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DESIGN CONSIDERATIONS FOR IMPLEMENTING A SHIPBOARD COMPUTER SUPPORTED COMMAND MANAGEMENT SYSTEM

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THESIS

DESIGN CONSIDERATIONS FOR IMPLEMENTING
A SHIPBOARD COMPUTER SUPPORTED
COMMAND MANAGEMENT SYSTEM

by

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This report outlines an approach for the implementation of a shipboard computer supported management information system. The physical design specifications and design philosophy are investigated. The application of mini-computer technology applied to the shipboard environment is presented. Specific administrative functions are recommended for automation.

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I. INTRODUCTION

At present, most shipboard information handling operations are performed manually and are cumbersome and often unreliable. Additionally, the manual operations are labor consuming to the extent that they pose a threat to the Navy's personnel and operational readiness. If personnel and operational readiness are to be maintained in a period of declining available resources, a more efficient and effective means of information handling must be employed.

The objective of this research was to outline an approach to utilize existing automated data processing technology in a shipboard environment in an effort to reduce the percentage of time shipboard personnel devote to repetitive administrative functions. Although specific hardware selection was not an intended objective, issues concerning hardware and software selection were investigated as they related to a shipboard environment. This effort was pursued because selection of a particular hardware suit can impose system limitations that can dictate success or failure for the system.

Investigation of shipboard administration functions revealed several functions which are likely candidates for automation. Differences in ships' size and mission are analogous to differences in commercial companies. Each has varied functions that are critical in one organization and of little consequence in another. This paper focuses on the problems of automating management functions aboard ships with manning levels below 500 personnel. As repeatedly emphasised in Ref. 1, a function or system that is not well defined or is not successfully operating in a manual mode, will fail when automated. Keeping this fact in mind while concentrating on functions that were extremely time consuming, led to selection of the following functions for automation consideration:

1. Shipboard Training and Record-Keeping
2. Maintenance of Personnel Records
3. Paper Inputs to the Manpower and Personnel System(MAPMIS)

Automating these functions exploits the commonality of the data base elements required to support them. This paper provides an analysis of the data base requirements and the design considerations to successfully generate the applications programs that collectively compose the ship's automated management system.

II. BACKGROUND

Several efforts have been made to develop computer-based shipboard management systems. These efforts have been fragmentary in nature. Results have been isolated computer-based packages which do not exploit the extensive commonality of data base elements that support several levels of management. Additionally, the interfacing with higher levels of command has been ignored in their design. As an example, a shipboard personnel record-keeping package requires almost identical data base elements as that of the data base utilized by the Bureau of Naval Personnel(BUPERS). A properly designed shipboard data base should be capable of automated preparation of inputs to the BUPERS data base.

Related efforts to that of the shipboard computer based management system that have beem pursued within the Navy are as follows:

1. Data Entry Aboard Ship(DEAS) Project (COMNAVSUPSYSCOM)

2. Development and Maintenance of Continuous Ship Maintenance Project(CSMP) by Minicomputers (CNM)

3. Data Processing in MLSF Ships. Computer-based system supporting supply, 3-M, and administrative functions in MLSF ships with Burroughs L3200 system installed (COMNAVSUPSYSCOM)

4. Application of Shipboard Computers to Instruction and Training Administration. (NPRDC)

5. Shipboard L-Tran (Lesson Translator). Current shipboard CAI for NTDS operators.

Additionally, the following efforts to automate shipboard functions are of particular interest to future applications:

A. APPLICATIONS ABOARD USS DAHLGREN

References 2-14 describe efforts sponsored by the Navy Personnel Research and Development Center (NPRDC) to utilize a minicomputer to automate shipboard functions. The minicomputer utilized was a commercial version that did not meet Military Specifications (MILSPECS) for shipboard employment. The system description and applications were as follows:

1. Hardware and Software Description

The system hardware and software avaialable for utilization aboard USS Dahlgren consisted of the following:

CENTRAL PROCESSING UNIT (NOVA 1200)
- 16 bit word-32K words memory
- memory cycle time-1.2 micro seconds
- physical size-H 10.5'', W 19'', D 23''
- power interrupt protected
- real time clock

TELETYPE (ASR-33)
- 10 characters per second
- paper tape reader and punch

CARD READER
225 cards per minute
table top mounted

DISK UNIT
fixed head
drive unit (512K words per unit)
interchargeable disk packs

LINE PRINTER
356 lines per minute
132 columns per line
table top mounted
OCR-A font

MAGNETIC TAPE CASSETTE UNITS (6)
5 tape drives

CRT REMOTE TERMINALS
table top mounted
20 lines-80 characters per line
physical size-H 15'', W 17'', D 27''

FORTRAN COMPILER

ALGOL COMPILER

EXTENDED BASIC INTERPRETER

EXTENDED ASSEMBLER

RELOCATABLE LOADER

RELOCATABLE MATH PACKAGE

REAL TIME DISC OPERATING SYSTEM (RDOS)

REAL TIME OPERATING SYSTEM (RTOS)

DISC OPERATING SYSTEM (DOS)

2. Applications

Two of the more significant applications applied to the NOVA 1200 were the development of a computer assisted instruction package to teach shipboard Damage Control and the automation of Supply Department functions.

Reference 13 describes in detail the computer assisted instruction effort. The programs were designed to run under the RDOS operating system and were written in Extended BASIC, version 3.6. The programs were designed as a series of overlays to be operated in a multi-user environment and in the swapping mode of BASIC. The system contained an executive program and 19 subprograms capable of accessing two data files: a student data base, and an examination statistics file.

The course of instruction was designed to satisfy current Personnel Qualification Standards (PQS) in Damage Control. Instruction was given off-line using textual material. Examinations were taken on-line via CRT. Students taking an examination were furnished on-line and hard-copy test results, diagnostics, and corrective actions for improvement.

