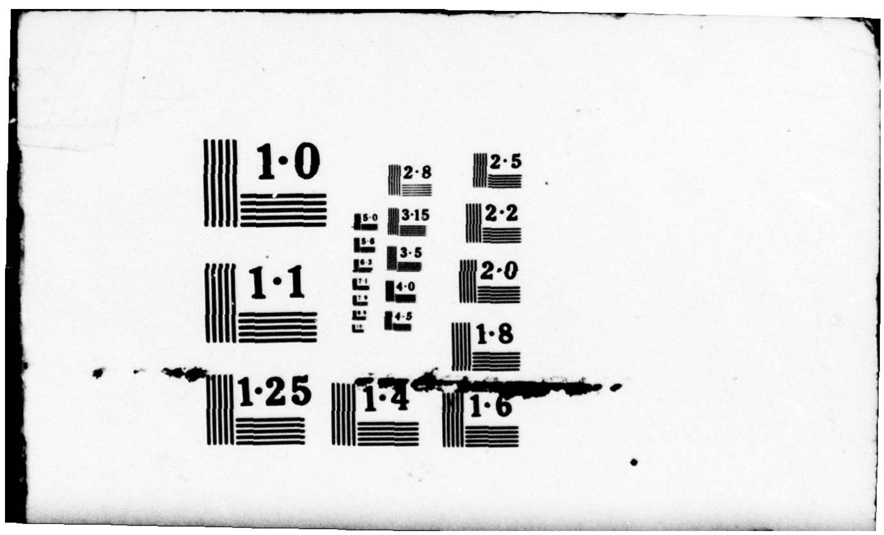
AD-A067 719 CONSTRUCTION ENGINEERING RESEARCH LAB (ARMY) CHAMPAI--ETC F/G 13/2
COMPUTER-AIDED ENGINEERING AND ARCHITECTURAL DESIGN SYSTEM (CAE--ETC(U)
JAN 79 DANIEL, MANN, JOHNSON, MENDENHALL DACA87-77-C-0009
UNCLASSIFIED CERL-TR-P-97-VOL-2 NL

1 OF 2
ADA
067719


1·0
2·8
2·5
3·15
2·2
3·5
2·0
4·0
1·1
4·5
1·8
1·25
1·4
1·6

construction
engineering
research
laboratory

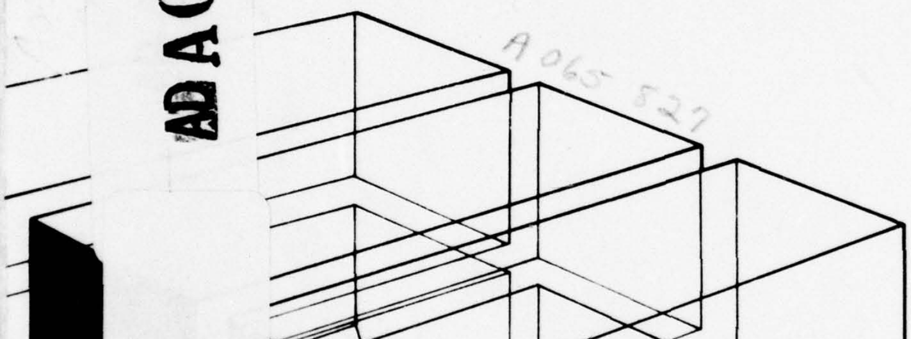
United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

TECHNICAL REPORT P-97
January 1979

LEVEL

COMPUTER-AIDED ENGINEERING AND ARCHITECTURAL DESIGN SYSTEM
VOLUME II: CONCISE REVIEW

A065 527



CERL

Approved for public release; distribution unlimited.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
14 CERL-TR-P-97 - VOL-2

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
6 COMPUTER-AIDED ENGINEERING AND ARCHITECTURAL DESIGN SYSTEM (CAEADS). VOLUME II. CONCISE REVIEW.

5. TYPE OF REPORT & PERIOD COVERED
9 FINAL rept.,

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
10 Daniel, Mann, Johnson & Mendenhall

8. CONTRACT OR GRANT NUMBER(s)
15 DACA87-77-C-0009

9. PERFORMING ORGANIZATION NAME AND ADDRESS

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
16 4A762731A741 T1-020 17

11. CONTROLLING OFFICE NAME AND ADDRESS
U.S. ARMY
CONSTRUCTION ENGINEERING RESEARCH LABORATORY
P.O. Box 4005, Champaign, IL 61820

12. REPORT DATE
11 Jan[redacted]79

13. NUMBER OF PAGES
124

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
12 128p.

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)
Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES
Copies are obtainable from National Technical Information Service
Springfield, VA 22151

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
CAEADS
computer-aided design
automated design procedures

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Computer-Aided Engineering and Architectural Design System (CAEADS) is being developed for the U.S. Army Corps of Engineers by the Construction Engineering Research Laboratory (CERL) in Champaign, Illinois. CAEADS will be an integrated system of computer aids to the design process for military construction, supporting the design and review activities of Corps District Offices and the design activities — Cont'

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

79 03 16 012

405 279

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Block 20 continued.

of private Architect/Engineer firms under contract to the Corps. CAEADS objectives are to achieve improved quality of facility design, enhance the responsiveness of the Military Construction (MC) design process, improve the productivity of Corps design staff, facilitate design review, and thus reduce the costs for construction and operation of military facilities.

This report presents a concise review of the work accomplished to further develop the CAEADS concept and to prepare system documents as required by AR 18-1. This concise review covers the purpose, guidelines, and scope of the study, and the scope and background of CAEADS. It reviews the MC process as it currently exists, discusses CAEADS requirements, system concepts, the CAEADS Economic Analysis, the proposed Project Master Plan, and a Preliminary Hardware/Software Analysis. It concludes with the results, conclusions, and recommendations developed in this study.

The results of this study are reported in eight volumes:

- Volume I - Summary
- Volume II - Concise Review
- Volume III - General Functional System Requirement (GFSR)
- Volume IV - CAEADS Economic Analysis (CAEADS/EA)
- Volume V - Detailed Functional System Requirement (DFSR)
- Volume VI - Project Master Plan (PMP)
- Volume VII - Preliminary Hardware/Software Analysis
- Volume VIII - Organization and Personnel Plan (OPP)

Volume I is written to stand alone, as well as summarize the other reports. Volume II is also written to stand alone; it is more detailed than Volume I and summarizes Volumes III through VIII. Volumes III through VIII contain detailed technical information of limited interest. Volumes I and II are available through NTIS; Volumes III through VIII can be made available through request to the Technical Monitor.

The analysis of CAEADS characteristics in this report concludes that CAEADS design objectives can be realized and that the proposed integrated CAEADS is both technically feasible and economically beneficial. The Project Master Plan proposes that CAEADS development, implementation and use occur in five stages over a period of 12 years. In conjunction with this master plan the CAEADS Economic Analysis compares the current method for MC design (the baseline alternative) to two computer-aided alternative methods (the stand-alone alternative and the integrated CAEADS alternative). This analysis indicates that an integrated CAEADS approach to MC design is most preferable because of increased design productivity and lower construction costs. Therefore, continuation of CAEADS development and implementation in accordance with the proposed master plan is recommended.

FOREWORD

This research was conducted by Daniel, Mann, Johnson, & Mendenhall (DMJM) for the Construction Engineering Research Laboratory (CERL) United States Army, under U.S. Army Engineer Division, Huntsville Contract Number DACA87-77-C-0009. This work is in support of a system design for a Computer-Aided Engineering and Architectural Design System (CAEADS) being developed under Project 4A762731A741, "Design, Construction, and Operation and Maintenance Technology for Military Facilities"; Task T1, "Development of Automated Procedures for Military Construction"; Work Unit 020, "Computer-Aided Engineering and Architectural Design System (CAEADS)." The applicable QCR is 3.03.004. The Technical Monitor is Mr. V. J. Gottschalk, DAEN-MPE-D, Directorate of Military Programs, Office of the Chief of Engineers. The CAEADS Project Manager is Mr. R. E. Larson, of CERL's Facilities System Division (FS). Mr. E. A. Lotz is Chief of FS. COL J. E. Hays is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.

Members of the project staff at DMJM include Perry Grant, David Leckie, Robert Stults, and Lavette Teague. From time to time assistance has been provided by Paul Konkel, Bruce Weinstein, Max Farrar, Stanley Katten, Ernest Swickard, and Michael Durkin. Architects and engineers within DMJM who have provided their time and talents include Derek Anderson, William Ropp, Anthony Lumsden, Jerry Tomlin, Thomas Saeda, William Meier, Jack Meadville, and Sam Lo. James Davis and Howard Kanter of Banneker, Davis, and Associates in Chicago assisted in CAEADS hardware/software analyses.

Providing valuable input to this study were Mary Oliverson of Applied Research of Cambridge (ARC), Canada; William Mitchell of ARC (via UCLA), Guy Weinzapfel of MIT, and Monte Miller of the Federal Computer Performance Evaluation and Simulation Bureau (FEDSIM). In addition, several others provided important review comments during this study, including Charles Eastman and Steven Fenves of Carnegie-

Mellon University, Louis Klotz of the University of New Hampshire, and James White of NASA.

Appreciation is extended to the engineering and design staffs at the U.S. Army Engineer District, Sacramento (under the direction of Richard Mueller) for providing valuable advice and information on the MC design process and procedures used in engineering and architectural design with the Corps of Engineers.

CONTENTS

CONTENTS (continued)

CONTENTS (continued)

FIGURES

TABLES

TABLES (continued)

CHAPTER 1

INTRODUCTION

a. The Concise Review.

(1) Purpose. The purpose of the Computer-Aided Engineering and Architectural Design System (CAEADS) Concise Review (Volume II) is to provide an overview of the other technically oriented documents (Volumes III through VIII) produced as a part of this study. In addition, the CAEADS Summary (Volume I) summarizes the results of this study, the current status of the CAEADS project, and the recommended plan of action for continuing development and implementation of CAEADS. For the convenience of the reader, Annex A to this Volume contains the Tables of Contents of all the Volumes, serving as an index for those interested in additional detail.

(2) Scope. The CAEADS Concise Review consists of eleven chapters. This initial chapter introduces CAEADS and outlines the contents of the volume. Chapter 2 discusses the CAEADS Project, its background, progress, and current status. Chapter 3 reviews MC design in terms of the primary functions and participants to be assisted by CAEADS. Chapter 4 relates the documents produced by this study to the Department of the Army requirements for Automated Data Processing (ADP) system definition planning, development, and implementation. The requirements for CAEADS, which constitute the major technical effort of this study, are presented in Chapter 5 in terms of functional, human factors, and ADP system requirements. Chapter 6 outlines the system concepts which were developed and have guided the study team and discusses some of the principal alternatives considered. Chapter 7 summarizes the results of the CAEADS Economic Analysis, comparing the costs and benefits of the current system with those of stand-alone computer applications support and with an integrated CAEADS. Chapter 8 is an overview of the proposed CAEADS

implementation plan. Chapter 9 contains the findings of the Preliminary Hardware/Software Analysis for CAEADS. Chapter 10 summarizes the CAEADS Organization and Personnel Plan. Chapter 11 presents the results, conclusions, and recommendations of the study.

b. CAEADS.

(1) Purpose. CAEADS is being developed by the U.S. Army Corps of Engineers (CE) Construction Engineering Research Laboratory (CERL) under the sponsorship of the Office of the Chief of Engineers (OCE). This system is to be an integrated set of computerized tools to assist programmers, planners, designers, and reviewers of Military Construction (MC) design projects. In many cases these tools will supplement present manual methods. In other cases manual techniques will be significantly altered or replaced by automated methods.

CAEADS will aid the design process for Military Construction beginning with the initial definition of requirements and extending through the preparation of construction drawings, specifications and associated cost estimates. The principal end products of CAEADS will be the documents required to obtain approval for initiation of architectural and engineering design, and the documents which constitute the bid package for facility construction.

The primary users of CAEADS will include engineers, architects, specifiers, and cost estimators in OCE and CE Division and District Offices. While CAEADS is intended primarily to serve CE users, it will also support the roles of U.S. Army Major Commands and Facility Engineers at Army installations who participate in the MC design process. Because approximately 80 percent of MC design is performed by private Architect/Engineer (A/E) firms under contract to the Corps, CAEADS will serve these users also.

The objectives of CAEADS are to achieve improved quality of facility design, enhance the responsiveness of the design process, improve the productivity and efficiency of the Corps design staff, and as a consequence, reduce the costs of constructing and operating facilities.

(2) Guidelines. CAEADS will be a system of integrated aids for design and design review which will

conform to and support current MC design procedures, and which will produce similar end products. It will enhance but not replace the decison-making capability of engineers, architects, specifiers, and cost estimators who use it. CAEADS will relieve professional architects and engineers from many details of routine processes and permit them to be more productive, but will not relieve them of their professional responsibility, supersede their judgment, or encroach on their opportunity to innovate. The emphasis will be on aiding the MC design process.

CAEADS will be designed for open-ended evolution in scope and effectiveness. It will be an integrated, flexible, and modular system in order to minimize the impact of advances in computer hardware and software over the life of CAEADS. It will provide continuity of user support throughout this evolution through the employment of a common interactive user interface. The components and subsystems of CAEADS will be independently cost effective within an integrated framework. This framework will facilitate coordination of design and review activities and provide for consistency of design information and end products. Because of the scope and complexity of CAEADS, system design, development, and implementation will be phased over a number of years, proceeding incrementally in accordance with the Project Master Plan.

(3) Scope. Organizationally, CAEADS will support both the Corps of Engineers and contractor A/E firms. It will also aid Facility Engineers in stating the needs for Military Construction and the requirements for occupancy and use of those facilities. CAEADS will encompass not only MC Army projects, but also projects assigned to the Corps for the Air Force and other military and civil organizations. Geographically, CAEADS will initially support the Corps District Offices responsible for MC design in the continental United States, and later will be expanded to include Corps projects outside the United States.

CAEADS will assist in pre-design as well as design and design review activities. It is oriented toward the statement of design requirements as well as the accomplishment and review of design. CAEADS is not a management information system as such, although it will be able to supply data which can assist in management of MC design. It will interface with other information systems such as the Army's Integrated Facilities System (IFS) to acquire needed data and will supply data to systems such as the Automated Military Project Reporting System (AMPRS).

c. Mode of Technology Transfer. This information will be disseminated in accordance with procedures set forth in AR 18-1, Management Information Systems: Policies, Objectives, Procedures and Responsibilities (Department of the Army, 22 March 1976).

CHAPTER 2

THE CAEADS PROJECT

a. Background.

(1) Computer Aids to Architectural and Engineering Design. The history of computer applications to architectural and engineering design began approximately two decades ago with the initial commercial availability of digital computers. During the 1960's, research at universities and industrial laboratories produced major advances in human-machine communication through the development of problem-oriented languages, interactive computer graphics, and time-shared computing. Major issues in information system design, such as data management, dynamic storage management, multi-user operating systems, system design, and programming methods were identified, and substantial progress has been made toward solving problems in these areas during the past decade. Throughout this period, computing systems have become increasingly powerful and sophisticated, and the cost per information processing operation has been reduced by several orders of magnitude.

Computer aids to building and site design, in the form of stand-alone programs for specific types of calculations, are now in widespread use. Computer programs are in use in this country and abroad to assist almost every computational task in the facility design process. However, with the exception of a few notable special purpose systems, no complete, integrated system has yet been developed for a variety of technical, economic, and institutional reasons. The size and scope of such a system would require multi-disciplinary participation, industry support and inter-agency coordination. The fragmentation and lack of coordination in the construction industry thus hinders development. Research and development toward integration of systems for use in building design have been pursued for at least the past 15 years. In related fields since 1969 the

Navy has been developing an integrated system for ship design called the Computer-Aided Design Environment (COMPADE) and work began in 1972 with feasibility studies for Integrated Programs for Aerospace Vehicle Design (IPAD) under the sponsorship of the National Aeronautics and Space Administration.

(2) CAEADS Development. Work toward CAEADS has been in progress at CERL for the past 4 years, preceded by 4 years of development of computer programs for design-related tasks. The first formal presentation of the requirements for a system of computer aids for MC design was in a General Functional System Requirement (GFSR) document prepared by CERL in November 1973 for a predecessor to CAEADS, the Automated Engineering and Architectural Design System (AEADS)[1]. Following extensive review and comments on that document, two investigations were pursued. One investigation, called AEADS I, identified those tasks or applications which could be computer-aided most rapidly and most cost-effectively. The other investigation, called AEADS II, began to define a framework for system design and implementation which considered all of the tasks which have to be accomplished in MC design, provided a structured hierarchy describing the relationships among the tasks, and identified those tasks that could be computer-aided. Both investigations were necessary preludes to system design and implementation and are consistent with Department of the Army requirements for defining and developing ADP systems.

---

[1] General Functional System Requirement (GFSR) for Automated Engineering and Architectural Design System (AEADS) (U.S. Army Construction Engineering Research Laboratory, November, 1973).

As a part of these efforts AEADS II concept design was prepared by Oliverson[2], Logcher[3], Eastman[4], and Westervelt[5]. These were reviewed along with the results of the AEADS I studies during the spring of 1976 and an initial cost-benefit analysis for the system was prepared[6].

In January 1977 this study began the next cycle of CAEADS development. The objectives of this study were to state the functional requirements for CAEADS in greater detail, to perform an economic analysis and suggest alternative hardware configurations based on these requirements, to prepare an action plan for subsequent system development and implementation, to update CAEADS planning documentation, and to clarify the CAEADS system concept as a basis for advanced system design.

---

[2] Oliverson, M., A Conceptual Design for an Automated Engineering and Architectural Design System (AEADS II) (Applied Research of Cambridge [Canada] Ltd., April 1976).

[3] Logcher, R.D., A Conceptual Design of the Computer-Aided Environmental Legislative Data System, Technical Report E-78/ADA019018 (U.S. Army Construction Engineering Research Laboratory, November 1975).

[4] Eastman, C.M., Feasibility and a Proposed Development of AEADS II (April 1976).

[5] Westervelt, F.H., AEADS II Conceptual System Design - Design Memorandum (April 1976).

[6] AEADS II Cost-Benefit Analysis (SAGE, June 1976).

Concurrently, CERL is continuing the development of computer programs whose capabilities will be integrated into CAEADS. These include the DD Form 1391 Processor[7], the Environmental Technical Information System (ETIS)[8], the System for Evaluation and Review of Criteria for Habitability (SEARCH)[9], the Industrialized Building System (IBS)[10], the Building Load and System Thermodynamics Analysis (BLAST) program[11], a system for the Computer Evaluation of Installation Utility Plans (CEUP)[12], and EDITSPEC, a document editing system for specifications[13].

---

7 Lev, O.E., Stellhorn, W.H., Preparation and Review of DD Form 1391, Technical Report P-69/ADA027585 (U.S. Army Construction Engineering Research Laboratory, June 1976.)

8 Urban, L.V., Balbach, H.E., Jain, R.K., Novak, E.W., Riggins, R.E., Computer-Aided Environmental Impact Analysis for Construction Activities: User's Manual, Technical Report E-50/ADA008988 (U.S. Army Construction Engineering Research Laboratory, March 1975.)

