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ECONOMIC ANALYSIS FOR MILITARY CONSTRUCTION DESIGN

CONCEPTS, TECHNIQUES, AND APPLICATIONS FOR THE ANALYST

INSTRUCTOR'S MANUAL

Rosalie T. Ruegg
Sieglinde K. Fuller

Computing and Applied Mathematics Laboratory
Office of Applied Economics



U.S. DEPARTMENT OF COMMERCE
Robert A. Mosbacher, Secretary
NATIONAL INSTITUTE OF STANDARDS
AND TECHNOLOGY
John W. Lyons, Director



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ECONOMIC ANALYSIS FOR MILITARY CONSTRUCTION DESIGN

CONCEPTS, TECHNIQUES, AND APPLICATIONS FOR THE ANALYST

INSTRUCTOR'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:
Rosalie T. Ruegg
Sieglinde K. Fuller

U.S. DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
Computing and Applied Mathematics Laboratory
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Sponsored by:
U.S. Army Corps of Engineers
Huntsville Training Division

September 1991



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PREFACE

This Instructor's Manual for *Economic Analysis for Military Construction Design: Concepts, Techniques, and Applications for the Analyst* is a guide for teaching 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 Instructor's Manual is coordinated with its companion volume, the Student's Manual for *Economic Analysis for Military Construction Design: Concepts, Techniques, and Applications for the Analyst*. Together they present the criteria and standards that govern EA/LCCA in MILCON design, treat basic economic concepts, give step-by-step instructions for performing EA/LCCA, and provide examples of calculations and analyses. The Instructor's Manual contains many suggestions to the instructor on how best to transfer knowledge to students. In addition, it contains a comprehensive test to evaluate students' before- and after-class knowledge of EA/LCCA.

The Instructor's Manual is designed for use by instructors who are experienced in the general economic theory of benefit-cost analysis and specifically in MILCON applications. Appendix B references supplemental texts which the instructor may wish to consult.

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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COURSE EVALUATION

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

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

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DETAILED SCHEDULE

(Time)	(Module)	(Topic)
DAY 1	PART I. ADMINISTRATIVE	
0800-0830	1.	ORIENTATION
	1.1	Welcome to Huntsville, Beville Center, and Course
	1.2	Overview of Training Materials
	1.3	Overview of Daily Schedule During Week
	1.4	Point Out Map and List of Restaurants
0830-0945	2.	PRETEST
0945-1000	BREAK	
	3.	<i>AIDS TO LEARNING is not a scheduled activity but a background resource module which is drawn on as needed throughout the course.</i>
PART II. BASICS OF ECONOMIC ANALYSIS		
1000-1200	4.	IMPROVING DECISIONS WITH ECONOMIC ANALYSIS/LIFE-CYCLE COST ANALYSIS (EA/LCCA)
1000-1015	4.1	First Cost and Life-Cycle Cost Perspectives
1015-1030	4.2	Why EA/LCCA is Important in Design
1030-1100	4.3	What EA/LCCA Entails
1100-1130	4.4	When to Do EA/LCCA
1130-1145	4.5	Knowledge and Skills Required of MILCON Design Professionals
1145-1200	4.6	Self-Assessment Using Scores on Pretest
1200-1300	LUNCH	

1300-1515	5. TIME VALUE OF MONEY CONCEPTS
1300-1330	5.1 Why and How to Adjust for Time
1330-1415	5.2 Two Ways to Treat Inflation
1415-1445	5.3 Government Discount Rates
1445-1515	5.4 Cash Flow Modeling
1515-1530	BREAK
1530-1700	6. ARITHMETIC OF EA/LCCA
1530-1600	6.1 Escalate to Estimate Future Dollar Costs & Benefits Based on Today's Price and Projected Rates of Price Change
1600-1630	6.2 Discount to Compute the Present Worth Equivalent of a Single Future Cost or Benefit
1630-1700	6.3 Discount to Compute the Present Worth Equivalent of a Series of Future Costs or Benefits
DAY 2	
0800-1200	REVIEW and CONTINUATION OF 6
0800-0830	REVIEW
0830-0930	6.3 Continues
0930-0945	BREAK
0945-1100	6.4 Exercise 6-1: Escalation/Discounting
1100-1130	6.5 Compute LCC
1130-1200	6.6 Exercise 6-2: LCC
1200-1300	LUNCH

1300-1700	7.	HOW TO PERFORM MILCON GENERAL ECONOMIC STUDIES
1300-1330	7.1	Criteria for General Economic Studies
1330-1415	7.2	Input Data & Cash-Flow Diagrams
1415-1440	7.3	Computing LCC Using Conventional Approach
1440-1530	7.4	Exercise 7-1: Conventional Approach
1530-1600	7.5	Computing LCC Using One-Step Approach

1445-1500 BREAK

1600-1620	7.6	Exercise 7-2: One-Step Approach
1620-1640	7.7	Ranking Design Alternatives
1640-1700	7.8	Exercises 7-3 and 7-4: Ranking

DAY 3

0800-0900 REVIEW

0900-1200 8. HOW TO PERFORM ENERGY CONSERVATION STUDIES

0900-0945	8.1	Criteria for Energy Conservation Studies
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0945-1000 BREAK

1000-1015	8.2	Exercise 8-1: Applicable Criteria
1015-1100	8.3	Computing LCC for Energy-Consuming Designs Using One-Step Approach
1100-1200	8.4	Exercise 8-2: One-Step Approach

1200-1300 LUNCH

1300-1700 9. DATA

1300-1330	9.1	Identifying Data Requirements (Exercise 9-1)
1330-1400	9.2	Estimating Construction Costs/Replacement Costs
1400-1445	9.3	Estimating Disposal Costs/Retention Values

1445-1500	BREAK	
1500-1515	9.4	Estimating Energy Costs
1515-1600	9.5	Estimating Maintenance and Repair Costs
1600-1700	9.6	Exercise 9-2: Using the M&R Database

DAY 4

PART III. TOPICS FOR THE EXPERIENCED ANALYST

0800-0930	11.	DEALING WITH UNCERTAINTIES
0800-0830	11.1	Overview of Selected Techniques
0830-0900	11.2	When Uncertainty Assessment Should Be Done (Exercise 11-1)
0900-0930	11.3	Exercise 11-2: Sensitivity Analysis
0930-0945	BREAK	
0945-1100	12.	CRITIQUE OF EA/LCCA
0945-1010	12.1	Guidelines for Reviewing EA/LCCA
1010-1100	12.2	Exercise 12-1: Critique of an LCC Study
1100-1600	13.	PUTTING EA/LCCA INTO PRACTICE
1100-1200	13.1	Deciding the Level of Effort
1200-1300	LUNCH	
1300-1330	13.2	Documentation
1330-1400	13.3	Presenting/"Selling" Results
1400-1430	13.4	Contracting with A-E Firms
1430-1445	BREAK	
1445-1600	13.5	Exercise 13-1: Presenting/"Selling" Results

1600-1700	10. PERFORMING LCCA WITH COMPUTERS
1600	10.1 Software for EA/LCCA
1630	10.2 Introduction to LCCID
1700-1800	BREAK
1800-2030	COMPUTER LAB
DAY 5	
0800-0900	14. OTHER ECONOMIC MEASURES
0900-1030	REVIEW
1030-1045	BREAK
1045-1145	15. POSTTEST
1145-1200	COURSE EVALUATION
1200-1300	LUNCH
1300-1445	16. SKILLS LABORATORY
	16.1 Review of Posttest
	16.2 Identifying Areas Needing More Work
	16.3 Additional Problems/Exercises
1445-1500	CLOSURE

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PART I. ADMINISTRATIVE

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EXPLANATION OF TYPOGRAPHY AND PAGINATION

Typography:

Text printed in Times Roman indicates text appearing in both the Instructor's Manual and the Student Workbook. When this material is shaded in the Instructor's Manual, it indicates that it appears on a "slide" page in the Student Workbook.

Text printed in Helvetica indicates material appearing only in the Instructor's Manual and destined to be communicated to the students.

Text printed in Helvetica italics indicates material appearing only in the Instructor's Manual and serving as instructions, helpful hints, clues, or explanations to the Instructor.

Pagination:

The pages are numbered by module, consecutively through the sections, e.g., Module 4, beginning with the front page, through section 4.6, will be numbered from 4-1 to 4-32.

The student material appearing in the Instructor's Manual has the same page numbers as the corresponding material in the Student Workbook; the overflow pages in the Instructor's Manual are numbered 4-1a, 4-1b, etc.

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LEARNING STYLES, INSTRUCTIONAL TECHNIQUES, AND TRAINING TRANSFER

To understand the importance of various instructional techniques to the learning process, you should be aware of alternative learning styles and know which instructional techniques respond to specific learning styles. You should also be aware of the need for special attention to ensure effective transfer of training to the job and to preventing relapse to pre-training practices. The following is a brief introduction to the topic.

LEARNING STYLES

There are at least four basic modes in which most people learn: (1) abstract conceptualization (thinking), (2) active experimentation (doing), (3) reflective observation (watching), and (4) concrete experience (feeling). Instructional methods tap into these modes of learning. For example, a lecture or reading assignment invites the student to learn by thinking new ideas. A demonstration allows the student to learn by watching someone else do a given thing. A hands-on-exercise allows the student to learn by doing. Activities which emphasize personal involvement and student/teacher and student/student interactions, such as team activities, discussion groups, question and answer sessions, and ice-breakers, are important to the student's attitudes about the learning.

Most people have a preferred style of learning. Some people prefer listening to lectures. Some are quickly frustrated by lecture, which they consider too passive, and want more active involvement. Some are most interested in underlying concepts, while others focus on how a thing works in practice. For some people, attitudes and emotions play a strong role in the learning process.

At the same time, most people do not have a single learning mode; rather they have some combination of the four basic modes, which can be described as a style of learning. Learning styles are related to a person's success in problem-solving, team participation, ability to manage people, and choice of careers. Studies of learning styles have identified four prevalent types, based on favored combinations of the above learning modes. A brief overview of each of the four types follows:

- (1) Combines abstract conceptualization and active experimentation
("Thinker-Doer")

People with this learning style tend to be good at finding practical uses for ideas and theories, for solving problems and making decisions based on the solutions. They tend to like technical tasks and careers.

Typical weakness: hasty decisions; solving the wrong problem.

(2) Combines concrete experience and reflective observation
("Feeler-Watcher")

People with this learning style tend to be good at viewing situations from many different points of view. They may be good at brainstorming, and less likely to take action. They tend to like the arts, entertainment, and service tasks and careers.

Typical weakness: can't make decisions; paralyzed by alternatives.

(3) Combines conceptualization and reflective observation
("Thinker-Watcher")

People with this learning style tend to be good at understanding and analyzing information and organizing it into a concise, logical form. They tend to be more concerned with logical soundness of an idea than practical value, and more focused on abstract ideas and concepts than on people. They tend to favor science careers.

Typical weakness: lack of practical application; deficient in interpersonal skills.

(4) Combines concrete experience and active experimentation
("Feeler-Doer")

People with this learning style tend to be good at committing to objectives and carrying out plans. They tend to want hands-on experience, and are more likely to be influenced by "gut" feeling than logical analysis. They prefer getting information from other people rather than from their own technical analysis. They tend to like action-oriented careers such as sales.

Typical weakness: gets caught up with trivial improvements; not good at building conceptual modeling and testing theories and ideas.

A typical classroom will contain people who strongly favor each of these learning styles. Even in a class composed primarily of design professionals, there will likely be a diversity of preferred learning styles (although we would expect the first listed to be prevalent in a class of engineers). Using a single instructional technique, such as all lecture, will tend to be less effective than using a variety of techniques. Yet instructors who are unaware of learning styles will automatically favor their own preferred learning style as the preferred teaching style. Furthermore, if "unenlightened" about learning styles, the instructor will tend to feel that his or her own favored learning style is superior to the others. If the instructor's favored style differs from the preferred style of most of the class, instruction is likely to miss the mark, even if it is well done. Using a variety of instructional styles has the dual advantages of not leaving anyone out and of giving everyone practice in achieving a balance of learning skills. Experts suggest that learning effectiveness is increased by improving one's ability to use all of the learning modes well.

For more on learning styles, see Users Guide for the Learning-Style Inventory, by Donna Smith and David A. Kolb. Boston: McBer and Company, 1985 (A manual for teachers and trainers).

INSTRUCTIONAL TECHNIQUES

For greater effectiveness, the course employs a variety of instructional techniques. Principal techniques used in the course are listed and briefly described as follows:

LECTURE -- well organized oral presentation of a subject area. Trains by requiring student to listen. Used in this course to get across basic concepts. Advantages are that it is an efficient way to cover a large amount of material.

DEMONSTRATION -- a visual presentation that shows how to use a procedure or to perform an act. Trains by requiring students to watch. Used in this course to show how to do calculations using formulas, worksheets, and tables. Advantages are that people are more likely to understand what they see demonstrated as they hear it discussed, and the pace is flexible.

DISCUSSION GROUP -- a meeting of two or more people to discuss a topic. Used in this course to help students digest information, increase retention rates through rehearsal, and develop contacts which may be beneficial back on the job. Advantages are that people gain practice pooling abilities, knowledge, and experience.

CASE STUDY (PROBLEM-SOLVING EXERCISE) -- students put concepts and procedures in practice under supervision in the context of semi-realistic conditions which may be encountered back on the job. Used in this course to help transfer material imparted through lecture and demonstration to long-term memory. Advantages are that it helps develop analytical and problem-solving skills, and people tend to remember better what they have actually done.

QUESTION AND ANSWER PERIOD -- an organized follow-up session to a lecture in which students ask questions, seek clarification of points made in the lecture, and ask for information not covered by the instructor. Advantages are that it provides immediate feedback to the instructor, allows audience participation and thereby increases understanding and retention, encourages students to pay close attention, and it is psychologically positive for the students to know they have the opportunity to agree, disagree, elaborate, share their own views, and seek clarification.

GROUP/TEAM PRESENTATION -- the group or team "captain" presents the collective findings of the team to the rest of the class, with the instructor as

moderator. Used in the class to reenforce interest, attention, and to give students practice under supervision using terminology and presenting results. It should be carefully controlled to keep the discussion moving.

COMPUTER LABORATORY -- "hands-on" use of computer software under supervision. Used in the class to train in use of LCCID. Advantages are that the student finds out that he or she can run the program to solve problems more easily.

PRETEST/POSTTEST -- assessing student's knowledge about the subject before training and after training based on his or her ability to answer representative questions and solve representative problems. The Pretest/Posttest are used in the course in combination to measure effectiveness of training. The Pretest is also useful in demonstrating to the student his or her areas of existing strengths and weaknesses. The Posttest reenforces student learning, and helps the instructors identify topics requiring additional work in the skills lab.

AUDIENCE REACTION TEAM -- several students agree to react to a presentation, interrupting the presentation to seek immediate clarification of points that are not clear and otherwise to help the instructor be understandable to the class and meet specific needs of the students. Used early in the course to encourage full participation, to stimulate interest, and to provide feedback to the instructor. Advantage is that it brings out student participation during a time that students may be passive. It is dropped in favor of general participation once the course is underway and participation is active.

"BUZZ QUESTION SESSION" -- the class is divided into groups of three or four for a brief time during which they discuss the subject matter and develop one or more questions which they would like most to have answered. Each group puts its questions to the rest of the class. The instructor serves as moderator and elaborates on the answers as necessary. Used for review sessions throughout the course. Advantages are that it identifies areas of special interest or confusion, stimulates the class to think about those topics, reenforces transfer of learning and encourages participation. Students learn while discussing formulation of questions as well as by having the questions answered.

SKILLS LAB -- a series of short problems are presented to the class to allow students additional practice in mastering selected subject areas. The questions and problems selected are focused in areas of weakness revealed by the Posttest results. Used at the end of the course as the wind-up session. Advantages are that it provides a final chance to impart the necessary skills and understanding to students before the course ends, and it is an active session to boost attention levels at a time students may begin focusing on travel home.

TRAINING TRANSFER

Student retention of what is learned is a principal challenge of training. Studies have shown that much of what is learned is lost within a relatively short time period, unless special attention is given to the effective transfer of training. To be effectively trained, students must first admit new information to their sensory registries, then to their short-term memories, then to their long-term memories. Otherwise not much that goes on in the classroom will actually be put into practice back on the job.

Potential actions to support transfer of training encompass actions taken before, during, and after training by the student's organization/manager, by the trainer, and by the trainee. Following are examples of actions that the trainer can take during classroom sessions to support the transfer of training:

- Emphasize the positive consequences associated with application of knowledge and skills from the course.
- State objectives of each training activity in terms of what they will be able to do differently upon completion of the course.
- Discuss or hold an exercise early in the course that addresses the need to unlearn old behaviors before new learning can take place.
- Facilitate student interactions and networking so that they are more likely to exchange information and support each other back on the job.
- Provide opportunities for trainees to perform "real work" during training that closely matches what they need to do on the job.
- Encourage students to think of possible on-the-job applications throughout the course and to record them on an "ideas and applications" list.
- Have a group discussion in which trainees anticipate potential obstacles they may face in actually implementing knowledge and skills learned and identify possible ways to overcome the obstacles.
- Provide individualized feedback to trainees on their skill development during the training sessions.

For more information on transfer of training to the job, consult the training and development literature, such as the following articles: Mary L. Broad, "Management Actions to Support Transfer of Training." Training & Development Journal, May 1982, pp. 124-130; Ruth C. Clark, "Nine Ways to Make Training Pay Off on the Job." Training, November 1986, pp. 83-87; and John W. Newstrom, "Leveraging Management Development Through the Management of Transfer." Journal of Management Development, 1987.

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TIPS ON MAKING THE COURSE MORE EFFECTIVE

- Have the participants introduce each other, call them by name frequently, and make them actively involved in the course.
- Use a diversity of teaching styles so that everyone's favored learning style is accommodated at least part of the time; use lecture, demonstration, individual and group exercises, individual and group presentations, drills, competitions, discussions, etc. Since the participants are mostly engineers, give them plenty of "learning by doing" exercises, a learning style often favored by engineers.
- Turn lights up and down frequently (i.e., don't keep lights down too long when showing slides). Have frequent "stand up and stretch" breaks.
- Start and stop promptly as scheduled. Announce exact time to be back from breaks and lunch, not elapsed time.
- Set the level of expectations; tell them what they will get out of the course and of each session and what they are expected to learn.
- Mix use of slides, overheads, flip chart, and blackboard.
- Add humor or an interesting story frequently.
- Have the names on both sides of the tent cards so you can call on people by name and everybody else can see the names too.
- Have frequent check points to identify points of confusion and clear them up.
- Know the learning objectives and key points for each session.
- Limit number of new concepts in a session to only two to three at a time. Limit number of items or levels of information to seven. Remember that people have difficulty organizing and remembering more than about seven items, and that "less can be more."
- Build in repetition in an interesting way.
- Allow frequently for some type of review, rehearsal, or exercise to move grasp of material from the sensory registry level to short-term memory to long-term memory.

- Relate new information to something they already know.
- Do not be too fast to answer every question or resolve every difficulty. Let the group do it!
- Use as a frequent summary, "What did you learn from this session, exercise, lecture, discussion, etc." Revisit the learning objectives frequently.
- Ask open-ended questions.
- Facilitate the group/team processes. Remember that not everyone will feel comfortable in a group/team, especially initially.
- Practice with the visuals; speak from the visuals, not the instructor's guide.
- On giving feedback: Focus on things the other person can change. Make your comments helpful to the other person, not to relieve yourself of frustration. Be descriptive and specific with suggestions for change or improvement.
- On receiving feedback: Listen carefully. Clarify to understand the point that is being made. Discuss possible changes -- how I might improve, what I can do differently.
- On taking questions from the floor. Always restate the question so that everyone can hear and therefore get more out of the discussion that ensues.
- Try to be more of a "process-oriented" trainer than a "content-oriented" trainer. For example, pay more attention to the effectiveness of student learning than to adhering rigidly to the instructional schedule at any cost. Encourage informality and spontaneity, and treat the unplanned and unexpected as learning opportunities rather than undesirable disruptions to formal procedures. Involve students actively in the learning process rather than control and dominate as the supreme expert. Focus on the creative process of identifying and solving open-ended, real-life problems rather than on getting the correct answer to 5 decimal places to narrowly focused problems. Keep in mind key ingredients to foster a climate of learning: spontaneity, enthusiasm, interest, relevance, immediacy, and rationale for learning. (But note that this does not mean to disregard the schedule!)

CONTINGENCY PLANS FOR FALLING BEHIND

When you realize that you are falling behind, don't rush. Rushing makes the students uncomfortable, and the message you want to get across loses its impact and effectiveness. To deal with this problem, follow these simple techniques:

- 1) Because it is usually difficult to get started right on time, or to control the timing of questions and answers, each hour of scheduled presentation is actually planned to last 50 minutes. This will allow you to lose five minutes in the beginning and to accommodate additional questions and discussion.
- 2) Prioritize the sections that may be deleted if it becomes necessary to make up time. The key point is that you should plan in advance what to eliminate, and in which order of priority, if you do fall behind.

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REQUIREMENTS FOR EQUIPMENT AND MATERIALS

You will need to give a list of needed equipment and materials to the USACE Training Division, Huntsville, well before the date of the course. Check on the equipment on the afternoon before the start of the course.

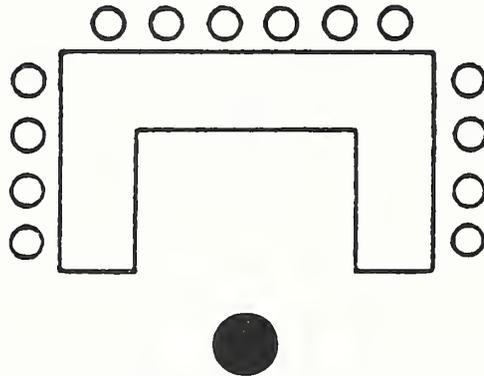
The following is a list of the equipment and materials you will need:

- Lectern/table
- Portable microphone if the room is large
- Slide projector
- Remote control with long cord
- Overhead projector
- Screen
- Extra light bulbs for projectors
- Flip chart stand and paper
- Chalkboard
- Magic markers
- Chalk
- Eraser
- Pointer
- Signs for direction to meeting
- Tent place cards and blank spares
- Badges

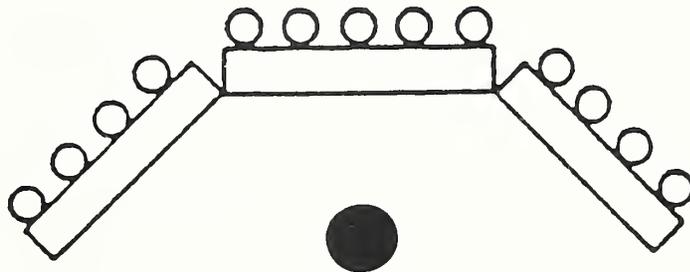
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SUGGESTED ROOM/SEATING ARRANGEMENTS

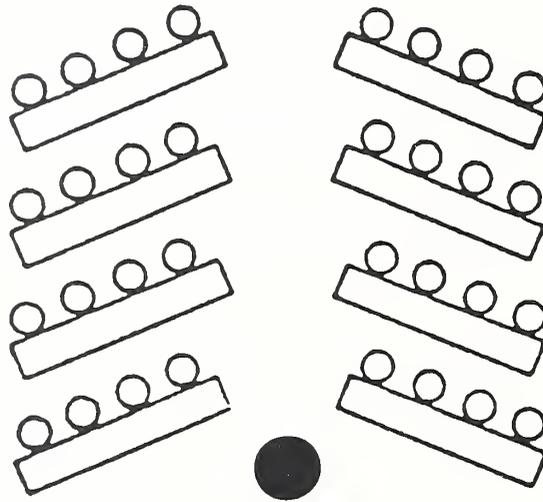
- 1) Room size is very important. It must be appropriate to the size of the group, not too large or too small, or your students will either feel lost or crowded.
- 2) The seating arrangement can contribute to the student's attention, interest and participation. In general, a wide and flat seating arrangement is better than a narrow and deep one. Aim for one of the arrangements pictured below.
 - a) U-shaped for maximum group participation



- b) Angled tables to bring two-thirds of the students closer to the instructor and to allow the students to see each other.



- c) Herring-bone pattern as an alternative to the usual classroom arrangement, again to allow the students to see each other better



If there are windows in the room, it is preferable that the instructor face the windows rather than the students. It is also preferable not to have a clock in the room.

CHECKLIST OF THINGS TO DO PRIOR TO START OF CLASS

Set up the room the day before the presentation or check the set-up if someone else did it.

Arrive at the room at least one hour before the presentation.

The following is a combined list for planning ahead and checking after arrival:

Facilities

- Name of person to call if you need help (office and home phone numbers)
- Restroom location
- Phone location
- Coffee, snacks, and lunch locations
- Stairs/elevators location
- Signs for directions to meeting
- Location of copy machine

Room

- Check light controls and experiment with levels
- Temperature controls
- Disconnect phone in your room
- Chairs/tables - numbers and arrangement
- Extension cord
- Electrical cords taped down

- ___ Location of electrical outlets
- ___ Adapter plug -- three-prong to two-prong

Overhead Projector

- ___ Spare bulb
- ___ Focused
- ___ Cleaned of fingerprints and lint
- ___ First transparency in place
- ___ Long-cord or remote control

Slide Projector

- ___ Spare bulb
- ___ Focused
- ___ Slide tray loaded and tray 1 cued to slot 1
- ___ Opaque slide in slot 1
- ___ Long stick pointer

Screen

- ___ Location
- ___ Size

Flip chart

- Paper supply
- Magic markers - two colors
- Check for dry markers
- Rubber band across top

Chalkboard

- Chalk
- Eraser
- Clean

Student Supplies

- Student Workbooks
- Reference Material
- Place cards
- Badges
- Roster

Instructor Supplies

- Instructor Manual
- Materials arranged on front table/lectern
- Course name and instructors' names placed on flip chart, blackboard, or screen

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MEMO TO STUDENTS

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

COURSE BROCHURE

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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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THE INSTRUCTORS
(Insert Biographies)

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LIST OF STUDENTS
(Insert Class Roster)

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

- Tab 1: WORKING DOCUMENTS
- Tab 2: TM 5-802-1
- Tab 3: Current Letter Supplement
- Tab 4: Escalation and Discount Tables
- Tab 5: OSAF Tables
- Tab 6: e-Values
- Tab 7: Maintenance and Repair Data
- Tab 8: LCCID Manual and Diskettes
- Tab 9: Catalogue -- LCCID Support
- Tab 10: SOURCE DOCUMENTS
- Tab 11: 10 CFR 436A
- Tab 12: NBS Handbook 135 and Annual Supplement
- Tab 13: OMB Circular A-94
- Tab 14: ECIP Guidance Memo
- Tab 15: AF Documents
- Tab 16: PROSPECT COURSE DESCRIPTIONS

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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

Telephone: Commercial: (202) 272-0466
Autovon: (202) 285-0466

Fax: (202) 272-0839
Verification: (202) 272-1490

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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

LESSON PLAN 1: ORIENTATION

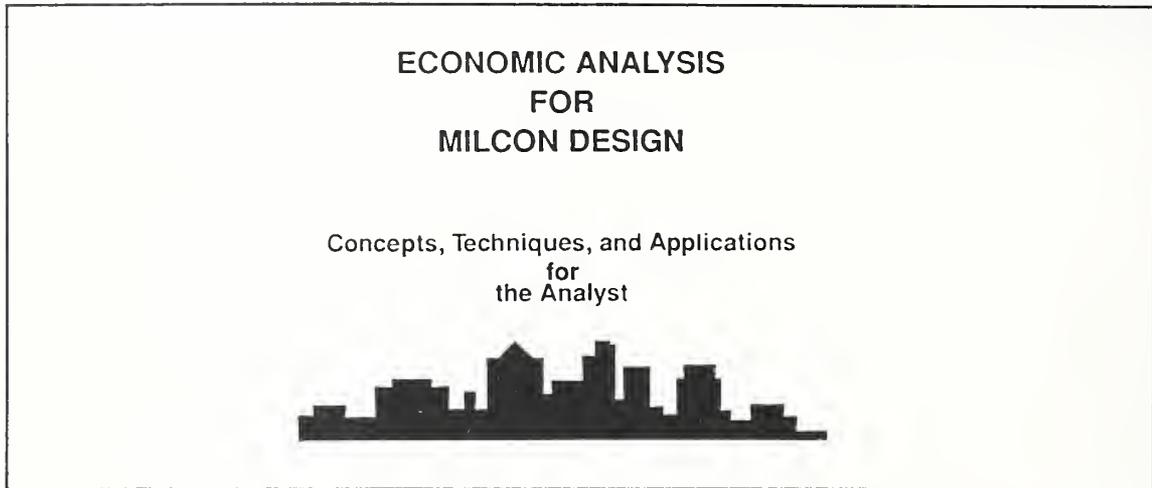
TIME	OVERVIEW	TRAINING AIDS OR CUES
0730	Review checklist to make sure everything is ready	
0800	1.1 Welcome students to course Introduce Instructors Ask students to put names on place cards Tell them about system of paired student introductions (Plan to have about 1/3 of the introductions after 1st break, 1/3 after lunch, and 1/3 after afternoon break)	S1-1
0808	1.2 Define the goal of the course and its benefits	S1-1
0811	1.3 Give a brief introduction to training materials - Key features - How to use	Workbook Notebook
0818	1.4 Review the Agenda Overview and discuss daily schedule	Agenda, V1-1
0825	1.5 Point out map, list of restaurants, other info Ask if there are any questions.	Map, List
0830	Ready to begin Pretest	

(Key: S = slide, V = Vugraph, F = Flipchart, W = Workbook, N = Notebook)

Instructions for Using Ice-Breaker for Student Introductions:

Request that each student be responsible for introducing a fellow student to the entire group. Ask them to choose someone they haven't met before class, and to get acquainted during break. They should be prepared for the introductions right after the first break even though all the introductions may not be completed until after the afternoon break. Request that they include at least one interesting personal piece of information about the person, in addition to the most relevant job-related information. Ask that they limit each introduction to two minutes.

The purpose of this approach is as an ice-breaker, to help people feel involved and comfortable early on, and to help set up a buddy system in which two people can learn together and support each other during the training and back on the job.



- The goal of the course is to train you to apply economics to the design of military structures.
 - This will help you make and recommend better design decisions, and that will save the government money.
- There is also a personal benefit to taking the course.
 - You will learn techniques which are applicable not only to tackling design decisions, but to many other decisions, ranging from personal decisions to business decisions.
 - The knowledge and skills you will learn in the course are highly transferable.

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

Outline:

2.1 Pretest

2.2 Answers to Pretest

2.3 Tally Sheets

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):

Day 1

- 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.

Day 1

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
- b) _____ \$1,159
- c) _____ \$1,000
- d) _____ \$1,611

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

- a) _____ \$1,685
- b) _____ \$1,159
- c) _____ \$1,000
- 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% d) _____ 6%
b) _____ 10% e) _____ 10.24%
c) _____ 2.4% 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% d) _____ 0%
b) _____ 10% e) _____ none of the above
c) _____ 6%

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.

Alternative A

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

Alternative B

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

Day 1

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2.2 ANSWERS TO PRETEST AND POSTTEST

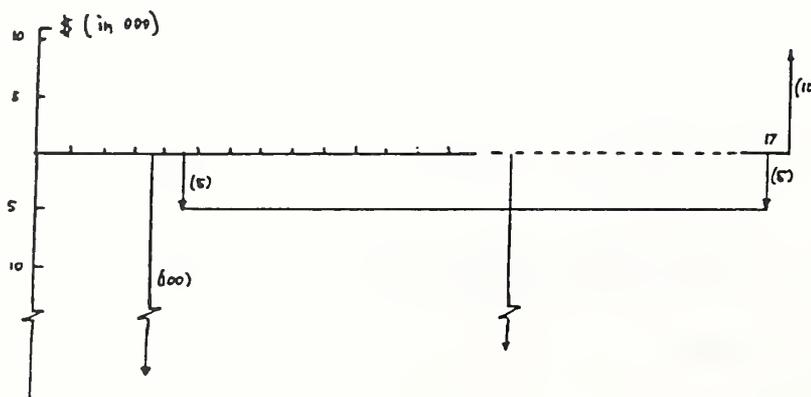
1. b)
2. b)
3. c); need information on annual space heating requirement, costs of installing and maintaining insulation, price of energy
4. b)
5. d); use the number of significant digits of the least accurate input as a guide
6. differing answers
7. b)
8. a); $5,000(1+0.10)^5=8,052.55$
9. a)
10. b)
11. d); c); $e=(1+0.04/1+0.07)-1=-0.0280$
12. c)
13. a)
14. c); $2,000 \times 1/(1+0.10)^{10}=771$
15. b)

$$2,000 \times \frac{(1+0.10)^{25}-1}{0.10(1+0.10)^{25}} = 18,154$$

16. b); $1,500 \times [1+(0.05+0.04+(0.05)(0.04))]^{10} = 3,616.74$
17. b); $1/(1.04)^{10} = 0.67$

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18. c); $0.04+0.06+(0.04)(0.06) = 0.1024$
19. b); $7\%-4\% = \text{about } 3\%$.
e); $[(1+0.07)/(1+0.04)]^{-1}=0.0288$
20. c); $[(1+0.10)/(1+0.10)]^{-1}=0.00$
21. d); $1,000 \times (1.10)^5 = 1,610.51$; inflation included
c); 1,000; inflation excluded
22. a); $10,000/(1+0.10)^{15} = 2,393.92$
23. a)
24. a)
25. b); $2,000/(1.04)^3 = 1,777.99$
26. a); $1,000 \times (1.03)^5 = 1,159.27$
27. d); The future amount in future dollars equals $1,000 \times (1-0.019)^5 = 909$
28. a); future dollars incl. inflation: $1,000 \times [(1.03)^5/(1.1025)^5] = 711.69$
c); today's dollars excl. inflation: $1,000 \times [(0.981)^5/(1.05)^5] = 711.87$
29. d)
30. c)
31. cashflow diagram



32. \$66,700
33. d)
34. b)
35. a)
36. b)
37. b)
38. b); the difference in LCC is less than 15% and A saves energy
39. b); LCC about the same; initial investment costs of A 50% higher
40. a)
41. b); $(28,000 \times 10 \times 0.5162 = 144,536$ (this is the non-FEMP factor)
42. a); Alternative A has lower LCC.
43. f) - all of the above
44. b); $19.40 \times 3,000 \times (1.05/1.07) = 57,112.15$
45. b)
46. b)
47. c)
48. d)
49. d)
50. a)

2.3 TALLY SHEET

CORRECT ANSWERS	1 b	2 b	3 e	4 b	5 d	6 differing	7 b
PRETEST	No _____ %	_____	_____	_____	_____	_____	_____
POSTTEST	No _____ %	_____	_____	_____	_____	_____	_____
TALLY FOR PRETEST							
TALLY FOR POSTTEST							

TALLY SHEET

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CORRECT ANSWERS	8 a	9 a	10 b	11 d,c	12 c	13 a	14 c
PRETEST	No _____ %	_____	_____	_____	_____	_____	_____
POSTTEST	No _____ %	_____	_____	_____	_____	_____	_____
TALLY FOR PRETEST							
TALLY FOR POSTTEST							

TALLY SHEET

CORRECT ANSWERS		15 b	16 b	17 b	18 c	19 b,b	20 c	21 d,c
PRETEST	$\frac{\text{No}}{\text{No}} \%$							
POSTTEST	$\frac{\text{No}}{\text{No}} \%$							
TALLY FOR PRETEST								
TALLY FOR POSTTEST								

TALLY SHEET

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CORRECT ANSWERS		22 a	23 a	24 a	25 b	26 a	27 d	28 a,c
PRETEST		No						
POSTTEST		%						
TALLY FOR PRETEST								
TALLY FOR POSTTEST								

TALLY SHEET

CORRECT ANSWERS	29 d	30 c	31 c-f diagr.	32 66,700	33 d	34 b	35 a
PRETEST	$\frac{\text{No}}{\text{No}} \%$						
POSTTEST	$\frac{\text{No}}{\text{No}} \%$						
TALLY FOR PRETEST							
TALLY FOR POSTTEST							

TALLY SHEET

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CORRECT ANSWERS	36 b	37 b	38 b	39 b	40 a	41 b	42 a
PRETEST	No _____ %	_____	_____	_____	_____	_____	_____
POSTTEST	No _____ %	_____	_____	_____	_____	_____	_____
TALLY FOR PRETEST							
TALLY FOR POSTTEST							

TALLY SHEET

CORRECT ANSWERS	43 f	44 b	45 b	46 b	47 c	48 d	49 d
PRETEST	$\frac{\text{No}}{\text{No}} \%$						
POSTTEST	$\frac{\text{No}}{\text{No}} \%$						
TALLY FOR PRETEST							
TALLY FOR POSTTEST							

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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

LESSON PLAN 3: AIDS TO LEARNING

This module is not part of the scheduled course of instruction. Rather, it is reference material which may be needed throughout the course.

Call the student's attention to this resource during the introduction to training materials given in Module 1, Orientation.

When the first acronyms and symbols are used, call the student's attention specifically to the list of acronyms and symbols in section 3.1.

Before starting Module 6, Arithmetic, remind students that they received instructions on using calculators prior to the course and are expected to know how to perform the operations required for the course. Point out that they can refer to the copy of instructions in section 3.2, if needed.

Bring up the issue of significant figures briefly in Module 6, stating that there are rules, but for the purpose of the arithmetic exercises -- where the focus is on performing calculations -- they will not be applied in that session. Bring up the issue again in Module 7, if there is time, or later during a review session. Direct students to section 3.3 and discuss the guidelines.

From time to time, ask students to think how they can apply a concept or technique to something back on the job. Ask them to jot down their ideas in section 3.4. State the requirement that everyone have at least one item on their list of ideas and applications by the end of the course. A quick way to verify compliance is to ask from time to time to see their sheets. A better approach is to announce that an instructor will meet with them to discuss their list of ideas sometime during the course and then schedule brief conferences.

The meetings can be scheduled during lunch or breaks or right after class, either singly or in groups of two or three.

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IN THE STUDENT'S MANUAL

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

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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 y^x

Calculate 5^3

<u>PRESS</u>	<u>DISPLAY</u>	<u>COMMENTS</u>
5	5.000	“y” value
y^x 3	3	Raise to power 3, the “x” value
=	125.000	Result: y^x

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

Calculate $6 \times (3+4)$

<u>PRESS</u>	<u>DISPLAY</u>	<u>COMMENTS</u>
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 $\frac{13.041 + 2.143 - 2.064}{4.843 + 3.219}$

<u>PRESS</u>	<u>DISPLAY</u>	<u>COMMENTS</u>
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.

<u>PRESS</u>	<u>DISPLAY</u>	<u>COMMENTS</u>
1.0265	1.0265	$1+e$
\div 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)
\div	-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 ten 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,

$$\begin{aligned} \$125 + \$4.27 + \$830 &= \$959.27, \text{ rounded to } \$960, \text{ if } \$830 \text{ is an} \\ &\text{approximation} \end{aligned}$$

$$\$1,597.54 + \$52.10 + \$2 = \$1,651.64, \text{ rounded to } \$1,652$$

- 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 \times 300 = \687 , but state it as about \$700, because the quantity input to the calculation has only one significant figure.

When to Apply Significant Figures Rule

- 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

LESSON PLAN 4: IMPROVING DECISIONS WITH EA/LCCA

Module 4 is intended to demonstrate that being able to perform EA/LCCA is a valuable skill, both for improving design of MILCON facilities and personal applications. It gives an overview of the methodology, Army and Air Force requirements, and target levels of performance. Students are asked to assess their current level of knowledge and skills.

TIME	OVERVIEW	TRAINING AIDS OR CUES
1000	<p>Ask students to turn to Module 4.</p> <p>Review the purpose of the module, the outline of 4, and the allotted time.</p> <p>Appoint an Audience Reaction Team and instruct them. (See Instructional Techniques -- Administrative.)</p> <p>Explain what is meant by EA, LCCA, EA/LCCA.</p>	<p>S4-1</p> <p>W4</p> <p>S4-2 (a-b)</p> <p>S4-3/4</p>
1008	<p>4.1 Ask them to turn page to beginning of 4.1. (First Costs vs LCC)</p> <p>Review specific learning objectives</p> <p>Contrast LCCA with First Costs in several examples.</p>	<p>Ws4.1</p> <p>S4-5</p>
1015	<p>4.2 Ask them to come up with design examples which need an LCC approach.</p> <p>Then present an example demonstrating that EA/LCCA can save money, and summarize principles.</p>	<p>Ws4.2</p> <p>S4-6</p> <p>S4-7/10</p>
1030	<p>4.3 Outline principal steps in performing EA/LCCA.</p>	<p>Ws4.3</p> <p>S4-11 (a-k)</p>
1100	<p>4.4 Give guidelines for when to perform EA/LCCA.</p> <p>When in principle & when to meet specific Army/Air Force requirements.</p>	<p>S4-12/13</p> <p>S4-14 (a-e)</p> <p>S4-15</p>
1130	<p>4.5 Discuss knowledge and skills design professionals need.</p> <p>Explain that the course is designed to give them the needed knowledge and skills.</p>	<p>Ws4.5</p>

(Key: S = slide, V = Vugraph, F = Flipchart, W = Workbook, s = section, N = Notebook)

LESSON PLAN 4: IMPROVING DECISIONS WITH EA/LCCA (continued)

TIME	OVERVIEW	TRAINING AIDS OR CUES
1145	<p>4.6 Pass out test results.</p> <p>Review learning objective. Give to each a page summarizing their results.</p> <p>Summarize test results for the class as a whole.</p> <p>Ask them to regard the course as a place to overcome any deficiencies indicated by the test. Tell them they will be tested again at the end of the course to determine progress made.</p>	<p>Ws4.6</p> <p>Test Scores</p> <p>Summary Scores</p>

(Key: S = slide, V = Vugraph, F = Flipchart, W = Workbook, s = section, N = Notebook)

If time remains: Review key points, then learning objectives of each section again, calling on students to demonstrate their achievement of the objectives.

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

- In this introductory module, you will
 - learn what life-cycle cost analysis is
 - see it demonstrated that the techniques you will learn this week can improve design decisions
 - find out when you should perform life-cycle cost analysis
 - learn exactly the knowledge and skills in economic analysis that HQ expects its design professionals to have
 - determine where you most need improvement by reviewing your test scores
- But before we go further, let me explain what we mean by “Economic Analysis/Life-Cycle Cost Analysis” -- terms which we frequently write in shorthand “EA/LCCA.”

Slide 4-2 (a - b)

Slide a has no highlighting. Slide b has the following words highlighted: alternative, time, benefits, costs.

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.

- We use the term “economic analysis” as it is generally used to refer to . . .

Put up slide b with highlights.

- Let me call your attention to several important aspects of economic analysis: we use it to compare alternatives; over time; with respect to their benefits and costs.

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.

- We use the term “life-cycle cost analysis” (or LCCA) to refer to a particular type of economic analysis having features which make it especially suitable for evaluating design decisions. LCCA is a type . . .
- There are other types of economic analysis, some of which we will also use in this course. But our emphasis is on LCCA.

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**

- LCCA has two characteristics which distinguish it from other types of economic analysis. (1) . . . , and (2) . . .

Go to flip chart

- We use the short hand notation "EA/LCCA" to refer to economic analysis with an emphasis on LCCA.

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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

LIFE-CYCLE COST ANALYSIS (LCCA) APPROACH
versus
FIRST COST APPROACH

- The LCC approach may be contrasted with the first-cost approach which simply chooses the alternative with the lowest first cost.
 - A first-cost approach is suitable for making choices among items for which first costs predominate, such as which brand of milk to buy.
 - We intuitively take an LCC approach (albeit informally) when we choose among many durable consumer goods such as automobiles. We think not only about the purchase price (i.e., the "first cost"), but also maintenance and repair costs, fuel costs, and resale value when we choose among alternative cars which will meet our needs equally well.
 - If the car with the lower first cost is also expected to have lower operating costs and/or higher resale value than its competitors, while performing equally well, there is little doubt about which to choose. The first-cost approach and the LCC approach are in sync.
 - But if the car with the lower first cost is expected to have higher operating costs and/or lower resale value, then it may not be the economic choice over the long run. In this case, the first-cost approach is inadequate; it may lead us to a uneconomic choice. We need an LCC approach.

- Taking the LCC approach, we may find after all that the alternative with the lower first costs is the economic choice. This would result if future costs were not low enough to compensate for the higher first costs.
 - On the other hand, we might find that the higher-first-cost alternative is the economic choice.
-
- Most consumers try to make the trade-offs among present and future costs, but they do it subjectively without rigorous analysis. But many public and private organizations require rigorous analysis according to specified criteria.
 - In this course you will learn how to use LCCA rigorously.

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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

DESIGN DECISIONS REQUIRING LCCA
EXAMPLES

- Let's think of some design decisions which need an LCC approach to solve.
 - Can you think of any?

Write on the flip chart any suggestions. And ask them what it is about each suggestion that causes them to think an LCC approach is needed.

Fallback examples:

- Windows: Glazing -- single, double, double (low emissivity), single with storms, triple
Window size
Overhangs versus no overhangs
- Floor coverings: vinyl versus terrazzo (in area with heavy traffic)
- HVAC systems: air conditioning system with seasonal energy efficiency rating (SEER) of 7.0 versus system with SEER of 9.1
- Exterior walls: painted stucco versus stucco with internal color
concrete, brick, wood, stucco, other
- Roof: built-up, shingles, tiles, metal
- Interior walls: metal assembly, wall board
- Lighting: type of lighting
daylight/artificial light tradeoffs

Slide 4-7

SELECTING A HEATING SYSTEM		
	<u>System A</u>	<u>System B</u>
Purchase & Install:	\$3,500	\$4,000
Efficiency:	0.68	0.87

- Let's look more closely at an example.
 - Suppose you had to choose a heating system for 50 houses on a military base in Nebraska.
 - Suppose you had two choices: System A with a lower energy efficiency and a lower first cost, and system B with a higher energy efficiency and a higher first cost.
 - Which would you choose?
 - How do you know which is best? Can you rely on first costs to decide?
 - What else do you need to know?

Write additional info on flip chart or board. Include: annual heating requirement, fuel oil prices (present & future), other affected costs, planned years to operate, the discount rate that indicates the government's time value of money, and retention/salvage values.

- LCCA provides a framework for making this decision.

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

- Here is the data needed to solve the problem . . .

Note to instructor: the multiplier is an OSAF factor which incorporates DOE-projected changes in energy prices over 25 years from the beneficial occupancy date (BOD), that is, the time the heating system is assumed to be put into use. This example assumes a DOS of June 1988 and a BOD of June 1990.

