

## APPENDIX E—COST-BENEFIT ANALYSIS

### PURPOSE

Current laws and regulations require agencies to conduct a cost/benefit analysis (CBA) prior to deciding whether to initiate, continue, or implement an IT investment. The level of detail required varies and should be commensurate with the size, complexity, and cost of the proposed investment. This appendix provides a layout of a CBA for a very large, complex, and costly IT investment. A scaled down version is appropriate for a smaller, less costly investment.

The CBA supports decision-making and helps ensure resources are effectively allocated to support mission requirements. The CBA should demonstrate that at least three alternatives (excluding the option of continuing current operations) were considered and the chosen alternative is the most cost-effective, within the context of budgetary and political considerations. Possible alternatives include:

- In-house development versus contractor development,
- In-house operation versus contractor operation,
- Current operational procedures versus new operational procedures, or
- One technical approach versus another technical approach.

The CBA should include comprehensive estimates of the projected benefits and costs for each alternative. Costs, tangible benefits, and intangible benefits (benefits which cannot be valued in dollars) should be included. Intangible benefits should be evaluated and assigned relative numeric values for comparison purposes. Sunk costs (costs incurred in the past) and realized benefits (savings or efficiencies already achieved) should not be considered since past experience is relevant only in helping estimate future benefits and costs. Investments should be initiated or continued only if the projected benefits exceed the projected costs.

A CBA should be performed for each investment alternative to enable the evaluation and comparison of alternatives. However, some mandatory systems will not provide net benefits to the government. In such cases, the lowest cost alternative should be selected. If functions are to be added to a mandatory system, though, the additional functions should provide benefits to the government.

### PROCESS

A CBA should be completed or updated at the following lifecycle milestones:

- Proposal initiation (Pre-Select Phase)
- E-Board proposal consideration (Select Phase)
- E-Board initiative review (annually during the Control Phase)
- Initial fielding (Evaluation Phase)
- Post-Implementation Review (Evaluation Phase)
- Operations and Maintenance review (Steady-State Phase)
- Annually for “major system” CPIC review.

The Project Sponsor ensures the CBA is done. The Project Sponsor can obtain expertise from the IPT in systems development and operation, budget, finance, statistics, procurement, architecture, and work processes, as needed.

The CBA process can be broken down into the following steps:

1. Determine/define objectives
2. Document current process
3. Estimate future requirements
4. Collect cost data for alternatives
5. Choose at least three alternatives
6. Document CBA assumptions
7. Estimate costs
8. Estimate benefits
9. Discount costs and benefits
10. Evaluate alternatives
11. Perform sensitivity analysis
12. Compare investments.

Each of these steps is detailed in the following sections. The numerical examples provided are from a variety of sources and do not relate to one specific investment.

### *1. Determine/Define Objectives*

The CBA should include a problem definition; pertinent background information such as staffing, system history, and customer satisfaction data; and a list of investment objectives that identify how the system will improve the work process and support the mission.

### *2. Document Current Process*

The current process should be thoroughly documented and address these areas:

- **Customer Service**—Each customer's role and services required should be clearly documented and quantified, if possible (e.g., in an average month, a customer inputs two megabytes (MB) of data and spends 10 hours on database maintenance).
- **System Capabilities**—Resources required for peak demand should be listed. For example, 100 MBs of disk storage space and Help Desk personnel to support 50 users.
- **System Architecture**—The hardware, software, and physical facilities required should be documented, including information necessary for determining system costs, expected future utility of items, and the item owner/leaser (i.e., government or contractor). Table E-1—displays the information desired.
- **System Costs**—Current costs provide the CBA baseline. Figure E-2—Cost Elements for Systems addresses the cost elements for most systems. However, a particular system may not include all elements identified within a category and may include some activities not shown.

