

Economic Analysis

*How to choose between
investment options*

Acknowledgments

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- Module 13 Economic Analysis
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 - Managing editor: Peter J. Braxton



Economic Analysis* Overview

• Key Ideas

- Competing investment alternatives
- Time value of money
- Commensurability of costs and benefits



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• Analytical Constructs

- Discount rates
 - Real and nominal
- Net present value (NPV)

$$PV = FV \cdot \left(\frac{1}{(1+i)^{(n-0.5)}} \right)$$

• Practical Applications

- Business Case Analysis
- Cost Benefit Analysis 
- Functional EA (FEA)
- Commercial Activities (A-76)
- Analysis of Alternatives (AoA)
- Clinger-Cohen compliance

• Related Topics

- Opportunity Cost 
- Benefits Estimating
- Inflation and Escalation 

* In this module, EA refers to a category of analysis.

Economic Analysis Outline

- Core Knowledge
 - Introduction to Economic Analysis (EA)
 - EA Process
 - Objective
 - Assumptions and Ground Rules
 - Alternatives
 - Cost and Benefits Estimates
 - Comparison Techniques
 - Sensitivity Analysis
 - Recommendation
- Summary
- Resources
- Related and Advanced Topics



EA Process Example

Introduction to Economic Analysis (EA)

- Definition
- Purpose
- Regulations
- Overview of EA Process

Economic Analysis - Definition

-  Economic Analysis (EA) is an objective method for making rational decisions among **discrete** alternatives
- Compares *time-phased, economically-adjusted* costs and benefits of solutions/alternatives for a defined problem/objective
 - Some guidance makes a distinction between what an EA entails vs. what a CBA entails
- A brief review of special cases of EAs is at the end of the module



AKA Cost Benefit Analysis (CBA)



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Economic Analysis - Purpose

- Facilitates the identification and examination of all possible solutions to a given problem
- Allows for “smart” allocation of scarce or competing resources
- Provides an objective, defensible justification for executing an alternative
 - Provides information useful for budget submission and justification
- Offers a basis against which program execution and success can be measured
- Often required as part of the DoD Milestone Decision process
- Other agencies require EA as part of their program analysis process

Economic Analysis Regulations

- [DoD Instruction 5000.02](#), “Operation of the Defense Acquisition System”
 - Analysis of Alternatives (AoA) required for milestone decisions for Major Defense Acquisition Programs (MDAPs)
- Clinger-Cohen Act [DAG] *Defense Acquisition Guidebook*, <https://akss.dau.mil/dag/>.
 - EA required for Major Automated Information Systems (MAISs) 
- [OMB Circular A-94](#), “Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs”
 - Contains discount rates for use in EAs
- [DoD Instruction 7041.3](#), “Economic Analysis for Decision Making”
- Similar regulations exist for other government agencies and services (FAA, NRO, etc.)

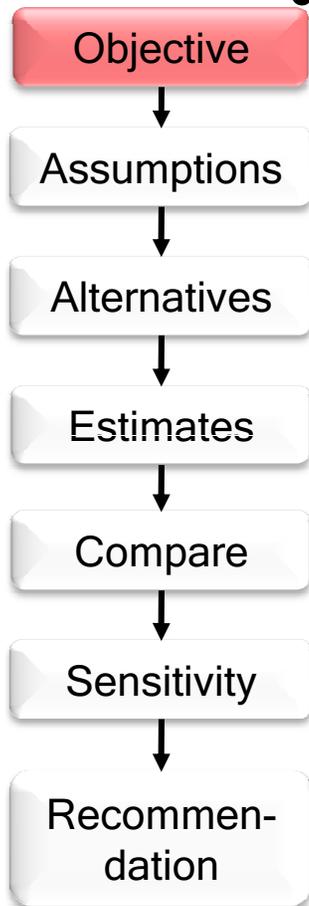
Overview of EA Process

- Define the Objective
- Formulate Assumptions & Ground Rules
- Identify and Examine Alternatives
- Develop **Cost** and Benefits Estimates
- Compare and Rank Alternatives
- Test Sensitivity of Alternative Rankings
- Formulate Recommendation

And, of course, document as you go!

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Step 1: Objective



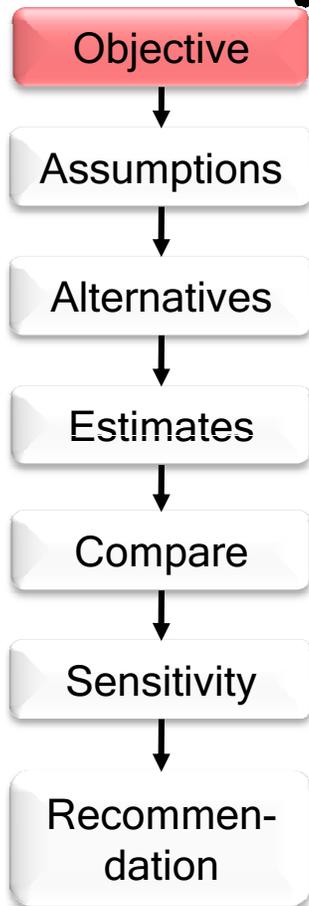
- Define the Objective 
 - Define the problem
 - Select an objective that is broad, yet relevant
 - Objective should:
 - Allow for multiple alternatives and *not* presuppose a solution
 - Address the problem versus addressing a symptom of the problem

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Objective is important for focusing and loosely bounding the analysis



Example - Toy Problem



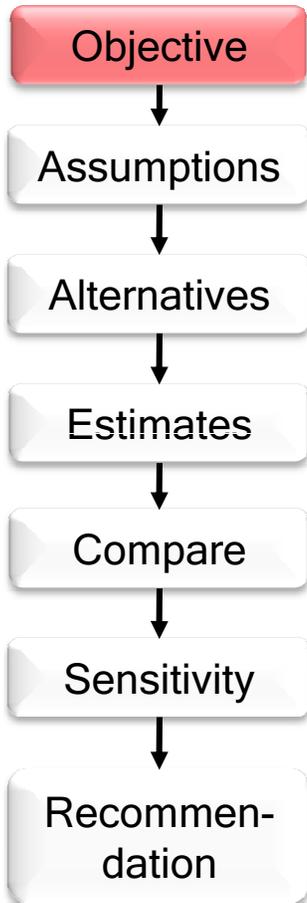
Problem: It takes forever to mow my lawn!
 Soccer season is starting soon and I don't have time for it anymore

Candidate Objectives:

1. Minimize time required to mow lawn
2. Maximize efficiency of mowing lawn
3. Identify optimal lawn maintenance program
4. Improve quality of life
5. Improve motivation tactics to get son to mow lawn



Example - Candidate Objectives

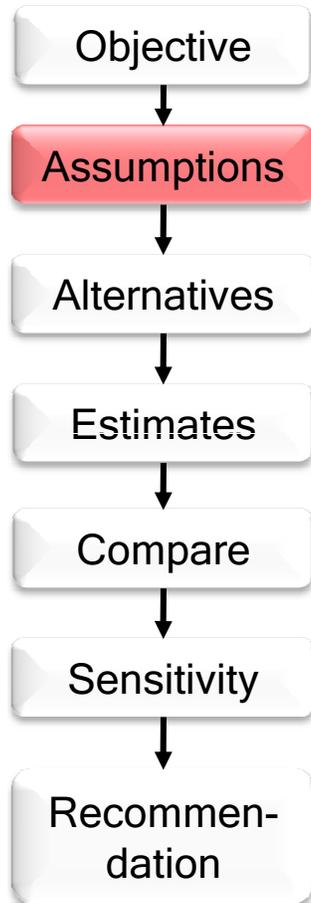


Candidate Objectives:

1. Minimize time required to mow lawn
 - **Too narrow** - focuses solely on time
 - Also, **focuses on symptom** (time management), not problem (lawn size/equipment)
2. Maximize efficiency of mowing lawn
 - Good objective, although increased efficiency does not necessarily mean happier homeowner
3. Identify optimal lawn maintenance program
 - Good objective - a little more broad and homeowner happier *if* he benefits from improvements
4. Improve quality of life
 - **Too broad**
5. Improve motivation tactics to get son to mow lawn
 - **Presupposes solution**

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Step 2: Assumptions & Ground Rules



- Formulate Assumptions and Ground Rules
 - Examine problem thoroughly
 - Develop *complete* list of assumptions and ground rules
 - Mathematical/methodology assumptions
 - “Limits of analysis” based on problem characteristics
 - Address both strict constraints and assumptions of convenience
 - Scrutinize assumptions for relevancy, necessity, and reasonableness

Assumptions provide the groundwork for defining the alternatives

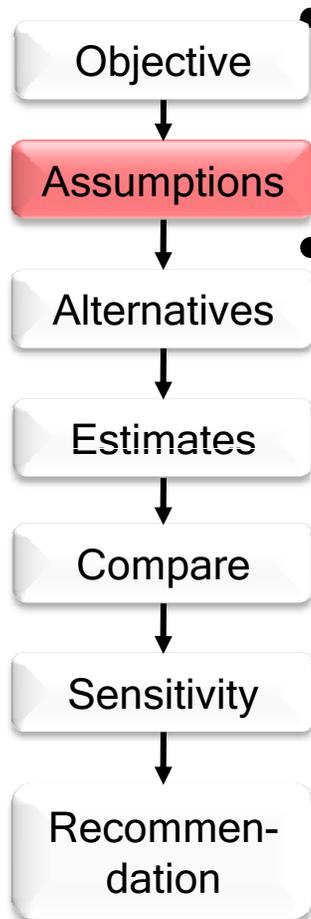
- Alternatives bound the analysis

**Document
data
sources!**

Document all assumptions!



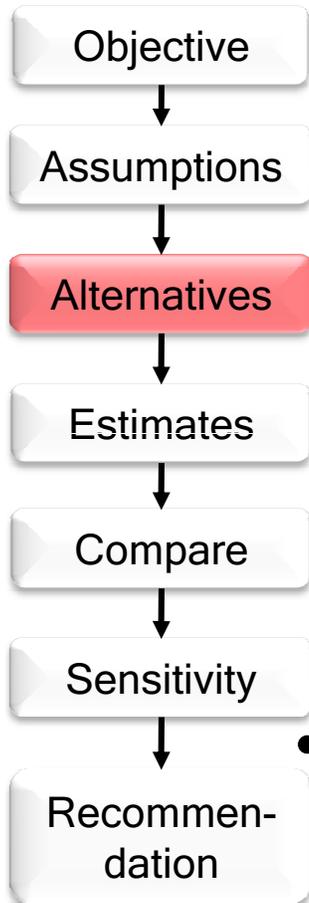
Example - Assumptions



- Objective:
 - Identify optimal lawn maintenance program
- Assumptions:
 - Focus on task of mowing lawn only
 - Excludes weeding or other tasks that could be part of lawn maintenance program
 - Need to mow lawn about 10 times per year

Note: we will revisit assumptions throughout the example

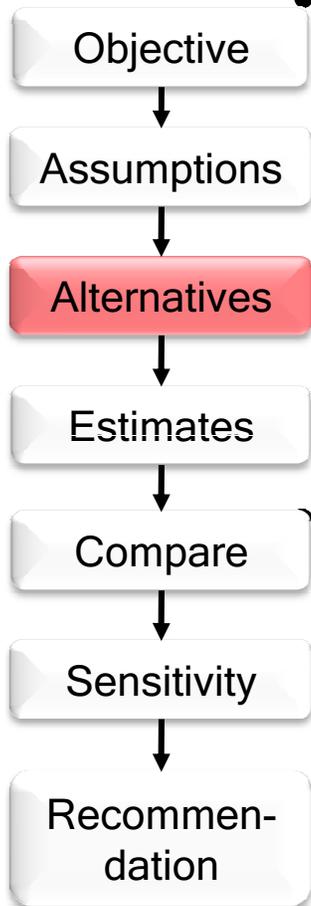
Step 3: Alternatives



- Identify and examine alternatives
 - Examine problem with the assumptions to help identify possible solutions
 - Develop alternatives without boundaries
 - Examine alternatives for unfeasible options
 - Document reasons for eliminating alternatives in case circumstances change to cause an alternative to be viable again
 - Note that alternative list may change during analysis
- Alternatives are critical, as they inherently are the first step in the decision-making process
 - They define what actions *could* be taken

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Minimum Number of Alternatives



