NISTIR 90-4255

ECONOMIC ANALYSIS FOR MILITARY CONSTRUCTION DESIGN

CONCEPTS, TECHNIQUES, AND APPLICATIONS FOR THE ANALYST

STUDENT'S MANUAL

Rosalie T. Ruegg
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U.S. DEPARTMENT OF COMMERCE
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STUDENT'S MANUAL

for
A Five-Day Course for Design Professionals

PROSPECT Course: ECO ANAL/MILCON DES: TECH
offered by the
Huntsville Training Division of the U.S. Army Corps of Engineers

Prepared by:
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Sponsored by:
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Huntsville Training Division

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PREFACE

This Student's Manual for *Economic Analysis for Military Construction Design: Concepts, Techniques, and Applications for the Analyst"* is a workbook for a five-day course on Economic Analysis/Life-Cycle Cost Analysis (EA/LCCA) of Military Construction (MILCON) facilities. The methodology and procedures in this manual are consistent with Army Technical Manual 5-802-1; they do not reflect the amendments to 10 CFR part 436, which update the guidelines for energy management programs for Federal buildings and are set forth in Federal Register, Vol. 55, No. 224, Nov. 20, 1990.

The purpose of the course is to provide MILCON design professionals with the knowledge and skills they need to perform economic analysis quickly and efficiently. At the request of the Huntsville Training Division of the U.S. Army Corps of Engineers (USACE), the Office of Applied Economics at the National Institute of Standards and Technology (NIST) has developed the course, prepared the supporting manuals, and presented the course.

This Student's Manual presents the criteria and standards that govern EA/LCCA in MILCON design, treats basic economic concepts, gives step-by-step instructions for performing EA/LCCA, and provides examples of calculations and analyses. It also contains worksheets and data tables for doing hands-on analysis in class. In addition, the manual contains a comprehensive test to evaluate students' before- and after-class knowledge of EA/LCCA.

The authors are indebted to their colleagues at the NIST Office of Applied Economics for their reviews of the manual and to the students who made many useful comments when the course was field-tested in Huntsville, AL. They are especially grateful to Dr. Larry Schindler of HQ USACE for his excellent comments, advice, and extensive guidance throughout the development of the course and the preparation of the training materials.

This course material is consistent with
Technical Manual 5-802-1,
Headquarters, Department of the Army, December 31, 1986,
and does not reflect subsequent changes by the Department of Energy
to the LCC Rules and Regulations pertaining to energy conservation.

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MEMO TO STUDENT

Dear Student,

This is your class workbook for learning concepts, techniques, and applications of economic analysis as applied to military construction design.

An outline of topics covered in the course and approximate times devoted to each appears on the next page. Brief biographies of the instructors and a list of students follow. A table of contents provides a directory to the 16 modules in the workbook.

The first module orients you to Huntsville and to the course. The second is a pretest which we give near the start of the course to measure your proficiency with the technical subject prior to training, and to learn more about current attitudes and practices concerning economic analysis. The third module provides aids to learning for your reference as needed throughout the course. It includes a glossary, list of symbols and abbreviations, instructions on using calculators (which were also mailed to you prior to the course), guidelines on significant figures, and a page for recording ideas and applications which you can take back to your job.

In Modules 4 through 9, we will establish the basics of performing economic analysis. In Modules 10 through 13, we will take up topics for the "experienced analyst," which we hope you are on the way to becoming. Of course, it takes considerable on-the-job practice with the techniques covered in the course to become a truly experienced analyst. But we think that you will benefit from an introduction to these more advanced topics.

Module 14 is a test which we administer at the end of the course to measure gains in proficiency with the subject. Module 15 is a skills laboratory which concludes the five-day training course. It gives students an opportunity to apply their new skills under supervision and to resolve remaining questions.

To assist with your notetaking, the Workbook contains all of the visuals used in the instruction with space for notes below. It also contains all the exercises which you will perform in class. Each of the technical modules lists the learning objectives and summarizes key points. Explanatory notes are also included from time to time.

The workbook is not intended to be used as a stand-alone tutorial. Rather, it is designed to be used with an instructor who provides additional information. However, the Workbook with your notes and completed exercises provides a useful document for later reference and review. We request that you take it back with you and use it.

We invite you to ask questions, try out procedures, and seek clarification of any questions you might have as we go along. It is our goal, through a combination of instructional activities, to help you discover the power of economic analysis to improve decisions in your daily work.

Sincerely,
Your instructors

ECONOMIC ANALYSIS FOR MILCON DESIGN
Concepts, Techniques, and Applications for the Analyst

Time	Day 1	Day 2	Day 3	Day 4	Day 5
	BASICS OF ECONOMIC ANALYSIS			ADVANCED TOPICS	
0800	(1) Orientation	Review	Review	(11) Uncertainty	(14) Other Economic Measures
	(2) Pretest				
0900		(6) Continued	(8) Energy Studies		
1000	(4) Improving Decisions with Economic Analysis			(12) Critique of EA/LCCA	Review
1100				(13) Putting EA/LCCA into Practice	(15) Posttest
					Evaluation
1200	LUNCH	LUNCH	LUNCH	LUNCH	LUNCH
1300	(5) Time Value of Money	(7) MILCON General Economic Studies	(9) Data	(13) Continued	(16) Skills Lab
1400					CLOSE
1500	(6) Arithmetic				
1600				(10) Performing LCCA with Computers	
1700	FREE	FREE	FREE	FREE	
Evening (1800-2030)				Computer Lab	

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ECONOMIC ANALYSIS FOR MILCON DESIGN: CONCEPTS, TECHNIQUES, AND APPLICATIONS FOR THE ANALYST

Short Title:	ECO ANAL/MILCON DES: TECH
Course Length:	38 Hours

PURPOSE

The course equips professionals actively involved in the design and review of MILCON projects to accomplish each of the following, in accordance with Army criteria: (a) select the appropriate type and level of economic analysis (EA)/life-cycle-cost analysis (LCCA), (b) conduct EA/LCCA studies and document the results in a cost-effective manner, (c) accomplish quick and incisive critical reviews of EA/LCCA studies performed by others, and (d) interpret results and make recommendations for the design decision.

DESCRIPTION

The course teaches economic analyses (EAs) for MILCON designs. It presents the Army criteria governing the conduct of EA and explains the key provisions; teaches how to use the life-cycle-costing method for measuring economic performance; demonstrates a variety of applications through realistic examples and case studies; discusses when and how to take into account uncertainties; provides guidance for collecting data and making assumptions; explains how to interpret and use EA results to select cost-effective designs from competing alternatives. The course also introduces computer software for EA calculations (with emphasis on the Corps' LCCID program); reviews savings-to-investment ratio and discounted payback methods; provides guidance on how to tailor the analysis and its documentation to the situation at hand; and helps develop skills in reviewing EAs performed by others, and in presenting and defending EA results. Classroom exercises give participants opportunities to apply knowledge and skills gained to typical MILCON design situations.

PREREQUISITES

Nominees must be assigned:

a. Occupational Series: 0110 and 0800

b. Grade: GS-07 through 13

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PART I. ADMINISTRATIVE

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FOLLOW-UP CONTACT ADDRESS

For follow-up questions on the course "ECONOMIC ANALYSIS FOR MILCON DESIGN, Concepts, Techniques, and Applications for the Analyst," contact

Dr. Larry Schindler

Mailing address:	HQ USACE (CEMP-EC) Office Chief of Engineers Rm. 3224 20 Massachusetts Ave., NW Washington, DC 20314-1000
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THE INSTRUCTORS

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LIST OF STUDENTS

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CONTENTS OF NOTEBOOK OF REFERENCE MATERIAL FOR ECO ANAL/MILCON DES: TECH

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MODULE 1

ORIENTATION

Purpose:

- To acquaint you with fellow students and the instructors
- To acquaint you with your environment and schedule
- To define the goal of the course and its benefits
- To introduce your training materials
- To answer questions and address problems you may have

Outline:

- Orientation Materials

Approximate Time:

30 minutes

Slide 1-1

ECONOMIC ANALYSIS
FOR
MILCON DESIGN

Concepts, Techniques, and Applications
for
the Analyst

MODULE 2

PRETEST

Purpose:

- To assess your knowledge about the subject before training
  - for self assessment of your current level of knowledge and skills in EA/LCCA and need for improvement
  - to help instructors identify topics requiring special work
  - to serve as a bench mark for measuring effectiveness of training

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2.1 PRETEST

1) Which of the following statements most accurately reflects your experience with economic analysis/life-cycle cost analysis (EA/LCCA)?
(Check the appropriate answer.)

____ I have used EA/LCCA extensively.

____ I have limited experience with EA/LCCA.

____ I have never used EA/LCCA, but I work closely with others who do.

____ I have never used EA/LCCA, but I have a new assignment that requires it.

____ None of the above. Explain: ______________________________

____

2) State your opinion about the usefulness and practicality of EA/LCCA applied to MILCON design:

3) List your personal objectives for the training course (what you hope to get out of it):

4) List the main obstacles you see to performing EA/LCCA as part of the MILCON design process:

5) Look at the list in this section, entitled "What design professionals need to be able to do."

   5a) Identify yourself as primarily a

   a) ____ DESIGN ENGINEER

   b) ____ COST ENGINEER

   c) ____ MANAGER

   ____ Design Manager

   ____ Project Manager

   ____ VE Officer

   ____ Other

   d) ____ OTHER ________________

   5b) Go to the job task section that best fits you, i.e., the task section for Design Engineers, Cost Engineers, or Managers (if you checked d above, take a position (a - c) that fits best) and

   - CHECK the task if you agree that you need to be able to do it in order to perform your job as it should be done.

   - CIRCLE the check mark if you believe you presently perform the task as it should be done.

5c) Did you check a) _____ all b) _____ most

c) _____ a few d) _____ none of the tasks?

Did you circle a) _____ all b) _____ most

c) _____ a few d) _____ none of the tasks?

WHAT DESIGN PROFESSIONALS NEED TO BE ABLE TO DO:

Tasks Involving Knowledge and Skills in Economic Analysis

JOB TASKS OF DESIGN ENGINEERS

Ideally, at the working level, Corps design engineers (in their capacities as designers, design reviewers, and members of value-engineering teams) will perform the following tasks as needed in the manner indicated:

1. Conduct preliminary studies to determine the appropriate type and level of effort for economic analysis/life-cycle cost analysis (EA/LCCA) for the MILCON design decision at hand, taking into account Army, Air Force, or Navy criteria.

2. Work with cost engineers and other colleagues to identify sources of data, obtain required data, and make necessary assumptions.

3. Taking the appropriate level of effort (as identified in 1) and being responsive to applicable criteria, perform EA/LCCA efficiently and correctly, taking into account uncertainties in the analysis.

4. Properly interpret the results of EA/LCCA in the context of the design process.

5. Develop clear and appropriate recommendations for design decisions based on economic considerations.

6. Provide appropriate documentation for EA/LCCA in a cost-effective manner for the conditions at hand.

7. Perform quick and incisive critical reviews of the EA/LCCAs conducted by others (including review of analyses, interpretation of results, and documentation) and identify any deficiencies, errors, and deviations from contract or other agreed-upon provisions.

8. Develop A-E contract provisions for EA/LCCA as needed, taking into account applicable criteria.

9. Communicate effectively with management regarding EA/LCCA requirements, status, and results.

10. Defend decisions based on EA/LCCA.

JOB TASKS OF COST ENGINEERS

Ideally, at the working level, cost engineers will perform the following tasks as needed:

1. Provide supporting cost data of appropriate quality and in the appropriate format to Corps design engineers.

2. Assist Corps design engineers in making appropriate assumptions.

3. Communicate effectively with Corps design engineers and management about cost estimating requirements for individual EA/LCCAs.

JOB TASKS OF MANAGERS

Ideally, at the management level, managers will perform the following tasks:

1. Assure that EA/LCCAs are conducted as an integral part of the design process for all MILCON projects.

2. Assure that all EA/LCCAs are conducted in accordance with current Army criteria.

3. Assure that the appropriate type and level of EA/LCCAs are applied to each design decision.

4. Assure that the results of EA/LCCAs are appropriately documented in a cost-effective manner, design-discipline-wide and project-wide.

5. Prepare reliable estimates of resources required to support the appropriate level of EA/LCCA effort for all aspects of each design project.

6. Develop appropriate requirements and criteria for cost-effective documentation of each level of EA/LCCA for each design project.

7. Determine standards of performance in EA/LCCA for staff supervised, evaluate performance, and identify related staff training needs.

8. Develop A-E contract provisions for EA/LCCA as needed, taking into account applicable criteria.

9. Accomplish quick and incisive critical reviews of EA/LCCAs conducted by others.

10. Make recommendations and decisions about the design process based on EA/LCCA analyses performed in-house and by A-E firms.

6) Choose the statement below which best describes the attitude in your office about economic analysis:

   a) _____ Economic analysis is a valuable decision tool.

   b) _____ Economic analysis is a nuisance which HQ/Higher Authority tries to inflict on us.

   c) _____ Economic analysis is just one more thing we take in stride, neither loving nor hating it.

   d) _____ The topic of economic analysis seldom comes up, and I am not aware of any attitude in my office about it.

7) Do you have a copy of the Technical Manual (TM 5-802-1) in your office?

   a) _____ Yes

   b) _____ No

   c) _____ Do not know

8) When you have performed economic evaluations in support of MILCON designs, which of the following best applied:

   a) _____ I used the results myself to make a design decision and prepared no documentation.

   b) _____ I used the results myself to make a design decision and filed the documentation.

   c) _____ I provided documentation to someone else who made the decision.

   d) _____ I gave an oral presentation and documentation to someone else who made the decision.

   e) _____ None of the above apply because I have not performed economic evaluations.

   f) _____ Other. Explain: ________________________________

TECHNICAL QUESTIONS

The following are technical questions relating to economic analysis. Each question is worth 1 point. Please leave a blank rather than guessing if you do not know the answer. Blanks will receive -1 point, wrong answers will receive -2 points.

1) Life-cycle costing

   a) _____ ignores first costs and takes into account future costs.

   b) _____ includes all relevant costs over a designated study period

   c) _____ neither a) nor b)

2) Life-cycle costing applies only to Army construction projects and has little applicability to solving other types of problems.

   a) _____ True

   b) _____ False

3) Adding attic insulation in building A, which saves 12.9 million Btu annually, is more cost-effective than adding attic insulation in building B, which saves 9.5 million Btu annually, given that insulation costs essentially the same in both buildings.

   a) _____ True

   b) _____ False

   c) _____ Can't tell

4) All economic analysis in support of MILCON design decisions are governed by the same set of criteria.

   a) _____ True

   b) _____ False

5) Suppose you are planning to renovate 234 houses on a military base. You estimate the initial cost of renovating the exterior of each house to be about $20,000. An A-E contractor estimates the initial cost of renovating the interior of each house at $17,958. In an initial planning document the appropriate way to express the full initial costs of renovating base housing is

   a) _____ $8,882,172

   b) _____ $8,882,200

   c) _____ $8,880,000

   d) _____ about $9 million

6) Suppose you had the choice of receiving $100 today or receiving $100 (guaranteed) in one year. Which would you choose? Place a check in the space in front of your choice.

   _____ $100 today or _____ $100 one year from now

   What about $100 today versus $105 (guaranteed) one year from now?

   _____ $100 today or _____ $105 one year from now

   Choose one from each of the following pairs

   _____ $100 today or _____ $110 (guaranteed) one year from now

   _____ $100 today or _____ $115 (guaranteed) one year from now

   _____ $100 today or _____ $120 (guaranteed) one year from now

   _____ $100 today or _____ $130 (guaranteed) one year from now

   _____ $100 today or _____ $140 (guaranteed) one year from now

   _____ $100 today or _____ $150 (guaranteed) one year from now

From your choice, what do you conclude is your annual minimum acceptable rate of return (MARR)?

MARR = _____ %

- Given that this is your annual minimum acceptable rate of return, what is the amount you would require in two years to make you willing to forego $100 today?

  Would require $ _______ in two years

- Given your annual minimum acceptable rate of return, how much would you be willing to spend today to avoid incurring a sure cost of $1,000 in one year?

  Willing to spend $ _______ now

- Given your annual minimum acceptable rate of return, how much would you be willing to spend today to avoid incurring a sure cost of $1,000 in two years?

  Willing to spend $ _______ now

7) Suppose you expect general price inflation to run about 4% per year and you are willing to invest in treasury bonds with a guaranteed return of 10% per annum. If you could be certain that the rate of inflation would be 0% instead of 4%, it would be reasonable to require a return on the bonds of about

a) _____ 10%

b) _____ 6%

c) _____ 4%

d) _____ 0%

8) Suppose you invest $5,000 in a mutual fund with an average annual return of 10% compounded annually. At the end of five years your investment will have grown to

a) _____ $8,052.55

b) _____ $7,500.00

c) _____ $5,500.00

9) Suppose you could replace the roof of your house today at a cost of $3,000, and you wish to estimate how much to budget for the replacement which you expect to be required five years from now. If roofing materials and labor are expected to increase at a rate of about 6% per year, you will need to budget approximately

a) _____ $4,000

b) _____ $3,000

c) _____ $2,000

d) _____ $3,180

e) _____ none of the above

10) To evaluate the cost effectiveness of one MILCON building design over its alternatives, it is necessary to forecast general price inflation and to add an inflation amount to the estimates of future operating, maintenance, repair, and replacement costs.

a) _____ True

b) _____ False

11) Suppose you are required to estimate future maintenance and repair costs for an HVAC system. General price inflation is forecasted to increase at a rate of 7% per annum, whereas prices for HVAC systems are forecasted to increase at an annual rate of only 4%. This means that in absolute terms (i.e., in current dollars) the HVAC price

    a) ____ increases at an annual rate of about 11%

    b) ____ increases at an annual rate of about 7%

    c) ____ increases at an annual rate of about 28%

    d) ____ decreases at an annual rate of about 3%

    e) ____ increases at an annual rate of about 3%

    And, it means that in relative terms (i.e., in constant dollars) the HVAC price

    a) ____ increases at an annual rate of about 7%

    b) ____ increases at an annual rate of about 4%

    c) ____ increases at an annual rate of about 3%

    d) ____ remains unchanged

    e) ____ increases at an annual rate of about 11%

12) Suppose you can reduce the energy costs of your house by installing insulation. You can pay for it by withdrawing funds from a money market account that pays 9% per annum, after taxes. Alternatively, you can use the money market funds to pay off a consumer loan you have outstanding at 12% per annum (after taxes). Improved comfort aside, i.e., on strictly economic grounds, the annual minimum acceptable rate of return required to induce you to install insulation is

   a) _____ 0% because the funds are already on hand

   b) _____ 9% because 9% will be lost by withdrawing the money

   c) _____ 12% because 12% could be saved by using the funds to pay off the loan instead of buying insulation

13) When an individual's or organization's minimum acceptable rate of return is used to calculate how much he, she or it would be willing to spend now in order to avoid a given future cost, the rate is typically called

   a) _____ the discount rate

   b) _____ the interest rate

   c) _____ the savings rate

   d) _____ the reduction rate

14) Suppose you are selecting a roof for a new house, and you find that a high-quality roof will last 20 years without major repairs or replacement, and a standard-quality roof will last only 10 years before it requires replacement costs of $2,000. The high-quality roof will cost you an extra $800 now. Assume you can finance the more expensive roof by taking out a larger mortgage loan at the going loan rate of 10%. The high-quality roof is

   a) _____ well worth the additional cost

   b) _____ clearly not worth the additional cost

   c) _____ likely to perform economically roughly the same as the standard quality roof

15) Suppose you are considering the use of floor coverings in a government building, saving an estimated $2,000 (constant dollars) annually in maintenance and repair expenditures over a period of 25 years. The government requires an annual minimum rate of return of 10% over and above general price inflation. Total savings starting today and accruing over 25 years will be equivalent to

a) _____ receiving a lump sum of exactly $50,000 today

b) _____ receiving a lump sum of less than $50,000 today

c) _____ receiving a lump sum of more than $50,000 today

d) _____ there is no way to determine the equivalent amount

16) Suppose the rate of general price inflation is about 4% per annum. Further assume that because of shortages, the price of oil escalates about 5% per annum faster than prices in general. In 10 years a quantity of oil which is priced at $1,500 today will have increased in price to about

a) _____ $2,250

b) _____ $3,600

c) _____ $9,300

d) _____ $2,850

17) One would conclude that with a general price inflation rate of 4%, in 10 years a dollar bill will buy

a) _____ about the same as what a dollar will buy today

b) _____ about two-thirds what a dollar will buy today

c) _____ about one-tenth what a dollar will buy today

d) _____ about one-third more than what a dollar will buy today

18) Suppose the general inflation rate is 6% per annum and you require a return at least 4% per annum over and above inflation. This means that you require a total return of about

a) ____ 6% per annum

b) ____ 4% per annum

c) ____ 10% per annum

d) ____ 24% per annum

e) ____ none of the above

19) If the total annual rate of change in fuel oil prices is 7% and the rate of general price inflation is 4%, you would say that the differential escalation rate for fuel oil is about

a) ____ 11%

b) ____ 3%

c) ____ 7%

More precisely, the differential escalation rate for fuel oil is

d) ____ 11.28%

e) ____ 2.88%

f) ____ 7.82%

20) Suppose annual maintenance and repair costs are expected to increase at the same annual rate as prices in general, say about 10%. In this case the differential annual rate of price escalation for maintenance and repair costs is

a) ____ 5%

b) ____ 7%

c) ____ 0%

d) ____ 10%

21) Refer back to question 20. Suppose you wish to estimate what maintenance and repair costs will be five years hence, based on the fact that they are $1,000 today. Stated in dollars of the future year (i.e., in current dollars which include inflation), the estimated future cost is

a) ____ $1,685 c) ____ $1,000

b) ____ $1,159 d) ____ $1,611

Stated in today's dollars (i.e., in constant dollars which exclude inflation), the estimated future cost is

a) ____ $1,685 c) ____ $1,000

b) ____ $1,159 d) ____ $1,611

22) What is the estimated present-worth equivalent of a cost of $10,000 which is expected to occur in 15 years if the discount rate is 10%?

a) ____ $2,394

b) ____ $9,091

c) ____ $10,000

d) ____ None of the above

23) Suppose you estimate a repair cost which is expected to occur in three years to be $2,000 in today's dollars (i.e., in constant dollars). Further suppose that the rate of general price inflation is 6% and that you require a 4% per annum return over and above inflation to make you willing to spend money now in order to save money in the future. The discount rate you would use to calculate the present-worth equivalent of the $2,000 future cost (in constant dollars) is

a) ____ 4%
b) ____ 10%
c) ____ 2.4%
d) ____ 6%
e) ____ 10.24%
f) ____ none of the above

24) Refer back to question 23. Suppose the rate of general price inflation were 0%. What discount rate would you use then?

a) ____ 4%
b) ____ 10%
c) ____ 6%
d) ____ 0%
e) ____ none of the above

25) Again refer back to question 23. The present-worth equivalent of the future amount of $2,000 is

a) ____ $1,679
b) ____ $1,778
c) ____ $1,370

26) Suppose an equipment replacement is expected to be required in five years. You estimate that the replacement would cost $1,000 if it were made today, and you need to know what it would cost in five years. Suppose general price inflation is expected to average 5% per annum, but the equipment is expected to increase in price only 3% per annum in absolute terms. Stated in dollars of the future year (i.e., in current dollars), the future replacement cost is estimated at

a) ____ $1,159 c) ____ $1,000

b) ____ $908 d) ____ $1,469

27) Refer back to question 26. Stated in today's prices (i.e., in constant dollars), the future replacement cost is estimated at

a) ____ $1,469 c) ____ $1,159

b) ____ $1,000 d) ____ $909

28) Again refer back to question 26. Suppose your minimum acceptable rate of return is 5% over and above inflation. Working in future year dollars (i.e., in current dollars) and including inflation in the discount rate, the present-worth equivalent of the future replacement cost is

a) ____ $712 c) ____ $1,181

b) ____ $1,000 d) ____ $1,390

Working in today's dollars and excluding inflation from the discount rate, the present worth equivalent of the future replacement cost is about

a) ____ $1,181 c) ____ $712

b) ____ $1,000 d) ____ $1,390

29) As a general rule, if one includes general price inflation in estimates of future costs (i.e., if one states future costs in current dollars), it is imperative also to

a) _____ deduct the differential escalation rate

b) _____ add the differential escalation rate

c) _____ exclude an estimate of the rate of general price inflation from the discount rate

d) _____ include an estimate of the rate of general price inflation in the discount rate

30) As a general rule, if one excludes general price inflation in estimates of future costs (i.e., if one states future costs in constant dollars), it is imperative also to

a) _____ add the differential escalation rate

b) _____ deduct the differential escalation rate

c) _____ exclude an estimate of the rate of general price inflation from the discount rate

d) _____ include an estimate of the rate of general price inflation in the discount rate

31) Draw a cash flow diagram based on the following information:

Construction will begin two years from the date of study and will last one year. Assume that the construction costs of $100,000 will be incurred at the mid point of the construction period. A repair cost of $20,000 will be incurred 15 years from the date of study; maintenance costs of $5,000 will be incurred annually beginning six months after the end of construction (beginning of beneficial occupancy). A retention value of $10,000, net of disposal costs will remain at the end of 25 years of occupancy.

32) Calculate the life-cycle cost of sliding entry doors for an Army reserve building -- one of several design alternatives for entry doors under consideration. Significant costs are limited to the following:

Present worth of installation costs	$57,600
Present worth of energy costs for photo-electric control system	$1,400
Present worth of annually recurring nonfuel O&M costs	$1,700
Present worth of replacement costs	$6,000

$ __________ = Life-cycle cost

33) Attic insulation can be added to Army housing to reduce energy costs. Assuming there is no insulation present and the space will accommodate insulation up to a level of R38 (resistance level 38), choose the cost-effective level based on the following life-cycle cost data:

	Insulation Level	LCC $
a) _____	0	25,000
b) _____	R11	15,000
c) _____	R19	8,800
d) _____	R30	7,500
e) _____	R38	8,200

34) A general economic study is to be performed for a MILCON building design. The building in question is to last indefinitely. In most cases the maximum analysis period for calculating life-cycle costs is how many years from Beneficial Occupancy Date (BOD)?

a) _____ 40 years

b) _____ 25 years

c) _____ 28 years

d) _____ 15 years

35) In order to compute the life-cycle cost of a MILCON design alternative, you should discount all amounts to their present-worth equivalent as of the

a) ____ Analysis Base Date (ABD)

b) ____ Beneficial Occupancy Date (BOD)

c) ____ Midpoint of Construction (MPC)

d) ____ Analysis End Date (AED)

e) ____ Time you select, since this will vary depending on the project

36) When estimating future costs for MILCON design alternatives, it is essential to include the projected rate of general price inflation in estimates of future costs.

a) ____ True

b) ____ False

37) The discount rate for general economic studies is

a) ____ 5%

b) ____ 10%

c) ____ 7%

d) ____ 6%

e) ____ 12%

f) ____ there is no specified rate

38) A routine economic analysis of parking lot surfaces shows the following results:

Surface Type	LCC	Initial Cost	Energy Cost
A	$37,000	$13,000	0
B	$40,000	$15,000	0

Is an uncertainty assessment required?

a) _____ yes

b) _____ no

39) Which of the following two design alternatives would you recommend?

a) _____ Alternative A: LCC = $40,000
Initial investment cost = $15,000

b) _____ Alternative B: LCC = $40,100
Initial investment cost = $10,000

40) In the economic analysis of energy-conserving building systems, which features are different from those of a general economic study?

a) _____ Discount rate

b) _____ Treatment of inflation

c) _____ Types of costs which may be included

d) _____ All of the above

41) Calculate the present worth of a series of annually recurring electricity costs of \$28,000 (in constant 1988 dollars) for a domestic hot water system to be installed in a housing complex of a military base in Texas. Assume that the Analysis Base Date (ABD) is July 1988 and the system will last 10 years. The discount rate is 10% and the appropriate One Step Adjustment Factor (OSAF) is 0.5162.

The PW of the series is

a) ____ \$107,900

b) ____ \$144,500

c) ____ \$280,000

d) ____ \$542,425

42) The following costs and energy consumption data are estimated for two alternative natural gas domestic hot water systems in an administration building in Ft. McCoy, WI. There is uncertainty regarding the energy consumption of alternative A, which may be up to 35% higher than the most likely estimate. Recommend the system to be selected.

<u>Alternative A</u>

Initial investment:	\$80,000
Natural gas consumption:	10,000 mill. Btu/year
LCC_A:	\$717,425
LCC_A, taking into account 35% higher energy consumption:	\$940,524

<u>Alternative B</u>

Initial Investment:	\$25,000
Natural gas consumption:	\$20,000 mill. Btu/year
LCC_B:	\$1,299,850

The system selected is

a) _____ Alternative A

b) _____ Alternative B

43) The Army's Construction Engineering Research Laboratory (CERL) has developed a database for estimating maintenance and repair costs. Which of the following statements are correct?

a) _____ Maintenance and repair costs are often the data most difficult to estimate.

b) _____ CERL's database facilitates the estimation of LCC maintenance and repair costs for components of major building systems.

c) _____ CERL's LCC cost factors for maintenance and repair are constructed from time study data.

d) _____ Cost factors are given per unit of component.

e) _____ Local wage rates can be reflected in maintenance and repair costs using CERL's database.

f) _____ All of the above.

44) Assume that an HVAC system uses 3,000 million Btu of electricity per year and the price today is $19.40/million Btu. If the differential rate of energy price escalation is projected to be 5% for the next year and the discount rate is 7% over and above general price inflation, the present worth of a year's energy consumption paid at the end of the first year is

a) _____ $58,200

b) _____ $57,112

c) _____ $60,920

45) Suppose the expected service life of an HVAC system in an Air Force administration building exceeds by 10 years the 25-year study period for an LCC analysis. This could be taken into account in an LCC study by

a) _____ including a replacement cost

b) _____ assuming a retention value at the end of the study period

c) _____ it cannot be taken into account

46) The most appropriate time for LCC analysis of MILCON designs is

a) _____ during preconcept design

b) _____ during concept design

c) _____ at the time of final design

47) Choose the statement you think is most valid for LCC analyses:

a) _____ LCCAs are very expensive and time-consuming and should be done only in support of major decisions.

b) _____ LCCAs are very inexpensive and should be done in support of all decisions.

c) _____ LCCAs can be done with varying levels of effort and are not always necessary.

48) As a project manager dealing with an A-E contractor on a design project, your responsibilities with respect to economic analysis include the following activities:

a) _____ Specify appropriate Army or Air Force

b) _____ Indicate desired level of effort

c) _____ Specify documentation requirements

d) _____ All of the above

49) Suppose alternative A has higher first cost but significantly lower life-cycle costs than alternative B. You can use the results of an LCC analysis to

a) _____ support a request for increased funds when the Current Work Estimate (CWE) is higher than the Programmed Amount (PA)

b) _____ support the recommendation of design alternative A to Higher Authority

c) _____ rebut criticism of design alternative A

d) _____ all of the above

50) Which of the following statements is incorrect? A computer-aided LCC analysis program, such as LCCID,

a) _____ determines the objectives of the analysis, identifies alternatives, and interprets results

b) _____ makes fast and accurate calculations

c) _____ incorporates ready data files

d) _____ makes it easier to use the methodology

e) _____ provides documentation

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MODULE 3

AIDS TO LEARNING

Purpose:

- To provide a convenient grouping of items which pertain to all of the other modules and to which you may wish to refer frequently

Outline:

3.1 Acronyms and Symbols

3.2 Use of the Hand-Held Calculator for LCC Calculations

3.3 Guidelines on Significant Figures

3.4 Ideas about Applications

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3.1 ACRONYMS AND SYMBOLS

A	- A Uniformly Recurring Annual Amount
A_i	- First in a Series of Annual Amounts Recurring Nonuniformly
ABD	- Analysis Base Date
AED	- Analysis End Date
A-E	- Architect-Engineer
AIRR	- Adjusted Internal Rate of Return
AR	- Army Regulation
ASA	- Assistant Secretary, Army
ASTM	- American Society for Testing and Materials
BCR	- Benefit-to-Cost Ratio
BOD	- Beneficial Occupancy Date
BRC	- Budget Review Committee
Btu	- British Thermal Units
BY	- Budget Year
CACES	- Computer-Aided Cost Estimating System
CCC	- Current Construction Cost
CD	- Construction Division
CDS	- Concept Design Study
CE	- Corps of Engineers
CONUS	- Continental United States
C_F	- Cost of an Item to Occur in the Future as of that Future Time
C_P	- Cost of an Item to Occur in the Future as of the Date of Study
CPI	- Consumer Price Index
CERL	- Construction Engineering Research Laboratory

D	- Market (Nominal) Discount Rate, Including General Price Inflation
d	- Real Discount Rate, Excluding General Price Inflation
DA	- Department of Army
DOE	- U.S. Department of Energy
DOS	- Date of Study
DPP (DPB)	- Discounted Payback
DY	- Design Year
E	- Total Rate of Price Escalation, Including General Price Inflation
e	- Differential Rate of Price Escalation, Excluding General Price Inflation
EA/LCCA	- Economic Analysis/Life-Cycle Cost Analysis
ECIP	- Energy Conservation Improvements Projects
EV	- Expected Value
F	- A Future Amount
FOA	- Field Operating Agency, USACE
FY	- Fiscal Year
HQDA	- Headquarters, U.S. Army Corps of Engineers
I	- Rate of General Price Inflation
kWh	- Kilowatt Hours
LCC	- Life-Cycle Costs or Life-Cycle Costing
LCCID	- Life-Cycle Cost in Design
MARR	- Minimum Acceptable Rate of Return
MCP	- Military Construction Program
MILCON	- Military Construction
MPC	- Midpoint of Construction
M&R	- Maintenance and Repair

N	-	Number of Years in the Study Period
NB	-	Net Benefits
NOMS Factor	-	Nominal O&M Savings Factor, the Ratio of Non-discounted Savings to the First-Cost Difference between Two Alternative Designs
NS	-	Net Savings
OCE	-	Office of the Chief of Engineers
O&M	-	Operation and Maintenance
ORR	-	Overall Rate of Return
OSAF Factor	-	One-Step Adjustment Factor
OSD	-	Office of the Secretary of Defense
p	-	Price
PA	-	Programmed Amount
PM	-	Project Manager
P	-	The Lump-Sum Time Equivalent Value of a Series of Recurring Costs as of the Time of Occurrence of the First Amount
PP (PB)	-	Payback Period
PPI	-	Producer Price Index
PW	-	Present Worth
Q	-	Quantity
SIR	-	Savings-to-Investment Ratio
SPB (SPP)	-	Simple Payback (Period)
SPW (SPV)	-	Single Present Worth (Value)
TM	-	Technical Manual
UCR	-	Uniform Capital Recovery
UPW (UPV)	-	Uniform Present Worth (Value)
UPW* (UPV*)	-	Modified Uniform Present Worth (Value)
USACE	-	U.S. Army Corps of Engineers

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3.2 USE OF THE HAND-HELD CALCULATOR FOR LCC CALCULATIONS

The arithmetic encountered in the course can be done with any hand-held calculator equipped with a power key [y^x], at least one pair of memory keys [STO and RCL], and a pair of parenthesis keys [(and)]. It is suggested that you review and practice the use of these keys on your calculator before coming to the course. If you are not familiar with the use of any of these keys, please review the examples provided below.

The first three examples demonstrate, in turn, the use of the power key, the memory keys, and the parenthesis keys. The fourth example demonstrates the combined use of all three sets of keys in terms of a factor frequently used in the course.

The keystroke sequences indicated in the examples are those for a Texas Instruments TI-30-SLR calculator; they are similar for most other calculators.

EXAMPLE 1. POWER KEY $\boxed{y^x}$

Calculate 5^3

PRESS	DISPLAY	COMMENTS
5	5.000	"y" value
$\boxed{y^x}$ 3	3	Raise to power 3, the "x" value
$\boxed{=}$	125.000	Result: y^x

EXAMPLE 2. PARENTHESIS KEYS FOR GROUPING NUMBERS AND OPERATIONS: [(] and [)]

Calculate 6 x (3+4)

PRESS	DISPLAY	COMMENTS
6 [x] [(]	6	Multiply 6 by the quantity that follows inside parentheses
3 [+] 4 [)]	7.000	End of parentheses signals end of quantity; arithmetic inside parentheses completed and result displayed
[=]	42.000	Result

EXAMPLE 3. MEMORY KEYS TO STORE INTERMEDIATE RESULTS: [STO] and [RCL]

Calculate $\frac{13.041 + 2.143 - 2.064}{4.843 + 3.219}$

PRESS	DISPLAY	COMMENTS
4.843 [+] 3.219 [=]	8.062	Calculate denominator
[STO]	8.062	Store denominator for future use
13.041 [+] 2.143 [-] 2.064 [=]	13.12	Calculate numerator
[÷] [RCL]	8.062	Divide by denominator (recalled from memory)
[=]	1.6273877	Result

EXAMPLE 4. COMBINED USE OF POWER KEY, PARENTHESIS KEYS, AND MEMORY KEYS

Calculate: $(v^k-1)/(v-1)$ where $v = (1+e)/(1+d)$.

Assume that e = 2.65%, d = 10%, and k = 25.

General approach: (1) calculate v and store it in memory; (2) calculate the numerator of the factor; (3) divide the numerator by the denominator.

PRESS	DISPLAY	COMMENTS
1.0265	1.0265	1+e
[÷] 1.1	1.1	Divide by (1+d)
[=]	0.9331818	v = (1+e)/(1+d)
[STO]	0.9331818	Store v for later use
[y^x] 25	25	Raise v to power k
[=]	0.177483	Result: v^k
[-] 1	1	Subtract 1 from v^k
[=]	-0.8225171	Result: (v^k-1)
[÷]	-0.8225171	Divide
[(] [RCL] [-] 1 [)]	-0.0668182	Quantity divided by: (v-1), where v is recalled from memory
[=]	12.309779	Result: factor $(v^k-1)/(v-1)$

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3.3 GUIDELINES ON SIGNIFICANT FIGURES

Data used in EA/LCCA typically are estimates which lack a high degree of accuracy. The following are guidelines for reflecting the nature of the data:

Significance of Zeros to the Left of the Decimal

- Zeros to the left are usually assumed not to be significant unless it is specified that they are.

  For example, the statement that a replacement cost expected 10 years from now is estimated at $100,000 is usually interpreted to mean about $100,000. The actual number could be $97,950, $104,999 or some other number rounded to $100,000.

- Zeros to the left are assumed to be significant if it is specified that they are.

  For example, the statement that a purchase price is exactly $50,000 means that all the figures are significant.

- Zeros can also be significant if implied in context, such as in the context of firm financial transactions.

  For example, the amount $100,000 used in the context of a bank loan would normally be interpreted to mean exactly $100,000.00.

Accuracy of Computed Numbers

- In addition, the total is no more accurate than the least accurate measurement. Similarly in subtraction, the result is no more accurate than the least accurate of the two measurements entering into the calculation. For example,

  $125 + $4.27 + $830 = $959.27, rounded to $960, if $830 is an approximation
  $1,597.54 + $52.10 + $2 = $1,651.64, rounded to $1,652

- In multiplication, the product should be considered to have only as many significant figures as the number of significant figures in the factor having the smallest number.

For example, suppose we know the price of an item is exactly \$2.29 per unit, and we estimate the quantity needed to be about 300 units. Compute total costs as \$2.29 x 300 = \$687, but state it as about \$700, because the quantity input to the calculation has only 1 significant figure.

<u>When to Apply Significant Figures Rule</u>

- To take advantage of the information we have, apply the significant figures rule as the last step in a series of calculations.

3.4 IDEAS ABOUT APPLICATIONS

Record ideas about promising on-the-job applications when they occur to you. Do not wait!

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MODULE 4

IMPROVING DECISIONS WITH ECONOMIC ANALYSIS/ LIFE-CYCLE COST ANALYSIS (EA/LCCA)

Purpose:

- To give you a conceptual understanding of EA/LCCA
- To demonstrate that the techniques you will learn can improve decisions
- To explain when you should perform EA/LCCA
- To itemize the knowledge and skills you need to perform EA/LCCA
- To identify where you need improvement

Outline:

4.1 First Cost and Life-Cycle Cost Perspectives

4.2 Why EA/LCCA Is Important in Design

4.3 What EA/LCCA Entails

4.4 When to do EA/LCCA

4.5 Knowledge and Skills Required of MILCON Design Professionals

4.6 Self-Assessment Using Scores on Pretest

Approximate Time:

2 hours

Slide 4-1

IMPROVING DECISIONS

WITH

ECONOMIC ANALYSIS/LIFE-CYCLE COST ANALYSIS (EA/LCCA)

Notes:

Slide 4-2

ECONOMIC ANALYSIS (EA)

a generic term referring to any systematic type of analysis procedure that can be used to estimate which of several alternative courses of action will provide maximum benefits less costs over some specified period of time.

Notes:

Slide 4-3

LIFE-CYCLE COST ANALYSIS (LCCA)

a type of ECONOMIC ANALYSIS which identifies the alternative with the lowest total cost of ownership over the long term.

Notes:

Slide 4-4

LCCA: TWO DISTINGUISHING CHARACTERISTICS

- **Benefits are about the same among alternatives, or are not of concern**
- **Time period covered is relatively long**

Notes:

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4.1 FIRST COST AND LIFE-CYCLE COST PERSPECTIVES

By the end of this section, you are expected to be able to

- give a clear, concise definition of LCCA
- explain the difference between an LCC approach and a first-cost approach to selecting among design alternatives
- give an example of when the first-cost approach to selecting among alternatives is appropriate, and when an LCC approach is needed
- state the conditions under which the first-cost approach and the LCC approach will agree as to which is the least-cost alternative
- state the conditions under which the two approaches may point to different alternatives
- explain the conditions under which you would accept the alternative indicated by the first-cost approach and when you would accept that indicated by the LCC approach when the two point to conflicting selections

Slide 4-5

LIFE-CYCLE COST ANALYSIS (LCCA) APPROACH

versus

FIRST COST APPROACH

Notes:

4.2 WHY EA/LCCA IS IMPORTANT IN DESIGN

By the end of this section, you are expected to be able to

- give several examples of design problems whose solution can be aided by EA/LCCA

Slide 4-6

DESIGN DECISIONS REQUIRING LCCA

EXAMPLES

Notes:

Slide 4-7

SELECTING A HEATING SYSTEM

	System A	System B
Purchase & Install:	$3,500	$4,000
Efficiency:	0.68	0.87

Notes:

Slide 4-8

LCCA DATA

AHL = 80 mill Btu

Today's fuel oil price = $4.64/mill Btu

Length of time = 25 years

Other cost differences: none

Multiplier = 0.5772

Notes:

Slide 4-9

LCC_A = \$11,377

LCC_B = \$10,157

Savings B:A = \$1,220/house

Total Savings = \$61,000

Notes:

Slide 4-10

LCCA USEFUL FOR

Choosing between systems where

- one has a higher first cost and the other has a higher future cost
- one has a higher first cost and the other has a shorter life

Notes:

4.3 WHAT EA/LCCA ENTAILS

By the end of this section, you are expected to be able to

- list the major steps in performing an EA/LCCA in support of a design choice

Slide 4-11

MAJOR STEPS IN EA/LCCA

1. List all feasible alternatives
2. Determine if a study is needed
3. If yes, determine the level of effort
4. Establish the analysis period and compile input data
5. Compute LCCs
6. Compare alternatives
7. Assess uncertainty
8. Rank design alternatives
9. Compute supplementary measures if needed (SIR, DPP, AIRR)
10. Document and disseminate

Notes:

4.4 WHEN TO DO EA/LCCA

By the end of this section, you are expected to be able to

- state the most advantageous times to perform EA/LCCA in a general sense
- identify three types of requirements for performing EA/LCCA for Army/Air Force design decisions
- identify manuals and reference materials containing the criteria and standards for conducting EA/LCCA in response to the three types of requirements

Slide 4-12

CARDINAL RULES:

- **Apply EA/LCCA as early as possible**
- **Repeat EA/LCCA as often as necessary**

Notes:

Slide 4-13

THREE TYPES OF REQUIREMENTS FOR EA

(Army & Air Force)

1. **General economic studies**

   (2 Types of Special Directed Studies)

2. **Special requirement by statute or executive order**

3. **Special requirements by OSD, HQDA, HQUSAF, or HQUSACE**

Notes:

Slide 4-14

GENERAL ECONOMIC STUDIES

[Objective: to determine ranking of design alternatives]

- EA to be routinely conducted for all facilities
- Throughout facilities acquisition process

  (from early planning stages thru construction)

- In support of decisions extending from initial concept through construction modifications

[Governing Criteria in TM 5-802-1]

Notes:

Slide 4-15

SPECIAL DIRECTED ECONOMIC STUDIES

- **Special requirements by statute or executive order**
    - **energy-conserving designs**
    - **wastewater treatment facilities**
- **Special requirements by OSD, HQDA, HQUSAF, or HQUSACE**

Notes:

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4.5 KNOWLEDGE AND SKILLS REQUIRED OF MILCON DESIGN PROFESSIONALS

Learning Objectives:

This session will

- let you know the target performance of design professionals with regard to economic analysis
- provide a checklist of specific knowledge and skills that you need to do your job according to the target performance, and that you will learn in the course

JOB TASKS

It is part of the day-to-day job of every design engineer in the Corps Field Operating Activities (FOAS), Divisions and Districts, to (1) make design decisions, (2) recommend design decisions, (3) review and approve design decisions made by others, and (4) review and recommend approval of design decisions made by others. The performance desired by HQ is, that in carrying out the day-to-day job, those responsible for the design process give an appropriate degree of attention to integrating economic analysis into the design process.