**Table E-1. System Architecture Information Requirements**

Hardware	Software	Physical Facilities
<u>Manufacturer</u> <u>Make/Model/Year</u> <u>Cost</u> <u>Power requirements</u> <u>Expected life</u> <u>Maintenance requirements</u> <u>Operating characteristics (e.g., size, speed, capacity, etc.)</u> <u>Operating systems supported</u>	<u>Manufacturer Name</u> <u>Version number</u> <u>Year acquired</u> <u>License term</u> <u>Hardware requirements</u> <u>Cost (annual or purchase)</u>	<u>Location</u> <u>Size</u> <u>Capacity</u> <u>Structure type</u> <u>Availability</u> <u>Annual cost</u>

**Table E-2. Cost Elements for Systems**

Cost Category	Cost Elements
Equipment, Leased or Purchased	Supercomputers, mainframes, minicomputers, microcomputers, disk drives, tape drives, printers, telecommunications, voice and data networks, terminals, modems, data encryption devices, and facsimile equipment.
Software, Leased or Purchased	Operating systems, utility programs, diagnostic programs, application programs, and commercial-off-the-shelf (COTS) software.
Commercial Services	Commercially-provided services, such as teleprocessing, local batch processing, on-line processing, Internet access, electronic mail, voice mail, cellular telephone, facsimile, and packet switching.
Support services (Contractor Personnel)	Commercially-provided services to support equipment, software, or services, such as maintenance, source data entry, training, planning, studies, facilities management, software development, system analysis and design, computer performance evaluation, and capacity management.
Supplies	Any consumable item designed specifically for use with equipment, software, services, or support services identified above.
Personnel (compensation and benefits)	Includes the salary (compensation) and benefits for government personnel who perform IT functions 51 percent or more of their time. Functions include but are not limited to program management, policy, IT management, systems development, operations, telecommunications, computer security, contracting, and secretarial support. Personnel who simply use IT assets incidental to the performance of their primary functions are not included.
Intra-governmental services	All IT services within agencies, and between executive branch agencies, judicial and legislative branches, and State and local governments.

### 3. Estimate Future Requirements

Future customer requirements determine the system capabilities and architecture, and ultimately affect system costs and benefits. Two items to consider are:

- **Lifecycle Time**—Determine the system lifecycle, or when the system is terminated and replaced by a system with significant changes in processing, operational capabilities, resource requirements, or system outputs. Large, complex systems should have a lifecycle of at least five years, and no more than ten to 12 years.
- **Lifecycle Demands**—Identify the most appropriate demand measures and use the measures to determine previous year's demands, calculate the change in demand from year to year, average the demand change, and use the average to make predictions. In a complex situation, more sophisticated tools, such as time-series and regression analysis, may be needed to forecast the future.

#### *4. Collect Cost Data*

Data can be collected, from the following sources, to estimate the costs of each investment alternative:

- **Historical Organization Data**—If contracts were used to provide system support in the past, they can provide the estimated future cost of leasing and purchasing hardware and hourly rates for contractor personnel. Contracts for other system support services can provide comparable cost data for the development and operation of a new system.
- **Current System Costs**—Current system costs can be used to price similar alternatives.
- **Market Research**—Quotes from multiple sources, such as vendors, Gartner Group, IDC Government, and government-wide agency contracts (GWACS), can provide an average, realistic price.
- **Publications**—Trade journals usually conduct annual surveys that provide general cost data for IT personnel. Government cost sources include the General Services Administration (GSA) pricing schedule and the OMB Circular A-76, "Performance of Commercial Activities" supplemental listing of inflation and tax rates.
- **Analyst Judgment**—If data is not available to provide an adequate cost estimate, the CBA team members can use judgment and experience to estimate costs. To provide a check against the estimates, discuss estimated costs with other IT professionals.
- **Special Studies**—Special studies can be conducted to collect cost data for large IT investments. For example, the Federal Aviation Administration (FAA) used three different in-house studies to provide costs for software conversion, internal operations, and potential benefits. These data sources became the foundation for a CBA.

#### *5. Choose at Least Three Alternatives*

A CBA should present at least three viable alternatives. "Do nothing" or "Continue current operations" should not be considered as an alternative. Each viable technical approach should be included as an alternative. However, the number of technical approaches may be limited if only one or two are compatible with the architecture or if some approaches are not feasible for reasons other than costs and benefits.

