Appendix N: Analyses for Decision Support

In addition to developing cost estimates, NASA cost estimators conduct analysis for decision support. Analysts may provide such support for a range of customers, from projects, to institutional issues at a Center, to decision makers at NASA Headquarters. As an example, over the life of a project, there are many choices that project personnel must make. Whether these decisions take the form of a Life-Cycle Cost (LCC) analysis, an engineering trade, an architecture selection, or an affordability assessment, decision makers look to the cost estimating community to help inform these choices with data. This appendix provides details on the following six topic areas used to provide analyses for decision support:

N.1. Sensitivity Analysis

- **N.1.1. Sensitivity Analysis Overview**—A review of the steps to conduct a sensitivity analysis.
- **N.1.2. Sensitivity Analysis Example**—A simple step-by-step example of how to complete and interpret a sensitivity analysis.

N.2. Trade Studies—Includes information about the following subjects:

- **N.2.1. Trade Study Analysis**—The activity of a multidisciplinary team to identify the most balanced technical solutions among a set of proposed viable solutions. Trade studies are commonly used to find the configuration that best meets conflicting performance requirements.
- **N.2.2. Make-Versus-Buy Analysis**—The process of analyzing the impact of producing an item in-house or acquiring it from an external source.
- **N.2.3. Lease-Versus-Buy Analysis**—The process of looking not only at financial comparisons, but also at a set of pre-established priorities.

N.3. Affordability Analysis—The act of establishing requirements for a program or project that fit within an affordable cost goal. The top-level affordability goal flows down to tasks that will challenge requirements and perform trade studies to ensure that the goal is met.

N.4. Cost As an Independent Variable (CAIV)—Provides highly capable systems that are affordable over the life cycle. It is essentially a planning activity establishing and adjusting program cost objectives through the use of cost-performance analyses/tradeoffs. It involves execution of the program in order to meet or reduce stated cost objectives.

N.5. Economic Analysis (EA)—Includes information on the following subjects:

- **N.2.1. EA Overview**—Provide the reasoning for initiating a project or task. The logic of the EA is that whenever resources such as money or effort are consumed, they should be in support of a specific need or objective.
- **N.2.2. Future Value (FV) and Present Value (PV)**—The method of compounding money to obtain its value at a future point in time; the method of discounting money to obtain its value at the present time. How to calculate discount factors for obtaining PV.
- **N.2.3. Steps for Performing an EA**—**I**terative process that leads to estimating economic measures-of-merit and providing a recommendation to decision makers. Special emphasis on how to estimate and interpret Net Present Value (NPV), which is a measure of an investment’s net value in today’s dollars.

N.6. Additional Resources—Documents and Web links that provide more details on the five Appendix N topics.

N.1. Sensitivity Analysis

N.1.1. Sensitivity Analysis Overview

As defined in section 3.1.1 of this handbook, sensitivity analysis is a technique used to treat uncertainty regarding requirements. It is used to evaluate the effects of changes in system parameters on the system cost (and/or schedule). Recall that the five steps in a sensitivity analysis are:

1. Compute the point estimate.
2. Select the elements for analysis.
3. Determine the range of values for each element selected for analysis.
4. Determine cost impact.
5. Graph or table results.

An example is provided below to demonstrate how to apply steps 1 through 5.

N.1.2. Sensitivity Analysis Example

The office administrator is tasked to procure new bookcases for the office staff. The requirements delineate that he needs four bookcases. Each will be 7 feet high and 30 inches wide and will be constructed out of ¾-inch oak.

Step 1: Based on the given information, he developed a point estimate of $1,000 for these bookcases (or $250 per bookcase).

Step 2: These types of tasks almost always change, so he decides to perform a sensitivity analysis against three of the requirements.

- Wood could change to 1-inch pine or ¾-inch cherry.
- Height could range between 6 and 8 feet.
- Width could range between 24 and 36 inches.

Step 3: Percentage changes for these three requirements changes are as follows:

- *Use a different wood*
  - Low Value: Save 10 percent with pine
  - High Value: Additional 25 percent with cherry
- *Change height dimensions*
  - Low Value: Save 15 percent by reducing height to 6 feet
  - High Value: Additional 15 percent by increasing height to 8 feet
- *Change width dimensions*
  - Low Value: Save 20 percent by reducing width to 24 inches
  - High Value: Additional 15 percent by increasing width to 36 inches

Step 4: He determined life-cycle cost impacts using each pair of high and low values (i.e., applied to one component at a time).

- *Calculate new cost if different type of wood*
  - Low Value: $900 (save 10 percent)
  - High Value: $1,250 (additional 25 percent)
- *Calculate new cost if height dimensions are modified*
  - Low Value: $850 (save 15 percent)
  - High Value: $1,150 (additional 15 percent)

- *Calculate new cost if width dimensions are modified*
  - Low Value: $800 (save 20 percent)
  - High Value: $1,150 (additional 15 percent)

Step 5: He graphed the results from Step 4. (Note that he could also table these results.)

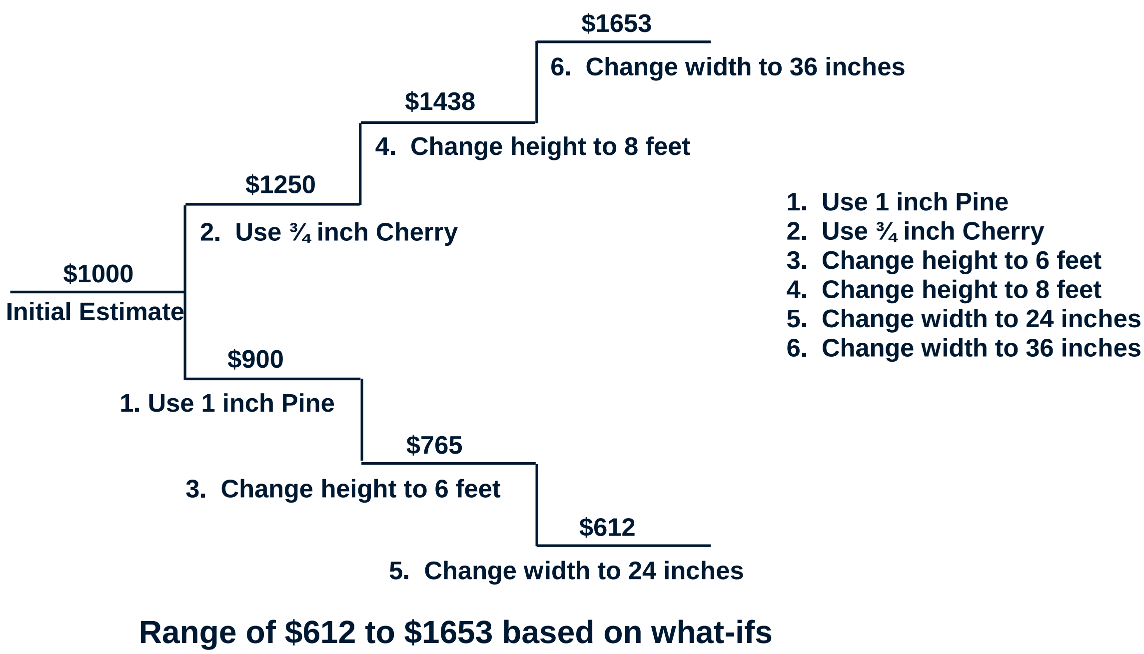


Figure N-1. Sensitivity Analysis of the Total Cost of Four Bookcases

The office administrator can get many takeaways from the results depicted in Figure N-1. For example, if the budget for new office furniture were constrained to a maximum of $1,500, he would be unable to afford four cherry bookcases that are 8 feet high and 36 inches wide (at a total cost of $1,653). From another perspective, if the office staff had no preference about the type of wood, the office administrator could save $100 by simply switching from oak to pine bookcases.

N.2. Trade Studies

N.2.1. Trade Study Analysis

Cost estimates are key inputs during cost/performance trade studies and are used to determine the most realistic and cost-effective mission architectures and system designs. The objective of a trade study is to obtain the merit of the worth (in a single figure) for each candidate and to select the one having the greatest relative value.

N.2.1.1. Trade Study Steps

The steps of conducting a trade study include the following:

1. Define the purpose.

2. State the problem.
3. Describe the selection scheme and criteria used.
4. Define the alternatives.
5. Estimate the costs and assess the performance of each alternative.
6. Determine the preferred approach.
7. Formulate recommendations.

N.2.1.2. Trade Study Example

In Figure N-1, each parameter includes both an objective and a threshold value. Threshold values are individually set by the respective Mission Directorate process for each trade study based on the maturity or risk characteristics of the program or project under consideration. The objective value for cost in this illustration is the objective value plus 10 percent. Cost, schedule, and performance may be traded off within the range between the objective and threshold (the "trade space") with the goal being to optimize cost and performance.

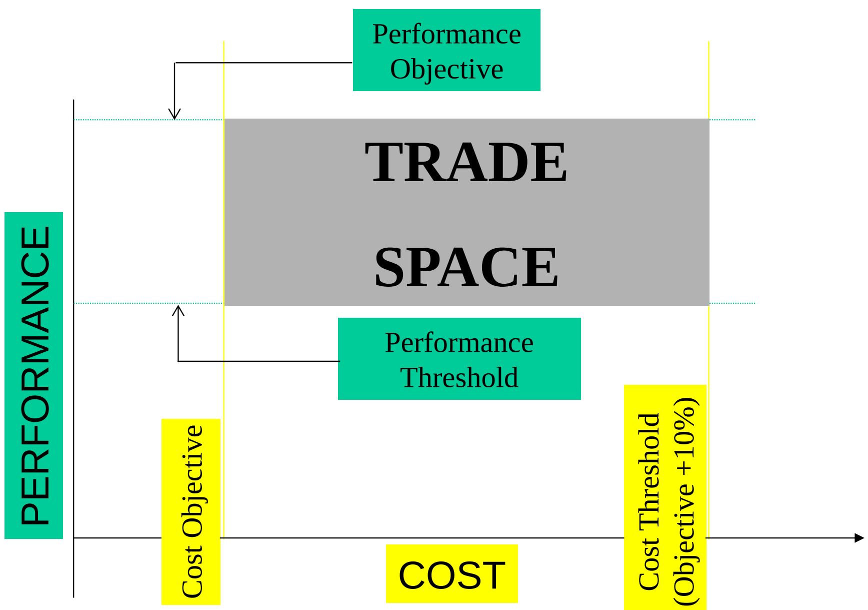


Figure N-2. Performance vs. Cost Trade Space

N.2.2. Make-Versus-Buy Analysis

N.2.2.1. Make-Versus-Buy Approach Considerations

Make-or-buy decisions are based on both strategic and operational assessments. The book *World Class Supply Management*[1] provides criteria for outsourcing, suggesting that an organization outsource all items that do not fit one of the following three criteria: (1) the item is critical to the success of the project; (2) the item requires specialized design and manufacturing skills or equipment with few qualified

[1] *World Class Supply Management: The Key to Supply Chain Management*, D. Burt, D. Dobler, S. Starling, 7th ed. Boston: McGraw-Hill/Irwin, 2003.

suppliers; and (3) the item fits with the organization's current or desired future core competencies. Items that meet at least one of these three criteria are considered strategic in nature and should be produced internally if possible.

At the operational level, other considerations must be assessed. Table N-1 shows other factors that may favor producing an item in-house.

Table N-1. Operational Factors Influencing the Make-Versus-Buy Decision

Make	Buy
Cost (may be less expensive to make the item)	Lack of in-house expertise
Desire to integrate project or organization operations	Lower Cost
Desire to employ excess production capacity	Limited production facilities or insufficient capacity
Need for control over production schedule	Desire to maintain a multiple-source policy
Desire to maintain a stable workforce	Brand preference or request by external customer
Lack of interest by qualified suppliers	Item not essential to the project or organizational strategy
Need to provide a second source	Political, social, or environmental reasons
Political, social, or environmental reasons (e.g., union pressure)	

The two most important operational factors to consider in a make-or-buy decision are the availability of production capacity/labor and cost. Once production capacity has been determined to be available, a cost assessment should be conducted. Cost elements should include all relevant costs. The desired goal of the cost assessment is to objectively compare in-house production and purchase costs. Cost elements to consider in the analysis may include those identified in Table N-2. Note that many of the "make" costs to consider are incremental. By definition, incremental costs would not be incurred if the item were purchased from an outside source. If an organization does not currently have the capacity to make the item, incremental costs will include variable costs plus the full portion of fixed overhead allocable to the item's production. If the organization has excess capacity that can be used to produce the item in question, only the variable overhead caused by production of the item is considered incremental. Therefore, with sufficient idle capacity, fixed costs are not incremental and should not be considered as part of the cost to make the item.