JOB TASKS OF DESIGN ENGINEERS

Ideally, at the working level, Corps design engineers (in their capacities as designers, design reviewers, and members of value-engineering teams) will perform the following tasks as needed in the manner indicated:

1. Conduct preliminary studies to determine the appropriate type and level of effort for economic analysis/life-cycle cost analysis (EA/LCCA) for the MILCON design decision at hand, taking into account Army and Air Force criteria.

2. Work with cost engineers and other colleagues to identify sources of data, obtain required data, and make necessary assumptions.

3. Taking the appropriate level of effort (as identified in 1) and being responsive to applicable criteria, perform EA/LCCA efficiently and correctly, taking into account uncertainties in the analysis.

4. Properly interpret the results of EA/LCCA in the context of the design process.

5. Develop clear and appropriate recommendations for design decisions based on economic considerations.

6. Provide appropriate documentation for EA/LCCA in a cost-effective manner for the conditions at hand.

7. Perform quick and incisive critical reviews of the EA/LCCAs conducted by others (including review of analyses, interpretation of results, and

documentation) and identify any deficiencies, errors, and deviations from contract or other agreed-upon provisions.

8. Develop A-E contract provisions for EA/LCCA as needed, taking into account applicable criteria.

9. Communicate effectively with management regarding EA/LCCA requirements, status, and results.

10. Defend decisions based on EA/LCCA.

JOB TASKS OF COST ENGINEERS

Ideally, at the working level, cost engineers will perform the following tasks as needed:

1. Provide supporting cost data of appropriate quality and in the appropriate format to Corps design engineers.

2. Assist Corps design engineers in making appropriate assumptions.

3. Communicate effectively with Corps design engineers and management about cost estimating requirements for individual EA/LCCAs.

JOB TASKS OF MANAGERS

Ideally, at the management level, managers will perform the following tasks:

1. Assure that EA/LCCAs are conducted as an integral part of the design process for all MILCON projects.

2. Assure that all EA/LCCAs are conducted in accordance with current Army or Air Force criteria.

3. Assure that the appropriate type and level of EA/LCCAs are applied to each design decision.

4. Assure that the results of EA/LCCAs are appropriately documented in a cost-effective manner, design-discipline-wide and project-wide.

5. Prepare reliable estimates of resources required to support the appropriate level of EA/LCCA effort for all aspects of each design project.

6. Develop appropriate requirements and criteria for cost-effective documentation of each level of EA/LCCA for each design project.

7. Determine standards of performance in EA/LCCA for staff supervised, evaluate performance, and identify related staff training needs.

8. Develop A-E contract provisions for EA/LCCA as needed, taking into account applicable criteria.

9. Accomplish quick and incisive critical reviews of EA/LCCAs conducted by others.

10. Make recommendations and decisions about the design process based on EA/LCCA analyses performed in-house and by A-E firms.

KNOWLEDGE, SKILLS, & ATTITUDES

KNOWLEDGE, SKILLS, AND ATTITUDES REQUIRED BY DESIGN ENGINEERS

1. Ability and willingness to recognize design problems to which economic analysis can be usefully applied, and skill in integrating economic analysis into the design process at different points.

2. Knowledge of applicable Army or Air Force criteria/standards for economic analysis, and ability to select the appropriate criteria for individual design situations.

3. Knowledge of the different levels and types of economic analysis, and the ability to select the appropriate level and type on a case-by-case basis for the design stage at hand.

4. Knowledge of informational requirements for performing economic analyses of different levels and types.

5. Skill in specifying cost data requirements and discussing data and assumptions with cost engineers and other colleagues in support of economic analyses of different levels and types.

6. Skill in determining when an uncertainty assessment is required for proper evaluation of results.

7. Skill in structuring problems for solution and making all necessary calculations, including calculations to account for uncertainties, using both manual approaches and computer programs.

8. Skill in interpreting clearly and correctly the results of economic analyses.

9. Skill in preparing cost-effective written documentation of results easily usable by others.

10. Skill in making sound recommendations based on economic analysis.

11. Skill in evaluating EA/LCCA studies performed by others, quickly and incisively.

12. Skill in communicating with management regarding EA/LCCA requirements, status, and results.

13. Skill in communicating requirements for EA/LCCA to A-E contractors.

14. Skill in estimating resource requirements for different levels of effort.

15. Conviction that the Corps wishes economic analysis to be included in the design process.

16. Belief that economic analysis can be a valuable tool in the design process.

17. Self confidence in ability to use economic analysis to improve the design process.

KNOWLEDGE, SKILLS, AND ATTITUDES REQUIRED BY COST ENGINEERS

1. Knowledge of the kinds of data and assumptions required for different types and levels of EA/LCCAs.

2. Skill in compiling required data in appropriate formats.

3. Skill in communicating with design engineers and management about cost estimating requirements for individual EA/LCCAs.

KNOWLEDGE, SKILLS, AND ATTITUDES REQUIRED BY MANAGERS

1. Knowledge of Army or Air Force criteria and standards for economic analysis.

2. Knowledge of the different levels and types of economic analysis, and an understanding of which ones are appropriate for different design decisions.

3. Knowledge of the informational requirements for performing economic analyses of different levels and types.

4. Knowledge of the technical skills required for formulating and solving problems of different levels of complexity.

5. Skill in estimating resource requirements in support of EA/LCCAs of different levels and types.

6. Knowledge of documentation requirements for understanding and evaluating economic analyses performed by others, and skill in preparing criteria for cost-effective documentation, which can be followed at the working level.

7. Knowledge of the meaning of analysis results.

8. Skill in developing A-E contract provisions for EA/LCCA in accordance with Army or Air Force criteria.

9. Skill in performing quick and incisive critical reviews of EA/LCCAs conducted by others.

10. Awareness of training opportunities in economic analysis.

11. Skill in communicating with staff, A-E contractors, and higher levels of management regarding all aspects of EA/LCCAs, including requirements for analyses, technical performance, meaning of results, and resource requirements.

12. Conviction that the Corps wishes economic analysis to be included in the design process.

13. Belief that economic analysis can be a valuable tool in the design process.

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4.6 SELF-ASSESSMENT USING SCORES ON PRETEST

Learning Objective:

- To identify critical areas of knowledge and skills in which you most need improvement

KEY POINTS

- Life-cycle cost analysis (LCCA) is a method of economic analysis (EA) which emphasizes costs, takes a long-term view, and is particularly useful for comparing alternatives that differ in their first costs and future costs.
- Using EA/LCCA can lower the total cost of ownership of facilities.
- EA/LCCA can be most effective in reducing total costs of ownership of facilities if it is applied early and repeated as conditions change.
- EA/LCCA is to be performed routinely as part of the design process for all MILCON facilities.
- In addition, there are special requirements for EA that arise from statute and Executive Order, as well as from HQDA, OSD, or HQUSACE directives.
- By actively participating in the course, you can expect to gain the knowledge and skills needed to perform economic analysis according to Army and Air Force standards.
- The knowledge and skills you will acquire in the course are highly transferable to other jobs and are useful for personal decision making.

MODULE 5

TIME VALUE OF MONEY CONCEPTS

Purpose:

- To help you understand concepts of time value of money and time-equivalent values
- To show how the concept of time-equivalent values applies to design decisions
- To demonstrate appropriate treatment of inflation in EA/LCCAs
- To explain why governments and other organizations use discount rates and what they are
- To show how to model estimates of dollar benefits and costs over the study period so as to simplify EA/LCC calculations

Outline:

5.1 Why and How to Adjust for Time

5.2 Two Ways to Treat Inflation

5.3 Government Discount Rates

5.4 Cash Flow Modeling

Approximate Time:

2 hours and 15 minutes

Slide 5-1

TIME VALUE OF MONEY CONCEPTS

Notes:

5.1 WHY AND HOW TO ADJUST FOR TIME

By the end of this session, you are expected to be able to

- explain why the worth of a dollar of cost or benefit depends on when the amount is to be paid or received
- explain what is meant by the phrase, "time-equivalent values"
- explain in concept what a discount rate is
- explain how a discount rate affects design decisions
- use the discount rate in a formula to find the present worth equivalent of a single future amount

Slide 5-2

Paying or receiving a dollar tomorrow

is not equivalent to

paying or receiving a dollar today.

Notes:

Slide 5-3

TIME-EQUIVALENT VALUES

(you'd just as soon have one amount as the other)

Notes:

Slide 5-4

DISCOUNT RATE (D or d)

rate at which a person or organization becomes willing to trade future dollars for present dollars

Used to Find PW given F

Notes:

Slide 5-5

DISCOUNT FORMULA

Single Present Worth (SPW) Formula

$$PW = F\ [1/(1+D)^{N}]$$

Notes:

Slide 5-6

RELEVANCE OF DISCOUNTING TO DESIGN

The ability to compute PW of F provides a sound basis for making design choices that increase costs today

but
- save in future costs
- increase future benefits

Notes:

Slide 5-7

DISCOUNTING EXAMPLE

Given D = 15%

Would it be worthwhile to spend $1,500 today to avoid a cost of $3,000 in 6 years?

PW = $3,000 [1/(1+0.15)^6 = $1,297

$1,297 (savings) < $1,500 (cost)

Notes:

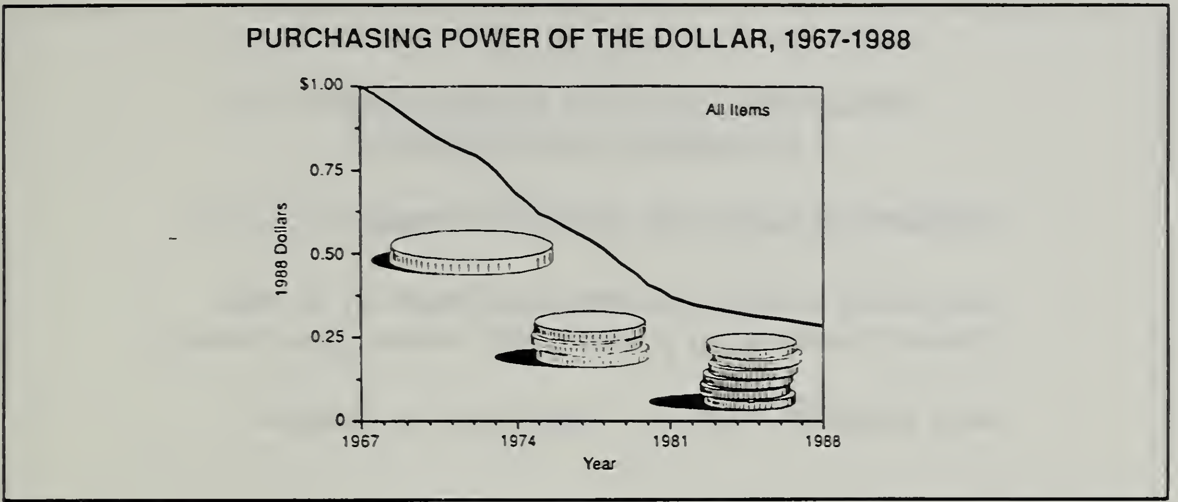
Slide 5-8

Why prefer

- **receiving $100 today to $100 in the future?**
- **paying $100 in the future instead of $100 today?**
  - **Inflation/deflation**
  - **"Real" earning potential**

Notes:

Slide 5-9



Notes:

Slide 5-10

INFLATION DISTORTS MEASUREMENT OF ECONOMIC PERFORMANCE

- $ is unit for measuring economic effects
- Comparing costs & benefits expressed in $s with different purchasing power gives meaningless results
- Valid EA/LCCA requires adjustment for inflation

Notes:

Slide 5-11

REAL EARNING POTENTIAL OF MONEY IN HAND

("real opportunity cost")

Notes:

Slide 5-12

SUMMARY

Two Factors Account for Time Value of Money

- **Inflation/deflation**
  (change in $'s purchasing power)

- **Real opportunity cost**
  (earnings lost)

Notes:

5.2 TWO WAYS TO ADJUST FOR INFLATION IN EA/LCCA

By the end of this section, you are expected to be able to

- explain two ways to adjust for inflation in EA/LCCA
- distinguish between absolute and relative rates of change in the prices of individual items
- estimate a future amount of cost or benefit in either current dollars or constant dollars by starting with today's prices and projected price level changes for the future
- explain the difference between "real" and "nominal" (or market) discount rates

Slide 5-13

TWO WAYS TO ADJUST FOR INFLATION

(1) Work in absolute (actual) terms

(Include general price inflation in prices & discount rate)

(2) Work in relative (differential) terms

(Exclude general price inflation from prices & discount rate)

Notes:

Slide 5-14

EXAMPLE OF WORKING IN ABSOLUTE TERMS

Inflation rate (I) = 5%
Real opportunity cost (d) = 3%
D = About 8% (precisely 8.15%)

Time of replacement (n) = 4 years
Price if replaced today (C_p) = $1,000
Projected rate of price change (E) = I = 5%
Replacement price in 4 years (C_F) = ?

$$C_F = C_p\ (1+E)^n$$
$$= \$1000\ (1+0.05)^4 = \$1{,}215.51$$

Present worth (PW) = ?

$$PW = C_F\ [\ 1/(1+D)^n]$$
$$= \$1{,}215.51\ [1/(1+0.0815)^4] = \$888.49$$

Notes:

- The equation for computing D, given the real opportunity cost and the inflation rate is

  D = (1+d)(1+I)-1.

  D = (1+0.03)(1+0.05) -1 = 0.0815 or 8.15%

  and, therefore,

  d = (1+D)/(1+I)-1

  d = (1+0.0815)/(1+0.05) -1 = 0.0300 or 3%

Slide 5-15

SECOND WAY OF ADJUSTING FOR INFLATION:

Work in relative (Differential) terms

i.e., exclude general price inflation from

- **prices**
- **discount rates**

Notes:

Slide 5-16

EXAMPLE OF WORKING IN RELATIVE (Differential) TERMS

Real opportunity cost (d) = 3% annually

Time of replacement (n) = 4 years
Price if replaced today (C_p) = \$1,000
Differential rate of price escalation (e) = 0%
Replacement price in 4 years (C_F) = ?

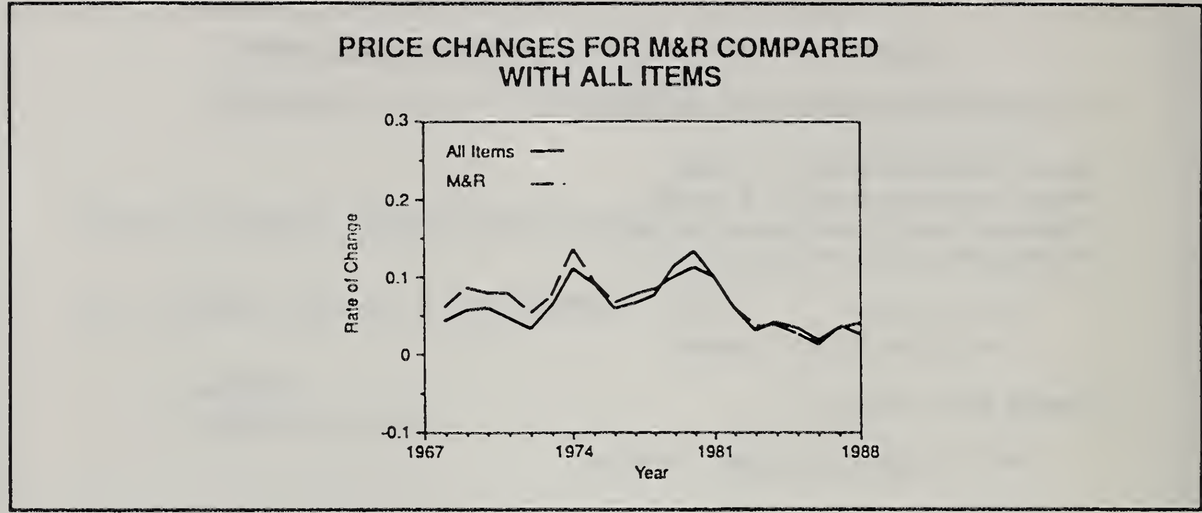
$$C_F = C_p\,(1+e)^n$$
$$= \$1{,}000\,(1+0)^4 = \$1{,}000$$

Present worth (PW) = ?

$$PW = \$1{,}000\,[1/(1+0.03)^4 = \$888.49$$

Notes:

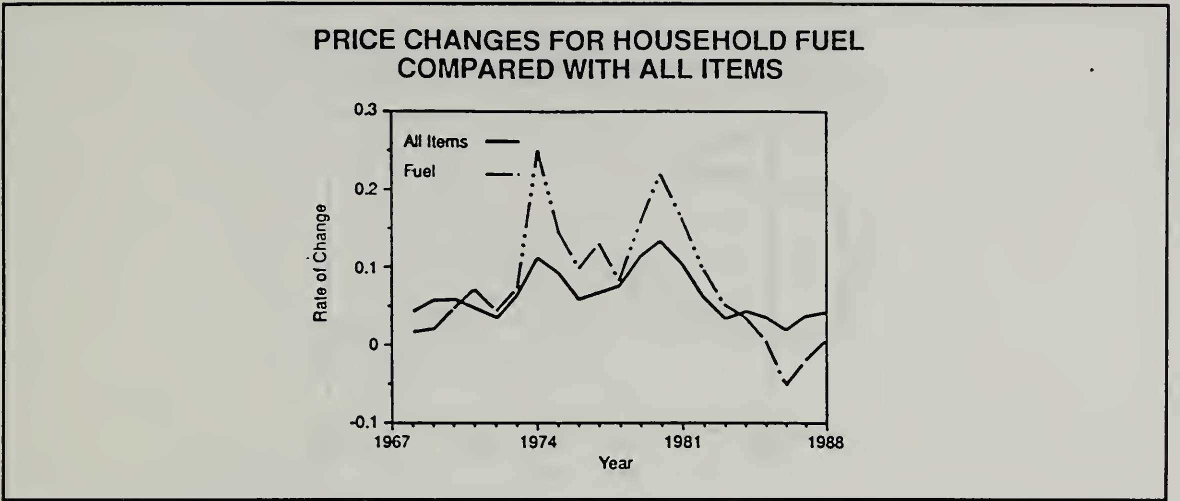
Slide 5-17



<u>1967-88 price increases</u>	<u>All items</u>	<u>M&R</u>
Absolute (E)	6.2%	6.8%
Relative, or differential, (e)	-	0.56%

Notes:

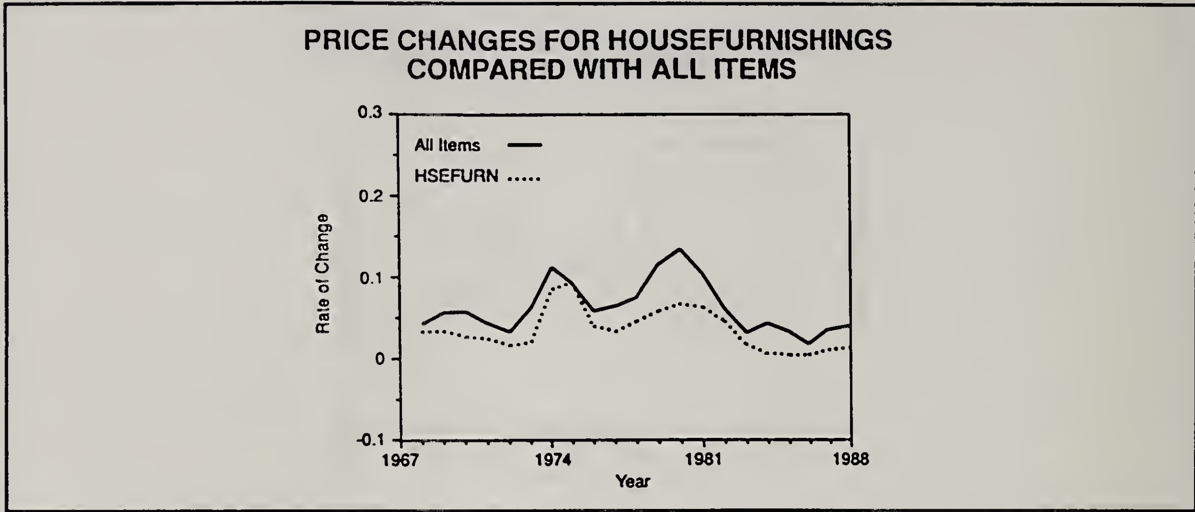
Slide 5-18



1967-88 price increases	All items	Fuel
Absolute (E)	6.2%	7.5%
Relative, or differential, (e)	-	1.22%

Notes:

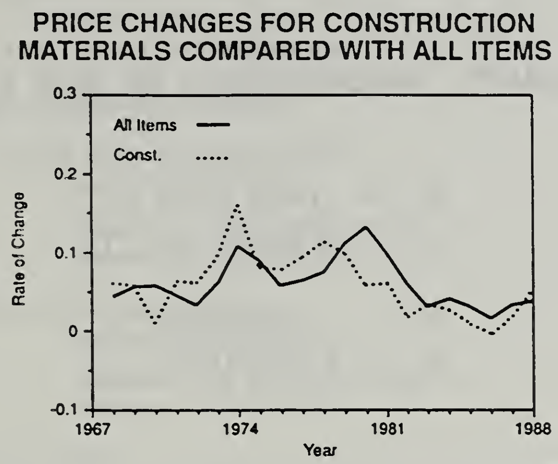
Slide 5-19



1967-88 price increases	All items	Furnishings
Absolute (E)	6.2%	3.5%
Relative, or differential, (e)	-	-2.5%

Notes:

Slide 5-20



1967-88 price increases	All items	Construction
Absolute (E)	6.2%	5.9%
Relative, or differential, (e)	-	-0.3%

Notes:

Slide 5-21

SUMMARY: RELATIONSHIP OF E, e, D, & d

$$E = (1+e)\ (1+I) - 1$$
$$e = (1+E)/(1+I) - 1$$

$$D = (1+d)\ (1+I) - 1$$
$$d = (1+D)/(1+I) - 1$$

where

E = absolute (actual) rate of change in price of a given item (i.e., including inflation)

e = rate of change in price of a given item relative to the rate of change in the general price level (i.e., excluding inflation)

D = nominal (market) discount rate (i.e., including inflation)

d = real discount rate over and above inflation (i.e., excluding inflation)

Notes:

Inflation simply cancels out of the combined escalation/discounting equation, such that the two ways of adjusting for inflation are mathematically equivalent:

$$PW = [C_p\ (1+E)^n]\ [1/(1+D)^n] \qquad \text{(Absolute Terms)}$$

$$= [C_p\ (1+(1+e)(1+I)-1)^n]\ [1/(1+(1+d)(1+I)-1)^n]$$

$$= [C_p\ (1+e)^n]\ [1/(1+d)^n] \qquad \text{(Relative Terms)}$$

Slide 5-22

SUMMARY

Two Ways of Adjusting for Inflation:

(1) Work in absolute (actual) terms
(i.e., include inflation)

- **Estimate C_F by escalating at rate E**
- **Discount C_F with rate D**

(2) Work in relative terms
(i.e., exclude inflation)

- **Estimate C_F by escalating at rate e**
- **Discount C_F with rate d**

Same Bottom Line

Notes:

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5.3 GOVERNMENT DISCOUNT RATES

By the end of this session, you are expected to be able to

- explain why the Government requires the use of discount rates
- describe how the value of the discount rate would affect a design decision
- identify the specific requirements for Federal discount rates applicable to most Federal building design decisions

Slide 5-23

DISCOUNT RATES FOR GOVERNMENT

- **Why?**
- **What?**
- **Effect?**

Notes:

Congress, as elected representatives of the people, reached a decision as of 1968 as to what the basis of the discount rate should be: It should reflect the opportunity cost in the private sector. (U.S. Congress Joint Economic Committee, Subcommittee on Economy in Government. Hearings on Economic Analysis of Public Investment Decisions: Interest Rate Policy and Discounting Analysis. 84th Congress, 2nd session, 1968.)

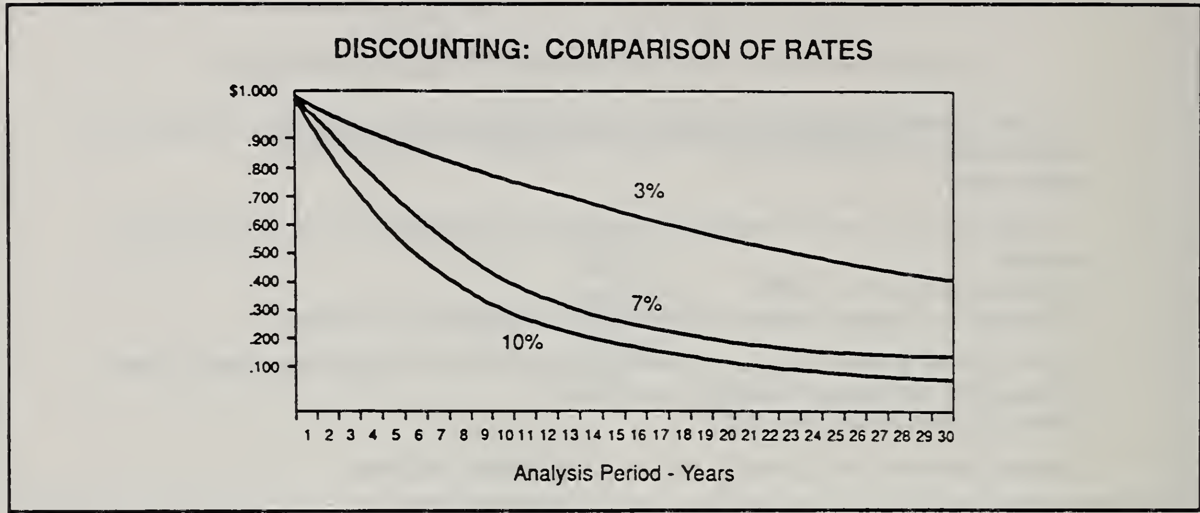
Slide 5-24

WHAT DISCOUNT RATES ARE USED BY THE GOVERNMENT?

- 10% real discount rate for evaluating most programs & projects having costs and benefits distributed over time
  (OMB A-94)
- 7% real discount rate for evaluating energy conservation and renewable energy projects
  (Energy Security Act, 1980)
  (Changed by Federal Energy Management Improvement Act, 1988)
- Current nominal rates based on treasury securities with maturities equal to term of lease for evaluating lease-buy decisions
  (OMB Circular A-104, rev. 1986)
- Special discount rate (formula) for evaluating water projects

Notes:

Slide 5-25



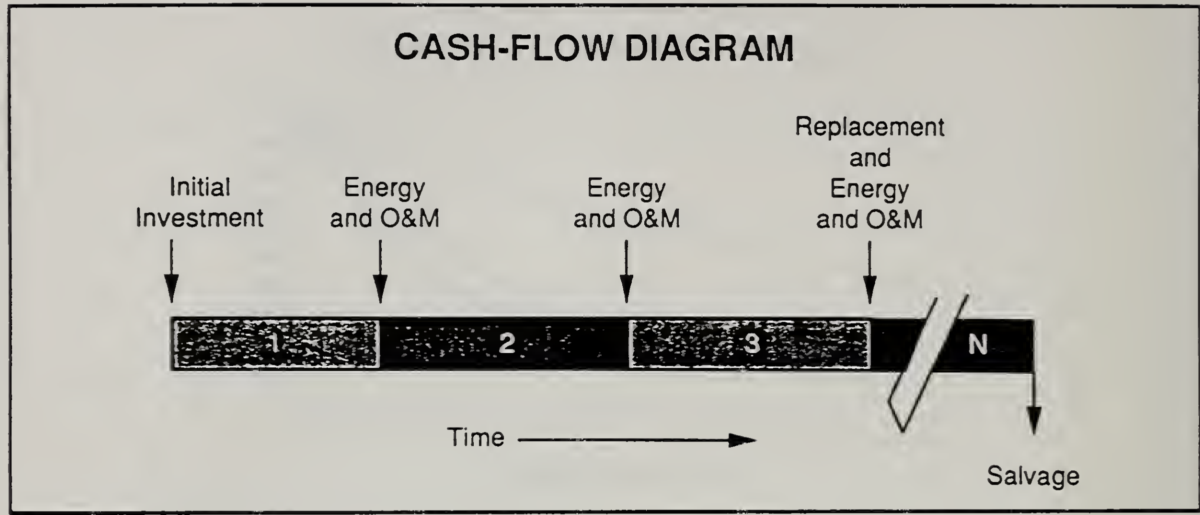
Notes:

5.4 CASH FLOW MODELING

At the end of this session you are expected to be able to

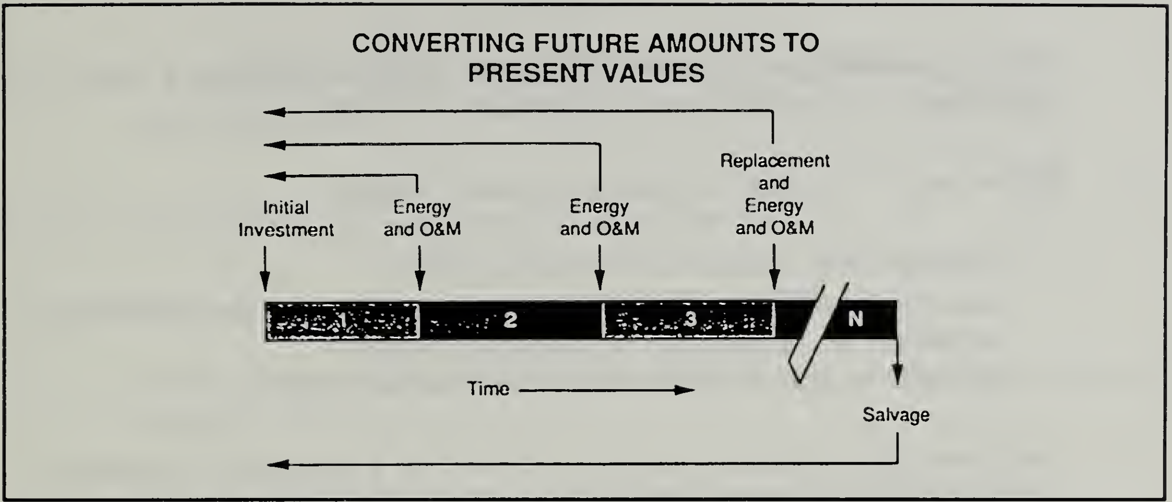
- explain what is meant by "cash flow modeling"
- be able to construct a simple, generic cash flow diagram

Slide 5-26



Notes:

Slide 5-27



Notes:

KEY POINTS

- People generally prefer receiving a dollar today to receiving a dollar at a future time, and prefer delaying payments to making them now.

- The value of the dollar is time-dependent because

  - inflation may change its purchasing power
  - money in hand may be used to earn a real return over and above inflation, i.e., money has an opportunity cost
  - another reason is that risk may increase with time

- The time value of money can be expressed as a required or minimum acceptable rate of return. When this rate is used to find the present equivalent value of future benefits and costs, it is called a discount rate.

- The minimum acceptable rate of return varies among individuals and organizations.

- Expressing benefits and costs as time-equivalent values makes it possible to assess the comparative economic value of alternative courses of action.

- Inflation is a distortion that must be adjusted for in EA/LCCA, either by (1) including inflation in cash flows and removing it by discounting with a nominal discount rate, or (2) excluding inflation both from cash flows and the discount rate at the outset.

- The Government specifies discount rates that are to be used in making decisions on behalf of the Government, such as design decisions for Federal buildings.

- Diagramming cash flows provides a checklist of relevant costs and benefits including their timing.

- Cash flows are commonly modeled more simply than they actually occur to make data gathering and computations easier.

MODULE 6

ARITHMETIC OF ECONOMIC ANALYSIS

By the end of this module you are expected to be able to

- calculate
  - future costs and benefits based on today's prices and projected rates of change
  - present worth equivalents of future costs and benefits
  - life-cycle costs
- use
  - escalation and discounting formulas
  - escalation factors, discount factors, and combined escalation/discount factors -- "annual series factors"

Outline:

6.1 Escalate to Estimate Future Dollar Costs and Benefits Based on Today's Prices and Projected Rates of Change

- With positive, negative, or zero price level changes
- In current dollars
- In constant dollars

6.2 Discount to Compute the Present Worth Equivalent of a Single Future Cost or Benefit

- When the future amount is given

- When the future amount has to be estimated

6.3 Discount to compute the Present Worth Equivalent of a Series of Future Costs or Benefits

- Uniform series

- Series escalating at a constant positive rate

- Series escalating at a constant negative rate

- Series beginning in the future

- Series escalating at a variable rate

6.4 Exercise 6-1: Escalation/Discounting

6.5 Compute LCC

6.6 Exercise 6-2: LCC

Approximate Time:

5 hours

Slide 6-1

ARITHMETIC OF ECONOMIC ANALYSIS/LCCA

- Escalation
- Discounting
- Combined Escalation & Discounting
- Using Formulas & Factors
- Calculating LCC

Notes:

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6.1 ESCALATE TO ESTIMATE FUTURE DOLLAR COSTS AND BENEFITS BASED ON TODAY'S PRICES AND PROJECTED RATES OF CHANGE

To estimate future dollar costs and benefits, a useful starting point is today's prices which are usually readily obtainable.

By the end of this section you are expected to be able to

- escalate today's price of an item forward to estimate its future price

Slide 6-2

ESCALATION:
CALCULATE A FUTURE AMOUNT BASED ON TODAY'S PRICE AND PROJECTED RATES OF CHANGE

- With positive, negative, and zero escalation
- In current dollars
- In constant dollars

Notes:

Slide 6-3

To find C_F when C_P is known

C_P -------------------------> C_F?

Escalation Formula: Single Compound Amount (SCA)

$$C_F = C_P(1+e)^n$$

where

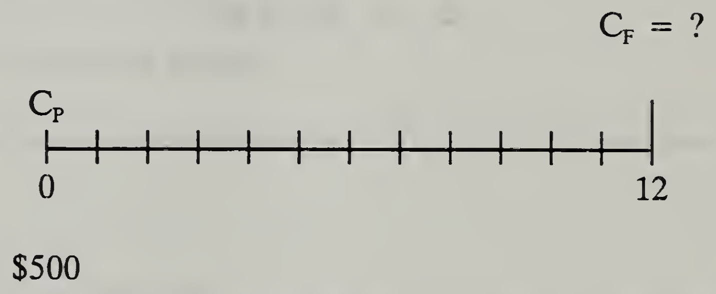
C_P = cost of an item to occur in the future as of the date of study
C_F = cost of an item to occur in the future as of that future time

Notes:

SAMPLE PROBLEMS

Example 6.1: ESTIMATE A FUTURE COST BASED ON TODAY'S PRICE AND POSITIVE ESCALATION

Suppose an item costs \$500 today. What will be the cost in 12 years if the price escalates at a rate of 10% compounded annually.



$$
\begin{aligned}
C_P &= \$500 \\
n &= 12 \\
e &= 0.10 \\
C_F &= ?
\end{aligned}
$$

$$
\begin{aligned}
C_F &= \$500 \times (1+0.10)^{12} \\
&= \$500 \times 3.1384 \\
&= \$1{,}569
\end{aligned}
$$

Instead of calculating the factor using the escalation formula, you can look up the factor in the Escalation Factor table and multiply it by C_P to obtain C_F.

ESCALATION FACTOR TABLE

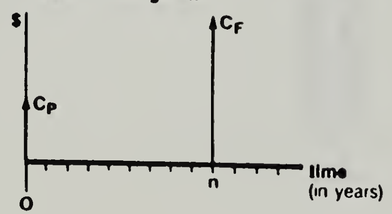
10% ESCALATION

12 YEARS

YEARS TO ESCALATE	-5%	-4%	-3%	-2%	-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	YEARS TO ESCALATE
1	0.950	0.960	0.970	0.980	0.990	1.000	1.010	1.020	1.030	1.040	1.050	1.060	1.070	1.080	1.090	1.100	1
2	0.903	0.922	0.941	0.960	0.980	1.000	1.020	1.040	1.061	1.082	1.102	1.124	1.145	1.166	1.188	1.210	2
3	0.857	0.885	0.913	0.941	0.970	1.000	1.030	1.061	1.093	1.125	1.158	1.191	1.225	1.260	1.295	1.331	3
4	0.815	0.849	0.885	0.922	0.961	1.000	1.041	1.082	1.126	1.170	1.216	1.262	1.311	1.360	1.412	1.464	4
5	0.774	0.815	0.859	0.904	0.951	1.000	1.051	1.104	1.159	1.217	1.276	1.338	1.403	1.469	1.539	1.611	5
6	0.735	0.783	0.833	0.886	0.941	1.000	1.062	1.126	1.194	1.265	1.340	1.419	1.501	1.587	1.677	1.772	6
7	0.698	0.751	0.808	0.868	0.932	1.000	1.072	1.149	1.230	1.316	1.407	1.504	1.606	1.714	1.828	1.949	7
8	0.663	0.721	0.784	0.851	0.923	1.000	1.083	1.172	1.267	1.369	1.477	1.594	1.718	1.851	1.993	2.144	8
9	0.630	0.693	0.760	0.834	0.914	1.000	1.094	1.195	1.305	1.423	1.551	1.689	1.838	1.999	2.172	2.358	9
10	0.599	0.665	0.737	0.817	0.904	1.000	1.105	1.219	1.344	1.480	1.629	1.791	1.967	2.159	2.367	2.594	10
11	0.569	0.638	0.715	0.801	0.895	1.000	1.116	1.243	1.384	1.539	1.710	1.898	2.105	2.332	2.580	2.853	11
12	0.540	0.613	0.694	0.785	0.886	1.000	1.127	1.268	1.426	1.601	1.796	2.012	2.252	2.518	2.813	3.138	12
13	0.513	0.588	0.673	0.769	0.878	1.000	1.138	1.294	1.469	1.665	1.886	2.133	2.410	2.720			
14	0.488	0.565	0.653	0.754	0.869	1.000	1.149	1.319	1.513	1.732	1.980	2.261	2.579	2.937			
15	0.463	0.542	0.633	0.739	0.860	1.000	1.161	1.346	1.558	1.801	2.079	2.397	2.759	3.172			
16	0.440	0.520	0.614	0.724	0.851	1.000	1.173	1.373	1.605	1.873	2.183	2.540	2.952	3.426			
17	0.418	0.500	0.596	0.709	0.843	1.000	1.184	1.400	1.653	1.948	2.292	2.693	3.159	3.700	4.328	5.054	17
18	0.397	0.480	0.578	0.695	0.835	1.000	1.196	1.428	1.702	2.026	2.407	2.854	3.380	3.996	4.717	5.560	18
19	0.377	0.460	0.561	0.681	0.826	1.000	1.208	1.457	1.754	2.107	2.527	3.026	3.617	4.316	5.142	6.116	19
20	0.358	0.442	0.544	0.668	0.818	1.000	1.220	1.486	1.806	2.191	2.653	3.207	3.870	4.661	5.604	6.727	20
21	0.341	0.424	0.527	0.654	0.810	1.000	1.232	1.516	1.860	2.279	2.786	3.400	4.141	5.034	6.109	7.400	21
22	0.324	0.407	0.512	0.641	0.802	1.000	1.245	1.546	1.916	2.370	2.925	3.604	4.430	5.437	6.659	8.140	22
23	0.307	0.391	0.496	0.628	0.794	1.000	1.257	1.577	1.974	2.465	3.072	3.820	4.741	5.871	7.258	8.954	23
24	0.292	0.375	0.481	0.616	0.786	1.000	1.270	1.608	2.033	2.563	3.225	4.049	5.072	6.341	7.911	9.850	24
25	0.277	0.360	0.467	0.603	0.778	1.000	1.282	1.641	2.094	2.666	3.386	4.292	5.427	6.848	8.623	10.835	25
26	0.264	0.346	0.453	0.591	0.770	1.000	1.295	1.673	2.157	2.772	3.556	4.549	5.807	7.396	9.399	11.918	26
27	0.250	0.332	0.439	0.580	0.762	1.000	1.308	1.707	2.221	2.883	3.733	4.822	6.214	7.988	10.245	13.110	27
28	0.238	0.319	0.426	0.568	0.755	1.000	1.321	1.741	2.288	2.999	3.920	5.112	6.649	8.627	11.167	14.421	28
29	0.226	0.306	0.413	0.557	0.747	1.000	1.335	1.776	2.357	3.119	4.116	5.418	7.114	9.317	12.172	15.863	29
30	0.215	0.294	0.401	0.545	0.740	1.000	1.348	1.811	2.427	3.243	4.322	5.743	7.612	10.063	13.268	17.449	30
35	0.166	0.240	0.344	0.493	0.703	1.000	1.417	2.000	2.814	3.946	5.516	7.686	10.677	14.785	20.414	28.102	35
40	0.129	0.195	0.296	0.446	0.669	1.000	1.489	2.208	3.262	4.801	7.040	10.286	14.974	21.725	31.409	45.259	40
45	0.099	0.159	0.254	0.403	0.636	1.000	1.565	2.438	3.782	5.841	8.985	13.765	21.002	31.920	48.327	72.890	45
50	0.077	0.130	0.218	0.364	0.605	1.000	1.645	2.692	4.384	7.107	11.467	18.420	29.457	46.902	74.358	117.391	50
.25	0.987	0.990	0.992	0.995	0.997	1.000	1.002	1.005	1.007	1.010	1.012	1.015	1.017	1.019	1.022	1.024	.25
.50	0.975	0.980	0.985	0.990	0.995	1.000	1.005	1.010	1.015	1.020	1.025	1.030	1.034	1.039	1.044	1.049	.50
.75	0.962	0.970	0.977	0.985	0.992	1.000	1.007	1.015	1.022	1.030	1.037	1.045	1.052	1.059	1.067	1.074	.75

3.138

Cash Flow Diagram:



Escalation Factor $= (1 + e)^n$

where e = annual escalation rate

d = number of escalation periods

Example 6.2: ESTIMATE A FUTURE COST BASED ON TODAY'S PRICE AND NEGATIVE ESCALATION

Suppose an item costs $500 today. What will be the cost in 12 years if the price "escalates" at a rate of -3% compounded annually.

$$C_P = \$500$$
$$n = 12$$
$$e = -0.03$$
$$C_F = ?$$

$$C_F = \$500 \times (1-0.03)^{12}$$
$$= \$500 \times 0.6938$$

$$= \$347$$

Example 6.3: ESTIMATE A FUTURE COST BASED ON TODAY'S PRICE AND ZERO ESCALATION

Change the annual escalation rate in problem 6.2 to 0% and compute the future amount.

$$
\begin{aligned}
C_p &= \$500 \\
n &= 12 \\
e &= 0.00 \\
C_F &= ?
\end{aligned}
$$

$$
\begin{aligned}
C_F &= \$500 \times (1+0.00)^{12} \\
&= \$500 \times 1.0000 \\
&= \$500
\end{aligned}
$$

Example 6.4: ESTIMATE A FUTURE COST IN CURRENT DOLLARS BASED ON TODAY'S PRICE

Suppose that an item costs \$500 today and escalates at an annual rate of 10% over and above inflation. Assume the annual rate of inflation is 5%. What will be the cost in 12 years in then-current dollars?

$$C_P = \$500$$
$$n = 12$$
$$e = 0.10$$
$$I = 0.05$$
$$E = (1+e)(1+I) - 1$$
$$C_F = ?$$

$$C_F = \$500 \text{ x } (1+E)^{12}$$
$$E = (1+0.10)(1+0.05) - 1 = 0.155$$
$$C_F = \$500 \text{ x } (1+0.155)^{12}$$
$$= \$500 \text{ x } 5.6362$$

$$= \$2{,}818$$

Example 6.5: ESTIMATE A FUTURE COST IN CONSTANT DOLLARS BASED ON TODAY'S PRICE

The price of an item which costs $500 today is expected to escalate at an annual rate of 15% including 5% inflation. Estimate what it will cost in 12 years in constant dollars (i.e., in dollars with today's purchasing power).

$$
\begin{aligned}
C_P &= \$500 \\
n &= 12 \\
E &= 0.15 \\
I &= 0.05 \\
e &= (1+E)/(1+I) - 1 = (1+0.15)/(1+0.05) - 1 \\
&= 0.095 \\
C_F &= ?
\end{aligned}
$$

$$
\begin{aligned}
C_F &= \$500 \times (1+e)^{12} \\
&= \$500 \times (1+0.095)^{12} \\
&= \$500 \times 2.9715 \\
&= \$1{,}486
\end{aligned}
$$

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6.2 DISCOUNT TO COMPUTE THE PRESENT WORTH EQUIVALENT OF A SINGLE FUTURE COST OR BENEFIT

To compare the life-cycle costs and benefits of alternative designs, all amounts have to be stated in time-equivalent dollars. We do this by discounting.

