AD-A099 116 CONSTRUCTION ENGINEERING RESEARCH LAB (ARMY) CHAMPAIGN IL F/G 9/2
MICROCOMPUTER APPLICATIONS TO THE MILITARY CONSTRUCTION--ARMY (--ETC(U)
FEB 81 J H SPOONAMORE
UNCLASSIFIED CERL-TR-P-119 NL

1 OF 1
AD A
099116

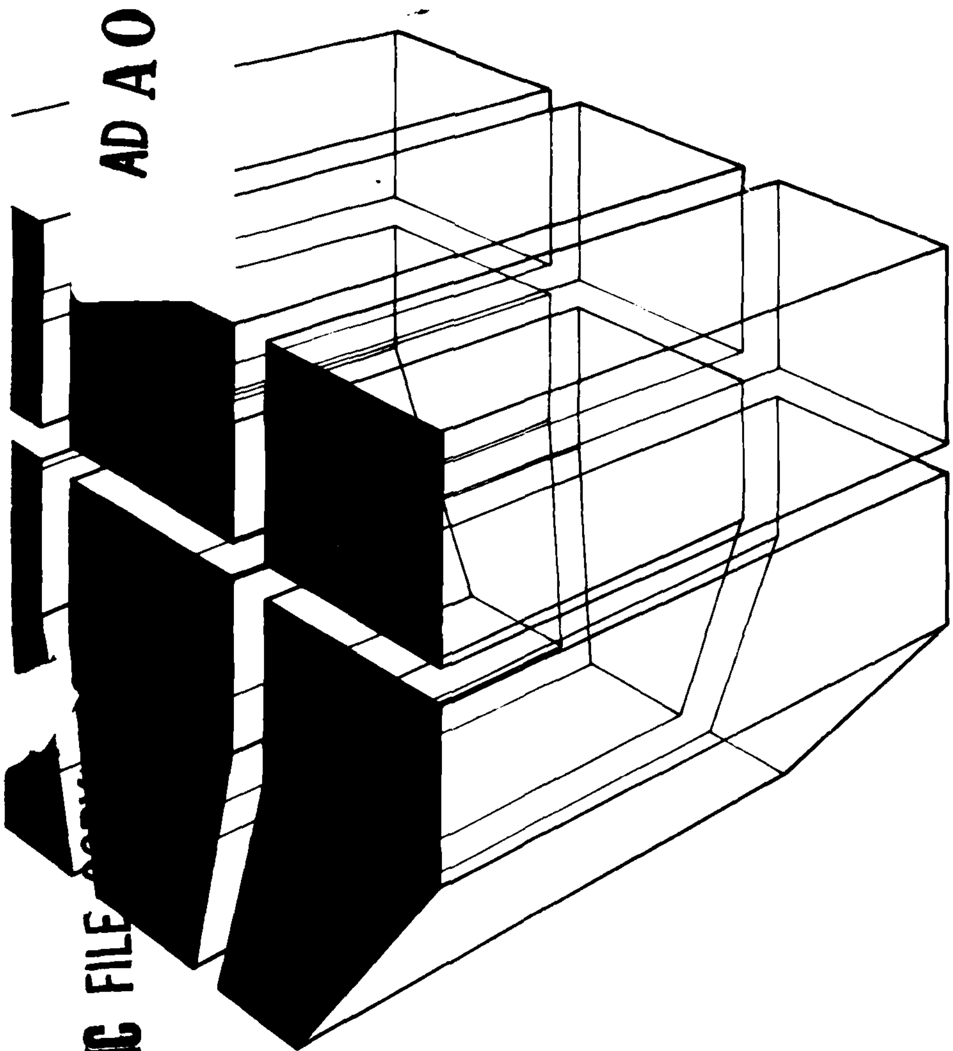
END
DATE
FILMED
6-81
DTIC

construction engineering research laboratory

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

TECHNICAL REPORT P-119
February 1981

MICROCOMPUTER APPLICATIONS TO THE MILITARY CONSTRUCTION — ARMY (MCA) PROCESS: CONCEPTS FOR IMPLEMENTATION AT ARMY CORPS OF ENGINEERS CONSTRUCTION FIELD OFFICES