Table N-2. Cost Factors in a Make-Versus-Buy Analysis

Make	Buy
Direct labor costs	Purchase price of the part (including associated fees)
Incremental production overhead costs	Transportation costs
Delivered purchased material costs	Receiving and inspection costs
Incremental managerial costs	Incremental purchasing costs
Incremental purchasing costs	Government oversight/Defense Contract Management Agency/Verification and Validation (V&V) costs
Incremental capital costs	
Incremental inventory-carrying costs	
Incremental quality systems costs	
Opportunity cost (if applicable)	

N.2.2.2. Make-Versus-Buy Example

As discussed, after consideration of strategic and operational factors, the decision to make or buy an item uses incremental analysis to determine the relevant costs. Opportunity costs must also be considered. For example, assume Company ABC uses part number V100 in several of its products. Company ABC currently produces 10,000 of part number V100 using $200 of direct labor, $250 of direct materials, $100 of overhead, and $50 of other incremental cost per item. The purchase of parts is under review by the company's management. Purchasing has determined it would cost $700 per unit to purchase 10,000 of part number V100 with an additional $50 of incremental internal-purchase-related costs per part. Should Company ABC continue to make part number V100 or should it purchase the part?

Table N-3 shows the total cost to produce part number V100 is $6 million, a savings of $1.5 million over the purchase option, so the choice would be for Company ABC to continue to make the part.

Table N-3. Example of Make-Versus-Buy Data

Quantity 10,000 (K$)	Make	Buy	Incremental Increase/(Decrease)
Direct Labor ($0.20)	$2,000		$2,000
Direct Materials ($0.25)	$2,500		$2,500
Incremental Overhead ($0.10)	$1,000		$1,000
Incremental Misc. Cost ($0.05)	$500		$500
Purchase Price ($0.70)		$7,000	$(7,000)
Misc. Purchasing Cost ($0.05)		$500	$(500)
Total Relevant Costs	**$6,000**	**$7,500**	**$(1,500)**

However, assume Company ABC can use the part number V100 production space for a product that would generate $2.5 million of additional operating income. Then the $2.5 million in additional operating income is considered an opportunity cost and is added to the "Make" column of the analysis. With opportunity cost included, the make-or-buy analysis would generate incremental costs of $8.5 million to make the part, $1 million more than purchasing the part. In this case, the company would likely choose to purchase part number V100 and produce the other product (see Table N-4).

Table N-4. Example of Make-Versus-Buy Calculation

Quantity 10,000 (K$)	Make	Buy	Incremental Increase/(Decrease)
Total Relevant Costs	$6,000	$7,500	$(1,500)
Opportunity Cost	$2,500		$2,500
Total Costs	**$8,500**	**$7,500**	**$1,000**

N.2.3. Lease-Versus-Buy Analysis

N.2.3.1. Lease-Versus-Buy Approach Considerations

A lease-versus-buy analysis can be performed once the decision is made to acquire an asset. This analysis is commonly used in business cases and applies most often to facilities and Information Technology (IT) projects. (See Appendix L for more information on Construction of Facilities cost estimating.) When analyzing the financial considerations under the lease-versus-buy decision process, considerations include the LCC of either leasing or buying and operating and maintaining the hardware.

The most meaningful financial comparison is the cost of lease financing versus the cost of debt financing. While comparing absolute LCC is important, it is equally critical to take into consideration fiscal budgetary constraints. While the LCC of leasing may be higher over the entire term the hardware is leased, the annual expenditures may fit better within NASA's budgetary limitations. However, the lease-versus-buy decision cannot be based purely on financial data or budgetary considerations. The decision must be made on a best value consideration. A best value selection analysis would introduce possible intangible benefits for either leasing or buying. Specific guidance on conducting these analyses is provided in the Office of Management and Budget's (OMB's) Circular A-94 (*http://www.whitehouse.gov/omb/circulars_a094/*).

Example factors to consider when making the decision to lease or buy include:

- Asset redeployment/disposal
- Asset tracking
- Maintenance options
- Political considerations
- Value of cancellation options
- Shortened product life cycle
- Technology refresh
- Convenience
- Ease of contracting
- Transference of residual risk

Traditionally, factors such as asset tracking and asset redeployment/disposal are considered to be advantages of leasing; however, circumstances could exist that would make these factors a disadvantage. Similarly, these types of benefits could be provided through certain procurement vehicles. It is critical to be aware of all competing purchase alternatives to leasing as well as the legislative and policy directives that guide leasing.

N.3. Affordability Analysis

N.3.1. Determining Affordability

Affordability is achieved by establishing top-level affordability goals that then flow down to projects and by challenging unaffordable requirements through life-cycle, cost-driven trade studies. Useful affordability tools include parametric cost estimating models, historic cost databases, cost trade processes, and modeling and simulation. Modeling and simulation includes adapting and applying models and simulations to a variety of applications (types of analyses and domains); developing new models and simulations, if needed, for new domains not previously analyzed/quantified; and performing verification, validation, and accreditation. Models and simulations provide a powerful tool for assistance in cost estimating as well as conducting cost/performance trades and CAIV studies.

N.4. Cost As an Independent Variable (CAIV)

A cost/performance trade within a CAIV study can be viewed as being a special application of the cost/performance trade, one in which the cost is fixed (i.e., independent) and the three other variables in the CAIV "equation,"—performance, schedule, and risk levels—are dependent on that fixed cost. This ensures that cost is elevated to the same level of concern as performance, schedule, and reliability and that design will converge on cost rather than cost converging on design.[2] A less formal process than a traditional CAIV analysis can also be considered and used, if appropriate. Referred to as Business Case Analysis (BCA) and Cost-Effectiveness Analysis, this discipline covers studies often referred to as Target Costing and Value Engineering analyses.

N.4.1. Steps in the CAIV Approach

Figure N-3 shows, at a high level, the CAIV process tailored to NASA.

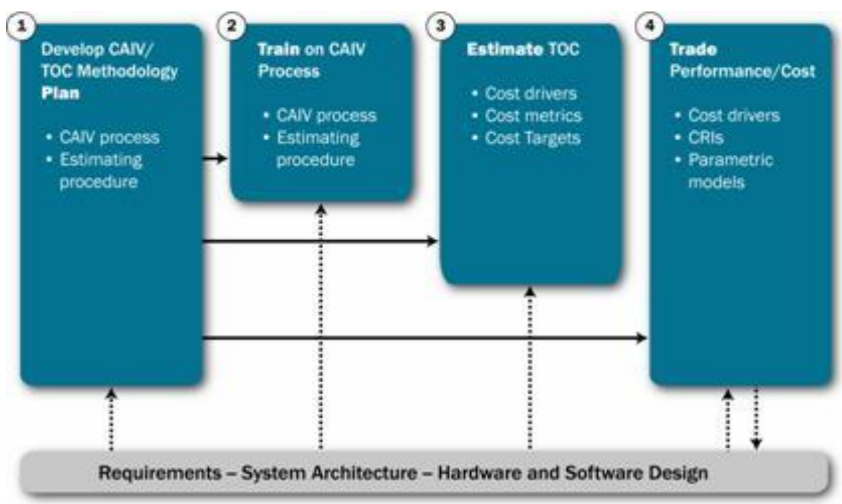


Figure N-3. CAIV Process Tailored to NASA

Step 1 involves high-level planning and development of the CAIV/Total Ownership Cost (TOC) methodology that the contractor will use, the establishment of broad goals and responsibilities, and agreement (buy-in) on CAIV procedures that the contractor will follow.

Step 2 involves CAIV awareness training for NASA systems and technical engineers and NASA managers so that CAIV is applied accurately and consistently. CAIV is tied closely to the existing parametric estimating process within the NASA Centers and its cost analysis support contractors.

[2] United Defense Limited Partnership, Crusader Program, Cost As an Independent Variable (CAIV) Plan, Revision 5, Contract DAAE30-95-C-0009, Document 44114E6364, June 1997.

Step 3 uses a program's cost baseline and holds that variable (cost) constant while allowing identified cost drivers to be manipulated to see their effect on cost. A hierarchy of affordability metrics can be derived from this baseline as an outcome of the CAIV and consists of the following:

- **Cost Targets**—Absolute values of cost, with a probability dimension, for specific programs, phases, contracts, or activities. An example of a cost target would be to procure the Crew Exploration Vehicle (CEV) for a total acquisition cost of $9 billion (in CY 2013 dollars), including all Government and contractor expenses. Cost targets can be expressed as a range of values that bound the "trade space"; the boundaries can be defined as follows:
    - **Threshold Cost**—The absolute highest cost allowable for an element if overall program-estimated LCC goals can be achieved. Breaching the threshold cost gives reason to cancel the element or project.
    - **Objective Cost**—A lower cost target that would be more difficult to achieve but that could offset overruns elsewhere in the program architecture.
    - **Cost Performance Measures (CPMs)**—Measures that combine absolute cost values with relevant performance measures. Examples include dollars per mission or flight, dollars per equivalent source lines of code (SLOC) developed or maintained, and dollars per unit mass of hardware developed or produced. These measures will change over time to reflect changing requirements, evolving design, and maturation of the program.

Step 4 integrates CAIV trades with the mainstream of systems engineering trades. When managers have a complete understanding of system-level cost drivers and the application of experience-calibrated parametric cost estimating models, they can oversee the trade process, ensuring that affordable design options are identified and objectively considered in the trade process.

Figure N-4 illustrates the overall trade space that is defined by the objective and threshold performance parameters, as well as by the objective and threshold cost values. If enough alternatives can be compared, their relationship might indicate a curve that may detect the "knee," or point of diminishing return (i.e., where a slight performance improvement incurs an unacceptable cost increase). Initial performance-cost trades may be limited to the Key Driving Requirements (KDR) in order to focus on primary cost drivers and to validate (or challenge) the main requirements based on affordability.

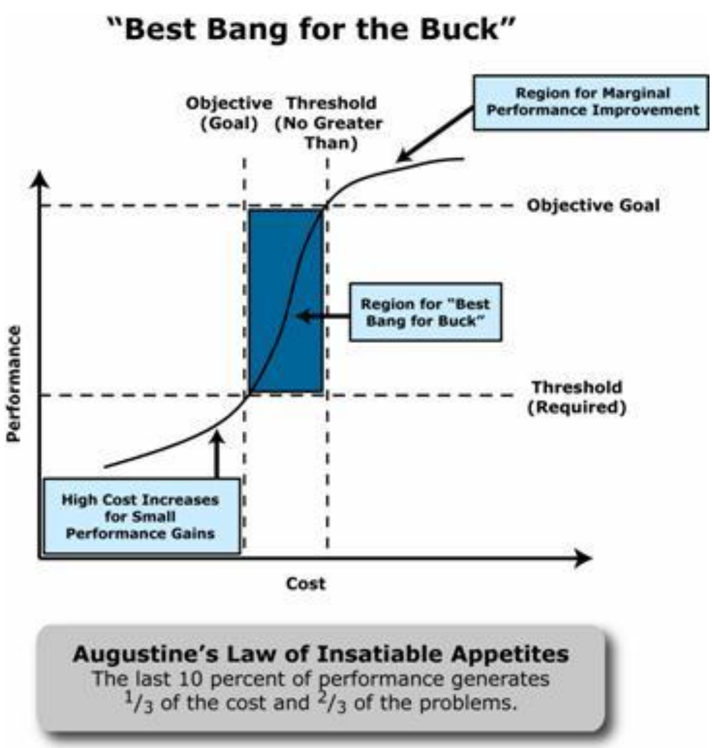


Figure N-4. CAIV Trade Space

N.5. Economic Analysis

This EA section includes information about the EA Methodology, PV, NPV, Return on Investment (ROI), and Internal Rate of Return (IRR).

N.5.1. Economic Analysis Overview

Figure N-5 illustrates the simple principle behind an EA—to determine the preferred alternative among various alternatives based upon cost and benefit data.