The effort to automate the supply functions was primarily the result of work done by University of Pennsylvania Wharton graduate students. A system titled USS Dahlgren Automated Logistics Control and Report Generating System(LOGCON) was developed to provide detailed supply information in a matter of seconds. LOGCON consisted of eight unique programs. The software documentation for all the programs is included in Ref. 15. LOGCON utilized four data files: two were random-access disk files and the other two were sequentially accessed tape files. LOGCON had the capability to prepare supply requisitions, determine if stock was available to satisfy a requisition, and to order up the high limit of an item when available stock was at or below its specified low level.

B. A TRAINING MANAGEMENT SYSTEM

In early 1975 the findings on the Pacific Fleet Propulsion Examining Board were that procedures being employed within the Engineering Department of USS Kitty Hawk(CV-63) for the management of training were ineffective. The principal problem being that the cumbersome manual system for recording Personnel Qualification Standards(PQS) training data proved an inadequate mechanism for the Training Officer to effectively supervise and coordinate the training. The operational unit commander(Commander Carrier Division One) initiated action to investigate automation of the training function to make it more responsive to the several levels of management within the ship.

1. System Description

Two computer systems were available for use in designing the computer based training management system; the YUK 1500 system and a Micro Data 1600 system. The two systems were compared in terms of their data processing characteristics and user convenience by personnel from the Naval Electronics Laboratory Center (NELC) and the Naval Personnel Research and Development Center (NPRDC). The Micro Data system with the addition of a CRT terminal and printer was selected for use. The general operating characteristics offered by the system were:

1. Inexpensive terminal installed within the Engineering Department

2. Total time sharing; random access

3. Individual update capability

4. Records available on-line at all times

5. Flexible sorting capability permitting varied reporting formats.

2. Data Base Design Criteria

In designing the elements to be included in the data base, the objective was to include sufficient elements to be able to format meaningful training reports to various levels of command while utilizing PQS as the basic vehicle for training and assignment of individuals. This design criteria was incorporated to make the basic system relocatable for use by any operational units employing PQS.

The Department Head, Executive Officer, and Commanding Officer required summary information to indicate the status of training at a given time. Typical data elements used in generating this level of report were:

1. RQD1-the number of stations manned during Condition 1

2. ASGN1-number of personnel assigned to a station during condition 1

3. ANQ1-number assigned this watch station not PQS qualified

Reports generated for use by the Division Officer required specific information on individuals to assess previous training, and to determine work assignments. Typical data elements utilized to generate this report were:

1. PQS-the PQS number assigned to the watch station

2. TRNG-number of personnel in training for the watch station

3. CRIT-PRD-number of watch station personnel with PRD less than 60 days

Space supervisors utilized some of the information available in the Division Officers report, but required specific information on individuals in their work centers. One of the primary considerations in designing the data elements was to facilitate alphabetical sorting of individuals when information is desired on a single individual. Sample data elements utilized in preparing the reports for work center supervisors are:

1. NAME-last name of individual
2. COND1-watch station assigned for Condition 1
3. L-DATE-PRD or discharge date

C. RESULTS

Although much time and effort was devoted to the two aforementioned systems, very little practical benefit resulted from either. The reason for this lack of results can be attributed to personnel involvement and the hardware utilized.

In both systems, enthusiastic personnel worked on their implementation, but failed to get non-computer oriented personnel involved in the development. As personnel were rotated, lack of system understanding resulted in users losing confidence in the systems and returning to manual methods of performing the functions.

The hardware utilized in both systems was off-the-shelf computing equipment. The systems had to be designed to fit the capabilities of the existing hardware. Varying underway conditions caused system readiness to be unpredictable.

Specifically, DAHLGREN experienced reliability problems with the fixed head disk drive units in heavy seas. An automated data system that displays marginal reliability is little improvement over manual operations.

III. SYSTEM DESIGN CONSIDERATIONS

A question often asked when discussing automation of non-tactical shipboard functions is, "Can existing shipboard computer systems be utilized?" On many combatant ships existing computer systems(e.g. NTDS) are an integral part of weapons systems or tactical-support systems. Reference 16 was a survey made to determine the suitability and availability of onboard computers for training and other non-tactical utilizations. The results of the survey were that computers installed for tactical purposes were hard-wired and not configured for other purposes and these computers were generally not available for other uses when the ship was underway.

The acquisition of any computing system involves detailed evaluation of tangible and other not easily measured factors. The comparison of computing systems in terms of hardware performance factors such as speed and storage capability are straightforward measurements. On the other hand, the evaluation of the reputation of a particular vendor and the problems of interfacing his equipment with that of another vendor are abstract considerations that must also be taken into account when selecting a system. Reference 1 provides a comprehensive checklist for utilization in system comparisons. Issues of particular interest to the shipboard environment are the following:

1. Reliability
2. Physical Planning Considerations
3. Mini vs Micro Computer
4. Software Considerations

A. RELIABILITY

In the selection of most computing systems , cost often has been the dominant criteria influencing the selection decision. In the case of the shipboard system other factors must be given greater weight in evaluating systems of comparable operating performance. Reliability of the system should be a major consideration in selection of any hardware suit. Two of the most commonly used criteria to evaluate reliability are Mean Time Between Failure(MTBF) and Mean Time to Repair(MTTR).

References 17 and 18 enumerate the Standard Military Specifications that have been developed for the protection of shipboard electrical equipment. Although utilization of MILSPECS is required and results in improved reliability, the purchaser must be aware of the price he must pay to ensure compliance with MILSPECS.

An example of the cost of complying to MILSPECS can be seen by comparing a Data General 830 with a Rolm 1602. These two mini-computer systems use the same circuit design and software. The Data General 830 is designed to meet commercial needs while the Rolm 1602 is a militarized version. A comparison of the two systems, each configured with the basic computer, 32K core memory, a control panel, a power monitor, and an automatic restart capability; revealed the Rolm 1602 purchase cost($48,650) to be more than double that of the Data General 830($18,050). On the reliability side, the Rolm 1602 had a MTBF of 13,200 hours as compared to the Data General 830 with a MTBF of 4510 hours. Assuming repair parts and technical expertise were available when a failure occurred, there was no significant difference in the MTTR of the two systems.

