RESTRICTIONS
See Attached Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval — Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with Government; except that items costing less than $1,000 vest with GIT is prior approval to purchase is obtained from the Contracting Officer.

COMMENTS:
Additional information will be provided upon receipt of definitizing MOD.
GEORGIA INSTITUTE OF TECHNOLOGY

OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

Date 7/12/84

Project No. A-3596

Includes Subproject No.(s) GTRI

Project Director(s) J. L. Grover

Effective Completion Date: 3/31/84


Title Study for Information Systems Upgrade for FORSCOM Engineers

Grant/Contract Closeout Actions Remaining:

☐ None
☐ Final Invoice or Final Fiscal Report
☐ Closing Documents
☐ Final Report of Inventions (Sent to Sponsor 4/10/84)
☐ Govt. Property Inventory & Related Certificate
☐ Classified Material Certificate
☐ Other

Continues Project No. Continued by Project No.

COPIES TO:

Project Director
Research Administrative Network
Research Property Management
Accounting
Procurement/EES Supply Services
Research Security Services
Reports Coordinator (OCA)
Legal Services

Library
GTRI
Research Communications (2)
Project File
Other I. Newton

Form OCA 60:1028
FINAL REPORT
PROJECT NO. A-3596

FORSCOM INFORMATION SYSTEM

BY
JEFFREY L. GROVER

CONTRACT No. F33657-82-G-2083-1E02
Department of the Army
U.S. Forces Command - Engineers
Resources Management Division
Fort Gilem, Georgia 30050

June 1984

GEORGIA INSTITUTE OF TECHNOLOGY
A Unit of the University System of Georgia
Engineering Experiment Station
Atlanta, Georgia 30332
FINAL TECHNICAL REPORT
ON GIT/ees PROJECT A-3596
FORSOM INFORMATION SYSTEM

BY
JEFFREY L. GROVER

PREPARED FOR
DEPARTMENT OF THE ARMY
U.S. FORCES COMMAND - ENGINEERS
RESOURCE MANAGEMENT DIVISION
FORT GILLEM, GEORGIA 30050

CONTRACT F33657-82-G-2083-1E02

JUNE 1984
This final technical report summarizes efforts conducted under Phase I of contract number F33657-82-G-2083-1E02. Technical efforts were directed toward the definition and implementation of an information network to support the U.S. Army FORSCOM Engineers, Resource Management Division activities.

Methods of assessing the requirements, and steps toward system design are discussed. Detailed source listings of a prototype information system are included. It was concluded that the information network will greatly improve the ability of the FORSCOM Engineers Resource Management Division to continue their efficient maintenance of operations information.
# TABLE OF CONTENTS

## I. INTRODUCTION
- A. Background 1
- B. Summary of Tasks
  - 1. Define System Needs 1
  - 2. Explore Existing Hardware 1
  - 3. Explore Existing Software 2
  - 4. Explore Other Information Systems 2
  - 5. Explore Local Area Networks 2
  - 6. Design and Implement a Limited Capability System 2
  - 7. Specification and Preliminary Design of Total System 3
- C. Report Organization 3

## II. REQUIREMENTS
- A. Central Node Requirements
  - 1. Interaction with Huntsville 5
  - 2. Interaction with Subordinate Installations 5
  - 3. Local Processing 5
  - 4. Report Generation 5
  - 5. Operator Interface 6
  - 6. Data Base Management 7
- B. Remote Node Requirements
  - 1. Interaction with Central Node 7
  - 2. Local Processing 7
  - 3. Report Generation 7
  - 4. Operator Interface 8
  - 5. Data Base Management 8

## III. STATE-OF-THE-ART DEVELOPMENTS
- A. Mass Storage 10
- B. Processors 10
- C. Data-Communications 11
- D. Local Area Networks 11
- E. Distributed Databases 12

## IV. TECHNICAL APPROACH
- A. Status to Date 13
- B. Prospect System Implementation
  - 1. System Overview 18
  - 2. System Operation 18

## V. LONG TERM GOALS
- A. User Population 19
- B. Evolution of the General Purpose Digital Computer 20
- C. Economic Basis for Computer Networking 20
- D. Network Technology 21
- E. Distributed Databases 21

## VI. SUMMARY AND CONCLUSIONS 23

APPENDIX A - PROSPECT SYSTEM USER'S MANUAL
APPENDIX B - PROSPECT SYSTEM SOURCE CODE LISTINGS
I. INTRODUCTION

This report summarizes efforts carried out by the Georgia Institute of Technology Engineering Experiment Station (GT/EES) for the U.S. Army FORSCOM Engineers under contract number F33657-82-G-2083-1E02.

A. BACKGROUND

The Resources Management Division of FORSCOM Engineers administers several programs requiring access to a large amount of information. The bulk of this information is manipulated and stored manually by Resource Management Division personnel and their point of contact (POC) at the subordinate installations. The communication of this information has been effected with the aid of telephone conversations and transmittal through the U.S. Postal Service. The amount of information which is handled in this manner continues to increase. At some point this amount of information will exceed the level at which efficient operation can be maintained. The Georgia Tech efforts have been directed toward providing a system to facilitate the information handling capabilities for current and future needs. This effort comprises the first phase of a multiple phase program to provide these capabilities.