#### *6. Document CBA Assumptions*

It is important to document all assumptions and, if possible, justify them on the basis of prior experiences or actual data. This can be an opportunity to explain why some alternatives are not included. If an alternative is eliminated because it is not feasible, the assumption should be clearly explained and justified.

#### *7. Estimate Costs*

Many factors should be considered during the process of estimating costs for alternatives. Full lifecycle costs for each competing alternative should be included, and the following factors should be addressed:

- **Activities and Resources**—Identify and estimate the costs associated with the initiation, design, development, operation, and maintenance of the IT system.
- **Cost Categories**—Identify costs in a way that relates to the budget and accounting processes. The cost categories should follow current USDA object class codes.
- **Personnel Costs**—Personnel costs are based on the guidance in OMB Circular A-76, “Supplemental Handbook, PART II—Preparing the Cost Comparison Estimates.” Government personnel costs include current salary by location and grade, fringe benefit factors, indirect or overhead costs, and General and Administrative costs.
- **Depreciation**—The cost of each tangible capital asset should be spread over the asset’s useful life (i.e., the number of years it will function as designed). OMB prefers that straight-line depreciation be used for capital assets.
- **Annual Costs**—All cost elements should be identified and estimated for each year of the system lifecycle. This is necessary for planning and budget considerations Table E-3—illustrates the cost estimates for an investment initiation activity.

**Table E-3. Sample Cost Estimates for an Investment Initiation Activity**

Activities/Cost Categories	Problem Definition	Work Process Evaluation	Requirements Definition	Security Plan	Performance Measures	Cost-Benefit Analysis	Total
Hardware							
Software							
Services							
Support Services		10,000	4,000	1,000	6,000	3,000	24,000
Supplies		100	100	0	100	100	400
Personnel	5,000	10,000	6,000	500	5,000	8,000	34,500
Inter-Agency Services							
<b>Total</b>	<b>5,000</b>	<b>20,100</b>	<b>10,100</b>	<b>1,500</b>	<b>11,100</b>	<b>11,100</b>	<b>58,900</b>

The costs for each year can be added to provide the estimated annual costs over the investment’s life. For example, Table E-4—Sample System Lifecycle Cost Estimates provides the total estimated costs for a 10-year investment. In the first year, in-house staff and contractors define the problem, evaluate the work process, define processing requirements, prepare the CBA, develop a request for proposals (RFP), and issue a contract for the system development. In the second year, a contractor designs and implements the system. The next eight years reflect operational and maintenance costs for equipment, software, in-house personnel, and contractor personnel. Years five and six also reflect in-house acquisition costs for establishing a new five-year contract for system maintenance and help desk support.

**Table E-4. Sample System Lifecycle Cost Estimates**

Year	Startup	Acquisition	Development	Operation	Maintenance	Total
1	100,000	100,000				200,000
2			800,000			800,000
3				200,000	80,000	280,000
4				200,000	60,000	260,000
5		50,000		200,000	50,000	300,000
6		50,000		200,000	50,000	300,000
7				200,000	40,000	240,000
8				200,000	30,000	230,000
9				200,000	30,000	230,000
10				200,000	30,000	230,000
<b>Total</b>	100,000	200,000	800,000	1,600,000	370,000	3,070,000

### 8. Estimate Benefits

The following six activities are completed to identify and estimate the value of benefits:

**Define Benefits**—Benefits are the services, capabilities, and qualities of each alternative, and can be viewed as the return from an investment. The following questions will help define benefits for IT systems and enable alternative comparisons:

- *Accuracy*—Will the system improve accuracy by reducing data entry errors?
- *Availability*—How long will it take to develop and implement the system?
- *Compatibility*—How compatible is the proposed alternative with existing procedures?
- *Efficiency*—Will one alternative provide faster or more accurate processing?
- *Maintainability*—Will one alternative have lower maintenance costs?
- *Modularity*—Will one alternative have more modular software components?
- *Reliability*—Does one alternative provide greater hardware or software reliability?
- *Security*—Does one alternative provide better security to prevent fraud, waste, or abuse?

**Identify Benefits**—Every proposed IT system should have identifiable benefits for both the organization and its customers. Organizational benefits could include flexibility, organizational strategy, risk management and control, organizational changes, and staffing impacts. Customer benefits could include improvements to the current IT services and the addition of new services. Customers should help identify and determine how to measure and evaluate the benefits.