The above comparisons while rather crude in nature highlight a simple fact the purchaser of a shipboard system must recognize. It will cost more in dollars to perform an automated function afloat than to perform the same function at a shore-based activity. This fact must be recognized and documented when performing the economic analysis required to justify purchase of the system.

B. PHYSICAL PLANNING CONSIDERATIONS

Once the performance design characteristics of the system have been established, system location plans must be carefully considered before a particular system is selected. When commercial systems are procured, system performance is given top consideration. Space requirements are secondary in nature, usually resulting in space being obtained (purchase or rental) to meet the requirements of the system selected. Space aboard most ships in commission in the United States Navy is a critical factor. The addition of any electrical equipment often requires removal of some existing equipment or the reduction of space allocated to personnel habitability. This requires that space requirements be a major factor in system selection. At a minimum the following factors should be closely examined in determining the suitability of a space for installation of a computing system:

1. Overall Square Footage
2. Deck Loading Restrictions
3. Air Conditioning
4. Humidity Control
5. Cable Length Requirements
6. Layout of Cable Trunks
7. Voltage Requirements
8. Ability to Keep Space Dust Free

C. MINI VS MICRO COMPUTER

The functions proposed for automation within this paper require prompt responses from the computing system to warrant automation. They do not, however, require the high instruction execution speeds available in many present day large-scale machines. This fact coupled with the space restrictions previously mentioned, reduce the choice to that of a mini-computer system or a micro-computer system.

Price and space requirements make the use of a micro-computer an attractive alternative. Technological development of the micro-computer has been limited only by the all important corresponding software development. In fact, many authors have pointed out that the introduction of the micro-computer has put software development for these devices back at the point where software was for macro-computers in the early 1950's. Until software development for micro-computers catches up to the technological hardware developments, a mini-computer is the only logical choice for use in automating shipboard administrative functions.

D. SOFTWARE CONSIDERATIONS

There exist many issues in implementing a data processing system on a mini-computer. To properly exploit the strengths and weaknesses of the mini-computer several software issues as they apply to various applications must be resolved. Reference 15 addresses many of the issues including the following:

1. Program Complexity
2. Storage Utilization
3. Operating System Complexity
4. Extent of Documentation
5. Assembly vs High Level Language

1. Program Complexity

In many applications the knowledge of what goes on within a program is of little consequence to the user. When a programmer writes a progam for his own use he may violate as many of the principles of good programming as he chooses. In general though there exists a trade-off between programmer care and user skill. The term "user" as applied to the shipboard environment ranges from the Data Processing Technician(DP), who will be responsible for maintaining certain programs, to the Seaman who will be expected to operate an on-line terminal as part of the training system.

The varied intelligence and backgrounds of the shipboard users is such that the programs written must display a high degree of "intelligence". The cues for interaction must be precise and simple. The programs must give concise error messages notifying the user when he has supplied unacceptable or impossible data. Programs that may require future shipboard modification must invoke simple, well documented logic to account for the inexperienced DPs. The trade-off for this action is larger, less efficient programs. In the commercial environment more emphasis is placed on the efficient use of the limited memory normally associated with a mini-computer system. In the shipboard environment the success of the system will depend upon the degree of usage by a cross section of the shipboard personnel. Usage in turn can be directly linked to simplicity of operation.

2. Storage Utilization

Although the price of core memory has been drastically reduced within the past ten years, it still represents a substantial enough investment to influence overall system design. Most common mini-computer configurations offer 32K or 64K of core memory per processor. There exists several popular schemes available for managing the available memory ranging from the simplest of allowing one user full access of core to sophisticated paging systems. The best scheme for utilization of memory is basically a factor of average program size and the number of anticipated users.

The shipboard system requires a time sharing environment to support multiple users. Again space limitations restrict the number of users. In the case of a Destroyer size ship, available space may only allow for installation of as little as four on-line terminals. In this situation partitioning memory into static partitions of 8K each or incorporating a simple swapping algorithm should yield satisfactory results. The trade-off to be recognized in partitioning the memory is that of restricting program size. The situation that must be avoided is one in which program size dictates programmers writing sophisticated programs at the expense of program clarity and simplicity of utilization.

3. Operating System Complexity

Here again the trade-off is one of convenience vs core utilization. Most mini-computer manufacturers offer one or more operating systems for their particular machines. Before deciding on a system with more than one operating system, the purchaser should require a demonstration of the degree of difficulty and time required to exchange the operating system residing in core with one from a mass storage device.

The limited number of simultaneous users in the shipboard environment dictates a rather simple minded operating system. Often a manufacturer will try to sell the most sophisticated operating system developed for his machine. It may prove worth-while to consider building an operating system designed specifically to match the desired requirements of that particular installation. The points to keep in mind in making the decision are that too complex an operating system will overburden core and that the more sophisticated the operating system the greater the probability of it containing holes or errors not previously encountered.

4. Extent of Documentation

Every programmer is continually reminded of the value of program documentation. In the mini-computer environment, while the value of documentation can not be overlooked, one must recognize that trade-offs exist. It is a true consequence that source program documentation causes programs to be larger and take up more space. In the case of the BASIC language, which is interpretive, the whole source program is put into core at run-time, and source statements are interpreted as they are sequentially executed. Thus blank cards inserted for spacing consume space within core.

If the source language of a program may be compiled or assembled and gotten into core image form, internal documentation will not affect the size of the loaded program at run-time. A compromise that exists is to store the source program on magnetic tape and store the core images of frequently run programs on disk. Another alternative is to have two versions of a program; one fully documented and stored on magnetic tape and the other with no documentation avaiable on disk.