9 Bryant, D.A., Dains, R.B., Spoonamore, J.H., Structure of SEARCH-2, Letter Report D-55 (U.S. Army Construction Engineering Research Laboratory, June 1975).

10 Kenney, T.A., Users Manual for Computerized Information on Industrialized Building System, Draft (U.S. Army Construction Engineering Research Laboratory).

11 The Building Loads Analysis and System Thermodynamics (BLAST) Program Volume I: User Instructions, Technical Report E-119/ADA048734 (U.S. Army Construction Engineering Research Laboratory, February 1977).

12 Heydt, G.T., Sauer, P.W., A Manual for the Use of the CERL Distribution Power Study Program Version 1.00 (Purdue University, School of Electrical Engineering, June 1976).

13 Neeley, Edgar S., Construction Specification Preparation Within the EDITSPEC System, Technical Report P-84/ADA045183 (U.S. Army Construction Engineering Research Laboratory, September 1977.)

OCE, through the Fort Worth District Office, is considering development of a system for computer-based master plan graphics and utility plans evaluation. CERL has also sponsored evaluation of automated drafting systems[14] and a special study of three-dimensional data bases for use in computer-aided facility design[15].

b. The Current CAEADS Study. The work performed in this study has included a review and analysis of available systems and research efforts relevant to CAEADS, visits to two CE District Offices to discuss the MC design process with District personnel, and preparation of eight volumes of this report. The report defines the architectural and engineering design and review functions within MC design, documents the concept of an integrated computer system to aid those functions, identifies anticipated system workloads, provides an evaluation of possible computer hardware and software configurations adequate to handle those workloads, presents an economic analysis of selected alternatives, and proposes a plan for the continued design and implementation of CAEADS. The work is based on current information in the field of computer-aided design, guidelines and assumptions furnished by CERL, the current level of definition of the system requirements, and the system design. Additional cycles of updating, review, and refinement are expected as CAEADS evolves.

---

[14] Weinzapfel, G., Evaluation of Need, Outline of Criteria and Recommendations for Procurement of Automated Drafting Systems for O.E.E. District Office Implementation (Draft) (March 1977).

[15] Mitchell, W.J., Oliverson, M., Computer Representation of Three-Dimensional Structures for CAEADS, Technical Report P-86/ADA052040 (U.S. Army Construction Engineering Research Laboratory, February 1978.)

CHAPTER 3

REVIEW OF MILITARY CONSTRUCTION DESIGN

a. Purpose. This chapter presents an overview of Military Construction (MC) design. Its purpose is to identify the participants in MC design whose activities will be supported by CAEADS, to outline the major sequence of events in MC design, and to introduce the terminology used in this report to describe the functions performed in current MC design and in the proposed CAEADS. The functions identified in this study for inclusion in CAEADS lead to the statement of CAEADS requirements contained in Chapter 5.

b. Participants. Military Construction (MC) design is performed by the U.S. Army Corps of Engineers and by Architects and Engineers under contract to the Corps. The facilities constructed at Army installations as a result of this process serve the requirements of Army Major Commands (MACOM). The Corps is also assigned the responsibility for the design of facilities for other military civilian users, such as the Air Force. The role of each of these participants in MC design is described below.

(1) Corps of Engineers Organization. The organization of the Corps of Engineers which supports its responsibility for MC design is shown in Figure 3-1. The organizational levels involved in MC design include OCE, CE Divisions, and CE Districts.

OCE provides advice and assistance to the Secretary of the Army, the Army Chief of Staff, and others in the Department of the Army in all matters pertaining to design, engineering, and construction of military facilities. The primary influence of OCE on MC design is in the development and provision of criteria, regulations, technical manuals, and guidelines for military construction.

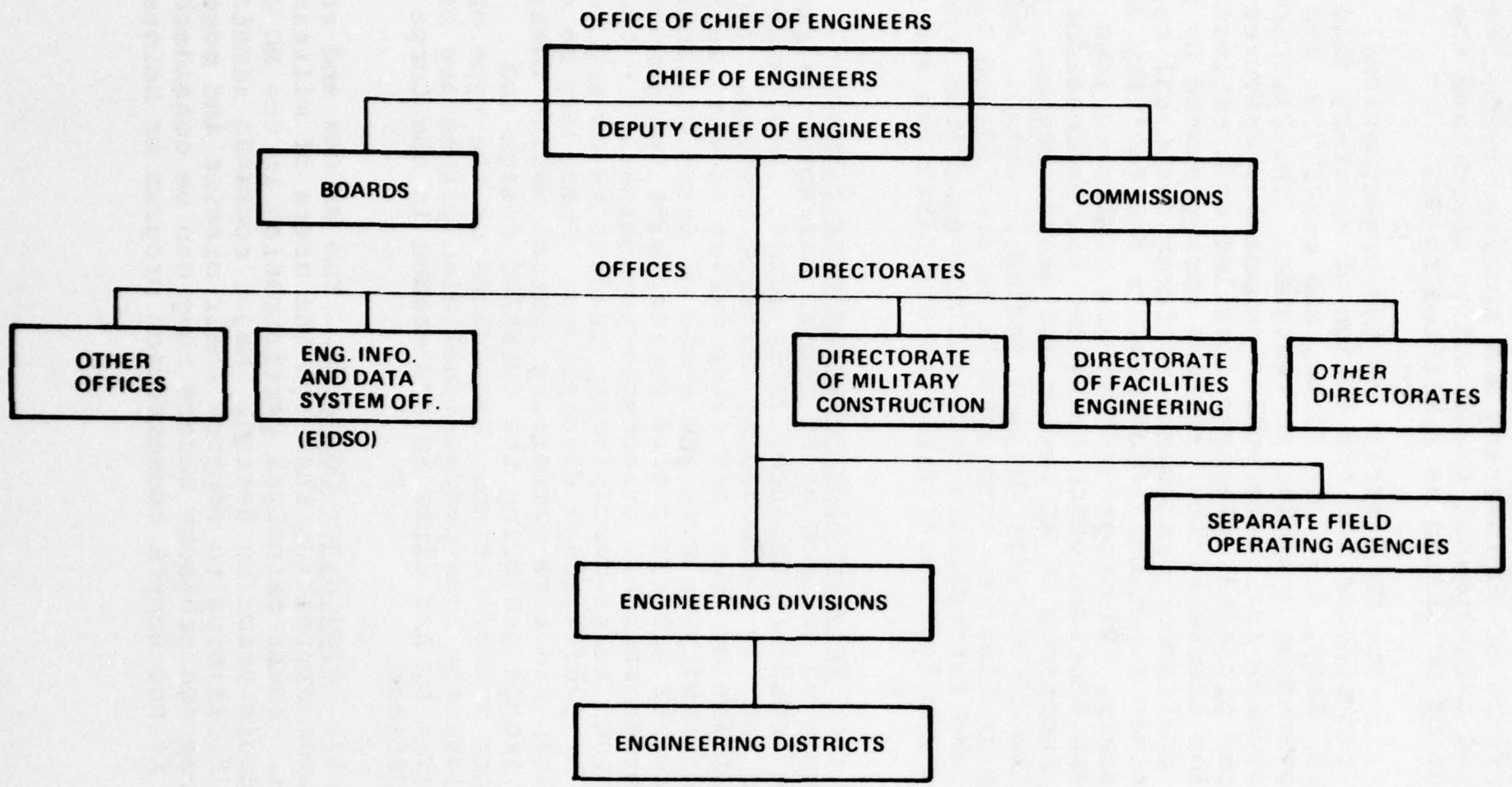


Figure 3-1. Organizational structure of the Corps of Engineers with responsibilities for MC design.

The mission of CE Division is to supervise the performance of engineering and architectural activities in specified geographical areas and to coordinate the performance of MC design as specified by OCE.

The CE District is the organizational level primarily responsible for the design of military facilities for the U.S. Army, U.S. Air Force, and other U.S. and foreign government agencies as assigned. The District performs studies for construction proposals, executes design for approved projects, prepares detailed cost estimates and construction documentation, reviews work produced by both Corps and contractor designers, performs technical analysis, and determines functional requirements for facility design when necessary. District Offices are organized into branches and sections which carry out the professional and technical functions of MC design and design review. The organization of District Offices varies in detail, reflecting variations in District size as well as specialized District expertise and responsibilities, but the disciplines represented at the section level are common to all Districts and to MC design.

(2) Private Architect/Engineer Firms. Approximately 80 percent of MC design currently is performed by private Architect/Engineer (A/E) firms. Design review of contractor work is performed by District Offices. The size and composition of these A/E firms varies widely, in keeping with the diversity in size and scope of Corps projects. The organization of A/E firms also varies, with two general types of organizational structures predominating - those organized into multi-disciplinary project teams and those organized by professional disciplines. There may be certain groups within the firm performing initial design tasks and different groups producing the detailed design and construction documentation. Regardless of the type of organization, the same professional disciplines are required for MC design by A/E firms as are needed in the Corps District Offices.

(3) Army Major Commands. The MACOMs and the installations supporting them are the users of military facilities. Their principal participation in the MC design process occurs prior to design. Major commands identify needs for facilities to support their mission and must approve proposed projects before they can be considered for inclusion in the Army's construction program or before funds

can be released for design. The Facility Engineer at each installation is responsible for defining and stating the user's requirements for each facility in accordance with Army regulations and updating their installation master plan, so that the proposed project can be evaluated for approval and assigned a priority for design, and so that an adequate budget for design and construction can be established. The principal documents prepared by the Facility Engineer are updates to installation master plans, the DD Form 1391, and the Project Development Brochure (PDB). The Facility Engineer also reviews the concept design for compliance with user requirements.

(4) Other Project Sponsoring Agencies. In many cases an MC design project originates in an organization outside of DA. In recent years Air Force projects have comprised a significant portion of the Corps workload. The Mideast Division is currently handling large-scale projects for the Government of Saudi Arabia. These organizations may establish their own set of user requirements and design criteria for facility design. For Air Force projects most of the pre-design activities occur prior to Corps involvement. In the case of hospitals, the Surgeon General's Office is responsible for representing the user and stating relevant requirements.

c. MC Design Process. The procedures used by the Corps for MC design are described below in the frame of reference established for the CAEADS system design. The process has been examined in some detail by Johnson[16] and by Lapp and Kirby[17].

---

[16] Johnson, J.H., Information Flow for Military Construction, Interim Report ADS-2/ADA033363 (U.S. Army Construction Engineering Research Laboratory, October 1976).

[17] Lapp, R.C., Kirby, J.G., Engineering and Design Performance Analysis, Interim Report C-75/ADA035208 (U.S. Army Construction Engineering Research Laboratory, December 1976).

Portions of the process have been studied further by Lev and Stellhorn[18] and by Neeley[19]. The overall process may be described in terms of three design phases, nine activity areas, and eight professional roles or disciplines.

(1) Project Phases. The MC design process for a typical project consists of three phases: Pre-Design, Concept Design, and Final Design (see Figure 3-2).

The Pre-Design Phase encompasses all activities and documents from the time the need for a facility is identified by the Department of the Army, a Major Command, or an individual installation until the beginning of Concept Design by a CE District Office or an A/E firm. It includes the preparation and review of the documents required to obtain approval to design the facility. The most important of these documents are the DD Form 1391 and the Project Development Brochure (PDB). The Pre-Design Phase also includes updating of installation master plans and the generation and selection of the requirements and criteria applicable to each specific project.

The Concept Design Phase represents 20 to 25 percent completion of the total design effort. In this phase the designers investigate alternative spatial configurations as well as structural, mechanical, and electrical systems and select the combination of configuration and systems which best satisfies the project requirements. Analysis procedures are directed toward the evaluation of tradeoffs among alternatives. At the conclusion of this phase there is a review by the District Office for conformity to user requirements, design criteria, and the project budget. The products of this phase are a set of concept design drawings, a cost estimate, and a list of the specification sections to be prepared later.

---

[18] Lev, O.E., Stellhorn, W.H., Preparation and Review of DD Form 1391, Technical Report P-69 (U.S. Army Construction Engineering Research Laboratory, June 1976).

[19] Neeley, Edgar S., Construction Specification Preparation Within the EDITSPEC System, Technical Report P-84/ADA045183 (U.S. Army Construction Engineering Research Laboratory, September 1977).

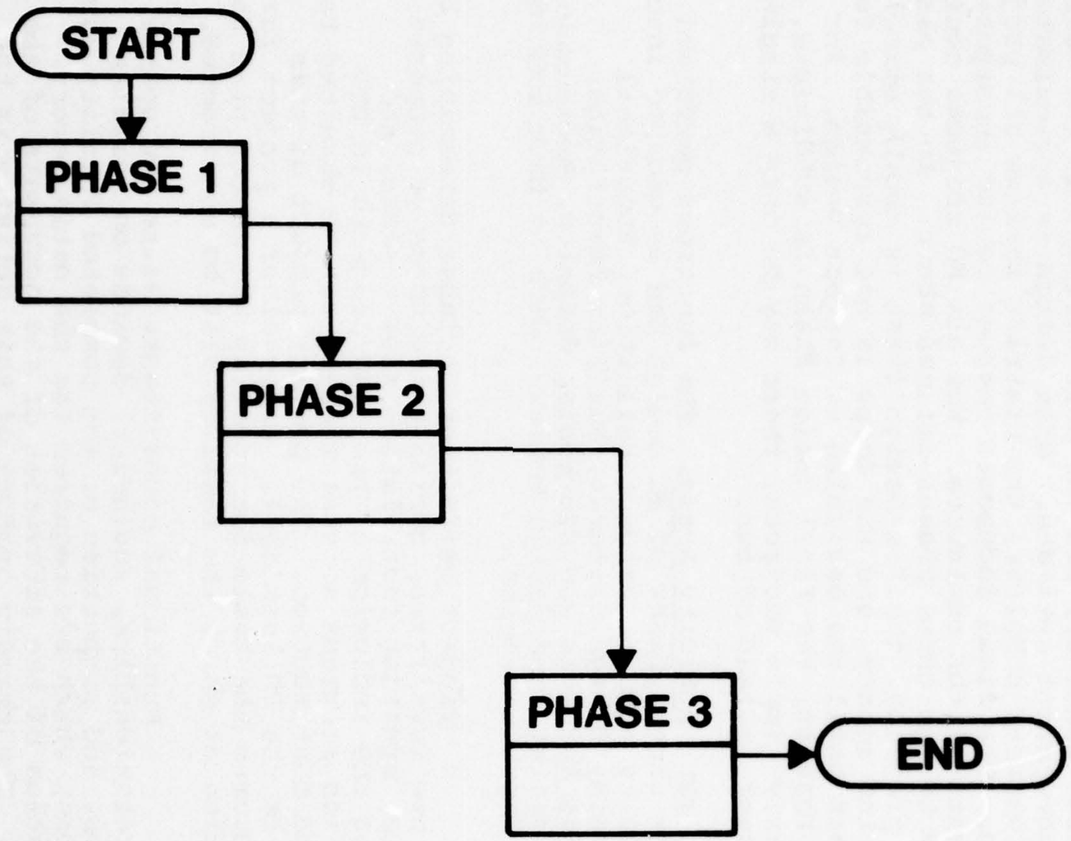


Figure 3-2. Sequence of phases.

In the Final Design Phase the design of the approved concept design is completed. This phase includes the engineering analyses of the major subsystems, as well as the detailed decisions about the materials, equipment, and components of the facility. The products are design drawings, specifications, and a detailed cost estimate. The drawings and specifications become the basis of the construction contract, and the cost estimate is the source for the government estimate. When design is approximately 90 to 95 percent complete, the District reviews all project documents. The final documents respond to and incorporate the comments of the reviewers. Not all MC projects conform precisely to the three phases defined above. In the case of non-Army projects, the Pre-Design Phase is usually accomplished by the using agency, and the Corps is not responsible for the project until the beginning of Concept Design. For some complex projects, the Final Design Phase is subdivided. For particularly simple projects, there may be only a single design phase instead of two.

(2) Activity Areas. The functions performed during the three phases of MC design can be grouped into nine activity areas: Project Definition, Functional Requirements, Design Criteria, Facility Description, Engineering Analysis and Synthesis, Graphics, Specifications, Cost Estimating, and Design Review. Each of these activity areas is described below.

Project Definition includes determining the need for new facilities, defining the scope or proposed new facilities, updating installation master plans, and requesting the inclusion of proposed projects in DOD construction programs so that funding can be obtained for design and construction. The primary product of this activity is the DD Form 1391. Approval of a project for design becomes the basis for updating the master plan for installation at which the facility will be constructed.

Functional Requirements state the spaces, spatial relationships, equipment, demands on building subsystems, and properties of the completed facility (such as finishes) which are required for the satisfactory accommodation of the activities of the occupants of the facility. The primary product of this activity is the Project Development Brochure (PDB). Activities in this area are concerned with maintaining the generalized requirements prescribed for various facility types, adapting and selecting those requirements appropriate to specific projects, and generating new requirements necessary for unique project conditions.

Design Criteria state performance requirements, materials types, and construction practices for the facility which are directly dependent on approved materials, construction practices, and facility subsystems standards and are only indirectly dependent on a specific facility type. Activities in this area are concerned with maintaining up-to-date design criteria and selecting those criteria that are relevant to a specific project because of the location or type of construction chosen for the project.

The Facility Description is the definitive description of the proposed facility. At any phase of design, it is a record of the design decisions that have been made to that point. This activity area includes initiating, recording, and modifying the Facility Description. In current MC design practice, the Facility Description is contained in the construction drawings and specifications and usually is not considered a separate entity. The major difference between the manual design process and the computer-assisted design process proposed for CAEADS consists of replacing or supplementing drawings and specifications by a computer-resident Facility Description.

Engineering Analysis and Synthesis are inverse processes. Analysis begins with a description of a subsystem of a facility (such as the structure or HVAC system) and proceeds with calculation of the system behavior with the aid of a mathematical model. Synthesis begins with a description of desired behavior and proceeds with the generation of a systems configuration, or, given a system configuration, the sizing of elements to assure the required behavior. There is a repertory of analysis and synthesis models and methods for specific subsystems within a facility and on a site. Analyses are used for checking the performance of subsystems as well as for comparing the performance of alternative design concepts and solutions.

Activities in the graphics area produce the plans, diagrams, and detailed drawings used in MC design, including installation master plans. In a computer-aided design process, the production of intermediate displays on devices such as cathode ray tubes or plotters may also be included in the graphics activity area.

Specifications are information in text form completing and supplementing the description of the facility contained in drawings. Each District maintains its adaptation of Corps Guide Specifications edited for local requirements and practices. From this District Master Specification, relevant sections are selected, modified, and expanded for each project.

The Cost Estimating activity area includes the preparation of cost estimates during all three phases of MC design. There are three types of cost estimates: an empirical cost estimate which is generally defined in terms of square-foot units and based on the procedures of AR 415-17[20]; a detailed estimate composed of unit costs and quantities for labor, material, and equipment, and prepared on ENG Form 3086; and a life-cycle cost estimate used to compare the costs of design alternatives in a framework which considers future operation and maintenance cost as well as initial construction costs.