**Establish Measurement Criteria**—Establishing measurement criteria for benefits is crucial because the Government Performance and Results Act (GPRA) and the Clinger-Cohen Act (CCA) emphasize tangible measures of success (benefits) related to the organization’s overall mission and goals. See Appendix G—Performance Measurement for guidance on how to develop performance measures.

**Classify Benefits**—Benefits that are “capable of being appraised at an actual or approximate value” are called tangible benefits. Benefits that cannot be assigned a dollar value are called intangible benefits.

**Estimate Tangible Benefits**—The dollar value of benefits can be estimated by determining the fair market value of the benefits. An important economic principle used in estimating public benefits is the market value concept. Market value is the price that a private sector organization would pay to purchase a product or service

**Quantify Intangible Benefits**—Intangible benefits can be quantified using a subjective, qualitative rating system. A qualitative rating system might evaluate potential benefits against the following:

- Provides Maximum Benefits (2 points)
- Provides Some Benefits (1 point)
- Provides No Benefits (0 points)
- Provides Some Negative Benefits (-1 point)
- Provides Maximum Negative Benefits (-2 points).

Once the rating system is selected, each benefit is evaluated for each alternative. This should be done by a group of three to five individuals familiar with the current IT system and the alternatives being evaluated. The numerical values assigned to the ratings then can be summed and averaged to obtain a score for each benefit. Table E-5—shows the scores for benefits A to D from four reviewers using a scale of 1 to 5.

**Table E-5. Sample Reviewer Scores for Intangible Benefits**

Benefit	Reviewer 1 Score	Reviewer 2 Score	Reviewer 3 Score	Reviewer 4 Score	Reviewer Average Score
A	5	4	3	5	4.25
B	4	2	3	4	3.25
C	3	2	5	4	3.50
D	4	3	2	2	2.75

An option that can be used in a qualitative assessment is to “weight” each benefit criteria with regard to importance. The more important the benefit, the higher the weight. The advantage of weighting is the more important benefits have a greater influence on the benefit analysis outcome. The weighting scale can vary between any two predetermined high and low weights. An example of calculating a weighted score is provided in Table E-6—and demonstrates using weighting factors makes Alternative 1 the clear winner.

**9. Discount Costs and Benefits**

After costs and benefits for each system lifecycle year have been identified, convert them to a common measurement unit by discounting future dollar values and transforming future benefits and costs to their “present value.” Present values are calculated by multiplying the future value times the discount factors published in the OMB Circular A-94.

**Table E-6. Sample Weighted Benefits Score**

Benefit	Alternative 1 Raw Score	Alternative 2 Raw Score	Weighting Factor	Alternative 1 Weighted Score	Alternative 2 Weighted Score
A	4	2	10	40	20
B	3	2	9	27	18
C	4	3	8	32	24
D	2	3	6	12	18
E	3	4	5	15	20
<b>Total</b>	16	14		126	100

Table E-7—shows annual costs and benefits for a system lifecycle, along with the discount factor, the discounted costs and benefits (present values), and the discounted net present value [NPV]. The discounted costs and benefits are computed by multiplying costs and benefits by the discount factor. The net benefit without discounting is \$380,000 (\$3,200,000 minus \$2,820,000) while the discounted NPV is less than \$60,000 because the biggest costs are incurred in the first two years, while the benefits are not accrued until the third year. When evaluating costs and benefits, be cautious of returns that accrue late in the investment's lifecycle. Due to discounting, benefits that accrue in later years do not offset costs as much as earlier-year benefits. Also, these later-year benefits are less certain. Both the business and IT environments may experience significant changes before these later-year benefits are realized.