B. SUMMARY OF TASKS

In order to provide the U.S. Army FORSCOM Engineers with the necessary implementation guidelines, and to implement a limited capability system, an integrated program consisting of the following tasks was undertaken:

1. DEFINE SYSTEM NEEDS

The Information System study required a study of ways to automate an existing data management process. Activities not previously administered have been included in the system concept, while those previously conducted were considered the starting point for this study. In as much, the first order of business was to understand those activities which were being performed. This activity required some definition of those systems which will be supported, identification of individuals currently working with these systems, and identification of those organizations both providing and using the resulting information. The major activities in this area consisted of interviewing all parties involved with the candidate systems to gain an understanding of the way the tasks are currently performed and any improvements they may suggest. Additional information was required from other ongoing tasks relating to the method of implementation for any previously automated portions of operation.

2. EXPLORE EXISTING HARDWARE

Some computer equipment does currently exist. In some cases, the equipment is being used for data handling and in other cases, it is just available for use. This task identified the equipment which currently exists, explored its capabilities and assessed its appropriateness for the envisioned information system.
This activity required discussions with the original equipment manufacturer as well as with Army personnel currently using the equipment. Areas considered included additional equipment which may be procured to adapt the available equipment to the desired system goal.

3. EXPLORE EXISTING SOFTWARE

The existing data management activities already have some software systems which are currently facilitating operation. This activity identified these pieces of software, evaluated their role in the activity and assessed their suitability for the overall system goal. Wherever possible the existing software will be utilized; but where the existing software package is inappropriate, or of marginal utility, recommendations will be made as to whether to modify or replace the software package.

4. EXPLORE OTHER INFORMATION SYSTEMS

The proposed Information System is not a new undertaking. Several other similar systems have been constructed for similar uses. The uniqueness of this system lies in the specific data to be managed and the manner in which it will be handled. The mechanisms used to implement the envisioned system will be a selection of current technologies available at this time. The information systems to be studied will include but not be limited to those in use by the armed forces and by other elements of the federal government. Particular attention was given to analyses of GSA resources.

5. EXPLORE LOCAL AREA NETWORKS

The current system concept requires a teleprocessing network spanning the North American continent. Each node of that network will include an autonomous computer system to be accessed by numerous individuals. Depending on the number of local users and their proximity to the local computer system, some Local Area Networking is considered desirable. A portion of the study has concerned itself with this problem. Topics considered have included the processing to be performed local to the installation, and local to the employee station, regularity of an employee's interactions with the system and that individual's accessibility to the installation processing node.

6. DESIGN AND IMPLEMENT A LIMITED CAPABILITY SYSTEM

The activities identified above have facilitated the formulation of a total system concept. This activity identified and implemented a reasonable subset of the total concept which will satisfy the near term needs of the Resources Management Division. The identification of this subset to implement considered the following: Requirements of the PROSPECT engineer training program, currently available resources, development time available, and capabilities of the agencies participating in the program. A basic information management system for administration of the PROSPECT program was developed to include HQ FORSCOM and subordinate FORSCOM installations. The installation of this limited capability system will be followed by an observation and evaluation phase to determine the success of this undertaking.
7. SPECIFICATION AND PRELIMINARY DESIGN OF THE TOTAL SYSTEM

The total information management system concept as it applies to the long term needs of the Resources Management Division will be documented. This document will include an analysis of previous methods of information management, current FORSCOM capabilities, and the state of the art of commercial equipment available. A preliminary design will be produced to provide additional guidance for further planning purposes.

C. REPORT ORGANIZATION

The following chapters detail the technical efforts conducted during phase one of this program. Section II details the specific FORSCOM needs that must be addressed to adequately achieve the desired capabilities upgrade. Section III describes the current state-of-the-art in the fields which apply to this program. Section IV provides a status update of the PROSPECT training program support system what was developed as a part of phase one. Section V defines the long term goals which must be met to provide a continuously suitable system in support of the Resource Management Division needs. Section VI summarizes the conclusions which may be drawn from the previous section and provides recommendations for further actions to be taken. Appendix A is the Software user's manual for the FORSCOM PROSPECT SYSTEM. Appendix B is the computer source listing of the FORSCOM PROSPECT SYSTEM.
IL REQUIREMENTS

The overriding goal of this program is to provide the U.S. Army FORSCOM Engineers with a State-Of-The-Art Computer Network. The characteristics of such a system must adequately address the workload needs present within the FORSCOM Engineers. Each of the target programs to be supported by the final system differs with regard to the type of information handled. All of the systems do, however, share several common attributes. The commonality among these systems allow the design of a general interconnection network, the initial network has been designed and implemented in support of the PROSPECT training program. The PROSPECT training program has been selected as the proto-type due to its set of typical attributes and its current information needs. Included in this section is a brief description of the system requirements for the PROSPECT system. Section IV details the design and status of that portion of the system. Section V discusses the planned upgrades to bring the limited capability system up to the complete system configuration.

The requirements for operation of the FORSCOM PROSPECT system are defined by first identifying the major goals of the system and then detailing these goals in a manner which lends itself to be the basis for a system specification document. The major goals of the FORSCOM PROSPECT system may be grouped into the following categories:

Interaction between the FORSCOM headquarters located at Ft. Gillem and the PROSPECT administrative organization located in Huntsville, Ala.

Interaction between the FORSCOM headquarters located at Ft. Gillem and the subordinate installations throughout the continental United States.

