AD-A053 851 NAVAL POSTGRADUATE SCHOOL MONTEREY CALIF F/G 5/9

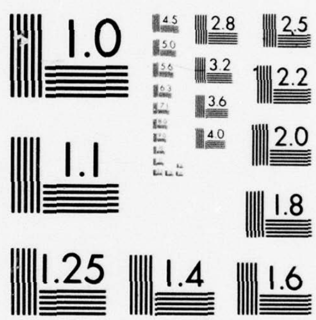
A STUDY OF THE SELECTION OF AN INFORMATION FLOW AND ANALYSIS SY--ETC(U)

MAR 78 G C LANNOU

UNCLASSIFIED NL

1 OF 2

AD A053851



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

NAVAL POSTGRADUATE SCHOOL

Monterey, California

THESIS

A STUDY OF THE SELECTION OF AN
INFORMATION FLOW AND ANALYSIS SYSTEM
FOR NAVAL UNDERWATER SYSTEMS CENTER

by

Gordon Calvert Lannou, Jr.

March 1978

Thesis Advisor: J.W. Creighton

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
(6) A Study of the Selection of an Information Flow and Analysis System for Naval Underwater Systems Center.

5. TYPE OF REPORT & PERIOD COVERED
(9) Master's Thesis, March 1978

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
(10) Gordon Calvert/Lannou, Jr.

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Naval Postgraduate School
Monterey, California 93940

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
Naval Postgraduate School
Monterey, California 93940

12. REPORT DATE
(11) March 1978

13. NUMBER OF PAGES
(12) 124 p.

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

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

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

18. SUPPLEMENTARY NOTES

Conn., needs

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

Computer System	Management Information Systems
Design	Systems
Communications	Operations
Information	Users
Information Systems	Utilization

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

The Naval Underwater Systems Center (NUSC) located in New London, Connecticut, has a need for an Information Flow and Analysis System (IFAS) for the Sonar Operational Training and Assessment Program (SOTAP). The study addresses the requirements for sonar operational programs. It discusses basic differences between weapons and information systems, and proposes a systems approach for the acquisition of a basic management information → over

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE (This)
(Page 1) S/N 0102-014-6601 |

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

251 450

(20. ABSTRACT Continued)

system. It presents the information system alternatives available to the SOTAP management and describes the existing information system, Personnel Training and Evaluation Program (PTEP). It discusses PTEP's FY 78 incorporation into the Navy's Versatile Training System (VTS) and how PTEP may be expanded and changed under VTS to include the sonar rating aboard Fleet Ballistic Missile (FBM) submarines with the end goal of improving ultimate user (sonar technicians) knowledge and performance of sonar weapons systems.

Approved for public release; distribution unlimited.

A Study of the Selection of an
Information Flow and Analysis System
for Naval Underwater Systems Center

by

Gordon Calvert Lannou, Jr.
Lieutenant, United States Navy
B.S.E.E., University of Texas, 1972

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
March 1978

Author ______________________

Approved by: ______________________
Thesis Advisor

____
Second Reader

____
Chairman, Department of Administrative Sciences

____
Dean of Information and Policy Sciences

ABSTRACT

The Naval Underwater Systems Center (NUSC) located in New London, Connecticut, has a need for an Information Flow and Analysis System (IFAS) for the Sonar Operational Training and Assessment Program (SOTAP). The study addresses the requirements for sonar operational programs. It discusses basic differences between weapons and information systems, and proposes a systems approach for the acquisition of a basic management information system. It presents the information system alternatives available to the SOTAP management and describes the existing information system, Personnel Training and Evaluation Program (PTEP). It disucsses PTEP's FY 78 incorporation into the Navy's Versatile Training System (VTS) and how PTEP may be expanded and changed under VTS to include the sonar rating aboard Fleet Ballistic Missile (FBM) submarines with the end goal of improving ultimate user (sonar technicians) knowledge and performance of sonar weapon systems.

TABLE OF CONTENTS

ACKNOWLEDGEMENT

The author would like to recognize the assistance received from Mr. Russell L. Brown, Mr. Ronald A. Nadeau, LCDR. Thomas J. Will, and STCM (SS) Gary M. Gilbert of Naval Underwater Systems Center, New London, who stimulated the author's interest in the Sonar Operational Training and Assessment Program (SOTAP). Mr. Russell L. Brown was particularly helpful in arranging for the author to sit in on some actual contract negotiation sessions with a potential SOTAP contractor. His review of the descriptive history contained in Chapter I was most helpful in getting the chronology of the program.

The author would also like to thank Mr. Larry Freeman, SOTAP Program Manager, who took the time to answer questions about the environment of his program acquisition and his perceptions on weapons systems acquisition.

Finally the author wants to formally thank my wife, Linda, who relieved me of many family obligations during the final crunch and to recognize the assistance and guidance of Professor J. W. Creighton who was able to keep the broad perspective of the entire subject when details seemed to make the task impossible.

While the author has made a sincere attempt to document the facts and events that have occurred during the development of several submarine programs, there may be some errors

in fact and interpretation. These errors and the extent to which they affect the conclusions and recommendations are acknowledged as the responsibility of the author.

I. INTRODUCTION

Sonar, an acronym for SOund NAvigation and Ranging, designates that branch of applied acoustics in which acoustic energy is propagated through a water medium [Ref. 1]. Systems which utilize underwater acoustic energy for observation or communications are referred to as sonar systems. They are used for many purposes ranging from peaceful "fish finders" and small boat navigation aids to large anti-submarine warfare (ASW) systems for detection and classification of ships, submarines, and mine hunting. Sonar systems also provide a means for both short and long distance underwater communications.

A. BACKGROUND OF SOTAP

A sonar on-board trainer (OBT) is believed by Mr. Russell L. Brown, Principal Investigator (SOTAP) to be needed for submarines but acquisition attempts until recently have not been fruitful. In the spring of 1973 a sonar on-board trainer was sea tested on a non-Digital Multi-Beam Steering (DIMUS) sonar suite aboard the U.S.S. WILLIAM H. BATES (SSN-680). An OBT is an Advanced Development Model (ADM) piece of hardware that can inject realistic target signals into the sonar suite. During the sea trials test of the hardware, the question of "How were the ship's personnel going to use the OBT?" became apparent to the sea trials test director, Mr. Russell L. Brown. By the end of the sea trials it was concluded that this piece of hardware would be of tremendous value in training sonarmen while standing their sonar watch. Another question posed was "What kind of operational training was going to be conducted?"

At this point it is necessary to distinguish between operator training and operational training. Operator training is defined as familiarization training centered around sonar equipment functions and modes, operation of controls and switch/dial settings and preliminary operational adjustments. On the other hand operational training is training in the effective utilization of the available system capabilities to accomplish specific tasks such as search, track, and classification procedures, detection recognition and general tactical procedures. Later, Commander, Submarine Development Group Two asked the question "How can you prove that training had occurred?" This led Mr. Brown to investigating operational team training concepts. A literature search and discussions with sonar fleet personnel and instructors eventually led to a contract for OBT training materials. Several technical improvements were then made to the OBT including switching from analog to digital displays.

By 1975 the improvements to the on-board trainer and the training materials had been completed. At this time a sea trials Operational Evaluation (OPEVAL) on the U.S.S. WILLIAM H. BATES (SSN-680) was conducted with structured training and performance evaluation. Through this OPEVAL it was proved that training did occur. Therefore, the question posed earlier by the Commodore had been answered. Although the sea trials had been evaluated an overall success, the OBT was judged as not very maintainable or reliable. A NAVSEA decision was made to not go with any production buy.

Several studies were conducted showing that the on-board trainer could interface with Digital Multi-Beam Steering (DIMUS) sonar systems. The AN/BQQ-5 had a training mode but the program office would not buy into the on-board trainer even though it had been shown that the OBT could interface with a DIMUS system. Therefore the SSN community never received the on-board trainer.

In 1976 Mr. Brown approached Strategic Systems Project Office (SSPO) with the operational team training concept since it was developing a land based Sonar Operational Trainer (SOT). SP-15 gave Mr. Brown $25,000 to do a pilot program for operational material for the SOT. By this action Mr. Brown had sold the concept of operational training materials. SP-15 also looked at the on-board trainer for SSBN's and decided to acquire them. Now, SOT training materials and OBT training materials were to be developed and integrated for ship and shore-based training by NUSC. It was at this time, October 1976, by a Memorandum of Agreement, Strategic Systems Project Office (SSPO) assigned to the Naval Underwater Systems Center (NUSC) the functions and responsibilities of Principal Developing Activity (PDA) for the Sonar Operational Training and Assessment Program (SOTAP) [Ref. 2]. Contracting Officer responsibilities for the program procurements to support SOTAP was delegated by NUSC to Naval Regional Procurement Office (NRPO) Philadelphia, Newport Division.

As the primary Requiring Activity, SSPO would provide program policy direction and funding, establish and maintain applicable training specifications, and monitor overall program effectiveness. As PDA, NUSC would develop, introduce, and maintain all program materials. These materials would implement the integration of Sonar Operational Trainers (SOT), On-Board Submarine Ocean Acoustic Trainers (SOAT), and AN/BQR-21 Unit Lab Trainer (ULT) into a system operational training on SSBN sonars, and operational assessment of both sonar and combined sonar/fire control teams.

Management of the SOTAP at NUSC would be the responsibility of the Submarine Sonar Product Line (Code 32). To ensure proper integration between training device and training material developments, a special Program Office (Code 3293) was established within the Product Line to manage all SSBN sonar operational training related programs. In view of the extensive need for fleet interaction, a Program Officer billet was obligated in support of the Program Office. In accordance with the SOTAP Memorandum-of-Agreement, NUSC will contract out a substantial portion of the Program's material development and maintenance efforts.

The program participants and their relationship to the program are listed below:

1.	COMSUBLANT/COMSUBPAC	- Operational Requirements
2.	SSPO	- Program Sponsor
3.	NUSC	- Principal Development Activity (SOT, SOTAP)
4.	NAVSEA	- Principal Development Activity (SOAT)
5.	TRAFAC	- SSBN Shipboard and Off-Crew Training Facilities

In 1977 with a budget of $100,000, NUSC was tasked to develop a new set of OBT training materials for the SSBN's. In their final form these materials were called Exercise Controller Guides (ECG). In August of 1977 the OBT was installed aboard the U.S.S. SIMON BOLIVAR (SSBN-641) and during sea trials a Technical Evaluation (TECHEVAL) on the hardware was successful. In September-October during patrol an OPEVAL with an Operational Test and Evaluation Force (OPTEVFOR) rider was conducted with the ECG. The OPEVAL was successful. To quote the Commanding Officer, Cdr. M. J. DeHaemer, "The ECG is an outstanding document in support of the OBT. The format and underlying concepts are sound and it was demonstrated to me during OPEVAL that the training method if very effective ..."

The foregoing illustrates the current state-of-the-art in submarine sonar operational programs and indicates that further development efforts are necessary to complete the specific needs of the Sonar Training and Assessment Program (SOTAP).

B. PURPOSE OF THE STUDY

The objectives of this study are:

1. To select an Information Flow and Analysis System (IFAS) for the Sonar Operational Training and Assessment Program (SOTAP).

2. To delineate the present real need for sonar operational training programs.

3. To describe some of the consequences of applying a management organization and principles geared to the development of weapons systems to the development of information systems.

4. To propose a systems approach for the acquisition of a basic management information system.

5. To identify and choose an information system alternative available to the SOTAP management, and propose recommendations that will be useful in implementing the SOTAP program IFAS.

This study focuses on broad management and organizational relationships, and therefore deliberately avoids to the maximum extent possible, the more technical aspects of computers and computer utilization.

C. METHOD OF RESEARCH

The basic procedural method utilized to accomplish the objectives in this investigation consisted of the following:

1. A literature review in the areas of management information systems, training information management, training data base, data base management, training data management, technology transfer, and government directives was made in order to provide a broad background in management practices of information systems development.

2. Three trips and numerous phone calls were used in conducting personnel interviews of program participants and other personnel to expand upon the meager amount of data available concerning team training concepts, and to obtain their expert opinion on SSBN submarine sonar operational training. The interviews were conducted informally with no set pattern being followed. They were tailored to the interviewee and were intended to provide the researcher with an insight into the atmosphere, attitude and functions of the various activities being interviewed and to provide pertinent information concerning the sonar personnel. The goal was to establish a rapport with the interviewee and to obtain candid information.

3. The information was compiled, then analyzed.

Chapter II delineates the need for sonar operational training programs, showing how advances in technology, personnel shortages and non-continuous operational periods at sea for Fleet Ballistic Missile (FBM) Sonar Technicians have led to the institution of the SOTAP program. Chapter III discusses weapons systems and information systems and the problems that could occur if management does not realize the basic differences. Chapter IV proposes a systems approach for the acquisition of a basic management information system. Chapter V presents the alternatives that are available to acquire a management information system from the author's viewpoint. Special attention is devoted to the present information system, Personnel and Training Evaluation Program (PTEP), which is already established for certain rating groups onboard the Fleet Ballistic Missile (FBM) Submarines. PTEP's information handling system conversion from a "batch process" to an on-line real-time capability under the Versatile Training System (VTS) by Fiscal Year 1978 is presented. Chapter VI gives conclusions and recommendations derived from the study.

Appendix A shows a systems overview drawing illustrating the information systems development process proposal. Appendix B paraphrases the important portions of Digital Equipment Corporation's sales brochure on its Resource Sharing Timesharing System/Extended (RSTS/E), the data management system used by VTS. Appendix C is the currently used PTEP optically scanned data scoring form.

II. NEED FOR SONAR OPERATIONAL TRAINING PROGRAMS

The goal of this chapter is to show that a real need exists for sonar operational training programs even though the existence of the SOTAP program, as described earlier in the background, was an evolution of events driven by technology (hardware) rather than need.

A. TECHNOLOGICAL ADVANCES

Technological change has gone on at an ever accelerating pace, especially since World War II. Moreover, technology has changed in ways that differ from the mechanistic, mass-production technology that until quite recently was considered to be all there was. Not only has the time required to translate a basic technical discovery to commercial production or process or usage decreased to a few years, but also the number of new products or processes is increasing exponentially [Ref. 3]. This is especially true in the Navy's submarine sonar area as reported from the SOTAP program office where the complexity of the Sonar's has increased so fast that there is now the problem of how to operate the highly sophisticated new equipment presently on-board the submarines.

The Navy has tried to rectify this problem by using several approaches. One requires the sonarmen to attend courses taught by the contractor on the new sonar equipment. For the most part though, these factory schools have taught the sonarmen the big systems viewpoint or what the sonar equipment "can do" and not "how to operate" the sonar to accomplish different functions such as searches, detection recognition, tracking, classifications, etc. Another approach used with the fast attack submarines emerging from the shipyards is to send a team of highly qualified personnel to the submarine to conduct a six-day intensified training program on the new sonar suite for the sonar technicians. Classes are conducted each of the six days starting at approximately 0800 hours and running until approximately 2300 hours. This approach has helped somewhat although it has been very hard on the sonar technicians with the standing of duty, making final alignment checks, fixing problems with their sonar equipment, and clean-ups in the eight hours left in each day.

B. PERSONNEL SHORTAGES

The main concern in the past was in the areas of nuclear reactor and ballistic missile technology on submarines [Ref. 4]. Now with an active sonar technology growth there is an increased emphasis at all levels in the newer highly sophisticated sonar equipments. Many of the more senior sonarmen are not adjusting to the technological change. Many of them don't understand the new technology. They feel that they have survived in the past with the older equipment and can in the future.

The submarine environment itself is a contributor to personnel shortages. First of all, not everyone can physically qualify for submarine duty. Although physically qualified for the Navy, sailors must undergo special physical examinations for submarine duty. Part of the physical test is done in the submarine escape training tank. Filled with over 100 feet of water, it simulates conditions that would exist on a sunken submarine. Future submariners must successfully ascend from 50 feet to the top of the tank using a special apparatus (Steinke hood) for breathing [Ref. 5]. The sailor must also pass a rigorous submarine radiation physical administered by a designated submarine medical officer.

Second, there are psychological aspects to consider. A phychological factor especially evident in submarines is claustrophobia. In an SSBN submarine the sailors are closed-in and submerged for the entire patrol living in small, cramped quarters.

Separations aren't easy and are especially difficult for the wife, parents, or friends of a submarine crew member, not only because of the frequency and length of the separations, but also because of necessary restrictions on active communication between crew member and friends. Once the boat departs for patrol a crew member cannot call, write, transmit messages, or send a telegram; his wife or friends can send him only a few 20-word "familygrams" (five during a Fleet Ballistic Missile, FBM, underwater patrol).

