternative maybe copied by using the Drag and Drop feature.

Copy Expense Button – Copy to either the Current, or another Alternative or Analysis.

Show Inflation Window

An ECONPACK Show Inflation Button displays a Table of Expenses with applied Selected Inflation Schedule in a Pop-Up Window.

Documentation Modules

There are a number of ways to enter information into ECONPACK using rich text format (RTF) with the MS Word text editor. An important feature is the Source/Derivation link located above the expense column. Alternatives have discussion links as well.

Economic Analysis Conversion

ECONPACK allows import of recent versions. For non-recent analyses that need to be converted to the new version, they can be emailed to joseph.lane@navy.mil. The Microsoft Access files will be sent to the USACE for conversion into new Java database files and returned by email.

Importing and Exporting Economic Analyses

By using the Import and Export function economic analyses can be exported to an ECONPACK file with an ECONPACK extension. The exported ECONPACK files are useful to add to EPG along with the Acrobat PDF report of the whole economic analysis.

Productivity Enhanced Features

- Inflation Schedule – May be defined and used in a Current Dollar Analysis. For Differential Inflation during a Constant Dollar Economic Analysis then costs are inflated manually.
- Discount Rate Sensitivity Analysis – Automatically generated between -2.0% and 10.0%.
- Data Fill Feature – Right click mouse and select fill from pop up list to fill column with value in current cell to save data entry typing.
- Shift Arrow Key – Moves ordering of alternatives or expenses for consistency.
- Open Analysis Menu Selection – Dialog box shows date created and modified.
- Toolbar Icons – Toolbar has Icons for Direct Navigation.
- ECONPACK Reports – Available in PDF for Reports or MS Word for Editing.
- Scientific Calculator – Accessed from the Tools menu or the Expense/Residuals Table. Especially useful for Source and Derivation calculations.

12.3 ECONPACK Economic Indicators

ROI Calculation

There is a return on investment (ROI) economic indicator. It is calculated from the savings to investment ratio (SIR). The SIR is the total present value (PV) of savings divided by the total PV of investment. The PV investment is reduced by the PV of the terminal value of the investment and any benefits that the investment generates during the period of analysis. See ECONPACK ROI EA Report. A ROI is what the investment generates in return after it pays for itself.

The ROI calculation formula is ROI = (SIR – 1) x 100%.

Subtracting 1 allows for the investment to pay for itself. For example, if the SIR is 5.0, then the total PV savings are five times the total PV of the investment. PV is used to adjust for the different cash flow timing. ROI is 400% because after the investment pays for itself, it generates a 4 times the investment return or in other words a 400% return.

Uniform Annual Cost

UAC economic indicator is available for Mission Requirement economic analyses. Under the Economic Indicator tab there is a View Calculations button next to the UAC that when clicked shows the UAC calculations made by ECONPACK. NPV is calculated by subtracting the discounted benefits and residuals from the discounted costs. Then UAC is calculated by dividing the NPV by the sum of the used discount factors during the economic life. Thereby, UAC is essentially a discount factor weighted average of the costs, benefits, and residuals. When comparing alternative with different economic lives then UAC allows a more accurate comparison of alternatives without the need for a residual value estimates as well as accounting for all costs and benefits over each alternative economic life.

Treatment of Benefits

Proposed alternative benefits are used by ECONPACK to reduce proposed alternative net investment costs. They are considered to be the result of the Investment rather than direct savings.

One example is a new power generator that can be used to generate extra electricity. If this extra electricity can be sold to a utility company on the power grid or used to replace other electricity on base and by doing so either saves money or generates income after expenses then it is an added benefit that ECONPACK uses to adjust the investment cost lower.

In the very unusual case that the benefits of a proposed alternative exceed the investment needed, the SIR would be a negative number because the net investment would be negative.

If a Benefit Cost Ratio aka Benefit Investment Ratio calculation is needed for a particular economic analysis or business case analysis then it can be calculated using the Life Cycle Cost and Return on Investment Economic Analysis Reports that ECONPACK generates. In that report the Status Quo alternative benefits and any residuals are subtracted from the savings because they would not occur with selection of the proposed alternative.

Discounted Payback Period (DPP)

The DPP is automatically generated in ECONPACK. The number occurs in a ROI economic analysis as the number of years it takes for the total PV of a proposed alternative investment to be returned through the total PV of savings over the current situation. Proposed alternative benefits and any residual value are currently used in ECONPACK to reduce the total proposed alternative investment whereas status quo benefits forgone are used to lower the total proposed alternative savings. The DPP appears in the Economic Indicators section of the Executive Summary Report.

In general, on the Cumulative Net Present Value (NPV) graph, discounted payback occurs at the point in time, if any, that the cumulative NPV of a proposed alternative crosses under the cumulative NPV of the current situation or default alternative. The DPP starts at the beginning of the Start Year or in other words the first year of the DPP is the Start Year.

When there is a One Time Salvage (OTSV), the cross under point does not match the ECONPACK Calculated DPP because on the graph the OTSV is shown at the end of the period of analysis (POA) and in the DDP calculation the residual is used to reduce the total investment. The result of this is that the cross under point [if any] occurs at a later point than the DPP would suggest because in the terminal value benefit of the facility does not occur until the end of the period of analysis. Alternatively, Straight Line Residual Schedule gives a declining benefit of the facility beginning at the BOD that is called the Beginning Year for the Residual Schedule.

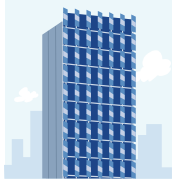
Another example of when the cross over point does not reflect the true time frame is when future Status Quo costs are avoided. ECONPACK counts these savings immediately by discounting them to year zero rather than accounting for them when they actually occur.

Inflation

General Inflation has little impact on whether a Current Dollar or Constant Dollar Economic Analysis is used because if all the data is inflated the impact is approximately canceled by the higher nominal discount that must be used. It will have no impact if the long term inflation estimate is calculated from the 30 year real and nominal OMB discount rates and there is no differential escalation in the analysis. This is because the inflation rate derived from the discount rates and the nominal discount factors will cancel each other out exactly. Navy uses Constant Dollar Economic Analysis. Differential inflation is estimated inflation rates on costs, benefits, and residuals that are above or below the long term inflation rate approximated by subtracting the real rate from the nominal rate. An exact calculation is made by dividing 1 plus the nominal rate by 1 plus the real rate and subtracting 1. Example nominal = 1.7% and real is -0.3%. Estimate is 1.7% - (-0.3%) = 2.0%. Exact calculation is (1+0.017)/ (1+ (-0.003) – 1 = 2.006%.

12.4 ECONPACK CONCEPTS & TECHNIQUES

Default Alternative



The default alternative is what is likely to happen in lieu of an investment in the proposed alternative. Usually, the default alternative is the status quo that is otherwise known as the current situation. Since the current situation already exists, its investment costs are usually lower than other alternatives. One exception is when considering a lease alternative. Leases also have low investment costs, but recurring cost usually rise more at time of lease renewal then other recurring costs like Operations and Maintenance.

In a Mission Requirement analysis, where there is no current situation, the default alternative could be the alternative with the lowest initial investment cost since this would be typically easiest to finance and would tend to be favored if an economic analysis had not been conducted. The other proposed alternatives can be compared against this benchmark alternative in a ROI analysis to determine whether a proposal that has higher initial investment costs would be worth the additional investment. The Mission Requirement economic analysis only compares the NPVs of the alternatives. By replacing the Status Quo alternative in a ROI analysis with the default alternative that has the lowest initial cost, the other economic indicators calculated by ECONPACK would provide additional useful information to the decision makers.

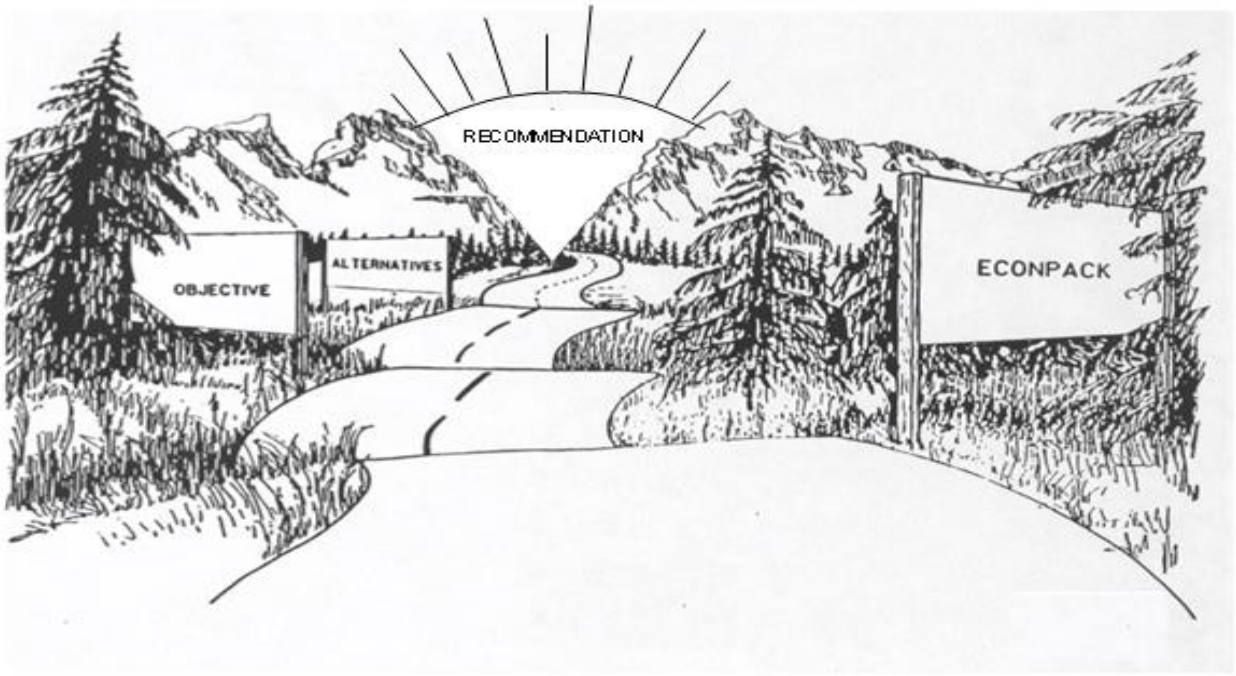
This allows for the comparison of differential investment costs and could be used to show the incremental investment impact [like incremental savings] or the total costs of both the default and the proposed alternative could be used to generate a total life cycle cost comparison. Having a default alterative allows for the calculation of economic indicators in addition to NPV, like SIR, DPP, ROI, and BIR.
To accomplish this type of economic analysis download the Navy ROI Low Invest ALT FY21 importable file located on Economic Analysis (sharepoint-mil.us) or contact Joe Lane at joseph.lane@navy.mil or 703-477-5947 for guidance on ROI Economic Analyses.

12.5 ECONPACK TROUBLESHOOTING

ECONPACK 4.0 was the first Java version of ECONPACK that came out in the September of 2009. All EA's done in ECONPAK 3.0.3 or higher may be importable into ECONPACK. For economic analyses that appear to be not importable the USACE may be able to convert the analysis.

Problems sometimes occur upgrading ECONPACK. If ECONPACK default location does not work then before installation create a folded C:\ECON4.0.NN where NN are the numbers of the current version and use that new location during the installation process.

Figure 11K, ECONPACK Big Picture



13. DOCUMENTATION STANDARDS

Documentation standards are used to facilitate the gathering and presenting of data into an organized report. The goal is to develop uniform economic analyses that are credible and easy to read and understand. A checklist is used to ensure all possibilities are considered and well documented.

Throughout this handbook, the importance of adequate documentation has been stressed. Confidence that the analysis is complete and credible and proper communication is critical to delivering a completed economic analysis. A thorough economic analysis is invaluable for future project and program evaluation.

13.1 DOCUMENTATION FORMATS AND TOOLS

It is NAVFAC policy for Economic Analyses documentation to be complete and credible. NAVFAC has allowed "flexibility" in economic analysis format to allow for a wide range of training, experience, and capabilities of field personnel who are tasked with the preparation of economic analyses.

The following formats are mandated or allowed for EA preparation depending on the type of project being submitted:

- ECONPACK Economic Analysis Package for Return on Investment Analysis
  To promote uniformity and consistency throughout NAVFAC, use of ECONPACK is required for the preparation of all Type I economic analyses. Statistics such as SIR, ROI, NPV, and DPP are calculated automatically.
- ECONPACK Economic Analysis Package for Mission Requirement Analyses
  To promote uniformity and consistency throughout NAVFAC, use of ECONPACK is required for the preparation of all Mission Requirement economic analyses. The main statistic for comparison in this type of analysis is the NPV.
- ECONPACK Economic Analysis Package for Partial Mission Requirement Analyses
- A Partial Mission Requirement Economic Analysis is conducted after determining there is only one possible alternative to meeting the project objective and all constraints imposed by the project. This is after reviewing of all other possible alternatives.
  ECONPACK Economic Analysis Package for Nominal Mission Requirement Analyses
  a Nominal Mission Requirement Economic Analysis is produced when the project is exempted from an economic analysis. An example a Public Law mandated the project.

All economic analyses packages should be prepared with a consistency amongst cost items in each alternative. That is, when alternatives include the same cost items (i.e., 1.Sustainment, 2.Utilities…), format the EA to have the cost items in the same order (e.g., sustainment appears before repair which appears before utilities in each alternative). Arrange the Cash Flow Tables so the order and naming conventions are consistent as in shown in figure 13A an example comparing the Life Cycle Cost Reports for both Status Quo and Renovation alternatives.

Life Cycle Cost Report

Alternative: Status Quo (Current Operations)

Year	Sustainment	Repair	Utilities	Deficiency Backlog Correction	Temporary Facilities
2013	$1,200	$0	$2,400	$300	$100
2014	$1,200	$0	$2,400	$300	$100
2015	$1,200	$0	$2,400	$300	$100
2016	$1,200	$0	$2,400	$300	$100
2017	$1,200	$0	$2,400	$300	$100
2018	$1,200	$0	$2,400	$300	$100
2019	$1,200	$0	$2,400	$300	$100
%NPV	30.00%	0.00%	60.00%	7.50%	2.50%
	$8,086	$0	$16,173	$2,022	$674
Discounting Convention	M-O-Y	M-O-Y	M-O-Y	M-O-Y	M-O-Y
Inflation Schedule	No Inflation	No Inflation	No Inflation	No Inflation	No Inflation
Category / Residual Schedule	Recurring Costs	Recurring Costs	Recurring Costs	Recurring Costs	Recurring Costs

Life Cycle Cost Report

Alternative: Renovation

Year	Renovation	Sustainment	Repair	Utilities	Deficiency Backlog Correction
2013	$40,000	$100	$0	$900	$0
2014	$40,000	$100	$0	$900	$0
2015	$0	$100	$0	$900	$0
2016	$0	$100	$0	$900	$0
2017	$0	$100	$0	$900	$0
2018	$0	$100	$0	$900	$0
2019	$0	$100	$0	$900	$0
%NPV	91.43%	0.78%	0.00%	7.01%	0.00%
	$79,131	$674	$0	$6,065	$0
Discounting Convention	M-O-Y	M-O-Y	M-O-Y	M-O-Y	M-O-Y
Inflation Schedule	No Inflation	No Inflation	No Inflation	No Inflation	No Inflation
Category / Residual Schedule	Recurring Costs	Recurring Costs	Recurring Costs	Recurring Costs	Recurring Costs

Figure 13A Life Cycle Cost Reports for Status Quo and Renovation Alternatives

ENERGY RETURN ON INVESTMENT (EROI) TEMPLATE

An energy spreadsheet has been developed that calculates the metrics used to evaluate energy projects. The POC at the NAVFAC Engineering and Expeditionary Warfare Center is Dan Magro in the Energy Management and Programs Office. Please contact Dan Magro at daniel.magro@navy.mil or your local FEC Regional Energy Program Manager for annual updates to the software. CNIC Energy Program Manager may also be contacted.

13.2 ECONOMIC ANALYSIS SUBMISSION OUTLINE

The following outline is a guide for preparing an economic analysis submission using ECONPACK software. The outline reflects that an economic analysis submission should be complete and credible and tell the entire story for the project. The following provides specifics on each section of the analysis:

a. Summary - This section should briefly summarize the entire analysis, with emphasis on the objective, alternatives, ranking of alternatives, conclusions, and recommendations.

b. 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.

c. Alternatives - All alternatives considered in the analysis should be listed and defined.

d. Assumptions - List and explain all assumptions used in the analysis.

e. Source and Derivation of Costs and Benefits - Show how the costs and benefits were

developed and document any sources used. It is important to provide traceability to credible cost data.

f. Costs, Benefits, and Present Value Summaries - Enter all information into ECONPACK. This allows all material to be managed and submitted in one complete packet.

g. Sensitivity Analysis - Show all uncertainty and/or risk analyses performed on dominant cost elements, economic life, discount rate, differential escalation rates, and other major assumptions.

h. Other Considerations – Provide additional information on decision considerations not previously discussed that should be included in the analysis (e.g. non-quantifiable variables).

i. Conclusions/Recommendations - Rank all alternatives and provide appropriate conclusions and recommendations based upon Items a-h.

j. Appendices – Provide detailed information supporting all cost and benefit estimates, including data sources, equations, projections, and calculations.

13.3 CHECKLIST FOR ANALYSTS AND REVIEWERS

The following checklist and lessons learned are required 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? Are they too broad?
e. Are intuitive judgments identified as such? Are uncertainties treated as facts? Can the facts be identified?
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 Relation-ships statistically

valid?
g. Are the estimates interpolated within the range of historical data or has extrapolation been used?
h. Was an average cost used where a marginal cost is appropriate?
i. 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, not measurable? 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 counted 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 viable 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 MILCON Program 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", "Base Closure Actions", "Force Lay down Changes" 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 re-pricing / funding adjustments by:

a. Using the DOD Facility Pricing Guide - 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 are 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 or construction efficiencies Or reduction in average cost per square foot).

4. In general, when the cost of facility renovation exceeds 70 percent of the new construction cost, it probably is a better value to use the new construction alternative. However, they may be reasons for pursuing renovation even when the cost exceeds 70 percent rule of thumb including situations when the facility in question is of historical significance.

5. Alteration projects should not exceed 70% of new construction costs. If it does, ASN approval will be required and the economic analysis will be needed.

6. 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.

7. Document operational delays and associated costs caused by the status quo, and fully explain their impact.

8. 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.

9. When developing project and alternatives be sure to include all costs. If repair or renovation exceeds 50% of the replacement cost, all building codes and some ATFP requirements will need to be met and included in the cost of the project. If ATFP requirements are not met for repair or new construction, be sure to include hardening costs as appropriate.