- Must always have at least two alternatives

- Status Quo:   AKA “As-Is” or Status Quo Plus

- Change nothing

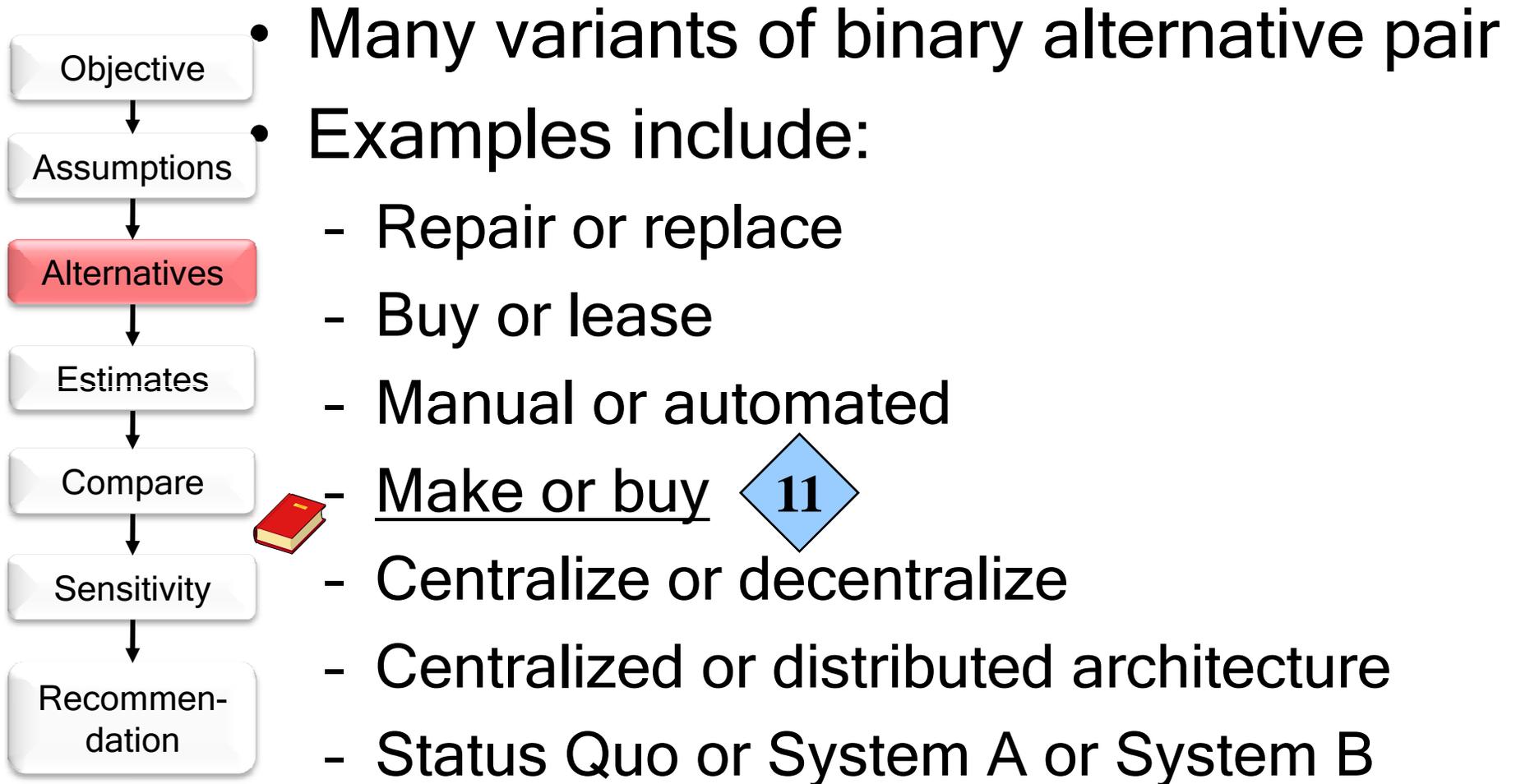
- Normally “Alternative 1”

- Alternative to Status Quo:  AKA “To-Be”
- Includes desired capabilities

Best to consider four alternatives if applicable

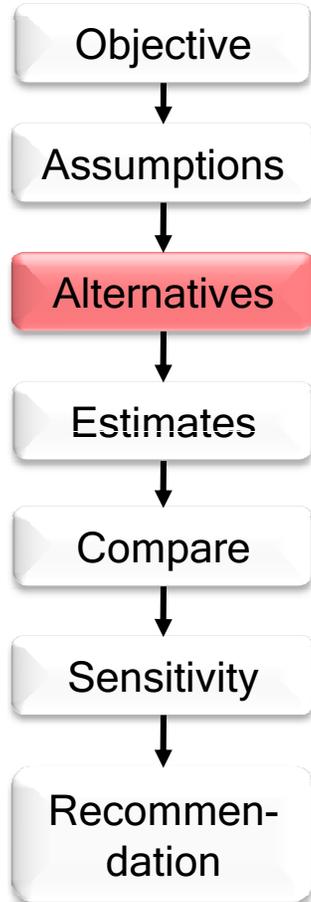
- Status Quo
- Modernize existing assets
- Lease/Privatization
- New Acquisition

Common Alternatives





Example - Alternatives



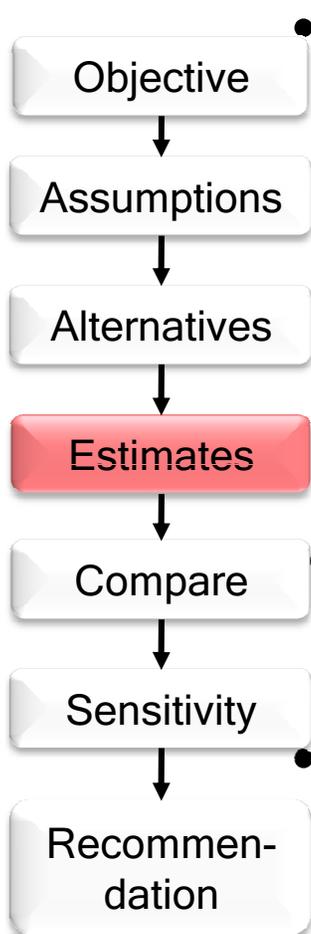
- Objective:

- Identify optimal lawn maintenance program

- Alternatives:

- Status Quo - do nothing
- Upgrade existing mower
 - Overhaul engine for greater speed/efficiency
 - Replace cutting deck with larger blades/deck
- Purchase new mower
- Outsource effort: Hire local lawn maintenance firm
- **Stop mowing lawn - NOT FEASIBLE**
- **Move to house with less lawn - NOT FEASIBLE**

Step 4: Cost and Benefits Estimates



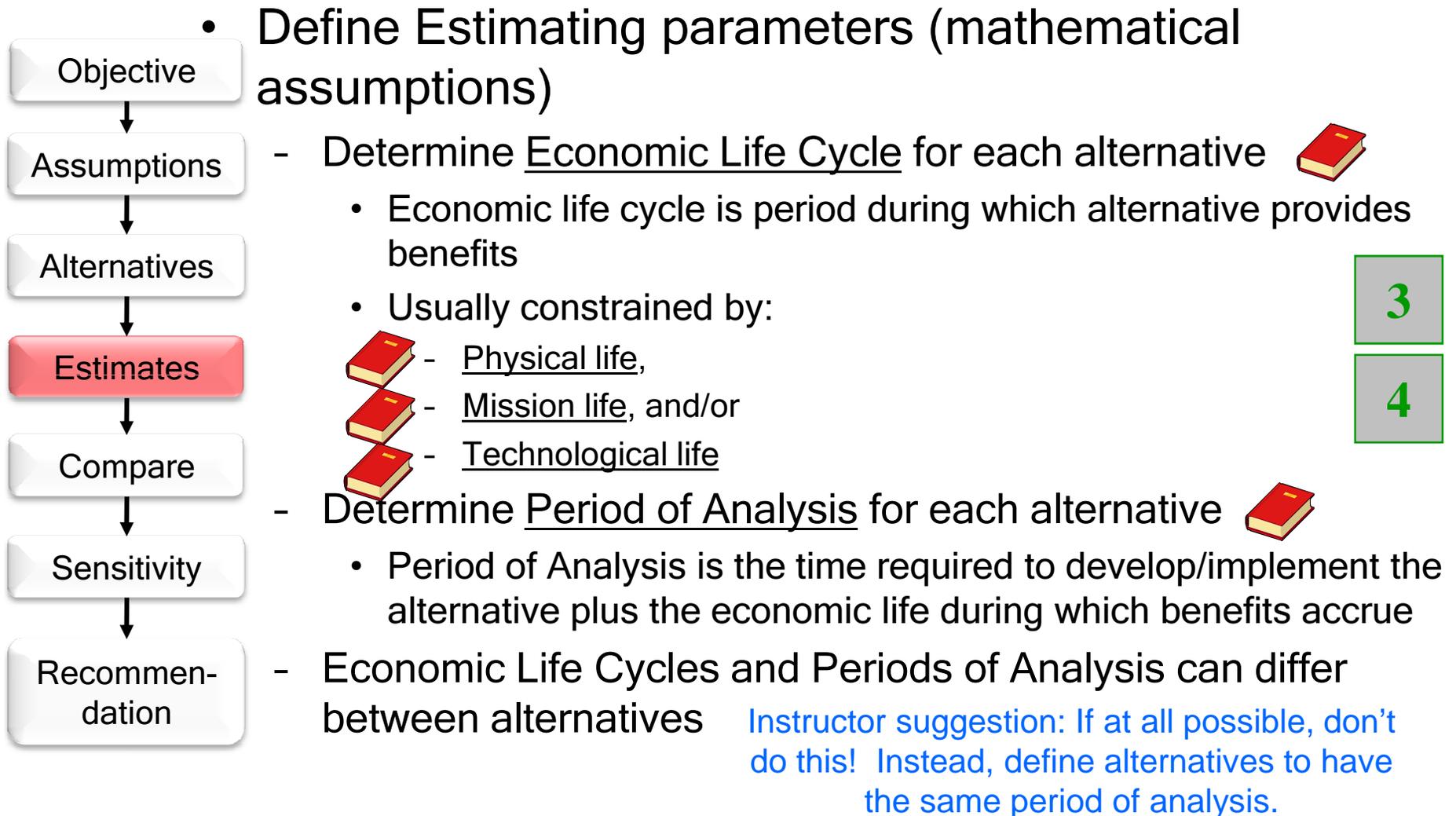
- Develop cost and benefits estimates:

- Define Cost and Benefits Estimating parameters (or mathematical assumptions)
- Develop comprehensive cost estimate for each alternative
- Define and quantify benefits for each alternative

Cost and benefit estimating involves several non-trivial sub-steps

Cost and Benefit Estimates are important as they serve as the **objective basis** for comparing alternatives

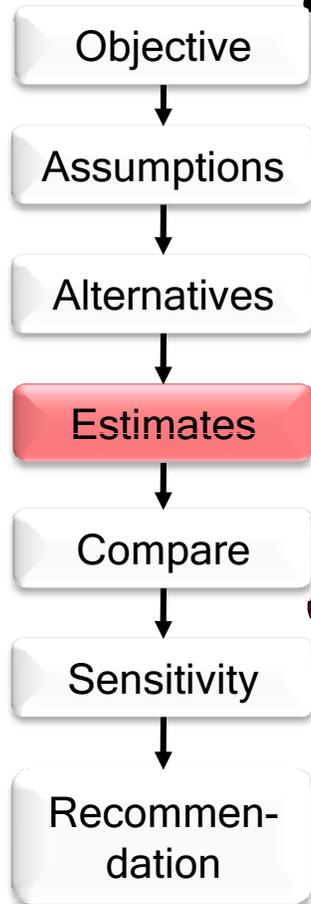
Estimating Parameters



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Parameters - Type of Dollars



• Constant Dollars or Current Dollars

Constant Dollars Also known as “real” or “base-year” dollars

- Adjusted for the effects of inflation (reflects the purchasing power of the dollar in a specified year)
- Most common
- **Must specify a base year**

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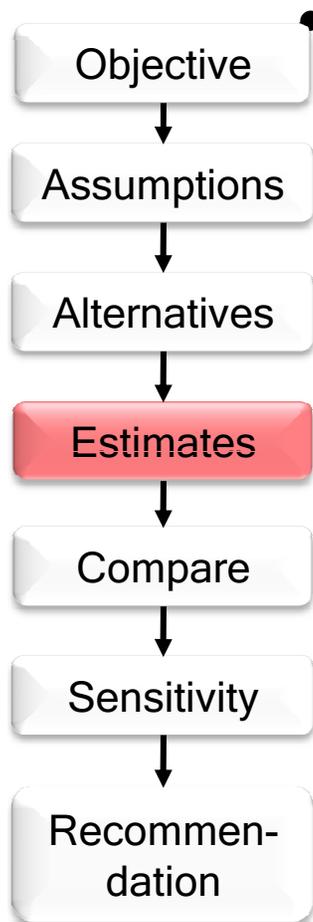
- Current Dollars Also known as nominal dollars

- Cost or Benefits data expressed in terms of “future purchasing power of the dollar”

Warning: Do not mix Constant and Current Dollars in the same analysis



Parameters - Base Year



• Determine Base Year for analysis

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- Year to which estimates are adjusted:

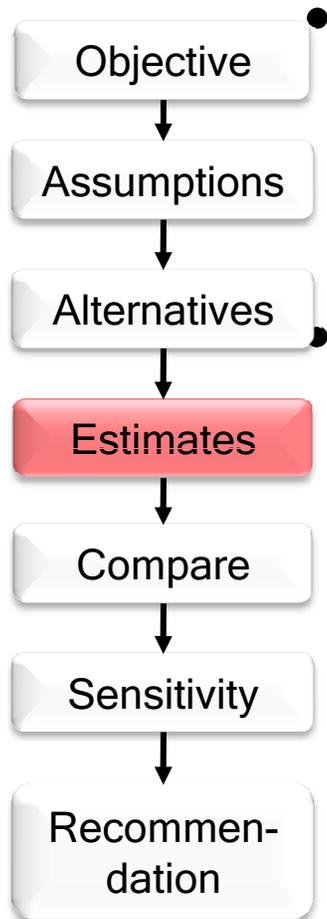
- De-escalation - constant \$ estimates only
- Discounting - both constant and current \$ estimates
- More information on Discounting and Net Present Value (NPV) on upcoming slides

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- Mandated as the first year of analysis, or the first fiscal year in which there is a difference in expenditures between alternatives



Example - Parameters



Objective:

- Identify optimal lawn maintenance program

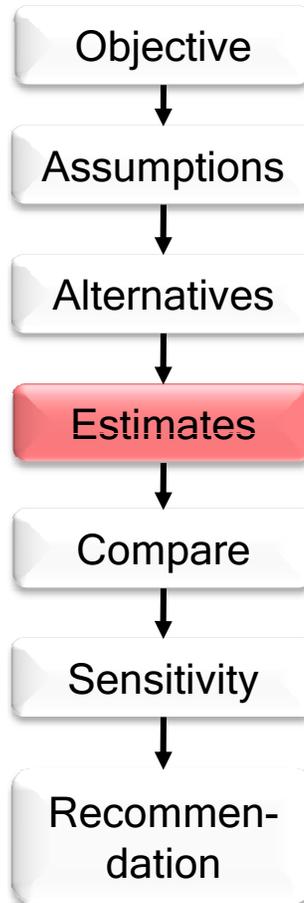
Estimating Parameters

- What are the Economic Lives and Periods of Analysis for my alternatives?
- Need more information on alternatives
- Conduct research