There is good reason for the restrictions on communications. Successful submarine operations depend heavily upon secrecy. The SSBN submarines are, in effect, mobile missile bases. Their sixty to seventy day maneuvers – trial runs for a situation everyone hopes will never occur – must be clandestine; the boats do not surface, they do not pull into port.

In the SSBN submarine community the commitments (i.e. an at-sea deterrent force with weapons covering targets) mean extended work days, and more "midnight oil" in-port to insure the at-sea readiness states that are necessary. Most people understand the necessity for increased working hours and unexpected deployments when associated with a real crisis. But, for many, the call for sacrifice has become routine and long-term, and the reasons are not always apparent. To work the civilian overtime, the price is paid in increased wages (double-time, time-and-a-half, etc.), but not so with the sailor. Based upon the author's experience and interviews with submarine personnel, it is the author's opinion that the price is paid in the long run. One price is the lack of adequate retention. Furthermore, correction of our retention problem is aggravated by the problem itself. Shortages mean more work and worse roatation schedules, making for further and worse shortages. On top of this the sonar technicians in the last few years have seen their proficiency pay go to nothing along with other actual and threatened military benefit reductions. A listing of military benefit reductions since Fiscal Year

1973 can be found in Ref. 6. Many SSBN submarines currently have to resort to non-sonar technician watchstanders in sonar to meet operational requirements.

C. OTHER PROBLEMS

SSBN submarines are designed for 90-day patrols, all under water; therefore each ship is manned by two complete crews, designated as the blue crew and the gold crew. When a ship returns from a patrol manned by the blue crew, the gold crew is ready to take the ship to sea again. This presents the problem of non-continuous operational periods of time at sea for each crew that is peculiar only to SSBN's. This results in the opinion of the author in an operational loss of learning which particularly affects the more junior, unexperienced part of the crew. To reduce this loss of learning, the SSBN, before going to sea on sea trials, conducts a "fast cruise." This is a period of several days moored alongside the tender. During this time the submarine simulates conditions at sea and conducts the type of operations that would be conducted at sea for two reasons. One reason is to ensure all the equipment aboard is working properly while the other reason is to re-train the crew in the various submarine operations.

The mission of the SSBN on patrol is to act as a strategic deterrent against our enemies. The SSBN is to submerge, remain undetected, and ready at all times to fire all their missiles within minutes if ordered to do so. Once a contact is detected, if possible, the SSBN will use all measures available to avoid the potential threat. Therefore, the mission and types of operations of an SSBN are not conducive to staying experienced in all sonar operational characteristics.

Other SSBN sonar team performance current training problems obtained through the SOTAP Program Office, Principal Investigator, are listed below:

1. Formal training focused on "How equipment operates" rather than "How to operate the equipment"

2. Non-standardized team training at the off-crew training sites

3. No reliable team performance evaluation capabilities

4. Current team training devices are obsolete

5. No operational training information flow between training sites.

III. COMPARISON OF WEAPONS SYSTEMS AND INFORMATION SYSTEMS

Although the management organization for the development of information systems in industry and government is very different from that in the military, traditional experience with the acquisition of hardware systems influences and prevades both areas. To bring out as forcefully as possible how this influence occurs and the management problems derived thereby for the development of information systems, the rest of this chapter is based on a comparison of the basic characteristics of weapons systems with those of information systems. This, of course, represents the extreme case since the development of weapons systems by the military occurs under conditions of unusual uncertainty, by contrast with nonmilitary hardware systems, and in the context of a highly formalized managerial structure and process.

A listing of the basic differences between weapons systems and information systems is listed in Table III-1 [Ref. 7]. It should be borne in mind that this list is highly simplified for the sake of the following explication. The author can deal here only with the more obvious differences. There are many additional differences in such areas as system testing, quality control, and maintenance, the cumulative effect of which has important implications for the management of the system development effort. These additional differences will not be addressed.

TABLE III-1

BASIC DIFFERENCES BETWEEN WEAPONS SYSTEMS AND INFORMATION SYSTEMS

Weapons Systems	Information Systems
1. Multiple users	1. Single users
2. Many-of-a-kind	2. One-of-a-kind
3. Model changes	3. Planned evolutionary change
4. Hardware state-of-the-art is critical	4. Software state-of-the-art is critical
5. High cost/effectiveness ratio	5. Low cost/effectiveness ratio
6. Operational independence	6. Functional integration

Bearing in mind the basic differences between weapons systems and information systems as shown in Table III-1 the rest of the chapter considers the consequences of applying a management organization and principles geared to the development of weapons systems to the development of information systems. The identifying numbers of the following sections correspond to the numbers in the table.

1. <u>The Information System is Custom-Made to Fit the User</u>

The same weapon or hardware system can be used equally effectively by a variety of users. A strategic missile can be employed by different services within the same country or by different countries. The same is true of ships. Such is not the case with information systems. An information system is tailor-made to fit the needs, objectives, and requirements of a unique user. Each military command and each industrial enterprise needs information of a special kind. In the industrial computer applications such as payroll accounting, inventory control, production control, banking, insurance, transportation, etc., an examination of the details of these applications in similar areas would still show basic differences such as differences in computer programs, in the format and content of displays and reports, in the construction of the data base, in the relationships among system components, and in the use of human beings as elements of the system.

Since each information system is custom-made to meet the special needs of a single user, the developer must study the operations of the current system, assuming there is one, in order to clarify the user's problems, to determine his needs and objectives, and to establish preliminary system requirements. The difficulty in study is obtaining complete and accurate information on all relevant areas of systems operations. Equal in importance to the study of the user's current system is the study and analysis of the system's future requirements.

2. Many of a Kind/One of a Kind

Many basic differences in weapons and software systems which have a profound impact on management stem from the fact that weapons systems, with some notable exceptions, are usually produced in large numbers from a prototype model. Information systems are one-of-a-kind, that is, only one operational system is ever developed from the design. The information system is not a mass produced article. But the fundamental difference pointed out here between weapons systems and information systems remains — current management organization and concepts are geared for the most part to a tradition of mass production, not the production of one-of-a-kind items.

A different attitude toward system testing is demanded of the manager because of the inherent differences between hardware systems and information systems. It is true that weapons systems can be reduced to obsolescence by technological advances. But as rapid as technological change is, no one will claim that it occurs on a daily basis. In any case, the physical environment for which the weapons system was designed does not change. Thus, it is possible to subject the weapon system to rigorous tests under controlled conditions to determine its reliability and design validity. Such is not the case for information systems. The information system must be tested for the full range of operational possibilities in an environment which may be undergoing change on a daily basis. The ability of the information system to adapt to such changes is, in itself, a test variable. To provide adequately for such system testing requires, first, understanding the need and, second, alloting the necessary resources to do the job.

The one-of-a-kind information system poses many special problems for training which do not exist for many-of-a-kind systems. Training must be conducted for the one-of-a-kind system without interfering with on-going operations. It might be necessary to design a simulation capability into the operational system in such a way that both operations and training can be conducted simultaneously.

Finally, it must be mentioned with respect to the many-of-a-kind/one-of-a-kind differentiation the managerial headache, shared with the developer, of phasing in the new system to assume operational responsibility without interfering with on-going activities [Refs. 8 and 9]. Few operations, military or nonmilitary, can afford to close up shop for a period of time, however short, in order to make the shift from one system to another. Must the user suffer through a period of degraded operational capability while the new system is being phased in and the old one phased out? In the one-of-a-kind system this is a major managerial dilemma. Thus, the phase-over period is a critical one, involving both training and operations, which call for much research, exploratory effort, planning, and design in order to ensure a smooth transition.

3. Model Changes/Planned Evolution

Another basic difference between hardware systems and information systems is to be found in the nature of their change and replacement through time. Weapons systems proceed through what is called "model" changes, whereas in information systems changes are referred to as "planned evolution." In the case of weapons systems, the initial weapon, if it changes at all, undergoes a series of incremental modifications as technology improves or requirements change, but the final model could not be technically implemented when the program for the weapon began. Each model is a part or complete replacement of the previous one although earlier versions may continue to be utilized in the weapons inventory. A typical example of model changes is the series of B-52 bombers. Similarly for missiles, torpedoes, etc. each subsequent model incorporates improved capabilities of various kinds – range, speed, altitude, reliability, or load capacity.

By contrast with weapons systems, information systems are evolutionary in that they are designed and implemented in several iterations to perform information-processing functions for a continuing enterprise. The information system evolves through a planned series of stages or phases each of which includes the addition of new tasks and functions which may have been conceived and regarded as feasible from the inception of the plan. It is also possible that functions not conceived during the original planning may be added at a later date, but these should be integrated with the long-range plan. The system as it exists at any stage or phase incorporates earlier phases; it does not replace them, as is the case with weapons systems, although the same functions may be performed by more efficient computer programs or better allocations of tasks among men and machines.

The term "evolution" is appropriate for information systems also in that they are adaptive to their environment. An information system has the capacity to adapt itself to changing situations and the capacity to learn from experience. These capacities are provided by its human components, who are themselves adaptable and capable of learning. Modifications to the system are made through an on-going dialogue between system users and designers. As they apply the system and gain experience with it, the users recommend to the designers improvements to procedures, computer programs, displays, etc. Eventually, by means of "heuristic" programming, information systems may have a capacity through their computer programs, as distinct from their human operators, to improve their performance by an inherent adaptive or learning capability [Ref. 10]. A weapons system is not adaptive in this sense.

A given model of an aircraft or a missile pushes the hardware state of the art to the limit. A given stage or phase of an information system does not necessarily reflect a limit of the computer state of the art. It may reflect a variety of other factors, such as the desire to initiate at least a modest capability as soon as possible, limited funding, or the fact that the user's requirements are not clearly known so that the ultimate system cannot be specified in detail immediately. Also, in the case of military information systems, the rate of technological change and of changes in mission requirements suggest that freezing the design as final at any given stage is undesirable. Hence, a modest beginning is made by using an initial operational capability with the understanding that later phases of the system will incorporate technological changes and new mission requirements. But the final operational capability for the information system is equivalent to that of the entire increment of models for a given weapons series.

The evolution of information systems raises a number of other questions related to recent changes in approach to systems acquisition by the Department of Defense. The intimate relationship which is necessary between the user and the software developer during the requirements and design phases in the development of information systems raises doubts about the desirability of competitive bidding between different software developers. A frequent complaint of users is that, even when one developer is involved, they are asked the same question about their operations by different personnel from the same development organization. Obtaining information about the user's daily operations as a basis for designing the new system is a delicate task even under ideal conditions. It is difficult to imagine the chaos if two or more software competitors were simultaneously engaged in obtaining operational information and conducting operations analyses.

4. Hardware/Software Sciences

Studies made within the defense establishment of military information systems and the private sector agree that computer technology exceeds at the present time our ability to put together the most effective systems [Ref. 8]. Hardware systems not specifically designed for military use, such as satellites and research rockets, all push the hardware state of the art in such areas as propulsion, guidance, miniaturization, and communications. Although information systems could profit from improvements in such areas as core storage capacities, speed of operations, display devices, and input/output devices, the technological limitations in these fields do not, of themselves, constitute insuperable constraints on the design of contemporary information systems.

The incorporation of the computer as the basic component in large-scale information systems to assist in decision making involves the designer of such systems in a host of so-called "soft" sciences such as human relations, management science, psychology, social psychology, sociology, applied anthropology, and human engineering. All these sciences are necessary in the design of information systems since they contribute to the understanding of the behavior of human beings as individuals and as members of groups. Valid performance measures for information systems in which human beings and group dynamics play vital roles cannot be established if the human and group factors are ignored. By contrast, in the design of weapons and other types of hardware systems, human beings and groups play minor or nonexistent roles [Ref. 11]. In such systems, therefore, the relevant sciences are the more traditional and more advanced "hard" sciences such as physics and chemistry.

One problem area is the types of skills required to produce software items. The typical potential user of an information system has been accustomed to buying hardware. As a result, he is familiar with the types of specialists normally involved in the design and production of hardware elements. He knows about system engineers, system analysts, and operations research, or at least he has heard that such specialists and fields of knowledge make contributions to the development of hardware systems, and he is willing to pay for these skills. But it is not uncommon to find not only that the typical user of an information system does not know what kinds of sciences play a role in the design and production of software, but also that he may have a bias or distinct prejudice against "soft" sciences. Since the output of the soft or social sciences is less tangible than the hard sciences, the user tends to be reluctant to pay for it.

The role of experts from the field of group dynamics, a branch of social psychology, may serve to illustrate the participation of nonhardware scientist in a particular information system development. RAND Corporation investigated the inadequate performance of systems with human beings as components and developed the System Training Program (STP) [Ref. 12]. One of the so-called STP principles emphasized by RAND researchers was the provision of knowledge of results to personnel participating in the training exercises. This knowledge of results was presented in a "debriefing" immediately following the exercise. It was not merely enough to solve the technical problems of recording trainee performance, analyzing the results, and summarizing them in some meaningful fashion. There were two other very important issues which the software developer had to resolve: (1) how could the results of the exercises be presented to the trainees, and (2) how should a debriefing be conducted to ensure maximum participation by all trainees?

These issues were investigated by the software developer's staff of experts on group dynamics, working closely with psychologists familiar with learning theory. Experience with the training program had shown that maximum problem-solving activity on the part of the trainees did not occur if the exercise results were presented in a manner which the trainees might interpret as blame fixing. Also, since many of the operations in the transmission of data and information during the exercises were invisible to both the observers and to the trainees, it was evident that full understanding of what had occurred during the exercise depended upon creating an atmosphere in the debriefing which would encourage personnel to talk freely about the actions and decisions they had taken.

How do you persuade people to talk freely about their mistakes in front of their peers and superiors? How do you suggest to military officers that maximum participation in a debriefing by all personnel can be achieved in a permissive, non-threatening, non-blame-fixing group atmosphere? How do you get individuals to think of their operational environment with a system perspective? Research on these issues was conducted by the group specialists and psychologists at RAND and manuals on the proper conduct of debriefings were published [Ref. 13]; and training programs for debriefing officers were held [Ref. 14].

Obviously, research activities in such areas as group dynamics and the relationships between displays and decision making consume scarce resources such as personnel, funds, and facilities. It takes time to conduct research, to publish the results, to develop the specifications for displays, and to develop orientation and training programs on the conduct of debriefings. The professional nonhardware scientists participating in the software development process are well aware that these activities are necessary to maximize system effectiveness, but it is up to the management of the users, procurement agencies, technical agencies, and hardware developers to understand why these things must be done to provide the necessary resources.

Another problem area is the lack of a commonly accepted set of terms to identify software items. The distinctive jargons of specialized disciplines, in addition to the lack of consensus on the identification and content of software products, contribute to confusion with respect to software terminology in current use. Another source of confusion is the fact that many of the terms used to refer to software products are borrowed from the hardware and weapons development fields.

The emergence of any new technology is always accompanied by an associated jargon specific to the processes, activities, and objects of that technology. The software field, no less than any other, has its own needs for a unique language. The fact that there is as yet no common agreement on the terminology used and that the referents of the terms change through time reflect the early stage of information system technology. Efforts to standardize terminology are being pushed within the data processing industry, in the armed services, and also within the Department of Defense.

5. Cost/Effectiveness Ratio

As the cost of weapons increases exponentially with their growing technological complexity and sophistication, each weapon considered for the national inventory must be carefully evaluated on the basis of the effectiveness purchased for each dollar invested. Similarly, an information system must be evaluated in terms of the effectiveness bought for a military command by the investment of limited funds. As the cost of both hardware systems and information systems rises steeply, managerial decisions must be made respecting the allotment of limited funds for more and better weapons or for more and better information systems.

When examined in terms of absolute dollar value, the price of an information system may appear high, paritcularly those costs accruing during the preproduction phases of development. There are two points to be considered here. First, the funds required to design and build a computer-based information system are amortized over the years in which successor systems are designed and built. The experience, knowledge and software products gained during the construction of the system are passed on to subsequent systems. Second, an information system provides the user with a very large amount of effectiveness for the money it costs when this effectiveness is measured over the life-span of the system. With appropriate modifications, given the planned evolutionary approach, the system will last for the life-span of the user. Funds alloted for the design and production of weapons systems, by contrast, are lost as soon as those weapons systems are fired, as in the case of missiles, or become obsolete in approximately four or five years due to a newer technological threat. It is meaningless, therefore, to compare weapons systems with information systems in terms of absolute dollars.

6. <u>Independent Operation/Operational Integration</u>

The typical weapons system is relatively self-contained and self-sufficient. It is this quality of independence of the system from the user which makes it possible for the same weapon to be used by various services within the same nation as well as by different nations, assuming the existence of an adequate technological base. By contrast, the information system is not self-sufficient or self-contained. This characteristic interdependence of information systems is referred to in the technical literature as "functional integration" and "technical integration." "Functional integration" refers to the operational interdependence of associated systems. "Technical integration" refers, as the term implies, to the compatible linkages of data and equipment in the mechanical or electronic sense.