by
Janet H. Spoonamore

CERL

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: CERL-TR-P-119
2. GOVT ACCESSION NO.: AD-A099 116
3. RECIPIENT'S CATALOG NUMBER:
4. TITLE (and Subtitle): MICROCOMPUTER APPLICATIONS TO THE MILITARY CONSTRUCTION - ARMY (MCA) PROCESS: CONCEPTS FOR IMPLEMENTATION AT ARMY CORPS OF ENGINEERS CONSTRUCTION FIELD OFFICES
5. TYPE OF REPORT & PERIOD COVERED: FINAL rept.
6. PERFORMING ORG. REPORT NUMBER:
7. AUTHOR(s): Janet H. Spoonamore
8. CONTRACT OR GRANT NUMBER(s):
9. PERFORMING ORGANIZATION NAME AND ADDRESS: U.S. ARMY CONSTRUCTION ENGINEERING RESEARCH LABORATORY P.O. Box 4005, Champaign, IL 61820
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 4A762731AT41-A-35
11. CONTROLLING OFFICE NAME AND ADDRESS:
12. REPORT DATE: Febr[redacted]981
13. NUMBER OF PAGES: 13
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):
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 the National Technical Information Service Springfield, VA 22151

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

microcomputers
construction
Army Corps of Engineers

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

The objectives of this report are (1) to assess the potential usefulness of microcomputer technology as a tool for project management at Corps of Engineers construction field offices, and (2) to present methods of effectively transferring that technology to field agencies.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Block 20 continued.

This report offers an overview of the construction management activities and the expected field office workload for military construction and civil works construction projects. In addition, the report describes the capabilities offered by microcomputer systems and the technology to be considered in acquiring these systems. The expected costs and benefits of the computer hardware and software are explained. Finally, approaches for extending this technology to the field are analyzed.

This report concludes that microcomputer systems make more efficient (1) updating network progress and pay, (2) analyzing contract modifications, and (3) handling general data. Microcomputer technology can be effectively transferred to the field by: (1) development of the system documentation required by Army Regulation 18-1; (2) coordination with Corps district and field offices; (3) allocation of funds and resources for extension to the field; (4) classification of the system as a class IV system; (5) selection of an assigned responsible agency to maintain the system; (6) cooperation among agencies involved in development and operation of the system.

FOREWORD

This investigation was performed for the Directorate of Military Programs, Office of the Chief of Engineers, under Project 4A762731AT41, "Design and Construction of Fixed Military Facilities"; Task A, "Design and Construction"; Work Unit 35, "Microprocessor Applications to the MC Process." The applicable QCR is 3.03.006. The OCE Technical Monitor was Mr. Phil Pinol.

This research was conducted at the U.S. Army Construction Engineering Research Laboratory (CERL) by the Facility Systems (FS) Division. Mr. Edward Lotz is Chief, FS Division. Mr. Carl Delong was Associate Investigator for the work unit.

COL Louis J. Circeo is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.

CONTENTS

TABLES

Number		Page

MICROCOMPUTER APPLICATIONS TO THE MILITARY CONSTRUCTION—ARMY (MCA) PROCESS: CONCEPTS FOR IMPLEMENTATION AT ARMY CORPS OF ENGINEERS CONSTRUCTION FIELD OFFICES

1 INTRODUCTION

Background

Army Corps of Engineers construction field offices manage the world's largest construction program. Since current technology can aid project administration, the Office of the Chief of Engineers (OCE) directed the U.S. Army Construction Engineering Research Laboratory (CERL) to study how microcomputers can support field office personnel in monitoring, administering, and incorporating changes in construction projects.

Objective

The overall objectives of this study are to identify Military Construction—Army (MCA) activities that can be automated with low-cost microprocessor hardware, and to specify, test, and transfer to area and resident engineer offices those microcomputer applications that can reduce costs.

This report (1) assesses the potential usefulness of microcomputer technology at construction field offices, and (2) presents methods of effectively transferring that technology to field agencies.

Approach

CERL identified the automated tools required by construction field offices. Computer configurations were designed to provide automated approaches, interactive systems, and hardware environments that best support users in the field. CERL developed a prototype research system enabling managers in the field to control project management better. This computer system includes capabilities for performing critical path method (CPM) analysis, updating progress during the course of a construction project, analyzing impacts of alternative schedules, and assessing the impacts of contract modifications. This system, running on a micro-based computer which sells for about $8000, was installed at Fort Benjamin Harrison, IN, for a short research test to provide CERL with information from users about the system's ease of operation, benefits, and problems.

Mode of Technology Transfer

The information in this report will impact Engineer Regulation (ER) 1-1-11, *Network Analysis System*, and draft Engineer Pamphlet, *Office Engineers Guide*. A functional description of the micro-based system will be developed as required by Army Regulation (AR) 18-1.[1]

Field Office Workload and Overview of Construction Management Activities

Construction field offices for the Corps of Engineers are either resident engineer offices or area engineer offices involved in construction management. The field engineers are responsible to the district office for the immediate on-site administration and direction of construction contracts.[2] Typical field office activities include technical and administrative responsibilities necessary to assure satisfactory construction. The office staff includes engineering, procurement, and clerical/administrative personnel. Staffing strengths are based on contract workload and vary considerably throughout districts and among offices. The average office managing 15 to 20 contracts has 18 to 20 full-time permanent staff.