Example - Parameters

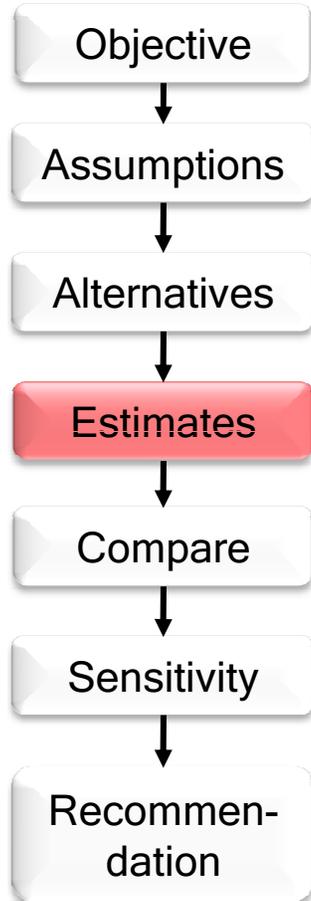
- Research results:



- Status Quo
 - Current mower is physically expected to last 2 yrs
- Upgrade existing mower
 - Time required to overhaul engine and replace cutting deck is 2 weeks, so effectively 0 yrs for this analysis
 - Once upgraded, mower is physically expected to last 5 yrs
- Purchase new mower
 - Time required to build/purchase new mower is 1 month, so effectively 0 yrs for this analysis
 - A new mower is physically expected to last 10 yrs
- Outsource effort
 - Able to hire firm immediately
 - Outsourced support can last indefinitely - will be based on an annual contract



Example - Parameters



- **Estimating Parameters**

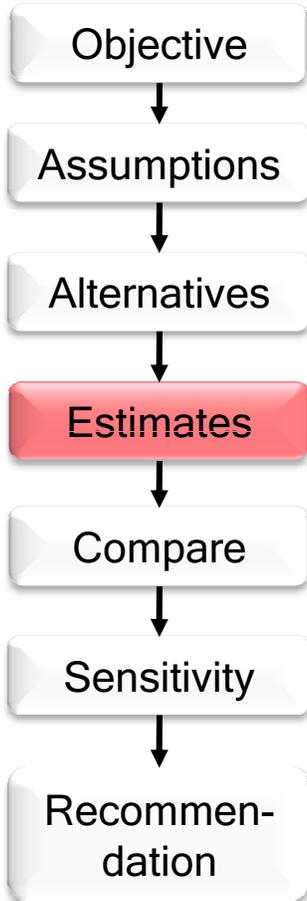
- Using research results, Economic Life and Period of Analysis for each alternative is:

Alternative	Economic Life	Period of Analysis
Status Quo	2 years	2 years
Upgrade existing mower	5 years	5 years (plus 1 week, which we are ignoring)
Purchase new mower	10 years	10 years (plus 1 month, which we are ignoring)
Outsource effort	Indefinite	Indefinite - use EA period of Analysis



Example - Parameters

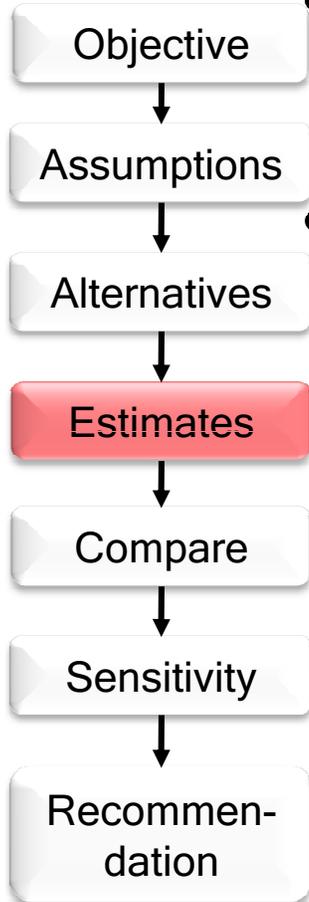
- Suggested method of defining alternatives:



Alternative	Period of Analysis
Status Quo: use the existing mower for its economic life of 2 years, then purchase additional maintenance to keep it operational for another 8 years.	10 years
Upgrade existing mower, which extends its life to 5 years. Then purchase whatever maintenance necessary to keep it operational for another 5 years.	10 years
Purchase new mower.	10 years
Outsource effort. Economic life is indefinite.	10 years



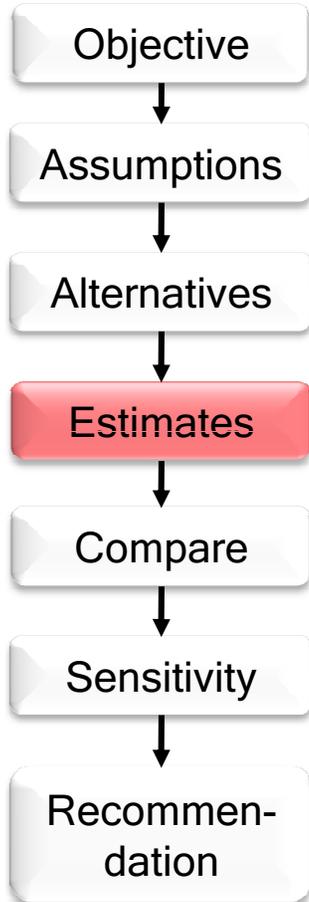
Example - Parameters



- EA Period of Analysis?
 - EA Period of Analysis = 10 yrs
- Constant \$ or Current \$?
 - Data I have is in terms of this year's \$
 - Estimate in **Constant FY08 \$**
 - FY08 = this year will be my Base Year



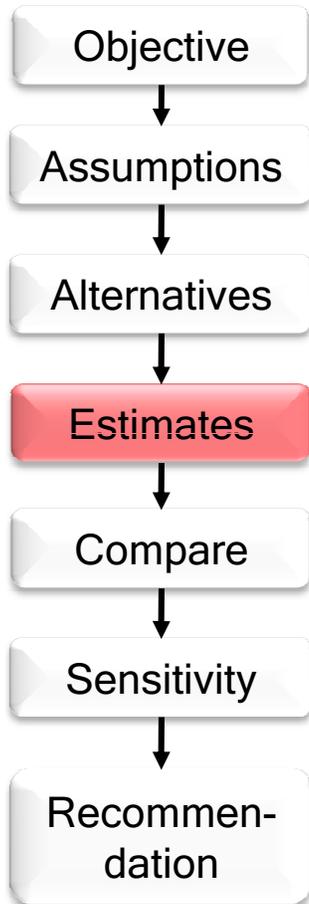
Example - Assumptions Redux



- Revisit Assumptions

- Focus on task of mowing lawn only
- Need to mow lawn about 10 times per year
- Not mowing lawn and moving are not feasible options at this time
- **Alternative Economic Life based on Physical Life**
 - Not Mission Life or Technological Life
- **EA Period of Analysis = 10 yrs, spanning FY08 through FY17**
- **Use Constant FY08\$ for estimates**

Cost Estimates



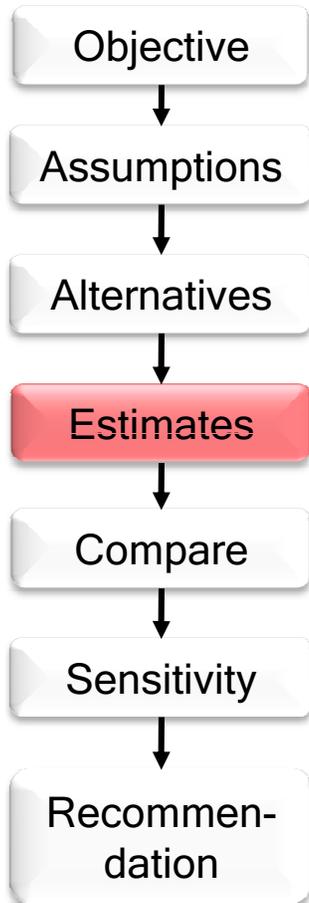
- Develop comprehensive cost estimate for each alternative

[881A] MIL-HDBK-881A, "Work Breakdown Structures for Defense Materiel Items, July 30, 2005.

- Useful to use Work Breakdown Structure (WBS) / Cost Element Structure (CES) to organize and capture all costs 
- Identify all applicable cost categories
 - EA Cost Estimate typically more extensive than Life Cycle Cost Estimate (LCCE)
 - **Costs to include:**
 - "Traditional" LCCE costs such as development, acquisition, operations, support, maintenance, disposal
 - Opportunity costs of existing assets/resources used if those assets/resources could be used elsewhere
 - Imputed costs, which are value of services provided without charge to a project (e.g., Base Operating Support)
 - Status Quo Phase-out costs for any Alternative that requires the Status Quo system to continue to operate while the Alternative is developed



Cost Estimates

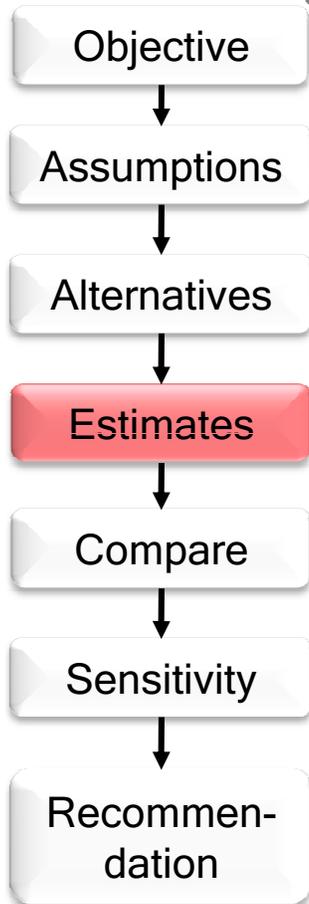


- Develop comprehensive cost estimate for each alternative
 - Identify all applicable cost categories (continued)
 - **Costs to exclude:**
 -  - **“Societal costs and benefits outside of the Federal Government are usually not included in a DoD analysis”**
 -  - **Sunk costs** - “These should be addressed in the assumptions for the analysis.”
 - **Costs captured under Benefits Estimate**
 - **Optional Costs**
 -  - **Wash costs**, which are costs that accrue equally by all alternatives
 - » Include if required to report total program costs
 - » Exclude if required to streamline decision making material

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[DoDI 7041.3] DoD Instruction 7041.3, “Economic Analysis for Decision-Making.”

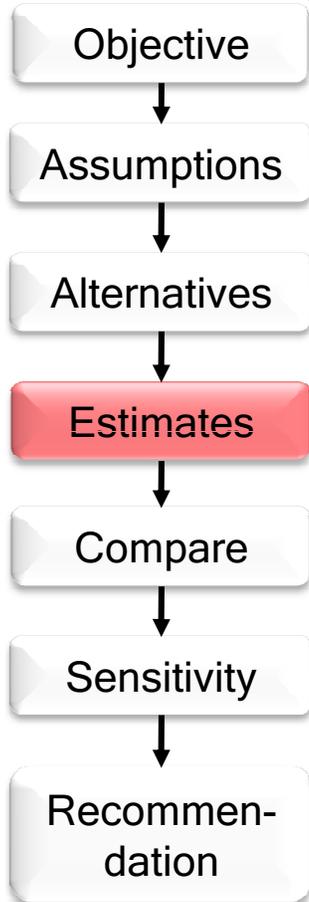
Cost Estimates



- Develop comprehensive cost estimate for each alternative
 - Develop cost estimate for all applicable cost categories within the WBS/CES framework
 - Level of detail of may be less than for LCCE
 - Level of detail depends on:
 - Data availability
 - Size of project
 - Level of oversight
 - Amount of effort available/desired for developing the EA
 - Use traditional cost estimating methods such as Analogy, Parametric
 - Cover entire EA Period of Analysis

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Benefits Estimate

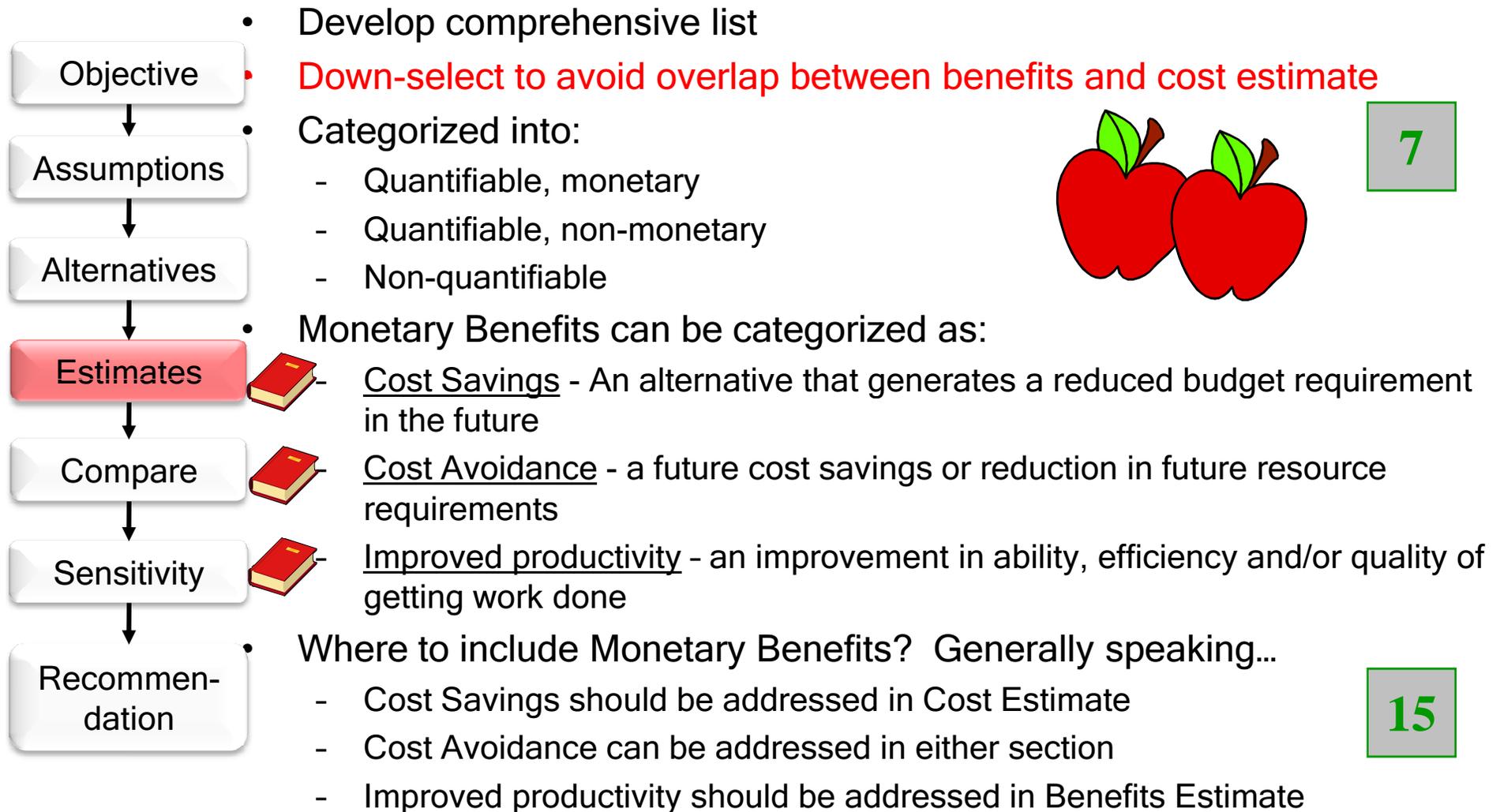


- Define and quantify benefits for each alternative

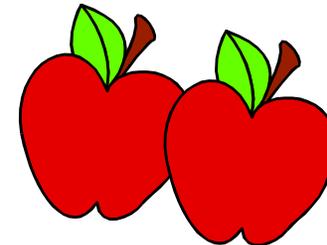
- Define alternative benefits 
- Quantify benefits
- Phase benefits

Best to quantify in terms of dollars if possible.