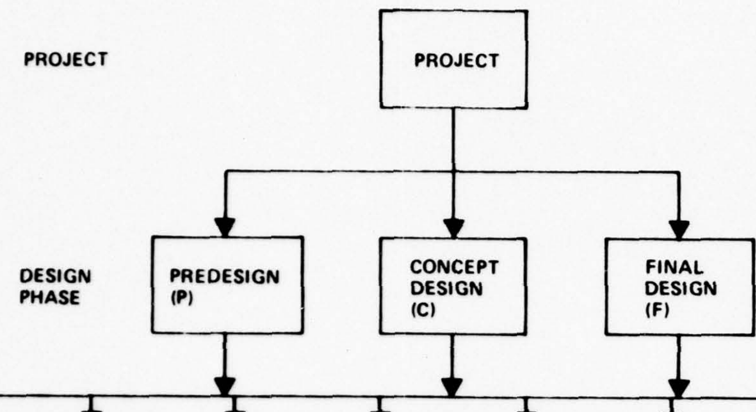
The Design Review activity area includes the review functions performed by the District Office as the concluding portion of each design phase. The proposed facility is checked for conformity to the project functional requirements, design criteria, and authorized construction cost.

(3) Design Disciplines. The functions in the various activity areas are performed by a number of participants with specialized professional roles. For the purposes of CAEADS these are grouped into eight disciplines: Facility Engineer, Architect, Structural Engineer, Mechanical Engineer, Electrical Engineer, Civil Engineer, Specifier, and Cost Estimator. The responsibilities of each are indicated by the discipline names.

(4) Hierarchy of Functions. Figure 3-3 shows the hierarchy of MC design functions as defined for CAEADS. It

---

[20] Empirical Cost Estimates for Military Construction and Cost Adjustment Factors, AR 415-17 (Headquarters, Department of the Army, January 1975).



ACTIVITY AREA / DISCIPLINE	PROJECT DEF	FUNC REQ	DESIGN CRIT	FACILITY DESC	ENGRNG ANAL & SYNTHESIS	GRAPHICS	COST EST	SPECS	REVIEW
FAC ENG	P	P				P			C
ARCHITECT		P	P,C	P,C,F	C,F	P,C,F			C,F
STRUCT ENG			P,C	P,C,F	C,F	C,F			C,F
MECH ENG			P,C	P,C,F	C,F	C,F			C,F
ELEC ENG			P,C	P,C,F	C,F	C,F			C,F
CIVIL ENG			P,C	P,C,F	C,F	C,F			C,F
COST ENG							P,C,F		C,F
SPEC ENG								C,F	C,F

Figure 3-3. CAEADS hierarchy of functions by design phase, activity area and discipline.

depicts the four levels of the hierarchy (Project, Design Phase, Activity Area, and Discipline) and summarizes Activity Areas and Disciplines in each of the three Design Phases. This results in approximately 70 functions at the discipline level. This functional hierarchy is the framework for the CAEADS functional requirements discussed in Chapter 5 and in more detail in Volume V.

CHAPTER 4

REVIEW OF DEPARTMENT OF THE ARMY PROCEDURES FOR ADP SYSTEM PLANNING AND DEFINITION

a. Purpose. This chapter discusses the procedures required by the Department of the Army (DA) for the development of automated data processing (ADP) systems, with emphasis on the requirements of the system definition and planning phase. The discussion includes an overview of the procedures and a description of the documents which must be prepared as the basis for system review, approval, and development. Thus, this chapter provides the context for the documents comprising this report in relation to Army policies and practices governing ADP system design, development, and implementation. It also explains the format in which the requirements for computer support of MC design must be presented at this stage of CAEADS development.

b. Overview of the Procedures. Army Regulation (AR) 18-1 establishes policies, objectives, procedures and responsibilities for automated information processing systems. The life cycle for an Army automated data processing system encompasses three phases: Systems Planning and Definition; System Development; and Systems Installation, Operation, and Maintenance. Each phase requires definitive and increasingly explicit systems documentation, review, and management. The documentation required for a system depends not only on the phase of the system life cycle but also on the classification of the system in accordance with categories established in AR 18-1.

(1) Phases in the System Life-Cycle. The first phase, Systems Planning and Definition, encompasses all documentation and procedures from concept formulation through requirements definition. Five key documents are produced in this phase: the General Functional System Requirement (GFSR), the Management Information System

Economic Analysis (MISEA), the Organization and Personnel Plan (OPP), the Detailed Functional System Requirement (DFSR), and the Project Master Plan (PMP). Each of these documents requires specific approval before the next is produced.

The second phase, Systems Development, encompasses all documentation and procedures from the time the DFSR is approved through prototype evaluation. It covers all actions short of placing the system on-line, including software and hardware acquisition and prototype testing.

The third phase, Systems Installation, Operation and Maintenance, encompasses all procedures for installing, operating, maintaining, and modifying the system. This phase continues until the system is superseded by its replacement or otherwise terminated.

(2) <u>Participants in the Process</u>. For each system there is a Proponent Agency (PA) and an Assigned Responsible Agency (ARA). The Proponent Agency is the organization with responsibility for the functions which the system automates. The Assigned Responsible Agency is the organization designated by Headquarters, Department of the Army (HQDA) to be responsible for the development, test, and maintenance of the system. The respective roles of HQDA, the PA and the APA are defined in the regulation.

(3) <u>Standards</u>. Standards for system design and programming are found in several sources. AR 18-1 establishes general standards for system design, including programming languages and policies for the acquisition of hardware and data base management software.

FIPS Publication 38[21], DOD 4120.17-M[22], and CSCM 18-1[23] all contain useful information or documentation standards for ADP system programming. In addition AR 18-7[24] contains standards for both the programming and operation of ADP systems.

c. Description of the Required Documentation. The contents of the five principal documents required for the Systems Planning and Definition Phase are summarized as follows:

(1) General Functional System Requirement (GFSR). The purpose of the GFSR is to provide a basis for initial determination of the general nature and degree of automation which could feasibly be undertaken. It describes the current system and a concept of the proposed system; the structure of the organization to be supported by the system; functional systems parameters; interfaces with other systems; regulatory requirements; operational environments and policies; workload; performance requirements; backup and flexibility requirements; test, installation, and conversion concepts; and communications and training requirements.

(2) Management Information Systems Economic Analysis (MISEA). The MISEA evaluates alternative data processing systems (the current system and two or more proposed systems) and contains problem/opportunity identification, relevant processing environment objectives,

---

21 Federal Information Processing Standards (FIPS) Publication 38, Guidelines for Documentation of Computer Programs and Automated Data Systems (U.S. Department of Commerce/National Bureau of Standards, 1976).

22 DOD 4120.17-M, Automated Data Systems: Documentation Standards Manual (Hq. U.S. Air Force, 1975).

23 CSCM 18-1, Automated Data Processing System Development, Maintenance, and Documentation Standards and Procedures Ms Manual, Vol. I, General, Chap. 6, "Documentation Standards" (Department of the Army).

24 AR 18-7, Management Information Systems: Data Processing Installation Management, Procedures, and Standards (Department of the Army, 22 March 1976).

assumptions and constraints, statement of alternatives, relevant costs and benefits, and comparison of alternatives, using sensitivity analyses as appropriate. The MISEA accompanies the GFSR and is updated periodically.

(3) Organization and Personnel Plan (OPP). The OPP provides estimates of manpower, space, skill, and ancillary non-ADP equipment requirements. Current and proposed system needs are compared to identify planned organizational changes.

(4) Detailed Functional System Requirement (DFSR). The DFSR defines the functional procedures necessary to develop the system and provides detailed guidance for development and maintenance of the system by the ARA. The DFSR consists of a basic document and nine annexes. The basic document provides a description of the system, documenting events since approval of the GFSR and updates the GFSR. The description includes hierarchical structure, systems functions, and automated functions. The annexes contain input and output descriptions, information elements, data base and external interface descriptions, telecommunication requirements, flow charts, logic charts and/or decision tables, and a glossary.

(5) Project Master Plan (PMP). The PMP is an action plan which places in context all the plans, schedules, costs, scopes of work, and resources required to complete the system. The PMP is the primary management document for controlling system development. It provides a detailed systems development schedule and outlines and defines the management concept and technical approach for project execution. As an action plan, the PMP specifically contains schedules and resource utilization plans, organizational relations and responsibilities, project life-cycle continuity plans for personnel and material, and decentralization and coordination policies.

d. Relation of the Procedures to the CAEADS Project.

(1) Classification of CAEADS. In terms of the categories established by AR 18-1, CAEADS is a Scientific and Engineering (S&E) system. As such, it is exempt from some of the requirements applicable to management systems. However, because of the scope and complexity of CAEADS, some GFSR and DFSR sections which are not mandatory for S&E

systems have been prepared as important aids to planning and managing the CAEADS effort.

CAEADS is a single command system (Corps of Engineers) serving multiple sites (the Districts and OCE) and requires more than 15 man-years of effort for system development. Thus, it is a Class A-2 system. Most of its subsystems will be Class B systems, although some which require more than 15 man-years to develop will be Class A-2.

The Proponent Agency (PA) for CAEADS is the Office of the Chief of Engineers, Directorate of Military Construction, and the Assigned Responsible Agency (ARA) is the Construction Engineering Research Laboratory. It is planned that CERL will be ARA for the development process (AR 18-1, MIS, life cycle, phases I and II), except where an organization (unknown) having ARA responsibility for maintenance may assume responsibility immediately following System Development Review (SDR) or immediately commencing with the Prototype Evaluation Test (PET).

(2) <u>Approach to CAEADS Planning, Definition, and Development</u>. The GFSR and DFSR for CAEADS present an overview of the system scope and requirements. The Project Master Plan presents an incremental approach to development and implementation and requires the justification of benefits of each subsystem of CAEADS as well as the total system. It should be clear from these documents that additional detailed planning is necessary as a prelude to the development and implementation of the CAEADS system framework and new subsystems as well as to the integration of systems now under development within the CAEADS framework. The approach recommended in this report is to prepare a DFSR and an Economic Analysis for each CAEADS subsystem as it is scheduled for development. This follows the "umbrella" approach proposed in the original AEADS GFSR.

CHAPTER 5

CAEADS REQUIREMENTS

a. Purpose and Scope. This chapter summarizes the requirements for CAEADS described in greater detail in the CAEADS GFSR and LFSR (Volumes III and V). These requirements are discussed in three major groups: requirements for direct support and performance of MC design functions identified in Chapter 4, requirements arising from a consideration of the human factors involved in the interaction between people and computer systems, and requirements implied by the nature of an evolving computer-aided design system of the comprehensive scope of CAEADS.

b. Functional Requirements. The primary requirement for CAEADS is the direct support of the procedures which constitute MC design. These have been identified as the tasks performed by eight professional disciplines in nine activity areas during three phases of the process. CAEADS must produce end products similar to those of the current system, as well as a variety of intermediate products. It must include or interface with the applications software necessary to carry out MC design procedures and produce the end products. It must store the information required by the computer-aided processes, and it must interface with other ADP systems which supply information to CAEADS, receive information from CAEADS, or provide information processing hardware and software not available within CAEADS.

(1) End Products. Table 5-1 lists the end products to be produced by CAEADS within each activity area and phase. Other CAEADS products will be intermediate versions and working copies of these documents. Additional specialized displays, diagrams, and drawings which facilitate interaction between CAEADS users and the system and which facilitate coordination and communication within and among the various design disciplines are also considered intermediate products.

Table 5-1

OUTLINE SHOWING PHASES, ACTIVITIES AND END PRODUCTS OF MC DESIGN

PHASE I - PRE-DESIGN PHASE

Project Definition

DD Form 1391
Project Development Brochure
Installation Master Plan

Functional Requirements

Project-Specific Functional Requirements

Design Criteria

Project-Specific Design Criteria

Cost Estimating

Empirical Cost Estimate, DD Form 1391
ENG Form 3086 Cost Estimate

PHASE II - CONCEPT DESIGN PHASE

Facility Description

Computer-Resident Facility Description

Engineering Analysis and Synthesis

Tabulation of Results

Graphics

Plan, Elevations, Sections and Subsystem Diagrams for Designed Facility and Its Site

Specifications

Outline Specifications

Table 5-1 (continued)

Cost Estimating

ENG Form 3086 Cost Estimate

Review

Review Comments

<u>PHASE III</u> - <u>FINAL DESIGN PHASE</u>

Design Criteria

Revised Project-Specific Design Criteria

Facility Description

Computer-Resident Facility Description

Engineering Analysis and Synthesis

Tabulation of Results

Graphics

Plans, Elevations, Sections, Details and Subsystem Diagrams for Designed Facility and Its Site

Specifications

Construction Specifications

Cost Estimating

ENG Form 3086 Cost Estimate
Government Estimate

Review

Review Comments

(2) Applications Software for Automated Functions. Various categories of applications software are needed or desirable for direct support of the various disciplines within each activity area and phase of the MC design process. Some of these software packages or subsystems will be contained within CAEADS. Others will be operational on outside hardware and require an interface to CAEADS. This includes proprietary software that is unavailable for direct incorporation into CAEADS and software which is too specialized or too infrequently used to be included in CAEADS. In some cases the CAEADS user will be best served by a choice of software within and outside CAEADS.

(3) Data Bases. Table 5-2 describes the data bases required by CAEADS. These provide for the continued storage of information required by computer-aided processes. The data bases are classified by location (District or OCE), by information type, and by relation to projects (project-independent or project-dependent).

(4) Interfaces With Other Systems. Table 5-3 presents the external interface requirements for CAEADS. These consist of links to systems which supply information used in MC design and links to system deriving management information from CAEADS. Interfaces to external systems for engineering analysis and synthesis are also required.

c. Human Factors. Human factors are often crucial to user acceptance of ADP systems, particularly where the users are sophisticated professionals as are the prospective users of CAEADS. Careful attention to human factors is also important for achieving the potential benefits of human-machine interaction. The various users of CAEADS are identified below and their roles are characterized. The requirements for the CAEADS user-computer interface are summarized.

(1) User Classification. CAEADS users can be classified according to their relation to the development and operation of the system. The primary users are the architects and engineers in the eight disciplines who carry out the tasks of MC design directly. Closely associated with them are the personnel at OCE and District Offices who update and maintain the data bases of Functional Requirements, Design Criteria, and Specifications. Other users directly supported by the system are Facility

Table 5-2

REQUIRED DATA BASES

Data Base Name	Use Type	Data Type
Form 1391 - Installation	Independent	Alphanumeric
Form 1391 - OCE	Independent	Alphanumeric
Functional Requirements	Independent	Text or Alphanumeric
Design Criteria	Independent	Text or Alphanumeric
Installation Master Plan	Independent	Geometric
Graphic Symbols and Formats	Independent	Graphic
Cost Data	Independent	Alphanumeric
Specifications	Independent	Text
Functional Requirements	Project	Text or Alphanumeric
Design Criteria	Project	Text or Alphanumeric
Facility Description	Project	Geometric
Engineering Work File	Project	Alphanumeric
Graphic Symbols and Formats	Project	Graphic
Cost Estimate	Project	Alphanumeric
Specifications	Project	Text
Review Comments	Project	Text
Documentation	Project	Text, Graphics

Table 5-3

CAEADS EXTERNAL INTERFACE REQUIREMENTS

External System	Interface to CAEADS	Interface from CAEADS
AMPRS		X
COEMIS	X	
IFS	X	X
Proprietary Programs	X	X
Outside Contractors	X	X

Engineers and personnel from MACOMs and OCE involved in the Pre-Design Phase. These users are concerned with system response, reliability, and ease of use as well as correctness of the applications software. Supporting the direct users of CAEADS are others who perform roles generally referred to as data base and system administration. These users carry out such tasks as authorizing access to the system and its data bases. They will be responsible for establishing data bases and software libraries for purging obsolete and superseded information, and for controlling backup of CAEADS information. The third group of users includes the system and subsystem developers who maintain CAEADS, correct errors as they are detected, extend the capabilities of the system by developing new software, and modifying CAEADS to incorporate advances in hardware and software. These users are concerned with modularity and clarity of system design and structure, and with high-level software aids which enable them to develop error-free applications and subsystems rapidly and economically.

(2) User Characteristics. Users may also be characterized by their degree of familiarity and sophistication in the use of CAEADS. CAEADS is designed to allow novices to use the system without expert guidance. The novice user is likely to be ill at ease and easily frustrated by imprecise terminal responses or delayed response times. He/she requires the assistance of tutorial dialogue and messages which help maintain confidence in the use of the system. The casual user is trained in terminal usage, feels comfortable interacting with a computer, and is generally familiar with CAEADS capabilities, but spends most of the time doing something other than using CAEADS. He/she requires descriptive cues and prompts as reminders of missing information, errors in command structure, and other details of CAEADS usage and protocol. The experienced user will spend much of the time using CAEADS (as opposed to learning CAEADS or requesting assistance from the system) and will have an almost instantaneous recall of CAEADS commands and conventions. He/she is attuned to the response pattern of interaction and tends to be intolerant of anything which delays or interferes with interaction. He/she requires abbreviated cues and prompts, maximum use of context to imply command parameters, and rapid response times.

(3) User Interfaces. To facilitate effective user interaction as well as to produce the required intermediate and end products, CAEADS must support a variety of terminal types. These terminal types and their characteristics are shown in Annex B. At these terminals the user will communicate with the system through a command language. The language will be compatible with the terminology of the professional disciplines and usable across the variety of input terminals, so that a specific command can be communicated consistently in alternative ways such as through specialized function keys, alphanumeric keyboards or menu selections. Patterns and protocols for user interaction must be common to all CAEADS subsystems and programs. CAEADS requires standards for the user interface as the means of continuity and uniformity of user interaction throughout the evolution of the system.

d. CAEADS System Requirements. In order to support the primary MC design functions through interaction with its users, CAEADS must be organized with a common and uniform set of information processing capabilities. These system-level capabilities treat the more specialized functional and human-interaction requirements consistently. They provide system-building tools for the orderly and efficient growth and development of CAEADS. In computer-aided design systems implemented on dedicated computers these capabilities are typically supplied by utility programs under the control of an executive program which extends and supplements the operating system of the host computer. However, other ways of configuring CAEADS hardware and software which exploit the potential of minicomputers and distributed processing could also satisfy the CAEADS system requirements. System requirements are summarized below.

(1) Data Base Support. CAEADS requires software to support creation, maintenance, update, and purge of the data bases identified in Table 5-2. The data base software must provide controlled and selective access to the data bases for the storage and retrieval of information contained in them. It must provide facilities for access from applications software and from user query languages. It will be one of the means of achieving the requirement for security and integrity of data which is discussed separately. As Table 5-2 indicates, CAEADS data bases may be classified by the form of the information they contain, text, or document data bases, tabular or alphanumeric data bases, and graphics data bases. In the future, facility

functional requirements and design criteria may be stored as data bases of boolean conditions or procedural checks. Only in the area of tabular data bases are there available standards and data base management software. These standards and software are a result of the work of the CODASYL Data Base Task Group. CAEADS requires a three-dimensional data base containing a geometric description of the facility and site as well as the attributes associated with the various components of the facility and site. This data base is a critical element of the CAEADS system design and a major basis for system integration. Requirements for the 3-D data base are the subject of a separate study.