In the past, the influence of weapons systems and a traditional hardware orientation has tended to emphasize technical integration at the expense of functional integration [Refs. 4 and 15]. There are other reasons, too, why functional integration is likely to be relatively neglected, such as the sensitivities of existing organizations to jurisdictional problems. For understandable reasons the decentralized department manager resists the trend toward "recentralization" made possible by computer based management systems. Early in the 1960's an important series of technical studies of the problems associated with the development of information systems stressed the point that the key problem facing management in the defense establishment is not merely technical integration, but functional integration as well [Ref. 16].

Functional interdependence of information systems affects the devoloper in other ways. In the course of system design, for example, the design effort is necessarily constrained by interface considerations. At each point of interface, ideal design decisions may have to give way to compromises in order to establish the necessary linkage with other systems. In such cases the developer may see the need for the coordination of design decisions with other agencies and organizations outside the immediate jurisdiction of his contract, but neither the user nor these agencies and organizations may recognize the need or be willing to devote the time, and effort to respond to it.

In summary this systematic comparison of weapons system characteristics with information systems characteristics brings out the extent to which contemporary management of users, procurement agencies, and technical agencies may be utilizing an irrelevant system model for the acquisition of information systems.

IV. SYSTEM DEVELOPMENT OF AN INFORMATION SYSTEM

In the course of its development every large-scale information system must pass through a sequence of phases in its life history. The use of the term "phase" in the context of systems development should be qualified. Only in a high level of abstraction is there distinguishable phases of development and that they represent a logical and temporal sequence. In some cases, the primary process within a phase which gives that phase its name, such as requirements or design, is also an activity or function which is performed in other phases as well. The system requirements, for example, must be determined before the initial design activity, but the determination of requirements does not terminate at any specific phase. Throughout the course of the development of a system, old requirements are constantly undergoing refinement while more detailed requirements are being generated. When the system first becomes operational, actual experience with it may give rise to new requirements. Changes in the system's environment or in technology may also result in the creation of new requirements. Similarly, system design, in addition to serving as a name for a logical and temporal phase which follows the requirements phase, is also a function which is carried out repetitively at different levels of the system development process.

Four project phases will be discussed in this chapter. Many authors on the systems-development process have also outlined the phases of a systems project. Laden and Gildersleeve have designated the first of these as a Survey, which is followed by Systems Investigation (data gathering), Systems Design, Programming, Filemaking, Clerical Procedures, Systems Testing, and Parallel Running [Ref. 17]. Their Survey and Systems Investigation covers what the author chooses to call Requirements (defining the need, generating a proposal, feasibility assessment, project start-up). Systems Design, Programming, Filemaking, Clerical Procedures corresponds to Development (Detailed System Design); and Systems Testing, Parallel Running is the same as the author's Implementation. To emphasize the total life-cycle concept the Utilization Phase was added.

Although Laden and Gildersleeve primarily addressed batch-processing systems in their book, Head outlines the basic development process steps found in real-time systems as Preliminary Technical Planning, Record Specification, Program Specification, Programming, System Testing and Conversion and Operation [Ref. 18]. Seemingly inevitable parallels to all these quite similar project structures can be found on further investigation [Refs. 19, 20 and 21]. This being so, perhaps the author can safely proceed to discuss these phases as they are variously described in greater detail, confident that, though the names are different, the substance is essentially the same. Appendix A contains a systems overview drawing showing the information systems development process.

It is not the intention of the following paragraphs to present a detailed checklist of the contents of each phase of a major project. This has been done for many different types of projects more than adequately, and the reader is referred to several sources [Refs. 17, 18, 19, 20, 21, and 22]. Rather the author has tried to survey the available literature and develop a basic systems approach oriented towards the possible acquisition needs of a Navy project for the acquisition of a computer-assisted management information system (MIS).

A. PHASE ONE – REQUIREMENTS

1. Pre-Proposal

The translation of a recognized need or opportunity in the systems area into preliminary informal "working papers" as a basis for further study and definition.

Ideas for systems work may originate anywhere in the organization, most frequently in the potential using organization itself. Definition of needs and opportunities is not at this stage expected to have taken into account related efforts, feasibility, or availability of resources. It is necessary first to define the problem area and its magnitude in order that the user can place it in the context of his overall objectives in the systems area, and decide on the relative emphasis he wants to give the proposal. Specifically, the objectives of this activity are as follows:

a. Definition of the problem area.

b. Ranking of importance to user.

c. Determination of the amount to be budgeted for a systems effort in this problem area for the coming planning period.

d. Providing a basis for communicating about the problem with concerned management and staff people both in the user organization and outside it.

Certain procedural steps that should be followed are:

a. At an early stage the person or group in the user organization responsible for overseeing and co-ordinating systems development performed for the organization, assumes responsibility for the pre-proposal activity even though the ideas may have originated elsewhere.

b. The user's systems manager (if one exists), governed by the policies established by his superiors for the conduct of his activities, prepares for his management the information necessary for them to make certain decisions. This information includes the description of a potential project, a general statement of its potential benefits and impact on the organization, its relationship to the user's ongoing developments or existing systems, its suggested priority, and the recommended amount of budget data that should be reserved for further work in the area over the ensuing budgetary period.

c. The management of the user organization must make a decision to authorize a proposal aimed toward establishing a project, based on the recommendations made to it by the systems manager. It must decide when and by whom this proposal effort is to be conducted.

The delay depicted in the drawing ensues between these two activities depending on the priority assigned by using organization. If given a high priority, further action may take place without delay.

2. Proposal Preparation

The conversion of internal "working papers" of the user organization into a systems proposal as a basis for communicating with the systems organization (if one exists).

The document will be referred to here as a "systems development proposal," that is, the user will propose that the systems organization undertake to develop the system described in the document. There is no intent to make this document conform to a standard set of ground rules with respect to form and content, but certain guidelines are suggested to facilitate subsequent study and negotiation. This is, therefore, not a formal procedure, since the systems organization ought always to be ready to discuss a user's requirements when the user feels the time is ripe for external consideration. There may be no clearcut division between Pre-proposal and Proposal Preparation in Phase One.

The systems proposal as a minimum should include the following:

a. A description of the system in terms of management functions included or signficantly changed.

b. A brief, preliminary description of the proposed systems concept, on-line, batch, type of communications, mode of input/output, etc.

c. A qualitative statement of the benefits expected, in order of importance (cost avoidance, improved service, improved timeliness, increased accuracy, etc.).

d. Relationships to any other of the user's systems in operation or under development, and to any other systems (if known).

e. The amount currently budgeted for the proposed system.

f. A statement of the importance of the need relative to other existing or forthcoming systems' development and to other management plans of the user.

The proposal may also include other information that would utlimately have to be developed for final management approval. This feasibility information should be quantitative and specific, and should deal with cost/benefit, technical risk, resource requirements, work plan, etc.

The procedural steps are presented below.

a. The user's management must decide:

(1) When it wants to present the systems proposal to the systems organization.

(2) What information about the system it wants to include.

(3) Whether "outside" help is to be called upon to render advice and assistance in preparing the proposal.

b. The user's system staff (if one exists) prepares the proposal, with a set of recommendations as to priority, budget allocation, timing, etc.

c. A presentation is made to the user's management, who decide to accept, reject, or defer. If a revision is called for then steps b and c above are repeated.

d. When user's management accepts the proposal, a formal copy is forwarded to the systems organization with a request for further action.

3. Initial User/System Organizational Assessment

Determining the study needs, if any, to convert the proposal into a formal project-authorization document for final management action, and setting up a study team to conduct such a study.

The objectives of this activity are to determine whether the proposal can and should be segmented into phases for sequential or parallel implementation, to determine if the phases of the proposal are similar in scope to other planned or on-going systems-development activities, and to define further detailed study requirements prior to recommending project authorization (including possibility of joint development of part or all of the proposed system with that of other users). If the proposal is satisfactory as is, and contains adequate information in the form necessary for management authorization, the next activity in this phase may be bypassed. A memorandum specifying that the proposal is either presently adequate for management authorization purposes or needs further study should be produced.

Procedural steps for this activity are as follows:

a. The systems organization assigns the proposal assessment responsibility to a staff group where user and systems personnel establish liaison for joint assessment of the proposal.

b. For systems proposals encompassing more than one functional area an attempt should be made to segment the proposal into a number of modular phases which could be authorized separately, if desired.

c. The sequence in which the steps should be undertaken and completed should be determined based on logical precedence.

d. A determination is made of the possible similarity in scope of each of the phases to other proposed or on-going efforts.

e. The requirements for further study of those phases requiring early management authorization is determined, including the additional information to be developed.

f. Recommendations are developed for the size, composition and work plan of a study team.

g. A study team manager and members are assigned to begin work with user and systems organization concurrence.

4. Additional Study

Conducting a feasibility study and preparing a feasibility report, containing recommendations and back-up information for management authorization of a project or series of related projects.

The objectives of this activity are identified as:

a. To identify specific phases to be "projectized" initially.

b. To develop complete data on the project(s) for management approval.

c. To view proposed projects in the context of other systems development activities, including: determining whether combining, in part or entirely, with similar developments is feasible, deciding what interfaces must be provided with other systems, and ensuring adaptability of the proposed system to organization change and growth.

The contents of a Feasibility Report or data for management consideration and project guidance is outlined below as a guide.

a. Description of the overall system in terms understandable to management.

b. The specific scope of the phase(s) of the system for which approval is presently being requested.

c. Summary of findings, conclusions.

d. Specific recommendations.

e. Alternatives considered, approach selected for purposes of feasibility evaluation.

f. Effect of selected approach on operations such as people, quality, effectiveness, cost and benefits (by project phases) including outlays by time period, savings (personnel and other), present value and discounted cash flow, intangible, non-quantifiable benefits and probability of their realization.

g. Effect on existing and planned systems, and what is to be done with respect to those systems.

h. Probability of technical success such as projections of technology (state-of-the-art) trends, projections of resource availabilities, comparison of requirements with projections (cost, effectiveness, schedule).

i. Recommended plan of action:

(1) phases to be approved and "projectized" now.

(2) resources required, type and quantity to be assigned.

(3) further study required prior to presentation of further phases for approval, and timing of the necessary preliminary studies.

5. Management Presentation

A presentation leading to informed understanding of the need for and consequences of authorizing the project in the proposed systems area.

The goals of this activity are as follows:

a. To assist in weighing the expected payoff of the proposed project and other projects competing for systems implementation resources.

b. To help decide when and at what level of effort a project should be established in order to maximize the opportunity for significant progress without significantly impeding the progress of other important efforts.

c. To permit consideration of payoff opportunities in terms of contribution to the overall division or organization posture in systems development, and not merely in terms of the merits of a project as an isolated system.

d. To permit cost/payoff estimates and permit evaluation, in terms of management objectives, of joint development of proposed systems among more than one division or functional group, where there is no apparent technical or functional reason for different systems.

e. To permit consistency in the evaluation of this project against other proposed projects on the basis of uniformly complete and accurate information.

In summary the Study Team should present its findings and make its recommendations as to the establishment of the project and a proposed work plan showing scheduled resource requirements. The planning staff should present its analysis of the impact of proposed project on resources available and on other systems activities. It should also present alternative courses of action realizing that management may request more information prior to making a decision, or may take under advisement at this point pending a decision.

6. Management Actions

Project approval and assignment of a project team with project responsibilities, resource levels, etc.; project disapproval or referral for more study.

The target aims of this activity are:

a. To decide whether there is enough information about a proposed project and its effects to make an intelligent allocation of resources.

b. To allocate systems resources (principally personnel) to this project, as compared to other proposed projects and other systems activities competing for them.

c. To select a start date for this project.

d. To assign management control responsibility for this project to a project team.

e. To establish project steering responsibility and reporting frequency.

f. To determine benchmarks or checkpoints to be met prior to the approval of further phases of the project.

g. To consider and make policy covering the general allocation of resources among projects, and between projects and non-project activities.

Payoff information may be based on no more than an educated guess in which case management may decide that further analysis is required before a decision as to priority in the use of resources can be made, especially for major projects. Existing projects may also find that previously assigned resources are inadequate, or that schedules must be altered. Requests for resource changes or major schedule changes must compete for resources against projects being newly considered.

If further study prior to authorization is deemed necessary then the study team is notified with the defined requirements for additional information and a due date is set. Otherwise a project and a project team is established to start work as assigned priority dictates. The project team consists of permanent members (including a project manager) drawn from the user organization, systems departments, and other groups as needed, and "loaned" to serve on the team for the duration.

In some cases further study on existing projects may be deemed necessary before future phases are authorized. This would be true particularly if the scope of the original study did not carry through all phases to project completion, or if problems arose in the course of the project such that certain previously arrived at conclusions were made invalid.

B. PHASE TWO - DEVELOPMENT

Once the scope and general configuration of the MIS have been established, the detailed design of the system may be started. The first step in systems design is not a technical one. It is concerned with gaining support for the work that follows. Systems designers must have the support of most members of the organization in order to obtain acceptance of the final system. At a minimum, members of the organization should be informed of the objectives and nature of the study. It is preferable, if possible, to draw many members into the study, at least in some small way.

The aim of the detailed design is to furnish a description of a system that achieves the goals of the gross system design requirements arrived at during the feasibility (gross) design. This description consists of drawings, flowcharts, hardware equipment requirements (computers, peripherals, communications, terminals), programming languages to be used, procedures, support tasks, specification of information record and file designs (input, output, files, tables, etc.) and organization and operating manuals required to run the system. Also part of the design is the documentation of analysis and testing, which justifies the design. The design must be sufficiently detailed that operating management and personnel may implement the system. Whereas the gross design gives the overall performance specifications for the MIS, the detailed design yields the construction and operating specifications.

1. Define the Subsystems

Although the gross design requires some assumptions concerning the subsystems, it is necessary now to review these subsystems and to redefine them if it seems appropriate. Based upon the gross design, investigation of the detailed activities of each major activity must be undertaken. Each large system must be broken down to determine all activities required and the necessary information inputs and outputs of each activity.

The information system must be based upon the operating system. Once this operating system is outlined by the selection of a gross concept, certain basic relationships among major activities become more or less fixed. However, there is still considerable freedom in establishing the detailed activities and their relationships. The degree of breakdown of the major activities, of course, determines the size and complexity of the network. If the activities are broken down too finely, the design will never be completed. If a major activity is broken down too coarsely, vital material, information, and decision needs will not be factored into the design. Furthermore, optional rearrangement or regrouping of activities will not be examined.

2. Operations and Information Flows

The development of the detailed design is first carried out for the subsystem, functional, and task levels of detail. It is very similar to detailed engineering design, which requires trial and error, shifting operations to find good arrangements, and performing calculations to check out the system. The equivalents of engineering sketches in MIS design are the flowcharts. There are three types of systems flowcharts [Refs. 8, 23, and 24]:

a. Task-oriented charts. These are block diagrams showing the relationships among the various tasks or activities. Subsequently, the detailed elemental steps required to complete an activity are analyzed and described step by step on an operations analysis form (sometimes called a flow-process chart).

b. Forms-oriented charts. These charts identify the forms used in communicating or reporting and trace the flow of all copies through the organization. In some cases, the chronological movement may receive emphasis.

c. Program flowcharts (block diagrams). Prepared by the people who give instructions to the computer, the program flowchart is a fundamental tool of programming, designed to show the logical sequence of steps to be carried out by the computer. It structures logic that the coding of the programs will follow.

The flowcharts are not the complete detailed design. They show primarily flows and relationships. Inputs and outputs are shown only in gross form. The quantitative relations among elements in the systems must be expressed in terms of mathematical models. Where this is not possible, detailed verbal descriptions must be used to actually develop the detailed operating design. The flowcharts are important, however, in developing the information necessary for managerial decisions with respect to the design for model constructions, and for programmed decision making in system operation.

3. <u>Determine Degree of Automation</u>

Each operation in the flowcharts should next be examined to establish the level of automation possible. By listing each operation along the horizontal axis of a chart and levels of automation along the vertical axis, an "automation profile" may be plotted. Widely contrasting levels of automation in a system may be suspect and should be examined.

4. <u>Develop the Data Base</u>

The data base is the data that must be obtained and usually stored for later retrieval for managerial decision making. It also consists of data that will be utilized in programmed decision making and real-time control. The data base is derived from the needs of management for information to guide the total organizational system.