Benefits Estimate - Define Benefits

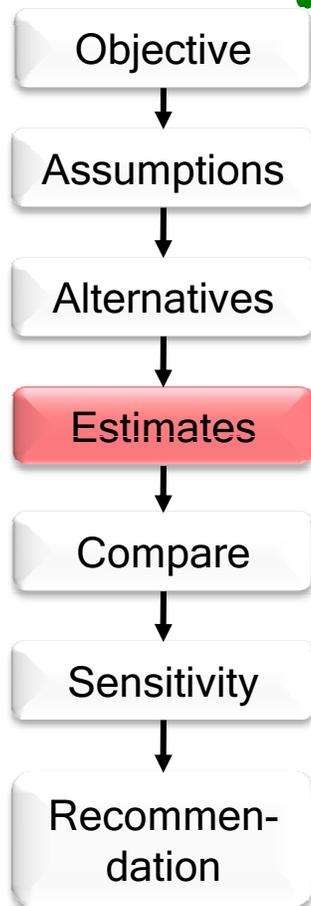


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Benefits Estimate - Define Benefits



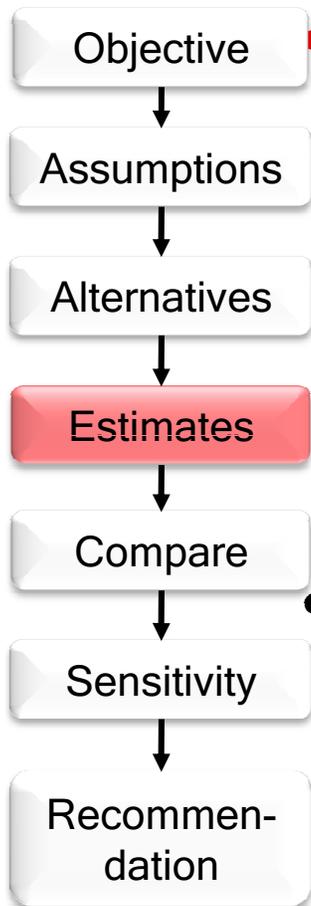
• Benefits to include

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- Residual/terminal/salvage values for assets at end of the period of analysis
 -  • Residual Value: Value of an asset at any time before the end of its economic life
 -  • Terminal Value: Value of asset at the end of its economic life
 -  • Salvage Value: Value of an asset at the end of its physical life (scrap/parts)
- Residual values may be tied to depreciation
 - Various methods are detailed in Related and Advanced Topics
 - Straight-line depreciation is usually sufficient for estimating residual/terminal/salvage values

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Benefits Estimate - Define Benefits



Benefits to exclude:

[DoDI 7041.3] DoD Instruction 7041.3, "Economic Analysis for Decision-Making."

- Societal costs and benefits outside the Federal Government are usually not included in a DoD analysis
- Realized benefits - however, these should be addressed as part of the assumptions
- Monetary benefits that are already captured in Cost Estimate

"Optional" Benefits

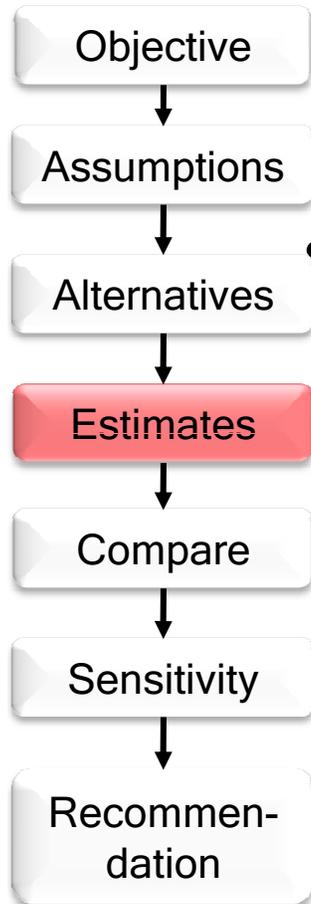
If ALL benefits are equal, then you are doing a "cost effectiveness analysis."

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- "Wash benefits"

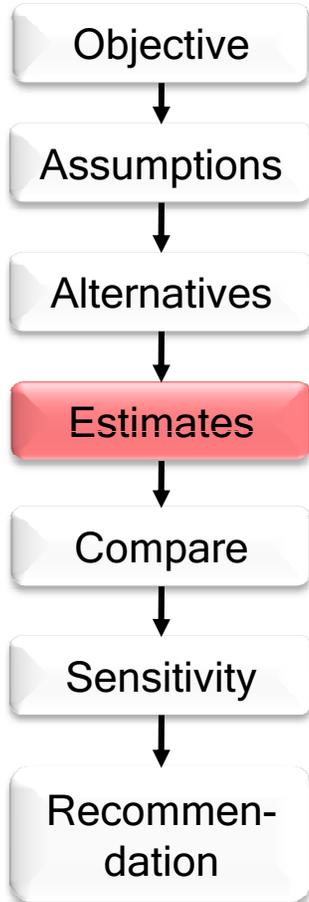
- Benefits realized equally by all alternatives
- Can include if required to report total program benefits
- Can exclude if required to streamline decision making material

Benefits Estimate - Quantify Benefits



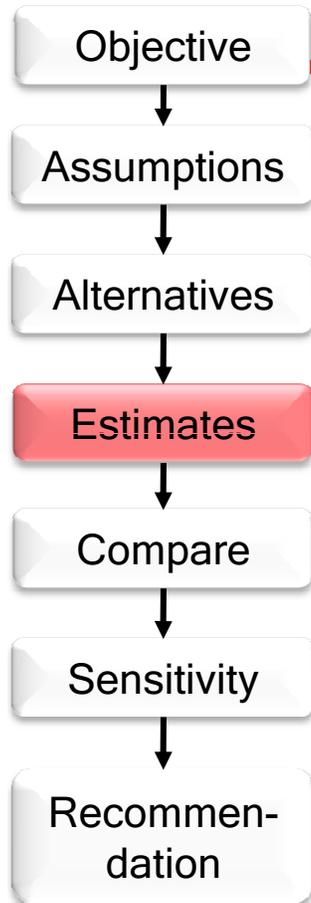
- Quantifying monetary benefits is similar to developing a cost estimate
 - Collect data, draw analogies, etc.
- For non-monetary but quantifiable benefits
 - Soliciting “expert assessment” of capability parameters ◆ 13
 - “Objectivize” the assessment as much as possible ◆ 2
 - Multiple interviews to same group
 - Interview to different groups
 - Review and scrubbing of results
 - Rank benefits according to the degree to which they achieve the objective or use weights to reflect relative value

Benefits Estimate - Phase Benefits



- Phase benefits according to when they will be realized
 - Phasing is critical for discounting and comparison reasons
 - Phasing of benefits should coincide with phasing of implementation of alternative system
 - Benefits should be phased through entire economic life

Example - Benefits Estimate



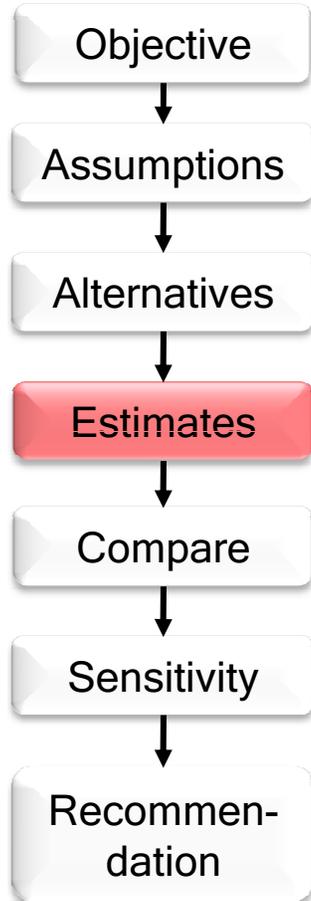
- Define and quantify benefits

Define candidate alternative benefits

- Time savings - upgraded mower, new mower, and outsource effort alternatives
- Ecological benefits/cleaner-running engine - upgraded mower and new mower alternatives
- Residual Values - new mower and outsource effort alternatives would have benefit of residual value of existing mower
- Salvage Value
 - Terminal Value = Salvage value because Economic life is at end of physical life
 - All alternatives would have Salvage Value except Outsource effort
- Cost avoidance of Annual Maintenance and Fuel/Oil for Outsource alternative



Example - Benefits Estimate

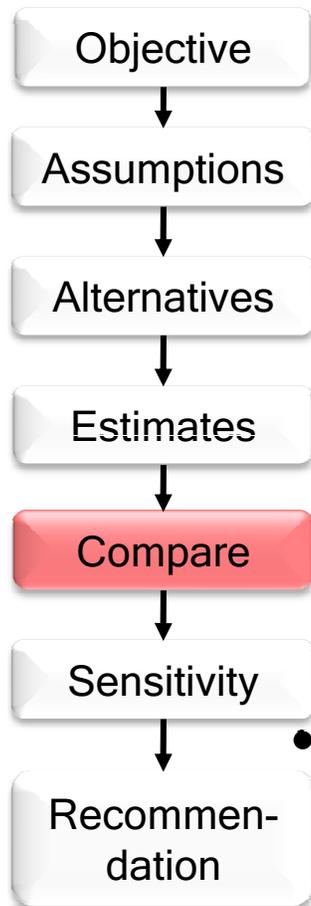


• Define and quantify benefits (Continued)

- Refine alternative benefits

- Time savings
 - Can be monetary if \$/hr value placed on homeowner's time
 - Can be non-monetary if expressed in terms of hours alone
 - Homeowner stated his time is worth \$20/hr - Therefore, this benefit can be expressed in monetary terms
- Ecological benefits/cleaner running engine
 - Non-quantifiable - will discuss in documentation
- Residual Values
 - Monetary
- Salvage Value
 - Monetary
- Cost avoidance of Annual Maintenance and Fuel/Oil
 - In Cost Estimate - will not include in Benefits Estimate

Step 5: Compare Alternatives

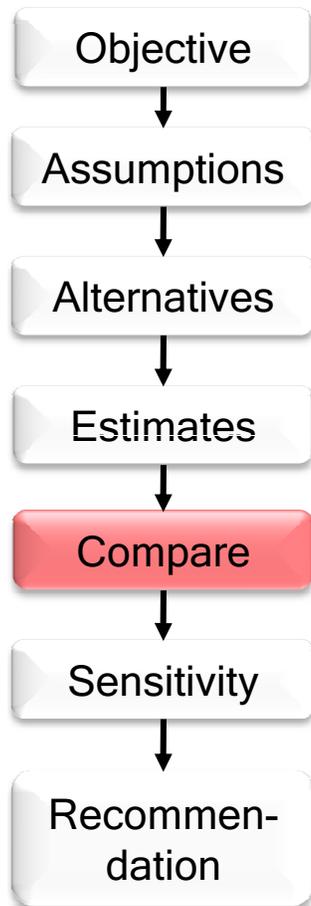


- Compare and rank alternatives
 - Phase costs and benefits by year
 - Adjust for inflation (if needed)
 - Discount costs and benefits
 - Select comparison technique that accommodates estimating assumptions (such as different economic lives)

Comparing and ranking alternatives involves several non-trivial sub-steps

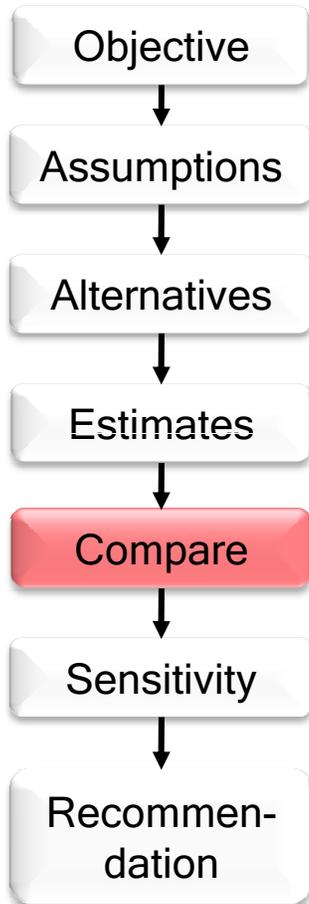
- Comparing Alternatives is important because it provides the first look at the concluding recommendation