(2) Processing Support. CAEADS processing requirements reflect the variety of data base types in the system. CAEADS software must support text editing and document processing, computationally intensive floating-point calculations for engineering analysis and synthesis, processing of geometric data, graphics processing for the production of displays and drawings, processing associated with the tabulation of cost estimates, and the generation of reports from alphanumeric or tabular data bases. It is highly desirable that uniform software be employed for application programs of similar procesing types, such as editing of specifications, preparation of PDB's, retrieval of environmental impact information or design criteria and other document editing and processing applications. The higher the level at which uniformity and commonality can be achieved, the greater the likelihood of reliability, and the lesser the impact of software modifications on system efficiency. In engineering analysis and synthesis uniform software for all flow networks such as HVAC ducts, steam and gas distribution systems, water, waste and drainage systems can achieve similar benefits. Circulation networks and electrical distribution systems should be able to share much of the flow network software.

(3) Communications Support. CAEADS must support communications between the Districts, MACOMs, FE's and OCE. It must also support access to CAEADS by contractor A/E firms. Communication links to remote processors for special purpose software are also required, as discussed in the section titled Interfaces With Other Systems. Other communications requirements will depend on the final locations chosen for CAEADS hardware--whether entirely District based, partly centralized, or decentralized in the form of a distributed computing network. Requirements for

communications support are quantified and evaluated in the CAEADS Preliminary Hardware/Software Analysis (Chapter 9).

(4) User Interaction Support. CAEADS must support user interaction through the standardized variety of terminal types identified in Annex B. This includes terminal control software and software for graphics displays, with interactive and non-interactive. It also includes the parsing, interpreting, and processing of the user command language and the interaction protocols discussed above. CAEADS should provide a command language definition capability to give subsystem and applications program developers a high-level tool for extending the repertory of user commands. The conventions for the internal representation of graphics displays, user commands, and system responses in CAEADS should be device-independent for reasons similar to those given above in the discussion of processing support.

(5) System Administration and Resource Accounting. CAEADS must also support the work of the Data Base and System Administrator at each data processing installation. It must provide facilities for the management of all CAEADS information, program libraries, system files, and catalogues, as well as data bases. It must provide procedures for authorizing access to CAEADS and CAEADS data bases for various classes of users at different levels of priority and for assigning and changing passwords and priorities under control of the administrator. When data bases and programs are modified, the system must record the identity of the user making the modifications, and if necesary, the authorization as well as the time and date of the changes. The level of detail at which an audit trail of the changes themselves can be maintained will be determined by analysis of the cost versus the benefits of such an audit. CAEADS must record the usage of system resources to allocate costs to users and projects, and to identify areas in which system modifications can improve response, utilization of resources, and system throughput.

(6) Flexibility for the Future. The necessity for CAEADS to develop through orderly and flexible growth and open-ended evolution over its more than a decade of useful life in the context of changing hardware and software technology implies additional management and technical system requirements. Management requirements are discussed in Chapter 8 of this Volume, and the technical requirements

are discussed here. The technical preconditions of flexibility include careful system design, modularity, controlled internal and external interfaces, uniformity and commonality of software among subsystems, a high degree of machine and device independence, existence of high-level system-building software, and selection of appropriate programming languages (not necessarily the same language for all portions of the system). This is necessary to maintain flexibility where applications are already developed and therefore are programmed in their respective languages and must be interfaced with CAEADS. The system must support compilers and processors for the languages chosen. One of the constraints on the development and implementation of CAEADS is the lack of widely supported languages for graphics applications and geometric data base applications comparable in familiarity and capability to that of FORTRAN in the area of scientific and engineering computation.

(7) System Security and Integrity. CAEADS must preserve system and data security and data integrity. Security requirements include protection against willful destruction of CAEADS programs, data bases and other system information through unauthorized access, vandalism, and sabotage as well as against nondestructive but unauthorized use of CAEADS information and CAEADS processing resources. Precautions must also be taken against accidental damage to hardware, software, and data through human error or natural catastrophes such as earthquake, fire, and flood. Security of data bases requires explicit permission or authorization before each user is permitted to read or write a data base. Restrictions on access will be enforced by hardware and software to the level of subsets of the various data bases, program libraries, and system files under control of the system administrator. Data integrity requirements arise from the need to maintain the consistency and compatability of logically related data elements in a multi-user, multi-disciplinary, interactive computing environment which supports simultaneous data access and dynamic modification of shared information such as the Facility Description. Total data security and integrity are impossible to achieve. Therefore it is also important for the system to detect and report breaches of security and integrity. Procedures for backup of CAEADS will provide for rapid resumption of operations and restoration of valid information in the event that security and integrity are compromised.

(8) System Reliability. Reliability requirements arise from the need to keep CAEADS operating continuously even after the failure of portions of the hardware or software. The maximum permissible downtime for any District is 6 days per year during scheduled hours of operating with the maximum consecutive period of interrupted service being 48 hours. Backup procedures will facilitate system restart. Hardware reliability is not likely to be a source of difficulty. Software reliability is best achieved through careful design and systematic testing procedures.

CHAPTER 6

CAEADS SYSTEM CONCEPTS

a. Purpose and Scope. Alternative CAEADS system concepts were developed in response to the CAEADS objectives and guidelines and the CAEADS requirements identified in this study and preceding studies referenced in Chapter 2. System concepts are discussed in terms of the design approach and the principal design alternatives considered for CAEADS.

b. Design Approach. This summary of the design approach to CAEADS emphasizes the factors having a major influence on the formulation of alternatives.

(1) District Orientation. The center of MC design is the District Office. Project-dependent information is not shared among Districts, but constitutes a significant portion of the CAEADS data bases. This fact and the proposed high degree of interaction between the designer and the facility description data base implies that project data bases should reside at the District Office (or at the office of the contractor A/E firm if use of the District hardware is not sufficiently convenient). User terminals and hardware to support query of the project data bases and a minicomputer system for graphical display of the facility description data base and production of drawings should also be located where design is performed. The alternatives for CAEADS are based on different locations for the remaining elements of the system--the project-independent data bases and the processor for applications programs such as document editing, cost estimating, and engineering analysis and synthesis.

(2) System Integration. Integration of MC design procedures in the nine activity areas throughout the three design phases and among the eight disciplines is a basic concept underlying CAEADS design. Integration will be

achieved through a single common facility description data base for each project, of which the 3-D data base is a key element. (Other means of integration are the overall system framework for all application areas, the common set of system utilities and modular software shared and invoked by all subsystems, and the common set of high-level system building tools for system and subsystem developers.) These have been mentioned in the discussion of CAEADS system requirements. Additional integration will be provided by a consistent user interface and common software for handling user interaction and CAEADS input and output. These methods of integration will be specified in the standards to be developed for the further design and development of CAEADS.

(3) Continuity for the User. Another major design concept is continuity for the user. This will be achieved by uniform standards adopted for user interaction with the system. As a result, all CAEADS users will deal with the system in a similar fashion at every stage of the system implementation no matter which tasks are being performed. These standards will allow for the variations in user sophistication discussed under human factors. They will allow CAEADS to maintain the same external appearance to all users even though the internal design of the system and subsystem evolves and changes. This approach will minimize the need for retraining of users as the system is developed and implemented. It will also encourage careful attention to human factors critical to the acceptance of CAEADS and justify the allocation of adequate resources to the user interface design.

(4) Modular System Design. To achieve the system requirement for flexibility and modularity the internal structure of CAEADS software will facilitate the modification and replacement of parts of the system at a variety of levels without affecting the rest of the system. This de-coupling will localize the effects of software changes. This approach will result in layered software with controlled interfaces between layers which have been identified and designed as part of the system. This will promote flexibility, modularity and independence in several dimensions. Examples include device-independent representations of drawings, diagrams, and displays; data access routines which are independent of data management software; internal representations of user commands which are independent of input terminals or devices; and representations of building subsystems which are independent

of specific algorithms or alternative application software packages. As transformation of information may be required at each interface, investigation of tradeoffs between the increased flexibility of extra layers and the overhead imposed by that transformation will be an important area of investigation in the advanced design of CAEADS.

CHAPTER 7

CAEADS ECONOMIC ANALYSIS

a. Scope and Approach. The CAEADS Economic Analysis (CAEADS/EA) consisted of the development and assessment of costs and benefits associated with three MC design system alternatives; the baseline alternative (existing MC design system), the stand-alone alternative, and the integrated CAEADS alternative. These alternatives were evaluated over a 12-year study period (FY 1978 through FY 1989). Included in the analysis were operations costs, applications design costs, system design costs, and hardware/software procurement costs. Benefits attributable to each alternative were identified as either design benefits or construction benefits. Further benefits, identified as intangible or non-quantified benefits, were described in the analysis but did not affect the economic comparison of the alternatives.

The following general assumptions are made for the CAEADS/EA:

(1) Stand-alone system programs will be operational during FY 1980. An integrated CAEADS will be operational during FY 1982.

(2) Initial CE participation in CAEADS will be limited to eight CE District Offices which perform MC design (see Volume III, Chapter 4, Organizational Structure).

(3) Use of CAEADS by agencies outside these Districts will include a phased introduction of CAEADS to MACOM, FE's, and private A/E firms performing MC design.

(4) There will be no increase in the number of MC design projects within the time frame of this analysis.

(5) The total MC design load carried by Design Offices is distributed such that 20 percent of the work is performed in the Corps Design Office and 80 percent of the work is contracted to private A/E firms.

(6) The project workload for the initial system will be 600 "typical" projects per year. A typical project consists of a building with a construction cost of $1,250,000, an area of 25,000 square feet, and a design effort of 3200 hours.

(7) Additional Corps Design Offices, specifically those in OCONUS, will be included in CAEADS at a later date.

Additional assumptions applied to a particular alternative are identified in the detailed descriptions found in Volume IV of this report.

b. Analysis Procedures. The analysis compared the costs and benefits of the three alternatives. The baseline system represented the current method of performing MC design, the stand-alone alternative introduced independent application programs to aid the MC design process, and the integrated CAEADS alternative proposed an integrated system of applications programs which utilized common data bases and standard system interfaces. Each alternative was subjected to the estimated annual project workload of 600 typical projects. A description of the typical project is given in Table 7-1. A summary of the design effort required for this typical project in each of the system alternatives is shown in Table 7-2.

The incremental costs for the development, implementation and use of the stand-alone alternative and the integrated CAEADS alternative are summarized in Table 7-3. These costs reflect the incremental difference between the two proposed alternatives and the baseline alternative for applications program design costs, system design costs, hardware and software procurement costs, and operations and use costs.

The tangible benefits quantified in this analysis are summarized in Table 7-4. These benefits are categorized as design benefits and construction benefits. Design benefits result from the reduction of design effort (see Table 7-2) and the reduction of technical errors which occur in design. Construction benefits result from lower

Table 7-1

PROFILE OF TYPICAL PROJECT

Construction Costs		$1,250,000
Design Costs		$ 75,000
Design Effort (hours)		
Pre-Design Phase	338	
Concept Design Phase	900	
Final Design Phase	1962	
Total Design Effort		3,200 hours
Square Footage		25,000 sq. ft.

Table 7-2

ANALYSIS OF DESIGN EFFORT BY ALTERNATIVE METHODS FOR MC DESIGN

	Manual (Hours)	Stand-Alone (Hours)	CAEADS (Hours)
DESIGN ACTIVITY - CE			
Master Plan and Project Definition	96	80	64
Functional Requirements	64	48	40
Review	192	192	160
TOTAL HOURS (% efficiency)	352 (100.0)	320 (110.0)	264 (133.3)
DESIGN ACTIVITY - CE AND/OR A/E			
Design Criteria	96	64	40
Architectural Design	208	208	0
Facility Description	0	0	540
Engineering Analysis and Synthesis	800	688	400
Graphics	1,296	640	320
Specifications	224	160	144
Cost Estimating	224	192	128
TOTAL HOURS (% efficiency)	2,848 (100.0)	1,952 (145.9)	1,572 (181.2)
OVERALL TOTAL HOURS (% efficiency)	3,200 (100.0)	2,272 (140.8)	1,836 (174.3)

Table 7-3

SUMMARY OF INCREMENTAL COSTS
FOR THE
STAND-ALONE ALTERNATIVE
AND THE
INTEGRATED CAEADS ALTERNATIVE
OVER THE 12-YEAR PERIOD
($ 000)

	Stand-Alone	Integrated
Applications Design	25,689	28,528
System Design	0	7,910
Procurement	8,154	15,687
Operations and Use	11,169	35,730
TOTAL COSTS	45,012	87,855

Table 7-4

SUMMARY OF INCREMENTAL BENEFITS
FOR THE
STAND-ALONE ALTERNATIVE
AND THE
INTEGRATED CAEADS ALTERNATIVE
OVER THE 12-YEAR PERIOD
($ 000)

	Stand-Alone	Integrated
Design Benefits	105,090	179,968
Construction Benefits	48,766	180,368
TOTAL BENEFITS	153,856	360,336

construction costs due to complete and consistent documentation.

Additional benefits which are intangible and were not quantified in this analysis include improved quality of end-products, more efficient use of space and reduction of spatial conflicts, greater conformance to CE requirements and criteria, greater consistency and standardization of end-products, improved control and coordination of design activities, enhanced design review capabilities, and improved operations and maintenance of facilities. These benefits are elaborated upon in Volume IV of this report.

c. Results. The results of the economic analysis' comparison of the stand-alone and integrated CAEADS alternatives to the baseline alternative include a summary of the benefit-cost ratio (B/C) and potential return on investment (ROI) for each alternative. The following summarizes these results.

(1) Stand-alone alternative. The total undiscounted incremental cost for the stand-alone alternative is $45,012,000 and the total benefits (design and construction) are $153,856,000, as shown in Tables 7-3 and 7-4.

The economic analysis performed on the undiscounted costs and benefits included calculation of a return on investment (ROI), in which cash flow was discounted at a rate of 10 percent per annum, and an undiscounted benefit-cost (B/C) ratio.

Figure 7-1 is a summary of the undiscounted cumulative cash flow for the stand-alone alternative, showing a comparison of the design benefits versus total benefits. For the analysis of all costs and design benefits only the ROI is 26.13 percent and the B/C ratio is 2.33. For the analysis of all costs and total benefits (design and costruction), the ROI is 34.16 percent and the B/C ratio is 3.42. Figure 7-1 also shows that the pay-back period for the stand-alone alternative considering design benefits only is almost 5 years (FY 1978 through FY 1982), whereas the pay-back period considering all benefits is 4 years (FY 1978 through FY 1981). The maximum additional investment required for the stand-alone alternative is approximately $4.7 million. Sunk costs for the stand-alone alternative are $6.8 million.

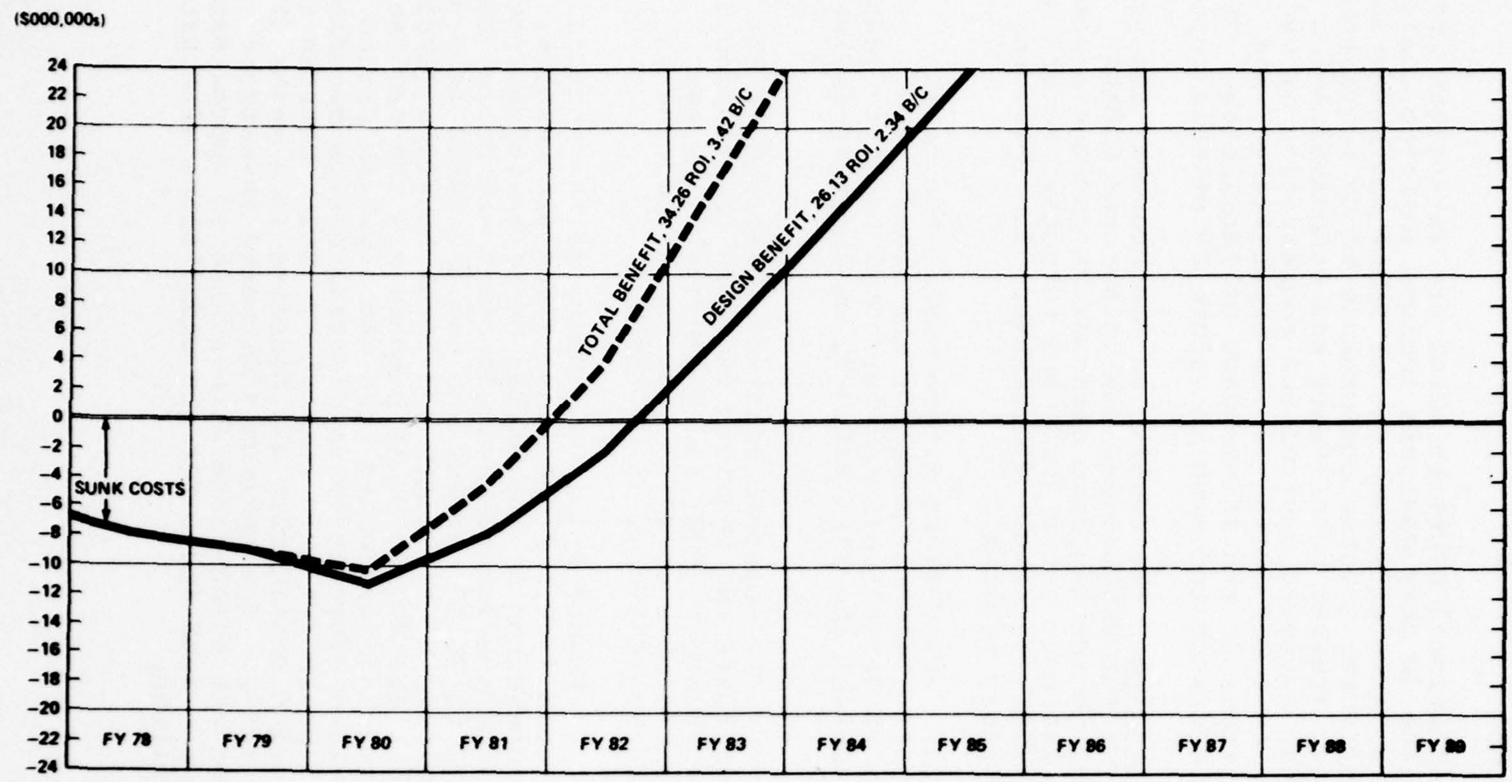


Figure 7-1. Comparison of estimated cash flow for stand-alone systems. (total benefit vs. design benefit only, at 40 percent improved efficiency)

(2) Integrated CAEADS alternative. The total undiscounted incremental cost for the integrated CAEADS alternative is $87,855,000, including sunk costs, and the total benefits (design and construction) are $179,968,000, as shown in Tables 7-3 and 7-4.

The economic analysis performed on undiscounted costs and benefits for the integrated CAEADS alternative included calculation of return on investment (ROI), in which cash flow is discounted at a 10 percent annual rate, and an undiscounted benefit-cost ratio. Figure 7-2 is a comparison of the undiscounted cumulative cash flow for the CAEADS alternative considering either design benefits only or total benefits (construction and design). This analysis shows the ROI considering design benefits only is 30.36 percent and the B/C ratio is 2.05. The ROI for CAEADS considering all benefits is 48.58 percent and the B/C ratio is 4.10. Figure 7-2 also shows that the pay-back period for CAEADS considering design benefits only is almost five years (FY 1978 through FY 1982), whereas the pay-back period considering all benefits is approximately 3 1/4 years (FY 1978 through 1st quarter 1981). The maximum additional investment required for CAEADS (excluding any contingency factor) is approximately $3 million. Sunk costs for CAEADS are $6.8 million.