10. Most Projects in EPG have an attached EA in the Electronic Document Management System (EDMS). These may be obtained and used as a large library of example Economic Analyses prepared in ECONPACK.

14. BUSINESS CASE ANALYSIS

In order to determine cost effective ways to meet mission requirements, economic analyses are conducted. For bigger picture evaluations such as, determining the need and most cost effective solution for a new mission requirement (global, regional or installation), a Business Case Analysis (BCA) is developed. Before beginning a BCA true requirement needs to be established by gathering and evaluating data. All options should be looked at to include non-facility options. Once the requirement is determined the process is similar to an economic analysis in that various alternatives are evaluated to meet the requirement. The biggest difference is the scope and variety of options reviewed.

14.1 OVERVIEW

BCA's are not new, however the Navy facilities community has not widely utilized this product. Many of NAVFAC customers are requesting BCA's to determine if a proposed facility project is the right solution. A BCA requirement for investigating is a report that discusses the merits and demerits of potential courses of action (COAs) with respect to the status quo. It is used to answer questions about requirements and optional solutions rather than immediately focusing on a facility solution and an Economic Analysis. A BCA would be utilized to determine where the appropriate place is to locate a new requirement, which installation, region will cost the least. This is done before detailed project specific work is begun.

According to the Defense Acquisition University Guidebook, "The Product Support Business Case Analysis (BCA) is used to assist in identifying the product support strategy that achieves the optimal balance between Warfighter capabilities and affordability. (Other names for a BCA are Economic Analysis, Cost-Benefit Analysis, and Benefit-Cost Analysis. Regardless of the name, it consists of a structured analytical process that aids decision making in identifying and comparing alternatives by examining the mission and business impacts (both financial and nonfinancial), risks, and sensitivities.)" The Guidebook also defines the Business Case as "The business case is the one location where all relevant facts are documented and linked together into a cohesive story. It is an executive-level document used by decision-makers for investment and acquisition decisions.'

A BCA presents qualitative as well as quantitative information in a format that is typically on the level of an executive summary. Using accurate quantitative information improves the objectivity of the analysis. However, having accurate information is not enough. There needs to be effective analysis of the information to determine the optimum course of action.

A Business Case Analysis is typically focused on a particular course of action or policy initiative. Each alternative provides unique benefits and unequal costs which must be analyzed as similar to a Cost Benefit Analysis (CBA). Typically it is the case that the benefits are not easily convertible into dollars or other units of measure. Thus, a qualitative discussion of the problem and the proposed solutions is accompanied by economic indicators and other quantitative measures. The proposed recommendation is made based on a thorough understanding and documentation of the problem, requirement, political environment and other pertinent criteria.

14.2 BCA COMPONENTS

A BCA should include the following chapters:

a. Executive Summary: Provides a high level summary of the key information, alternatives reviewed and recommendation. This includes describing the positive and negative aspects of the current situation and providing a summary of the one time and annual costs of alternatives considered.

b. Qualitative Benefits: Benefits not readily convertible into dollars should be explained to provide a basic understanding of why the options should be considered. Explain any benefits using numbers or statistics rather than dollars when applicable. Also discuss benefits that are not easily converted into dollars, numbers, or statistics.

c. Purpose: A clear concise statement of the reason for performing the BCA which provides information on the value of the analysis. The following provides an example of a purpose:

   The purpose of this Business Case Analysis (BCA) is to provide Navy Leadership with the strategic impact (including costs and benefits) associated with implementing the SIP Initiative. Our BCA provides decision makers with economic indicators such as Cost/Benefit Ratio, Break Even Point, and Net Present Value. These indicators along with qualitative factors were used to evaluate our investment alternatives.

d. Background: In this section provide historical facts that helps the reader understand the big picture. Provide dates and when previous events or processes were completed. The impacts of previous implementations and their unique history can be explained.

e. Current Environment: Explain current environment problems and advantages.

f. Business Case Analysis Approach: A typical discussion of the BCA approach is described as shown. Facility costs fall into a three major areas.

   1. Initial Costs
      - Project Management including oversight and day to day management of the Initiative including process models, business rules, and policy development.

   2. Annual Recurring Costs
      - Recurring Costs including recurring building cost.

   3. One Time Costs
      - Move Consolidation including cost to relocate personnel in order to vacate buildings for demolition.
      - Demolition Costs including cost to demolish vacated buildings.

   Cost savings are grouped into two major categories.

   1. Demolition Savings
      - Reduced Operational, Sustainment, and Restoration Savings due to facility demolition.

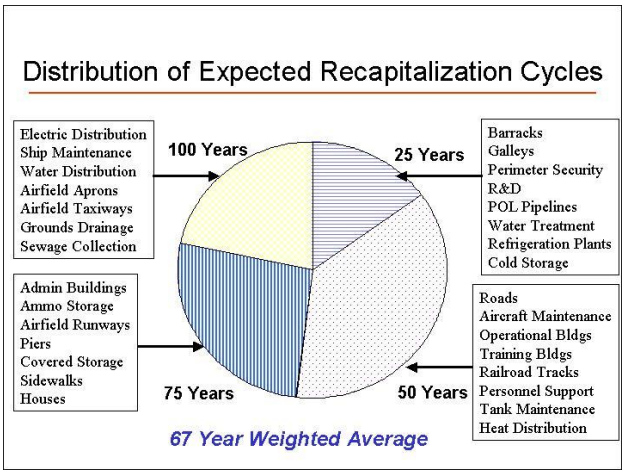
2. Caretaker Savings
    - Reduced Operational, Sustainment, and Restoration Savings due to placing facilities into caretaker status.

The BCA also identifies qualitative benefits such as improved work equipment, reduced employee downtime, and emergency planning (see Qualitative Benefits section beginning on page NN).

Cost/Benefit Analysis: The Cost/Benefit Analysis needs to include assumptions, one time as well as recurring costs and benefits.

Period of Analysis: Consideration also needs to be given to the period of analysis. There will usually be a lead time for the period for development, testing, and implementation. Take into consideration how long the process or facility is expected to last as well as how long the mission will be needed and when any technology will need to be replaced. Make the period of analysis end when the useful life of the process or facility is up. Useful life typically ends when one of the mission, physical, or technological lives ends. For example, if the mission in a certain area for a facility is 35 years and the physical life is 35 years.

Time Value of Money: Another factor is the time value of money. Use OMB generated discount factors to discount future costs and benefits to the present value. The sum of these present values is the economic indicator known as the net present value (NPV).



Other Economic Indicators: There are other economic analysis indicators such as discounted payback period, savings to investment ration, benefit to investment ratio, return on investment that are discussed in other chapters of this handbook.

Sensitivity Analysis: The assumptions, costs, and benefits including the period of analysis are all candidates for sensitivity analysis. Focus on those items that based on experience represent the biggest potential for variation and are large enough to have a significant impact on the results of the analysis.

Cost Benefit Analysis – Results and Recommendations: Here is a sample format for a results and recommendations section.

There were three main economic indicators calculated in this BCA.

- The breakeven point occurs within a reasonable period of number to number of years after the installation of the New Process Tool depending on the timing and amount of reduced footprint savings as well as whether or not the type of facilities are placed in caretaker status or demolished. The breakeven point is the point where discounted payback occurs.

- With a BCR of N.N, the benefits are estimated to be about six times the Costs when discounted over a span of NN years.

- The present value of the benefits exceeded the present value of the costs by about $N.N million. Even more savings would occur if we extended the POA to more than NN years.

These economic indicators indicate that the New Process Tool Initiative is a good investment. The potential benefits are deemed to adequately outweigh the risks. Furthermore, down the road, this system may be adapted and applied to other types of facilities besides this type of facility. This would likely result in even more savings to the US Navy and the Department of Defense. Therefore, acquisition and implementation of the New Process Tool is recommended.

Qualitative Benefits: This is where you focus on information that is not easily converted into dollars. When possible it is recommend that the information be described or summarized by using metrics and other statistics. For information not easily convertible into statistics, use a narrative comparing the various alternatives. Include what may happen if certain events occur as well as the best and worst case scenarios.

Summary: The summary section may include the two sub areas Capability Delivered and Impact If Not Provided.

Capability Delivered: In this area describe the capability of the finished product. What will the process or facility provide for the Commands, the Navy, and the United States?

Impact If Not Provided: This is sort of the opposite of capability delivered. What savings will the Navy likely be foregoing? Will full realization of goals be thwarted? How about inefficiencies, delays, and frustration that will affect morale?

14.3 ECONOMIC INDICATORS

Table 14A is an example of an effective way to display information in an executive summary.

ECON Indicators	15% Reduced Footprint	Caretaker Solution	No Reduced Footprint
Present Value of Benefits	$M	$M	$M
Present Value of Costs	$M	$M	$M
Net Present Value	$M	$M	$M
Benefit Cost Ratio	NN.N	NN.N	NN.N
Payback Year	20NN	20NN	20NN

Table 14A, Summary of Benefits and Costs over NN Years

14.4 CASH FLOW TABLES

Another effective technique is to embed cash flow tables in the form of Excel spreadsheets. The calculations for the breakeven point are illustrated in this discounted cash flow table using millions of dollars.

CASH FLOW DISCOUNT TABLE WITH ECONOMIC INDICATORS

OMB CURRENT REAL DISCOUNT RATE = 0.400%

FY	INVEST	MOVE	DEMO	MAINTAIN	SAVINGS	DIS FAC	DIS COSTS	DIS BENS	CPV
2021	$45.000	$1.000	$1.000	$1.000	$5.000	0.9980	$47.904	$4.990	$42.914
2022	$0.000	$1.000	$1.000	$1.000	$5.000	0.9940	$2.982	$4.970	$40.926
2023	$0.000	$1.000	$1.000	$1.000	$5.000	0.9901	$2.970	$4.950	$38.946
2024	$0.000	$1.000	$1.000	$1.000	$5.000	0.9861	$2.958	$4.931	$36.974
2025	$0.000	$1.000	$1.000	$1.000	$5.000	0.9822	$2.947	$4.911	$35.009
2026	$0.000	$1.000	$1.000	$1.000	$5.000	0.9783	$2.935	$4.891	$33.053
2027	$0.000	$1.000	$1.000	$1.000	$5.000	0.9744	$2.923	$4.872	$31.104
2028	$0.000	$1.000	$1.000	$1.000	$5.000	0.9705	$2.912	$4.853	$29.163
2029	$0.000	$1.000	$1.000	$1.000	$5.000	0.9666	$2.900	$4.833	$27.230
2030	$0.000	$1.000	$1.000	$1.000	$5.000	0.9628	$2.888	$4.814	$25.304
2031	$0.000	$1.000	$1.000	$1.000	$5.000	0.9590	$2.877	$4.795	$23.386
2032	$0.000	$1.000	$1.000	$1.000	$5.000	0.9551	$2.865	$4.776	$21.476
2033	$0.000	$1.000	$1.000	$1.000	$5.000	0.9513	$2.854	$4.757	$19.573
2034	$0.000	$1.000	$1.000	$1.000	$5.000	0.9475	$2.843	$4.738	$17.678
2035	$0.000	$1.000	$1.000	$1.000	$5.000	0.9438	$2.831	$4.719	$15.791
2036	$0.000	$1.000	$1.000	$1.000	$5.000	0.9400	$2.820	$4.700	$13.911
2037	$0.000	$1.000	$1.000	$1.000	$5.000	0.9363	$2.809	$4.681	$12.038
2038	$0.000	$1.000	$1.000	$1.000	$5.000	0.9325	$2.798	$4.663	$10.173
2039	$0.000	$1.000	$1.000	$1.000	$5.000	0.9288	$2.786	$4.644	$8.316
2040	$0.000	$1.000	$1.000	$1.000	$5.000	0.9251	$2.775	$4.626	$6.465
2041	$0.000	$1.000	$1.000	$1.000	$5.000	0.9214	$2.764	$4.607	$4.623
2042	$0.000	$1.000	$1.000	$1.000	$5.000	0.9178	$2.753	$4.589	$2.787
2043	$0.000	$1.000	$1.000	$1.000	$5.000	0.9141	$2.742	$4.570	$0.959
2044	$0.000	$1.000	$1.000	$1.000	$5.000	0.9105	$2.731	$4.552	-$0.862
2045	$0.000	$1.000	$1.000	$1.000	$5.000	0.9068	$2.720	$4.534	-$2.676
2046	$0.000	$1.000	$1.000	$1.000	$5.000	0.9032	$2.710	$4.516	-$4.482

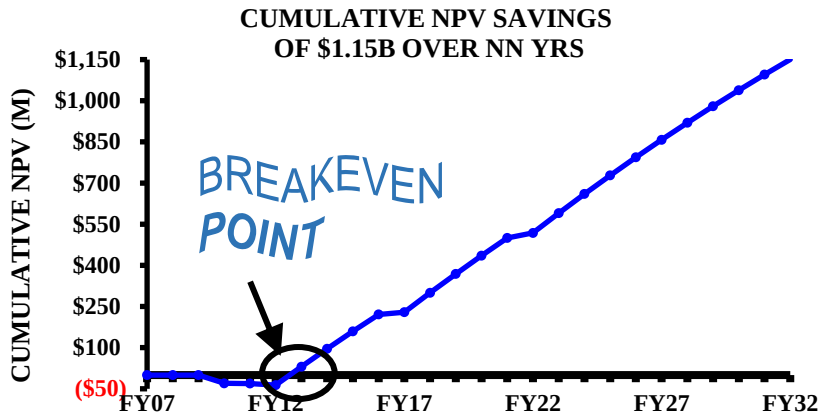
PV BENEFITS	PV COSTS	NPV	BCR	PAYPACK
$123.481	$118.999	-$4.482	1.038	2044

Table 14B - Cash Flow Discount Table with Economic Indicators

The cash flow table shows that the discounted payback occurs during fiscal year highlighted year NNNN. The graph on the next page shows the potential saving over 25 years of the analysis period.

14.5 Cumulative NPV Graph with Breakeven Point

Another effective technique is to highlight the breakeven point in an embedded PowerPoint chart.



14.6 Organize Data by Using Tables

It is also effective to use tables to organize cost information. Table 14C represents a table format that can be used.

One Time Costs [OTCs]	Cost
OTC I	$
OTC II	$
OTC III	$
OTC IV	$
OTC V	$
Subtotal	**$**
Other OTCs	**$**
Additional OT Move Costs	$
Additional OT Demolition Costs	$
Total One Time Costs	**$**
Annual Recurring Costs [ARCs]	
ARC I	$
ARC II	$
ARC III	$
Total Annual Costs	**$**

Table 14C - Typical Cost Table

If the DOD Facility Pricing Guide is used, it is recommended that a table of the cost elements be shown in the BCA. Table 14D is an example of a DOD FPG Cost Factors Table.

Cost Category	Cost/Square Foot
Construction	0
Sustainment	0
Restoration and Modernization	0
Lease	0
Operational Factors	**Cost/Square Foot**
Fire and Emergency Management	0
Energy	0
Water and Wastewater	0
Real Property Management	0
Custodial	0
Refuse	0
Grounds Maintenance	0
Pesticides	0
Energy Management	0
Total	0

Table 14D - DOD FPG Cost Factors Table

14.7 MODERNIZATION REQUIREMENT

The Plant Replacement Value (PRV) = $N can be calculated by using this embedded calculator. Double click on calculator to open. In order to keep a facility up to modern standards, a modernization requirement can be used to estimate the Restoration and Modernization (R&M) that will be needed each year. By using the Restoration and Modernization (R&M) factor of N, the Modernization Requirement Savings would thereby be R&M Factor x PRV = N x PRV = $N/YR.

PLANT REPLACEMENT VALUE CALCULATOR

PRV	SF	CCF	ACF	HRA	PDF	SIOH	CON
$545,926.50	3000	$150.00	1.00	1.00	1.09	1.06	1.05

PRV = Plant Replacement Value.
SF = Square Feet of Facility.
CCF = Construction Cost Factor from the DOD FPG.
ACF = Area Cost Factor from the DOD FPG.
HRA = Historical Records Adjustment is 1.05 for historic faclities or districts and 1.00 otherwise.
PDF = Planning and Design Factor of 1.09.
SIOH = Supervisory Inspection and Overhead of 1.06 for CONUS and 1.065 for OCONUS.
CON = Contingency Factor of 1.05.

14.8 ADDITIONAL INFORMATION

See our Business Case Analysis Template Elements for Shore Infrastructure Plans for more ideas and a good example to copy and adapt. Contact Joe Lane at joseph.lane@navy.mil, DSN 325-9195, or visit our website for additional information.

https://hub.navfac.navy.mil/webcenter/portal/am/Programs+[A-H]/Economic+Analysis

APPENDIX A - ECONOMIC ANALYSIS PRIMER

This primer is designed to provide highlights of the economic analysis principles and process for those needing a refresher. For additional information, visit the NAVFAC Asset Management Economic Analysis section website:

https://hub.navfac.navy.mil/webcenter/portal/am/Programs+[A-H]/Economic+Analysis

A. ECONOMIC ANALYSIS REQUIREMENTS

Facilities Project Instruction OPNAVINST 11010.20 requires a formal net present value life-cycle Economic Analysis (EA) be prepared for all repair and construction project above specified threshold limits.

Guidelines and formats for preparing economic analyses are contained in Chapters 1 – 13 of the Economic Analysis Handbook, NAVFAC P-442. Discount factors are updated annually and published by the Office of Management and Budget in Appendix C of OMB Circular A-94, http://www.whitehouse.gov/omb/circulars/index.html**.** Results of analyses are to be summarized and provided on the DD 1391 with backup documentation provided as part of the project package. An EA is required even when the NAVFAC client does not use the 1391 project form. Economic Analyses are prepared using ECONPACK software.

B. ECONOMIC LIFE

The economic life of a facility is the length of time that the facility has economic viability. It is determined by the mission, technological, and physical life of the facility. The shortest of the three lives determines the economic life of the facility. The following provides a brief definition for each type of facility life:

- The mission life is determined by how long it is expected that the facility's function will be performed in the particular location. Use judgment as to whether the installation is expanding, contracting, or will likely be closed.

- The technological life is determined by how long it is expected that the facility will be technologically viable. Use judgment as to whether the facility has imbedded technology that will likely become obsolete after a certain number of years.

- The physical life is determined by using DOD recapitalization guidance of 67 years. Physical life is similar to Service Life that is published in the DOD Facility Pricing Guide.

For a component or repair project, calculate the physical life using the component / repair alternative that will last the longest.

The period of analysis (POA) is the lead-time plus the economic life. Lead-time is usually between one to two years, dependent on the time it takes to build the facility and prepare it for beneficial

occupancy. The Beneficial Occupancy Date (BOD) is the official date the facility is available to use. Figure XX provides a graphical representation of a potential POA.