Comparison - Time Phasing



- Phase costs and benefits by year
 - If not already done as part of the estimating step, identify what costs and benefits occur in each FY for every alternative
 - Inflationary and discounting adjustments are dependent on year in which costs/benefits occur
 - Accuracy of costs/benefits phasing could impact the recommendation
 - Any uncertainties should be identified as candidates for sensitivity analysis
 - For non-monetary but quantifiable and non-quantifiable benefits, phasing still critical for comparing relative benefits between alternatives

Comparison - Inflation

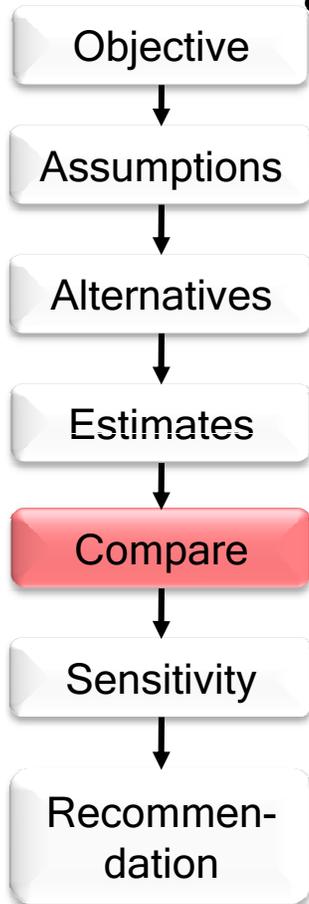


- Adjust for inflation

- If needed, adjust costs and monetary benefits to
 - Constant \$ using same Base Year (**preferred method**); *or*
 - Current \$
 depending on assumption made regarding use of Constant/Current \$
- Escalation often accomplished during estimating step
 - Should be verified as part of Comparison step
- If using Constant \$, forward-priced amounts need to be de-escalated (**preferred method**)
- If using Current \$, amounts reflecting today's prices need to be escalated



Comparison - Discounting



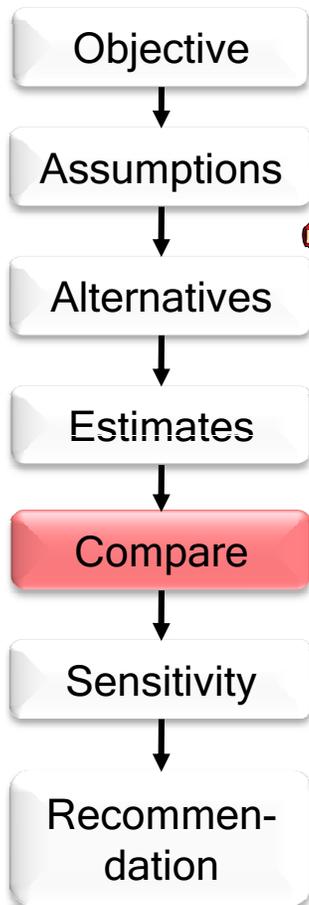
- Discount costs and benefits
 - To equitably compare alternatives, costs and monetary benefits must be discounted to reflect the time value of money 
 - Discounting “puts the E in EA”
 - Adjusts estimates based on economics to allow for an “economics-free” comparison of alternatives



AKA Present Value Analysis

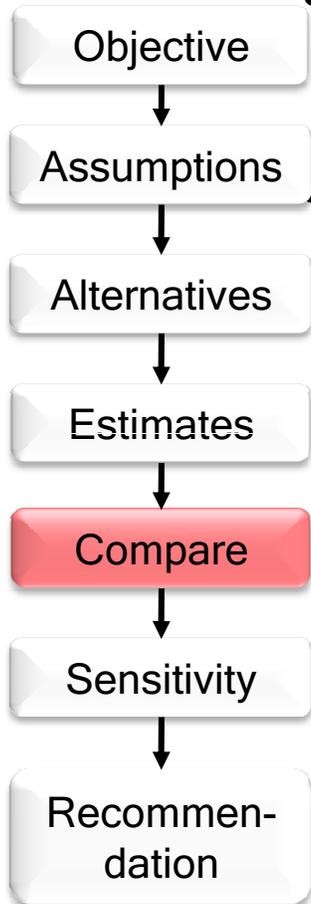
Key concept to Economic Analysis

Discounting Concept



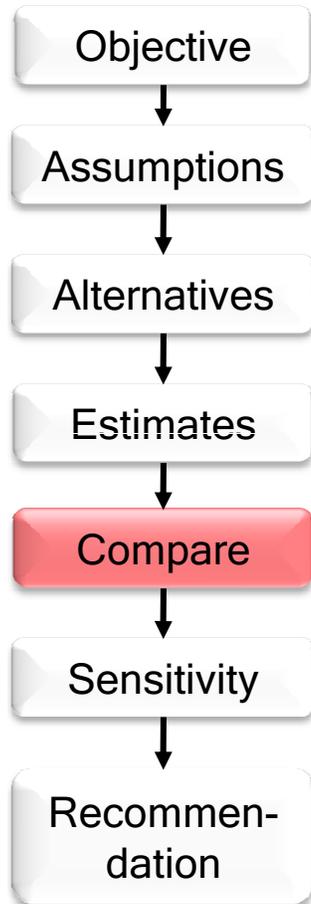
- Resource outlay (or gain) in the future is worth less than a similar outlay/gain today
- Using funds today prevents the investment of those funds in an interest-growing opportunity, resulting in less resource availability a year from now
- Similarly, gaining funds today (via benefits) allows investment of those funds in an interest-growing opportunity resulting in larger return than if benefits are realized a year from now
- Discounting transforms gains and losses that occur in different years to a common unit of measurement

Discounting Example



- I have \$100 today
 - Without investing, I will have \$100 next year
- How does my \$100 today compare with my \$100 next year?
 - I take today's \$100 and invest it in an opportunity with a simple rate of return of 10% 
 - Next year my \$100 is actually worth:
 - Present Principal (PP) * (1+Rate) = Future Principal (FP)
 - \$100 * (1+10%*) = \$110
- So my \$100 this year is worth more than my \$100 next year

Discounting Example



- How does \$100 spent today compare with a \$100 spent next year?
 - How much do I need to invest today to equal \$100 next year?
- If I want \$100 next year, then solve for PP
 - IF $PP * (1 + \text{Rate}) = FP$ **“PP” = PV**
 - THEN $PP = FP / (1 + \text{Rate})$ **“FP” = FV**
 - $PP = \$100 / (1 + 10\%) = \90.91
- Spending \$100 today costs more than spending \$100 next year
 - Spending \$100 next year is equivalent to spending only \$90.91 today

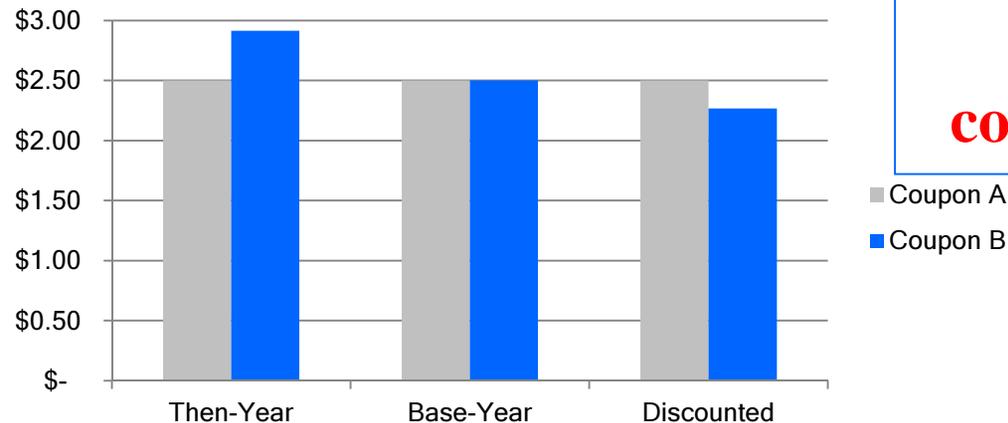
Another Example

- Alternative A: you get a coupon for a milkshake redeemable today or any time in the future. Currently, a milkshake is worth \$2.50.
- Alternative B: you get a milkshake coupon redeemable in 2 years or thereafter.
- The inflation rate on milkshakes is 8%
- Assume a real discount rate of 5%
- Calculate the following:
 - What is the value of each coupon in current-year dollars?
 - What is the value of each coupon in base-year dollars?
 - What is the value of the coupon in discounted dollars?

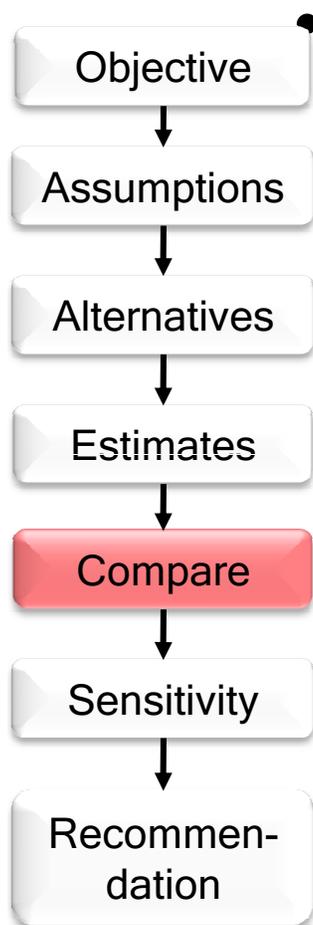
Another Example

- Current-Year dollars:
 - Coupon A: \$2.50
 - Coupon B: $PV \cdot (1+i)^n = 2.50 \cdot (1.08)^2 = \2.92
- Base-Year dollars:
 - Coupon A: \$2.50
 - Coupon B: \$2.50
- Discounted Dollars:
 - Coupon A: \$2.50
 - Coupon B: $PV = FV / (1+i)^n = 2.50 / (1.05)^2 = \2.27

Which is the correct choice? Most people, even non-cost-analysts, will recognize coupon A as the best option. Only discounted dollars produce the correct decision.



Discounting vs. Inflation



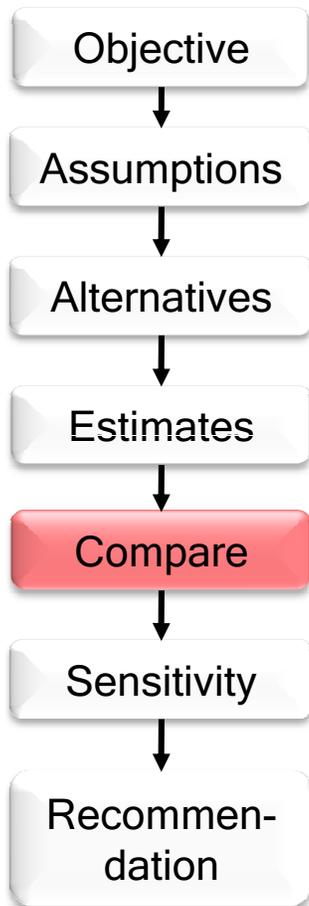
- Discounting is *not* the same as inflation
 - Inflation adjusts for price level changes
 - Discounting adjusts for differences in investment opportunity
 - Inflation *does* influence interest rates, so inflation and discounting are related
 - But, inflation does *not* fully adjust for lost or gained investment opportunities

Comparison - Discount Rates

v1.1



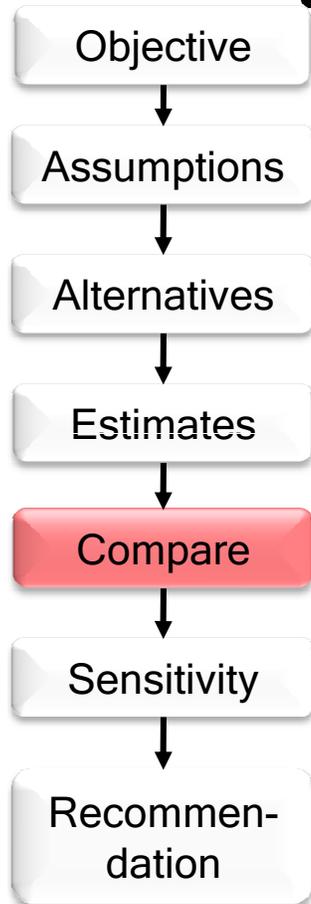
8



- Published as part of President's Budget annually
- Appendix C to OMB Circular A-94
- Based on Government's cost of borrowing
- Interest rates on Treasury notes with maturities of 3, 5, 7, 10, and 30 years
 - For periods of analysis between these maturity times, linear **interpolation** of rates is acceptable
- Rates assume Base Year is the President's Budget Submission year

Some agencies (for example FAA) publish mandated discount rates for their programs.