One of the important characteristics of data bases is that they can be accessed by one or more information systems and/or one or more organizational units. Thus input errors may be introduced by many different input sources; fixing the accountability for them becomes a much more difficult task. In addition the confidential nature of certain data files demands that data base access be limited to individuals who have a demonstrated "need to know" [Ref. 23].

5. Develop the Software

Although software programming development in the technical sense is not a primary concern of management, management does have the responsibility of insuring that the software is an economical and effective part of the MIS. Software development, particularly good programming, is generally an expensive activity that cannot be slighted.

The coordination of the systems design group and the computer organization should start at the time of the gross design. Trained programmers should be on hand at the start of detailed design work and many months prior to installation. There are some principal steps in softward development for systems over which management, through the systems designers, should maintain surveillance. These steps carried out by the computer organization, are:

a. Develop standards and procedures for programming. Standardized charting symbols, techniques, and records should be maintained.

b. Study the gross system specifications and work with the system designers in the development of the detailed design. The computer programmers should be a part of the design team by contributing their expertise as needed.

c. Develop the data-processing logic and prepare the programming flowcharts. When the programming charts are completed, they should be reviewed by the systems design group.

d. Code the instructions given by the flowcharts. This is the writing of detailed instructions to the computer. Good coding should balance gains from economical use of machine operation. Another important goal for the coding process is to build error control into the machine instructions.

e. Test the program. The aim is to find, diagnose, and correct errors by running sample problems and checkout programs on the computer. Actually this "debugging" process often continues into the implementation phase, where it is a much more expensive process.

f. Document the programming, coding, and testing. This is an extremely important step. Too often rough sketches, preliminary programs and codes, and test results are not up-dated to the "final" or most recent status. Not only should documentation be maintained completely up to date, but the contents should be easily interpreted by anyone skilled in the field. It is the management's responsibility to insure that this proper documentation takes place.

6. Information Outputs

A system of reports should be established, not to isolate the manager from routine detail but to provide him with increasing detail at each level of operation as he needs it to solve problems and make decisions. Standard typed reports and well-planned computer-output summary reports will probably be the basic formats for communication of information to managers for some time yet. Video communications and cathode-ray-type presentation of information offer speed and flexibility.

The growing computer sophistication of today's managers is increasing the use of time-sharing terminals as a means of getting information to managers. Managers are able to utilize models to ask the "What if I do this...?" type of question and receive the information within seconds or minutes.

In general, the format should be established to save the manager's time. A wide variety of new communications and display equipment has been developed and the systems designer should remain abreast of these developments.

7. Document the Detailed Design

The end product of the detailed design project is production of the documents that specify the system, its operation, and its design justification. Documentation should consist of:

a. A summary flowchart.

b. Detailed flowcharts.

c. Operations activity sheets showing inputs, outputs, and transfer functions.

d. Specification of the data base or master file.

e. Computer hardware requirements.

f. Software (programs).

g. Personnel requirements by type of skill or discipline.

h. Final (updated) performance specifications.

i. Cost of installation and implementation of the system.

j. Cost of operating the system per unit of time.

k. Program for modification or termination of the system.

l. An executive digest of the MIS design. This is a report that top management can read rapidly in order to get the essence of the system, its potential for the organization, its cost, and its general configuration.

Some documentation should be on standardized forms. Input-output-activity diagrams or listings are an example. Obviously, standard symbols should be used on flowcharts and guidelines should be established for flowchart format. Some documentation is unique to a project, such as the data base, and the format and classification of items should be determined by the needs of the particular user. Other documentation should simply follow good reporting style.

C. PHASE THREE — IMPLEMENTATION

The three main phases in implementation take place in series: these are the initial installation, the test of the system as a whole and the evaluation of the system. On the other hand, many implementation activities should be undertaken in parallel in order to reduce implementation time. For example, acquisition of data for the data base and forms design for collection of information may be carried out in parallel. Training of personnel and preparation of software may be in parallel with each other and with other implementation activities.

It is apparent, then, that the first step in the implementation procedure is to plan the implementation.

1. Implementation Alternatives

There are four basic methods for implementing the MIS once work has been completed. These are:

a. Install a system in a new operation or organiztion, one just being formed.

b. Cut off the old system and install the new. This produces a time gap during which no system is in operation. It is practical only for small systems where installation requires one or two days. An exception to this would be the installation of a larger system during an organization's vacation shutdown or some other period of inactivity.

c. Phase-in by segments. Small parts or subsystems are substituted for the old. If this method is possible, some careful questions should be asked about the design of the new system. Is it really just an automation of isolated groups of clerical activities? Generally, new systems are not substitutable piece by piece for previous nonsystems. However, in upgrading old systems, this may be a very desirable method.

d. Operate in parallel and phase-in. The new system is installed and operated in parallel with the current system until it has been checked out; then the current system is cut out. This method is expensive because of the manpower and related costs. However, it is required in certain essential systems. Its big advantage is that the system is fairly well debugged when it becomes the essential information system of the organization.

2. Obtain Space, Plan Layout

The installation of a new system to replace a current one may require a major revision of facilities as well as completely new office, computer room, and production layouts. The MIS project manager must prepare rough layouts and estimates of particular floor areas he feels will be needed. He should then prepare cost estimates and submit a proposal for management's approval.

Facilities and space planning should begin as soon as approval of gross space allocations has been obtained. The urgency for such planning is twofold. First, there may be a long lead time if new partitions, electrical work, air-conditioning, or even new buildings are required. Second, the detailed work flow depends upon the physical arrangements of the buildings. The training of operations personnel will be more successful if it is based on exact physical relationships among the people and the equipment.

Space planning must take into account the space occupied by people, the space occupied by equipment, and the movement of people and equipment in the work process. Related to these are the number and kinds of exits; storage areas; location of utilities, outlets, and controls; environmental requirements for the equipments; safety factors; and working conditions for the personnel. It is a short-sighted policy to scrimp on facilities and human environment when a major renovation is required to install a new system.

3. <u>Develop Procedures for Implementation</u>

Procedures for evaluating and selecting hardware must be spelled out. Procedures for buying or constructing software should be established. Procedures for phasing in parts of the MIS or for operating the MIS in parallel must be developed. Obviously there are many procedures that must be delineated in advance if the entire implementation is to be saved from chaos.

A major part of implementing the MIS is the testing of each segment of the total system as it is installed. So far, the only testing that has been done is a simulation of the system during the detailed design phase. The testing of segments of MIS during installation requires application of line personnel to actual files, software, and hardware for operations or specially designed test problems.

It is necessary to develop the testing procedures on the basis of the design and test specifications. The procedures should prescribe:

a. Which segments of the system will be tested

b. When such tests are to be performed

c. Test problems to be run

d. Who will perform the tests

e. How the tests will be run

f. Who will evaluate test results and approve the system segment or recommend modification.

For example, the complete detailed procedure for the accomplishment of the test specification might include organization of personnel for conduct of the test; provision of necessary forms and data sheets; statement of conditions to exist at the start of the test; a list of all equipment, software, and file data required for the test; and step-by-step procedure for all the people participating in the test.

Components may be tested relatively independently of the system to which they belong. Test for accuracy, range of inputs, frequency of inputs, usual operating conditions, human factor characteristics, and reliability are all of concern. As more components are installed, subsystems may be tested. There is a considerable difference between the testing of a component and the testing of a system. Systems tests require verification of multiple inputs, complex logic systems, interaction of humans and widely varied equipment, interfacing of systems, and timing aspects of the many parts.

If, for example, the programming for the computer fails to work in the system test, costly delays may take place. Often, minor difficulties cropping up require redesign of forms, procedures, work flow or organizational changes. The training program itself is being tested, since, if the supervisors and operators lose confidence in the system at this point, they may resist further implementation of the new system in subtle ways.

4. Train the Personnel

A program should be developed to impress upon management and support personnel the nature and goals of the MIS and to train operating personnel in their new duties. Particular attention should be paid to the training of first-line supervisors. They must have a thorough understanding of what the new MIS is like and what it is supposed to do. Since, in essence, they oversee the operation of the system, they must learn how it will operate. They are faced with many changes in their work and they must obtain acceptance of changes by their subordinates.

Finally, longer and more formal training programs should be established for people who perform the daily operational tasks of the MIS. These are the clerks, the computer operators, the input and output machine operators, file maintenance personnel, and possibly printing production and graphic arts personnel.

5. Develop the Software, Acquire the Hardware

A comprehensive discussion of the preparation of computer programs and the evaluation of computer and peripheral equipment does not fall within the constraints of this thesis effort, rather with identifying the managerial considerations of MIS design. Systems designers and programmers provide the flow diagrams and the block diagrams during the development stage. Some modification may be required, however, as the implementation stage progresses. In the implementation stage, coders convert block diagrams into sequences of statement or instructions for the processing (computer) equipment.

The development of software and the acquisition of new equipment are usually the limiting items in getting an MIS implemented [Ref. 8]. When possible, these tasks should be started during the design stage. There is, of course, some risk of loss in starting early, but it must be balanced against the considerable delay involved in the sequential approach to design and implementation of the MIS.

6. Develop Forms

A vast amount of detailed data, both external and internal to the organization, must be collected for input to the MIS. Obviously, the form insures that the right information is supplied in a manner that simplifies processing for computer storage. Many factors affect the design of both input and output forms. When considering a new form the first questions should always be:

a. Is this form really necessary?

b. What form(s), if any, will it replace?

c. Can existing forms be revised to include the required information?

d. How was this information previously supplied?

After gathering satisfactory answers to these questions then the design of the new form can proceed. The most important principle of form design is to plan the form with the user(s) in mind. Other considerations should be:

a. How many copies are to be prepared?

b. Will the form be permanent?

c. Is it for internal or external use?

d. What quality of paper and size of form should be used?

e. Is the form simple and easy to understand?

f. Is the make-up of the form straight-forward and in accordance with machine processing acceptance?

The following principles should contribute to good form design:

a. Bold type should be used to emphasize important information.

b. Filing information should be near the top of the form.

c. Every form should have a title.

d. Headings should be as small as possible, leaving sufficient space for written data.

e. A good printing style should be selected to make the form attractive in appearance.

f. The form should include only essential information.

g. The form should be designed so that a minimum of recording and recopying is required.

h. If the form precedes another form, or is dependent on another form, the same general sequence and arrangement should be followed so that recopying and recording can easily be accomplished.

i. Once the form is designed, it should be analyzed to determine whether it is sufficiently clear and all necessary instructions are printed on the form.

Output forms of the MIS must be prepared at the implementation stage, when they can be both designed and tested. Further, the problems of printing and inventory size and location must be resolved. The output forms are what the managers see, and so these forms or formats should be designed so that key information and variances are easily discernible. A periodic report form should be a summary form that is keyed to a hierarchy of increasingly detailed formats or forms. Managers may then pursue specific questions easily by asking for the underlying details.

7. Develop the Files

In the development phase, each item of data for the files is specified and the retrieval methods (indexes) are developed. In the implementation phase, forms must be designed so that the data may be analyzed by the programmers and coders for storage in the computer. Thus, the file name, maximum number of characters required to record each data element, frequency of access, volume of operations on the element, retention characteristics, and updating frequency are examples of relevant information required to translate a specification into a file element [Ref. 23]. The development of files or data bases belongs in the conceptual realm of information system designers and storage and retrieval experts. The translation of specifications for files into computer programs is a function of computer specialists.

8. Cut Over

Cutover is the point at which the new component replaces the old component or the new system replaces the old system. This usually involves a good deal of last minute physical transfer of files, rearrangement of office furniture, and movement of work stations and people. Old forms, old files, and old equipment are suddenly retired.

Despite component and system testing, there are likely to be "bugs" in the system. Having extra supervisory help, with the systems designers on hand, is one way of preventing first-day cutover panic. Design analysts should also be present to iron out "bugs" of all kinds that may arise.

9. Document the System

Documentation of the MIS means preparation of written descriptions of the scope, purpose, information flow components, and operating procedures of the system. Documentation is not a frill; it is a necessity for trouble-shooting, replacement of subsystems, interfacing with other systems, and for training new operating personnel, and also for evaluating and upgrading the system.

If the system is properly documented:

a. A new team of operators could be brought in and could learn to operate the MIS on the basis of the documentation available.

b. Designers not familiar with the organization or MIS could, from the documentation, reconstruct the system.

c. A common reference design is available for managers, designers and programmers concerned with system maintenance.

d. The information systems analyst will have a valuable data source for developing new MIS, schedules, manpower plans, and costs.

D. PHASE FOUR – UTILIZATION

The Use period of the System Life Cycle is that long period where the system can now be operated to fulfill its system requirements. Once the new system is in operation, system evaluation and modification begin. This phase should be a continuing effort which seeks to take advantage of new developments as they occur. It is during this period that the true cost-effectiveness of the system can be measured. The Use period really includes three activities, Operations and Support, Modification, and Retirement.

Systems design involvement in the system is not complete until the system is obsolete and finally retired from use. During the Use period, some problems with the system not previously encountered will arise. These serve as a basis for design changes. In addition, new uses or requirements for the system will result in modifications to meet changing requirements. In this way, early obsolescence is minimized.

Finally, when the system no longer proves to be cost-effectively used or modified to meet existing or new system requirements, it is retired. This will usually generate new system requirements and the System Life Cycle will start all over again. Sometimes, the System Life Cycle starts with a brand new requirement rather than as a second-generation system. This may be as a result of a new technological breakthrough which allows us to feasibly and effectively do what we could not previously.

V. INFORMATION SYSTEM ANALYSIS

A. SOTAP IDENTIFIABLE ELEMENTS

Certain elements of an information flow system have already been tentatively identified by SOTAP [Ref. 25]:

1. Training and Assessment Data/Scoring Information Sheets for data transfer to a storage and analysis facility will be in the form suitable for reading by an optical scanning device such as used by PTEP. Appendix C is a copy of the current PTEP scoring form.

2. Use of in-place PTEP and its on site support personnel for the actual handling of assessment and training information if PTEP is used for the formation of a SOTAP IFAS.

3. Periodic, NUSC sponsored operational training meetings for SOT instructors. These meetings will facilitate a free flow of information between the SOT training sites in New London, Connecticut and Charleston, South Carolina.

4. Navy sponsored pre/post SOT training conferences which will aid in establishing the training syllabus for a particular sonar team as it begins its week of SOT training or deployed shipboard training.

5. A data storage and analysis capability will be provided under SOTAP.

B. PTEP BACKGROUND

OPNAV INSTRUCTION 1500.23A, of 15 June 1972, established the Fleet Ballistic Missile Weapon System Training Program along with its major elements, one of which is the Personnel and Training Evaluation Program (PTEP). The administration of PTEP tasks (encompassing personnel testing, data collection, analysis and evaluation, and EDP support) are conducted and controlled in an organized and standardized manner to ensure the continuity and reliability of required input data to PTEP and the validity and relevancy of PTEP feedback information (trends, deficiencies, and recommendations) to other Training Program activities and commands. As established by OPNAV NOTICE 5450, of 19 February 1974, authority and responsibility for Polaris/Poseidon PTEP implementation are delegated by the Chief of Naval Operations to the Chief of Naval Education and Training, and are exercised by the Chief of Naval Technical Training through the Central Test Site (CTS) for PTEP. CTS directs the CTS Detachments in administering PTEP and conducting evaluations. CTS is located at the Dam Neck training site. CTS Detachments are located at the Charleston, New London, and Pearl Harbor training sites. Figure V-1 shows the PTEP organization.