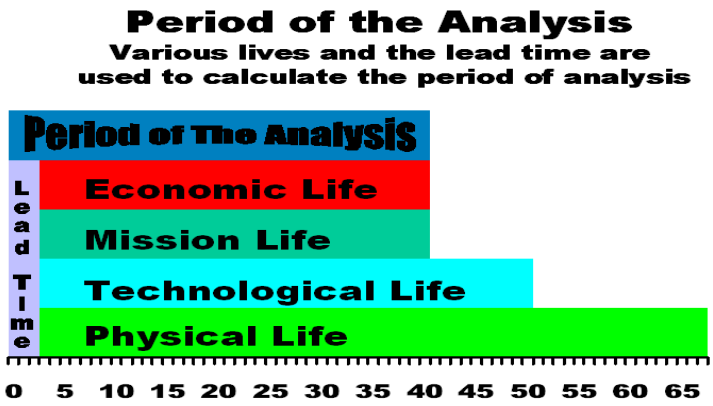


Figure A.1

MILCON Projects Period of Analysis: For MILCON projects being considered in the MILCON Planning and Programming Process (MTP[3]), use a standardized economic life of 30 years, with a lead time of 2 years, for a period of analysis (POA) of 32 years.

Energy Projects Period of Analysis: For all energy projects and the designs for new buildings, the Energy Independence Security Act (EISA) of 2007, SEC. 441, PUBLIC BUILDING LIFE-CYCLE COSTS states that Section 544(a) (1) of the National Energy Conservation Policy Act (42 U.S.C. 8254(a) (1)) was amended by increasing the period of analysis (POA) for energy projects and the design of new federal buildings from 25 to 40 years unless the expected life of the energy system is less than 40 years where the POA would then equal the life of the energy system.

Special Projects Period of Analysis: For special projects economic analyses that have an alternative with significant improvement in energy efficiency, it is important to do a sensitivity analysis on the POA and if the results are sensitive, highlight this finding in the Executive Summary. Furthermore, if increasing the POA to 40 years changes the least cost alternative to the one that has the most energy efficiency, then increase the POA to 40 years.

C. TERMINAL VALUE

The terminal value is determined by using the onetime salvage value residual schedule in ECONPACK. The terminal value (use start value in ECONPACK residual schedule for a one time salvage value) is determined by estimating the percentage of remaining life left in the facility and multiplying this by the initial cost of the facility.

Terminal Value = [(Physical Life – Physical Life Used Up)/Physical Life] x Initial Cost.

While using straight line depreciation in ECONPACK is easier and gives the same net present values (NPVs), using that method results in the facility being credited as an asset after it is purchased or repaired and then depreciated over time. However, the US Government very rarely sells facilities so that the crediting of the asset is somewhat misleading. With the onetime salvage

residual schedule method the credit appears at the end of the analysis. This makes the terminal value easy to understand especially when displayed in a NPV graph.

For MILCON projects, use current guidance of straight line depreciation.

D. SELECTION OF THE BASE YEAR

For constant dollar analyses that the Navy conducts, all costs and benefits are placed in the purchasing power of a single year that is called the base year. The Base Year is also referred to as the reference year for all present value calculations and is the year to which all costs and benefits are to be discounted.

For economic analyses prepared for MCON projects, use the proposed funding year, AKA, the next available budget year as the base year to be consistent with the purchasing power of the MILCON project estimate. For example, suppose that the next available funding year (i.e. budget year) is 2015, and the project cost is estimated in that year, then escalate all costs and benefits in the economic analysis to the purchasing power of that year using the DOD Facility Pricing Guide UFC 3-701-01 escalation tables. For economic analysis prepared for Special Projects, use the same base year. This is consistent with the USACE ECONPACK base year definition.

E. DISCOUNT RATES & CONVENTION

Discount rates are used to discount future cash flows in order to bring those cash flows back to present day dollar value. Nominal discount rates include inflation in the discount rates. Real rates do not include inflation.

Discount rates are updated annually on the OMB web site between January and February. To confirm that you are using the latest rate, refer to the general OMB circular site, select Circular A-94, and then select Appendix C. The OMB site is:

http://www.whitehouse.gov/omb/circulars/index.html

Choose real rates when conducting a constant dollar economic analysis and nominal rates when conducting a current dollar economic analysis. Usually, constant dollar economic analyses are preferred. They are simpler in that they are run without inflation factors and thereby use real interest rates. Occasionally, current dollar economic analyses are performed. These analyses are more complex in that they are run with inflation factors and thereby use nominal interest rates. Generally, use the method that is easier to use. If most of the costs are already in constant dollars, then use constant dollars with the real discount rate. If, on the other hand most costs are already in future year dollars (AKA out year dollars), then it is better to use the nominal rate with future year dollars.

The classic case when future year dollars are used is when there is a long lease. This is because the lease has the purchasing power of future year dollars even though the payment is constant. However, this is usually not the case these days since leases are often renewed annually so that constant dollar analyses are easier to use.

Cash Flow usually occurs throughout the year. So, using middle of the year (MOY) discount rates is recommended. The recommended discount rate has changed from former guidance that recommended end of year (EOY) discounting. This change was made because all cash flows for the year do not usually occur on the last day of the calendar year. MOY discounting more accurately reflects the timing of the cash flows.

F. NAVFAC COST ENGINEERING

A combination of actual maintenance backlog, historical records of maintenance costs, and pricing guides, should be used in preparing economic analyses. Consult the NAVFAC Cost Engineers for help in creating cost estimates for specific projects. In addition, the NAVFAC Cost Engineering website is a good resource for finding information on cost estimating for new construction and maintenance pricing along with cost estimating formulas and inflation indexes. The NAVFAC Cost Engineering web page is http://www.uscost.net/CostEngineering/documents.htm. Additional references for completion of cost estimates for MILCON and special projects are available on the NAVFAC Asset Management website https://portal.navfac.navy.mil/portal/page/portal/am/am_hq/economicanalysis

- Facilities Projects Manual OPNAVINST 11010.20 provides detailed guidance for determining the type of project based on total cost of construction involved in a specific project. It provides guidance on the preparation of Military Construction (MILCON) and Non-appropriated Funded (NAF) project documentation.

- Shore Facilities Planning System (SFPS) Manual explains the process for the planning of shore facilities. It provides guidance for the preparation of site approval documentation required for MILCON, NAF, and special projects.

G. UTILITIES

Energy Managers in the Public Works Offices provide utility billing, rates and annual usage data for all facilities on base. They can also provide trouble call printouts for past years as well as any documented repairs done to specific facilities. RS Means Reference Books also provide a good reference for some unit price and operating expense data for various types of facilities.

When preparing an economic analysis for utility systems, the utility costs should be reduced for the proposed alternative as compared to the status quo situation. For new construction the reduction is most often greater than the repair alternative. For example, the repair alternative could have a 10% reduction of the status quo utility costs and the new construction alternative could have a 25% reduction over the status quo alternative. For an extensive repair project where the repair alternative is similar to the new construction alternative, the utility cost savings might be 25% for both the repair and the new construction alternatives.

Use these guidelines of 10 to 25 percent savings unless detailed estimates are feasible. Work with the Energy Manager to determine the most likely reduction. This estimated reduction, will end up being measured and actual reduction in funding for utilities will be impacted, so ensure the number is achievable.

H. OTHER COST CONSIDERATIONS

DOD Financial Management Regulation, DOD 7000.14-R, provides guidance on completing a DD1391, including the addition of contingency, SIOH, and ATFP. The regulation does not specify rates for these other costs. Each service determines the applicable rates to be added for project estimation. Refer to the below guidance for Navy application of other costs:

a. SIOH: SIOH rates are determined by appropriation, not the type of work (i.e. construction or repair). The SIOH rate for Special Projects is 8%. The SIOH rate for MILCON Projects in CONUS is 5.7%, OCONUS 6.2%, and for projects with the Corps of Engineers as construction agent 6.5%.

b. ATFP: The following provides guidance on ATFP costs from the NAVFAC ATFP Ashore Program Manager:

(e) Antiterrorism Force Protection/physical security measures: the entry under primary facility will show physical security improvements (e.g. special structural improvements, mass notification, windows, etc.). Where land acquisition serves a specific purpose such as stand-off distance for AT, the acquisition shall be listed as an antiterrorism force protection subordinate component to the primary facility. (f) Antiterrorism force protection/physical security measures such as physical security site improvements (e.g. fencing, perimeter/security lighting, vehicle barriers, berms and landscaping, etc.) shall be listed under supporting facilities.

UFC 4-010-01 DOD Minimum Antiterrorism Standards for Buildings requires that a seismic safety evaluation be done when a repair project value exceeds 50% of the facility replacement cost. Many repair special projects exceed this 50% requirement. The ATFP standards are also mandatory when: the building is being converted to higher occupancy; windows are being replaced; or facility additions greater than 50 % of existing square feet are planned. ATFP standards also apply to leased facilities where DOD populations meet density requirements for inhabited buildings.

Other applicable ATFP references are:

1. UFC 3-400-01- Energy Conservation
2. UFC 4-010-01- DOD Minimum Standards for Buildings
3. UFC 3-600-01-Fire Protection Engineering for Facilities
4. NIST GCR 11-917-12 -Standards of Seismic Safety for Existing Federally Owned and Leased Buildings.

General Building Requirements. UFC 3-101-01 Architecture guidance. Comply with UFC 1-200-01, DOD Building Code. UFC 1-200-01 provides applicability of model building codes and government unique criteria for design disciplines and building systems, as well as for accessibility, antiterrorism, security, high performance and sustainability requirements, and safety. Use this UFC in addition to UFC 1-200-01 and the UFCs and government criteria referenced therein.

I. REASONABLE ALTERNATIVES

All reasonable alternatives should be considered and compared in the economic analysis. Those that are nonviable must be explained in the Alternatives Considered section of the analysis. The following provides a list of alternatives that should be considered:

1. As Is or Status Quo (Current Operations).
2. Other Facilities on Base[1].
3. Repair or Renovate Existing Facility.
4. Renovation/New Construction Mix.
5. New Construction.
6. Variable Housing Allowance / Basic Allowance for Housing
7. Leasing[2].
8. Other DOD or Federal Agency Facilities.
9. Contracting Out (Services Only).
10. Privatization or Privatizing Usually DOD Operations.
11. Public Private Venture.
12. Enhanced Use Lease (EUL).
13. Community Utilization (Use of Private Facilities).
14. Combination of the Above Alternatives.
15. Other Innovative Alternative.

[1] Note that reuse involving conversion from one function to another will require additional building code compliance and will typically be considered new construction, UFC 3-701-01 and OPNAVINST 11010.20.

[2] GSA is a good source for availability in your area and expected costs.

J. ASSUMPTIONS

Assumptions are explicit statements describing present or future circumstances that may affect the outcome of an analysis. List all the assumptions made for facility and costs that relate to each alternatives. Assumptions apply specifically to the project and location and will vary for each economic analysis. When preparing the Life Cycle Elements section, it is probable that more assumptions will be realized and added to the list. The following describes the types of assumptions that are considered and how they are considered:

- A wash cost is one that applies exactly the same across all Alternatives. Two possible examples of wash costs are Furniture Costs and Moving Costs. They would be the same for all alternatives.

- A sunk cost is one that was made prior to the projects request for funding. Sunk costs do not need to be included in the EA under the Life Cycle Elements. However, they do add background information for the reviewers understanding of the project and should be listed as an assumption. Examples of sunk costs are Surveys and Studies that were conducted prior to the EA.

- Mission related assumptions (e.g., workload, platform types, ship basing, and ship life cycle).

- Variable assumptions are used to provide more specific detail to each of the alternatives.
    1. Lead-time required (number of years needed for construction) may vary for each of the alternatives, or it may be the same.
    2. Services provided in Lease costs.
    3. Define what constitutes Non-recurring costs. HVAC; Roof replacement; window replacement, etc.

K. ECONOMIC INDICATORS

Return on Investment Economic Analysis

NPV is an economic indicator in a Return on Investment (ROI) economic analysis. Other indicators include the Savings to Investment (SIR) ratio, the Return on Investment (ROI) percentage, and the Discounted Payback Period (DPP). ECONPACK automatically calculates these indicators by comparing the viable alternatives to the viable Status Quo alternative.

Mission Requirement Economic Analyses

In a Mission Requirement (MR) economic analysis the Status Quo alternative is not viable. Net Present Value (NPV) is the only economic indicator in a typical MR economic analysis because there is not a viable Status Quo alternative to compare other viable alternatives against.

MR to ROI Economic Analysis

If the Status Quo is not a viable alternative, the Least Initial Cost alternative can replace the Status Quo alternative in a ROI economic analysis. This alternative would typically be chosen if an economic analysis was not conducted and it can then be compared against the other viable alternatives.

Selection of the Preferred Alternative

When using a NPV economic analysis, the lowest NPV alternative is not always the preferred alternative. In the case where the NPV of one alternative is close to that of another, the non-quantifiable costs and benefits play an important role in the selection of the preferred alternative. DOD does Cost Effectiveness Analyses, attempting to make each alternative as equivalent as possible. However, the process is not perfect and so there is usually some differential in the benefits provided. The rationale for the selection of the alternatives including the preferred one should be documented clearly in the narrative of the analysis.

L. GENERAL INFLATION RATE

A general inflation rate is calculated annually, in early February corresponding to the release of the OMB Circular A-94 discount rates. The general inflation rate can be approximated as the difference between the nominal discount rate and the real discount rate. The exact calculation for long term inflation is

(1 + 30 year nominal rate) / (1 + 30 year real rate) - 1

For example, the long term 2013 inflation estimate is (1 + 0.030) / (1 + 0.011) – 1 = 1.8793%. The approximation is 3.0% - 1.1% = 1.9%.

M. LAND APPRECIATION RATE

Land is assumed to appreciate on average each year at a rate of 1.5% above the general inflation rate, i.e. a real rate of 1.5% Thereby, the nominal land appreciation rate that includes inflation for 2013 and beyond is equal to 1.018793% x 1.015% - 1 or 3.4075% per year. The real rate of 1.5% is what is used for Navy constant dollar analyses. This 1.5% rate is also called a differential rate because it is added to constant dollar analysis where the other costs are not adjusted unless they are expected to appreciate or depreciate differently than the general long term anticipated rate of inflation.

N. LEASE ALTERNATIVE CONSIDERATIONS

Per OMB Circular A-94 direction, if a Lease alternative has a lease that is renegotiated each year to adjust for inflation and market conditions, then in essence it becomes a recurring cost and a constant dollar is done using the real interest rate. For a long-term lease not renegotiated each year, a current dollar analysis is done using the nominal discount rate, because the out year lease costs are in "then year dollars". Then year dollars are also referred to as out year dollars in that they have the power to purchase the goods or services in the out years that occur in the future. When using then year dollars, all the costs in the analysis need to be in "then year dollars" and the nominal discount rate needs to be used.

Estimating Lease Costs

Contact your local NAVFAC real estate professional for lease information, including possible availability and typical lease costs. The Realty professional will provide necessary information on how the lease will be established in accordance with Secretary of the Navy Instruction (SECNAVINST) 11010.47 and Real Estate Procedural Manual NAVFAC P-73. There are many considerations that are included in estimating for lease costs. Ensure you discuss the following with the realty professional consulted:

a. Services: Some lease costs may include costs for services such as janitorial, utilities and other operational costs. Clarify which services are included and list them in the assumptions for the leasing alternative.

b. Length of the lease: Consider the minimal length of the lease and expected cost increases for each time the lease is renewed. Most government leases have a period of 5 years. The economic analysis is for a 20-30 year period. Therefore, most leases will be renewed multiple times (as many as 5). Ensure the lease costs are adjusted to reflect each renewal.

c. Lease availability: At some locations there may be no available property to lease, or if property is available, it does not meet the requirements and requires conversion. If conversion is required, those costs must be added into to overall cost of the alternative. Conversions of lease spaces follow the same UFC's and OPNAVINST 11010.20 regulations as any other DOD project, and also require approval of landlord/owner. In most cases the government is responsible for restoring the leased space. If no property is

available, the alternative can still be included as a nonviable alternative considered, to show a well thought out evaluation.

Imputed Costs

Cost effective economic analyses are designed to investigate comparably equivalent alternatives. Imputed costs are those costs that are indirectly rather than directly incurred. For example, the annual recurring cost of an off base lease includes costs such as insurance, real estate taxes, land, and other services. The on base construction alternative should account for similar costs and services that are also provided. To ascribe these indirect costs is known as imputing. Including all indirect cost into the New Construction alternative as imputed costs does this.

Imputed costs are those costs that are indirectly rather than directly incurred. For instance, a lease of an off base building includes costs such as insurance, real estate taxes, and land. The Department of the Navy (DON) does not directly incur these costs. They own land, they provide Public Works Services, fire, and police protection. If the building is damaged by fire, weather, or vandalism, the DON provides the repairs that are needed to restore the building to full functioning capability. The land and services are included in the price of a private sector lease.

In the public sector there is a real cost of providing the land and services. The fewer buildings that the Navy maintains then the less land and services it will need to provide. While the Navy often does not sell the excess land to public and private entities, by giving the land back to the states and local governments, the land can be used to benefit society through parks, housing, or industry which provides jobs.

Imputing costs is merely ascribing a value to these indirect costs so that they will be accounted for and the economic analysis comparison will be a fair comparison of alternatives.

a. Imputed Insurance: When there is a lease alternative, the owner of the facility pays to insure the facility. The government on the other hand is self-insured. This means there is a hidden cost that the government must bear. This cost needs to be imputed to the government owned alternatives. The cost is estimated by using local estimates. When local estimates are not available, a default value of 0.75% of the appraised/replacement should be used.

b. Imputed Real Estate Taxes: When a lease alternative is off base, the owner of the facility pays local real estate taxes. These are used to pay for local infrastructure, security, and other services. In the case of the on base alternatives, the government pays for the infrastructure and services. This is a real cost that needs to be accounted for in the alternatives that are on base. Local estimates are used in this case or a default value of 1.5% of the appraised/replacement value.

c. Imputed Land: When a lease alternative is off base, there is a value to the land on base that would no longer be needed for the facility. This value needs to be addressed in the on base alternatives as an imputed cost. Due to the wide variations in cost because of local conditions there is no default value for land. Local land estimates need to be used.

d. BAQ/VHA Cost: When BAQ/VHA allowance does not cover 100% of the rental cost and there is an on base alternative like a BEQ/BOQ that covers 100% of the rental cost then the differential rent cost can be imputed to the BAQ/VHA to account for additional rent that the sailor has to pay for living off-base.

e. Imputed Facility Cost: When a lease alternative is off base, there is a value to the facility on base that would no longer be needed for the mission. This value needs to be addressed in the on base alternatives as an imputed cost. Generally, the estimated cost of a new facility of the same size can be discounted by the percent of the facility life remaining in the same way that terminal value is estimated.

O. ALIGNMENT WITH DD1391

Information from the economic analysis ECONPACK generated Executive Summary Report needs to be condensed into the DD1391.