Slide 4-9

LCC_A = \$11,377	
LCC_B = \$10,157	
<hr style="width: 20%; margin: 0 auto;"/>	
Savings B:A	= \$1,220/house
Total Savings	= \$61,000

- LCC_A reveals that System B is estimated to be the cost-effective system.

The calculations are given below. If the class wishes to see them, it seems desirable to show them, and there is time, do so on the flip chart.

$$\begin{aligned} \text{LCC}_A &= \$3,500 + [(80 \text{ mill Btu}/.68)(\$4.64/\text{mill Btu})(25)(0.5772)] \\ &= \$11,377 \end{aligned}$$

$$\begin{aligned} \text{LCC}_B &= \$4,000 + [(80 \text{ mill Btu}/.87)(\$4.64/\text{mill Btu})(25)(0.5772)] \\ &= \$10,157 \end{aligned}$$

- Each unit is expected to save \$1,220 over the long term, and the total savings across all 50 houses is expected to be \$61,000.
- Making the choice on the basis of first cost would have wasted about \$61,000.
- And choosing System B without LCCA might be difficult to defend. No one would know whether it was the right decision or not.

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**

- In summary, LCCA is useful in design for choosing . . .

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

Day 1

Slides 4-11 (a - k)

Series with highlighting: a=title only, b-k= addition of each line, one-by-one, where only the addition is highlighted.

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

Walk them through each step. Emphasize importance of #1. Explain in general terms what each step entails, and indicate that the rest of the course is to elaborate on each of these steps so that they can do the 10 steps according to governing criteria.

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 requirement

CARDINAL RULES:

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

- Let's begin with a discussion of WHEN to do EA/LCCA in the sense of time.

Emphasize the importance of applying it early when decisions can be "made on paper," and repeating it as conditions change.

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**

- The Army and Air Force have very similar requirements and criteria for economic analysis.
- I will give a brief overview of those requirements now, and in later sessions we will go into the specifics.
 - There are three types of requirements for LCC-based economic studies as a part of designing facilities in the Military Construction Process (MCP).
 - The first type, and the one which is our primary focus of attention is General economic studies.
 - The second two types can be grouped together as Special Directed economic studies.

Slides 4-14 (a - e)

Series with highlighting: a=lines 1&2, b-d = each bullet item added one at a time, with new one highlighted, e=governing criteria only highlighted.

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]

- The objective of a general economic study is to determine the relative economic ranking of design alternatives. Preferred is the alternative which results in the lowest construction and operating costs consistent with total life-cycle economy.
 - For most design features, the designer will make the selection.
 - In the case of design features which are normally selected by the construction contractor from a list of approved alternatives provided by the designer, the ranking of alternatives identifies the relative cost effectiveness of the alternatives and may serve as the basis for eliminating the least economical from the list of options provided to the contractor.
 - The preferred system should be the alternative that results in the lowest construction and procurement costs consistent with total life-cycle economy. Note that it is not simply the alternative that is estimated to have the lowest LCC. In those cases where there is not a clear-cut difference in estimated LCCs of alternatives due to uncertainties in the estimates, other factors then take precedence in the ranking process: first costs and

energy costs. We will revisit this issue of the exact selection criteria later on.

- Were you aware that there is a basic requirement established by headquarters of each of the military services that an economic analysis be conducted routinely as part of the design process for all military facilities?
 - The requirement covers the evaluation of design alternatives throughout the facilities acquisition process -- from early planning stages through construction.
 - The requirement also applies to decisions throughout the design process, beginning with initial concept and predesign studies and extending through design modification decisions, including value engineering activities.
- The criteria and standards for conducting General Economic Studies are contained in Technical Manual (TM-5-802-1) which you will find in your notebook of documents.
- Turn to your TM, chapter 2, and you will find a section on criteria and standards

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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**

- Special requirements for economic analysis may be established by statute or executive order for specific design applications, such as
 - energy conservation and renewable energy designs
 - wastewater treatment facilities
- Congress, by statute, or the President, by Executive Order, can call for economic studies. These are usually in support of a specific national goal, such as to reduce consumption of non-renewable energy. A lead agency is designated and specific Federal regulations are developed which are codified in the Code of Federal Regulations.
 - Criteria for performing EA in support of energy conservation decisions are contained in 10 CFR 436, subpart A, and in NBS HB 135.
 - The TM also gives the criteria and standards for special directed economic studies in Chapter 2.
- Sometimes, in addition to the routine requirement for economic analysis, Headquarters, Department of Army (HQDA), the Office of the Secretary of Defense (OSD), or HQUSACE may require a special economic study on a one-time or limited application basis. This may be done, for example, to
 - collect data requested by a congressional committee
 - ensure that a study is conducted for a particular project

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- encourage consideration of a variety of alternative designs for a design feature that has been found to be a maintenance and repair problem
- to evaluate the effect of a proposed change in criteria on the design of a particular type of facility

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IN STUDENT'S MANUAL

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
- In your Workbook you will find a list of tasks related to economic analysis which we think you need to be able to do in order to perform your day-to-day jobs according to desired performance standards.

We developed this list of tasks by first identifying Army and Air Force requirements for economic analysis in construction design, and then determining what design engineers, cost engineers, and managers of the design process need to do to meet those requirements according to desired performance standards. We consider this the IDEAL.

- You saw this list of tasks in the Pretest. Look at it again quickly. What is your reaction?
- The list of tasks served as the basis for identifying specific knowledge and skills which are required. That is, to do the listed tasks well, you need to be able to understand certain concepts and be able to perform certain operations.

The list of knowledge and skills served as the basis for developing this training course, which is directed at improving job performance.

- In your Workbook you will also find the list of knowledge and skills. Look at it quickly.

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I suggest you use it

- as a checklist during the course to verify that you are learning what you need to know
- after the course to assist recall and application

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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.

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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

Pass out individual score sheets.

Discuss overall performance of class

Tell them not to be discouraged if they didn't do well. After all, they are here to learn.

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

LESSON PLAN 5: TIME VALUE OF MONEY CONCEPTS

Module 5 is designed to get across the point that money has a time value, and to prompt the students to think of different dollar amounts as being equivalent values in time. It teaches how time preference can be expressed in a discount rate, and how the discount rate can be used to calculate time-equivalent amounts. It explains the relevance of time/money relationships to capital spending decisions in general, and to Federal design decisions in particular. The topic is presented early in the course because the concepts and the calculation procedures are fundamental to the remaining sessions.

TIME	OVERVIEW	TRAINING AIDS OR CUES
1300	<p>Ask students to turn to Module 5.</p> <p>Review the purpose of the module, the outline, and allotted time.</p> <p>Select a new Audience Reaction Team. Remember to check with team members from time to time to see if they have any questions. Prompt and encourage them to participate.</p>	S5-1 W5.0
1303	<p>5.1 Ask them to turn page to beginning of 5.1.</p> <p>Review specific learning objectives of 5.1.</p> <p>Explain how & why to adjust for the timing of benefits and costs in EA/LCCA.</p>	W5.1 S5-2/12, F
1330	5.2 Review specific learning objectives of 5.2	W5.2
1333	Explain 2 ways to adjust for inflation	S5-13/22
1415	5.3 Review specific learning objectives of 5.3	W5.3
1418	Describe discount rates, with emphasis on Federal rates	S5-23/25
1430	<p>5.4 Review specific learning objectives of 5.4</p> <p>Explain what is meant by "cash flow modeling" and demonstrate how to construct a simple, generic cash flow diagram.</p>	W5.4 S5-26/28
1445	Announce Break	

(Key: S = slide, V = Vugraph, F = Flipchart, W = Workbook, s = section, N = Notebook)

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TIME VALUE OF MONEY CONCEPTS

Have this slide up while going over module objectives and outline.

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

**Paying or receiving a dollar tomorrow
is not equivalent to
paying or receiving a dollar today.**

Read statement. Then ask a student if given the choice of receiving \$100 cash today or a bank note with a guaranteed payment of \$100 one year from now, which he or she would choose. Use Props: \$100 bill or play money and representations of bank note face values ranging from \$100 to \$125, payable in 1 year.

- Most people prefer getting a hundred dollars today to getting \$100 next year.
- If you got the \$100 now, one year from now you could have more than \$100.
- But if I raised the future amount, eventually I could find a future amount which you would prefer to having \$100 today.

Ask same student if he or she would be willing to take a bank note with a value of \$105 one year from now instead of the \$100 today; \$108, \$109, etc. until the student switches to prefer the future amount. Identify the point of indifference -- i.e., the amount just before the cross over.

GO TO FLIP CHART

Write amounts on the flip chart, and verify with the student that he or she is indifferent between receiving \$100 today and \$x in one year. Then state that to "student" these are "time-equivalent amounts." Ask rest of class to think about what amount one year from now would be to them time-equivalent to \$100 today. Sample a few students.

Slide 5-3

TIME-EQUIVALENT VALUES

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

- Let me emphasize that when I say two dollar amounts are time equivalent, I mean that you would just as soon have one as the other.

GO TO FLIP CHART

Refer back to flip chart numbers that are time-equivalent values to the student, and work through the following calculations on the flip chart.

- Notice that from “student’s” time-equivalent numbers, we can determine his (her) minimum acceptable rate of return (MARR), that is the rate of return “student” requires to make him (her) just willing to trade present dollars for future dollars. How do we know “student’s” MARR? We can look at the two time-equivalent amounts and see that in order for the present amount, \$100, to equal the future amount, \$x, an annual rate of return of z percent is necessary. It’s easy to see in this case because we start with \$100 and end up with \$x in one year.
- What is the mathematical operation to determine MARR? Note that we can raise \$100 to \$x by multiplying \$100 times $(1+0.z)$. z, expressed as a percent, is “student’s” MARR; i.e., minimum acceptable rate of return on an annual basis. Unless “student” expects to receive back the initial amount of \$100, plus at least an additional z percent, he or she will not be willing to give up the \$100 now.

That is,

$$\$100 (1+0.z) = \$x$$

And, therefore, if we know the present amount \$100 and its future time-equivalent value \$x, we can solve for z as follows:

$$0.z = (\$x/\$100) - 1$$

- And, if we are given the future amount \$x to occur in one year and know that “student’s” MARR is z percent, we can easily solve for the present equivalent worth (denoted PW), by rearranging the equation and dividing \$x by (1+0.z), i.e.,

$$PW(1+0.z) = \$x,$$

$$PW = \$x/(1+0.z) = \$x [1/(1+0.z)]$$

$$PW = \$100$$

- We can use this same operation to find the “present worth equivalent” of any other future amount, such as of a \$275 cost to be paid one year from now.

$$\text{i.e., } PW = \$275/(1+0.z) = \$y$$

- We estimate that \$y today and \$275 one year from now are time-equivalent values to “student.” That is, we expect that he (she) would just as soon pay \$y today as pay \$275 in one year.
- When we go beyond one period (a year in the example), we can see the compounding effect. Suppose, for example, we want to estimate how much “student” would require in three years in order to be willing to give up \$100 now. Let’s call the future amount F.

$$\begin{aligned} F &= \$100 (1+0.z)(1+0.z)(1+0.z) \\ &= \$100 (1+0.z)^3 \\ &= \$w \end{aligned}$$

The compounding results because “student” requires a return on previous earnings. For example, if you earn 8% on a savings account in this period,

in the next period you want to receive interest on the original amount in the account plus interest on the previously earned interest which has been credited to your account.

- By like token, when we are given a future amount, and we want to compute its present worth equivalent, the compounding effect is present. Suppose, for example, we want to estimate how much “student” would be willing to give up today in order to get \$w in three years. That is, \$w is given, and its present worth, PW, is what we wish to find.

$$\begin{aligned}PW &= \$w [1/((1+0.z)(1+0.z)(1+0.z))] \\ &= \$w [1/(1+0.z)^3] \\ &= \$100\end{aligned}$$

- Note that multiple-year calculations are usually indicated simply by adding an exponent to $(1+0.z)$ to correspond to the number of years before the future amount occurs.
- I wonder if “another student” would be willing to give up \$500 today in order to receive \$5,000 in 15 years. If he went away and left us in charge of making decisions such as this for him, what would we need to know, and how could we figure out what to do?
- Suppose, in representing his interests, we have to choose for him between having \$2,000 today and the sum of \$1,000 in five years plus \$10,000 in 10 years. How would we go about making this decision?

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

- When we use a person or organization's minimum acceptable rate of return, or MARR, to find the present worth of a future amount, it is customary to call it a discount rate. We will call it a discount rate from now on.
- We use the symbol "D," or "d," depending on how we are handling inflation. For now, we will use D.
- The discount rate is the rate . . . We can use it to compute the present worth equivalent (PW) of a future amount (F), i.e., an amount today that we would be equally willing to pay or receive as to pay or receive a specified amount at a future time.

Ask what "student's" discount rate is. Sample several other students to reinforce the idea that the MARR is the discount rate.

Check with the Audience Reaction Team to see if any points require clarification. Ask one of the team members briefly to summarize the concept of time-equivalent values as they understand it.

Slide 5-5

DISCOUNT FORMULA**Single Present Worth (SPW) Formula**

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

- The equation we have been using to find the present value (PW) of a future amount (F) has a name. It is called the single present worth (or value) formula and is often abbreviated SPW or SPV in engineering economics textbooks. We will call it "Discount Formula" for short.
- The process of using the discount rate to find PW of F is usually called "Discounting."

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

- Think of the relevance of discounting to design decisions.
- Being able to compute the present worth of future amounts allows us correctly to make design choices that result in spending more up front in order either to save in future costs or increase future benefits, or both.
- It enables us to make economic tradeoffs between present and future dollars. By “economic” I mean choices that save or benefit more than they cost.

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?**

$$\text{PW} = \$3,000 [1/(1+0.15)^6] = \$1,297$$

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

- Let's take an example.

Walk through the example, emphasizing meaning of discount rate. Point out that the decision maker requires \$115 one year from now to be willing to part with \$100 today.

- Discounting shows that saving \$3,000 in six years is time-equivalent to saving only about \$1,300 today. Thus, present value savings are less than the present value costs of achieving the costs.
- Conclusion: not worthwhile for this person to spend \$1,500 today to avoid a cost of \$3,000 in six years. But what if a different person with a lower discount rate -- say 6% -- were faced with the same decision? Would it be worthwhile for that person to spend \$1,500 today to avoid a cost of \$3,000 in six years?

Why prefer

- receiving \$100 today to \$100 in the future?
- paying \$100 in the future instead of \$100 today?
 - Inflation/deflation
 - “Real” earning potential

- We’ve established that most people would rather receive \$100 today . . . or pay \$100 in the future . . .
- But why?
- “Student,” why do you require a return of z percent to make you willing to trade present dollars for future dollars?
- There are two major factors which account for the time value of money:
 - One is inflation -- or deflation -- which happens when the purchasing power of each dollar falls -- or rises.
 - The other is a real opportunity cost which reflects an earning potential over and above inflation.
- Some of you may have thought about these two factors when you identified your MARR value earlier -- perhaps as separate factors or as lumped together. Some of you may have picked a MARR based on rates of return you can get at a bank, or some other investment opportunity available to you. If you based your MARR on market rates, these factors -- expectation about inflation and a required earning potential over and above inflation -- are built in.

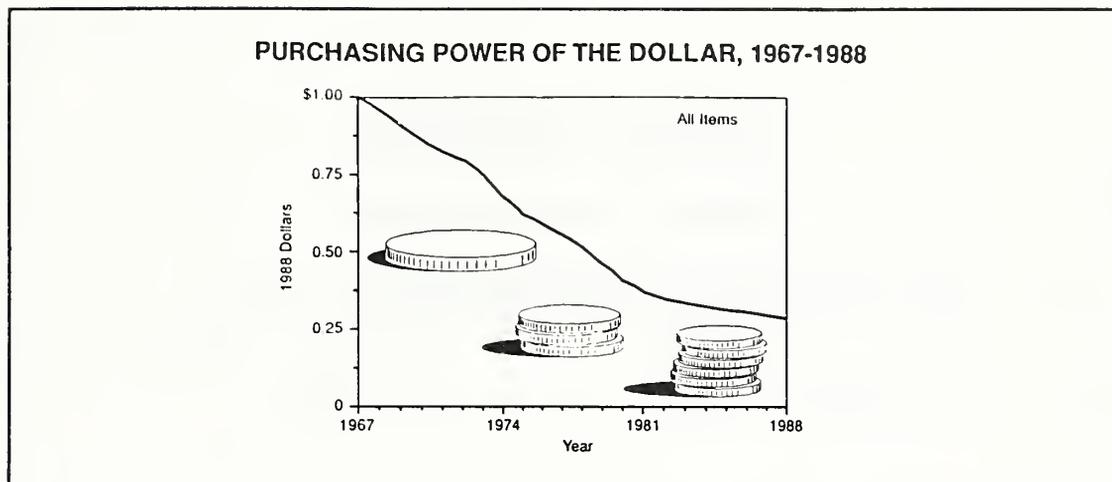
A third factor may be raised here: risk as an increasing function of time. Discuss it if it arises, but try to deemphasize it.

- We must adjust all dollar inputs to an EA/LCCA for both of these effects.
- Let's look more closely at each of these factors, starting with inflation.

Day 1

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Slide 5-9



- The dollar's purchasing power has not been stable over time.
 - From 1967 to 1988, for example, the dollar's buying power declined substantially. It took about four 1988 dollars to buy what one 1967 dollar would buy.
 - As inflation causes the purchasing power of the dollar to grow smaller, it takes more and more smaller-valued dollars to buy the same thing.
 - Inflation causes us to value a future dollar less than a present dollar because the purchasing power of the future dollar probably will have eroded by the time it occurs.

**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**

Discuss each bullet item on the slide. Emphasize that inflation changes the value of the unit of measure, but not necessarily the real condition measured.

- The dollar is the unit in which we measure economic effects.
- Comparing costs and benefits which are expressed in \$s with different purchasing power gives meaningless results. It is analogous to changing the foot (or meter's) length while taking measurements of a building's physical dimensions. How could you compare the size of two rooms if the measurements of one were taken with a measuring stick on which the foot were defined as this long (*indicate non-standard length*) and the other were taken with a measuring stick on which the foot were defined as this long (*indicate a different non-standard length*), unless you first adjusted the measurements to a standard unit of measure?
- Suppose your salary doubled during the period 1967 to 1988. Does this mean that you became able to buy twice the goods and services you could buy before 1967? No, in fact your buying power was approximately cut in half. We have to adjust for inflation to find out what really happened to your economic situation.
- Likewise we must adjust for inflation in performing EA/LCCA. Otherwise, our analysis is invalid.

Slide 5-11

REAL EARNING POTENTIAL OF MONEY IN HAND**("real opportunity cost")**

- But even if there were no price inflation, there is another important reason to adjust for the time value of money.
 - The sooner you receive a dollar, the sooner you can put it to use. To delay receiving it means a loss of potential earnings -- what economists like to call a "real opportunity cost incurred."
 - Likewise, the longer you defer paying a dollar you owe, the longer you get to use it yourself, or, if you have to borrow it to repay your debt, the longer you avoid borrowing costs, regardless of whether there is inflation or not.
- This is the other reason we must take into account the time value of money in EA/LCCA.
- It means valuing a dollar received in the future less than a dollar received at the present, even if each dollar has exactly the same purchasing power. This is an important point!

Ask "student" what rate of return he or she would require if it were certain that the dollar's purchasing power would remain fixed. Point out the inflation rate and the "real rate of return" implied by the answer. Explain that market rates of return reflect both components.

SUMMARY

Two Factors Account for Time Value of Money

- **Inflation/deflation**
(change in \$'s purchasing power)
- **Real opportunity cost**
(earnings lost)

State slide content.

- In the example, how did we adjust for the time value of money? By discounting, we adjusted for both components: inflation and real opportunity cost. "Student's" MARR reflected both his or her inflation assumption and real earning potential lost.
- We always adjust for the second item, i.e., real opportunity cost, by discounting dollar inputs in EA/LCCA.
- We also often adjust for the inflation component through discounting. But there is another way of adjusting for inflation which you need to know about.
- The next section explains, compares, and illustrates the two ways to treat inflation in EA/LCCA.

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

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)

- Let me begin by listing the two ways to adjust for inflation in EA/LCCA. They are
 - 1
 - 2

- As I said, the first way is straightforward.
 - Estimate future costs and benefits using prices you expect actually to occur in the future years. (Economists call these “current dollar prices,” short for “then-current prices.”)

 - Then discount the amounts to present worth equivalence, using a market (or nominal) discount rate that incorporates both the expected rate of future general price inflation, as well as the real opportunity cost. The discounting operation effectively removes the effects of price inflation and adjusts for real opportunity cost at the same time.

 - How might one estimate future costs and benefits in future year prices? The starting point is usually today’s price of the item in question -- information which is generally readily available. The next step is to estimate the rate of change that will occur in the actual price, taking into account both general price inflation and changes in demand and supply which may exert upward or downward pressure on prices in the future. Then it is a simple matter to escalate the starting price forward over time to estimate

the future amount. Of course, sometimes the overall rate of change may be negative, but I use the term “escalation” as a general term for applying the rate of change to the starting price, because positive change is typical. I use the symbol “E” for the escalation rate that includes general price inflation.

- Let me emphasize. By escalation, I refer to estimating a future price based on the price today and a projected rate of change in the price. The purpose of this operation is to obtain estimates of future costs and benefits which are inputs to EA/LCCA. These future amounts must then be discounted to present worth equivalence.
- If someone else provides the data for future year costs already expressed in dollars of those future years it is not necessary to escalate. But it is necessary to discount using a discount rate that also includes projected inflation, i.e., a nominal discount rate.

Make sure everyone understands the different purpose served by escalation and by discounting.

Day 1

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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) = ?

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

- Let's see an example of the first way to adjust for inflation: working in absolute terms.
 - Suppose you think the future inflation rate (I) will be 5% annually.
 - Suppose you are getting a rate of return 3% higher than the inflation rate on your best alternative use of funds; i.e., your real opportunity cost or real discount rate (d) = 3%.
 - What would your nominal discount rate (D) be in this case? (Note that we use D to indicate that inflation is included in the discount rate.)
 - To compensate you for both the inflation rate and the real opportunity cost requires a total minimum rate of return of about 8%, i.e., $D = 5\% + 3\%$ (approx).
 - But not exactly, because of interaction between the two rates.

GO TO FLIP CHART

- More precisely, $D = 0.05 + 0.03 + (0.05)(0.03) = 0.0815$ or 8.15%. Note that the cross product of the two rates is a component of D. A simple example illustrates the cross-product term: Suppose you gave your child an allowance of \$1.00 a day last year and the annual rate of inflation was

10%. Suppose you wish to raise the child's real buying power this year by 20%. By what percentage increase must you raise the allowance? Well, it takes \$1.10 just to stay even. The 20% raise must be applied to \$1.10; i.e., $\$1.10(1.20) = \1.32 . The rate of increase is 32%, not $10\% + 20\% = 30\%$.

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

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

$$D = (1+0.03)(1+0.05) - 1 = 0.0815 \text{ or } 8.15\%$$

and, therefore,

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

$$d = (1+0.0815)/(1+0.05) - 1 = 0.0300 \text{ or } 3\%$$

- Now let's suppose you want to find the present worth equivalent of an equipment replacement cost that you expect four years from now. You know what it would cost to make the replacement today (C_p), but you don't yet have an estimate of the actual replacement cost in four years (C_f), which you need for the EA/LCCA. You can use today's price as a starting point for estimating C_f .

$$C_p = \$1,000$$

- Suppose you think that the rate of change in actual price of the equipment (E) will be about the same rate as the rate of general price inflation (I), which we assume to be 5%.

$$E = I = 5\%$$

$$N = 4 \text{ years}$$

$$\begin{aligned} C_f &= C_p (1+E)^n \\ &= \$1000 (1+.05)^4 = \$1,215.51 \end{aligned}$$

- This gives us an estimate of the future cost in actual prices of that future year.

- Now we discount C_F to present worth using the discount rate which also includes inflation, 8.15%; i.e.,

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

SECOND WAY OF ADJUSTING FOR INFLATION:

Work in relative (Differential) terms

i.e., exclude general price inflation from

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

- Now let's look more closely at the second way to adjust for inflation in EA/LCCA.

Describe it again.

- Instead of putting inflation into future cost and benefit estimates and into the discount rate, we can simply leave it out of both future amounts and the discount rate. Taking this approach, future amounts are all entered into the EA/LCCA already in constant dollars.
- To estimate future costs and benefits, you can still use today's prices as a starting point for developing estimates. But instead of escalating them forward at a rate that reflects general price inflation and real changes in price due to changing demand and supply conditions, you take into account only the latter. I use the symbol "e" for the rate of escalation which excludes general price inflation.
- If someone else provides input data for an EA/LCCA and indicates that future amounts are expressed in constant dollars, note that you do not need to escalate. But you do need to discount the future amounts using a real discount rate.

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) = ?

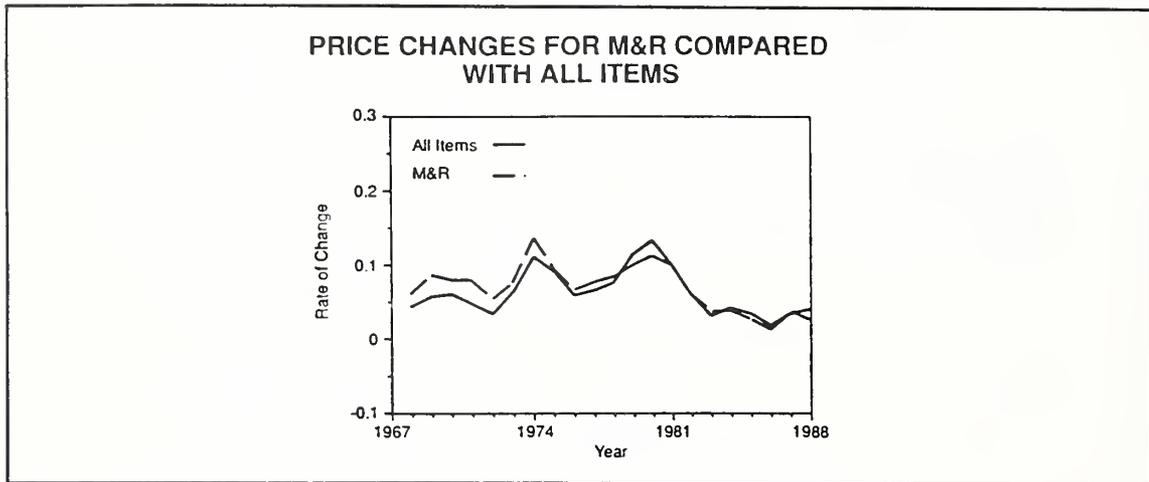
$$\begin{aligned} C_F &= C_p (1+e)^n \\ &= \$1,000 (1+0)^4 = \$1,000 \end{aligned}$$

Present worth (PW) = ?

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

- Let's redo the previous example using the second way of adjusting for inflation, the "relative" approach.
- This approach is a simplification which has advantages. We do not need to know what the inflation rate will be if we take this approach, because future prices and the discount rate are all expressed over and above inflation.
- Taking the relative approach, we use the real opportunity cost (d) as the discount rate; i.e., $d = 3\%$.
- If the replacement equipment increases in price at the same rate as prices in general, its relative, or differential, rate of change (e) is zero. Hence, C_F , stated in dollars with a constant purchasing power (what economists call "constant dollars") is \$1,000.
- Discounting C_F to present worth using $d = 3\%$, we find the identical amount as when we used $E = 5\%$ and $D = 8.15\%$.
- Now let's look at several graphs to further illustrate what we mean by absolute price change, E, and relative price change, e.

Slide 5-17



1967-88 price increases

All items

M&R

Absolute (E)

6.2%

6.8%

Relative, or differential, (e)

-

0.56%

- This first graph plots the annual rate of change in maintenance and repair costs (abbreviated M&R), together with the annual rate of change in prices in general.

Explain how to read the chart.

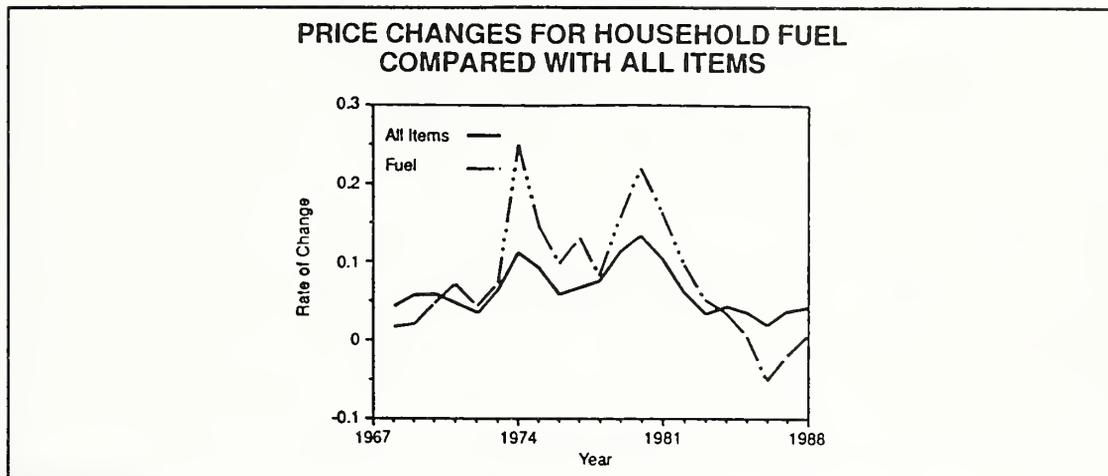
- The data are from the Consumer Price Index, which is a measure of price change compiled by the Department of Labor.
- First look at the dotted line which shows the annual rate of change in actual prices of M&R from 1967 through 1988. The rate of change in actual M&R prices (E) averaged 6.8% per year over the 21 year period, reflecting annual rates of about 7% from 1967 through 1972, 9% from 1973 through 1982, and 3% from 1983 through 1988.
- Suppose you wanted to use the first way of adjusting for inflation, i.e., to work in absolute or actual prices and discount with a nominal discount rate. Further suppose you assume that M&R prices will increase over the next 10 years at the average rate of change experienced over this past 21-year period. You

would set $E = 6.8\%$ for the purpose of escalating today's M&R cost out to the future years in which you expect those costs to occur. The resulting estimates would be in current dollars.

- Then to discount the future current dollar amounts to present worth, you should use a nominal discount rate which also includes an estimate for general price inflation.
- Suppose instead you wanted to use the second way of adjusting for inflation, i.e., to work in relative terms and discount with a real discount rate. Again suppose you assume that M&R prices will increase over the next 10 years at the average rate of change experienced over the period 1967-1988. Using this approach, you need to compare the rate of change in M&R with the rate of change in prices in general (the solid line labeled "all items") to find the relative rate of change in M&R prices. The annual rate of change in prices of "all items" averaged 6.2%.
 - Comparing 6.8 with 6.2%, we see that M&R prices changed at close to the same rate as prices in general. This means that M&R goods and services remained essentially unchanged in relative affordability. The value of e could be set at 0%, or more precisely at 0.56% (i.e., $e = (1.068/1.062) - 1$), for the purpose of estimating future M&R costs in constant dollars.
 - Then to discount the future amounts to present worth, you should use a real discount rate which also excludes general price inflation.

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Slide 5-18

1967-88 price increasesAll itemsFuel

Absolute (E)

6.2%

7.5%

Relative, or differential, (e)

-

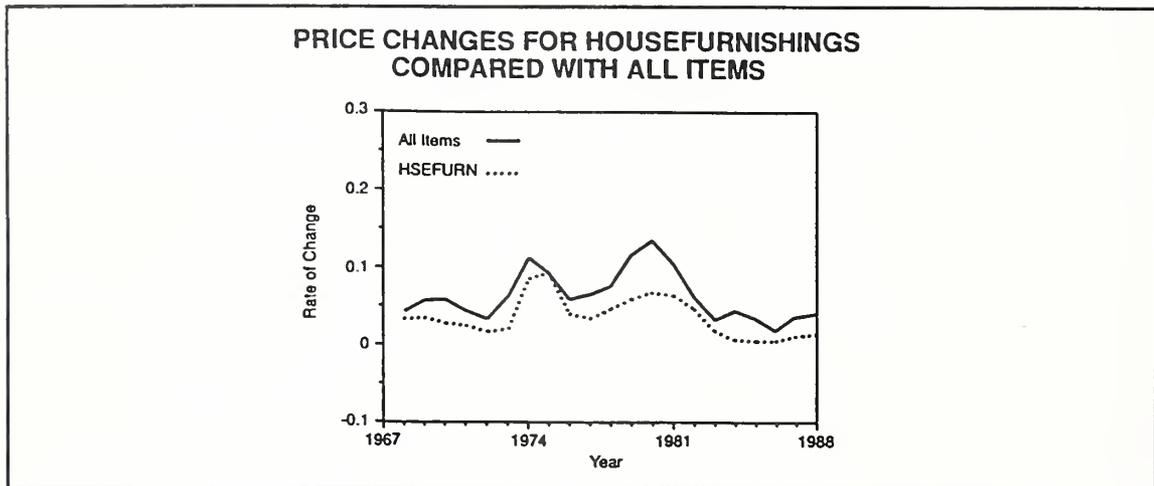
1.22%

- This second graph plots the annual rate of change in household fuel (dashed line), together with the annual rate of change in prices in general, "all items."

Explain again briefly how to read the chart.

- The rate of change in actual household fuel prices (E) averaged 7.5% over the 21 year period, reflecting high rates in 1974 and 1980 and low rates in the late 1960's and 1980's. Fuel oil prices increased on the average faster than prices in general, causing fuel to become relatively more costly.
- Suppose you wanted to use the first way of adjusting for inflation, i.e., to work in absolute or actual prices and discount with a nominal discount rate, and wanted to base future price estimates on the average rate of change during this period. What value of E would you use? Would the resulting estimates be in current or constant dollars? What type of discount rate, real or nominal?
- Suppose instead you wanted to use the second way of adjusting for inflation, i.e., to work in relative terms and discount with a real discount rate, and wanted to base future price estimates on the average rate of change during this period. What value of e would you use? Etc.

Slide 5-19



1967-88 price increases

All items

Furnishings

Absolute (E)

6.2%

3.5%

Relative, or differential, (e)

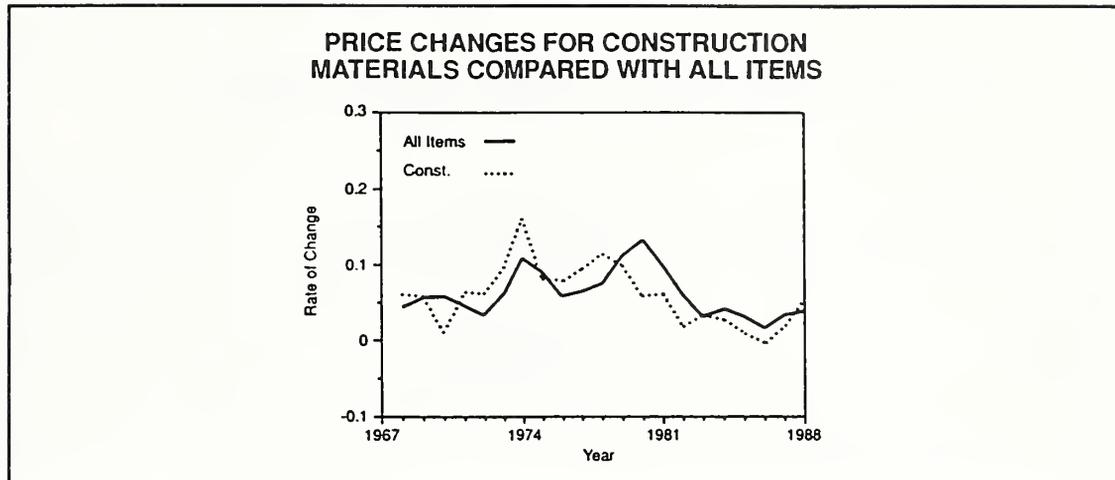
-

-2.5%

- Now let's look at a category of goods for which actual prices increased over the 21-year period, but at a rate relatively slower than prices in general.

Explain chart, and identify values of E and e.

Slide 5-20

1967-88 price increasesAll itemsConstruction

Absolute (E)

6.2%

5.9%

Relative, or differential, (e)

-

-0.3%

- Prices of construction materials are interesting to look at historically.

Briefly orient students to graph.

- The average rate of change is just slightly less than that for all items, meaning that the relative affordability of construction materials has changed very little over the entire period. But, as you can see, the two lines are divergent most of the time, with construction material prices first rising faster, then slower than most other prices.
- The relative pattern of change suggests that for long-run estimates of construction materials costs (as may be needed for replacement costs in EA/LCCA), assuming $e = 0$ is probably reasonable, but for short-run estimates (as are needed for budget purposes), a better forecasting model is needed.

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)

If there are questions about this topic, GO TO FLIP CHART and demonstrate (1) how E and e, and D and d, are related through the inflation rate, I; and (2) how inflation cancels out of the combined escalation/discounting equation. Otherwise, simply point out that they can find this demonstrated in their workbook.

$$E = \text{absolute (or actual) rate of change in the price of an item}$$

$$= (1+e)(1+I)-1, \text{ where}$$

$$e = \text{relative (or differential) rate of change in price as compared with}$$

$$\text{the rate of general price inflation, I,}$$

$$= (1+E)/(1+I)-1, \text{ where}$$

$$e = 0, \text{ when } E = I.$$

$$D = \text{market or nominal discount rate}$$

$$= (1+d)(1+I)-1, \text{ where}$$

$$d = \text{real discount rate, exclusive of general price inflation,}$$

$$= (1+D)/(1+I)-1.$$

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

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

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

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

Day 1

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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

Questions and answers

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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

DISCOUNT RATES FOR GOVERNMENT

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

- The Federal Government makes thousands of decisions every day which affect present and future expenditures. Just as individuals, businesses, and non-profit organizations require some minimum rate of return to be willing to incur higher first costs in order to obtain future savings or benefits, so does the Government.
- As in the private sector, the required rate of return is imposed by setting a discount rate. A design alternative will not appear cost effective unless the rate of return, in terms of fuel or M&R savings, is in excess of the discount rate.
- In this section we consider why the government should require a rate of return on higher-cost design alternatives. What should the rate or rates be? What are they in practice? And what is the effect of Government discount rates?
- Let's begin with Why.

Initiate discussion, asking questions such as the following:

- *Do you think it makes sense for the government to have discount rates?*
- *Is it sound economic practice?*
- *Are funds free to the Government?*

- Funding for government programs comes primarily from tax receipts and from borrowing in competition with private sector borrowers. Tax dollars are taken directly from the private sector. Government borrowing pushes up interest rates, which raises the cost of money to other borrowers. The use of tax money and borrowed money by the Government to construct buildings, dams, etc., and to buy equipment and materials imposes a cost on the private sector.
- Since the Government takes funds from the private sector, where they are expected to yield a return, there is an opportunity cost associated with Government expenditures. Use of a discount rate allows the Government to impose a required rate of return in making decisions affecting current and future spending, just as the discount rate allows individuals, businesses, and other organizations to impose a minimum acceptable rate of return.
- What should that discount rate be in theory? Should there be one or more?

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.)

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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

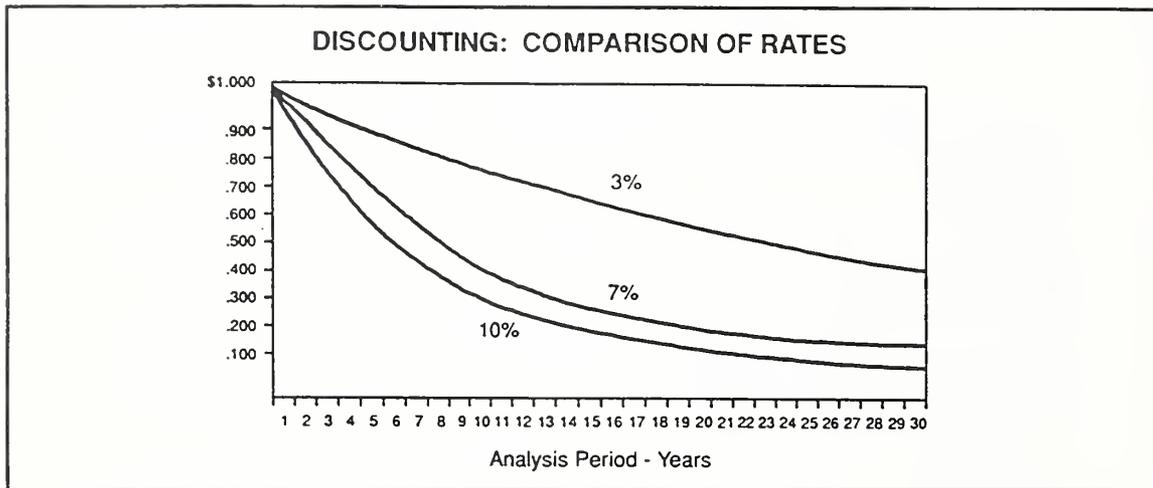
Review each of the four discount rates. Copy of OMB A-94 is included in Notebook of references.

- We will be concerned in this course primarily with the first two of these discount rates: 10% and 7%.
 - The 10% real discount rate is the most widely used in Government. It was set at 10% in the early 1970's to approximate the before-tax average annual return in the private sector. Many think the real return in the private sector is lower today than 10% and argue for a lower government discount rate.
 - The 7% real discount rate is a specially legislated rate. It was set lower than 10% to encourage federal investment in energy conservation.

Point out that legislation has changed the 7% real rate to a rate to be determined by the Secretary of Energy. This new rate will be set at the beginning of each fiscal year, beginning with FY 91.

- For lease-buy evaluations, which are concerned with how to obtain the use of real property rather than whether to obtain it, the discount rate is a nominal rate calculated by formula, as specified by OMB Circular A-104, rev. 1986.
- The discount rate which governs decisions regarding water projects and other National Economic Development (NED) programs, is calculated annually by the U.S. Treasury according to formula as specified by the Code of Federal Regulations.

Slide 5-25



- This slide shows the impact of the discount rate over time. The higher the discount rate and the longer into the future a dollar is received or paid, the lower its equivalent value today.

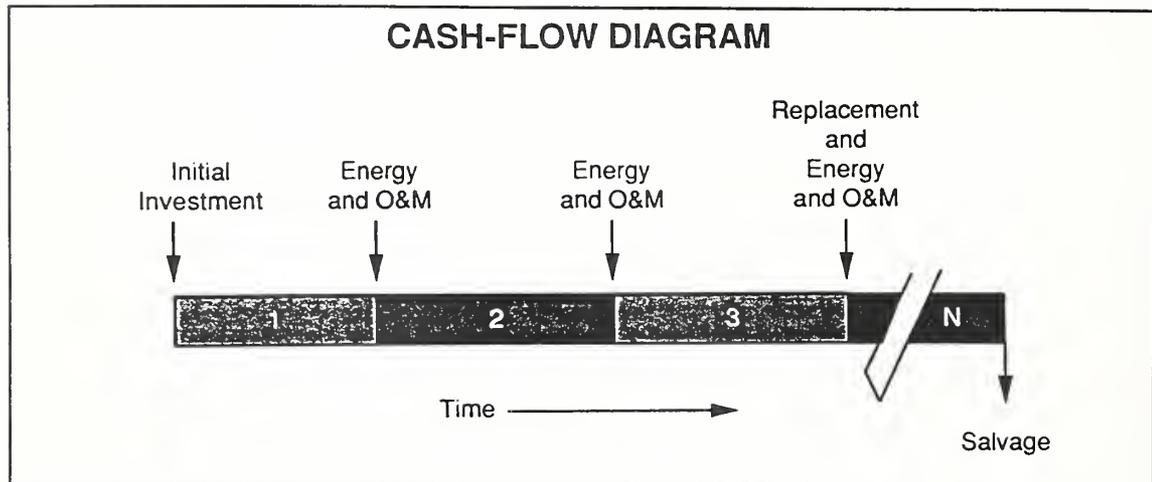
Give some examples.

- The higher the discount rate imposed, the lower the present worth equivalent of a future amount. Therefore, the higher the future savings and benefits required for a program or project to be acceptable on economic grounds. Hence, we would expect that the higher the discount rate, the less likely it is that design alternatives that cost more up front will be acceptable on grounds of their future savings.

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

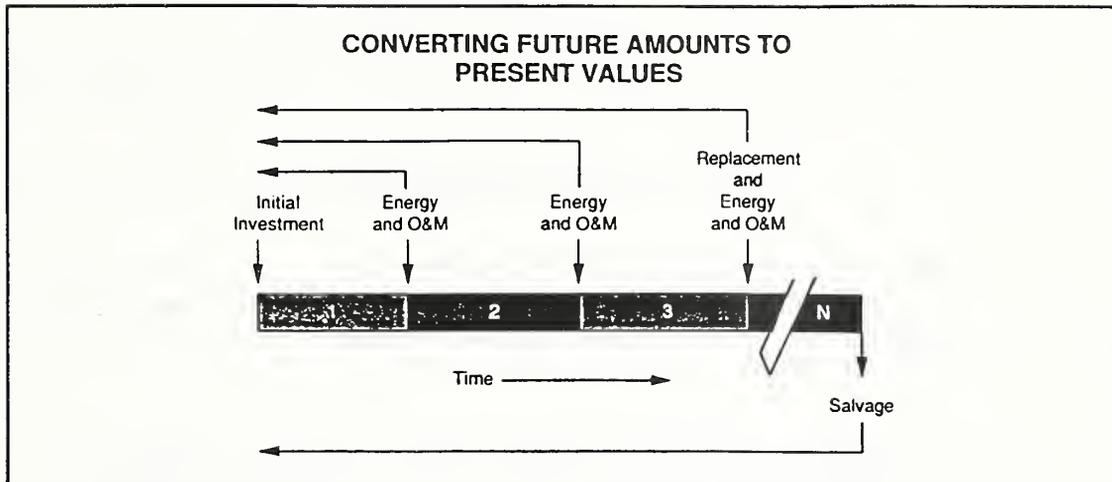


- The term “cash flow” is used to refer to the stream of costs and benefits measurable in dollars which arise from a decision.
- It is common practice in economics to develop a simplified model of the pattern of cash flow that is expected to result from a decision, rather than to attempt to predict with precision exactly when each dollar of cost or benefit will occur. Cash flow modeling makes calculations easier with little sacrifice in accuracy. It also facilitates data gathering.
 - Amounts that will occur at different times within a year are often modeled as though they occur as a lump sum, either at the beginning of the year, middle of the year, or end of the year, or as though they continuously flow throughout the year.
 - Amounts that are expected to more-or-less recur each year in the study period are usually modeled as a recurring series, either constant each year, increasing at a constant annual rate, or increasing at a rate that periodically changes.
- A cash flow diagram is a picture of how cash flows are to be represented.