5. Assembly vs High Level Language

Another trade-off that must be considered is the use of assembly language to save core and disk space or the use of a high level language for ease of programming and program maintenance. The Data Processing Technicians who will be assigned aboard ship will generally possess little background in working with assembly language. In most instances the Data Processing Technicians will only be familiar with CMS-2, used on Navy tactical systems, or COBOL. Those programs where maintenance is anticipated or uniqueness is not desired should be written in a high level language. The operating system and training programs where standardization among ships of a class is the desired objective should be coded in assembly language.

The choice of the high level language to be utilized in the applications programs is greatly influenced by the hardware selection and the amount of core purchased. While it would be desireable to write the programs in COBOL due to its familiarity among Navy DPs, it is not presently a practical alternative. The core requirements of available COBOL compilers have resticted implementation of COBOL in the mini-computer environment. The development of a new high level language incurs a high initial cost. Some currently available popular mini-computer languages and their descriptions are as follows:

a. FOCAL

FOCAL is a simple programming language which was designed for implementation on the DEC PDP-8. FOCAL is non block structured. Variables are not declared in FOCAL. Storage is allocated for a variable after the first occurrence of a SET command. Array elements are allocated one at a time when they are first referenced in the program. FOCAL supports the standard arithmetic operators, but relational operators are not implemented. Program control is provided by the IF, GO, GOTO, DO, RETURN, and FOR statements. I/O is not very sophisticated in FOCAL. The I/O commands are ASK and TYPE. FOCAL provides quite a number of built in functions(i.e. trigometric) and has the facility to let the user define his own functions. Although FOCAL is easily learned, it is machine oriented and bound to the PDP. Its usefulness in simple program application is offset by its lack of power and transportability.

b. PL-11

PL-11 is a block structured language which was created for use on the DEC PDP-11. PL-11 constructs are good for writing readable, structured programs. All variables and procedures in PL-11 must be declared. The Bit data type allows the user to reference individual bits in main memory through use of the SET and CLEAR commands. PL-11 offers the standard arithmetic and logical operators. Iterative control within a program is effected through use of a standard type of looping. Nesting of procedures to any desired level is permitted and recursive calls are allowed. By declaring a variable to be of type STACK the programmer may make use of the PUSH and POP functions which serve to manipulate the top-of-stack element. PL-11 functions make special use of PDP-11 hardware features and is thus non-transportable.

c. C

C is a compiler that was first developed on a PDP-11 and used to implement the UNIX operating system. C is neither block structured nor based on a commonly used high level laguage. C supports the standard arithmetic and relational operators and in addition some unusual operators influenced by the hardware of the PDP-11. Program control is accomplished through use of the IF, WHILE, FOR, DO, and SWITCH statements. The SWITCH statement is equivalent to the traditional "CASE" statement. Functions in C may be recursively called. Formatted I/O is accomplished through library routines which convert decimal, octal, and floating point values to or from ASCII. As with the two previously mentioned languages, C is highly machine dependent.

d. FORTRAN IV

Many mini-computers make use of powerful FORTRAN compilers. Using a standard operating system implemented in assembler code, they provide the capability for supporting a powerful FORTRAN which is compatible with IBM's level G compiler. Utilizing an INLINE statement they allow inclusion of assembler code between FORTRAN statements providing greater programmer flexibility. The drawback of these compilers , as with all FORTRAN compilers, is the difficulty encountered in utilizing them in non-numerical applications.

e. BASIC

The programming simplicity of BASIC has made it one of the most popular mini-computer languages. The editor, file storage, and program execution are combined into a single system allowing BASIC to be independent of any operating system. The Dartmouth standard BASIC includes more powerful constructs than it's FORTRAN IV counterpart by supporting string manipulations, matrix operations, formatted I/O, external subroutines and a file system. Additionally, BASIC programs execute interpretively which circumvents problems of compilation caused by limited memory. With suitable extensions, BASIC can be used for a variety of sophisticated and demanding applications. A BASIC programmer does not manage main memory directly. Instead, he manages program space which consists of numbered instructions and variables both of which require space in main memory. When BASIC programs become too large to fit main memory, the programs must be broken into overlay modules with inter-module sequencing logic. Reference 9 presents a structuring and design strategy for managing overlays.

Weighing equally the factors of programmers ability, machine independence, and power of the language, an extended version of BASIC becomes an attractive choice of a high level language for use in the shipboard management system.

IV. INTERFACE WITH MAPMIS

A high percentage of shipboard administration time is dedicated to generation, verification, and correction of inputs to the Navy's Manpower and Personnel Management Information System(MAPMIS). Presently, source data is entered into the MAPMIS data base as a result of internal Bupers functions as well as world-wide field data reporting. The present reporting process is error prone resulting in a significant rate of errors being introduced into the data base. This situation has resulted in many costly, faulty decisions by the users of the data base(i.e. detailing an individual to fill a billet that was previously filled, but not recorded in the data base).

The nature of errors in the data base can be the result of several circumstances. Errors attributed to lack of timeliness can occur if decisions are made on a data base that does not reflect the most recent personnel transactions. The most common errors are inaccurately reported information or the failure to report information required to update the data base. The worst situation develops when faulty information that has been entered into the data base is used to edit inputs, resulting in rejection of entirely correct information.

The present method utilized to handle errors is to research them at the point of detection, usually Bupers, and if possible correct them and re-attempt to update the data base. This method of error research is manpower-intensive and even with the significant resources presently available, resolution is frequently not attainable, causing an accumulation of backlogs. Often, reports must be returned to the ships and shore stations originating them. When this situation arises, errors associated with timeliness may result.

Bupers has undertaken a source data improvement program to identify areas in which accuracy and timeliness can be improved. The short range plan utilizes existing structures for reporting. The current OCR reporting formats and the Diary system will be maintained. What will change is the method by which the data is transmitted, verified, and entered into the MAPMIS data base.