Introducing automated tools to the field office or resident engineer office is unlikely to affect the number of staff members; CERL's field data indicate that current understaffing is expected to continue. However, automated data processing (ADP) support to the office should reduce the time spent in repetitive calculations of schedules, thus allowing more time for evaluating contract modifications, and for monitoring, inspecting, and administering contracts.

Corps field offices manage all significant changes in a project's schedule and requirements. A survey of the change order impact problem indicates that Corps projects often exceed original estimates.[3] A study by Sowers recommends that construction managers use network analysis tools for evaluating changes to a project.[4]

---

[1] *Network Analysis System* (Department of the Army [DA], Office of the Chief of Engineers [OCE], 1 March, 1973); *Management Information Systems: Policies, Objectives, Procedures, and Responsibilities*, Army Regulation (AR) 18-1 (Headquarters [HQ], DA, 22 March 1976).

[2] *Resident Engineers Management Guide*, Engineer Pamphlet (EP) 415-1-260 (DA, OCE, October 1973), p 2-1.

[3] "Design Changes, the Largest Cause of Overruns," *Engineering News Record*, Vol 194, No. 10 (March 6, 1975), p 10.

[4] George F. Sowers, "Changed Soil Conditions and Rock Conditions in Construction," *Journal of the Construction Division*, American Society of Civil Engineers, Vol 97, No. CO2 (November 1971), p 266.

2 CAPABILITIES OFFERED BY MICROCOMPUTER SYSTEMS

The computerized CPM system has been developed to track progress on construction contracts and to evaluate modifications to these contracts. The functions provided include the traditional critical path methods calculation, alternative network comparisons, and contract partial payment calculations. The CPM operating on CERL's research equipment handles up to 1200 activities. The capacity of this equipment in terms of both speed and memory size is sufficient. However, an extension of the system's hardware and software is planned to accommodate an unlimited number of activities.

CPM Analysis

Traditional network analysis of project activities includes the following activity input data: originating node, terminating node, and duration. For determining progress in terms of cost and time, additional data are required: activity costs, percentage completed, units placed, actual start, and actual finish. The CPM analysis calculates each activity's early and late start and finish based on actual start and finish. In addition, summaries of total project time and cost can be produced. All data entry is performed interactively using a keyboard and cathode ray tube (CRT)-formatted displays. Errors detectable at entry are flagged immediately to be corrected. Redundant data entry often can be avoided—when parts of activity data are changed, for example. The data entry process is designed to encourage proper entry and reduce errors. General project information and individual activity data are maintained by the system for retrieval, analysis, and reporting. Network loops are detected and displayed. The calculations for starts and finishes are performed taking into account actual start and finish dates. The system's report, showing the analysis results, can be sorted in order of nodes, late finish, early start, or slack.

Alternative Network Comparisons

Clearly, when a contract undergoes several additions, changes, and deletions, organizing project activities becomes time-consuming. The additional time and cost of contract modifications must be assessed. And the development of progress reports and payment require modification breakouts. ADP can handle these tasks efficiently. The automated functions which compare alternative versions of the project allow examination of impacts on cost and time, and display the activities affected directly and indirectly by modification.

Contract Payment Calculations

Periodic payment calculations for partial work completion use the project network and progress data entered into the system. For each period, new data on the progress of individual activities are entered to update the old information—such as units placed, percentage completed, and actual start and finish dates. Calculations based on activity progress produce the periodic payment estimate.

Other Potential Applications

A general data base management system may be operable on microprocessor equipment. The field office engineers currently maintain local cost data for labor, equipment, and materials. These costs are used in estimating contract modifications and administering change orders to the contract. By using a general-purpose data base management system, the field office engineer can maintain current data, retrieve the data, and produce computations in many different forms. Summaries of local cost data can be produced from the system. These data base management systems are currently available in the marketplace and typically cost from $100 to $250.

A general-purpose word processing capability could be used in the field office to expedite handling of correspondence and reports. The system's hardware and software are well suited to entry and maintenance of text information. Although producing letters and reports requires a typewriter-quality printer, such equipment is easily interfaced to the system.