- Diagramming cash flows provides a visual checklist of relevant effects, including their timing. It organizes data. It helps others grasp the problem quickly. It is easy to do because it is usually more of a sketch than a formal drawing and the conventions of cash flow modeling simplifies what is to be drawn.
- Here is a cash flow diagram that illustrates some of the conventions employed:
 - The horizontal line is a time scale moving from left to right.
 - Year labels are typically applied to intervals of time rather than points on the time scale unless specific dates are used, in which case the points are labeled with dates.
 - Note that the end of year 1 coincides with the beginning of year 2, etc.
- In this example, initial investment costs are depicted as occurring at the beginning of the study period, and the recurring energy and O&M costs occur as lump sums at the end of each year. Later on in the course we will develop cash flow diagrams that follow MILCON conventions for cash flow modeling. These diagrams will show key dates for MILCON design cash flows as points on the time scale and will include planning and construction periods.

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Slide 5-27



- Once the patterns of cash flows are established, the next step is to convert them all to a common time.
- The common time for expressing all cash flows can be
 - (1) the present, whereby all cash amounts are converted to an equivalent lump sum occurring now, that is, a **PRESENT WORTH OR VALUE**;
 - (2) annual, whereby all cash amounts are converted to an equivalent value occurring in a uniform amount each year over the study period, that is, an **ANNUAL VALUE**; or
 - (3) the future, whereby all cash amounts are converted to an equivalent lump sum occurring at some common time in the future, that is, a **FUTURE VALUE**.
- The common time we will use for EA/LCCA is the Present.

To make the transition to Module 6, announce that students will have the opportunity to practice the arithmetic of escalating and discounting in the next module, "The Arithmetic of LCC Analysis."

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

Day 1

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

LESSON PLAN 6: ARITHMETIC OF EA/LCCA

This module demonstrates how to do each type of calculation required for EA/LCCA using general formulas and "factors," and provides students practice under supervision.

TIME	OVERVIEW	TRAINING AIDS OR CUES
Day 1 1530- 1700 & Day 2 0800- 1200	ARITHMETIC OF EA/LCCA	S6-1
Day 1 1530	Ask students to turn to Module 6. Review the purpose of the module, the outline, and the allotted time.	
1533	6.1 Introduce section 6.1: [How to escalate to estimate future dollar costs & benefits based on today's price and projected rates of price change] Show general formula.	S6-2 S6-3
1600	6.2 Introduce section 6.2: [How to discount to compute the PW equivalent of a single future cost or benefit] Show general formulas for case where future amount is given. Introduce each problem example, show how it is solved on the board or flipchart and with slides, using formulas and factors.	B or F Examples 6.1-6.5 V esc table S6-s1/s5 S6-4 S6-5 (a & b) B or F Examples 6.6-6.8 V disc table S6-s6/s8

(Key: S = Slide, S-s = Solution Slide, V = Vugraph, F = Flipchart, B = Blackboard, W = Workbook, N = Notebook)

LESSON PLAN 6: ARITHMETIC OF EA/LCCA (continued)

TIME	OVERVIEW	TRAINING AIDS OR CUES
	<p>Show general formulas for combined escalation/discounting for case where future amount is to be estimated in combination with discounting.</p> <p>Continue with problem examples.</p>	<p>S6-6 (a & b)</p> <p>B or F Examples 6.9-6.10 V esc table V disc table S6-s9/s10</p>
1630	<p>6.3 Introduce section 6.3: [How to escalate and discount in combination to compute the present worth equivalent of a series of future costs or benefits]</p> <p>Show general formula.</p> <p>Introduce each problem example, show how it is solved on the board or flipchart and with slides, using formulas or factors or both.</p> <p>Try to complete through example 6.13.</p>	<p>S6-7</p> <p>S6-8</p> <p>Examples 6.11-6.13 V ann series table S6-s11/s13</p>
1700	END OF DAY 1	
Day 2		
0800	REVIEW time value of money concepts and basic discounting operations. Then review basic escalation operations.	<p>B or F V esc/disc/ann series tables</p>
0830	6.3 Complete demonstration of combined escalation/discounting of series of future amounts.	<p>Examples 6.14-6.17 S6-s14/s17</p>
0930	Announce break	

(Key: S = Slide, S-s = Solution Slide, V = Vugraph, F = Flipchart, B = Blackboard, W = Workbook, N = Notebook)

LESSON PLAN 6: ARITHMETIC OF EA/LCCA (continued)

TIME	OVERVIEW	TRAINING AIDS OR CUES
0945	<p>6.4 Announce Exercise 6-1: Escalation/Discounting</p> <p>Escalation and Discounting Problems to be solved by students. If short of time, assign just those problems in "Contingency Plans."</p> <p>Review solutions to Exercise 6-1.</p>	<p>Exercise 6-1</p> <p>S6-s18/s47</p>
1100	<p>6.5 Introduce section 6.5: [How to compute LCC for a generic case].</p> <p>Demonstrate how to compute LCC.</p>	LCC Example
1130	<p>6.6 Announce Exercise 6-2: LCC</p> <p>Problem to be solved by students</p> <p>Review solution to Exercise 6-2.</p>	<p>S6-s48/s50</p> <p>Exercise 6-2</p> <p>B or F</p> <p>S6-s51/s53</p>
1200	LUNCH	

(Key: S = Slide, S-s = Solution Slide, V = Vugraph, F = Flipchart, B = Blackboard, W = Workbook, N = Notebook)

Day 1

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Slide 6-1

ARITHMETIC OF ECONOMIC ANALYSIS/LCCA

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

Put this slide up while introducing Module 6.

- Now that you have the basic concepts behind discounting and escalation, let's work on developing your computational skills.
- In this module we go through the arithmetic of escalating and discounting cash flows. We will cover all of the escalating and discounting operations you are likely to need for performing EA/LCCA. We will start with simple cash flows and progress to the more complex. We end the module by putting together various cash flows in a simple LCC analysis.
- Here we focus on the arithmetic. In this module our purpose is not to present realistic design problems; we use generic cash flows in order to emphasize the various patterns of cash flow and how to treat them. We use exact amounts for the cash flows and carry out computations to the nearest dollar.
- We will teach you two ways to escalate and discount: (1) by using FORMULAS and (2) by using precalculated FACTORS looked up in tables. The formulas and factors we will use in this module are those generally used in engineering economics. Later, in Module 7 we will introduce you to specialized factors generated specifically for MILCON use.
- You will use the computational skills developed in this module to perform General Economic Studies for MILCON in Module 7.

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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

**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**

Put this slide up while reviewing the learning objective of section 6.1, and outlining the topics to be covered.

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

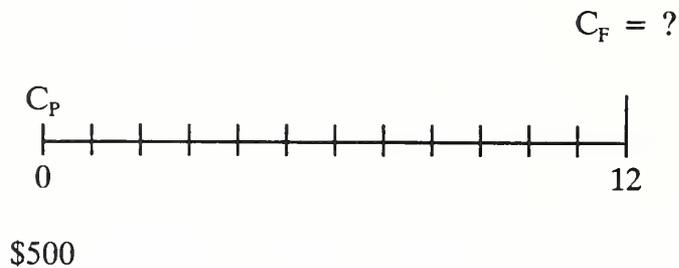
C_f = cost of an item to occur in the future as of that future time

Define C_p and C_f and discuss the formula and cash-flow diagram. Make sure they understand that C_p and C_f are not time-equivalent values to the decision maker.

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?



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

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

Demonstrate how to solve the problem using the formula.

Introduce solution using factors.

- Note that for $e = 0.10$ and $n = 12$, a multiplier, 3.1384, is computed from the term $(1 + 0.10)^{12}$. A different multiplier can be computed for each value of e and n . This has been done and the multipliers compiled in a table.

Show the vignette of Escalation Factor Table. Explain how it is set up and how to find the right table. Ask them to take the set of tables out of their notebook and find the escalation factor table. Ask them to find the factor 3.138 in their table.

- Here is a table of escalation factors. This table is from the TM. Look in the 10% escalation rate column and the 12 year row. At the intersection find 3.138. The look-up factors are given to three decimal places in the TM tables.

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 .

Day 1

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ESCALATION FACTOR TABLE

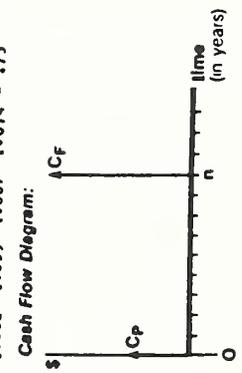
10% ESCALATION

ESCALATION FACTOR TABLE

YEARS TO ESCALATE	ANNUAL ESCALATION RATE												YEARS TO ESCALATE				
	-5%	-4%	-3%	-2%	-1%	0%	1%	2%	3%	4%	5%	6%		7%	8%	9%	10%
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	1.081	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	2.852	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	1.663	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	48.377	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

12 YEARS



Escalation Factor = $(1 + e)^n$
 where e = annual escalation rate
 n = 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.

$$\begin{aligned}C_p &= \$500 \\n &= 12 \\e &= -0.03 \\C_F &= ?\end{aligned}$$

$\begin{aligned}C_F &= \$500 \times (1-0.03)^{12} \\&= \$500 \times 0.6938 \\&= \$347\end{aligned}$

- Note that we use the term "escalation" as a general term to mean rate of change, regardless of whether it is negative or positive.

Demonstrate how the problem is solved.

Show an Escalation Factor Table on the vugraph (this time one without a factor highlighted).

- Alternatively, look up the escalation factor for 12 years and an escalation rate of -3% in the Escalation Factor Table. Find it. What is it? It is 0.694, and it gives you the same result as using the formula (aside from possible differences due to rounding).

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.

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

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

Demonstrate how to solve the problem.

Ask them to find the factor. Ask what it is. Then show the previous Escalation Factor Table again on the vugraph and show where the factor is located.

- Looking in the Escalation Table, in the column for a zero annual escalation rate, you will find the number 1.000 as the escalation factor. Whenever the escalation rate is zero, the factor equals n.
- When would a "zero escalation" rate be appropriate for estimating a future amount?
 - (1) If one works in absolute (actual) terms and there is no inflation, or
 - (2) If one works in relative terms and there is no difference between the rate of change in prices of the item in question and the rate of change in prices of all items.
- Recall that we use E to indicate that the escalation rate is the projected rate of change in actual prices, including general price inflation, and e to indicate it is a differential rate, over and above the rate of change in the general price level. Using E gives an estimated future amount stated in projected actual dollars of the future time (i.e., in current dollars). Using e gives an estimated future amount stated in constantly valued dollars (i.e., in constant dollars).

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?

$$\begin{aligned}
 C_p &= \$500 \\
 n &= 12 \\
 e &= 0.10 \\
 I &= 0.05 \\
 E &= (1+e)(1+I) - 1 \\
 C_F &= ?
 \end{aligned}$$

C_F	$=$	$\$500 \times (1+E)^{12}$
E	$=$	$(1+0.10)(1+0.05) - 1 = 0.155$
C_F	$=$	$\$500 \times (1+0.155)^{12}$
	$=$	$\$500 \times 5.6362$
	$=$	$\$2,818$

Demonstrate how to solve the problem.

- In order to be able to state the future amount in current dollars, you need the nominal rate of escalation, E, which includes both inflation and the differential rate of escalation. Since you know the inflation rate and the differential escalation rate, you can calculate E.
- The Escalation Factor table does not extend to escalation rates beyond 10%. Furthermore, it contains factors only for integer values from -5% to +10%. To use it for non-integer escalation rates requires interpolation, as we will demonstrate later.
- Insert the E value in the escalation equation and solve for C_F .

Remind them that the resulting estimate is in then-current dollars.

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} $

Demonstrate how to solve the problem.

- To state the future cost in constant dollars, you need the differential rate of escalation. Calculate it. Since it does not appear in the Escalation Factor Table, use the formula as shown to calculate C_F or interpolate to find the factor in the table. (It is easier to calculate it.)

Remind them that the resulting estimate of C_F is in constant dollars.

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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

**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**

Put this slide up while reviewing the learning objective of section 6.2, and outlining the topics to be covered.

Slide a has "d" in formula highlighted; slide b replaces "d" with "D" in formula and highlights it.

Slide 6-5 (a & b)

To find PW when C_f is known

PW? <----- C_f

Discount Formula: Single Present Worth (SPW)

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

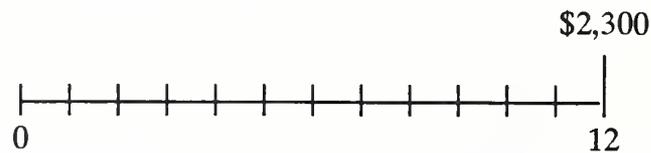
Explain that we begin with the case where C_f is given, i.e., we do not need to estimate it as part of the calculation. This is the formula for that case. Discuss the formula and cash-flow diagram in general. Then point out that d in the formula means that this version is appropriate for discounting given future amounts which are expressed in constant dollars.

Change slide to b with D highlighted, and point out that D in the formula means that it is appropriate for discounting given future amounts which are expressed in then-current dollars.

Go back to slide a while introducing example 6.6 because it requires d .

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?



$$PW = ?$$

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

$\begin{aligned} PW &= \$2,300 \times 1/(1+0.07)^{12} \\ &= \$2,300 \times 0.4440 \\ \\ PW &= \$1,021 \end{aligned}$
--

Demonstrate how to solve the problem.

Show vugraph of Discount Factor Table.

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.

Show factor 0.444 in vugraph of Discount Factor Table and show how it would be used to solve the problem.

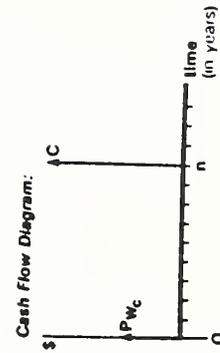
DISCOUNT FACTOR TABLE

7% DISCOUNT RATE DISCOUNT FACTOR TABLE

YEARS	DISCOUNT RATE %	YEARS
1	0.9313	1
2	0.8734	2
3	0.8163	3
4	0.7629	4
5	0.7130	5
6	0.6667	6
7	0.6227	7
8	0.5820	8
9	0.5439	9
10	0.5083	10
11	0.4751	11
12	0.4440	12
13		13
14		14
15		15
16		16
17		17
18	0.2959	18
19	0.2765	19
20	0.2584	20
21	0.2415	21
22	0.2257	22
23	0.2109	23
24	0.1971	24
25	0.1842	25
26	0.1722	26
27	0.1609	27
28	0.1504	28
29	0.1406	29
30	0.1314	30
35	0.0937	35
40	0.0668	40
45	0.0476	45
50	0.0339	50
.25	0.9812	.25
.50	0.9667	.50
.75	0.9505	.75

12 YEARS

0.4440



$$\text{Discount Factor} = \frac{1}{(1 + d)^n}$$

where d = discount rate
 n = number of discounting periods

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%.

$$\begin{aligned}C_F &= \$5,000 \\n &= 12 \\d &= 0.07 \\I &= 0.03 \\D &= (1+d)(1+I) - 1 \\PW &= ?\end{aligned}$$

$\begin{aligned}PW &= \$5,000 \times 1/(1+D)^n \\D &= (1+0.07)(1+0.03) - 1 = 0.1021 \\PW &= \$5,000 \times 1/(1+0.1021)^{12} \\&= \$5,000 \times 0.3114 \\ \\PW &= \$1,557\end{aligned}$
--

Change slide to 6-5b, showing D.

Demonstrate how to solve the problem, noting the need for a nominal discount rate. Calculate D. Point out that factors for D = 10.21% are not in the Discount Factor Table, and therefore we use the formula.

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 \times 1/(1+d)^n \\ d &= (1+0.102)/(1+0.03) - 1 = 0.07 \\ PW &= \$3,507 \times 1/(1+0.07)^{12} \\ &= \$3,507 \times 0.4440 \\ \\ PW &= \$1,557 \end{aligned} $
--

Point out that the \$5,000 of problem 6.7 was in current dollars, reflecting an annual inflation rate of 3%. Therefore, we can remove 3% annual inflation from \$5,000 over 12 years to restate the same cost in constant dollars, i.e., \$3,507. Demonstrate how to solve the problem with the future cost stated in constant dollars, pointing out that a real discount rate is needed. Calculate d. Point out that the present worth amounts in problems 6.7 and 6.8 are the same. This is because \$5,000 in current dollars equals \$3,507 in constant dollars when the inflation rate is 3%, and the nominal discount rate 10.2 equals the real discount rate 7% when the inflation rate is 3%. The point of doing this is to demonstrate again the equivalence of the two ways of treating inflation: putting it in or leaving it out.

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Slide a has "e" and "d" in formula highlighted; slide b replaces "e" with "E" and "d" with "D" and highlights them.

Slide 6-6 (a - b)

To find PW when C_F has to be estimated

PW? <----- C_F ?

Escalation Formula combined with Discount Formula

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

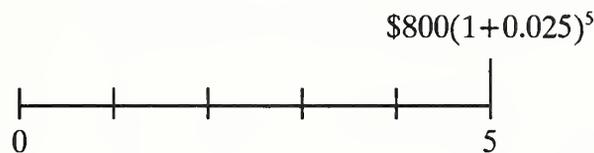
Show slide 6-6a and explain that it is the formula we will use to find PW of a single future amount when the future amount C_F must first be estimated in constant dollars from today's amount C_p . Note that C_F does not appear in the formula because its value is computed as an intermediate step.

Show slide 6-6b and explain that we will use it to find PW when the future amount must first be estimated in current dollars. Switch back to 6-6a for problem 6.9.

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 five years from now. The cost would be \$800 if it occurred today; price escalation over the next five years is projected at an annual differential rate of 2.5%. The annual real discount rate is 7%.

$$\begin{aligned} C_p &= \$800 \\ n &= 5 \\ d &= 0.07 \\ e &= 0.025 \\ PW &= ? \end{aligned}$$



$$PW = ?$$

$$\begin{aligned} PW &= \$800 \times \frac{(1+0.025)^5}{(1+0.07)^5} \\ &= \$800 \times \frac{1.1314}{1.4026} \\ &= \$800 \times 0.80667 \\ PW &= \$645 \end{aligned}$$

(Note: carried through in calculator)

Demonstrate how to work the problem using the formula.

Show how to use the factors in combination, with interpolation. Ask them to find their Escalation and Discount Factor Tables. First show on the vugraph of the Escalation Factor Table and interpolate to find the factor, and then show the Discount Factor Table.

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%.

$$0.055 \times 0.5 = 0.0275$$

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

$$1.104 + 0.0275 = 1.131$$

- To summarize:

$\text{Escalation Factor for 2.5\%, 5yr} = 1.104 + 0.5(1.159-1.104) = 1.131$
--

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

Use these two factors in combination to calculate the PW:

$\begin{aligned} \text{PW} &= C_p \times \text{escalation factor} \times \text{discount factor} \\ &= \$800 \times 1.131 \times 0.713 \\ &= \$800 \times 0.807 \\ \text{PW} &= \$646 \text{ (note small difference due to rounding)} \end{aligned}$

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.

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

$$\begin{aligned}
 PW &= \$800 \times \frac{(1+E)^5}{(1+D)^5} \\
 E &= (1+0.025)(1+0.06) - 1 = 0.0865 \\
 D &= (1+0.07)(1+0.06) - 1 = 0.1342 \\
 PW &= \$800 \times \frac{(1.0865)^5}{(1.1342)^5} \\
 &= \$800 \times 0.8067 \\
 &= \$645
 \end{aligned}$$

(Note: carried through in calculator)

Put slide 6-6b back up.

Demonstrate how to solve the problem.

- Remember, if you compute the future amount in current dollars, you use escalation rate E. To calculate the present worth of a future amount in current dollars, use a nominal discount rate D. Note that the result is identical to that

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obtained by using a differential escalation rate and a real discount rate, as demonstrated in the previous example. Let's just calculate it using the formula instead of using factors because $D = 13.42\%$ is not in our set of tables, and we would have to interpolate to find the escalation factor for $E = 8.65\%$.

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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

**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**

Put this slide up while discussing the learning objective of this section.

Slide 6-8

To find PW when A_1 is known

A_1 = initial amount in the series

Annual cash-flow-series equivalence formula

$$PW = A_1 \times (v^k - 1)/(v - 1)$$

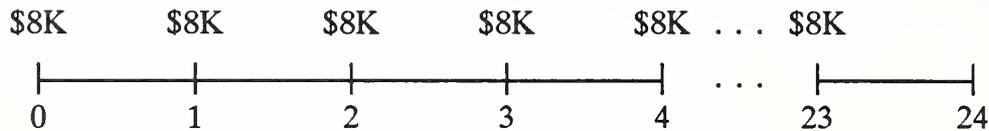
where $v = (1+e)/(1+d)$ and $e \neq d$

Explain the formula and discuss how we will use it to solve problems given in examples 6.11 through 6.17.

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%.

$$\begin{aligned} A_1 &= \$8,000 \\ k &= 25 \\ d &= 0.10 \\ e &= 0 \\ PW &= ? \end{aligned}$$



$$PW = ?$$

$$\begin{aligned} PW &= \$8,000 \times (v^k - 1) / (v - 1) \\ &= \$8,000 \times [((1+0)/(1+0.10))^{25} - 1] / [(1+0)/(1+0.10) - 1] \\ &= \$8,000 \times 9.985 \\ \\ PW &= \$79,878 \end{aligned}$$

Demonstrate how to solve the problem using the equation. Note again that the result shown is obtained by carrying through all the calculations in the calculator, rather than rounding at intermediate steps.

Ask them to find the Annual Series Table in the set, show it on the vugraph and explain how it is set up and how to use it. Explain how it differs from the two previous Factor Tables.

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.

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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.

$$\begin{aligned} A_1 &= \$8,000 \\ k &= 25 \\ d &= 0.10 \\ e &= 0.04 \\ PW &= ? \end{aligned}$$



PW = ?

$$\begin{aligned} PW &= \$8,000 \times (v^k - 1)/(v - 1) \\ &= \$8,000 \times [((1 + 0.04)/(1 + 0.10))^25 - 1]/[(1 + 0.04)/(1 + 0.10) - 1] \\ &= 8,000 \times 13.822 \\ PW &= \$110,580 \end{aligned}$$

Demonstrate how to solve the problem using the equation and then using the factor.

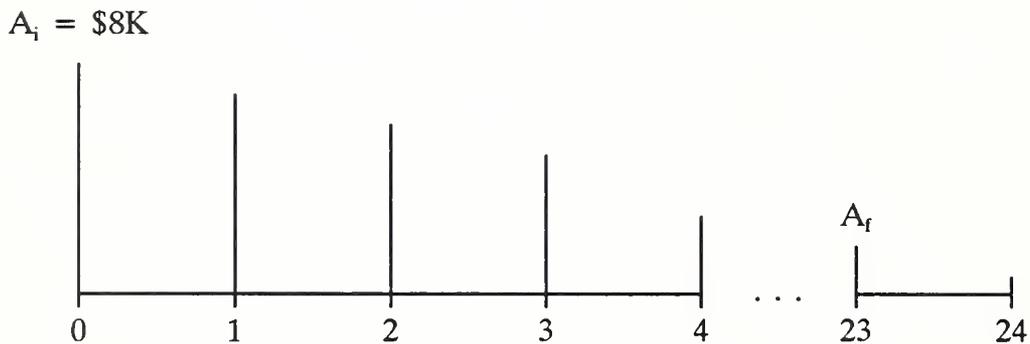
Alternatively, look up the annual series factor in the table. For $e = 4\%$, and $k = 25$, it is 13.822.

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.

$$\begin{aligned} A_1 &= \$8,000 \\ k &= 25 \\ d &= 0.10 \\ e &= -0.04 \\ PW &= ? \end{aligned}$$



PW = ?

$$\begin{aligned} PW &= \$8,000 \times (v^k - 1) / (v - 1) \\ &= \$8,000 \times [((1 - 0.04) / (1 + 0.10))^{25} - 1] / [(1 - 0.04) / (1 + 0.10) - 1] \\ &= \$8,000 \times 7.596 \\ \\ PW &= \$60,766 \end{aligned}$$

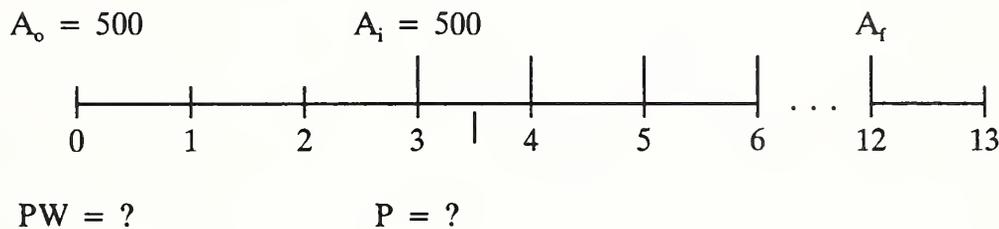
Demonstrate how to solve the problem using the equation. Then show solution by factor.

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 three 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.

$$\begin{array}{rcl} A_0 & = & \$500 \\ n & = & 3 \\ PW & = & ? \end{array} \qquad \begin{array}{rcl} e & = & 0 \\ k & = & 10 \\ d & = & 0.07 \end{array}$$



Demonstrate how to solve the problem by equation in three steps. Then show the solution by factors.

SOLUTION:

STEP 1: Calculate the magnitude of the initial cost of the series (A_1):

$$\begin{aligned} A_1 &= A_0 \times (1+e)^n \\ &= \$500 \times (1+0)^3 \\ &= \$500 \end{aligned}$$

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):

$$\begin{aligned}
 P &= A_i \times (v^k - 1) / (v - 1) \\
 &= \$500 \times [((1+0)/(1+0.07))^{10} - 1] / [(1+0)/(1+0.07) - 1] \\
 &= \$500 \times 7.515 \\
 &= \$3,758 \quad \text{(Note that this is the time equivalent value of} \\
 &\quad \text{the series 3 years after the beginning of the} \\
 &\quad \text{analysis period. We need it as of the} \\
 &\quad \text{beginning of the analysis period.)}
 \end{aligned}$$

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

$$\begin{aligned}
 PW &= P \times \frac{1}{(1+d)^n} \\
 PW &= \$3,758 \times \frac{1}{(1+0.07)^3} \\
 &= \$3,758 \times 0.8163 \\
 PW &= \$3,068
 \end{aligned}$$

Alternatively, solve the problem using factors:

$$\begin{aligned} A_i &= \$500 \times 1.000 \quad (\text{escalation factor from Escalation Factor Table, for} \\ & \quad e = 0\%, n = 3) \\ &= \$500 \end{aligned}$$

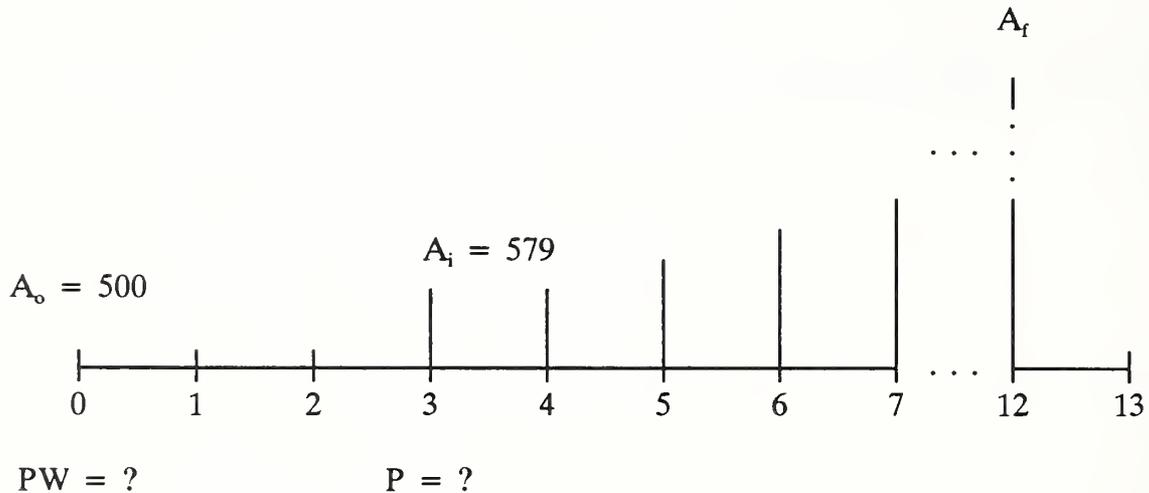
$$\begin{aligned} P &= \$500 \times 7.515 \quad (\text{annual series factor from Annual Series Factor Table,} \\ & \quad \text{for } d = 7\%, e = 0\%, k = 10) \\ &= \$3,758 \end{aligned}$$

$$\begin{aligned} PW &= \$3,758 \times 0.8163 \quad (\text{discount factor from Discount Factor Table, for} \\ & \quad d = 7\%, n = 3) \\ &= \$3,068 \end{aligned}$$

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_0	=	\$500	e	=	0.05
A_i	=	$A_0 \times (1+e)^n$	k	=	10
n	=	3	d	=	0.07
PW	=	?			



Demonstrate solution by equation using the three steps. Then show solution by factors.

SOLUTION:

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

$$\begin{aligned}
 A_i &= \$500 \times (1+0.05)^3 \\
 &= \$500 \times 1.158 \\
 &= \$579
 \end{aligned}$$

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):

$$\begin{aligned}
 P &= A_1 \times (v^k - 1) / (v - 1) \\
 &= \$579 \times [((1 + 0.05) / (1 + 0.07))^{10} - 1] / [(1 + 0.05) / (1 + 0.07) - 1] \\
 &= \$579 \times 9.199 \\
 &= \$5,326
 \end{aligned}$$

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

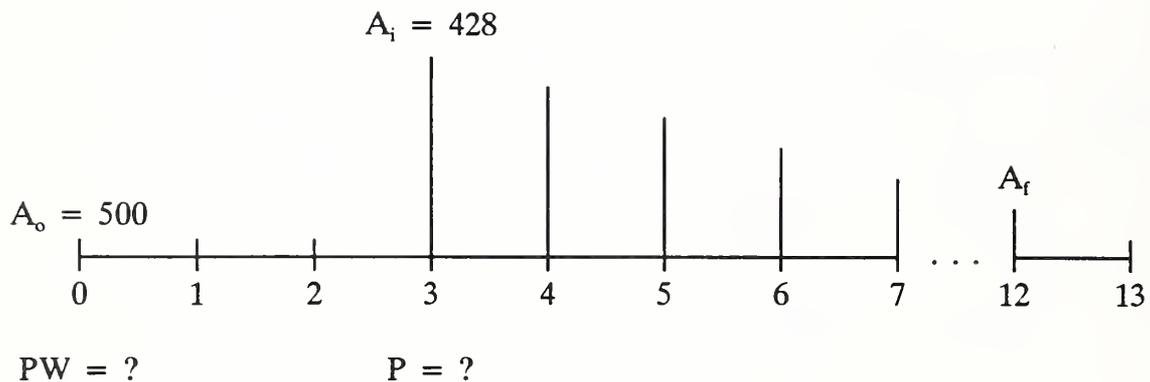
$$\begin{aligned}
 PW &= P \times \frac{1}{(1 + d)^n} \\
 PW &= \$5,326 \times \frac{1}{(1 + 0.07)^3} \\
 &= \$5,326 \times 0.8163 \\
 PW &= \$4,348
 \end{aligned}$$

Alternatively, solve the problem using factors:

$$\begin{aligned}
 A_1 &= \$500 \times 1.158 \quad (\text{escalation factor, Escalation Factor Table, } e = 0\%, n = 3) \\
 &= \$579 \\
 P &= \$579 \times 9.199 \quad (\text{annual series factor, Annual Series Factor Table, } d = 7\%, e = 0\%, k = 10) \\
 &= \$5,326 \\
 PW &= \$5,326 \times 0.8163 \quad (\text{discount factor, Discount Factor Table, } d = 7\%, n = 3) \\
 PW &= \$4,348
 \end{aligned}$$

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.



Demonstrate solution only by factor.

SOLUTION BY FACTORS:

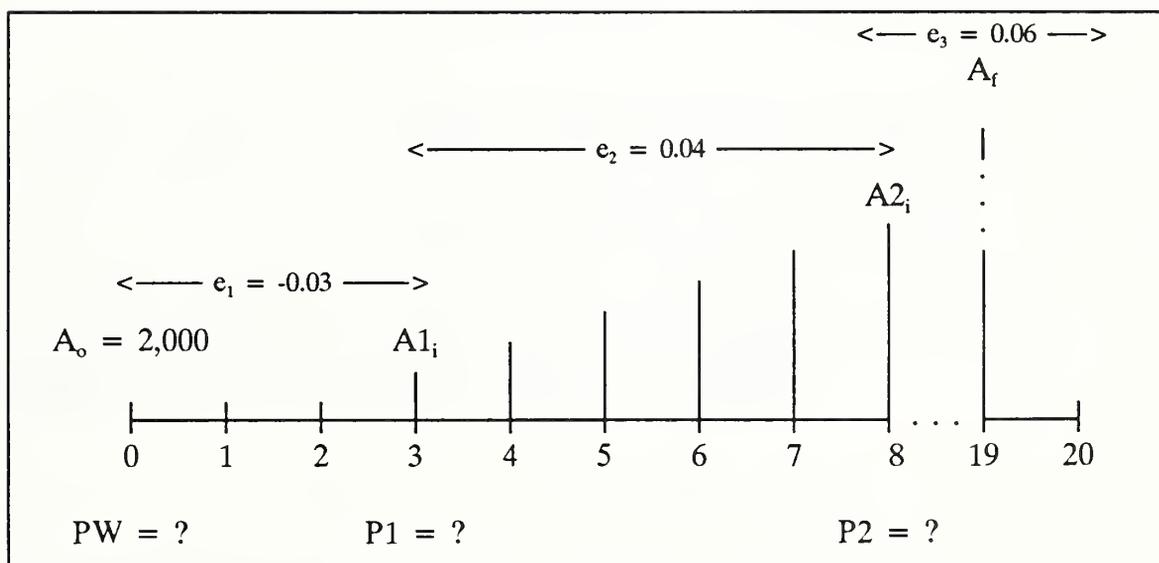
A_i	=	$\$500 \times 0.857$	(escalation factor, Escalation Factor Table, $e = -5\%$, $n = 3$)
	=	$\$428$	
P	=	$\$428 \times 6.203$	(annual series factor, Annual Series Factor Table, $e = -5\%$, $d = 7\%$, $k = 10$)
	=	$\$2,660$	
PW	=	$\$2,660 \times 0.8163$	(discount factor, Discount Factor Table, $d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

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.

$$\begin{array}{llll}
 A_o & = & \$2,000 & d & = & 0.07 \\
 n & = & 3 & e_1 & = & -0.03 \\
 k_1 & = & 5 & e_2 & = & 0.04 \\
 k_2 & = & 12 & e_3 & = & 0.06 \\
 A1_i & = & \text{initial payment of first subseries} & & & \\
 A2_i & = & \text{initial payment of second subseries} & & & \\
 A_f & = & \text{final payment} & & & \\
 PW & = & ? & & &
 \end{array}$$

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.



Demonstrate how to solve the problem in six steps using "conventional" factors. At the end of the solution, summarize the six steps.

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:

$$\begin{aligned} A1_i &= A_0 \times \text{escalation factor } (e_1 = -3\%, n = 3) \\ &= \$2,000 \times 0.913 \\ &= \$1,826 \end{aligned}$$

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.)

$$\begin{aligned} P1 &= A1_i \times \text{annual series } (e_2 = 4\%, k = 5, d = 7\%) \\ &= \$1,826 \times 4.727 \\ &= \$8,632 \end{aligned}$$

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:

$$\begin{aligned} A2_i &= A_0 \times \text{escalation factor for period prior to first subseries} \\ &\quad (e_1 = -3\%, n = 3) \\ &\quad \times \text{escalation factor for escalation period of first subseries} \\ &\quad (e_2 = 4\%, 5 \text{ years}) \\ &= \$2,000 \times 0.913 \times 1.217 \\ &= \$2,222 \end{aligned}$$

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

$$\begin{aligned}
 P2 &= A2_1 \times \text{annual series factor } (e_3 = 6\%, k_2 = 12, d = 7\%) \\
 &= \$2,222 \times 11.402 \\
 &= \$25,335
 \end{aligned}$$

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

$$\begin{aligned}
 PW1 &= P1 \times \text{discount factor } (d = 7\%, n = 3) \\
 &= \$8,632 \times 0.8163 \\
 &= \$7,046 \\
 \\
 PW2 &= P2 \times \text{discount factor } (d = 7\%, n = 8) \\
 &= \$25,335 \times 0.5820 \\
 &= \$14,745
 \end{aligned}$$

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:

$$\begin{aligned}
 PW &= PW1 + PW2 \\
 &= \$7,046 + \$14,745 \\
 &= \$21,791
 \end{aligned}$$

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:

$$A1_i = A_0 \times \text{escalation factor} \\ \text{for escalation period from beginning of analysis period to} \\ \text{time first subseries begins}$$

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

$$P1 = A1_i \times \text{annual series factor} \\ \text{for number of payments in subseries 1, escalating at rate } e_2$$

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

$$A2_i = A_0 \times \text{escalation factors} \\ \text{covering each escalation period from the beginning of the} \\ \text{analysis period to the time the second subseries begins}$$

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

$$P2 = A2_i \times \text{annual series factor} \\ \text{for number of payments in subseries 2, escalating at rate } e_3$$

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

$$PW1 = P1 \times \text{discount factor}$$

$$PW2 = P2 \times \text{discount factor}$$

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.

Day 2

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%.

$$\begin{aligned}C_P &= \$1,000 \\n &= 10 \\e &= 0.10\end{aligned}$$

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 :

$$\text{Escalation Factor} =$$

$$C_F =$$

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 :

$$\text{Escalation Factor} =$$

$$C_F =$$

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.

$$\begin{aligned} C_p &= \$1,500 \\ n &= 3 \\ I &= 0.04 \end{aligned}$$

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 :

$$\text{Escalation Factor} =$$

$$C_F =$$

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%.

$$\begin{aligned}C_F &= \$800 \\n &= 8 \\d &= 0.07\end{aligned}$$

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:

$$\text{Discount Factor} =$$

$$PW =$$

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.

$$\begin{aligned}C_p &= \$500 \\n &= 9 \\d &= 0.07 \\e &= 0.024\end{aligned}$$

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%)

$$\text{Escalation Factor} =$$

$$\text{Discount Factor} =$$

$$PW =$$

Problem 6

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

$$\begin{aligned}C_p &= \$500 \\n &= 9 \\d &= 0.07 \\e &= -0.05\end{aligned}$$

- a. Use the formula:

$$PW =$$

- b. Write the escalation and discount factors:

$$\text{Escalation Factor} =$$

$$\text{Discount Factor} =$$

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., $A_0 = A_1$). The series is projected to escalate at the rate of general price inflation. The real discount rate is 7%.

$$\begin{aligned} A_0 &= A_1 = \$300 \\ k &= 6 \\ d &= 0.07 \\ e &= 0 \end{aligned}$$

a. Draw a cash flow diagram:

b. Calculate PW using the annual series formula:

$$\text{PW} =$$

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

$$\text{Annual Series Factor} =$$

$$\text{PW} =$$

Problem 8

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

$$\begin{aligned} A_0 &= A_1 = \$300 \\ k &= 6 \\ d &= 0.07 \\ e &= 0.03 \end{aligned}$$

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:

$$\text{Annual Series Factor} =$$

Day 2

Problem 9

Redo problem 7 but assume a negative rate of escalation.

$$\begin{aligned} A_0 &= A_1 = \$300 \\ k &= 6 \\ d &= 0.07 \\ e &= -0.05 \end{aligned}$$

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:

$$\text{Annual Series Factor} =$$

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%.

$$\begin{array}{ll} A_0 & = \text{\$5,000} & d & = 0.10 \\ n & = 3 & e & = 0 \\ k & = 10 \end{array}$$

a. Draw a cash flow diagram:

b. Calculate PW using the appropriate formulas:

$$A_i =$$

$$P =$$

$$PW =$$

Day 2

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%.

$$\begin{array}{rcl} A_0 & = & \$5,000 \\ n & = & 3 \\ k & = & 10 \end{array} \quad \begin{array}{rcl} d & = & 0.10 \\ e & = & 0.04 \end{array}$$

a. Draw a cash flow diagram:

b. Calculate PW using factors:

$$A_t =$$

$$P =$$

$$PW =$$

Day 2

Problem 12

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

$$\begin{array}{lcl} A_0 & = & \$5,000 \\ n & = & 3 \\ k & = & 10 \end{array} \qquad \begin{array}{lcl} d & = & 0.10 \\ e & = & -0.05 \end{array}$$

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%.

$$\begin{array}{ll}
 A_0 & = \quad \$500 & d & = \quad 0.07 \\
 n & = \quad 2 & e_1 & = \quad -0.02 \\
 k_1 & = \quad 5 & e_2 & = \quad 0.03 \\
 k_2 & = \quad 6 & e_3 & = \quad 0.05 \\
 A1_i & = \quad \text{initial payment of first subseries} \\
 A2_i & = \quad \text{initial payment of second subseries}
 \end{array}$$

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 5 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

Slide 6-S18

PROBLEM 1

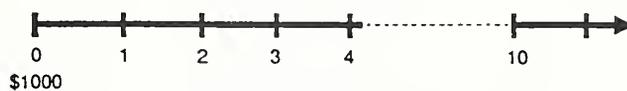
$$C_p = \$1,000$$

$$n = 10$$

$$e = 0.10$$

Find the future value C_F

$C_F = ?$



PROBLEM 1

SOLUTION

$$\begin{aligned}C_F &= C_p \times \text{Escalation Formula} \\ &= 1,000 \times (1 + 0.10)^{10} \\ &= 1,000 \times 2.594\end{aligned}$$

$$C_F = \$ 2,954$$

Slide 6-S20

PROBLEM 2

Find the PW if $e = -0.05$

SOLUTION

$$F = 1,000 \times (1 - 0.05)^{10}$$

$$= 1,000 \times 0.599$$

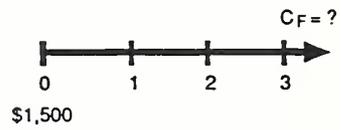
$$F = \$599$$

Slide 6-S21

PROBLEM 3

$$\begin{aligned} C_p &= \$1,500 \\ n &= 3 \\ i &= 0.04 \end{aligned}$$

Find the future value C_F



Slide 6-S22

PROBLEM 3

SOLUTION

$$C_F = 1,500 (1 + E)^3$$

$$\begin{aligned} E &= (1 + e)(1 + I) - 1 \\ &= (1 + 0)(1 + 0.04) - 1 = 0.04 \end{aligned}$$

$$\begin{aligned} C_F &= 1,500 (1.04)^3 \\ &= 1,500 \times 1.125 \end{aligned}$$

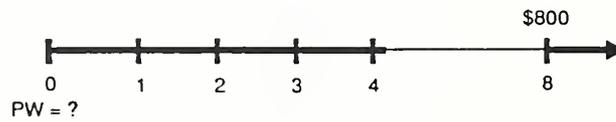
$$C_F = 1,687.30$$

Slide 6-S23

PROBLEM 4

$$\begin{aligned} C_F &= \$800 \\ n &= 8 \\ d &= 0.07 \end{aligned}$$

Find the present worth PW



Slide 6-S24

PROBLEM 4

SOLUTION

PW = C_F x Discounting Formula

$$= 800 \times \frac{1}{(1 + 0.07)^8}$$

$$= 800 \times 0.5820$$

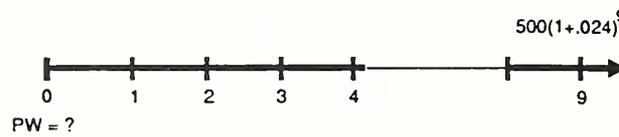
$$PW = \$466$$

Slide 6-S25

PROBLEM 5

$$\begin{aligned} C_p &= \$500 \\ n &= 9 \\ d &= 0.07 \\ e &= 0.024 \end{aligned}$$

Find the present worth PW



Slide 6-S26

PROBLEM 5

SOLUTION

 $PW = C_p \times \text{Escalation Formula/Discounting Formula}$

$$= 500 \times \frac{(1 + 0.024)^9}{(1 + 0.07)^9}$$

$$= 500 \times 0.6733$$

$$PW = \$337$$

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PROBLEM 5

SOLUTION

Using Factors

$$PW = 500 \times \text{esc. factor} \times \text{discount factor}$$

Interpolate to find the escalation factor:

$$1.195 + 0.4(1.304 - 1.195) = 1.239$$

$$\begin{aligned} PW &= 500 \times 1.239 \times 0.544 \\ &= 500 \times 0.6740 \end{aligned}$$

$$PW = \$337$$

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PROBLEM 6

Find the present worth if $e = -0.05$

SOLUTION

$$PW = 500 \frac{(1 - 0.05)^9}{(1 + 0.07)^9}$$

$$= 500 \times 0.3428$$

$$PW = \$171$$

Slide 6-S29

PROBLEM 7

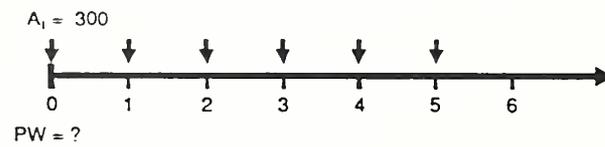
$$A_t = \$300$$

$$k = 6$$

$$d = 0.07$$

$$e = 0$$

Find the present worth PW



Slide 6-S30

PROBLEM 7

SOLUTION

$$\begin{aligned}PW &= A_j \times \text{Annual Series Formula} \\ &= 300 \times \left[\frac{(1+0)/(1+0.07)^6 - 1}{(1+0)/(1+0.07) - 1} \right] \\ &= 300 \times 5.100\end{aligned}$$

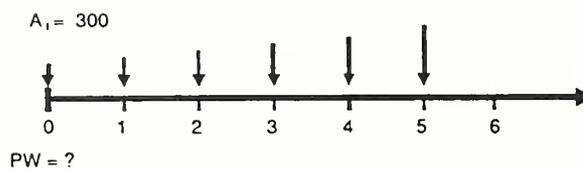
$$PW = 1,530$$

Slide 6-S31

PROBLEM 8

$$\begin{array}{lcl} A_1 & = & \$300 \\ k & = & 6 \end{array} \qquad \begin{array}{lcl} d & = & 0.07 \\ e & = & 0.03 \end{array}$$