**Table E-7. Sample Discounted Lifecycle Costs and Benefits**

Year	Annual Cost (AC)	Annual Benefit (AB)	Discount Factor (DF)	Discounted Cost (DC) ACxDF	Discounted Benefit (DB) ABxDF	Discounted Net DB - DC
1	150,000		0.9667	145,005		(145,005)
2	600,000		0.9035	542,100		(542,100)
3	280,000	400,000	0.8444	236,432	337,760	101,328
4	260,000	400,000	0.7891	205,166	315,640	110,474
5	300,000	400,000	0.7375	221,250	295,000	73,750
6	300,000	400,000	0.6893	206,790	275,720	68,930
7	240,000	400,000	0.6442	154,608	257,680	103,072
8	230,000	400,000	0.6020	138,460	240,800	102,340
9	230,000	400,000	0.5626	129,398	225,040	95,642
10	230,000	400,000	0.5258	120,934	210,320	89,386
<b>Total</b>	2,820,000	3,200,000		2,100,143	2,157,960	57,817

### 10. Evaluate Alternatives

Many benefits cannot be quantified in dollar terms. As a result, evaluating alternatives cannot always be done using present values, but valid evaluations can be made using a combination of dollar values and quantified relative values (values that are numeric, but do not represent dollar values).

**Evaluate All Dollar Values**—Once all the costs and benefits for each competing alternative have been assigned dollar values and discounted, the NPV of the alternatives should be compared and ranked. When the alternative with the lowest discounted cost provides the highest discounted benefit, it is the clear winner, as shown in Table E-8.

**Table E-8. Sample Investment Comparison**  
(Lowest Cost System Provides Highest Benefit)

Alternative	Discounted Cost (DC)	Discounted Benefit (DB)	Discounted Net (DB - DC)	Benefit-Cost Ratio (DB/DC)
1	1,800,000	2,200,000	400,000	1.22
2	1,850,000	1,750,000	(-100,000)	0.95
3	2,000,000	2,000,000	0	1.00
4	2,200,000	2,100,000	(-100,000)	0.95

**Discounted Net**—There will probably be very few cases where the alternative with the lowest discounted cost provides the highest discounted benefit. The next number to consider is the Discounted Net (Discounted Benefit minus Discounted Cost). If one alternative clearly has the highest Discounted Net, it is considered the best alternative; however, it is usually advisable to look at other factors.

**Benefit-Cost Ratio**—When the alternative with the highest discounted net is not a clear winner, the benefit-cost ratio or BCR (discounted benefit divided by discounted cost) may be used to differentiate between alternatives with very similar or equal Discounted Nets. In Table E-9— Alternative 4 would be the winner because it has a higher BCR than Alternative 5. Alternatives 4 and 5 are clearly superior to other alternatives because they have the highest discounted net.

**Evaluate With Intangible Benefits**—When all the benefits are intangible, evaluation will be based on quantifying relative benefits.

**Table E-9. Sample Investment Comparison**  
(Other Than Lowest Cost System Provides Highest Benefit)

Alternative	Discounted Cost (DC)	Discounted Benefit (DB)	Discounted Net (DB-DC)	Benefit-Cost Ratio (DB/DC)
1	1,500,000	1,600,000	100,000	1.07
2	1,600,000	1,750,000	150,000	1.09
3	1,900,000	2,000,000	100,000	1.05
4	2,000,000	2,450,000	450,000	1.23
5	3,000,000	3,450,000	450,000	1.15

### 11. Perform Sensitivity Analysis

Sensitivity analysis tests the sensitivity of input parameters and the reliability of the CBA result. Sensitivity analysis should assure reviewers the CBA provides a sound basis for decisions. The sensitivity analysis process requires the following:

**Identify Input Parameters**—The assumptions documented earlier in the CBA are used to identify the model inputs to test for sensitivity. Good inputs to test are those that have significant (large) cost factors and a wide range of maximum and minimum estimated values. Some common parameters include:

- System requirement definition costs
- System development costs
- System operation costs
- Transition costs, especially software conversion
- System lifecycle
- Peak system demands.

**Repeat the Cost Analysis**—For each parameter identified, determine the minimum and maximum values. Then, choose either the minimum or maximum value as the new parameter value (the number selected should be the one that most differs from the value used in the original analysis). Repeat the CBA with the new parameter value and document the results. Prepare a table like Table E-10—to summarize the different outcomes and enable the results to be quickly evaluated.