Processing capabilities, at both the FORSCOM headquarters and the subordinate installations, required to transfer and maintain the information necessary to support the PROSPECT system.

Report generation and archival processing, at both the FORSCOM headquarters and the subordinate installations, necessary to assist the decision making processes in support of administering the PROSPECT program.

The major goals outlined above are not exclusively centralized at a particular node of the processing network. These goals will be satisfied by functions which are to be performed throughout the entire system. The next section begins to identify functional requirements for each of the nodes of the system. For simplicity of discussion at this time, the subordinate installations will be treated as a generic model. There is a distinct probability that the actual system implementation will result in functional attributes unique to specific installations.
A. CENTRAL NODE (FORSCOM HEADQUARTERS) REQUIREMENTS

1. Interaction with Huntsville
   - Access to an information interchange medium similarly accessible by the PROSPECT program office in Huntsville.
   - Capability to interact on the interchange medium using a protocol which is compatible with the Huntsville operation.
   - Capability to handle the interchanged information in a format compatible to both the Huntsville operation and the internal system needs.
   - Access to the data base management sub-system in support of the requirements indicated above.

2. Interaction with Subordinate Installations
   - Access to an information interchange medium similarly accessible by the subordinate installations.
   - Capability to interact on the interchange medium using a protocol which is compatible with the installation operations.
   - Capability to handle the interchanged information in a format compatible to both the installation operations and the internal system needs.

3. Local Processing
   - Capability to process data for temporary storage or the generation of reporting information.
   - Access to the PROSPECT data base management system for the retrieval and storage of processed data and archival backup.

4. Report Generation
   - Capability to generate reports from on-line pre-processed data available through the data base management system.
   - Access to the PROSPECT data base management system for the retrieval of processed data for display and transfer over the communication channels.
   - The reporting requirements at the central node of the PROSPECT information system may be divided into several categories as described below.
   - Standard procedure reports are those reports which are to be generated under all conditions. These reports are required for tracking and documentation of all interactions between the...
central node, Huntsville program office, and the subordinate installations. The reports which fall into this category are as follows:

- Unmarked Catalog listing
- Marked Catalog listing, installation specific
- Marked Catalog listing, FORSCOM cumulative
- Registration request to Huntsville
- FORSCOM allotment reports from Huntsville
- Installation specific allotment reports
- Personnel attending, sessions, installation specific
  with fee and per diem amounts included
- Personnel attending sessions, FORSCOM cumulative
  with fee and per diem amounts included
- Expenditures reports, installation specific
- Expenditures reports, FORSCOM cumulative

o Abnormal Procedure reports are those reports which are not necessarily required for tracking operations. These reports are intended to provide a supportive role to the standard procedure reports. The reports which fall into this category are as follows:

- Attendee cancellations
- Free spaces resulting from attendee cancellations
- Waiting list for attending if cancellation occurs

o Tickler Reports are those reports which are generated for the purpose of ensuring that the required interactions take place during the proper time interval. In essence these reports are reminders that a deadline is approaching for an action which has not yet taken place. The reports may be generated for those deadlines which are 30 and 60 days away from occurrence. The reports which fall into this category are as follows:

- Reminder to installations of approaching deadline
to register for a course session
- Reminder to attendees of approaching sessions
- Reminder to installation POC to transfer the funds at each quarterly interval

5. Operator Interface

o Capability to interact with a system user who specifies the particular operation to be undertaken.

o The operating procedures and syntactical construct of the control language are to be designed with human factor considerations accounted for.

o An interactions log (dayfile) should be maintained to record all interactions between backup operations. This provision
will allow for efficient reconstruction of a data base in the event of compromise. An additional advantage to the use of this provision is to provide an audit trail of operations for the system analyst's review in the event of recurring problems.

6. Database Management
   o On-line mass storage facility for retention of any and all information necessary to support the operation of the system requirements.
   o Provisions for interfacing to all portions of the system which require the retrieval, storage, manipulation, or monitoring of PROSPECT related information.
   o Data security arrangement to ensure that only those portions of the system authorized to access specific information types are granted access.
   o Off-line mass storage arrangement for regular back-up operations as required for archival and safeguarding purposes.

B. REMOTE NODE (SUBORDINATE INSTALLATIONS) REQUIREMENTS

1. Interaction with Central Node
   o Access to an information interchange medium similarly accessible by the FORSCOM headquarters.
   o Capability to interact on the interchange medium using a protocol which is compatible with the FORSCOM headquarters operations.
   o Capability of handling the interchanged information in a format compatible to both the central node operations and the internal system needs.
   o Access to the data management subsystem in support of the requirements indicated above.

2. Local Processing
   o Capability to process data for temporary storage or the generation of reporting information.

3. Report Generation
   o Capability to generate reports using on-line pre-processed data available through the data base management system.
   o Access to the local data base management system for the retrieval and storage of processed data and archival backup.
The reporting requirements at the central node of the PROSPECT information system may be divided into several categories as described below.

Standard procedure reports are those reports which are to be generated under all conditions. These reports are required for tracking and documentation of all interactions between the central node and the subordinate installations. The reports which fall into this category are as follows:

- Unmarked Catalog listings
- Marked Catalog listing, installation specific
- Installation specific allotment reports
- Personnel attending sessions, installation specific
  with fee and per diem amounts included
- Expenditures reports, installation specific

Special handling reports are those reports which are not necessarily required for tracking operations. These reports are intended to provide a supportive role to the standard procedure reports. The reports which fall into this category are as follows:

- Reminder to installation that deadline is approaching
to register for a course session
- Reminder to attendees of approaching sessions
- Reminder to installation POC to transfer the funds
  at each quarterly interval

4. Operator interface

- Capability to interact with a system user who specifies the particular operation to be undertaken.