C. PTEP DEFINITION AND RESPONSIBILITIES

PTEP serves as the evaluation element of the Training Program. It provides the organization, procedures, and responsibilities for the qualitative assessment of the

PTEP-ORGANIZATION

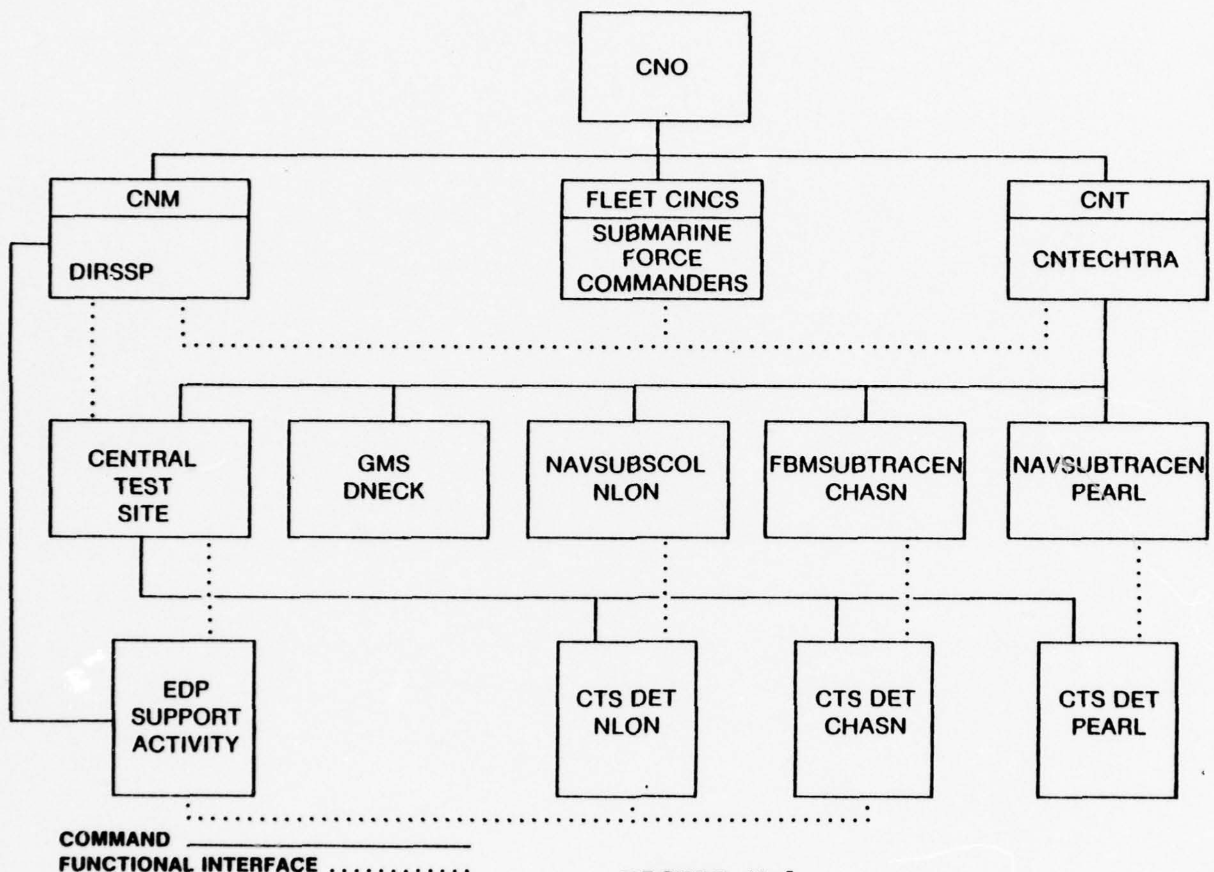


FIGURE V-1

technical proficiency of personnel, and the evaluation of the effectiveness of all Training Program elements in defining and providing efficient training, and the reporting of findings and formulated corrective action recommendations.

The measurement of personnel proficiency is accomplished through the administration of standardized tests which are based on the personnel knowledge and skill requirements set forth in the Personnel Performance Profiles (PPP) and the Training Path System (TPS), both of which are elements of the Training Program. Personnel test results are analyzed and evaluated, in conjunction with other supportive data, to identify trends and deficiencies.

Training effectiveness is assessed through the individual and collective evaluation of all elements of the Training Program. Training materials are analyzed and evaluated, in conjunction with other pertinent data (e.g., criteria on which the training is based and personnel test results) to identify trends and deficiencies.

Identified trends and deficiencies are studied to determine causes within the Training Program; and positive recommendations for corrective actions are formulated. These findings and recommendations are reported to appropriate commands for use as the basis for implementing improvements in training and in all Training Program elements, and to assist in planning training and in determining the most effective use of personnel.

Administration of the fully implemented PTEP occurs in an iterative cycle consisting of data collection, analysis and evaluation, and reporting. The primary component of PTEP is analysis and evaluation. All other PTEP tasks serve in supportive roles, either providing data input to the analysis and evaluation effort, providing data processing support, or providing documentation of the procedures for analysis and evaluation and the other, supportive PTEP components.

Knowledge and skill test instruments are designed for PTEP to measure specific achievement levels delineated by the PPP and TPS. The administration of selected groups of test instruments assist in the identification of trends and deficiencies in personnel proficiency and training effectiveness related to specific PPP and TPS knowledge and skill requirements.

The primary types of test instruments used in Polaris/Poseidon PTEP tests are multiple-choice knowledge test items and simulated skill test exercises. The acquisition of the test instruments is based on the requirements defined when the specific personnel testing objectives (quantitative and qualitative) are determined. Test instrument requirements are defined in terms of the detailed components of the PPP and TPS; and, thus, they provide for complete accountability regarding the capability of PTEP personnel testing and its extent of coverage. Test instruments are obtained from training system contractors, Navy training activities, CTS, and the CTS Detachments. Review and maintenance (for format, currency, effectiveness, and relevancy) of the test instruments is an on-going task.

Knowledge test items are either open-book or closed-book type, depending on the specific testing objectives and the operational requirements. Test items are prepared in accordance with the specifications set forth in NAVORD OD 45519 to ensure the use of standardized format and conformance to the PPP and TPS. Upon receipt, CTS personnel review test items for technical accuracy, relevancy, and conformance to the prescribed specifications and test instrument requirements. The test items are then input to the EDP file of test items, from where they are selected for use in PTEP personnel tests.

Skill test exercises are equipment simulation testing devices. These exercises are provided to CTS in manuscript form, from which they are verified for specified applicability with respect to the PPP and TPS and for technical accuracy and relevancy by CTS for administration in PTEP skill test parts.

Personnel testing is the component of PTEP which provides the primary source of data required to determine individual proficiency levels, with respect to knowledge and skill achievement, and to determine training effectiveness. Testing is accomplished through the administration of standardized tests to personnel whose training is provided by the Training Program. Test results are reported to the appropriate commands to assist in planning training and in determining the most effective use of personnel, and are input to the analysis and evaluation component of PTEP to assist in identifying and verifying trends and deficiencies, and to support the formulation of recommendations to increase the effectiveness of the Training Program. Two types of tests are primarily used in Polaris/Poseidon PTEP: System Achievement Tests (SATs) and Course Achievement Tests (CATs). Particular test versions are comprised of knowledge test items and/or skill test devices, depending on their availability and the testing objectives.

SATs are used to measure personnel proficiency, relative to the overall knowledge and skill requirements defined in the PPP and TPS for specific personnel categories Navy Enlisted Classifications (NECs), thereby determining the adequacy of personnel in supporting the mission. Each SAT is applicable to a particular Training Path Chart (TPC), and consists of knowledge test items and/or skill test devices which sample from among all of the Training Objective Statement (TOS) knowledge depths and skill levels delineated in the Training Level Assignments (TLA) for that TPC. (The TPC, TOS, and TLA are components of the TPS.) SATs are administered to SSBN personnel during their off-crew period. Second-level maintenance and instructor personnel are tested annually with SATs. Each SAT version remains effective for administration for a period not longer than 6 months (for SSBN examinees) or 12 months (for other examinees), after which it is retired and replaced with one different, but constructed to the same design specifications (applicable portions of the PPP and TPS).

CATs are administered in training courses to measure training effectiveness (the scope of which includes the quality of instruction, training facilities, hardware, and documentation support) and the level of trainee comprehension of training presented. Each CAT is applicable to a particular course or major portion thereof, and consists of knowledge test items and/or skill test devices which sample from among all of the TOS knowledge depths and skill levels delineated for that course or course portion in the curriculum Profile Item to Topic Objective Assignment Chart (OAC) for that course. CAT administration occurs immediately following the applicable portion of training. Each CAT version remains effective for administration for a period not longer than 12 months, after which it is retired and replaced with one different, but constructed to the same design specifications (applicable portions of the PPP and TPS).

Analysis and evaluation is the component of PTEP which provides qualitative assessment of the Training Program. It is the process through which personnel testing, data collection, and analysis are integrated to identify deficiencies and to recommend corrective actions. This process monitors and measures the effectiveness of the Training Program, and thereby serves as a significant basis on which improvements are determined and developed.

Polaris/Poseidon PTEP analysis and evaluation are directed toward four major areas: personnel, training, PPP/TPS, and the PTEP personnel tests. These analyses and evaluations are performed in a collective manner to enable the identification of trends and deficiencies and the formulation of corrective action recommendations affecting any element of the Training Program. These trends, deficiencies, and recommendations are reported in a timely manner to appropriate Training Program management activities and commands.

Each personnel test version used in PTEP is evaluated to determine the adequacy and efficiency of the overall test, as well as its constituent test instruments, in fulfilling the test design specifications. An inherent part of this evaluation is the evaluation of the test design specifications themselves, to determine whether they adequately and efficiently serve to describe the test vehicle requirements with respect to the overall testing objectives.

The adequacy of personnel to support the prescribed mission is evaluated primarily from personnel test results. Evaluations are directed toward each individual participant, as well as each identifiable group of participants (e.g., all technicians of a common NEC/TPC and of a common SSBN crew), and consider personnel history data and other pertinent data, as applicable.

The effectiveness and efficiency of training, conducted as part of the Training Program, are evaluated from the training materials, the criteria on which the training is based, and personnel test results. Evaluations are conducted to determine whether the training fulfills the requirements set forth in the PPP and TPS, and whether duplicate training exists among related courses or course segments.

The accuracy and currency of the PPP and TPS are evaluated with respect to the operational hardware and software. Evaluations are also conducted to determine the effectiveness of the PPP and TPS in serving as definitive standards for all other elements of the Training Program.

Several report types are used to disseminate PTEP personnel test results and evaluation information (i.e., trends, deficiencies, conclusions, and recommendations). These reports provide for the following:

1. Immediate feedback of PTEP personnel test results.
2. Reporting of follow-on results of detailed analysis and evaluation performed after each PTEP test version is retired.
3. Immediate feedback of identified Training Program deficiencies and recommended corrective actions.
4. As-required progress reporting of personnel indications, including current performance levels, conclusions, and related training and documentation data.

The amount of data routinely processed within PTEP is such that EDP support is required to provide the necessary timeliness and efficiency. EDP support is used for direct support of PTEP data collection, analysis, and reporting activities. Polaris/Poseidon PTEP used EDP to facilitate test generation, test scoring and reporting, personnel test and nontest data collection, and analysis of personnel, curricula, and training facilities data.

The PTEP EDP system is composed of five major subsystems.

1. The Test Generation Subsystem includes programs for maintenance of the test item and test reference files, and programs for generation and maintenance of knowledge test parts for SATs and CATs, scoring keys for knowledge and skill test parts, and other data used in scoring and reporting functions. Subsystem requirements are detailed in DDL Specifications TEG 100, TEG 110, and TEG 120.

2. The Test Scoring and Reporting Subsystem includes programs to accept, edit, and store raw test data (examinee answer sheets and skill test scoring sheets), and to assemble, score, and report test results. Teleprocessing programs are also provided to facilitate remote input/output capabilities. Subsystem requirements are detailed in DDL Specification TEG 200.

3. The Personnel Subsystem stores and maintains records for Poseidon enlisted personnel, and selects and prints formal Personnel Data Sheets for evaluation and administrative purposes. Subsystem requirements are detailed in DDL Specifications TEG 300 and TEG 310.

4. The Test Analysis Subsystem analyzes test data collected during the effective "life" of a given personnel

test version. Programs are included which analyze scores to support personnel, curricula, and facility evaluation, and which compute and report a variety of statistical data to support maintenance and improvement of the PTEP test instruments. Basic subsystem requirements are documented DDL Specification TEG 400. An additional program computes inter-score correlations and displays frequency distributions of scores.

5. The Query Subsystem provides the capability to support special studies and investigations by retrieving pertinent information from the EDP files. Preprocessor programs accept user-defined record selection data reporting instructions and prepare an EDP program to execute those instructions. Subsystem requirements are detailed in DDL Specification TEG 500.

The Poseidon PTEP EDP system is installed at the Data Processing Facility, Polaris Missile Facility-Atlantic (POMFLANT), Charleston, South Carolina. The following items are the significant features and characteristics of that system.

1. Computer. IBM System 360, Model F30, is used, with core extended to a capacity of 96K bytes.

2. Operating System. Disk Operation System (DOS) is used.

3. Mass Memory. Mass memory consists of Model 2314 disk storage facilities. (At most, five disk drivers are used at any time.)

4. Input. Data inputs are accomplished by Model 2540 card reader and Model 2701 data adapter unit with appropriate data sets (for teleprocessing applications).

5. Output. Data outputs are accomplished by Model 1403 line printer, Model 2540 card punch, and the same teleprocessing interface devices used for data input.

6. Data Storage. Data storage devices are removable disk packs for use in the 2314 disk facility. Data are stored on six "current" and four "backup" disk packs.

7. Computer Software and Utility Programs. The Poseidon PTEP EDP system uses ANS COBOL and FORTRAN IV compilers, plus utility programs for card-to-disk copy and disk-sort. Basic assembly language (BAL) programs using basic teleprocessing access method (BTAM) instructions control teleprocessing functions.

8. Remote Access. Poseidon PTEP test sites at Guided Missiles School, Dam Neck, Virginia; Submarine Base, New London, Connecticut; and FBM Training Center, Charleston, South Carolina use AUTOVON phone lines to input personnel test data and receive test reports. Test site facilities include:

a. Optical Scanning Device. OPSCAN Corporation Model 17 scanner is used to "read" raw test data and test scoring requests from paper into machine compatible forms.

b. Teletypewriter. Western Union Model ASR 33 teletype with appropriate data set is used.

Documentation is prepared and maintained current to describe PTEP and to set forth its detailed implementation procedures and data forms. Procedures and forms are documented for the personnel testing, analysis and evaluation (including nontest data collection), and EDP components of PTEP. Polaris/Poseidon PTEP description and procedures are documented in NAVORD OD 45953. This documentation is maintained current and effective through continuous monitoring of the personnel testing, analysis and evaluation, and EDP components of PTEP. Changes to NAVORD OD 45953 are prepared and issued as required to reflect the actual implementation procedures and data forms employed, as they are modified to improve the effectiveness of PTEP.

D. VTS BACKGROUND

The Versatile Training System (VTS), a development of Naval Weapons Center California, is presently planned to provide Test and Information Handling (IH) support for TRIDENT-1 PTEP functions. The VTS is designed to provide all training support required to improve the effectiveness of training both officer and enlisted personnel of Naval Aviation Fleet Readiness Squadrons, Naval Aviation Operational Squadrons, Naval Aviation Maintenance Training Detachments, U.S. Marine Corps Aviation Training Activities, Naval Air Station and Marine Corps Air Station Aircraft Intermediate Maintenance Departments, TRIDENT SSBNs, and Submarine Training Support Activities. The VTS looked promising from several viewpoints. It was driven by a popular, extremely powerful commercial minicomputer of relatively small cost (compared to large scale systems). Additionally, it could be purchased as a Federal Procurement Schedule, Group 66 item, thereby facilitating the procedures for its procurement. Realizing the apparent efficiency of the multi-application of VTS, PM-2 placed an order with NWC, China Lake to prepare and install a VTS at TRITRAFAC by August, 1978 [Ref. 26]. It is presently planned that each TRIDENT SSBN off-crew office, the FBM Training Center and the Submarine Group would have a remote terminal to access real time the personnel training data files. Also presently planned under TRIDENT is the placement of a VTS remote terminal at PERS 5C, the Enlisted Submarine Detailer in Washington, D.C. NNC's tasks were to include responsibilities for developing TRIDENT-unique software and for programming and integrating the PTEP software into the system.

In November of 1976 the Officer in Charge, Central Test Site for PTEP recommended to SSPO that action be initiated to procure a VTS to support Polaris/Poseidon and TRIDENT-1 Backfit PTEP programs [Ref. 27]. Approval was granted for VTS implementation to support Poseidon and TRIDENT-1 Backfit PTEP programs with scheduled installation and operation to coincide with TRIDENT PTEP completion in FY 78.

E. PTEP MODIFICATION WITH VTS

The VTS as presently planned will provide PTEP with their existing system with the addition of an "on-line" mode with the capability of many users (63 with future expansion to 128) interacting with the computer equipment simultaneously on different jobs. The presently planned PTEP option includes a PDP 11-70 mainframe at Guided Missiles School (GMS), Dam Neck, plus incremental Peripheral equipment increase to accommodate removal of PTEP data base from POMFLANT computer and storage onto the PDP 11-70 at GMS, Dam Neck. This option would also provide Charleston, S.C. and New London, Connecticut CTS detachments with a PDP 11-60 and peripherals. The present data retrieval system at POMFLANT is slow and cumbersome [Ref. 27]. The ability of CTS to answer management questions in a realistic time frame is severely limited by EDP support. For example, a simple question as "How many NEC ____ personnel are not conversion trained?" would take a minimum of two days and more commonly a week to answer. With VTS the answer could be obtained in approximately thirty minutes.