Find the present worth PW



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PROBLEM 8

SOLUTION

$$PW = 300 (v^6 - 1)/(v - 1)$$
$$v = (1 + 0.03)/(1 + 0.07) = 0.963$$

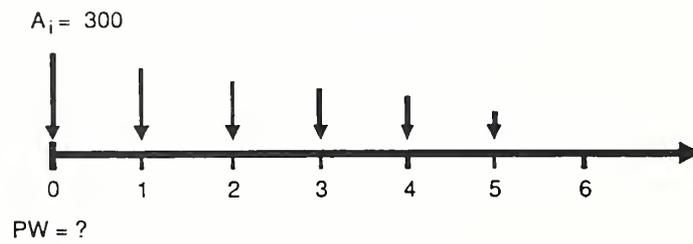
$$PW = 300 (0.963^6 - 1)/(0.963 - 1)$$
$$= 300 \times 5.466$$

$$PW = 1,639$$

Slide 6-S33

PROBLEM 9

Find the present worth PW if $e = -0.05$



Slide 6-S34

PROBLEM 9

SOLUTION

$$\begin{aligned}PW &= 300 \times [((1 - 0.05)/(1 + 0.07))^6 - 1]/[(1 - 0.05)/(1 + 0.07) - 1] \\ &= 300 \times 4.5490\end{aligned}$$

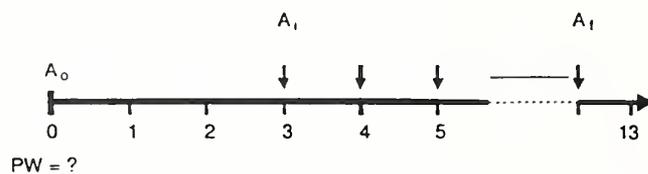
$$PW = \$1,365$$

Slide 6-S35

PROBLEM 10

$$\begin{array}{ll} A_0 = \$5,000 & d = 0.10 \\ n = 3 & e = 0 \\ k = 10 & A_i = 5,000(1+0)^3 \end{array}$$

Find the present worth PW



Slide 6-S36

PROBLEM 10

SOLUTION

STEP 1: Find the initial amount A_i
that begins the series

$$A_i = A_0 \times \text{Escalation Formula} \\ = 5,000 \times (1 + 0)^3$$

$$A_i = 5,000$$

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PROBLEM 10

SOLUTION

STEP 2: Find the equivalent one-time cost P
as of the beginning of the series

$$\begin{aligned} P &= 5,000 \times [((1 + 0)/(1 + 0.10))^{10} - 1] / [(1 + 0)/(1 + 0.10) - 1] \\ &= 5,000 \times 6.7590 \\ &= 33,795 \end{aligned}$$

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PROBLEM 10**SOLUTION**

STEP 3: Find the present worth PW as of the beginning of the study period

PW = P x Discount Formula

$$= 33,795 \times \frac{1}{(1 + 0.10)^3}$$

$$= 33,795 \times 0.7513$$

$$\text{PW} = \$25,390$$

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PROBLEM 10

SOLUTION

Using Factors

$$\begin{aligned} A_i &= A_0 \times \text{Escalation Factor } (n=3, e=0) \\ &= 5,000 \times 1.000 \\ &= 5,000 \end{aligned}$$

$$\begin{aligned} P &= A_i \times \text{Annual Series Factor } (d=10\%, k=10, e=0) \\ &= 5,000 \times 6.759 \\ &= 33,795.12 \end{aligned}$$

$$\begin{aligned} PW &= P \times \text{Discount Factor } (d=10\%, n=3, e=0) \\ &= 33,795 \times 0.7513 \end{aligned}$$

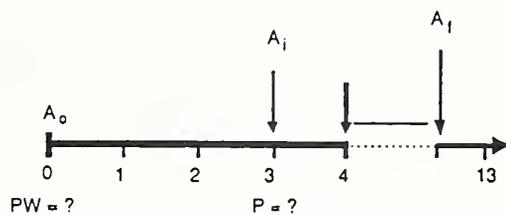
$$PW = 25,390$$

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PROBLEM 11

Find PW if the series escalates uniformly
at an annual rate of 4%

$$\begin{array}{ll} A_0 = \$5,000 & d = 0.10 \\ n = 3 & e = 0.04 \\ k = 10 \end{array}$$



Slide 6-S41

PROBLEM 11

SOLUTION

Using Factors

$$A_j = 5,000 \times 1.125 \text{ (escalation factor, } e = 4\%, n=3) \\ = 5,625$$

$$P = 5,625 \times 8.184 \text{ (Annual Series Factor, } e = 4\%, d = 10\%, k = 10) \\ = 46,035$$

$$PW = 46,035 \times 0.7513$$

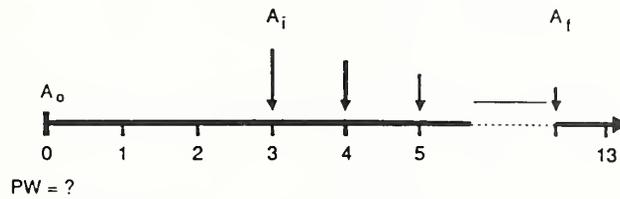
$$PW = 34,586$$

Slide 6-S42

PROBLEM 12

Find the present worth of the series:

$$\begin{array}{l} A_0 = \$5,000 \\ n = 3 \\ k = 10 \end{array} \quad \begin{array}{l} d = 0.10 \\ e = -0.05 \end{array}$$



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PROBLEM 12

SOLUTION
Using Factors

$$A_i = 5,000 \times 0.857$$
$$= 4,285$$

$$P = 4,285 \times 5.641$$
$$= 24,172$$

$$PW = 24,172 \times 0.7513$$

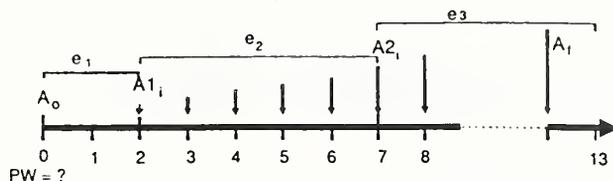
$$PW = 18,160$$

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PROBLEM 13

Find present worth PW of a series of payments
when the escalation rate varies:

$$\begin{aligned} A_0 &= \$500 & d &= 0.07 \\ n &= 2 & e_1 &= -0.02 \\ k_1 &= 5 & e_2 &= 0.03 \\ k_2 &= 6 & e_3 &= 0.05 \\ A1_i &= \text{initial payment of first subseries} \\ A2_i &= \text{initial payment of second subseries} \end{aligned}$$



Slide 6-S45

PROBLEM 13

SOLUTION

$$\begin{aligned}\text{STEP 1: } A1_1 &= A_0 \times \text{Escalation Factor } (e_1=-2\%, n=2, d=7\%) \\ &= 500 \times 0.960 \\ A1_1 &= 480\end{aligned}$$

$$\begin{aligned}\text{STEP 2: } P1 &= A1_1 \times \text{Annual Series Factor } (e_2=3\%, k=5, d=7\%) \\ &= 480 \times 4.640 \\ P1 &= 2,227\end{aligned}$$

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PROBLEM 13**SOLUTION**

$$\begin{aligned}\text{STEP 3: } A_{2_1} &= A_0 \times \text{Escalation Factor } (e_1=-2\%,n=2,d=7\%) \\ &\quad \times \text{Escalation Factor } (e_2=3\%,n=5,d=7\%) \\ &= 500 \times 0.960 \times 1.159 \\ A_{2_1} &= 556\end{aligned}$$

$$\begin{aligned}\text{STEP 4: } P_2 &= A_{2_1} \times \text{Annual Series Factor } (e_3=5\%,k_2=6,d=7\%) \\ &= 556 \times 5.727 \\ P_2 &= 3,184\end{aligned}$$

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PROBLEM 13

SOLUTION

$$\begin{aligned} \text{STEP 5: } PW1 &= P1 \times \text{Discount Factor (n=2,d=7\%)} \\ &= 2,227 \times 0.8734 \\ &= 1,945 \end{aligned}$$

$$\begin{aligned} PW2 &= P2 \times \text{Discount Factor (n=7,d=7\%)} \\ &= 3,184 \times 0.6227 \\ &= 1,983 \end{aligned}$$

$$\begin{aligned} \text{STEP 6: } PW &= PW1 + PW2 \\ &= 1,945 + 1,983 \end{aligned}$$

$$PW = 3,928$$

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

Day 2

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

DATA	<u>Equipment A</u>	<u>Equipment B</u>
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)	$A_o = \$6,500/\text{yr}$	\$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

Present the example and solve the problem step by step using factors. Ask students to refer to the table of data in their manuals. Show the slide giving LCC (A). Then show how each PW amount is found using the flip chart or blackboard. Repeat the presentation for LCC (B). Show the slide comparing LCC (A) and LCC (B).

STEP 1. COMPUTE LCC FOR EQUIPMENT A:

$$\text{PW (Procurement)} = \$10,000$$

(already in PW)

$$\text{PW (Maintenance)} = \$2,000 \times 8.367 \times 0.9535 = \$15,956$$

$A_0 \times \text{Annual Series Factor, } e = 0 \times \text{SPW } 0.5\text{yrs}$

$$\text{PW (Repair)} = (\$600 \times 0.6209) + (\$600 \times 0.3855) = \$604$$

1st repair 2nd repair

$$\text{PW (Fuel)} = (\$6,500 \times 1.040) \times 10.429 \times 0.9091 = \$64,092$$

$(A_1 = A_0 \times \text{Esc. Fact.}) \times \text{Annual Series Factor} \times \text{SPW } 1\text{yr}$

$$\text{PW (Net Salvage)} = 0$$

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

Day 2

STEP 2. COMPUTE LCC FOR EQUIPMENT B

$$\text{PW (Procurement)} = \$20,000$$

(already in PW)

$$\text{PW (Maintenance)} = \$1,000 \times 8.367 \times 0.9535 = \$7,978$$

$A_0 \times \text{Annual Series Factor, } e = 0 \times \text{SPW } 0.5\text{yrs}$

$$\text{PW (Repair)} = \$500 \times 0.4665 = \$233$$

Discount Factor for yr 8

$$\text{PW (Fuel)} = (\$4,500 \times 1.040) \times 10.429 \times 0.9091 = \$44,371$$

$(A_i = A_0 \times \text{Esc. Fact.}) \times \text{Annual Series Factor} \times \text{SPW } 1\text{yr}$

$$\text{PW (Net Salvage)} = \$1,000 \times 0.2394 = \$239$$

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

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

$\text{LCC (A)} = \$90,652$

$\text{LCC (B)} = \$72,343$

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)	$A_0 = \$2,600$	\$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

SOLUTION TO EXERCISE 6-2

STEP 1. COMPUTE LCC FOR SINGLE GLAZED, WOOD FRAME WINDOWS:

$$\text{PW (Purchase \& Install)} = \$12,000$$

(already in PW)

$$\text{PW (Cleaning)} = \$500 \times 9.365 \times 0.9535 = \$4,465$$

$A_0 \times \text{Annual Series Factor, } (e = 0) \times$
SPW 0.5yr

$$\text{PW (Painting)} = (\$2,000 \times 0.6209) + (\$2,000 \times 0.3855)$$

1st repair 2nd repair

$$+ (\$2,000 \times 0.2394) = \$2,492$$

3rd repair

$$\text{PW (Fuel)} = (\$2,600 \times 1.010) \times 10.713 \times 0.9535 = \$26,824$$

$(A_1 = A_0 \times \text{Esc. Fact.}) \times \text{Annual Series Factor} \times$
SPW 0.5yr

$$\text{PW (Resale)} = 0$$

$$\text{LCC (SGW)} = \$12,000 + \$4,465 + \$2,492 + \$26,824 - 0 = \$45,781$$

STEP 2. COMPUTE LCC FOR DOUBLE GLAZED VINYL WINDOWS:

$$\text{PW (Purchase \& Install)} = \$17,000$$

(already in PW)

$$\text{PW (Cleaning)} = \$500 \times 9.365 \times 0.9535 = \$4,465$$

$A_0 \times \text{Annual Series Factor, } e = 0 \times \text{SPW } 0.5\text{yr}$

$$\text{PW (Painting)} = (\$500 \times 0.3855) = \$193$$

1st repair

$$\text{PW (Fuel)} = (\$1,900 \times 1.010) \times 10.713 \times 0.9535 = \$19,602$$

$(A_1 = A_0 \times \text{Esc. Fact.}) \times \text{Annual Series Factor} \times \text{SPW } 0.5\text{yr}$

$$\text{PW (Resale)} = \$5,000 \times 0.1486 = \$743$$

$$\text{LCC (DGW)} = \$17,000 + \$4,465 + \$193 + \$19,602 - \$743 = \$40,517$$

STEP 3. COMPARE LCCs:

$$\begin{aligned} \text{LCC (SGW)} &= \$45,781 \\ \text{LCC (DGW)} &= \$40,517 \end{aligned}$$

Selection: on basis on LCC alone, choose double-glazed vinyl windows.

Review the solution. Point out that they could omit cleaning costs from the analysis. Point out that many of the elements are common to the alternatives which simplifies the analysis of multiple alternatives. Examine which items account for DGW's lower LCC.

If time permits, discuss significant figures -- Module 3. Point out that MILCON cost estimates are rarely more accurate than to about 2 numbers.

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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

LESSON PLAN 7: HOW TO PERFORM MILCON GENERAL ECONOMIC STUDIES

This module adds the specifics needed to perform EA/LCCA for MILCON general economic studies, using DA Form 5605 according to Army/Air Force criteria.

TIME	OVERVIEW	TRAINING AIDS OR CUES
1300	<p>Ask students to turn to Module 7.</p> <p>Review purpose of Module 7, outline, and allotted time.</p> <p>Briefly review requirements for and objectives of general economic studies, as covered in Module 4 (s 4.4).</p>	<p>S7-1</p> <p>W7</p> <p>Ws4.4</p>
1305	<p>7.1 Ask students to turn to beginning of 7.1 (criteria).</p> <p>Review learning objectives of 7.1.</p> <p>Present Army/Air Force criteria.</p>	<p>Ws7.1, TM, c2</p> <p>S7-2/6</p>
1330	<p>7.2 Ask students to turn to beginning of 7.2. (input data and cash flow diagram).</p> <p>Review learning objectives of 7.2.</p> <p>Walk through DA Form 5605-3.</p> <p>Show by example how to complete the "Basic Input Data Summary" sheet taking each section of the sheet in turn.</p>	<p>Ws7.2</p> <p>TM, V7-1/9</p>
1415	<p>7.3 Ask students to turn to beginning of 7.3 (LCC-conventional approach).</p> <p>Review learning objectives of 7.3.</p> <p>Walk through DA Form 5605-4.</p> <p>Show by example how to complete the "Present Worth: Conventional Approach" sheet using data inputs from Input Data sheet.</p>	<p>Ws7.3</p> <p>TM</p> <p>V7-10/13</p>

(Key: S = slide, V = Vugraph, F = Flip chart, W = Workbook, s = section, N = Notebook, TM = Technical Manual, c = chapter, Ex = exercise)

LESSON PLAN 7: HOW TO PERFORM MILCON GENERAL ECONOMIC STUDIES (continued)

TIME	OVERVIEW	TRAINING AIDS OR CUES
1440	<p>7.4 Ask students to turn to beginning of 7.4 (LCC-exercise).</p> <p>Ask them to work in pairs.</p> <p>Review the objective of the exercise</p> <p>Ask them to try to be finished by 1515.</p> <p>Ask them to raise their hands when they are finished in order that one of the instructors can verify that they have successfully completed the exercise.</p> <p>Announce that they can go on break as soon as they have been checked off.</p> <p>Check results (do this formally using list of students)</p> <p>Quickly review results</p>	<p>Ws7.4</p> <p>Ex 7.1</p> <p>V7-S1/S3</p>
1530	<p>Ask them to turn to beginning of 7.5 (LCC-One step).</p> <p>Review learning objectives of 7.5.</p> <p>Provide an overview of the one-step approach, pointing out how it differs from the conventional approach.</p> <p>Walk through DA Form 5605-5.</p> <p>Show by example how to complete the "Present Worth: One-Step" sheet using data inputs from Input Data sheet.</p>	<p>Ws7.5</p> <p>S7-7</p> <p>TM</p> <p>V7-14/20</p>
1600	<p>7.6 Ask students to turn to beginning of 7.6 (one-step exercise).</p> <p>Ask them to work in pairs again.</p> <p>Review learning objectives and requirements for the exercise.</p> <p>Ask them to try to be finished by 1620.</p>	<p>Ws7.6</p> <p>Ex 7.2</p>

(Key: S = slide, V = Vugraph, F = Flip chart, W = Workbook, s = section, N = Notebook, TM = Technical Manual, c = chapter, Ex = exercise)

LESSON PLAN 7: HOW TO PERFORM MILCON GENERAL ECONOMIC STUDIES (continued)

TIME	OVERVIEW	TRAINING AIDS OR CUES
1620	<p>Ask them to raise their hands when they are finished in order that one of the instructors can verify that they have successfully completed the exercise.</p> <p>7.7 Ask students to turn to beginning of 7.7 (Ranking).</p> <p>Review learning objectives.</p> <p>Explain how to use results of LCC to rank alternatives.</p> <p>Demonstrate ranking for the example.</p>	<p>V7-S4</p> <p>Ws7.7</p> <p>S7-8/11</p> <p>V7-21</p>
1640	<p>7.8 Ask students to turn to beginning of 7.8 (Ranking-exercise).</p> <p>Review learning objectives and requirements for the exercises.</p> <p>Ask them to rank the alternative they evaluated in Exercises 7.1 and 7.2, relative to another alternative for which data is given.</p>	<p>Ws7.8</p> <p>Ex 7.3</p>
1650	<p>Discuss results of Exercise 7.3.</p> <p>If there is time, do Exercise 7.4; if not now do near end of first-period review session next day. Discuss the reasons for each choice.</p>	<p>V7-S5</p> <p>V7-S6</p>

(Key: S = slide, V = Vugraph, F = Flip chart, W = Workbook, s = section, N = Notebook, TM = Technical Manual, c = chapter, Ex = exercise)

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**HOW TO PERFORM
MILCON GENERAL ECONOMIC STUDIES**

Put up this slide while asking students to turn to module and objectives.

- You now know generally how to apply the LCC method. Now let's learn how to apply it to MILCON design decisions.

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

CRITERIA FOR GENERAL ECONOMIC STUDIES

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

- Criteria for performing general economic studies may be grouped into three categories: . . . You should follow these criteria when performing LCC for MILCON design.
- Let's take a look at these criteria. I think you're sufficiently acquainted with the LCC method, discounting, and treatment of inflation to understand the terminology. Please feel free to ask for clarification.
- Consult your TM (chapter 2) for future reference to the criteria.
- Before we get into the details of the criteria, I want to highlight several which are most important, i.e., "thou shalt's:"
 - Take into account all feasible alternatives
 - Use a real discount rate of 10%
 - Use an analysis period which extends no longer than 25 years beyond the beneficial occupancy date (BOD).

Write these most important criteria on the flip chart.

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

- Here are eight criteria which pertain to methodology. Let's discuss them.
- As we indicated earlier, the LCC method meets the need for most design analyses and is the principal method you will use. It is a technically correct and appropriate method for making choices among design alternatives which meet minimum performance requirements.
- A second criterion is that all technically feasible design alternatives be considered for LCCA. Note that this is one of the most important criteria, as I indicated before.

Discuss which alternatives should actually have an LCCA performed -- those offering the possibility of long-run savings.

- It is important to consider a variety of design options, because no matter how good the economic analysis, the outcome can be no better than the best alternative considered.

Slide 7-4 (a-e)

CRITERIA 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**

- Now let's consider the criteria that concern data.
- The first is on the list of the most important criteria. The discount rate for general economic studies is 10%. This is a real discount rate, excluding general price inflation.
- Costs and benefits are estimated initially as of the DOS and the purchasing power of the dollar is held constant as of that time.
- Actual prices are used, such as the price of natural gas at the facility in question.
- Initial costs and benefits are escalated forward at rates which exclude purely inflationary changes.
 - Energy costs are escalated forward at DOE projected rates, which exclude general price inflation.
 - If reasonable projections are available for other prices, other costs and benefits are escalated at those rates; otherwise their escalation rates are set at 0. In other words, there must be relatively high confidence in the projections in order to use them.

- The Tech Manual also provides guidance on sources of data.
 - Construction costs are to be determined according to MCP Engineering Criteria, Guidance, Practice.
 - Energy quantity can be calculated using an energy analysis program.
 - A database has been developed for estimating maintenance and repair costs, which we will cover later in the course.

Discuss other sources of data, such as previous studies.

Day 2

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Slide 7-5

CRITERIA CONCERNING MANAGEMENT CONSIDERATIONS

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

- These last two criteria are listed under “management” because they pertain to the time and resources allocated to performing EA/LCCA and to recording the results.
 - Compliance requires different levels of effort for different sets of conditions.
 - We will focus on these criteria the fourth day of the course.
- As you perform MILCON exercises, you will become familiar with the criteria.
- By following the criteria, your analysis will be consistent with Army and Air Force requirements.

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

- In addition to criteria, there are other guidelines for performing general economic studies. One of these is to indicate key dates:
 - DOS, the date of study -- time the analysis performed
 - ABD, the analysis base date -- the date to which present worth is computed (ABD=DOS)
 - MPC, mid-point of construction -- the middle of the construction period at which time construction cost are assumed to occur
 - BOD, beneficial occupancy date -- the end of the construction period at which time maintenance and operating costs begin to occur
 - AED, analysis end date -- the end of the study period

Discuss typical key dates and relate them to the cash-flow model.

- A third criterion is that the discounting approach be to convert all cash flows to present worth (PW) at the DOS. This means expressing all amounts as a time-equivalent lump sum occurring at the DOS.

- It is a good idea to have everyone use the same discounting approach because it eliminates one of the sources of different answers and facilitates communication about economic studies.

- A fourth criterion sets a limit on the time frame, i.e., the length of the analysis period. It begins with the DOS and should extend no longer than the lesser of the economic life or 25 yrs from the BOD. Note that this is another of the most important criteria.
 - Projected economic lives longer than 25 years beyond the BOD must be justified in writing and approved by HQDA, unless the use of longer lives is specifically authorized by HQDA.
 - If projected life of a facility is less than 25, use the actual projected life.
 - Note that design alternatives must be evaluated over the same time frame.
 - Setting the 25-yr limit on the period after BOD reflects the dual needs to take into account the long-run consequences of the design decision and to match DoD's planning horizon for facilities.

- A fifth criterion is to include all relevant and significant monetary costs and benefits over the analysis period.
 - Non-monetary effects are not measured by the LCC method.
 - A building cost or benefit is relevant to a design decision if its amount changes as a result of the design decision. For example, energy costs are relevant to the selection of window design, even though they are not directly associated with buying, installing, and maintaining windows.
 - Sunk costs, i.e., costs already incurred as a result of past decisions, are not relevant to a current decision.
 - Don't waste time and resources estimating costs and benefits too small to make a difference to the outcome.

- A sixth criterion is to adjust for inflation by taking into account relative, not absolute, changes in prices. That means excluding at the outset of an analysis purely inflationary changes that reflect declines in the purchasing power of the

dollar. Costs and benefits are expressed in constant dollars and the discount rate as a real rate, without inflation.

- A seventh criterion concerns cash-flow modeling. Construction costs are modeled as a lump sum at the MPC. Annually recurring costs are modeled as a series of yearly lump-sum amounts at the middle of the year. Non-annually recurring costs are modeled as lump-sum amounts approximately when they are actually expected to occur.
- The eighth criterion concerns what to do about uncertainty in EA/LCCA. Uncertainties arise about data inputs, such as quantities, unit costs, and timing of cash flows.
 - An assessment of uncertainty is required when the choice among alternatives is not clear cut.
 - There are a number of techniques for assessing uncertainty, including sensitivity analysis, which we will examine in more detail in Module 11.
 - An assessment is not required when the LCCA results are clear cut (either clearly conclusive or clearly inconclusive).

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

Ask them to turn to the set of worksheets in the back of the TM.

- We recommend that you use this set of worksheets to do your economic analyses, and require A-E contractors to use it. Using it offers the following advantages:
 - It will help you do the analysis according to criteria.
 - It is self-documenting and saves time.
 - It carries the computations forward step-by-step in logical sequence, so you'll be able to follow the intermediate steps and know what is going on and be less likely to make a careless error.
 - By standardizing analyses, it facilitates the reviewing process. You know where to look for information.
- Let's see how we use it to solve a decision problem, beginning with the first sheet (5605-3), which you see here.
- In your workbook you will see data for a design alternative.

Briefly review the data. Explain that the e values come from Notebook tab "e values."

- Let's enter the data in the "Basic Input Data Summary" Worksheet.

See completed "Basic Input Data Summary," Vugraph 7-9.

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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:	1 year
BOD:	End of Construction Period (7/91)
First Recurring Cost:	Usually 6 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 _____

- Let's record the identifying information for the project here.

Write in info on overlay.

Vugraph 7-3. Blow up of key date section

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	

- Let's record the key dates here.

Write in key dates.

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:		

■ Here we record . . .

Write in region, discount rate, and escalation rates.

Day 2

■ Here we record . . .

Write in cost elements, costs on DOS, times, sources of data. Make the point that recording the sources of data is an important part of documentation. Emphasize that they take this seriously and describe the sources adequately to be understood by others and to reveal the reliability of the data.

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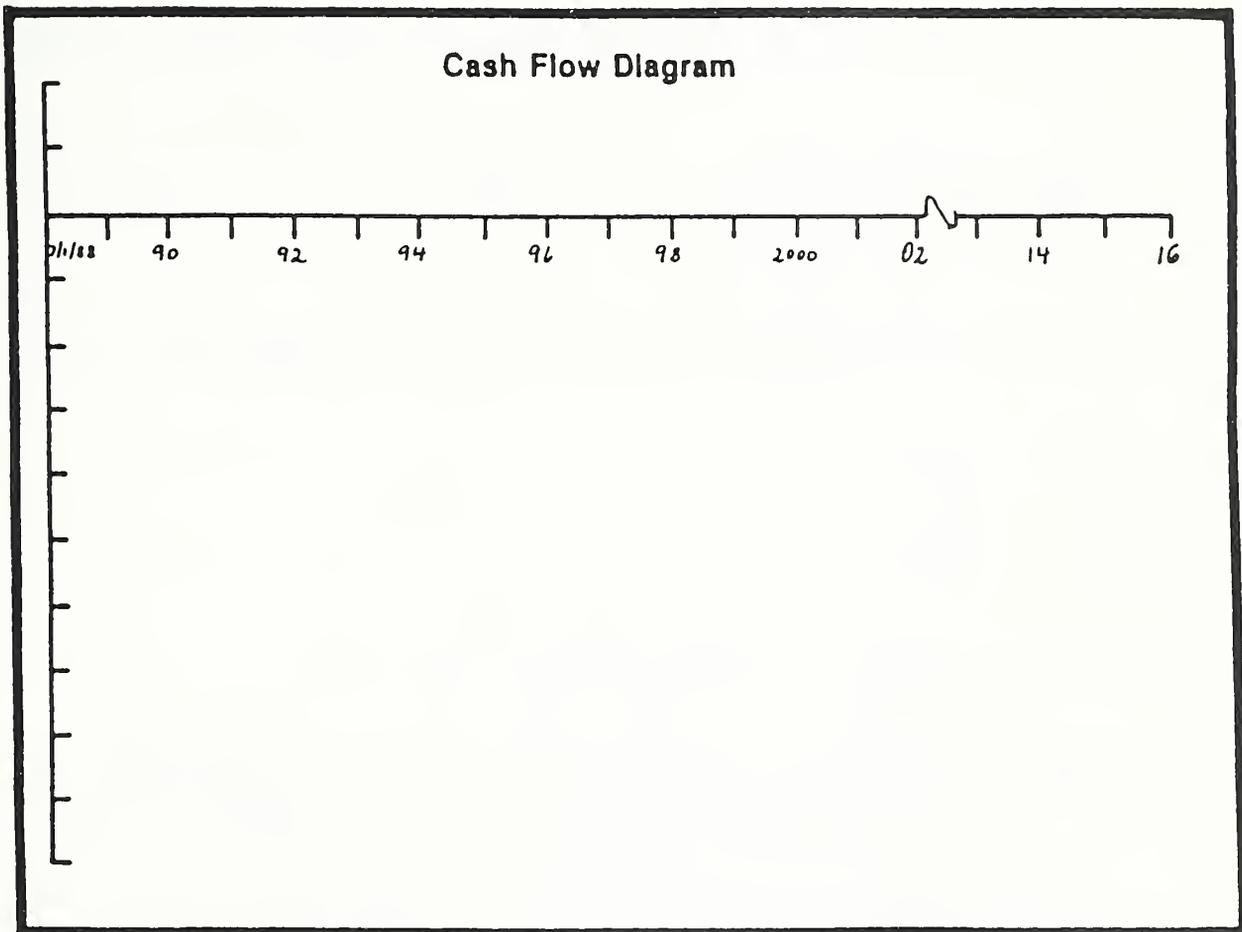
Vugraph 7-6. Blow up of principal assumptions part of form

Principal Assumptions

- Here we record any critical assumptions to the analysis.

Give several examples, and state there are not any in the example.

Vugraph 7-7. Blow up of cash flow diagram



Briefly review the construction of a cash flow diagram. Point out how this one differs from the generic one shown earlier.

- Note that this diagram is specially constructed for LCC analysis with costs to be displayed below the line, and benefits (as negative costs) above the line.
- Note the vertical scale to the left of the diagram. This is for indicating the magnitude of the cash flows.

■ First we need to designate the key dates on the time line.

Fill in each of the following dates on the overlay, or use an overlay with the dates already on it.

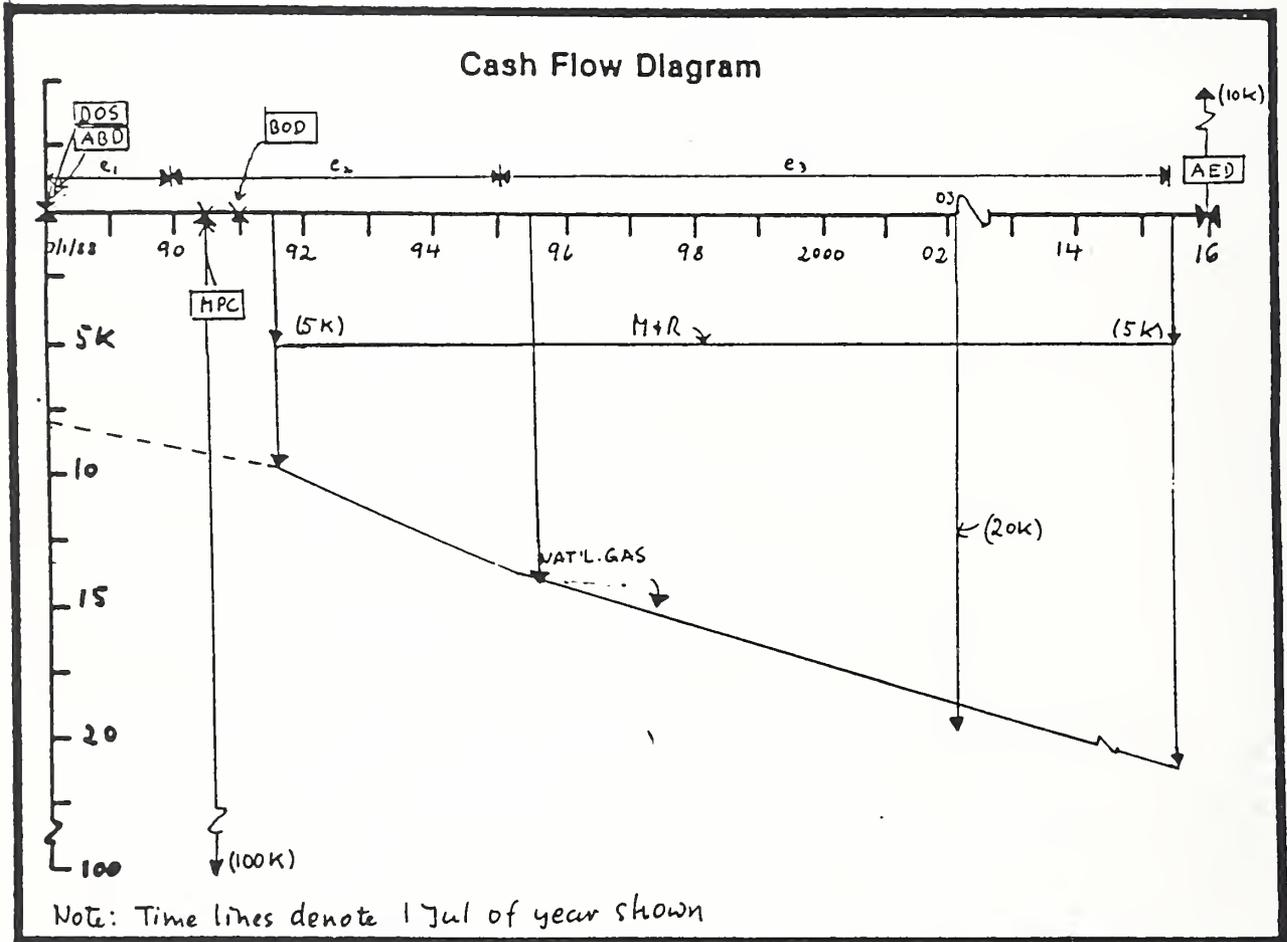
DOS/ABD	7/88
MPC	1/91
BOD	7/91
AED	7/16

■ Now we need to label the y-axis.

Write in amounts and sketch on the overlay. See Vugraph 7-9. Point out how recurring costs are treated. They start accruing on the BOD but are modeled as a lump sum in the middle of each year because of the mid-year convention. Hence, the arrow at mid year. Note that the continuous line indicating recurring costs does not mean they are continuous; it is simply an easy way to suggest that these costs recur over an extended period. Suggest that they first sketch in pencil the lines for recurring costs with escalation and then redo them more exactly after they have calculated several future amounts to provide bench marks.

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



■ Here is a neater version of the cash flow diagram.

Vugraph 7-9. Completed form

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

**LIFE CYCLE COST ANALYSIS
 BASIC INPUT DATA SUMMARY**

For use of this form, see TM 5-822-1; the proponent agency is USAACE.

Criteria Reference	H&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	H
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

Cash Flow Diagram

NOTE: Time lines denote 1 Jul of year shown

Cost Element	Cost on ABD X $\times 10^3$ O $\times 10^4$	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 94		M&R Database
Natural Gas	8	1 Jan 92-1 Jan 94		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 _____

Day 2

- And here is the entire completed input data summary form.
- Note that it provides a quick overview and handy documentation of a project. If you were looking through a file of previous studies, you could quickly ascertain the costs and benefits of a project from this sheet.
- Now we are ready to calculate present worths. Let's go to the next section.

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IN THE STUDENT'S MANUAL

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

We will use the data from the Basic Input Data Summary we completed for the exterior doors.

- This form helps to organize and document the calculations of PW for each cash flow.

Walk them through the sheet, explaining each part.

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

One-Time Costs	X \$ x 10 ³ : \$ x 10 ⁴	Years From ABD	Cost on ABD	Escalation Factor	Escal. Cost (Time Incurred)	Discount Factor	Present Worth on ABD	Criteria Reference			
								Analysis Base Date (ABD)	Analysis End Date (AED)		
								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-Jul 87-90 90-95 95-16		
								Nat'l Gas	2.63	9.17	6.10
								Other	0.00	0.00	0.00

Day 2

- Let's begin with the one-time costs. Complete the form for initial investment cost.

Write entries on the overlay and explain. See Vugraph 7-13 for data. Ask students to find in the notebook the factor tables used in the conventional approach. Review briefly each of the tables. Use factors instead of formulas.

- Calculate PW of replacement costs.

Write entries on the overlay and explain.

- Calculate PW of retention value. Enter it as a negative cost.

Write entries on the overlay and explain.

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Day 2

- Here is the form with PW calculated for each cash flow.
- The last step in completing the form is to compute LCC by summing PWs of the cash flows.

Write the amounts on the overlay and sum. Be careful! The form uses the term "net present worth" (incorrectly) to mean LCC.

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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 Childing Door

LIFE CYCLE COST ANALYSIS
PRESENT WORTH:
CONVENTIONAL APPROACH

For use of this form, see TM 8-802-1; the proponent agency is USACE.

One-Time Costs X \$ x 10 ⁴ : \$ x 10 ⁴	Years From ABD	Cost on ABD	Escalation Factor	Escal. Cost (Time Incurred)	Discount Factor	Present Worth on ABD	Criteria Reference	Analysis Base Date (ABD)	Analysis End Date (AED)	Midpoint of Construction	BOO for Analysis	Annual Discount Rate	Type of Cost	Differential Escalation Rate per Year (%)	Present Worth on ABD																																																		
																Timeframe: Jul-74	87-90	90-95	95-16																																														
Initial Investment	2.5	100	(1.0) ^{2.5}	100	(1.1) ^{2.5} = .788	78.8	HRDA	Jul 88	Jul 2016	Jan 91	Jul 91	10%	Major	0.00	35.7																																																		
Replacement Cost	15	20	(1.0) ¹⁵	20	(1.1) ¹⁵ = .239	4.8							Minor	0.00	27.2																																																		
Retention V.	28	-10	(1.0) ²⁸	-10	(1.1) ²⁸ = .069	-0.7									98.7																																																		
<table border="1"> <thead> <tr> <th rowspan="2">Annual Costs X \$ x 10⁴ : \$ x 10⁴</th> <th rowspan="2">Years from ABD</th> <th rowspan="2">First Incurred</th> <th rowspan="2">Last Incurred</th> <th rowspan="2">Total No. of Payments</th> <th rowspan="2">Annual Cost on ABD</th> <th rowspan="2">Escalation Factor</th> <th rowspan="2">Escal. Cost (Time First Incurred)</th> <th rowspan="2">1st Ann. Cost in Series</th> <th rowspan="2">Equi. Single Cost</th> <th rowspan="2">Discount Factor</th> <th rowspan="2">Present Worth on ABD</th> </tr> <tr> <th>Annual Cost in Series</th> <th>Equi. Single Cost</th> </tr> </thead> <tbody> <tr> <td>HRD</td> <td>3.5</td> <td>27.5</td> <td>2.5</td> <td>2.5</td> <td>5</td> <td>(1.0)^{3.5}</td> <td>5</td> <td>5</td> <td>9.985</td> <td>.7164</td> <td>35.7</td> </tr> <tr> <td>Natural Gas</td> <td>3.5</td> <td>6.5</td> <td>4</td> <td>4</td> <td>8</td> <td>(1.026)^{10.91}</td> <td>9.6</td> <td>3.955</td> <td>38.0</td> <td>.7164</td> <td>27.2</td> </tr> <tr> <td></td> <td>7.5</td> <td>22.5</td> <td>21</td> <td>21</td> <td>8</td> <td>(1.026)^{11.09}</td> <td>13.48</td> <td>14.995</td> <td>201.8</td> <td>.4892</td> <td>98.7</td> </tr> </tbody> </table>																Annual Costs X \$ x 10 ⁴ : \$ x 10 ⁴	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	Equi. Single Cost	Discount Factor	Present Worth on ABD	Annual Cost in Series	Equi. Single Cost	HRD	3.5	27.5	2.5	2.5	5	(1.0) ^{3.5}	5	5	9.985	.7164	35.7	Natural Gas	3.5	6.5	4	4	8	(1.026) ^{10.91}	9.6	3.955	38.0	.7164	27.2		7.5	22.5	21	21	8	(1.026) ^{11.09}	13.48	14.995	201.8	.4892	98.7
Annual Costs X \$ x 10 ⁴ : \$ x 10 ⁴	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	Equi. Single Cost	Discount Factor	Present Worth on ABD																																																						
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<table border="1"> <thead> <tr> <th>Net Present Worth:</th> <th>Initial Costs</th> <th>Energy/Fuel Costs</th> <th>M&R Costs</th> <th>Other Costs</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td></td> <td>78.8</td> <td>125.9</td> <td>35.7</td> <td>4.1</td> <td>245</td> </tr> </tbody> </table>																Net Present Worth:	Initial Costs	Energy/Fuel Costs	M&R Costs	Other Costs	Total		78.8	125.9	35.7	4.1	245																																						
Net Present Worth:	Initial Costs	Energy/Fuel Costs	M&R Costs	Other Costs	Total																																																												
	78.8	125.9	35.7	4.1	245																																																												

DA FORM 5605-4-R, DEC 86

Sheet _____ of _____

- Here we have an estimate of LCC for this particular design alternative. But recall a single LCC measure is insufficient for making a decision. We need to compare this LCC against LCCs of alternative exterior door designs.

Day 2

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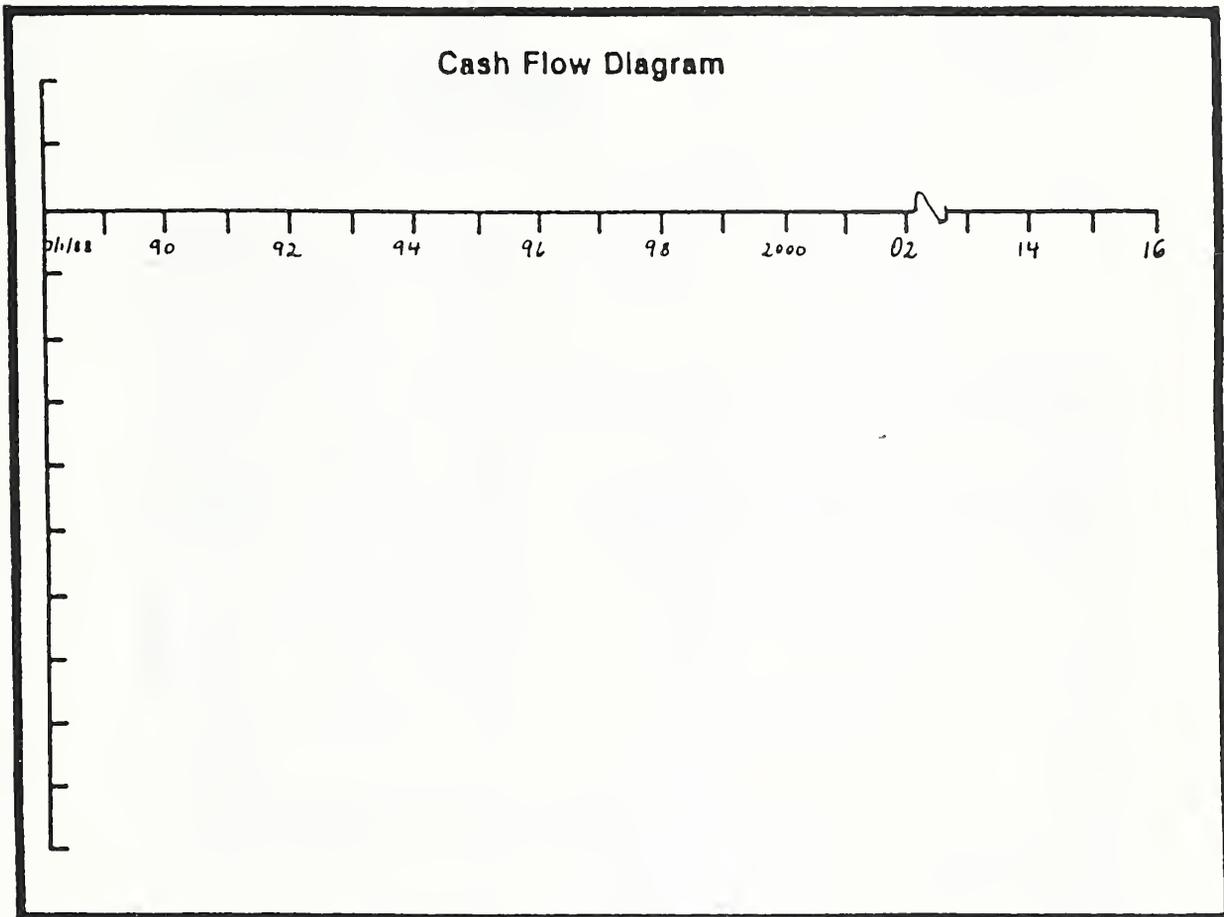
7.4 EXERCISE 7.1: COMPUTE LCC USING CONVENTIONAL APPROACH

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:	2 years from DOS		
Length of Construction Period:	1 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 6 months after BOD)	\$12,000/yr plus escalation		
Repair Cost (as of DOS): (Repair cost first occurs 5 years after BOD)	\$5,000/every 5 years		
Retention Value (as of DOS): (Retention value occurs 25 years after BOD)	\$7,500		
Differential Escalation Rates ("e values")	<u>1987-90</u>	<u>90-95</u>	<u>95 & beyond</u>
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. Enlarged Cash Flow Diagram



Vugraph 7-S1. Solution 7-1

Completed Basic Input Data Summary

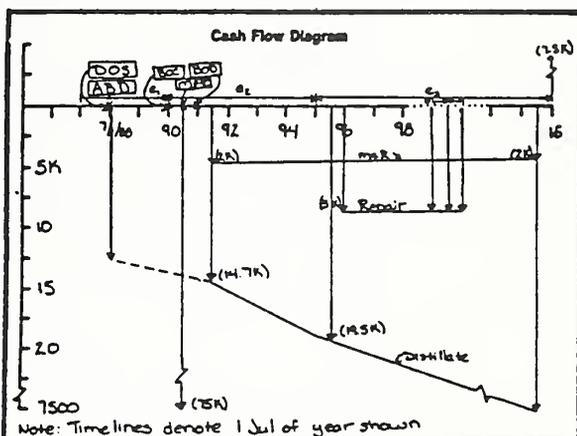
Project No. & Title PN Sbr, Veh. Mt. Shop
 Installation & Location Fort X, HV, AL
 Design Feature Exterior Wall
 AR. No. A Title Tile Wall

LIFE CYCLE COST ANALYSIS BASIC INPUT DATA SUMMARY

For use of this form, see TM 8-802-1; the proponent agency is USACE.