Figures 7-3 and 7-4 compare the economic performance of the stand-alone and integrated CAEADS alternatives. Figure 7-3 shows the two alternatives considering all costs and only design benefits. Figure 7-4 compares the two alternatives considering all costs and all benefits (design and construction).

Table 7-5 summarizes the results of the comparison of the stand-alone and integrated CAEADS alternative with the baseline alternative. Listed are the incremental costs and sunk costs for development, implementation and use for each alternative over the 12-year study period. Estimated benefits that result from improved design efficiency and reduced construction costs are also shown. The bottom half of the table lists the effects that each alternative will have on specific issues related to MC design. Automation in the stand-alone alternative provides opportunities for improved design efficiency. However, communications and coordination are still left to individual participants in the design process, and are therefore subject to human error and misunderstanding. In contrast, the integrated CAEADS

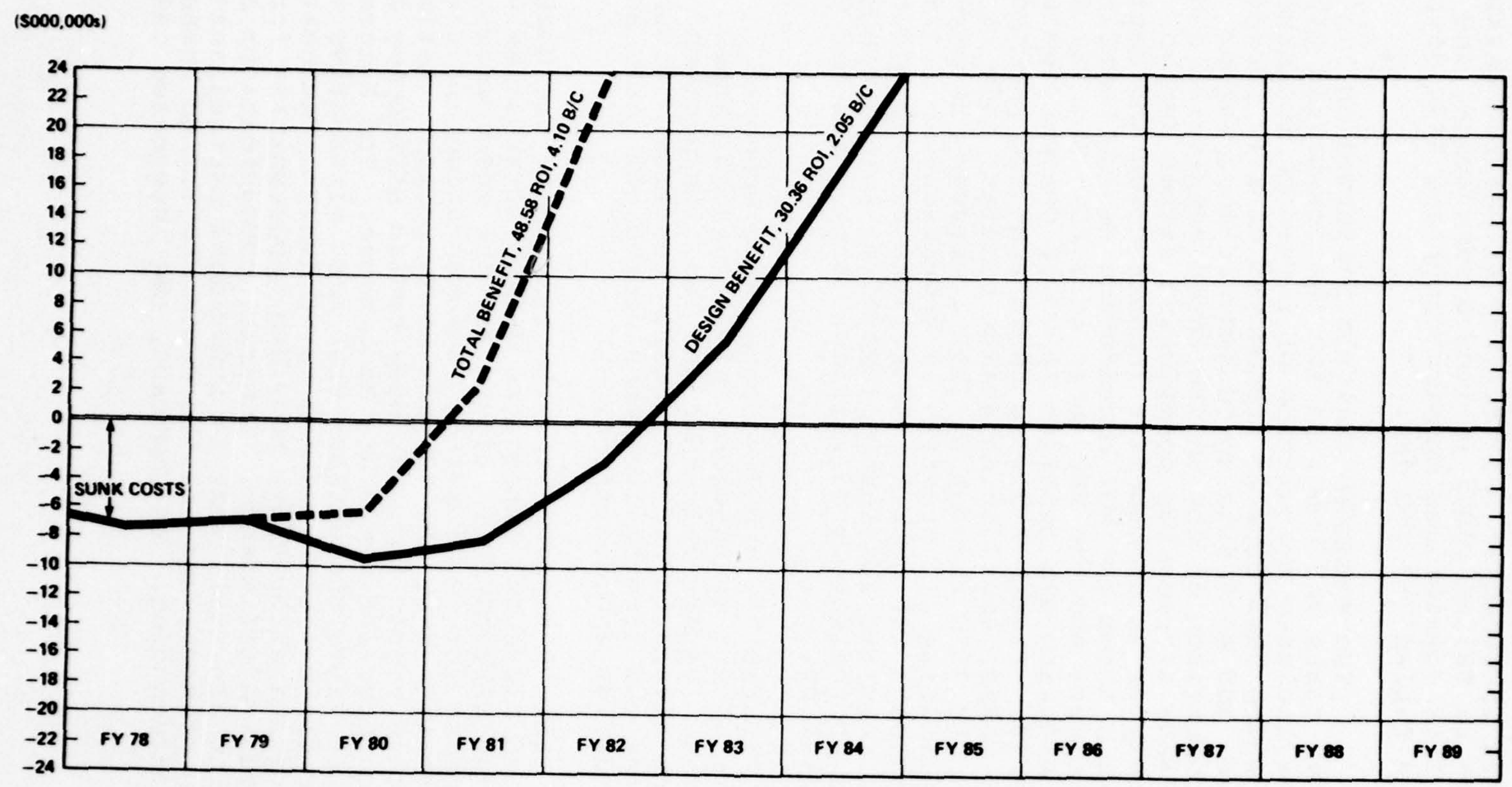


Figure 7-2. Comparison of estimated cash flow for CAEADS systems.
(total benefit vs. design benefit only, at 75 percent improved efficiency)

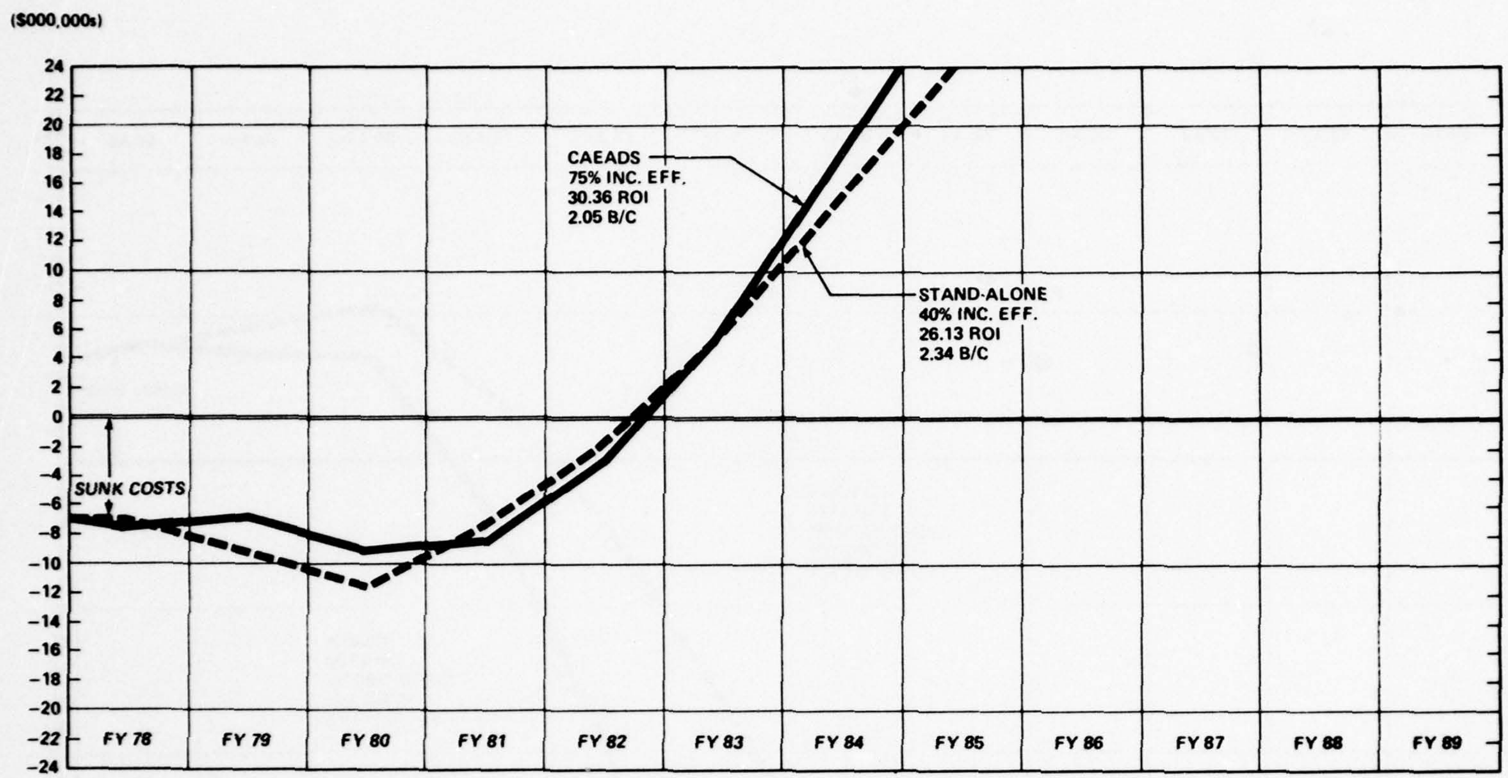


Figure 7-3. Comparison of estimated cash flow for CAEADS and stand-alone alternatives – design benefits only.

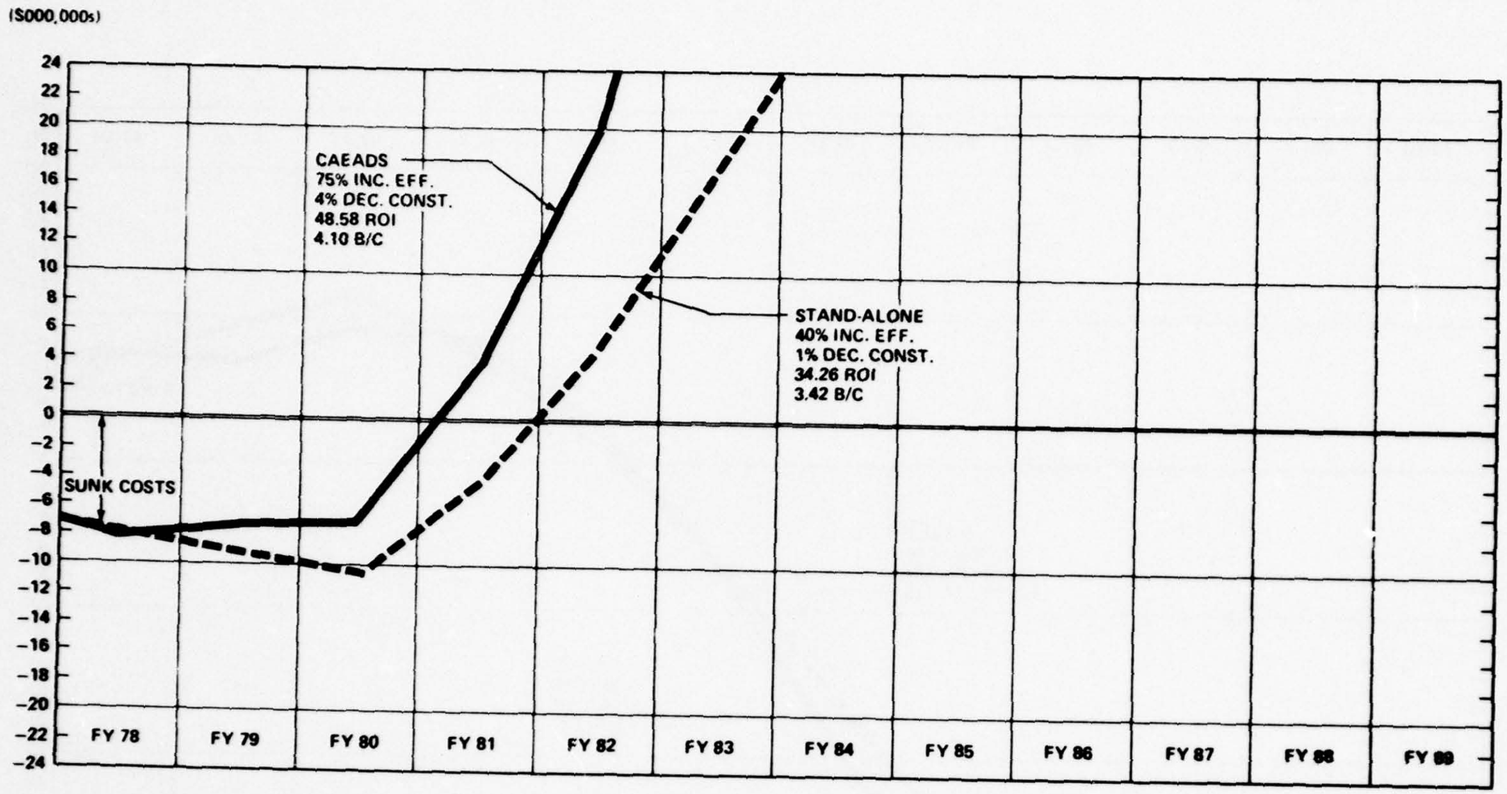


Figure 7-4. Comparison of estimated cash flow for CAEADS and stand-alone alternatives – total benefits.

Table 7-5. Summary of comparison of alternatives.

	BASELINE ALTERNATIVE	STAND-ALONE ALTERNATIVE	INTEGRATED CAEADS ALTERNATIVE
Incremental Cost	$ 0	$ 45,012,000	$ 87,855,000
Sunk Cost	$ 0	$ 6,834,000	$ 6,834,000
Incremental Design Benefit	$ 0	$105,090,000	$179,968,000
Incremental Construction Benefit	$ 0	$ 48,766,000	$180,368,000
Total Incremental Benefits	$ 0	$153,856,000	$360,336,000
Benefit/Cost Ratio – ROI			
Design Benefits Only	1.0 –	2.33 26.13%	2.05 30.36%
Design & Construction	1.0 –	3.42 34.26%	4.10 48.58%
MC Design Issues/Resolution			
Coordination	Communication and coordination left to individual participants; process subject to delays, omissions, and duplication	Structured inputs and outputs and standard applications programs facilitate coordination. No change in method of communication, which is left to individual participants.	Computer stores all information in Facility Description or accesses project-independent information from data files. All latest information is available on command by user; automatic identification of spatial interferences, conflicting criteria, conflicting documentation, etc.
Timeliness	Manual document production, cross-checking, and correction is a time-consuming process subject to human error.	Document production time is decreased, but still requires manual cross-checking and review. Some improvement of timeliness of changes.	Automated cross-checking, conflict detection, and review. Changes are implemented faster and apply to all documentation through the Facility Description. Rapid access to current document status.
Product Quality	Subject to errors, omissions, and conflicts due to lack of coordination and communications.	Improved analysis and subsystem design. Susceptible to errors, omissions, and conflicts due to poor interdisciplinary communication and coordination.	Improved analysis and subsystem design; automatic identification of interference and conflict at time of occurrence will eliminate a majority of errors and conflicts. Facilitates optimization of design and more thorough design review.

will indicate errors and conflicts in design documentation at the time of occurrence, preventing further design development until the conflict is resolved. This capability will insure that all elements of a design will be compatible with each other. The fact that all design information resides in a single design data base accessible by all disciplines further limits the possibility that any design participant will use out-dated or incorrect information.

d. Conclusions and Recommendations. The comparative economic analysis indicates that the integrated CAEADS alternative is a significantly superior system providing improved end-products, more timely production of design documentation, and reductions in design and construction costs. The economic performance of the integrated CAEADS alternative over the 12-year study period further supports the conclusion that this alternative represents the best approach to performing MC design. It is therefore recommended that the integrated CAEADS alternative be selected and implemented.

CHAPTER 8

PROJECT MASTER PLAN

a. Purpose and Scope. The current Project Master Plan (PMP) specifies a concept of the tasks that are necessary to develop, implement, and use CAEADS over the 12-year study period (FY 1978-1987). The plan is made up of development tasks, support tasks, and use of the system. The planned tasks and stages for the proposed activity and products will be modified as the master plan is updated in the future.

b. Tasks.

(1) Research. Investigation of unresolved issues necessary for the development of CAEADS.

(2) Research System Use. Experimentation with a state-of-the-art computer-aided design system as a source for information and experience necessary for full system design.

(3) Standards Development. Development of CAEADS standards for human-machine interaction, documentation, general system capabilities, information and data base management, graphics, and programming methods.

(4) Advanced System Design. Revisions to the GFSR and DFSR, and advanced design of the system in response to the GFSR and DFSR.

(5) System Programming. Preparation, basic testing, and documentation of software that comprises part of the CAEADS operating environment.

(6) Applications Design. Design of applications software for specific MC design tasks in accordance with standards and system design.

(7) Application Programming. Implementation, basic testing, and documentation of application software within the CAEADS operating environment.

(8) Data Conversion. Conversion of data needed for project-independent data bases from manual to automated form.

(9) Procurement. Procurement of hardware, firmware, and vendor-supplied operating system software.

(10) System Test. Testing of the completed CAEADS hardware/software/data base configuration under field conditions.

(11) Operations Design. Design of procedures for operation of CAEADS and adjustment of MC design procedures related to CAEADS use.

(12) Training Preparation. Preparation of materials for describing the appearance structure, and use of CAEADS.

(13) User Training. Training based on prepared materials.

(14) System Use. Use of CAEADS as part of MC design and monitoring of the system for maintenance needs.

(15) User Advisory Group Participation. Collection and documentation of user group experience with CAEADS.

(16) Outside Group Participation. Collection and documentation of outside A/E experience with CAEADS.

c. Stages. The Project Master Plan is divided into five stages: CAEADS I, IIA, IIB, IIC, and IID. Each stage consists of a period of development, implementation, use, and support tasks associated with use. The sequence of stages presents the user with an orderly expansion of the capabilities of the system. The five stages are described below.

(1) CAEADS I, Coordinated Components (Common User-Machine Interface), in use from mid-1980 to mid-1982. This initial stage establishes a single, coherent mode of

human-machine interaction and applies it as the user interface to a limited set of CAEADS capabilities, including SEARCH, and initial capabilities for 1391 Processor, Specifications, Cost Estimating, BLAST, and CEUP. The interaction method will be retained throughout the life of CAEADS.

(2) CAEADS IIA, Basic Integration (Common Operating Environment), in use from mid-1982 to the end of 1983. This second stage establishes a common operating environment composed of unified hardware, operating systems, data base management systems, communications facilities, and work stations. This improved environment provides initial capabilities for Functional Requirements, Design Criteria, Project Definition, Facility Description, Engineering Analysis and Synthesis, and Graphics Activity Areas. All capabilities of the Specifications, Cost Estimating, PDB and 1391 activity areas are provided.

(3) CAEADS IIB, Enhanced Integration, in use from the beginning of 1984 to mid-1985. This stage extends the capabilities established to CAEADS IIA to include all Project Definition, Facility Description, Engineering Analysis and Synthesis, and Graphics capabilities. Inclusion of revised and improved Functional Requirements and Design Criteria, and initial Design Review capabilities are planned.

(4) CAEADS IIC, Extended Integration, in use from mid-1985 to the end of 1985. This stage extends the capabilities established in CAEADS IIB to include all Functional Requirements, Design Criteria and Design Review capabilities, completing implementation of all activity areas in CAEADS.

(5) CAEADS IID, Post-Development, in use from the beginning of 1986 and thereafter. This final stage maintains the full capabilities established in CAEADS IIC, incorporating improvements in the state of the art as they become available, and initiating the research and development of future improvements to the system.