Comparison - Present Value



- Formula for calculating Present Value:

$$PV = FV \cdot \left(\frac{1}{(1+i)^n} \right)$$

11

12

where:

PV = Present Value 

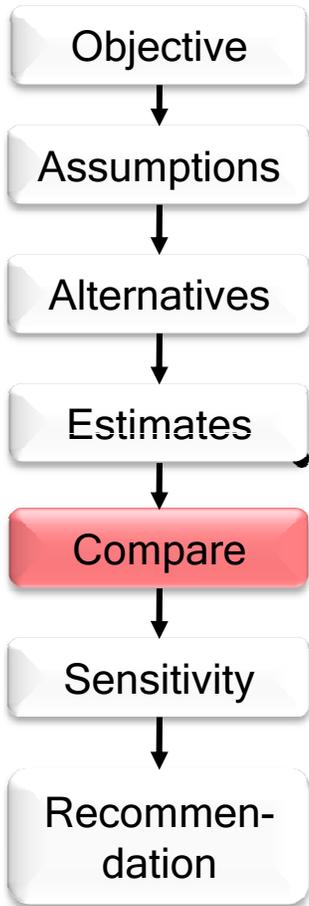
FV = Future Value 

i = interest rate (from OMB Circular) to be compounded over n periods

n = number of periods

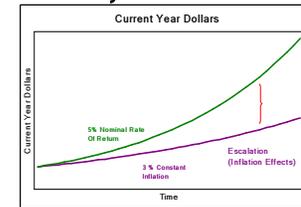
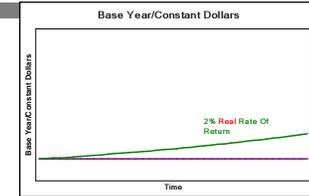
Discount
Factor

Discount Rates and Factors



Types of Discount rates (i)

- **Real:** for use with constant dollars
 - Most common rate used for EAs since EAs are typically conducted using constant dollars
- **Nominal:** for use with current dollars; include inflationary adjustment



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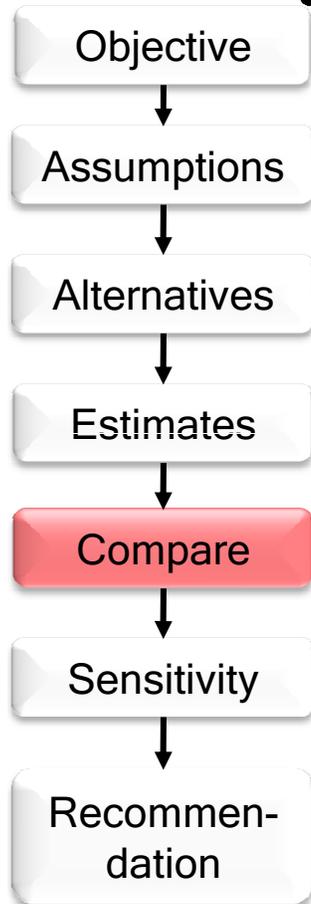
Types of Discount Factors

- Mid-year factors account for expenditures/benefits accruing evenly over the course of a year
 - Most common factors to use
 - Replace “n” with “(n-0.5)” in formula
- End of year factors assume all cost/benefits happen at one time at the end of the year

$$\left(\frac{1}{(1+i)^{(n-0.5)}} \right)$$

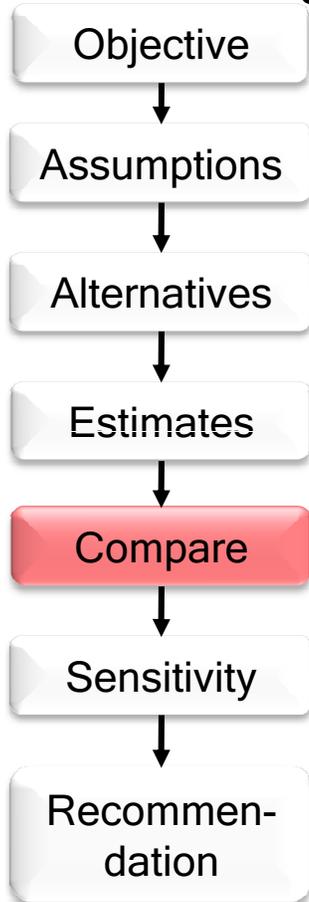
$$\left(\frac{1}{(1+i)^n} \right)$$

Comparison - Techniques



- Select comparison technique that accommodates estimating assumptions (such as different economic lives)
 - Cost and monetary benefit estimates have been economically adjusted
 - Still may have non-equal comparison due to differing economic lives
 - Recall that the Period of Analysis chosen can also be used to “even out” unequal economic lives
 - Shortest life
 - Common denominator life

Comparison - Preferred Technique

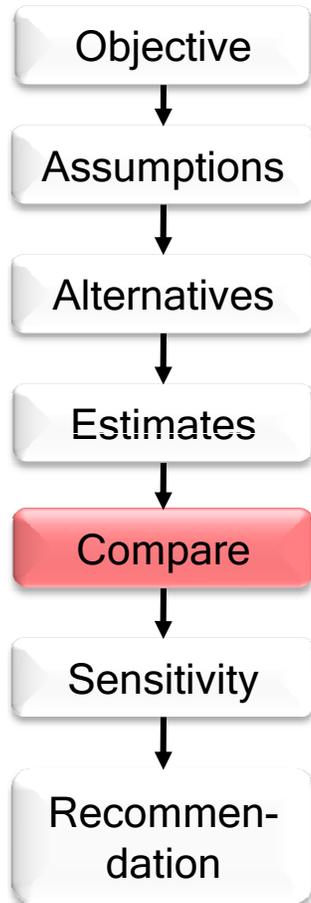


- Primary Economic Comparison for government programs:

20

- Present Value Analysis - For equal economic lives
- Can be used with both monetary and non-monetary benefits
 - If benefits monetary, apply same calculation to benefit \$ as to cost \$
 - If benefits non-monetary, apply calculations only to cost \$, then consider benefits' "value" when ranking alternatives

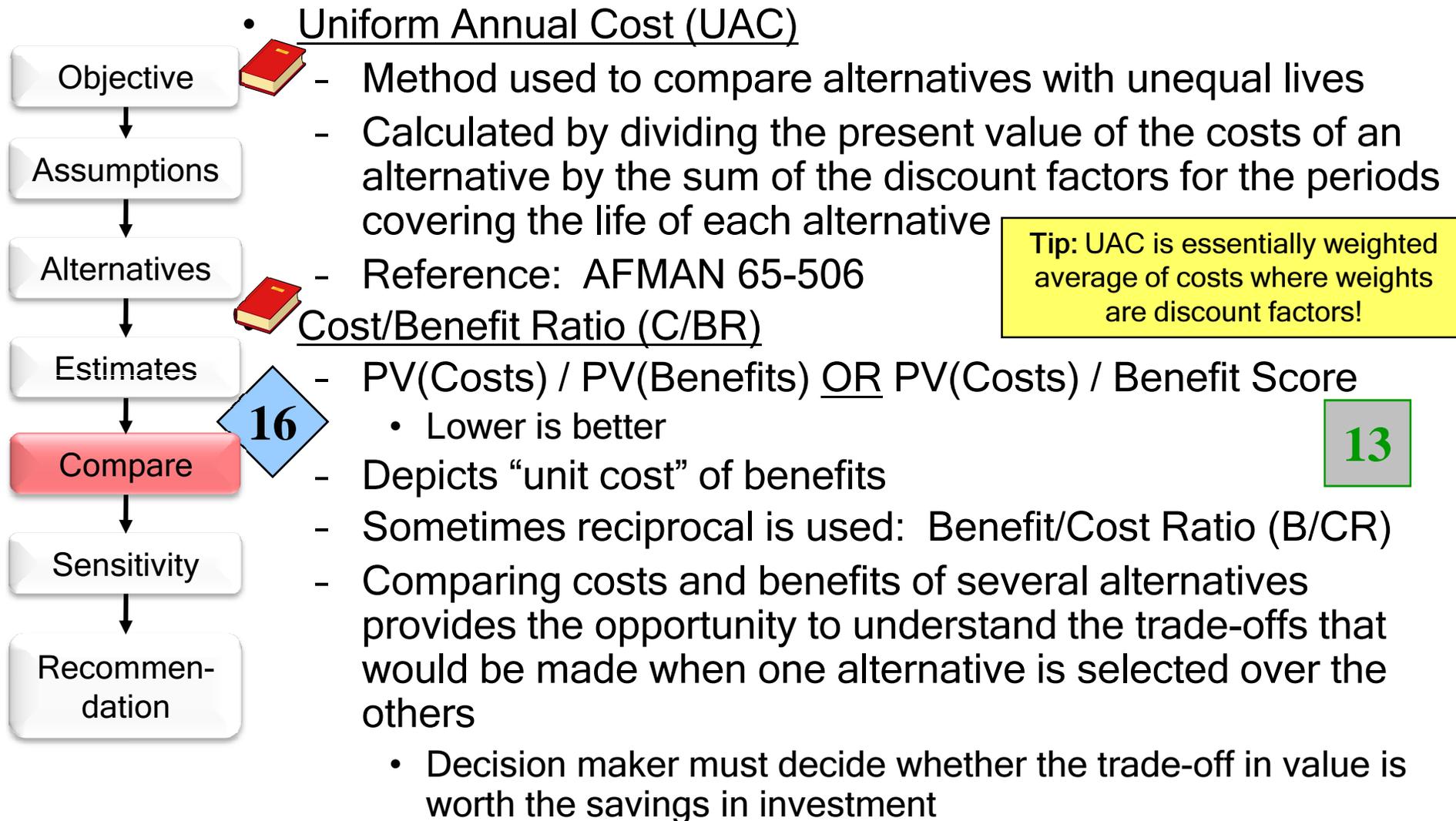
Net Present Value (NPV)



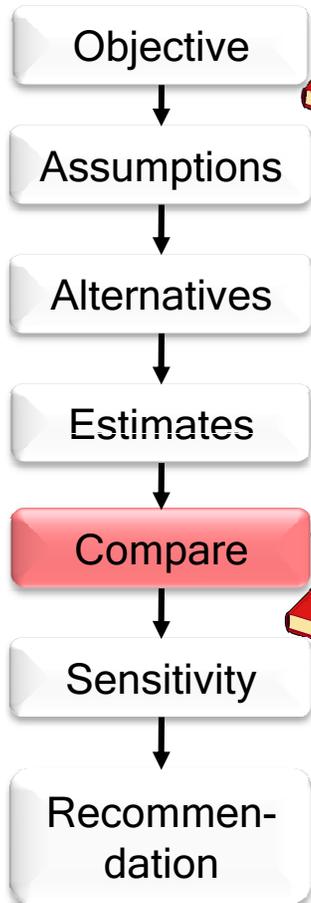
- $NPV = PV(\text{Benefits}) - PV(\text{Costs})$
 - Discounted monetized value of expected net benefits
- Discounting benefits and costs transforms gains and losses occurring in different time periods to a common unit of measurement
- Standard criterion for justifying investments on economic principles:
 - $NPV > 0$
- Compare and Rank Alternatives based on NPV

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Comparison Techniques - Other



Comparison Techniques - Other



• Savings/Investment Ratio (SIR)

- SIR = PV(Savings) / PV(Investment)
- Higher is better
- Measures financial benefit gained from an investment



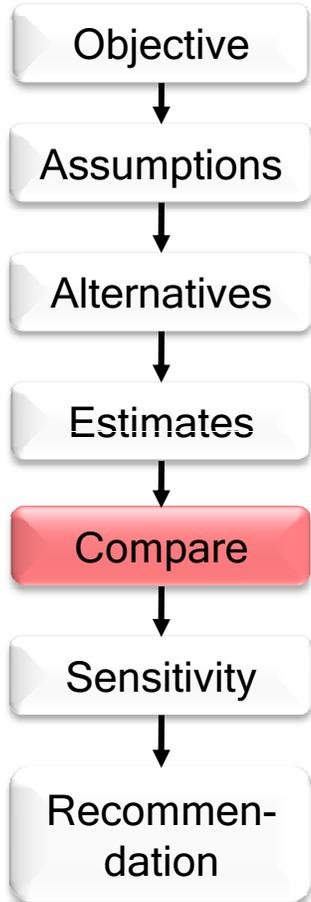
AKA Return On Investment (ROI)

• Internal Rate of Return (IRR)

- Attempts to capture project merit as a single % value
- Discount rate which makes NPV = 0
- Requires Excel Solver or **IRR() function**

$$0 = \sum_{t=0}^n \frac{CF_t}{(1+r)^t}$$

Comparison Techniques - Other



- Payback Period Analysis



AKA Discounted Payback

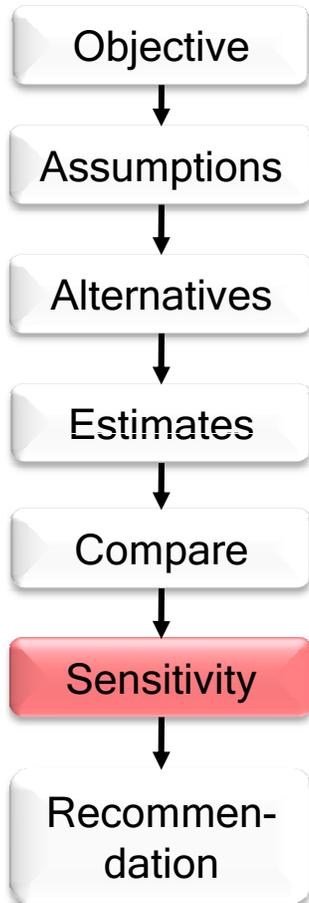
- Determines length of time an alternative must realize cost avoidances or savings to offset the investment costs

- Break-Even Analysis

- Comparison focuses on “break-even” point in time at which there is no one preferred alternative
- Works best with only two options
 - Status Quo plus one Alternative

The year in which cumulative NPV becomes positive.

Step 6: Test Sensitivity



- Test Sensitivity of Recommendations

- List assumptions and constraints on which to perform sensitivity analysis
 - Most likely to change
 - Most uncertain / Least-understood
 - Significant Cost or Benefits drivers 
 - Factors with key relationships to the analysis results
- Recalculate analysis using discounted costs
- Compare and rank alternatives using new data

14

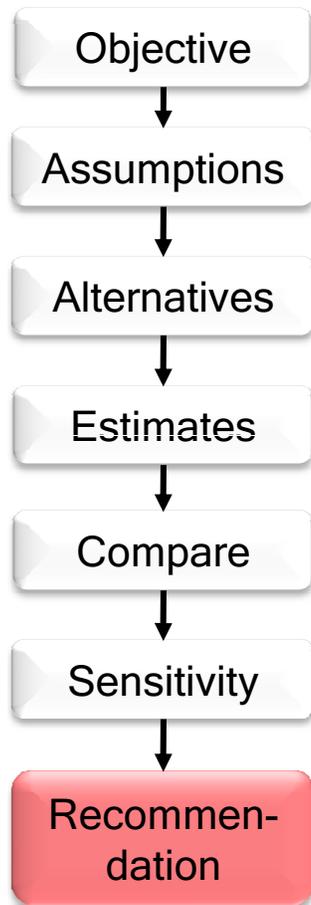
Sensitivity analysis is important because:

- Highlights recommendation strengths/weaknesses
- Could lead to further analysis on validity of assumptions

Sensitivity Analysis

- Each assumption is changed, varying only one assumption at a time.
- For each sensitivity change, record the impact to cost, benefit, and recommended decision.
- Rank assumptions by degree of impact.