Criteria Reference		HQDA	
Date of Study (DOS)		Jul 88	
Analysis Base Date (ABD)		Jul 88	
Analysis End Date (AED)		Jul 16	
Midpoint of Construction		Jan 91	
Beneficial Occupancy Date (BOD)	Actual Projected	Jul 91	
	Assumed for Analysis		
DOE Region		4	
Annual Discount Rate		10%	
Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe: Jul-Jul 87-90, 90-95, 95-20		
DISTILLATE	4.54	7.75	4.44
OTHER	0	0	0

Principal Assumptions	



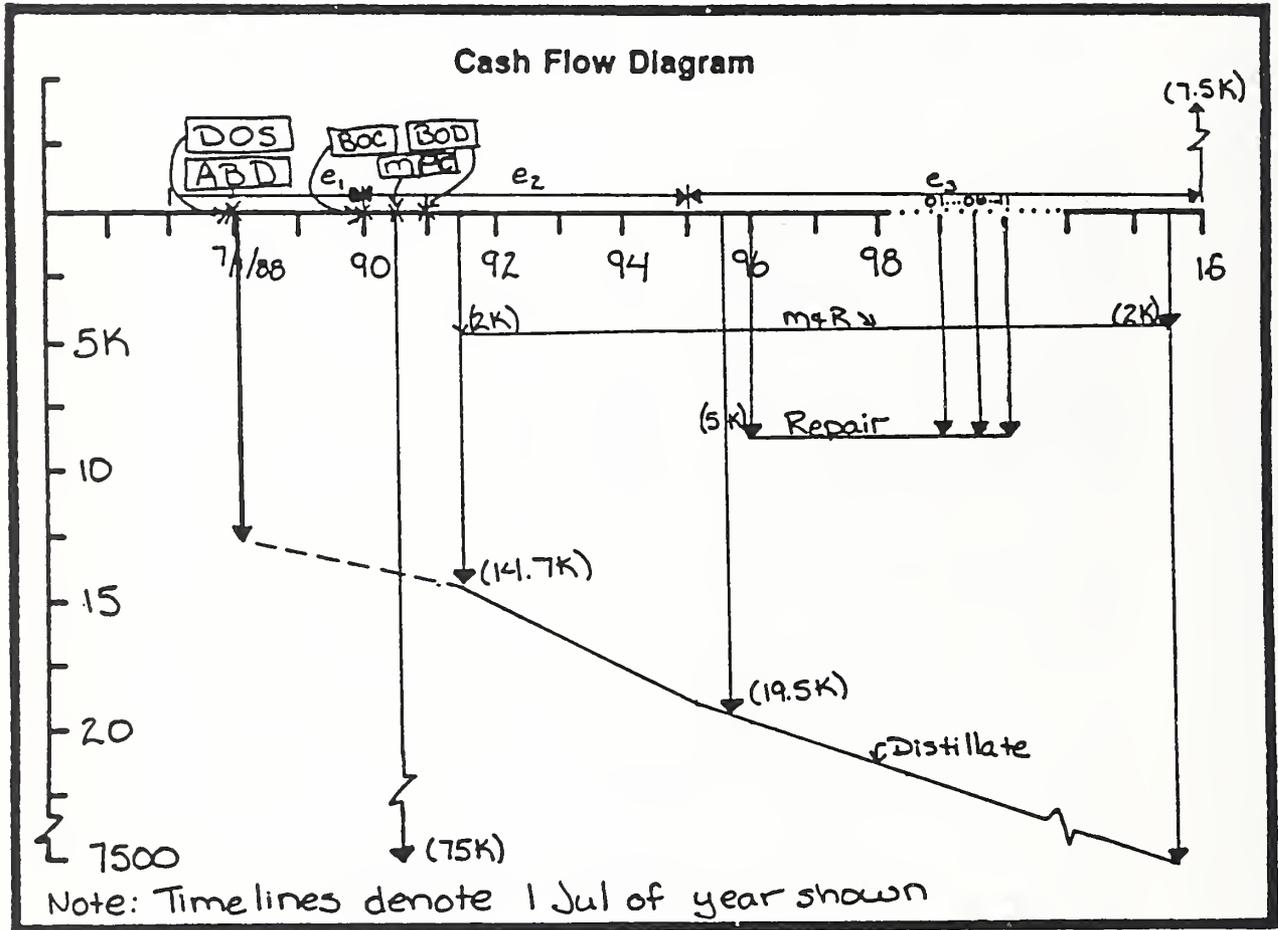
Cost Element	Cost on ABD X \$ x 10 ³ = \$ x 10 ⁶	Time Cost Incurred**		Source(s) of Data
		Actual Projected Dates	Dates for Analysis (if Differential)*	
Initial Investm.	75	Jan 91		Eng. Estimate
M+R	2.0 / yr.	Jan 91 - Jan 16		M+R Database
Repair	3.0 / 5 yr.	Jul 96, 01, 06, 11		Eng. Estimate
Retention V.	- 7.5	Jul 16		Eng. Estimate
Distillate	12.0 / yr	Jan 92 - Jan 16		BLAST Progr. Est.

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 7-S2. Solution 7-1

Completed Enlarged Cash Flow Diagram



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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

ONE-STEP ADJUSTMENT FACTORS (OSAFs)

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

- The one-step approach uses special factor tables to simplify calculations. As we mentioned in Module 6, it is possible to build into factors most of the required calculations.
- This takes a lot of work out of EA/LCCA.
- A single factor -- the one-step adjustment factor (OSAF) -- allows us to calculate the PW of recurring M&R and energy costs which start anywhere from one to nine years after the DOS, modeled as occurring at the middle of the year. Contrast that with the general factors we used before which left us with a 6-step calculation procedure for energy costs.
- OSAF factors express PW as a fraction of what the amount would be without discounting and escalation. For example, an OSAF factor of 0.7500 means that the PW amount is 75% as great as the total undiscounted, unescalated amount.
- Look in your Notebook at tab, "OSAF Tables."

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**

- You will find the following factor tables in the set of OSAF tables.

Point out that the first two are single tables, while the third is a set -- one for each energy type in each region.

Vugraph 7-15. Energy Table

REGION 1: ELECTRICITY

INDUSTRIAL SECTOR

REGION 1: ELECTRICITY

"ONE STEP" ADJUSTMENT FACTORS (OSAFS) / NORMALIZED UP** 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	.5630	.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	.1007	.0907	.0827	.0754

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

NOTES: <1> TABULATED OSAFS (UP**/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 FEMP CRITERIA (DOE STANDARD): ACTUAL PROJECTED BOD, 10% DISCOUNT RATE, AND MIDDLE-OF-YEAR CONVENTION

■ Let's look first at the set of OSAF energy tables because they offer the greatest computational advantages. Here you see a table of OSAFs for calculating the present worth of electricity costs for industrial applications in DOE Region 1 BODs from one to nine years after the DOS.

Explain the format of the table, including the FEMP/NON-FEMP columns. Explain how the OSAF is used (Slide 7-9), and show the example on the flip chart or blackboard. Point out that the table applies only to the energy type and region designated.

To use energy OSAFs for general economic studies:

- 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.,

$$PW = \text{Annual cost as of DOS} \times k \times \text{OSAF}$$

EXAMPLE:

	For BOD = 7/92	
	k = 25 years	PW = \$1,000 x 25 x 0.2199
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.

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

$$\text{PW} = \text{Annual cost as of DOS } (A_0) \times \text{number of payments } (R) \times \text{OSAF}$$

Put this slide up while explaining how to use special energy OSAFs.

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 FEMP 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%

■ Now let's look at the OSAF headed, "One-Step Adjustment Factors/Normalized UPW* Factors; All Regions: Maintenance and Repair (M&R)."

Explain the format of the table, including FEMP/NON-FEMP columns. Point out the assumption of no differential escalation. Explain how the OSAF is used (Slide 7-10), and show the example on the flip chart or blackboard. Point out that this table is applicable for any region, because the factors do not contain region-unique data.

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:

$$\begin{array}{ll} \text{For BOD} = 7/94 & \\ k = 15 \text{ years} & \\ \text{Annual M\&R} = \$25,000 & \end{array} \quad \begin{array}{l} \text{PW} = \$25,000 \times 15 \times 0.2978 \\ = \$111,675 \end{array}$$

Slide 7-10

To find PW of uniform annual series

$$PW? \leftarrow A + A + \dots + A$$

$$PW = \text{Annual cost (A)} \times \text{number of payments (k)} \times \text{OSAF}$$

Use this slide to discuss the OSAF computations for a uniform series, such as routine M&R costs.

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
0.50	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	0.1361
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 FES 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

$$PW? < \text{-----} C_F$$

$$C_F \times \text{OSAF for one-time costs}$$

Use this slide to discuss the OSAF computations for a single future amount.

- Now let's look at the table headed "one-step" adjustment factors (OSAFs)/standard SPW factors; All Regions: One-Time Costs. It completes the set of tables.

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.

Explain how the OSAF is used (Slide 7-11), and show the example on the flip chart.

EXAMPLE:

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

$$PW = \$5,000 \times 0.3855 \times 0.9535 = \$1,838$$

- This is the worksheet that you need to use for the one-step approach.
- I will demonstrate how to use this form to calculate PWs, using the same example as we used for the conventional approach.

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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 6-802-1; the proponent agency is USACE.

One-Time Costs	<input type="checkbox"/> \$ x 10 ³ <input type="checkbox"/> \$ x 10 ⁴	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

Day 2

- First fill in the key dates for reference. See Vugraph 7-22 for data.
- Now compute one-time costs.

Calculate PWs of initial investment costs, replacement and retention value, writing entries on the overlay and explaining each step. Use factors for 2 years and 0.5 years to compute the OSAF for investment cost.

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

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

LIFE CYCLE COST ANALYSIS

PRESENT WORTH: ONE-STEP APPROACH

For use of this form, use TM 5-803-1; the proponent agency is USACE.

One-Time Costs X \$ x 10 ⁴ 1) \$ x 10 ⁴	Years from ABD	Cost On ABD	One Step Adj. Factor Table 1	Present Worth on ABD	Criteria Reference	HQ DA
Initial Investment	2.5	100	0.7880	78.8	Analysis Base Date (ABD)	JUL 88
Replacement	15	20	0.2394	4.8	Analysis End Date (AED)	JUL 2016
Retention V.	28	-10	0.0693	-0.7	Midpoint of Construction	JAN 91
					BOD for Analysis	JUL 91
					Annual Discount Rate	10%
					Type of Cost	Differential Escalation Rate per Year (%) Timeframe: 74-76 87-90, 90-95, 95-16
					Nat'l Gas	2.73 9.17 6.10
					Other	0.00 0.00 0.00

Annual Costs X \$ x 10 ⁴ 1) \$ x 10 ⁴	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:					

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*Use One-Step Table 2 for M&R costs (n = 0).

Use One-Step Table 3 for energy/fuel costs (n = prescribed value).

Sheet _____ of _____

Day 2

- The last thing to do is to compute LCC.

Sum PWs and write entries on the overlay.

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

Project No. & Title PN 567 Hess 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	<input checked="" type="checkbox"/> \$ x 10 ³ <input type="checkbox"/> \$ x 10 ⁴	Years from ABD	Cost On ABD	One Step Adj. Factor Table 1	Present Worth on ABD	Criteria Reference	H&DA		
Initial Investment		2.5	100	0.7880	78.8	Analysis Base Date (ABD)	JUL 88		
Replacement		15	20	0.2394	4.8	Analysis End Date (AED)	JUL 2016		
Retention Value		28	-10	0.0693	-0.7	Midpoint of Construction	JAN 91		
						BOD for Analysis	JUL 91		
						Annual Discount Rate	10%		
						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	<input checked="" type="checkbox"/> \$ x 10 ³ <input type="checkbox"/> \$ x 10 ⁴	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

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

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.)

Vugraph 7-S4. Completed PW: One-Step Approach Sheet

LIFE CYCLE COST ANALYSIS

**PRESENT WORTH:
ONE-STEP APPROACH**

Project No. & Title PN 568, Veh. Maint. Shop
 Installation & Location Fort X, Huntsv., AL
 Design Feature Exterior Wall
 Alt. No. A Title Tile Wall

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

One-Time Costs <input checked="" type="checkbox"/> \$ x 10 ³ <input type="checkbox"/> \$ x 10 ⁶	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)
Initial Investment	2.5	75	0.7888	59.2	HQDA	Jul 88
Retention V.	28	-7.5	0.0693	-0.5		Jul 16
Repair yr. 5	8	5	0.4665	2.3	Midpoint of Construction	Jan 91
10	13	5	0.2897	1.4	BOD for Analysis	Jul 91
15	18	5	0.1799	0.9	Annual Discount Rate	10%
20	23	5	0.1117	0.6	Type of Cost	Differential Escalation Rate per Year (%) Timeframe: Jul-Jul 87-90, 90-95, 95-20
					Other	0.00 0.00 0.00

Annual Costs <input checked="" type="checkbox"/> \$ x 10 ³ <input type="checkbox"/> \$ 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	25	2	50	0.2838	14.2
Distillate	25	12	300	0.5526	165.8

	Initial Costs	Energy/Fuel Costs	M&R Costs	Other Costs	Total
Net Present Worth:	59.2	165.8	14.2	4.7	244

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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 DA Form 5605-2

RANKING DESIGN ALTERNATIVES ON THE BASIS OF LCCs

<u>Design Alternative</u>	<u>LCC</u>	<u>Rank</u>
A	\$100K	1
B	\$150K	2
C	\$200K	3

- The purpose of this slide is to emphasize the point that we need to compute LCCs for alternatives, and then we need to see how the alternatives compare with respect to their LCCs.
- We need to rank the design alternatives in order of preference and to provide documentation for the decision. The TM gives principles for ranking alternatives in Chapter 2 (2-2, c).
- In this simple illustration, the ranking is straightforward. There is a relatively large difference in the LCCs of alternatives. The alternative with the lowest LCC is assigned the highest ranking (i.e., preference), and the one with the highest LCC is assigned the lowest ranking. Alternative A should be strongly recommended on economic grounds.

Slide 7-13

CONCLUSIVENESS OF LCC RESULTS

LCC results may be

- | | |
|---|--------------------------------------|
| <ul style="list-style-type: none"> • Clearly Conclusive | Rank by LCC |
| <ul style="list-style-type: none"> • Clearly Inconclusive | Other ranking criteria needed |
| <ul style="list-style-type: none"> • Neither clearly conclusive nor clearly inconclusive | Uncertainty assessment may be needed |

- But the outcome of LCCA is not always as conclusive as that illustrated in the previous slide. The results of the LCCA may not reveal a clear-cut preference for one alternative over others. You may need other criteria for making the selection. Or you may need to perform uncertainty assessment to try to gain a clearer idea of the likely consequences of alternatives.
- This slide summarizes the possibilities of the outcome of LCCA.

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.

- We will discuss the other criteria in just a moment.

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.

Day 2

- We will discuss when a design decision is considered routine and when non-routine, later in the course.
- Now let's look more closely at the second case, when LCC results are inconclusive and other criteria are needed to break the tie.

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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

- This is a list of the specific tie-breaking criteria.

Discuss them. In discussing the last criterion, emphasize that what is meant by "judgment" is professional judgment of the designer as to which of the alternatives tied for top ranking represents the best overall choice for that particular application. Close with reminder of condition under which they apply.

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 10 ³ \$ x 10 ⁶				
		Initial	Energy	M&R	Other	Total

ECONOMIC RANKING				
Rank	Alternative No. & Title	Economic Advantage 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 Participant - Name	Discipline	Organization	Telephone No.

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Sheet _____ of _____

- This summary form is used to document the LCCA and to assign rankings to guide the choice among alternatives.
- Let's complete it for the demonstration example, choosing exterior doors. First we fill in the results of the LCC analysis of design A.

Write in on overlay.

- Let's suppose that we also had measured LCC for an alternative design B, which had the following PWs and total: Initial, \$60.0; Energy, \$165.0; M&R, \$12.0; other, \$6.0; and total, \$243.

Write in on overlay.

- What ranking would you assign to these two alternatives?
- Alternatives receive same ranking. Tie breaking rules don't apply. Both initial cost and energy cost differences exceed 15% criteria. Choice would be made on basis of professional judgment.

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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 Extension Doors

**LIFE CYCLE COST ANALYSIS
 SUMMARY**

For use of this form, see TM 8-802-1; the proponent agency is USACE.

Date of Study 1 July 88

ALTERNATIVES ANALYZED						
No.	Description/Title	Present Worth : : \$ x 10 ³ : : \$ x 10 ⁴				Total
		Initial	Energy	M&R	Other	
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%		Compar- able LCCs

KEY ASSUMPTIONS	NARRATIVE SUMMARY (Comments/Lessons Learned/Observations/Recommendations/Etc.)
	Both initial cost + energy cost differ- ences exceed 15% criterion. Choice to be made on basis of judgment

Key Participants - Name	Discipline	Organization	Telephone No.

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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

Project No. & Title PN 568, Veh. Maint. Shop
 Installation & Location Fort X, Huntsv, AL
 Design Feature Exterior Wall
 Date of Study July 88

**LIFE CYCLE COST ANALYSIS
SUMMARY**

For use of this form, see TM 8-802-1; the proponent agency is USACE.

ALTERNATIVES ANALYZED						
No.	Description/TM's	Present Worth $1: \$ \times 10^3$ $1: \$ \times 10^6$				
		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.

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Sheet _____ of _____

Vugraph 7-S5. Exercise 7-3
Completed LCCA: Summary Sheet

LIFE CYCLE COST ANALYSIS
SUMMARY

Project No. & Title PN 568, Veh. Maint. Shop
Installation & Location Fort X, Hunter, AL
Design Feature Exterior Wall

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

Date of Study July 88

ALTERNATIVES ANALYZED						
No.	Description/Title	Present Worth : \$ x 10 ³ : \$ x 10 ⁶				
		Initial	Energy	M&R	Other	Total
A	Tile	59.1	165.8	14.2	4.7	243.8
B	Special Veneer	80	110.0	4.0	1.0	195.0

ECONOMIC RANKING				
Rank	Alternative No. & Title	Economic Advantage of Top-Ranked Alternative		Basis for No. 1 Ranking
		LCC (PW) Difference (Dollars & Percent)	Other (Initial, Energy, Etc.)	
1	B Special Veneer	48.8K	Tie breaking not required	LCCs
2	A Tile	25%		

KEY ASSUMPTIONS	NARRATIVE SUMMARY (Comments/Lessons Learned/Observations/Recommendations/Etc.)

Key Participants - Name	Discipline	Organization	Telephone No.

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Sheet _____ of _____

Day 2

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**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	

Vugraph 7-S6. Solution to Exercise 7-4

SET	ALTER-NATIVE	LCC	INITIAL COSTS	ENERGY USE	RANK
1	A	\$50,000	\$25,000	13,000 kWh	1
	B	\$48,000	\$35,000	12,500 kWh	2
2	A	\$5,000	\$1,000	0	1
	B	\$8,000	\$500	0	2
3	A	\$15,800	\$5,000	2,000 gal oil	2
	B	\$16,000	\$5,700	1,400 gal oil	1
4	A	\$26,000	\$12,000	50,000 kWh	2
	B	\$20,000	\$15,000	60,000 kWh	1
5	A	\$160,000	\$25,000	1,000 gal oil	1
	B	\$180,000	\$24,600	960 gal oil	2
6	A	\$15,000-\$30,000	\$10,000	0	1
	B	\$20,000-\$25,000	\$12,000	0	2
7	A	\$100,000	\$40,000	10,000 kWh	1
	B	\$112,000	\$41,000	11,000 kWh	2

Alternatives are listed in order ranked with argument in parenthesis.

Set 1: A,B (initial cost); Set 2: A, B (LCC); Set 3: B,A (energy); Set 4: B,A (LCC); Set 5: A,B if routine (Otherwise, perform uncertainty assessment); Set 6: A,B (Initial Costs); Set 6: A,B (lower first cost, lower energy; no uncertainty assessment needed).

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.



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

LESSON PLAN 8: HOW TO PERFORM ENERGY CONSERVATION STUDIES

This module adds the specifics needed to perform EA/LCCA for energy conservation studies, using DA Form 5605 according to "FEMP criteria."

TIME	OVERVIEW	TRAINING AIDS OR CUES
0800	REVIEW Divide students into groups of 3 or 4 for a "Buzz Question Session" (see Admin -- Instructional Techniques). Questions to come from material up through Module 7.	B or F
0900	Ask students to turn to Module 8. Review purpose of Module 8, outline, and allotted time. Introduce energy conservation studies as a type of special directed economic study whose requirements are established by statute and executive order.	S8-1 W8 S8-2/5
0915	8.1 Present criteria for performing energy conservation studies and compare and contrast them with those for general economic studies. Discuss when energy conservation studies are required and how they are distinguishable from general economic studies of design features that affect a facility's energy use.	S8-6 (a-j) S8-7
0945	Announce Break	
1000	8.2 Introduce exercise 8-1 which is to identify the correct criteria for energy conservation studies versus general economic studies. Lead class in doing the exercise.	Ex 8-1
1045	8.3 Demonstrate how to evaluate energy conserving design alternatives using OSAF tables.	Problem Statement V8-1/26
1100	8.4 Introduce exercise 8-2. Ask students to work in pairs. Suggests that each member of the pair be responsible for computing the LCC for one of the two alternatives, and that they work together to decide the approach and to check each other's work.	Ex 8-2 Blank Forms

Key: S = slide, V = Vugraph, F = Flip chart, W = Workbook, s = section, N = Notebook, TM = Technical Manual, c = chapter, B= Blackboard, Ex = Exercise

LESSON PLAN 8: HOW TO PERFORM ENERGY CONSERVATION STUDIES (continued)

TIME	OVERVIEW	TRAINING AIDS OR CUES
	<p>When most have finished the calculations, call on five students in sequence to present the solution.</p> <p>Provide them Vugraphs of the forms with blank overlays for their presentations.</p> <p>Ask for questions.</p> <p>1200 Announce Lunch</p>	<p>Transparencies of Forms for Student Presentations</p> <p>Completed Solution Forms</p>

Key: S = slide, V = Vugraph, F = Flip chart, W = Workbook, s = section, N = Notebook, TM = Technical Manual, c = chapter, B= Blackboard, Ex = Exercise

HOW TO PERFORM ENERGY CONSERVATION STUDIES

Put up this slide while asking students to turn to module and objectives.

- You know how to perform MILCON general economic studies. Now let's look at energy conservation studies.

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**

- In Module 4 we indicated that there are three types of requirements for EA, the first being general economic studies -- which we treated in Module 7 -- and the other two both being types of special directed studies -- those directed by statute or executive order and those directed by OSD, HQDA, HQUSAF or HQUSACE.

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**

- As you can see here, studies of energy-conserving designs come under the category of studies directed by statute or executive order.
- Congress and the President established special requirements for energy conservation studies in response to the energy crises of the 1970's and the ensuing national goal to reduce consumption of non-renewable energy.

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)

- Key legislation and executive orders are . . .
- DOE was designated the lead agency to develop specific Federal regulations to implement the provisions of the legislation and executive order.
- Federal agencies were directed by legislation and executive order to make Federal buildings -- new and existing -- "life-cycle-cost effective," taking into account energy and other costs.
- DOE led the effort to establish an "LCC Rule" that sets forth the criteria (i.e., the methodology, procedures, and certain specified data) for performing EA evaluations of proposed investments in energy conservation and substitution of renewable energy sources.
 - The LCC Rule explains in brief how they are to do this.
 - National Institute of Standards and Technology NBS Handbook 135 explains the criteria in more detail and illustrates its use in sample applications. (NIST serves as the technical research arm of DOE in developing EA methodology and procedures for energy conservation.)

- The LCC Rule for performing energy conservation EA studies is
 - codified in the Code of Federal Regulations to which all Federal agencies are subject (See 10 CFR Section 436, subpart A)
 - amplified in National Institute of Standards and Technology NBS Handbook 135
 - summarized in chapter 2 of the TM
 - occasionally revised (e.g., rule change Nov. 20, 1990, Fed. Reg., Vol. 55, No. 224)

Show them Handbook 135 and provide a few copies for examination with a sign-up sheet for those who would like to be mailed a copy; ask them to look at chapter 2 of the TM; indicate that they can obtain up-to-date criteria after the course by contacting Dr. Schindler at the address given. (Refer to Administrative Section.)

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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

- The specific DOE program charged with responsibility for this effort is the Federal Energy Management Program (FEMP). We sometimes refer to the criteria for performing Federal energy conservation studies as "FEMP criteria."

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
- In this section, we will examine the criteria for performing energy conservation studies, and see how they differ from criteria for general economic studies.

Series of 2 slides with highlighting. Slide a = everything above the line; slide b shows the entire text and highlights the part below the line.

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**

- Rather than go through all of the criteria one-by-one, let's use the criteria for general economic studies as the point of reference and focus on what is different for energy studies. This lists summarizes the criteria which are different, with the most important listed above the line.

Discuss each item in the list.

- All other criteria for energy studies are the same as those for general economic studies. For example, in energy conservation studies as in general economic studies, LCCA is the principal form of analysis; the analysis is performed in constant dollars, i.e., without inflation added in; cost and benefits are discounted to their present worth equivalents.
- A revision of the LCC rule was approved in 1990 (10 CFR part 436, Fed. Reg./ Vol. 55, No. 224, Nov. 20, 1990). When the changes have been disseminated by HQUSACE, energy conservation studies for MILCON applications will be performed more like general economic studies.

In case it appears desirable to discuss what the criteria are after the LCC Rule change (1990 change), the following notes are provided:

Discount rate to change annually (tied to long-run Treasury bonds)

Non-energy e values still set at 0

More emphasis placed on uncertainty analysis

Use of SIR and DPP retained and AIRR added as an alternative to SIR for active solar

Remaining rules are flexible enough to allow energy studies to look much like general studies aside from the above items.

- 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

- You will be notified by HQ when there are changes in the criteria. HQUSACE will disseminate revised criteria when they are changed (via EIRS Bulletin or ETL on an interim basis; via revised TM for long hauls).
- If you perform economic analysis of energy conservation projects in conjunction with the Energy Conservation Investment Program (ECIP), there is one more difference you need to be aware of -- a difference in documentation. ECIP has a special form for documentation, whereas the same form we used for general economic studies (i.e., DA Form 5605) can be used to evaluate energy conservation projects outside of ECIP.

Refer them to the ECIP Guidance Memorandum in the Notebook of Reference Documents.

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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

- How do you tell when the special LCC Rule for energy conservation applies and when the criteria for general economic studies apply?
- Here are guidelines for determining when you should use the criteria of a general economic study (section 7.1) and when you should use the criteria that pertain to energy conservation and renewable energy decisions (section 8.1).

Review guidelines on slide.

- In some cases you may not be sure if a design which saves energy is provided for by current design criteria (i.e., should be treated as a general economic study) or whether it should be regarded as a special energy conservation study. If in doubt as to which set of criteria applies, use the special energy conservation criteria for evaluating a design alternative which saves energy. Does anyone know why? (Because it is statutory.)

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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		

SOLUTION TO 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	10% real	7% real
Date of Study	1/1990	1/1990
Number of Years Construction Costs are Discounted	2.5	0
Percentage Reduction in Construction Costs	0	10%
Number of Years until First Energy Cost is Incurred	3.5	1
Total Number of Years in Analysis Period	28	25
Method of Adjusting for Inflation	State Costs in Constant \$s	State Costs in Constant \$s
Principal Method of Analysis	LCCA	LCCA

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IN THE STUDENT'S MANUAL

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
-
- In this section, we will demonstrate with a case example how to perform energy conservation studies according to FEMP criteria.
 - I would like for you to work along with me.
 - We will use the DA Forms 5605 again.

Complete the forms using enlargements of each part, and writing the answers on an overlay.

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
 Midpoint 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	Alt B
	<u>Conventional Design</u>	<u>Energy-Conserving</u>
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

Start with vugraph of DA Form 5605-3 - blank

- This is the Basic Input Data Summary Sheet we used before. Recall that we use it to help keep track of the data and to identify the calculations we will need to do, and, additionally, to document the study.

- Let's complete it, beginning with the identifying information for the project in the upper left-hand corner.

Vugraph 8-1a. Blow up of project description

Project No. & Title _____

Installation & Location _____

Design Feature _____

Alt. No. _____ **Title** _____

- Here we see that portion of the sheet enlarged.

Complete it using an overlay, asking for student input, and explaining the reason for each entry. For guidance, see the completed form at the end of the presentation of each of the parts.

Vugraph 8-1b. Blow up of Date section

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	

Write in dates on overlay, explaining each.

Vugraph 8-1c. Blow up of region, discount rate, escal rates

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

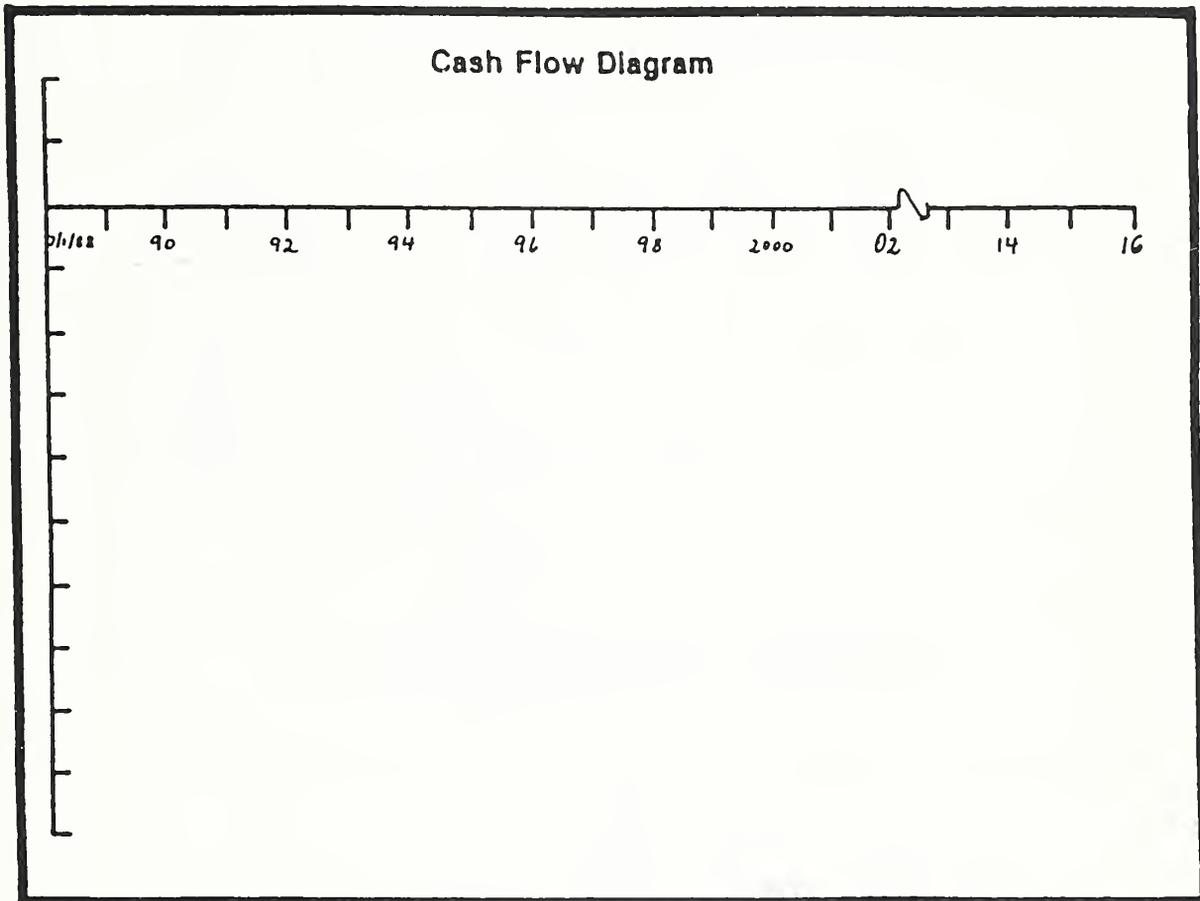
Write in information on overlay, explaining each item.

Vugraph 8-1e. Blow up of principal assumptions part of form

Principal Assumptions

- Here we record any critical assumptions to the analysis not apparent elsewhere on the form. There are not any in this case.

Vugraph 8-1f. Blow up of cash flow diagram



Drop in the overlay on which the sketch is already drawn, or sketch it.

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Vugraph 8-2. Completed Input Data Summary Form

Project No. & Title PA2 Admin. Bldg
 Installation & Location Fert X, Madison, WI
 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		<u>FEMP</u>	
Date of Study (DOS)		<u>7/88</u>	
Analysis Base Date (ABD)		<u>7/88</u>	
Analysis End Date (AED)		<u>7/13</u>	
Midpoint of Construction		<u>1/91</u>	
Beneficial Occupancy Data (BOD)	Actual Projected	<u>7/91</u>	
	Assumed for Analysis	<u>7/88</u>	
DOE Region		<u>5</u>	
Annual Discount Rate		<u>17%</u>	
Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe: <u>88-90, 90-95, 95-13</u>		
<u>Nat Gas</u>	<u>2.80</u>	<u>8.25</u>	<u>5.32</u>

Principal Assumptions

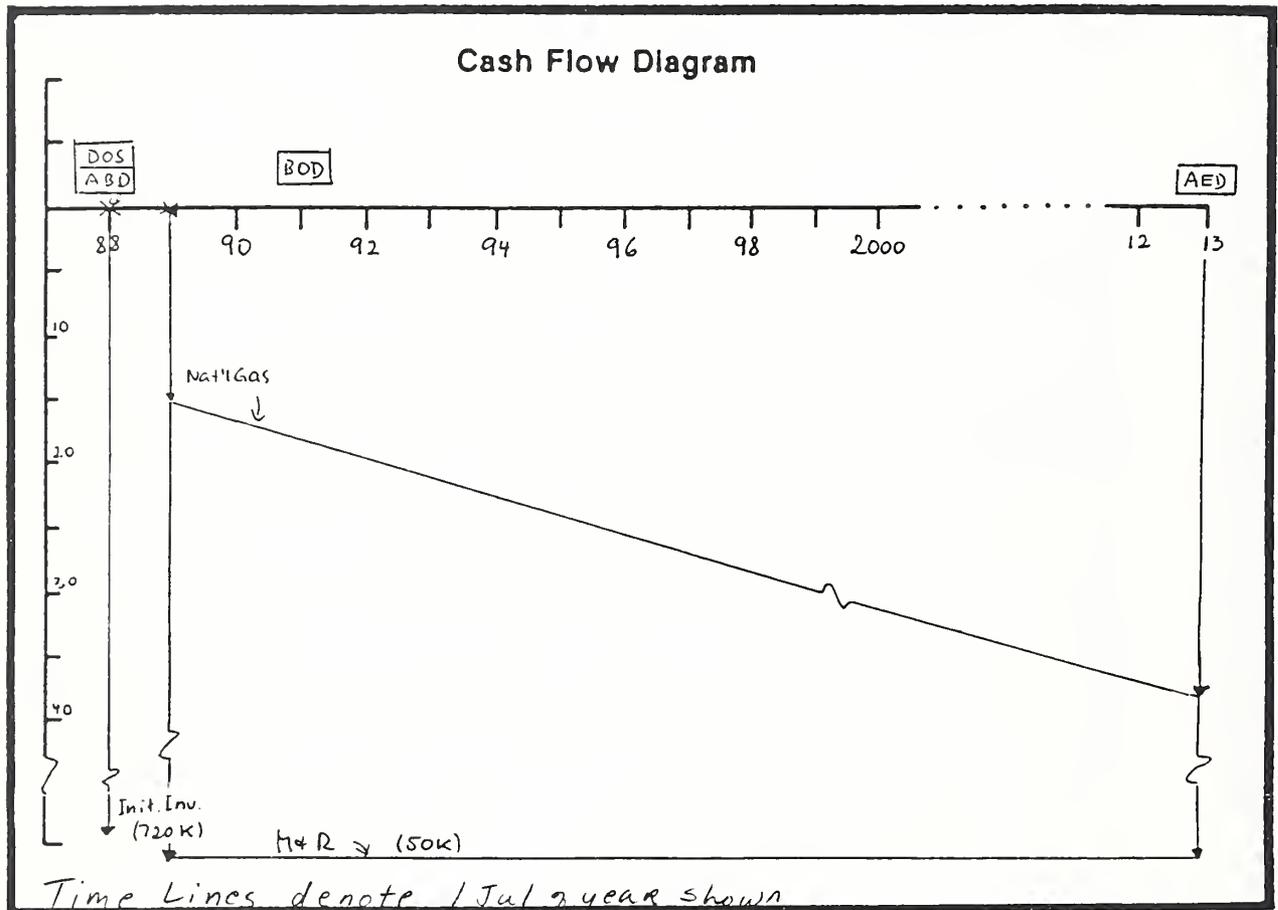
Cash Flow Diagram

Cost Element	Cost on ABD √ \$ x 10 ³ _ \$ x 10 ⁴	Time Cost Incurred**		Source(s) of Data
		Actual Projected Dates	Dates for Analysis (If Different)*	
<u>Initial Cost</u>	<u>720 (800 less 10%)</u>	<u>1/91</u>	<u>7/88</u>	<u>Cost Engineer's Est. (App. 1)</u>
<u>M + R Cost</u>	<u>50</u>	<u>1/92 - 1/16</u>	<u>7/89 - 7/13</u>	<u>Past Experience (App. 2)</u>
<u>Natural Gas</u>	<u>15</u>	<u>1/92 - 1/16</u>	<u>7/89 - 7/13</u>	<u>BLAST (App. 3)</u>

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

■ Here is the completed Input Data Summary Form for the "Conventional Design."

Vugraph 8-3. Blow-up of cash flow diagram -- completed



Vugraph 8-4a. Enlargement of top part of sheet
RH info filled in

Project No. & Title PNZ 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	$\begin{matrix} \text{U} \$ \times 10^3 \\ \text{L} \$ \times 10^6 \end{matrix}$	Years from ABD	Cost On ABD	One Step Adj. Factor Table 1	Present Worth on ABD	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:
						Nat Gas	2.80 8.25 5.32

- Fill in the dates from the data summary form to keep that information in front of you.
- Now compute present worth of one-time costs.

Complete this section on the overlay, explaining each calculation. Use as a guide the completed form at the end of the presentation of the parts.

Vugraph 8-4c. One-step sheet completed, except for bottom line

Project No. & Title PN 2 Admin Bldg
 Installation & Location Fort X, Madison, WI
 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 8-802-1; the proponent agency is USACE.

One-Time Costs	$\sqrt{\$ \times 10^4}$.. $\$ \times 10^4$	Years from ABD	Cost On ABD	One Step Adj Factor Table 1	Present Worth on ABD	Criteria Reference	FEMP		
Initial Cost		0	720	1.0000	7.20	Analysis Base Date (ABD)	7/88		
						Analysis End Date (AED)	7/13		
						Midpoint of Construction	1/91		
						BDD 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	$\sqrt{\$ \times 10^4}$.. $\$ \times 10^4$	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					

DA FDRM 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 _____

■ The last thing to do for this alternative is to compute LCC.

Sum PWs and write entries on the overlay.

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Vugraph 8-5. PW: One-Step Approach Sheet -- completed

Project No. & Title PN 2 Admin. Bldg
 Installation & Location Fort X, Madison, WI
 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 10 ³ - \$ x 10 ⁶	Years from ABD	Cost on ABD	One Step Adj. Factor Table 1	Present Worth on ABD	Criteria Reference
<i>Initial Cost</i>	<i>0</i>	<i>720</i>	<i>1.0000</i>	<i>7.20</i>	<i>FEMP</i>
					Analysis Base Date (ABD) <i>7/88</i>
					Analysis End Date (AED) <i>7/13</i>
					Midpoint of Construction <i>1/91</i>
					BOD for Analysis <i>7/88</i>
					Annual Discount Rate <i>7%</i>
					Differential Escalation Rate per Year (%) Timeframe: <i>88-90, 90-95, 95-13</i>
					<i>Nat Gas</i> <i>2.80</i> <i>8.25</i> <i>5.32</i>

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
<i>M + R Cost</i>	<i>25</i>	<i>50</i>	<i>1,250</i>	<i>0.4661</i>	<i>583</i>
<i>Natural Gas</i>	<i>25</i>	<i>15</i>	<i>375</i>	<i>0.8499</i>	<i>319</i>

	Initial Costs	Energy/Fuel Costs	M&R Costs	Other Costs	Total
Net Present Worth:	<i>720</i>	<i>319</i>	<i>583</i>	<i>-</i>	<i>1,622</i>

DA FORM 5605-S-R, DEC 86

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

Sheet _____ of _____

Return to vugraph of DA Form 5605-3 -- blank

- Now we need to repeat the process for the alternative, energy conserving design.

If you think students need to see step by step all the computations demonstrated again, and if time permits, do it. Otherwise you can merely refer to the process of completing the set of forms for this alternative, and go straight to the completed form at the end of the parts presentation. But if you do this, make sure to emphasize that the LCC evaluation must be repeated for each alternative. A set of vugraphs with all of the parts enlarged is provided in the instructional material in case you think presentation of the LCC computations for alternative B is needed, but each of the parts are not repeated here. They are blanks identical to those used for demonstrating alternative A.

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Vugraph 8-7. Completed Input Data Summary Form

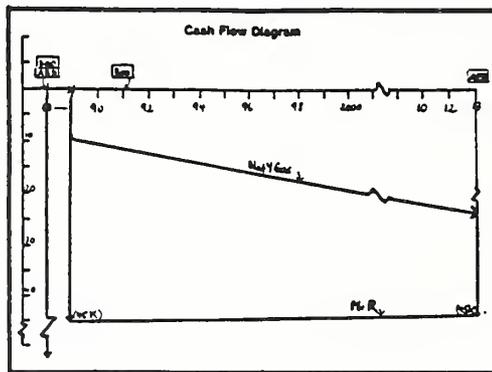
Project No. & Title PN2 Admin. Bldg
 Installation & Location Fort X, Madison, WS
 Design Feature Envelope
 Alt. No. B Title Earth-Bermed Design

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		<u>FEMP</u>	
Date of Study (DOS)		<u>7/88</u>	
Analysis Base Date (ABD)		<u>7/88</u>	
Analysis End Date (AED)		<u>7/13</u>	
Midpoint of Construction		<u>1/91</u>	
Beneficial Occupancy Date (BOD)	Actual Projected	<u>7/91</u>	
	Assumed for Analysis	<u>7/88</u>	
DOE Region		<u>5</u>	
Annual Discount Rate		<u>7%</u>	
Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe: <u>88-90, 90-95, 95-13</u>		
<u>Nat Gas</u>	<u>2.80</u>	<u>8.25</u>	<u>5.32</u>

Principal Assumptions



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)*	
<u>Initial Cost</u>	<u>878 (975 less 10%)</u>	<u>1/91</u>	<u>7/88</u>	<u>Cost Engineer's Est. (APP.1)</u>
<u>M + R Cost</u>	<u>45</u>	<u>1/92 - 1/16</u>	<u>7/89 - 7/13</u>	<u>Past Experience (APP.2)</u>
<u>Natural Gas</u>	<u>8</u>	<u>1/92 - 1/16</u>	<u>7/89 - 7/13</u>	<u>BLAST (APP.3)</u>

DA FORM 5605-3-R, DEC 86

* Note: Taking a 10% reduction in initial costs of both designs is equivalent to taking
 *When 10 CFR438A Criteria Apply a 10% reduction in the difference.
 **For Recurring Annual Costs, show date of first and last costs only. Sheet _____ of _____

■ Here is the completed Input Data Summary Form for the energy conserving design.

Vugraph 8-9. PW: One-Step Sheet -- completed

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

**PRESENT WORTH:
ONE-STEP APPROACH**

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

One-Time Costs	$\$ \times 10^3$.. $\$ \times 10^4$	Years from ABD	Cost On ABD	One Step Adj. Factor Table 1	Present Worth on ABD	Critsrie Reference	FEMP
Initial Cost		0	878	1.0000	878	Analysis Base Date (ABD)	7/88
						Analysis End Date (AED)	4/13
						Midpoint of Construction	1/91
						BOD for Analysis	7/88
						Annual Discount Rate	7%
						Differential Escalation Rates per Year (%)	Timeframe: 88-90, 90-95, 95-13
						Nat Gas	2.80 8.25 5.32

Annual Costs	$\$ \times 10^3$.. $\$ \times 10^4$	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-S-R, DEC 86

*Use One-Step Table 2 for M&R costs (e = 0).

Use One-Step Table 3 for energy/fuel costs (s = prescribed e value).

Sheet _____ of _____

Vugraph 8-10. DA Form 5605-2 -- blank

Project No. & Title _____
 Installation & Location _____
 Design Features _____
 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 1. \$ x 10 ³ 2. \$ 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 _____

- Next we rank the design alternatives and recommend which is preferred in terms of their LCCs.

Write results on overlay and discuss. Use as a guide the completed form which follows.

- Alternative B is preferred over A, based on LCCs.

It is important to make the following point:

- Notice that the difference in LCCs appears to be trivial expressed as a percentage of the total, but also notice that viewed incrementally a different picture emerges. For an additional expenditure of \$175,000 (or \$158,000 taking into account the 10% credit), about \$50,000 of net savings is estimated. This means that total savings are estimated to be large enough to cover all costs, provide the required 7% rate of return imposed by the discount rate, and provide about \$50,000 extra. Think of net savings as analogous to profit; all costs are already deducted.

A common error is to dismiss the net savings in an example like this as unimportant. The error stems from including total investment costs in the LCC measures rather than only the part of costs affected by the choice. Notice that most of the investment costs (\$800,000) are common to both designs. The same costs included in LCCs of alternatives will be offsetting, and therefore will not affect the dollar difference between alternatives. However, it will understate the percentage difference in LCCs, and that may influence an incorrect choice if the percentage difference in LCCs is a factor in the decision. Since this is an energy conservation analysis, the alternative with the lowest LCC would normally be selected even if the LCC difference were relatively small.

We present this example with total investment costs included because including more than the costs affected is a common practice, particularly in building design studies, and we think it is important that you understand the implications. Supplementary economic measures, such as the savings-to-investment ratio (SIR) which compares the savings with the additional investment cost of one alternative relative to another, are often helpful in gaining a fuller understanding of economic performance. (We will learn how to compute SIRs later in the course.)

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Vugraph 8-11. DA Form 5605-2 -- completed

Project No. & Title PNZ Admin. Bldg
 Installation & Location Fert X, Madison, WS
 Design Feature Envelope
 Date of Study 7/88

**LIFE CYCLE COST ANALYSIS
SUMMARY**

For use of this form, see TM 8-802-1; the proponent agency is USACE.