As shown in Figure N-5, the benefit streams expected to flow from investments are typically composed of multiple components, some of which can be characterized in terms of cost savings and cost avoidance (in financial terms); others that can be quantified, but not in cost or financial terms; and still others that simply cannot be quantified. For the benefit streams that can be quantified in financial terms, the PV metric is applied to investment cash flows (costs) and cash flows from cost savings and cost avoidances (benefits) on a comparable basis with respect to timing.

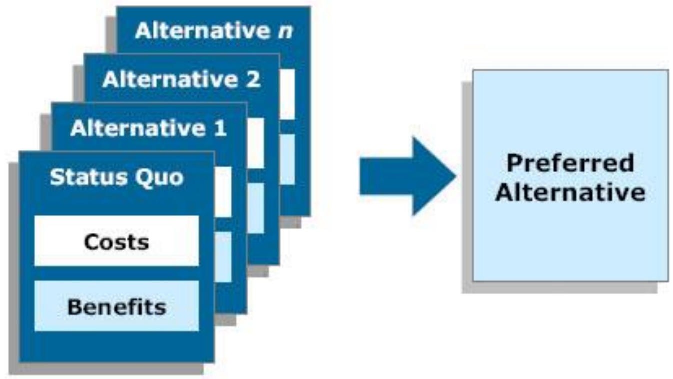


Figure N-5. Economic Analysis Objective

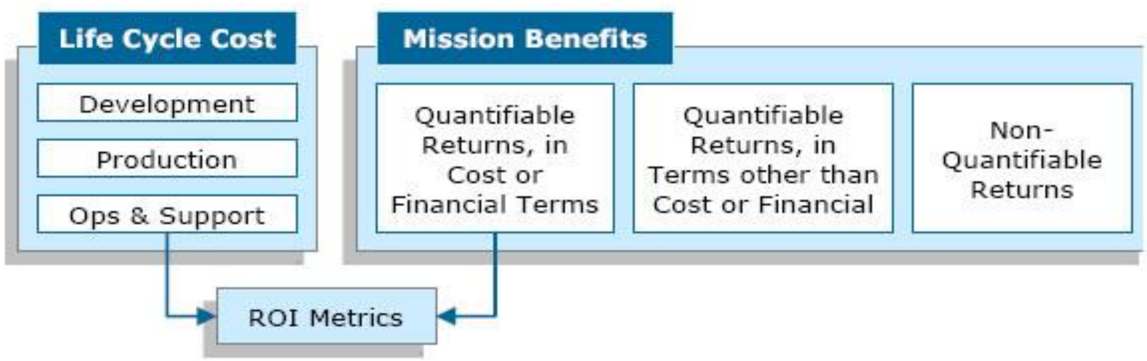


Figure N-6. Cost Benefit Analysis Framework

The development of ROI metrics, typically in the form of a ratio, can help decision makers select among investment alternatives. ROI ratios, such as savings/investment and payback ratio, can be used to identify attractive alternatives. The computation of any traditional ROI metrics can only take into account outcomes that are characterized in cost or financial terms. What is not immediately evident from Figure N-6 is the fact that the generation of an ROI metric can only result from a comparison of two or more alternatives, one of which serves as a reference point and is typically defined as the baseline or the status quo alternative.

Financially quantifiable benefits and ROI metrics should not be all that leaders rely upon when selecting alternatives for NASA. To paint the complete picture, the contribution to effectiveness of quantifiable, nonfinancial benefits and the contribution to effectiveness of typically non-quantifiable benefits should be measured using decision framework techniques such as the Analytic Hierarchy Process (AHP) or the

Multi-Attribute Utility Theory (MAUT). These decision framework techniques bring structure to complex problems where multiple alternatives need to be considered across a range of goals and objectives. They also help to develop stakeholder buy-in, facilitate an understanding of the project complexities, and shed light on the decision-making process. The techniques establish a structure that articulates and prioritizes the goals and objectives that different alternatives are expected to meet, while providing a mechanism to develop normalized scores of effectiveness.

The quantification of financial benefits, the development of ROI metrics, and the measurement of the effectiveness of nonfinancial benefits and non-quantifiable benefits serve the overall objective of making a sound recommendation in an EA. Table N-5 summarizes two types of EAs.

Table N-5. Types of Economic Analyses

Different EA Types	Description
Analysis of Alternatives (AOA) Level of Effort: *Requires a large team, may take many months to accomplish, and addresses the full Life-Cycle Cost Estimate (LCCE)*	Compares the operational effectiveness, suitability, and LCCE of the most promising of several conceptual alternatives that appear to satisfy established capability needs. Two major components of an AOA are a cost-effectiveness analysis and a cost analysis. An AOA's analysis and conclusions are then typically used to justify initiating an acquisition program. An AOA also examines mission threat and dependencies on other programs. Many times, an AOA cannot quantify benefits. For example, there is no agreed-upon monetary value for what a human life is worth. In this case, a cost-effectiveness analysis is more appropriate. A Cost Estimation and Analysis (CEA) is conducted whenever it is unnecessary or impractical to consider the dollar value of the benefits. This happens when the various alternatives have the same annual monetary benefits. Both the AOA and CEA should address each alternative's advantages and disadvantages and the associated risks and uncertainties of how these might influence the comparison.
Economic Analysis (EA) Level of Effort: *Requires a large team, may take many months to accomplish, and addresses the full LCCE*	This is a conceptual framework for systematically investigating problems of choice. Posing various alternatives for reaching an objective, it analyzes the LCCE and benefits of each one, usually with a ROI analysis. PV is also an important concept. Since there is time value to money, it is necessary to determine when the expenditures for the alternatives will be made. The EA expands cost analysis by examining the effects of the time-value-of-money on investment decisions. After cost estimates have been generated, they must be time-phased to allow for alternative expenditure patterns. Assuming equal benefits, the alternative whose PV cost is least is the most desirable because it implies a more efficient allocation of resources.

N.5.2. Future Value and Present Value

The PV metric captures the time-value-of-money by adjusting through compounding and discounting cash flows to reflect the increased value of money when invested.

N.5.2.1. Calculating Future Value

Compound interest occurs when the interest charged (or received) over a period is based upon the balance of principal and interest of the previous period. The Future Value (FV), representing the total amount received or repaid, is based on compound interest for a single payment or receipt. FV is calculated as $PV(1+ i)^n$ where *i* is the interest rate and *n* is the number of years from the date of initiation for the project. Another way to describe this calculation is that FV equals the product of a single payment or receipt (PV) and compound interest factor, $(1+ i)^n$.

Compound interest is the preferred method to depict the value of money accumulated (or paid) over time. For example, suppose you had $909.09 today (PV) and invested it at an annual interest rate of 10 percent. Because this PV of $909.09 accumulates $90.91 of interest over a year, you would collect $1,000 in one year (FV). You can calculate this FV as:

$$FV = PV \; x \; Compound \; Interest \; Factor \qquad \text{(Equation N-1)}$$

$$FV = PV\,(1+i)^n \qquad \text{(Equation N-2)}$$

$$= \$909.09(1+0.10)^1 = \$1{,}000$$

But what if you decided to withdraw the money in 5 years, not 1 year? Assuming the interest rate remains fixed at 10 percent, your FV would become:

$$FV = \$909.09(1+0.10)^5 = \$1{,}464$$

In this case, $909.09 was "invested" at an interest rate of 10 percent to become "worth" $1,464 just 5 years later. It becomes apparent, therefore, that time-value-of-money, depicted as compound interest, can have significant impacts on the FV of a principle deposit or investment.

N.5.2.2. Calculating Present Value

To determine the PV of money, a discount rate must be applied to costs. There are two different types of discount rates:

- Real discount rate is adjusted to eliminate the effects of expected inflation and used to discount constant-year dollars or real benefits or costs.

Nominal Discount Rate – Expected Inflation Rate = Real Discount Rate

- A nominal discount rate is adjusted to reflect inflation used to discount then-year dollars or nominal benefits and costs.

Figure N-7 illustrates this relationship between PV, base-year, and budget-year dollars.

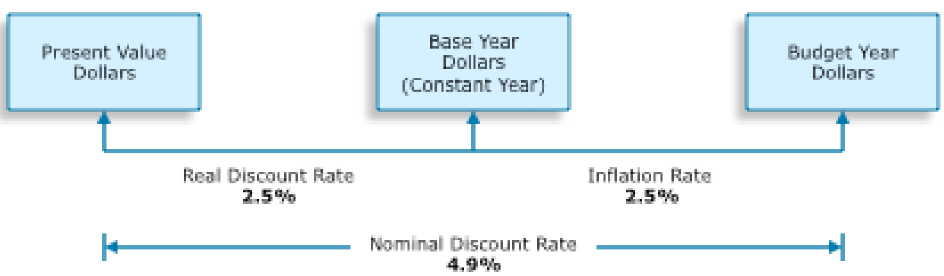


Figure N-7. Present Value, Base-Year, and Budget-Year Cost Relationships

Budget-year dollars incorporate the effects of inflation and adjust for the time-value-of-money—the concept that a given amount of money is worth more today than in the future due to inflation. Base-year dollars are adjusted for the time-value-of-money, and PV dollars have the effects of inflation and time-value-of-money removed.

Real and nominal discount rates are provided by the OMB in Circular No. A-94. The rates are updated each calendar year and can be found at *http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html*.

Discounting translates projected cash flows into PV terms using specified discount factors. As illustrated in Figure N-8, the ***discount factor*** is equal to $1/(1+i)^n$ or $(1+i)^{-n}$ where i is the interest rate and n is the number of years from the date of initiation for the project. Figure N-9 provides an example of how discounting is applied.

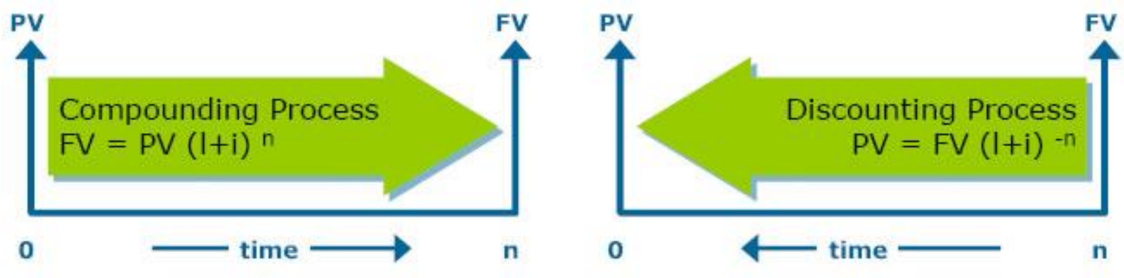


Figure N-8. Compounding and Discounting

Costs are in Budget Year Dollars	2006	2007	2008	2009	2010
Total Annual Outlays	**$250,000**	**$256,000**	**$262,144**	**$268,435**	**$274,878**
E-O-Y Discount Factor	0.9533	0.9088	0.8663	0.8258	0.7873
Present Value	$238,322	$232,642	$227,098	$221,686	$216,403
Cumulative Present Value	$238,322	$470,965	$698,063	$919,749	$1,136,151
	0.9533 = 1 / (1+4.9%)^1	0.9088 = 1 / (1+4.9%)^2	0.8663 = 1 / (1+4.9%)^3	0.8258 = 1 / (1+4.9%)^4	0.7873 = 1 / (1+4.9%)^5

4.9% Nominal Discount Rate
End of Year Discount Factor

TOTAL OUTLAY
$1,311,457

NPV
$1,136,151

Figure N-9. Example of Discounting

N.5.2.2.1. End-of-Year and Middle-of-Year Discount Factors

The two most common discounting conventions used to evaluate Federal expenditures are end-of-year (EOY) and middle-of-year (MOY). This section provides descriptions of EOY and MOY factors associated with these discounting conventions.

<u>End-of-Year (EOY) Discount Factor Calculation</u>

The EOY discounting convention is where a payment is administratively placed at the end of the discount period. This is appropriate where you know the timing is closer to the end of a year. When using the EOY method for a specific payment, include justification in the source and derivation of costs section.