- The DD1391 Total Funds Requested must match the initial MILCON or Repair cost in the EA. Total Funds Requested is the Total Funded Project Cost plus additional costs like Planning and Design and Moving Equipment that will need to be incurred in the future if the alternative is selected.
- Briefly summarize each of the alternatives considered in Block 11 of the DD1391; Economic Alternatives Considered.
- Add the recommendation from the EA Executive Summary Report into the DD1391.
- The Total Funded Cost from the DD1391 should be used in the EA rather than the Total Request since this is closer to the true cost of the MILCON or Repair project.
- Match the net present values (NPVs) in the DD1391 with the NPVs in the EA. This should be done each time a revision is made to either the 1391 or EA.

P. ECONPACK

Current versions of ECONPACK may be found on the NAVFAC ECONPACK Wiki page. The link to the wiki page can be found on the Economic Analysis program page of the AM HQ website.

Q. RETURN ON INVESTMENT ANALYSIS

Return on investment (ROI) is sometimes broadly used to refer to a number of economic indicators such as the present value of the benefits received from an investment.
In the context of an economic analysis, ROI is the percentage of the net investment that is returned to the Navy after the net investment is paid for by the net saving generated by selecting the proposed alternative over the status quo alternative. For example, an ROI of 100% means that after the net investment is paid for, the savings over the period of analysis is equal to 100% of the cost of the net investment. The adjective net is used because ECONPACK adjusts the saving and the investment. For example, the proposed alternative investment is adjusted by reducing it by the benefits generated by the proposed alternative if there are any. In this calculation all costs and benefits are discounted to account for the time value of money.

Expectations are higher investments should bring quicker returns. That is not always the case and why sometimes a ROI is done as a quick test of the soundness of an alternative.

The Savings to Investment Ratio (SIR) is commonly used as part of an Economic Analysis. SIR measures the savings achieved per dollar invested, by evaluating the ratio of the present value of the savings divided by the present value of the investment. This ratio is similar to ROI. When there are benefits other than savings that are convertible into dollars, the benefit to investment ratio (BIR) is used. The BIR is the ratio of the present value of the benefits including savings divided by the present value of the investment.

When determining the return on investment consider whether or not the investment pays for itself. Both SIR and BIR include as savings, the present value of the investment salvage value at the end of the life cycle. A SIR or BIR equal to 1 indicates that the present value of the savings and salvage value equals the present value of the investment. This is the breakeven point. A SIR or BIR of 1 indicates that the investment is fully recouped over the period of analysis (POA). In this case, there is no return on the investment at all because all that happens over the POA is that you get your money back. Since discounting takes into account the time value of money the net effect of all your efforts is as if you did not invest any money at all.

If on the other hand, the SIR or BIR is 1.5, then you have recouped your investment and increased it by 50%. There would be a 50% ROI.

The formula for calculating ROI from SIR is ROI = (SIR-1) x 100% and for calculating ROI from BIR is ROI = (BIR-1) x 100%. The reason for subtracting 1 is to account for the original investment represented by the 1. Both BIR and SIR include the investment salvage value at the end of the period of analysis which must be taken into account.

Due to misconceptions about ROI, in a number of cases the formula ROI = SIR x 100% has been used. This should not be used, since it does not accurately reflect return on investment.

Note that electronic ROI is a decision analysis workbook for Energy Projects that is maintained and updated by CNIC HQ.

R. DISCOUNT RATE AND COST SENSITIVITY ANALYSIS

ECONPACK does an automatic discount rate sensitivity analysis between 1 and 10 percent. This determines whether there will be change in the ranking of the alternatives if the discount rate were different than it is today. Note that the discount rates are updated annually and determine how heavily costs and benefits will be reduced to bring them back to the purchasing power of the base year.

Cost sensitivity analyses measure the impact on the relative ranking of the alternatives by Net Present Value (NPV) when the cost of an expense or benefit is increased or decreased. Usually three to four cost sensitivity analyses are run focusing on those cost items with the greatest potential for variation and those that make up the greatest percentage of the net present values.

Also, as mentioned previously a period of analysis sensitivity analysis is recommended for energy intensive projects and when the NPVs are relatively close to each other.

S. ACRONYMS

BOD	Beneficial Occupancy Date
BCA	Business Case Analysis
EA	Economic Analysis
NPV	Net Present Value
SIR	Savings to Investment Ratio
DPP	Discounted Payback Period
PRV	Plant Replacement Value
CTR	Contracting Technical Representative
MILCON	Military Construction
MCON	Military Construction Navy Funding Account
FPG	Facilities Pricing Guide
POA	Period of Analysis
BIR	Benefit to Investment Ratio
ROI	Return on Investment
EROI	Electronic Return on Investment

T. COMMON ECONOMIC ANALYSIS ERRORS

Error #1 - Lack of Alternatives Explored. Too few alternatives explored, discussed, or included. Evaluate and discuss all alternatives considered.

Error #2 - Wrong Discount Rate Used. Usually this occurs when either an out of date discount rate is used or the real rate is used when the nominal one should have been used or vice versa.

Error #3 - No Sensitivity Analysis Completed. Inadequate or no sensitivity analysis is included in the economic analysis. Sensitivity analysis is needed to examine the potential impact of errors in the cost estimates and assumptions. There should be a logical justification on why certain cost items and assumptions were chosen for cost sensitivity over others.

Error #4 - Incorrect Period of Analysis Used. The period of time over which the economic analysis is conducted is not correct.

Error #5 - No Terminal Value Applied. The terminal value was not included in the economic analysis when there was remaining physical life left in a facility at the end of the analysis period.

Error #6 - Equal Recurring Costs Were Assumed. Another common mistake is incorrectly assuming that the maintenance, repairs, and utility costs for each alternative will be the same. These costs are dependent on the age and quality of the facilities.

Error #7 - No Imputed Costs Ascribed. Imputed real estate taxes, land, and insurance are not included in the New Construction alternative when there is an off-base alternative such as a lease.

Error #8 - Incomplete Documentation Presented. There is incomplete or minimal documentation of sources of cost estimates and their derivation. For example, a project that is used for cost estimation needs to be referenced. Also, calculations used to derive cost estimates need to be shown.

Error #9 - Incorrect Facility Replacement Cost. This may be the result of an improper new construction calculation or inadequate justification or documentation when using a similar facility project to estimate the cost. A cost estimate using the FPG should be used to verify your results.

Error #10 – Data not included because resource for data is unknown. There is good modeling as well as actual data out there, consult with SME's in PW, Planning, Energy and Capital Improvements for help in finding data or resources for good data.

Error #11 – Operation Data that is incomplete. There is incomplete or no operational cost data, (e.g. direct labor, material handling, transportation) for each alternative.

Error #12 – Incorrect Data Entered. Data was incorrectly entered. For example the difference between cost items for each alternative (i.e. savings) is entered instead of entering the cost items for each alternative and using ECONPACK to calculate the differential cost; hence savings.

APPENDIX B - EA POLICY INSTRUCTIONS

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 the most current guidance is followed during the preparation of the economic analysis.

1. OMB CIRCULAR NO. A-94 (Revised 29 October 1992). Subj: "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs". This guideline prescribes current discount rates for general use in the economic evaluation of projects and programs. The guideline cites general policy for the treatment of inflation in economic analyses; however, it does not apply to the evaluation of decisions regarding acquisition of commercial-type services by Government or contractor operation (this guidance is contained in OMB CIRCULAR NO. A-76 OF 29 MAY 2003).

https://www.whitehouse.gov/omb/information-for-agencies/circulars/

2. DoDI 7041.3 (07 November 1995) Subj: "Economic Analysis for Decision-making". This instruction establishes policy and procedural guidance for economic analysis of proposed DOD programs, projects, and activities, and for program evaluation of ongoing DOD activities.

https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/704103p.pdf?ver=2019-08-12-152105-700

3. DOD Financial Management Regulation (DOD FMR) 7000.14-R (2008) "DOD Financial Management Policy and Procedures." The DOD FMR directs statutory and regulatory financial management requirements, systems, and functions for all appropriated and non-appropriated, working capital, revolving, and trust fund activities.

http://www.defenselink.mil/comptroller/fmr/

4. DOD Facilities Pricing Guide UFC 3-701-01. The DOD Facilities Pricing Guide supports a spectrum of facility planning, investment and analysis needs. The latest version of the Guide was revised to reflect updated cost and pricing data for FY 2009 and is intended to correspond with preparation of the DOD budget for FY 2011. It includes reference information organized into three chapters - Unit Costs for Military Construction Projects, Unit Costs for DOD Facilities Cost Models, and Common Cost Adjustment Factors. The Office of the Deputy Under Secretary of Defense for Installations and Environment is the proponent for the Facilities Pricing Guide.

http://www.uscost.net/CostEngineering/documents.htm

5. NAVFAC Building Cost Index Historical. Historical indices are based upon the Engineering News Record Building cost index. All indices are based upon fiscal year rates.

http://www.uscost.net/CostEngineering/documents.htm

6. NAVFAC Supporting Facility Guidance Unit Costs. Price Includes Contractor's Overhead and

Profit Escalation is to the midpoint of construction, Oct 1 (assumes 1 year of construction) and ACF (Area Cost Factor) = 1.0.

http://www.uscost.net/CostEngineering/documents.htm

7. The Unified Facilities Criteria (UFC) System.

The Unified Facilities Criteria (UFC) system prescribed by MIL-STD 3007 provides planning, design, construction, sustainment, restoration, and modernization criteria, and applies to the Military Departments, the Defense Agencies, and the DOD Field Activities in accordance with USD (AT&L) Memorandum dated 29 May 2002.

UFC are living documents and will be periodically reviewed, updated, and made available to users as part of the Services' responsibility for providing technical criteria for military construction. Headquarters, U.S. Army Corps of Engineers (HQUSACE), Naval Facilities Engineering Command (NAVFAC), and Air Force Civil Engineer Center (AFCEC) are responsible for administration of the UFC system.

The following three UFC's establish criteria and standards for development and preparation of cost estimates for military construction projects used in an economic analysis. These UFC's address cost estimates for new construction and alteration projects, including cost data (based on historic data and experience) and cost adjustment factors for project size, location and inflation. They can be found at the NAVFAC Cost Engineering web page at http://www.uscost.net/CostEngineering/documents.htm. Updates to these UFC's are posted as they become available:

UFC 3-700-01, Programming Cost Estimates for Military Construction, provides guidance for programming estimates prepared for budget review.

UFC 3-701-01, DOD Facilities Pricing Guide, provides current unit costs for typical types of DOD MILCON facilities, sustainment and modernization cost factors, area cost factors, and inflation factors (updated annually).

UFC 3-740-05, Handbook: Construction Cost Estimating provides guidance for detailed cost estimating performed during design and solicitation of a MILCON project.

8. Handbook: Construction Cost Estimating UFC 3-740-05. This document is a complete update to UFC 3-700-02A, establishing uniform guidance to describe methods, procedures, and formats for the preparation of construction cost estimates and construction contract modification estimates. It addresses all phases of construction cost estimating from planning phases through modification estimates during construction. The term “construction” includes remedial action environmental projects, dredging, and other construction type work often implemented as service contracts.

http://www.uscost.net/CostEngineering/Documents/UFC_3-740.pdf

9. MIL-HDBK 1190 (1 September 1987). Subj: "Facility Planning and Design Guide". The design guide requires that life cycle costs be considered in engineering economic studies which are requisite to the design of military facilities.

http://www.scribd.com/doc/44297353/MIL-HDBK-1190-Facility-Planning-and-Design-Guide

10. O M B Circular No. A-94 (Revised 29 October 1992). Subj: "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs". This publication establishes specialized procedures for the economic analysis of general purpose real property buy vs. lease analyses of third party options.

http://www.whitehouse.gov/omb/circulars/a094/a094.html

11. DoDI 4165.6 (13 October 2004) Certified current November 18, 2008. Subj: "Real Property". This publication requires an economic analysis in accordance with DoDI 7041.3 when proposed leasehold is in lieu of new construction.

http://www.dtic.mil/whs/directives/corres/pdf/416506p.pdf

12. OPNAVINST 11010.20X, "Facilities Projects Instruction". Where X is the current version of the instruction. This instruction provides procedures for submission of engineering data and documents to support Military Construction and Special Projects.

http://doni.daps.dla.mil/_layouts/1033/searchresults.aspx

13. OMB Circular No.A-76 (Revised 29 May 2003). Subj: "Performance of Commercial Activities". This instruction reaffirms the general policy of Government reliance on the private sector for goods and services.

http://www.whitehouse.gov/omb/circulars/a076/a76_rev2003.pdf

14. Revised Supplement to OMB Circular A-76. This publication provides detailed instructions for developing comprehensive cost comparisons for acquiring a product or service by contract vs. providing the service with 'in-house' Government resources.

http://www.whitehouse.gov/omb/circulars/a076supp.pdf

15. DOD Directive 4100.15 (10 March 1989): Commercial Activity Program. This instruction prescribes Department of Defense policy governing the establishment and operation of commercial or industrial activities by DOD components.

http://www.dtic.mil/whs/directives/corres/pdf/410015p.pdf

16. DODINST 4100.33 (incorporating through change 3, of 6 October 1995, Subj: Commercial Activities Program Procedures". This instruction implements criterion for use by the Military

Departments and Defense Agencies in regard to the commercial or industrial activities which they operate and manage.

http://www.dtic.mil/whs/directives/corres/pdf/410033p.pdf

17. OMB Circular Number A-109 (5 April 1976), Subj: "Major System Acquisition". This instruction establishes policies to be followed by executive branch agencies for the acquisition of major systems.
https://akss.dau.mil/Documents/Policy/OMB%20Circular%20A-109.doc

18. DOD Directive 8910.1 (11 June 1993 certified current as of 21 November 2003), Subj: "Management and Control of Information Requirements". Establishes policy and assigns responsibilities for the management and control of information requirements.

http://www.dtic.mil/doctrine/education/edusurvey_DoDd89101.pdf

19. DODINST 8120.2 (14 January 1993), Subj: "Automated Information System (AIS) Life-Cycle Management (LCM) Process, Review and Milestone Approval Procedures"

http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA391647&Location=U2&doc=GetTRDoc.pdf

20. SECNAVINST 5000.2C (November 19, 2004), Subj: "Implementation and Operation of the Defense Acquisition System and the Joint Capabilities Integration and Development System"

http://www.ntip.navy.mil/cap/documents/5000.2C.pdf

21. NAVFACINST 11010.45, Regional Planning Instruction, The Regional Planning Instruction (RPI) provides an organizing framework for all planning instructions, guidance and advice for the Navy shore establishment.

https://portal.navfac.navy.mil/portal/page/portal/docs/doc_store_pub/11010.45(basic)_2.pdf

APPENDIX C – EXAMPLE- STATEMENT OF WORK FOR A BUSINESS CASE ANALYSIS

Appendix C is a Business Case Analysis (BCA) Statement of Work (SOW) for typical Navy facilities structured by using the NASA Business Case Analysis Guide that uses ECONPACK to calculate the economic indicators. The SOW provides a lot of structure to the contractor who typically needs a lot of guidance on how to conduct a NAVFAC economic analysis or BCA. NAVFAC has more experience with economic analyses than with BCAs so that contractor ideas are valuable to consider.

Business Case Analysis (BCA) Report
For
Naval District Washington (NDW) Region
****
NAVAL FACILITIES ENGINEERING COMMAND
(NAVFAC) WASHINGTON
WASHINGTON, DC
****
Statement of Work

Contract Number: xxx
Task Order: xxx

I. Introduction

NAVFAC Washington seeks contractor support for the Department of the Navy's Business Case Analysis (BCA) report in support of the Regionally Integrated Master Program (RIMP). A BCA report provides a best-value analysis of alternatives that considers the cost, as well as other quantifiable and non-quantifiable factors supporting a business decision such as performance, reliability, and maintainability. The BCA should provide convincing evidence that justifies a decision and the tangible or intangible return to the Government.

II. Project Description

- Conduct a Business Case Analysis (BCA) study for each of the six (6) categories within the Naval District Washington (NDW) region.
- Prepare a complete BCA report for each category to examine both the financial implications of a particular alternative, such as life-cycle costs, net present value and other quantifiable objectives, as well as other intangible objectives (which are difficult to place a dollar value), that enables decision-makers to base investment decision on facts while discovering the potential risks and rewards of the specific decisions.

III. Objectives

The BCA reports shall be correct, clear, unbiased, and efficient.
a) Correctness – The report should accurately reflect the best estimates of future benefit and cost streams for each analyzed alternative. All meaningful costs and benefits should be included and

validated against the best available data sources. Uncertainty and variances in estimated values should be consistently captured and reported. Intangible factors should also be presented and analyzed consistently.

b) Clarity – The report should be easily understood by all project stakeholders including project sponsors, project managers, process owners, and decision-makers. The project approach, analysis of alternatives, and recommended decisions should all be clearly presented. There is significant complexity in understanding and presenting the impact of any business investment. There is similar significant complexity in the financial analysis of alternatives. This complexity should be managed in presenting the business case by carefully defining terms, approach, and results.

c) Unbiased – All meaningful alternatives should be presented and analyzed in a consistent manner.

d) Efficient – The goal of the BCA report is to provide a best-value analysis among the alternative approaches in each category and identify and analyze quantitative/qualitative benefits and costs, in order to provide the decision-makers a thorough business case to make a practical investment decision.

IV. Scope of Work

The contractor shall evaluate all viable alternatives in each BCA category, identify potential alternatives, identify potential resource requirements to support alternatives and identify issues or concerns in establishment of each alternative. The contractor shall test the government's concept for development for each BCA category and location against market conditions, taking into consideration the government's financial objectives (Footprint Reduction, Energy Efficiency, minimize Operational and Life-Cycle Costs), and conduct an analysis for each BCA category.

Task 1 The contractor shall develop a Business Case Analysis report for each of the six (6) BCA categories. The report shall be completed using the following steps (include tables and figures to provide visual illustration):

- The contractor shall perform an analysis of the alternatives (i.e., strength, weakness, opportunity and threat) and briefly summarize the cost analysis conducted to generate accurate Life-Cycle Cost estimates for each alternative. Summarize sensitivity analysis performed on cost drivers, the effect of cost, risk and schedule on each alternative.

- Where the analysis leads to a facility solution, the contractor shall conduct an assessment of the project location (specified in the BCA category) to collect data, identify impacts and potential resources needed for alternatives (i.e., new construction, refurbish/renovate an existing building, propose option to lease space near the project location or other innovative alternative such as public private venture), and assess important assumptions, constraints and conditions having a major influence on the business case analysis and its conclusions.

- The contractor shall summarize benefits analysis activities conducted to generate accurate Life-Cycle benefit estimates for each alternative. The summary should provide enough information to show the differentiation and relative merits of each alternative.