ALTERNATIVES ANALYZED						
No.	Description/Title	Present Worth · \$ x 10 ³				Total
		Initial	Energy	M&R	Other	
A	Conventional Design	720	319	583	-	1,622
B	Earth-Berm Design	878	170	524	-	1,572

ECONOMIC RANKING				
Rank	Alternative No. & Title	Economic Advantage of Top-Ranked Alternative		Basis for No. 1 Ranking
		LCC (PW) Difference (Dollars & Percent)	Other (Initial, Energy, Etc.)	
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 Participant - Name	Discipline	Organization	Telephone No.
I.M. Architect	Architect	U.S. ACE	X X X X X
M.E. Tow	Architect	USACE	X X X X X

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

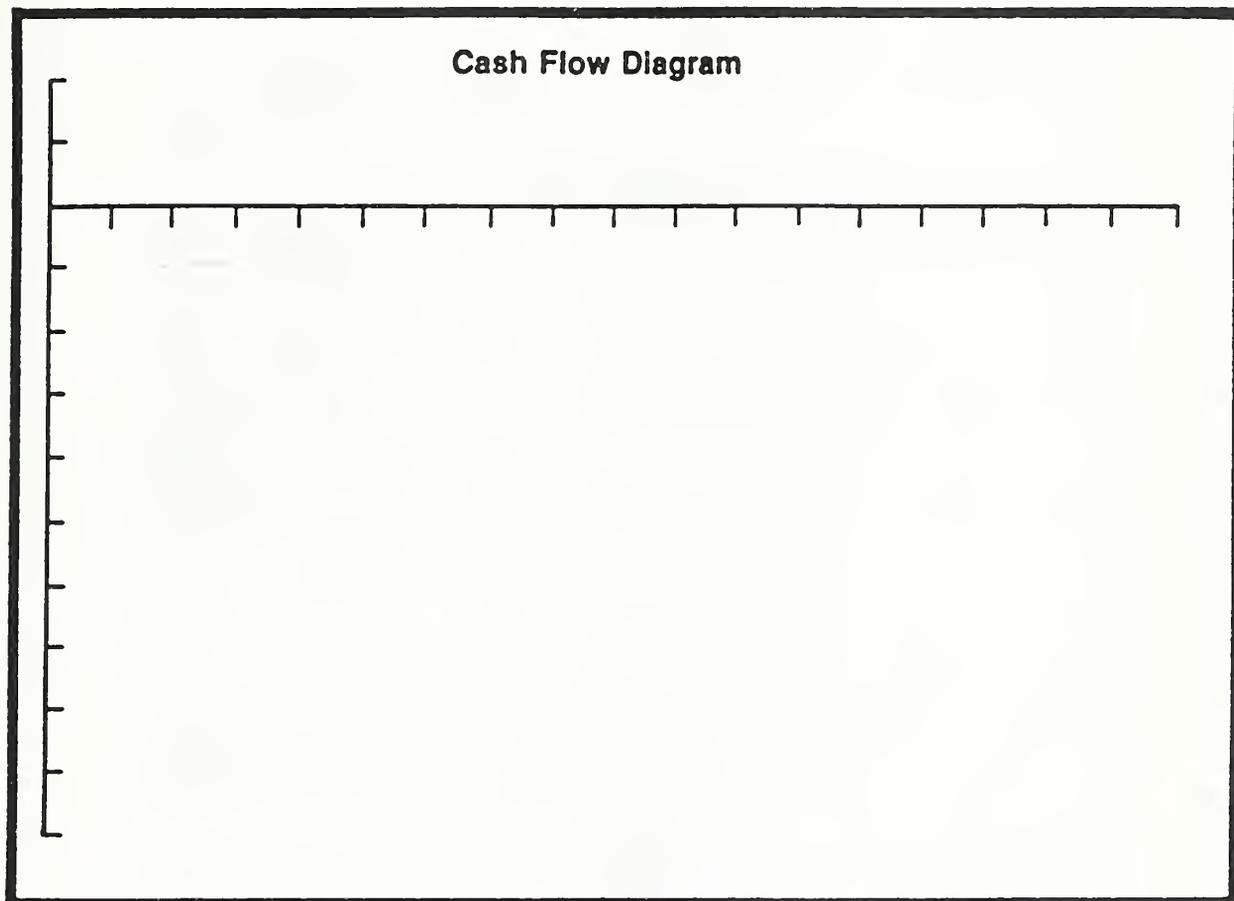
Data (continued):

	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

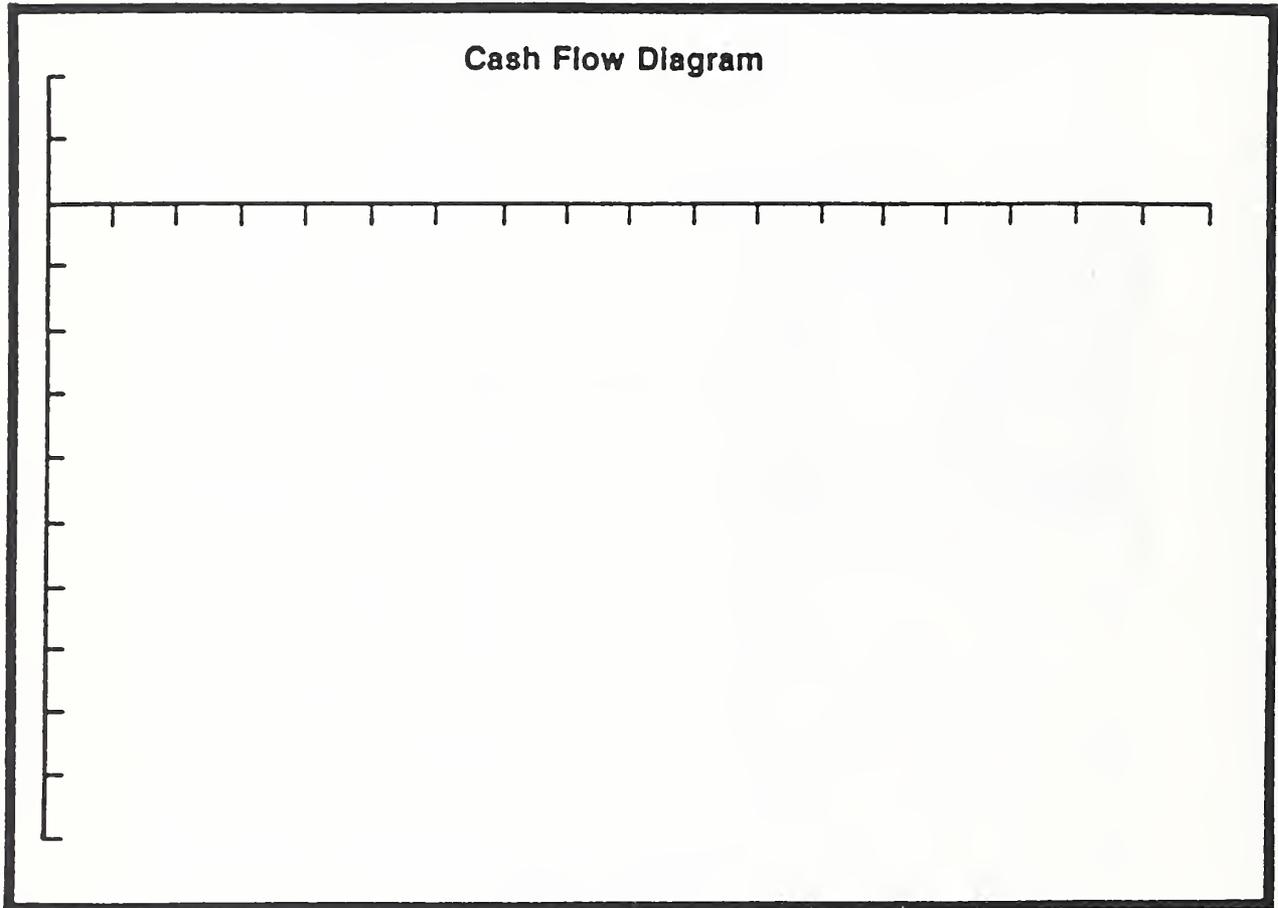
Dates: DOS = ABD = 7/88; Start of Construction = 7/90; BOD = 7/91

- *If the class is divided into two groups to do this problem, the fan replacement should be included in the analysis.*

Form 8-13. Blow up of cash flow diagram -- blank



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	<input type="checkbox"/> \$ x 10 ³ <input type="checkbox"/> \$ x 10 ⁶	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	<input type="checkbox"/> \$ x 10 ³ <input type="checkbox"/> \$ 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

	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 (s = 0).

Use One-Step Table 3 for energy/fuel costs (s = prescribed value).

Sheet _____ of _____

Form 8-18. 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 8-802-1; the proponent agency is USACE.

ALTERNATIVES ANALYZED						
No.	Description/Title	Present Worth 10^3 10^6				
		Initial	Energy	M&R	Other	Total

ECONOMIC RANKING				
Rank	Alternative No. & Title	Economic Advantage 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-S1. Completed DA Form 5605-3
for Alt A

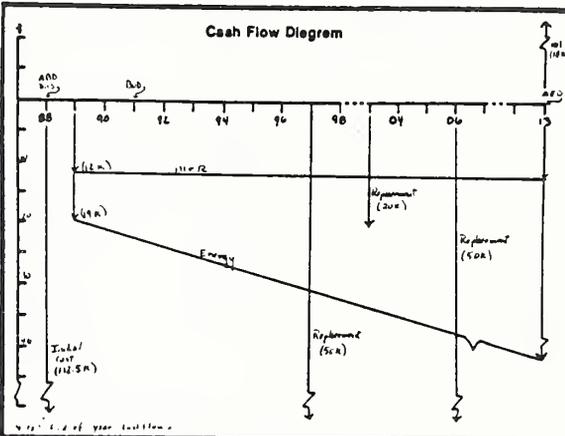
Project No. & Title PN 1 Administration Bldg
 Installation & Location Fort G, Mississippi
 Design Feature H V A C
 Alt. No. A Title Variable - Volume - No Economizer

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)		8/88	
Analysis End Date (AED)		9/13	
Midpoint of Construction		1/91	
Beneficial Occupancy Date (BDD)	Actual Projected	7/91	
	Assumed for Analysis	7/88	
DOE Region		4	
Annual Discount Rate		7%	
Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe: 88-90 90-95 95-13		
Elect	-2.99	-2.52	-0.10
Dist	4.54	7.75	4.44
Other	0	0	0

Principal Assumptions	



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)*	
Initial Cost	112.5 (125 kg app)	1/91	7/88	Cost Engineers Est (App 1)
Replacement (Plant)	50.0	7/00	7/97	Past Study (App 2)
Replacement (Fan)*	20.0	7/06	7/03	Past Study "
Replacement (Plant)	50.0	7/09	7/06	Past Study "
Retention Value	-18.0	7/11a	7/13	Value of like ship (App 3)
Electricity	17.0	1/92-1/16	7/89-7/13	BLAST (App 4)
Dist. Waste	2.0	1/92-1/16	7/89-7/13	BLAST (" 4)
M&R	12.0	1/92-1/16	7/89-7/13	BLAST (" 4)

* Fan is shown here for the record but is omitted from the LCC computation because it is identical for both alternatives.

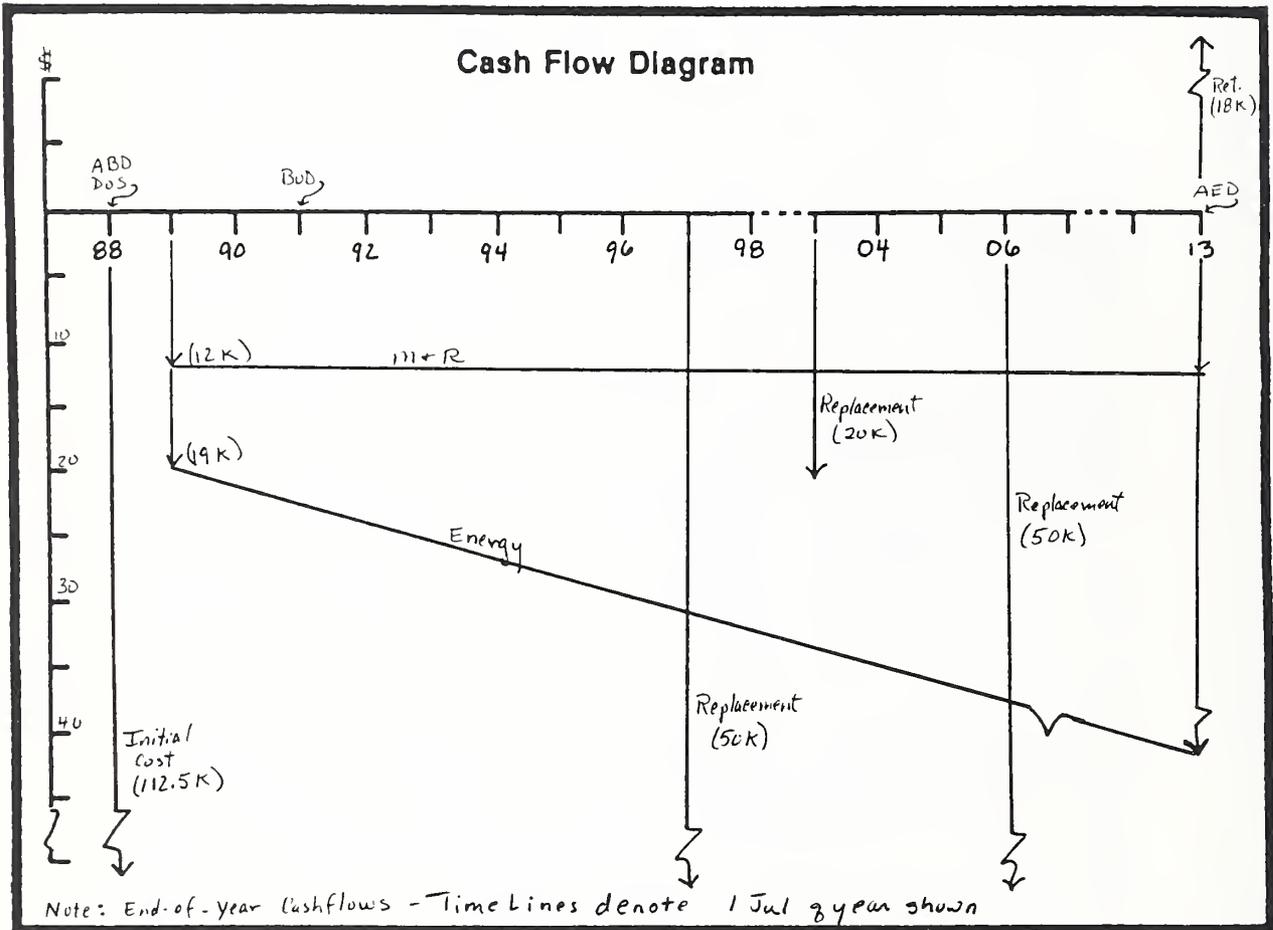
DA FORM 5605-3-R, DEC 86

*When 10 CFR436A Criteria Apply

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

Sheet _____ of _____

Vugraph 8-S1a. Completed enlarged cash-flow diagram



Vugraph 8-S2. Completed DA Form 5605-5
for Alt A

Project No. & Title PN1 Administration Bldg
Installation & Location Fort Q, Mississippi
Design Features HVAC
Alt. No. A Title Variable Volume - No Economizer

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	$\sqrt{\$ \times 10^3}$ $\sqrt{\$ \times 10^4}$	Years from ABD	Cost on ABD	One Step Adj. Factor Table 1	Present Worth on ABD	Critaris Reference	FEMP
Initial Cost		0	112.5	1.0000	112.5	Analysis Base Date (ABD)	7/88
Replacement (Plant)		9	50.0	0.5439	27.2	Analysis End Date (AED)	7/13
Replacement (Plant)		18	50.0	0.2959	14.8	Midpoint of Construction	7/91
Retention Value		25	18.0	0.1842	-3.3	BOD for Analysis	7/88
						Annual Discount Rate	7%
						Type of Cost	Differential Escalation Rates per Year (%)
							Timeframe: 89-90, 90-95, 95-13
						Elect	-2.99, -2.52, -0.10
						Dist	4.54, 7.75, 4.44
						Other	0, 0, 0
* Fan omitted because it is the same for Alts A+B							

Annual Costs	$\sqrt{\$ \times 10^3}$ $\sqrt{\$ \times 10^4}$	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	17.0	425.0	0.3910	166.2
Distribute		25	2.0	50.0	0.8361	41.8
M+R		25	12.0	300.0	0.4661	139.8

	Initial Costs	Energy/Fuel Costs	M&R Costs	Other Costs	Total
Net Present Worth:	112.5	208.0	139.8	38.7	499

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*Use One-Step Table 2 for M&R costs (a = 0).

Use One-Step Table 3 for energy/fuel costs (a = prescribed value).

Sheet _____ of _____

Vugraph 8-S3. Completed DA Form 5605-3
for Alt B

Project No. & Title PNI Administration Bldg
 Installation & Location Fort G, Mississippi
 Design Feature HVAC
 Alt. No. B This Variable - Volume - Economizer

LIFE CYCLE COST ANALYSIS
BASIC INPUT DATA SUMMARY

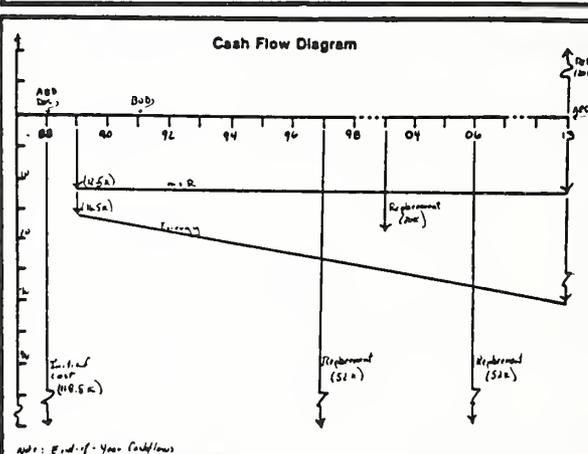
For use of this form, see TM 5-802-1; the proponent agency is USACE.

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 Data (BOD)	Actual Projected
	Assumed for Analysis
	7/91
	7/88

DOE Region	4
Annual Discount Rate	7%

Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe:	88-90	90-95
Elect	-2.99	-2.52	-0.10
Dist	4.54	7.75	4.44
Other	0	0	0

Principal Assumptions	



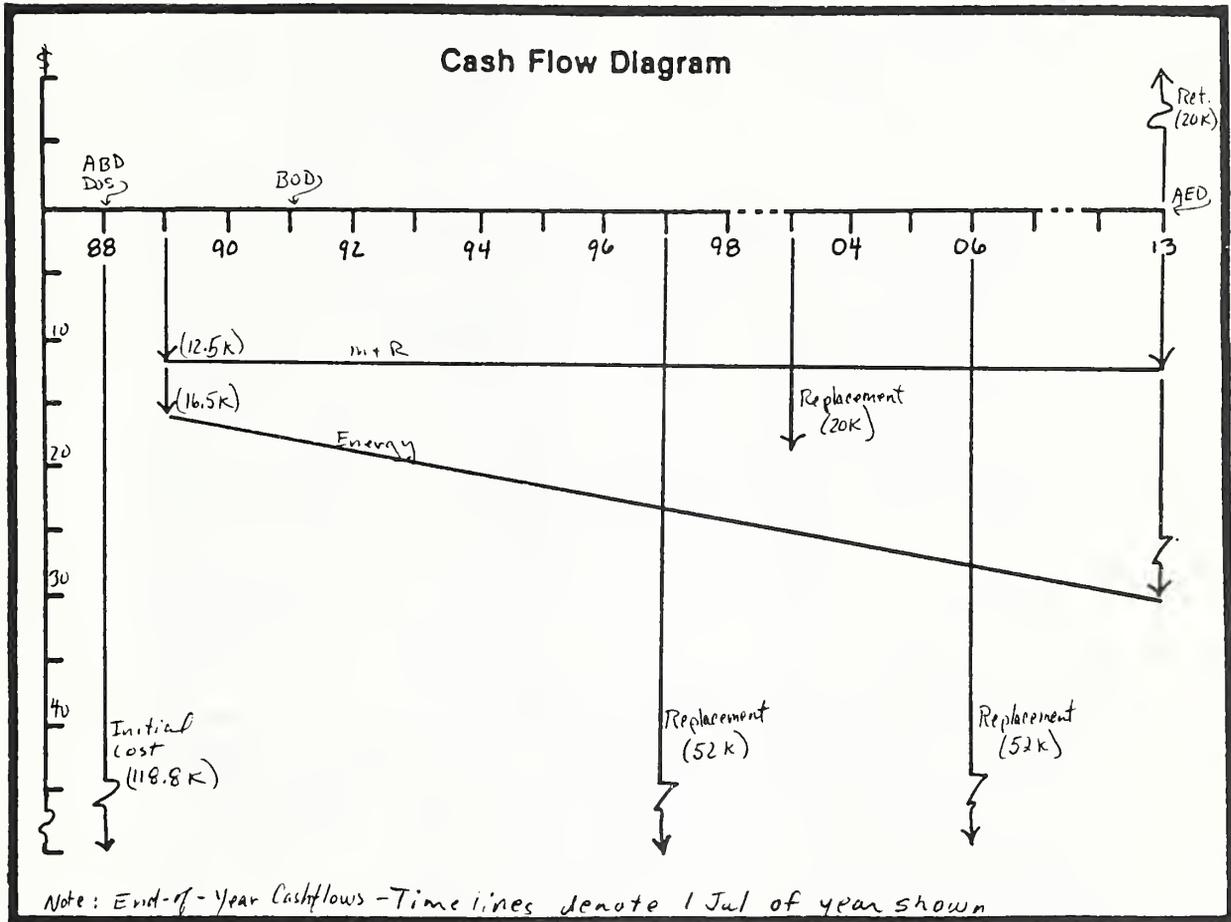
Cost Element	Cost on ABD \$ x 10 ³ - \$ x 10 ⁶	Time Cost Incurred**		Source(s) of Data
		Actual Projected Date	Date for Analysis (if Different)*	
Total Cost	118.8 (132 less 103)	1/91	7/88	Cost Engineers Est (App. 1)
Replacement (Plant)	52.0	7/00	7/97	Past Study (App. 2)
Replacement (Fan)*	20.0	7/06	7/03	Past Study (App. 2)
Replacement (Plant)	52.0	7/09	7/06	Past Study (App. 2)
Retention Value	-20.0	7/16	7/13	Value of like Equip (App. 3)
Electricity	15.0	1/92 - 1/16	7/89 - 7/13	BLAST (App. 4)
Dist. / life	1.5	1/92 - 1/16	7/89 - 7/13	BLAST (" 4)
M & R	12.5	1/92 - 1/16	7/89 - 7/13	BLAST (" 4)

* Fan is shown here for the record but is omitted from the LCC computations because it is identical for both alternatives.

*When 10 CFR436A Criteria Apply

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

Vugraph 8-S3a. Completed enlarged cash-flow diagram



Vugraph 8-S4. Completed DA Form 5605-5
for Alt B

Project No. & Title PNI Administration Bldg
 Installation & Location Fort Q, Mississippi
 Design Feature HVAC
 Alt. No. B Title Variable-Volume-Economizer

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 L. \$ x 10 ⁴	Years from ABD	Cost On ABD	One Step Adj. Factor Table 1	Present Worth on ABD	Criteria Reference	FEMP
Initial Cost	0	0	118.8	1.0000	118.8	Analysis Base Date (ABD)	7/88
Replacement (Plant)	9	9	52.0	0.5439	28.3	Analysis End Date (AED)	7/13
Replacement (Plant)	18	18	52.0	0.2959	15.4	Midpoint of Construction	1/91
Retention Value	25	25	-20.0	0.1842	-3.7	BOD for Analysis	7/88
						Annual Discount Rate	7%
						Type of Cost	Differential Escalation Rate per Year (%) Timeframe: 88-90, 90-95, 95-13
						Dist	4.54 7.75 4.44
						Other	0 0 0
* Fan omitted because it is the same for A/B & B							

Annual Costs	✓ \$ x 10 ³ L. \$ x 10 ⁴	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	25	15.0	375.0	0.3910	146.6
Distillate Oil	25	25	1.5	37.5	0.8361	31.4
M+R	25	25	12.5	312.5	0.4661	145.7

	Initial Costs	Energy/Fuel Costs	M&R Costs	Other Costs	Total
Net Present Worth:	118.8	177.4	145.7	40.0	482

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-S5. Completed DA Form 5605-2
for A&B

Project No. & Title PNJ Administration Bldg
 Installation & Location Fort G, Mississippi
 Design Feature HVAC
 Date of Study 7/85

**LIFE CYCLE COST ANALYSIS
SUMMARY**

For use of this form, see TM 8-802-1; the proponent agency is USACE.

ALTERNATIVES ANALYZED						
No.	Description/Title	Present Worth $\sqrt{\$ \times 10^3}$: $\$ \times 10^4$				Total
		Initial	Energy	M&R	Other	
A	Var. Vol - No Economizer	112.5	208.0	139.8	38.7	499
B	Var. Vol - Economizer	118.8	177.4	145.7	40.0	482

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 Var. Vol. - Economizer	\$17K	Saves Energy	Lower LCC
2	A Var Vol - No Economizer	3%		

KEY ASSUMPTIONS	NARRATIVE SUMMARY (Comments/Lessons Learned/Observations/Recommendations/Etc.)
	For an additional expenditure up front of \$6-\$7K, about \$24K in total savings is estimated.

Key Participants - Name	Discipline	Organization	Telephone No.
A. B. Job	Mech. Engineer	USACE	x x x x
K. D. Long	Mech. Engineer	USACE	x x x x

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Sheet _____ of _____

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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

LESSON PLAN 9: DATA

Whereas the preceding modules focus primarily on how to use data to evaluate design alternatives, this module focuses on how to obtain the data needed. The topic is important because the inability to obtain data and the use of wrong data are serious stumbling blocks for many would-be practitioners of economic analysis.

TIME	OVERVIEW	TRAINING AIDS OR CUES
1300	Ask students to turn to Module 9. Review the purpose of the module, the outline of 9, and the allotted time.	S9-1 W9
1308	9.1 Ask them to turn to beginning of 9.1. Discuss data requirements Assign Exercise 9-1	Ws9.1, F or B S9-2/3 Exercise 9-1 Solution 9-1
1330	9.2 Discuss estimation of construction costs Demonstrate how to estimate replacement costs	S9-5 S9-5/8
1400	9.3 Demonstrate how to estimate disposal costs and retention values	S9-9/12 S9-13/16
1445	Announce break, return at 1500	
1500	9.4 Discuss energy analysis programs Demonstrate how to estimate energy costs when consumption or fuel type changes Reenforce use of OSAF Review source of energy price data	S9-17 S9-18 S9-19, F or B S9-20 S9-21
1515	9.5 Explain how to use CERL M&R data Demonstrate how to use it Point out special features of the database	S9-22/23 V 9-a/e S9-24/26
1600	9.6 Assign Exercise 9-2 on using the database	Exercise 9-2

(Key: S = slide, V = Vugraph, F = Flipchart, W = Workbook, s = section, N = Notebook)

LESSON PLAN 9: DATA (continued)

TIME	OVERVIEW	TRAINING AIDS OR CUES
1650	Solution to Exercise 9-2 Ask students to think of potential on-the-job applications of topics covered in this module and record them in Module 3, "Ideas"	Solution 9-2 Mod 3

(Key: S = slide, V = Vugraph, F = Flipchart, W = Workbook, s = section, N = Notebook)

Slide 9-1

DATA

- What you need
- How to get it

- Often analysts learn the methods of economic evaluation and feel like they are ready to put the methods into practice. Then they fall apart when faced with actual application because they do not know how to obtain the necessary data.

Review the purpose of the module, outline, and approximate time.

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

- Before we discuss how to get data, let's make sure we know what data we need.

FLIP CHART

POTENTIAL DATA REQUIREMENTS

- land costs
- site preparation costs
- planning and design costs
- construction costs
- energy costs
- maintenance costs
- repair costs
- replacement costs
- retention value
- disposal costs
- revenue
- dollar value of other benefits
- discount rate
- system lives
- analysis period
- other

- A useful starting point is to identify the potential kinds of data we might need.
- What kinds of data might we need?

As students respond, write the kinds of data on a flip chart under heading "Data Requirements." The list will likely include those listed above.

- But do we include all of these in every EA/LCCA?
- Which ones do we include?

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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**

- There is no point in including costs which will not be affected by the design choice.
- This is unlike budgeting or accounting, which requires taking into account all costs and revenue.
- In fact, including in the LCC measure costs that are not affected raises the totals and may interfere with interpreting results by making the changes appear trivial in comparison with the totals.
- Suppose we are comparing alternative plumbing systems. What is an example of a kind of cost which is unlikely to be affected by the plumbing choice?
 - E.g., costs of the electrical system
 - Should we include electrical system costs in the plumbing analysis?
- Suppose we are trying to decide whether to replace the existing lighting system in a building with an energy conserving system. Should we include the purchase and installation costs of the existing system in the LCC comparison of the two?

- No, costs already incurred as a result of a past decision should not be included in an analysis to make a current decision. They are **SUNK COSTS**.

- Suppose alternatives are expected to require the same maintenance costs or to incur the same disposal costs. Should those costs be included. No, they will increase the totals making the actual effect appear less important in relationship to the totals, and they will not affect the dollar change in LCC.

- What costs should you take into account in LCCs? Costs associated with keeping the existing system: Salvage (less costs of disposal), energy, M&R if affected, replacement (including light bulbs), retention value at end of analysis period. Costs associated with the replacement system: purchase and installation costs of new system, energy, M&R if affected, replacement (including light bulbs), retention value at end of analysis period.

If it appears necessary for clarity, give other examples of sunk costs. This concept sometimes is difficult to get across.

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Slide 9-3

WHAT ABOUT PENALTIES/BENEFITS NOT MEASURED IN DOLLARS?

- LCCA requires that costs and benefits be stated in monetary terms, i.e., in dollars. Penalties and benefits that arise as a result of selecting one particular design alternative and not another for a given application which are not expressed in non-monetary terms are not captured.

Discuss this topic, by asking questions such as the following:

- Can you think of penalties or benefits which might not be expressible in monetary terms?
- Do you often encounter penalties or benefits which you would find difficult or impossible to measure in dollars when you are evaluating MILCON design alternatives?

If they indicate concern about the issue of non-monetary penalties or benefits, discuss the topic further, including the following points:

- Enhanced performance effects, such as improved physical appearance or greater comfort of one system relative to another, tend to be difficult to measure in dollars.

- One approach is to credit no extra benefits for performance in excess of minimum standards. Since only alternatives which meet minimum performance requirements should be considered, this means according them equal benefits.
 - In practice, this means that most costs and benefits which should be included will be measurable in dollars.
 - And if there are important non-monetary effects which should be taken into account, it is important that these effects be part of the documentation upon which the final decision is made. This can be done by appending qualitative information to the LCC results.
- Now I will ask you to put these guidelines into practice in performing exercise 9-1 in your Workbook. Here is the way I would like you to do the exercise:
- First, perform the exercise individually. Try to do it quickly.
 - Second, compare your answer with your neighbor's and try to reach agreement between the two of you on the correct set of answers.
 - Third, the two of you compare your set of answers with those of your nearest pair of neighbors and try to reach agreement on a common set of answers.
 - Then I will ask one of you to give us the answers and define your choices.

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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	

SOLUTION TO EXERCISE 9-1

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 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

*Need to know data only in order to know that you can leave it out of the LCCA.

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- | | | |
|-------|--|------------|
| ✓ 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 end of its 30 year life | \$45,000 |
| ✓ 22. | The amount the new system will add to scrap value, net of disposal costs in 10 years | \$10,000 |
| ? 23. | The new system operates more quietly than the existing system | |

Day 3

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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
-
- First, it is important to acknowledge that architectural cost estimating is an inexact science at best. Two estimators are unlikely to arrive at the same total cost for the same structure even after the design is complete. This is reflected at the bid stage. Typically there will be a spread of bid amounts for a given job.
 - When you consider that the best time to do EA/LCCA is as early in the design phase as possible, it is not surprising that even the initial costs will usually be inexact.

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

- Approximations of costs are usually sufficiently accurate for EA/LCCA. Remember, waiting for more accurate data before performing EA/LCCA usually means missing the opportunities for greatest cost savings.
- Of course, if we are dealing with an off-the-shelf system, we may be able to obtain highly accurate estimates with little cost in time and effort by calling a supplier or contractor, or by looking in a catalogue.
- And if someone else has evaluated a similar system or structure, AND HAS PROVIDED ADEQUATE DOCUMENTATION, we may be able to obtain good estimates inexpensively from the previous study.

Further discussion of using construction cost estimating systems is beyond the scope of the course. It is presumed that most of the students will be familiar with these systems.

Slide 9-5

ESTIMATING REPLACEMENT COSTS

- **Start with today's cost**
- **Take account of**
 - **system life**
 - **analysis period**

- A good starting point in most cases is to consider what it would cost to make the replacement today.
- Estimate the timing of the replacement on the basis of expected system/component life. To do this, look at past experience and databases. Good news! A database of maintenance and repair data, which we will address shortly, covers most building components and incorporates replacement costs along with maintenance and repair. When you use that database, you will estimate replacements in combination with M&R costs.
- Estimate the number of replacements by relating system/component life to the analysis period.

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, $C_f = ?$

- Let's take an example. Here is information on the cost today of replacing a component that we expect to replace in 10 years. Suppose we want an analysis period for the LCCA of 25 years. (For the purpose of this discussion, let's assume the DOS, ABD, and BOD are identical.) That means two replacements to take into account. Let's suppose we have no good reason to expect the price of this item to escalate differently from prices in general, such that $e = 0$.
- What are the estimated future replacement costs?

Have students supply answers.

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)

Have students supply answer.

Replacement costs, $C_F = \$6,000$ (yr 10) & $\$6,000$ (yr 20)

$d = 10\%$

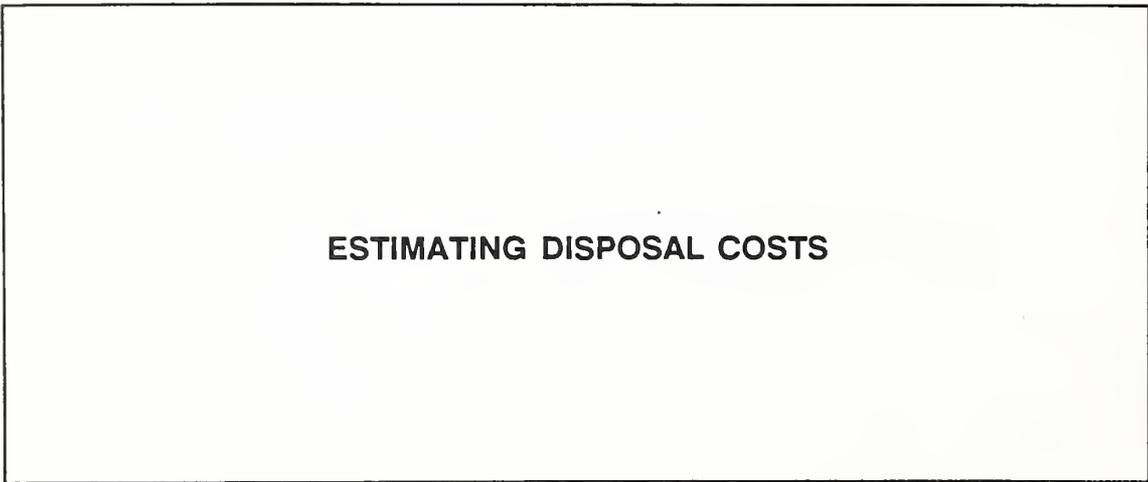
$$\begin{aligned} \text{PW} &= [\$6,000 (1/(1+0.10)^{10})] + [\$6,000 (1/(1+0.10)^{20})] \\ &= \$2,313 + \$892 \\ &= \$3,205 \end{aligned}$$

- Also, of course, we would need to compute PW of the replacement costs once we had estimated them.

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
-
- If, at the end of the analysis period, a facility is to be demolished or shut down, or a building system taken out of use, there will be disposal costs to take into account. Any salvage or scrap value can be subtracted out of the disposal costs, but the total will often be a negative cash flow, i.e., a cost.
 - Recall that for both general economic studies and FEMP studies the analysis period ends no later than 25 years after occupancy. The economic life of many building systems may extend beyond that 25-year period. If there is no good reason to believe that the particular facility under design is to be demolished or shut down, or the building system under design is taken out of use, it is customary to estimate the value remaining at the end of the analysis period, i.e., the “retention value.”



- How do we estimate disposal costs?

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, $C_f = ?$

- Let's take an example.
- Suppose you are evaluating alternative designs for a temporary structure which will be needed for 10 years. The design alternatives differ in their disposal costs, and therefore you need to take into account disposal costs in computing LCCs.
- Suppose you call a contractor and inquire what it would cost now to dispose of a similar structure, 10 years old, less any salvage value. The answer is about \$50,000.
- Next you need to estimate the cost in constant dollars as of the AED. To do this, you need an e value. Unless you have a reasonable basis for projecting that the differential escalation rate for disposal cost is non-zero, assume $e = 0$.

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, $C_f = \$50,000$

- Therefore the estimate of future disposal cost is \$50,000.
- The general estimating procedure we used was to
 - Start with what it would cost as of the ABD to dispose of comparable items with ages equal to the age the item in question will have at the AED. In absence of a reasonable basis for projecting a non-zero differential escalation rate for disposal costs, assume $e = 0$. If there is a sound basis for estimating a non-zero e value, do so and use it, but only for "NON-FEMP" applications.
 - Estimate the salvage or scrap value as of the ABD of comparable items with ages equal to the age the item in question will have at the AED. (Depending on the item to be disposed, this estimate may be part of the disposal cost estimate, i.e., disposal costs might be stated net of salvage.) Again, in absence of a reasonable basis for projecting a non-zero differential escalation rate for salvage value, assume $e = 0$. If there is a sound basis for estimating a non-zero e value, do so and use it, but only for "NON-FEMP" applications.
 - Subtract estimated salvage value from estimated disposal costs to get the future estimate of disposal costs less salvage. The estimate is in constant dollars.

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Disposal costs, $C_f = \$50,000$

$$\text{PW} = \$50,000 (1/(1+0.10)^{10})$$

$$= \$19,277$$

- Once you have the estimated future amount you will need to compute its PW.

ESTIMATING RETENTION VALUES

- Now let's look at a procedure for estimating retention value. That is the value remaining past the end of the analysis period when the life of one or more of the design alternatives is projected to exceed the maximum allowable analysis period.

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 =

- Let's take an example.

Review the example which entails a roof covering with a service life of 15 years. It is replaced at the end of 15 years. At the end of the 25-year analysis period, the replacement covering has 5 years of expected life remaining. There is no good reason at this time to believe that this building is to be demolished or shut down after 25 years.

- A procedure for estimating future retention value is to
 - Prorate the cost of the item over the expected life and compute the percentage remaining at the end of the analysis period.
 - Apply that percentage to the cost of the item.
 - Escalate the resulting cost to the end of the analysis period to estimate the retention value as of the AED. (Unless there is a reasonable basis for assuming a non-zero differential escalation rate for the price of the replacement item, assume $e = 0$.)
- In this example, what is the percentage of the acquisition cost remaining after 25 years?
- What is the dollar retention value?

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 = $5/15 = 33.3\%$

$$\begin{aligned} \$ \text{ Retention value} &= 0.333 (\$20,000)(1+0.00)^{25} \\ &= \$6,660 \end{aligned}$$

- Assuming the roof covering is “used up” in equal yearly increments, 33.3% of its initial value will be still remaining at the end of the 25th year.
- With a 0 differential escalation rate, retention value in constant dollars is estimated at \$6,660.

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$$\text{Retention value} = 0.333 (\$20,000)(1+0.00)^{10}$$

$$= \$6,660$$

$$\text{PW} = \$6,660 (1/(1+0.10)^{25})$$

$$= \$615$$

- Remember that for LCCA, we need the PW equivalent of the future retention value.
- Discounting the estimated value, we find a present worth equivalent of \$615.
- Note how small PW is. When the analysis period is long, retention values are often of little consequence. Also replacement costs tend to be less significant to a decision than do initial costs.

Day 3

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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
-
- Because energy consumption data are important in energy conservation studies, we identify several energy analysis programs.
 - You have already learned how to compute the present worth equivalent of a series of future energy costs escalating at DOE-projected rates. But those calculations require that annual energy consumption remain constant. What if future consumption is not expected to remain constant? In this section, we will show you briefly how to compute energy costs year-by-year to provide you the flexibility you may need for treating special cases.
 - We conclude the section with a quick review of how, when annual consumption is uniform, you can use the OSAF tables to estimate future costs and discount them to present worth in a combined operation. This approach gives the present worth, but does not reveal the estimates of future costs.

ENERGY CONSUMPTION DATA

- To estimate energy costs, we need both consumption data and energy price data.
- Our focus is on prices, but let's spend a few minutes on estimating energy consumption data.

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ENERGY ANALYSIS COMPUTER PROGRAMS

- **BLAST**
- **DOE2**

- You probably know of BLAST (CERL's energy analysis program) and DOE2. Do you use them?
- A version of ASEAM (A Simplified Energy Analysis Method) has been developed to incorporate DOE2 calculations. Contact the Federal Energy Management Program Office of the Department of Energy for further information.

ESTIMATING FUTURE ENERGY COSTS YEAR-BY-YEAR

$$\begin{aligned} C_F(\text{energy}) &= \text{Quantity}_F \times \text{Price}_F \\ &= Q_F \times P_F \end{aligned}$$

Explain that one can change the quantity of energy consumed from year to year and change the prices or type of fuel. But it requires that future energy costs be estimated year by year and discounted year by year.

Discuss why the annual energy load might change over time, e.g., change in facility use or modification. Discuss why the heating (cooling) system efficiency (coefficient of performance) might change over time, e.g., system deterioration, modification, or replacement. Explain why it might be necessary to change the type of energy during the analysis period, e.g., the source of energy changes from a coal-fired plant to district heat.

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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.

- You may occasionally need to calculate energy costs year by year. But whenever annual consumption is expected to be constant and the fuel type is not expected to change, you will want to take advantage of the simplification offered by the OSAF tables. Recall that you can use them to estimate the present worth of the entire series of future energy costs, simply by this computation.

Day 3

GO TO FLIP CHART

Ask them to calculate the PW of 25 years of energy costs needed for a general economic study, assuming the following:

$$Q = 15,000 \text{ mill Btu}$$

$$p_p = \$6.00/\text{mill Btu}$$

$$\text{Location} = \text{Denver}$$

$$\text{Fuel Type} = \text{Distillate oil}$$

$$\text{BOD} = 7/93$$

$$\text{Solution: } 15,000 \times \$6.00 \times 25 \times 0.5062 = \$1,138,950$$

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ENERGY PRICE DATA

- A brief review of energy price data before we conclude this section:
- Energy price forecasts are developed by DOE's Energy Information Administration.
- DOE's forecasts are given in constant dollars, i.e., without inclusion of general price inflation.
- NIST converts the raw price forecasts into forms useful for performing economic analysis.

Hold up a copy of Energy Prices and Discount Factors for Life-Cycle Cost Analysis, NBSIR 85-3273, and refer participants to the section of the Notebook with HB 135 and Annual Supplement. Note that the forecasts and the data tables are updated annually.

- Army converts the energy price data into its preferred format, the OSAF tables which cover a range of BODs.
- Each year DOE revises its forecast, NIST prepares its data report, and Army updates and releases its set of data tables.

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

**ESTIMATING MAINTENANCE & REPAIR COSTS
WITH
CERL'S DATABASE**

- In the past, obtaining good maintenance and repair (M&R) data has been difficult. Historical databases have generally been unreliable.
- Because of these difficulties an effort was started some years back to develop a single centralized database for M&R costs.
- Development of the database was carried out by the Construction Engineering Research Laboratory (CERL).
- Objectives were to develop a database for LCCA that would require minimum work by the user. To that end, CERL developed a database which allows the user to look up (or construct) unit rates to which he or she can apply facility-specific wage and equipment rates and adjust material costs for location and date.

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%

- To demonstrate how the data is used, I will assume that we are designing an administration building for family housing located at Fort Eustis, Virginia, and we need to perform a general economic study of alternative roof coverings.
 - Family housing at Fort Eustis, Virginia.
 - The DOS is January 1990. The BOD is January 1993. The analysis period goes 25 years past BOD and the discount rate is 10%.
 - The roof area to be covered is 10,000 SF. The alternative to be evaluated is builtup roofing.

- This table is for computing the present worth of maintenance and repair cost (including major replacements), using a discount rate of 10%, mid-year occurrence of costs, and a BOD three years after DOS.
- It was generated by a computer program prepared by CERL. It is possible to get a hardcopy of the data, such as you see here, or to get the software for generating the data in this and other formats.
- After you have an idea of how to use the data, I will give you more description as to how it is constructed.
- Look first at the left four columns labeled "Present Worth of All 25 Year Maintenance and Repair Costs." Look closely at the column headed "labor."

Day 3

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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%)					Wash. D.C. Total	ANNUAL MAINTENANCE AND REPAIR PLUS HIGH COST REPAIR AND REPLACEMENT COSTS														
		By Resources						Annual Maintenance and Repair					Replacement and High Cost Tasks									
		Labor	Mat'l	Equip.	Labor	Mat'l		Equip.	Labor	Mat'l	Equip.	Yr	Labor	Mat'l	Equip.							
ARCHITECTURE																						
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	SF	0.02440	0.33090	0.01180		0.87	0.00248	0.03219	0.00119	14	0.02414	0.69960	0.01207									
MOD. BIT./THERMOPLASTIC MEMBRANE REPLACEMENT OR REPAIR - M.B./T. R	SF	0.01680	0.23950	0.00650		0.61	0.00174	0.02203	0.00088	20	0.05659	0.85860	0.02829									
THERMOSETTING MEMBRANE REPLACEMENT - THERMOSETTING ROOF	SF	0.01850	0.10440	0.00890		0.51	0.00259	0.01459	0.00124	20	0.03683	0.69960	0.01841									
SLATE	SF	0.01820	0.24340	0.00870		0.64	0.00254	0.03404	0.00122	70	0.06885	6.04200	0.03442									
CEMENT ASBESTOS TILE	SF	0.01550	0.20990	0.00740		0.55	0.00217	0.02935	0.00103	70	0.05437	7.5190	0.02718									
ROLL ROOFING	SF	0.07140	0.42700	0.03640		2.00	0.00754	0.01557	0.00387	10	0.10169	3.07400	0.05084									
TOTAL ROOF REPLACEMENT - ROLL ROOF	SF	0.02210	0.22150	0.01170		0.71	0.00259	0.02385	0.00140	10	0.04141	0.74963	0.02070									
SHINGLES										40	0.04118	0.74497	0.02059									
REPLACE NEW OVER EXISTING - SHINGLED ROOF										20	0.02996	0.43460	0.01498									
METAL																						
FIBERGLASS RIGID STP. ROOF	SF	0.01460	0.11060	0.00740		0.43	0.00205	0.01547	0.00103	30	0.36265	2.17300	0.18132									
CONCRETE, SEALED PANEL 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 RF4	SF	0.04300	0.11750	0.02120		1.07	0.00601	0.01643	0.00297	60	0.06123	24.07419	0.03061									
CONCRETE SEALED POURED FIBERGLASS, RIGID ROOF	SF	0.03900	0.08410	0.02020		0.95	0.00545	0.01176	0.00282	300	0.04342	24.07419	0.02171									
TOTAL ROOF REPLACEMENT - FIBERGLASS RIGID	SF	0.09830	0.63020	0.04950		2.80	0.01375	0.08811	0.00692	500	3.81056	18.03219	1.90528									
	SF	0.03800	1.15340	0.01930		1.99	0.00463	0.06269	0.00236	20	0.04133	6.01550	0.02066									

See NOTES on the last page of this table for Explanation of Column Headings

Day 3

Work on flip chart to show how it is used.