Step 7: Formulate Recommendations



- And finally...Formulate Recommendations

- **Synthesize *all* data**

- Baseline Cost/Benefit Comparisons
- Sensitivity Analysis Results
- Discussion on non-quantifiable benefits

- Rank all alternatives

- **Select recommended course of action and provide a solid foundation of analysis on which that recommendation is based**

- Good to have justification material ready to support second and third place alternatives in case of questions

Providing the decision-maker information to help them make an informed decision is *the goal* of the Economic Analysis

Economic Analysis Summary

- EA provides objectivity and completeness to decision making process
 - Includes discussion and/or analysis of all possible alternatives/solutions to a predefined objective/problem
 - Economically adjusts time-phased costs and benefits
- EA critical for program and budget decisions as it maximizes estimated value received for investment of scarce or competing resources
- EA provides objective, defensible justification for executing a selected alternative

Backup

Resources

- References
- Benefits Identification and Quantification Questionnaire
- Economic Analysis Checklist

References - Government

- Federal



- OMB Circular A-94, “Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs,” OMB, 1992, <http://www.whitehouse.gov/omb/circulars/a094/a094.html>

- Current rates in Appendix C of Circular

- OMB Circular A-76, “Performance of Commercial Activities,” OMB, 1983 (revised 1999), <http://www.whitehouse.gov/omb/circulars/a076/a076.html>

- Defense

- DoD Instruction 7041.3, “Economic Analysis for Decision Making,” USD(C), 1995
- Defense Acquisition Guidebook, Chapter 3 Affordability and Life-Cycle Resource Estimates, OSD, 2004, <https://akss.dau.mil/dag/>
- “Discounted Present Value, Inflation Accounting, and Special Economic Topics,” Bryan Jack and Susan Edelman, PA&E, 1998, <http://www.ra.pae.osd.mil/adodcas/docs/inflate.pdf>

References - Services

- Army 
 - *Department of the Army Economic Analysis Manual*, US Army Cost and Economic Analysis Center, 2001
 - AR 11-18: The Cost and Economic Analysis Program, HQDA (SAFM-CA), 1995
- Navy/Marine
 - *NISMC Life Cycle Management (LCM) Review Handbook*, NISMC, 1994
 - *U.S. Marine Corps Systems Cost Analysis Handbook*, ACPQMB, 1998
 - NAVSEA Cost Estimating Handbook, Section V, 2005
 - "Project-Level Financial Analysis Primer," Fred K. Blackburn, TASC, Inc., 1997
- Air Force
 - AF Manual 65-506: Economic Analysis, SAF/FMC, 10 Nov 04
 - AF Instruction 65-501: Economic Analysis, SAF/FMC, 10 Nov 04

AIS Benefits Questionnaire

- Benefits Identification and Quantification Questionnaire
 - The list of questions on the following slides is designed to facilitate the identification and quantification of benefits for Automated Information Systems (AIS)
 - Many questions are useful to consider for non-AIS programs too
 - Published in the NISMC Life Cycle Management (LCM) Review Handbook

AIS Benefits Questionnaire 1-9

Potential AIS Benefit Drivers

1. Simplicity - Will mission operations be simplified or more complex?
2. Speed - Will operations be faster or slower? Satisfies minimum requirements?
3. Acceptability - Does the alternative contribute to the operation of parallel or higher level organizations? Does it improve quality of information for decision makers?
4. Redundancy - Will the system reduce redundant operations?
5. Reusability - Will system or parts of system be reusable?
6. Accuracy - Does the alternative improve error rates or accuracy of information?
7. Reliability - Will information be more reliable. Will external systems be more reliable in performance?
8. Adaptability - Is the project adaptable to existing DoD industry/national/international standards?
9. Retirement - Will the system allow retirement or replacement of other systems?

NISMC Life Cycle Management (LCM) Review Handbook, NISMC, 1994

AIS Benefits Questionnaire 10-16

Potential AIS Benefit Drivers

10. Morale - Will the project contribute to a positive employee attitude towards work?
11. Management Effectiveness - Will management decisions be better/worse?
12. Production - Will the number of products (transactions, documents, parts, etc.) produced be increased? What is value of increased production? Benefit cannot exceed requirement level. Value cannot be greater than value of not meeting the requirement.
13. Productivity - Will the rate of production (number per hour, etc.) increase? Will the system decrease the number of resources needed to produce the same product or allow more items to be produced with existing resources?
14. Force Structure - Will any structure changes result?
15. Quality - Will a better product be produced? Will better service be provided? Will quality of products be more consistent?
16. R&D - Will R&D proposals be impacted?

NISMC Life Cycle Management (LCM) Review Handbook, NISMC, 1994

AIS Benefits Questionnaire 17-26

Potential AIS Benefit Drivers

17. Security - Will more precautions be needed? Will the system be capable of handling classified/sensitive unclassified data? Will greater security or less security result?
18. Service Life - How long will the equipment be able to support the operation? Will the equipment be obsolete before it reaches the end or its useful life?
19. Systems Design - Will Systems Design be impacted?
20. Versatility - Will the equipment provide additional capacity/capability beyond that required for the system?
21. Systems Procurement - Will Systems Procurement be impacted?
22. Flexibility - Will force structure be more adaptable to surge & changing mission requirements?
23. Survivability - Will systems be more survivable?
24. Communicability - Will interaction be more understandable/usable?
25. Availability - Will systems be more available to meet mission requirements?
26. Systems O&S - Will external systems O&S be impacted?

NISMC Life Cycle Management (LCM) Review Handbook, NISMC, 1994

AIS Benefits Questionnaire 27-35

Potential AIS Benefit Drivers

27. Rounds on Target - Will rounds or mission target be impacted?
28. Administration Actions - Will they be reduced? Paper?
29. Organizational Overhead (General Administration) - Will it be impacted?
30. Transportation - Will transportation and distribution costs be reduced?
31. Facilities - Will facilities requirements be reduced/increased?
32. Base Closures - Will base realignment/closure be impacted?
33. Defense Management Review - Will Defense Management Review decisions be implemented?
34. Stock Fund - Will Stock Fund be impacted?
35. Industrial Fund - Will Industrial Funds be Impacted?

NISMC Life Cycle Management (LCM) Review Handbook, NISMC, 1994

EA Checklist

- Army EA manual and AF EA manual both contain a checklist for conducting an EA
- Checklists are similar, but the Army checklist was more extensive
- The Army EA Checklist is included on the following slides for reference

EA Checklist - Objective

1. Objective/problem review checklist
 - a. Is the objective clear and specific?
 - b. Is the objective realistic and attainable?
 - c. Is the objective statement in terms of output or accomplishment?
 - d. Is the objective, as stated, unbiased as to the means of meeting the objective?
 - e. Are the expected outputs/accomplishments defined in quantifiable, measurable terms?
 - f. Are criteria specified for selection of a preferred course of action?
 - g. Can progress toward attainment of the objective be measured?
 - h. Is the objective statement phrased so that the type and variety of potential alternatives are not unnecessarily limited?
 - i. If a completion or implementation date is required, has it been specified?
 - j. Is the statement of the objective/problem well documented?

Department of the Army Economic Analysis Manual, US Army Cost and Economic Analysis Center, 2001

EA Checklist - Assumptions

2. Assumptions/constraints
 - a. Are all assumptions realistic and justified?
 - b. Are all assumptions pertinent to the analysis identified and rationale provided?
 - c. Are all assumptions identified as such?
 - d. Are assumptions used only when facts cannot be obtained?
 - e. Do the assumptions preclude potential alternative solutions?
 - f. Is an assumed future "state of nature" identified?
 - g. Do assumptions include economic life and future workload?
 - h. Is a project time frame established?
 - i. Are funding/budget constraints considered and identified?
 - j. Are space, construction, furniture and lab equipment needs included?
 - k. Are necessary geographical constraints included?
 - l. Are assumptions too restrictive or too broad?
 - m. Are facts presented as assumptions? Can the facts be verified?
Are uncertainties treated as facts?
 - n. Are all assumptions/constraints well documented?

EA Checklist - Alternatives

3. Alternatives

- a. Have all feasible alternatives been considered?
- b. Is the status quo presented as an alternative? If not, this needs to be explained in the documentation.
- c. Are all alternatives presented feasible?
- d. Is the status quo used as a basis for comparison?
- e. If appropriate, is lease versus buy evaluated as an alternative?
- f. Are the alternatives distinctly different, rather than a mere restructuring of a single course of action?
- g. Are options applicable to each alternative presented?
- h. Has the rationale for immediate rejection of alternatives, prior to full analysis, been provided?
- i. Have alternatives omitted from the analysis been identified and rationale provided for their omission?

Department of the Army Economic Analysis Manual, US Army Cost and Economic Analysis Center, 2001

EA Checklist - Alternatives

3. Alternatives (continued)
 - j. If other Government organizations can provide the desired product or service, have they been identified as alternatives?
 - k. If the project increases productive capacity, has a contracting alternative been examined?
 - l. Are the alternatives well defined?
 - m. Do alternatives overlap one another? Why?

Department of the Army Economic Analysis Manual, US Army Cost and Economic Analysis Center, 2001

EA Checklist - Cost Estimating

4. Cost estimating
 - a. Have all costs, including common costs, been provided for each alternative?
 - b. Have cost estimates been provided for the status quo? Are they reasonable? Can they be verified?
 - c. Do labor costs consider specific skill levels, fringe benefits, overtime, and shift differential?
 - d. Is future equipment replacement properly included as an investment cost (production and deployment)?
 - e. Are current asset values, residual values, and inherited assets considered? Is the method of determining these values adequate? Has it been identified and explained?
 - f. Is space or operating area included as a capital asset and not as an operating cost?
 - g. Are cost collection methods correct?
 - h. Are CERs and methodologies identified? Are CERs adequate and structurally valid?

Department of the Army Economic Analysis Manual, US Army Cost and Economic Analysis Center, 2001

EA Checklist - Cost Estimating

4. Cost estimating (continued)
 - i. Are the sources of estimates identified? Are these sources accurate and appropriate?
 - j. Are future costs evaluated in terms of constant dollars?
 - k. Have cash flows been discounted at an appropriate discount rate?
 - l. If inflation or cost escalation is included, have the rate and the source of the rate been identified?
 - m. Are cost savings or avoidance determined only by comparing with the "status quo?"
 - n. Are cost factors current and supportable?
 - o. Is appropriate backup documentation, e.g. cost data sheets and variable explanation sheets, provided to support cost estimates?
 - p. Are cost estimates consistent with assumptions and constraints?
 - q. Has the life cycle cost estimate been provided for all feasible alternatives?

EA Checklist - Benefits



5. Benefit analysis

- a. Have all project benefits, been included and adequately explained?
- b. Are the benefits identified in quantifiable, measurable terms as much as possible?
- c. Do the benefits relate to the project objective?
- d. Are secondary, side benefits identified as such?
- e. Has a ranking or priority system been developed for evaluating importance of non-quantifiable benefits?
- f. Are negative benefits identified and quantified?
- g. Is the list of benefits free of double counting?
- h. Are the assumptions identified and rationale explained? Are they too restrictive or too broad?
- i. Are estimating techniques defined? Are they appropriate?

Department of the Army Economic Analysis Manual, US Army Cost and Economic Analysis Center, 2001

EA Checklist - Benefits

5. Benefit analysis (continued)
 - j. Are information/estimation sources clearly identified?
 - k. Is all the benefit information tabulated for ease of examination?
 - l. Are data collection methods valid and adequate?
 - m. Are benefits estimating techniques valid?
 - n. If savings have been claimed, will a budget actually be reduced?
Have the identified savings been fully coordinated with the impacted activity?
 - o. Have all advantages and disadvantages of the alternatives been identified?
 - p. Were the criteria used to measure the benefits justified by the context of the EA?
 - q. Is expert opinion used? Were these experts properly qualified?
 - r. Has there been a rational assessment of nonquantifiable factors?

Department of the Army Economic Analysis Manual, US Army Cost and Economic Analysis Center, 2001

EA Checklist - Comparison

6. Comparative analysis of costs and benefits
 - a. Do the comparison and selection criteria agree with those in the project or mission objective statement?
 - b. Do the alternatives permit attainment of the project objective?
 - c. Have costs and benefits information for each alternative been combined to show relationships such as cost benefit ratios, and so on?
 - d. Are the alternatives compared to the status quo?
 - e. Were alternatives compared using the proper quantitative technique(s); such as benefit cost ratio, savings-to-investment ratio, etc? Does the benefit-cost ratio reflect worthwhile alternatives for completeness?
 - f. Was an incremental analysis performed?
 - g. Have trade-offs between benefits been considered?
 - h. Does the analysis seem free of bias in favor of a particular alternative (for example, no benefits indicated for one or more of the alternatives, biased assumptions, and so on)?
 - i. Was the cost impact of parallel operations included?
 - j. Are the economic lives reasonable?

*Department of the Army Economic
Analysis Manual, US Army Cost and
Economic Analysis Center, 2001*

EA Checklist - Sensitivity

7. Sensitivity/risk/uncertainty analysis
 - a. If a risk analysis has been performed, how were the probability estimates derived?
 - b. Has an uncertainty analysis been performed? What technique was used (for example, a fortiori or contingency analysis)?
 - c. Were ranges of values used for unknown quantities?
 - d. Were point values varied to illustrate impact?
 - e. Have all relevant "what if" questions been answered? Are they documented in the EA?
 - f. Has a sensitivity analysis been performed to show the impact of changes in dominant cost elements? Examples are length of economic life; volume, mix or pattern of workload; requirements; organizational structure; equipment, hardware, or software configuration; or, impact on the length of time for project completion. If no sensitivity analysis has been performed, why not?
 - g. What do the sensitivity analysis results imply about the relative ranking of alternatives?
 - h. Would the recommendation stay the same if an unknown characteristic varied within a feasible range?