A. REPORTING STRUCTURE

Under the MAPMIS system, there will exist five basic nodes or reporting levels in the system. They are in the order of their data processing capability:

1. Central Processing Node
2. A. D. S.
3. High Level Terminal (HLT)
4. Low Level Terminal (LLT)
5. Remote Unit

The central processing node will be the MAPMIS itself. The A. D. S. activities are those with large existing personnel data bases such as the Chief of Naval Education and Training (CNET). Ships reporting their local transactions will not be concerned with these activities. The lowest reporting node will be a separated unit incapable of supporting a low level terminal. An example of such a unit might be a motil medical team attached to a Marine Corps unit. A ship configured with a mini-computer would be considered a low level terminal activity reporting personnel information to the MAPMIS through a high level terminal activity.

A high level terminal activity is characterized by the maintenance of a local data base kept in synchronization with the Bupers data base. This concept is dependent upon the concept of a centralized base personnel office. As an example, instead of every Navy activity in the geographical location of San Diego manning its own personnel office, a central base personnel office will maintain a local data base on the order of 10,000 officer and enlisted personnel.

The HLT will be supported by a mini-computer with sufficient disk capacity to maintain the local data base. The mini-computer will be capable of intelligent terminal processing of a large variety of data input formats. The high level terminal activity will support remote data stations via a hard-wired arrangement or through use of a modem and a telephone data set. The HLT processor will provide operators at remote data stations with error analysis such as syntax, formating errors, or validation errors against the local data base.

The data in the data base will be a slave of the central data base of MAPMIS and kept in synchronization through a feedback transmission scheme. All HLTs will be identical in operation except for the number of personnel within each local data base.

In general, a low level terminal activity(LLT) is characterized by its inability to maintain a local data base. Although a ship configured with a mini-computer surely has the capacity to maintain a local personnel data base, its lack of telecommunications capability while underway prohibits synchronization of its data base with that of the MAPMIS. Therefore it will be classified as a LLT as will ships having no local data processing capability; configured only with a simple low level terminal. The output of an LLT will be transactions recorded on bulk media such as data tape cassettes or floppy disks that will be forwarded to an HLT for input into the system. When underway a ship would utilize this approach. While inport, the ship would be tied to the HLT via modem and telephone data set.

B. DATA TRANSMISSION

The greatest density of data flow will occur between the HLTs and the central processing facility. Periodically the HLTs will transmit all transactions that have accumulated to that time. The central processing facility will in turn pass a feedback transmission for the purpose of validation.

A significant amount of data transmission will occur within the HLT itself. Personnel clerks at user activities will prepare rough worksheets in OCR or Diary formats. When entering the data in the HLT data base, they will select the report type by depressing a function key. The system will go into the correct mode for receiving the data for that report and provide cues for entering it. As the operator enters data, static information will be provided to cross check the data. As an example, if a man's social security number is entered, the system will feed back the man's name. The operator can then tell if he has entered the social security number correctly and if he is processing information on the desired individual.

The local processor edits the incoming data checking it for correct format and syntax. As an example, when age is called for, the processor may only allow numbers between 17 and 45 to be entered. When the report is completed the information contained in it is compared to the local data base to ensure that it is consistant with information already contained within the data base.

An additional feature of the HLT will be the ability to prepare formal documents that require a signature. These documents will be prepared on the local line printer and forwarded to the cognizant command for signature. Services such as preparation of personnel rosters or personnel "tickler" actions will also be available upon request.

When a ship gets underway, it shifts from a remote HLT user to a LLT. In this situation a significantly different approach will be taken to data entry. The personnel clerk will still prepare the data in rough OCR or Diary format. The processing difference occurs in the level of editing. The ship will possess no personnel local data base against which to check the input data. Data that is entered will only be checked for logical correctness such as format and syntax. If the data passes the low level editing, it will be output on cassette. At first opportunity the cassette will be forwarded by courier or postal servive to the specified HLT for entry into the local data base.

If upon arrival at a HLT, transactions do not pass the editing requirements of the HLT, an attempt will be made to locally correct the transaction. If the correction cannot be effected at the HLT, a feedback transaction will be prepared and returned to the LLT to rectify the error.

C. PRIVACY CONSIDERATIONS

The introduction of several local data bases requires that the standards of personal privacy as set forth in the Privacy Act of 1974 be applied. The local data bases are part of a reporting system and no decisions concerning individuals will be made based on the data contained in them. Additionally, no disclosures will be made from data in the data bases. The data in the local data bases will subscribe to the standards of "routine use" as set forth in the Privacy Act.

V. AUTOMATED TRAINING

The task of accomplishing the required training necessary to insure a ship's combat readiness takes a high percentage of the Navy's manpower and fiscal resources. The moving of shipboard personnel to, and maintaining them at shore based schools is a costly requirement. This requirement exists due to the complex technology incorporated in the training and the lack of sufficient instructional personnel to carry out the training at local commands.

The training that is carried out at the shipboard level is most often administered to groups of individuals. The effectiveness of this training method depends upon the competence and teaching skills of the instructor and the comprehension level of the personnel receiving the training. The method does not allow for differences in learning abilities of those individuals receiving the training. Additionally, the effectiveness of the individual instructors is difficult to measure.

The use of the computer in administering shipboard training offers the following benefits:

1. Complex Training at Shipboard Level
2. Standardization of Training
3. Individuals Taught at Their Own Pace
4. Reduced Training Costs
5. Instant Individual/Command Training Status

A. DEGREE OF AUTOMATION

Two methods of utilizing a computer to assist in the training effort were investigated. They were:

1. Computer Assisted Instruction (CAI)
2. Computer Integrated Instruction (CII)

Computer assisted instruction has become an increasingly popular vehicle to train military personnel at shore based activities. CAI instruction is administered predominantly on-line. Under this method of instruction a student receives the basic lesson via a CRT terminal, takes his examinations on-line, and receives diagnostics and prescriptives also administered via the CRT.

Computer integrated instruction is a method in which basic instruction is accomplished off-line via printed materials. Testing, diagnostics, and prescriptives are received on-line. The off-line training consists of programmed instruction (PI), audiovisual instruction (A/V), and self study guides (SSG).