- The operating procedures and syntactical construct of the control language are to be designed with human factor considerations accounted for.

- An interactions log (dayfile) should be maintained to record all interactions between backup operations. This provision will allow for efficient reconstruction of a data base in the event of compromise. An additional advantage to the use of this provision is to provide an audit trail of operations for the system analyst's review in the event of recurring problems.

5. Database management

- On-line mass storage facility for retention of any and all information necessary to support the operation of the local system requirements.
o Provisions for interfacing to all portions of the system which require the retrieval, storage, manipulation, or monitoring of PROSPECT related information.

o Data security arrangement to ensure that only those portions of the system authorized to access specific information types are granted access.

o Off-line mass storage arrangement for regular back-up operations as required for archival and safeguarding purposes.
III. STATE-OF-THE-ART DEVELOPMENTS

In recent years the computer revolution has evolved into what is now referred to as the information revolution. This change can be characterized by a shift in the role of computers in support of their users. This shift in the computer's role is largely attributed to three factors; the availability of relatively inexpensive computing equipment, the general acceptance of computers by the populace, and the ever increasing bulk of information necessary to perform daily functions. These factors have spurred recent activities in various areas which are directly applicable to this program. The most notable areas are described below with mention of their status and anticipated future directions.

A. MASS STORAGE

The two primary measures of system performance have traditionally been memory size and processing speed. This section addresses recent advances in mass memory size, the following section will address processing speed.

The combination of increased performance, capacity, and intelligence is enabling Winchester Disk Add-On Sub-Systems to accelerat the evolution of multi-user systems.

Such advances are also eroding the distinctions between mini and micro systems. Mass-storage technologies previously found only on mini computers are rapidly moving down to the Personal Computer (PC) level. Perhaps the major performance improving feature on Winchester Subsystems is the use of intelligent controllers and solid state cache memory, both at the mini and micro levels. With a disk cache, an intelligent controller runs algorithms to determine the disk sectors that are accessed most frequently. Those sectors are maintained in solid-state memory, many times faster than an electromechanical drive. In addition, while the host computer sequentially accesses data from the disk, the controller automatically reads in the next logical sector, anticipating the computers' next requests.

B. PROCESSORS (Execution Speed/Architectural)

The importance of speed specifications varies depending on the type of processor being evaluated. Main frame computers, for example, typically operate with significant but unpredictable computational burdens. Therefore, speed represents a reasonable criteria for determining how efficiently a main frame will operate. Most micro-processors, on the other hand, are dedicated to a single function or a narrowly defined range of functions, as a result, raw speed figures can prove misleading.

A better way to judge the suitability of a microprocessor to a specific purpose involves architecture evaluations.
C. DATA-COMMUNICATIONS

Practical data communication can be added to a system for a nominal cost by utilizing newly developed low-speed modem component technology. The complexities of FCC Approval and Signal-Processing Design have been eliminated. Link installation cost are very low since the telephone network is accessible to all for the cost of a telephone call.

The availability of new low-speed modem hardware and software is not the only factor contributing to the recent interest in communications technology. Concepts such as local area networks, electronic mail, remote product diagnosis and remote data base access have focused attention on low-speed modems as an inexpensive standardized access method to the communications media.

Low speed does not imply poor performance. In the telephone network, data-transmission speeds are limited to typically less than 9600 bits/sec, but, as a practical economic matter, to less than 1200 Bits/sec for two-wire unconditioned lines, operating full duplex - the so-called "normal telephone service."

D. LOCAL AREA NETWORKS (LAN)

There are several motivations for implementing a local area network. But perhaps the most fundamental reason is that LANs simply make good economic sense. Comparing a $1-million main frame with $1-million worth of microcomputers would show that the micro technology provides hundreds of times the computing power of the single main frame. The disadvantage, of course, is that 100 microcomputers scattered around the organization have limited value if they can't share their information. However, by linking these isolated machines together, networking can create main frame computer potency at microcomputer economy levels.

A second reason to implement a local area network is to provide a means of communicating between dissimilar devices. The goal in all cases is to distribute the processing power as widely as possible and to minimize the hand carrying of hard copy by maximizing electronic routing. For some installations a third reason for local area networks is the economy that comes from pooling expensive peripherals. But from the user's point of view, the overriding considerations of today's market are cost and availability.

The characteristic that most defines the power of a local network is bandwidth, because it indicates the amount of information that can be transmitted through a channel in a given time. This is, in theory, the limiting factor in determining how many users can be accomodated, as well as the number and types of peripherals. For example, activities involving text editing, graphics, and compiling are very disk intensive and require significant bandwidth to reduce overall network loading times.
E. DISTRIBUTED DATABASES

Today, there is no commercially available, truly distributed database management system on the market. However, systems which distribute a single integrated database and its control system across multiple machines are about to be introduced by several firms.

The reason for these introductions is simple. Large users of database management systems typically run five or six different, non-integrated databases to handle the ever-increasing amounts of on-line data and computerized operations in their many divisions. Unfortunately, a centralized database system limits a database's size and its number of users. In addition, they suffer from failure problems that can take a network full of users out of action.