- The contractor shall summarize the economic analysis in each BCA category. Discount rates per Office of Management & Budget (OMB) guidelines shall be used to calculate net present value estimates of costs and benefits for each alternative in each BCA category. Other economic indicators such as benefit cost ratio, savings to investment ratio, return on investment, and discounted payback period shall be calculated using ECONPACK.

- The contractor shall have a risk statement for each alternative in each BCA category. Identify major risks and planned mitigation strategies for each alternative. Discuss the comparative risk assessment for the initial investment decision including sensitivity analysis of costs that may vary and impact results of analysis.
- The contractor shall identify the recommended alternative in each BCA category and summarize the rationale for the recommendation.

- The BCA report outline includes:

I. Executive Summary
II. Project Summary
    a. Project Definition/Problem Statement
    b. Assumptions
    c. Alternatives
    d. Data Plan
    e. Data Collection
    f. Findings
III. Life Cycle Cost Analysis
    a. Alternatives
    b. Cost Analysis/Cost Comparison
    c. Benefit Analysis
    d. Risk Analysis
    e. Sensitivity Analysis
IV. Conclusions and Recommendations
V. Tables and Graphs
VI. References

Task 2 The contractor shall identify opportunities between and among potential BCA categories that can be bundled together to leverage opportunities. For example, if the conference center and lodging facilities present an opportunity to be bundled together, include this innovative alternative in both the conference center and the lodging facility BCA report.

Task 3 The contractor shall develop a final report incorporating comments received on the draft report and comments received at the meetings. As part of this task, the contractor shall also develop a Microsoft Office PowerPoint format briefing showing final findings and recommendations. The contractor will be required to attend a briefing at NAVFAC Washington to present findings for each BCA report.

Task 4 The contractor shall input the Life Cycle Costs and benefits into ECONPACK and provide a full standard report as an Appendix for each BCA category report with highlights in the Life Cycle Cost Analysis section.

V. BCA Category and Location

This study will require the contractor to perform a Business Case Analysis for each of the following six (6) categories utilizing the Navy's resources (of Land and/or Facilities) to best support the Navy's Mission.
BCA categories to be analyzed under this contract:

Conference Centers
Conference facilities exist or have been proposed at multiple locations within NDW. This BCA will examine alternatives ranging from dispersed conference facilities at multiple locations to consolidated conference facilities at one or two locations. The BCA will determine the best approach to meet NDW's conferencing requirements. Conference facilities currently exist or have been proposed at:

- NSF Dahlgren
- NSF Indian Head
- NSF Carderock
- NSA Annapolis
- NAS Patuxent River
- NAF Anacostia
- Washington Navy Yard

Transient/Unaccompanied Lodging Facility
Lodging for transient and unaccompanied personnel is limited within the National Capital Region. This BCA will examine the current requirement for lodging within NDW, identify the most critical or desirable location(s) for additional lodging, and explore methods of meeting this requirement ranging from expanding Navy provided lodging, Enhanced Use Lease, to Public Private Ventures or use of local hotels.

Remote Work Campus
Office, Research and Development, and Support space is in limited in certain locations within NDW. In the private sector many businesses are utilizing "office hoteling", alternate work locations remote from the main corporate office, virtual offices, and telework to diminish demand within headquarters facilities. This BCA will examine the potential for such approaches within NDW, examining the potential for application of such approaches across various supporting and supported commands, and examining potential locations for remote business parks or "hotel offices" utilizing existing facilities or new facilities developed through traditional MCON construction or through EUL/PPV approaches.

Solomon's Recreation
Solomon's Island Recreation Area (SIRA) has been studied for potential development through an Enhanced Use Lease. Currently SIRA is developed and managed by the Navy's Fleet and Family Support organization. This BCA will examine these two differing approaches to the future

development and management of SIRA to determine which approach provides the greatest benefit to NDW.

Unmanned Aerial Vehicle (UAV) RDAT&E

Research, Development, Acquisition, Testing and Evaluation (RDATE&E) of Unmanned Aerial Vehicles and component and supported systems takes place at various locations within NDW. This BCA will examine the various RDAT&E requirements across the region and consider whether these requirements are best met at multiple discrete locations or through consolidation of supporting facilities at one or more locations. UAV related work is currently undertaken at:

- NSF Dahlgren
- NAS Patuxent River
- OLF Webster Field

Integrated Product Team/Integrated Test Team

RDAT&E programs require significant support from firms under contract to the government. In many instances, this support requires close interaction between government and contractor employees in real or virtual teams. This BCA will examine the benefits and trade-offs in providing government facilities to house these integrated government/contractor teams as opposed to limiting facility support to private contractors (requiring contractor provided facilities off base). The BCA will examine impacts of costs and benefits in an all inclusive manner, incorporating operational, contract, facility management, and program impacts on costs and benefits.

VI. Key Elements

The contractor shall include the following elements in the analysis of each BCA category.

- Supply and Demand Key Elements:

Supply

Step 1 - Define the Facility Category
Step 2 – Take an Inventory of Assets
Step 3 – Assess Supply Availability and Development Ability of Land and Existing Facilities

Demand

Step 1 – Determine the Demand for the Asset
Step 2 – Determine the Quantity, Size, and Distribution of Facilities that are required
Step 3 – Determine the Current and Future Potential Utilization of the Facility
Step 4 – Consider whether there a need for Guaranteed Occupancy or Demand

- Alternative Key Elements:

Partnering

Step 1 - Determine the Advantages of Enhancing the Existing Asset

Step 2 - Determine whether Location is better On Base or Off Base
Step 3 – Assess whether there are Partnering Opportunities with Other DOD Agencies
Step 4 – Consider if Underutilized Land is Available for a EUL Alternative

Privatization

Step 1 – Consider the Feasibility of Private Sector Use of the Facility
Step 2 – Assess the Feasibility of a Public Private Venture
Step 3 – Assess whether the Operation of the Facility is better run by DOD or Private Industry

Multiple Use

Step 1 – Determine whether the Facilities have Multiple Use Capabilities
Step 2 – Consider Opportunities for Combining Types of Categories

Security

Step 1 – Assess Current and Future Security Concerns of all Viable Alternatives
Step 2 – Determine if there are Contractor Access Issues

- Alternatives to Determine Feasibility:

1. As Is or Status Quo (Current Operations).
2. Other Facilities on Base.
3. Repair or Renovate Existing Facility.
4. Renovation/New Construction Mix.
5. New Construction.
6. VHA / BAH (Barracks Only).
7. Leasing.
8. Other DOD or Federal Agency Facilities.
9. Contracting Out (Services Only).
10. Privatization or Privatizing Usually DOD Operations.
11. Public Private Venture.
12. Enhanced Use Lease (EUL).
13. Community Utilization (Use of Private Facilities).
14. Combination of the Above Alternatives.
15. Other Innovative Alternative.

VII. Deliverables and Submittals

1. The contractor shall attend meetings with NAVFAC staff to discuss scope of work, methodology, goals, objectives and the schedule for the project. The contractor shall present an outline of strategy for project completion at the Kick-off meeting.

2. The contractors will coordinate with the installation POCs to collect site data. Within one (1) week of a meeting, briefing or phone conference call, the contractor shall prepare meeting minutes for distribution to the Project Manager

3. The contractor shall provide periodic progress reports at the completion of each stage:
   - Project Definition/Problem Statement,
   - Assumptions and Alternatives,
   - Methodology Plan and Data Collection,
   - Findings,
   - Life Cycle Cost Analysis, and
   - Recommendation.

4. BCA Report*.
   A draft working paper, pre-final and final report will be submitted and prepared by the contractor; as directed by the government and delivered in the following quantities/formats:

Draft working paper	5 print copies, 2 CD-ROM copies
Progress Reports	Email
Meeting minutes	Email
Pre-Final report	5 print copies, 2 CD-ROM copies
Final report and briefing	10 print copies, 2 CD-ROM copies

*The contractor shall develop a Business Case Analysis report for each of the six (6) BCA categories (separate each location within the BCA report with section dividers). A total of sixty (60) Final BCA reports shall be submitted.

5. Upon receipt of comments from the NAVFAC from the pre-final plan, the contractor shall prepare and conduct a final presentation for staff and leadership.

VIII. Schedule

Deliverable products shall be due according to the following schedule:

Initial BCA Assessment	30 days after contract award
Cost Analysis	20 days after BCA Assessment
Benefit Analysis	10 days after Alternative Cost
ECONPACK draft report	15 days after Benefit Analysis
Draft working paper**	15 days after ECONPACK draft report
Pre-Final report	15 days after Draft working paper
Final report	15 days after Pre-Final
Final briefing	at government request

** Upon review of the working draft paper, a review meeting will be held at NAVFAC Washington to discuss any modifications / changes required prior to submission of pre-final plan.

IX. General Information

Documents should be produced using Microsoft Word, Excel and PowerPoint, ECONPACK, and Adobe Acrobat formats.

The contractor is responsible for the professional and technical accuracy and coordination of all work or services furnished. Products submitted by the contractor shall be reviewed by NAVFAC Washington for compliance with government requirements and criteria. Errors or deficiencies in the contractor's product shall be corrected by the contractor with no additional cost or fee to the government.

All work areas are unclassified and all products resulting from this contract will be unclassified. The contractor shall not discuss or release information concerning operations or recommendations developed during the course of this contract to the general public, newspapers, or other media, public officials, community leaders, etc. without prior approval of the Navy. Products developed under this contract will remain the property of the government and will be retained by the government at the conclusion of the contract. Deliverable products must be marked as "PROCUREMENT SENSITIVE / DO NOT RELEASE."

All requests to visit Naval District Washington (NDW) bases must be arranged in advance and shall be cleared prior to a site visit. Conference room space will be provided as available for the contractor's use during visits. Limited quick-copy capacity will be provided. The contractor will be provided access to all available data sources on a "need-to-know" basis. The contractor shall schedule all transportation required for visits to NDW bases.

The contractor's responsibility is directly to the Contracting Officer via the Contract Specialist. Any requested change/deviation in scope must be brought to the attention of and/or approved by the Contracting Officer. In no case will changes to the contract scope be made at the activity level or by any person other than the Contracting Officer.

APPENDIX D – PRESENT VALUE (PV) TABLES AND FORMULAE

TABLE A (Project Year Discount Factors – Single Amount)

TABLE B (Project Year Discount Factors – Cumulative Uniform Series)

2.00%

	Table A	Table B
YR(n)	a(n)	b(n)
1	0.990148	0.990148
2	0.970733	1.96088
3	0.951699	2.912579
4	0.933038	3.845617
5	0.914743	4.760361
6	0.896807	5.657168
7	0.879223	6.536391
8	0.861983	7.398374
9	0.845081	8.243455
10	0.828511	9.071966
11	0.812266	9.884232
12	0.796339	10.68057
13	0.780725	11.4613
14	0.765416	12.22671
15	0.750408	12.97712
16	0.735694	13.71281
17	0.721269	14.43408
18	0.707126	15.14121
19	0.693261	15.83447
20	0.679668	16.51414
21	0.666341	17.18048
22	0.653275	17.83375
23	0.640466	18.47422
24	0.627908	19.10213
25	0.615596	19.71772
26	0.603525	20.32125
27	0.591692	20.91294
28	0.58009	21.49303
29	0.568716	22.06175
30	0.557564	22.61931

2.50%

	Table A	Table B
YR(n)	a(n)	b(n)
1	0.98773	0.98773
2	0.963639	1.951368
3	0.940135	2.891503
4	0.917205	3.808709
5	0.894834	4.703543
6	0.873009	5.576552
7	0.851716	6.428268
8	0.830943	7.259211
9	0.810676	8.069886
10	0.790903	8.860789
11	0.771613	9.632402
12	0.752793	10.3852
13	0.734432	11.11963
14	0.716519	11.83615
15	0.699043	12.53519
16	0.681993	13.21718
17	0.665359	13.88254
18	0.649131	14.53167
19	0.633299	15.16497
20	0.617852	15.78282
21	0.602783	16.38561
22	0.588081	16.97369
23	0.573737	17.54742
24	0.559744	18.10717
25	0.546091	18.65326
26	0.532772	19.18603
27	0.519778	19.70581
28	0.5071	20.21291
29	0.494732	20.70764
30	0.482665	21.19031

Note that a (n) (single present value) factors are based on Middle-of-Year compounding using $\frac{1}{(1+i)^{n-1/2}}$ and that b (n) (cumulative uniform series) factors represent the cumulative sum of PV factors in a(n) column.

3.00%

YR(n)	Table A a(n)	Table B b(n)
1	0.985329	0.985329
2	0.95663	1.94196
3	0.928767	2.870727
4	0.901716	3.772443
5	0.875452	4.647895
6	0.849954	5.497849
7	0.825198	6.323047
8	0.801163	7.124209
9	0.777828	7.902038
10	0.755173	8.65721
11	0.733178	9.390388
12	0.711823	10.10221
13	0.69109	10.7933
14	0.670961	11.46426
15	0.651419	12.11568
16	0.632445	12.74813
17	0.614025	13.36215
18	0.59614	13.95829
19	0.578777	14.53707
20	0.56192	15.09899
21	0.545553	15.64454
22	0.529663	16.1742
23	0.514236	16.68844
24	0.499258	17.1877
25	0.484717	17.67241
26	0.470599	18.14301
27	0.456892	18.59991
28	0.443584	19.04349
29	0.430665	19.47415
30	0.418121	19.89228

3.50%

YR(n)	Table A a(n)	Table B b(n)
1	0.982946	0.982946
2	0.949707	1.932653
3	0.917591	2.850244
4	0.886561	3.736805
5	0.856581	4.593386
6	0.827614	5.421001
7	0.799628	6.220628
8	0.772587	6.993215
9	0.746461	7.739676
10	0.721218	8.460894
11	0.696829	9.157723
12	0.673265	9.830988
13	0.650497	10.48149
14	0.6285	11.10999
15	0.607246	11.71723
16	0.586711	12.30394
17	0.566871	12.87081
18	0.547701	13.41852
19	0.52918	13.9477
20	0.511285	14.45898
21	0.493995	14.95298
22	0.47729	15.43027
23	0.46115	15.89142
24	0.445555	16.33697
25	0.430488	16.76746
26	0.415931	17.18339
27	0.401866	17.58526
28	0.388276	17.97353
29	0.375146	18.34868
30	0.36246	18.71114

Note that a (n) (single present value) factors are based on Middle-of-Year compounding using $\frac{1}{(1+i)^{n-1/2}}$ and that b (n) (cumulative uniform series) factors represent the cumulative sum of PV factors in a(n) column.

4.00%

	Table A	Table B
YR(n)	a(n)	b(n)
1	0.980581	0.980581
2	0.942866	1.923447
3	0.906602	2.830049
4	0.871733	3.701781
5	0.838204	4.539986
6	0.805966	5.345952
7	0.774967	6.120919
8	0.745161	6.866079
9	0.716501	7.58258
10	0.688943	8.271523
11	0.662445	8.933968
12	0.636967	9.570935
13	0.612468	10.1834
14	0.588911	10.77231
15	0.566261	11.33857
16	0.544482	11.88306
17	0.52354	12.4066
18	0.503404	12.91
19	0.484042	13.39404
20	0.465425	13.85947
21	0.447524	14.30699
22	0.430312	14.7373
23	0.413761	15.15107
24	0.397847	15.54891
25	0.382546	15.93146
26	0.367832	16.29929
27	0.353685	16.65298
28	0.340082	16.99306
29	0.327002	17.32006
30	0.314425	17.63448

4.50%

	Table A	Table B
YR(n)	a(n)	b(n)
1	0.978232	0.978232
2	0.936107	1.914339
3	0.895796	2.810135
4	0.857221	3.667357
5	0.820308	4.487664
6	0.784983	5.272648
7	0.75118	6.023828
8	0.718833	6.74266
9	0.687878	7.430539
10	0.658257	8.088795
11	0.629911	8.718706
12	0.602785	9.321491
13	0.576828	9.898319
14	0.551989	10.45031
15	0.528219	10.97853
16	0.505472	11.484
17	0.483706	11.9677
18	0.462876	12.43058
19	0.442944	12.87352
20	0.42387	13.29739
21	0.405617	13.70301
22	0.38815	14.09116
23	0.371436	14.4626
24	0.355441	14.81804
25	0.340135	15.15817
26	0.325488	15.48366
27	0.311471	15.79513
28	0.298059	16.09319
29	0.285224	16.37841
30	0.272941	16.65136

Note that a (n) (single present value) factors are based on Middle-of-Year compounding using $\frac{1}{(1+i)^{n-1/2}}$ and that b (n) (cumulative uniform series) factors represent the cumulative sum of PV factors in a(n) column.

5.00%

	Table A	Table B
YR(n)	a(n)	b(n)
1	0.9759	0.9759
2	0.929429	1.905329
3	0.88517	2.790499
4	0.843019	3.633518
5	0.802875	4.436393
6	0.764643	5.201037
7	0.728232	5.929268
8	0.693554	6.622822
9	0.660528	7.28335
10	0.629074	7.912424
11	0.599118	8.511542
12	0.570589	9.08213
13	0.543418	9.625548
14	0.517541	10.14309
15	0.492896	10.63598
16	0.469425	11.10541
17	0.447071	11.55248
18	0.425782	11.97826
19	0.405507	12.38377
20	0.386197	12.76997
21	0.367806	13.13777
22	0.350292	13.48806
23	0.333611	13.82168
24	0.317725	14.1394
25	0.302595	14.442
26	0.288186	14.73018
27	0.274463	15.00464
28	0.261393	15.26604
29	0.248946	15.51498
30	0.237091	15.75207

5.50%

	Table A	Table B
YR(n)	a(n)	b(n)
1	0.973585	0.973585
2	0.922829	1.896414
3	0.87472	2.771134
4	0.829118	3.600252
5	0.785894	4.386146
6	0.744923	5.131069
7	0.706088	5.837157
8	0.669278	6.506435
9	0.634387	7.140822
10	0.601314	7.742136
11	0.569966	8.312102
12	0.540252	8.852355
13	0.512088	9.364442
14	0.485391	9.849834
15	0.460086	10.30992
16	0.436101	10.74602
17	0.413366	11.15939
18	0.391816	11.5512
19	0.371389	11.92259
20	0.352028	12.27462
21	0.333676	12.6083
22	0.31628	12.92458
23	0.299792	13.22437
24	0.284163	13.50853
25	0.269349	13.77788
26	0.255307	14.03319
27	0.241997	14.27518
28	0.229381	14.50456
29	0.217423	14.72199
30	0.206088	14.92807

Note that a (n) (single present value) factors are based on Middle-of-Year compounding using $\frac{1}{(1+i)^{n-1/2}}$ and that b (n) (cumulative uniform series) factors represent the cumulative sum of PV factors in a(n) column.