Educators generally favor the CAI method because it holds the individual's attention while leading him from lesson through examination. The drawbacks of this method are that programs tend to be extremely large due to the required verbosity of the lesson. The limited memory of a mini-computer system makes this an undesirable program characteristic. CAI requires that an individual spend long periods at the CRT terminal. This situation could cause contention for terminal time on ships capable of maintaining a limited number of terminals due to space restrictions. The CII method, however, requires an extremely simple insruction set for the user. The system can be implemented with as little as three user commands. These commands should allow the user to check his training status, call a shopping list of available examinations, and select the desired examination.

B. SYSTEM OPERATION

The basic support materials for the CII will be prepared by the Naval Training Command. Specific subject areas will be broken into several modules. The normal sequence of instruction for each module is:

1. Take a pre-test on the computer
2. Take the module lesson off-line
3. Take a post-test on the computer

The pre-test is used to measure existing knowledge of the material presented in a particular module. Passage of a pre-test demonstrates proficiency in the material presented in the module and the qualification will be entered on the individuals training record. If the pre-test is failed, specific lessons will be presented on the CRT and a hard-copy furnished via the printer. Upon completion of the prescribed material, a post-test will be taken on-line. If the post test is failed the individual is directed to retake the prescribed lessons for the module. Figure-1 illustrates the procedural flow of the system.

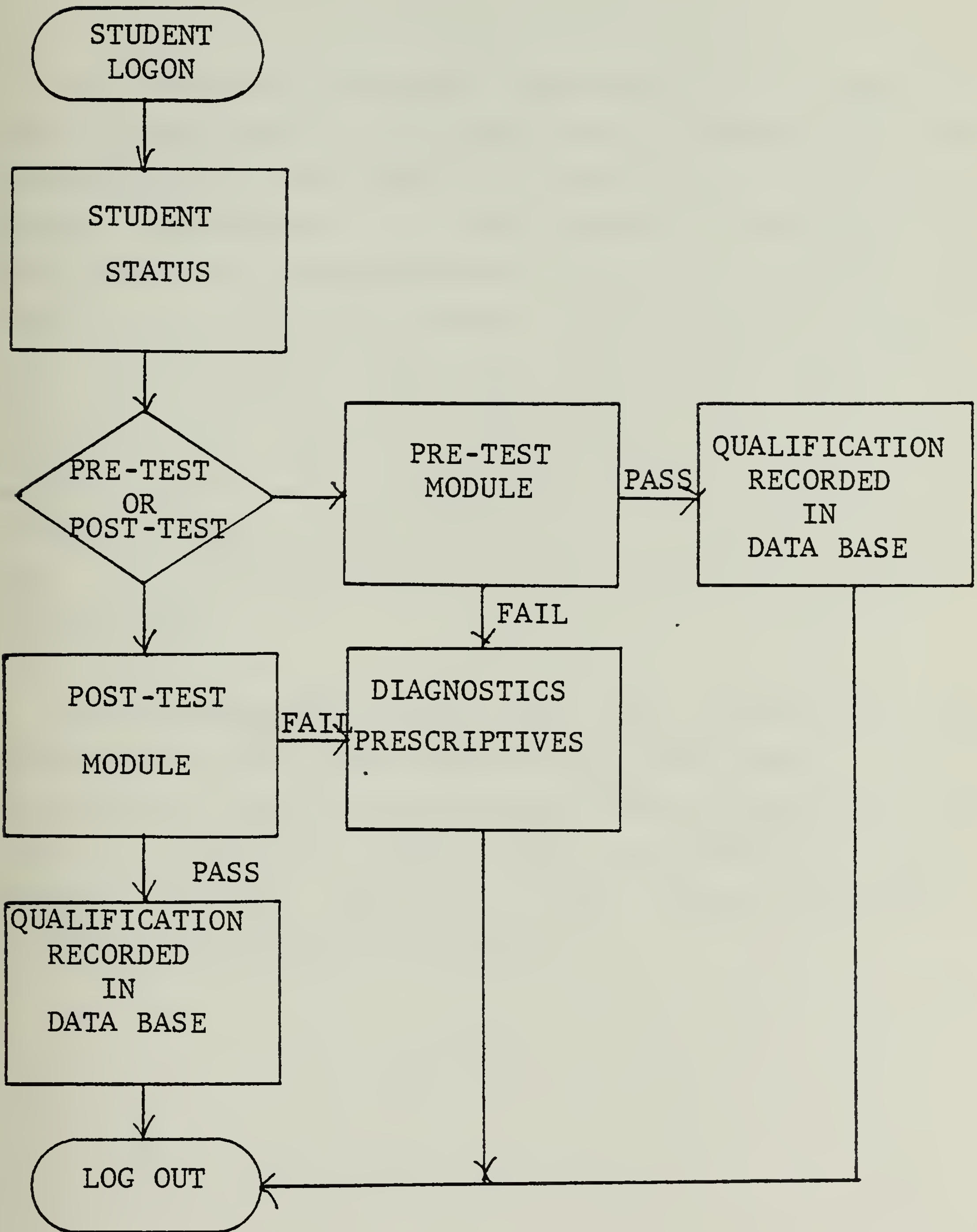

FIGURE 1 - PROCEDURAL FLOW

C. FILE REQUIREMENTS

The computer integrated instruction can be supported in its simplest form by two data files: a student data base and an examination data base. The student data base will contain general information on the student for identification and will record his training status for the various training subjects he is undertaking. Information to be included in the student data base is module status pre-test and post-test results, and start/completion dates. Figure-2 represents the flow of information in the system. The student data base will be maintained on magnetic tape and loaded to disk at the beginning of a training period. The tape will be updated at the end of the last training period of the day.

The examination data base will consist of a separate physical file for each pre-test and post-test. A relatively inexpensive method of maintaining these files is on cassette tapes. The cassette files will be loaded to disk upon request of the individual user. These files will not be modified by shipboard personnel.