Distributed database management systems have none of these disadvantages. They accommodate an unlimited number of computers, disk drives, memories, and users. In the distributed design, most data is stored locally and under local control. This decreases communications costs and response times and gives the staff with the greatest knowledge of the data the responsibility for maintaining it.

There are still other advantages to distributed data. Redundantly stored data increases the potential for computers to do parallel processing, which further decreases response times, and in a distributed system, if one database fails, the surviving computers merely continue processing.
IV. TECHNICAL APPROACH

The FORSCOM Information System Concept was developed in a general manner, independent of implementation hardware constraints. In parallel with this effort, a study to identify a suitable subset of the entire system was conducted. This study identified the PROSPECT training system to be the best choice for immediate implementation. This selection was based on three primary criteria;

- The PROSPECT system possessed all of the traits required for the complete system; database management, telecommunications and report generation.
- The PROSPECT system can be viewed as a self-contained module suitable for incorporation into the larger system.
- The PROSPECT system information needs are of significant volume to warrant immediate implementation.

A. STATUS TO DATE

The major activities conducted to date are described in this section. These activities include efforts leading to, but not including, the actual implementation of the PROSPECT system.

1. Assessed the processing needs in support of the PROSPECT system, partially as a result of an initial effort which was instituted in the March 1983 timeframe.

2. Reviewed the anticipated information handling needs in support of the various other systems which are to be incorporated into the final system plan.

3. Evaluated the existing equipment and its suitability for the above assessed needs. This mainly revolved around the Four-Phase equipment due to its availability. Early on it was identified that the short project duration would prohibit any large scale procurement activities so at that time it appeared as though Four-Phase equipment was the prime candidate.

4. An effort was undertaken to distribute questionnaires designed to identify any equipment that would be available and suitable for this application; that proved both ineffective and inconclusive. The only other contender was a Wang 2200 system resident at FORSCOM headquarters. At the time this activity was undertaken, it was determined that the Four-Phase systems would be most appropriate. Discussions were undertaken with the Four-Phase sales office in the Washington, D.C. area, Federal Region, as well as with Luther Oswald and Chip Reed of FESA who are currently responsible for the maintenance of that equipment. That group of individuals indicated that the Four-Phase system that has been configured for FESS operation is undergoing a major reconfiguration over the current period terminating approximately November, 1984. Part of that reconfiguration does
involve telecommunications capabilities which will be well suited to PROSPECT system application. The approach taken at this point has been to work together with Chip Reed, who is heading up that reconfiguration effort, interjecting PROSPECT system's needs into his overall configuration plan. At this time there does not seem to be any conflict and it is anticipated that FESA will procure items that will efficiently enhance the current implementation plans.

5. Review of the various organizations which must be interfaced with as a part of completing this project.

A. U.S. Army FORSCOM. Those discussions have revolved around the current information needs as they currently exist, as well as any anticipated needs that can be projected at this time. The goal of these discussions is to assess their needs and to more accurately define and develop a system that will satisfy those requirements.

B. Four-Phase Offices of Atlanta, Georgia and Washington, D.C. Those discussions have revolved around the current status of the equipment, the upgrades as they are currently planned, and the capabilities of their product line. The goals for these discussions have been to derive the maximum computational power from the existing vendor items.

C. EDS Corporation, the Contracting Organization which is implementing the VIABLE system approach for the U.S. Army. Those discussions have been limited to the technical requirements for integration into the VIABLE system. At this time, it appears that the major requirement is for synchronous communication using the IBM SDLC protocol at a 9600 Baud rate. Although compatibility with this system is planned, there is no intent to interface with it until some time in 1984 or 1985, due to contracting constraints between EDS and the U.S. Army.

D. FESA. This organization is responsible for the hardware and software configuration of the Four-Phase systems. These discussions have revolved around the current state of that equipment, the long-term planned upgrades, the upgrades that are currently being implemented, and the rationale behind each of them. In as much as FESA is the administrator for that system, then we are confined to any hardware or software modifications which can be justified to that organization and essentially be implemented by that organization. Georgia Tech will serve as a development arm of that group because that system is the responsibility of FESA and cannot be modified it without their concurrence.

E. The fifth and final group is actually within FESA, that is the organization that has developed FESS, which is the major software system that runs on the Four-Phase machines. Discussions there have been in terms of compatibility. Georgia Tech has been directed to
implement the PROSPECT system on a non-competing basis with the FESS system. This requires a more thorough understanding of that system's needs, both in processing time, mass storage requirements, and in the nomenclature for file naming.

6. Development of the system concept. The specifications document is currently in preparation and will also be available at a future date. The system concept takes into account various levels of implementation. The original intent was to provide an on-line telecommunications system near term. Due to the configuration modifications mentioned previously, it appears that the on-line telecommunications will not be available as early as hoped. A fall-back position has been to use a magnetic tape, via the U.S. Mail, as an interchange medium. This is somewhat less than desirable, but it is the only way to implement the system before November, due to the expected delivery date of the communications capabilities.

7. Definition of the system modules necessary to effect the system operation. Again, these modules have been defined at various levels of operation which correspond to the levels of implementation mentioned in section 6 above. Where possible, identification of the modules have been included for these various levels of implementation, where they cannot be identical, they are as compatible as possible to allow the reconfiguration once the necessary capabilities are available.