6.00%

	Table A	Table B
YR(n)	a(n)	b(n)
1	0.971286	0.971286
2	0.916307	1.887593
3	0.864441	2.752034
4	0.81551	3.567545
5	0.769349	4.336894
6	0.725801	5.062695
7	0.684718	5.747413
8	0.645961	6.393374
9	0.609397	7.002771
10	0.574903	7.577673
11	0.542361	8.120034
12	0.511661	8.631696
13	0.482699	9.114395
14	0.455377	9.569772
15	0.429601	9.999372
16	0.405284	10.40466
17	0.382343	10.787
18	0.360701	11.1477
19	0.340284	11.48798
20	0.321023	11.80901
21	0.302852	12.11186
22	0.285709	12.39757
23	0.269537	12.6671
24	0.25428	12.92138
25	0.239887	13.16127
26	0.226308	13.38758
27	0.213498	13.60108
28	0.201414	13.80249
29	0.190013	13.9925
30	0.179257	14.17176

6.50%

	Table A	Table B
YR(n)	a(n)	b(n)
1	0.969003	0.969003
2	0.909862	1.878865
3	0.854331	2.733196
4	0.802188	3.535384
5	0.753229	4.288613
6	0.707257	4.99587
7	0.664091	5.659961
8	0.62356	6.28352
9	0.585502	6.869022
10	0.549767	7.418789
11	0.516213	7.935002
12	0.484707	8.41971
13	0.455124	8.874834
14	0.427347	9.30218
15	0.401264	9.703445
16	0.376774	10.08022
17	0.353779	10.434
18	0.332186	10.76618
19	0.311912	11.0781
20	0.292875	11.37097
21	0.275	11.64597
22	0.258216	11.90419
23	0.242456	12.14664
24	0.227659	12.3743
25	0.213764	12.58807
26	0.200717	12.78878
27	0.188467	12.97725
28	0.176964	13.15422
29	0.166164	13.32038
30	0.156022	13.4764

Note that a (n) (single present value) factors are based on Middle-of-Year compounding using $\frac{1}{(1+i)^{n-1/2}}$ and that b (n) (cumulative uniform series) factors represent the cumulative sum of PV factors in a (n) column.

7.00%

	Table A	Table B
YR(n)	a(n)	b(n)
1	0.966736	0.966736
2	0.903492	1.870229
3	0.844385	2.714614
4	0.789145	3.503759
5	0.737519	4.241277
6	0.68927	4.930547
7	0.644177	5.574724
8	0.602035	6.176759
9	0.562649	6.739409
10	0.525841	7.265249
11	0.49144	7.756689
12	0.45929	8.215979
13	0.429243	8.645221
14	0.401161	9.046382
15	0.374917	9.4213
16	0.35039	9.771689
17	0.327467	10.09916
18	0.306044	10.4052
19	0.286022	10.69122
20	0.267311	10.95853
21	0.249823	11.20836
22	0.23348	11.44184
23	0.218205	11.66004
24	0.20393	11.86397
25	0.190589	12.05456
26	0.17812	12.23268
27	0.166468	12.39915
28	0.155577	12.55473
29	0.145399	12.70012
30	0.135887	12.83601

7.50%

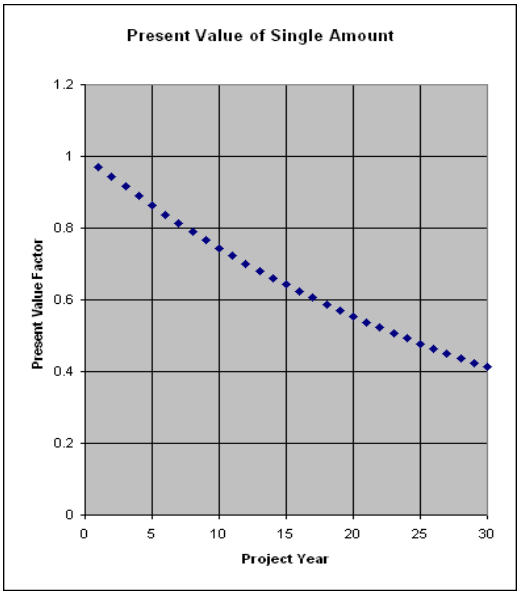
	Table A	Table B
YR(n)	a(n)	b(n)
1	0.964486	0.964486
2	0.897196	1.861682
3	0.834601	2.696282
4	0.776373	3.472655
5	0.722207	4.194863
6	0.671821	4.866684
7	0.62495	5.491633
8	0.581348	6.072982
9	0.540789	6.613771
10	0.50306	7.116831
11	0.467963	7.584793
12	0.435314	8.020107
13	0.404943	8.42505
14	0.376691	8.801742
15	0.350411	9.152153
16	0.325963	9.478116
17	0.303222	9.781338
18	0.282067	10.0634
19	0.262388	10.32579
20	0.244082	10.56987
21	0.227053	10.79693
22	0.211212	11.00814
23	0.196476	11.20461
24	0.182768	11.38738
25	0.170017	11.5574
26	0.158155	11.71555
27	0.147121	11.86268
28	0.136857	11.99953
29	0.127309	12.12684
30	0.118427	12.24527

Note that a (n) (single present value) factors are based on Middle-of-Year compounding using $\frac{1}{(1+i)^{n-1/2}}$ and that b (n) (cumulative uniform series) factors represent the cumulative sum of PV factors in a(n) column.

GRAPH of TABLE A (Present Value of Single Amount)

3.00%

	Table A	Table B
YR(n)	a(n)	b(n)
1	0.970874	0.970874
2	0.942596	1.91347
3	0.915142	2.828611
4	0.888487	3.717098
5	0.862609	4.579707
6	0.837484	5.417191
7	0.813092	6.230283
8	0.789409	7.019692
9	0.766417	7.786109
10	0.744094	8.530203
11	0.722421	9.252624
12	0.70138	9.954004
13	0.680951	10.63496
14	0.661118	11.29607
15	0.641862	11.93794
16	0.623167	12.5611
17	0.605016	13.16612
18	0.587395	13.75351
19	0.570286	14.3238
20	0.553676	14.87747
21	0.537549	15.41502
22	0.521893	15.93692
23	0.506692	16.44361
24	0.491934	16.93554
25	0.477606	17.41315
26	0.463695	17.87684
27	0.450189	18.32703
28	0.437077	18.76411
29	0.424346	19.18845
30	0.411987	19.60044



Discount factors are graphed in the chart to the left. Higher the discount rate the lower the present value. With low discount rates the out year costs and benefits as well as terminal value have a greater impact on NPV.

GRAPH of TABLE B (Cumulative Uniform Series Factors)

3.00%

	Table A	Table B
YR(n)	a(n)	b(n)
1	0.970874	0.970874
2	0.942596	1.91347
3	0.915142	2.828611
4	0.888487	3.717098
5	0.862609	4.579707
6	0.837484	5.417191
7	0.813092	6.230283
8	0.789409	7.019692
9	0.766417	7.786109
10	0.744094	8.530203
11	0.722421	9.252624
12	0.70138	9.954004
13	0.680951	10.63496
14	0.661118	11.29607
15	0.641862	11.93794
16	0.623167	12.5611
17	0.605016	13.16612
18	0.587395	13.75351
19	0.570286	14.3238
20	0.553676	14.87747
21	0.537549	15.41502
22	0.521893	15.93692
23	0.506692	16.44361
24	0.491934	16.93554
25	0.477606	17.41315
26	0.463695	17.87684
27	0.450189	18.32703
28	0.437077	18.76411
29	0.424346	19.18845
30	0.411987	19.60044

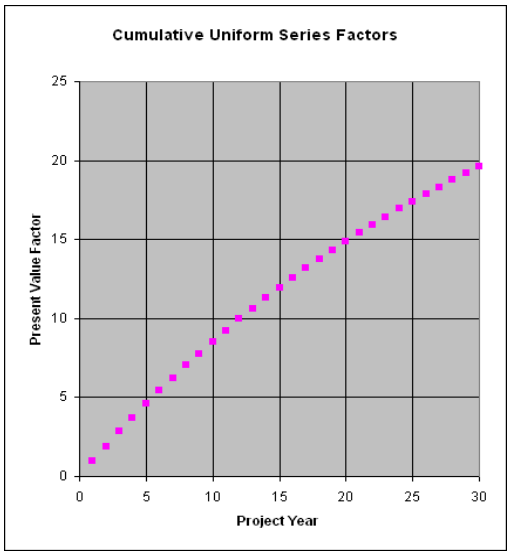


Table B factors are graphed in the chart to the left. Note that the cumulative present value of a uniform series of costs begins to gradually level off as the number of years becomes large. Due to this effect the assumption of an economic life in excess of 30 years usually does not have a large impact on the present value of life cycle costs.

TABLE C Conversion Table (SIR to Discounted Payback Period)

	Discounted Payback Period (Yrs.) For Economic Life Shown							
SIR	5	10	15	20	25	30	35	40
1.0	5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
1.1	4.43	8.58	12.34	15.60	18.30	20.41	21.96	23.06
1.2	3.98	7.53	10.54	12.97	14.82	16.16	17.08	17.70
1.3	3.62	6.71	9.23	11.16	12.57	13.55	14.21	14.64
1.4	3.31	6.06	8.22	9.83	10.97	11.74	12.25	12.58
1.5	3.06	5.53	7.42	8.80	9.75	10.39	10.81	11.07
1.6	2.84	5.08	6.77	7.97	8.79	9.33	9.69	9.91
1.7	2.65	4.71	6.22	7.29	8.01	8.48	8.79	8.98
1.8	2.48	4.38	5.76	6.72	7.36	7.78	8.05	8.22
1.9	2.33	4.10	5.37	6.24	6.82	7.19	7.43	7.59
2.0	2.20	3.85	5.02	5.82	6.35	6.69	6.91	7.04
2.1	2.09	3.63	4.72	5.45	5.94	6.25	6.45	6.58
2.2	1.98	3.44	4.45	5.13	5.58	5.87	6.05	6.17
2.3	1.89	3.26	4.21	4.85	5.27	5.53	5.70	5.81
2.4	1.80	3.10	4.00	4.60	4.99	5.23	5.39	5.49
2.5	1.73	2.96	3.81	4.37	4.73	4.97	5.11	5.21
2.6	1.65	2.83	3.63	4.16	4.51	4.72	4.86	4.95
2.7	1.59	2.71	3.47	3.97	4.30	4.51	4.64	4.72
2.8	1.53	2.60	3.33	3.80	4.11	4.31	4.43	4.51
2.9	1.47	2.50	3.19	3.65	3.94	4.12	4.24	4.32
3.0	1.42	2.40	3.07	3.50	3.78	3.96	4.07	4.14
3.1	1.37	2.32	2.95	3.37	3.64	3.80	3.91	3.98
3.2	1.32	2.24	2.85	3.25	3.50	3.66	3.76	3.83
3.3	1.28	2.16	2.75	3.13	3.37	3.53	3.63	3.69
3.4	1.24	2.09	2.66	3.02	3.26	3.41	3.50	3.56
3.5	1.20	2.03	2.57	2.92	3.15	3.29	3.38	3.44
3.6	1.17	1.96	2.49	2.83	3.05	3.19	3.27	3.33
3.7	1.13	1.91	2.41	2.74	2.95	3.09	3.17	3.22
3.8	1.10	1.85	2.34	2.66	2.86	2.99	3.07	3.12
3.9	1.07	1.80	2.28	2.58	2.78	2.90	2.98	3.03
4.0	1.04	1.75	2.21	2.51	2.70	2.82	2.89	2.94
4.5	0.92	1.54	1.94	2.20	2.36	2.47	2.53	2.57
5.0	0.83	1.38	1.73	1.96	2.10	2.19	2.25	2.28
5.5	0.75	1.24	1.56	1.76	1.89	1.97	2.02	2.05
6.0	0.68	1.13	1.42	1.61	1.72	1.79	1.84	1.87
6.5	0.63	1.04	1.31	1.47	1.58	1.64	1.69	1.71
7.0	0.58	0.96	1.21	1.36	1.46	1.52	1.56	1.58
7.5	0.54	0.90	1.12	1.26	1.35	1.41	1.44	1.47

Note that this table should only be used 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 a 3% discount rate however it is not dependent on discount factors and applies for any discount rate.

PRESENT VALUE FORMULAE

These present value formulae are calculated using the end of year (EOY) discounting convention where all costs and benefits are assumed to occur at the end of each year.

Table A Formula Single Amount Factor

$$a_n = \frac{1}{(1+R)^n}$$

Table B Formula Cumulative Uniform Series Factor

$$b_n = \frac{(1+R)^n - 1}{R(1+R)^n}$$

Where n = the number of years and R = the effective annual discount rate.

The number of years of discounting in the EOY factor is reduced by 1 for BOY discounting and by ½ for EOY discounting.

Beginning of the Year (BOY) Discount Factor

$$a_n = \frac{1}{(1+R)^{n-1}}$$

Middle of the Year (MOY) Discount Factor

$$a_n = \frac{1}{(1+R)^{n-\frac{1}{2}}}$$

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 $I = Sb_n$, where I = the investment, S = the annual savings, b_n = the Table B factor for n years, and n = the number of years to discounted payback.

Substituting the expression for the Table B factor from the previous subsection, results in the equation $I = S\left[\frac{(1+R)^n - 1}{R(1+R)^n}\right]$.

Rearranging terms leads to $R\frac{I}{S} = R\frac{(1+R)^n - 1}{(1+R)^n} = \frac{(1+R)^n}{(1+R)^n} - \frac{1^n}{(1+R)^n} = 1 - \frac{1}{(1+R)^n}$ or

$\frac{1}{(1+R)^n} = 1 - R\frac{I}{S}$.

Then, taking the natural logarithm of both sides of the equation, we have

$\ln(1+R)^n = \ln\left[1 - R\frac{I}{S}\right]$ Or $-n\ln(1+R) = \ln\left[1 - R\frac{I}{S}\right]$ implying $n = \frac{-\ln\left[1 - R\frac{I}{S}\right]}{\ln(1+R)}$.

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 $SIR = \frac{Sb_e}{I}$, where b_n, 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 $\frac{I}{S}$ term in the formula for discounted payback with no lead time in order to duplicate, or extend Table C.

Incremental Benefit Cost Ratio (BCR)

Incremental benefit to investment ratio (BIR) analysis is a good way to prioritize investment alternatives. It has the advantage over Incremental savings to investment analysis (SIR) in that it allows consideration of benefits other than savings. When the benefits of all available alternatives

are the same except differences in savings then Incremental BIR analysis reduces to Incremental SIR analysis.

Incremental BIR analysis begins by identifying the relevant alternatives and arranging them in increasing order of initial investment cost. Afterward, the BIRs are compared with one another and alternatives with BIRs that are less than one are not considered because they do not pay for the investment over time. The final steps are to examine the Incremental BIRs and then choose the best alternatives based on the investment funds available and the highest BIRs.

Example

For a constant dollar, 30 year analysis using the January 2001 OMB Circular A-94 real discount rate of 3.2%, the relevant alternatives are identified and arranged in order of increasing initial cost. BIR = Present Value (PV) of Benefits / PV of Initial Costs = Uniform Annual Benefits (P/A, 3.2, 30) / Initial Cost where (P/A, 3.2, 30) = $[(1.032)^{30} - 1] / [0.032(1.032)^{30}] = 19.103278$ is the conversion factor used to transform the Uniform Annual Benefits (UABs) into their PV. UABs include all savings and productivity enhancements over the Status Quo alternative, which can be quantified in dollars as well as the terminal value benefits. Individual benefits can be annualized into UABs using the conversion factors (A/F, i, n) and (A/P, i, n) or directly converted into PV by using the conversion factor $1/(1+i)^n$ where i is the discount rate - in this case 3.2% and n is the year of the analysis when the benefit occurs.

Alternative	A	B	C
Initial Cost ($K)	1000	2000	3000
Annual Benefits (ABs)	100	200	250
BIR	1.910	1.910	1.59

All alternatives BIRs are greater than 1. So, none of the alternatives are rejected at this point.

Alternative	B-A	C-B
Incremental Initial Cost ($K)	1000	1000
Incremental ABs	100	50
Incremental BIR	1.910	0.955

In this example, the incremental investment B-A and hence alternative B is desirable as long as another 1000K investment is not found which has a BIR greater than 1.910. However, the incremental investment of C-B and hence alternative C is not desirable since the BIR is less than one. In other words, present worth of the incremental ABs of
C-B is not greater than the present worth of the incremental investment of C-B and so alternative C is not worth the investment. Following the process of this example, limited investment funds can be optimized.

Conclusion

Incremental BIR analysis is an effective tool that can be used to prioritize investment opportunities when limited investment funds are available. For example, from purely a financial point of view, if there were only two choices of ether investing $2000K in Alternative B or $3000K in Alternative C, it is better to invest in Alternative B and not invest the extra $1000K.

Reference

Incremental BIR is discussed in depth in the book Engineering Economic Analysis, Seventh Edition.

APPENDIX E – GUIDELINES FOR ENERGY - RELATED ANALYSES

Introduction

NAVFAC has been a leader in energy conservation initiatives for building and improving Navy facilities. This appendix highlights important policy and guidelines to use in continuing energy leadership.

Over the years, there have been many laws, acts, memorandum of agreements, executive orders, and DOD policy developments that have impacted energy related economic analyses. This appendix attempts to highlight many of these important events and show their impact.

Energy Policy and Guidance

The Department of the Navy strives to meet energy cost, performance, intensity, and consumption targets mandated by Executive Order and legislation for federal facilities.

- The Energy Policy Act of 2005 (EP Act 2005) which was signed into law in August 2005. EP Act 2005 revised annual energy reduction goals, re-authorized Energy Savings Performance Contracts, requires federal procurement of ENERGY STAR® or FEMP (Federal Emergency Management Program) designated products, and updates federal green building standards especially for energy efficiency and sustainable design.

- The Energy Independence and Security Act of 2007 (EISA 2007), an Act of Congress concerning the energy policy of the United States, was signed into law in December 2007. The act will increase energy independence and security; increase the protection of clean renewable fuels; and increase the efficiency of products, buildings, and vehicles.

- Executive Order (EO) 13423 of 26 January 2007 – Strengthening Federal Environmental, Energy, and Transportation Management, specifies certain energy goals for all Federal buildings.
  1. One goal is to improve energy efficiency and reduce greenhouse gas emissions of the agency, through reduction of energy intensity by either 3 percent annually through the end of fiscal year 2015 or by 30 percent by the end of fiscal year 2015 relative to the baseline of the agency's energy use in fiscal 2003.
  2. Another major goal is reduced water consumption. The impact of water consumption on energy use is twofold. One, water holds a lot of heat and by reducing water consumption we are also reducing the energy used to heat hot water. Two, energy is used to purify and pump the water. Beginning in FY2008, reduce water consumption intensity, relative to the baseline of the agency's water consumption in fiscal year 2007, through life-cycle cost-effective measures by 2 percent annually through the end of fiscal year 2015 or 16 percent by the end of fiscal year 2015.
  3. Besides direct energy and water consumption goals, Sustainable Design is emphasized as well as reduced fleet consumption of petroleum, recycling, and environmental protection.
  4. A "Guiding Principles" document "High Performance and Sustainable Buildings Guidance" (Dec 2008) document was produced that provides additional instructions for the implementation of EO 13423 and has a section on strategy and tools. This includes

advice on funding, distributed generation, metering, auditing, Energy Star® Tools, Labs21 program, energy purchasing, and water efficient products.