Technological Changes

Microcomputer hardware in the past had limited capabilities because of small memory size and slow disk speed. Technology is now overcoming these limitations; the capacity and speed of microcomputer systems have increased dramatically. In addition, their reliability is improving.

The microcomputer system which is a potential tool for the field office engineer will be as powerful as large computer systems 10 years ago; the costs for these microcomputers are affordable for Corps construction managers.

3 EXPECTED COSTS AND BENEFITS

Costs for Microcomputers

CERL estimates that about 50 Corps of Engineers field offices have workloads that microcomputers could support. The cost for installing, operating, and maintaining microcomputers at 50 Army construction field offices includes:

1. Software acquisition
2. Hardware acquisition
3. Installation training
4. Recurring software and hardware maintenance for a system life of 8 years (FY82 to FY89).

Expected costs (discounted at 10 percent of present values for FY80) for the total life cycle of the system are $1,778,000. These costs are detailed in the following sections.

Development Costs

Development costs cover identifying system requirements and designing ADP approaches to meet these requirements. CERL's microprocessor version of the CPM system is written entirely in FORTRAN and is easily converted to other hardware. Software for a data base management system is readily available and can be acquired with the hardware. Table 1 shows software development costs (both sunk and planned) for CPM applications.

Investment Costs

These nonrecurring costs cover acquisition of the microcomputer hardware and software, as well as initial training, support, and documentation required for conversion to the new system. Table 2 shows the breakdown of investment costs for 50 installations.

Table 1
Proposed System Software Development Costs
(In Thousands)

FY	Sunk	Planned
77	$45	
78	$60	
79	$72	
80		$60
81		$10

Operations and Maintenance Costs

Operations and maintenance costs cover system hardware and software maintenance for the 50 installations. Costs are recurring after an initial year of system installation. Some maintenance is to be performed by the vendors, and other maintenance is done in-house by the assigned responsible agency (ARA). Costs include vendor hardware maintenance at $155.00 per month per office, ARA in-house software maintenance (one GS-12 at $40,000 per year), and the ARA's in-house hardware specialist (one computer specialist GS-12 at $40,000). Computer operations are inherent in the functional use of the interactive system and are not considered here. Table 3 shows the maintenance cost for the system's life.

Benefits from Microcomputer Systems

The automated system—including CPM applications, data base management, and word processing—reduces manual data handling and saves work in the field office. In addition, more comprehensive and detailed construction management ensures a more responsive end-product—the facility—for the using service.

Additional benefits from using the automated system tools include both expected direct time savings in construction management activities, and possible indirect savings in construction costs. The direct costs/time savings can be broken into three construction management activities:

Table 2
Proposed System Investment Costs
(In Thousands)

FY	Activity	Cost
81	Documentation	$15
81	Training	$72
81	Software Conversion	$10
81-82	Software Purchase	$55
81-82	Hardware Purchase	$800

Table 3
Proposed System Operation and Mantenance Costs
(In Thousands)

FY	Activity	Cost
81	Vendor Hardware Maintenance (25 offices)	46.5
82-89	Vendor Hardware Maintenance (50 offices)	93
81-89	ARA: Hardware/Software Maintenance	80

1. Updating network progress and pay estimates.

2. Analysis of contract modifications

3. General data handling activities.

These expected benefits in time savings for staff members involved in construction management have associated costs of $2,442,000 for the 8-year life cycle of the system (discounted at 10 percent of present value for FY80). The benefits are detailed below.

Although *real* cost savings may be achieved both in field office effort and construction costs, measuring impacts in terms of benefits, rather than savings, allows a more realistic basis for decision-making. One may choose whether to invest in the proposed alternative to derive its benefits. For the following discussion of benefits, it is estimated that the typical field office handles an average of 15 projects, each averaging $1.3 million. The office averages 20 staff members and a total construction workload (civil and military) of $20 million.

Benefits in Updating Network Progress and Pay Estimates

These benefits result from the process of recording and summarizing the monthly progress of work, and paying for contractors' materials, labor, and equipment. The units of work that have progressed (the activities represented in the CPM or bar chart) must be accounted and summarized. In each office, about 90 staff hours (6 per project) are spent on this activity; this time could be reduced by 25 percent with the automated CPM applications—a savings of 22.5 staff hours at $20/hr, or $450 per month per office.

Benefits in Analyzing Contract Modifications

These benefits result from the process of analyzing direct and indirect impacts of contract modifications both in terms of project duration and costs. The proposed modification is broken into alternative activities (and costs), and an effective scheduling is derived. In each office, about 90 staff hours per month (6 per project) are spent deriving contract modifications impacts. The automated CPM applications are expected to reduce this time by about 15 percent—13.5 staff hours at $20/hr, or $270 per month per office. In addition, the computer system should lower modification costs.