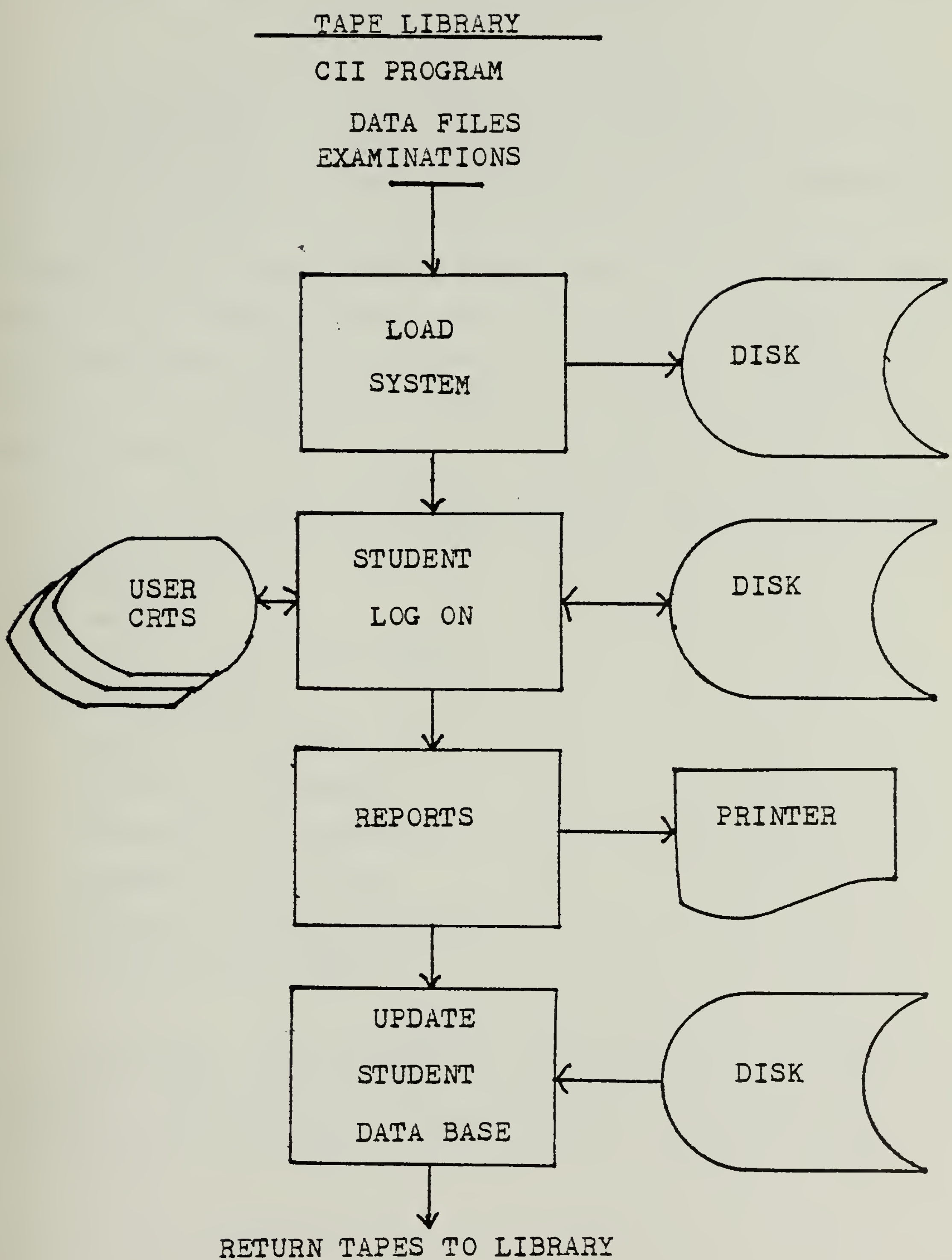

FIGURE - 2 INFORMATION FLOW

D. DATA ELEMENTS

The training modules should be structured to satisfy PQS requirements for those particular subject areas where PQS has been implemented. The information in the student data base should be a complete record of the PQS program and the status of each individual aboard the ship. The simplest method of constructing the file is to design it as a variable length file composed of logical records, one per person. The number of physical records composing each logical record will be a function of the degree of training required for the individual associated with that logical record. The student data base should contain these minimum data elements:

1. Name
2. Social Security Number
3. Work Center
4. Modules Required
5. Modules Completed
6. Modules in Progress
7. Module Start Dates
8. Module Completion Dates
9. Test Score Results

Additional data elements can be added if desired by the Command. This will affect the number of physical records required and the total length of each logical record.

VI. PERSONNEL RECORDS

The interface with MAPMIS outlined in Chapter IV is totally dependent upon conversion to the Central-Base Personnel Office concept. Should this concept be rejected or postponed, ships with data processing capabilities should maintain a local personnel data base. The data elements contained in the data base should match those required on the various paper inputs now being submitted as entry data to MAPMIS.

Reference 4 offers a simple but effective scheme for managing a generalized personnel data base.

A. SYSTEM DESCRIPTION

The proposed system requires a data base and a dictionary that defines the data in the data base. The dictionary is a file containing specific descriptions of the data base elements. The dictionary file contains the identification, characteristics, and storage locations of each data element and is dynamically accessed by I/O commands. A dictionary manager program is required to allow the user to add, change, and delete records and to print the contents of the dictionary. A file manager program is required to allow the user to generate report headers and to query the data base.

The basic design philosophy is structured for a main data base and data subsets. The subsets provide multi-level query by a series of selective reductions. The subsets are created from the main data base in response to a SELECT command. Each subsequent subset is formed by an additional SELECT command operating on the most recently created subset.

Subsets are selected based upon the parameter input by the user, e.g., age or name. As an example of the subset reduction process, assume the data base contained only the following information:

Name: J. Brown, Rate: BM1
Name: R. Jones, Rate: BM2
Name: A. Smith, Rate: BM1
Name: E. Smith, Rate: BM2

Using the SELECT command with the parameter name Smith would cause the subset of the last two records to be formed. Reusing the SELECT command with the parameter rate BM2 would form a subset of the last record only. Figure-3 shows the system flow for the query process.