- Executive Order (EO) 13514 of 8 October 2009 – Federal Leadership in Environmental, Energy and Economic Performance builds upon EO 13423 and modifies certain goals.
    1. It calls for the reduction of potable water use intensity by 2% annually through 2020 or 26 percent by the end of FY20 and for a 2% annual reduction in irrigation, landscape and industrial water.
    2. Additionally the EO codifies compliance with the "Guiding Principles" explained above as well as the requirement to build net zero buildings by 2020.

- The Whole Building Design Guide website is a federal tool that provides guidance on incorporating energy and water savings into the sustainable design of facilities and includes a Navy 1391 Sustainable Design LEED / Cost Tool.

  The Whole Building Design Guide website is also the official clearing house for DOD Unified Facility Criteria and contains UFC 1-200-02 High Performance and Sustainable Building Requirements.

  This UFC is organized around the Guiding Principles and provides minimum requirements and guidance to achieve high performance and sustainable facilities that comply with the *Energy Policy Act of 2005*, the *Energy Independence and Security Act of* 2007, EO 13423, EO 13514, and the *Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings* (Guiding Principles). ,

Energy Indexes

Energy indexes 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 NIST Interagency Report (IR) 85-3273-23 (Rev. 5/08) Annual Supplement to NIST Handbook 135. In general, the NISTIR energy indexes and discount factors should be used in economic analyses of the following energy project categories for existing facilities:

1. EMCS or HVAC Controls
2. Steam and Condensate Upgrades
3. Boiler Plant Modifications
4. Heating, Ventilation, Air-Systems
5. Weatherization
6. Lighting Systems Replacement
7. Energy Recovery Systems
8. Electrical Energy Systems
9. Renewable Energy Systems Conditioning (HVAC)
10. Facility Energy Improvements

Energy Project Management

The Energy Project Management Guide is for use by NAVFAC personnel that are involved in energy project planning, design and execution. The purpose of this document is to provide guidance and standardize the process for developing and executing energy and water efficiency improvement projects. It contains information on Energy Life Cycle Cost Analysis (LCCA) including inflation and discount rates, project economics, various project costs, project savings and a comparison of LCCA and energy Return on Investment (eROI) tools.

It also addresses the various energy programs and financing options available to implement energy or water efficiency projects. It is provided primarily for use by the NAVFAC Energy Project Development Team as a handy reference on processes, approval chains and general guidelines involved with the various energy project programs to assist in performing project development duties for all supported commands.

It covers all the various players in an energy project and their overall roles – including these four key members; the Project Manager (PM), Installation Energy Manager (EM), Contracting Officer (KO) and Utilities and Energy Management Subject Matter Expert (UEM SME). While this guide is not intended to specifically define Marine Corps roles or processes, it is of value for the Marine Corps energy teams to better understand the standardized NAVFAC procedures, recommendations, and guidelines for developing and implementing energy and water conservation projects. You can find the Energy Project Management Guide P-801 on the NAVFAC HQ website.

APPENDIX F - EA FOR SELF-AMORTIZING UNSPECIFIED MINOR CONSTRUCTION PROJECTS

INTRODUCTION

Unspecified Minor Construction (UMC) projects represent a special class of Military Construction (MILCON) funded projects and are, therefore, accorded a different set of criteria and funding limits than Special Projects ($\leq$ $750,000) or regular MILCON projects (> $750,000). The funding "window" for projects that meet the UMC criteria is >$750,000 and $\leq$$2,000,000. (Note: The ceiling goes to $3,000,000 when the UMC project corrects problems related to life, safety and health.) As explained below, UMC projects may in some cases be justified on the basis of economics. Such projects must be supported by Return on Investment (ROI) economic analyses (see Subsection 5.1). Because of the special nature of Unspecified Minor Construction projects, economic analyses supporting these projects are also somewhat specialized. It is for this reason that a discussion of UMC economic analyses has been reserved for this appendix.

GENERAL BACKGROUND

Unspecified Minor Construction projects are accomplished by authority of 10 U.S.C. 2805. To qualify for UMC funding, a project must satisfy UMC Project Eligibility Criteria.

As there are many more projects proposed than are possible to fund, the following criteria are used to screen projects:

(1) A new primary mission assignment cannot be carried out without the requested construction.

(2) Unexpected growth in existing primary missions cannot be accommodated without the requested construction.

(3) Unexpectedly rapid progress in a high priority research and development effort cannot be exploited without the requested construction.

(4) A hazard to life and property meeting the Occupational Safety and Health Act, Category IA, cannot be corrected without the requested construction.

(5) The requested construction is necessary to conform to regulatory or statutory requirements to continue performing primary missions.

(6) Unexpected new items of major equipment, which are necessary for the performance of a primary mission, cannot be put into operation without the requested construction.

(7) The security of nuclear or other classified special weapons or materials would be jeopardized without the requested construction.

(8) Unexpected loss or severe reduction in supporting utility sources or systems will jeopardize the ability to continue to perform primary missions without the requested construction.

(9) The requested construction is a self-amortizing minor construction project, provided the construction will within 3 years following completion of the project result in savings in maintenance and operating costs in excess of the cost of the project. The computation of savings must compare present and proposed total systems investment cost, and not just the cost of the added facilities.

For additional details concerning statutory guidelines and limitations, funding authority, approval chains, and actual UMC project preparation and submission procedures, the reader is referred to OPNAVINST 11010.20, "Facilities Projects Manual," Chapter 4. The remainder of this appendix will discuss the economic analyses associated with those construction projects costing between >$750,000 and $2,000,000 (including SIOH, contingency and design costs for design-build projects) that are funded from the military construction appropriation (MILCON). See OPNAVINST 11010.20 Section 4.2.1 concerning UMC projects that would precede or follow a major construction project.

ECONOMIC ANALYSES IN SUPPORT OF UMC 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 (if the project is prioritized and approved the first time through the process – there are many more projects than there are funding and many of the projects drop out of the priority list and may be resubmitted year after year). By contrast, the approval process for UMC projects is expeditious, usually requiring only a few months. Thus, UMC 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 Return on Investment (ROI) economic analyses. They must of necessity be comparing a status quo (existing situation) against a proposed alternative. Examples of self-amortizing UMC 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 UMC projects, supporting economic analyses do not conform to normal guidelines as set forth in the main text of this handbook. Although UMC economic analyses are Return on Investment analyses, no savings/ investment ratio computation is necessary. Economic projects qualify for Unspecified Minor Construction funding when 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 UMC projects through the next six years, it is unlikely a project justified solely on economic payback will be considered for funding.

Example D-l: Suppose Alternative A represents the status quo and Alternative B represents an alternate proposal (i.e., a proposed UMC project), with the following cost data:

ALTERNATIVE A:

Project Year	Recurring Cost
1	$845K
2	$845K
3	$845K

ALTERNATIVE B:

Project Year	Investment Cost	Recurring Cost
0	$1,750K	---

NOTE: The cost must be between >$750,000 and $2,000,000. $1,750,000 is the average UMC cost we are seeing these days.

1	---	$155K
2	---	$155K
3	---	$155K

Then cumulative present value savings may be computed:

Project Year	Alt A Cost	Alt B Cost	Savings	Discount Factor	P.V. Savings	Cum Savings
1	$845K	$155K	$690K	.985	$680K	$680K
2	$845K	$155K	$690K	.957	$660K	$1340K
3	$845K	$155K	$690K	.929	$641K	$1981K

Note that the cumulative present value of savings for three years of $1981K are greater than the investment cost of $1,750K for Alternative B, so Alternative B meets the three year discounted payback criterion. Since the cumulative present value of savings after two years, $1340K, 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.)

$$\frac{x-2}{3-2}=\frac{Investment Cost-2nd YR.Cum.P.V.Savings}{3rd YR.Cum.P.V.Savings-2nd YR.Cum.P.V.Savings}=\frac{\$1750K-\$1340K}{\$1981K-\$1340K}=\frac{x-2}{1}=0.64$$

$$x=0.64+2=2.64$$

The discounted payback period is estimated to be 2.64 years.

For a formatted example of an economic analysis supporting an Unspecified Minor Construction project, see Example D-2.

CAVEAT

The economic guidelines set down in the OPNAVINST 11010.20 are explicit. To be acceptable for UMC 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 Construction 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 non-appropriated 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 Return on Investment (ROI) 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.

Section 4.4.4a of OPNAVINST 11010.20 Facility Projects Instruction indicates that UMC projects are requirements identified too late to be included in the current budget submission, and which

cannot be deferred to the next regular MILCON program because there is no interim viable alternative or other permanent method of satisfying the facilities requirement. Documentation to establish credibility of costs and savings will significantly improve the chances for approval of UMC projects.

DIVER TRAINING FACILITIES UMC PROJECT P-999 EXAMPLE

The following is an example adapted from an actual UMC analysis submission. It is intended to serve as a model. ECONPACK was used to document costs for each alternative and compare the financial results using a Return on Investment Analysis.

```
      DATE GENERATED:  02 Feb 2009
      TIME GENERATED:  08:27:35
      VERSION:  ECONPACK 3.2.1

                                UMC Example
                            ECONOMIC ANALYSIS

                          EXECUTIVE SUMMARY REPORT

PROJECT TITLE:      Diver Training Facilities
TYPE OF ANALYSIS:   Return on Investment
DISCOUNT RATE:      3%
PERIOD OF ANALYSIS: 3 Years
START YEAR:         2008
BASE YEAR:          2008
DOLLAR ANALYSIS:    Current Dollars

PROJECT OBJECTIVE:

Continue Second Class Diver Training Mission

BACKGROUND

Background and Objective

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:
ALTERNATIVES CONSIDERED FOR THIS ANALYSIS:

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 2008 and budgeted at
```

$1,950,000. 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 $1,750,000; collateral equipment required is estimated at $153,200. The barge will be retired to salvage.

ASSUMPTIONS OF THE ANALYSIS:

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 occupants of the repaired buildings would perform a function different than diver training while the budgetary impact remains the same. Therefore, repair costs for these buildings are included for both alternatives.

ECONOMIC INDICATORS:

ALTERNATIVE NAME	NPV	SIR	DPP
Alternative A - Continue at Naval Station	$1,944,017	N/A	N /A
Alternative B - Relocate to Naval Amphibious	$1,775,052	1.1	0.9 YEARS

NON-MONETARY CONSIDERATIONS:

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.

RESULTS AND RECOMMENDATIONS:

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.

ACTION OFFICER : John Doe
PHONE NUMBER : 111-444-5555
EMAIL ADDRESS : John.Doe@navy.mil
ORGANIZATION : Department of the Navy

LIFE CYCLE COST REPORT

Alternative A - Continue at Naval Station (Status Quo)

YEAR	Renovation (1)	Maintenance and Repair (2)	TOTAL ANNUAL OUTLAYS	MIDDLE OF YEAR DISCOUNT FACTORS	PRESENT VALUE
2008	$1,950,000	$0	$1,950,000	0.985	$1,921,392
2009	$0	$12,000	$12,000	0.957	$11,480
2010	$0	$12,000	$12,000	0.929	$11,145
%NPV	98.84	1.16			
	$1,921,392	$22,625			

DISCOUNTING CONVENTION M-O-Y M-O-Y
INFLATION SCHEDULE No Inflation No Inflation
CATEGORY/ RES SCHD Non-Recurring Costs Recurring Costs

LIFE CYCLE COST REPORT

Alternative A - Continue at Naval Station (Status Quo)

YEAR	CUMULATIVE NET PRESENT VALUE
2008	$1,921,392
2009	$1,932,872
2010	$1,944,017

CATEGORY/
RES SCHD

3% DISCOUNT RATE, 3 YEARS

LIFE CYCLE COST REPORT

Alternative B - Relocate to Naval Amphibious Base (NAB)

YEAR	Renovation/ Construction (1)	Recurring Operations (2)	TOTAL ANNUAL OUTLAYS	MIDDLE OF YEAR DISCOUNT FACTORS	PRESENT VALUE
2008	$1,750,000	$40,000	$1,790,000	0.985	$1,763,739
2009	$0	$6,000	$6,000	0.957	$5,740
2010	$0	$6,000	$6,000	0.929	$5,573
%NPV	97.14	2.86			
	$1,724,326	$50,726			

DISCOUNTING CONVENTION M-O-Y M-O-Y
INFLATION SCHEDULE No Inflation No Inflation
CATEGORY/ RES SCHD Non-Recurring Costs Recurring Costs

LIFE CYCLE COST REPORT

Alternative B - Relocate to Naval Amphibious Base (NAB)

YEAR	CUMULATIVE NET PRESENT VALUE
2008	$1,763,739
2009	$1,769,479
2010	$1,775,052

CATEGORY/
RES SCHD
3% DISCOUNT RATE, 3 YEARS
RETURN ON INVESTMENT ECONOMIC ANALYSIS REPORT

Status Quo Alternative: Alternative A - Continue at Naval Station (Status Quo)
Proposed Alternative: Alternative B - Relocate to Naval Amphibious Base (NAB)

Recurring Annual Operating Costs

Project Year(s)	Status Quo Alternative	Proposed Alternative	Differential Costs	Present Value Factor	Present Value of Differential Costs
2008	$0	$40,000	-$40,000	0.985	-$39,413
2009	$12,000	$6,000	$6,000	0.957	$5,740
2010	$12,000	$6,000	$6,000	0.929	$5,573
Totals	$24,000	$52,000	-$28,000		-$28,101

RETURN ON INVESTMENT ECONOMIC ANALYSIS REPORT

Total present value of proposed alternative non-recurring costs	$1,724,326
Less: present value of proposed alternative benefits	$0
Less: present value of proposed alternative residuals	$0
Total present value of investment	$1,724,326
Total present value of differential costs	-$28,101
Plus: present value of status quo non-recurring costs eliminated	$1,921,392
Less: present value of status quo benefits	$0
Less: present value of status quo residuals	$0
Total present value of savings	$1,893,291
Savings-to-Investment Ratio (SIR)	1.1

Payback occurs in first year

For Status Quo:

Recurring Costs: Maintenance and Repair

Non-Recurring Costs: Renovation

For Proposed Alternative:

Recurring Costs: Recurring Operations

Non-Recurring Costs: Renovation/ Construction

LIFE CYCLE COST REPORT

SOURCES AND DERIVATIONS:

Alternative A - Continue at Naval Station (Status Quo)

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 dry docking 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 dry dock will be funded if P-999 is not approved. The FY 2010 overhaul budget includes $2,150,000 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	$137,400
(2) Repairs to classrooms and head	$230,000
(3) Repair and overhaul hyperbaric chambers	$485,000
(4) Docking/undocking berthing and services	$231,000
(5) Craft preservation (hull, housing structure)	$199,400
(6) Fendering replacement	$147,500
(7) Electrical system repair	$223,200
(8) Steam and water system repairs (galvanic protection)	$373,500
(9) Void preservation	$123,000
	$2,150,000

(Although not included in the three year period addressed by this payback analysis, the barge would also require later expenditures of approximately $115,000 three every three years on the normal cycle for routine overhaul which includes craft preservation and void preservation.)

b. Buildings 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

Alternative B - Relocate to Naval Amphibious Base (NAB)

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.

$1,200,000

Collateral Equipment - Based on list of furniture, lockers, equipment, etc., at delivered prices (supplied through GSA).

$550,000

Total Investment Cost = $1,750,000

Operation Costs

A. First Year

1. Repairs

a. Buildings 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

2. Maintenance

a. NAB Building 107, float

$ 4,000

Total First Year Cost = $40,000

B. Annual Cost for the Remaining Two Years

1. Maintenance

a. Buildings 191. 425,470 - Continued annual maintenance for these three buildings.

Estimated Cost = $2.000

b. NAB Bldg 107, float

$4.000

APPENDIX G - ECONOMIC ANALYSIS FOR MILCON PROJECTS

NAVFAC HQ MILCON - MILCON 101 - AllDocs (sharepoint-mil.us)

ECONOMIC ANALYSIS for MILCON Projects "An End-User's Perspective" & MCON/MCNR Projects Cost Development Process & Improving Execution guidance updated annually. Key 2023 slides.

ECONOMIC ANALYSIS for MILCON Projects "An End-User's Perspective"

JOHN THURBER
MCON Programming
202-685-9401
March 2023

Facilities Contribute to:

- Operational readiness **(Training buildings)**
- Mission support **(Piers & Runways)**
- Quality of service **(Workspaces & Gyms)**
- Personnel morale & retention **(Barracks)**
- Life, safety & health **(Fire Stations & Security Fences)**
- Environmental protection **(Treatment plants)**
- Future capabilities **(Test Centers & Labs)**

All have some economics associated

Facilities-Related Problems
Economic Specific

- Operational inefficiency **(Ships "nested" berthing)**
- Productivity constraints **(Aircraft maintenance)**
- Workarounds **("Jammed" missile storage)**
- Material theft & spoilage **(Leaky roof)**
- Delays & shut-downs **(Aircraft engine testing)**
- External complaints **(Oil spills)**
- Rising costs **(Energy)**

3

Economic Analysis for MCON Projects

Why do I have to do them??

It's such a pain . . .

You gotta!! **(but more importantly)** ***You oughtta!!***

Because . . .