By the end of this section you are expected to be able to

- discount to find the present worth equivalent of a single future amount when the future amount is given
- discount to find the present worth equivalent of a single future amount when the future amount has to be estimated

Slide 6-4

DISCOUNT A SINGLE FUTURE COST TO FIND ITS PRESENT WORTH EQUIVALENT

- **When the future amount is given**
- **When the future amount has to be estimated**

Notes:

Slide 6-5 (a & b)

To find PW when C_F is known

PW? <------------------------- C_F

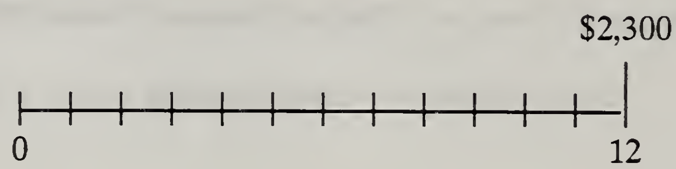
Discount Formula: Single Present Worth (SPW)

$$PW = C_F [1/(1+d)^n]$$

Notes:

Example 6.6: COMPUTE THE PRESENT WORTH OF A SINGLE FUTURE COST GIVEN IN CONSTANT DOLLARS

What is the present worth equivalent of a future cost of $2,300 (in this year's dollars, (i.e., in constant dollars) to be incurred in 12 years, if the real discount rate is 7% per year?



PW = ?

$$
\begin{aligned}
C_F &= \$2{,}300 \\
n &= 12 \\
d &= 0.07 \\
PW &= ?
\end{aligned}
$$

$$
\begin{aligned}
PW &= \$2{,}300 \times 1/(1+0.07)^{12} \\
&= \$2{,}300 \times 0.4440
\end{aligned}
$$

$$PW = \$1{,}021$$

The multiplier 0.444 can also be found in a table of factors based on specified values of d and n. These factors are usually called single present worth (SPW) factors. Here we use the short-hand designation "Discount Factors" and "Discount Factor Table" to refer to these. Find the Discount Factor Table in your set. Find the factor.

DISCOUNT FACTOR TABLE

7% DISCOUNT RATE

12 YEARS

0.4440

DISCOUNT FACTOR TABLE

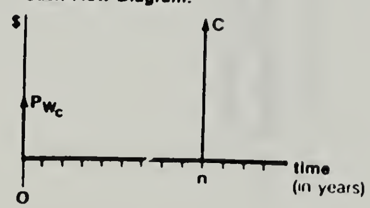
YEARS	DISCOUNT 7%	RATE 10%	YEARS
1	0.9346	0.9091	1
2	0.8734	0.8264	2
3	0.8163	0.7513	3
4	0.7629	0.6830	4
5	0.7130	0.6209	5
6	0.6663	0.5645	6
7	0.6227	0.5132	7
8	0.5820	0.4665	8
9	0.5439	0.4241	9
10	0.5083	0.3855	10
11	0.4751	0.3505	11
12	$\boxed{0.4440}$	0.3186	12
13		0.2897	13
14		0.2633	14
15		0.2394	15
16		0.2176	16
17		0.1978	17
18	0.2959	0.1799	18
19	0.2765	0.1635	19
20	0.2584	0.1486	20
21	0.2415	0.1351	21
22	0.2257	0.1228	22
23	0.2109	0.1117	23
24	0.1971	0.1015	24
25	0.1842	0.0923	25
26	0.1722	0.0839	26
27	0.1609	0.0763	27
28	0.1504	0.0693	28
29	0.1406	0.0630	29
30	0.1314	0.0573	30
35	0.0937	0.0356	35
40	0.0668	0.0221	40
45	0.0476	0.0137	45
50	0.0339	0.0085	50
.25	0.9832	0.9765	.25
.50	0.9667	0.9535	.50
.75	0.9505	0.9310	.75

Discount Factor $= 1/(1 + d)^n$

where d = *discount rate*

n = *number of discounting periods*

Cash Flow Diagram:



Example 6.7: COMPUTE THE PRESENT WORTH OF A SINGLE FUTURE COST GIVEN IN CURRENT DOLLARS

What is the present worth equivalent of a future cost of $5,000 (in then-current dollars) to be incurred in 12 years, if the annual real discount rate is 7% and the annual inflation rate 3%.

C_F = \$5,000
n = 12
d = 0.07
I = 0.03
D = (1+d)(1+I) - 1
PW = ?

PW = $\$5,000 \text{ x } 1/(1+D)^n$
D = (1+0.07)(1+0.03) - 1 = 0.1021
PW = $\$5,000 \text{ x } 1/(1+0.1021)^{12}$
= \$5,000 x 0.3114

PW = \$1,557

Example 6.8: COMPUTE THE PRESENT WORTH OF THE SAME FUTURE COST AS IN EXAMPLE 6.7 BUT GIVEN IN CONSTANT DOLLARS INSTEAD OF CURRENT DOLLARS

What is the present worth equivalent of a cost of $3,507 (in this year's dollars, i.e., in constant dollars) to be incurred in 12 years, if we know the nominal discount rate is 10.2% and includes 3% inflation.

$$
\begin{aligned}
C_F &= \$3{,}507 \\
n &= 12 \\
D &= 0.102 \\
I &= 0.03 \\
d &= (1+D)/(1+I) - 1 \\
PW &= ?
\end{aligned}
$$

$$
\begin{aligned}
PW &= \$3{,}507 \text{ x } 1/(1+d)^n \\
d &= (1+0.102)/(1+0.03) - 1 = 0.07 \\
PW &= \$3{,}507 \text{ x } 1/(1+0.07)^{12} \\
&= \$3{,}507 \text{ x } 0.4440
\end{aligned}
$$

$$PW = \$1{,}557$$

Slide 6-6 (a - b)

To find PW when C_F has to be estimated

PW? <------------------------- C_F?

Escalation Formula combined with Discount Formula

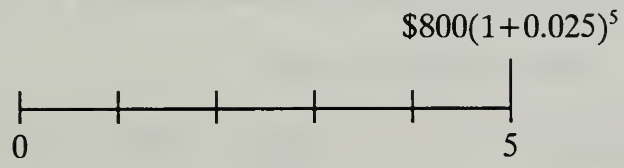
$$PW = C_P \frac{(1+e)^h}{(1+d)^h}$$

Notes:

Example 6.9: COMPUTE THE PRESENT WORTH OF A SINGLE FUTURE COST WHEN THE FUTURE COST IS TO BE ESTIMATED IN CONSTANT DOLLARS

Find the present worth of a future cost that is expected to occur 5 years from now. The cost would be \$800 if it occurred today; price escalation over the next 5 years is projected at an annual differential rate of 2.5%. The annual real discount rate is 7%.

C_P = \$800
n = 5
d = 0.07
e = 0.025
PW = ?



PW = ?

$$PW = \$800 \times \frac{(1+0.025)^5}{(1+0.07)^5}$$

$$= \$800 \times \frac{1.1314}{1.4026}$$

(Note: carried through in calculator)

$$= \$800 \times 0.80667$$

$$PW = \$645$$

Instead of using the formula you can use the appropriate escalation factor from the Escalation Factor Table and the appropriate discount factor from the Discount Factor Table in combination.

- But since the escalation rate is 2.5%, using the factor table requires that you interpolate between the escalation factors for 2 and 3%

- The difference between the 3% escalation factor for year 5 and the 2% escalation factor for year 5 is

  1.159 - 1.104 = 0.055

- Multiply this difference by 0.5 to get the value for 0.5%.

  0.055 x 0.5 = 0.0275

- Add this to the 2% factor to get the value for a 2.5% escalation

  1.104 + 0.0275 = 1.131

- To summarize:

Escalation Factor for 2.5%, 5yr = 1.104 + 0.5(1.159-1.104) = 1.131

Look up the discount factor in the Discount Factor Table. It is 0.713.

Use these two factors in combination to calculate the PW:

PW = C_P x escalation factor x discount factor

= \$800 x 1.131 x 0.713

= \$800 x 0.807

PW = \$646 (note small difference due to rounding)

Example 6.10: COMPUTE THE PRESENT WORTH OF A SINGLE FUTURE COST WHEN THE FUTURE COST IS TO BE ESTIMATED IN CURRENT DOLLARS

Redo Example 6.9, but now assume that the future cost is to be estimated in current dollars. If it occurred today, it would be \$800, but it is not expected to occur for five years. Estimate the future cost in current dollars and discount it to determine its present worth equivalent.

$$
\begin{aligned}
C_P &= \$800 \\
n &= 5 \\
e &= 0.025 \\
I &= 0.06 \\
E &= (1+e)(1+I) - 1 = \\
d &= 0.07 \\
D &= (1+d)(1+I) - 1 = \\
PW &= ?
\end{aligned}
$$

$$PW = \$800 \times \frac{(1+E)^5}{(1+D)^5}$$

$$
\begin{aligned}
E &= (1+0.025)(1+0.06) - 1 = 0.0865 \\
D &= (1+0.07)(1+0.06) - 1 = 0.1342
\end{aligned}
$$

$$PW = \$800 \times \frac{(1.0865)^5}{(1.1342)^5}$$ (Note: carried through in calculator)

$$= \$800 \times 0.8067$$

$$= \$645$$

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6.3 DISCOUNT TO COMPUTE THE PRESENT WORTH EQUIVALENT OF A SERIES OF FUTURE COSTS OR BENEFITS

When costs or benefits recur periodically, it is possible to use a short-cut calculation procedure which avoids the need to escalate and discount each amount in the series separately. Some series do not begin at the beginning of the analysis period. An adjustment is required in this case to compute PW of the series.

By the end of this section, you are expected to be able to

- calculate the present worth of series of cash flows having different rates of escalation and different starting times

Slide 6-7

COMPUTE THE PRESENT WORTH OF A SERIES OF FUTURE AMOUNTS

- **Uniform series**
- **Series escalating at a constant positive rate**
- **Series escalating at a constant negative rate**
- **Series beginning in the future**
- **Series escalating at a variable rate**

Notes:

Slide 6-8

To find PW when A_i is known

A_i = initial amount in the series

Annual cash-flow-series equivalence formula

$$PW = A_i \times (v^k-1)/(v-1)$$

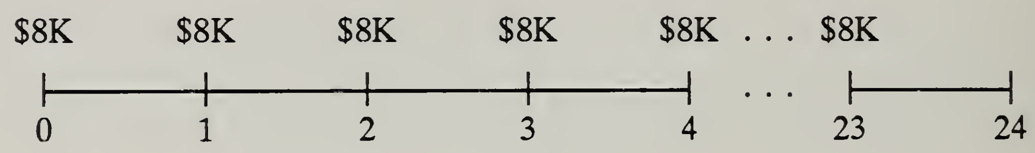
where $v = (1+e)/(1+d)$ and $e \neq d$

Notes:

Example 6.11: COMPUTE THE PRESENT WORTH OF A UNIFORM SERIES OF FUTURE AMOUNTS (e.g., zero differential rate of escalation)

Find the present worth of a series of annual payments that recur 25 times over the analysis period. The initial payment of $8,000 occurs at the beginning of the first year of the analysis period, the second occurs at the beginning of the second year, and so forth. Assume the series escalates at the rate of general price inflation, meaning the differential escalation rate is zero. The discount rate is 10% per year.

A_i = $8,000
k = 25
d = 0.10
e = 0
PW = ?



PW = ?

$$PW = \$8,000 \times (v^k-1)/(v-1)$$

$$= \$8,000 \times [((1+0)/(1+0.10))^{25} - 1]/[(1+0)/(1+0.10) -1]$$
$$= \$8,000 \times 9.985$$

$$PW = \$79,878$$

Alternatively, look in the Annual Series Table - Annual Discount Rate = 10% - you will find the annual series factor for a series of 25 and 0% differential rate of escalation to be 9.985. Multiply the factor times the initial payment to obtain PW of the entire series.

ANNUAL SERIES FACTOR TABLE

0% DIFFERENTIAL RATE OF ESCALATION

ANNUAL SERIES FACTOR TABLE

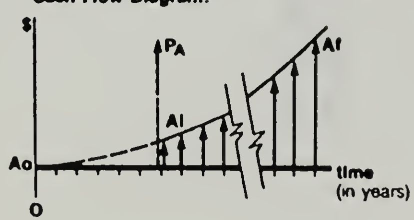
Annual Discount Rate = 10%

25 PAYMENTS

9.985

NO. IN SERIES	ANNUAL ESCALATION RATE																NO. IN SERIES
	-5%	-4%	-3%	-2%	-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	
1	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1
2	1.864	1.873	1.882	1.891	1.900	1.909	1.918	1.927	1.936	1.945	1.955	1.964	1.973	1.982	1.991	2.000	2
3	2.610	2.634	2.659	2.685	2.710	2.736	2.761	2.787	2.813	2.839	2.866	2.892	2.919	2.946	2.973	3.000	3
4	3.254	3.299	3.345	3.392	3.439	3.487	3.535	3.584	3.634	3.684	3.735	3.787	3.839	3.892	3.946	4.000	4
5	3.810	3.879	3.950	4.022	4.095	4.170	4.246	4.324	4.403	4.483	4.566	4.649	4.735	4.821	4.910	5.000	5
6	4.290	4.385	4.483	4.583	4.686	4.791	4.899	5.009	5.123	5.239	5.358	5.480	5.605	5.734	5.865	6.000	6
7	4.705	4.827	4.953	5.083	5.217	5.355	5.498	5.645	5.797	5.953	6.115	6.281	6.453	6.630	6.812	7.000	7
8	5.064	5.213	5.368	5.529	5.695	5.868	6.048	6.234	6.428	6.628	6.837	7.053	7.277	7.509	7.750	8.000	8
9	5.373	5.549	5.733	5.925	6.126	6.335	6.553	6.781	7.019	7.267	7.526	7.796	8.078	8.372	8.680	9.000	9
10	5.641	5.843	6.056	6.279	6.513	6.759	7.017	7.288	7.572	7.871	8.184	8.513	8.858	9.220	9.601	10.000	10
11	5.871	6.100	6.340	6.594	6.862	7.145	7.443	7.758	8.090	8.441	8.812	9.203	9.616	10.053	10.513	11.000	11
12	6.071	6.323	6.591	6.875	7.176	7.495	7.834	8.194	8.575	8.981	9.411	9.868	10.354	10.870	11.418	12.000	12
13	6.243	6.518	6.812	7.125	7.458	7.814	8.193	8.598	9.030	9.491	9.983	10.510	11.072	11.672	12.314	13.000	13
14	6.392	6.689	7.007	7.347	7.712	8.103	8.523	8.972	9.455	9.973	10.530	11.127	11.770	12.460	13.202	14.000	14
15	6.520	6.838	7.179	7.546	7.941	8.367	8.825	9.320	9.853	10.429	11.051	11.723	12.449	13.233	14.082	15.000	15
16	6.631	6.967	7.330	7.723	8.147	8.606	9.103	9.642	10.226	10.860	11.549	12.296	13.109	13.993	14.954	16.000	16
17	6.727	7.081	7.464	7.880	8.332	8.824	9.358	9.941	10.576	11.268	12.024	12.849	13.752	14.738	15.818	17.000	17
18	6.809	7.179	7.582	8.021	8.499	9.022	9.593	10.218	10.903	11.653	12.477	13.382	14.377	15.470	16.674	18.000	18
19	6.881	7.266	7.686	8.146	8.649	9.201	9.808	10.475	11.209	12.018	12.910	13.895	14.985	16.189	17.523	19.000	19
20	6.943	7.341	7.778	8.257	8.784	9.365	10.005	10.713	11.496	12.362	13.323	14.390	15.576	16.895	18.363	20.000	20
21	6.996	7.407	7.858	8.356	8.906	9.514	10.187	10.934	11.764	12.688	13.718	14.867	16.151	17.588	19.196	21.000	21
22	7.042	7.464	7.930	8.445	9.015	9.649	10.353	11.139	12.015	12.996	14.094	15.326	16.711	18.268	20.022	22.000	22
23	7.082	7.514	7.993	8.523	9.114	9.772	10.506	11.329	12.251	13.287	14.454	15.769	17.255	18.936	20.840	23.000	23
24	7.116	7.558	8.048	8.594	9.202	9.883	10.647	11.505	12.471	13.562	14.797	16.196	17.784	19.591	21.650	24.000	24
25	7.146	7.596	8.097	8.656	9.282	$\boxed{9.985}$	10.776	11.668	12.678	13.822	15.124	16.607	18.299	20.235	22.454	25.000	25
26	7.171	7.629	8.140	8.712				11.819	12.871	14.069	15.437	17.003	18.800	20.967	23.250	26.000	26
27	7.193	7.658	8.178	8.761				11.960	13.052	14.301	15.735	17.384	19.287	21.488	24.038	27.000	27
28	7.212	7.683	8.211	8.806				12.090	13.221	14.521	16.020	17.752	19.761	22.097	24.820	28.000	28
29	7.229	7.706	8.241	8.845				12.211	13.380	14.729	16.291	18.107	20.222	22.695	25.594	29.000	29
30	7.243	7.725	8.267	8.880				12.323	13.528	14.926	16.551	18.448	20.671	23.283	26.361	30.000	30
35	7.290	7.790	8.358	9.006	9.750	10.609	11.606	12.771	14.141	15.759	17.682	19.979	22.736	26.063	30.095	35.000	35
40	7.313	7.823	8.406	9.076	9.852	10.757	11.820	13.079	14.582	16.389	18.578	21.250	24.535	28.600	33.661	40.000	40
45	7.323	7.840	8.432	9.116	9.913	10.849	11.960	13.290	14.899	16.864	19.288	22.307	26.102	30.914	37.069	45.000	45
50	7.329	7.848	8.446	9.138	9.948	10.906	12.051	13.435	15.127	17.223	19.851	23.185	27.466	33.026	40.324	50.000	50

Cash Flow Diagram:



Annual Series Factor $= (v^k - 1)/(v - 1)$

where $v = (1 + e)/(1 + d)$

e = annual escalation rate

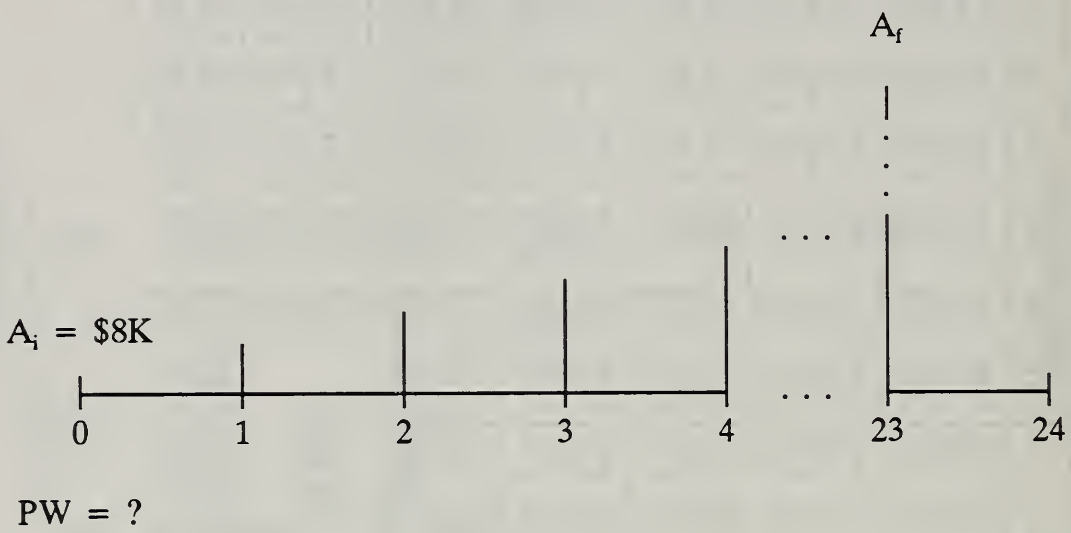
d = discount rate

k = number of amounts in series

Example 6.12: COMPUTE THE PRESENT WORTH OF A SERIES OF FUTURE AMOUNTS ESCALATING AT A CONSTANT POSITIVE RATE

Use the same assumptions as in the previous example except change the escalation rate to 4% higher than general price inflation.

A_i = \$8,000
k = 25
d = 0.10
e = 0.04
PW = ?



$$PW = \$8{,}000 \times (v^k - 1)/(v - 1)$$

$$= \$8{,}000 \times [((1+0.04)/(1+0.10))^{25} - 1]/[(1+0.04)/(1+0.10) - 1]$$
$$= 8{,}000 \times 13.822$$

$$PW = \$110{,}580$$

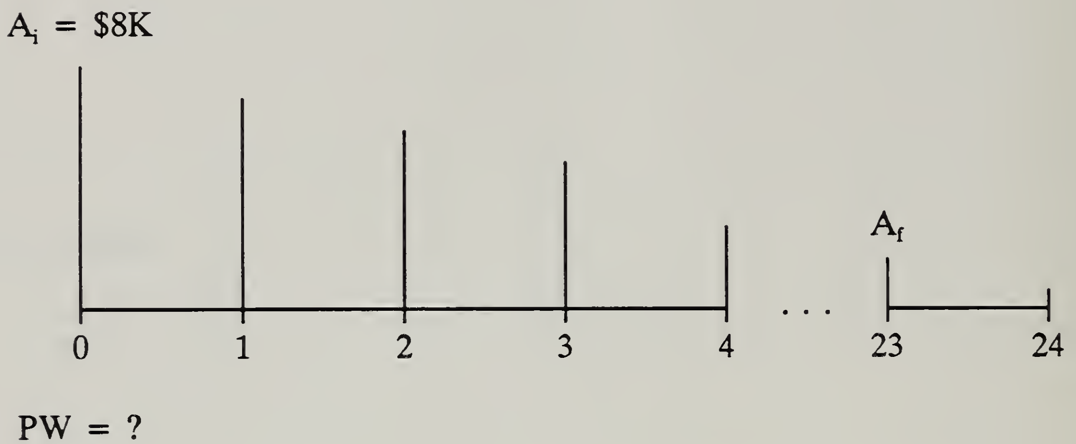
Alternatively, look up the annual series factor in the table. For e = 4%, and k = 25, it is 13.822.

What does $110,580 mean? It is the amount today that is time equivalent to the series of future amounts escalating at 4% per year.

Example 6.13: COMPUTE THE PRESENT WORTH OF A SERIES OF FUTURE AMOUNTS ESCALATING AT A CONSTANT NEGATIVE RATE

Use the same assumptions as in the previous example except change the differential escalation rate to -4%. Calculate present worth.

A_i	=	\$8,000
k	=	25
d	=	0.10
e	=	-0.04
PW	=	?



$$PW = \$8,000 \times (v^k-1)/(v-1)$$

$$= \$8,000 \times [((1-0.04)/(1+0.10))^{25}-1]/[(1-0.04)/(1+0.10) - 1]$$
$$= \$8,000 \times 7.596$$

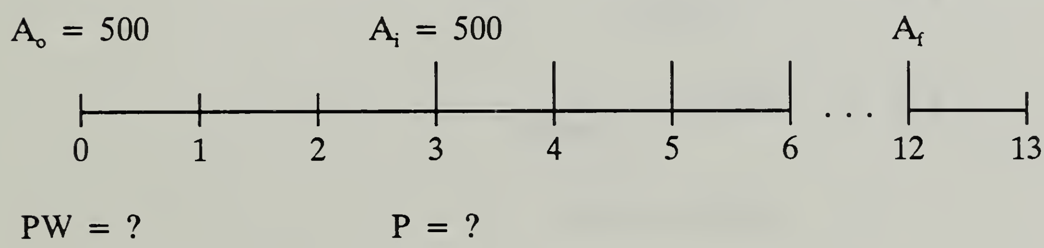
$$PW = \$60,766$$

The corresponding annual series factor from the Annual Series Factor Table is 7.596.

Example 6.14: COMPUTE THE PRESENT WORTH OF A UNIFORM SERIES OF FUTURE AMOUNTS THAT BEGINS TO OCCUR IN THE FUTURE

A series of annual costs begins to occur 3 years after the beginning of the analysis period. The series consists of 10 consecutive amounts spaced at one-year intervals. The initial amount would be \$500 if it occurred at the beginning of the analysis period. The differential escalation rate is zero, and the annual real discount rate is 7%. Compute the present worth equivalence of the series at the beginning of the analysis period.

A_o	= \$500		e	=	0
			k	=	10
n	= 3		d	=	0.07
PW	= ?				



SOLUTION:

STEP 1: Calculate the magnitude of the initial cost of the series (A_i):

$$
\begin{aligned}
A_i &= A_o \times (1+e)^n \\
&= \$500 \times (1+0)^3 \\
&= \$500
\end{aligned}
$$

STEP 2: Calculate the equivalent one-time cost of the series (P) of 10 payments as of the beginning of the series (i.e., at the time of the initial cost in the series):

$$P = A_i \times (v^k-1)/(v-1)$$

$$= \$500 \times [((1+0)/(1+0.07))^{10} - 1]/[(1+0)/(1+0.07) - 1]$$

$$= \$500 \times 7.515$$

$$= \$3{,}758$$

(Note that this is the time equivalent value of the series three years after the beginning of the analysis period. We need it as of the beginning of the analysis period.)

STEP 3: Calculate the present worth as of the beginning of the analysis period:

$$PW = P \times \frac{1}{(1+d)^n}$$

$$PW = \$3{,}758 \times \frac{1}{(1+0.07)^3}$$

$$= \$3{,}758 \times 0.8163$$

$$PW = \$3{,}068$$

Alternatively, solve the problem using factors:

$$A_i = \$500 \times 1.000$$ (escalation factor from Escalation Factor Table, for $e = 0\%$, $n = 3$)

$$= \$500$$

$$P = \$500 \times 7.515$$ (annual series factor from Annual Series Factor Table, for $d = 7\%$, $e = 0\%$, $k = 10$)

$$= \$3{,}758$$

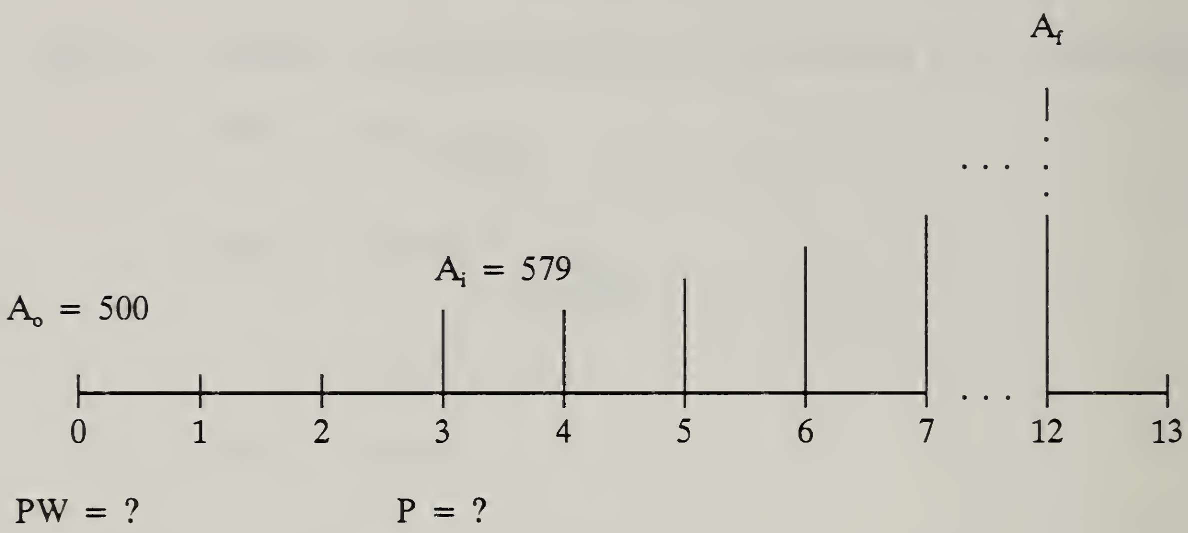
PW = \$3,758 x 0.8163 (discount factor from Discount Factor Table, for d = 7%, n = 3)

= \$3,068

Example 6.15: COMPUTE THE PRESENT WORTH OF A SERIES THAT BEGINS TO OCCUR IN THE FUTURE AND ESCALATES AT A CONSTANT POSITIVE RATE

Change one assumption in Example 6.14 and find the new PW. Assume that the series escalates at a constant annual rate of 5%.

A_o	=	\$500	e	=	0.05
A_i	=	A_o x $(1+e)^n$	k	=	10
n	=	3	d	=	0.07
PW	=	?			



SOLUTION:

STEP 1: Calculate the magnitude of the initial cost in the series (A_i):

$$A_i = \$500 \times (1+0.05)^3$$
$$= \$500 \times 1.158$$
$$= \$579$$

STEP 2: Calculate the equivalent one-time cost of the series as of the beginning of the series (i.e., at the time of the initial cost in the series):

$$P = A_i \times (v^k-1)/(v-1)$$

$$= \$579 \times [((1+0.05)/(1+0.07))^{10} - 1]/[(1+0.05)/(1+0.07) - 1]$$

$$= \$579 \times 9.199$$

$$= \$5{,}326$$

STEP 3: Calculate the present worth as of the beginning of the analysis period:

$$PW = P \times \frac{1}{(1+d)^n}$$

$$PW = \$5{,}326 \times \frac{1}{(1+0.07)^3}$$

$$= \$5{,}326 \times 0.8163$$

$$PW = \$4{,}348$$

Alternatively, solve the problem using factors:

A_i = \$500 x 1.158 (escalation factor, Escalation Factor Table, e = 0%, n = 3)

= \$579

P = \$579 x 9.199 (annual series factor, Annual Series Factor Table, d = 7%, e = 0%, k = 10)

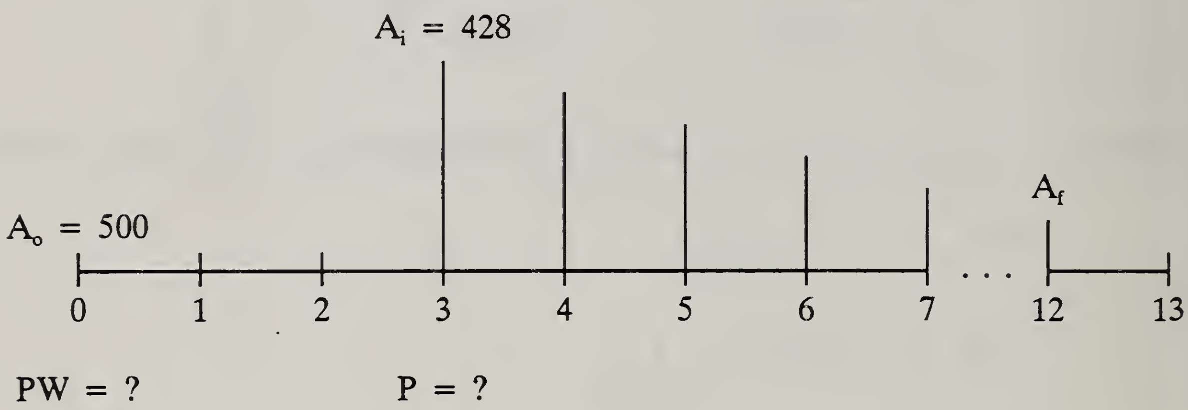
= \$5,326

PW = \$5,326 x 0.8163 (discount factor, Discount Factor Table, d = 7%, n = 3)

PW = \$4,348

Example 6.16: COMPUTE THE PRESENT WORTH OF A SERIES THAT BEGINS TO OCCUR IN THE FUTURE AND ESCALATES AT A CONSTANT NEGATIVE RATE

Keep all assumptions of example 6.15, except change the differential escalation rate to a negative 5%. Use factors to find PW.



SOLUTION BY FACTORS:

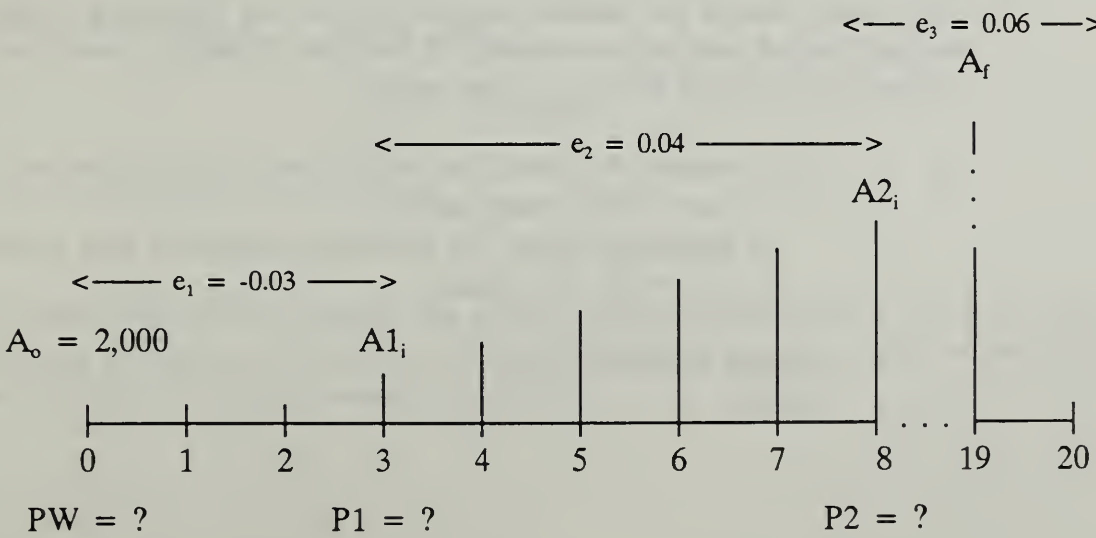
A_i	=	\$500 x 0.857	(escalation factor, Escalation Factor Table, e = -5%, n = 3)
	=	\$428	
P	=	\$428 x 6.203	(annual series factor, Annual Series Factor Table, e = -5%, d = 7%, k = 10)
	=	\$2,660	
PW	=	\$2,660 x 0.8163	(discount factor, Discount Factor Table, d = 7%, n = 3)
PW	=	\$2,170	

Example 6.17: COMPUTE THE PRESENT WORTH OF A SERIES ESCALATING AT VARIABLE RATES

Assume that a certain amount of energy is consumed annually over a 17 year period, and that the bills are paid annually. The first payment is incurred three years from the beginning of the analysis period. The cost of that annual consumption based on energy prices at the beginning of the analysis period (i.e., in constant dollars of the beginning as of the analysis period) is $2,000. The differential escalation rate over the three-year period until the first payment is -3%. Over the next five years, the differential escalation rate is 4%, and thereafter it is 6%. Assume a real discount rate of 7%. Find the present worth of this series as of the beginning of the analysis period.

A_o	=	$2,000	d	=	0.07
n	=	3	e_1	=	-0.03
k_1	=	5	e_2	=	0.04
k_2	=	12	e_3	=	0.06
$A1_i$	=	initial payment of first subseries			
$A2_i$	=	initial payment of second subseries			
A_f	=	final payment			
PW	=	?			

Model this problem as though there were two successive subseries, one starting three years after the beginning of the analysis period and consisting of five payments, and the second one starting eight years after the beginning of the analysis period and consisting of 12 payments. Use factors to solve the problem.



SOLUTION USING FACTORS:

STEP 1: Calculate the magnitude of the first payment in the first subseries three years from the beginning of the analysis period:

$A1_i$ = A_o x escalation factor (e_1 = -3%, n = 3)
= \$2,000 x 0.913
= \$1,826

Note that the first annual payment in the first series occurs at the time the escalation rate changes from e_1 to e_2, and the first subseries consists of that payment plus four other payments escalating at e_2. The first payment in the second series occurs at the time the escalation rate changes from e_2 to e_3 and consists of that payment plus 11 other payments escalating at e_3.

STEP 2: Find the equivalent one-time cost of the first subseries at three years (P1): (It consists of five payments.)

P1 = $A1_i$ x annual series (e_2 = 4%, k = 5, d = 7%)

= \$1,826 x 4.727
= \$8,632

STEP 3: Calculate the magnitude of the first payment in the second subseries. The known cost of the annual consumption at the beginning of the analysis period has to be escalated to the time when the escalation rate changes from 4% to 6%, i.e., eight years:

$A2_i$ = A_o x escalation factor for period prior to first subseries (e_1 = -3%, three years)
x escalation factor for escalation period of first subseries (e_2 = 4%, five years)

= \$2,000 x 0.913 x 1.217
= \$2,222

STEP 4: Find the equivalent one-time cost of the second subseries at eight years (P2). The subseries consists of 12 payments:

$$P2 = A2_i \text{ x annual series factor } (e_3 = 6\%,\ k_2 = 12,\ d = 7\%)$$

$$= \$2{,}222 \text{ x } 11.402$$
$$= \$25{,}335$$

STEP 5: Calculate the PW of each of the equivalent one-time costs (P1 and P2 of the two subseries:

$$PW1 = P1 \text{ x discount factor } (d = 7\%,\ n = 3)$$

$$= \$8{,}632 \text{ x } 0.8163$$
$$= \$7{,}046$$

$$PW2 = P2 \text{ x discount factor } (d = 7\%,\ n = 8)$$

$$= \$25{,}335 \text{ x } 0.5820$$
$$= \$14{,}745$$

STEP 6: The last step is to sum the two values to get the present worth of a series of annually recurring payments when the escalation rate varies over the analysis period:

$$PW = PW1 + PW2$$

$$= \$7{,}046 + \$14{,}745$$

$$= \$21{,}791$$

The results indicate that paying the energy bills over the analysis period is time equivalent to paying a lump sum of $22,508 at the beginning of the analysis period, based on the data and consumptions given.

SUMMARY OF STEPS TO COMPUTE THE PRESENT WORTH OF A SERIES OF ANNUALLY RECURRING AMOUNTS WHEN THE ESCALATION RATE VARIES OVER THE ANALYSIS PERIOD:

STEP 1: Calculate initial amount $A1_i$ for the first subseries:

$A1_i$ = A_o x escalation factor
for escalation period from beginning of analysis period to time first subseries begins

STEP 2: Calculate the one-time equivalent cost for subseries 1 as of the beginning of the subseries:

P1 = $A1_i$ x annual series factor
for number of payments in subseries 1, escalating at rate e_2

STEP 3: Calculate initial amount $A2_i$ for subseries 2:

$A2_i$ = A_o x escalation factors
covering each escalation period from the beginning of the analysis period to the time the second subseries begins

STEP 4: Calculate the equivalent one-time cost for subseries 2:

P2 = $A2_i$ x annual series factor
for number of payments in subseries 2, escalating at rate e_3

STEP 5: Calculate the present worth equivalents of both subseries as of the beginning of the analysis period:

PW1 = P1 x discount factor

PW2 = P2 x discount factor

STEP 6: Sum the one-time costs of the two subseries to get the present worth equivalent of the entire annual series of costs:

$$PW = PW1 + PW2$$

Notice that there are six steps to the calculation procedure even using factors. In Module 7 we will introduce a special set of factor tables which will greatly simplify the calculations. They are tables of factors which have built in to single multipliers most of the calculations in the six-step procedure.

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6.4 EXERCISE 6-1: ESCALATION/DISCOUNTING

The purpose of this exercise is to provide you practice in (1) escalating to estimate future costs and benefits based on today's prices and projected rates of price escalation, and (2) discounting to present worth the various types of cash flows encountered in life-cycle cost analysis. Mastering the basic arithmetic operations lays the foundation for advancing to the specific cash flows of MILCON design evaluations in the next two modules.

Use the set of discount tables in the Notebook of Reference Materials. Note that directories in front of the tables explain how to use them, or you can refer back to the examples in this module if you need guidance.

Problem 1

Estimate in constant dollars the cost of an item in 10 years, C_F, based on the fact that it costs $1,000 today and the projected annual differential escalation rate is 10%.

C_P = $1,000
n = 10
e = 0.10

a. Draw a cash flow diagram:

b. Calculate the future cost, C_F, using the escalation formula:

C_F =

c. Find the appropriate escalation factor in the set of escalation and discount tables in your Notebook of Reference Documents, write it here, and use it to calculate C_F:

Escalation Factor =

C_F =

Problem 2

Redo problem 1, but assume a differential escalation rate of -5%.

$$C_P = \$1{,}000$$
$$n = 10$$
$$e = -0.05$$

a. Calculate the future cost, C_F, using the escalation formula:

C_F =

b. Find the escalation factor in the table, write it here, and use it to calculate C_F:

Escalation Factor =

C_F =

Problem 3

A repair cost is expected to occur three years from now. If it occurred today, the repair cost would be $1,500. The projected inflation rate is 4%, and relevant repair prices are projected to escalate at the rate of inflation. Express the future amount in current dollars.

$$C_P = \$1{,}500$$
$$n = 3$$
$$I = 0.04$$

a. Draw a cash-flow diagram:

b. Calculate the future cost, C_F, using the escalation formula:

C_F =

c. Find the escalation factor in the table, write it here, and use it to calculate C_F:

Escalation Factor =

C_F =

Problem 4

Find the present worth (PW) of a salvage value of $800 expected to be received eight years from today, given a discount rate of 7%.

C_F = $800
n = 8
d = 0.07

a. Draw a cash flow diagram:

b. Calculate the present worth, using the discount formula:

PW =

c. Find the appropriate discount factor in the Discount Factor Table in your Notebook of Reference Materials, write it here, and use it to calculate PW:

Discount Factor =

PW =

Problem 5

A replacement component must be purchased at the end of nine years. If purchased today, the price would be $500. The price is expected to increase at a rate 2.4% faster than general price inflation over the nine years. The discount rate is 7%. Estimate the future replacement cost and find its present worth in a combined escalation/discount calculation.

C_P = $500
n = 9
d = 0.07
e = 0.024

a. Draw a cash flow diagram:

b. Calculate PW, using the combined escalation/discount formula:

PW =

c. Find the escalation and discount factors needed to solve this problem in the tables in your Notebook, write them here, and use them to calculate PW (Note: this will require you to interpolate between the escalation factors for 2% and 3%):

Escalation Factor =

Discount Factor =

PW =

Problem 6

Redo problem 5, but assume an escalation rate of -5%.

$$C_P = \$500$$
$$n = 9$$
$$d = 0.07$$
$$e = -0.05$$

a. Use the formula:

PW =

b. Write the escalation and discount factors:

Escalation Factor =

Discount Factor =

Problem 7

Find the present worth of a series of maintenance and repair costs which recur annually over six years. The initial payment of $300 occurs at the beginning of the first year of the analysis period (i.e., $A_o = A_i$). The series is projected to escalate at the rate of general price inflation. The real discount rate is 7%.

$$A_o = A_i = \$300$$
$$k = 6$$
$$d = 0.07$$
$$e = 0$$

a. Draw a cash flow diagram:

b. Calculate PW using the annual series formula:

PW =

c. Find the annual series factor, write it here, and use it to calculate PW:

Annual Series Factor =

PW =

Problem 8

Redo problem 7 but assume that the recurring cost escalates at a rate 3% faster than general price inflation.

$$A_o = A_i = \$300$$
$$k = 6$$
$$d = 0.07$$
$$e = 0.03$$

a. Draw a cash flow diagram:

b. Calculate PW using the annual series formula:

PW =

c. Find the appropriate annual series factor and write it here:

Annual Series Factor =

Problem 9

Redo problem 7 but assume a negative rate of escalation.

$$A_o = A_i = \$300$$
$$k = 6$$
$$d = 0.07$$
$$e = -0.05$$

a. Draw a cash flow diagram:

b. Calculate PW using the annual series formula:

P =

c. Find the annual series factor and write it here:

Annual Series Factor =

Problem 10

A series of annual M&R costs starts three years after the beginning of the analysis period and escalates at the same rate as general price inflation. The annual amount, if it occurred at the beginning of the analysis period, would be $5,000. There are 10 amounts in the series. The discount rate is 10%.

A_o	=	$5,000	d	=	0.10
n	=	3	e	=	0
k	=	10			

a. Draw a cash flow diagram:

b. Calculate PW using the appropriate formulas:

A_i =

P =

PW =

Problem 10 continued:

c. Find the appropriate factors needed to solve the problem, write them here, and use them to calculate PW:

Escalation Factor =

Annual Series Factor =

Discount Factor =

PW =

Problem 11

Redo problem 10, but assume that the series of costs escalates uniformly at an annual rate of 4%.