B. USER COMMANDS

The extent of the command set made available to the user should again be primarily influenced by simplicity of use. It should allow the user as a minimum to carry out the following functions:

1. Add records to the data base
2. Modify existing records
3. Delete records
4. Sort records
5. Format printed reports
6. Display records on the CRT

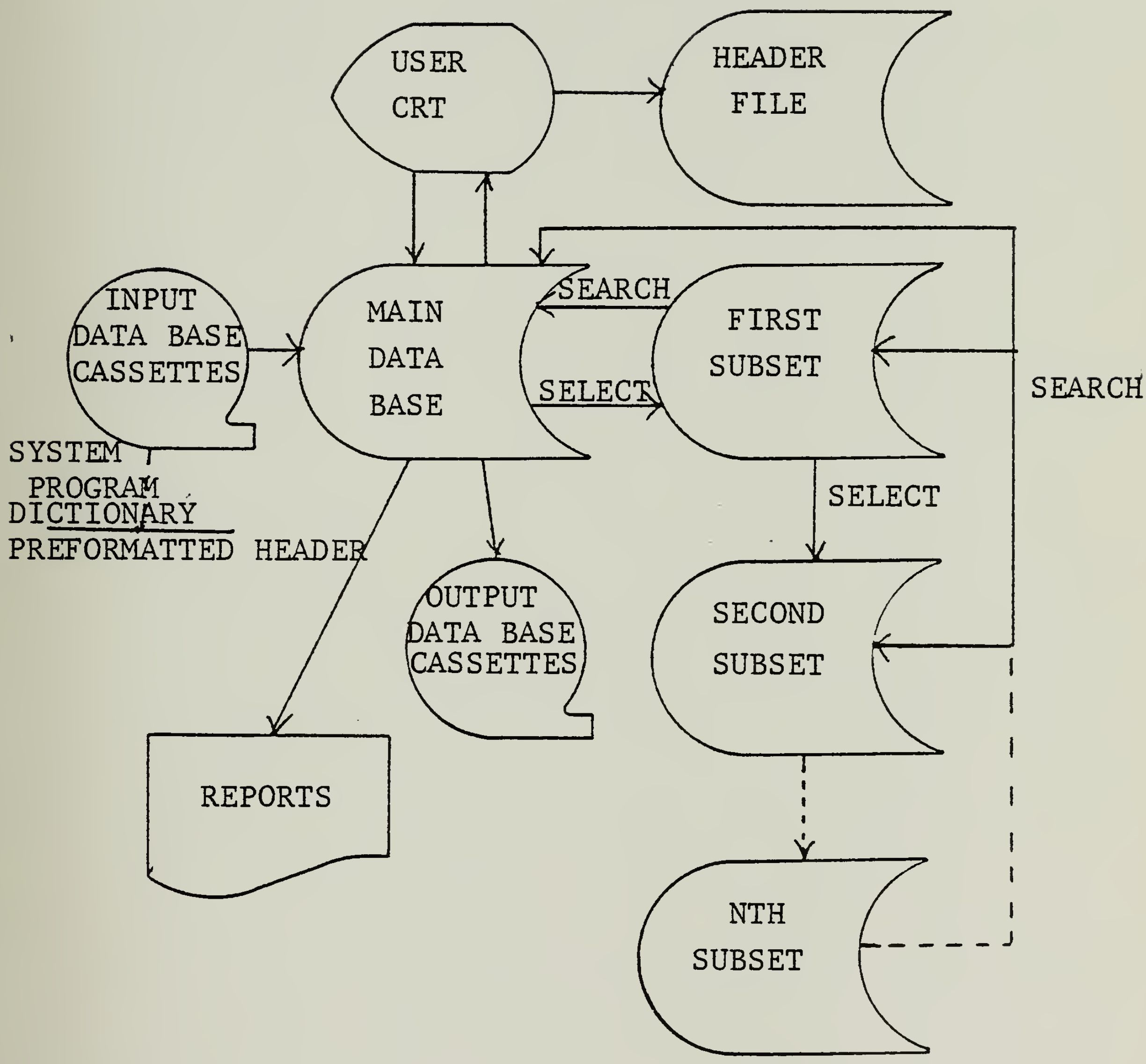

FIGURE 3 - SYSTEM FLOW

A command missing from many systems that should be included is an "EXPLANATORY" command. This command should provide an inexperienced user a concise, easily understood explanation of each user command available on the system.

VII. CONCLUSIONS

An automated shipboard command management and readiness information system is needed. The basic subsystems to be included are limited primarily by computer capacity and the extent to which they can time-share the system. A basic factor is commonality of data base elements to support specific subsystems.

The training and administration function is the foundation for assessing operational readiness status of individual crew members, teams, and the entire ship. This subsystem must provide both training deficiencies and training attainment data in the context of ship-specific requirements. It should incorporate the Personnel Qualification Standards concept and other requirements established by training directives. Output should include required training information from the ship to higher levels of command. The subsystem will enable commands to select which crew members and knowledge/skill areas should be trained aboard ship or at training centers ashore.

In designing any hardware/software system, there are a number of crucial questions to which the system designer must find answers. One of the most important in a shipboard application is the role of the human operator in the operation of the system. The man-machine interface must account for the limited computer exposure of most shipboard personnel.

Cost effectiveness will be enhanced by maximum use of the system and careful choice of functions to be automated.

Simplicity of use will encourage users. Design considerations that involve trade-offs between simplicity and efficiency should be weighted to favor simplicity.

Future developments in micro-computer software should be carefully examined before actual implementation of a system. As software becomes available to simplify routine data processing operations, the advantages offered by the micro-computer in the areas of cost and size will strongly favor its usage.

Many additional subsystems exist as candidates for automation such as payroll, supply, and PMS accomplishments. Automation of these subsystems should only be attempted after the training and administration subsystems are running smoothly. Such new projects must be carefully examined to determine their contention for system resources.

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