**TableE-10. Sample Sensitivity Analysis**

Parameter	Parameter Value	Best Alternative
<b>Development Cost (\$)</b>	1,500,000	A
	2,000,000	A
	2,500,000	B
<b>Transition Costs (\$)</b>	100,000	A
	200,000	A
<b>System Lifecycle (Years)</b>	5	A
	10	B
	15	C
<b>Benefits (\$)</b>	1,500,000	A
	2,250,000	A
	3,000,000	B

**Evaluate Results**—Compare the original set of inputs and the resulting outcomes to the outcomes obtained by varying the input parameters. In the previous table, the original values are the first value listed for each parameter. Sensitivity is measured by how much change in a parameter is required to change the alternative selected in the original analysis. The sensitivity guidelines include the following:

- A parameter is not considered sensitive if it requires a decrease of 50 percent or an increase of 100 percent to cause a change in the selected alternative.

- A parameter is considered sensitive if a change between 10 and 50 percent causes a change in the selected alternative.
- A parameter is considered very sensitive if a change of 10 percent or less causes a change in the selected alternative.

In the previous example, the analysis would appear to be somewhat sensitive to the development costs, but not sensitive to the transition costs and benefits.

### 12. Compare Investments

Even if the CBA shows that benefits will outweigh costs, using Payback Period and Return on Investment (ROI) analysis help demonstrate an investment is a better utilization of funds than other proposed investments.

Table E-11—illustrates that the money invested in the system’s development, installation, and operation is not offset by the benefits until the 10th year. In other words, the payback period for the system is 10 years, which is generally unacceptable, making it difficult for this investment to obtain funding.

**Table E-11. Sample Payback Period**

Year	Annual Cost (AC)	Annual Benefit (AB)	Discount Factor (DF)	Discounted Cost (DC) ACxDF	Discounted Benefit (DB) ABxDF	Discounted Net DB - DC	Cumulative Discounted Net
1	150,000		0.9667	145,010	0	(145,010)	(145,010)
2	600,000		0.9035	542,095	0	(542,095)	(687,106)
3	280,000	400,000	0.8444	236,428	337,754	101,326	(585,779)
4	260,000	400,000	0.7891	205,178	315,658	110,480	(475,299)
5	300,000	400,000	0.7375	221,256	295,007	73,751	(401,547)
6	300,000	400,000	0.6893	206,781	275,708	68,927	(332,620)
7	240,000	400,000	0.6442	154,603	257,671	103,068	(229,552)
8	230,000	400,000	0.6020	138,468	240,814	102,346	(127,206)
9	230,000	400,000	0.5626	129,409	225,060	95,651	(31,556)
10	230,000	400,000	0.5258	120,943	210,336	89,393	57,837
<b>Total</b>	<b>2,820,000</b>	<b>3,200,000</b>		<b>2,100,171</b>	<b>2,158,008</b>	<b>57,837</b>	

**Return on Investment**—ROI is often used when comparing proposed investments. Total Discounted Net (Total Discounted Benefits minus the Total Discounted Costs) is often referred to as the return or profit from an investment. ROI is calculated by dividing the Total Discounted Net by the Total Discounted Cost. In the figure above, ROI is the Total Discounted Net (\$57,837) divided by Total Discounted Costs (\$2,100,171) and equals 0.0275. Since ROI is often cited as a percentage, multiplying by 100 converts the decimal rate to 2.75.



The ROI is really just another way to express the BCR. In the example above, the BCR is the Total Discounted Benefit (\$2,158,008) divided by the Total Discounted Costs (\$2,100,171) and equals 1.0275. The 1.0275 can also be expressed as 102.75 percent. This means that the benefits are 2.75 percent greater than the costs. Compute the ROI by subtracting 1 from the BCR.

The ROI must also be adjusted for risk. To adjust ROI for risk, use the process described for calculating the risk factor described in Appendix F.2. The "risk factor" for all risks should be totaled and added to the investment cost. Adjusting the ROI for risk will aid in comparing alternatives with different potential risk levels and will help ensure that returns for investments with higher risk potential are fully understood. (See Appendix F, Risk Assessment, for a more detailed discussion on risk analysis.)