A_o	=	\$5,000	d	=	0.10
n	=	3	e	=	0.04
k	=	10			

a. Draw a cash flow diagram:

b. Calculate PW using factors:

A_i =

P =

PW =

Problem 12

Redo problem 10 but assume that there is a negative escalation rate of 5%.

A_o	=	\$5,000	d	=	0.10
n	=	3	e	=	-0.05
k	=	10			

a. Draw a cash flow diagram:

b. Calculate PW using factors:

A_i =

P =

PW =

Problem 13

Compute the PW of an annual series consisting of 11 payments expected to escalate at a variable rate over the analysis period. The annual amount based on prices at the beginning of the analysis period is $500. The first payment is incurred two years after the beginning of the analysis period. The escalation rate for the two years before the first payment is made is -2%. The escalation rate over the next five years is 3%, and over the remaining six years it is 5%. The discount rate is 7%.

A_o	=	$500	d	=	0.07
n	=	2	e_1	=	-0.02
k_1	=	5	e_2	=	0.03
k_2	=	6	e_3	=	0.05
$A1_i$	=	initial payment of first subseries			
$A2_i$	=	initial payment of second subseries			

a. Draw a cash flow diagram:

b. Calculate PW using factors:

- Find the magnitude of the first payment in the first subseries:

  $A1_i$ =

- Find the equivalent one-time cost of the five payments in the first subseries:

  P1 =

Problem 13 continued:

- Find the magnitude of the first payment in the second subseries:

  $A2_i$ =

- Find the equivalent one-time cost of the six payments as of the beginning of the second subseries:

  P2 =

- Find the present worth of the first subseries as of the beginning of the analysis period:

  PW1 =

- Find the present worth of the second subseries as of the beginning of the analysis period:

  PW2 =

- Find the present worth of the entire series of payments:

  PW =

State what the answer means:

END OF EXERCISE 6-1

6.5 COMPUTE LCC

The purpose of this section is to demonstrate how to bring together present worth calculations to compute the life-cycle costs of alternatives.

By the end of sections 6.5 and 6.6, you are expected to be able to

- calculate LCCs of alternatives
- choose from the alternatives on the basis of LCCs

Example 6.18: USE LCCA TO CHOOSE BETWEEN THE FOLLOWING PIECES OF EQUIPMENT FOR DOING THE SAME JOB:

DATA	Equipment A	Equipment B
Cost of Procurement (Beginning of analysis period)	$10,000	$20,000
Routine Maintenance Costs (e = 0) (Series starts midway 1st year)	$2,000/yr	$1,000/yr
Repair Cost (End of year in which it occurs)	$600/yrs 5&10	$500/yr 8
Fuel Costs (uniform e = 4%) (Series starts end of 1st year)	A_o = $6,500/yr	$4,500/yr
Salvage Value Net of Disposal (Received at end of last year)	0 in year 15	$1,000 in year 15
Service Life	15 years	15 years

Annual Discount Rate = 10% real

Analysis Period = 15 years

All Amounts Stated in Constant Dollars

STEP 1. COMPUTE LCC FOR EQUIPMENT A:

PW (Procurement) = \$10,000
(already in PW)

PW (Maintenance) = \$2,000 x 8.367 x 0.9535 = \$15,956
A_o x Annual Series Factor, e = 0 x SPW 0.5yrs

PW (Repair) = (\$600 x 0.6209) + (\$600 x 0.3855) = \$604
1st repair 2nd repair

PW (Fuel) = (\$6,500 x 1.040) x 10.429 x 0.9091 = \$64,092
(A_i = A_o x Esc. Fact.) x Annual Series Factor x SPW 1yr

PW (Net Salvage) = 0

LCC (A) = \$10,000 + \$15,956 + \$604 + \$64,092 - 0 = \$90,652

STEP 2. COMPUTE LCC FOR EQUIPMENT B:

PW (Procurement) = \$20,000
(already in PW)

PW (Maintenance) = \$1,000 x 8.367 x 0.9535 = \$7,978
A_o x Annual Series Factor, e = 0 x SPW 0.5yrs

PW (Repair) = \$500 x 0.4665 = \$233
Discount Factor for yr 8

PW (Fuel) = (\$4,500 x 1.040) x 10.429 x 0.9091 = \$44,371
(A_i = A_o x Esc. Fact.) x Annual Series Factor x SPW 1yr

PW (Net Salvage) = \$1,000 x 0.2394 = \$239

LCC (B) = \$20,000 + \$7,978 + \$233 + \$44,371 - \$239 = \$72,343

STEP 3. COMPARE LCC AND CHOOSE THE ALTERNATIVE WITH THE LOWEST LCC:

LCC (A) = \$90,652

LCC (B) = \$72,343

Choose Equipment B

6.6 EXERCISE 6-2: LCC

The purpose of this section is to provide you practice in applying escalation and discounting skills to compare alternatives on the basis of their life-cycle costs (LCCs).

Calculate LCCs for the following window alternatives and make a choice between them based on their LCCs:

DATA	WINDOW ALTERNATIVES	
	Single Glazed Wood Frames	Double Glazed Vinyl-Clad Frames
Purchase & Installation (Beginning of analysis period)	\$12,000	\$17,000
Cleaning Costs (e = 0) (Series starts midway 1st year)	\$500/yr	\$500/yr
Painting and Repair (End of year in which it occurs)	\$2,000/yrs 5,10,15	\$500/yr 10
Fuel Costs (uniform e = 2%) (Series starts midway 1st year)	A_o = \$2,600	\$1,900
Resale of Building (End of last year)	0	\$5,000

Annual Discount Rate = 10% real

Analysis Period = 20 years

All Amounts Stated in Constant Dollars

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MODULE 7

HOW TO PERFORM MILCON GENERAL ECONOMIC STUDIES

Purpose:

- To take you from generic calculations to specific MILCON design analysis
- To present the Army/Air Force criteria for general economic studies
- To give you hands-on practice in performing general economic studies according to criteria

Outline:

7.1 Criteria for General Economic Studies

7.2 Input Data & Cash-Flow Diagrams

7.3 Computing LCC Using Conventional Approach

7.4 Exercise 7-1: Conventional Approach

7.5 Computing LCC Using One-Step Approach

7.6 Exercise 7-2: One-Step Approach

7.7 Ranking Design Alternatives

7.8 Exercises 7-3 & 7-4: Ranking

Approximate Time:

4 hours

Slide 7-1

HOW TO PERFORM

MILCON GENERAL ECONOMIC STUDIES

Notes:

7.1 CRITERIA FOR GENERAL ECONOMIC STUDIES

By the end of this section, you are expected to be able to

- describe the criteria governing MILCON general economic studies

Slide 7-2

CRITERIA FOR GENERAL ECONOMIC STUDIES

1. **Methodology**
2. **Data & Parameters**
3. **Management Considerations**

Notes:

Slide 7-3 (a-i)

METHODOLOGY CRITERIA

1. EA method: LCC (principal)
2. Coverage of each analysis: all feasible alternatives
3. Discounting approach: PW at DOS
4. Time frame: ABD thru lesser of economic life or 25 yrs from BOD
5. Measured effects: all relevant & signif $ costs & benefits
6. Inflation: relative approach – constant $ & real d
7. Cash-flow model: construction – MPC
   annually recurring – mid year
   non-annually recurring – actual
8. Uncertainty: assessment required when critical to ranking

Notes:

Slide 7-4 (a-e)

CRITICATERIA CONCERNING DATA AND PARAMETERS

- Discount rate: 10%
- Initial costs & benefits: $ as of DOS
- Actual prices
- Projected changes in prices
  - energy: use DOE e values
  - other: use available projections if reasonable; otherwise use e = 0

Notes:

Slide 7-5

CRITERIA CONCERNING MANAGEMENT CONSIDERATIONS

- Choose cost-effective level of EA/LCCA
- Document study results

Notes:

Slide 7-6

INDICATE KEY CALENDAR DATES

- (DOS) Date of Study, e.g., 1/90
- (ABD) Analysis Base Date (=DOS)
- (MPC) Midpoint of Construction, e.g., 7/92
- (BOD) Beneficial Occupancy Date, e.g, 1/93
- (AED) Analysis End Date, e.g., 1/18

Notes:

7.2 INPUT DATA & CASH FLOW DIAGRAM

By the end of this session, you are expected to be able to

- summarize and document input data on DA Form 5605-3
- prepare cash flow diagrams using calendar dates and MILCON cash-flow modeling conventions

Vugraph 7-1. DA Form 5605-3
(Basic Input Data Summary)

Project No. & Title ____________________
Installation & Location ____________________
Design Feature ____________________
Alt. No. ________ Title ____________________

LIFE CYCLE COST ANALYSIS
BASIC INPUT DATA SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference		
Date of Study (DOS)		
Analysis Base Date (ABD)		
Analysis End Date (AED)		
Midpoint of Construction		
Beneficial Occupancy Date (BOD)	Actual Projected	
	Assumed for Analysis	
DOE Region		
Annual Discount Rate		

Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe:		

Principal Assumptions

Cash Flow Diagram

Cost Element	Cost on ABD ☐ $ x 10³ ☐ $ x 10⁶	Time Cost Incurred**		Source(s) of Data
		Actual Projected Dates	Dates for Analysis (If Different)*	

DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply
**For Recurring Annual Costs, show date of first and last costs only.

Sheet ________ of ________

INPUT DATA

The study is being performed on 7/1/88, and that is also the analysis base date. Two alternatives, A & B are being considered for exterior doors for a mess hall at Fort Bragg, NC. The project is assigned the number 567. Data for alternative A are as follows:

DOS:	7/88
ABD:	7/88
Construction Start:	7/90
Construction Period:	One year
BOD:	End of Construction Period (7/91)
First Recurring Cost:	Usually six months after BOD (1/92)
Analysis Period:	From 7/88 extending 25 years past BOD (7/16)

Cost Element	Costs on DOS	Time to be Incurred	Data Sources
Initial Investment	$100,000	1/91	Supplier est.
Replacement	$ 20,000	7/03	Supplier est.
M&R	$ 5,000	1/92 (1st)	M&R Database
Natural Gas	$ 8,000	1/92 (1st)	BLAST Program
Retention Value	$-10,000	7/16	Estimating Procedure Described in Attachment 1

DOE Region = 4 (Huntsville)

Differential Escalation (e values)

	July 1 - June 30		
	87-90	90-95	95-16
Natural gas	2.63%	9.17%	6.10%
Other	0	0	0

Vugraph 7-2. Blow up of project description

Project No. & Title ________________________________

Installation & Location ________________________________

Design Feature ________________________________

Alt. No. ________ Title ________________________________

Vugraph 7-3. Blow up of key date section

<table>
<tr><td colspan="2">Criteria Reference</td><td></td></tr>
<tr><td colspan="2">Date of Study (DOS)</td><td></td></tr>
<tr><td colspan="2">Analysis Base Date (ABD)</td><td></td></tr>
<tr><td colspan="2">Analysis End Date (AED)</td><td></td></tr>
<tr><td colspan="2">Midpoint of Construction</td><td></td></tr>
<tr><td rowspan="2">Beneficial Occupancy Date (BOD)</td><td>Actual
Projected</td><td></td></tr>
<tr><td>Assumed for Analysis</td><td></td></tr>
</table>

Vugraph 7-4. Blow up of DOE region, discount rate, escal rates

DOE Region			
Annual Discount Rate			
Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe:		

Vugraph 7-5. Blow up of bottom part of form

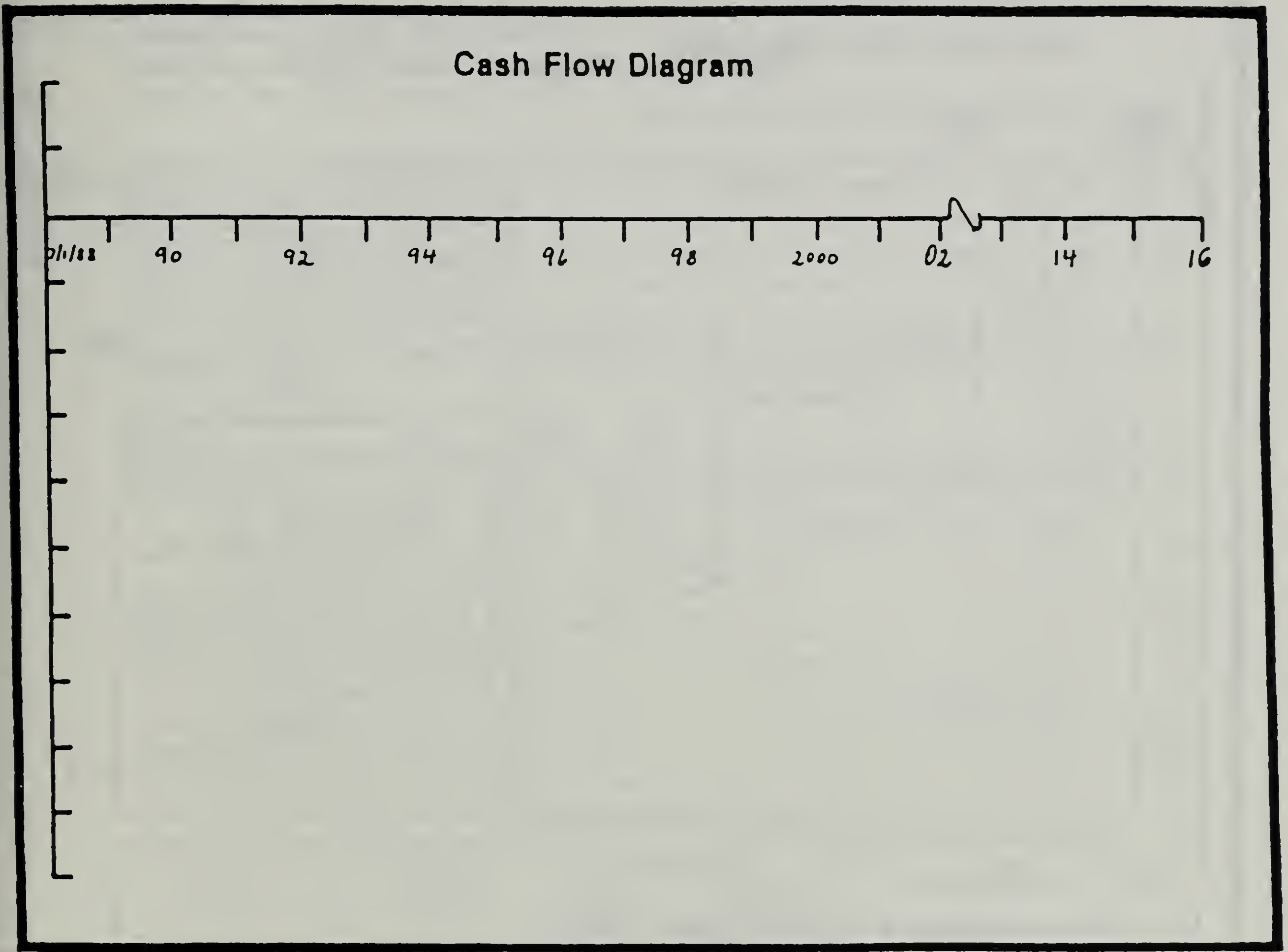
Cost Element	Cost on ABD ☐ $ x 10^3 ☐ $ x 10^6	Time Cost Incurred**		Source(s) of Data
		Actual Projected Dates	Dates for Analysis (If Different)*	

DA FORM 5605-3-R, DEC 86

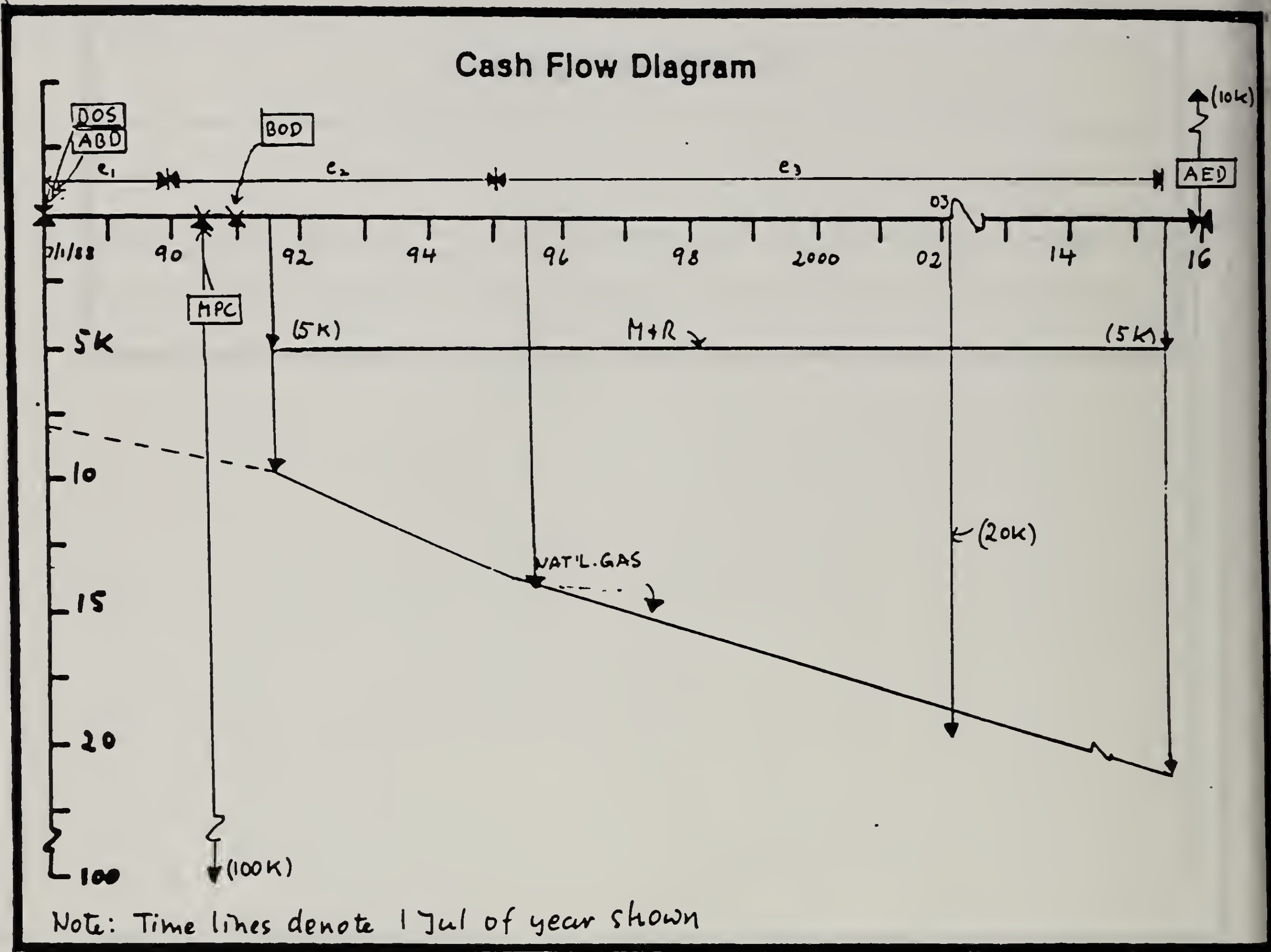
Vugraph 7-6. Blow up of principal assumptions part of form

Principal Assumptions

Vugraph 7-7. Blow up of cash flow diagram



Vugraph 7-8. Blow up of cash flow diagram completed



Vugraph 7-9. Completed form

Project No. & Title PN 567 Mess Hall
Installation & Location ARCDE Fort Bragg NC
Design Feature Exterior Doors
Alt. No. A Title Sliding Door

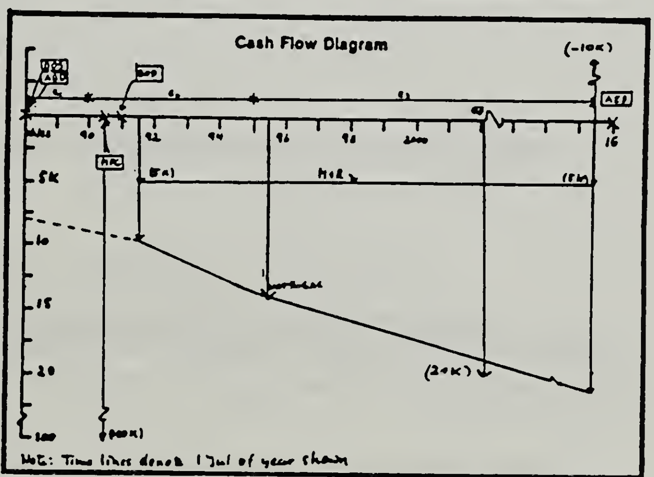
LIFE CYCLE COST ANALYSIS
BASIC INPUT DATA SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference		HQ DA
Date of Study (DOS)		1 JUL 88
Analysis Base Date (ABD)		1 JUL 88
Analysis End Date (AED)		1 JUL 2016
Midpoint of Construction		1 JAN 91
Beneficial Occupancy Date (BOD)	Actual Projected	1 JUL 91
	Assumed for Analysis	
DOE Region		4
Annual Discount Rate		10 %

Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe: JUL – JUN		
	87-90	90-95	95-16
Nat'l. Gas	2.63	9.17	6.10
Other	0.00	0.00	0.00

Principal Assumptions



Cost Element	Cost on ABD ☒ $ x 10³ ☐ $ x 10⁶	Time Cost Incurred**		Source(s) of Data
		Actual Projected Dates	Dates for Analysis (If Different)*	
Initial Investment	100	1 Jan 91		Supplier Estimate
Replacement	20	1 Jul 2003		Supplier Estimate
M+R	5	1 Jan 92 - 1 Jan 16		M+R Database
Natural Gas	8	1 Jan 92 - 1 Jan 16		BLAST Progr.
Retention V.	-10	1 Jul 16		Attachment 1

DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply
**For Recurring Annual Costs, show date of first and last costs only.

Sheet______ of______

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7.3 COMPUTING LCC: CONVENTIONAL APPROACH

By the end of sessions 7.3 and 7.4 you are expected to be able to

- calculate present worths of cash flows typically encountered in general economic studies using the "conventional approach," and calculate LCC
- use DA Form 5605-4 to structure and document the calculations

Vugraph 7-10. DA Form 5605-4 (Present Worth: Conventional Approach)

Project No. & Title ____________________

Installation & Location ____________________

Design Feature ____________________

Alt. No. ______ Title ____________________

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: CONVENTIONAL APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference	
Analysis Base Date (ABD)	
Analysis End Date (AED)	
Midpoint of Construction	
BOD for Analysis	
Annual Discount Rate	

Type of Cost	Differential Escalation Rate per Year (%) Timeframe:	

One-Time Costs ($ x 10³ / $ x 10⁶)	Years From ABD	Cost on ABD	Escalation Factor	Escal.Cost (Time Incurred)	Discount Factor	Present Worth on ABD

Annual Costs ($ x 10³ / $ x 10⁶)	Years from ABD		Total No. of Payments	Annual Cost on ABD	Escalation Factor	Escal.Cost (Time First Incurred)			Discount Factor	Present Worth on ABD
	First Incurred	Last Incurred				1st Ann. Cost in Series	Annual Series Eq Factor	Equiv. Single Cost		

Net Present Worth: ______ Initial Costs + ______ Energy/Fuel Costs + ______ M&R Costs + ______ Other Costs = ______ Total

DA FORM 5605-4-R, DEC 86

Sheet ______ of ______

Vugraph 7-11. Blow up of one-time cost section of form

One-Time Costs X $ x 10³ : $ x 10⁶	Years From ABD	Cost on ABD	Escalation Factor	Escal. Cost (Time Incurred)	Discount Factor	Present Worth on ABD

Criteria Reference	HQDA
Analysis Base Date (ABD)	Jul 88
Analysis End Date (AED)	Jul 2016
Midpoint of Construction	Jan 91
BOD for Analysis	Jul 91
Annual Discount Rate	10%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul-Jun 87-90	90-95	95-16
Nat'l Gas	2.63	9.17	6.10
Other	0.00	0.00	0.00

Vugraph 7-12. Blowup of annual cost section

Annual Costs [ ] $ x 10^3 [ ] $ x 10^6	Years from ABD		Total No. of Payments	Annual Cost on ABD	Escalation Factor	Escal.Cost (Time First Incurred)			Discount Factor	Present Worth on ABD
	First Incurred	Last Incurred				1st Ann. Cost in Series	Annual Series Eq Factor	Equiv. Single Cost		

Vugraph 7-13. DA Form 5605-4 completed, except for LCC on last line

Project No. & Title PN 567 Mess Hall
Installation & Location ABCDE, Fort Bragg, NC
Design Feature Exterior Doors
Alt. No. A Title Sliding Door

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: CONVENTIONAL APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference	HQDA
Analysis Base Date (ABD)	Jul 88
Analysis End Date (AED)	Jul 2016
Midpoint of Construction	Jan 91
BOD for Analysis	Jul 91
Annual Discount Rate	10%

Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe: Jul-Jun 87-90	90-95	95-16
Nat'l G.	2.63	9.17	6.10
Other	0.00	0.00	0.00

One-Time Costs X $ x 10³ : $ x 10⁶	Years From ABD	Cost on ABD	Escalation Factor	Escal.Cost (Time Incurred)	Discount Factor	Present Worth on ABD
Initial Investment	2.5	100	$(1.0)^{2.5}$	100	$(\frac{1}{1.1})^{2.5}=.788$	78.8
Replacement Cost	15	20	$(1.0)^{15}$	20	$(\frac{1}{1.1})^{15}=.239$	4.8
Retention V.	28	-10	$(1.0)^{28}$	-10	$(\frac{1}{1.1})^{28}=.069$	-0.7

Annual Costs X $ x 10³ : $ x 10⁶	Years from ABD: First Incurred	Years from ABD: Last Incurred	Total No. of Payments	Annual Cost on ABD	Escalation Factor	Escal.Cost (Time First Incurred): 1st Ann. Cost in Series	Annual Series Eq Factor	Equiv. Single Cost	Discount Factor	Present Worth on ABD
M&R	3.5	27.5	25	5	$(1.0)^{3.5}$	5	9.985	49.9	.7164	35.7
Natural gas										
(1) 92-95	3.5	6.5	4	8	$(1.0263)^{2}(1.0917)^{1.5}$	9.6	3.955	38.0	.7164	27.2
(2) 96-16	7.5	27.5	21	8	$(1.0263)^{2}(1.0917)^{5}(1.0610)^{.5}$	13.46	14.995	201.8	.4892	98.7

Net Present Worth: Initial Costs ______ + Energy/Fuel Costs ______ + M&R Costs ______ + Other Costs ______ = Total ______

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Sheet ______ of ______

Vugraph 7-14. Present Worth: Conventional Approach
(DA Form 5604-4 completed)

Project No. & Title PN 567 Mess Hall
Installation & Location ABCDE, Fort Bragg, NC
Design Feature Exterior Doors
Alt. No. A Title Sliding Door

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: CONVENTIONAL APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs (X $ x 10³ / $ x 10⁶)	Years From ABD	Cost on ABD	Escalation Factor	Escal.Cost (Time Incurred)	Discount Factor	Present Worth on ABD
Initial Investment	2.5	100	$(1.0)^{2.5}$	100	$(\frac{1}{1.1})^{2.5}$ = .788	78.8
Replacement Cost	15	20	$(1.0)^{15}$	20	$(\frac{1}{1.1})^{15}$ = .239	4.8
Retention V.	28	-10	$(1.0)^{28}$	-10	$(\frac{1}{1.1})^{28}$ = .069	-0.7

Criteria Reference	HQDA
Analysis Base Date (ABD)	Jul 88
Analysis End Date (AED)	Jul 2016
Midpoint of Construction	Jan 91
BOD for Analysis	Jul 91
Annual Discount Rate	10%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul-Jun 87-90	90-95	95-16
Nat'l G.	2.63	9.17	6.10
Other	0.00	0.00	0.00

Annual Costs (X $ x 10³ / $ x 10⁶)	Years from ABD: First Incurred	Last Incurred	Total No. of Payments	Annual Cost on ABD	Escalation Factor	Escal.Cost (Time First Incurred): 1st Ann. Cost in Series	Annual Series Eq Factor	Equiv. Single Cost	Discount Factor	Present Worth on ABD
M&R	3.5	27.5	25	5	$(1.0)^{3.5}$	5	9.985	49.9	.7164	35.7
Natural gas										
① 92-95	3.5	6.5	4	8	$(1.0263)^{2}(1.0917)^{1.5}$	9.6	3.955	38.0	.7164	27.2
② 96-16	7.5	27.5	21	8	$(1.0263)^{2}(1.0917)^{5}(1.0610)^{.5}$	13.46	14.995	201.8	.4892	98.7

Net Present Worth:	Initial Costs	Energy/Fuel Costs	M&R Costs	Other Costs	Total
	78.8 +	125.9 +	35.7 +	4.1 =	245

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Sheet ______ of ______

7.4 EXERCISE 7-1: COMPUTE LCC USING CONVENTIONAL APPROACH

Suppose you have been asked to design a vehicle maintenance shop for Fort X in Huntsville, and you need to select among alternative exterior wall surfaces. Compute LCC of exterior wall design alternative A (Tile) by completing the attached DA Forms 5605-3 and 4, based on the following data:

Project Number:	PN568
Date of Study (DOS):	7/88
Analysis Base Date (ABD):	7/88
Beginning of Construction:	Two years from DOS
Length of Construction Period:	One year
Beneficial Occupancy Date (BOD):	End of Construction Period
Initial Investment Costs (as of DOS):	$75,000
M&R Costs (as of DOS):	$2,000/yr
Distillate Fuel (as of DOS): (M&R and Fuel costs start six months after BOD)	$12,000/yr plus escalation
Repair Cost (as of DOS): (Repair cost first occurs five years after BOD)	$5,000/every five years
Retention Value (as of DOS): (Retention value occurs 25 years after BOD)	$7,500

Differential Escalation Rates ("e values")	1987-90	90-95	95 & beyond
Distillate (Hint: Look them up)			
Other	0	0	0

Data Sources: Initial investment -- Means Cost Data; M&R -- M&R Database; Repair -- Repair Records; Retention Value -- Prorated cost described in attachment; Energy -- BLAST.

Exercise 7-1. Basic Input Data Summary

Project No. & Title ______________________

Installation & Location ______________________

Design Feature ______________________

Alt. No. ________ Title ______________________

LIFE CYCLE COST ANALYSIS

BASIC INPUT DATA SUMMARY

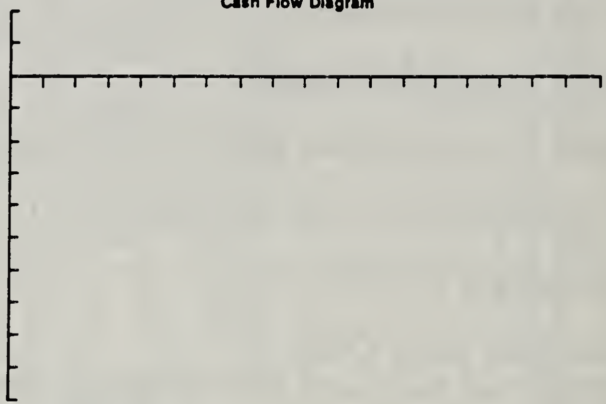
For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference		
Date of Study (DOS)		
Analysis Base Date (ABD)		
Analysis End Date (AED)		
Midpoint of Construction		
Beneficial Occupancy Date (BOD)	Actual Projected	
	Assumed for Analysis	
DOE Region		
Annual Discount Rate		

Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe:		

Principal Assumptions

Cash Flow Diagram



Cost Element	Cost on ABD ☐ $ x 10³ ☐ $ x 10⁶	Time Cost Incurred**		Source(s) of Data
		Actual Projected Dates	Dates for Analysis (If Different)*	

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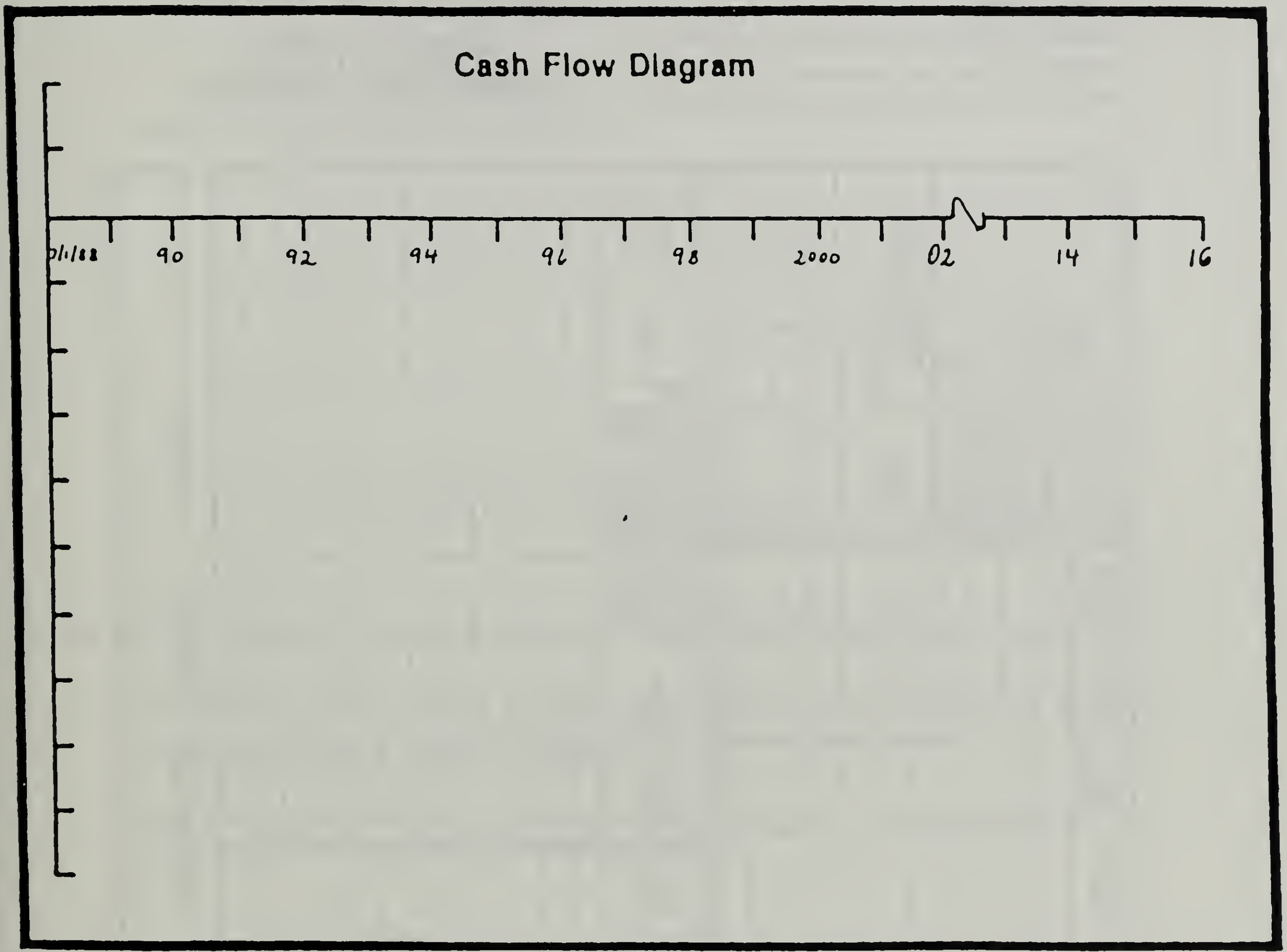
*When 10 CFR436A Criteria Apply

**For Recurring Annual Costs, show date of first and last costs only.

Sheet ________ of ________

Exercise 7-1. Enlarged Cash Flow Diagram



Exercise 7-1. Present Worth: Conventional Approach

Project No. & Title ____________________

Installation & Location ____________________

Design Feature ____________________

Alt. No. ______ Title ____________________

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: CONVENTIONAL APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference	
Analysis Base Date (ABD)	
Analysis End Date (AED)	
Midpoint of Construction	
BOD for Analysis	
Annual Discount Rate	

Type of Cost	Differential Escalation Rate per Year (%)	
	Timeframe:	

One-Time Costs ($\$ \times 10^3$ / $\$ \times 10^6$)	Years From ABD	Cost on ABD	Escalation Factor	Escal.Cost (Time Incurred)	Discount Factor	Present Worth on ABD

Annual Costs ($\$ \times 10^3$ / $\$ \times 10^6$)	Years from ABD: First Incurred	Years from ABD: Last Incurred	Total No. of Payments	Annual Cost on ABD	Escalation Factor	Escal.Cost (Time First Incurred): 1st Ann. Cost In Series	Escal.Cost (Time First Incurred): Annual Series Eq Factor	Escal.Cost (Time First Incurred): Equiv. Single Cost	Discount Factor	Present Worth on ABD

Net Present Worth: ______ Initial Costs + ______ Energy/Fuel Costs + ______ M&R Costs + ______ Other Costs = ______ Total

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Sheet ______ of ______

7.5 COMPUTING LCC: ONE-STEP APPROACH

By the end of sessions 7.5 and 7.6 you are expected to be able to

- calculate present worths of cash flows typically encountered in general economic studies using the simplified "one-step approach"
- use DA Form 5605-5 to structure and document the calculations

Slide 7-7

ONE-STEP ADJUSTMENT FACTORS (OSAFs)

- Special factor tables simplify calculations
- Factors express PW as fraction of the undiscounted/ unescalated amount

Notes:

Slide 7-8

ONE-STEP ADJUSTMENT FACTORS (OSAFs)

1) **OSAFs/Standard SPW Factors; All Regions: One-Time Costs**

2) **OSAFs/Normalized UPW* Factors; All Regions: M&R**

3) **OSAFs/Normalized UPW* Factors; Region #: Energy Type**

Notes:

Vugraph 7-15. Energy Table

REGION 1: ELECTRICITY — INDUSTRIAL SECTOR — REGION 1: ELECTRICITY

"ONE STEP" ADJUSTMENT FACTORS (OSAFS) / NORMALIZED UPW* FACTORS <1>

JUNE 1988

ANALYSIS PERIOD, k (NUMBER OF PAYMENTS)	BENEFICIAL OCCUPANCY DATE									
	FOR FEMP <2>	FOR NON-FEMP APPLICATIONS <3>								
	JUL 1987	JUL 1989	JUL 1990	JUL 1991	JUL 1992	JUL 1993	JUL 1994	JUL 1995	JUL 1996	JUL 1997
1	.9658	.8288	.7293	.6376	.5586	.4989	.4511	.4070	.3673	.3323
2	.9237	.7790	.6834	.5981	.5287	.4750	.4291	.3872	.3498	.3182
3	.8817	.7319	.6418	.5650	.5029	.4523	.4085	.3689	.3345	.3057
4	.8417	.6885	.6061	.5365	.4789	.4311	.3895	.3527	.3211	.2935
5	.8022	.6506	.5751	.5106	.4566	.4113	.3724	.3383	.3083	.2817
6	.7661	.6174	.5471	.4868	.4359	.3934	.3571	.3247	.2959	.2703
7	.7342	.5873	.5214	.4647	.4170	.3773	.3428	.3118	.2842	.2594
8	.7057	.5598	.4978	.4446	.4000	.3623	.3292	.2995	.2729	.2492
9	.6792	.5345	.4762	.4264	.3841	.3481	.3164	.2878	.2623	.2394
10	.6548	.5115	.4567	.4095	.3691	.3346	.3042	.2768	.2522	.2302
11	.6321	.4905	.4385	.3935	.3550	.3219	.2926	.2663	.2426	.2214
12	.6115	.4711	.4215	.3785	.3416	.3098	.2817	.2563	.2336	.2131
13	.5925	.4528	.4055	.3644	.3289	.2984	.2713	.2469	.2250	.2053
14	.5745	.4357	.3904	.3510	.3170	.2876	.2615	.2380	.2168	.1978
15	.5575	.4196	.3762	.3383	.3056	.2773	.2522	.2295	.2091	.1908
16	.5414	.4045	.3628	.3264	.2949	.2676	.2434	.2215	.2018	.1841
17	.5260	.3902	.3501	.3151	.2847	.2584	.2350	.2139	.1949	.1778
18	.5114	.3767	.3381	.3043	.2751	.2497	.2271	.2067	.1883	.1718
19	.4974	.3639	.3267	.2942	.2659	.2414	.2195	.1998	.1821	.1661
20	.4841	.3518	.3159	.2845	.2572	.2335	.2124	.1933	.1762	.1607
21	.4713	.3403	.3057	.2754	.2490	.2260	.2056	.1871	.1705	.1555
22	.4591	.3295	.2960	.2667	.2412	.2189	.1991	.1813	.1652	.1507
23	.4473	.3192	.2868	.2584	.2337	.2122	.1930	.1757	.1601	.1460
24	.4361	.3094	.2780	.2505	.2266	.2057	.1872	.1704	.1552	.1416
25	.4253	.3000	.2697	.2431	.2199	.1996	.1816	.1653	.1506	.1374
30	.3772	.2598	.2336	.2106	.1906	.1731	.1574	.1433	.1306	.1191
35	.3374	.2279	.2050	.1849	.1673	.1519	.1382	.1258	.1146	.1046
40	.3041	.2023	.1820	.1641	.1486	.1349	.1227	.1117	.1018	.0929
45	.2760	.1814	.1632	.1472	.1333	.1210	.1101	.1002	.0913	.0833
50	.2521	.1642	.1477	.1333	.1206	.1096	.0997	.0907	.0827	.0754

TABLE 3.1.EL "ONE STEP" ADJUSTMENT FACTORS — REGION 1: ELECTRICITY

NOTES: <1> TABULATED OSAFS (UPW*/k) VALID THRU DECEMBER 1988
<2> OSAFS BASED ON FEMP CRITERIA (10CFR436A): FIXED (ARTIFICIAL) BOD, 7% DISCOUNT RATE, AND END-OF-YEAR CONVENTION
<3> OSAFS BASED ON FEDS CRITERIA (DOD STANDARD): ACTUAL PROJECTED BOD, 10% DISCOUNT RATE, AND MIDDLE-OF-YEAR CONVENTION

<u>To use energy OSAFs for general economic studies</u>:

- Find Applicable BOD in "Non-FEMP" column.
- In "k" column find number of payments in the analysis period.
- For that k, find OSAF in BOD column.
- Multiply total unescalated/undiscounted cost by the OSAF to find PW, i.e.,

PW = Annual cost as of DOS x k x OSAF

EXAMPLE:

For BOD =	7/92	PW	= $1,000 x 25 x 0.2199
k =	25 years		
Annual Electricity Cost as of DOS =	$1,000		= $5,498

- In contrast, using the conventional approach would require first dividing the cash flow into three subseries, one to cover each escalation rate period; then using escalation factors to find the initial payment beginning each subseries; then using annual equivalence factors to find the one-time equivalent worth of each subseries at the beginning of the subseries; then finding the PW of each of those amounts; and finally summing to find the total PW as of the ABD.

- It is in calculating PW of energy costs that you will find the OSAF tables most beneficial.

- As of June 1988, there was a set of five tables for each of 10 DOE regions of the country. The map at the front of the OSAF tables in your Notebook shows the regions. The number of regions has since been reduced to the four census regions. There are separate tables for electricity, distillate oil, residual oil, natural gas, and steam coal.