To determine the EOY discount factor, the right side of the PV formula (Equation 2) can be broken down into two parts: (1) the FV (e.g. the total amount of money in a savings account after 5 years) and (2) the discount factor (e.g. the factor that adjusts the FV to PV). This slight variation to Equation N-2 is depicted in Equation N-3.

$$PV = FV * \frac{1}{(1+i)^n} \qquad \text{(Equation N-3)}$$

where:

$$\text{Discount Factor} = \frac{1}{(1+i)^n} \qquad \text{(Equation N-4)}$$

Substituting:

PV = *FV* * Discount Factor (Equation N-5)

Offering a more detailed examination of the previous example, Equation N-3 reveals how the FV of your car ($10,000) is "discounted" to a PV of $6,209.21. Equation N-4, an excerpt of Equation N-3, represents the EOY discount factor (for converting any FV to its respective PV). Given an interest rate of 10 percent over a period of 5 years, the discount factor can be calculated as:

$$\text{Discount Factor } = \frac{1}{(1+0.10)^5} = 0.6209$$

Substituting the given values into Equation 5 produces the same solution produced from Equation N-3:

PV = *FV* * Discount Factor

PV = $10,000 * 0.6209 = $6,209

It becomes apparent, therefore, that time-value-of-money, depicted as a discount rate, can have significant impacts on the PV of a principle deposit or investment.

Middle-of-Year (MOY) Discount Factor Calculation

The MOY discounting convention is used where a payment is administratively placed at the middle of a discount period. This is accepted by OMB as an approximation of continuous payments or payments evenly spread throughout a year. OMB guidance advocates the use of midyear discount factors, which have the advantage of providing greater accuracy than end-of-year factors. When outlays of funds are spaced evenly throughout a year, midyear discounting is considered an acceptable approximation for continuous discounting. When outlays are not spaced evenly, and the precise timing of outlays is unknown, midyear discounting minimizes the potential error. This is the preferred method of discounting and should be the default method. Built-in formulae for most spreadsheets do not support MOY, so formulae must be constructed as described later.

It is not uncommon to depict expenditures to occur at mid-year. The method for calculating midyear discount factors is based on the following formula:

$$\text{Discount Factor } = \frac{1}{(1+i)^{n-0.5}}$$

(Equation N-6)

Applying the MOY convention to our car example (instead of the EOY convention), the discount factor increases slightly from 0.6209 to 0.6512 as shown:

$$\text{Discount Factor} = \frac{1}{(1+0.10)^{(5-0.5)}} = 0.6512$$

Note that in order to calculate realistic EOY and MOY discount factors, it is necessary to have the most current discount rates and an accurate Period of Analysis.

As described in Step 5 of the EA Process (in the next section), applying the appropriate discount factor to future cash streams is essential to putting all alternatives on a level playing field. Discounting converts future cash flows from FVs to PVs that can then, and only then, be used for comparing and ranking alternatives.

Common EOY and MOY "Cash Flows"

A new project typically requires an initial capital investment at the beginning of year 1 (at time = 0). Investments may need to continue for several years (e.g., EOY 1, 2, and 3). Salvage value and disposal cost (at end-of-service life) also tend to occur at EOY. Therefore, it is necessary to apply EOY discount factors to these types of cash flows.

These three exceptions aside, remaining project expenditures, such as project operations cost or building maintenance expenses, are typically depicted as MOY cash flows. Therefore, MOY discount factors should be applied to these cash flows.

N.5.3. Steps for Performing an Economic Analysis

As described in section 3.6.1, the seven steps for performing an EA are:

1. Prepare statement of objective.
2. List assumptions and constraints.
3. Identify alternatives.
4. Identify and estimate benefits and costs.
5. Rank alternatives using economic measures-of-merit.
6. Perform sensitivity and risk analyses.
7. Prepare results and recommendation (documentation).

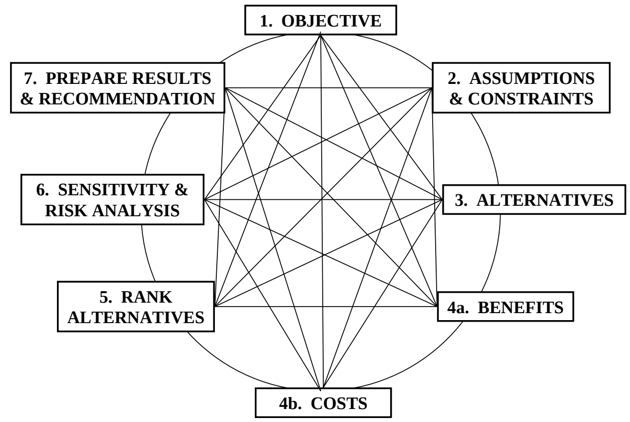


Figure N-10. Steps for Performing an EA

Although this section will review these steps in series, the EA process is most often an iterative one (see Figure N-10). There are many interrelationships among the steps in the process. Rather than performing each step in order to completion, the steps may be revisited during the analysis.

N.5.3.1. Prepare Statement of Objective (Step 1)

It is difficult to solve a problem if you do not know what the problem is. The need to perform an EA usually stems from an existing problem, changing threat, or changing mission. The statement of the objective should clearly define and quantify, to the fullest extent possible, what we are trying to accomplish. The statement of the objective should not assume a specific means of achieving the desired result and cover two areas: (a) describe the problem and requirement, then (b) define the objective.

The Problem and Requirement. You usually get this information from a boss who tells you to go fix a problem. The analyst may be at a disadvantage because the "real problem" as seen by higher headquarters may not be obvious to the team assigned to do the study.

A project is usually proposed to correct a deficiency. Deficiencies that might prompt a project include:

1. A need for a new functional requirement due to a new mission or mission change.
2. A space shortage.
3. An engineering deficiency.
4. An environmental, health, safety, fire protection, or security problem.
5. A trend of excessive operations and support costs.
6. Functional inadequacy. For example, fielding a new system where it did not fit the size or capability of support facilities or storage areas.
7. An inefficient condition, including inefficient use of energy or space.

Often a project identified to meet one requirement may be expanded to meet others. For instance, a facility addition designed to accommodate space storage requirements may also correct structural deficiencies or increase energy conservation.

The Objective Statement. THIS IS THE MOST IMPORTANT STEP and involves both the decision maker and analyst. Both must understand why the EA is being performed. Also, be sure to include all key functional people at this time. Consider using functional area persons, experts, academia, and the like.

A good objective statement should consist of three parts:

1. The product or service to be provided,
2. The measurement system, and
3. The selection criteria.

The product or service to be provided is exactly what will be provided, manufactured, produced, procured, or delivered. First, consider the mission or function desired. Although it does not seem very well defined yet, it is only because the alternatives more readily define the product or service. The wording of the objective statement is critical. Be specific enough to include the problem to be addressed, yet broad enough to pick up all feasible alternatives. Be careful not to word the objective statement to lead toward any one alternative.

The objective should be stated in quantifiable terms to the greatest extent possible because it is easier to compare and rank alternatives if you can compare apples to apples or numbers to numbers. Second, performance measurement criteria need to be established so that the relative costs and benefits of each alternative can be compared and related directly to the objective.

The measurement system is that standard by which the product or service to be provided will be measured. It can be stated in terms of a standard, regulation, or building code, or a goal against which the results of the selected problem solution can be measured. You must be able to measure the output in order to determine the attainment of the goal.

The selection criteria may include financial and nonfinancial comparisons such as Net Present Value (NPV), Equivalent Uniform Annual Worth, Savings Investment Ratio, Benefit/Cost Ratio, or decision analysis scores and may become the basis for your recommended decision methodology.

N.5.3.2. List Assumptions and Constraints (Step 2)

It is important to list constraints that each alternative must meet to weed out infeasible alternatives early. List only those assumptions that are absolutely necessary because the more assumptions, the more chances to introduce uncertainty into the study. Finally, identify any limitations in the scope of the study such as limited timeframe or personnel to perform the study.

Assumption #1: Economic Life. The first and commonly foremost assumption required in every EA is that of each alternative's economic life. Economic life is defined as the period of time over which the benefits from an alternative are expected to accrue (i.e., we receive the use or benefit of an alternative). It is commonly equal to the years associated with operating and support. Each alternative has its own economic life. The economic life of a given alternative is usually the shortest of the physical life, mission life, or technological life.

- *Physical life* is the estimated years that an asset can physically be used to accomplish the function for which it was intended.
- *Mission life* is the estimated years over which the need for the asset is anticipated.
- *Technological life* is the estimated years a facility, piece of equipment, or automated information system will be used before it becomes obsolete due to changes in technology.

Assumption #2: Period of Analysis. Another important assumption is described as the Period of Analysis. The Period of Analysis starts from the year the first costs are incurred for each alternative and ends in the last year costs are incurred for that alternative. Since it includes disposal costs, the Period of Analysis may extend for some number of years beyond the end of economic life.

Other Assumptions. Although listed as the second step in the analysis process, the formulation of assumptions is, in reality, continued through every phase. Care must be taken not to oversimplify the scenario and thereby distort the analysis too much from practical consideration. Assumptions are used to help:

- define the study problem
- establish alternatives
- provide means for treating unknown or difficult-to-quantify elements
- perform calculations
- report study results

The formulation of assumptions is an integral part of an EA. It is accomplished whenever and wherever required, and, in fact, may be necessary when determining the original objective of the analysis.

The following items, by nature of their uncertainty, qualify as assumptions:

- Any future events
- Future economic assumptions
- Inflation factors
- Costs and benefits
- Projected workload
- Estimated economic life
- Changes to requirements

Constraints. In all phases of the business community, public or private, managers operate in an environment of restrictions, limiting what they can and cannot do. Whether the restrictions are "outside" constraints or self-imposed, they must be considered prior to developing possible courses of action.

Constraints such as the size or range of the manager's "operating area" are dependent upon total organizational freedom as well as the decision maker's position within the organization. There may be constraining organizational policies or procedures. There may be budgetary, funding, or personnel considerations. The manager may be limited to a specific amount of working area. There may be restrictions caused by production deadlines or other time-related considerations. Whatever their particular characteristics, these external constraints or barriers are beyond the control of the analyst or manager and provide boundary limitations for alternative solutions to a particular problem.

Constraints are things you know about but do not have the power to change. Sometimes all you can do is ask the imposing authority for relief or exemption. You must list all constraints because they are conditions that bind the analysis and influence the generation of alternatives.

Some constraints might be:

- budget
- funding
- operations
- organization
- facilities
- personnel strength ceilings
- working area
- milestones
- schedules
- deadlines
- cost apportionments
- production rates
- manning factors
- NASA Center or NASA-wide policies

N.5.3.3. Identify Alternatives (Step 3)

There is normally more than one way to achieve a goal or objective. Each is an alternative—a different means to fulfill the need. All reasonable ways of satisfying the objective should be documented and discussed. Innovative and improved ways of doing business should be actively sought. As a minimum, each of the following alternatives must be considered:

- Do nothing or status quo (the existing way of meeting the objective)
- Modification of existing assets. This may include renovation, conversion, upgrade, expansion, or other forms of improving existing assets or services.
- Leasing or privatization
- New acquisition

Each alternative solution has its own mix of costs and benefits. One method may require a multitude of personnel while another may require a large capital investment. The number of alternatives is usually limited only by the creativity and thoroughness of the problem solver.

Challenges in Quantifying Benefits

Quantification of benefits can sometimes be an extremely difficult task. The reason is that benefits or effectiveness tend to have intangibles, as well as a number of different measures for the more tangible, quantifiable components.

In most cases, there is no common denominator like dollars in the case of costs. One way to address such a situation could be to rank the returns according to a hierarchy of values so that a more rational choice of alternatives can be made. Even if a benefit cannot be quantified, it should be documented and described in the EA.

In the development of alternatives, the search can be either random or systematic. Examples of the random approach include the familiar brainstorming or “thinking outside the box” creativity. The random method of search will probably uncover, to a greater extent than the systematic method, a new technology breakthrough alternative.

The systematic approach of identifying alternatives is more difficult but much preferred because of its thoroughness. This is the planned effort that uses some amount of advance information. The analyst sits down and formulates a survey to ask experts about the best solution to a current problem. The systematic approach of identifying alternatives seeks to gain information from a broad source of people so that the best possible solution can be advanced.

The search for alternative solutions to an existing problem (or for replacements for current solutions) definitely should not overlook the current way of doing things. This assumes, however, that the current method is feasible and valid. At the very least, the current alternative is a standard against which to compare new possibilities.