Other benefits that will come with PTEP as a part of VTS will be commonality with TRIDENT information handling, shared cost in updating, reduced requirement for contractor support personnel, more efficient use of Naval Personnel, improved measurement capabilities, cost significantly less than the present system to operate, and have a greater potential for growth [Ref. 27]. A typical submarine VTS is depicted in Figure V-2. Appendix B contains excerpts from Digital Equipment Corporation's Resource Time Sharing System/Extended (RTSE/E) brochure explaining the data management system used [Ref. 28].

F. ALTERNATIVES

1. Modify the Present Management Information System

The existing PTEP, which is currently being implemented for Poseidon/TRIDENT-1 Backfit with VTS could be used as a baseline for development of a SOTAP IFAS. The VTS can be expanded to accept, store, and manipulate data from other interactive training measurement devices [Ref. 27]. This gives PTEP measurement output capabilities in areas where none currently exist. A Sonar personnel testing baseline (SAT's and CAT's) is currently under development by the PTEP CTS.

The measurement of sonar/fire control team personnel proficiency would be accomplished through the administration of standardized training and assessment exercises which would be based on the sonar/fire control team knowledge and skill requirements set forth in the Sonar Team Performance Profile (STPP) and the Fire Control Team Performance Profile (FCTPP), both of which would be added elements of the Training Program to be developed.

Another necessary modification would be the optically scanned data scoring sheet. Currently, as shown in Appendix C,

SUBMARINE VTS CONCEPT

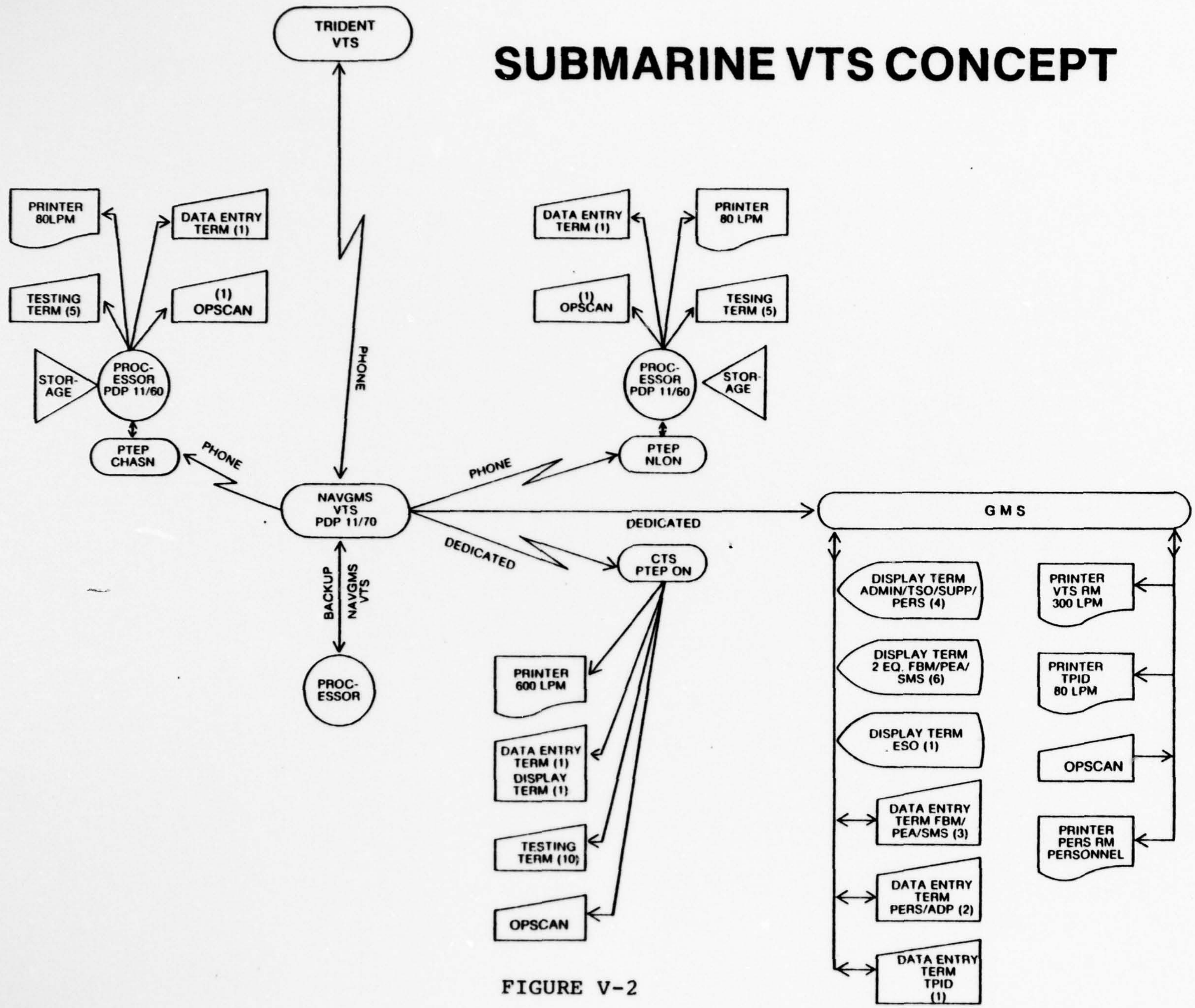


FIGURE V-2

the data sheet is designed for scoring one person's data per sheet. Modifications, such as condensing the fields as has been done partially on the top of the present form, would make it possible to enter many trainee's results on one page reducing the amount of paper handling necessary for inputing to the computer.

Equally important and most likely the most critical is the modification and/or development of the software packages. As the complexity of software has grown there has been an ever-increasing time lag in meeting these needs and maintaining the programs. The problems and resulting expense involved has become all but prohibitive. Seemingly, as one set of needs are met others present themselves and usually the entire programs have to be redesigned [Ref. 8].

Another disadvantage is that the present IH system may not be completely modifiable to obtain the results desired for the SOTAP IFAS.

One of the more propitious aspects of this alternative is that the information system will not have to be purchased; therefore, no large capital investment is required. SOTAP would just have to pay for the modification of the present system to accommodate SOTAP needs. Another distinct advantage is the use of existing Naval personnel at the PTEP CTS and detachments. Once a part of PTEP, the cost of updating PTEP data handling functions could therefore be shared amongst the several users. The commonality with the TRIDENT Information Handling (IH) would permit several realizable benefits such as easy exchange of data and the efficiencies recognized by CTS/DIRSSP managing a single IH system; TRIDENT, TRIDENT-1 Backfit, Poseidon common data would not require duplicate handling and storage; and, improved capability in testing or data presentation for either TRIDENT, POSEIDON, or the NAVAIR system would be realized in the SOTAP IFAS at no additional cost.

2. Develop a New Management Information System

The results of developing a new management information system for the SOTAP IFAS which may or may not be compatible with other submarine training information handling systems has one distinct advantage; in that, from ground-up the system can be designed and tailored to the specific needs of the SOTAP IFAS. If the decision is made to acquire a new system, NUSC must then approach the problems which will accompany such an endeavor. These problems will, of course, vary to some degree with the acquiring activity and the equipment system to be acquired. However, considerations involved in the selection of equipment, the acquisition and training of qualified personnel, the plans necessary in acquiring the new system, the provision for the physical facilities needed by the computer and its associated peripheral equipment and the cost of installations and operations are just some of the common features brought out in Chapter IV regardless of the particular system to be installed.

In the case of the Navy it is the office of the Automatic Data Processing Equipment Selection Office (ADPESO) established in July, 1967 that is charged with the overall coordination of automatic data processing equipment (ADPE) requirements. Prior to its formation the selection of ADPE was accomplished by the various heads of departmental components. A full time staff was hired and the responsibility for selection was centralized and elevated to a higher level in the Department of the Navy, a field activity under command of the Chief of Naval Operations.

With the acquisition of any complex system, schedule and available funding are key issues to consider. Funding available, the acquisition process is still a lengthy process under ADPESO which has five, very rigid and extremely time consuming, steps in their computer procurement process. If funding is not available either for purchase or lease then investigation into the possibility of sharing equipment with other government agencies in the local area or to acquire unused government-owned equipment through the reutilization program. The General Services Administration publishes a periodic summary of all government-owned equipment not presently being used that can be acquired for only the cost of packing and transportation. Pertinent directives are DOD INST 4160.19M and SECNAVINST 10462.17.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

What seems to be clear to the author, as the Navy moves into the 1980's, is that more is being required than can be accomplished. The inevitable result is low quality performance, unfulfilled requirements, or both — and both are unacceptable. The situation is being aggravated further by continuing reductions in Navy force levels and other economy measures invoked without equally compensating reductions in missions and requirements. For example, if the Defense Department budget this year goes through as proposed, the Navy is going to lose about 11,700 authorized billets, most of them to come out of the training "pipeline" [Ref. 29].

What is the answer to this dilemma? Obviously, we in the Navy cannot control national commitments. We cannot effect the technological gains of our potential enemies, nor would we wish to slow down the pace of our own technical growth. Yet, all these things contribute to escalating commitments and requirements. The author believes that the Sonar Operational Training and Assessment Program is an outstanding imaginative idea to deal with these problems and to harness our technology to serve us in a way that reduces, not increases, individual training effort.

B. RECOMMENDATIONS

Making decisions would be relatively easy if all one had to do was look at the analysis of all the alternatives and choose the most beneficial. However, James Schlesinger writing to the Senate Committee on Government Operations in 1968 stated that analysis has been greatly oversold [Ref. 30].

> In recent years it has been recognized in public statements (as well as the textbooks) that analysis is not a scientific procedure for reaching decisions which avoid intuitive elements, but rather a mechanism for sharpening the intuitions of the decisionmaker ... No matter how large a contribution that analysis makes, the role of subjective preference of the decisionmaker remains imposing. Analysis is, in the end, a method of investigating rather than solving problems. [Ref. 30].

There is a difference between the quantifiable and unquantifiable. The decisionmaker must look at and evaluate more than just the quantifiable aspects of the alternatives. Using experience and judgment, one must attempt to put subjective values on unquantifiables. However, there is not enough information about uncertainties to absolutely quantify the unquantifiables; therefore, the author's recommendations must be more biased toward using previous experience and judgment based on investigative efforts undertaken during this thesis endeavor.

After weighing all the advantages and disadvantages of the alternatives, the author would recommend Alternative 1 — Modify the present management information system. Since there are many uncertainties in choosing any alternatives, the author feels that selecting Alternative 1 will allow SOTAP to keep the most options open at the least cost. The author believes that the currently budgeted dollars in the SOTAP program should be adequate for PTEP modification. Probably the most important reason has to do with "guaranteed satisfaction." It would be a terrible mistake to make a large capital investment and be dissatisfied. Management would be upset for making the wrong decision in addition to paying more for that choice.

Further recommendations include installing a VTS remote terminal at SUBLANT, Norfolk, Virginia, to provide the Type Commander access to sonar operational performance evaluations. This action would also allow the Type Commander access to any Submarine VTS information. The major advantage being the reduction of paper report submissions. Providing VTS remote terminals at NUSC, each SSBN off-crew office, each FBM Training Center, and each Submarine Group in New London, Connecticut, and Charleston, South Carolina, is recommended. This would allow real time access to the data files and complete the information flow chain. Facilities are available in Digital Equipment Corporation's RSTS/E system for sending messages to all terminal users, thus providing a useful means of information flow between shore-based training sites. In addition, quarterly NUSC sponsored sonar operational training meetings for FBM Training Centers sonar personnel including SOT instructors and off-crew status SSBN sonar personnel in New London, Connecticut, and Charleston, South Carolina, to facilitate a free flow of sonar operational training information flow is recommended. Properly scheduled quarterly meetings would ensure that all SSBN sonar teams (users) would be involved in the training information feedback.

The author also recommends for user feedback to use the SSBN Weapon System Trouble and Failure Report/Training Material Change Recommendation (TFR/TMCR) system for recommending changes to SOTAP materials. The mechanism is already in existence and FBM Weapon System personnel including Sonar Technicians are familiar with the system. TFR's are presently required on Training problems. NAVSEA OD 28385 Volume I (TFR Instructions) discusses training problems as related to Training Management Documentation (i.e., OD 45953-PTEP Manual). With slight modifications to NAVSEA OD 28385 Volume I, other applicable publications, directives, and instructions a user-feedback information flow reporting system could be implemented for the SOTAP IFAS.

C. AUTHOR'S COMMENTS

Advanced education, coupled with personal experience, enables one to develop the necessary management acumen to effectively cope with the future. Management courses such as those offered at the Naval Postgraduate School provide managers insights into management, organizational behavior, and systems which increase their capability to be effective managers. However, one can sit in the classroom gathering knowledge about the principles of management until eternity and still not become an effective manager. One must get into the environment and understand the climate before he can begin to manage effectively. For this reason the author wanted to examine the real environment of project management and learn first hand how things are done (i.e. uniting theory and practice), rather than write a thesis only from library research.

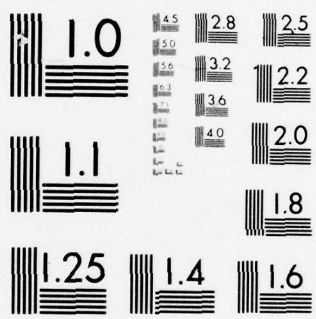
Working with the SOTAP Program Management at NUSC, New London, and applying systems acquisition management principles acquired at the Naval Postgraduate School has been a gratifying experience. Bridging the gap between education and the real environment has cemented the foundation of knowledge.

AD-A053 851 NAVAL POSTGRADUATE SCHOOL MONTEREY CALIF F/G 5/9
A STUDY OF THE SELECTION OF AN INFORMATION FLOW AND ANALYSIS SY--ETC(U)
MAR 78 G C LANNOU