Slide 7-9

To find PW of a series of energy costs based on DoE-projected escalation rates

PW = Annual cost as of DOS (A_o) x number of payments (R) x OSAF

Notes:

Vugraph 7-16. M&R Table

ALL REGIONS: MAINTENANCE AND REPAIR (M&R) <4>

ALL REGIONS: MAINTENANCE AND REPAIR (M&R) <4>

"ONE STEP" ADJUSTMENT FACTORS (OSAFS) / NORMALIZED UPW* FACTORS <1>

JUNE 1988

ANALYSIS PERIOD, k (NUMBER OF PAYMENTS)	BENEFICIAL OCCUPANCY DATE									
	FOR FEMP <2>	FOR NON-FEMP APPLICATIONS <3>								
	JUL 1987	JUL 1989	JUL 1990	JUL 1991	JUL 1992	JUL 1993	JUL 1994	JUL 1995	JUL 1996	JUL 1997
1	.9346	.8599	.7818	.7107	.6461	.5873	.5339	.4854	.4413	.4012
2	.9040	.8208	.7462	.6784	.6167	.5606	.5097	.4633	.4212	.3829
3	.8748	.7841	.7128	.6480	.5891	.5356	.4869	.4426	.4024	.3658
4	.8468	.7496	.6815	.6195	.5632	.5120	.4654	.4231	.3847	.3497
5	.8200	.7172	.6520	.5927	.5388	.4898	.4453	.4048	.3680	.3346
6	.7944	.6866	.6242	.5675	.5159	.4690	.4263	.3876	.3523	.3203
7	.7699	.6579	.5981	.5437	.4943	.4493	.4085	.3714	.3376	.3069
8	.7464	.6308	.5735	.5213	.4739	.4308	.3917	.3561	.3237	.2943
9	.7239	.6053	.5503	.5002	.4548	.4134	.3758	.3417	.3106	.2824
10	.7024	.5812	.5284	.4804	.4367	.3970	.3609	.3281	.2983	.2711
11	.6817	.5585	.5078	.4616	.4196	.3815	.3468	.3153	.2866	.2606
12	.6619	.5371	.4883	.4439	.4035	.3668	.3335	.3032	.2756	.2506
13	.6429	.5169	.4699	.4272	.3883	.3530	.3209	.2918	.2652	.2411
14	.6247	.4977	.4525	.4114	.3740	.3400	.3091	.2810	.2554	.2322
15	.6072	.4796	.4360	.3964	.3604	.3276	.2978	.2707	.2461	.2238
16	.5904	.4625	.4205	.3823	.3475	.3159	.2872	.2611	.2374	.2158
17	.5743	.4463	.4058	.3689	.3353	.3049	.2771	.2519	.2290	.2082
18	.5588	.4310	.3918	.3562	.3238	.2944	.2676	.2433	.2212	.2011
19	.5440	.4164	.3786	.3442	.3129	.2844	.2586	.2351	.2137	.1943
20	.5297	.4027	.3661	.3328	.3025	.2750	.2500	.2273	.2066	.1878
21	.5160	.3896	.3542	.3220	.2927	.2661	.2419	.2199	.1999	.1817
22	.5028	.3771	.3429	.3117	.2834	.2576	.2342	.2129	.1935	.1759
23	.4901	.3653	.3321	.3019	.2745	.2495	.2268	.2062	.1875	.1704
24	.4779	.3541	.3219	.2927	.2661	.2419	.2199	.1999	.1817	.1652
25	.4661	.3434	.3122	.2838	.2580	.2346	.2133	.1939	.1762	.1602
30	.4136	.2972	.2702	.2457	.2233	.2030	.1846	.1678	.1525	.1387
35	.3699	.2606	.2370	.2154	.1958	.1780	.1618	.1471	.1338	.1216
40	.3333	.2313	.2102	.1911	.1737	.1580	.1436	.1305	.1187	.1079
45	.3023	.2073	.1885	.1713	.1558	.1416	.1287	.1170	.1064	.0967
50	.2760	.1876	.1705	.1550	.1409	.1281	.1165	.1059	.0963	.0875

TABLE 2 "ONE STEP" ADJUSTMENT FACTORS — ALL REGIONS, MAINTENANCE AND REPAIR (M&R)

NOTES:
<1> TABULATED OSAFS (UPW*/k) VALID THRU DECEMBER 1988
<2> OSAFS BASED ON FEMP CRITERIA (10CFR436A): FIXED (ARTIFICIAL) BOD, 7% DISCOUNT RATE, AND END-OF-YEAR CONVENTION
<3> OSAFS BASED ON FEDS CRITERIA (DOD STANDARD): ACTUAL PROJECTED BOD, 10% DISCOUNT RATE, AND MIDDLE-OF-YEAR CONVENTION
<4> ADJUSTMENT FACTORS BASED ON ASSUMED DIFFERENTIAL ESCALATION RATE OF 0%

You can use these factors to calculate the PW of M&R costs that start as much as nine years after DOS. Using them eliminates the step in the conventional approach of applying a discount factor to account for the difference between DOS and BOD.

But the factors apply only when there is no differential escalation in M&R costs. If there is differential escalation, it is necessary to use the conventional approach.

- They are used just like the energy OSAFs: locate the OSAF for BOD and k, and multiply it by the product of annual M&R (as of DOS) times k.

EXAMPLE:

For BOD = 7/94		
k = 15 years	PW =	\$25,000 x 15 x 0.2978
Annual M&R = \$25,000	=	\$111,675

Slide 7-10

To find PW of uniform annual series

PW? <---- A + A + . . . + A

PW = Annual cost (A) x number of payments (k) x OSAF

Notes:

Vugraph 7-17. One-Time Costs Table

ALL REGIONS: ONE-TIME COSTS <4>

ALL REGIONS: ONE-TIME COSTS <4>

"ONE-STEP" ADJUSTMENT FACTORS (OSAFs)/STANDARD SPW FACTORS <1>

FOR FEMP APPLICATIONS <2>				FOR NON-FEMP APPLICATIONS <3>			
TIME COST INCURRED (YEARS AFTER) (FEMP ABO)	OSAF/SPW FACTOR	TIME COST INCURRED (YEARS AFTER) (FEMP ABO)	OSAF/SPW FACTOR	TIME COST INCURRED (YEARS) (AFTER DOS)	OSAF/SPW FACTOR	TIME COST INCURRED (YEARS) (AFTER DOS)	OSAF/SPW FACTOR
0.00	1.0000	16.0	0.3387	0.00	1.0000	16.0	0.2176
0.25	0.9832	17.0	0.3166	0.25	0.9765	17.0	0.1978
0.60	0.9667	18.0	0.2959	0.50	0.9535	18.0	0.1799
0.75	0.9505	19.0	0.2765	0.75	0.9310	19.0	0.1635
		20.0	0.2584			20.0	0.1486
1.0	0.9346	21.0	0.2416	1.0	0.9091	21.0	0.1351
2.0	0.8734	22.0	0.2257	2.0	0.8264	22.0	0.1228
3.0	0.8163	23.0	0.2109	3.0	0.7513	23.0	0.1117
4.0	0.7629	24.0	0.1971	4.0	0.6830	24.0	0.1015
5.0	0.7130	25.0	0.1842	5.0	0.6209	25.0	0.0923
6.0	0.6663	26.0	0.1722	6.0	0.5645	26.0	0.0839
7.0	0.6227	27.0	0.1609	7.0	0.5132	27.0	0.0763
8.0	0.5820	28.0	0.1504	8.0	0.4665	28.0	0.0693
9.0	0.5439	29.0	0.1406	9.0	0.4241	29.0	0.0630
10.0	0.5083	30.0	0.1314	10.0	0.3855	30.0	0.0573
11.0	0.4751	35.0	0.0937	11.0	0.3505	35.0	0.0356
12.0	0.4440	40.0	0.0668	12.0	0.3186	40.0	0.0221
13.0	0.4150	45.0	0.0476	13.0	0.2897	45.0	0.0137
14.0	0.3878	50.0	0.0339	14.0	0.2633	50.0	0.0085
15.0	0.3624			15.0	0.2394		

TABLE 1. "ONE-STEP" ADJUSTMENT FACTORS--ALL REGIONS, ONE-TIME COSTS

NOTES: <1> TABULATED OSAFs (SPW) VALID FOR INDEFINITE PERIOD (NOT CALENDAR-DEPENDENT)
<2> OSAFs BASED ON FEMP CRITERIA (10CFR436A): 7% DISCOUNT RATE
<3> OSAFs BASED ON FEDS CRITERIA (DOD STANDARD): 10% DISCOUNT RATE
<4> OSAFs BASED ON ASSUMED DIFFERENTIAL ESCALATION RATE OF 0%

Slide 7-11

To find PW of a future one-time cost

PW? <------------------------- C_F

C_F x OSAF for one-time costs

Note that OSAF factors for one-time costs are identical to the conventional SPW discount factors. Both sets of factors express the PW as a ratio of the given future amount. They do not combine escalation with discounting. It is necessary to have the future estimate of cost or benefit before applying this OSAF. The table is repeated for convenience as part of the OSAF series of tables, in a similar format to those for M&R and energy.

Notice that factors for less than a year are provided. These are helpful for finding PW when n is not an integer.

EXAMPLE:

For Cost of $5,000 incurred 10.5 years after DOS

PW = $5,000 x 0.3855 x 0.9535 = $1,838

Notes:

Vugraph 7-18. Present Worth: One-Step Approach Sheet (DA Form 5605-5)

Project No. & Title ______________________________
Installation & Location ______________________________
Design Feature ______________________________
Alt. No. ________ Title ______________________________

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: ONE-STEP APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs [ ] $ x 10³ [ ] $ x 10⁶	Years from ABD	Cost On ABD	One Step Adj.Factor Table 1	Present Worth on ABD

Criteria Reference	
Analysis Base Date (ABD)	
Analysis End Date (AED)	
Midpoint of Construction	
BOD for Analysis	
Annual Discount Rate	

Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe:		

Annual Costs [ ] $ x 10³ [ ] $ x 10⁶	Total No. of Payments	Annual Cost on ABD	Total Nominal Cost on ABD	One Step Adjustment Factor* Table Factor x DOS Correction	Present Worth on ABD

	Initial Costs	Energy/Fuel Costs	M&R Costs	Other Costs	Total
Net Present Worth:	________ +	________ +	________ +	________ =	________

DA FORM 5605-5-R, DEC 86

*Use One-Step Table 2 for M&R costs (e = 0).
Use One-Step Table 3 for energy/fuel costs (e = prescribed e value).

Sheet ________ of ________

Vugraph 7-19. Enlargement of top part of sheet

Project No. & Title ______________________

Installation & Location ______________________

Design Feature ______________________

Alt. No. ________ Title ______________________

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: ONE-STEP APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs [ ] $ x 10³ [ ] $ x 10⁶	Years from ABD	Cost On ABD	One Step Adj.Factor Table 1	Present Worth on ABD

Criteria Reference	HQDA
Analysis Base Date (ABD)	1 Jul 88
Analysis End Date (AED)	1 Jul 2016
Midpoint of Construction	1 Jan 91
BOD for Analysis	1 Jul 91
Annual Discount Rate	10%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul - Jun		
	87-90	90-95	95-16
Nat'l Gas	2.63	9.17	6.10
Other	0.00	0.00	0.00

Vugraph 7-20. Enlargement of annual costs part of sheet

Annual Costs ☐ $ x 10³ ☐ $ x 10⁶	Total No. of Payments	Annual Cost on ABD	Total Nominal Cost on ABD	One Step Adjustment Factor* Table Factor x DOS Correction	Present Worth on ABD

	Initial Costs		Energy/Fuel Costs		M&R Costs		Other Costs		Total
Net Present Worth:	______	+	______	+	______	+	______	=	______

Vugraph 7-21. One-step sheet completed, except for bottom line

Project No. & Title PN 567 Moss Hall
Installation & Location ABCDE, Fort Bragg, NC
Design Feature Exterior Doors
Alt. No. A Title Sliding Door

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: ONE-STEP APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs (X) $ x 10³ ( ) $ x 10⁶	Years from ABD	Cost On ABD	One Step Adj. Factor Table 1	Present Worth on ABD
Initial Investment	2.5	100	0.7880	78.8
Replacement	15	20	0.2394	4.8
Retention V.	28	-10	0.0693	-0.7

Criteria Reference	HQDA
Analysis Base Date (ABD)	JUL 88
Analysis End Date (AED)	JUL 2016
Midpoint of Construction	JAN 91
BOD for Analysis	JUL 91
Annual Discount Rate	10%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: JUL - JUN		
	87-90	90-95	95-16
Nat'l Gas	2.63	9.17	6.10
Other	0.00	0.00	0.00

Annual Costs (X) $ x 10³ ( ) $ x 10⁶	Total No. of Payments	Annual Cost on ABD	Total Nominal Cost on ABD	One Step Adjustment Factor* Table Factor x DOS Correction	Present Worth on ABD
M&R	25	5	125	0.2838	35.5
Natural Gas	25	8	200	0.6655	133.1

	Initial Costs	Energy/Fuel Costs	M&R Costs	Other Costs	Total
Net Present Worth:	______ +	______ +	______ +	______ =	______

DA FORM 5605-5-R, DEC 86

*Use One-Step Table 2 for M&R costs (e = 0).
Use One-Step Table 3 for energy/fuel costs (e = prescribed e value).

Sheet ______ of ______

Vugraph 7-22. One-step sheet with bottom line filled in

Project No. & Title PN 567 Mess Hall
Installation & Location ABCDE, Fort Bragg, NC
Design Feature Exterior Doors
Alt. No. A Title Sliding Door

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: ONE-STEP APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs [X] $ x 10³ [ ] $ x 10⁶	Years from ABD	Cost On ABD	One Step Adj.Factor Table 1	Present Worth on ABD
Initial Investment	2.5	100	0.7880	78.8
Replacement	15	20	0.2394	4.8
Retention Value	28	-10	0.0693	- 0.7

Criteria Reference	HQDA
Analysis Base Date (ABD)	JUL 88
Analysis End Date (AED)	JUL 2016
Midpoint of Construction	JAN 91
BOD for Analysis	JUL 91
Annual Discount Rate	10%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: 87-90	90-95	95-16
Nat'l Gas	2.63	9.17	6.10
Other	0.00	0.00	0.00

Annual Costs [X] $ x 10³ [ ] $ x 10⁶	Total No. of Payments	Annual Cost on ABD	Total Nominal Cost on ABD	One Step Adjustment Factor* Table Factor x DOS Correction	Present Worth on ABD
M+R	25	5	125	0.2838	35.5
Natural Gas	25	8	200	0.6655	133.1

	Initial Costs		Energy/Fuel Costs		M&R Costs		Other Costs		Total
Net Present Worth:	78.8	+	133.1	+	35.5	+	4.1	=	252

DA FORM 5605-5-R, DEC 86

*Use One-Step Table 2 for M&R costs (e = 0).
Use One-Step Table 3 for energy/fuel costs (e = prescribed e value).

Sheet ______ of ______

7.6 EXERCISE 7-2: COMPUTE LCC USING ONE-STEP APPROACH

Compute LCC of exterior wall design alternative by completing the attached DA Form 5605-5, based on the data given for Exercise 7-1. (Refer back to the Basic Input Data Summary (DA Form 5605-3) that you completed for Exercise 7-1, p. 7-28.)

Exercise 7-2. Present Worth: One-Step Approach Sheet (DA Form 5605-5)

Project No. & Title ____________________

Installation & Location ____________________

Design Feature ____________________

Alt. No. ________ Title ____________________

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: ONE-STEP APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs [ ] $ x 10³ [ ] $ x 10⁶	Years from ABD	Cost On ABD	One Step Adj.Factor Table 1	Present Worth on ABD

Criteria Reference	
Analysis Base Date (ABD)	
Analysis End Date (AED)	
Midpoint of Construction	
BOD for Analysis	
Annual Discount Rate	

Type of Cost	Differential Escalation Rate per Year (%) Timeframe:		

Annual Costs [ ] $ x 10³ [ ] $ x 10⁶	Total No. of Payments	Annual Cost on ABD	Total Nominal Cost on ABD	One Step Adjustment Factor* Table Factor x DOS Correction	Present Worth on ABD

	Initial Costs		Energy/Fuel Costs		M&R Costs		Other Costs		Total
Net Present Worth:	________	+	________	+	________	+	________	=	________

DA FORM 5605-5-R, DEC 86

*Use One-Step Table 2 for M&R costs (e = 0).
Use One-Step Table 3 for energy/fuel costs (e = prescribed e value).

Sheet ________ of ________

7.7 RANKING DESIGN ALTERNATIVES

By the end of this session you are expected to be able to

- assign economic rankings to design alternatives as an aid to selecting among them

- document the LCC results with Form DA 5605-2

Slide 7-12

RANKING DESIGN ALTERNATIVES ON THE BASIS OF LCCs

Design Alternative	LCC	Rank
A	$100K	1
B	$150K	2
C	$200K	3

Notes:

Slide 7-13

CONCLUSIVENESS OF LCC RESULTS

LCC results may be

• **Clearly Conclusive**	**Rank by LCC**
• **Clearly Inconclusive**	**Other ranking criteria needed**
• **Neither clearly conclusive nor clearly inconclusive**	**Uncertainty assessment may be needed**

LCC results are conclusive when the LCC of one alternative is substantially less than the LCCs of other alternatives. In this case, rank the alternatives in order of their LCCs, with preference given to the alternative with the lowest LCC.

LCC results are inconclusive when LCCs of alternatives are essentially equal, or uncertainties are so great that differences in LCCs are not clear. The alternatives are considered equal in terms of LCC. In this case, other criteria are needed to break the LCC tie. Uncertainty assessment is generally not required.

LCC results are neither clearly conclusive nor clearly inconclusive when LCC results are close but not identical. We think there is a difference in LCCs, but we are not sure if it is statistically significant. In this case, guidelines for design selection depend on whether the decision is routine or non-routine. When it is routine, the alternative with the lowest LCC is usually selected. When it is non-routine, uncertainty assessment is usually performed.

Slide 7-14

TIE-BREAKING CRITERIA

- **Energy use**
- **Initial costs**

When design alternatives have comparable LCCs, the decision is based on two additional criteria: comparative energy use and comparative initial procurement costs.

Slide 7-15

TIE-BREAKING CRITERIA

Choose the alternative which has

- lower initial costs and equal or lower energy consumption (measured at source)
- lower energy consumption and equal or lower initial costs
- annual energy consumption at least 15% lower & initial costs no more than 15% higher
- initial costs at least 15% lower & annual energy consumption no more than 15% higher
- if none of above applies, assign equal ranking and make selection on judgment

Notes:

Vugraph 7-23. DA Form 5605-2: Summary

Project No. & Title ____________________

Installation & Location ____________________

Design Feature ____________________

Date of Study ____________________

LIFE CYCLE COST ANALYSIS
SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

ALTERNATIVES ANALYZED						
No.	Description/Title	Present Worth ( ) $ x 10³ ( ) $ x 10⁶				
		Initial	Energy	M&R	Other	Total

ECONOMIC RANKING				
Rank	Alternative No. & Title	Economic Advantages of Top-Ranked Alternative		Basis for No. 1 Ranking
		LCC (PW) Difference (Dollars & Percent)	Other (Initial, Energy, Etc.)	

KEY ASSUMPTIONS

NARRATIVE SUMMARY (Comments/Lessons Learned/Observations/Recommendations/Etc.)

Key Participants - Name	Discipline	Organization	Telephone No.

DA FORM 5605-2-R, DEC 86

Sheet ______ of ______

Vugraph 7-24. DA Form 5605-2: Summary -- completed form

Project No. & Title PN 567 Mess Hall
Installation & Location ABCDE, Fort Bragg, NC
Design Feature Exterior Doors

Date of Study 1 July 88

LIFE CYCLE COST ANALYSIS
SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

ALTERNATIVES ANALYZED						
No.	Description/Title	Present Worth ( ) $ x 10³ ( ) $ x 10⁶				
		Initial	Energy	M&R	Other	Total
A	Sliding Doors	78.8	125.9	35.7	4.1	245
B	Revolving Doors	60.0	165.0	12.0	6.0	243

ECONOMIC RANKING				
Rank	Alternative No. & Title	Economic Advantages of Top-Ranked Alternative		Basis for No. 1 Ranking
		LCC (PW) Difference (Dollars & Percent)	Other (Initial, Energy, Etc.)	
	A. Sliding Doors B. Revolving Doors	$ 1.5K .6%		Comparable LCCs

KEY ASSUMPTIONS

NARRATIVE SUMMARY (Comments/Lessons Learned/Observations/Recommendations/Etc.)
Both initial cost + energy cost differences exceed 15% criterion. Choice to be made on basis of judgment

Key Participants - Name	Discipline	Organization	Telephone No.

DA FORM 5605-2-R, DEC 86

Sheet ______ of ______

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7.8 EXERCISES 7-3 & 7-4: RANK ALTERNATIVES

Exercise 7-3: Use DA Form 5605-2 to rank the design alternative whose LCC you computed in exercise 7-2, against the alternative shown on the form. (Refer back to p. 7-48.)

Exercise 7-4: More practice in ranking design alternatives

Vugraph 7-25. Exercise 7-3
LCCA: Summary Sheet

LIFE CYCLE COST ANALYSIS
SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Project No. & Title PN 568, Veh. Maint. Shop
Installation & Location Fort X, Huntsv., AL
Design Feature Exterior Wall
Date of Study July 88

ALTERNATIVES ANALYZED						
No.	Description/Title	Present Worth ( ) $ x 10³ ( ) $ x 10⁶				
		Initial	Energy	M&R	Other	Total
A						
B	Special Veneer	80	110.0	4.0	1.0	195.0

ECONOMIC RANKING				
Rank	Alternative No. & Title	Economic Advantages of Top-Ranked Alternative		Basis for No. 1 Ranking
		LCC (PW) Difference (Dollars & Percent)	Other (Initial, Energy, Etc.)	

KEY ASSUMPTIONS

NARRATIVE SUMMARY (Comments/Lessons Learned/Observations/Recommendations/Etc.)

Key Participants - Name	Discipline	Organization	Telephone No.

DA FORM 5605-2-R, DEC 86

Sheet ______ of ______

ADDITIONAL PRACTICE IN RANKING DESIGN ALTERNATIVES: EXERCISE 7-4

Rank A & B in each of the following sets of design alternatives:

SET	ALTER-NATIVE	LCC	INITIAL COSTS	ENERGY USE	RANK
1	A	$50,000	$25,000	13,000 kWh	
	B	$48,000	$35,000	12,500 kWh	
2	A	$5,000	$1,000	0	
	B	$8,000	$500	0	
3	A	$15,800	$5,000	2,000 gal oil	
	B	$16,000	$5,700	1,400 gal oil	
4	A	$26,000	$12,000	50,000 kWh	
	B	$20,000	$15,000	60,000 kWh	
5	A	$160,000	$25,000	1,000 gal oil	
	B	$180,000	$24,600	960 gal oil	
6	A	$15,000-$30,000	$10,000	0	
	B	$20,000-$25,000	$12,000	0	
7	A	$100,000	$40,000	10,000 kWh	
	B	$112,000	$41,000	11,000 kWh	

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This section is consistent with the Criteria and Standards for Energy Conservation Studies in Technical Manual 5-802-1, Headquarters, Department of the Army, December 31, 1986. The material does not reflect the amendments to 10 CFR part 436 updating the guidelines applicable to energy management programs for Federal buildings. The amendments are set forth in Federal Register, Vol. 55, No. 224, Nov. 20, 1990. A list of the amendments is provided on page 8-8. TM 5-802-1 is currently being revised accordingly.

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MODULE 8

HOW TO PERFORM ENERGY CONSERVATION STUDIES

Purpose:

- To present the criteria for energy conservation studies
- To give you hands-on practice in performing EA/LCCA of energy conserving designs according to "FEMP criteria"

Outline:

8.1 Criteria for Energy Conservation Studies

8.2 Exercise 8-1: Applicable Criteria

8.3 Computing LCC for Energy Conserving Designs Using One-Step Approach

8.4 Exercise 8-2: One-Step Approach

Approximate Time:

3 hours

Slide 8-1

HOW TO PERFORM ENERGY CONSERVATION STUDIES

Notes:

Slide 8-2

THREE TYPES OF REQUIREMENTS FOR EA

(Army & Air Force)

1. **General economic studies**

(2 Types of Special Directed Studies)

2. **Special requirement by statute or executive order**
3. **Special requirements by OSD, HQDA, HQUSAF, HQUSACE**

Notes:

Slide 8-3

SPECIAL DIRECTED ECONOMIC STUDIES

- Special requirements by statute or executive order
  - Energy-conserving designs
  - Wastewater treatment facilities
- Special requirements by OSD, HQDA, HQUSAF, HQUSACE

Notes:

Slide 8-4

LEGISLATION, EXECUTIVE ORDER, AND FEDERAL REGULATIONS DIRECTING EA FOR ENERGY CONSERVATION

- Energy Policy and Conservation Act (EPCA)
- National Energy Conservation Policy Act (NECPA)
- Executive Order 11912 (as amended by 12003)
- Energy Security Act
- Military Construction Codification Act
- Federal Energy Management Improvement Act
- Code of Federal Regulations (10 CFR, Sec 436, A)

Notes:

Slide 8-5

LCC RULE FOR ENERGY CONSERVATION	
Administered by:	Federal Energy Management Program Office of Assistant Secretary for Conservation and Renewable Energy U.S. Department of Energy
Mailing Address:	FEMP CE 44 U.S. Department of Energy 1000 Independence Avenue, SW Washington, DC 20585
Telephone:	(202) 586-1145 FTS 8-896-1145

Notes:

8.1 CRITERIA FOR ENERGY CONSERVATION STUDIES

By the end of sections 8.1 and 8.2, you are expected to be able to

- describe the criteria governing energy conservation studies
- list the major differences between criteria for general economic studies and criteria for energy conservation studies
- explain the circumstances under which you would apply each set of criteria

Slide 8-6 (a-b)

ESSENTIAL DIFFERENCES IN CRITERIA
(Energy Studies vs General Studies)

- **Discount Rate: 7% real**
- **Assumption of Instantaneous Construction**
- **10% Reduction in Investment Costs**
- **Non-Energy e Values must be 0**

Other differences:

- **End-of-Year Cash Flows**
- **SIR & DPP Calculations for Solar**
- **Less Emphasis on Uncertainty Analysis**

Notes:

The following is a summary of amendments to 10 CFR part 436 updating the guidelines applicable to energy management programs for Federal buildings (Federal Register/Vol 55, No. 224, Nov. 20, 1990):

DISCOUNT RATE to change annually (tied to long-term Treasury bonds)
10% INVESTMENT CREDIT eliminated
CONSTRUCTION PERIOD allowed (but not required)
STUDY PERIOD up to 25 years from BOD allowed
TIMING OF CASH FLOWS within year flexible
NON-ENERGY e VALUES still set at 0
More emphasis placed on UNCERTAINTY ASSESSMENT
Use of SIR and DPP retained and AIRR added as an alternative to SIR for active solar.

Slide 8-7

APPLICABILITY OF ENERGY-CONSERVATION LCC RULE TO MILCON DESIGN DECISIONS

- Non-renewable Resources

LCC Rule applies to situations where the opportunity exists for an energy-saving design initiative not provided for by current design criteria. TM calls this "extraordinary energy saving design initiative" (i.e., does not apply to routine choices among conventional design alternatives covered by General Economic Studies)

- Renewable Resources

LCC Rule applies to all projects in MCP and to all design features within those projects that use significant amounts of fossil-fuel-derived energy

Notes:

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8.2 EXERCISE 8-1: APPLICABLE CRITERIA

Suppose you are asked to perform a general economic study and an energy conservation study. The date you perform both analyses is January 1990. Assume that up-to-date energy price projections (e values) are available. Assume that in both cases, construction will not begin for two years, and the construction period will last one year. You have been asked to use the longest allowable analysis period for both analyses.

Provide the Information Requested:

	General Study	Energy Study
Discount Rate		
Date of Study		
Number of Years Construction Costs are Discounted		
Percentage Reduction in Construction Costs		
Date First Energy Cost is Incurred		
Source of Energy e Values		
Source of Non-energy e Values		
Date Study Ends		
Method of Adjusting for Inflation		
Principal Method of Analysis		

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8.3 COMPUTING LCC FOR ENERGY CONSERVING DESIGNS

By the end of sections 8.3 and 8.4, you are expected to be able to

- summarize and document input data for energy studies on DA Form 5605-3
- prepare cash flow diagrams for energy studies
- calculate present worth equivalents of cash flows typically encountered in energy conservation studies using the "one-step approach," calculate LCC, and interpret the analysis results
- use DA Forms 5605 to structure and document the calculations

SAMPLE ENERGY CONSERVATION STUDY

Problem Statement:

A new administration building is planned for an Army facility in Madison, Wisconsin. The resulting building is three-stories with an underground parking level. It is approximately square in shape with double glazing comprising 35% of the wall area on all sides.

The design engineer sees opportunities for conserving energy by elongating the building on its east-west axis to provide greater exposure of the south side to solar radiation, earth-berming the north wall of the first floor, and reducing the window area to 25% and concentrating the glazed area on the south side. Because of modification in shape and interior layout, opportunities for daylighting are expected to be as good for this design as for the conventional design (and probably better). Both of the designs meet all functional requirements and will last indefinitely. Their construction costs, maintenance and repair costs, and energy costs are expected to differ. Determine if the proposed design changes are estimated to be cost effective.

Projected Date of Study (= ABD):	7/1/88
Mid-point of Construction:	1/1/91
Projected Beneficial Occupancy Date:	7/1/91
Analysis Period:	Maximum Allowable
Project number:	PN2 (FY 90)

Cost and Energy Consumption Data:

	Alt A Conventional Design	Alt B Energy-Conserving
Initial Investment costs:	$800,000	$975,000
M&R costs:	$50,000/yr	$45,000/yr

Natural Gas:

7/1/88 price	$3.75/10^6 Btu	$3.75/10^6 Btu
Annual consumption	4,000 x 10^6 Btu	2,100 x 10^6 Btu

Vugraph 8-1. DA Form 5605-3 (blank)

Project No. & Title ____________________

Installation & Location ____________________

Design Feature ____________________

Alt. No ________ Title ____________________

LIFE CYCLE COST ANALYSIS

BASIC INPUT DATA SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference		
Date of Study (DOS)		
Analysis Base Date (ABD)		
Analysis End Date (AED)		
Midpoint of Construction		
Beneficial Occupancy Date (BOD)	Actual Projected	
	Assumed for Analysis	
DOE Region		
Annual Discount Rate		

Type of Cost	Differential Escalation Rate per Year (%) Timeframe:		

Principal Assumptions

Cash Flow Diagram

Cost Element	Cost on ABD ☐ $ x 10³ ☐ $ x 10⁶	Time Cost Incurred**		Source(s) of Data
		Actual Projected Dates	Dates for Analysis (If Different)*	

DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply

**For Recurring Annual Costs, show date of first and last costs only.

Sheet ________ of ________

Vugraph 8-2. Completed Input Data Summary Form

Project No. & Title PN2 Admin. Bldg

Installation & Location Fort X, Madison, WS

Design Feature Envelope

Alt. No. A Title Conventional Design

LIFE CYCLE COST ANALYSIS

BASIC INPUT DATA SUMMARY

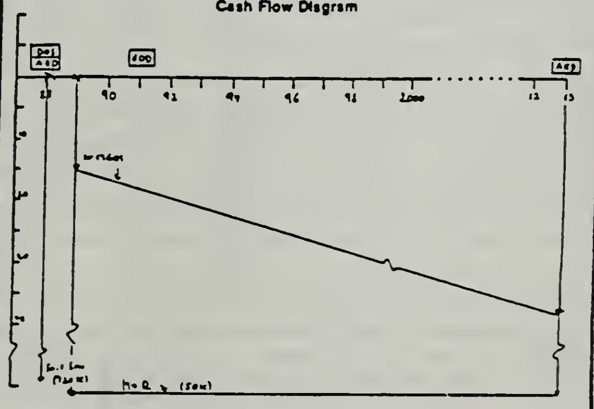
For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference		FEMP
Date of Study (DOS)		7/88
Analysis Base Date (ABD)		7/88
Analysis End Date (AED)		7/13
Midpoint of Construction		1/91
Beneficial Occupancy Date (BOD)	Actual Projected	7/91
	Assumed for Analysis	7/88
DOE Region		5
Annual Discount Rate		7%

Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe:		
	88-90	90-95	95-13
Nat Gas	2.80	8.25	5.32

Principal Assumptions

Cash Flow Diagram



Cost Element	Cost on ABD ✓ $ x 10³ _ $ x 10⁶	Time Cost Incurred** Actual Projected Dates	Time Cost Incurred** Dates for Analysis (If Different)*	Source(s) of Data
Initial Cost	720 (800 less 10%)	1/91	7/88	Cost Engineer's Est. (App 1)
M+R Cost	50	1/92 - 1/16	7/89 - 7/13	Past Experience (App. 2)
Natural Gas	15	1/92 - 1/16	7/89 - 7/13	BLAST (App. 3)

DA FORM 5605-3-R, DEC 86

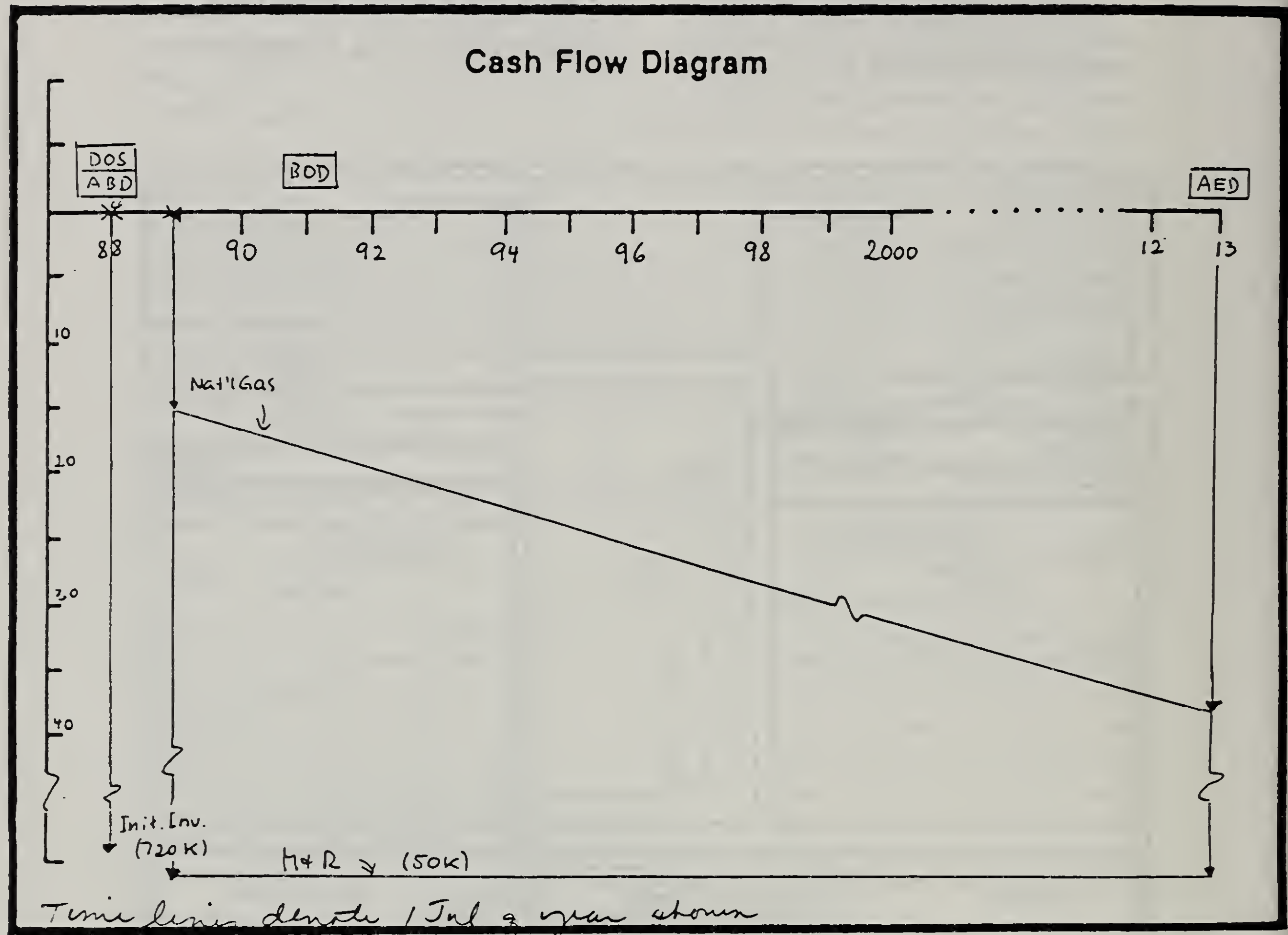
*Note: Taking a 10% reduction in initial costs of both designs is equivalent to taking a 10% reduction in their difference.

*When 10 CFR436A Criteria Apply

**For Recurring Annual Costs, show date of first and last costs only.

Sheet______ of______

Vugraph 8-3. Blow-up of cash flow diagram -- completed



Vugraph 8-4. PW: One-Step Approach Sheet -- blank

Project No. & Title ______________________

Installation & Location ______________________

Design Feature ______________________

Alt. No. ________ Title ______________________

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: ONE-STEP APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs [ ] $ x 10³ [ ] $ x 10⁶	Years from ABD	Cost On ABD	One Step Adj. Factor Table 1	Present Worth on ABD

Criteria Reference	
Analysis Base Date (ABD)	
Analysis End Date (AED)	
Midpoint of Construction	
BOD for Analysis	
Annual Discount Rate	

Type of Cost	Differential Escalation Rate per Year (%) Timeframe:		

Annual Costs [ ] $ x 10³ [ ] $ x 10⁶	Total No. of Payments	Annual Cost on ABD	Total Nominal Cost on ABD	One Step Adjustment Factor* Table Factor x DOS Correction	Present Worth on ABD

	Initial Costs		Energy/Fuel Costs		M&R Costs		Other Costs		Total
Net Present Worth:	________	+	________	+	________	+	________	=	________

DA FORM 5605-5-R, DEC 86

*Use One-Step Table 2 for M&R costs (e = 0).
Use One-Step Table 3 for energy/fuel costs (e = prescribed e value).

Sheet ________ of ________

Vugraph 8-5. PW: One-Step Approach Sheet -- completed

Project No. & Title PN 2 Admin. Bldg
Installation & Location Fort X, Madison, WS
Design Feature Envelope
Alt. No. A Title Conventional Design

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: ONE-STEP APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs ✓ $ x 10³ / $ x 10⁶	Years from ABD	Cost On ABD	One Step Adj.Factor Table 1	Present Worth on ABD
Initial Cost	0	720	1.0000	720

Criteria Reference	FEMP
Analysis Base Date (ABD)	7/88
Analysis End Date (AED)	7/13
Midpoint of Construction	1/91
BOD for Analysis	7/88
Annual Discount Rate	7%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: 88-90	90-95	95-13
Nat Gas	2.80	8.25	5.32

Annual Costs ✓ $ x 10³ / $ x 10⁶	Total No. of Payments	Annual Cost on ABD	Total Nominal Cost on ABD	One Step Adjustment Factor* Table Factor x DOS Correction	Present Worth on ABD
M + R Cost	25	50	1,250	0.4661	583
Natural Gas	25	15	375	0.8499	319

	Initial Costs	Energy/Fuel Costs	M&R Costs	Other Costs	Total
Net Present Worth:	720 +	319 +	583 +	— =	1,622

DA FORM 5605-5-R, DEC 86

*Use One-Step Table 2 for M&R costs (e = 0).
Use One-Step Table 3 for energy/fuel costs (e = prescribed e value).

Sheet ______ of ______

Vugraph 8-6. DA Form 5605-3 (blank)

Project No. & Title ____________________

Installation & Location ____________________

Design Feature ____________________

Alt. No. ________ Title ____________________

LIFE CYCLE COST ANALYSIS

BASIC INPUT DATA SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference		
Date of Study (DOS)		
Analysis Base Date (ABD)		
Analysis End Date (AED)		
Midpoint of Construction		
Beneficial Occupancy Date (BOD)	Actual Projected	
	Assumed for Analysis	
DOE Region		
Annual Discount Rate		

Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe:		

Principal Assumptions

Cash Flow Diagram

Cost Element	Cost on ABD ☐ $ x 10³ ☐ $ x 10⁶	Time Cost Incurred**		Source(s) of Data
		Actual Projected Dates	Dates for Analysis (If Different)*	

DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply

**For Recurring Annual Costs, show data of first and last costs only.

Sheet ________ of ________

Vugraph 8-7. Completed Input Data Summary Form

Project No. & Title PN2 Admin. Bldg
Installation & Location Fort X, Madison WS
Design Feature Envelope
Alt. No. B Title Earth - Bermed Design

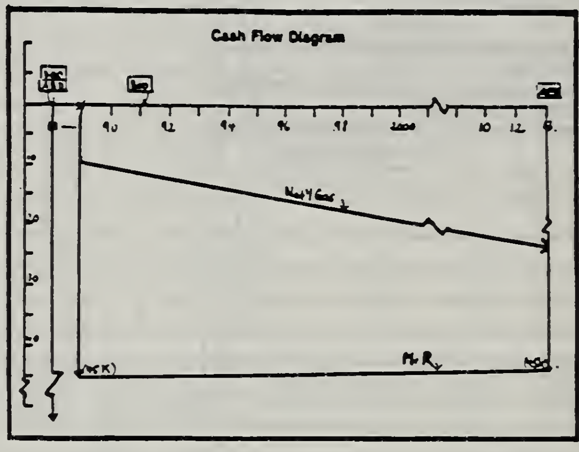
LIFE CYCLE COST ANALYSIS
BASIC INPUT DATA SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference		FEMP
Date of Study (DOS)		7/88
Analysis Base Date (ABD)		7/88
Analysis End Date (AED)		7/13
Midpoint of Construction		1/91
Beneficial Occupancy Date (BOD)	Actual Projected	7/91
	Assumed for Analysis	7/88
DOE Region		5
Annual Discount Rate		7%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: 88-90	90-95	95-13
Nat Gas	2.80	8.25	5.32

Principal Assumptions



Cost Element	Cost on ABD $ x 10³ / _ $ x 10⁶	Time Cost Incurred** Actual Projected Dates	Dates for Analysis (If Different)*	Source(s) of Data
	*			
Initial Cost	878 (975 less 10%)	1/91	7/88	Cost Engineer's Est. (APP. 1)
M + R Cost	45	1/92 - 1/16	7/89 - 7/13	Past Experience (App. 2)
Natural Gas	8	1/92 - 1/16	7/89 - 7/13	BLAST (App. 3)

DA FORM 5605-3-R, DEC 86

* Note: Taking a 10% reduction in initial costs of both designs is equivalent to taking a 10% reduction in the difference.

*When 10 CFR436A Criteria Apply

**For Recurring Annual Costs, show date of first and last costs only.

Sheet ______ of ______

Vugraph 8-8. PW: One-Step Approach Sheet -- blank

Project No. & Title ______________________

Installation & Location ______________________

Design Feature ______________________

Alt. No. ______ Title ______________________

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: ONE-STEP APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs [ ] $ x 10³ [ ] $ x 10⁶	Years from ABD	Cost On ABD	One Step Adj. Factor Table 1	Present Worth on ABD

Criteria Reference	
Analysis Base Date (ABD)	
Analysis End Date (AED)	
Midpoint of Construction	
BOD for Analysis	
Annual Discount Rate	

Type of Cost	Differential Escalation Rate per Year (%) Timeframe:		

Annual Costs [ ] $ x 10³ [ ] $ x 10⁶	Total No. of Payments	Annual Cost on ABD	Total Nominal Cost on ABD	One Step Adjustment Factor* Table Factor x DOS Correction	Present Worth on ABD

	Initial Costs		Energy/Fuel Costs		M&R Costs		Other Costs		Total
Net Present Worth:	______	+	______	+	______	+	______	=	______

DA FORM 5605-5-R, DEC 86

*Use One-Step Table 2 for M&R costs (e = 0).
Use One-Step Table 3 for energy/fuel costs (e = prescribed e value).

Sheet ______ of ______

Vugraph 8-9. PW: One-Step Sheet -- completed

Project No. & Title PN 2 Admin. Bldg
Installation & Location Fort X, Madison, WS
Design Feature Envelope
Alt. No. B Title Earth - Bermed Design

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: ONE-STEP APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs ✓ \$ x 10^3 / \$ x 10^6	Years from ABD	Cost On ABD	One Step Adj.Factor Table 1	Present Worth on ABD
Initial Cost	0	878	1.0000	878

Criteria Reference	FEMP
Analysis Base Date (ABD)	7/88
Analysis End Date (AED)	7/13
Midpoint of Construction	1/91
BOD for Analysis	7/88
Annual Discount Rate	7%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: 88-90	90-95	95-13
Nat Gas	2.80	8.25	5.32

Annual Costs ✓ \$ x 10^3 / \$ x 10^6	Total No. of Payments	Annual Cost on ABD	Total Nominal Cost on ABD	One Step Adjustment Factor* Table Factor x DOS Correction	Present Worth on ABD
M+R Costs	25	45	1,125	0.4661	524
Natural Gas	25	8	200	0.8499	170

	Initial Costs		Energy/Fuel Costs		M&R Costs		Other Costs		Total
Net Present Worth:	878	+	170	+	524	+	—	=	1,572

DA FORM 5605-5-R, DEC 86

*Use One-Step Table 2 for M&R costs (e = 0).
Use One-Step Table 3 for energy/fuel costs (e = prescribed e value).

Sheet_____ of _____

Vugraph 8-10. DA Form 5605-2 -- blank

Project No. & Title ____________________

Installation & Location ____________________

Design Feature ____________________

Date of Study ____________________

LIFE CYCLE COST ANALYSIS
SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

ALTERNATIVES ANALYZED						
No.	Description/Title	Present Worth ( ) $ x 10^3 ( ) $ x 10^6				
		Initial	Energy	M&R	Other	Total

ECONOMIC RANKING				
Rank	Alternative No. & Title	Economic Advantages of Top-Ranked Alternative		Basis for No. 1 Ranking
		LCC (PW) Difference (Dollars & Percent)	Other (Initial, Energy, Etc.)	