8. An assessment of the means to implement these modules. To date it appears that the most viable programming languages on the Four-Phase systems are VISION, a special-purpose display handler unique to the Four-Phase system; and VISIONCOBOL which is a subset of COBOL/74 which allows COBOL operation within the VISION environment. A complete COBOL/74 subsystem is available, but it is not compatible with VISION. In order to run a program in that environment we would have to bring the system down thereby interfering with the operation of FESS. In the event that COBOL/74 capabilities are deemed necessary we would be constrained to perform those activities after normal working hours. This is somewhat less than desirable and will be avoided if at all possible. In addition to looking at the programming languages which will be used in system implementation, a thorough investigation of the program staff requirements has been developed. That staff has been assembled, briefed as to their involvement, and has begun work towards the final design of that code.

9. Design of the system modules. As mentioned earlier, a design document is being prepared and will be made available which details this phase of activity.

10. Initiation of the Training Program. Georgia Tech personnel traveled to Fort Lee, Virginia, September 7-8, 1983, and met with Ms. Karen Hinke who traveled from Fort Belvoir, Virginia. That individual is knowledgeable in the Four-Phase equipment line and has development experience on the FESS subsystem. Ms. Hinke has offered to conduct a two-day condensed course during which essential information was presented. This will allow Georgia Tech to continue further with its design.
Sample compilations in each of the languages were effected demonstrating that the Fort MacPherson machine can be used essentially immediately. The second part of the training program involved attendance at Four-Phase training seminars. Two Georgia Tech staff members attended a seminar in Atlanta from September 26 through October 7. This training seminar provided the staff members with a working knowledge of the Four-Phase system operation and the VISION programming language.

11. Selection of Target Hardware. The Four-Phase product line had been identified as the target machine for development of the PROSPECT Information System based on the following line of reasoning:

- Effective start date of product development was July 21, 1983.
- Desired implementation date was identified at October 1, 1983.
- The procurement cycle for a new system was estimated to be 90 days.
- The FESS Four-Phase equipment was considered available for the purposes of the subject applications.
- Program development capabilities on the Four-Phase product line exists within the U.S. Army.

As of 1 September 1983, the merit of using the Four-Phase product line appeared in doubt due to the following findings:

- The availability of the FESS Systems does not appear to be valid. This conclusion has resulted from discussions with individuals as chronicled below:

  **Chip Reed, Jeff Holste - FESA**

  Early discussions revolved around the existing configuration of the FESS equipment. Later discussions included planned upgrades to that equipment and our desired use of the final system. At that time, implementation was discussed to the point of identifying the approval process required for installation. The process included a review of disk requirements, main memory requirements, and scheduling considerations. Ms. Karen Hinke was identified as our contact point for these matters.

  The current dialog indicates that there are numerous other applications in development at FESA scheduled for installation on the FESS system. These other systems have effectively consumed the reserve capabilities of the FESS System.
Larry Cash - Fort McPherson

Preliminary discussions regarding the use of Fort McPherson's FESS system for program development. Initial concerns were logistic; when will Georgia Tech personnel be there, where will they sit, is there a terminal available, and do they know how to use the system. Once these issues were resolved, a formal request was issued to Lt. Col. Sapp. The response to that request and subsequent discussions have included additional topics of concern: personnel security, maintaining the integrity of their system, and the availability of one of their operators to supervise Georgia Tech's interactions.

The procurement cycle for a Four-Phase development system appears to be prohibitive. The options considered are discussed below.

1. Use of the Fort McPherson FESS system for extensive development efforts was considered and now appears unlikely. This is largely due to their concerns of maintaining an orderly operation during our development period. It appears that they experienced a lengthy and trying period before the system reached the current stable condition. They do not want to jeopardize that stability.

2. Use of a development system at the Atlanta offices of Four-Phase had been explored. This alternative had been considered due to the status of the other alternatives. The subject machine is used for training purposes so its availability will be limited at best.

3. Procurement of a Four-Phase development system through the office of Mr. Mike Antonucci, AMO, was identified as the most likely means of procurement.

As of 1 October 1983, it appeared that the most efficient course of action was to select an alternate target machine for near-term implementation. The subject of near-term development on a Four-Phase system with long-term implementation on another machine has been discussed. At that time it was decided to forego near-term Four-Phase development and direct Georgia Tech's efforts toward development of the total system on the alternate machine. The major considerations for taking this action were:

- Capability of utilizing equipment with support capabilities extending beyond the prime vendor. The Four-Phase line is not second-sourced or compatible with any other computer line. This climate has resulted in a slow and costly relationship in the past and there is no indication that this situation will change.

- Capability of utilizing third party hardware and software items, thereby significantly reducing development effort, time, and expense.
- Ability to begin development immediately on a Georgia Tech-owned machine upon selection, rather than delaying development further.

For these reasons the following approach has been undertaken for development of the PROSPECT Information System.

B. PROSPECT SYSTEM IMPLEMENTATION

The PROSPECT Information System is a subset of the complete FORSCOM Information System. This set of programs has been implemented using Ashton-Tate dBASE II as the programming language running on an IBM-Personal Computer. dBASE II has been used in this capacity to serve as a prototyping language. Due to two factors, this prototype phase was undertaken as a preliminary step before code is committed to a formal programming language. The factors are:

- The short development schedule allowed was incapable of supporting a large database design effort,
- The high-level nature of dBASE has allowed expedient modifications of the application code in a manner which has satisfactorily supported the evolving system concept.