UNCLASSIFIED NL

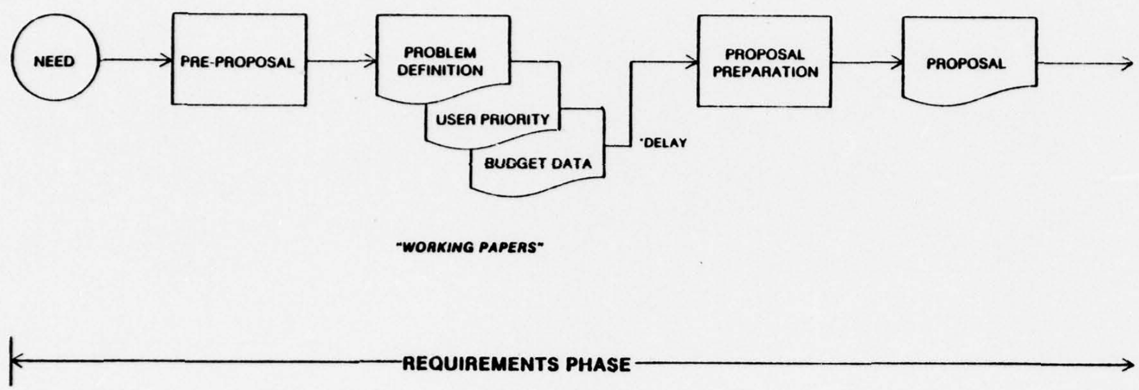
2 OF 2
AD
A053851

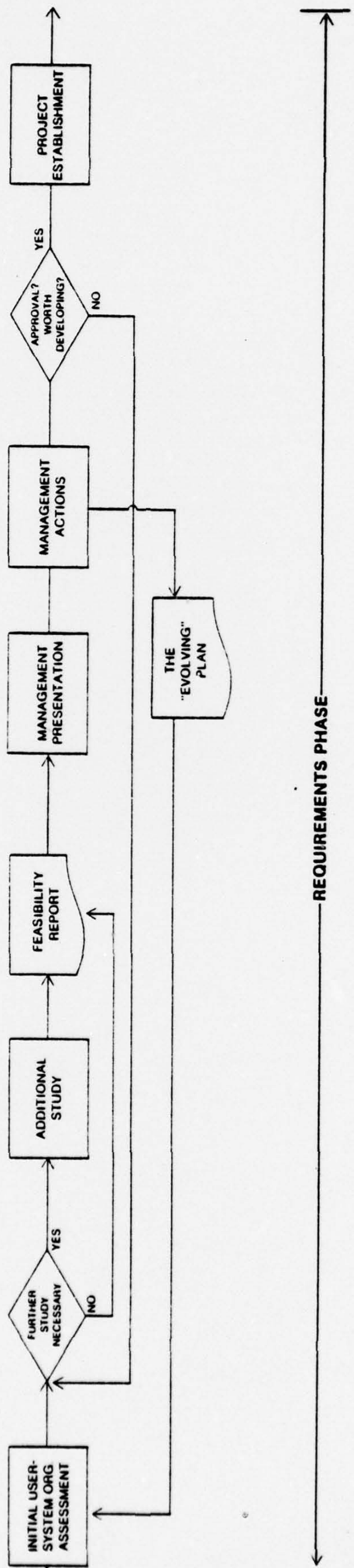
END
DATE
FILMED
6 -78
DDC

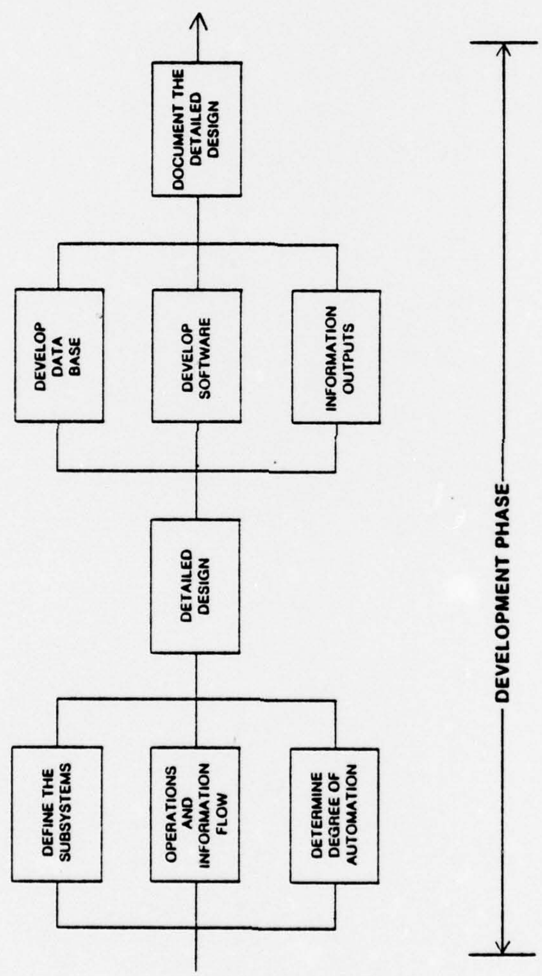

1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

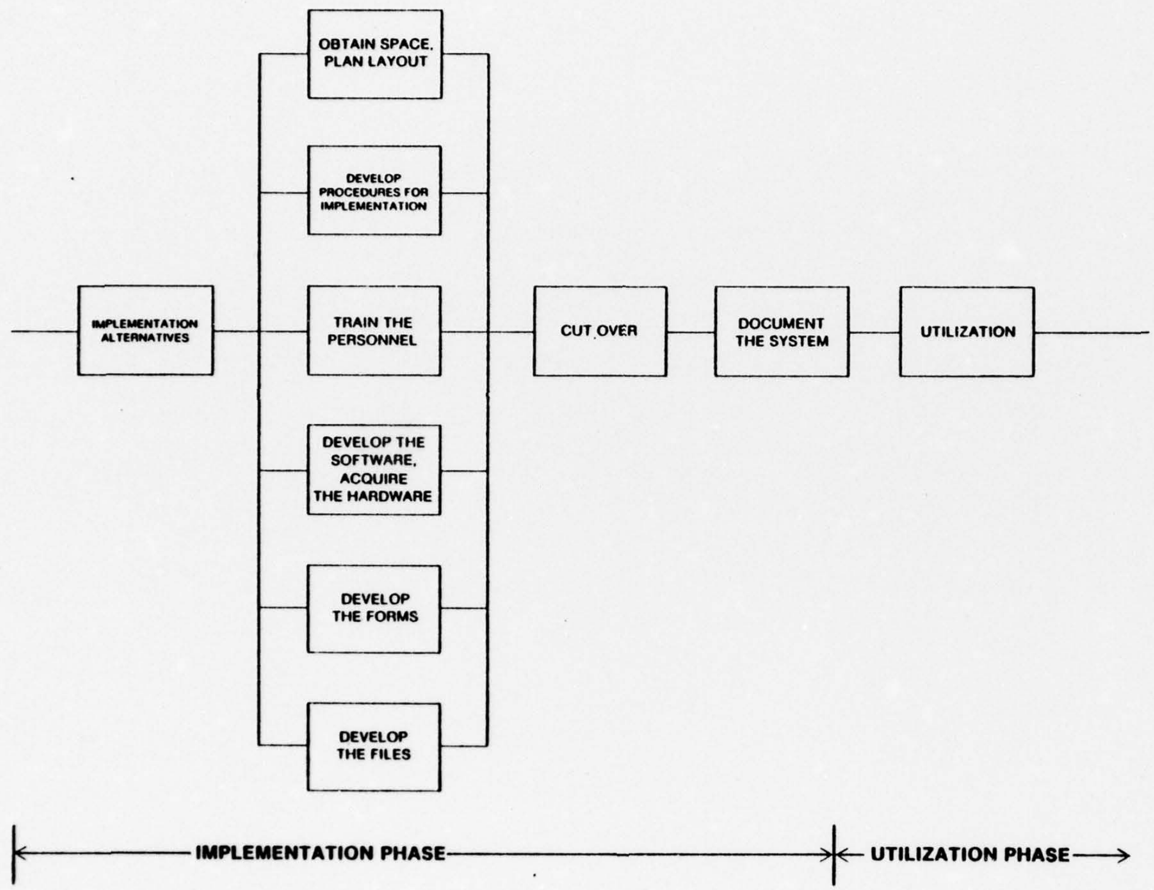
APPENDIX A

SYSTEMS OVERVIEW DRAWING OF
AN INFORMATION SYSTEM DEVELOPMENT PROCESS


NEED
PRE-PROPOSAL
PROBLEM DEFINITION
USER PRIORITY
BUDGET DATA
'DELAY
PROPOSAL PREPARATION
PROPOSAL
"WORKING PAPERS"
REQUIREMENTS PHASE


INITIAL USER-SYSTEM ORG ASSESSMENT
FURTHER STUDY NECESSARY
YES
NO
ADDITIONAL STUDY
FEASIBILITY REPORT
MANAGEMENT PRESENTATION
MANAGEMENT ACTIONS
APPROVAL? WORTH DEVELOPING?
YES
NO
PROJECT ESTABLISHMENT
THE "EVOLVING" PLAN
REQUIREMENTS PHASE


DEFINE THE SUBSYSTEMS
OPERATIONS AND INFORMATION FLOW
DETERMINE DEGREE OF AUTOMATION
DETAILED DESIGN
DEVELOP DATA BASE
DEVELOP SOFTWARE
INFORMATION OUTPUTS
DOCUMENT THE DETAILED DESIGN
DEVELOPMENT PHASE


IMPLEMENTATION ALTERNATIVES
OBTAIN SPACE, PLAN LAYOUT
DEVELOP PROCEDURES FOR IMPLEMENTATION
TRAIN THE PERSONNEL
DEVELOP THE SOFTWARE, ACQUIRE THE HARDWARE
DEVELOP THE FORMS
DEVELOP THE FILES
CUT OVER
DOCUMENT THE SYSTEM
UTILIZATION
IMPLEMENTATION PHASE
UTILIZATION PHASE

APPENDIX B

RESOURCE SHARING TIMESHARING SYSTEM/EXTENDED (RSTS/E) SUMMARY

A. GENERAL

RSTS/E (Resource Sharing Timesharing System/Extended) is the primary timesharing system for the PDP-11 Family. It provides general timesharing facilities through the BASIC-PLUS language, an enriched version of Dartmouth Standard BASIC. An optional batch COBOL facility is available to enhance the business data processing requirements of certain applications. The system features complete system utilization from an interactive terminal, with a large number of such terminals being active concurrently, through flexible combinations of local, remote, and multiplexed interfaces.

The RSTS/E system requires a PDP-11 systems-level computer (PDP-11/35, 11/40, 11/45), 32K words of parity memory, hardware memory management, and disk storage with adequate backup. User access and file protection are provided, and RSTS/E supports a wide range of PDP-11 peripherals. For a normal mix of jobs, up to 32 concurrent users can be supported on a PDP-11/45 system, and up to 24 concurrent users on a PDP-11/35 or 11/40.

To make full use of the power of the PDP-11/70, RSTS/E has been expanded to accommodate up to 63 concurrent users. The system supports the high-performance peripherals necessary to ensure the continuous performance for the large numbers of users, and the flexibility to provide interactive data base management for business applications, as well as the scientific resources for the general timeshared applications commonly found in educational environments.

B. RESOURCE SHARING

RSTS/E users have on-line access to a wide range of program and data files. Files may be created, updated, extended and deleted from the user's terminal or under program control. Up to 12 files may be open at any one time. Since files may be opened and closed during the running of a program, the actual number referenced in a program may be far greater than 12. The total number of files a user may have stored in a disk library is bounded only by the total system disk capacity and the library demands of the other users.

RSTS/E files are not limited to a disk files. Data may be read-in from a card reader and printed on a high-speed printer. The on-line user can assign devices, even other terminals, for input and output functions through his programs. Thus, individual users get exclusive use of these devices for as long as required, then release them for others to use. This is known as "resource sharing."

Private data files may be stored on removable disk cartridges, disk packs, DECtape or paper tape. Confidential files may be dismounted when not in use and kept under lock and key. These stored files may be as large as 33.5 million bytes, yet accessible on a completely random basis.

C. THREE TYPES OF DATA

RSTS/E has the capability to handle three types of data-floating point, integer and character string. Floating-point numbers are used for most numeric representation and may be one of two levels of precision: 7 decimal digits (two computer words) or 17 digits (four words). Number size may vary from approximately 10^{38} to 10^{-38}.

Integers may be used for greater processing efficiency as indices, counters and subscripts. They are whole numbers in the range -32,768 to 32,767.

Character strings are available for powerful processing of non-numeric data. Strings may be as short as a single character or unlimited in length. Strings used in virtual memory are limited to 512 characters. Groups of strings, a list of names and addresses for example, may be organized in tables or arrays just like numeric information. Since strings can be read from or written to external files in a sequential or random manner, whole files of textual data may be built up and updated on-line.

D. VIRTUAL ARRAYS

The concept of virtual memory essentially makes the system disks an extension of main memory. This permits the user to manipulate large arrays of tables of data without cutting into program size and indeed, process larger masses of data than will fit in the entire main memory of the system. Furthermore, the user can access large amounts of data without the need for explicit read/write programming.

Data in virtual memory arrays may also be processed using MATRIX statements. These statements perform operations on multiple elements of virtual memory arrays with a single statement.

Virtual memory may be used to store any type of data — floating-point, integer or character string. Floating-point virtual memory might be used by an industrial distributor to store customer account balances on a daily basis. Character string virtual memory could be used to store names and course preferences for a college on-line registrations system.

RSTS/E uses a system of in-core 256-word buffers when processing virtual memory arrays. With this system, a disk transfer is not necessarily made every time a virtual memory variable is referenced. Consequently, virtual memory is as mindful of processor efficiency as it is of programming ease.

E. MULTIPLE-USER ACCESS TO COMMON FILES

It is often desirable to have one or more on-line disk files simultaneously accessible to more than one user. For example, in an order entry/inventory control system, several clerks might be entering orders and each must have access to the same customer master file and inventory control file. Or in a college on-line registrations system, students would register and enter their course preferences at a number of terminals simultaneously.

Under RSTE/E, any number of users may read data from the same file simultaneously. Typically, only one user at a time may write on the file. However, when multiple-user updating is desirable, as previously described, the UPDATE feature permits this to be handled safely by locking out a physical disk record from other users while one user is in the process of updating the record. While the record is locked out, other users are temporarily prevented from accessing it, although they can read or write any other record in the file not currently locked out. When the locked-out record is updated, it then once again becomes accessible to other users. In this way, all users are guaranteed access only to current, valid records instead of records that are not up to date because they are in the process of being altered by another user.

F. BASIC-PLUS, AN EXPANDED LANGUAGE

Timesharing users interact with RSTS/E using BASIC-PLUS. The language is easy to learn and work with, yet puts the enormous power of the system at the user's fingertips. The immediate mode of operation enables the terminal to be used for simple calculations. Dynamic debugging is faster since programs may be interrupted at any point, checked, corrected, and operation resumed.

BASIC-PLUS automatically checks all program commands for accuracy when they are entered. Errors are reported immediately. Since each program line is compiled as it is entered, there are no frustrating delays, even on the RUN command.

BASIC-PLUS is a significant extension of Dartmouth BASIC to increase its utility and make RSTS/E the ideal tool to solve a broad range of problems. For example, administrative applications such as on-line order entry, inventory control and payroll may be implemented efficiently by using language features suited for data processing. Text-processing applications such as Computer Assisted instruction, (CAI), automated letter or document editing and production may utilize the set of character string handling functions. The utility of BASIC for computational applications such as structural design and simulation is extended with language features which allow more concise, and therefore, more efficient programming and program execution. BASIC-PLUS eliminates the constraints of BASIC for a variety of applications programming tasks.

Calculations in BASIC-PLUS are generally executed using floating-point variables. The magnitude range of numbers lies between 0.14×10^{-38} and $1.7 \times 10^{+38}$. Two levels of precision are available: 7 decimal digits (two computer words) or 17 decimal digits (four computer words). The degree of precision used is a system generation parameter. Whichever is chosen applies to all users of the system unless the system is regenerated for a different degree of precision.

BASIC-PLUS also allows the use of integers. These are whole numbers in the range -32,768 to 32,767. The most common uses of integers are in counting, indexing and subscript operations. Since integers only occupy one computer word, their use often increases the execution efficiency of programs.

BASIC-PLUS provides a comprehensive set of mathematical functions to the user – trigonometric, logarithmic, absolute value, truncation, pi, random number generator and square root. Logical and relational operators are also available.

G. IMMEDIATE MODE OF EXECUTION

Normal timesharing use of RSTS/E consists of typing program text using a keyboard terminal and at the end of the program typing a RUN command at which time the program executes. A second mode of using RSTS/E, called immediate mode, consists of typing program statements on the keyboard and having them executed immediately. Program statements are identified in either case except that, in immediate mode, they are typed without line numbers.

Two uses of immediate mode might be 1) performance of simple calculations in situations which do not occur with sufficient frequency to justify writing a program and 2) program debugging. To debug a program a user can place the STOP statement liberally throughout the program. Each STOP statement causes the program to halt and prints the line number at which the STOP occurred, at which time the user can examine and change various data values in immediate mode and give a command to continue program execution.

H. MATRIX OPERATIONS

The user of RSTS/E may improve processing and programming efficiency by organizing his numeric data into one- and two-dimensional arrays or matrices. The BASIC-PLUS matrix commands add, subtract, multiply and invert entire data matrices in a single operation. Commands are also available to initialize a matrix to zeroes, ones, or to the identity matrix.

Both numeric and character string matrices may be input, read, and printed with single commands. If the matrices won't fit in main memory the BASIC-PLUS virtual memory facility can be used as an extension of main memory as needed. Thus, array size never restricts program size, or vice versa; RSTS/E offers unlimited array capability even with the largest programs.

I. EXTENDED PROGRAM STATEMENT CODING

The effectiveness of RSTS/E in solving problems in a broad variety of application areas is significantly increased with the addition of numerous extensions to the structure (syntax) of the BASIC program statements. These highly flexible program statements, previously found only in advanced scientific languages like ALGOL, permit more concise expression of complex program steps.

J. STRING OPERATIONS

Many RSTS/E applications, such as Computer Assisted instruction, text editing, and business data processing, require efficient processing of alphabetic data such as names, addresses and even entire sentences. BASIC-PLUS provides for the processing of character strings of various lengths, the maximum length being limited only by the available memory. When using the virtual memory, character strings can have a maximum length of 512 characters.

A comprehensive group of string operations is provided in BASIC-PLUS. Strings may be appended to one another. Strings may be compared to one another to see, for example, if a keyboard response is correct or to alphabetize a list of names.

Functions are available to extract, examine or search for a string of characters contained within a larger string. Further enhancing the utility of string variables is the capability of using string arrays as matrices. With this feature, an entire list of alphabetic data, say a list of names, could be read-in with a single statement, processed, and output with another statement. In standard BASIC, without string arrays, separate READ and WRITE statements would be required for each name in the list.

K. PROGRAMMABLE TIMING CONTROL

BASIC-PLUS gives the user the ability to control certain operations in actual time. The SLEEP function allows the user to suspend a program from execution for a specified number of seconds. When this time interval has elapsed, execution resumes. Let us say a RSTS/E installation has a substantial number of users trying to print on a single line printer. Rather than each one of these users getting in a queue, inserting a SLEEP command in his program to wait a few seconds if the line printer is busy, then trying to access it again, consider this more elegant approach with BASIC-PLUS. Each user writes his line printer output into a specified disk file. Then a program running at the system manager's terminal examines the disk file periodically and, if it has data on it, prints it on the line printer. If the disk file is empty, the program SLEEPS a few seconds and examines it again, providing optimum throughput without user delay.