KEY ASSUMPTIONS

NARRATIVE SUMMARY (Comments/Lessons Learned/Observations/Recommendations/Etc.)

Key Participants - Name	Discipline	Organization	Telephone No.

DA FORM 5605-2-R, DEC 86

Sheet ________ of ________

Vugraph 8-11. DA Form 5605-2 -- completed

Project No. & Title PN 2 Admin. Bldg
Installation & Location Fort X, Madison, WS
Design Feature Envelope
Date of Study 7/88

LIFE CYCLE COST ANALYSIS SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

ALTERNATIVES ANALYZED

No.	Description/Title	Present Worth $ x 10³ $ x 10⁶ Initial	Energy	M&R	Other	Total
A	Conventional Design	720	319	583	—	1,622
B	Earth - Berm Design	878	170	524	—	1,572

ECONOMIC RANKING

Rank	Alternative No. & Title	Economic Advantages of Top-Ranked Alternative: LCC (PW) Difference (Dollars & Percent)	Other (Initial, Energy, Etc.)	Basis for No. 1 Ranking
1	B Earth Berm	$50,000	Energy	Lower
2	A Conventional	3%	Savings	LCC

KEY ASSUMPTIONS

NARRATIVE SUMMARY
(Comments/Lessons Learned/Observations/Recommendations/Etc.)

Although the reduction in LCC offered by Alt B appears small in comparison with the totals, it appears more significant when compared against the extra amount spent. Keep in mind that about $800K of initial cost is common to both designs.

Key Participants - Name	Discipline	Organization	Telephone No.
I. M. Architect	Architect	U.S.A.C.E.	x xxxx
M. E. Too	Architect	USACE	x xx xx

DA FORM 5605-2-R, DEC 86

Sheet ______ of ______

8.4 EXERCISE 8-2: ONE-STEP APPROACH

This session gives participants practice

- performing energy conservation studies under supervision in accordance with "FEMP criteria"
- presenting the results of energy conservation studies

EXERCISE 8-2: ONE-STEP APPROACH

Perform an LCC analysis of two alternative HVAC systems being considered for an administration building to be constructed at Fort Q in Mississippi:

- Alternative A, a variable-volume system without an energy economizer cycle
- Alternative B, a variable-volume system with an energy economizer cycle

A previous analysis has identified alternative A as the "best" of conventional designs. It is the baseline against which to evaluate the alternative with an energy economizer cycle. (See key dates at end of "Data.")

Compute LCCs of the two alternatives using the one-step approach and FEMP criteria for energy conservation studies. Compare LCCs and recommend a system.

Use DA Form 5605-3 for data inputs; DA Form 5605-5 to compute LCCs; and DA Form 5605-2 to compare the results and record the LCC ranking.

Data:

	Alt A	Alt B
Purchase & Installation	$125,000	$132,000
Replacement (Plant) (7/00)	50,000	52,000
Replacement (Fan) (7/06)	20,000	20,000
Replacement (Plant) (7/09)	50,000	52,000
Net Retention Value (7/16)	18,000	20,000
Maintenance & Repair (yearly)	12,000	12,500

Data (continued):

	Alt A	Alt B
Annual Energy Costs (in prices at the beginning of the analysis period)		
Electricity	$17,000	$15,000
Distillate	2,000	1,500
Expected Service Life	35 years	35 years

Dates: DOS = ABD = 7/88; Start of Construction = 7/90; BOD = 7/91

Form 8-12. DA Form 5605-3
Basic Data Input Summary -- blank

LIFE CYCLE COST ANALYSIS
BASIC INPUT DATA SUMMARY

Project No. & Title ______________________
Installation & Location ______________________
Design Feature ______________________
Alt. No. ________ Title ______________________

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference		
Date of Study (DOS)		
Analysis Base Date (ABD)		
Analysis End Date (AED)		
Midpoint of Construction		
Beneficial Occupancy Date (BOD)	Actual Projected	
	Assumed for Analysis	
DOE Region		
Annual Discount Rate		

Type of Cost	Differential Escalation Rate per Year (%) Timeframe:		

Principal Assumptions

Cash Flow Diagram

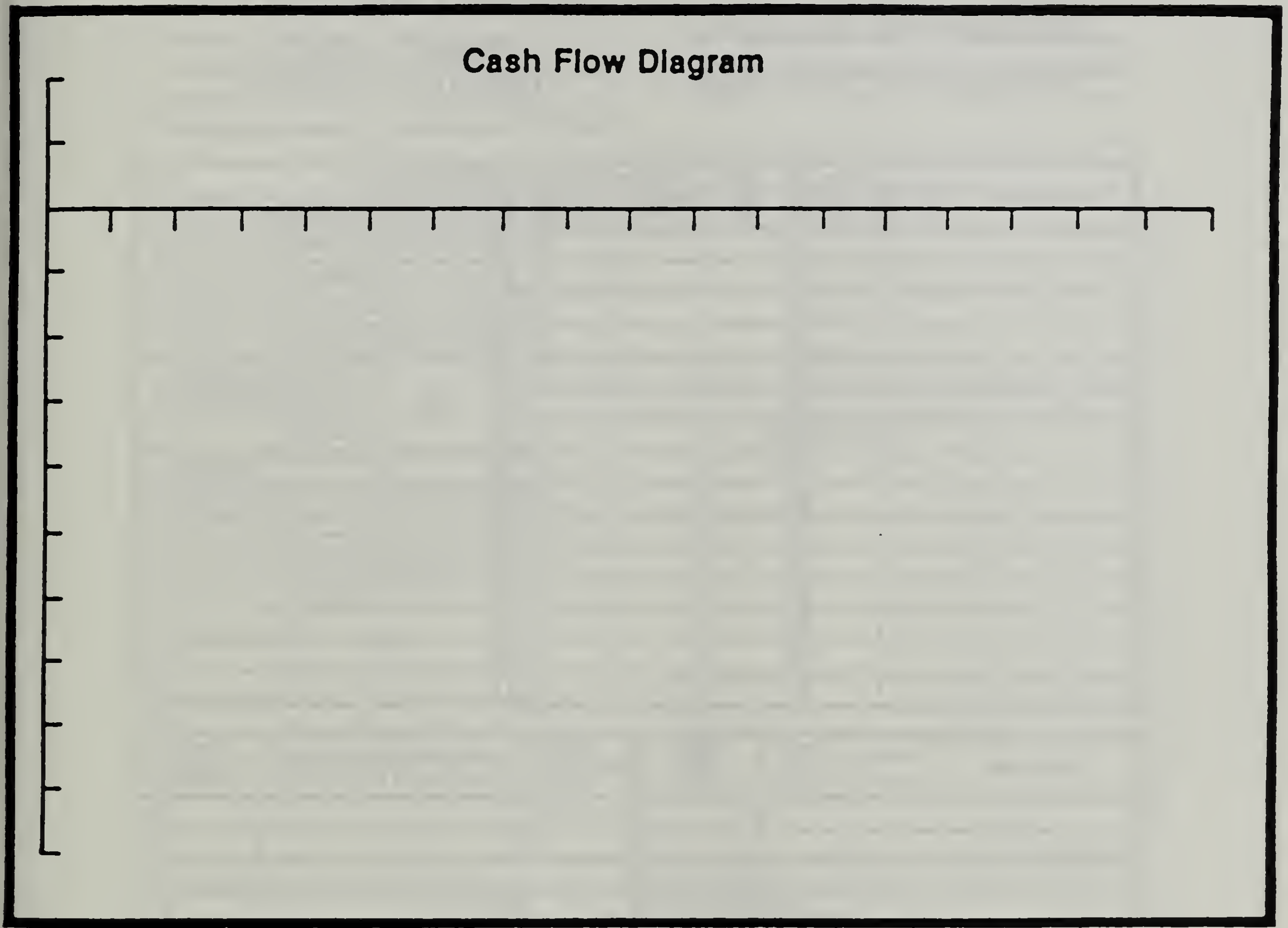
Cost Element	Cost on ABD ☐ $ x 10³ ☐ $ x 10⁶	Time Cost Incurred**		Source(s) of Data
		Actual Projected Dates	Dates for Analysis (If Different)*	

DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply
**For Recurring Annual Costs, show date of first and last costs only.

Sheet ________ of ________

Form 8-13. Blow up of cash flow diagram -- blank



Form 8-14. DA Form 5605-5 -- blank one-step

Project No. & Title ______________________

Installation & Location ______________________

Design Feature ______________________

Alt. No. ________ Title ______________________

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: ONE-STEP APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs [ ] $ x 10³ [ ] $ x 10⁶	Years from ABD	Cost On ABD	One Step Adj.Factor Table 1	Present Worth on ABD

Criteria Reference	
Analysis Base Date (ABD)	
Analysis End Date (AED)	
Midpoint of Construction	
BOD for Analysis	
Annual Discount Rate	

Type of Cost	Differential Escalation Rate per Year (%) Timeframe:		

Annual Costs [ ] $ x 10³ [ ] $ x 10⁶	Total No. of Payments	Annual Cost on ABD	Total Nominal Cost on ABD	One Step Adjustment Factor* Table Factor x DOS Correction	Present Worth on ABD

	Initial Costs		Energy/Fuel Costs		M&R Costs		Other Costs		Total
Net Present Worth:	________	+	________	+	________	+	________	=	________

DA FORM 5605-5-R, DEC 86

*Use One-Step Table 2 for M&R costs (e = 0).
Use One-Step Table 3 for energy/fuel costs (e = prescribed e value).

Sheet ________ of ________

Form 8-15. DA Form 5605-3
Basic Data Input Summary -- blank

Project No. & Title ______________________

Installation & Location ______________________

Design Feature ______________________

Alt. No ________ Title ______________________

LIFE CYCLE COST ANALYSIS

BASIC INPUT DATA SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference		
Date of Study (DOS)		
Analysis Base Date (ABD)		
Analysis End Date (AED)		
Midpoint of Construction		
Beneficial Occupancy Date (BOD)	Actual Projected	
	Assumed for Analysis	
DOE Region		
Annual Discount Rate		

Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe:		

Principal Assumptions

Cash Flow Diagram

Cost Element	Cost on ABD ☐ $ x 10³ ☐ $ x 10⁶	Time Cost Incurred**		Source(s) of Data
		Actual Projected Dates	Dates for Analysis (If Different)*	

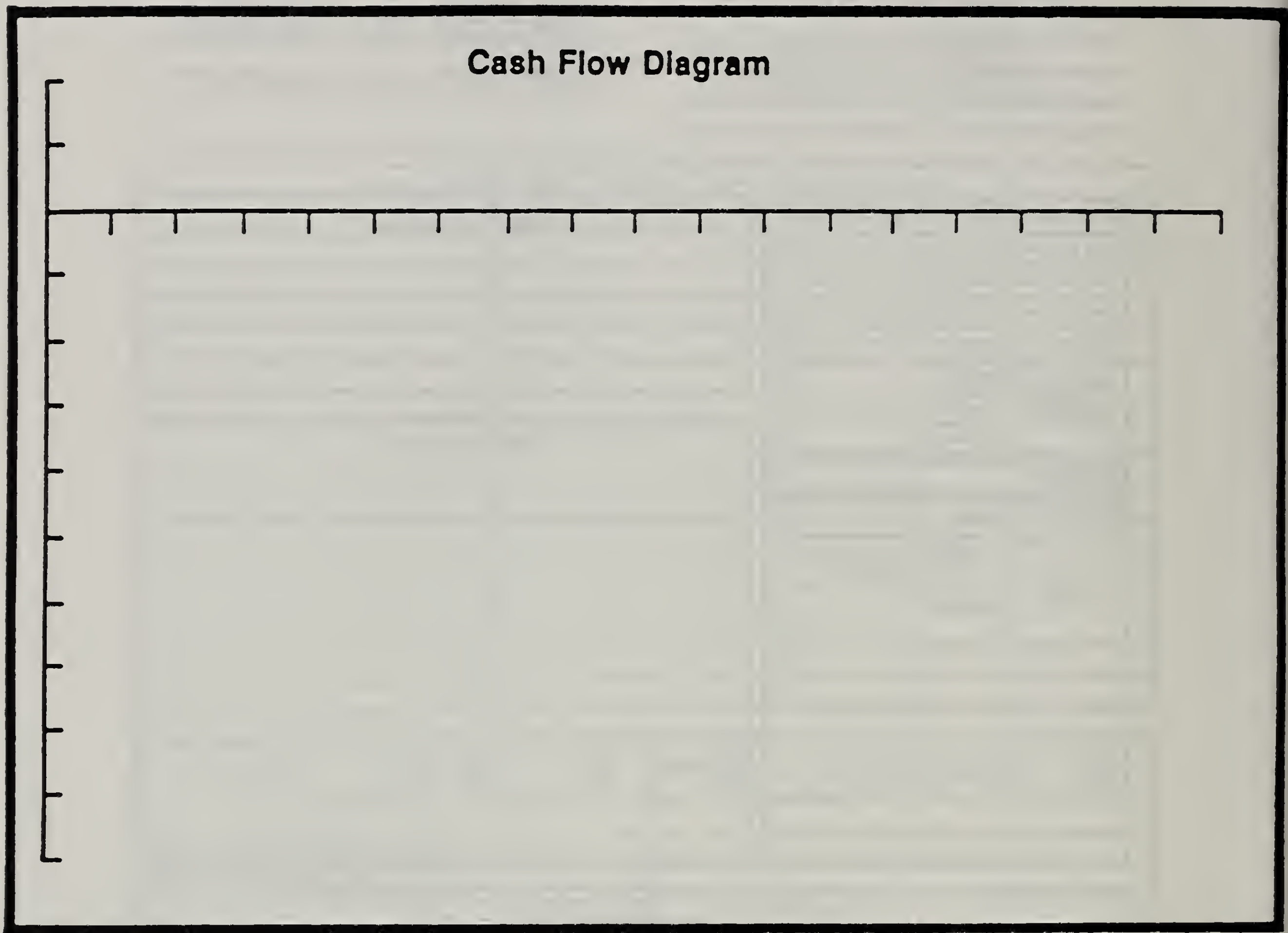
DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply

**For Recurring Annual Costs, show date of first and last costs only.

Sheet ________ of ________

Form 8-16. Blow up of cash flow diagram -- blank



Form 8-17. DA Form 5605-5 -- blank

Project No. & Title ____________________

Installation & Location ____________________

Design Feature ____________________

Alt. No. ________ Title ____________________

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: ONE-STEP APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs [ ] $ x 10³ [ ] $ x 10⁶	Years from ABD	Cost On ABD	One Step Adj.Factor Table 1	Present Worth on ABD

Criteria Reference	
Analysis Base Date (ABD)	
Analysis End Date (AED)	
Midpoint of Construction	
BOD for Analysis	
Annual Discount Rate	

Type of Cost	Differential Escalation Rate per Year (%) Timeframe:		

Annual Costs [ ] $ x 10³ [ ] $ x 10⁶	Total No. of Payments	Annual Cost on ABD	Total Nominal Cost on ABD	One Step Adjustment Factor* Table Factor x DOS Correction	Present Worth on ABD

	Initial Costs		Energy/Fuel Costs		M&R Costs		Other Costs		Total
Net Present Worth:	________	+	________	+	________	+	________	=	________

DA FORM 5605-5-R, DEC 86

*Use One-Step Table 2 for M&R costs (e = 0).
Use One-Step Table 3 for energy/fuel costs (e = prescribed e value).

Sheet ________ of ________

Form 8-18. DA Form 5605-2 -- blank

LIFE CYCLE COST ANALYSIS
SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Project No. & Title ____________________

Installation & Location ____________________

Design Feature ____________________

Date of Study ____________________

ALTERNATIVES ANALYZED						
No.	Description/Title	Present Worth [ ] $ x 10^3 [ ] $ x 10^6				
		Initial	Energy	M&R	Other	Total

ECONOMIC RANKING				
Rank	Alternative No. & Title	Economic Advantages of Top-Ranked Alternative		Basis for No. 1 Ranking
		LCC (PW) Difference (Dollars & Percent)	Other (Initial, Energy, Etc.)	

KEY ASSUMPTIONS

NARRATIVE SUMMARY (Comments/Lessons Learned/Observations/Recommendations/Etc.)

Key Participants - Name	Discipline	Organization	Telephone No.

DA FORM 5605-2-R, DEC 86

Sheet ______ of ______

MODULE 9

DATA

Purpose:

- To explain data requirements for EA/LCCA
- To acquaint you with sources of data
- To provide practice under supervision using the M&R Database

Outline:

9.1 Identifying Data Requirements (Exercise 9-1)

9.2 Estimating Construction/Procurement Costs & Replacement Costs

9.3 Estimating Disposal Costs/Retention Values

9.4 Estimating Energy Costs

9.5 Estimating Maintenance and Repair Costs

9.6 Exercise 9-2: Using the M&R Database

Approximate Time:

4 hours

Slide 9-1

DATA

- **What you need**
- **How to get it**

Notes:

9.1 IDENTIFYING DATA REQUIREMENTS (EXERCISE 9-1)

By the end of this section, you are expected to be able to

- identify data relevant to choosing among alternative building designs

Slide 9-2

WHAT TO INCLUDE

- Include costs which will be changed by the choice
- Omit those not affected
  - unrelated costs
  - costs occurred in the past ("sunk costs")
  - common costs

Notes:

Slide 9-3

WHAT ABOUT PENALTIES/BENEFITS NOT MEASURED IN DOLLARS?

Notes:

EXERCISE 9-1: IDENTIFYING DATA REQUIREMENTS

Suppose in a rehab project you want to evaluate whether it is cost effective to replace the existing HVAC system with a new system. Assume that the existing system can continue to meet heating and cooling requirements over the remaining 10 years that the building is expected to be occupied. From the following list, check the data you need:

1.	Original land costs	$100,000
2.	Original site improvements	$50,000
3.	Initial construction costs	$5,000
4.	Purchase and installation costs of the existing HVAC system	$10,000
5.	Duct work for the existing HVAC system	$10,000
6.	Modification of the existing duct work to meet requirements of the new HVAC system	$2,000
7.	Purchase and installation costs of the new HVAC system	$50,000
8.	Maintenance cost of the existing HVAC	$2,000/year
9.	Maintenance cost of the new HVAC	$2,000/year
10.	Heating efficiency/cooling Coefficient of Performance (COP) of existing system	0.65/2.0
11.	Heating efficiency/cooling COP of new system	0.80/3.0
12.	Current price of energy used by the existing system	$25.00/MBtu
13.	Current price of energy used by the new system	$22.00/MBtu
14.	Projected rate of change in price of energy used by existing system	7%/year

15.	Projected rate of change in price of energy used by new system	5%/year
16.	Building heating load (annual)	3,000 MBtu
17.	Building cooling load (annual)	4,000 MBtu
18.	Existing HVAC system's current salvage value less disposal costs	$5,000
19.	New HVAC system's salvage value, less removal costs, if it were kept in service 30 years	$10,000
20.	Replacement costs of existing system at end of its 15 year remaining life	$35,000
21.	Replacement of new system at the end of its 30 year life	$45,000
22.	The salvage value of the new system in 10 years	$10,000
23.	The new system operates more quietly than the existing system	

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9.2 ESTIMATING CONSTRUCTION/PROCUREMENT COSTS & REPLACEMENT COSTS

By the end of this section, you are expected to be able to

- explain how to estimate future construction and replacement costs based on today's costs
- describe the level of detail required for estimates of construction/procurement/ replacement costs for EA/LCCA

Slide 9-4

CONSTRUCTION COST ESTIMATING APPROACH

What level of accuracy?

- **Detailed construction estimates are normally not used for EA/LCCA. They are the basis for bids and are usually made after EA/LCCA, not before**
- **But if accurate data are readily available, use them**

Notes:

Slide 9-5

ESTIMATING REPLACEMENT COSTS

- Start with today's cost
- Take account of
    - system life
    - analysis period

Notes:

Slide 9-6

ESTIMATING REPLACEMENT COST: EXAMPLE

- Cost of replacing component today, C_P = $6,000
- Expected component life = 10 years
- Analysis period, N = 25 years
- Projected differential price escalation rate, e = 0

Replacement costs, C_F = ?

Notes:

Slide 9-7

ESTIMATING REPLACEMENT COST: EXAMPLE

- **Cost of replacing component today, C_P = \$6,000**
- **Expected component life = 10 years**
- **Analysis period, N = 25 years**
- **Projected differential price escalation rate, e = 0**

Replacement costs, C_F = \$6,000 (yr 10) & \$6,000 (yr 20)

Notes:

Slide 9-8

Replacement costs, C_F = \$6,000 (yr 10) & \$6,000 (yr 20)

d = 10%

$$PW = [\$6{,}000\ (1/(1+0.10)^{10})] + [\$6{,}000\ (1/(1+0.10)^{20})]$$
$$= \$2{,}313 + \$892$$
$$= \$3{,}205$$

Notes:

9.3 ESTIMATING DISPOSAL COSTS/RETENTION VALUES

By the end of this section, you are expected to be able to

- estimate a disposal cost to account for demolition or shut down at the end of the analysis period

- estimate a retention value to account for value remaining at the end of the analysis period

Slide 11-9

ESTIMATE RANGE OF RESULTS

Notes:

Slide 9-10

ESTIMATING DISPOSAL COSTS: EXAMPLE

- Expected time of disposal, N = 10 years
- Cost of disposal of similar comparably aged item today, C_P = $50,000
  (item 10 years older)
- Projected differential price escalation, e = 0
- Salvage value, S = 0

Disposal costs, C_F = ?

Notes:

Slide 9-11

ESTIMATING DISPOSAL COSTS: EXAMPLE

- Expected time of disposal, N = 10 years
- Cost of disposal of similar comparably aged item today, C_P = \$50,000
- Projected differential price escalation, e = 0
- Salvage value, S = 0

Disposal costs, C_F = \$50,000

Notes:

Slide 9-12

Disposal costs, C_F = \$50,000

$$PW = \$50{,}000\ (1/(1+0.10)^{10})$$

$$= \$19{,}277$$

Notes:

Slide 9-13

ESTIMATING RETENTION VALUES

Notes:

Slide 9-14

ESTIMATING RETENTION VALUES

- Roof covering life = 15 years
- Analysis period = 25 years
- Cost of replacing today, C_p = \$20,000
- Projected differential price escalation rate, e = 0

% of acquisition cost remaining after 25 yrs = ?

\$ Retention value =

Notes:

Slide 9-15

ESTIMATING RETENTION VALUES

- Roof covering life = 15 years
- Analysis period = 25 years
- Cost of replacing today, C_p = $20,000
- Projected differential price escalation, e = 0

% of replacement cost remaining after 25 yrs = 5/15 = 33.3%

$$\$ \text{ Retention value} = 0.333\ (\$20{,}000)(1+0.00)^{25} = \$6{,}660$$

Notes:

Slide 9-16

Retention value = 0.333 (\$20,000)(1+0.00)^{10}

= \$6,660

PW = \$6,660 (1/(1+0.10)^{25})

= \$615

Notes:

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9.4 ESTIMATING ENERGY COSTS

By the end of this section, you are expected to be able to

- identify several computer programs for analyzing energy consumption data
- estimate future energy costs year-by-year based on the price at the ABD, the projected rate of price escalation, and projected consumption

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ENERGY CONSUMPTION DATA

Notes:

Slide 9-18

ENERGY ANALYSIS COMPUTER PROGRAMS

- **BLAST**
- **DOE2**

Note:

A version of ASEAM (A Simiplified Energy Analysis Method) has been developed to incorporate DOE2 calculations. Contact the Fedral Energy Management Program Office of the Department of Energy for further information.

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ESTIMATING FUTURE ENERGY COSTS YEAR-BY-YEAR

$$C_F(\text{energy}) = \text{Quantity}_F \times \text{Price}_F$$

$$= Q_F \times P_F$$

Notes:

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TAKE ADVANTAGE OF OSAF
SIMPLIFIED ENERGY COST ESTIMATION WHEN POSSIBLE

$$PW = (Q)(p_P)(N)(OSAF)$$

where

Q	=	annual consumption
p_P	=	price at DOS
N	=	analysis period
OSAF	=	appropriate OSAF for the region, energy type, discount rate, DOS and BOD, and analysis period.

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ENERGY PRICE DATA

Notes:

9.5 ESTIMATING MAINTENANCE AND REPAIR COSTS

By the end of this section, you are expected to be able to

- to use CERL's database to estimate life-cycle maintenance and repair costs for components of major building systems, including architectural, electrical, plumbing, and HVAC systems

- be acquainted with the structure and special features of the database which are important to using it correctly

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ESTIMATING MAINTENANCE & REPAIR COSTS

WITH

CERL'S DATABASE

Notes:

Slide 9-23

ASSUMPTIONS FOR M&R COST DEMONSTRATION

Location:	Fort Eustis, VA
Alternatives:	Roof coverings -- builtup
Roofing area:	10,000 SF
DOS:	1/90
BOD:	1/93
Analysis period:	25 years from BOD
Discount rate:	10%

Notes:

Vugraph 9-1a

LIFE CYCLE COST ANALYSIS

EPS BASED MAINTENANCE AND REPAIR COST DATA FOR USE IN LIFE CYCLE COST ANALYSIS ($ PER UNIT MEASURE — PAGE 1

COMPONENT DESCRIPTION	UM	PRESENT WORTH OF ALL 25 YEAR MAINT. AND REPAIR COSTS (d-10%)				ANNUAL MAINTENANCE AND REPAIR PLUS HIGH COST REPAIR AND REPLACEMENT COSTS						
		By Resources			Wash. D.C.	Annual Maintenance and Repair			Replacement and High Cost Tasks			
		Labor	Mat'rl	Equip.	Total	Labor	Mat'rl	Equip.	Yr	Labor	Mat'rl	Equip.
ARCHITECTURE												
ROOFING												
ROOF COVERING												
BUILTUP ROOFING	SF	0.03990	0.37220	0.02000	1.25	0.00488	0.03172	0.00244	28	0.04938	0.70490	0.02469
PLACE NEW MEMBRANE OVER EXISTING -BUILTUP									14	0.02414	0.69960	0.01207
MOD. BIT./THERMOPLASTIC	SF	0.02440	0.33090	0.01180	0.87	0.00248	0.03219	0.00119	20	0.05659	0.85860	0.02829
MEMBRANE REPLACEMENT OR REPAIR - M.B./T. R									20	0.05659	0.85860	0.02829
THERMOSETTING	SF	0.01680	0.23950	0.00850	0.61	0.00174	0.02203	0.00088	20	0.03683	0.69960	0.01841
MEMBRANE REPLACEMENT - THERMOSETTING ROOF									20	0.03683	0.69960	0.01841
SLATE	SF	0.01850	0.10440	0.00890	0.51	0.00259	0.01459	0.00124	70	0.06885	6.04200	0.03442
CEMENT ASBESTOS	SF	0.01820	0.24340	0.00870	0.64	0.00254	0.03404	0.00122	70	0.05437	0.75190	0.02718
TILE	SF	0.01550	0.20990	0.00740	0.55	0.00217	0.02935	0.00103	70	0.10169	3.07400	0.05084
ROLL ROOFING	SF	0.07140	0.42700	0.03640	2.00	0.00754	0.01557	0.00387	10	0.04141	0.74963	0.02070
TOTAL ROOF REPLACEMENT - ROLL ROOF									10	0.04141	0.74963	0.02070
SHINGLES	SF	0.02210	0.22150	0.01170	0.71	0.00259	0.02385	0.00140	40	0.04118	0.74497	0.02059
REPLACE NEW OVER EXISTING - SHINGLED ROOF									20	0.02996	0.43460	0.01498
METAL	SF	0.01460	0.11060	0.00740	0.43	0.00205	0.01547	0.00103	30	0.36265	2.17300	0.18132
FIBERGLASS RIGID STP. ROOF	SF	0.02190	1.15340	0.01080	1.64	0.00232	0.06269	0.00113	20	0.04543	6.01550	0.02272
CONCRETE, SEALED PANEL ROOF	SF	0.04300	0.11750	0.02120	1.07	0.00601	0.01643	0.00297	60	0.06123	24.07419	0.03061
CONCRETE, SEALED PANEL RF4	SF	0.03900	0.08410	0.02020	0.95	0.00545	0.01176	0.00282	300	0.04342	24.07419	0.02171
CONCRETE SEALED POURED	SF	0.09830	0.63020	0.04950	2.80	0.01375	0.08811	0.00692	500	3.81056	18.03219	1.90528
FIBERGLASS, RIGID ROOF	SF	0.03800	1.15340	0.01930	1.99	0.00463	0.06269	0.00236	20	0.04133	6.01550	0.02066
TOTAL ROOF REPLACEMENT - FIBERGLASS RIGID									20	0.04133	6.01550	0.02066

See NOTES on the last page of this table for Explanation of Column Headings

Vugraph 9-1b

LIFE CYCLE COST ANALYSIS

EPS BASED MAINTENANCE AND REPAIR COST DATA FOR USE IN LIFE CYCLE COST ANALYSIS ($ PER UNIT MEASURE — PAGE 1

COMPONENT DESCRIPTION	UM	PRESENT WORTH OF ALL 25 YEAR MAINT. AND REPAIR COSTS (d=10%) — By Resources				ANNUAL MAINTENANCE AND REPAIR PLUS HIGH COST REPAIR AND REPLACEMENT COSTS — Annual Maintenance and Repair			Replacement and High Cost Tasks			
		Labor	Mat'rl	Equip.	Wash. D.C. Total	Labor	Mat'rl	Equip.	Yr	Labor	Mat'rl	Equip.
ARCHITECTURE												
ROOFING												
ROOF COVERING												
BUILTUP ROOFING	SF	$\boxed{0.03990}$	0.37220	0.02000	1.25	0.00488	0.03172	0.00244	28	0.04938	0.70490	0.02469
PLACE NEW MEMBRANE OVER EXISTING -BUILTUP									14	0.02414	0.69960	0.01207
MOD. BIT./THERMOPLASTIC	SF	0.02440	0.33090	0.01180	0.87	0.00248	0.03219	0.00119	20	0.05659	0.85860	0.02829
MEMBRANE REPLACEMENT OR REPAIR - M.B./T. R									20	0.05659	0.85860	0.02829
THERMOSETTING	SF	0.01680	0.23950	0.00850	0.61	0.00174	0.02203	0.00088	20	0.03683	0.69960	0.01841
MEMBRANE REPLACEMENT - THERMOSETTING ROOF									20	0.03683	0.69960	0.01841
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CEMENT ASBESTOS	SF	0.01820	0.24340	0.00870	0.64	0.00254	0.03404	0.00122	70	0.05437	0.75190	0.02718
TILE	SF	0.01550	0.20990	0.00740	0.55	0.00217	0.02935	0.00103	70	0.10169	3.07400	0.05084
ROLL ROOFING	SF	0.07140	0.42700	0.03640	2.00	0.00754	0.01557	0.00387	10	0.04141	0.74963	0.02070
TOTAL ROOF REPLACEMENT - ROLL ROOF									10	0.04141	0.74963	0.02070
SHINGLES	SF	0.02210	0.22150	0.01170	0.71	0.00259	0.02385	0.00140	40	0.04118	0.74497	0.02059
REPLACE NEW OVER EXISTING - SHINGLED ROOF									20	0.02996	0.43460	0.01498
METAL	SF	0.01460	0.11060	0.00740	0.43	0.00205	0.01547	0.00103	30	0.36265	2.17300	0.18132
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CONCRETE, SEALED PANEL RF4	SF	0.03900	0.08410	0.02020	0.95	0.00545	0.01176	0.00282	300	0.04342	24.07419	0.02171
CONCRETE SEALED POURED	SF	0.09830	0.63020	0.04950	2.80	0.01375	0.08811	0.00692	500	3.81056	18.03219	1.90528
FIBERGLASS, RIGID ROOF	SF	0.03800	1.15340	0.01930	1.99	0.00463	0.06269	0.00236	20	0.04133	6.01550	0.02066
TOTAL ROOF REPLACEMENT - FIBERGLASS RIGID									20	0.04133	6.01550	0.02066

See NOTES on the last page of this table for Explanation of Column Headings

Vugraph 9-1c

LIFE CYCLE COST ANALYSIS

EPS BASED MAINTENANCE AND REPAIR COST DATA FOR USE IN LIFE CYCLE COST ANALYSIS ($ PER UNIT MEASURE   PAGE 1

COMPONENT DESCRIPTION		PRESENT WORTH OF ALL 25 YEAR MAINT. AND REPAIR COSTS (d=10%)				ANNUAL MAINTENANCE AND REPAIR PLUS HIGH COST REPAIR AND REPLACEMENT COSTS						
		By Resources			Wash. D.C.	Annual Maintenance and Repair			Replacement and High Cost Tasks			
	UM	Labor	Mat'rl	Equip.	Total	Labor	Mat'rl	Equip.	Yr	Labor	Mat'rl	Equip.
ARCHITECTURE												
ROOFING												
ROOF COVERING												
BUILTUP ROOFING	SF	0.03990	$\boxed{0.37220}$	0.02000	1.25	0.00488	0.03172	0.00244	28	0.04938	0.70490	0.02469
PLACE NEW MEMBRANE OVER EXISTING -BUILTUP									14	0.02414	0.69960	0.01207
MOD. BIT./THERMOPLASTIC	SF	0.02440	0.33090	0.01180	0.87	0.00248	0.03219	0.00119	20	0.05659	0.85860	0.02829
MEMBRANE REPLACEMENT OR REPAIR - M.B./T. R									20	0.05659	0.85860	0.02829
THERMOSETTING	SF	0.01680	0.23950	0.00850	0.61	0.00174	0.02203	0.00088	20	0.03683	0.69960	0.01841
MEMBRANE REPLACEMENT - THERMOSETTING ROOF									20	0.03683	0.69960	0.01841
SLATE	SF	0.01850	0.10440	0.00890	0.51	0.00259	0.01459	0.00124	70	0.06885	6.04200	0.03442
CEMENT ASBESTOS	SF	0.01820	0.24340	0.00870	0.64	0.00254	0.03404	0.00122	70	0.05437	0.75190	0.02718
TILE	SF	0.01550	0.20990	0.00740	0.55	0.00217	0.02935	0.00103	70	0.10169	3.07400	0.05084
ROLL ROOFING	SF	0.07140	0.42700	0.03640	2.00	0.00754	0.01557	0.00387	10	0.04141	0.74963	0.02070
TOTAL ROOF REPLACEMENT - ROLL ROOF									10	0.04141	0.74963	0.02070
SHINGLES	SF	0.02210	0.22150	0.01170	0.71	0.00259	0.02385	0.00140	40	0.04118	0.74497	0.02059
REPLACE NEW OVER EXISTING - SHINGLED ROOF									20	0.02996	0.43460	0.01498
METAL	SF	0.01460	0.11060	0.00740	0.43	0.00205	0.01547	0.00103	30	0.36265	2.17300	0.18132
FIBERGLASS RIGID STP. ROOF	SF	0.02190	1.15340	0.01080	1.64	0.00232	0.06269	0.00113	20	0.04543	6.01550	0.02272
CONCRETE, SEALED PANEL ROOF	SF	0.04300	0.11750	0.02120	1.07	0.00601	0.01643	0.00297	60	0.06123	24.07419	0.03061
CONCRETE, SEALED PANEL RF4	SF	0.03900	0.08410	0.02020	0.95	0.00545	0.01176	0.00282	300	0.04342	24.07419	0.02171
CONCRETE SEALED POURED	SF	0.09830	0.63020	0.04950	2.80	0.01375	0.08811	0.00692	500	3.81056	18.03219	1.90528
FIBERGLASS, RIGID ROOF	SF	0.03800	1.15340	0.01930	1.99	0.00463	0.06269	0.00236	20	0.04133	6.01550	0.02066
TOTAL ROOF REPLACEMENT - FIBERGLASS RIGID									20	0.04133	6.01550	0.02066

See NOTES on the last page of this table for Explanation of Column Headings

Vugraph 9-1d

LIFE CYCLE COST ANALYSIS

EPS BASED MAINTENANCE AND REPAIR COST DATA FOR USE IN LIFE CYCLE COST ANALYSIS ($ PER UNIT MEASURE — PAGE 1

COMPONENT DESCRIPTION	UM	PRESENT WORTH OF ALL 25 YEAR MAINT. AND REPAIR COSTS (d-10%)				ANNUAL MAINTENANCE AND REPAIR PLUS HIGH COST REPAIR AND REPLACEMENT COSTS						
		By Resources			Wash. D.C. Total	Annual Maintenance and Repair			Replacement and High Cost Tasks			
		Labor	Mat'rl	Equip.		Labor	Mat'rl	Equip.	Yr	Labor	Mat'rl	Equip.
ARCHITECTURE												
ROOFING												
ROOF COVERING												
BUILTUP ROOFING	SF	0.03990	0.37220	0.02000	1.25	0.00488	0.03172	0.00244	28	0.04938	0.70490	0.02469
PLACE NEW MEMBRANE OVER EXISTING -BUILTUP									14	0.02414	0.69960	0.01207
MOD. BIT./THERMOPLASTIC	SF	0.02440	0.33090	0.01180	0.87	0.00248	0.03219	0.00119	20	0.05659	0.85860	0.02829
MEMBRANE REPLACEMENT OR REPAIR - M.B./T. R									20	0.05659	0.85860	0.02829
THERMOSETTING	SF	0.01680	0.23950	0.00850	0.61	0.00174	0.02203	0.00088	20	0.03683	0.69960	0.01841
MEMBRANE REPLACEMENT - THERMOSETTING ROOF									20	0.03683	0.69960	0.01841
SLATE	SF	0.01850	0.10440	0.00890	0.51	0.00259	0.01459	0.00124	70	0.06885	6.04200	0.03442
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TILE	SF	0.01550	0.20990	0.00740	0.55	0.00217	0.02935	0.00103	70	0.10169	3.07400	0.05084
ROLL ROOFING	SF	0.07140	0.42700	0.03640	2.00	0.00754	0.01557	0.00387	10	0.04141	0.74963	0.02070
TOTAL ROOF REPLACEMENT - ROLL ROOF									10	0.04141	0.74963	0.02070
SHINGLES	SF	0.02210	0.22150	0.01170	0.71	0.00259	0.02385	0.00140	40	0.04118	0.74497	0.02059
REPLACE NEW OVER EXISTING - SHINGLED ROOF									20	0.02996	0.43460	0.01498
METAL	SF	0.01460	0.11060	0.00740	0.43	0.00205	0.01547	0.00103	30	0.36265	2.17300	0.18132
FIBERGLASS RIGID STP. ROOF	SF	0.02190	1.15340	0.01080	1.64	0.00232	0.06269	0.00113	20	0.04543	6.01550	0.02272
CONCRETE, SEALED PANEL ROOF	SF	0.04300	0.11750	0.02120	1.07	0.00601	0.01643	0.00297	60	0.06123	24.07419	0.03061
CONCRETE, SEALED PANEL RF4	SF	0.03900	0.08410	0.02020	0.95	0.00545	0.01176	0.00282	300	0.04342	24.07419	0.02171
CONCRETE SEALED POURED	SF	0.09830	0.63020	0.04950	2.80	0.01375	0.08811	0.00692	500	3.81056	18.03219	1.90528
FIBERGLASS, RIGID ROOF	SF	0.03800	1.15340	0.01930	1.99	0.00463	0.06269	0.00236	20	0.04133	6.01550	0.02066
TOTAL ROOF REPLACEMENT - FIBERGLASS RIGID									20	0.04133	6.01550	0.02066

See NOTES on the last page of this table for Explanation of Column Headings

Vugraph 9-1e

LIFE CYCLE COST ANALYSIS

EPS BASED MAINTENANCE AND REPAIR COST DATA FOR USE IN LIFE CYCLE COST ANALYSIS ($ PER UNIT MEASURE — PAGE 1

COMPONENT DESCRIPTION	UM	PRESENT WORTH OF ALL 25 YEAR MAINT. AND REPAIR COSTS (d=10%)				ANNUAL MAINTENANCE AND REPAIR PLUS HIGH COST REPAIR AND REPLACEMENT COSTS						
		By Resources			Wash. D.C. Total	Annual Maintenance and Repair			Replacement and High Cost Tasks			
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ROOF COVERING												
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PLACE NEW MEMBRANE OVER EXISTING -BUILTUP									14	0.02414	0.69960	0.01207
MOD. BIT./THERMOPLASTIC	SF	0.02440	0.33090	0.01180	0.87	0.00248	0.03219	0.00119	20	0.05659	0.85860	0.02829
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THERMOSETTING	SF	0.01680	0.23950	0.00850	0.61	0.00174	0.02203	0.00088	20	0.03683	0.69960	0.01841
MEMBRANE REPLACEMENT - THERMOSETTING ROOF									20	0.03683	0.69960	0.01841
SLATE	SF	0.01850	0.10440	0.00890	0.51	0.00259	0.01459	0.00124	70	0.06885	6.04200	0.03442
CEMENT ASBESTOS	SF	0.01820	0.24340	0.00870	0.64	0.00254	0.03404	0.00122	70	0.05437	0.75190	0.02718
TILE	SF	0.01550	0.20990	0.00740	0.55	0.00217	0.02935	0.00103	70	0.10169	3.07400	0.05084
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CONCRETE, SEALED PANEL RF4	SF	0.03900	0.08410	0.02020	0.95	0.00545	0.01176	0.00282	300	0.04342	24.07419	0.02171
CONCRETE SEALED POURED	SF	0.09830	0.63020	0.04950	2.80	0.01375	0.08811	0.00692	500	3.81056	18.03219	1.90528
FIBERGLASS, RIGID ROOF	SF	0.03800	1.15340	0.01930	1.99	0.00463	0.06269	0.00236	20	0.04133	6.01550	0.02066
TOTAL ROOF REPLACEMENT - FIBERGLASS RIGID									20	0.04133	6.01550	0.02066

See NOTES on the last page of this table for Explanation of Column Headings

Slide 9-24

COMPUTE LCC FOR BUILTUP ROOFING

	PW Initial		PW M&R		PW Retention
LCC/SF (Bulltup Roofing) =	[$0.8037/SF	+	$0.9989/SF	-	$0.0078/SF]
=	$1.7948/SF				
LCC (Bulltup Roofing) =	$1.7948/SF x 10,000 SF				
=	$17,948				

Notes:

Slide 9-25

SPECIAL FEATURES OF THE DATABASE

- Constructed from the ground up from time study data (Engineered Performance Standards)
- Covers nearly all building components
- Incorporates all maintenance, repair, & replacements for continued service
- Geared to LCC studies

Notes:

Slide 9-26

M&R DATA AVAILABLE

for

Architectural
Electrical
Plumbing
HVAC

Notes:

Slide 9-27

HOW TO USE THE DATABASE: SUMMARY

1. Find LCCA table for building system
2. Record index for labor
4. Multiply labor index by hourly wage rate
5. Record index for material
6. Multiply material index by ACF and MCP index
7. Record index for equipment
8. Multiply equip index by equip hourly rate
9. Sum results of steps 4, 6, & 8 for PW (M&R/SF)
10. Compute PW of M&R by multiplying by SF
11. Add to PW of initial cost & salvage value

where

ACF	=	area cost factor
MCP Index	=	Tri-Service MCP (inflation) Index

For Further Information about the LCC maintenance database, contact:

Facility System Division
Construction Engineering Research Laboratory
Corps of Engineers
Department of the Army
P.O. Box 4005
Champaign, Illinois 61820-1305

Edgar S. Neely, Civil Engineer (217) 373-6721

Robert D. Neathammer, Staff Statistician (217) 373-7259

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9.6 EXERCISE 9-2: USING THE M&R DATABASE

Use the following table to compute the present worth of M&R costs over 25 years for 15,000 SF of shingle roofing on a gym at the U.S. Military Academy. Use the ACF 1.17 to adjust for location. Use the factor 1.09 to update materials costs from 1985 to the DOS. Use $13.85/hour as the wage rate for roofers, and use $3.45/hour as the equipment charge rate.