The following sections, together with the referenced appendicies, describe the FORSCOM PROSPECT Information System as it currently exists.

1. System Overview

The PROSPECT Information System is a microprocessor-based, teleprocessing distributed database system. The complete system consists of a network of several IBM personal computers which share information for the purpose of administering the PROSPECT course registration process for FORSCOM personnel. The public switched-telephone network provides the interchange medium over which data transmission is effected. The system has been developed in dBASE II, a high level database management facility, which has allowed the rapid implementation of an otherwise complex undertaking. The system has been made "turn-key" in an effort to provide maximum capability while minimizing the required technical expertise of the user. A complete set of source listings are provided as Appendix B of this document.

2. System Operation

Appendix A is a complete up-to-date operators manual for operation of the FORSCOM PROSPECT system.
V. LONG TERM GOALS

Although the concept of Computer Networks goes back to the early development of time-sharing, the recent revolutionary decrease in the cost of processors and memory has redefined the role of computers. An examination of computer communications networks must consider the following basic issues:

User population
Evolution of the digital computer
Economic basis for computer networking
Network technology

A. USER POPULATION

The concept of distributed data processing and computer networking primarily relates to the processing requirements of the various categories of users. Such categories depend on the type of processing required, the system resources needed to support such processing and the programming or administrative support needed or available at the user location.

The type of processing required by the user is the first determination of the type of distributed processor and computer network configuration that should be implemented. The user may require a specialized service, for example an on-line data base inquiry/response service, or a general service, for example a time-sharing service. The concept of a distributive processing system is to provide as much processing power at the user location as is feasible for the particular application, considering the constraints of:

The number of users at the remote location
The number and mix of programs being run
The system resources required at the remote location
The support available at the remote location
The economic trade-offs involved

The number of users determines the number of terminals or other facilities that should be provided at the remote location. The number and mix of programs determines the type of terminals (CRT, HARDCOPY, ETC.) that are
to be provided. The system resources required at the remote location is dictated by the type of processing being done, and whether the user should be able to interact with other network elements.

The support available at the remote location should not be underestimated. Systems analysts, system programmers, and applications programmers are skilled professionals, and their services are both unnecessary and uneconomical for most routine data processing activities. The goal of the computer network is therefore to provide as much flexibility and processing power at the user location, without the requirement of sophisticated programming capability by the user.

A final point which must be considered with reference to the user population is the economic trade-off between hardware, software, and data processing personnel. Hardware is the least expensive element in the network, and the duplication of hardware may be the most cost effective way of implementing a network.

B. EVOLUTION OF THE GENERAL-PURPOSE DIGITAL COMPUTER

As hardware technology becomes less and less expensive, the concept of a general-purpose computer operating with specialized software may not be the most practical or cost-effective solution to the processing needs of a wide variety of users. The availability and low-cost of special purpose or dedicated processors may be a feasible alternative to general purpose main-frame computers.

A number of such dedicated processors may be implemented in a distributed processing network. In such a network not only processing but data systems functions, and control are distributed. The traditional main-frame computer may still be present in such a network, but it functions now as that of a host computer supervising the network.

C. ECONOMIC BASIS FOR COMPUTER NETWORKING

Computer networks are concerned with the handling of computer-processed data. It is therefore important that the computer facilities incorporate communications capabilities and are compatible with data communications standards, such requirements are more significant then they normally might seem. Only recently have the major computer manufactures announced products, both hardware and software, that are oriented to data communications. Furthermore, data communications standards are only now being accepted.

Another aspect of the computer facilities which should be evaluated is their adaption to data communications and the use of an interactive data file. If
the computer facilities were developed as stand-alone units, the effort and expense of implementing processor or memory sharing at remote locations may not be justified. The first economic criteria is whether the existing or planned computer facilities are data communications oriented, as determined by the nature of the processing task and the availability of hardware with communications capabilities. The second point of cost/effectiveness of computer networks compared with alternative information transfer facilities. Data communications is a very rapid, yet very expensive, method of transferring information from one location to another. The mail, or private transportation, are economically preferable alternatives when the speed of the information transfer is not essential.

Another aspect of cost effectiveness which must be considered is the economies of scale. A computer network serves to combine several smaller systems into a single large system. It could be expected that the single large system works as a unit and offers an economic advantage over the sum total of the smaller systems working alone.

D. NETWORK TECHNOLOGY

Computer communication networks are one of the most complex and expensive projects that are undertaken in the computer field. In order to be competitive, such networks must be designed with the capability of using not only present technology, but also future technologies as they become available.

It must be emphasized that such advances in network technology make possible new applications of computer communications networks. Once such applications have been implemented, the entire structure of the industry may be changed. The telecommunications industry and the appearance of specialized common carriers are just a few examples.

Although a network may be initially structured on the basis of existing resources in specific locations, once the network has been implemented it then affects all future growth patterns of the organization. Not only service facilities but administrative structures are developed around the computer communications network.