- The number 0.03990 is an index indicating the labor hours per SF of builtup roofing to maintain it, repair it, and replace it as needed over a 25 year period.
- Multiplying the labor index times the labor wage rate on the DOS for roofers at Fort Eustis gives the present worth equivalent cost per SF. For example, suppose the wage rate on the DOS is \$13.50 per hour.

$$PW (\text{labor/SF}) = 0.03990 \text{ hours/SF} \times \$13.50/\text{hour} = \$0.5387/\text{SF}$$

- Now look at the next column headed "material."

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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	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'l	Equip.		Labor	Mat'l	Equip.	Yr	Labor	Mat'l	Equip.										
ARCHITECTURE																						
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																						
MOD. BIT./THERMOPLASTIC MEMBRANE REPLACEMENT OR REPAIR - M.B./T. R	SF	0.02440	0.33090	0.01180	0.87		0.00248	0.03219	0.00119	14	0.02414	0.69960	0.01207									
THERMOSETTING MEMBRANE REPLACEMENT - THERMOSETTING ROOF	SF	0.01680	0.23950	0.00850	0.61		0.00174	0.02203	0.00088	20	0.05659	0.85860	0.02829									
SLATE	SF	0.01850	0.10440	0.00890	0.51		0.00259	0.01459	0.00124	20	0.03683	0.69960	0.01841									
CEMENT ASBESTOS	SF	0.01820	0.24340	0.00870	0.64		0.00254	0.03404	0.00122	70	0.06885	6.04200	0.03442									
TILE	SF	0.01550	0.20990	0.00740	0.55		0.00217	0.02935	0.00103	70	0.05437	0.75190	0.02718									
ROLL ROOFING	SF	0.07140	0.42700	0.03640	2.00		0.00754	0.01557	0.00387	10	0.10169	3.07400	0.05084									
TOTAL ROOF REPLACEMENT - ROLL ROOF																						
SHINGLES	SF	0.02210	0.22150	0.01170	0.71		0.00259	0.02385	0.00140	10	0.04141	0.74963	0.02070									
REPLACE NEW OVER EXISTING - SHINGLED ROOF																						
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 R/F4	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 FIBERGLASS, RIGID ROOF	SF	0.09830	0.63020	0.04950	2.80		0.01375	0.08811	0.00592	500	3.81056	18.03219	1.90528									
TOTAL ROOF REPLACEMENT - FIBERGLASS RIGID																						
FIBERGLASS RIGID	SF	0.03800	1.15340	0.01930	1.99		0.00463	0.06269	0.00236	20	0.04133	6.01550	0.02066									

See NOTES on the last page of this table for Explanation of Column Headings

Work on flip chart to show how it is used.

- The number 0.37220 is an index giving material costs per SF in Washington, DC, as of July 1985. It must be multiplied by an Area Cost Factor (ACF) to make it fit Fort Eustis instead of Washington, DC, and it must be multiplied by a Tri-Services MCP (inflation) Index. It is used to adjust past dollars to dollars as of the ABD to update the prices from 1985 to 1990. The appropriate ACF = 0.96. Let's say the appropriate MCP Index is 1.12.

$$PW \text{ (material/SF)} = \$0.37220/\text{SF} \times 0.96 \times 1.12 = \$0.4002/\text{SF}$$

- Materials costs were obtained from the Corps of Engineers' Computer-Aided Cost Estimating System (CACES), now called the Computer-Aided Cost Engineering Support System, which contains costs for materials used in new construction in the Washington, DC area as of June 1985.

- Look next at the column headed "equip."

Day 3

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Vugraph 9-1d

LIFE CYCLE COST ANALYSIS

COMPONENT DESCRIPTION		EPS BASED MAINTENANCE AND REPAIR COST DATA FOR USE IN LIFE CYCLE COST ANALYSIS (\$ PER UNIT MEASURE)										PAGE 1		
		PRESENT WORTH OF ALL 25 YEAR MAINT. AND REPAIR COSTS (g-10%)					ANNUAL MAINTENANCE AND REPAIR PLUS HIGH COST REPAIR AND REPLACEMENT COSTS					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		Yr	Labor	Mat'r'l	Equip.		
UM	Labor	Mat'r'l	Equip.	↓	0.02000	0.00488	0.03172	0.00244	28	0.04938	0.70490	0.02469		
ARCHITECTURE	SF	0.03990	0.37220	0.02000	1.25	0.00488	0.03172	0.00244	28	0.04938	0.70490	0.02469		
ROOF COVERING	SF	0.02440	0.33090	0.01180	0.87	0.00248	0.03219	0.00119	14	0.02414	0.69960	0.01207		
BUILTUP ROOFING	SF	0.01680	0.23950	0.00850	0.61	0.00174	0.02203	0.00088	20	0.05659	0.85860	0.02829		
PLACE NEW MEMBRANE OVER EXISTING -BUILTUP	SF	0.01850	0.10440	0.00890	0.51	0.00259	0.01459	0.00124	20	0.03683	0.69960	0.01841		
MOD. BIT./THERMOPLASTIC MEMBRANE REPLACEMENT OR REPAIR - M.B./T. R	SF	0.01820	0.24340	0.00870	0.64	0.00254	0.03404	0.00122	70	0.06885	6.04200	0.03442		
THERMOSETTING MEMBRANE REPLACEMENT - THERMOSETTING ROOF	SF	0.01550	0.20990	0.00740	0.55	0.00217	0.02935	0.00103	70	0.05437	0.75190	0.02718		
SLATE	SF	0.07140	0.42700	0.03640	2.00	0.00754	0.01557	0.00387	10	0.10169	3.07400	0.05084		
CEMENT ASBESTOS TILE	SF	0.02210	0.22150	0.01170	0.71	0.00259	0.02385	0.00140	10	0.04141	0.74963	0.02070		
ROLL ROOFING	SF	0.01460	0.11060	0.00740	0.43	0.00205	0.01547	0.00103	40	0.04118	0.74497	0.02059		
TOTAL ROOF REPLACEMENT - ROLL ROOF	SF	0.02190	1.15340	0.01080	1.64	0.00232	0.05269	0.00113	20	0.02996	0.43460	0.01498		
SHINGLES	SF	0.04300	0.11750	0.02120	1.07	0.00601	0.01643	0.00297	60	0.06123	24.07419	0.03061		
REPLACE NEW OVER EXISTING - SHINGLED ROOF	SF	0.03900	0.08410	0.02020	0.95	0.00545	0.01176	0.00282	300	0.04342	24.07419	0.02171		
METAL	SF	0.09830	0.63020	0.04950	2.80	0.01375	0.08811	0.00692	500	3.81056	18.03219	1.90528		
FIBERGLASS RIGID STP. ROOF CONCRETE, SEALED PANEL ROOF	SF	0.03800	1.15340	0.01930	1.99	0.00463	0.06269	0.00236	20	0.04133	6.01550	0.02066		
CONCRETE, SEALED PANEL R/F4	SF								20	0.04133	6.01550	0.02066		
CONCRETE SEALED POURED FIBERGLASS, RIGID ROOF	SF								20	0.04133	6.01550	0.02066		
TOTAL ROOF REPLACEMENT - FIBERGLASS RIGID	SF								20	0.04133	6.01550	0.02066		

See NOTES on the last page of this table for Explanation of Column Headings

Day 3

Work on flip chart to show how it is used.

- The number 0.02000 is an index expressing equipment hours per SF. Suppose the installation equipment hourly rate at the DOS is \$3.00.

$$PW (\text{equipment/SF}) = \$0.02000/\text{SF} \times \$3.00/\text{hour} = \$0.0600/\text{SF}$$

Show on flip chart how PW of M&R costs are calculated.

- Total PW of M&R costs per SF:

$$\begin{aligned} PW (\text{M\&R/SF}) &= \$0.5387/\text{SF} + \$0.4002/\text{SF} + \$0.0600/\text{SF} \\ &= \$0.9989/\text{SF} \end{aligned}$$

- Total PW of M&R costs:

$$PW (\text{M\&R}) = \$0.9989/\text{SF} \times 10,000 \text{ SF} = \$9,989$$

Show on flip chart how PW of initial cost and retention value can be estimated on SF basis and added to PW M&R per SF, as follows:

- Compute PW of Initial Cost:

Suppose initial purchase and installation = \$1.02/SF (in constant DOS dollars).

Escalate to mid-year of construction (7/92) at $e = 0$; therefore, initial purchase and installation in DOS dollars as of the mid-point of construction = \$1.02/SF.

Discount with the factor for 2.5 years:

$$\begin{aligned} PW (\text{Initial Cost/SF}) &= \$1.02/\text{SF} \times (1/(1+0.10)^{2.5}) \\ &= \$0.8037/\text{SF} \end{aligned}$$

- Compute PW of Retention Value:

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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											
		Labor	Mat'l	Equip.		Labor	Mat'l	Equip.	Yr	Labor	Mat'l	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																				
MOD. BIT./THERMOPLASTIC MEMBRANE REPLACEMENT OR REPAIR - M.B./T. R	SF	0.02440	0.33090	0.01180	0.87	0.00248	0.03219	0.00119				14	0.02414	0.69960	0.01207					
THERMOSETTING MEMBRANE REPLACEMENT - THERMOSETTING ROOF	SF	0.01680	0.23950	0.00850	0.61	0.00174	0.02203	0.00088				20	0.05659	0.85860	0.02829					
SLATE	SF	0.01850	0.10440	0.00890	0.51	0.00259	0.01459	0.00124				20	0.03683	0.69960	0.01841					
CEMENT ASBESTOS	SF	0.01820	0.24340	0.00870	0.64	0.00254	0.03404	0.00122				70	0.06885	6.04200	0.03442					
TILE	SF	0.01550	0.20990	0.00740	0.55	0.00217	0.02935	0.00103				70	0.05437	0.75190	0.02718					
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																				
SHINGLES	SF	0.02210	0.22150	0.01170	0.71	0.00259	0.02385	0.00140				10	0.04141	0.74963	0.02070					
REPLACE NEW OVER EXISTING - SHINGLED ROOF												40	0.04118	0.74497	0.02059					
METAL	SF	0.01460	0.11060	0.00740	0.43	0.00205	0.01547	0.00103				20	0.02956	0.43460	0.01498					
FIBERGLASS RIGID STP. ROOF	SF	0.02190	1.15340	0.01080	1.64	0.00232	0.06269	0.00113				30	0.36265	2.17300	0.18132					
CONCRETE, SEALED PANEL ROOF	SF	0.04300	0.11750	0.02120	1.07	0.00601	0.01643	0.00297				20	0.04543	6.01550	0.02272					
CONCRETE, SEALED PANEL RF4	SF	0.03900	0.08410	0.02020	0.95	0.00545	0.01176	0.00282				60	0.06123	24.07419	0.3061					
CONCRETE SEALED POURED FIBERGLASS, RIGID ROOF	SF	0.09830	0.63020	0.04950	2.80	0.01375	0.08811	0.00692				300	0.04342	24.07419	0.02171					
TOTAL ROOF REPLACEMENT - FIBERGLASS RIGID												500	3.81056	18.03219	1.94528					
	SF	0.03800	1.15340	0.01930	1.39	0.00463	0.06269	0.00236				20	0.04133	6.01550	0.02066					

See NOTES on the last page of this table for Explanation of Column Headings

Show on flip chart how to compute retention value.

Look in the first of the right-hand columns headed "Replacement and High Cost Tasks," and find 28 under the column headed "Yr." This means that the average life of a builtup roof is 28 years. Hence, at the end of the 25 years after BOD, the roof covering is expected to have three years of remaining life. That is, $3/28 = 11\%$ remaining. The retention value must be discounted for 28 years; the Discount Factor is 0.0693. Retention value is computed as follows:

$$\text{PW (Retention Value)} = \$1.02 \times 0.11 \times 0.0693 = \$0.0078$$

Day 3

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Slide 9-24

COMPUTE LCC FOR BUILTUP ROOFING

	PW Initial	PW M&R	PW Retention
LCC/SF (Builtup Roofing)	= [\$0.8037/SF + \$0.9989/SF - \$0.0078/SF]		
	= \$1.7948/SF		

LCC (Builtup Roofing)	= \$1.7948/SF x 10,000 SF		
	= \$17,948		

- Sum PW initial cost and PW M&R cost and subtract PW retention value, as shown, to find LCC (builtup roofing) per SF, and multiply by 10,000 SF to compute total cost. Briefly summarize how each of the PW cost numbers were calculated.
- If time permits, describe how to use the column headed Wash. DC. Explain that it
 - provides a very rough approximation, but is useful for obtaining a quick idea of how alternative components compare with respect to their relative maintenance costs,
 - uses the DC factor without adjustment, and
 - allows you to use this part of the table to ascertain comparative LCC maintenance costs for alternative components.
- For example, we can see from this column of the table that -- in Washington, DC -- at any rate -- tile roofing costs less than half as much to maintain as builtup roofing.
- This Washington, DC column is for gaining a fast impression of comparative M&R costs.

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**

- Let me review a few of the special features of the database.
- The data are not averages of historical costs. The labor and equipment cost data are constructed from time study data developed through work-sampling studies and method-time-motion studies. The underlying studies were performed for the military.
 - Time studies were conducted to determine the average time it takes to do a wide variety of job elements, such as removing and replacing a screw, or setting up a ladder. (Work-sampling studies are done by measuring with a stop-watch the actual time required for on-the-job performance. Method-time-motion studies break down jobs into motions and use standard tables to determine the time.)
 - In those cases where this data was not available, it was developed from data provided by manufacturers, service contractors, and DEH (Directorate of Engineering and Housing).
 - A job element is the smallest unit of work measured. Job elements are the core of the estimating system. By determining all the job elements required for various maintenance tasks and their frequencies of occurrence, it was possible to estimate aggregate time for maintenance.

- Engineered Performance Standards (EPS) represent an intermediate level of aggregation of the time study data. The LCC database is based on EPS.
 - In a step-by-step “roll-up” process the data are aggregated to fit the needs of a life-cycle cost perspective.
-
- The LCC data base covers nearly all building components.
 - The LCC cost factors incorporate all maintenance, repair, and replacements needed for continued service.
 - The database is specially geared to LCC studies.

Day 3

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Slide 9-26

M&R DATA AVAILABLE

for

**Architectural
Electrical
Plumbing
HVAC**

- The LCC maintenance data are organized and published in a series of reports for each of four major types of building systems: list.

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

- Here is a summary of the steps needed to use the table to compute present worth of M&R and LCC.
- Where do you get the other data you need?
 - Hourly wage and equipment rates at the installation, from the DEH Office.
 - ACFs are available on PAX Newsletter 20.
 - Tri-Service MCP Index is available in PAX Newsletter 19.
- The columns of the table headed "Annual Maintenance and Repair" are for use with EA/LCCA computer programs such as LCCID which require data input in a fixed format.

- Now let me give you more information on the database.
 - To develop the LCC cost estimates, experts were consulted about the tasks required to maintain a component in good condition over 25 years.
 - A “roll-up” was done to aggregate the unit costs of all the required tasks.
 - The present-worth cost factors were derived by converting the labor hours and equipment (vehicle) hours to a dollar cost basis by multiplying them times a \$1.00/hour charge rate, and discounting the costs occurring each year over a 25 year period to present value. The BOD was assumed to be three years after the DOS, since this is typical for MILCON projects. Other BOD’s can also be used.
 - You can apply your own labor and equipment rates, and, in the case of materials, your location and time adjustments to the present-worth cost factors to derive estimates of life-cycle maintenance costs in present value dollars.
 - You specify component quantity.

Day 3

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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

Day 3

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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) =

9.6 SOLUTION TO 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 an ACF of 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.

$$\text{PW (Labor/SF)} = \frac{\text{index}}{\text{hr/SF}} \times \text{labor rate} = 0.02210 \text{ hr/SF} \times \$13.85/\text{hr} = \$0.3061/\text{SF}$$

$$\text{PW (Materials/SF)} = \frac{\text{index}}{\text{SF}} \times \text{ACF} \times \text{update} = \$0.22150/\text{SF} \times 1.17 \times 1.09 = \$0.2825/\text{SF}$$

$$\text{PW (Equipment/SF)} = \frac{\text{index}}{\text{hr/SF}} \times \frac{\text{equipment charge}}{\text{rate}} = 0.01170 \text{ hr/SF} \times \$3.45/\text{hr} = \$0.0404/\text{SF}$$

$$\text{Total PW (M\&R)/SF} = (\$0.3061 + \$0.2825 + \$0.0404)/\text{SF}$$

$$\text{Total PW (M\&R)} = 15,000 \text{ SF} (\$0.629)/\text{SF}$$

$$\text{Total PW (M\&R)} = \boxed{\$9,435}$$

Day 3

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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.

Ask participants to take a few minutes to think how they might apply the information presented in this session to a problem they are working on back in the office. Suggest that they make notes on potential applications in Module 3, “Ideas about Application.”

Day 3

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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)

LESSON PLAN 10: PERFORMING LCCA WITH COMPUTERS

TIME	OVERVIEW	TRAINING AIDS OR CUES
1600	<p>Introduce them to "Advanced Topics (III)"</p> <p>Ask students to turn to Module 10.</p> <p>Review the purpose of the module, the outline, and allotted time.</p>	<p>W10 S10-1</p>
1603	<p>10.1 First emphasize the advantages of using computers for LCCA, emphasizing what they can do for you. Then emphasize what they can not do for you. Ask about prior experience with software.</p>	<p>S10-2/3</p>
1610	<p>Lead discussion of factors to consider in selecting software. Record them on flip chart; summarize with the slide.</p>	<p>F, S1-04</p>
1620	<p>Review briefly the EA computer programs available for MILCON Design Studies.</p>	<p>S10-5</p>
1630	<p>10.2 Introduce LCCID. Try to provide enough background that they will know what to expect when they go into the computer lab.</p>	<p>S10-6 S10-7 (a-e) S10-8/9</p>
1700	<p>Announce a one-hour dinner break to be followed by the computer lab. If it is at a different site, describe arrangements for transportation. Give the room number.</p>	
1800	<p>Computer Lab: Let students know how they are to be assigned to computers. Introduce guest expert on LCCID or, if you are responsible, conduct the computer lab. Assist them to get the program up and running. Assign Case Study 1. Provide individual attention as needed. Make sure all students successfully complete the assignment. If time permits, assign Case Study 2 or allow them to work on a problem of their choosing. Continue providing individual assistance as needed.</p>	<p>computers CDs UM CS 1 CS 2</p>
2030	<p>Announce end of computer lab.</p>	

Key: S = slide, V = Vugraph, F = Flipchart, W = Workbook, N = Notebook, CS = Case Study, CD = Computer Diskettes, UM = User's Manual

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PERFORMING EA/LCCA WITH COMPUTERS

Put this slide up while introducing the module.

- The material we have covered thus far in the course has established the fundamentals for performing LCCA. You know how to perform a basic LCCA manually, using the DA Forms. This takes the mystery out of computer software for EA/LCCA and helps you to use it correctly. Without this background, software users are highly likely to misuse software -- mainly by entering data inputs incorrectly -- and misinterpreting the output. With the background you now have, you should be ready for software.
- In this module we will get you started using LCCID, a computer program specially developed for MILCON design applications. LCCID stands for LCC in Design.
- We will also identify several other computer programs that are used for EA/LCCA, and discuss factors to consider in selecting software.

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

EXISTING SOFTWARE WILL

- **Perform fast and accurate calculations**
- **Make it easier to follow criteria**
- **Provide some of the data**
- **Supply part or all documentation**

- Existing software can do a lot. It can
 - relieve you of calculating LCCs by hand. This saves time and reduces the likelihood of mathematical errors in the analysis.
 - make it easier to follow criteria by building them into the software. For example, the value of the discount rate can be built in; the maximum length of the analysis period; conventions for modeling cash flows; and so on. In addition, you need not know all the nuances of the evaluation method in order to perform the analysis.
 - reduce data gathering efforts by incorporating data files such as escalation rates.
 - provide a computer printout which documents the study.

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**

- Existing software will NOT . . .
- We want to encourage you to use software. But we want to discourage you from thinking that a computer program provides all the answers.
- What general factors do we need to consider in selecting computer software for a given this application?

Generate discussion and write responses on flip chart, or if time is short, go straight to slide 10-4. After discussing and writing on flip chart, summarize by using 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?**

- There are many methodologies and models used in government and private applications and no one computer program can serve them all. Computer programs are developed for specific purposes, customers, and applications.
- Analysts need to investigate available computer programs to determine what program(s) will fit their needs. The following questions should be asked about programs being considered for your applications:
 - What are the purported applications for the program?
 - Is there an active users group?
 - Is the program endorsed by the sponsor of the economic study? To what extent does it incorporate the applicable criteria to be followed?
 - Does the program run on the computer(s) available to the user (including memory requirements)?
 - Is the program well documented and supported? The better the program is documented the easier it will be for the user to understand how to use it. Well supported programs can also be relied upon to keep up to date with changing economic criteria.

- Does the information reported by the program meet your needs? Be sure that the program reports such measures as savings-to-investment ratio when that is needed in the analysis.
 - Will using the program increase your productivity. Do your requirements justify the cost of the program? Choose a program that will be helpful at a cost that is justified by intended application.
- Of the many computer programs available for economic analysis, only a few of them are known to follow the criteria for MILCON general economic studies and Federal Energy Management Program energy studies. Let's take a look at what is available.

Day 4

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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

- The Corps of Engineers' Life-Cycle Cost In Design (LCCID) computer program was developed specifically for MILCON design applications. It is designed to be compatible with FEMP, OMB-94 and ECIP criteria. This is the software we will use in the computer lab. The LCCID diskettes and User Manual are provided in the Notebook.
- Our focus is on LCCID, but there are 3 other software packages we would like you to know about.
- Two of them are commercially developed packages determined to be consistent with LCCID:
 - "Government Economics" by Trane Company, and
 - "Advanced Economic Analysis" by the Carrier Corporation.
 - The Corps has validated these programs to be consistent with LCCID.
- There are four points in the validation test:
 - Compatibility with all current criteria
 - "Lock-in" of criteria (or indication of deviation)

- Standardized input and output formats
- Built-in DOE e values
- The last listed is a program called FBLCC, short for “Federal Building Life-Cycle Cost” (FBLCC). It was developed by the National Institute of Standards and Technology (NIST) for government-wide use, rather than for dedicated DOD applications. It was originally developed to perform economic analysis in support of FEMP LCC studies, and later was expanded to accommodate studies performed according to A-94 criteria as well. FBLCC is taught as part of the 3-day LCC/ASEAM workshops offered through the GSA Training Center. It can be ordered from NTIS, US. Dept. of Commerce, 5285 Port Royal Road, Springfield, VA 22161.
- Additional computer programs that meet DOD needs may be developed in the future.

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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

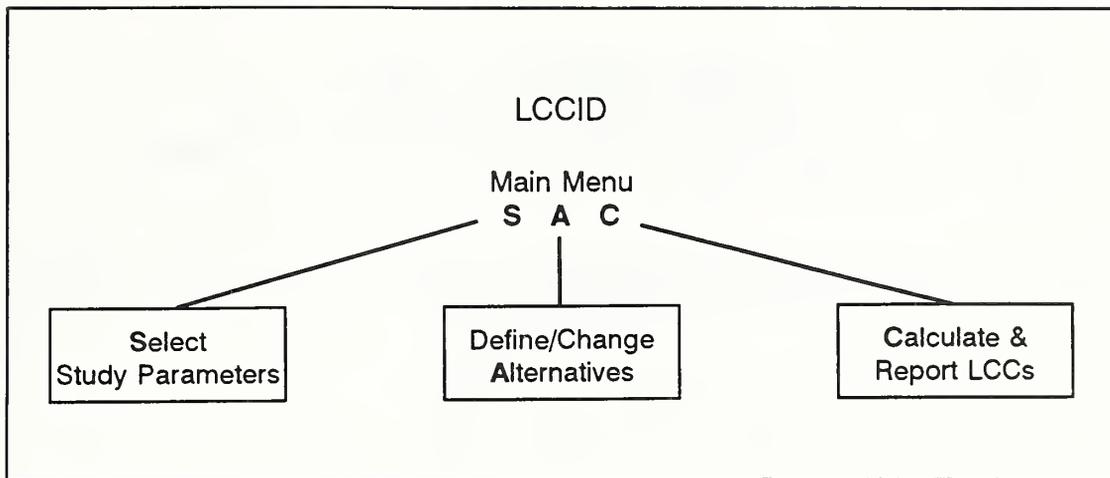
- use LCCID to perform simple EA/LCCA
- describe the special features of LCCID
- interpret a sample printout of the LCCID Output Report

**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)

- The Life-Cycle Cost In Design computer program, LCCID is tailored . . . and is appropriate for performing . . .
- It runs on all IBM or IBM compatible PCs and other computers supporting MS-DOS 2.0 or PC-DOS 2.0 or higher with sufficient memory. You need a minimum of 448K RAM in order to use it.
- In your Notebook you will find a copy of the LCCID program diskettes (there are 2), the User's Manual, "Ready Reference sheets, Release Notes, and Installation Instructions."

Slide 10-7 (a-d)



Put up slide 10-7a.

- Let me give you a quick overview of how the program operates so that you will know what to expect when you go into the computer lab.
- The program is menu-driven. When you start the program, you will see a menu with several options. You will press an S, for "Select Study Parameters." This will take you to another menu which will allow you to select criteria. You have the options of indicating that the study is
 - Military Construction Army
 - Military Construction Navy
 - Military Construction AF

And to indicate the significance of energy on the feature being studied as

- Significant or Primary
- Incidental
- Not Applicable

If you indicate that energy is significant, then you are asked to state whether your objective is to

- Select the Best Conventional Design (d = 10%)
- Perform a Special Directed Design Study (FEMP, d = 7%)
- Perform a Retrofit Study for the Energy Conservation Investment Program (ECIP) (d = 7%)

If you indicate that your objective is to perform a special directed design study, you are next asked of it is for a solar or non-solar design.

At the end of this process, the criteria are summarized.

- You are also asked to select the key study dates

Put up slide 10-7b.

- After selecting all the study parameters, you are returned to the main menu, where the next thing you will need to do is to define alternatives. This is where you enter the specific data for each alternative, including investment costs, M&R, etc.

Put up slide 10-7c.

- After you have entered all the data for the alternatives, you will be ready to calculate and report LCCs.

Put up slide 10-7d.

- This is a simplified overview of the process. For a more detailed look, go to the LCCID Ready Reference sheets in your Notebook.
- I also want to call your attention to the box in the upper left-hand corner of the Ready Reference sheets headed "Miscellaneous Commands." Note that by typing "HELP" or "@," you can receive assistance while you are in the program.

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LCCID USER'S MANUAL

- **User instructions**
- **Reference**
- **Tutorial**

- I also would like to ask you to at least glance through the User's Guide. It provides instructions, serves as a reference, and gives a tutorial.

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**

- LCCID is distributed and supported by the University of Illinois under contract to CERL.
- You have information on the BLAST Support Office following the User's Guide in your Notebook.
- Note that OSAF tables incorporating the latest e values are also available from BSO.

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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:	2 years from DOS
Length of Construction Period:	1 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 6 months after BOD)	\$12,000/yr plus escalation 2.609 MBtu at \$4.60/MBtu
Repair Cost (as of DOS): (Repair cost first occurs 5 years after BOD)	\$5,000/every 5 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 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.

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

Day 4

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	\$15,000
	1,252 MBtu	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

LESSON PLAN 11: DEALING WITH UNCERTAINTIES

TIME	OVERVIEW	TRAINING AIDS OR CUES
0800	<p>Ask students to turn to Module 11.</p> <p>Review the purpose of the module, the outline, and allotted time.</p> <p>Discuss why there are uncertainties.</p>	<p>W11</p> <p>S11-1</p>
0810	11.1 Give an overview of techniques, emphasizing SA.	S11-2/7
0830	<p>11.2 Discuss conditions under which uncertainty should be done.</p> <p>Divide class into groups and ask them to discuss the 5 questions of Exercise 11-1 and decide answers.</p> <p>Compare answers and discuss.</p>	<p>S11-8</p> <p>Ex 11-1</p>
0900	<p>11.3 Ask class to perform exercise 11-2 working alone</p> <p>Review the solution of 11.2.</p> <p>If there is more time, review key points</p>	Ex 11-2
0930	Announce Break	

Key: S = slide, V = Vugraph, Ex = Exercise, F = Flipchart, W = Workbook, N = Notebook

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SOURCES OF UNCERTAINTY IN EA/LCCA

- **Variability in data inputs**
 - **Prices**
 - **Quantities**
 - **Timing of costs & benefits**
- **System performance**
- **Circumstances of use**

- It goes without saying that we are uncertain about the future. We can't know with certainty the exact values of all the data inputs to EA/LCCA. LCCAs are based on estimates rather than on known quantities. Present and future prices, quantities, and the timing of costs and benefits may differ from those estimated. Systems may not perform as we believed they would. We may end up using buildings and systems differently than we had expected and longer or shorter than we had planned.
- When the actual input values differ from the estimates and assumptions, the outcome may differ from that predicted by the economic evaluation.
- This means that we may select a design that turns out not to have been the best choice.
- Sometimes when design professionals think about the uncertainties inherent in performing EA, they may take the position that they know nothing about the magnitude of future costs and benefits. But I assure you that is an overreaction. We often can come quite close to predicting unknown magnitudes once we know the setting within which they occur. Let's take a simple example which demonstrates how you can narrow the range of potential values as you find out more about the circumstances. For example, suppose I say that I am thinking of a piece of string. How long is it? Now I qualify that statement by telling you that the string is in the trunk of my car. Now guess how long it is. I can also tell you that I took it out of my glove box and put it

in the trunk. How long is it? Actually, I have it in my pocket right now. How long do you think it is? Here it is. How long do you think it is?

See how we are able to move from a state of complete uncertainty to a high level of certainty by finding out more about the context and conditions.

Give other examples if you have them.

- One more point. I would like to remind you that most of the decisions you make about buildings entail uncertainty. But usually the consequences of being wrong are much more serious. If you are wrong in your cost estimate, money will be lost; if you are wrong in your engineering decisions, the building may fall in!
- We try through “uncertainty analysis” to become better informed about possible outcomes and their likelihood of occurring, so that we can avoid poor choices that are predictable. Of course, we still might not be right in every decision, but we can improve our percentages.
- Let’s see what uncertainty analysis is and what it offers in the way of improvements to design decisions.

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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

UNCERTAINTY ANALYSIS

**analytical techniques for taking into account
the degree of uncertainty about input values
for an economic analysis**

- By “uncertainty analysis” we mean formal analytical techniques for . . .

Slide 11-3

TECHNIQUES FOR DEALING WITH UNCERTAINTY

- Probability-based analysis
- Sensitivity analysis
- Others

- There are a number of uncertainty analysis techniques in use. Those that are probability-based are generally the most sophisticated and provide the most information.
- By probability-based, I mean that they express variable input values not as single “best-guess” values, but as a distribution of values.

GO TO FLIP CHART

- For example, instead of using a single, best-guess estimate that the time of replacement will be 10 years, you would estimate the probabilities that it will occur at various times; e.g.,

Time of Replacement (years)	Probability of Occurrence (%)
8	15
9	20
10	30
11	21
12	12
13	2
	<hr style="width: 20%; margin: 0 auto;"/>
	100

- This is a probability distribution of the time of replacement. It might be developed from records of past frequency of replacements.
- We can compute its "expected value," which is the weighted average of the frequencies, by summing the products of the possible input values times their probabilities of occurrence, as follows:

$$\begin{aligned}EV &= (8)(0.15) + (9)(0.20) + (10)(0.30) + (11)(0.21) + (12)(0.12) \\ &\quad + (13)(0.02) \\ &= 10\end{aligned}$$

Note that the "expected value" of the distribution in this case is 10 years, which was also the best-guess estimate. But now we have more information. What can be done with the information?

- We can use distributions of input values to calculate a distribution of LCC. The process is called simulation analysis. Simulation is performed by drawing randomly an input value from distributions for several inputs. Draw a value from each input distribution, combine them with constants, and compute one LCC. Repeat the process many times until you have a distribution of LCCs. It is then possible to calculate the expected value of the LCC distribution, to measure the variability of the distribution, and to compile a cumulative distribution function which tells us the probability that LCC will be greater or less than specified values. This gives us a quantified measure of the likelihood that the LCC will have various values. We might conclude from such an analysis, for example, that there a 60% probability that the LCC of Design A will be \$8,000 or less, an 85% probability that it will be \$10,000 or less, and a 99% probability that it will be \$15,000 or less.
- (There is another technique for obtaining probability functions for LCC without the repeated trials of simulation called the mathematical/analytical technique.)
- To perform probability analysis requires estimates of the probabilities that different values will occur. These estimates may be based on recorded data or they may be based on subjectivity.

- Probability analysis is growing in use, particularly with the availability of computer software packages that run on a microcomputer and perform the calculations.
- The TM states that a probability approach to uncertainty analysis should be taken when possible. But it recognizes that “the rigorous probabilistic approach is too complex for routine use” . . . and states that “reasonable approximations to that approach are preferred for MCP design applications.”
- For those cases in which a probability approach is not feasible, the TM calls for sensitivity analysis as the next preferred technique for dealing with uncertainty. It is easy to do and may shed light on a decision under uncertainty by showing what the outcome will be if one or more of the input values are different from the best-guess estimate.
- There are other techniques for dealing with uncertainty, such as the risk-adjusted discount rate technique, the certainty equivalent technique, and breakeven analysis. It should also be mentioned that there are various techniques that are based on probabilities, such as decision tree analysis, expected value analysis, mathematical/analytical technique, and simulation.
- A survey of techniques for treating uncertainty and risk in the economic evaluation of building investments is provided by the following report which we suggest that you obtain:

NIST Special Publication 757, Techniques for Treating Uncertainty and Risk in the Economic Evaluation of Building Investments, by Harold E. Marshall.

- Now let's look more closely at sensitivity analysis since it is a very practical technique that can easily be added to the basics you have acquired thus far. It is widely used.

SENSITIVITY ANALYSIS IS PERFORMED --

**by repeating an economic evaluation
with one or more input values changed.**

- Sensitivity analysis is performed by . . . All you have to do to perform sensitivity analysis is change the value of an input and redo the calculations.

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**

- Sensitivity analysis is used in three, closely related ways . . .
- Let's see an example of each.

Slide 11-6

IDENTIFY CRITICAL INPUTS	
<u>10% change in input</u>	<u>% change in output</u>
input 1	2%
input 2	10%
* input 3	20%

Conclusion: devote more resources to improving data estimates for input 3 than input 1.

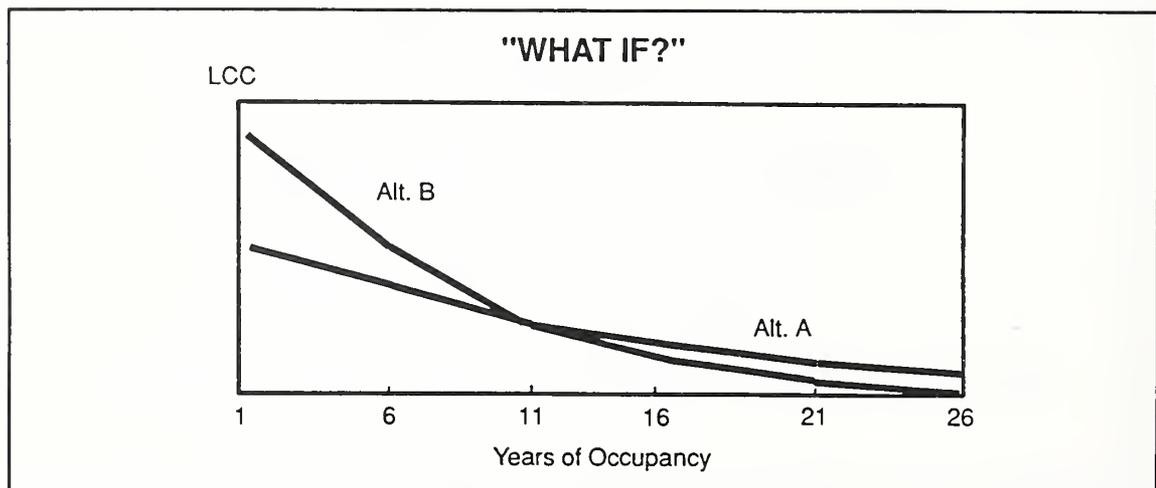
- This illustrates sensitivity analysis as a techniques for identifying the critical inputs. Note that, for a change in any one input, the other input values remain fixed. Input 1 might be retention value, for example, and input 3 might be a price escalation rate. This application of sensitivity analysis is helpful in identifying the input values which are most critical to the outcome. It tells us that it is more worthwhile to try to improve the quality of the estimate for input 3 than for input 1 or 2.

Slide 11-7

"WHAT IF?"	
<u>Scenario</u>	<u>LCC</u>
1	\$10,000
2	9,000
3	11,000
4	8,000

- Here we see an example of sensitivity analysis used to answer "what if" questions. If scenario 4 holds true, LCC is estimated as low as \$8,000, but if scenario 3 holds, LCC is estimated as high as \$11,000. Scenario 4 might be the case of no major repairs, whereas scenario 3 might be the case of higher than average repairs.

Slide 11-8

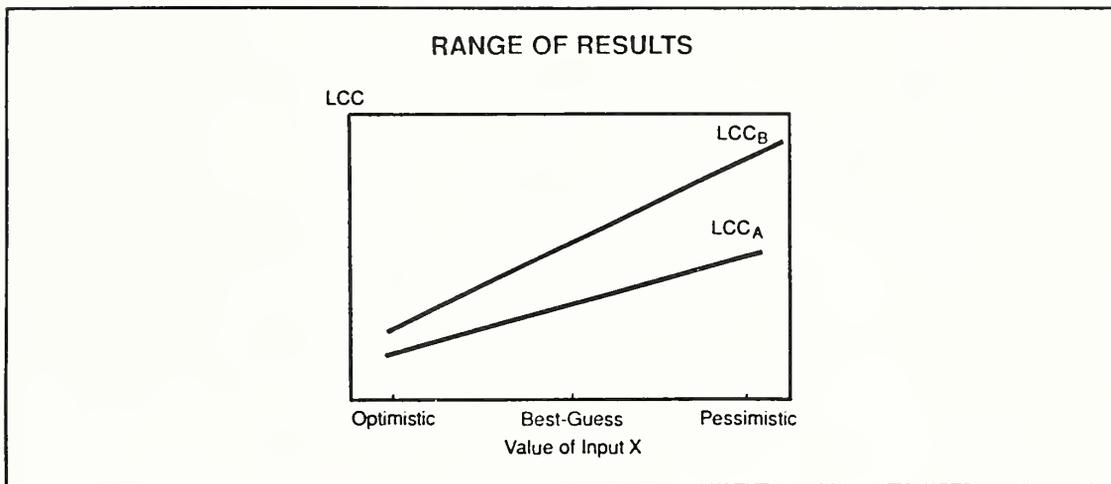


- Here we see another example of sensitivity analysis used to answer a what if question. What if we need a building for a shorter time than we think.

Explain the graph.

- Suppose we think it most likely that we will need the building about 16 years. Under this assumption, design alternative B is the choice with lowest LCC.
- But suppose we know there is a possibility that we will use the building only about half as long, or 8 years. Does the selection of B hold up? No, alternative A becomes the best choice. The results of the sensitivity analysis tells us that we need to pay close attention to how long we will need the building. But it also shows us that if we are reasonably certain that we will need the building for a period of at least 11 years, B is estimated to be the best choice. Although it doesn't tell us with certainty which alternative to select, it provides useful information for making the choice.

Slide 11-9



- This slide illustrates using sensitivity analysis to show LCCs as a range based on pessimistic, best-guess, and optimistic values of an input.

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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?

- To decide if you should do uncertainty assessment, ask if any of these factors applies.

Discuss the factors listed.

- Now we will do exercise 11-1 which will clarify how these factors affect whether or not we need to do uncertainty assessment.

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

Day 4

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.

SOLUTION TO EXERCISE 11-1: WHEN TO PERFORM SENSITIVITY ANALYSIS

Uncertainty Assessment Should be Done: 2, 4, 5

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 8 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.

Day 4

SOLUTION TO EXERCISE 11-2

Recomputing LCC for Alt B based on M&R cost of \$0.8/yr results in an LCC of \$51, maintaining a small advantage for B over A. Select B.

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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

Point out that they need to be able to review not only studies performed by A-E contractors but also studies performed by colleagues, and, perhaps even more importantly, they need to be able to review their own work.

LESSON PLAN 12: CRITIQUE OF EA/LCCA

TIME	OVERVIEW	TRAINING AIDS OR CUES
0945	<p>Ask students to turn to Module 12</p> <p>Review the purpose of the module, the outline, and the allotted time.</p>	W12
0950	<p>12.1 State that DA Form is helpful in reviewing studies performed by A-E contractors, other design professionals, and themselves. Ask the students to turn to the Outline of Recommended General Procedure for Conducting a Review.</p> <p>Point out the main items to check and deviations to identify.</p>	<p>W12.1</p> <p>S12-1 (a-e)</p> <p>S12-2 (a-d)</p> <p>S12-3 (a-d)</p>
1010	<p>12.2 Exercise 12-1.</p> <p>Ask the students to form groups of four to review the report. Give them a time limit and ask them to identify as many flaws and shortcomings with the study as they can within the time. Ask them to elect spokesman for the group. Call on each spokesman to present the results. Each one after the first gives only those items not yet identified.</p>	DA Forms 5605

Key: S = slide, V = Vugraph, F = Flipchart, W = Workbook, etc.

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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.

Series of slides a through e. Slide a shows just the heading and second line (off to the side); slide b adds the first bullet; slide c, the second bullet; etc. Each bullet is highlighted when it is added.

Slide 12-1 (a-e)

QUICK & INCISIVE REVIEWS

1st Priority Check:

- **Documentation**
- **Alternatives**
- **Principal assumptions**
- **Selection decision**

- To perform an incisive review of an EA/LCCA study quickly, we recommend that you check the following in the order shown:
 - First check the documentation.
 - Is any information missing on the forms? Is that information critical?
 - Are backup data and calculations furnished or clearly referenced?
 - Next check the alternatives which were considered, thinking about how rational and reasonable they seem.
 - The third most important step is to check the principal assumptions. Are they reasonable?
 - The fourth is to check the selection decision. Is it properly based on LCCA? Is it reasonable in terms of engineering judgment/experience?
- Give priority to these four checks. If you have only a few minutes to look at a study, focus on these four aspects.

Series of slides a through d. Slide a shows just the heading and second line (off to the side); slide b adds the first bullet; slide c, the second bullet; etc. Each bullet is highlighted when it is added.

Slide 12-2 (a-d)

QUICK & INCISIVE REVIEWS

- 2nd Priority Check:**
- **Key criteria cited and used**
 - **Cost & benefit input data**
 - **Calculations**

- If you have additional time, we recommend that you next check on these three aspects.
 - Are the key criteria cited and used correctly?
 - Look at the input data for costs and benefits. Are the amounts and timings properly recorded and do they look reasonable?
 - Now look at the calculations. Perform a spot check using simplified approximation techniques or a method different from that used originally.

Series of slides a through d. Slide a shows just the heading and second line (off to the side); slide b adds the first bullet; slide c, the second bullet; etc. Each bullet is highlighted when it is added.

Slide 12-3 (a-d)

QUICK & INCISIVE REVIEWS

- Identify Deviations:**
- **From contract provisions**
 - **From applicable criteria**
 - **From other agreed-on provisions**

- A final thing to do in your quick review is to look for any deviations from contract provisions, from applicable criteria, and from other agreed-on provisions.

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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)

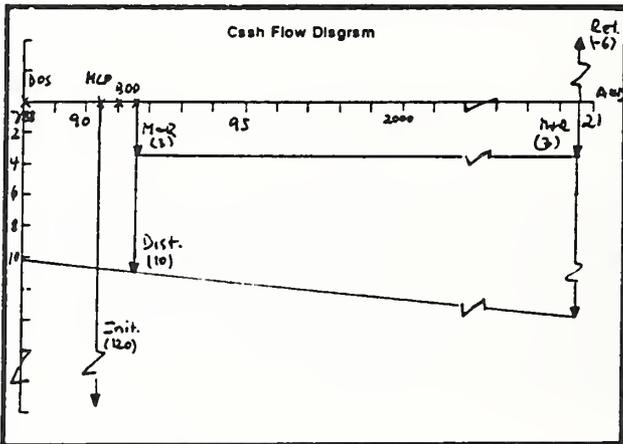
Project No. & Title 318 Floor Finish
 Installation & Location Building X
 Design Feature Maintenance
 Alt. No. A Title Grease Block

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	



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)*	
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		Rest 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 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		Principal Assumptions		
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.)			

Cash Flow Diagram

Cost Element	Cost on ABD X 5 x 10 ³ - 5 x 10 ⁴	Time Cost Incurred**		Source(s) of Data
		Actual Projected Dates	Dates for Analysis (if Different)*	
Initial Investm.	225	JAN 91		Eng. Estimate
M&R	6	JAN 92 - JAN 21		Eng Estimate
Distillate	10	JAN 92 - JAN 21		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 5605-2
(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 $\times 10^3$ or $\times 10^6$				Total
		Initial	Energy	M&R	Other	
A	Cresote 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	51% lower energy	LCC
2	A - Cresote Block	(12%)		

KEY ASSUMPTIONS	NARRATIVE SUMMARY (Comments/Lessons Learned/Observations/Recommendations/Etc.)
	First cost is 46% higher
	Energy cost is 51% lower

Key Participants - Name	Disciplina	Organization	Telephone No.

DA FORM 5605-2-R, DEC 86

Sheet _____ of _____

SOLUTION TO EXERCISE 12-1

ALTERNATIVE A:

DA Form 5605-3 - Basic Input Data Summary

- 1) Project Identification:
Line 1 incorrect (PN 318 (FY90) Recr. Center)
Line 2 incorrect (Cheney Center, Fort Oaks, Mich.)
Line 3 incorrect (Floor Finish)
Line 4 correct

- 2) Key Dates:
Criteria reference missing (HQDA)
Date assumed for analysis missing (Jul 91)
No justification cited for 30-year analysis period

- 4) Region:
Not identified (5)

- 5) Annual Discount Rate:
Incorrect (should be 10% for Gen. Econ. Study)

- 6) Diff. Esc. Rate:
8% with 5% inflation is arbitrary and incorrect; should be DoE projected rate excluding inflation; should also specify that escalation rates are zero for other cost elements.