There are, however, a number of factors in generating alternatives that may limit the range or variety that can be developed. These may be inherent biases preventing the analyst from considering certain aspects or possibilities, or there may be resource limitations that force a halt before all concepts are pursued. Some limiting factors are:

- Routine pressure of normal activities
- Tradeoffs between time and the effort expended and probability of new alternatives or additional data
- Precedence of past actions
- Nature of the organization
- Scope of the analysis (feasibility study versus detailed project report)
- Forced deadlines limiting the analysis time
- Specific lists of alternatives from higher levels of management

These are not valid reasons to limit the search for alternatives. Be aware of their existence, deal with them by working around them, and try not to let them artificially constrain the number of alternatives.

N.5.3.4. Identify and Estimate Benefits and Costs (Step 4)

As described in the EA overview, costs must be viewed from the perspective of the Federal Government as a whole—not solely from the perspective of the organization for which the analysis is being done. Thus, project initiatives commonly have economic impacts that ripple beyond what is "owned" by the program itself. For example, a proposed technology demonstration initiative has the potential to divert funds away from three other NASA initiatives, improve the safety of U.S. citizens, improve the future effectiveness of two active NASA missions, and lead to reduced carbon-based emissions (environmental benefits). This same initiative could also lead to dramatic profits for Private Company X, but since those profits would not fall directly under the purview of the Federal Government, they should not be part of a Government EA.

Identify and Estimate Benefits. Benefits are the outputs of each alternative. They are what the Government expects to receive for the resources expended. They include measures of utility, effectiveness, and performance, and should be related to the objective. All benefits to the Federal Government should be included. In order for the analyst to avoid double-counting benefits or costs, they must be mutually exclusive.

Many benefits, described in many ways, are relatively easy to quantify. These include:

Quantifiable Benefit	Examples
Reduced Resource Requirements:	Personnel, Training, Maintenance, etc.
Improved Data Entry:	Reduced Staff Time, Reduced Error Rates
Improved IT Usage:	Storage and Retrieval, Distributed Processing
Improved Operating Performance:	Reduced Error Rates, Better Quality and Productivity
Cost Avoidance:	Eliminate Future Staff Growth, Need for Equipment
Cost Savings:	Reduced Budget, No Impact on Mission Effectiveness

Other benefits are nearly impossible to quantify in terms of dollars. Some typical *non-quantifiable benefits* include:

- Greater versatility
- Improved decision making
- Better presentation of information
- Fulfillment of operating requirements
- Improved timeliness
- Improved morale

So, the purpose of the benefit analysis is to present (to the appropriate decision maker) an orderly, comprehensive, and meaningful display of all returns expected for each alternative. In general, the following should be considered:

- A systematic procedure should be used to establish types of output;
- All benefits or returns should be identified and recorded for each of the alternatives under consideration; and
- A quantitative evaluation should be devised, if possible, for each type of output.

Benefits analysis can be rather subjective because judgments and priorities come into play. Nevertheless, benefits should be quantified whenever possible. Such measurements will vary from monetization of improved air quality to precise quantities of physical output to ranking and weighting each benefit. Verbal descriptions can often be transformed into numbers.

Example: Valuation of Benefits (Intangibles). A simple technique of ranking and weighting is described in this section. The general process is to first identify each benefit or decision criteria and each feasible alternative in a matrix. Then, for each benefit, assign a weight based on how important the attribute is to the overall objective. (Note: A higher number for weight shows greater relative importance.) Next, rank each alternative (again, a high number is best) based on how well the alternative satisfies the objective. For each benefit and alternative, multiply the weight by the rank to determine the weighted rank. Add the weighted ranks for each alternative. The alternative with the largest sum is the preferred alternative based on benefits. The benefit scores computed by this method have no measurable units and are only used for comparison of alternatives.

Consider the following example of benefits analysis. Due to a new 6-year NASA project starting up in fiscal year 2015, 450 NASA employees and contractors will need to relocate to a new office building. The status quo of moving into one or more existing LaRC buildings is infeasible due to limited *existing* office space available at LaRC. Therefore, additional facility space needs to be leased or purchased. In addition, it was determined that a permanent building shall not be constructed because the project will end in fiscal year 2020.

For illustrative purposes, assume that EA Step 2 (list assumptions and constraints) results in just two feasible alternatives:

> (1) Alternative A—Lease a facility space that is 12 miles west of LaRC . Ample office space is available immediately in an existing building that would be suitable and comfortable.
>
> (2) Alternative B—Buy temporary buildings to be placed at LaRC. Although the acquisition effort is more involved with such a purchase (versus a lease), the purchase of five temporary buildings could be accomplished in time for the move. The buildings would be somewhat less comfortable than the leased office space. However, the buildings can be located in areas that would allow the employees to still benefit from being on the "campus" of LaRC.

After a discussion with decision makers, analysts determine that there are three primary intangible benefits associated with each alternative: Proximity (i.e., how close the office is to LaRC), Availability (i.e., when the building is available), and Comfort (e.g., furniture, lighting, indoor temperature). Decision makers indicated that proximity is the most important benefit. *Proximity* is rated three times more important than *Comfort*; *Availability* is rated twice as important as *Comfort*. These benefit ratings are valuated under the "Weight" column in Table N-6.

Elicitation with decision makers continues by scoring each of the three benefits. For example, the analyst presents to decision makers the following list of possible scores with respect to Proximity:

If Leasing a Building provides …	then Score =
Poor Proximity	**1**
Below Average Proximity	**2**
Average Proximity	**3**
Good Proximity	**4**
Excellent Proximity	**5**

As shown in Table N-6, decision makers gave the “Lease Building” alternative a “Proximity” benefit score of only 2, and they gave the “Buy Temp Buildings” alternative the highest “Proximity” benefit score of 5.

Now that the analyst has a weight and score for each benefit, she is able to complete the benefit valuation for each alternative by (a) calculating weighted scores of each benefit, then (b) summing up these weighted scores. The alternative with the higher sum of weighted scores is then considered to provide more intangible benefit. In this example, as shown in Table N-6, buying the temporary buildings has an overall higher weighted score and, therefore, provides more intangible benefit versus leasing buildings.

Table N-6. Valuating Nonquantifiable Benefits of Leasing Versus Buying Buildings

		Lease Building		Buy Temp Buildings	
Benefit	**Weight**	**Score**	**Weighted Score**	**Score**	**Weighted Score**
Proximity	**3**	2	**6**	5	**15**
Availability	**2**	5	**10**	3	**6**
Comfort	**1**	4	**4**	2	**2**
		Sum =	***20***	***Sum =***	***23***

In this example, the interviewees “scored” leasing a building as “Below Average Proximity” (score = 2). The rationale for many of the respondents was that the building distance from LaRC would add 10–15 minutes to commute time.

Upon ranking and weighting the three benefits against each alternative, it was clear that the total benefit difference between leasing versus buying was not significant. Nevertheless, as Table N-6 indicates, buying temporary buildings within the confines of LaRC had a benefit score slightly higher than that of the “Lease Building” alternative (23 versus 20). This preference was driven by the proximity benefit of the temporary buildings.

Identify and Estimate Costs. There are two fundamental concepts in determining costs for each alternative. The first concept is life-cycle cost analysis. The second concept is cost estimating methods.

The following basic principles are essential for identifying and estimating costs for an EA:

- The viewpoint should reflect the total cost to the Federal Government.
- The viewpoint should include nonbudgetary and opportunity costs to Government.
- The viewpoint should document the source and derivation of all costs.

Life-Cycle Cost. A life-cycle cost reflects the sum of nonrecurring and recurring costs. More specifically, life-cycle cost equals the total cost of research and development, investment, operating and support, and disposal. Life-cycle cost for each feasible alternative should include all costs to the Government from beginning through termination or salvage point for the entire life of a program or project.

There are two general categories of cost: nonrecurring (one-time investment) and recurring (operational). This distinction is necessary because the timing and annual rate of costs incurred are important factors in an analysis.

Nonrecurring Cost. Nonrecurring cost is a one-time cost category that includes such considerations as acquisition of equipment real property, nonrecurring operation and support costs, and other such investments. It also includes:

- The cost of rehabilitation, modification, or addition of land, buildings, machinery, and equipment;
- The cost of freight, foundations, and installations required by the project;
- The value of nonrecurring services received from others, both internal and external, when the cost of these services can be measured, as well as one-time personnel costs such as separation costs or hiring costs;
- The costs of leaseholds required for the alternative; and
- Working capital, current assets on hand or on order (including inventories of consumable items and resources required for the project).

Recurring Cost. Recurring costs are the annual costs required to operate and maintain a program or project. This category considers personnel costs, materials consumed, operating overhead, and support services required annually.

Cost Terminology Specific to Economic Analysis. An EA has its own unique vocabulary of dozens of EA-specific cost language terms. Nine essential terms are defined below:

- Depreciation: Depreciation is an accounting convention that impacts cash flows only when an income tax structure exists. DOD components do not pay taxes, and thus tax depreciation is not applicable in DOD-owned alternatives and should not be included in an economic analysis of Government investments. Activities under the Defense Working Capital Fund are allowed to use depreciation techniques to determine the values of assets and capital recovery customer fees or surcharges on prices of products and services to customers.
- Externalities: This type of cost can occur when a Federal action affects others (positively or negatively) without those others paying or being compensated for that action. For example, a new Air Force program may cause a 50 percent increase in employment in and around a region. The “external” cost to that region might be dramatic increases in traffic and air pollution. Such change in traffic and air pollution can lead to longer average commuting times, decreased work productivity, increased road maintenance, increased air pollution, and a higher incidence of automobile accidents. Using various economic methods, economists publish monetized values of these secondary impacts (e.g., the cost of NOx to society is $12,700 per ton per year). Therefore, although often difficult, it is possible to translate externalities into monetary cost impacts.
- Incremental: These are additional costs necessary to achieve a change in the output of a particular project (a form of differential cost). Calculating the change in cash flows from a status quo project to a more efficient project is an example of an incremental cash flow. What commonly occurs when one considers alternatives is that an alternative requires an incremental increase in capital (procurement cost) to realize an incremental decrease in operating and support costs.
- Intangibles: Used interchangeably with “nonquantifiable,” intangibles are those elements of the alternatives that could not be depicted in monetary terms. Examples include changes in comfort, aesthetics, flexibility, safety, or morale—all of which can be extremely difficult to translate into dollars and cents.
- Opportunity Costs: Value of a good or service foregone or sacrificed by use of limited resources on a less effective or less gainful project. Decisions have “opportunity cost” because choosing one thing in a world of scarcity means giving up something else. For example, a person going to college foregoes earnings that he or she would have received working a paid job for 4 years. The opportunity cost of the time spent studying and going to classes is lost earnings.

- Phase-out: Lead-time is included in an EA if an alternative involves equipment that must be developed or modified before it can be used. For such an alternative, costs must be incurred for parallel operations of the status quo while the development or modification is taking place. These costs are called phase-out costs or parallel system operating costs. They must be added to the life-cycle cost of the new or modified system.
- Sunk: These are costs that have already been incurred or were irrevocably committed prior to the beginning of the period-of-comparison. They may be mentioned in the narrative of the EA report but are not included in the cost analysis. Only costs that can be influenced by the decision maker are included in the analysis. 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.
- Terminal: Also referred to as “residual” or “salvage value,” these are costs that will be incurred because of actions taken to conclude or terminate a program. These terms refer to the expected value of existing facilities or assets (e.g., land, buildings, equipment, or automated information systems) when they are no longer being used or have reached the end of their useful lives. Terminal values should be included in the cost analysis as a reduction to the cost of the alternative to which they apply. Many factors influence estimates of these values; for example, (a) probability of continued need for product (for Government or private use), (b) appreciation, and (c) depreciation. Functional area directives often specify terminal value determination procedures. Be aware of these for your functional area!
- Wash: Also called “nondifferential costs,” wash costs are those costs that apply equally to all alternatives. They can be included or excluded and should be described in the narrative of the EA report.

The determination of the cost of each proposed investment is based on the costs of adopting the alternative. Such costs are determined after due allowances for those resources are already paid for, regardless of whether or not the alternative is adopted or if the allowances would be available for use if the alternative were adopted. To determine the cost of an alternative, all the resource implications are considered. The alternative is treated in a system context. For example, the cost (admittedly oversimplified) of adopting a new radio would include not only the cost of the radio and its development, but also the costs of training people to operate it, the total cost of maintaining the radios, and cost of the additional radios required for maintenance float replacement, combat consumption, and so forth.