E. DISTRIBUTED DATABASES

Today, there is no commercially available, truly distributed database management system on the market. However, systems which distribute a single integrated database and its control system across multiple machines are about to be introduced by several firms.
The reason for these introductions is simple. Large users of database management systems typically run five or six different, non-integrated databases to handle the ever-increasing amounts of on-line data and computerized operations in their many divisions. Unfortunately, a centralized database system limits a database's size and its number of users. What's more, they suffer from failure problems that can take a network full of users out of action.

Distributed database management systems have none of these disadvantages. They accommodate an unlimited number of computers, disk drives, memories, and users. In the distributed design, most data is stored locally and under local control. This decreases communications cost and response times and gives the staff with the greatest knowledge of the data the responsibility of maintaining it.
Phase I of the FORSCOM information system program began with the definition of a few long-term goals. These goals were to:

1. Assess the current and future automation needs of the U.S. Army FORSCOM Engineer's Resource Management Division.
2. Define a phased plan of implementing an automated system to support those needs, and
3. Begin the implementation process.

Activities in support of the first goal dealt with gaining a working knowledge of functions currently performed by personnel in the Resource Management Division. These activities concentrated on the information handling functions associated with several programs administered within the Resource Management Division. The results of the investigation has resulted in the determination that all of the functions share many common attributes. These attributes can be categorized as follows:

1. FORSCOM Headquarters serves as the central organization coordinating the entry and processing of administrative information.
2. Army installations throughout the Continental United States provide independent components of the information maintained by FORSCOM Headquarters.
3. The installation's point of contact for each of the administered programs reports to the respective installation's master planner.
4. Several individuals at FORSCOM Headquarters require access to the maintained information.
5. The processing requirements to support the information maintenance activities are primarily; word processing, list processing and simple arithmetic functions.

This information has identified three distinct, yet interdependent, disciplines which are required to successfully address the system needs. The disciplines are:

1. Distributive data base management,
2. Inter-processor communications, and
3. Applications programming,

Components from each of these areas have contributed to the current system configuration concept. Each installation will have limited access to the data required for system operation. The central site (HQ) will include data management, master report generation, and the ability to emulate any of the subordinate installations. Advanced data base techniques employed include; relational data structures, query processing, concurrency control, data security, and transaction management. Teleprocessing
techniques employed include; high-speed transmission on voice-grade lines, support of SNA-SDLC protocols, transaction processing, and unattended processing modes.

In order to address the second goal three items are required;

1. A definition of the system requirements,
2. An awareness of the resources available to implement a specified capability, and
3. An awareness of the cost/performance measurements to be employed to assess the system's successfulness.

The first of these items, the system requirements, became available once the first goal had been achieved. The second item, resources available, involves the potential orchestration of available hardware, software and personnel necessary to attain the goal of an operational system. It is worthwhile noting that in this context "available" means either currently in hand, available for procurement at this time, or imminently available for procurement.

Early in the program there was an attempt to identify equipment or software currently available to FORSCOM engineers which may be suitable for use in the PROSPECT system. Additionally a survey was conducted of vendor items, either currently available or announced which may be suitable for this system. The findings from these investigations are presented later in this section.

The final item necessary for defining the implementation plan is an awareness of the program evaluation procedure. Simply put, if no portion of the system is available until the entire system is available then no measure of progress can be observed by the reviewing agency. Additionally, there is also an incremental nature to both the system users familiarity with automation equipment, and the sequencing of resources made available for such a system. These factors combine to identify a need to attain some degree of capability in as short a period of time as possible, then expand on that capability in an incremental fashion commensurate with user acceptance and the resources available. The expansion capability requires that the initial system foundation be constructed in a manner which will support all phases of system implementation. The foregoing items, together with additional considerations have resulted in the following list of criteria for system development:

1. Modular system design
2. Upward expandable components
3. Uniformity of operator interaction
4. Easy to use and maintain

The third goal of Phase I was to begin the implementation process. Attaining this goal requires that the necessary resources become available in synchronization with the phased implementation plan identified earlier. The primary resources necessary, after time and money, are; an understanding of the problem to be solved, the framework within which the solution must be implemented, the hardware and software necessary to implement the solution, and professional personnel to perform the implementation. All of these items, except the implementation hardware and software, are considered available within the FORSCOM/Georgia Tech environment. The necessary hardware and software complement have been selected as a result of a joint analysis of needs conducted by FORSCOM and Georgia Tech personnel. To date this analysis has identified the need to
employ readily available hardware components throughout the system to enhance flexibility and familiarity, while minimizing potential system down-time resulting from component failures. For these reasons, the IBM-PC has been identified as the most viable vehicle for implementing the proposed system. The major criteria for this determination are summarized as follows:

1. Wide-spread use of IBM equipment, PC's included, within the U.S. Army,
2. Extensive community of third-party hardware & software vendors providing IBM-PC compatible products, and
3. Readily available third-party vendors to support training and maintenance activities.

The software components of the system will rely heavily upon currently available packages with custom programs providing functions not commercially available. In keeping with previously identified design criteria, the custom software development is being conducted in distinct phases in the interest of acquiring capabilities quickly, initial implementations have utilized programming languages which facilitate rapid development capabilities. Final implementations are coded in runtime efficient languages. This allows FORSCOM personnel to utilize developed programs in as short a time frame as possible. The disadvantage to this approach is that while development speed is enhanced, execution speed suffers. This trade-off is deemed acceptable due to the feasibility study nature of this rapid development, this approach provides the design staff with a prototyping mechanism to prove, or disprove design criteria before finalizing total system characteristics.