Benefits in General Data Handling

Benefits in general data handling result from the process of organizing, recording, updating, and summarizing local project cost data (labor, equipment, and materials), office budget data, and word processing. Each office spends about 40 hours per month on these activities; expected savings of 25 percent can be achieved with the data base management system and word processing system. This is a reduction of 10 hours at $20/hr, or $200 per month per office.

Benefit Summary

Table 4 summarizes functional benefits in construction management direct effort.

Unquantifiable Benefits

The objective of the proposed automated tools is to manage the construction process more effectively. The automated CPM applications will provide more detailed progress measures and more information to pinpoint major project delays and to determine corrective actions. In addition, facility delivery time should be shortened. The automated CPM applications will allow comprehensive analysis of modifications, and consideration of more alternative approaches and schedules. Therefore, more cost-effective and timely changes can be incorporated into the project.

The resulting savings in the final costs of the facility are difficult to predict and validate without long-term studies of many projects. However, the introduction of automated CPM analysis for progress reporting and impact analysis can produce large savings in construction costs. For example, savings on contract modification alone would be substantial since costs due to modifications (both direct and indirect impacts) presently involve many millions of dollars annually in Corps military and civil projects.

Table 4
Proposed System Annual Recurring Field Office Benefits for 50 Offices (In Thousands): FY82-89

Activity	Cost
Network Progress	$270
Modification Analysis	$162
General Data Handling	$126
Total	$552

Discounting

Discounted costs and benefits are presented for the system life in Table 5.

Table 5
Proposed System Discounted Costs and Benefits—Based on FY80 Dollars (In Thousands)

System Costs/Benefits	Value
Research and Development Costs	$ 69
Investment Costs	$ 829
Initial Maintenance (FY81) Costs	$ 115
Recurring Accumulated Maintenance (FY82-89) Costs	$ 765
Total Life-Cycle Costs	**$1778**
Recurring Accumulated Benefits (FY82-89)	**$2442**

4 APPROACHES TO FIELD IMPLEMENTATION, OPERATION, AND MAINTENANCE

Based on the potential benefits of micro-based tools, a plan to fund and effectively support transition to the technology should be prepared; the tools should then be delivered to construction field offices. Three major actions will contribute to the successful installation of this system. First, the authorization (under AR 18-1) to proceed from one phase of system development to another requires preparing suitable information for the process of system approval. Second, investment funds must be budgeted for acquisition of hardware and software. Third, the life-cycle system activities (such as training and maintenance) and their associated expenses must be scheduled, budgeted, and allocated.

Authorization

To manage the approval process, the organizational elements with responsibility for supervising the microcomputer system's life cycle must be identified. Under AR 18-1, systems are classified by their impacts on the organization, the major command, and the Army.[5]

Development and installation of a small system can be authorized by the major command which is to use it. Systems having large software and hardware acquisition, operation, and maintenance costs require higher levels of authorization.

Microprocessor applications to the MCA process serve the Corps field offices and require less than $3 million for development costs from concept to installation. The equipment configurations at the field offices cannot be classified as data processing installations (DPIs). It is recommended that the proposed system be classified a class IV system because: (1) a single DPI (the ARA for maintenance) will manage the field equipment; (2) the equipment in operation produces minor impacts to current ADP support in the Corps; and (3) the development and installation effort is less than $3 million.

The proponent of this proposed microprocessor system is OCE, Directorate of Military Programs, Construction Division. If the system is classified class IV, this organization (having available supportive information) will be responsible for initiating each phase of the system's life cycle. These phases include development, acquisition, extension, and operations and maintenance; the first three are sequential, and each leads to a decision about beginning the next. The proponent has the authority to approve or disapprove at each of these phases.

The authorization documents from which the proponent makes decisions are governed by Department of Defense (DOD), Army, and OCE regulations. The Department of the Army requires the use of the approach described in revised Technical Bulletin (TB) 18-111.[6]

It is recommended that new DOD standards for documentation be applied—i.e., the functional description (FD) and data requirements document (RD). These are described in DOD 7935.1-S, *Automated System Documentation Standards*.[7]

Investment Strategies

AR 18-1 establishes authorization for acquisition of general purpose ADP equipment (ADPE). Microprocessor equipment can be purchased or leased; Table 6 shows costs.

[5] *Management Information Systems: Policies, Objectives, Procedures, and Responsibilities*, AR 18-1 (HQ, DA, 22 March 1976).