The CAEADS Master Plan has been divided into stages for three reasons: to provide system benefits from progressively available applications at the earliest possible time while other applications are being developed; to minimize disruption of MC design processes by gradually introducing system applications at intervals over the development of CAEADS; and to improve the system by using experience from early developed stages as input to design and implementation of later stages.

Figures 8-1 and 8-2 show abbreviated schedules for each CAEADS stage in terms of system characteristics and applications programs.

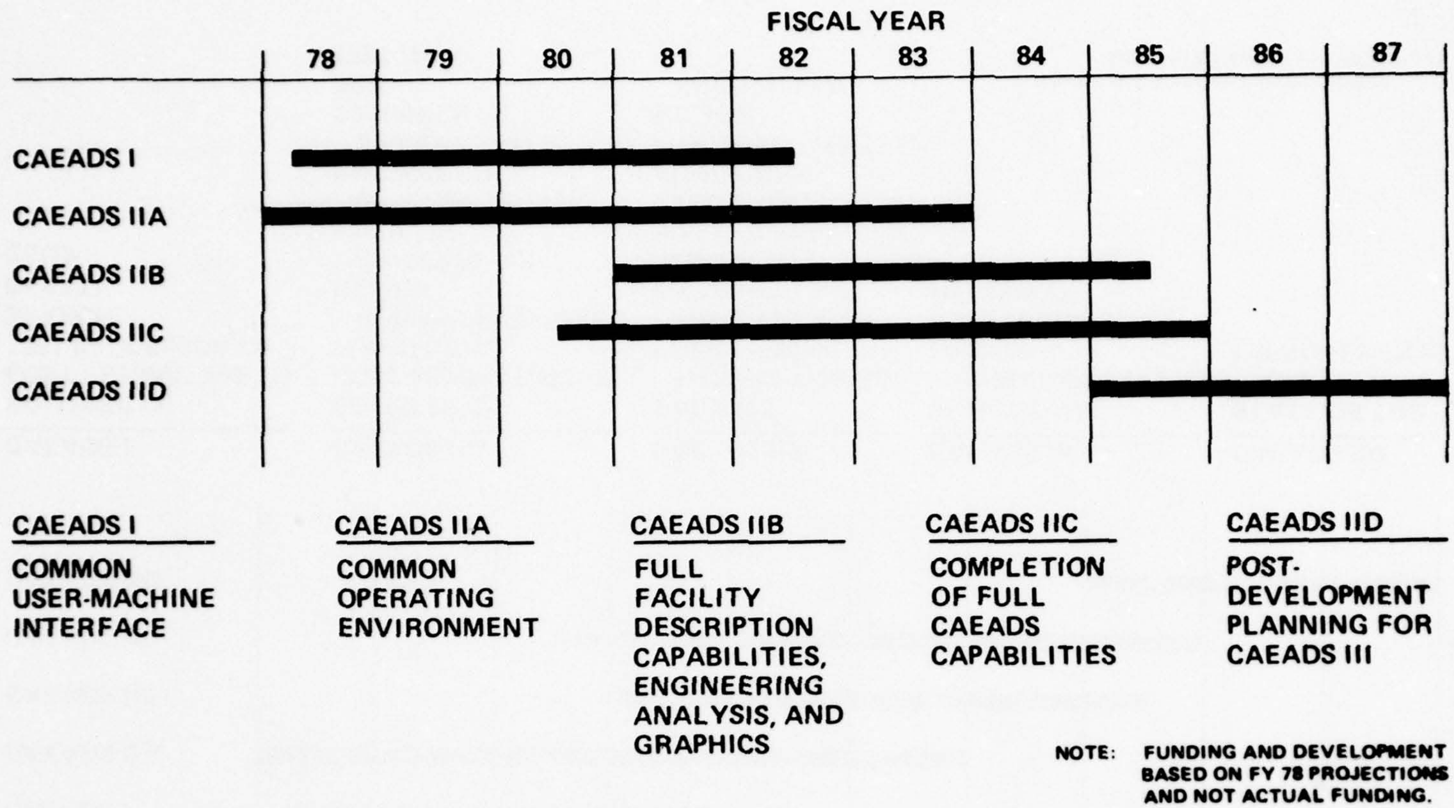
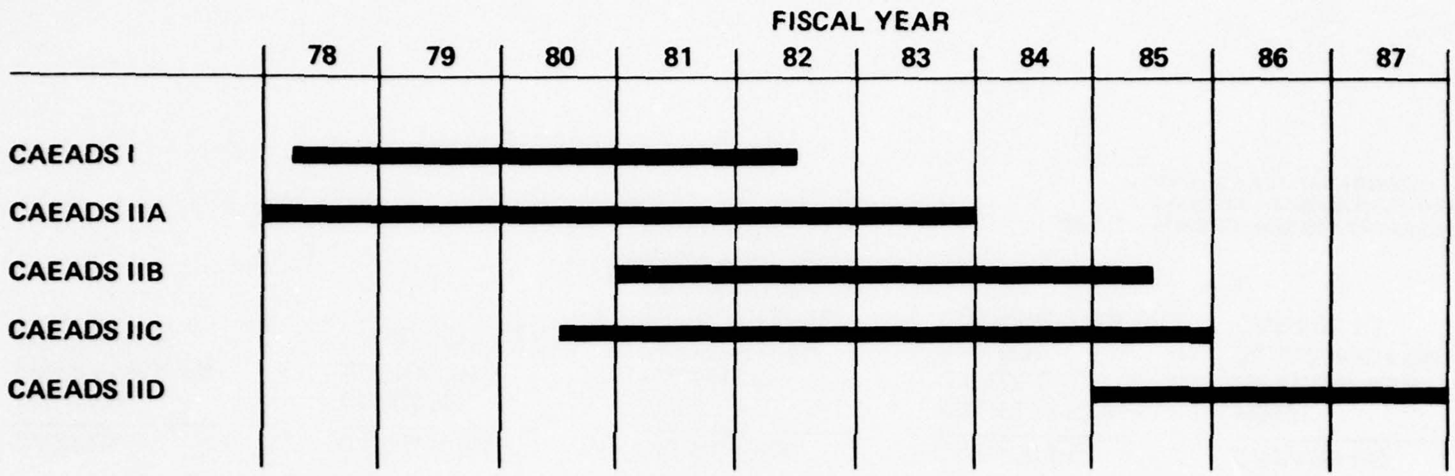


Figure 8-1. CAEADS master planning characteristics.



CAEADS I

EDITSPEC (1)
COST ESTIMATING (1)
1391 PROCESSOR (1)
SEARCH
BLAST
CEUP

CAEADS IIA

EDITSPEC (2)
COST ESTIMATING (2)
FUNCTIONAL
  REQUIREMENTS (1)
DESIGN
  CRITERIA (1)
FACILITY
  DESCRIPTION (1)
ENGINEERING
  ANALYSIS (1)
GRAPHICS (1)
PDB
1391 (2)

CAEADS IIB

FACILITY
  DESCRIPTION (2)
ENGINEERING
  ANALYSIS (2)
GRAPHICS (2)
REVIEW (1)
MASTER PLAN
  DATA BASE
FUNCTIONAL
  REQUIREMENTS (2)
DESIGN
  CRITERIA (2)

CAEADS IIC

FUNCTIONAL
  REQUIREMENTS (3)
DESIGN
  CRITERIA (3)
REVIEW (2)

CAEADS IID

STATE-OF-THE
  ART
IMPROVEMENTS

NOTE: NUMBERS IN PARENTHESES INDICATE LEVELS OF CAPABILITY

Figure 8-2. CAEADS master plan applications.

CHAPTER 9

PRELIMINARY HARDWARE/SOFTWARE ANALYSIS

a. Purpose and Scope. This chapter presents a CAEADS preliminary computer hardware/software configuration. System functional requirements are presented, a number of system alternatives are identified, analyzed, and discussed, and a baseline computer configuration for CAEADS is recommended.

b. Assumptions. For the purpose of the CAEADS preliminary system design, the following assumptions have been made.

(1) Data used for the workload analysis has been derived from the Corps 301-000 Master File. It has been assumed that Fiscal Years 1975 and 1976 are representative of CE construction activity.

(2) It was assumed that there would be no growth in either the number of projects, the average project cost, or the total construction activity over the time period covered by this study.

(3) Two system alternatives are based on the assumption that there will be a consolidation of project-independent functions. This consolidation results in the creation of regional centers servicing multiple districts.

(4) There are no constraints on the geographical location of computer resources other than placement within or close proximity to existing District Offices.

(5) The system requirements outlined in the GFSR and DFSR can be satisfied using present computer hardware and software technology.

(6) Computer hardware implementation will be consistent with the Project Master Plan (PMP) outlined in Volume VI.

c. Sources of Workload Data. The principal sources of input for this workload analysis include: Table 1 in Empirical Cost Estimates for Military Construction, AR-415-17; data extracted from the 301-000 Master File; data in Volumes III, IV, and V of this report; and various reference materials.

Data was available and collected covering a 2-year period, fiscal years 1975 and 1976. Table 9-1 tabulates the results of this analysis.

Average monthly workload requirements were computed by extending the Average Project Size by the Number of Projects and dividing the result by 24 (data covers a 2-year period).

Peak monthly workload requirements were determined to be 1.85 times the monthly average workload (Annex G, Volume IV, CAEADS Economic Analysis). The results of this analysis are tabulated in Table 9-2.

A statistical investigation was made on the significance that could be placed on the average project size data shown in Tables 9-1 and 9-2. It was concluded that:

(1) the average project size, Corps-wide, is a reasonable representation of a "typical" project;

(2) because of the approximate equality of a statistically significant average project cost of $1,148,083 and the average project cost figure of $1,250,000 described in Chapter 3, Volume IV, CAEADS Economic Analysis, the average project cost ($1,250,000) is used throughout the remainder of this analysis;

(3) a statistical analysis on the significance of the average project size for each District could not be conducted from the data available. It was assumed, however, that

Table 9-1

WORKLOAD VOLUME ANALYSIS OF CONSTRUCTION COSTS - FISCAL YEARS 1975 AND 1976
($ 000,000)

District	Number of Projects	Construction Costs	Project Size
Baltimore	170	$ 258.2	$1.519
Fort Worth	489	632.0	1.292
Mobile	180	234.2	1.301
New York	153	98.1	.641
Norfolk	166	247.3	1.490
Omaha/KC	605	402.0	.664
Sacramento/LA	246	281.6	1.145
Savannah	127	294.0	2.315
TOTAL	2,136	$2,447.3	$1.146

Table 9-2

MONTHLY WORKLOAD REQUIREMENTS OF CONSTRUCTION COST BY DISTRICT ($ 000,000)

District	Average Project Size	Average Monthly Cost	Peak Monthly Cost	Percent
Baltimore	$1.519	$ 10.760	$ 19.906	10.5%
Fort Worth	1.292	26.324	48.699	25.9
Mobile	1.301	9.758	18.052	9.6
New York	.641	4.086	7.559	4.0
Norfolk	1.490	10.306	19.066	10.1
Omaha/KC	.664	16.738	30.966	16.4
Sacramento/LA	1.145	11.736	21.712	11.5
Savannah	2.315	12.250	22.663	12.0
TOTAL	$1.146	$101.994	$188.689	100.0%

District average project sizes computed as arithmetic means reasonable representations.

d. Estimating Factors. The measurements of workload requirements expressed in construction dollars and shown in Table 9-2 were converted into computer processing requirements by the use of empirical estimating factors. These factors are square feet, number of drawings, number of pages of specifications, and the number of pages of cost estimates.

To convert construction cost dollars to square feet, an estimating factor was developed from the Empirical Cost Estimate Data by extending the square feet of each construction type by its respective unit cost and dividing the sum of the extended costs by the number of construction classes yielding the average cost in dollars per square foot. The estimating factor of $37.50 per square foot was derived in this manner.

Estimating factors for number of drawings, pages of specifications, and pages of cost estimates were derived from data gathered from DMJM's project reporting system. These data showed an empirical relationship between the above-mentioned factors and construction cost.

For example, it was found that a project approximating $1 million in construction cost would produce:

300 pages of specifications

115 drawings

67 pages of cost estimates

Workload volumes measured in square feet, pages of specifications, number of drawings, and pages of cost estimates are assumed to be valid estimators of computer processing requirements.

This method of developing workload requirements was chosen because of three equally important factors. First, available workload data was neither sufficiently complete nor specific for a detailed workload analysis. Second, CAEADS represents the first major effort of its type and there exists no standard or prototype system to use as a guide. Third, the present phase of CAEADS system development is not sufficiently complete to permit a detailed system design from which to generate precise hardware/software requirements.

e. Workload Forecast. Data collection and empirical estimating procedures were utilized to calculate an average monthly workload and a peak monthly workload for each District. The results of these computations are tabulated in Tables 9-3 through 9-6.

The percent distribution of computer processing requirements by the eight Districts is shown graphically in Figure 9-1. The percent distribution was calculated by dividing the Average Monthly Construction Cost for each District by the Total Monthly Construction Costs for the eight Districts as shown in Table 9-2.

f. System Alternatives. The alternatives outlined below are methods of organizing the various system components. Each alternative is made up of processors and connecting data lines. These alternatives have not been subjected to network analysis.

(1) Alternative 1: Districts Only. This alternative is based upon the existing structure of ADP in the Corps. It calls for upgrading of equipment where required, but it minimized changes in current procedures.

In this alternative, there are eight Districts with computers. Kansas City and Los Angeles would be linked via communications lines to Omaha and Sacramento, respectively. There are no regions in Alternative 1.

(2) Alternative 2: One Region. The second alternative calls for one regional ADP processing center supporting District-based CAEADS installations. A tentative regional location would be either Baltimore, Maryland, or Washington, D.C.

(3) Alternative 3: Two Regions. This alternative employs two regional ADP processing centers supporting District-based CAEADS installations. Tentative regional locations are Fort Worth, Texas, or Sacramento, California, in the west, and Baltimore, Maryland, in the east.

The two regions are the assigned computers for users in the various Corps Districts, with the

Table 9-3

CAEADS MONTHLY WORKLOAD REQUIREMENTS
BY PROJECT AREA
(Square Feet)

District	Average Project	Average Monthly Requirements	Peak Monthly Requirements
Baltimore	40,507	286,933	530,827
Fort Worth	34,453	701,973	1,298,640
Mobile	34,693	260,213	481,387
New York	17,093	108,960	201,573
Norfolk	39,733	274,827	508,427
Omaha/KC	17,707	446,347	825,760
Sacramento/LA	30,533	312,960	578,987
Savannah	62,000	326,667	604,347
TOTAL	32,000	75,946,667	140,501,330

A conversion factor of 37.5 was applied to the average project cost for each District to estimate average square feet requirements.

Table 9-4

CAEADS MONTHLY WORKLOAD REQUIREMENTS
IN PAGES OF SPECIFICATIONS

District	Average Project	Average Monthly Requirements	Peak Monthly Requirements
Baltimore	455.7	3,228	5,972
Fort Worth	387.6	7,897	14,610
Mobile	390.3	2,927	5,416
New York	192.3	1,226	2,268
Norfolk	447.0	3,092	5,720
Omaha/KC	199.2	5,021	9,920
Sacramento/LA	343.5	3,521	6,514
Savannah	694.5	3,675	6,799
TOTAL	375.0	30,598	56,607

A conversion factor of 300 pages per million dollars of construction cost was applied to the project cost for each District to estimate average pages of specifications.

Table 9-5

CAEADS MONTHLY WORKLOAD REQUIREMENTS
IN NUMBER OF DRAWINGS

District	Average Project	Average Monthly Requirements	Peak Monthly Requirements
Baltimore	175	1,237	2,289
Fort Worth	149	3,027	5,600
Mobile	150	1,122	2,076
New York	74	470	869
Norfolk	171	1,185	2,192
Omaha/KC	76	1,925	3,561
Sacramento/LA	132	1,350	2,497
Savannah	266	1,409	2,606
TOTAL	144	11,729	21,699

A conversion factor of 115 drawings per million dollars of construction cost was applied to the average project cost for each District to estimate the number of drawings.

Table 9-6

CAEADS MONTHLY WORKLOAD REQUIREMENTS
IN PAGES OF COST ESTIMATES

District	Average Project	Average Monthly Requirements	Peak Monthly Requirements
Baltimore	102	721	1,334
Fort Worth	87	1,764	3,263
Mobile	87	654	1,209
New York	43	274	506
Norfolk	100	690	1,277
Omaha/KC	44	1,121	2,075
Sacramento/LA	77	786	1,455
Savannah	155	820	1,518
TOTAL	84	6,834	12,642

A conversion factor of 67 pages per million dollars of construction cost was applied to the average project cost for each District given to estimate average pages of cost estimates.

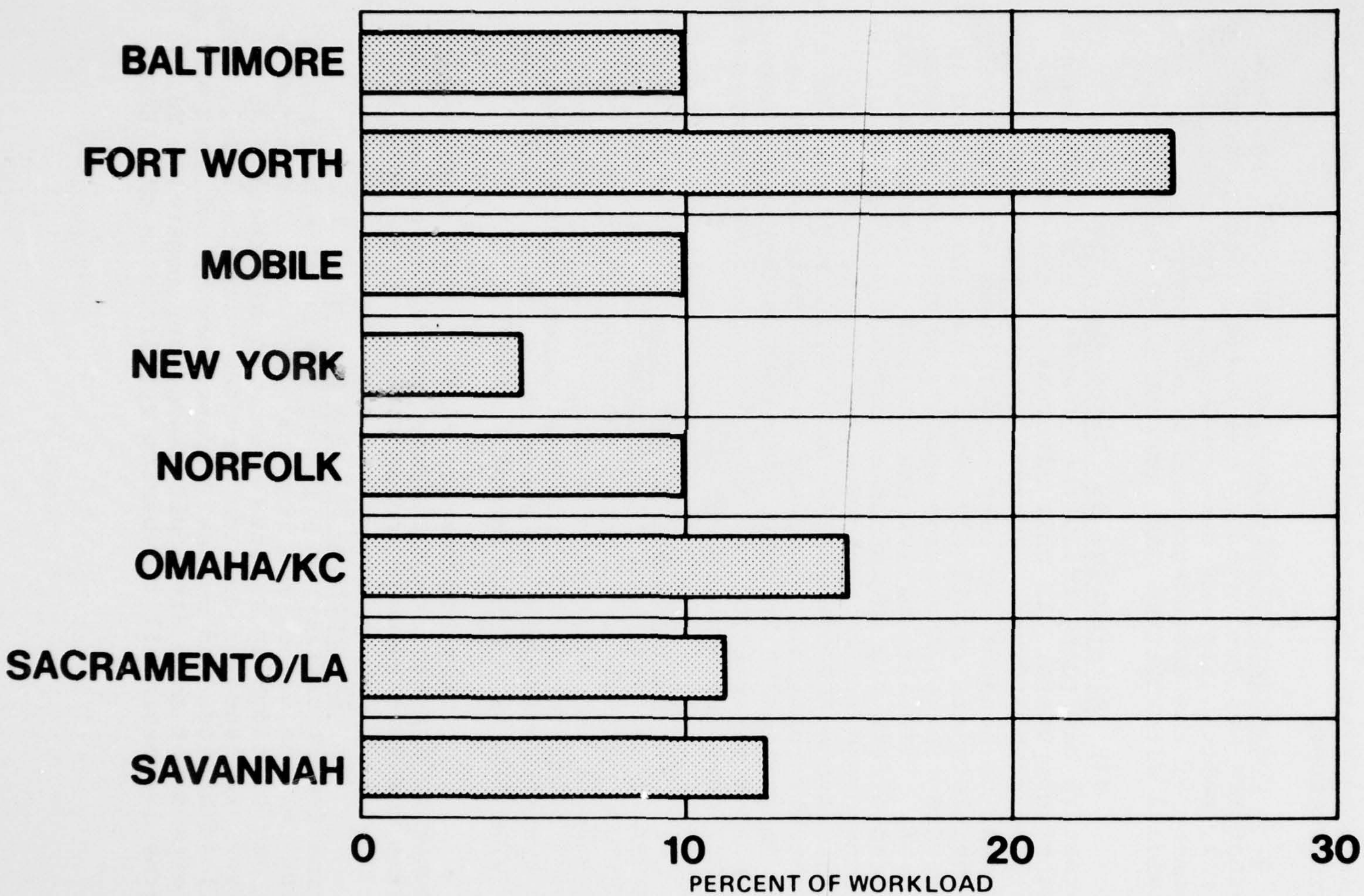


Figure 9-1. Work load distribution of CAEADS computer processing requirements by District.

assignments based on geographic and load-balancing considerations.

g. Comparison of Alternatives. Each of the three alternatives was evaluated on the basis of cost, management control, reliability and service level. The following is a summary of the advantages and disadvantages of the individual alternatives with respect to these factors.