EA Checklist - Recommendation

8. Recommendation checklist
 - a. Are the recommendations logically derived from the material?
 - b. Are the recommendations feasible in the real world of political or policy considerations?
 - c. Are the recommendations based on significant differences between the alternatives?
 - d. Do benefits exceed costs for the preferred alternative?
 - e. Does the analysis data support the recommendation?
 - f. Is the recommended alternative supported with proper rationale? Are the reasons clearly identified and documented?
 - g. Have all significant differences between the recommended alternative and others been emphasized?

Department of the Army Economic Analysis Manual, US Army Cost and Economic Analysis Center, 2001

EA Checklist - Documentation

9. Documentation checklist
 - a. Is the EA documentation consistent with other program documentation?
 - b. Will the EA "stand on its own?"
 - c. Will an independent reviewer be able to reach the same conclusion?
 - d. Is the EA documentation adequate for the reviewer to duplicate cost and benefits estimates?

Department of the Army Economic Analysis Manual, US Army Cost and Economic Analysis Center, 2001

Related and Advanced Topics

- Special Cases
- Benefits Analysis
- NPV vs. IRR and Payback Period
- Depreciation

Special Cases

- Functional Economic Analysis (FEA)
- Commercial Activities (A-76)
- Analysis of Alternatives (AoA)
- Lease-Purchase Decisions
- Other Special Cases



Special Cases - FEA

- Economic Analyses or variants of an EA are used in some special studies
-  Functional Economic Analysis (FEA)
 - FEA focuses on business process improvement
 - Involves EA calculations, but incorporates strategic plans, process analysis and other business functions
 - Goal of FEA is to improve effectiveness, reduce costs, and streamline organization
 - Goal is *not* to develop a new capability



Special Cases - A-76

- Commercial Activities (A-76)
 - Sometimes referred to as Outsource or Privatization Studies
 - A-76 focuses on determining if private industry can provide service “better” than government
 - Studies are governed by strict rules regarding what can/cannot be outsourced and how to conduct estimates
 - OMB Circular A-76 provide guidance and rules on conducting a study



Special Cases - A-76

- Commercial Activities (A-76)
 - Analysis involves an informal comparison of costs
 - Analysis assumes alternatives can perform activities identically
 - Specific benefits estimate is not required
 - However, alternatives must be defined carefully while keeping benefits in mind to ensure assumption that activities can be performed identically is upheld



Special Cases - AoA



• Analysis of Alternatives (AoA)

- A formal process that compares the merits of different military systems being considered for acquisition



AKA Cost and Operational Effectiveness Analysis (COEA)

- AoAs consider both cost and effectiveness
- DoDI 5000.2: “For a major defense acquisition program (Acquisition Category I), an Analysis of Alternatives (AoA) is required at major milestone decision points”

Analysis Handbook, A Guide for Performing Analysis Studies: For Analysis of Alternatives and Functional Solution Analyses, Office of Aerospace Studies, AFMC, July 2004.

Tip: AoAs are generally the earliest and broadest of EA-type studies.



Special Cases - Lease-Purchase

- Lease-Purchase Decisions
 - Standalone special EA or an analysis that part of a larger EA effort
 - Usually involves two alternatives: lease, purchase
 - Cost and Benefits estimate usually not as extensive as with Major System Acquisitions
 - Involves impact analysis of unique items:
 - Taxes
 - Costs for Ancillary Services
 - Costs associated with acquiring property and preparing it for use
 - Repair/Improvements costs (if included in lease)
 - Operations costs (if included in lease)
 - Imputed property taxes
 - Imputed insurance premiums



Special Cases - Other

- Guidance on other “special cases” varies by organization
- Examples include:
 - MILCON Projects
 - Overseas Activities
 - Warranty Analysis
 - Asset Sale Analysis



Quantifying Non-Monetary Benefits

- Produce common list of benefits as basis for assessing all alternatives
- Rank benefits in order of importance
- Prioritize benefits (assign “weight points”)
- Estimate how much each alternative meets the objective
 - 100 percent - Optimum Solution
 - 0 percent - Does Not Meet Objectives
- Multiply percentage estimate and benefit weight points to determine benefit value
- The alternative with the highest benefit score is the alternative that would yield the most benefit

** The sum of benefit values is the benefit score for that alternative



Sample Benefits Matrix

Benefits	Weight Points	Alternative 1	Alternative 2		Alternative 3		Alternative 4		Alternative 5	
Aesthetics	10	Not Feasible	90%	9	90%	9	90%	9	90%	9
Building Functions	8		50%	4	60%	4.8	65%	5.2	60%	4.8
Durability	7.5	Not Feasible	55%	4.125	55%	4.125	65%	4.875	50%	3.75
Flexibility in Functional Use and Disposition	4	Not Feasible	85%	3.4	70%	2.8	75%	3	60%	2.4
Location	4	Not Feasible	50%	2	50%	2	50%	2	40%	1.6
Operation & Maintenance	4	Not Feasible	50%	2	50%	2	50%	2	40%	1.6
Total Benefit Score		N/A	24.53		24.73		26.08		23.15	
Total NPV		N/A	\$34,596,762		\$42,157,114		\$68,307,235		\$35,604,337	
Benefit/Cost Ratio		N/A	7.1		5.8		3.8		6.5	
Scale	100% Optimum solution; 0% Does not meet criteria									
Weight Points	1 is least important, 10 is most important; More than one benefit can have the same weight									
Benefit/Cost Ratio	Derived by dividing the benefit score by the NPV									
NOTE: Alternative 2 has the highest B/CR; meaning for ever \$1 spent, get \$7.1 in benefits.										

NOTE: Above matrix included in supporting documentation. Conclusion matrix included in EA Recommendation paragraph.

Conclusion			
Alternatives Examined	Net Discounted Cost (10 Years)	Benefit Score	Benefit/Cost Ratio
1. Statis Quo	Not Feasible		
2. Alternative 1	\$34,596,762	24.53	7.1
3. Alternative 2	\$42,157,114	24.73	5.8
4. Alternative 3	\$68,307,235	26.08	3.8
5. Alternative 4	\$35,604,337	23.15	6.5
6. Alternative 5	Not Feasible		



Benefits Analysis Documentation

- Identification and Definition:
 - Clearly defined list of all non-monetary benefits and explanation of impact each has on overall project
- Categorization:
 - Documented categorization of all non-monetary benefits as to their importance for consideration in the EA
- Measurement:
 - Method and process undertaken to arrive at final outcome
- Ranking:
 - Final results of benefits analysis process
- Participating Personnel:
 - List of names, titles, organization/office, and phone number



Net Present Value (NPV)

- Examines project cash flows and discounts them to a given base year
- Decision criteria
 - Accept all projects with a positive NPV
 - Reject all those with a negative NPV
 - If infeasible to accept all projects with positive NPVs, highest NPVs should be selected over lower NPVs
- Optimal solution maximizes total NPV of multiple projects subject to annual funding limitations



Return on Investment (ROI) Analysis

- Attempts to derive single value which summarizes merits of a project
- Projects with higher ROIs should be accepted over those with lower ROIs
- Problems
 - ROI method ignores size/scale of projects
 - Possible to derive more than one result
 - For projects with positive cash flows preceding negative cash flows, ROI decision rule can lead to selection of project with negative NPV

Payback Period Analysis

- Looks at years required to recover project's original investment with discounted cash flows
- If payback period within desired time horizon, project should be accepted
- Project with shorter payback period would be selected over one with a longer payback period
- Drawbacks
 - Ignores cash flows generated after the project has paid for itself
 - Does not provide decision rule for deciding between multiple projects with identical payback periods
 - No generally accepted procedures for determining required number of years for project to pay for itself

Depreciation

-  Depreciation: the phenomenon that assets with finite lives lose value over time
 - Roughly corresponds to normal “wear and tear”
 - “Blue-book” value of an automobile, e.g.
- Non-cash expenditure
- Important for accounting, tax, and capital planning purposes
- (Cumulative) Depreciation =
 Initial Value - Current (Residual) Value
- Depreciation methods calculate path from Initial Value to Terminal Value



Depreciation Methods



Straight-Line - constant value every year

- Simplest and most common



Sinking Fund - Annuity so that total depreciation = residual value at end of life

- Rate of depreciation increases with time



Declining Balance - each period's depreciation = residual value x (factor/N)

- N = number of periods
- Most common factor is 2 ("double-declining balance")
- Rate of depreciation decreases with time
- Fast depreciation early is perhaps most realistic
 - Your car loses value as you drive it out of the showroom!
 - Also advantageous for tax purposes
 - Modified Accelerated Cost Recovery System (MACRS) variant is used for U.S. Income Tax



Sum of the Years Digit - each period's depreciation = total depreciation x period number (from the end) / sum

- Historical method, fairly easy to compute
- Rate of depreciation decreases with time - less early depreciation than declining balance

• Others - Units of Production, Units of Time



Unit V - Module 13



Depreciation Methods - Illustrated

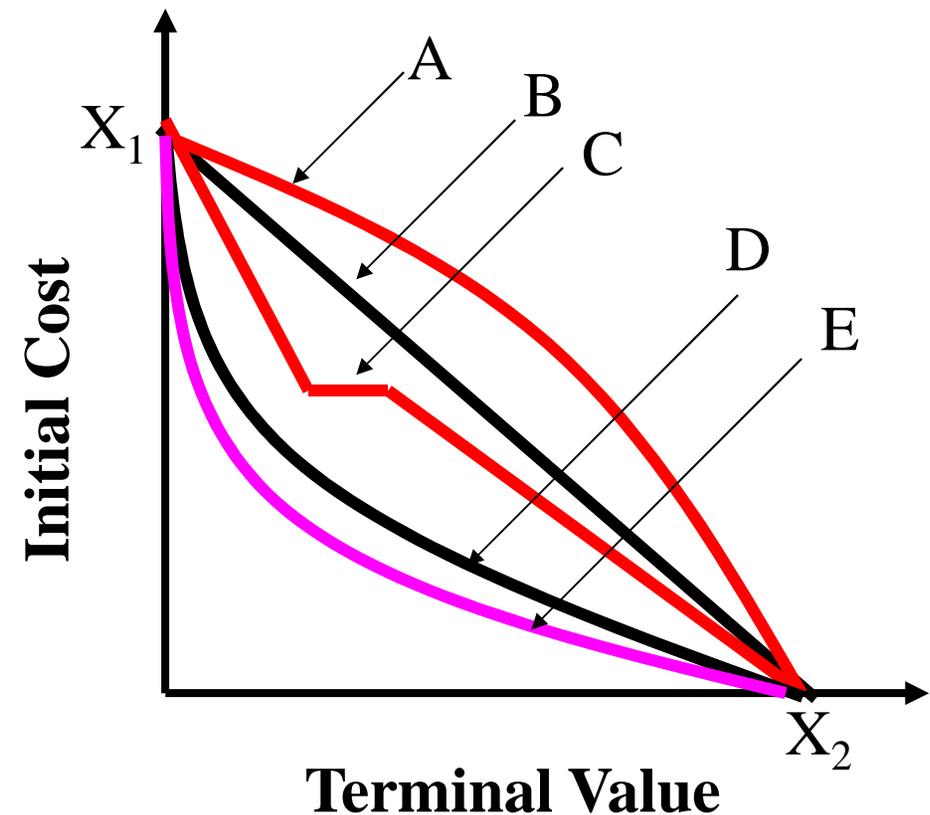
A = Sinking Fund Method

B = Straight Line Method

 C = Multiple Straight Line Method

D = Sum of the Years Digit Method

E = Declining Balance Method



Depreciation Methods - Straight Line

Depreciation = (Cost - Residual value) / Useful life

Example: On April 1, 2006, Company A purchased an equipment at the cost of \$140,000. This equipment is estimated to have 5 year useful life. At the end of the 5th year, the salvage value (residual value) will be \$20,000. Company A recognizes depreciation to the nearest whole month. Calculated depreciation expenses for 2006, 2007 and 2008:

Depreciation for 2006
 $= (\$140,000 - \$20,000) \times 1/5 \times 9/12 = \$18,000$

Equipment Cost Salvage Value 5 yr useful life 9 Months (April - December)

Depreciation for 2007
 $= (\$140,000 - \$20,000) \times 1/5 \times 12/12 = \$24,000$

Depreciation for 2008
 $= (\$140,000 - \$20,000) \times 1/5 \times 12/12 = \$24,000$

Depreciation Methods - Declining Balance

Depreciation = Book value x Depreciation rate
Book value = Cost - Accumulated depreciation

Depreciation rate for double declining balance method
= Straight line depreciation rate x 200%

Depreciation rate for 150% declining balance method
= Straight line depreciation rate x 150%

Example, Double declining balance depreciation:

On April 1, 2006, Company A purchased an equipment at the cost of \$140,000. This equipment is estimated to have a 5-year useful life. At the end of the 5th year, the salvage value (residual value) will be \$20,000. Company A recognizes depreciation to the nearest whole month.



Depreciation Methods - Declining Balance Example

Calculated depreciation expenses for 2006, 2007 and 2008:
Useful life = 5 years--> Straight line depreciation rate = $1/5 = 20\%$ per year

Depreciation rate for double declining balance method

$$= 20\% \times 200\% = 20\% \times 2 = 40\% \text{ per year}$$

Depreciation for 2006

$$= \$140,000 \times 40\% \times 9/12 = \$42,000$$

Depreciation for 2007

$$= (\$140,000 - \$42,000) \times 40\% \times 12/12 = \$39,200$$

Depreciation for 2008

$$= (\$140,000 - \$42,000 - \$39,200) \times 40\% \times 12/12 = \$23,520$$

Year	Book Value at the beginning	Depreciation Rate	Depreciation Expense	Book Value at the year-end
2006	\$140,000	40%	\$42,000 (*1)	\$98,000
2007	\$98,000	40%	\$39,200 (*2)	\$58,800
2008	\$58,800	40%	\$23,520 (*3)	\$35,280
2009	\$35,280	40%	\$14,112 (*4)	\$21,168
2010	\$21,168	40%	\$1,168 (*5)	\$20,000