PW (Labor/SF) =

PW (Materials/SF) =

PW (Equipment/SF) =

Total PW (M&R/SF) =

Total PW (M&R) =

LIFE CYCLE COST ANALYSIS

LIFE CYCLE COST ANALYSIS

EPS BASED MAINTENANCE AND REPAIR COST DATA FOR USE IN LIFE CYCLE COST ANALYSIS ($ PER UNIT MEASURE — PAGE 1

COMPONENT DESCRIPTION	UM	PRESENT WORTH OF ALL 25 YEAR MAINT. AND REPAIR COSTS (d=10%)				ANNUAL MAINTENANCE AND REPAIR PLUS HIGH COST REPAIR AND REPLACEMENT COSTS						
		By Resources			Wash. D.C. Total	Annual Maintenance and Repair			Replacement and High Cost Tasks			
		Labor	Mat'rl	Equip.		Labor	Mat'rl	Equip.	Yr	Labor	Mat'rl	Equip.
ARCHITECTURE												
ROOFING												
ROOF COVERING												
BUILTUP ROOFING	SF	0.03990	0.37220	0.02000	1.25	0.00488	0.03172	0.00244	28	0.04938	0.70490	0.02469
PLACE NEW MEMBRANE OVER EXISTING -BUILTUP									14	0.02414	0.69960	0.01207
MOD. BIT./THERMOPLASTIC	SF	0.02440	0.33090	0.01180	0.87	0.00248	0.03219	0.00119	20	0.05659	0.85860	0.02829
MEMBRANE REPLACEMENT OR REPAIR - M.B./T. R									20	0.05659	0.85860	0.02829
THERMOSETTING	SF	0.01680	0.23950	0.00850	0.61	0.00174	0.02203	0.00088	20	0.03683	0.69960	0.01841
MEMBRANE REPLACEMENT - THERMOSETTING ROOF									20	0.03683	0.69960	0.01841
SLATE	SF	0.01850	0.10440	0.00890	0.51	0.00259	0.01459	0.00124	70	0.06885	6.04200	0.03442
CEMENT ASBESTOS	SF	0.01820	0.24340	0.00870	0.64	0.00254	0.03404	0.00122	70	0.05437	0.75190	0.02718
TILE	SF	0.01550	0.20990	0.00740	0.55	0.00217	0.02935	0.00103	70	0.10169	3.07400	0.05084
ROLL ROOFING	SF	0.07140	0.42700	0.03640	2.00	0.00754	0.01557	0.00387	10	0.04141	0.74963	0.02070
TOTAL ROOF REPLACEMENT - ROLL ROOF									10	0.04141	0.74963	0.02070
SHINGLES	SF	0.02210	0.22150	0.01170	0.71	0.00259	0.02385	0.00140	40	0.04118	0.74497	0.02059
REPLACE NEW OVER EXISTING - SHINGLED ROOF									20	0.02996	0.43460	0.01498
METAL	SF	0.01460	0.11060	0.00740	0.43	0.00205	0.01547	0.00103	30	0.36265	2.17300	0.18132
FIBERGLASS RIGID STP. ROOF	SF	0.02190	1.15340	0.01080	1.64	0.00232	0.06269	0.00113	20	0.04543	6.01550	0.02272
CONCRETE, SEALED PANEL ROOF	SF	0.04300	0.11750	0.02120	1.07	0.00601	0.01643	0.00297	60	0.06123	24.07419	0.03061
CONCRETE, SEALED PANEL RF4	SF	0.03900	0.08410	0.02020	0.95	0.00545	0.01176	0.00282	300	0.04342	24.07419	0.02171
CONCRETE SEALED POURED	SF	0.09830	0.63020	0.04950	2.80	0.01375	0.08811	0.00692	500	3.81056	18.03219	1.90528
FIBERGLASS, RIGID ROOF	SF	0.03800	1.15340	0.01930	1.99	0.00463	0.06269	0.00236	20	0.04133	6.01550	0.02066
TOTAL ROOF REPLACEMENT - FIBERGLASS RIGID									20	0.04133	6.01550	0.02066

See NOTES on the last page of this table for Explanation of Column Headings

KEY POINTS

- Omit from EA/LCCA costs (& benefits) which are not affected by the choice of alternatives, including sunk costs.

- Detailed estimates are normally not used for economic analysis. They are the basis for bids and are usually made after economic analysis, not for economic analysis.

- To avoid unduly penalizing the economic performance of a building system which has service life remaining at the end of the analysis period, a cost credit called a retention value is attributed to that system. The retention value is usually estimated by prorating the initial cost of the system over its estimated service life, and taking the amount remaining at the end of the analysis period as the retention value.

- Maintenance data for performing LCC analysis are readily available from CERL in a series of published reports, one for each of the major building systems: architecture, HVAC, plumbing, and electrical.

- The set of 25 year PW data is to be used for manual calculations when the analysis period is 25 years.

- The set of annual data, together with "replacement/high cost" data, is to be used with the LCCID computer program and for manual calculations when the analysis period is not 25 years.

- The CERL database has the advantage of allowing you to use your own up-to-date labor and equipment charge rates and to adjust material costs for your location and date of study.

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MODULE 10

PERFORMING LCCA WITH COMPUTERS

Purpose:

- To introduce you to performing LCCA using computer software
- To discuss factors in selecting and using software

Outline:

10.1 Software for EA/LCCA

10.2 Introduction to LCCID

Computer Lab

Approximate Time:

3 hours and 30 minutes (1 hour classroom; 2.5 hours computer lab)

Slide 10-1

PERFORMING EA/LCCA WITH COMPUTERS

Notes:

10.1 SOFTWARE FOR EA/LCCA

By the end of this section, you are expected to be able to

- list several aspects of EA that existing software can do for you and several things that you have to do
- list key factors to consider in selecting software for EA/LCCA
- identify several computer programs that are useful for EA/LCCA

Slide 10-2

EXISTING SOFTWARE WILL

- **Perform fast and accurate calculations**
- **Make it easier to follow criteria**
- **Provide some of the data**
- **Supply part or all documentation**

Notes:

Slide 10-3

EXISTING SOFTWARE WILL NOT

- Decide when an analysis is needed
- Select the appropriate level of effort
- Assemble all input data
- Make all data & assumptions consistent
- Interpret results
- Make a decision

Notes:

Slide 10-4

FACTORS TO CONSIDER WHEN SELECTING SOFTWARE

- For what application?
- Is there an active users group?
- Is it endorsed for this application?
- Is it compatible with my hardware?
- How well is it documented and supported?
- Is it adequate for my needs?
- Will using it increase productivity?

Notes:

Slide 10-5

SOFTWARE FOR MILCON EA/LCCA STUDIES

- LCCID
  - Developed by CERL
  - Consistent with OMB A-94, FEMP, ECIP
  - Specifically for MILCON applications
- "GOVERNMENT ECONOMICS"
  - Developed by Trane Company
  - Corps validated (consistent with LCCID)
- "ADVANCED ECONOMIC ANALYSIS"
  - Developed by Carrier Corp.
  - Corps validated (consistent with LCCID)
- FBLCC
  - Developed by NIST
  - Consistent with FEMP, OMB A-94,
  - Based on NIST HB 135
  - For government-wide use

Notes:

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10.2 INTRODUCTION TO LCCID

By the end of this section and the computer lab, you are expected to be able to

- use LCCID to perform simple EA/LCCA
- describe the special features of LCCID
- interpret a sample printout of the LCCID Output Report

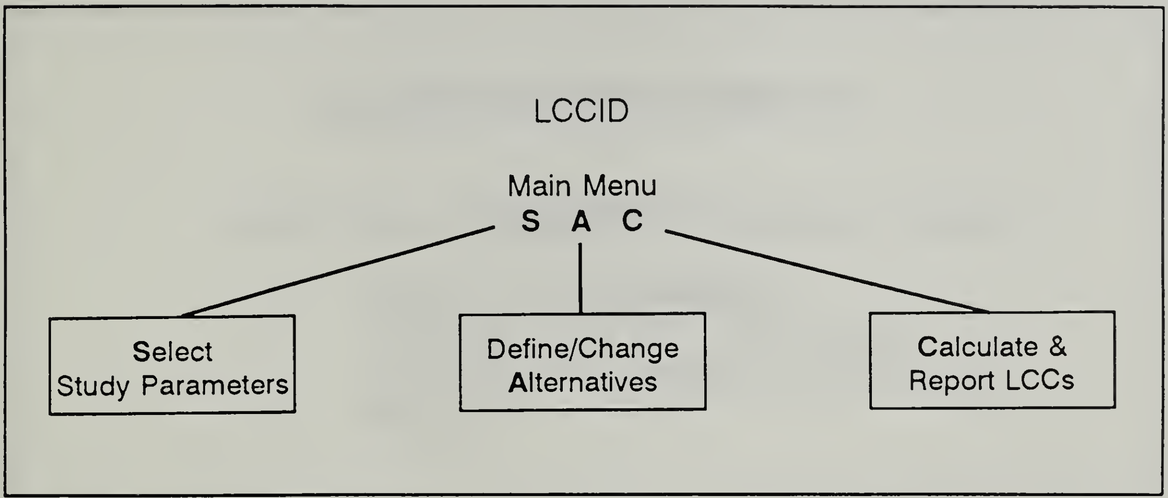
Slide 10-6

LIFE-CYCLE COST IN DESIGN
(LCCID)

- Tailored to DOD needs
  - incorporates criteria of Army/Navy/Air Force
  - calculates required economic measures
- For performing
  - general economic studies
  - energy conservation studies (FEMP & ECIP)

Notes:

Slide 10-7 (a-d)



Notes:

Slide 10-8

LCCID USER'S MANUAL

- User instructions
- Reference
- Tutorial

Notes:

Slide 10-9

LCCID DISTRIBUTION & SUPPORT

BLAST Support Office (BSO), University of Illinois

- **Updates (at least annually)**
- **"Annually" for DOE e-value inputs**
- **As needed for fixes, enhancements, etc.**
- **Support**

Notes:

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10.2 LCCID COMPUTER LAB

Two case studies are provided for LCCID solution. These are examples that you have solved manually in class. The first requires a general economic study; the second, an energy conservation study. Do Case Study 10-1 first, and have an instructor verify that you successfully completed the exercise. Then, if time permits, do Case Study 10-2.

CASE STUDY 10-1: USING LCCID FOR A GENERAL ECONOMIC STUDY

Compute LCC using conventional approach. Suppose you have been asked to design a vehicle maintenance shop for Fort X in Huntsville, and you need to select among alternative exterior wall surfaces. Compute LCC of exterior wall design alternative A (Tile) by completing the attached DA Forms 5605-3 and 4, based on the following data:

Project Number:	PN568
Date of Study (DOS):	7/88
Analysis Base Date (ABD):	7/88
Beginning of Construction:	Two years from DOS
Length of Construction Period:	One year
Beneficial Occupancy Date (BOD):	End of Construction Period
Initial Investment Costs (as of DOS):	\$75,000
M&R Costs (as of DOS):	\$2,000/yr
Distillate Fuel (as of DOS): (M&R and Fuel costs start six months after BOD)	\$12,000/yr plus escalation 2,609 MBtu at \$4.60/MBtu
Repair Cost (as of DOS): (Repair cost first occurs five years after BOD)	\$5,000/every five years
Retention Value (as of DOS): (Retention value occurs 25 years after BOD)	\$7,500

Differential Escalation Rates:
("e values")

Energy	Use set for 1987 (which were still in effect at time of this study)
Other	0

Data Sources: Initial investment -- Means Cost Data; M&R -- M&R Database; Repair -- Repair Records; Retention Value -- Prorated cost described in attachment; Energy -- BLAST.

CASE STUDY 10-2: USING LCCID FOR AN ENERGY CONSERVATION STUDY

Perform an LCC analysis of two alternative HVAC systems being considered for an administration building to be constructed on Fort X in Mississippi:

- Alternative A, a variable-volume system <u>without</u> an energy economizer cycle

- Alternative B, a variable-volume system <u>with</u> an energy economizer cycle

A previous analysis has identified alternative A as the "best" of conventional designs. It is the baseline against which to evaluate the alternative with an energy economizer cycle.

Compute LCCs of the two alternatives using the one-step approach and FEMP criteria for energy conservation studies. Compare LCCs and recommend a system. (See key dates below.)

Use DA Form 5605-3 for data inputs; DA Form 5605-5 to compute LCCs; and DA Form 5605-2 to compare the results and record the LCC ranking.

Data:

	Alt A	Alt B
Purchase & Installation	$125,000	$132,000
Replacement (Plant) (7/00)	50,000	52,000
Replacement (Fan) (7/06)	20,000	20,000
Replacement (Plant) (7/09)	50,000	52,000
Net Retention Value (7/16)	18,000	20,000
Maintenance & Repair (yearly)	12,000	12,500

Data (continued):

	Alt A	Alt B
Annual Energy Costs (in prices at the beginning of the analysis period; use set of data for 1987)		
Electricity	$17,000 1,252 MBtu	$15,000 1,105 MBtu at $13.58/MBtu
Distillate	2,000 435 MBtu	1,500 326 MBtu at $4.60/MBtu
Expected Service Life	35 years	35 years

Dates: DOS = ABD = 7/88; Start of Construction = 7/90; BOD = 7/91

KEY POINTS

- Computer programs for EA/LCCA can speed calculations and increase accuracy, make it easier to follow criteria, provide some of the data, supply part or all documentation, but there is much that remains for you, the analyst, to do.
- It pays to select your computer program carefully; the wrong program hinders rather than helps your analysis.
- Make sure that programs selected for use are compatible with all current criteria.
- Computer software is a useful tool only if used correctly.
- LCCID and LCCID -- compatible programs (including commercially developed programs) are tailored to your EA/LCCA needs.

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MODULE 11

DEALING WITH UNCERTAINTIES

Purpose:

- To emphasize that uncertainty is a fact of life for EA/LCCA
- To point out that uncertainty in input data may cause the outcome of a design choice to be different than indicated by results of an economic study
- To acquaint you with some of the techniques for dealing with uncertainties
- To introduce you to sensitivity analysis

Outline:

11.1 Overview of Selected Techniques

11.2 When Uncertainty Assessment Should Be Done (Exercise 11-1)

11.3 Exercise 11-2: Sensitivity Analysis

Approximate Time:

1 hour and 30 minutes

Slide 11-1

SOURCES OF UNCERTAINTY IN EA/LCCA

- Variability in data inputs
  - Prices
  - Quantities
  - Timing of costs & benefits
- System performance
- Circumstances of use

Notes:

11.1 OVERVIEW OF SELECTED TECHNIQUES

By the end of this section and section 11.3, you are expected to be able to

- describe several techniques for dealing with uncertainty
- perform sensitivity analysis

Slide 11-2

UNCERTAINTY ANALYSIS

analytical techniques for taking into account the degree of uncertainty about input values for an economic analysis

Notes:

Slide 11-3

TECHNIQUES FOR DEALING WITH UNCERTAINTY

- **Probability-based analysis**
- **Sensitivity analysis**
- **Others**

Notes:

NIST Special Publication 757, Techniques for Treating Uncertainty and Risk in the Economic Evaluation of Building Investments, by Harold E. Marshall.

Slide 11-4

SENSITIVITY ANALYSIS IS PERFORMED --

by repeating an economic evaluation with one or more input values changed.

Notes:

Slide 11-5

SENSITIVITY ANALYSIS IS USED TO

- **Identify key data and assumptions**
- **Test "what if" questions**
- **Show outcome as a low-to-high range**

Notes:

Slide 11-6

IDENTIFY CRITICAL INPUTS

10% change in input	% change in output
input 1	2%
input 2	10%
* input 3	20%

Conclusion: devote more resources to improving data estimates for input 3 than input 1.

Notes:

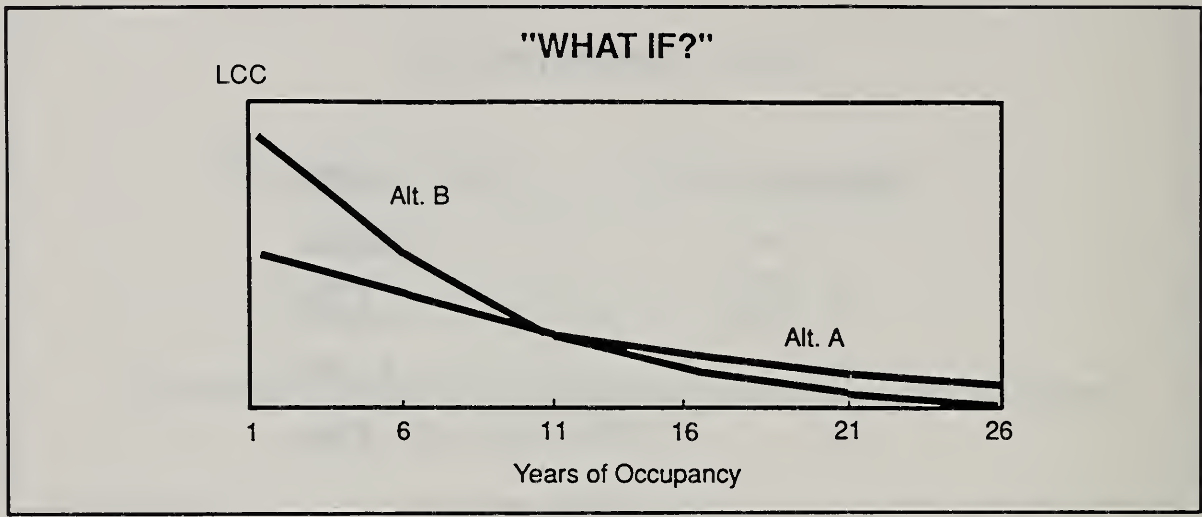
Slide 11-7

"WHAT IF?"

Scenario	LCC
1	$10,000
2	9,000
3	11,000
4	8,000

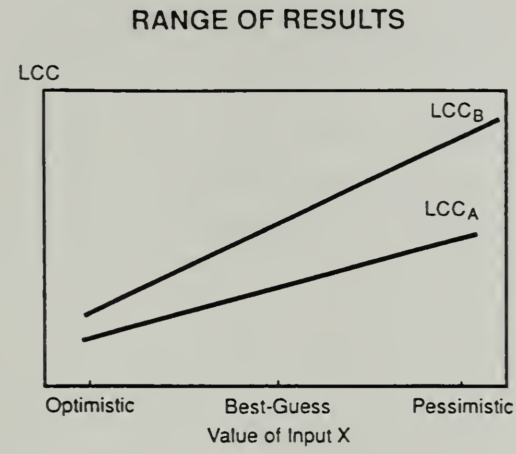
Notes:

Slide 11-8



Notes:

Slide 11-9



Notes:

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11.2 WHEN UNCERTAINTY ASSESSMENT SHOULD BE DONE

By the end of this section, you are expected to be able to

- identify conditions under which you should perform uncertainty assessment as part of EA/LCCA for MILCON design

- identify conditions under which you should not perform uncertainty assessment as part of EA/LCCA for MILCON design

Slide 11-10

FACTORS WHICH DETERMINE NEED FOR UNCERTAINTY ASSESSMENT

- **Are LCCA results clear cut?**
- **Is approval required by higher authority?**
- **Are the LCCA results controversial?**
  - **Deviation from criteria?**
  - **Change from common practice?**
  - **Rejection of user preference?**
  - **Large increase in first cost for small decrease in LCC?**

Notes:

EXERCISE 11-1: WHEN TO PERFORM SENSITIVITY ANALYSIS

Place a check next to the following cases for which you think an uncertainty assessment should be done.

1. You have completed a routine, basic economic study of alternative floor covering materials for a school. The LCC results are as follows:

Floor Covering Material	LCC
A	$15,000
B	14,800
C	15,200

2. You know there is a strong sentiment among families slated for base housing for natural gas furnaces rather than heat pumps. The basic LCC analysis supports selection of heat pumps.

3. A basic economic study of alternative interior wall partitions for a reserve training building in Nebraska shows the following results:

Partition Type	LCC
X	$22,000
Y	30,000

4. An LCC analysis of paving materials for a parking surface shows the following results:

Surface Type	LCC	Initial Cost	Energy Cost
P	$33,000	$20,000	0
Q	38,000	15,000	0

5. Normally vinyl tile floor covering is used in corridors of building type Y. But an LCC analysis indicates that terrazzo floors are cost effective in this particular case due to higher-than-average traffic of heavy rolling carts.

11.3 EXERCISE 11-2: SENSITIVITY ANALYSIS

Decide if an uncertainty assessment is required for the following case and perform it if necessary. Recommend a selection.

Alternative Parking Surface A (asphalt w/2" wearing surface)

"Best Guess" Estimates:

Initial Investment:	$40K
Replacement (1" top) after eight yrs:	$10K
Replacement (1" top) after 16 yrs:	$10K
M&R:	$0.8K/yr

LCC: $53K

Alternative Parking Surface B (asphalt w/3" wearing surface)

"Best Guess" Estimates:

Initial investment:	$42K
Replacement (1" top) after 12 yrs:	$10K
M&R:	$0.4K/yr

LCC: $48K

There is uncertainty regarding the maintenance cost advantage of Alt B over Alt A. Alt B may cost about the same to maintain as Alt A. HQUSACE is currently investigating roadway and parking lot paving decisions. Assume construction is accomplished in a one-month period three years after DOS.

KEY POINTS

- A single-value measure of work implies a level of certainty that seldom exists in economic analysis.
- Probability analysis can provide a quantitative estimate of the chance (risk) of making the wrong choice.
- The TM provides guidance/requirements as to when uncertainty assessment should be undertaken and what techniques are to be considered.
- Sensitivity analysis is a simple and practical technique which in certain cases can help to improve decisions.

MODULE 12

CRITIQUE OF EA/LCCA

Purpose:

- To train students to perform quick and incisive critiques of analyses

Outline:

12.1 Guidelines for Reviewing EA/LCCA

12.2 Exercise 12-1: Critique of an LCC Study

Approximate Time:

1 hour

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12.1 GUIDELINES FOR REVIEWING EA/LCCA

By the end of this module you are expected to be able to

- review DA Forms 5605 and quickly identify incorrect data, assumptions, calculations, and ranking decisions

OUTLINE OF RECOMMENDED GENERAL PROCEDURE FOR CONDUCTING A REVIEW

1) Review contract provisions with regard to EA/LCCA.

2) Clarify unclear contract provisions.

3) Examine contractor draft report as a whole to make sure

   - the provisions of the contract are met

   - the documentation is sufficient for a quick and incisive review.

4) Make sure the inclusion or exclusion of evaluated alternatives was done "correctly."

5) Examine results of EA/LCCA and evaluate the documented rationale for the selection decision.

6) Evaluate the reasonableness of the design selection based on engineering judgment.

7) Select the level of detail at which to conduct the EA/LCCA review.

8) Check to make sure the key provisions of criteria (Chapter 2 of TM 5-802-1) were followed.

9) Review and spot-check the accuracy and validity of input data and key assumptions.

10) Validate the accuracy of the EA/LCCA calculations; compare the PW calculations with the data inputs for consistency; check a few selected calculations by either

    - simplified approximation techniques, rules of thumb, etc., or

    - a method different from that used by the contractor.

11) Document clearly and concisely all deviations found and return report to contractor for correction and resubmission.

Slide 12-1 (a-e)

QUICK & INCISIVE REVIEWS

1st Priority Check:

- Documentation
- Alternatives
- Principal assumptions
- Selection decision

Notes:

Slide 12-2 (a-d)

QUICK & INCISIVE REVIEWS

2nd Priority Check:
- **Key criteria cited and used**
- **Cost & benefit input data**
- **Calculations**

Notes:

Slide 12-3 (a-d)

QUICK & INCISIVE REVIEWS

Identify Deviations:
- **From contract provisions**
- **From applicable criteria**
- **From other agreed-on provisions**

Notes:

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12.2 EXERCISE 12-1: CRITIQUE OF AN LCC STUDY

An A-E contractor was asked to perform an EA/LCCA on floor finish alternatives for the Cheney Center, a 50,000 sq. ft. Army recreation center in Fort Oaks, Michigan. The specifications required the contractor to follow HQDA criteria and to submit the analysis report on DA Forms 5605-2, 3 and 4. Quickly review the report according to the guidelines given in section 12.1.

DA Form 5605-3
(Basic Input Data Summary, completed for A)

Project No. & Title 318 Floor Finish
Installation & Location Building X
Design Feature Maintenance
Alt. No. A Title Creosote Block

LIFE CYCLE COST ANALYSIS
BASIC INPUT DATA SUMMARY

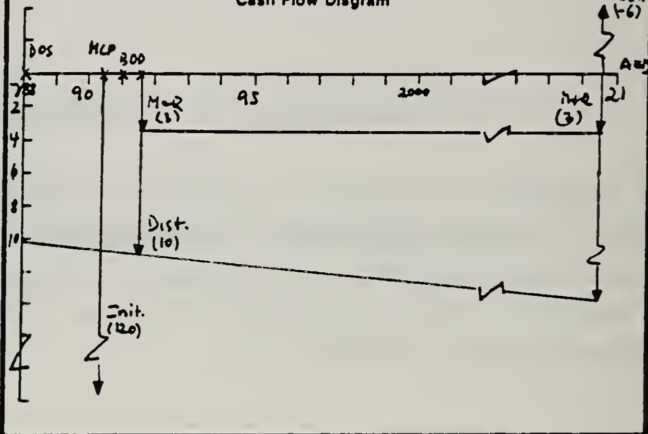
For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference		
Date of Study (DOS)		JUL 88
Analysis Base Date (ABD)		JUL 88
Analysis End Date (AED)		JUL 21
Midpoint of Construction		JAN 91
Beneficial Occupancy Date (BOD)	Actual Projected	JUL 91
	Assumed for Analysis	X
DOE Region		
Annual Discount Rate		7%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: 87-90	90-95	96-21
Distill.	8% (incl. 5% infl.)		

Principal Assumptions

Cash Flow Diagram



Cost Element	Cost on ABD \$ x 10³ _ \$ x 10⁶	Time Cost Incurred** Actual Projected Dates	Dates for Analysis (If Different)*	Source(s) of Data
Initial Investm.	120	JAN 91		Eng. Estimate
M&R	3	JAN 92-JAN 21		Eng. Estimate
Distillate	10	JAN 92-JAN 21		BLAST Progr.
Retention V.	6	JUL 21		Best guess

DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply
**For Recurring Annual Costs, show date of first and last costs only.

Sheet _______ of _______

DA Form 5605-4
(Present Worth: Conventional Approach, completed for A)

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: CONVENTIONAL APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Project No. & Title 3rd Floor Finish
Installation & Location Building X
Design Feature Maintenance
Alt. No. A Title Creosote Block

Criteria Reference	
Analysis Base Date (ABD)	JUL 88
Analysis End Date (AED)	JUL 21
Midpoint of Construction	JAN 91
BOD for Analysis	JUL 91
Annual Discount Rate	7%

Differential Escalation Rate per Year (%)			
Type of Cost	Timeframe: 87-90	90-95	96-21
Distillate	8%	(5% infl.)	

One-Time Costs ($ x 10³ / $ x 10⁶)	Years From ABD	Cost on ABD	Escalation Factor	Escal.Cost (Time Incurred)	Discount Factor	Present Worth on ABD
Initial Investm.	2.5	120	$(1.0)^{2.5}$	120	.8444	101.3
Retention Value	33.5	-6	$(1.0)^{33.5}$	-6	.1037	-.62

Annual Costs ($ x 10³ / $ x 10⁶)	Years from ABD: First Incurred	Years from ABD: Last Incurred	Total No. of Payments	Annual Cost on ABD	Escalation Factor	Escal.Cost (Time First Incurred): 1st Ann. Cost in Series	Annual Series Eq Factor	Equiv. Single Cost	Discount Factor	Present Worth on ABD
M&R	3.5	32.5	30	3	$(1.0)^{3.5}$	3	13.2777	39.8	.7891	31.4
Distillate	3.5	32.5	30	10	$(1.08)^{3.5}$	13	34.4435	447.8	.7891	353.4

Net Present Worth: Initial Costs 101.3 + Energy/Fuel Costs 353.4 + M&R Costs 31.4 + Other Costs .62 = Total 485.5

DA FORM 5605-4-R, DEC 86

Sheet ______ of ______

DA Form 5603
(Basic Input Data Summary, completed for B)

Project No. & Title: 318 Floor Finish
Installation & Location: Building X
Design Feature: Maintenance
Alt. No.: B Title: Walnut Parquet

LIFE CYCLE COST ANALYSIS
BASIC INPUT DATA SUMMARY

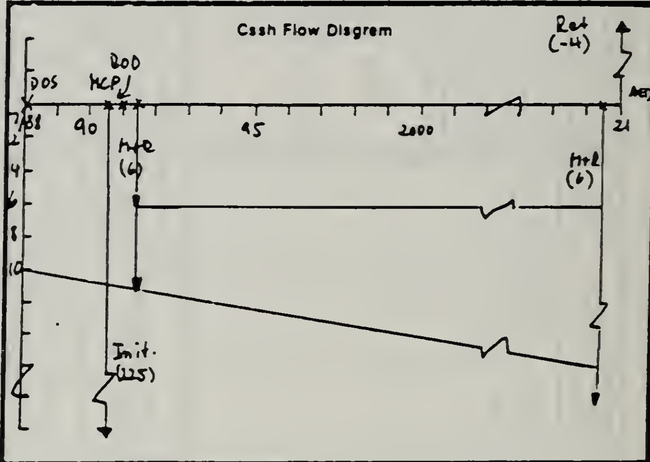
For use of this form, see TM 5-802-1, the proponent agency is USACE.

Criteria Reference		
Date of Study (DOS)		JUL 88
Analysis Base Date (ABD)		JUL 88
Analysis End Date (AED)		JUL 21
Midpoint of Construction		JAN 91
Beneficial Occupancy Date (BOD)	Actual Projected	JUL 91
	Assumed for Analysis	X
DOE Region		
Annual Discount Rate		7%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: 87-90	90-95	96-21
Distillate	8%	(5% infl.)	

Principal Assumptions

Cash Flow Diagram



Cost Element	Cost on ABD X $ x 10³ _ $ x 10⁶	Time Cost Incurred** Actual Projected Dates	Dates for Analysis (If Different)*	Source(s) of Data
Initial Investm.	225	JAN 91		Eng. Estimate
M&R	6	JAN92 - JAN21		Eng Estimate
Distillate	10	JAN92 - JAN21		BLAST Progr.
Retention V.	4	JUL 21		Best Guess

DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply
**For Recurring Annual Costs, show date of first and last costs only.

Sheet ______ of ______

DA Form 5605-4
(Present Worth: Conventional Approach, completed for B)

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: CONVENTIONAL APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Project No. & Title 318 Floor Finish

Installation & Location Building X

Design Feature Maintenance

Alt. No. B Title Walnut Parquet

Criteria Reference	
Analysis Base Date (ABD)	JUL 88
Analysis End Date (AED)	JUL 21
Midpoint of Construction	JAN 91
BOD for Analysis	JUL 91
Annual Discount Rate	7%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: 87-90	90-95	96-21
Distillate	8%	(5% infl.)	

One-Time Costs (X $ x 10³ / $ x 10⁶)	Years From ABD	Cost on ABD	Escalation Factor	Escal. Cost (Time Incurred)	Discount Factor	Present Worth on ABD
Init. Investm.	2.5	225	$(1.0)^{2.5}$	225	.8444	190
Retention Value	30	−4	$(1.0)^{30}$	−4	.1314	.53

Annual Costs (X $ x 10³ / $ x 10⁶)	Years from ABD: First Incurred	Last Incurred	Total No. of Payments	Annual Cost on ABD	Escalation Factor	Escal. Cost (Time First Incurred): 1st Ann. Cost in Series	Annual Series Eq Factor	Equiv. Single Cost	Discount Factor	Present Worth on ABD
M&R	3.5	32.5	30	6	$(1.0)^{3.5}$	5	13.2777	66.4	.7891	52.4
Distillate	3.5	32.5	30	10	$(1.08)^{3.5}$	13	34.4435	447.8	.3891	174.2

Net Present Worth:	Initial Costs		Energy/Fuel Costs		M&R Costs		Other Costs		Total
	190	+	174.2	+	62.4	+	− .53	=	426

DA FORM 5605-4-R, DEC 86

Sheet ______ of ______

DA Form 5605-2
(Summary, completed for A & B)

Project No. & Title 318 Floor Finish
Installation & Location Building X
Design Feature Maintenance

Date of Study JUL 88

LIFE CYCLE COST ANALYSIS
SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

ALTERNATIVES ANALYZED						
No.	Description/Title	Present Worth ~~X~~ $ x 10³ $ x 10⁶				
		Initial	Energy	M&R	Other	Total
A	Creosote Block	101.3	353.4	31.4	.62	485.5
B	Walnut Parquet	190	174.2	62.4	-.53	426

ECONOMIC RANKING				
Rank	Alternative No. & Title	Economic Advantages of Top-Ranked Alternative		Basis for No. 1 Ranking
		LCC (PW) Difference (Dollars & Percent)	Other (Initial, Energy, Etc.)	
1	B - Walnut Parquet	$ 59.5K lower (12%)	51% lower energy	LCC
2	A - Creosote Block			

KEY ASSUMPTIONS

NARRATIVE SUMMARY (Comments/Lessons Learned/Observations/Recommendations/Etc.)
First cost is 46% higher
Energy cost is 51% lower

Key Participants - Name	Discipline	Organization	Telephone No.

DA FORM 5605-2-R, DEC 86

Sheet ______ of ______

MODULE 13

PUTTING EA/LCCA INTO PRACTICE

Purpose:

To provide guidance in

- Deciding the appropriate level of effort to devote to EA/LCCA, and the appropriate level of documentation
- Presenting/"selling" results of EA/LCCA
- Providing specifications to A-E contractors for performing EA/LCCA under contract

Outline:

13.1 Deciding the Level of Effort

13.2 Documentation

13.3 Presenting/"Selling" Results

13.4 Contracting with A-E Firms

13.5 Exercise 13-1: Presenting/"Selling" Results

Approximate Time:

4 hours

Slide 13-1

PUTTING EA/LCCA INTO PRACTICE

- **What level of effort?**
- **How much documentation?**
- **How to present & sell the results?**
- **What provisions to include in A-E contracts?**

Notes:

13.1 DECIDING THE LEVEL OF EFFORT

By the end of this module, you are expected to be able to

- describe several levels of effort for EA/LCCA and explain the factors to consider in deciding which level to choose

Slide 13-2

HOW MUCH TO SPEND ON EA/LCCA?

- **$$$$$**
- **$$$**
- **$$**
- **$**
- **0**

Notes:

Slide 13-3

Step 1

DETERMINE GENERAL REQUIREMENTS FROM TM

(TM 2-2a)

Notes:

Slide 13-4

LCCA REQUIRED REGARDLESS

- **Special directives**
- **Pressures to dictate choice**
- **Innovative design considered**

Notes:

Slide 13-5

IN MOST CASES DECIDE LCCA COVERAGE
ON BASIS OF STUDY COST EFFECTIVENESS

LCCA is most likely to be cost effective when

- there are dramatic differences in cash-flow profiles
- there is a feature common to a number of projects

Notes:

Slide 13-6

LCCA WAIVED

- **Rankings established by past study**
- **Cost of the LCCA > potential savings**

---

also when

- **Study costs > 1% of PA**

Notes:

Slide 13-7

Step 2

DETERMINE SPECIFIC REQUIREMENTS

Notes:

Slide 13-8

Step 3

ASSESS IMPLICATIONS OF "POLITICAL" CONSIDERATIONS

- **Source of requirement**
- **Anticipated levels of review**
- **Visibility/controversiality**
- **Known preferences in the command structure**
- **Anticipated viability of project**

Notes:

Slide 13-9

Step 4

DETERMINE FEASIBILITY OF USING/ADAPTING PREVIOUSLY CONDUCTED ANALYSES

Notes:

Slide 13-10

Step 5

CONDUCT SIMPLE SCREENING PROCEDURE TO DETERMINE IF A STUDY IS WARRANTED

Notes:

Slide 13-11

Step 6

DETERMINE THE LEVEL OF EFFORT LIKELY TO BE APPROPRIATE BASED ON STEPS 1-5

Notes:

Slide 13-12

Step 7

ADJUST THE LEVEL OF EFFORT AS REQUIRED AS EVENTS UNFOLD

Notes:

7 STEPS SUMMARY

1. Determine general requirements from TM (2-2a), i.e., scope, coverage, and exceptions.

2. Determine specific requirements from special rules or instructions (if any), e.g., special directed studies.

3. Assess implications of pertinent "political" considerations, e.g.,

   - source of the requirement (statutory vs. routine)

   - anticipated levels of review

   - visibility/controversiality

   - known preferences in the command structure

   - anticipated viability of project.

4. Determine feasibility of using/adapting previously conducted analyses.

5. Conduct simple screening procedure to determine if a study is warranted (where no previous study is available).

6. Determine the level of effort likely appropriate based on Steps 1-5.

7. Adjust the level of effort as required as events unfold.

Slide 13-13

NOMS FACTOR SCREENING TECHNIQUE

Rule-of-thumb approach for general economic studies for determining if a higher first-cost alternative is likely to be life-cycle cost effective.

Notes:

SCREENING PROCEDURE FOR ASSESSING PAYOFF POTENTIAL OF CONDUCTING AN ECONOMIC ANALYSIS

("NOMS FACTOR" SCREENING TECHNIQUE)

STAGE 1:

1. Estimate difference in initial costs between alternative with lowest initial cost and a higher priced alternative.

2. Estimate difference in total future costs of the two alternatives, i.e., the "nominal" savings. (That is, no discounting is performed.)

3. Calculate the "Nominal O&M Savings Factor" (NOMS Factor) as the ratio of nominal savings to the first-cost difference.

4. Conduct "Zero Order" Screening:

   - If NOMS FACTOR < 1, Payoff Potential of Economic Study is Nil. Do not perform LCCA.

   - If NOMS FACTOR > 3, Payoff Potential of Economic Study is Good. Perform LCCA.

   - If NOMS FACTOR >> 3, Payoff Potential of Economic Study is Great. This is the case where you should especially perform LCCA.

   - If 1 < NOMS FACTOR < 3, Payoff Potential is Unknown. Continue with next stage of screening procedure.

STAGE 2:

1. Make Rough Estimate of Minimum NOMS FACTOR Required for Payback

   When savings are mainly in M&R or very low-e value fuels & normal MILCON design conditions prevail (i.e., d = 10%, three years to BOD, 25 year post-BOD period),

   Minimum NOMS FACTOR = 3

   Under more "favorable" conditions,

   Minimum NOMS FACTOR is lower

   e.g., 1.5 for higher-e fuels (>5% average rate)
   1.0 for 1-year study

   - If NOMS FACTOR < 90% of Est. Minimum Value, Payoff Potential is Low.

   - If NOMS FACTOR > 125% of Est. Minimum Value, Payoff Potential is Good.

   - For Intermediate Values of NOMS FACTOR, Payoff Potential is unknown.

2. If NOMS FACTOR > minimum required, perform an LCCA.

Slide 13-14

Factors influencing minimum "nominal" savings required for cost effectiveness:

- **discount rate**
- **project calendar**
- **years of operation**
- **escalation rates**

Notes:

Slide 13-15

KEY POINTS IN SELECTING A LEVEL OF EFFORT

- LCCA not needed in every case
- Avoid new study if old will work
- Screening technique may help
- Detailed data not necessary for most LCCA
- Comprehensive study probably worthwhile for high-stakes and controversial decisions

Notes:

13.2 DOCUMENTATION

By the end of this section, you are expected to be able to

- describe the Army criteria for documenting EA/LCCA studies
- be able to list key elements in documentation

Slide 13-16

DOCUMENTATION

a "stand-alone" written record of an economic study for project files which is comprehensible to others & which sets forth

- **what was done**
- **data**
- **principal results**
- **technical & administrative lessons learned**

Notes:

Slide 13-17

CRITERIA FOR DOCUMENTATION
TM 5-802-1, Chapter 2, (p. 2-7)

Basic Requirement:

A written record will be provided for every economic study, regardless of the size of the project and the conclusiveness of the results. The written record will be made a part of the design documentation and included in the project files.

Notes:

Slide 13-18

DISTRIBUTION

- Among design professionals within the organization
- To higher authority when
  - significant or unusual findings
  - changes from common practice
  - significantly improved procedures

Notes:

Slide 13-19

WHY DOCUMENT?

- To help analyst keep track of evaluation process
- To provide record of inputs, assumptions, results, & interpretation
  - to answer future questions
  - for use in other decisions
- To meet criteria

Notes:

Slide 13-20

HOW DOCUMENT?

Core material

- **with DA Form 5605 (& attachments)**
- **with LCCID or equivalent software**

Supporting material as necessary

Notes:

SUMMARY DESCRIPTION OF DOCUMENTATION TASK

Provide documentation for the economic analysis in a cost-effective manner.

1. Throughout the analysis, document key information/data

   - include assumptions, prices and quantities, timing, economic parameters, calculations, analyses, and results, and

   - make maximum use of standard forms, worksheets, checklists, computer printouts, and other types of "self-documenting" materials.

2. At the outset, determine Army requirements for the documentation in accordance with TM ¶ 2-2.

3. Prepare the documentation package (narrative, graphics, reference material, and appendices) to be the minimum judged appropriate and sufficient within the criteria requirements and under the circumstances at hand.

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13.3 PRESENTING/"SELLING" RESULTS

By the end of this section, you are expected to be able to

- prepare for principal challenges that you may receive while presenting study results
- defend study results that are based on sound analysis

Slide 13-21

STEPS IN ANALYZING STUDY RESULTS

1. Rank alternatives in LCC order
2. Assess quality of input data
3. Select on basis of LCCs if possible
4. Apply tie-breaking criteria (if LCCs close or data quality poor)
5. Conduct an uncertainty assessment if unsure about significance of LCC difference
6. Select on basis of LCCs if supported by results of the uncertainty assessment; otherwise select according to professional judgment

Notes:

Slide 13-22

PRINCIPAL CHALLENGES

Be prepared for attempts by others to have study results reversed -- with little or no substantive justification -- on grounds of some "overriding consideration."

Notes:

Slide 13-23

PRINCIPAL DEFENSE

A sound economic study, with properly validated LCC results, is the best defense

Notes:

Slide 13-24

CHARACTERISTICS OF A SOUND ECONOMIC STUDY

- Conducted in accordance with applicable criteria
- Results validated by an uncertainty assessment where appropriate and necessary
- Documented in accordance with applicable criteria

Notes:

Slide 13-25

WHY NOT REVERSE OR IGNORE THE RESULTS OF A SOUND ECONOMIC STUDY?

- **Long-run building costs are likely to be higher**
- **Wasteful to perform studies which are ignored**

Notes:

13.4 CONTRACTING WITH A-E FIRMS

By the end of this session, you are expected to be able to

- list the important provisions regarding EA/LCCA to include in specifications for A-E contracts

Slide 13-26

CONTRACTING WITH A-E FIRMS

What provisions to include in specifications?

Notes:

13.5 EXERCISE 13-1: PRESENTING/"SELLING" RESULTS

This exercise is intended to focus attention on the need for sound economic analysis as the starting point for successfully selling design recommendations on the basis of EA/LCCA results.

Read the two reports which follow. Decide if you would feel comfortable presenting or "selling" to your boss the recommendation of Report 1; of Report 2.

If you are assigned the role of presenter by the instructor, your job is to do your best **with the material at hand** to make a case for adopting the report's recommendation.

If you are assigned the role of decision maker, your job is to review the reports, listen to the presentation critically, and challenge the recommendation being made. Accept the recommendation if and when you are convinced of its merits.

EXERCISE 13-1: PRESENTING/"SELLING" RESULTS

EA/LCCA REPORT 1: WASTE-HEAT RECOVERY SYSTEM

Identifying Information

Installation & Location:	Seymour AFB, NC
Building:	Administrative building with large computer facility
Design Feature:	Waste-Heat Recovery System
Alternative X:	Include the Waste-Heat Recovery System
Alternative Y:	Omit the Waste-Heat Recovery System

Key Dates

DOS:	6/88
ABD:	6/88
BOD:	6/91
AED:	6/13

Recommendation

Include the proposed waste-heat recovery system in the computer facility to provide heating for adjacent offices.

Basis for Recommendation

Attached report by A-E Contractor XYZ who was hired to investigate the potential.

Attached Report by A-E Contractor

In 1978 we performed an economic analysis of retrofiting a heat wheel in a dental products plant in Syracuse, NY to capture waste heat for heating adjacent office space. The square footage of dental office space to be heated is comparable to that of the office space adjoining the computer lab.

In that study, we estimated an annual rate of return of 15%. Due to cost overruns on acquisition costs, the actual rate of return was reduced to about 9%.

We think this is ample grounds for concluding that the proposed waste-heat recovery system for the computer facility will be cost effective, particularly when we take into account inflation since 1978.

EA/LCCA REPORT 2: USE OF AN INNOVATIVE LIGHTING SYSTEM IN A RESERVE CENTER

Identifying Information

Installation & Location:	Laramie, WY
Building:	Reserve Center
Design Feature:	Innovative Lighting System
Alternative A:	Use the innovative lighting system
Alternative B:	Use the conventional system

Key Dates

DOS:	06/88
ABD:	06/88
BOD:	12/90
AED:	06/13

Recommendation

Include the innovative lighting system in the reserve center.

Basis for Recommendation

Attached report by A-E Contractor OPQ who was hired to investigate the potential.