Inflation must be recognized in EA by two primary methods. The first and preferred method is to exclude inflation by using “base-year dollar” estimates. The second method is to use “then-year dollar” estimates that include inflation. The inflationary impact is commonly estimated by inflation indices. These forecasted inflation factors are available through cost analysis or comptroller channels at higher headquarters. A common technique is to use factors linked to the type of appropriation funding. Examples are separate factors for Research and Development or Operations and Maintenance. If inflation factors are used, you should document their source and derivation in your report.

EA requires measuring the value of costs. The unit of measure is the dollar. To avoid distortions due to changes in the value of the dollar over time, as when the general price level changes, all estimates of costs should normally be made initially in terms of base-year dollar values—that is, in terms of the general purchasing power of the dollar in the base-year of the analysis. Projected annual costs should vary only to the extent that the required level of procured goods and services is expected to vary during the project life. For example, it would be legitimate for annual costs to reflect an increase in the anticipated amount of repairs needed, as measured by prices in effect at the beginning of the project life, since this represents a real cost increase and not an inflationary one.

Because base-year dollar estimates are most commonly used for EAs, the numbers given are generally not budget estimates, which usually reflect some anticipated inflation.

N.5.3.5. Rank Alternatives Using Economic Measures-of-Merit (Step 5)

Decide which alternative is the “best buy for the dollar” by ranking the alternatives. For a “best buy,” we must determine the value of the benefits and compare the costs. In comparing a number of alternatives, a relatively quick comparison and ranking can be accomplished by categorizing the choices in terms of equality of costs and benefits. The comparison of alternatives has two major purposes: (1) to highlight the key issues associated with each alternative and (2) to focus on the tradeoffs (in costs and benefits) that are available to the decision maker.

Just because a pair of alternatives meets the minimum requirement does not necessarily mean that they have equal benefits. It is not uncommon to have competing alternatives that have unequal benefits and unequal costs. Under such scenarios, the analyst may need to employ noneconomic methods in addition to economic methods.

Selecting and Applying Preferred Economic Measures-of-Merit. In EA, current Federal policy requires us to use specific discount rates. When you apply discount factors to base-year dollars, you are accounting for two economic or financial phenomena. First, by discounting, you are considering the “time-value-of-money”, i.e., a dollar today is worth more than a dollar in the future. Second, by using a discount rate, you are assuming an “opportunity cost of capital.” In other words, you are requiring a return on the investment of Government funds.

A number of standard financial measures are available for the evaluation of alternatives. They provide insight into different views of the same situation. The choice of what measures to use should be based on the objective of the project and is made by the analyst, reviewers, and management. Often, a number of measures are used together to present a financial picture to the decision maker. An example is using the results of Net PV, Equivalent Uniform Annual Worth, and Discounted Payback Period. Each measure contributes to the understanding of the decision situation. Common financial measures and nonfinancial measures are listed as follows:

- Net Present Value (NPV)
- Equivalent Uniform Annual Worth (EUAW)
- Savings/Investment Ratio (SIR)
- Discounted Payback Period and Nondiscounted Payback Period
- Internal Rate of Return (IRR)
- Discounted Breakeven Point and Nondiscounted Breakeven Point
- Capitalized Cost
- Incremental Analysis
- Benefit/Investment Ratio
- Benefit/Cost Ratio (BCR)
- Decision Analysis Scores

In order to determine the better alternative from an EA viewpoint, you must apply one or more of the financial measures listed above. For this lesson, you will focus on two of the measures: NPV and EUAW. Both measures require the adjustment of costs for the time-value-of-money. You will make such adjustments using cash flow diagrams.

Cash Flow Diagrams (CFD). Many everyday economic problems involve periodic payments and receipts of money. A cash flow diagram provides a graphic representation of such cash receipts and disbursements. Cash flow diagrams are useful for analysis because, with a simple graphic, they can depict a complex situation. Secondly, cash flow diagrams assist the analyst to select an approach for solving time-value-of-money adjustments.

How to Construct a CFD. These guidelines are conventions and should not be interpreted as fixed rules and regulations. A CFD is a graphical representation of current and future resource expenditures and receipts (expressed in dollar terms). The first step is the drawing of a horizontal line to illustrate the considered time period. Divide the line into equal parts symbolizing the discount (interest) periods. For EA, the usual time interval is 1 year. The time periods are then numbered chronologically. The left end point is often called "time zero or base period" and represents the time of decision. For large-scale investments that require separate budget submissions and authorizations, it is common to synchronize the analysis periods with fiscal years. For other cases it is not necessary to synchronize the periods with fiscal or calendar years.

Use vertical arrows to illustrate fund outflows and inflows. Outflows and inflows are differentiated by the direction of the arrows. Arrows may be placed either above or below the line. Use downward arrows to represent outflows, or expenditures, and upward arrows to represent inflows or receipts. With discrete payments, a separate arrow represents each separate payment. To illustrate a future equal (uniform) uninterrupted series of amounts, you have the option to draw only the first and last arrows then connect the ends of the arrows with a straight line. This is done instead of drawing a separate arrow for each discrete payment.

The location of the arrow on the time line represents also the type of discounting for that payment. The most common methods include: Beginning-of-Year, Middle-of-Year, and End-of-Year. The placement of the arrow is administrative only and need not match the exact timing of the payment. As an example, with End-of-Year discounting to approximate a steady flow throughout the year, the entire year of payments is represented by a single arrow at the end of the year. The end of one year is considered the same as the beginning of the following year.

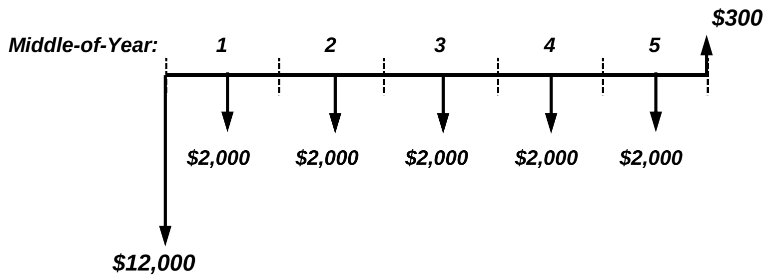
CFD Example: An office requires a new copy machine that will be used to produce 200,000 copies per year. One alternative is the purchase of a new copying machine. The machine will cost $12,000 that will be paid one month after delivery. The machine would be delivered immediately. Operating and maintenance costs are estimated to be $0.01 per copy. The copy machine will last for 5 years, at which time it will have a salvage value of $300. An alternative is contracted service at a cost of $0.03 per copy. The discount rate is 2.3 percent. Tabular and CFD results for each alternative are shown in Figure N-11:

i = 2.3% **Copies per Year: 200,000**

Purchase Option

Cost per copy equals: $0.01

	EOY 0	MOY 1	MOY 2	MOY 3	MOY 4	MOY 5	EOY 5
Expenses	$12,000	$2,000	$2,000	$2,000	$2,000	$2,000	
Receipts							$300
Net Cashflow:	-$12,000	-$2,000	-$2,000	-$2,000	-$2,000	-$2,000	$300



Contract:

Cost per copy equals: $0.03

	MOY 1	MOY 2	MOY 3	MOY 4	MOY 5
Expenses	$6,000	$6,000	$6,000	$6,000	$6,000
Receipts					
Net Cashflow:	-$6,000	-$6,000	-$6,000	-$6,000	-$6,000

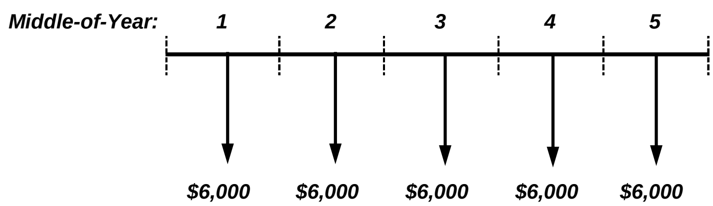


Figure N-11. Cash Flow Diagrams of Purchasing Copier Versus Contracting Copy Service

Note that each alternative is depicted with a separate CFD. The “Purchase Option” has different EOY cash flows while the “Contract” alternative is depicted as five discrete EOY expenditures of $6,000.

Net Present Value—NPV is the preferred financial measure for usage by OMB and DOD. NPV shows whether total costs are less than or greater than total benefits. However, this measure is valid only where the economic lives of all alternatives are equal. If the economic lives are not aligned and equal, then there is the inherent problem of benefit or value received from one alternative over some time that is not received from another. NPV is a popular measure-of-merit because it represents all costs and benefits reduced to a single discounted net value. This permits simple comparison of alternatives on an equitable basis.

To compare investments in terms of their NPV, all costs and receipts for each alternative are put in terms of their worth as of the date on which a comparison is to be made. (The date of comparison usually is the present or a base year.) The following conditions apply to this present worth method. Note that for these conditions, economic life is assumed to be equal to the Period of Analysis.

- Economic lives of alternatives must be finite. For example, pump A has been estimated to have a physical life of 6 years. Pump B has an estimated life of 12 years.
- Economic lives of alternatives must be equal, or else they must be placed on equal terms.

If alternatives have unequal economic lives, then three adjustments are possible:

1. Assume multiple procurements are possible for each alternative until both have the same economic life. Here we assume that the same value of benefit can be purchased again and again. This situation may be numerically correct, but may not be considered reasonable if technology is a factor. The assumption that the same benefit or value can he procured again at the same cost ignores obsolescence and new technology. As an example, if two alternatives have economic lives of 6 and 8 years, the common multiple would be 24 years, which might be unrealistic.

2. Shorten the economic life of the longer alternative. This may result in a terminal value. As an example: If two alternatives have economic lives of 6 and 8 years, use 6 years. The concern then is to determine if the alternative with 2 years remaining on its normal economic life has any salvage or terminal value.

3. Extend the economic life of the shorter alternative. This may result in additional costs, increased costs, or a degradation of benefits. For example, if two alternatives have economic lives of 6 and 8 years, force both to have 8-year economic lives.

Depicting and Calculating NPV

For a complex situation with a number of separate payments, compute each payment as a separate equivalency back to the PV and then aggregate the amounts into an NPV. To compute NPV, follow these steps:

Step 1: Construct a cash flow diagram based upon tabular or spreadsheet data to display costs and financial benefits by year. Notate if costs are in constant-year or then-year dollars.

Step 2: Compute the PV of each annual cost and benefit. Inflows and outflows will have opposite algebraic signs.

Step 3: Sum the PV of costs and the PV of benefits to estimate NPV.

To estimate NPV, future benefits and costs must be discounted. Discount factors can be reflected in real* or nominal terms as defined by OMB Circular A-94, Appendix C. The discount rate used depends on the type of dollars to be adjusted (see Figure N-12).

Real Discount Rates—Adjusted to eliminate the effects of expected inflation and used to discount Constant Year dollars or real benefits and costs. A real discount rate can be approximated by subtracting expected inflation from a nominal discount rate.

Nominal Discount Rates—Reflect expected inflation and used to discount *Then Year* (inflated) dollars or nominal benefits and costs.

* in this case, "real" indicates that the effects of general inflation have been removed

Figure N-12. Definitions of Real and Nominal Discount Rates

NPV is computed by assigning monetary values to benefits and costs, discounting future benefits and costs using an appropriate discount rate, and subtracting the sum total of discounted costs from the sum total of discounted benefits. Discounting benefits and costs transforms gains and losses occurring in different time periods to a common unit of measurement.

For most Government-generated cost estimates, discount rates provided in OMB Circular A-94 are used to discount all cash flows. Projects with positive NPV are usually preferred. Projects with negative NPV should usually be avoided. Investment costs and cost savings are in budget-year dollars (include the inflation and the time-value-of-money, i.e., nominal inflation rate). The PV of the sum of the difference between the initial investment costs and cost savings equals the NPV.