[6] *Army Automation Technical Documentation*, TB 18-111 (HQ, DA, 1979).

[7] *Automated Data System Documentation Standards*, Department of Defense (DOD) Standard 7935.1-S (DOD, Office of the Assistant Secretary of Defense, 13 September 1977).

Table 6
Costs of Leasing and Purchasing Microsystems

	Annual Lease	Purchase
50 Processors + Memory	$ 25,000	$100,000
50 Other ADPE	$175,000	$700,000

Purchase of ADPE requires approval of the Department of the Army, whereas leasing only needs the approval of the major command, OCE. It is recommended that the equipment be leased because:

1. A smaller amount of capital is needed at the initial investment;

2. Technological advancements in the micro field warrant leasing versus purchase;

3. Third-party lease-maintenance contracts are simpler to administer and manage.

Given the commitment to lease, fund allocation and distribution present problems. The alternatives available are: (1) lump sum contract, delivery upon one fund allocation; and (2) requirements contract, delivery upon field offices' funds.

It is recommended that a requirements contract be developed and initiated by delivery orders from either districts or field offices. This approach is preferable because:

1. Single source funds need not be budgeted;

2. Changes in deliveries can be accomodated during the installation of equipment;

3. Vendors can deliver small computer systems on a requirements basis.

System Life-Cycle Activities

The organizations involved in the three phases of system development are the proponent, OCE; the ARA for phase I (system approval) and phase II (system development and prototype testing); and the ARA for phase III (system extension).

CERL recommends appointment of a phase III ARA to be responsible for installation, maintenance, and operation of the system. OCE's selection of this organization may include the following steps:

1. Distribution of this report with a cover letter soliciting comments from districts.

2. Invitation of selected district personnel to an in-progress review (IRP) for the system.

3. Evaluation of the phase I and II ARAs, considering their available staffing and construction program workload.

Potential ARAs for phase III include Corps district offices having an active military construction program. The construction division of the district office and the district ADP coordinator offer engineering and ADP support for training personnel, maintaining skills at field offices, providing consultation in using and operating the system, and administering vendor contracts. This organization must judge whether CERL's estimates of staffing requirements are reasonable. From this point, coordination between CERL and the phase III ARA will increase until a complete transfer of responsibility is achieved.

Table 7 shows the life-cycle activities for delivering a microcomputer system to the field offices. Table 8 shows the milestone chart for installing the microcomputer system at 50 offices.

5 CONCLUSIONS

This report has assessed the usefulness of microcomputers in construction project management. Microcomputer systems can make more efficient (1) updating network progress and pay; (2) analyzing contract modifications; and (3) handling general data.

Microcomputer technology can be effectively transferred to the field by the following steps:

1. Development of the system documentation required by AR 18 1.

2. Coordination with Corps district and field offices.

3. Allocation of funds and resources for extension to the field.

4. Classification of the system as a class IV system.

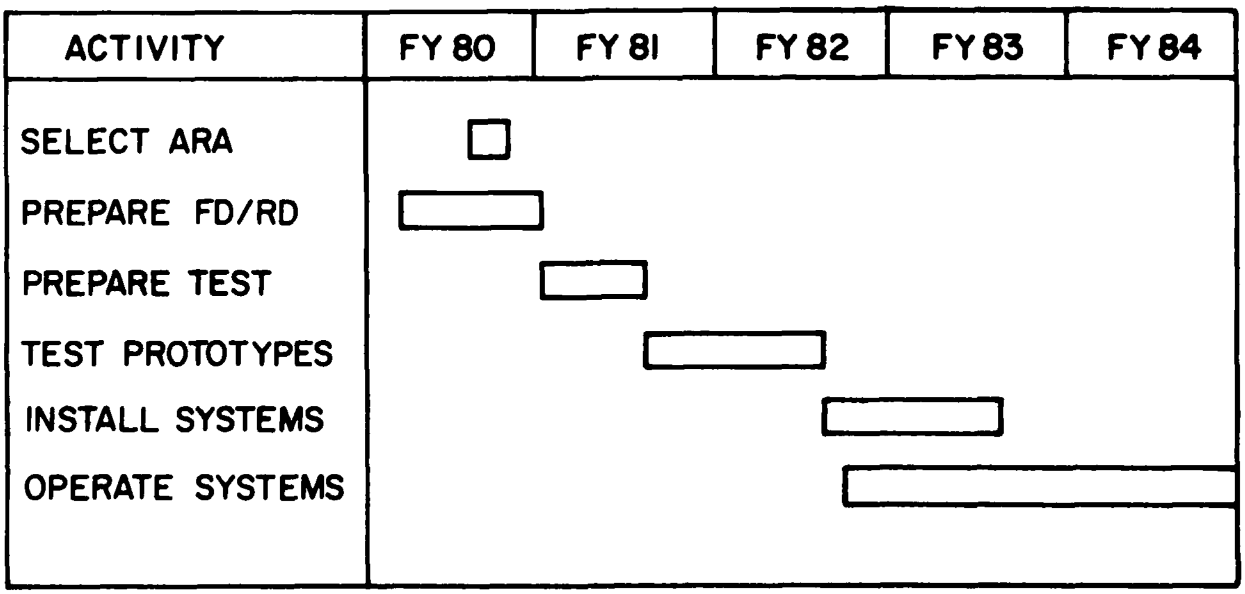
5. Selection of an ARA to maintain the system.