Summary of EA/LCCA Results:

Based on Most Probable Values of Input Data

LCC (A) = $117K

LCC (B) = $139K

Net Savings of Alt A over Alt B = $22K
Percentage Reduction in LCC = 16%

Based on Sensitivity Analysis:

(Using Most Pessimistic Input Data)

LCC (A) = $125K

LCC (B) = $139K

Net Savings of Alt A over Alt B= $14K
Percentage Reduction in LCC = 10%

Attached Report by A-E Contractor

Completed DA Form 5605-3 for Alt A

Project No. & Title PN 101 Reserve Center
Installation & Location Fort Z, Laramie, WY
Design Feature Lighting System
Alt. No. A Title Innovative Lighting System

LIFE CYCLE COST ANALYSIS
BASIC INPUT DATA SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

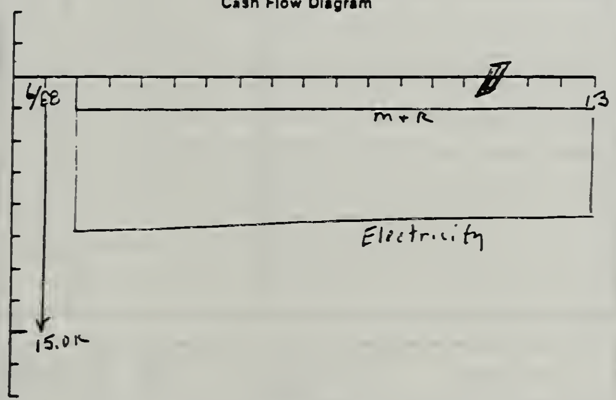
Criteria Reference		FEMP
Date of Study (DOS)		6/88
Analysis Base Date (ABD)		6/88
Analysis End Date (AED)		6/13
Midpoint of Construction		12/90
Beneficial Occupancy Date (BOD)	Actual Projected	6/91
	Assumed for Analysis	6/88
DOE Region		8
Annual Discount Rate		7%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: 88-90	90-95	95-13
Elec	-3.37	-1.03	-0.05
Other	0	0	0

Principal Assumptions

It is assumed -- based on extensive private sector experience -- that the lighting system will perform in an acceptable way and meet all performance requirements.

Cash Flow Diagram



Cost Element	Cost on ABD ✓ $ x 10³ _ $ x 10⁶	Time Cost Incurred** Actual Projected Dates	Dates for Analysis (If Different)*	Source(s) of Data
Initial Costs	$15.0K	12/90	6/88	Cost Engineer's Est. (App 1)
M+R (Lamps)	0.2K	12/91-12/16	6/88-6/13	Manufacturer's Info (App 2)
Electricity	9.8K	12/91-12/16	6/88-6/13	DOE 2 (App. 3)
Retention Value	0			

DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply
**For Recurring Annual Costs, show date of first and last costs only.

Sheet 1 of 5

Completed DA Form 5605-5 for Alt A

Project No. & Title PN 101 Reserve Center
Installation & Location Fort Z, Laramie WY
Design Feature Lighting System
Alt. No. A Title Innovative Lighting System

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: ONE-STEP APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs ✓$ x 10³ / $ x 10⁶	Years from ABD	Cost On ABD	One Step Adj.Factor Table 1	Present Worth on ABD
Initial Costs	0	$15.0K	1.0	$15.0K

Criteria Reference	FEMP
Analysis Base Date (ABD)	6/88
Analysis End Date (AED)	6/13
Midpoint of Construction	12/90
BOD for Analysis	6/88
Annual Discount Rate	7%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: 88-90	90-95	95-13
Elec	-3.37	-1.03	-0.05
Other	0	0	0

Annual Costs ✓$ x 10³ / $ x 10⁶	Total No. of Payments	Annual Cost on ABD	Total Nominal Cost on ABD	One Step Adjustment Factor* Table Factor x DOS Correction	Present Worth on ABD
Electricity	25	9.8K	$245.0K	0.4050	$99.2K
M + R (Lamps)	25	0.2K	$5.0K	0.4661	$2.3K

Net Present Worth:	Initial Costs	Energy/Fuel Costs	M&R Costs	Other Costs	Total
	$15.0K +	$99.2K +	$2.3K +	— =	$117

DA FORM 5605-5-R, DEC 86

*Use One-Step Table 2 for M&R costs (e = 0).
Use One-Step Table 3 for energy/fuel costs (e = prescribed e value).

Sheet 2 of 5

Completed DA Form 5605-3 for Alt B

Project No. & Title PN 101 Reserve Center
Installation & Location Fort Z, Laramie, WY
Design Feature Lighting System
Alt. No. B Title Conventional System

LIFE CYCLE COST ANALYSIS
BASIC INPUT DATA SUMMARY

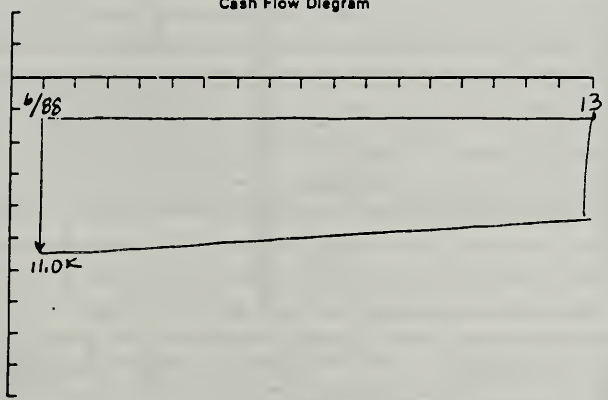
For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference		FEMP
Date of Study (DOS)		10/88
Analysis Base Date (ABD)		6/88
Analysis End Date (AED)		6/13
Midpoint of Construction		12/90
Beneficial Occupancy Date (BOD)	Actual Projected	6/91
	Assumed for Analysis	6/88
DOE Region		8
Annual Discount Rate		7%

Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe: 88-90	90-95	95-13
Elec.	-3.37	-1.03	-0.05
Other	0	0	0

Principal Assumptions

Cash Flow Diagram



Cost Element	Cost on ABD ~~$ x 10³~~ $ x 10⁶	Time Cost Incurred** Actual Projected Dates	Dates for Analysis (If Different)*	Source(s) of Data
Initial Costs	$11.0K	12/90	6/88	Cost Engineer's Est (App 4)
Mtr R (Lamps)	0.1K	12/91-12/16	6/88-6/13	Manufacturer's Info (App 5)
Electricity	12.5K	12/91-12/16	6/88-6/13	DOE2 (App 6)
Retention Value	0			

DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply
**For Recurring Annual Costs, show date of first and last costs only.

Sheet 3 of 5

Completed DA Form 5605-5 for Alt B

Project No. & Title PN 161 Reserve Center
Installation & Location Fort Z, Laramie, WY
Design Feature Lighting System
Alt. No. B Title Conventional System

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: ONE-STEP APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs ✓ $ x 10³ / $ x 10⁶	Years from ABD	Cost On ABD	One Step Adj. Factor Table 1	Present Worth on ABD
Initial Costs	0	$11.0K	1.0	$11.0K

Criteria Reference	FEMP
Analysis Base Date (ABD)	6/88
Analysis End Date (AED)	6/13
Midpoint of Construction	12/90
BOD for Analysis	6/88
Annual Discount Rate	7%

Type of Cost	Differential Escalation Rate per Year (%) Timeframe: 88-90	90-95	95-13
Elec	-3.37	-1.03	-0.05
Other	0	0	0

Annual Costs ✓ $ x 10³ / $ x 10⁶	Total No. of Payments	Annual Cost on ABD	Total Nominal Cost on ABD	One Step Adjustment Factor* Table Factor x DOS Correction	Present Worth on ABD
Electricity	25	$12.5K	$312.5K	0.4050	$126.6K
M + R (Lamps)	25	$0.1K	$2.5K	0.4661	$ 1.2K

	Initial Costs	Energy/Fuel Costs	M&R Costs	Other Costs	Total
Net Present Worth:	$11.0K +	$126.6K +	$1.2K +	— =	$139K

DA FORM 5605-5-R, DEC 86

*Use One-Step Table 2 for M&R costs (e = 0).
Use One-Step Table 3 for energy/fuel costs (e = prescribed e value).

Sheet 4 of 5

Completed DA Form 5605-2

Project No. & Title PN 101 Reserve Center

Installation & Location Fort Z, Laramie, WY

Design Feature Lighting System

Date of Study 6/88

LIFE CYCLE COST ANALYSIS SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

ALTERNATIVES ANALYZED						
No.	Description/Title	Present Worth $ x 10³ $ x 10⁶				
		Initial	Energy	M&R	Other	Total
A	Innovative System	$15.0K	$99.2K	$2.3K	–	$117K
B	Conventional System	$11.0K	$126.6K	$1.2K	–	$139K

ECONOMIC RANKING				
Rank	Alternative No. & Title	Economic Advantages of Top-Ranked Alternative		Basis for No. 1 Ranking
		LCC (PW) Difference (Dollars & Percent)	Other (Initial, Energy, Etc.)	
1 2	A Innovative System B Conventional System	$22K 16% less	Saves Energy	LCC

KEY ASSUMPTIONS
Based on Extensive private sector use -- Innovative system assumed to meet minimum performance standards

NARRATIVE SUMMARY (Comments/Lessons Learned/Observations/Recommendations/Etc.)
Sensitivity analysis supports the selection. Using pessimistic assumptions that the system costs more to install and maintain & saves less energy, it is still estimated to be the cost-effective choice.*

Key Participants - Name	Discipline	Organization	Telephone No.
I. R. Engineer	Electrical Engineer	U.S. ACE.	x xx x x
M.T. Costs	Cost Engineer	U.S.A.C.E	x x x x x

DA FORM 5605-2-R, DEC 86

* Sensitivity Analysis not shown.

Sheet 5 of 5

KEY POINTS

- It is important to choose the correct level of effort for an economic study. Spending too little means costly decisions; spending too much means wasting resources on the study.
- There are rules of thumb which can be useful in choosing the level of effort.
- Documentation helps keep track of the evaluation process, provides record which may be useful in the future, and is required.
- The best defense against challenges to design decisions made on the basis of EA/LCCA is a sound economic study performed according to criteria.
- A thorough understanding of EA concepts and criteria is essential for communicating your needs to design engineers and A-E contractors.
- Contractors need to be informed of the requirements and criteria for EA/LCCA.

MODULE 14

OTHER ECONOMIC MEASURES

Purpose:

- To acquaint you with other measures of economic performance which
  - you may have to compute in response to special requirements
  - you may wish to compute as supplementary measures to use in presenting/"selling" results of EA/LCCA

Outline:

14.1 Net LCC Savings

14.2 Savings-to-Investment Ratio

14.3 Discounted Payback Period

Approximate Time:

1 hour and 30 minutes

Slide 14-1

OTHER ECONOMIC MEASURES

- **Net LCC Savings**
- **Savings-to-Investment Ratio (SIR)**
- **Discounted Payback Period (DPP)**

Notes:

DEMONSTRATION OF HOW TO COMPUTE SIR AND DPP USING DA FORM 5605-1

Sample Problem Data:

An active solar hot water system is being considered in lieu of a conventional hot water system for an Air Force base launderette in Phoenix, Arizona. The solar energy hot water system is packaged with an auxiliary backup system whose costs are included as part of the solar energy system's cost.

Undiscounted/Unescalated ($s as of ABD)	Solar Energy System	Conventional System
Purchase and Installation	$35,000	$8,000
Maintenance & Repair (e = 0)	1,500/yr at ABD	200/yr
Replacement Cost (e = 0)	2,000/yr 10	8,000/yr 12
Energy Cost (DOE e values) (Electricity)	10,000/yr at ABD	16,000/yr at ABD
Retention Value	0 at AED	0 at AED

DOS = 7/88
ABD = 7/88
AED = 7/13

Discount rate, d = 7%

Present Worth		
Purchase & Installation	35,000	8,000
Maintenance & Repair	17,479	2,331
Replacement Cost (e = 0)	1,017	3,552
Energy Cost	104,175	166,680

Project No. & Title ____________________

Installation & Location ____________________

Design Feature ____________________

Baseline System ____________________

Investment ____________________

LIFE CYCLE COST ANALYSIS

SAVINGS-TO-INVESTMENT RATIO (SIR) & DISCOUNTED PAYBACK CALCULATION

For use of this form, see TM 5-802-1; the proponent agency is USACE.

SIR Calculation				Discounted Payback Calculation				
				Trial Values of Post-BOD Analysis Period, n(years)				
Element of Calculation	System	Type of Cost/Benefit		n =	n =	n =	n =	n =
PW of Operating & Maintenance Costs ☐ $ x 10³ ☐ $ x 10⁶	Base-line	Energy/Fuel						
		Other O&M						
		Total						
	Invest-ment	Energy/Fuel						
		Other O&M						
		Total						
	Δ	Net Savings						
PW of Capital Costs ☐ $ x 10³ ☐ $ x 10⁶	Base-line	Initial (MCP)						
		Replacements						
		Terminal						
		Other						
		Total Net						
	Invest-ment	Initial (MCP)						
		Replacements						
		Terminal						
		Other						
		Total Net						
	Δ	Extra Investment						
SIR	Δ	Net Savings / Extra Investment						

Next Trial n Value (Years)	A = This SIR — 1.0							
	B = This SIR — Last SIR*							
	C = Ratio of A to B							
	D = Last n* — This n							
	E = Product of C & D							
	F = Next n = This n + E							

DA FORM 5605-1-R, DEC 86

*In calculating First Trial n Value for Discounted Payback Calculation, Use Last SIR = Last n = 0.

Sheet ________ of ________

Project No. & Title: PN1 Launderotte
Installation & Location: AiR Force Base X, Ph
Design Feature: Process Hot Water System
Baseline System: Conventional Hot Water System
Investment: Solar Hot Water System

LIFE CYCLE COST ANALYSIS

SAVINGS-TO-INVESTMENT RATIO (SIR) & DISCOUNTED PAYBACK CALCULATION

For use of this form, see TM 5-802-1; the proponent agency is USACE.

SIR Calculation				Discounted Payback Calculation — Trial Values of Post-BOD Analysis Period, n(years)				
Element of Calculation	System	Type of Cost/Benefit		n = 13	n =	n =	n =	n =
PW of Operating & Maintenance Costs ☐ $ x 10³ ☐ $ x 10⁶	Baseline	Energy/Fuel	166,680	86,674				
		Other O&M	2,331	1,212				
		Total	169,011	87,886				
	Investment	Energy/Fuel	104,175	54,171				
		Other O&M	17,479	9,089				
		Total	121,654	63,260				
	Δ	Net Savings	47,357	24,626				
PW of Capital Costs ☐ $ x 10³ ☐ $ x 10⁶	Baseline	Initial (MCP)	8,000	8,000				
		Replacements	3,320	3,320				
		Terminal	0	0				
		Other	–	–				
		Total Net	11,320	11,320				
	Investment	Initial (MCP)	35,000	35,000				
		Replacements	1,017	1,017				
		Terminal	0	0				
		Other	–	–				
		Total Net	36,017	36,017				
	Δ	Extra Investment	24,697	24,697				
SIR	Δ	Net Savings / Extra Investment	1.9*	~1.0				

Next Trial n Value (Years)							
	A = This SIR — 1.0	0.9					
	B = This SIR — Last SIR*	1.9					
	C = Ratio of A to B	0.47					
	D = Last n* — This n	-25					
	E = Product of C & D	-11.8					
	F = Next n = This n + E	13.2					

DA FORM 5605-1-R, DEC 86

*In calculating First Trial n Value for Discounted Payback Calculation, Use Last SIR = Last n = 0.

Sheet ______ of ______

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MODULE 15

POSTTEST

Purpose:

- To assess your understanding of EA/LCCA after training
  - for self assessment of your current level of understanding
  - to help instructors evaluate the effectiveness of the course
  - to get feedback on topics that need further practice in the Skills Lab

Time Allotted:

1 hour

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POSTTEST

The following are technical questions relating to economic analysis. Each question is worth 1 point. Please leave a blank rather than guessing if you do not know the answer. Blanks will receive -1 point, wrong answers will receive -2 points.

1) Life-cycle costing

   a) _____ ignores first costs and takes into account future costs.

   b) _____ includes all relevant costs over a designated study period

   c) _____ neither a) nor b)

2) Life-cycle costing applies only to Army construction projects and has little applicability to solving other types of problems.

   a) _____ True

   b) _____ False

3) Adding attic insulation in building A, which saves 12.9 million Btu annually, is more cost-effective than adding attic insulation in building B, which saves 9.5 million Btu annually, given that insulation costs essentially the same in both buildings.

   a) _____ True

   b) _____ False

   c) _____ Can't tell

4) All economic analysis in support of MILCON design decisions are governed by the same set of criteria.

   a) _____ True

   b) _____ False

5) Suppose you are planning to renovate 234 houses on a military base. You estimate the initial cost of renovating the exterior of each house to be about $20,000. An A-E contractor estimates the initial cost of renovating the interior of each house at $17,958. In an initial planning document the appropriate way to express the full initial costs of renovating base housing is

a) ____ $8,882,172

b) ____ $8,882,200

c) ____ $8,880,000

d) ____ about $9 million

6) Suppose you had the choice of receiving $100 today or receiving $100 (guaranteed) in one year. Which would you choose? Place a check in the space in front of your choice.

____ $100 today or ____ $100 one year from now

What about $100 today versus $105 (guaranteed) one year from now?

____ $100 today or ____ $105 one year from now

Choose one from each of the following pairs

____ $100 today or ____ $110 (guaranteed) one year from now

____ $100 today or ____ $115 (guaranteed) one year from now

____ $100 today or ____ $120 (guaranteed) one year from now

____ $100 today or ____ $130 (guaranteed) one year from now

____ $100 today or ____ $140 (guaranteed) one year from now

____ $100 today or ____ $150 (guaranteed) one year from now

From your choice, what do you conclude is your annual minimum acceptable rate of return (MARR)?

MARR = ____ %

- Given that this is your annual minimum acceptable rate of return, what is the amount you would require in two years to make you willing to forego $100 today?

  Would require $ ______ in two years

- Given your annual minimum acceptable rate of return, how much would you be willing to spend today to avoid incurring a sure cost of $1,000 in one year?

  Willing to spend $ ______ now

- Given your annual minimum acceptable rate of return, how much would you be willing to spend today to avoid incurring a sure cost of $1,000 in two years?

  Willing to spend $ ______ now

7) Suppose you expect general price inflation to run about 4% per year and you are willing to invest in treasury bonds with a guaranteed return of 10% per annum. If you could be certain that the rate of inflation would be 0% instead of 4%, it would be reasonable to require a return on the bonds of about

   a) ____ 10%

   b) ____ 6%

   c) ____ 4%

   d) ____ 0%

8) Suppose you invest $5,000 in a mutual fund with an average annual return of 10% compounded annually. At the end of five years your investment will have grown to

a) ____ $8,052.55

b) ____ $7,500.00

c) ____ $5,500.00

9) Suppose you could replace the roof of your house today at a cost of $3,000, and you wish to estimate how much to budget for the replacement which you expect to be required five years from now. If roofing materials and labor are expected to increase at a rate of about 6% per year, you will need to budget approximately

a) ____ $4,000

b) ____ $3,000

c) ____ $2,000

d) ____ $3,180

e) ____ none of the above

10) To evaluate the cost effectiveness of one MILCON building design over its alternatives, it is necessary to forecast general price inflation and to add an inflation amount to the estimates of future operating, maintenance, repair, and replacement costs.

a) ____ True

b) ____ False

11) Suppose you are required to estimate future maintenance and repair costs for an HVAC system. General price inflation is forecasted to increase at a rate of 7% per annum, whereas prices for HVAC systems are forecasted to increase at an annual rate of only 4%. This means that in absolute terms (i.e., in current dollars) the HVAC price

a) _____ increases at an annual rate of about 11%

b) _____ increases at an annual rate of about 7%

c) _____ increases at an annual rate of about 28%

d) _____ decreases at an annual rate of about 3%

e) _____ increases at an annual rate of about 3%

And, it means that in relative terms (i.e., in constant dollars) the HVAC price

a) _____ increases at an annual rate of about 7%

b) _____ increases at an annual rate of about 4%

c) _____ increases at an annual rate of about 3%

d) _____ remains unchanged

e) _____ increases at an annual rate of about 11%

12) Suppose you can reduce the energy costs of your house by installing insulation. You can pay for it by withdrawing funds from a money market account that pays 9% per annum, after taxes. Alternatively, you can use the money market funds to pay off a consumer loan you have outstanding at 12% per annum (after taxes). Improved comfort aside, i.e., on strictly economic grounds, the annual minimum acceptable rate of return required to induce you to install insulation is

a) ____ 0% because the funds are already on hand

b) ____ 9% because 9% will be lost by withdrawing the money

c) ____ 12% because 12% could be saved by using the funds to pay off the loan instead of buying insulation

13) When an individual's or organization's minimum acceptable rate of return is used to calculate how much he, she or it would be willing to spend now in order to avoid a given future cost, the rate is typically called

a) ____ the discount rate

b) ____ the interest rate

c) ____ the savings rate

d) ____ the reduction rate

14) Suppose you are selecting a roof for a new house, and you find that a high-quality roof will last 20 years without major repairs or replacement, and a standard-quality roof will last only 10 years before it requires replacement costs of $2,000. The high-quality roof will cost you an extra $800 now. Assume you can finance the more expensive roof by taking out a larger mortgage loan at the going loan rate of 10%. The high-quality roof is

a) ____ well worth the additional cost

b) ____ clearly not worth the additional cost

c) ____ likely to perform economically roughly the same as the standard quality roof

15) Suppose you are considering the use of floor coverings in a government building, saving an estimated $2,000 (constant dollars) annually in maintenance and repair expenditures over a period of 25 years. The government requires an annual minimum rate of return of 10% over and above general price inflation. Total savings starting today and accruing over 25 years will be equivalent to

a) _____ receiving a lump sum of exactly $50,000 today

b) _____ receiving a lump sum of less than $50,000 today

c) _____ receiving a lump sum of more than $50,000 today

d) _____ there is no way to determine the equivalent amount

16) Suppose the rate of general price inflation is about 4% per annum. Further assume that because of shortages, the price of oil escalates about 5% per annum faster than prices in general. In 10 years a quantity of oil which is priced at $1,500 today will have increased in price to about

a) _____ $2,250

b) _____ $3,600

c) _____ $9,300

d) _____ $2,850

17) One would conclude that with a general price inflation rate of 4%, in 10 years a dollar bill will buy

a) _____ about the same as what a dollar will buy today

b) _____ about two-thirds what a dollar will buy today

c) _____ about one-tenth what a dollar will buy today

d) _____ about one-third more than what a dollar will buy today

18) Suppose the general inflation rate is 6% per annum and you require a return at least 4% per annum over and above inflation. This means that you require a total return of about

a) ____ 6% per annum

b) ____ 4% per annum

c) ____ 10% per annum

d) ____ 24% per annum

e) ____ none of the above

19) If the total annual rate of change in fuel oil prices is 7% and the rate of general price inflation is 4%, you would say that the differential escalation rate for fuel oil is about

a) ____ 11%

b) ____ 3%

c) ____ 7%

More precisely, the differential escalation rate for fuel oil is

d) ____ 11.28%

e) ____ 2.88%

f) ____ 7.82%

20) Suppose annual maintenance and repair costs are expected to increase at the same annual rate as prices in general, say about 10%. In this case the differential annual rate of price escalation for maintenance and repair costs is

a) ____ 5%

b) ____ 7%

c) ____ 0%

d) ____ 10%

21) Refer back to question 20. Suppose you wish to estimate what maintenance and repair costs will be five years hence, based on the fact that they are $1,000 today. Stated in dollars of the future year (i.e., in current dollars which include inflation), the estimated future cost is

a) ____ $1,685 c) ____ $1,000

b) ____ $1,159 d) ____ $1,611

Stated in today's dollars (i.e., in constant dollars which exclude inflation), the estimated future cost is

a) ____ $1,685 c) ____ $1,000

b) ____ $1,159 d) ____ $1,611

22) What is the estimated present-worth equivalent of a cost of $10,000 which is expected to occur in 15 years if the discount rate is 10%?

a) ____ $2,394

b) ____ $9,091

c) ____ $10,000

d) ____ None of the above

23) Suppose you estimate a repair cost which is expected to occur in three years to be $2,000 in today's dollars (i.e., in constant dollars). Further suppose that the rate of general price inflation is 6% and that you require a 4% per annum return over and above inflation to make you willing to spend money now in order to save money in the future. The discount rate you would use to calculate the present-worth equivalent of the $2,000 future cost (in constant dollars) is

a) ____ 4%
b) ____ 10%
c) ____ 2.4%
d) ____ 6%
e) ____ 10.24%
f) ____ none of the above

24) Refer back to question 23. Suppose the rate of general price inflation were 0%. What discount rate would you use then?

a) ____ 4%
b) ____ 10%
c) ____ 6%
d) ____ 0%
e) ____ none of the above

25) Again refer back to question 23. The present-worth equivalent of the future amount of $2,000 is

a) ____ $1,679
b) ____ $1,778
c) ____ $1,370

26) Suppose an equipment replacement is expected to be required in five years. You estimate that the replacement would cost $1,000 if it were made today, and you need to know what it would cost in five years. Suppose general price inflation is expected to average 5% per annum, but the equipment is expected to increase in price only 3% per annum in absolute terms. Stated in dollars of the future year (i.e., in current dollars), the future replacement cost is estimated at

a) ____ $1,159 c) ____ $1,000

b) ____ $908 d) ____ $1,469

27) Refer back to question 26. Stated in today's prices (i.e., in constant dollars), the future replacement cost is estimated at

a) ____ $1,469 c) ____ $1,159

b) ____ $1,000 d) ____ $909

28) Again refer back to question 26. Suppose your minimum acceptable rate of return is 5% over and above inflation. Working in future year dollars (i.e., in current dollars) and including inflation in the discount rate, the present-worth equivalent of the future replacement cost is

a) ____ $712 c) ____ $1,181

b) ____ $1,000 d) ____ $1,390

Working in today's dollars and excluding inflation from the discount rate, the present worth equivalent of the future replacement cost is about

a) ____ $1,181 c) ____ $712

b) ____ $1,000 d) ____ $1,390

29) As a general rule, if one includes general price inflation in estimates of future costs (i.e., if one states future costs in current dollars), it is imperative also to

a) _____ deduct the differential escalation rate

b) _____ add the differential escalation rate

c) _____ exclude an estimate of the rate of general price inflation from the discount rate

d) _____ include an estimate of the rate of general price inflation in the discount rate

30) As a general rule, if one excludes general price inflation in estimates of future costs (i.e., if one states future costs in constant dollars), it is imperative also to

a) _____ add the differential escalation rate

b) _____ deduct the differential escalation rate

c) _____ exclude an estimate of the rate of general price inflation from the discount rate

d) _____ include an estimate of the rate of general price inflation in the discount rate

31) Draw a cash flow diagram based on the following information:

Construction will begin two years from the date of study and will last one year. Assume that the construction costs of $100,000 will be incurred at the mid point of the construction period. A repair cost of $20,000 will be incurred 15 years from the date of study; maintenance costs of $5,000 will be incurred annually beginning six months after the end of construction (beginning of beneficial occupancy). A retention value of $10,000, net of disposal costs will remain at the end of 25 years of occupancy.

32) Calculate the life-cycle cost of sliding entry doors for an Army reserve building -- one of several design alternatives for entry doors under consideration. Significant costs are limited to the following:

Present worth of installation costs	$57,600
Present worth of energy costs for photo-electric control system	$1,400
Present worth of annually recurring nonfuel O&M costs	$1,700
Present worth of replacement costs	$6,000

$ __________ = Life-cycle cost

33) Attic insulation can be added to Army housing to reduce energy costs. Assuming there is no insulation present and the space will accommodate insulation up to a level of R38 (resistance level 38), choose the cost-effective level based on the following life-cycle cost data:

	Insulation Level	LCC $
a) ____	0	25,000
b) ____	R11	15,000
c) ____	R19	8,800
d) ____	R30	7,500
e) ____	R38	8,200

34) A general economic study is to be performed for a MILCON building design. The building in question is to last indefinitely. In most cases the maximum analysis period for calculating life-cycle costs is how many years from Beneficial Occupancy Date (BOD)?

a) ____ 40 years

b) ____ 25 years

c) ____ 28 years

d) ____ 15 years

35) In order to compute the life-cycle cost of a MILCON design alternative, you should discount all amounts to their present-worth equivalent as of the

a) ____ Analysis Base Date (ABD)

b) ____ Beneficial Occupancy Date (BOD)

c) ____ Midpoint of Construction (MPC)

d) ____ Analysis End Date (AED)

e) ____ Time you select, since this will vary depending on the project

36) When estimating future costs for MILCON design alternatives, it is essential to include the projected rate of general price inflation in estimates of future costs.

a) ____ True

b) ____ False

37) The discount rate for general economic studies is

a) ____ 5%

b) ____ 10%

c) ____ 7%

d) ____ 6%

e) ____ 12%

f) ____ there is no specified rate

38) A routine economic analysis of parking lot surfaces shows the following results:

Surface Type	LCC	Initial Cost	Energy Cost
A	$37,000	$13,000	0
B	$40,000	$15,000	0

Is an uncertainty assessment required?

a) _____ yes

b) _____ no

39) Which of the following two design alternatives would you recommend?

a) _____ Alternative A: LCC = $40,000
Initial investment cost = $15,000

b) _____ Alternative B: LCC = $40,100
Initial investment cost = $10,000

40) In the economic analysis of energy-conserving building systems, which features are different from those of a general economic study?

a) _____ Discount rate

b) _____ Treatment of inflation

c) _____ Types of costs which may be included

d) _____ All of the above

41) Calculate the present worth of a series of annually recurring electricity costs of $28,000 (in constant 1988 dollars) for a domestic hot water system to be installed in a housing complex of a military base in Texas. Assume that the Analysis Base Date (ABD) is July 1988 and the system will last 10 years. The discount rate is 10% and the appropriate One Step Adjustment Factor (OSAF) is 0.5162.

The PW of the series is

a) ____ $107,900

b) ____ $144,500

c) ____ $280,000

d) ____ $542,425

42) The following costs and energy consumption data are estimated for two alternative natural gas domestic hot water systems in an administration building in Ft. McCoy, WI. There is uncertainty regarding the energy consumption of alternative A, which may be up to 35% higher than the most likely estimate. Recommend the system to be selected.

<u>Alternative A</u>

Initial investment:	$80,000
Natural gas consumption:	10,000 mill. Btu/year
LCC_A:	$717,425
LCC_A, taking into account 35% higher energy consumption:	$940,524

<u>Alternative B</u>

Initial Investment:	$25,000
Natural gas consumption:	$20,000 mill. Btu/year
LCC_B:	$1,299,850

The system selected is

a) ____ Alternative A

b) ____ Alternative B

43) The Army's Construction Engineering Research Laboratory (CERL) has developed a database for estimating maintenance and repair costs. Which of the following statements are correct?

a) ____ Maintenance and repair costs are often the data most difficult to estimate.

b) ____ CERL's database facilitates the estimation of LCC maintenance and repair costs for components of major building systems.

c) ____ CERL's LCC cost factors for maintenance and repair are constructed from time study data.

d) ____ Cost factors are given per unit of component.

e) ____ Local wage rates can be reflected in maintenance and repair costs using CERL's database.

f) ____ All of the above.

44) Assume that an HVAC system uses 3,000 million Btu of electricity per year and the price today is $19.40/million Btu. If the differential rate of energy price escalation is projected to be 5% for the next year and the discount rate is 7% over and above general price inflation, the present worth of a year's energy consumption paid at the end of the first year is

a) ____ $58,200

b) ____ $57,112

c) ____ $60,920

45) Suppose the expected service life of an HVAC system in an Air Force administration building exceeds by 10 years the 25-year study period for an LCC analysis. This could be taken into account in an LCC study by

a) _____ including a replacement cost

b) _____ assuming a retention value at the end of the study period

c) _____ it cannot be taken into account

46) The most appropriate time for LCC analysis of MILCON designs is

a) _____ during preconcept design

b) _____ during concept design

c) _____ at the time of final design

47) Choose the statement you think is most valid for LCC analyses:

a) _____ LCCAs are very expensive and time-consuming and should be done only in support of major decisions.

b) _____ LCCAs are very inexpensive and should be done in support of all decisions.

c) _____ LCCAs can be done with varying levels of effort and are not always necessary.

48) As a project manager dealing with an A-E contractor on a design project, your responsibilities with respect to economic analysis include the following activities:

a) _____ Specify appropriate Army or Air Force

b) _____ Indicate desired level of effort

c) _____ Specify documentation requirements

d) _____ All of the above

49) Suppose alternative A has higher first cost but significantly lower life-cycle costs than alternative B. You can use the results of an LCC analysis to

a) _____ support a request for increased funds when the Current Work Estimate (CWE) is higher than the Programmed Amount (PA)

b) _____ support the recommendation of design alternative A to Higher Authority

c) _____ rebut criticism of design alternative A

d) _____ all of the above

50) Which of the following statements is incorrect? A computer-aided LCC analysis program, such as LCCID,

a) _____ determines the objectives of the analysis, identifies alternatives, and interprets results

b) _____ makes fast and accurate calculations

c) _____ incorporates ready data files

d) _____ makes it easier to use the methodology

e) _____ provides documentation

END

MODULE 16

SKILLS LABORATORY

Purpose:

- To review results of posttest
- To give you an opportunity to bring up specific issues that still need clarification
- To discuss issues to be treated in future courses

Outline:

16.1 Review of Posttest

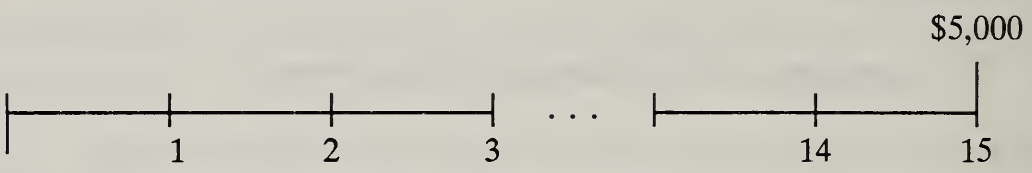
16.2 Identifying Areas Needing More Work

16.3 Additional Problems/Exercises

Exercise 16-1: Use OSAF to Compute the Present Worth of Single Future Amount

Use OSAF to compute the present worth of a single cost of $5,000 expected to occur in 15 years. The discount rate is 10%.

C_F = \$5,000
n = 15
d = 0.10
PW = ?



PW = ?

PW = C_F x OSAF (ONE-TIME COST TABLE)

= \$5,000 x 0.2394

PW = \$1,197

Solve the problem using OSAF.

Exercise 16-2: Compute Present Worth of Series of Energy Costs Escalating at DOE-Projected Rates and Beginning to Accrue at the BOD

Assume the BOD is July 1992. Annual electricity costs for Region 1 as of the DOS (June 1988) are estimated at $3,000, but they do not begin to accrue until the BOD, with the first payment six months after BOD. The annual discount rate is a real rate of 10%. Compute the present worth of electricity costs based on 25 years of occupancy.

A_o = $3,000
k = 25
d = 0.10
e = DoE-projected energy escalation rates
PW = ?

SOLUTION:

The factor 0.2199 in the column headed July 1992 (the BOD) and for 25 payments shows that the PW of the series equals about 22% of the sum of the unescalated, undiscounted payments.

PW = A_o x k x OSAF (Electricity Table (Region 1), k = 25, BOD = 7/92)
= $3,000 x 25 x 0.2199

PW = $16,493

In contrast, the conventional approach would require that we first divide the series into three subseries, find the initial amounts of each subseries by applying escalation factors, then use annual series factors to find the one-time equivalent cost of each subseries, find the PW of each one-time equivalent cost, and finally find the total PW for the entire series.

Exercise 16-3: Compute the Present Worth of a Uniform Series of M&R Costs that Begins to Accrue at the BOD

Assume the BOD is July 1991. A routine repair cost as of the DOS (June 1988) equals $8,000. It is expected to occur in each of the 25 years after BOD, with the first payment occurring six months after BOD. The cost is projected to escalate at the same rate as general price inflation over the entire analysis period. The real discount rate is 10%. Compute the present worth of the series using OSAFs.

$$
\begin{aligned}
A_o &= \$8{,}000 \\
k &= 25 \\
e &= 0 \\
d &= 0.10 \\
PW &= ?
\end{aligned}
$$

SOLUTION:

Look in the column headed July 1991, and find the factor for 25 payments: 0.2838. The factor tells us that the PW is 28% of the unescalated/undiscounted sum of the series.

$$
\begin{aligned}
PW &= A_o \times k \times OSAF \quad \text{(M\&R TABLE, 3-year lag, k = 25)} \\
&= \$8{,}000 \times 25 \times 0.2838
\end{aligned}
$$

$$PW = \$56{,}760$$

Note that these factors apply only when there is no differential escalation in M&R costs (or other annually recurring costs). If there is differential escalation, it is necessary to use the conventional approach.

Recall that with the conventional approach we would first use the annual series factor to find the one-time cost of the series of payments over 25 years and then apply the SPW factor to find the PW as of the beginning of the study period. The SPW factor would have to be interpolated for 3.5 years to match the mid-year convention of the OSAF Tables.

Exercise 16-4: LCCA of a Roadway/Parking Surface

Do an LCCA as part of an economic study for a FY 90 project involving the construction of a reserve training building in the Tidewater area of Virginia. The LCCA is to be conducted in accordance with the provisions of a general economic study (HQDA). The ABD is the actual date on which the study is performed (the DOS); the midpoint of construction (Jan 91) and the BOD (Jul 91) are taken as the actual projected dates for these events. The study period is 25 years from BOD. The two alternatives considered have the following specifications:

	ALTERNATIVE A	ALTERNATIVE B
Type of Surface:	Asphalt with 2" wearing surface	Asphalt with 3" wearing surface
Initial Investm.:	$45,400	50,900
Replacement (1" top):	Year 8: $8,900 Year 16: $8,900	Year 12: 8,900
Annual M&R costs:	$600	$400

Use One-Step worksheets to document, and to compute the LCC and rank the alternatives.

Vugraph 16-S1. Basic Input Data Summary for Alt A

Project No. & Title ____________________

Installation & Location ____________________

Design Feature ____________________

Alt. No ________ Title ____________________

LIFE CYCLE COST ANALYSIS

BASIC INPUT DATA SUMMARY

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference		
Date of Study (DOS)		
Analysis Base Date (ABD)		
Analysis End Date (AED)		
Midpoint of Construction		
Beneficial Occupancy Date (BOD)	Actual Projected	
	Assumed for Analysis	
DOE Region		
Annual Discount Rate		

Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe:		

Principal Assumptions

Cash Flow Diagram

Cost Element	Cost on ABD ☐ $ x 10³ ☐ $ x 10⁶	Time Cost Incurred**		Source(s) of Data
		Actual Projected Dates	Dates for Analysis (If Different)*	

DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply

**For Recurring Annual Costs, show date of first and last costs only.

Sheet ________ of ________

Vugraph 16-S2. Present Worth: One-Step Approach for Alt A

Project No. & Title ______________________

Installation & Location ______________________

Design Feature ______________________

Alt. No. ________ Title ______________________

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: ONE-STEP APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs ☐ $ x 10³ ☐ $ x 10⁶	Years from ABD	Cost On ABD	One Step Adj.Factor Table 1	Present Worth on ABD

Criteria Reference	
Analysis Base Date (ABD)	
Analysis End Date (AED)	
Midpoint of Construction	
BOD for Analysis	
Annual Discount Rate	

Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe:		

Annual Costs ☐ $ x 10³ ☐ $ x 10⁶	Total No. of Payments	Annual Cost on ABD	Total Nominal Cost on ABD	One Step Adjustment Factor* Table Factor x DOS Correction	Present Worth on ABD

	Initial Costs		Energy/Fuel Costs		M&R Costs		Other Costs		Total
Net Present Worth:	________	+	________	+	________	+	________	=	________

DA FORM 5605-5-R, DEC 86

*Use One-Step Table 2 for M&R costs (e = 0).
Use One-Step Table 3 for energy/fuel costs (e = prescribed e value).

Sheet ________ of ________

Vugraph 16-S3. Basic Input Data Summary for Alt B

LIFE CYCLE COST ANALYSIS
BASIC INPUT DATA SUMMARY

Project No. & Title ____________________

Installation & Location ____________________

Design Feature ____________________

Alt. No. ________ Title ____________________

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Criteria Reference		
Date of Study (DOS)		
Analysis Base Date (ABD)		
Analysis End Date (AED)		
Midpoint of Construction		
Beneficial Occupancy Date (BOD)	Actual Projected	
	Assumed for Analysis	
DOE Region		
Annual Discount Rate		

Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe:		

Principal Assumptions

Cash Flow Diagram

Cost Element	Cost on ABD ☐ $ x 10³ ☐ $ x 10⁶	Time Cost Incurred**		Source(s) of Data
		Actual Projected Dates	Dates for Analysis (If Different)*	

DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply

**For Recurring Annual Costs, show date of first and last costs only.

Sheet ________ of ________

Vugraph 16-S4. Present Worth: One-Step Approach for Alt B

Project No. & Title ____________
Installation & Location ____________
Design Feature ____________
Alt. No. ______ Title ____________

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: ONE-STEP APPROACH

For use of this form, see TM 5-802-1; the proponent agency is USACE.

One-Time Costs ☐ $ x 10³ ☐ $ x 10⁶	Years from ABD	Cost On ABD	One Step Adj.Factor Table 1	Present Worth on ABD

Criteria Reference	
Analysis Base Date (ABD)	
Analysis End Date (AED)	
Midpoint of Construction	
BOD for Analysis	
Annual Discount Rate	

Type of Cost	Differential Escalation Rate per Year (%) Timeframe:		

Annual Costs ☐ $ x 10³ ☐ $ x 10⁶	Total No. of Payments	Annual Cost on ABD	Total Nominal Cost on ABD	One Step Adjustment Factor* Table Factor x DOS Correction	Present Worth on ABD

	Initial Costs		Energy/Fuel Costs		M&R Costs		Other Costs		Total
Net Present Worth:	________	+	________	+	________	+	________	=	________

DA FORM 5605-5-R, DEC 86

*Use One-Step Table 2 for M&R costs (e = 0).
Use One-Step Table 3 for energy/fuel costs (e = prescribed e value).

Sheet ______ of ______

Vugraph 16-S5. Summary for Alt A and B

LIFE CYCLE COST ANALYSIS
SUMMARY

Project No. & Title ____________

Installation & Location ____________

Design Feature ____________

For use of this form, see TM 5-802-1; the proponent agency is USACE.

Date of Study ____________

ALTERNATIVES ANALYZED						
No.	Description/Title	Present Worth [ ] $ x 10³ [ ] $ x 10⁶				
		Initial	Energy	M&R	Other	Total

ECONOMIC RANKING				
Rank	Alternative No. & Title	Economic Advantages of Top-Ranked Alternative		Basis for No. 1 Ranking
		LCC (PW) Difference (Dollars & Percent)	Other (Initial, Energy, Etc.)	

KEY ASSUMPTIONS

NARRATIVE SUMMARY (Comments/Lessons Learned/Observations/Recommendations/Etc.)

Key Participants - Name	Discipline	Organization	Telephone No.

DA FORM 5605-2-R, DEC 86

Sheet ______ of ______

MODULE 17

SOLUTIONS TO EXERCISES

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Economic Analysis for MILCON Design: Student's Manual
(Concepts, Techniques, and Applications for the Analyst)

AUTHOR(S)

Rosalie T. Ruegg and Sieglinde K. Fuller

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). SUPPLEMENTARY NOTES

[ ] DOCUMENT DESCRIBES A COMPUTER PROGRAM; SF-185, FIPS SOFTWARE SUMMARY, IS ATTACHED.

I. ABSTRACT (A 200-WORD OR LESS FACTUAL SUMMARY OF MOST SIGNIFICANT INFORMATION. IF DOCUMENT INCLUDES A SIGNIFICANT BIBLIOGRAPHY OR LITERATURE SURVEY, MENTION IT HERE.)

This is the class workbook for a five-day course, "Economic Analysis for Military Construction Design: Concepts, Techniques, and Applications for the Analyst." The course equips design professionals to conduct, document, and review economic studies of building and facility design alternatives in accordance with Army and Air Force requirements. It demonstrates a variety of applications through realistic examples and case studies. The workbook covers 16 training modules; including orientation, pre and post tests, aids to learning, time value of money, mathematical operations, general economic studies, energy conservation studies, data, computer software, and uncertainty and risk analysis. Each of the technical modules lists learning objectives and summarizes key points. The manual is designed not as a stand-alone tutorial, but as a working document for a course taught by an instructor who provides additional information.

2. KEY WORDS (6 TO 12 ENTRIES; ALPHABETICAL ORDER; CAPITALIZE ONLY PROPER NAMES; AND SEPARATE KEY WORDS BY SEMICOLONS)

building economics; design economics; economic analysis; life-cycle costing; military construction; training course

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