(1) Alternative 1: Districts Only. This alternative has potentially the greatest mix of different kinds of computers. In this alternative the computers should be standardized. In reality they should be limited in number to account for varying workloads and compatibility. The computers are relatively small since the workload is widely distributed and large amounts of outside services are used. This alternative has the lowest communications cost and offers the advantage of minimal disruption of the existing organization structure. Achieving a balanced workload among ADP centers may be difficult with this alternative, and roughly identical computers to all Districts may be found impractical. Further, this configuration as presently defined has no facility for data communications between the District computer centers and OCE.

(2) Alternative 2: One Region. This alternative is based on the assumption that there will be a consolidation of certain project-independent functions which will be processed by the regional computer. It offers improved possibilities for workload balancing, and standardization of computer configurations among Districts along with the best opportunity for management control.

This alternative calls for a large regional computer to support District-based installations and would realize the advantages associated with economy of scale.

(3) Alternative 3: Two Regions. This alternative is similar in all respects to Alternative 2 except for the use of two regional processors. Communications cost may be slightly greater than with Alternative 2; however, reliance on outside services would be less. Better workload balance and system response may be achieved but at the expense of more difficult management control. This alternative meets all the backup requirements of CAEADS.

h. Baseline Hardware/Software Configuration. The configuration upon which this analysis is based is derived from Alternative 3, as described in the previous section.

Hardware/software operating specifications for the District computer have been patterned after similar computer configurations operating at Applied Research of Cambridge, Cambridge, England (developers of the OXSYS System); Evans and Sutherland Computer Corporation, Salt Lake City, Utah (developers of the E&S Design System); and Carnegie-Mellon University, Pittsburgh, Pennsylvania (developers of the BDS/GLIDE System)[25].

(1) District Baseline Computer Configuration. Each District computer center will house one or more identical computer configurations. The standardization of the District computer configuration will permit maximum use of common programs and total portability of work between Districts. Workload variations will be handled by duplicating the standard configuration as many times as is necessary to meet each District's requirements.

Standard Configuration. The standard District computer configuration is proposed as follows:

- 512K characters of main memory
- 1 300 LPM, high-speed printer
- 2 magnetic tape drives (800 bpi @ 45 ips)
- 320 million characters of disc storage
- 1 line controller
- 1 plotter
- 16 asynchronous lines
- 1 RJE line
- 5 work stations (each consisting of 1 TTY terminal, 1 CRT display unit, and 1 digitizer)
- COBOL/FORTRAN/RPG compilers
- Communications software.

---

[25] Mitchell, W.J., Oliverson, M., Computer Representation of Three-Dimensional Structures for CAEADS, Technical Report P-86/ADA052040 (U.S. Army Construction Engineering Research Laboratory, February 1978).

The plotter may not necessarily be duplicated even though the District may require more than one standard configuration. The specific number of plotters is subject to additional study.

<u>Capacity</u>. The standard District configuration is capable of handling up to 15 projects representing 6,400,000 square feet of construction design, and processing 63 simultaneous user operations.

<u>District Computer Requirements</u>. The expected throughput capacity of the standard District computer configuration is stated in paragraph (2), above. To determine the number of standard configurations required to process the workload for each District requires an analysis of the many factors involved and the selection of the proper number based on the most limiting factor.

Table 9-7 shows the number of standard computer configurations required by each District to meet its projected workload. In each case where two or more configurations are recommended, the limiting factor was the throughput capacity of the workstations. This would suggest that further detailed study of the workload requirements might modify the standard District computer configuration described in paragraph (1).

(2) <u>Regional Baseline Computer Configuration</u>. The regional large-scale computer configuration will incorporate scientific/engineering and general data processing capabilities. The regional computer will be data linked to the District minicomputers and will be capable of accepting requests for processing from the District computer, as well as directing data from the regional data bases to the District data base for local use.

The regional computer should possess the following features:

Machine cycle time in the 75-100 nanosecond range.

Virtual main storage in the 16 million character range.

High speed I/O channel capability.

Table 9-7

DISTRICT COMPUTER REQUIREMENTS

District	Number of Projects	Number of Projects Active Monthly	Required Number of Computers
Baltimore	170	48	3
Fort Worth	489	137	7
Mobile	180	51	3
New York	153	43	2
Norfolk	166	47	2
Omaha/KC	605	169	9
Sacramento/LA	246	69	4
Savannah	127	36	2
TOTALS	2,136	600	32

Full complement of basic I/O units (readers, punches, printers, and visual displays).

Direct access external storage of 1,000 million characters.

Communications controllers (CPU-independent)

I/O controllers (CPU-independent)

Universal instruction set with hardware extended floating point operations.

The IBM 3033 series, Amdahl 470V/6, Burroughs B7800, and Itel AS/6 are examples of configurations in this class.

(3) Software Requirements. The software requirements of CAEADS are classified into (1) operating systems, (2) data base management systems, and (3) applications software. Each type of software is described below.

Operating System Software. This software will be provided with the hardware configuration described in the previous sections. In the case of the District computers, operating and control system software will control interactive processing, background processing of analysis jobs, and communications with external service bureaus. In the case of the regional computers, operating and control system software will control the processing of large batch jobs, communications with District computers and communications with external service bureaus. Unless system requirements for CAEADS change substantially, no special software development or procurement will be necessary for operating system functions.

Data Base Management Software. In order to generate and maintain the CAEADS data bases, data base management software (DBMS) will be required. In the case of tabular data bases, well-defined standards exist and several products are available to choose from. Similar standards and products do not exist for text and geometric data bases. DBMS to handle these types of data bases may have to be developed if not commercially available.

Applications Software. Software must be provided for the major subsystems. In some cases this software is already developed or under development. In other cases a competitive procurement may be necessary to acquire the requisite software, or the software may have to be developed. In a few cases the requirements for applications software will be satisfied by external computer service bureaus. Some of the applications areas are: Specifications, Project Definition, Data Base Management, Facility Description, Engineering Analysis and Synthesis, Cost Estimating, and Graphics.

i. Conclusions. The following are some of the more significant findings affecting the specification of preliminary hardware/software requirements for CAEADS:

(1) System Functions. The system functions extracted from the CAEADS information flow were sufficient to provide a gross estimate of computer processing requirements.

(2) Quality of Workload Data. Data regarding MC design and construction activity at the Corps level is adequate for the establishment of preliminary workload requirements. However, data on District activity consisted only of the number of projects and the construction cost associated with those projects. It is inadequate for detailed analysis and additional data is required before further analysis can be performed.

(3) Estimating Factors. The estimating factors extracted from AR-415-17 and the standard practices manual of DMJM provided a sound basis for developing an empirical estimate of computer processing requirements.

(4) System Alternatives. Two alternatives are based on an assumption that there will be a consolidation of project-independent computer processing functions. This consolidation results in the creation of regional centers servicing multiple Districts. Establishment of such centers may require HDQA or a higher authority approval.

(5) Baseline Computer Configurations. As a result of observations at selected installations, the proposed District computer configurations are reasonable representations of working configurations responsive to

CAEADS. The regional computer configurations are off-the-shelf items readily available from multiple sources.

(6) Software Requirements. CAEADS is software dependent. The keystone of CAEADS is the Facility Descriptor. Three versions of similar software exist, any of which could be adopted to CAEADS.

j. Recommendations. Based on the findings of the study and analysis of workload, the following recommendations were reached.

(1) There should be a detailed review of historical volume information and planned Corps construction activity in order to better determine the capacity requirements for the hardware/software configurations.

(2) There should be an on-site review with potential users of CAEADS. Variations and recommendations should be noted, evaluated and adopted, if advisable, before detail design begins.

(3) There should be regularly scheduled periodic review of further system development efforts to insure compatibility between the currently defined hardware/software requirements and any new requirements possibly imposed by system design decisions.

CHAPTER 10

ORGANIZATION AND PERSONNEL PLAN

a. Purpose and Scope. The Organization and Personnel Plan (OPP) presents sufficient manpower and qualitative personnel information to enable OCE to foresee strength and skill changes resulting from CAEADS.

For CAEADS, Department of the Army Table of Equipment and Table of Distribution and Allowances (TOE/TDA) documents are unaffected. Only Corps equipment and personnel are directly affected. Uniformed military personnel are affected negligibly, if at all. Training will be done by the Corps, for both the Corps and other Army agencies, and will not affect other Department of the Army training programs.

b. Approach. The following major assumptions are made for the OPP.

(1) Base Years. The base years for strength and skill changes are:

(a) Current year FY77

(b) The first year CAEADS is forecasted to be in reasonably steady-state operation FY87

(2) Construction, Operation, and Maintenance Benefits.

(a) Annual construction and operation savings (no maintenance savings) $10,000,000

(b) Supervision and administration cost rate 5%

(c) Average construction employee is GS 10/2; annual cost with fringe benefits and overhead is - $30,000

(3) Engineering and Design Benefits.

(a) Annual engineering and design savings	None
(b) Annual added computer machine costs offset by reduced manpower costs	$2,500,000
(c) In-house design percentage of total design	20%
(d) Design cost as a percent of construction cost	6%
(e) Government Architect/Engineer (A/E) contract management cost as a percent of A/E contract cost	33 1/3%
(f) Average engineering and design employee is GS 11/5; annual cost with fringe benefits and overhead is -	$36,000

(4) Construction Workload.

(a) Total annual military construction program (less Saudi Arabia), FY87	$1,800,000,000
(b) Percentage of total program (no Saudi Arabia) to be automated by FY87	66 2/3%

(5) Hardware Support.

(a) Large regional computers	2
(b) Small local computers	20

(6) Manpower Support - Automatic Data Processing (ADP).

(a) Available Aug 77 in affected installations	239
(b) CAEADS computer program and data base maintenance personnel, FY87	32
(c) Contractor personnel	0

c. Tables. Subparagraphs (1) and (2) below are the titles of OPP tables, as described by AR 18-1 (Figures G-1 and G-2 of the AR). Figure G-3 (Section III: Estimated Ancillary Equipment Requirements) does not pertain to this OPP. The OPP table cited in subparagraph (1) summarizes the contents of the OPP table cited in subparagraph (2). The OPP table in subparagraph (2) is supported by tables listed in subparagraphs (3) and (4). The OPP table of subparagraph (4) is supported, in turn, by tables cited in subparagraphs (5), (6), and (7).

Subparagraphs (1) and (4) are of more general interest and are reproduced herein as Tables 10-1 and 10-2. In Table 10-1, A08 is add 8, and M30 is minus 30.

(1) Organization and Personnel Plan - Section I: Estimated Civilian Manpower Requirements. (Reproduced as Table 10-1.)

(2) Organization and Personnel Plan - Section II: Civilian Personnel and Civilian Classification Distribution. (Not reproduced herein.)

(3) Corps of Engineers Data Processing Installations Manpower (Aug 77) (installations which will support CAEADS). (Not reproduced herein.)

(4) Planned Organizational Changes, Gains, and Losses by Specialty and Organization. (Reproduced as Table 10-2.)

(5) CAEADS Data Processing Installation (DPI) Operator and Support Personnel (Production Manpower). (Not reproduced herein.)

(6) CAEADS DPI Support Personnel (Computer Program and Data Base Maintenance Manpower). (Not reproduced herein.)

(7) Planned Organizational Changes. (Not reproduced herein.)

d. Results. Summary estimates of the eventual CAEADS impact on the Corps of Engineers organization and personnel are given below. The estimates, based on many assumptions regarding future events, should prove to be reliable mean values; the eventual figures might be two-thirds to three-halves the values shown.

Table 10-1. Organization and Personnel Plan
Section I: Estimated Civilian Manpower Space Requirements

Category	Personnel
A. Current Organization - Available Manpower	
1. DPI Operator and Maintenance Personnel (see Table 3-2)	99
2. DPI Support Personnel (see Table 3-2)	140
3. Other Support Personnel	0
4. Total Available Manpower Spaces	239
B. Estimated Manpower Requirements to Support this GFSR	
1. DPI Operator and Maintenance Personnel (see Table 3-2)	131
2. DPI Support Personnel (see Table 3-2)	188
3. Other Support Personnel	0
4. Total Manpower Space Requirement	319

C. Planned Organizational Changes (see Table 3-4)

	Organization	Engrg	Constr	ADP	Net
1.	SWD	-	-	A08	A08
2.	EDPC	-	-	A43	A43
3.	CERL	-	-	A03	A03
4.	MRO	M30	M04	A04	M30
5.	NAB	M10	M01	A03	M08
6.	NAN	M09	M01	A03	M07
7.	NAO	M09	M01	A03	M07
8.	SAM	M10	M02	A03	M09
9.	SAS	M08	M01	A03	M06
10.	SPK	M09	M02	A03	M08
11.	SWF	M29	M04	A04	M29
	Total	M114	M16	A80	M50

1. Available Manpower (line A-4)	239
2. Estimated Requirements (line B-4)	319
3. Organizational Changes (total of part C)	130
4. Impact of GFSR Changes	
a. Additional Requirements	0
b. Savings (lines D-1 plus D-3 less D-2)	50

Table 10-2. Planned Organizational Changes, Gains, and Losses by Specialty and Organization (See Tables 2-1, 2-2, and 2-3)

Category / Specialty	Grade	Organization: SWD	EDPC	CERL	MRO	NAB	NAN	NAO	SAM	SAS	SPK	SWF	Tot
Gains: DPI Op and Maint Pers (See Table 2-1)													
Supervisory Computer Operator	8	1	1										2
Computer Operator	7	1	1										2
Computer Operator	6	1	1										2
Computer Operator	5		1	1	1	1	1	1	1	1	1	1	10
Computer Aid/Technician	5	2	2										4
Peripheral Operator	3	1	2	1	1	1	1	1	1	1	1	1	12
Subtotals		6	8	2	2	2	2	2	2	2	2	2	32
Gains: DPI Support Pers (See Table 2-1)													
Computer System Analyst	12	1	2		1							1	5
Computer System Analyst	11			1		1	1	1	1	1	1		7
Computer Programmer	11	1	1		1							1	4
Subtotals		2	3	1	2	1	1	1	1	1	1	2	16
Gains: DPI Support Pers (See Table 2-2)													
Supv Computer System Analyst	13		1										1
Computer System Analyst	12		1										1
Computer Programmer	12		3										3
Engineer	12		1										1
Computer System Analyst	11		2										2
Computer Programmer	11		9										9
Engineer	11		2										2
Computer Programmer	9		3										3
Engineer	9		1										1
Computer Programmer	5		1										1
Computer Aid	4		2										2
Data Transcriber	4		2										2
Data Transcriber	3		4										4
Subtotals			32										32
Subtotals DPI Support Pers		2	35	1	2	1	1	1	1	1	1	2	48
Total Gains		8	43	3	4	3	3	3	3	3	3	4	80
Losses: Engrg and Des Pers (See Table 2-3)													
Engineer	12				8	2	2	2	2	2	2	8	28
Engineer	11				10	3	3	3	3	2	3	9	36
Engineer	9				4	2	1	1	2	1	1	4	16
Engineer	7				2	1	1	1	1	1	1	2	10
Engineering Draftsman/Tech	7				6	2	2	2	2	2	2	6	24
Subtotals					30	10	9	9	10	8	9	29	114
Losses: Construction Pers (See Table 2-3)													
Engineer	11				2	1/2	1/2	1/2	1	1/2	1	2	8
Construction Rep/Inspector	9				2	1/2	1/2	1/2	1	1/2	1	2	8
Subtotals					4	1	1	1	2	1	2	4	16
Total Losses					34	11	10	10	12	9	11	33	130
Net Gains or Losses		8	43	3	-30	-8	-7	-7	-9	-6	-8	-29	-50

Engineering positions		
Upgraded, transferred, or eliminated	800	(100%)
Upgraded to some extent	686	(86%)
Transferred to ADP	80	(10%)
Eliminated	34	(4%)
Construction positions eliminated	16	
Spaces transferred geographically	54	

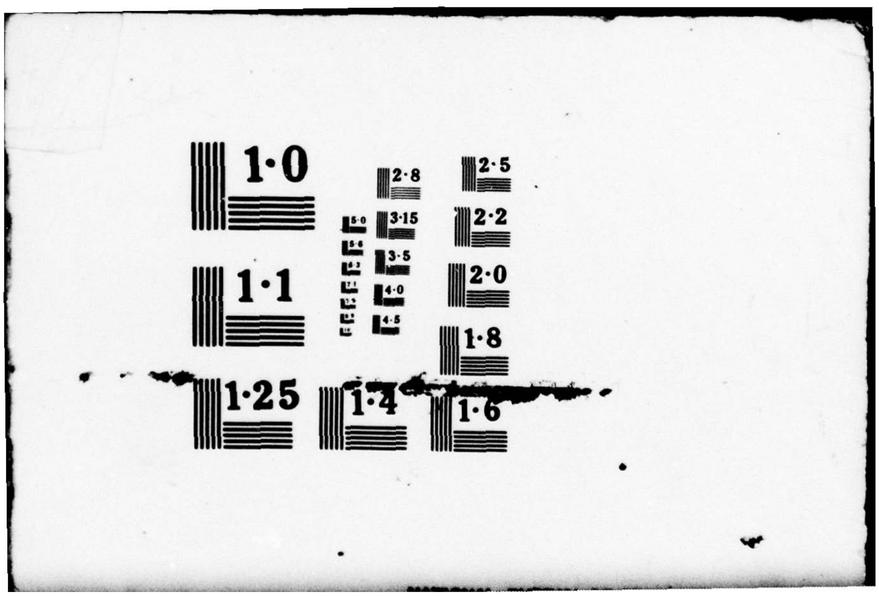
The transfer of 10 percent of the military engineering and design professional and technical positions to ADP over the next 10 years represents a 9 percent increase in Corps ADP assigned manpower. Of 858 Corps ADP employees, 523 are now in organizations which will certainly support CAEADS.