- OSD requires them & Regions, Enterprises, CNIC, MCICOM & FMB use them
- E/A are practical decision-making tools (look at the requirements & alternatives; what will work?)
- E/A can help justify normally unsaleable projects
- They can add points to project scores
- E/A conclusions can be the DECIDING factor on whether a project makes the cut

4

Economic Analysis for MCON Projects
Simple General Guidelines

- Investigate all *REASONABLE* alternatives
- Consider full life-cycle costs & benefits
- Basic assumptions must be rational
- Include the cost of the MCON project!!
- Include equipment investments
- Include temporary relocation costs
- For demo within MCON alternative: deduct the ST costs for the building to demolished

5

Economic Analysis for MCON Projects
Simple Technical Guidelines

- Use COE Econpack program (widely available)
- Use 30-year economic life comparison + 2-year lead time for construction = 32 yr period of analysis
  - **For "pure" energy projects, use 40 + 2 year period of analysis.**
- Use current 2.0% real discount rate (2.0% for 2023 from OMB A-94 from OMB A-94 – for 30 years)
- Use 67-year straight-line depreciation for determining terminal value (1.5% per year; 67yr = formerly the OSD recap rate but still a useful metric)
- Establish base year: escalate costs to proposed funding year (next available budget year is FY 2024)

6

Economic Analysis for MCON Projects
Simple Technical Guidelines

Land Acquisition Scenarios

- The value of land is assumed to appreciate over time
  - The value of facilities is assumed to depreciate
- Land appreciation "residual schedule" assumes an annual 1.5 %/year appreciation rate (add no inflation schedule)
- Start appreciation at the beginning of the analysis period and appreciate to the end of the analysis (i.e., 32nd year)
- This is then discounted using the current real discount rate (constant dollar analysis) with end of year discounting

7

Economic Analysis for MCON Projects
Simple Technical Guidelines

- Display upfront investments (MCON, O&M) in first year (disregard outlays)
- Use "mid-year entry" methodology (assume recurring costs are spread evenly over the year)
- Use DOD Facilities Cost Factors Handbook (sustainment & construction cost factors)
- Include 4.0% for design portion of Design-Build contract in project cost (other design & RFP costs are sunk costs)
- Provide backup documentation for all cost data (actual data, algorithm approach, projections)

8

Economic Analysis for MCON Projects

Common One-time Costs (first 2 years only)

- Land acquisition & land easements
- New construction
- Rehabilitation & modernization
- Equipment investments
- Function relocation (permanent or temporary)
- One-time personnel expenses
- Demolition & site restoration (may take place later than second year of project life)
- Residual/terminal value (end of project life)

9

Economic Analysis for MCON Projects

Common Recurring Costs

- Personnel (operations, maintenance)
- Maintenance (day-to-day, minor repairs)
- Utilities (water, electrical)
- Rental & leases** (trailers, rolling stock)
- Consumables (storage canisters, fuel)
- Equipment (fork lift, test sets)
- Other operating expenses (travel, security)
- Upgrades (re-roof, HVAC)

** Leases will likely include imputed costs (e.g., taxes, land cost)

10

Economic Analysis for MCON Projects

Identify Alternatives - Considerations

- Ways to meet the mission & objectives?
- What are the *REASONABLE* alternatives?
- Are alternatives assumed away? Why?
- What are we doing today? What is wrong with this alternative?
- What is the cost of each alternative?
- What are the operational impacts of each alternative (good and bad)?

11

Economic Analysis for MCON Projects

TYPE I Economic Analysis (Primary)

- Requirements are being met today
- Are there less expensive ways of doing the mission? Compare costs of the alternatives
- Analysis will show returns on investment
- Will result in payback periods – Attractive paybacks are five years or less
- Part of sound business decision-making

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Economic Analysis for MCON Projects

TYPE II Economic Analysis (Secondary)

- Requirement is not being met today
- Develop alternatives that will support the mission - Which alternative has the most attractive economic advantages?
- Attractive payback unlikely but economics are important considerations
  - Always consider life cycle implications

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Economic Analysis for MCON Projects

MCON Scoring Model

- Rewards attractive economics (5 years or less) Contributes to Overall Cost Reduction
  - Up to 7.0% of Strategic Alignment/Guiding Principles project score or up to 4.55% of overall score

Other Benefits

- Encourages Regions to reduce costs through facility consolidation & demolition of old, high-cost facilities
- Shows OSD we are actively reducing infrastructure, improving quality of service, reducing costs
- Encourages economics in decision-making through life-cycle cost analysis

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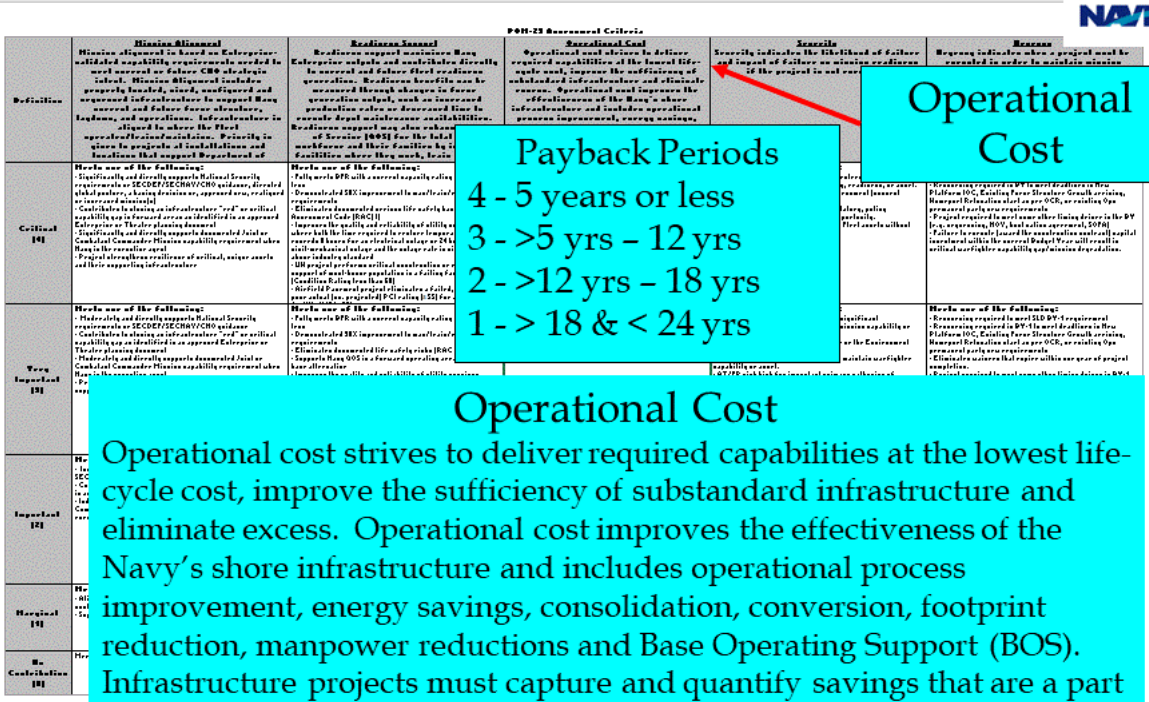
POM-25 MILCON Scoring Model

POM25 Decision Lens Model Weights

Criteria	Subset Weight	Overall Weight
Strategic Alignment/Guiding Principles	**62.42%**	
Mission Alignment	63.63%	39.72%
Readiness Support	28.24%	17.63%
Operational Cost	8.13%	5.07%
Subtotal	*100.00%*	*62.42%*
Installation Figure of Merit	**8.49%**	
Capacity	48.51%	4.12%
Condition	34.36%	2.92%
Configuration	17.13%	1.45%
Subtotal	*100.00%*	*8.49%*
Risk Assessment	**29.09%**	
Severity	100.00%	29.09%
Subtotal	*100.00%*	*29.09%*

Decision Lens – POM 25 Assessment Criteria



Operational Cost

Payback Periods
4 - 5 years or less
3 - >5 yrs – 12 yrs
2 - >12 yrs – 18 yrs
1 - > 18 & < 24 yrs

Operational Cost

Operational cost strives to deliver required capabilities at the lowest life-cycle cost, improve the sufficiency of substandard infrastructure and eliminate excess. Operational cost improves the effectiveness of the Navy's shore infrastructure and includes operational process improvement, energy savings, consolidation, conversion, footprint reduction, manpower reductions and Base Operating Support (BOS). Infrastructure projects must capture and quantify savings that are a part of the Navy's total ownership cost.

Economic Analysis for MCON Projects

SMIG Scoring Model
"Workaround Avoidance"

Consideration by the SMIG Working Group may be given to "Economic Advantages"

- Extends weapon system life (30yrs to 45yrs)
- Avoids costs (won't have to re-roof again)
- Reduces aircraft diverts to alternate fields
- Reduces per diem (BQ vice hotels)
- Increases training opportunities (train during adverse weather)
- Increases RDT&E opportunities (more tests)

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Economic Analysis for MCON Projects

"Wild" Assumptions (examples)

- Threaten repair $$ overspending if MCON is not provided – **very common**
- Claim reductions in workforce – **rarely happens; FMB wants budget "proof"**
- Overestimate productivity improvements – **10% improvement ok; 50-100% not believable**

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- Credibility has been damaged!!
- Some reviewers: "It's all bogus! Can't back up the numbers. Can't show that it will ever happen. Award no more than minimal points." We are on the defensive!

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Economic Analysis for MCON Projects

Poorly done economic analysis
WILL HURT YOU!

- Miss opportunity to gain points
- Might miss the programming cut
- Damages credibility during budget review
  - **FMB asked for NPV data for FY 2013 – first time in a long time**
- Could result in project being marked
- Could lead to wrong decisions – end up with long term adverse impacts (operational & economic)

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Economic Analysis for MCON Projects

Attributes of a Good Economic Analysis

- Reasonable, well-documented assumptions
- Accurate costs & benefits calculations
- Balanced consideration of ALL alternatives
- No technical errors
- Includes all up-front, one-time costs
- Status Quo is not eliminated as an option

==========

We need to restore confidence in eco analyses!

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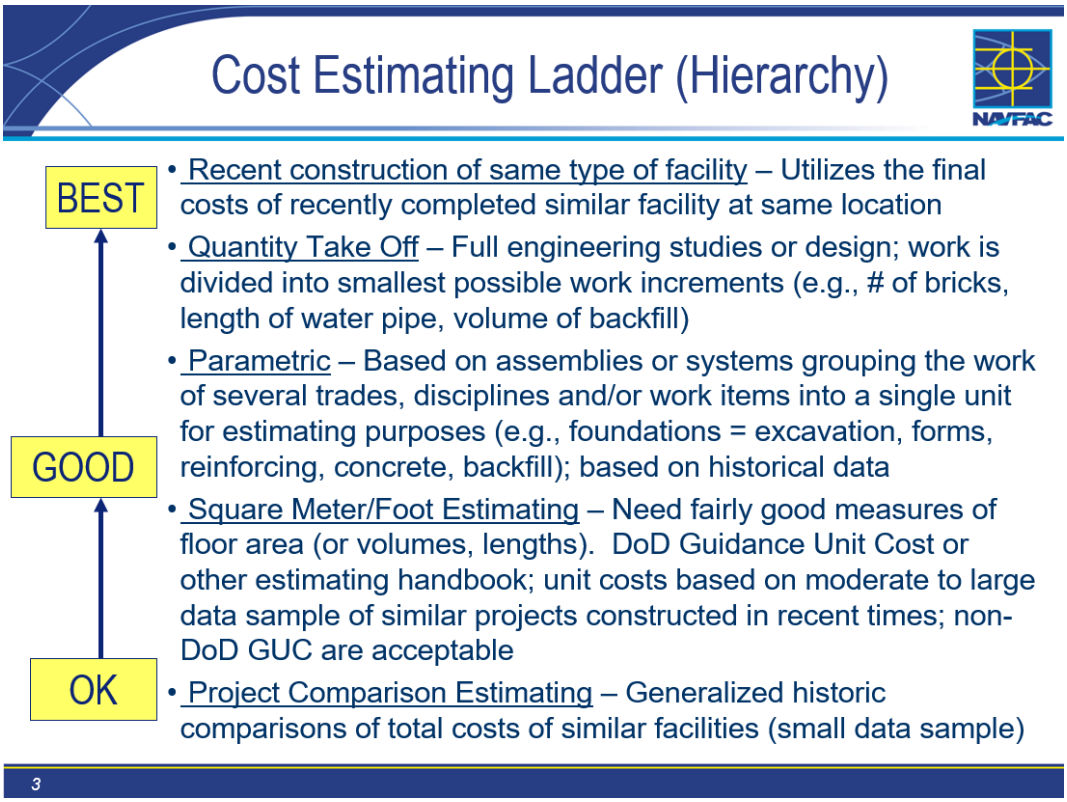
QUESTIONS??

Navy Project Cost Development Steps

- Installation/Public Works Department DD 1391
  - Develop preliminary cost estimate; funded by O&MN
  - Prepared by installation; sometimes with help from FEC and/or A/E
  - Use DoD Guidance Unit Costs or basic Parametric Cost Estimating (PCE)
- Region/Facilities Engineering Command (FEC) DD 1391
  - Produce “budget-ready” cost & DD 1391; 15% design & PCE (Class 3)
  - Developed by FEC and/or A/E; funded by MILCON design (MILCON-D)
  - Use best cost estimating tools (see Cost Estimating Ladder on next slide)
- Consistency Review Board
  - “Virtual panel” of HQ PMs working with FEC PMs, DMs & Cost Engineers
  - Review all budget year Region/FEC DD 1391s for which BPA/PDA was issued
  - Ensure CRB guidelines were used; produce consistent, “budget-ready” DD 1391s
  - Adjust costs as needed; provide side-by-side exhibits explaining cost changes
- Program Final DD 1391
  - Make final adjustments for Navy Comptroller budget book submission

2



APPENDIX H – GLOSSARY OF ECONOMIC ANALYSIS RELATED TERMS

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). Many of the terms explained in this glossary may be found the main body of the handbook by executing a Find search from the pull down Edit menu.

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.

Analysis -A systematic approach to problem solving. Complex problems are made simpler by separating them into more understandable elements. It involves the identification of purposes and facts, the statement of defensible assumptions, and the derivation of conclusions there from. 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. It 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. It 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.

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, it is 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 air pollution control system required by Government regulation. Sometimes it is 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 rolls 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. This 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.

Confidence level - Quantitative statement of the assurance or confidence is 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 remove the effect of price changes over time. They are derived by dividing current dollar values by their corresponding price indexes. 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 price of the 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 – Is 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 pro-rations concerning outlays previously made. They exclude 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. It is 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 – Is 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. It refers to the ratio of the dollar value of benefit divided by cost and 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. It 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 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. It 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 – Is an increase in costs per unit increase in program activity. Also, it is the additional cost needed to make a change in the level or nature of output. If the incremental cost per

ton is $100 for an increase in production from 100 to 150 tons per month but only 75 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. It 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. An example of induced cost is deterioration in environmental quality resulting from a water resource project. See: Externalities.

Cost, joint – Is the 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 – Is the benefits that could have been obtained by the best alternative use of resources which have been committed to a particular use. Opportunity cost is 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 - Is a predetermined cost criterion that is a basis for pricing outputs, evaluating performance, and preparing budgets. It 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. It 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 – Are 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 in relation to 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 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-l degrees of freedom.

Delphi method – Is a 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 (continued) - A way of improving the panel or committee approach by subjecting the views of the individual experts to each other's 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 – It is 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. This is an offset against positive benefits. A social disbenefit is a social diseconomy or loss of social benefits. For example, problems created by urban renewal projects in dislocating people from their communities. See: Externalities.

Discount factor – Is 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 – This is related to present value. See: Present value.

Discount rate - The interest rate used in calculating the present value of expected yearly costs and benefits and 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. It reflects investment opportunity cost as well as the present dollar value of future costs and benefits.

Diseconomy – Is damage received as a consequence of the economic activities of another for which the damaged does not receive sufficient 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. It depicts quantitative relationships that determine results in terms of economic concepts such as costs, benefits, 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 – Is a systematic approach to the problem of choosing how to employ scarce resources and an investigation of the full implications of achieving a given objective in the most efficient and effective manner.

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 – Is 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. It 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. (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. It is the 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, elasticity is the change in number of bus riders in response to the change in bus fares.

Endogenous variable – Is 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. It is 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. It is 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.

Externalities - Benefits and costs (economies or diseconomies) that affect parties other than the ones directly involved. These are 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. Fiscal policy is 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, and rainfall are generally considered to be free goods.

Frequency distribution – Is 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, a function is the principal purpose a program that is intended to serve. For example, public safety, health protection, surface transportation. It is 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 and y 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. It is 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 – Is 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) – Is the total national output of final goods and services at market prices for a given period.

Heuristic problem solving – Is 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 – Is 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_o/P_oQ_o, x l00 where P_n is the price for each item in the given year. P_o, is the price of each item in the base year and Q_o, is the quantity of each item in the base year. The numerator and denominator are summed over all goods included in the index.

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 – Is 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.

Isocost 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 – Is 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 – Is a 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 – Is the change in total revenue due to one-unit change in output.

Markov analysis – Is 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. It is also known as an average, or mean and 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, and 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.

Mission Requirement Economic Analysis – Is an economic analysis where the status quo is not a viable alternative. Viable alternatives are compared against each to find a cost effective solution to meeting the mission requirement.

Mode - The observation which occurs most frequently in a set of observations. It is a measure of central tendency in a frequency distribution. It is 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 – Is 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 – Is a catch-all label referring to methods of simulated sampling.
When taking physical samples 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 distributions and then sampling from these theoretical populations by means of a random number table or generator.

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 continuous 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 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, etcetera in addition to subjective methods such as common sense and judgments based on experience. For example, OR could 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) 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. A parameter differs from a statistic which is derived from a sample. An example is the parameter for the mean of population while x is the statistic for the sample, an estimate of the mean. Parameters are frequently denoted by Greek letters to distinguish them from corresponding sample values.

Pareto optimum – Is 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 – Is the length of time over which an investment outlay will be recovered. It is 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 – Is 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. A 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 population is the total number of inhabitants in a country or the total number of vouchers for a program. It is 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 1 foot has greater precision than an estimate of 10 feet having a3D 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 that is 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 or inflation procedures to make alternative programs and actions comparable regardless of time differences in the money flows. See: Discounting, Discount factor, and Inflation.

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 – Is 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 – Are 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	0.70
Receiving vouchers	0.25
Inventory adjustment vouchers	0.05
	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 – Is 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 – Is the appraising the efficiency and effectiveness of ongoing or completed programs. It aims at a program improvement through comparisons of existing programs with alternative programs and techniques. Program evaluation 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 may be applied to any operation in which objects arrive at a service facility of limited capacity.

Random variable – Is 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. It is 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, is 53 -10 = 43. It is 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 - Is an 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 $y = a + bx + cx + dx + ... + zx$. 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. These include 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.

Return on Investment – Is an economic analysis where the status quo is a viable alternative. Other alternative are compared against the status quo to see if money could be saved.

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 – Is 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 that 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 – Is 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 performed 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 – Is the 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 – Is 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. It is used to develop 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 – Is the estimated value of the asset at the end of the project life.

Technological spillover - A spillover that 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 are made on a variable at consecutive points in time or during consecutive intervals of time. An example of a time series is 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. It is 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 utility is synonymous with satisfaction, pleasure or benefit.

Valuation – Is the process of reducing to a common base the measurements (dollars, for example) 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. It is usually referred to as worth in money and is 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. It is 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 that 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. A dependent variable is one whose value is determined by other variables (or constants) in the structure of an equation or mathematical expression. A predetermined variable is one 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, and *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 – Is 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).

APPENDIX I - BIBLIOGRAPHY

The following references may be useful to the reader looking for background information to expand 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 A - EA Policy Instructions.)

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