6. Cooperation among the agencies involved in development and operation of the system.

Table 7
System Life-Cycle Activities for Microcomputer Applications to the MCA Process

Organization	Authorization	Development	Acquisition	Extension	Operation	Maintenance
OCE (DAEN-MPC)	Establish system class	Approve prototype test	Approve for extension	Review system extension	Review operation	Review maintenance
CERL-FS	Conduct IPR	Research, develop, test	Prototype test			
ARA for maintenance	Selection to be made	Review procurement specifications	Review prototype test	Install system equipment	Report on operation	Provide maintenance
Field office users		Select prototype users	Training, operation of system: 3 sites	Training, operation of system: 50 sites	Operation of system by users	

Table 8
Milestone Chart



CERL DISTRIBUTION

Chief of Engineers
ATTN: Tech Monitor
ATTN: DAEN-ASI-L (2)
ATTN: DAEN-CCP
ATTN: DAEN-CW
ATTN: DAEN-CWE
ATTN: DAEN-CWM-R
ATTN: DAEN-CWO
ATTN: DAEN-CWP
ATTN: DAEN-MP
ATTN: DAEN-MPC
ATTN: DAEN-MPE
ATTN: DAEN-MPO
ATTN: DAEN-MPR-A
ATTN: DAEN-RD
ATTN: DAEN-RDC
ATTN: DAEN-RDM
ATTN: DAEN-RM
ATTN: DAEN-ZC
ATTN: DAEN-ZCE
ATTN: DAEN-ZCI
ATTN: DAEN-ZCM

US Army Engineer Districts
ATTN: Library
Alaska
Al Batin
Albuquerque
Baltimore
Buffalo
Charleston
Chicago
Detroit
Far East
Fort Worth
Galveston
Huntington
Jacksonville
Japan
Kansas City
Little Rock
Los Angeles
Louisville
Memphis
Mobile
Nashville
New Orleans
New York
Norfolk
Omaha
Philadelphia
Pittsburgh
Portland
Riyadh
Rock Island
Sacramento
San Francisco
Savannah
Seattle
St. Louis
St. Paul
Tulsa
Vicksburg
Walla Walla
Wilmington

US Army Engineer Districts
New York
Ft. Worth
Baltimore
Norfolk
Savannah
Mobile
Kansas City
Omaha
Los Angeles
Sacramento
For distribution to field offices

US Army Engineer Divisions
ATTN: Library
Europe
Huntsville
Lower Mississippi Valley
Middle East
Middle East (Rear)
Missouri River
New England
North Atlantic
North Central
North Pacific
Ohio River
Pacific Ocean
South Atlantic
South Pacific
Southwestern

Engineering Societies Library
New York, NY

FESA, ATTN: Library

ETL, ATTN: Library

Engr. Studies Center, ATTN: Library

Inst. for Water Res., ATTN: Library

Army Instl. and Major Activities (CONUS)
DARCOM - Dir., Inst., & Svcs.
ATTN: Facilities Engineer
ARRADCOM
Aberdeen Proving Ground
Army Matls. and Mechanics Res. Ctr.
Corpus Christi Army Depot
Harry Diamond Laboratories
Dugway Proving Ground
Jefferson Proving Ground
Fort Monmouth
Letterkenny Army Depot
Natick Research and Dev. Ctr.
New Cumberland Army Depot
Pueblo Army Depot
Red River Army Depot
Redstone Arsenal
Rock Island Arsenal
Savanna Army Depot
Sharpe Army Depot
Seneca Army Depot
Tobyhanna Army Depot
Tooele Army Depot
Watervliet Arsenal
Yuma Proving Ground
White Sands Missile Range

FORSCOM
FORSCOM Engineer, ATTN: AFEN-FE
ATTN: Facilities Engineers
Fort Buchanan
Fort Bragg
Fort Campbell
Fort Carson
Fort Devens
Fort Drum
Fort Hood
Fort Indiantown Gap
Fort Irwin
Fort Sam Houston
Fort Lewis
Fort McCoy
Fort McPherson
Fort George G. Meade
Fort Ord
Fort Polk
Fort Richardson
Fort Riley
Presidio of San Francisco
Fort Sheridan
Fort Stewart
Fort Wainwright
Vancouver Bks.