AD-A067 719 CONSTRUCTION ENGINEERING RESEARCH LAB (ARMY) CHAMPAI--ETC F/G 13/2
COMPUTER-AIDED ENGINEERING AND ARCHITECTURAL DESIGN SYSTEM (CAE--ETC(U)
JAN 79 DANIEL, MANN, JOHNSON, MENDENHALL DACA87-77-C-0009

UNCLASSIFIED CERL-TR-P-97-VOL-2 NL

2 OF 2
ADA
067719

END
DATE
FILMED
6-79
DDC


1·0
2·8
2·5
3·15
2·2
3·5
2·0
4·0
4·5
1·8
1·1
1·25
1·4
1·6

CHAPTER 11

RESULTS, CONCLUSIONS, AND RECOMMENDATIONS

a. Results. AR 18-1 Planning and Definition Phase documentation (functional and resource) requirements have been produced and are summarized below.

(1) The updated GFSR clarifies the scope of CAEADS to include support for the three phases of MC design identified and described in Chapter 3.

(2) The CAEADS Economic Analysis compared the current Corps MC design system with two alternatives: uncoordinated applications packages (stand-alone systems) and an Integrated CAEADS. CAEADS was found to have a significantly greater benefit than the other alternatives.

(3) The DFSR provides a comprehensive presentation of the MC design functions by project phase, activity area, and discipline. This presentation provides a reasonable picture of the overall scope of CAEADS information processing requirements for direct support of MC design tasks. It also furnishes estimates of system workloads based upon the requirements of a typical project. The requirements are not intended to be the basis for the development of individual CAEADS applications subsystems, nor are they adequate for that purpose. Rather they are to be the basis for advanced system design by identifying the portions of the overall system for which common software modules need to be developed and by suggesting the kinds of internal interfaces to be specified by the system designers.

(4) The Project Master Plan identifies and describes the tasks required for the development, implementation, and use of CAEADS over the next 12 years (see Chapter 8).

(5) The Preliminary Hardware/Software Analysis identifies the equipment capacity required for processing CAEADS workload. It also compares alternate hardware configurations and locations and concludes that a network of District Office minicomputers linked to a biregional processing center is the most desirable alternative.

(6) The Organization and Personnel Plan presents manpower space requirements, and position classification distribution estimates.

b. Conclusions.

(1) CAEADS development and implementation are confirmed to be technically feasible. The most technically demanding area is the three-dimensional facility description data base. The development of this capability is likely to require some advances in the state of the art before full implementation can be realized, but existing software which can provide a base for further development has been identified in a related study[26].

(2) The successful development of CAEADS requires the adoption of design and programming standards for the entire system and all constituent subsystems. This will assure a common manner of user interaction with all parts of the system and provide maximum sharing of software modules among subsystems in the interest of commonality, flexibility, extensibility, and reliability.

(3) Continued management commitment at OCE and CERL will remain critical for CAEADS, just as they are critical for any project of the scope and complexity of CAEADS. Beginning with the approval of the DFSR and PMP, continuity of the CAEADS design team and uninterrupted effort toward system design and implementation, and adherence to the action plan are especially important.

---

[26] Mitchell, W.J., Oliverson, M., Computer Representation of Three-Dimensional Structures for CAEADS, Technical Report P-86/ADA 052040 (U.S. Army Construction Engineering Research Laboratory, February 1978).

(4) The Economic Analysis indicates that design and construction benefits resulting from implementation and use of CAEADS will exceed costs by a significant ratio. Benefits result from reduced design effort, fewer design errors, and reduced construction costs.

(5) After CAEADS has been implemented, an eventual reallocation of resources among the two design phases is expected. More analysis of alternatives during Concept Design can be anticipated. As life cycle cost comparisons and building energy analyses become routine for all but the smallest projects, more extensive analyses based on more detailed definition of building subsystems are likely during Concept Design. There will be a corresponding reduction in the effort devoted to Final Design as most construction drawings will be produced directly from the computer-resident Facility Description.

(6) Additional experience is needed with the application of computer aids to the specifics of Corps design practice, as well as the human factors involved in interacting with computer-resident design information and procedures, in order to confirm and supplement the results of this study. Feedback from carefully designed studies of existing systems in use on selected Corps projects can contribute to the advanced system design of CAEADS and can supply better system workload data for both the existing and the proposed systems.

c. Issues to Be Resolved. Major policy issues relating to the use of CAEADS by architectural and engineering firms under contract with CE need to be addressed. These include determination of how contractor equipment will be paid for, charges for contractor use of CAEADS software on CE projects, source and amount of contractor personnel training, and the amount of technical support provided to the contractor by CE. These issues are extremely important in view of the fact that approximately 80 percent of Corps workload is performed by outside A/E firms under contract to the various CE District Offices.

Issues regarding A/E access to CAEADS functions, whether A/Es will be required to set up their own terminals in their offices, will use centrally located terminals in Corps offices, or whether A/E firms will have access to

CAEADS at all need to be carefully evaluated and policy recommendations formulated.

d. Recommendations.

(1) The development of the integrated CAEADS should proceed in accordance with the proposed Project Master Plan.

(2) The Corps of Engineers should continue its present commitment of resources to CAEADS, including allocation of high-level management responsibility. CAEADS is a large project and will not be implemented successfully without a major commitment to control, coordinate, and fund its development.

(3) End users, especially District Offices, should continue to be consulted frequently during CAEADS advanced design and development. The experience of users with various prospective subsystems and the recommendations of users will continue to be valuable inputs to system development.

(4) An advisory group from the private sector consisting of Architects/Engineers, suppliers of engineering software and processing services, and computer-aided design system developers in related fields should be formed to play a role similar to that of the Field Users Advisory Group, representative Goverment users (Corps Division and District Offices and Major Army Commands), a permanent group established by OCE.

(5) Separate economic analyses and DFSR's or equivalent documents should continue to be required for prospective and new CAEADS subsystems. These documents should conform to the overall requirements of CAEADS.

(6) The design of new CAEADS subsystems, the programming of subsystems for which design has been completed, and the implementation of existing systems intended for incorporation in CAEADS should be deferred until the CAEADS design and programming standards have been prepared and adopted. Systems ready to be field tested should proceed with those tests so that the results can contribute to the design of CAEADS.

(7) Policies for access to and use of CAEADS by A/E firms should be developed by OCE in close consultation with the user advisory groups. There appear to be significant unresolved issues related to the extensive introduction of effective, publicly developed computer aids into existing professional practice.

(8) An available design system which incorporates some of the capabilities required by CAEADS should be procured for controlled use and experimentation on Corps projects in a Corps District for a limited time. This usage will serve as a basis for development and confirmation of workload data, further definition of user interface requirements, and more definitive determination of the state of the art upon which the design strategy and advanced system design for CAEADS must be based.

ANNEX A

TABLES OF CONTENTS FOR ALL VOLUMES

TABLES OF CONTENTS

TABLES OF CONTENTS

(VOLUME I, continued)

TABLES OF CONTENTS (continued)

TABLES OF CONTENTS

(VOLUME II, continued)

TABIES OF CONTENTS

(VOLUME II, continued)

TABLES OF CONTENTS (continued)

TABLES OF CONTENTS

(VOLUME III, continued)

TABLES CF CONTENTS

(VOLUME III, continued)

TABLES OF CONTENTS

(VOLUME III, continued)

TABLES OF CONTENTS

(VOLUME III, continued)

TABLES OF CONTENTS

(VOLUME III, continued)

TABLES OF CONTENTS

(VOLUME IV, continued)

TABLES OF CONTENTS

(VOLUME V, continued)

TABLES OF CONTENTS

(VOLUME VI, continued)

TABLES OF CONTENTS

(VOLUME VII, continued)

TABLES OF CONTENTS

(VOLUME VII, continued)

TABLES OF CONTENTS

(VOLUME VIII, continued)

ANNEX B

TERMINAL TYPES - INPUT/OUTPUT MEDIA

ANNEX B

TERMINAL TYPES - INPUT/OUTPUT MEDIA

REQUIRED INPUT MEDIA

Text Entry. Entry of a page of text, 60 character * 50 lines. Unit = text page (3000 characters).

Display Entry. Entry of a page of display, consisting of alphanumeric character set, multiple character sizes, 90 degree character rotation, column and row delineation; black and color on white. Unit = display page (1500 characters).

Graphic Entry. Entry of a 10 1/2" * 10 1/2" vector graphic image, consisting of 4000 vectors, 2.5 mil resolution, with eight line widths; labeled with full alphanumeric character set, multiple character sizes, and all character orientations. Unit = graphic image (20000 characters).

Text Edit. Alphanumeric entry of commands for addition, modification, deletion of a text page. Unit = user contact hours.

Display Select. Alphanumeric entry and direct selection of table elements as a means for identifying and/or giving information about an 8" * 10 1/2" display page. Unit = user contact hour.

REQUIRED OUTPUT MEDIA

Text Softcopy. 8" * 10 1/2" page display with full alphanumeric character set, 60 characters * 50 lines; 1 second page regeneration; black on white, and white on black. Unit = user contact hour.

Display Softcopy. 8" * 10 1/2" page display with full alphanumeric character set, multiple character sizes, 90 degree character orientations, column and row delineation for schedules; 1 second page regeneration; black and color on white. Unit = user contact hour.

<u>Graphic Softcopy</u>. 10 1/2" * 10 1/2" vector graphics image, 4000 vectors, 2.5 mil resolution, with eight line widths/intensities; labeled with full alphanumeric character set, multiple character sizes, and all character orientations; 2 second image regeneration; simultaneous display of 10 1/2" * 8" vector graphic image, similar capabilities, 15 second image regeneration. Black on white or white on black. Unit = user contact hour.

<u>Text Print</u>. 8" * 10 1/2" paper hardcopy, with full alphanumeric character set, 60 characters * 50 lines; black on white. Unit = text page (3000 characters).

<u>Graphic Plot</u>. Vector graphic hardcopy, capable of economical reproduction to 46" * 36", 80000 vectors, 2.5 mil resolution, with eight line widths; labeled with full alphanumeric character set, multiple character sizes, all character orientations. Unit = graphic image (10 1/2" * 10 1/2" segment, 20000 characters).

REFERENCES

AEADS II Cost-Benefit Analysis (SAGE, June 1976).

AR 18-7, Management Information Systems: Data Processing Installation Management, Procedures, and Standards (Department of the Army, 22 March 1976).

Bryant, D.A., Dains, R.B., Spoonamore, J.H., Structure of SEARCH-2, Letter Report D-55 (U.S. Army Construction Engineering Research Laboratory, June 1975).

The Building Loads Analysis and System Thermodynamics (BLAST) Program Volume I: User Instructions, Technical Report E-119/ADA048734 (U.S. Army Construction Engineering Research Laboratory, February 1977).

CSCM 18-1, Automated Data Processing System Development, Maintenance, and Documentation Standards and Procedures Ms Manual Vol. I, General, Chap. 6, "Documentation Standards" (Department of the Army).

DOD 4120.17-M, Automated Data Systems: Documentation Standards Manual (Hq. U.S. Air Force, 1975).

Eastman, C.M., Feasibility and a Proposed Development of AEADS II (April 1976).

Empirical Cost Estimates for Military Construction and Cost Adjustment Factors, AR 415-17 (Headquarters, Department of the Army, January 1975).

Federal Information Processing Standards (FIPS) Publication 38, Guidelines for Documentation of Computer Programs and Automated Data Systems (U.S. Department of Commerce/ National Bureau of Standards, 1976).

General Functional System Requirement (GFSR) for Automated Engineering and Architectural Design System (AEADS) (U.S. Army Construction Engineering Research Laboratory, November, 1973).

Heydt, G.T., Sauer, P.W., A Manual for the Use of the CERL Distribution Power Study Program Version 1.00 (Purdue University, School of Electrical Engineering, June 1976).

Johnson, J.H., Information Flow for Military Construction, Interim Report ADS-2/ADA033363 (U.S. Army Construction Engineering Research Laboratory, October 1976).

Kenney, T.A., Users Manual for Computerized Information on Industrialized Building System, Draft (U.S. Army Construction Engineering Research Laboratory).

Lapp, R.C., Kirby, J.G., Engineering and Design Performance Analysis, Interim Report C-75/ADA035208 (U.S. Army Construction Engineering Research Laboratory, December 1976).

Lev, O.E., Stellhorn, W.H., Preparation and Review of DD Form 1391, Technical Report P-69/ADA027585 (U.S. Army Construction Engineering Research Laboratory, June 1976).

Logcher, R.D., A Conceptual Design of the Computer-Aided Environmental Legislative Data System, Technical Report E-78/ADA019018 (U.S. Army Construction Engineering Research Laboratory, November 1975).

Mitchell, W.J., Oliverson, M., Computer Representation of Three-Dimensional Structures for CAEADS, Technical Report P-86/ADA052040 (U.S. Army Construction Engineering Research Laboratory, February 1978).

Neeley, Edgar S., Construction Specification Preparation Within the EDITSPEC System, Technical Report P-84/ADA045183 (U.S. Army Construction Engineering Research Laboratory, September 1977).

REFERENCES (Cont'd)

Oliverson, M., A Conceptual Design for an Automated Engineering and Architectural Design System (AEADS II) (Applied Research of Cambridge [Canada] Ltd., April 1976).

Urban, L.V., Balbach, H.E., Jain, R.K., Novak, E.W., Riggins, R.E., Computer-Aided Environmental Impact Analysis for Construction Activities: User's Manual, Technical Report E-50/ADA008988 (U.S. Army Construction Engineering Research Laboratory, March 1975).

Weinzapfel, G., Evaluation of Need, Outline of Criteria and Recommendations for Procurement of Automated Drafting Systems for O.E.E. District Office Implementation (Draft) (March 1977).

Westervelt, F.H., AEADS II Conceptual System Design - Design Memorandum (April 1976).

Chief of Engineers
ATTN: Tech Monitor
ATTN: DAEN-ASI-L (2)
ATTN: DAEN-MPO
ATTN: DAEN-MPZ-A
ATTN: DAEN-MPR
ATTN: DAEN-ROL
ATTN: DAEN-DS (2)
ATTN: DAEN-DSE
ATTN: DAEN-MPE
ATTN: DAEN-MPE-B
ATTN: DAEN-MPE-T
ATTN: DAEN-MPE-I
ATTN: DAEN-MPE-S
ATTN: DAEN-MPE-E

US Army Engineer District
Saudi Arabia
ATTN: Library
New York
ATTN: Chief, Design Br.
Baltimore
ATTN: Library
ATTN: Chief, Engr Div
ATTN: Mr. Enn Veskimets
Norfolk
ATTN: Library
ATTN: Chief, NAOEN-D
Savannah
ATTN: Library
ATTN: Chief, SASAS-L
Mobile
ATTN: Library
ATTN: Chief, SAMEN-C
ATTN: Mr. George L. Phillips, Jr.
Kansas City
ATTN: Library (2)
ATTN: Chief, Engr Div
Omaha
ATTN: Chief, Engr Div
ATTN: Mr. Ornell H. Asleson
Fort Worth
ATTN: Library
ATTN: Mr. Robert D. Duvall
ATTN: Mr. Paul Schwartz
Los Angeles
ATTN: Library
ATTN: Chief, SPLED-D
Sacramento
ATTN: Library, Room 8307
ATTN: Chief, SPKED-D
ATTN: Mr. E. G. Jones
Far East
ATTN: Chief, Engr Div
Alaska
ATTN: Library
ATTN: Chief, NPADE-R

US Army Engineer Division
Europe
ATTN: Technical Library
North Atlantic
ATTN: Chief, NADEN-T
Middle East (Rear)
ATTN: MEDED-T
South Atlantic
ATTN: Chief, SADEN-TA
ATTN: Library
ATTN: Mr. Thomas H. Nichols
Huntsville
ATTN: Library (2)
ATTN: Chief, HNDED-CS
ATTN: Chief, HNDED-M
ATTN: Mr. James T. Ammons
ATTN: Mr. Thor S. Anderson
ATTN: Mr. Hugh H. Sharp
Missouri River
ATTN: Library (2)
Southwestern
ATTN: Library
ATTN: Chief, SWDED-TA
Pacific Ocean
ATTN: Chief, Engr Div
ATTN: FM&S Branch
ATTN: Chief, PODED-D
ATTN: Mr. Howard Kobayashi
North Pacific
ATTN: Chief, Engr Div

Facilities Engineer
Ft. Bliss, TX 79916
ATTN: Mr. James E. Kemp
Ft. Hood, TX 76544
ATTN: Mr. Orlon Hill

AF Civil Engr Center/XRL
Tyndall AFB, FL 32401

Naval Facilities Engr Command
Alexandria, VA 22332

Port Hueneme, CA 93043
ATTN: Library (Code L08A)
ATTN: Moreell Library

Washington, D.C.
ATTN: Building Research Advisory Board
ATTN: Library of Congress (2)

Defense Documentation Center (12)

Engineering Societies Library
New York, NY 10017

Ft. Monroe, VA 23651
ATTN: HQ TRADOC, Mr. Ray Spunzo

Ft. McPherson, GA 30330
ATTN: HQ FORSCOM, Mr. Ronald D. Collins

Chief of Engineers
ATTN: DAEN-DS (2)
ATTN: DAEN-DSE
ATTN: DAEN-MPE
ATTN: DAEN-MPE-B
ATTN: DAEN-MPE-T
ATTN: DAEN-MPE-I
ATTN: DAEN-MPE-S
ATTN: DAEN-MPE-E

Ft. Monroe, VA 23651
ATTN: HQ TRADOC
Mr. Ray Spunzo

Ft. McPherson, GA 30330
ATTN: HQ FORSCOM
Mr. Ronald D. Collins

US Army Engineer District
Omaha
ATTN: Mr. Ornell H. Asleson
Baltimore
ATTN: Mr. Enn Veskimets
Mobile
ATTN: Mr. George L. Phillips, Jr.
Sacramento
ATTN: Mr. E. G. Jones
Fort Worth
ATTN: Mr. Robert D. Duvall
ATTN: Mr. Paul Schwartz

US Army Engineer Division
Huntsville
ATTN: Mr. James T. Ammons
ATTN: Mr. Thor S. Anderson
ATTN: Mr. Hugh H. Sharp
Pacific Ocean
ATTN: Mr. Howard Kobayashi
South Atlantic
ATTN: Mr. Thomas H. Nichols

Facilities Engineer
Ft. Bliss, TX 79916
ATTN: Mr. James E. Kemp
Ft. Hood, TX 76544
ATTN: Mr. Orlon Hill

Daniel, Mann, Johnson, and Mendenhall
Computer-aided Engineering and Architectural Design System (CAEADS).--Champaign, IL : Construction Engineering Research Laboratory ; Springfield, VA : available from NTIS, 1979.
2 v. : ill. ; 27 cm. (Technical report ; P-97)
Contents: v.1. Summary.--v.2. Concise review.

1. Architectural design-data processing. 2. CAEADS. 3. U.S. Army-military construction operations-data processing. I. Title. II. Series: U.S. Construction Engineering Research Laboratory. Technical report ; P-97.