In some applications, the length of time a terminal user takes to respond to a message printed at his terminal is a significant variable. The WAIT function provides an interval timer feature which may be used for signaling the program that the terminal user has not responded within some specified length of time. One example of the use of the WAIT function is in CAI applications where one measure of student performance may be "think time." If the student takes more than five seconds, for example, to respond to a question, the computer can restate the question in another manner, and record the delay as one element of the student's overall performance.

An additional real-time feature provides year, month, day and time-of-day information to RSTS/E programs.

L. FORMATTED OUTPUT

Many applications, such as business data processing, require more flexible control of the printing format than Dartmouth BASIC allows. BASIC-PLUS includes a PRINT USING statement which may be used to achieve precise definition of printed data format. PRINT USING allows character, decimal and exponential data field lengths and positions to be defined, and mixed, in a line of output. In addition, leading dollar sign or asterisk symbols may be "floated" to automatically precede the most significant digit of decimal fields. Also, trailing minus signs may be specified for compatibility with accounting report standards.

Format	BASIC-PLUS	Standard BASIC
Floating dollar sign	$95.20	$ 95.2
	$4,382.69	$ 4,382.69
	$0.43	$ 0.43
Asterisk fill	$***20.32	not available
	$**120.48	
Comma insertion	4,832,684.15	4832684.15
Decimal point alignment	1,497.00	1497
Trailing minus sign	572.83-	-572.83

M. ERROR RECOVERY

One of the more frustrating situations for a timesharing terminal user is having a program cancelled because of an input/output error. This situation, though rare, may be eliminated in RSTS/E by use of the ON ERROR GO TO statement. This subroutine call statement is triggered by a variety of input/output operation errors. The called subroutine is passed a value which identifies the error type, and attempts to recover from the error condition. If the subroutine is successful, normal execution of the application program resumes.

Occasionally, problems will occur within the telephone system causing an unexpected disconnect for a remote user. In this event, the remote terminal may be cut off from the job, but the program will continue to execute. The user can then re-dial the computer system, re-attach the job, and then continue interaction with the program.

In all cases, on hardware or software error, the file system is kept intact and secure. In the unlikely event of a system "crash", users merely have to perform a simple determination of the status of their file processing at the time of the crash, and then continue.

N. EFFICIENT SCHEDULING ALGORITHM

RSTS/E installations can expect exceptional efficiency of operation because the operating system continuously and dynamically allocates processor time, memory space, file space and peripheral access on a best-fit/best-throughput basis. The RSTS/E operating system automatically and dynamically assigns one of the 255 job priority levels to each timesharing job. These priority levels are based on such criteria as job size, computing requirements, current time since last quantum of runtime for the job, and input/output requirements. They may also be altered by the System Manager.

Disk allocation is made dynamically as users require. Users do not have to plan ahead for their use of disk space; however, additional efficiencies may be realized if they do. Specifying contiguous disk segments can decrease the number of disk accesses required for reading and writing large files.

O. CONTROL OF USER ACCESS AND RESOURCES

RSTS/E provides facilities to aid the System Manager in accurate and efficient control of system use. The System Manager may specify each user's programmer and project number, password, maximum logged-out disk space and maximum number of files.

If desired, user access to the system can be controlled by the System Manager. In fact, if desired, access could be controlled automatically, through a program, thus relieving the tedium of system administration. For example, in a school, certain use could automatically be limited to 30 minutes of log-in time per day or two log-ins per day. Should users fail to log-off at the designated time, the System Manager can force a log-off of the user's terminal which will preserve files, but terminate job execution.

Facilities are available for the System Manager to send messages to all terminal users. Also, an automatic shutdown system is provided which periodically warns users that the system will shut down at a designated time. Any users still active at the designated time are logged-off in an orderly fashion, with full integrity of all active files.

Access to peripheral devices is generally open to all users under the resource sharing concept on a first-come, first-served basis. However, the capability is available to the System Manager to intervene in peripheral assignment. In addition, the System Manager can specify how the space on the system disks is to be allocated.

P. SYSTEM USAGE ACCOUNTING

The System Manager, as well as any terminal user, can determine the status of the RSTS/E system through use of the SYSTAT program. The program gives information of:

1. Status of all jobs
2. Disk structure and status
3. Status of other peripheral devices
4. Run-time to data

A more detailed accounting of specific user, of all users, is possible using the MONEY program. For each unique account, MONEY yields information on:

1. CPU run-time
2. Connect time of the user's terminal
3. Memory usage
4. Peripheral device usage
5. Number of log-ins and log-outs
6. Disk storage allocation

Q. SYSTEM FILE AND SECURITY

As mentioned, to gain access to a RSTS/E system, a user must first have a programmer number assigned by the System

Manager. Thereafter, user identity is established by entering number and password (non-printing) into the system. Either the user or System Manager has the capability of changing this password at any time. This facility, when combined with the individual file access protection codes, provides an effective means of safeguarding user data.

Additional protection can be provided by "private" removable disk packs and cartridges. A private disk is one upon which only authorized users may create files. Other users may access these files only if protection codes permit. Private disks may be mounted or dismounted from the on-line system at any time. When not in use, they may be kept under lock and key.

Each terminal user has full control over the degree of privacy desired for each file created. Access may be limited to one user, to those in the same group (or project), or to all system users. Access may be read-only, write-only, or read/write.

R. BATCH COBOL OPTION

A RSTS/E system may be further enhanced for business data processing applications by the addition of the PDP-11 COBOL language processor. COBOL programs and run in batch mode under RSTS/E, and are given a fixed amount of execution time under the scheduling algorithm, depending on the number of users and the priority level assigned to the jobs. When a batch COBOL job is executing, response at BASIC-PLUS terminals is not appreciably degraded, since the COBOL job competes for time in a similar fashion as all other users. COBOL jobs have access to system resources in the same manner as BASIC-PLUS jobs. The COBOL language processor conforms to the ANSI 1974 standard.

S. COMMERCIAL EXTENSIONS

A commercial extension package is available to enhance the capabilities of the RSTS/E system in business data processing applications. This extension package consists of a disk sort, indexed file access method, decimal arithmetic capacity and line printer spooling.

1. Disk Sort Package

The disk sort package is a series of programs allowing the user to sort records on a disk file into a specified order. Up to 15 different fields can be specified for input data files containing up to 32,650 records — up to 512 characters per record. The SORT Program may be called from the user program or may be initiated via interactive commands.

2. Indexed File Access Method

The Indexed File Access Method (IAM) allows the user to access disk file data records randomly. This capability allows a user to achieve fast, random access to data records without concern for the intricacies of disk file organization. Sequential processing of these records is supported either directly (if there have been no records added to the file since the last file organization) or by means of file output from the SORT package.

3. Decimal Arithmetic Option

The decimal arithmetic option replaces the standard floating-point arithmetic with four-word fixed-point arithmetic. This format achieves 18 places of accuracy with 12 places to the left of the decimal point. Since all numbers represented in this manner, including fractions, are true decimal numbers, there can be no cumulative error due to repeated operations. For this reason, the representation is normally preferred when performing accounting functions.

4. Line Printer Spooling

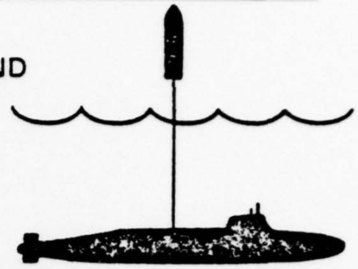
The line printer spooling package is a series of BASIC-PLUS programs which allow the user to specify disk or magnetic tape files to be output to a system line printer — or other device. To utilize the spooler, the user enters the request for output; the request is queued and initiated when the output device becomes available. In this way, possible conflicts in using the system line printer are avoided. User programs can go on to perform other tasks nad system throughput can often be increased by as much as 25 percent. Included in the package is support for multiple line printers.

APPENDIX C

LOCATION

SOCIAL SECURITY NO. | TEST DATE Y Y M M D D | P G | SECTION

FBMWS PERSONNEL AND TRAINING EVALUATION PROGRAM



GROUP

Answer choices for each item: 1 2 3 4

	5	12	19	26	33	40	47	54
(EXAMPLE)	6	13	20	27	34	41	48	55
0	7	14	21	28	35	42	49	56
1	8	15	22	29	36	43	50	57
2	9	16	23	30	37	44	51	58
3	10	17	24	31	38	45	52	59
4	11	18	25	32	39	46	53	60

TEST

	65	72	79	86	93	100	107	114
	66	73	80	87	94	101	108	115
	67	74	81	88	95	102	109	116
61	68	75	82	89	96	103	110	117
62	69	76	83	90	97	104	111	118
63	70	77	84	91	98	105	112	119
64	71	78	85	92	99	106	113	120

RATE/RANK

	125	132	139	146	153	160	167	174
	126	133	140	147	154	161	168	175
	127	134	141	148	155	162	169	176
121	128	135	142	149	156	163	170	177
122	129	136	143	150	157	164	171	178
123	130	137	144	151	158	165	172	179
124	131	138	145	152	159	166	173	180

NAME

Use No.2 or softer black lead pencil only. Erase completely any answer you wish to change. Make no stray marks on this answer sheet. Make heavy black marks that fill the space completely.

ANSWER SHEET

PT EP 032

DO NOT FOLD–BEND–SPINDLE OR MUTILATE

LIST OF REFERENCES

1. Bureau of Ships 0967-129-3010, Introduction to Sonar Technology, by TRACOR, INC., p. 1, December, 1965.

2. Memorandum of Agreement, Strategic Systems Project Office and Naval Underwater Systems Center, Subject: The Sonar Operational Training and Assessment Program, October, 1976.

3. Hofer, I. E., A Review of Safety Needs and Safety Personnel Requirements in the Navy, Master's Thesis, Naval Postgraduate School, 1977.

4. Kline, M. B., A Critical Appraisal of the Requirements Determination Process, paper presented at the Naval Aviation Executive Institute Colloquium, Monterey, California, 25-30 April 1976.

5. "Sub Escape Training Still a Must for Crew," Navy Times, p. 29, 7 November 1977.

6. "BENEFIT EROSION: Details of Service Chiefs' Warning to Rumsfeld," Navy Times, p. 12, 7 February 1977.

7. System Development Corporation TM-864, Software Design and Implementation, by J. W. Singleton, 30 November 1962.

8. Elliott, C. O. and Wasley, R. S., Business Information Processing Systems, 4th ed., Richard D. Irwin, Inc., 1975.

9. Schoderbek, P. P., Management Systems, John Wiley and Sons, Inc., 1967.

10. Simon, H. A. and Newell A., "Heuristic Problem Solving: The Next Advance in Operations Research," Operations Research, VI, p. 1-10, January-February, 1958.

11. Kline , M. B., Maintainability Considerations in Systems Design, p. 8, Naval Postgraduate School, Monterey, 1976.

12. Chapman, R. L., and others, "The System Research Laboratory's Air Defense Experiments," Management Science, V, p. 250-269, No. 3 April, 1959.

13. System Development Corporation TM-132, How to Lead a Debriefing, by A. Katcher and M. Hunter, 19 November 1957.

14. System Development Corporation TM-101, A Method for Training Debriefing Leaders, by A. Katcher and J. Jaffe, 27 January 1958.

15. Defense Acquisition Study, National Security Industrial Association, 1 July 1970.

16. Institute for Defense Analysis-Summary Report, Summer Study on Command and Control, 15 September 1961.

17. Laden, H. N. and Gildersleeve, T. R., Systems Design for Computer Applications, John Wiley and Sons, Inc., 1963.

18. Head, R. V., Real-Time Business Systems, Holt, Rinehart and Winston, Inc., 1965.

19. Martin, J., Programming Real-Time Computer Systems, Prentice-Hall Inc., 1965.

20. Sackman , H., Computers, Systems Science, and Evolving Society, John Wiley and Sons, Inc., 1967.

21. Wilson, I. G. and Wilson, M. E., Information, Computers, and Systems, John Wiley and Sons, Inc., 1965.

22. Design of Real Time Computer Systems, Prentice-Hall, Inc., 1967.

23. Alexander , M. J., Information Systems Analysis, Science Research Associates, Inc., 1974.

24. Arnold, R. R., Hill, H. C., and Nichols, A. V., Modern Data Processing, John Wiley and Sons, Inc., 1969.

25. Freeman, L., Will, T. J., and Brown, R. L., SOTAP, Sonar Operational Training and Assessment Program, Implementation Plan, Naval Underwater Systems Center, 1 July 1977.

26. Naval Weapons Center China Lake REG 31408-88-76, Versatile Training System Functional Description for Naval Aviation Activities, by Hamerdinger, H. E., 15 April 1977.

27. Central Test Site, Personnel and Training Evaluation Program Memorandum to Director, Strategic Systems Projects, Subject: Polaris/Poseidon/Trident-1 Backfit PTEP Versatile Training System, 24 November 1976.

28. Digital Dquipment Corporation Sales Brochure, Subject: "RSTE/E Resource Sharing Timesharing System/Extended," 1973.

29. Smith, P., "Navy Loses 11,700 Billets, Most From Training 'Pipeline'," Navy Times, p. 3, 6 February 1978.

30. U.S. Congress, Senate, Committee on Government Operations, by Schlesinger, J. R., "Uses and Abuses of Analysis," 1968.

BIBLIOGRAPHY

Bannar, C. J., Technological Developments in Information Processing and the Resultant Impact on User Organizations, Master's Thesis, Naval Postgraduate School, 1977.

Belden, D. L., and Cammack, E. G., Procurement, 4th ed., Industrial College of the Armed Forces, 1973.

Benjamin, R. I., Control of the Information System Development Cycle, John Wiley and Sons, Inc., 1971.

Chief of Naval Operations Instruction 1500.28A, Subject: "Fleet Ballistic Missile Weapons System Training Program," 15 June 1972.

Cicio, J. D., Development of a Computer Based Management Information System, Master's Thesis, Naval Postgraduate School, 1972.

Commission on Government Procurement, Report of the Commission on Government Procurement, Government Printing Office, December 1972.

Department of Defense Directive 5000.1, Subject: "Major Systems Acquisitions," 18 January 1977.

Department of Defense Directive 5000.2, Subject: "Major System Acquisition Process," 18 January 1977.

Director, Strategic Systems Project NAVORD OD 23520 (3rd rev), Subject: "FBM Training System Development, Production, and Support Requirements," 8 January 1975.

Gallagher, J. D., Management Information Systems and the Computer, American Management Association, Inc., 1961.

House, A. L., Study of a Computer Selection Process, Master's Thesis, Naval Postgraduate School, 1974.

Howerton, P. W., Information Handling: First Principles, Cleaver-Hume Press, 1963.

Kanter, J., Management-Oriented Management Information Systems, Prentice-Hall, Inc., 1972.

Naval Weapons Center China Lake REG 31408-170-76, Versatile Training System Implementation Plan for the Trident Training Facility, by Hamerdinger, H. E., 25 January 1977.

Office of Management and Budget Circular A-109, Subject: "Major Systems Acquisitions," Executive Office of the President, 5 April 1976.

Strategic Systems Projects Instruction 3100.1D, Subject: "Trouble and Failure Report Program," 1 July 1974.

Suess, K. J., and Thaler, J. F., Demonstration of the Feasibility of Automating the Information System of a Small Service Organization Using A Generalized Computer Software Package, Master's Thesis, Naval Postgraduate School, 1976.

Weisman, H. M., Information Systems, Services, and Centers, Becker and Hays, Inc., 1972.

INITIAL DISTRIBUTION LIST

		No. Copies
1.	Defense Documentation Center Cameron Station Alexandria, Virginia 22314	2
2.	Library, Code 0142 Naval Postgraduate School Monterey, California 93940	2
3.	Department Chairman, Code 54 Department of Administrative Sciences Naval Postgraduate School Monterey, California 93940	1
4.	Professor M. G. Sovereign, Code 55 Department of Operations Research and Administrative Sciences Naval Postgraduate School Monterey, California 93940	1
5.	Professor J. W. Creighton, Code 55Cf Department of Administrative Sciences Naval Postgraduate School Monterey, California 93940	2
6.	LCDR J. D. Buttinger, Code 54Bk Department of Administrative Sciences Naval Postgraduate School Monterey, California 93940	1
7.	Mr. Russell L. Brown Sonar Operational Training and Assessment Program Naval Underwater Systems Center New London, Connecticut 06320	5
5.	Lieutenant G. C. Lannou, Jr. 1511 Lindberg Baytown, Texas 77520	2