Here is an example for discounting deferred costs and benefits.[3] Assuming a 10-year program, the Government will commit to the stream of real (or constant-year dollar) expenditures and benefits as depicted in the CFD (Figure N-13) as follows:

***i* = 7%**

Government 10-year Program where each Cash Flow is End-of-Year (EOY).
Constant Year 2015 Dollars x 000,000

	EOY 0	EOY 1	EOY 2	EOY 3	EOY 4	EOY 5	EOY 6	EOY 7	EOY 8	EOY 9	EOY 10	Total
Yearly Cost	$0	$10	$20	$30	$30	$20	$10	$5	$5	$5	$5	$140
Yearly Benefit	$0	$0	$5	$10	$30	$40	$40	$40	$40	$40	$25	$270
Net Cashflow:	$0	-$10	-$15	-$20	$0	$20	$30	$35	$35	$35	$20	$130

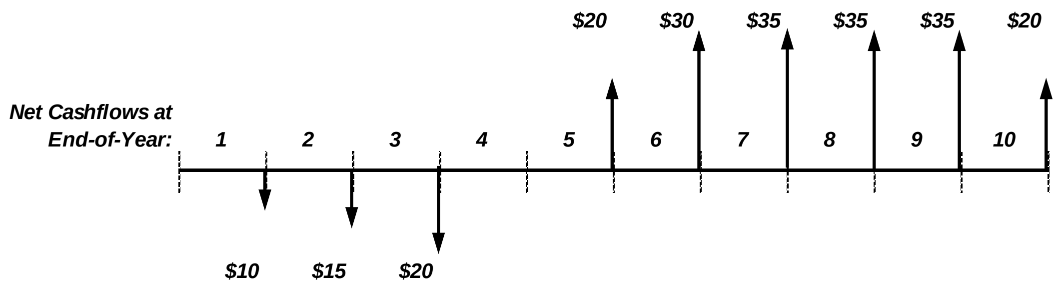


Figure N-13. Cash Flow Diagram of Government 10-Year Program

The CFD above shows each cash flow as a net amount in each year. Real costs feeding into the net cash flow appear in column 2 of Table N-7; real benefits are shown in column 3.

The discount factor for a 7 percent discount rate is shown in column 4 of Table N-7. The PV cost for each of the 10 years is calculated by multiplying column 2 by column 4. The PV benefit for each of the 10 years is calculated by multiplying column 3 by column 4. The PVs of costs and benefits are presented in columns 5 and 6 of Table N-7.

Table N-7. Discounted Costs and Benefits over Time

Year Since Initiation Renewal or Expansion (1)	Expected Yearly Cost (2)	Expected Yearly Benefit (3)	Discount Factors for 7% (4)	PV of Costs, Col. 2 × Col. 4 (5)	PV of Benefits, Col. 3 × Col. 4 (6)
1	$10.00	$ 0.00	0.9346	$ 9.35	$0.00
2	20.00	0.00	0.8734	17.47	0.00
3	30.00	5.00	0.8163	24.49	4.08
4	30.00	10.00	0.7629	22.89	7.63
5	20.00	30.00	0.7130	14.26	21.39
6	10.00	40.00	0.6663	6.66	26.65
7	5.00	40.00	0.6227	3.11	24.91
8	5.00	40.00	0.5820	2.91	23.28

[3] OMB Circular A-94, http://www.whitehouse.gov/omb/circulars_a094/.

Year Since Initiation Renewal or Expansion (1)	Expected Yearly Cost (2)	Expected Yearly Benefit (3)	Discount Factors for 7% (4)	PV of Costs, Col. 2 × Col. 4 (5)	PV of Benefits, Col. 3 × Col. 4 (6)
9	5.00	40.00	0.5439	2.72	21.76
10	5.00	25.00	0.5083	2.54	12.71
Total				**$106.40**	**$142.41**

NOTE: The discount factor is calculated as $1/(1 + i)^t$ where *i* is the interest rate (7%) and *t* is the year.

The sum of column 5 is the total PV of costs, and the sum of column 6 is the total PV of benefits. NPV is +$36.01 (column 6 total minus column 5 total), which is the difference between the sum of discounted benefits and the sum of discounted costs. Figure N-14 shows this cash flow and the discounted value of the cash flow over time. Annual costs are shown in red while the annual benefits are shown in blue. The annual difference between the two is shown in green. The annual cash flow turns positive in the fifth year. The total of all the green bars is the NPV (+$36.01).

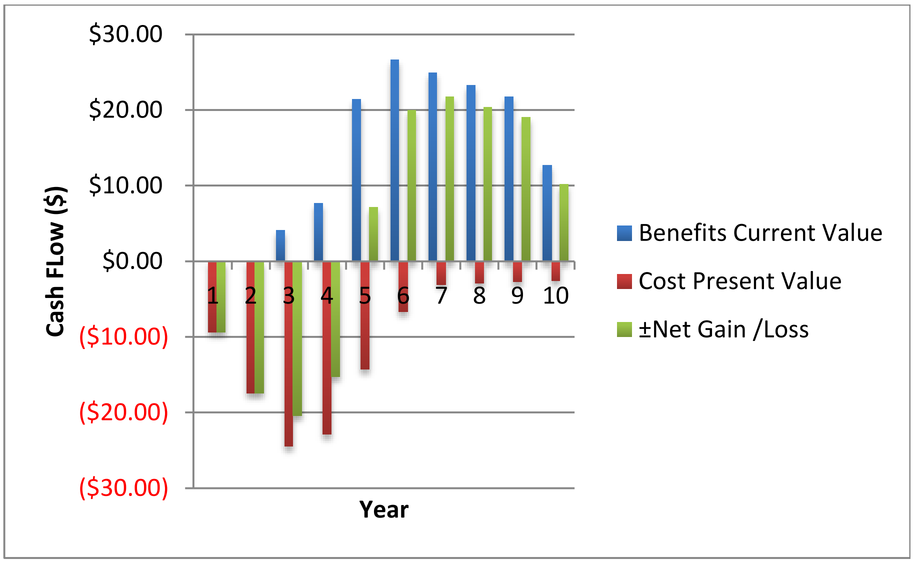


Figure N-14. Cash Flows and Discounted Cumulative Cash Flows over Time

Note that an alternative way to achieve the same NPV result of +$36.01 is to estimate the product of each *net cash flow* (see CFD in Figure N-14) with its respective discount rate, then sum up these values.

Return on Investment (ROI)

The ROI can be maximized by:

- Minimizing costs
- Maximizing returns
- Accelerating returns

A relatively small improvement in all three may have a major impact on the overall economic return of the investment.

Figure N-15 shows that ROI is the net benefit expressed as a percentage of the investment amount.

$$ROI = \frac{NPV}{PV\ Investment}$$

Figure N-15. Example ROI Calculation

ROI is the incremental financial gain from an investment, divided by the cost of the investment. The ROI for a project using the data from Table N-7 equals 33.8 percent.

PV of the investment = $106.40
PV of the cost savings = $142.41
NPV = $36.01
ROI = $36.01/$106.4 = 33.8%

The Savings to Investment Ratio (SIR), a popular ROI metric, represents the ratio of savings to investment. In terms of the basic NPV formula, “Savings” represents PV of the cost savings and “Investment” is PV of the investment costs.

SIR = PV cost savings/PV investment
SIR = $142.41/$106.40 = 1.34

Computing the amount of time it takes for a project to pay for itself (or return its initial investment) is another commonly used criterion for selecting among alternative courses of action. Typically, the relevant time period is expressed in terms of the number of years it takes before an investment breaks even. Assuming that one is using discounted cash flows as the basis for the calculation of the payback period, the basic question to be answered is at what point in time does the PV (cost savings) equal the PV (initial investment)? In the simplest of cases, the benefits (or returns) begin predictably at the completion of the investment phase and occur in an equal amount each time period. However, in the analyses we typically do, especially for large projects that take years to complete, benefits may begin accruing prior to completion of the investment phase and do not occur in equal annual amounts. In both simple and complex situations, the payback period in years, x, can be found with the formula below.

This formula may require solution by iteration and is likely to result in an answer that represents a fraction of a year and is found by interpolation. The mathematically correct answer to this equation can also be portrayed graphically in a form that generates a more approximate answer. An example of such a graph is shown in Figure N-16. Note that the breakeven point occurs early in 2010.

$$\sum_{t=1}^{t=x} \text{PV(Cost Savings)} = \text{PV(Initial Investment)}$$

(where *t* = time periods in years)

Figure N-16. Discounted Payback Period

Equivalent Uniform Annual Worth (EUAW). We should also take into account the fact that alternatives may have different economic lives. When this is true, EUAW is a common economic measure-of-merit used to evaluate each alternative.

The NPV is reduced to an "average cost per benefit year" annual payment (or receipt) that can be compared with that of a competing project. This method is particularly applicable for comparison of alternatives, such as plant equipment, with unequal lives of capital investments.

All receipts and expenditures are transformed into an equivalent annual worth over the life of the project or investment. The alternative with the highest (i.e., most positive) EUAW is the most economical choice. As with NPV, the choice of the most economical alternative (based upon having the highest EUAW) assumes that all alternatives have equal nonmonetary benefits.

In addition, use of the EUAW method (rather than NPV) is required when project lifetime is either infinite or indefinite. With an infinite or indefinite life, one must still assume a specific economic life. It is not unusual for a service to be required for a period longer than the physical life of the investment. In these cases, the EUAW method assumes the automatic equal replacement of the investment and the repeating of cash flows, which results in a repetitive cycle of expenditures.

Computation of EUAW is performed in three steps:

Step 1: Compute the NPV of an alternative using PV techniques (for more on PV and NPV, refer to pages N-13 through N-15 and N-27 through N-29). Typically, this is calculated by estimating the sum of the project's discounted investments, discounted Operations and Maintenance (O&M) costs, and discounted salvage value.

Step 2: Compute the Capital Recovery Factor (CRF) using the formula provided in Equation N-7:

$$CRF = \left[\frac{i(1+i)^n}{(1+i)^n - 1}\right] \qquad \text{(Equation N-7)}$$

where *i* is the discount rate and *n* is the number of years (i.e., Period of Analysis).

Note that the CRF formula changes slightly for cash flows that are MOY:

$$CRF = \left[\frac{i(1+i)^{n-0.5}}{(1+i)^n - 1}\right] \qquad \text{(Equation N-8)}$$

Step 3: Multiply the NPV (calculated in step 1) by the CRF (calculated in step 2):

$$EUAW = NPV \ast CRF \qquad \text{(Equation N-9)}$$

EUAW Example. Going back to the "Lease versus Buy" building example on page N-21, the project already completed step 1 of the EUAW method by calculating NPVs for each alternative. The project assumed a real discount factor of 2.7 percent (*i = 0.027*).

Table N-8. Cash Flows and NPVs of Alternatives A and B (Example)

Alternative A - Lease Building				
Project Year	**Total Cost** Constant FY$15	**Discount Factor** Type	Value	**Present Value** Constant FY$15
1	-$50,000	MOY	0.9868	-$49,338
2	-$50,000	MOY	0.9608	-$48,041
3	-$50,000	MOY	0.9356	-$46,778
4	-$50,000	MOY	0.9110	-$45,548
5	-$50,000	MOY	0.8870	-$44,351
6	-$50,000	MOY	0.8637	-$43,185
Total	**-$300,000**		**NPV =**	**-$277,242**

Alternative B - Buy Temporary Buildings				
Project Year	**Total Cost** Constant FY$15	**Discount Factor** Type	Value	**Present Value** Constant FY$15
0	-$200,000	EOY	1.0000	-$200,000
1	-$30,000	MOY	0.9868	-$29,603
2	-$30,000	MOY	0.9608	-$28,825
3	-$30,000	MOY	0.9356	-$28,067
4	-$30,000	MOY	0.9110	-$27,329
5	-$30,000	MOY	0.8870	-$26,611
6	-$30,000	MOY	0.8637	-$25,911
7	-$30,000	MOY	0.8410	-$25,230
8	-$30,000	MOY	0.8189	-$24,566
Sub-Total	**-$440,000**			**-$416,142**
8	$50,000	EOY	0.8080	$40,402
Total	**-$390,000**		**NPV =**	**-$375,739**

In Table N-8, it appears that Alternative A would be the preferred option due to it having a higher NPV (i.e., its NPV of –$277,242 is “more positive” than Alternative B’s NPV of –$375,739). However, the economic lives of the two alternatives are different (Alternative A = 6 years; Alternative B = 8 years), so the NPVs cannot be fairly compared for the cash flows in their present form. Calculation of EUAW for each alternative enables an “apples-to-apples” comparison. Continuing to steps 2 and 3 of the EUAW method, a CRF can be calculated for each alternative:

Alternative A only has MOY cash flows in each of 6 years (n = 6). Therefore:

$$CRF_A = \left[\frac{i(1+i)^{n-0.5}}{(1+i)^n - 1}\right] = \left[\frac{0.027(1+0.027)^{6-0.5}}{(1+0.027)^6 - 1}\right] = \left[\frac{0.03126}{0.17334}\right] = 0.18035$$

$$EUAW_A = NPV * CRF = -\$277{,}242 * 0.18035 = -\$50{,}000$$

Similar to Alternative A, Alternative B has MOY cash flows in year 1 through year 8:

$$CRF_{B1} = \left[\frac{i(1+i)^{n-0.5}}{(1+i)^n - 1}\right] = \left[\frac{0.027(1+0.027)^{8-0.5}}{(1+0.027)^8 - 1}\right] = \left[\frac{0.03297}{0.23755}\right] = 0.13880$$

The NPV of Alternative B's MOY cash flows equal –$246,142 (refer to Alternative B of Table N-8). Having this NPV and CRF for Alternative B's MOY cash flows yields the first part of Alternative B's EUAW:

$$EUAW_{B1} = NPV \ * CRF = -\$216{,}142 * 0.13880 \quad = -\$30{,}000$$

Unlike Alternative A, Alternative B also has two EOY cash flows in year 0 and year 8. Therefore:

$$CRF_{B2} = \left[\frac{i(1+i)^{n}}{(1+i)^n - 1}\right] = \left[\frac{0.027(1+0.027)^{8}}{(1+0.027)^8 - 1}\right] = \left[\frac{0.03341}{0.23755}\right] = 0.14066$$

The NPV of Alternative B's EOY cash flows equal –$200,000 + $40,402 = –$159,598 (refer to Table N-9). Having this NPV and CRF for Alternative B's EOY cash flows yields the second part of Alternative B's EUAW:

$$EUAW_{B2} = NPV \ * CRF = -\$159{,}598 * 0.14066 \quad = -\$22{,}449$$

Summing up the EUAW for Alternative B, we get:

$$EUAW_B = EUAW_{B1} + EUAW_{B2} = -\$30{,}000 + -\$22{,}449 = -\$52{,}449$$

In this example, leasing office space produces a slightly higher EUAW than buying temporary buildings. In other words, the average discounted annual cost to lease office space ($50,000) is less than that to buy temporary buildings ($52,152).

N.5.3.6. Perform Sensitivity and Risk Analysis (Step 6)

Uncertainty is always present in economic decision making because we make assumptions in conducting the analysis and use estimates of benefits and costs. When anyone tries to estimate costs or predict future occurrences over a long time, variations are bound to occur between the estimated and the actual occurrences. It is important to analyze whether changes in assumptions, quantitative values, or priorities will affect the recommendation. Sensitivity and risk analyses can provide ranges of expected benefits and costs that may provide the decision maker better information than a single financial measure. How these variations affect the results of an EA is the heart of the sensitivity analysis.

Sensitivity analysis. The EA sensitivity analysis (a "what-if" exercise) tests whether the conclusion of an EA will change if a benefit, cost, or other assumed variable changes. An EA sensitivity analysis should be performed when:

- The results of the EA do not clearly favor any one alternative, or
- There is uncertainty about an assumption that can impact the estimate of costs and benefits in the EA.

During an EA, the discount rate used may play a key role in the acceptance or rejection of an alternative. Occasionally, an alternative may be economically feasible when evaluated using one discount rate but not another. An evaluation of the alternatives to indicate their relative values at varying discount rates is another useful type of sensitivity analysis. Other examples of variables or assumptions used for an EA sensitivity analysis include:

- costs or reimbursements
- performance output or benefits
- system lives or economic life
- estimation of operation-support-maintenance factors
- schedules
- other risk or unknown aspects

Once you are aware that an assumption or variable has a strong impact upon the recommendation, an in-depth evaluation should be performed. It is imperative that as high a degree of confidence as possible be established and that this degree of confidence be made clear to the analysis reviewer/approver.

Going back to our example of leasing office space versus buying a temporary building (i.e., Alternative A versus Alternative B in Table N-9), we learn that experts believe that the salvage value for Alternative B could easily increase by 50 percent or more depending on market conditions around 2020. In other words, the buildings salvage value could increase from $50,000 to $75,000. Incorporating this possible change into the calculations for life-cycle cost and NPV, we get:

Table N-9. Modified Cash Flow and NPV of Alternative B (Example)

Alternative B - Buy Temporary Buildings				
Project Year	**Total Cost** Constant FY$15	**Discount Factor** Type	Value	**Present Value** Constant FY$15
0	-$200,000	EOY	1.0000	-$200,000
1	-$30,000	MOY	0.9868	-$29,603
2	-$30,000	MOY	0.9608	-$28,825
3	-$30,000	MOY	0.9356	-$28,067
4	-$30,000	MOY	0.9110	-$27,329
5	-$30,000	MOY	0.8870	-$26,611
6	-$30,000	MOY	0.8637	-$25,911
7	-$30,000	MOY	0.8410	-$25,230
8	-$30,000	MOY	0.8189	-$24,566
Sub-Total	**-$440,000**			**-$416,142**
8	$75,000	EOY	0.8080	$60,604
Total	**-$365,000**		**NPV =**	**-$355,538**

With a life-cycle cost of $365,000, Alternative B still, of course, has a lower life-cycle cost than Alternative A ($400,000). However, recall that economic measures (like NPV and EUAW), not life-cycle cost, must be used to determine the preferred alternative. Because this specific example has two unequal economic lives, NPVs for each alternative cannot be directly compared. To get a fair comparison of alternatives, we recalculate Alternative B's EUAW, now accounting for a 50 percent increase in salvage value.

The revised NPV of Alternative B's EOY cash flows equal –$200,000 + $60,604 = –$139,396 (refer to Table N-9). Having this NPV and CRF (calculated on page N-34) for Alternative B's EOY cash flows yields a revised second part of Alternative B's EUAW:

$$EUAW_{B2} = NPV * CRF = -\$139{,}396 * 0.14066 = -\$19{,}607$$

Summing up the revised EUAW for Alternative B, we get:

$$EUAW_{B} = EUAW_{B1} + EUAW_{B2} = -\$30{,}000 + -\$19{,}607 = -\$49{,}607$$

In this sensitivity part of the example, buying temporary buildings produces a slightly higher EUAW than leasing office space. In other words, the average discounted annual cost to buy temporary buildings ($49,607) is less than that to lease office space ($50,000). Therefore, the sensitivity analysis causes our preferred alternative to switch from Alternative A to Alternative B.

Risk analysis. In some cases, a risk analysis for an EA may be warranted. Risk analysis deals with the likelihood and expectation of possible outcomes using probability concepts. Examples of tools that can be used to perform risk analysis include expected value, probability theory, simulation techniques, and decision analysis.

N.5.3.7. Prepare Results and Recommendations (Step 7)

The current environment is a world of congressional oversight and accounting for every dollar. In that environment, it becomes extremely important to make certain all the hard work expended to prepare an EA is properly organized and contains every element the decision maker wants to see.

The EA report should begin with an executive summary of the analysis based on the benefits and costs of the alternatives and an interpretation of the results to include a recommendation of the preferred alternative. The body of the report must include all sources of data and calculations in order to provide an auditable stand-alone document. The actual decision will be based on quantitative factors, as well as qualitative factors, such as the judgment and experience of the decision maker.

The complete analysis should now be structured to facilitate understanding on the part of the decision maker. The analyst has two courses of action:

1) Present alternatives in a ranking from which the ultimate course of action can be selected, or

2) Make a firm recommendation for the manager's consideration.

The latter is not only preferred by most decision makers, but also insures that analysis has been performed, not just data collection.

There are no strict rules governing the amount of documentation needed or what the documentation should exactly look like. Nevertheless, it is useful to see how Federal and non-Federal organizations organize and document EAs. For example, Department of Defense Instruction (DODI) Number 7041.3 (Economic Analysis for Decisionmaking) can serve as a framework to create a template for documenting an EA.[4]

[4] Department of Defense Instruction (DODI), Number 7041.3 (November 7, 1995): Economic Analysis for Decisionmaking. http://www.dtic.mil/whs/directives/corres/pdf/704103p.pdf

Always remember, the analyst is the honest broker and is only providing tools to support the decision maker. Decision makers are not bound by the study and its recommendations. Nevertheless, a well-executed EA with good documentation tends to steer decision makers in a better direction. Furthermore, a well-documented EA can also be invaluable for future program evaluation or for analysis of related programs.

N.6. Additional Resources

- NPR 7120.5E NASA Program and Project Management Processes and Requirements. *http://nodis3.gsfc.nasa.gov/displayDir.cfm?t=NPR&c=7120&s=5E*
- NASA Systems Engineering Processes and Requirements NPR 7123.1. *http://nodis3.gsfc.nasa.gov/displayDir.cfm?t=NPR&c=7123&s=1A*
- Burt, David N., Donald W. Dobler, and S. L. Starling, *World Class Supply Management: The Key to Supply Chain Management*, 7th ed. Boston: McGraw-Hill, 2003.
- R. Gregory Michel, "Make or Buy? Using Cost Analysis To Decide Whether To Outsource Public Services," August 2004, Government Finance Review. *http://www.gfoa.org/downloads/GFRAug04.pdf*
- "Build Versus Buy: Understanding the Total Cost of Embedded Design," National Instruments. *http://zone.ni.com/devzone/cda/tut/p/id/6083*
- Charles Dominick, C.P.M., SPSM, "The Make or Buy Procurement Decision," Next Level Purchasing, 2005. *http://www.nextlevelpurchasing.com/articles/make-buy-procurement-decision.html*
- "Make-or-Buy Decision," Answers.com. *http://www.answers.com/topic/make-or-buy-outsource-decision*
- "Make v. Buy: Considerations When Outsourcing To Reduce Cost," EMS Consulting Group, 2005. *http://www.emsstrategies.com/makevbuyarticle.html*
- NASA Federal Acquisition Regulation (FAR) Supplement, version 4.0, November 2004. Visit *http://www.hq.nasa.gov/office/procurement/regs/nfstoc.htm*, then go to sections 1815.407-2, Make-or-Buy Programs, and 1815.408-70, NASA Solicitation Provisions and Contract Clauses.
- NASA New Start Inflation Index (Updates on the NASA CAD Web site): *http://www.nasa.gov/offices/ooe/CAD/Publications.html#.VO56ojo1-gQ*
- The Standard for Models and Simulations (NASA-STD-(I)-7009). *https://standards.nasa.gov/documents/detail/3315599*
- Cost As an Independent Variable: Principles and Implementation. *http://www.dau.mil/pubscats/PubsCats/AR%20Journal/arq2000/kaye.pdf*
- Controlling Costs—A Historical Perspective. *http://www.dau.mil/pubscats/PubsCats/PM/articles96/kausal2.pdf*
- OMB Circular A-94. *http://www.whitehouse.gov/omb/circulars/a094/a094.html*
- GAO Cost Assessment Guide. *http://www.gao.gov/new.items/d071134sp.pdf*
- An Analytical Hierarchy Process Approach to the Analysis of Quality in Telecommunications Systems. *http://ieeexplore.ieee.org/iel2/645/6841/00276672.pdf?arnumber=276672*

- NASA NPR 2830.1 NASA Enterprise Architecture Procedures—Appendix E: Approaches for Conducting Alternatives Analysis. *http://nodis3.gsfc.nasa.gov/displayDir.cfm?Internal_ID=N_PR_2830_0001_&page_name=AppendixE*
- Circular No. A-11, Preparation, Submission, and Execution of the Budget, OMB, August 2011. *http://www.whitehouse.gov/sites/default/files/omb/assets/a11_current_year/a_11_2011.pdf*
- NASA Business Case Guide for Real Property and Facilities Projects Investments, November 2010, click on Business Case Guide link at *http://www.hq.nasa.gov/office/codej/codejx/*.
- Capability Development Return on Investment for the NASA Aeronautics Program. *http://ieeexplore.ieee.org/iel5/10446/33170/01562857.pdf?isnumber=&arnumber=1562857*
- Chapter 12 (Economic Analysis), taken from BCF106: Fundamentals of Cost Analysis class, Defense Acquisition University (June 2009). *https://myclass.dau.mil/bbcswebdav/institution/Courses/Deployed/BCF/BCF106/Student_Materials/12%20Economic%20Analysis/Economic%20Analysis_Jun%2009.pdf*
- Economic Analysis Handbook, 2nd Edition, as published by the Defense Economic Analysis Council and the Defense Resources Management Institute. *https://acc.dau.mil/CommunityBrowser.aspx?id=54803*