- 7) Cashflow Diagram:
Line for distillate should not be extended to LH axis: (should begin at six mos. after BOD = Jan 92); retention value occurring at Jan 21 instead of Jul 21.

- 8) Cost Elements:
Incorrect data sources: Eng. Estimates or best guess not sufficient; BLAST Program energy analysis not necessary, because floor finishes do not affect energy consumption enough to warrant use of BLAST; not indicated whether costs are in thousands or millions.

Day 4

DA Form 5605-4 - Present Worth: Conventional Approach

- 1) Same omissions as above in Key Data and Escalation Rate boxes.
- 2) PW Calculations for One-time Costs:
Correct except for missing \$ x 10³
- 3) PW Calculations for Annual Costs:
Correct, except for use of wrong escalation rate and missing \$ x 10³
- 4) Net Present Worth:
All entries correct except for "Other Costs" (should be negative instead of positive for retention value)

ALTERNATIVE B

DA Form 5605-3 - Basic Input Data Summary

- 1) Project Identification:
Line 1 incorrect (PN 318 (FY90) Recr. Center)
Line 2 incorrect (Cheney Center, Fort Oaks, Mich.)
Line 3 incorrect (Floor Finish)
Line 4 correct
- 2) Key Dates:
Criteria reference missing (HQDA)
Date assumed for analysis missing (Jul 91)
No justification cited for 30-year analysis period
- 4) Region:
Not identified (5)
- 5) Annual Discount Rate:
Incorrect (should be 10% for Gen. Econ. Study)
- 6) Diff. Esc. Rate:
8% with 5% inflation is arbitrary and incorrect: should be DoE projected rate excluding inflation; should also specify that escalation rate is zero for other cost elements.

- 7) Cashflow Diagram:
Correct, except for line for distillate should not be extended to LH axis (should begin at six mos. after BOD = Jan 92)
- 8) Cost Elements:
Incorrect data sources: Eng. Estimates or best guess not sufficient; BLAST Program energy analysis not necessary, because floor finishings do not affect energy consumption enough to warrant use of BLAST.

DA Form 5605-4 - Present Worth: Conventional Approach

- 1) Same omissions as above in Key Date and Escalation Rate boxes.
- 2) PW Calculations for One-time Costs:
Correct for initial investment; incorrect for retention value (occurs at 33.5 years)
- 3) PW Calculations for Annual Costs:
Correct for M&R; incorrect for Distillate: wrong escalation rate and wrong discount factor; causes PW of energy cost to be too low.
- 4) Net Present Worth:
Incorrect (Energy Costs should be 353.4 as for Alt. A; total too low because of wrong energy cost calculation)

ALTERNATIVES A AND B

DA Form 5605-2 - Summary

- 1) Description:
Other Costs in line A incorrect (should be negative)
- 2) Economic Ranking:
Incorrect: the mistake in calculating the energy cost caused B to be ranked higher.

Comments:

- a) Alternative B had higher initial cost, higher M&R cost, lower retention value and equal energy cost. No economic analysis was necessary.
- b) The difference in energy costs between A and B should have been noticed even without doing calculations.
- c) Several other alternatives could have been specified, such as vinyl tile, commercial carpeting, artificial turf, etc.
- d) Since energy consumption was the same in both cases, it could have been omitted from the analysis.
- e) Decision as to whether or not sensitivity analysis has to be performed is not documented.

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

LESSON PLAN 13: PUTTING EA/LCCA INTO PRACTICE

TIME	OVERVIEW	TRAINING AIDS OR CUES
1100	Introduce Module 13	W13 S13-1, S13-2
1103	13.1 Introduce the concept of level of effort Discuss alternative levels of effort Ask students to turn to 2-2a (p. 2-2) of the TM and review the general requirements for the study effort. Refer them to summary of 7-step procedure given on p. 13-15. Walk them through each step. In the first step refer them to TM requirements.	TM (2-2a) Ws13.1 S13-3/12 TM 2-2a (S13-4/6)
1130	Walk through the "NOMS FACTOR" screening procedure, giving them the example on the board or flip chart of how it works at each step. Close discussion of level of effort with summary of key points.	S13-13/14 Ws13.1 F or B S13-15
1200	Announce lunch	
1300	13.2 Introduce subject of documentation. Define what is meant by documentation. Refer to TM criteria for documentation. Discuss distribution of documentation. Discuss importance of documentation. Discuss how to document. Close discussion of documentation by calling their attention to the summary description.	Ws13.2 S13-16 TM 2-2d S13-17 S13-18 S13-19 S13-20 Ws13.2

Key: S = slide, V = Vugraph, F = Flipchart, W = Workbook, s = Workbook section,
N = Notebook, TM = Technical Manual

LESSON PLAN 13: PUTTING EA/LCCA INTO PRACTICE (continued)

TIME	OVERVIEW	TRAINING AIDS OR CUES
1330	<p>13.3 Introduce subject of presenting/"selling" results.</p> <p>Begin by reviewing how they are to analyze study results to make a design decision.</p> <p>Raise the issue that selections based on study results will often be challenged.</p> <p>Ask students to give reasons why.</p> <p>State that the best defense to most challenges is a sound study. Indicate that HQ views a sound study as evidence for taking a number of actions.</p> <p>Give characteristics of a sound study, and reasons why not to reverse or ignore the results.</p>	<p>Ws13.3</p> <p>S13-21</p> <p>S13-22 F or B</p> <p>S13-23</p> <p>S13-24/26</p>
1400	<p>13.4 Introduce subject of contracting with A-E firms. Form the class into groups and ask them to develop a checklist of provisions to include in contract specifications. Have spokesperson for first group give entire list. Spokespersons for other groups add to or delete from the list.</p>	<p>Ws13.4</p> <p>F or B</p>
1430	<p>Announce Break</p>	
1445	<p>13.5 Introduce exercise 13-1 on presenting/selling. Give students 5 minutes to review the two reports. Ask students how many would be willing to present/"sell" the results of the first report; and how many the second report. The first report is weak; invite them to challenge the instructor as he or she makes a pitch for the higher first-cost alternative described in that report. Then ask a student to present/"sell" the alternative of the second report, and ask the class to challenge. Have students review in their groups the second study and formulate challenges while the presenter prepares.</p>	<p>Ws13.5</p> <p>Ex 13-1 F or B</p>
1600	<p>Announce beginning of Module 10 on computers.</p>	

Key: S = slide, V = Vugraph, F = Flipchart, W = Workbook, s = Workbook section, N = Notebook, TM = Technical Manual

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?**

- In this module, we will focus on issues which arise in conjunction with planning, documenting, presenting/selling, and contracting for EA/LCCA -- issues which are important to putting EA/LCCA into practice.
- These functions may be more managerial than technical in nature, but every design professional will probably have to deal with them at one time or another.
 - Most, if not all, of you need to know how much effort you should devote -- or you should require an A-E contractor to devote -- to economic studies in support of individual design decisions as they arise.
 - You need to think about the documentation you will provide or you will require others to provide.
 - You need to know how to get results from the studies that are performed, so they are not just empty paper exercises. You need to know when you have a strong case for going with a higher first cost alternative on grounds of LCC, and when you need to strengthen that case. You need to be able to communicate study results convincingly to others.
- Here again you will need to pick up hands-on experience with LCCAs before you can expect to be highly proficient in these areas. Based on what you've learned so far in the course, however, you should have enough understanding of the subject matter to get something out of the more advanced topics.

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

HOW MUCH TO SPEND ON EA/LCCA?

- \$\$\$\$\$
- \$\$\$
- \$\$
- \$
- 0

- Economic studies are not free! But they need not always be expensive. EA/LCCAs can range from quick analyses performed in under an hour to comprehensive, well-documented analyses that may take months.
- You will need to decide the level of effort to devote to each study on a case-by-case basis. And you will need to plan for the resulting resource requirement.
- The intention of HQ is that the level of effort for each situation be the “cost-effective level.”
- Common mistakes are
 - to do almost no economic comparison of alternatives
 - to waste resources on overly comprehensive analyses too late in the decision process

However, the second mistake is probably far less common in MILCON than the first.

- We want you to avoid both of these mistakes.
- We suggest a 7-step procedure to determine the appropriate level of effort on a case-by-case basis:

Refer them to the 7 steps outlined in their Workbooks.

Slide 13-3

Step 1
DETERMINE GENERAL REQUIREMENTS FROM TM
(TM 2-2a)

- First consult the TM, p. 2-2, for general requirements. There you will find that there are some conditions under which an economic analysis can be waived and some under which an economic analysis is required regardless of its cost-effectiveness potential.
- This is a first cut at determining the level of effort, because it lets us know whether the level will be zero or not, and implies how important a study is under certain conditions.

LCCA REQUIRED REGARDLESS

- **Special directives**
- **Pressures to dictate choice**
- **Innovative design considered**

- Under these conditions, the TM calls for LCCA regardless of the potential in a particular case for saving money by performing the LCCA. (The only exception is when the rankings have already been estimated by a previous study.)
 - An example of the first condition is when LCCA is required by statute.
 - An example of the second condition is when there is strong user preference or a V-E study.
- The implication is that for these cases you should devote sufficient resources to an economic study to give it credibility under scrutiny.

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**

- The TM urges you in most cases to decide the level of effort based on cost effectiveness; that is, spend enough on the economic study to improve your decisions, but don't waste resources on refining a study beyond the point of potential gain.
- The philosophy is straightforward, but knowing exactly what will be the cost-effective level of effort in each situation is determined in practice largely by professional judgment. (You will develop an appreciation for this naturally as you gain hands-on experience doing LCCAs.)
- The TM calls your attention to two conditions, listed here, which are signals that an LCCA is likely to be worthwhile: (1) when alternatives have dramatically different cash-flow profiles, and (2) when there is a feature common to a number of projects.

LCCA WAIVED

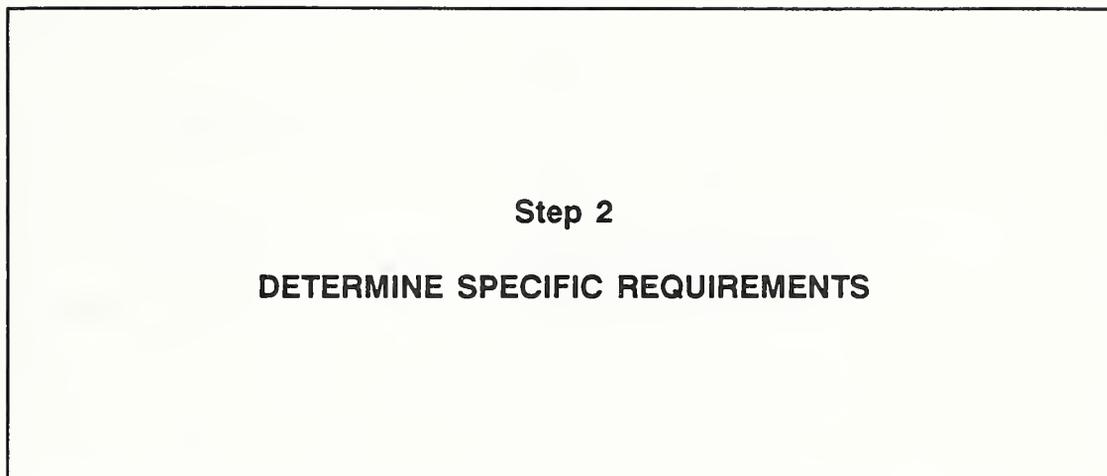
- **Rankings established by past study**
 - **Cost of the LCCA > potential savings**
-

also when

- **Study costs > 1% of PA**

- The requirement for LCCA is waived, even for studies required by statute, if a past study which fits the present case has been done. The past study should be offered as documentation.
- The second item is sufficient grounds for waiving general economic studies.
- The third item is also sufficient grounds for waiving general economic studies.

Slide 13-7



- Determine if there are any specific requirements in special rules or instructions, governing the particular project or design feature, which will influence the level of effort.
- There is a requirement for solar energy studies, for example, that additional economic evaluation measures -- SIR and DPP -- be computed. This adds a little to the level of effort.

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**

- Step 3 is to assess implications of . . .

Discuss

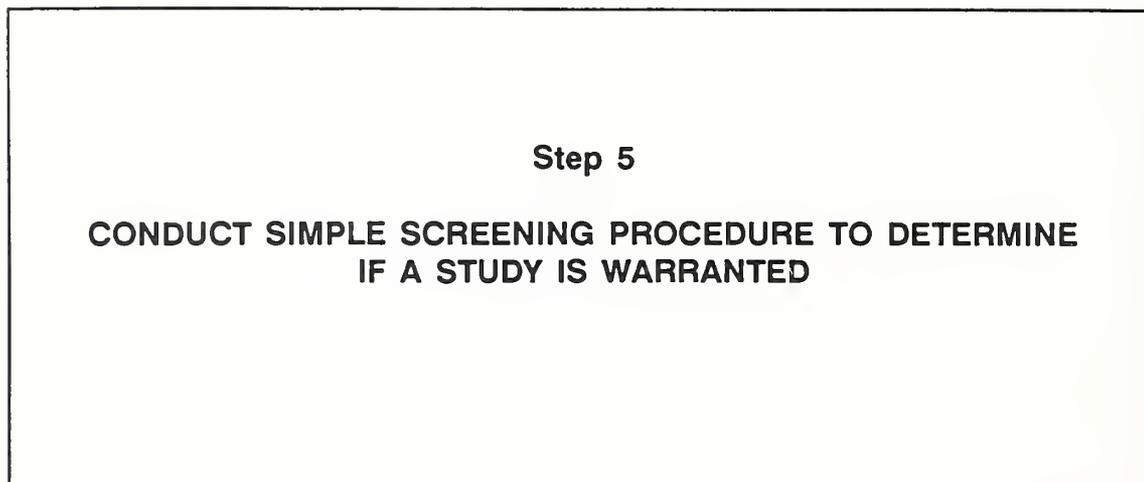
Slide 13-9

Step 4

**DETERMINE FEASIBILITY OF USING/ADAPTING PREVIOUSLY
CONDUCTED ANALYSES**

- Step 4 is to determine feasibility of . . .

Explain how this differs from Step 1. Give examples.



- Step 5 is to conduct a simple screening procedure to determine if a study is warranted.
- We will shortly present one that HQUSAC developed. As you gain experience you may prefer to develop your own screening procedure.

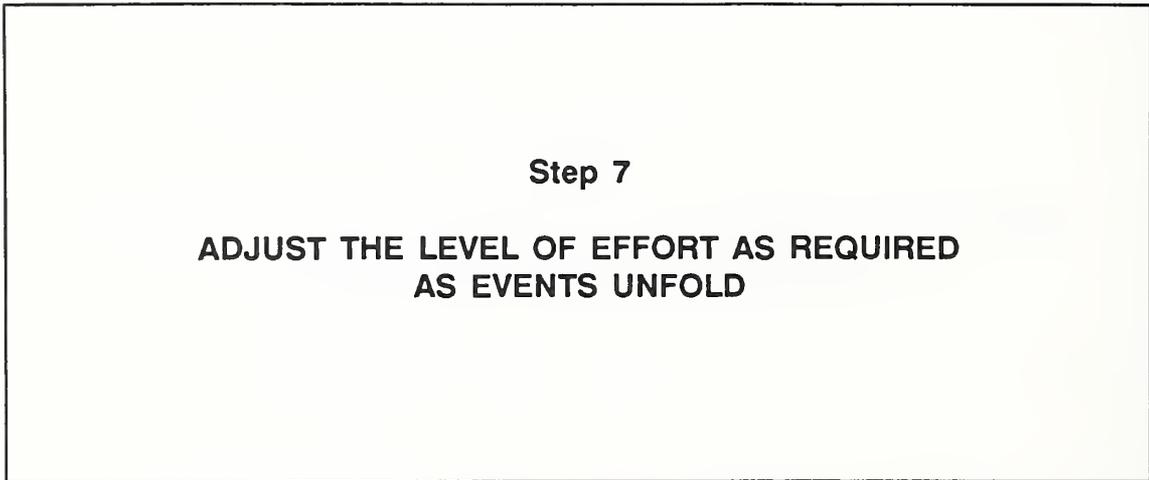
Slide 13-11

Step 6

**DETERMINE THE LEVEL OF EFFORT LIKELY TO BE
APPROPRIATE BASED ON STEPS 1-5**

- Step 6 is to determine the level of effort . . .

Discuss



- Step 7 is to adjust the level of effort . . .

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.

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.

- If Alt A costs more initially than Alt B, then Alt A will also be more costly in terms of LCC, unless:
 - Alt A saves enough in future costs to overcome the initial cost differential.
- If Alt A costs more initially and in the future than Alt B, Alt A will definitely have higher LCC, and no study is needed to determine that Alt B is the cost-effective choice!!!
- Hence, a reasonable approach for screening is to employ a test which will eliminate those alternatives that have little chance of meeting the condition that their future cost savings will overcome their higher initial cost.
- The NOMS Factor screening technique is a rule-of-thumb approach for . . . (see slide)
- It works without discounting cash flows to present worth.
- Remember, the goal of the screening technique is to
 - Identify tradeoffs where a higher initial-cost alternative looks like a big winner that justifies an LCCA, and

- Identify tradeoffs that are too close to call or not worthwhile, so that the LCCA can be concentrated on the cases most likely to produce long-run cost reductions.

- Let's look at the "NOMS Factor" Screening Technique, and see how it works in an example.

Day 4

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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 $\gg 3$, Payoff Potential of Economic Study is Great. This is the case where you should especially perform LCCA.
 - If $1 < \text{NOMS FACTOR} < 3$, 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., $d = 10\%$, 3 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.

Give simple example to illustrate the procedure while walking through it, such as the following:

EXAMPLE OF HOW "NOMS FACTOR" SCREENING TECHNIQUE IS APPLIED:

Two alternatives, A & B, are considered. Alt A costs more, but uses less distillate fuel which has a relatively high e value.

1. Difference in initial costs:

$$\begin{array}{r} \text{Alt A} = \$5,000 \\ \text{Alt B} = \$1,000 \\ \hline \$4,000 \end{array}$$

2. Difference in total future costs:

$$\begin{array}{r} \text{Alt A} = \$800/\text{yr} \times 25 \text{ yrs} = \$20,000 \\ \text{Alt B} = \$1,200/\text{yr} \times 25 \text{ yrs} = \$30,000 \\ \hline \text{"nominal savings"} \quad \$10,000 \end{array}$$

3. Ratio of nominal savings to first cost difference:

$$\$10,000/\$4,000 = 2.5$$

4. Conclusion, payoff potential unknown at first stage of screening.

5. Second Stage: ratio > minimum NOMS FACTOR of 1.5

6. Subject these alternatives to an LCCA.

Day 4

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Slide 13-14

Factors influencing minimum “nominal” savings required for cost effectiveness:

- **discount rate**
- **project calendar**
- **years of operation**
- **escalation rates**

- Crucial to whether an alternative will pass the test are factors which influence the present worth equivalent of its future cash flows.
- These are the key factors that must be built into a screening algorithm.
- They are . . .
- They are important because they influence the minimum amount of “nominal” savings, i.e., savings before escalation and discounting are taken into account, required for cost effectiveness.
- For example, if the discount rate were 4% and the projected escalation rate in energy costs were 8%, it would take a much smaller amount of “nominal” savings to cause an energy conserving design alternative to be cost effective on a LCC basis than if the discount rate were 10% and the projected escalation rate only 2%.
- In developing the NOMS Factors, conservative estimates were used of the key factors.

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**

- Let me call your attention to several key points about selecting a level of effort:

...

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

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**

- **By “documentation,” I mean . . .**

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.

- Let's look at the criteria for documentation. . . .

DISTRIBUTION

- **Among design professionals within the organization**
- **To higher authority when**
 - **significant or unusual findings**
 - **changes from common practice**
 - **significantly improved procedures**

- What do you do with the documentation once you have it?
- The TM calls for distribution to . . .

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**

- Why document?
- There are at least three reasons: . . .

HOW DOCUMENT?

Core material

- with DA Form 5605 (& attachments)
- with LCCID or equivalent software

Supporting material as necessary

- Documentation is made easy with DA Form 5605 and with printouts provided by the LCCID computer program.
- At core of all EA/LCCA.
- The DA Forms 5605 or the LCCID (or equivalent) printouts form the core of the documentation package. In addition, where necessary, there may be other material.

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

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**

- Let's begin with a review of the steps in analyzing study results and arriving at a recommendation of alternatives.
- This is a good starting point for the discussion of how to present and defend results, because the first thing is to make sure that you have followed the required procedure in arriving at the results you will then present, defend, and hopefully "sell" to others as the best decision.
- After computing LCCs, the first step is to rank the alternatives in ascending order of their LCCs.
- The second step is to assess the quality of input data.
- The third step is to determine if a design selection can be made on the basis of LCCs with a "reasonable" degree of confidence.
- If the decision is not made in step 3, the fourth step is to determine if a design selection clearly can not be made on the basis of LCCs because there is not a significant difference or because the quality of the data is inadequate to draw a conclusion. In this case, apply the tie-breaking criteria.

Refer to the tie-breaking criteria.

- If the decision is not made in step 4, the fifth step is to determine the advisability of conducting an uncertainty assessment. If so, you will need to select a method.

- The sixth step is to determine -- based on results of the uncertainty assessment -- if
 - a design selection can be made on LCC grounds alone, or, if not

 - proceed with design selection according to the professional judgment of the designer, based on what appears to be the best choice in light of all factors.

Day 4

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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."

- After you have arrived at a selection, be prepared . . .
- What are some of the common reasons for challenging study results?

Lead discussion, writing factors on flip chart. Try to draw out the students on this question. The following are common reasons:

- *for initial-cost reductions*
 - *to take advantage of value-engineering proposal*
 - *to select design feature compatible with existing criteria*
 - *to provide full range of alternatives to construction contractor in order to promote competition and ensure minimum first cost*
 - *to satisfy special user preference or request*
 - *lack of confidence in LCCs (e.g., questionable validity)*
- How do you defend against these challenges?

PRINCIPAL DEFENSE

A sound economic study, with properly validated LCC results, is the best defense

- The best defense against virtually all challenges is . . .
- A sound study, for example, provides sufficient justification for all of the following:
 - Exceeding the PA

(This is true even when discovered after budget approval by Congress, because there are other and more cost-effective solutions available in such cases -- e.g, (1) cost reductions in other design features, (2) reduction in project scope, and (3) reprogramming from other projects.)

- Deviations/exceptions from design criteria/policy
- Restriction of competition
- Rejection of VE proposal
- Rejection of special user preference or request

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**

- These are characteristics of a sound economic study: . . .

**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

- We strongly encourage you to make the effort to defend selections that are based on sound economic study.
- Failing to do so will cause long-run building costs to be higher, and the cost of the study to be wasted. It will cost the taxpayers not only once, but twice.

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

CONTRACTING WITH A-E FIRMS

What provisions to include in specifications?

- You now know what you need to do in the way of EA/LCCA and you know how to do it. But what about your A-E contractors? What can you do to increase the likelihood that they will perform EA/LCCA according to requirements and criteria?
- Divide into groups and spend the next 10 minutes putting together a checklist of important provisions to include in specifications for economic analysis. Appoint a spokesperson for your group to give your findings to the rest of the class.

At the end of 10 minutes, call on a group spokesperson to put list on board or flip chart. Then ask next group spokesperson to add to or delete from the starting list; then the next, and so on. At the end of the process, summarize the main provisions. At a minimum, the list should include:

- *performance of EA/LCCA according to the current TM*
- *using current e values*
- *using LCCID or LCCID extensions or DA Forms 5606 for calculations and documentation*
- *an oral briefing on results*

The following is a sample checklist for A-E contracts, suggested by a group of students:

- (1) Specify Scope for LCCA
- (2) Provide example
- (3) Require that the A-E contractor use TM 5-802-1 (Dec. 86) for consistency
- (4) Provide LCCID Software, Cerl Database, and e-values
- (5) Provide OSAF Tables
- (6) Specify computer language
- (7) Put everything in writing
- (8) Require regular briefings by A-E contractor
- (9) Make specifications part of preliminary negotiations

Day 4

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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 retrofitting 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

$$\text{LCC (A)} = \$117\text{K}$$

$$\text{LCC (B)} = \$139\text{K}$$

$$\text{Net Savings of Alt A over Alt B} = \$22\text{K}$$

$$\text{Percentage Reduction in LCC} = 16\%$$

Based on Sensitivity Analysis:

(Using Most Pessimistic Input Data)

$$\text{LCC (A)} = \$125\text{K}$$

$$\text{LCC (B)} = \$139\text{K}$$

$$\text{Net Savings of Alt A over Alt B} = \$14\text{K}$$

$$\text{Percentage Reduction in LCC} = 10\%$$

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

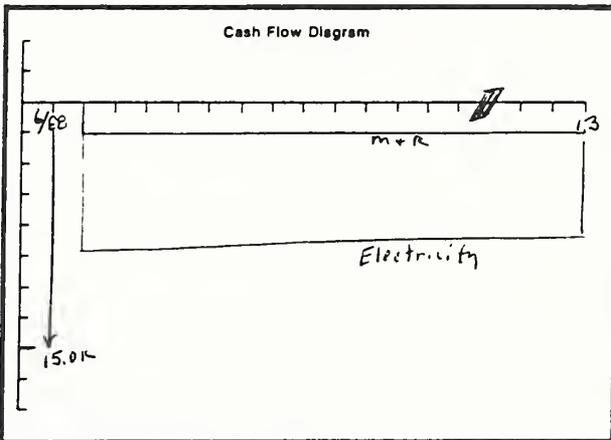
LIFE CYCLE COST ANALYSIS
BASIC INPUT DATA SUMMARY

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

Criteria Reference		<u>FEMP</u>	
Date of Study (DOS)		<u>6/88</u>	
Analysis Base Date (ABD)		<u>6/88</u>	
Analysis End Date (AED)		<u>6/13</u>	
Midpoint of Construction		<u>12/90</u>	
Beneficial Occupancy Date (BOD)	Actual Projected	<u>6/91</u>	
	Assumed for Analysis	<u>6/88</u>	
DOE Region		<u>8</u>	
Annual Discount Rate		<u>7%</u>	
Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe: <u>88-90</u> <u>90-95</u> <u>95-13</u>		
<u>ELEC</u>	<u>-3.37</u>	<u>-1.03</u>	<u>-0.05</u>
<u>Other</u>	<u>0</u>	<u>0</u>	<u>0</u>

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.



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)*	
<u>Initial Costs</u>	<u>\$15.0K</u>	<u>12/90</u>	<u>6/88</u>	<u>Cost Engineer's Est. (App 1)</u>
<u>m+r (Lamps)</u>	<u>0.2K</u>	<u>12/91-12/16</u>	<u>6/88-6/13</u>	<u>Manufacturer's Info (App 2)</u>
<u>Electricity</u>	<u>9.8K</u>	<u>12/91-12/16</u>	<u>6/88-6/13</u>	<u>DOE 2 (App. 3)</u>
<u>Retention Value</u>	<u>0</u>			

DA FORM 5605-3-R, DEC 86

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

Completed DA Form 5605-5 for Alt A

Project No. & Title PN 101 Reserve Center
 Installation & Location Fort 2, 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 10 ³ \$ x 10 ⁴	Years from ABD	Cost On ABD	One Step Adj. Factor Table 1	Present Worth on ABD	Criteria Reference
<u>Initial Costs</u>	<u>0</u>	<u>\$15.0K</u>	<u>1.0</u>	<u>\$15.0K</u>	<u>FEMP</u>
					Analysis Base Date (ABD) <u>6/88</u>
					Analysis End Date (AED) <u>6/13</u>
					Midpoint of Construction <u>12/90</u>
					BOD for Analysis <u>6/88</u>
					Annual Discount Rate <u>7%</u>
					Differential Escalation Rate per Year (%) Timeframe: <u>88-90, 90-95, 95-13</u>
					<u>ELEC</u> <u>-3.37</u> <u>-1.03</u> <u>-0.05</u>
					<u>Other</u> <u>0</u> <u>0</u> <u>0</u>

Annual Costs \$ x 10 ³ \$ x 10 ⁴	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
<u>Electricity</u>	<u>25</u>	<u>9.8K</u>	<u>\$245.0K</u>	<u>0.4050</u>	<u>\$99.2K</u>
<u>M + R (Lamps)</u>	<u>25</u>	<u>0.2K</u>	<u>\$5.0K</u>	<u>0.4661</u>	<u>\$2.3K</u>

	Initial Costs	Energy/Fuel Costs	M&R Costs	Other Costs	Total
Net Present Worth:	<u>\$15.0K</u>	<u>\$99.2K</u>	<u>\$2.3K</u>	<u>—</u>	<u>\$117</u>

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 a value).

Sheet 2 of 5

Completed DA Form 5605-3 for Alt B

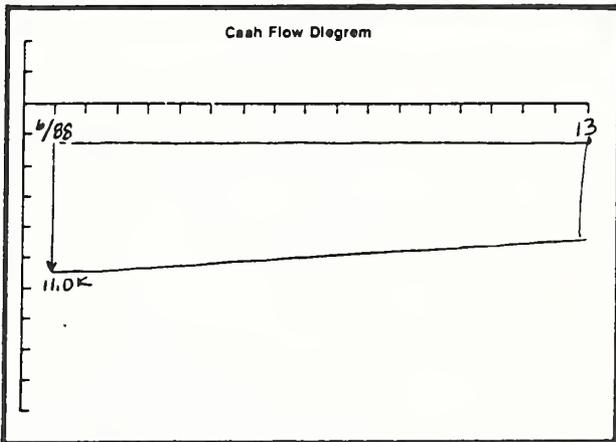
Project No. & Title PN 101 Reserve Center
 Installation & Location Ft Z, Laramie, WY
 Design Feature Lighting System
 Alt. No. 3 Title Conventional System

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		<u>FEMP</u>	
Date of Study (DOS)		<u>6/88</u>	
Analysis Base Date (ABD)		<u>6/88</u>	
Analysis End Date (AED)		<u>6/13</u>	
Midpoint of Construction		<u>12/90</u>	
Beneficial Occupancy Date (BOD)	Actual Projected	<u>6/91</u>	
	Assumed for Analysis	<u>6/88</u>	
DOE Region		<u>8</u>	
Annual Discount Rate		<u>7%</u>	
Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe: <u>88-90, 90-95, 95-13</u>		
<u>Elec.</u>	<u>-3.37</u>	<u>-1.03</u>	<u>-0.05</u>
<u>Other</u>	<u>0</u>	<u>0</u>	<u>0</u>

Principal Assumptions	



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)*	
<u>Initial Costs</u>	<u>\$ 11.0 K</u>	<u>12/90</u>	<u>6/88</u>	<u>Cost Engineers Est (App 4)</u>
<u>Mt R (Lamps)</u>	<u>0.1 K</u>	<u>12/91-12/16</u>	<u>6/88-6/13</u>	<u>Manufacturers Info (App 5)</u>
<u>Electricity</u>	<u>12.5 K</u>	<u>12/91-12/16</u>	<u>6/88-6/13</u>	<u>DOE2 (App 6)</u>
<u>Retention Value</u>	<u>0</u>			

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 101 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	\checkmark \$ x 10 ³ \$ x 10 ⁶	Years from ABD	Cost On ABD	One Step Adj. Factor Table 1	Present Worth on ABD	Criteria Reference	FEMP
Initial Costs		0	\$11.0K	1.0	\$11.0K	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	\checkmark \$ 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
Electricity		25	\$12.5K	\$312.5K	0.4656	\$126.6K
Mt 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 (a = prescribed e value).

Sheet 4 of 5

Completed DA Form 5605-2

Project No. & Title PN 101 Reserve Center
 Installation & Location Fort 2, 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 10 ³				
		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		Beats for No. 1 Ranking
		LCC (PW) Difference (Dollars & Percent)	Other (Initial, Energy, Etc.)	
1	A Innovative System	\$22K	Saves Energy	LCC
2	B Conventional System	16% less		

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 + save less energy, it is still estimated to be the cost-effective choice.*

Key Participants - Name	Discipline	Organization	Telephone No.
E. K. Engineer	Electrical Engineer	U.S. A.C.E.	x x x 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

LESSON PLAN 14: OTHER ECONOMIC MEASURES

TIME	OVERVIEW	TRAINING AIDS OR CUES
0800	<p>Ask students to turn to Module 14.</p> <p>Review the purpose of the module, the outline, and allotted time.</p> <p>Give an overview of the three methods. Present Net LCC Savings quickly, and spend most of the time on SIR and DPP.</p>	<p>W14, S14-1</p> <p>F or B</p>
0830	<p>Demonstrate how the SIR is calculated using DA Form 5605-1.</p>	<p>V14-1, V14-s1</p>
0900	<p>Demonstrate how the DPP is calculated using DA Form 5605-1.</p>	<p>V14-2, V14-s2</p>
0930	<p>Begin REVIEW</p>	

Key: S = slide, V = Vugraph, F = Flipchart, B = Board, W = Workbook, N = Notebook

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OTHER ECONOMIC MEASURES

- **Net LCC Savings**
- **Savings-to-Investment Ratio (SIR)**
- **Discounted Payback Period (DPP)**

- Let's discuss three other measures of economic performance which you will encounter in economic analysis for MILCON design decisions.
- The first, "Net LCC Savings," is computed simply by taking the difference between LCCs for the two alternative designs being compared.
 - In general usage, this measure is usually called simply "Net Savings," "Net Present Worth" or "Net Present Value."
 - Net LCC Savings may be positive, meaning that the alternative from which LCC of the other is subtracted is estimated to have lower LCC, and therefore is the cost-effective choice.
 - Net LCC Savings may be negative, meaning that the alternative is estimated to have higher LCC, and therefore is not the cost-effective choice.
 - Net LCC Savings may be zero, or close to zero, meaning that the two alternatives are about equal in terms of estimated economic performance.

Give simple examples on the board of positive, negative, and zero Net LCC Savings.

- The second measure of economic performance listed is the “Savings-to-Investment Ratio.” Like it sounds, it expresses economic performance as a ratio of savings to investment cost. Savings are the difference between the present worth maintenance, repair, and energy costs of two alternatives. Investment cost is the difference between their capital-related costs, which include construction/procurement costs, replacement costs, disposal costs, and retention value.
 - Unlike the LCC method which requires at least two measures of LCC to compare alternatives, the SIR method provides the comparison in a single number.
 - For example, a ratio greater than 1.0 means that savings of the alternative with the higher cost of construction/procurement is the cost-effective choice.
 - A ratio less than 1.0 means that the alternative with the higher cost of construction/procurement is not the cost-effective choice.
 - A ratio of 1.0 or approximately 1.0 means that the two alternatives are estimated to be about equal in their economic performance.
 - The higher the ratio, the more cost effective the alternative with the higher cost of construction/procurement is estimated to be relative to the other alternative. An SIR = 6 for Alt A relative to Alt B, for example, means that Alt A is estimated to save the equivalent of \$6.00 for every additional dollar it costs, over and beyond meeting the requirement of a 10% rate of return imposed by a discount rate of 10%.
- The third measure listed, the “Discounted Payback Period,” gives the number of years until the additional cost of the alternative with the higher construction/procurement cost is covered by cumulative present worth savings. It indicates when we break even, in the sense of recovering investment costs.
 - The lower the DPP, the faster we recover investment costs; i.e., the sooner we break even.
 - For example, DPP = eight years for Alt A means that we expect to recover in savings the additional cost of Alt A over Alt B in eight years.

- When are the SIR and DPP used?
 - The SIR is called for by FEMP LCC Rules for ranking ECIP projects to determine funding priority. The higher a project's SIR relative to projects competing for limited funding, the higher its priority to be funded under rules of that program.
 - It is a Congressional requirement for MCP facilities that SIR and DPP be documented for EA/LCCAs involving active solar energy systems.
- Now let's see how to compute these additional measures.

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.

<u>Undiscounted/Unescalated</u> (\$s as of ABD)	<u>Solar Energy System</u>	<u>Conventional System</u>
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 PW Laundryette
 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				
Element of Calculation	System	Type of Cost/Benefit		
PW of Operating & Maintenance Costs <input type="checkbox"/> \$ x 10 ³ <input type="checkbox"/> \$ x 10 ⁶	Base-line	Energy/Fuel	166,680	
		Other O&M	2,331	
		Total	169,011	
	Investment	Energy/Fuel	104,125	
		Other O&M	17,479	
		Total	121,604	
		Δ	Net Savings	47,357
	PW of Capital Costs <input type="checkbox"/> \$ x 10 ³ <input type="checkbox"/> \$ x 10 ⁶	Base-line	Initial (MCP)	8,000
			Replacements	3,320
Terminal			0	
Other			-	
Total Net			11,320	
Investment		Initial (MCP)	35,000	
		Replacements	1,017	
		Terminal	0	
		Other	-	
		Total Net	36,017	
		Δ	Extra Investment	24,697
SIR		Δ	Net Savings Extra Investment	1.9*

Discounted Payback Calculation					
Trial Values of Post-BOD Analysis Period, n(years)					
n = 13	n =	n =	n =	n =	n =
86,674					
1,212					
87,886					
54,171					
9,089					
63,260					
24,626					
8,000					
3,320					
0					
-					
11,320					
35,000					
1,017					
0					
-					
36,017					
24,697					
~ 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

LESSON PLAN 15: POSTTEST

TIME	OVERVIEW	TRAINING AIDS OR CUES
1045	<p>15.1 Introduce the Posttest. Ask students not to guess.</p> <p>Ask students to turn in Test when finished. Ask them to fill out the COURSE EVALUATION form before leaving for lunch. Tell them that class will resume for the Skills Laboratory at 1 p.m.</p> <p>Note that the tests are to be graded using the tally sheet in Module 2. The test scores are needed by 1 p.m. Both the posttest and the pretest will be returned to the students. The instructor needs a summary report on scores.</p>	<p>Posttest</p> <p>Course Evaluation Sheets</p> <p>Scores Summary</p>
1145	COURSE EVALUATION	
1200	LUNCH	

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IN THE STUDENT'S MANUAL

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

LESSON PLAN 16: SKILLS LABORATORY

TIME	OVERVIEW	TRAINING AIDS OR CUES
1300	16.1 Review test results. Comment on improvements over the pretest. Return both pretests and posttests to students.	pretest, posttest
1330	16.2 Use the results of the posttest to identify areas that need clarification. Elicit questions and comments from students.	B, F
1415	16.3 If time permits, use prepared examples for an additional exercise.	B, F, V16-1/3
1445	CLOSURE	

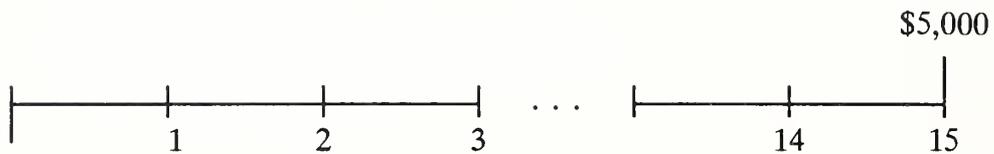
Key: V = Vugraph, F = Flipchart, B = Board

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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%.

$$\begin{aligned} C_F &= \$5,000 \\ n &= 15 \\ d &= 0.10 \\ PW &= ? \end{aligned}$$



$$PW = ?$$

$$PW = C_F \times \text{OSAF (ONE-TIME COST TABLE)}$$

$$= \$5,000 \times 0.2394$$

$$PW = \$1,197$$

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.

$$\begin{aligned}
 A_0 &= \$3,000 \\
 k &= 25 \\
 d &= 0.10 \\
 e &= \text{DoE-projected energy escalation rates} \\
 \text{PW} &= ?
 \end{aligned}$$

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.

$$\begin{aligned}
 \text{PW} &= A_0 \times k \times \text{OSAF (Electricity Table (Region 1), } k = 25, \text{ BOD} = 7/92) \\
 &= \$3,000 \times 25 \times 0.2199
 \end{aligned}$$

$$\text{PW} = \$16,493$$

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.

$$\begin{aligned} A_0 &= \$8,000 \\ k &= 25 \\ e &= 0 \\ d &= 0.10 \\ PW &= ? \end{aligned}$$

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.

$$\begin{aligned} PW &= A_0 \times k \times \text{OSAF (M\&R TABLE, 3-year lag, } k = 25) \\ &= \$8,000 \times 25 \times 0.2838 \end{aligned}$$

$$PW = \$56,760$$

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

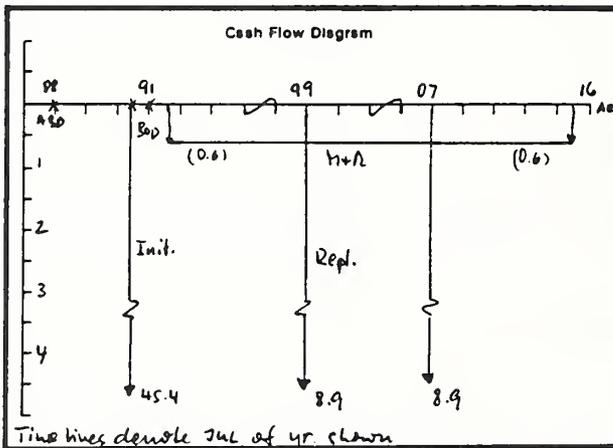
Project No. & Title PN 360 (FY 90) Res. Bldg.
 Installation & Location Reserve Center VA
 Design Feature Roadway / Parking Surface
 Alt. No. A Title Asphalt w/ 2" Wearing Surface

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		HQDA	
Date of Study (DOS)		JUL 88	
Analysis Base Date (ABD)		JUL 88	
Analysis End Date (AED)		JUL 16	
Midpoint of Construction		JAN 91	
Beneficial Occupancy Date (BOD)	Actual Projected	JUL 91	
	Assumed for Analysis	JUL 91	
DOE Region		3	
Annual Discount Rate		10%	
Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe:		
	87-90	90-95	95-16
All	0.00	0.00	0.00

Principals Assumptions



Cost Element	Cost on ABD X \$ x 10 ³ \$ x 10 ⁶	Time Cost Incurred**		Source(s) of Data
		Actual Projected Dates	Dates for Analysis (if Different)*	
Init. Investm.	45.4	JAN 91		Supplier's Info. (App. A)
Replacement				
1" top 4 ft. 8	8.9	JUL 99		Supplier's Info. (App. B)
Replacement				
1" top 4 ft. 16	8.9	JUL 07		Supplier's Info. (App. B)
M&R	0.6	JAN 92-JAN 16		M&R Database

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-S3. Basic Input Data Summary for Alt B

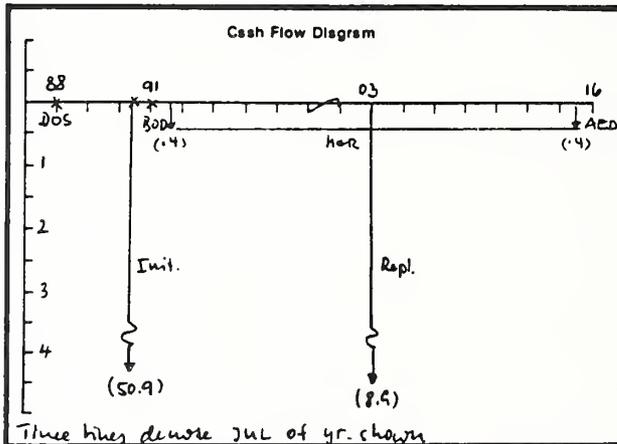
Project No. & Title PN 360 (FY 90) Res. Rd. g.
 Installation & Location Reserve Center, VA
 Design Feature Roadway / Parking Surface
 Alt. No. B Title Asphalt w/3" Wearings.

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		HRDA	
Date of Study (DOS)		JUL 88	
Analysis Base Date (ABD)		JUL 88	
Analysis End Date (AED)		JUL 16	
Midpoint of Construction		JAN 91	
Beneficial Occupancy Date (BOD)	Actual Projected	JUL 91	
	Assumed for Analysis	JUL 91	
DOE Region		3	
Annual Discount Rate		10%	
Type of Cost	Differential Escalation Rate per Year (%)		
	Timeframe: 87-90 90-95 95-16		
All	0.00	0.00	0.00

Principal Assumptions



Cost Element	Cost on ABD X's x 10 ³ S x 10 ⁶	Time Cost Incurred**		Source(s) of Data
		Actual Projected Date	Date for Analysis (if Different)*	
Init. Investm.	50.9	JAN 91		Supplier's Inf. (App. A)
Replacement				
1" top yr. 12	8.9	JUL 03		Supplier's Inf. (App. B)
M+R	0.4	JAN 92-JAN 16		M+R Data base

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-S5. Summary for Alt A and B

Project No. & Title PN 360 (FY 90) Res. Bldg.
 Installation & Location Reserve Center VA
 Design Feature Roadway/Parking Surface

**LIFE CYCLE COST ANALYSIS
SUMMARY**

Date of Study JUL 88

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

ALTERNATIVES ANALYZED						
No.	Description/Title	Present Worth				
		Initial	Energy	M&R	Other	Total
A	Asphalt w/2" Wearing Surf.	35.8	0.00	4.3	4.6	44.7
B	Asphalt w/3" Wearing Surf.	40.1	0.00	2.8	2.1	45.0

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.)	
1	Asphalt w/2" w.s.	\$ 300 less than 1%	lower first cost	first cost (uncert. not relevant)
2	Asphalt w/3" w.s.			

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 _____

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5. AUTHOR(S)
Rosalie T. Ruegg and Sieglinde K. Fuller

6. PERFORMING ORGANIZATION (IF JOINT OR OTHER THAN NIST, SEE INSTRUCTIONS)
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NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
GAITHERSBURG, MD 20899

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Huntsville, AL 35807-4301

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11. ABSTRACT (A 200-WORD OR LESS FACTUAL SUMMARY OF MOST SIGNIFICANT INFORMATION. IF DOCUMENT INCLUDES A SIGNIFICANT BIBLIOGRAPHY OR LITERATURE SURVEY, MENTION IT HERE.)

The Instructor's Manual is a detailed guidebook for teaching the five-day course, "Economic Analysis for Military Construction Design: Concepts, Techniques, and Applications for the Analyst." It provides numerous aids for teaching the course, including pre-course check-lists, descriptions of instructional techniques, tips for making the course more effective, and step-by-step lesson plans. Copies of all slides and vugraphs are reproduced in the guidebook, together with presentation text, exercises, and solutions. Through special fonts and page numbering system geared to the Student Manual, the instructor always knows exactly what the student sees without the necessity of manipulating both manuals at once.

12. 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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