TRADOC
HQ, TRADOC, ATTN: ATEN-FE
ATTN: Facilities Engineer
Fort Belvoir
Fort Benning
Fort Bliss
Carlisle Barracks
Fort Chaffee
Fort Dix
Fort Eustis
Fort Gordon
Fort Hamilton
Fort Benjamin Harrison
Fort Jackson
Fort Knox
Fort Leavenworth
Fort Lee
Fort McClellan
Fort Monroe
Fort Rucker
Fort Sill
Fort Leonard Wood

MDW
ATTN: Facilities Engineer
Cameron Station
Fort Lesley J. McNair
Fort Myer

HSC
HQ USAHSC, ATTN: HSLO-F
ATTN: Facilities Engineer
Fitzsimons Army Medical Center
Walter Reed Army Medical Center

USACC
ATTN: Facilities Engineer
Fort Huachuca
Fort Ritchie

MTMC
HQ, ATTN: MTMC-SA
ATTN: Facilities Engineer
Oakland Army Base
Bayonne MOT
Sunny Point MOT

US Military Academy
ATTN: Facilities Engineer
ATTN: Dept of Geography & Computer Science

USAES, Fort Belvoir, VA
ATTN: ATZA-DTE-EM
ATTN: ATZA-DTE-SU
ATTN: Engr. Library

Chief Inst. Div., I&SA, Rock Island.

USA ARRCOM, ATTN: Dir., Instl & S.
TARCOM, Fac. Div.
TECOM, ATTN: DRSTE-LG-F
TSARCOM, ATTN: STSAS-F
NARAD COM, ATTN: DRDNA-F
AMMRC, ATTN: DRXMR-WE

HQ, XVIII Airborne Corps and Ft. Bragg
ATTN: AFZA-FE-EE

HQ, 7th Army Training Command
ATTN: AETTG-DEH (5)

HQ USAREUR and 7th Army
ODCS/Engineer
ATTN: AEAEN-EH (4)

V Corps
ATTN: AETVDEH (5)

VII Corps
ATTN: AETSDEH (5)

21st Support Command
ATTN: AEREH (5)

US Army Berlin
ATTN: AEBA-EN (2)

US Army Southern European Task Force
ATTN: AESE-ENG (5)

US Army Installation Support Activity Europe
ATTN: AEUES-RP

8th USA, Korea
ATTN: EAFE
Cdr, Fac Engr Act (8)
AFE, Yongsan Area
AFE, 2D Inf Div
AFE, Area II Spt Det
AFE, Cp Humphreys
AFE, Pusan
AFE, Taegu

DLA ATTN: DLA-WI

USA Japan (USARJ)
Ch, FE Div, AJEN-FE
Fac Engr (Honshu)
Fac Engr (Okinawa)

ROK/US Combined Forces Command
ATTN: EUSA-HHC-CFC/Engr

416th Engineer Command
ATTN: Facilities Engineering

Norton AFB
ATTN: AFRCE-MX/DEE

Ft. Belvoir, VA 22060
ATTN: Learning Resources Center
ATTN: Kingman Building, Library

West Point, NY 10996
ATTN: Library

INSCOM - Ch, Instl. Div.
ATTN: Facilities Engineer
Vint Hill Farms Station
Arlington Hall Station

WESTCOM
ATTN: Facilities Engineer
Fort Shafter

Waterways Experiment Station
ATTN: Library

Cold Regions Research Engineering Lab
ATTN: Library

US Government Printing Office
Receiving Section/Depository Copies (2)

Defense Technical Information Center
ATTN: DDA (12)

Spoonamore, Janet H
    Microcomputer applications to the Military Construction - Army (MCA) process : concepts for implementation at Army Corps of Engineers construction field offices. — Champaign, IL : Construction Engineering Research Laboratory ; available from NTIS, 1981.
    13 p. (Technical report ; P-119)

    1. U.S. Army - military construction operations. 2. Microcomputers. I. Title. II. Series : U.S. Army. Construction Engineering Research Laboratory. Technical report ; P-119.

DAT
ILM