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SHIPBOARD NON-TACTICAL
COMPUTER SYSTEMS OF THE U.S. NAVY

by

William J. McMican
and
James J. Richards

March 1985

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This thesis reviews the development and application of current non-tactical shipboard ADP systems in the U.S. Navy, and provides an analysis of each systems' strengths and weaknesses. The primary focus of this review includes Perq/ZOG, WANG installations, and SNAP II. The methodologies of procurement, development and implemenation vary as widely as the scope and complexity of the various systems. This analysis provides insight into some primary managemer t issues, limitations, and constraits encountered in providing non-tactical automatic data processing to the fleet. Additional keywords: U.S.S. Carl Vinson

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I. INTRODUCTION

"For want of a nail the shoe is lost, for want of a shoe the horse is lost, for want of a horse the rider is lost". [Ref. 1]

These familiar words from an old verse still ring true today, except with the U.S. Navy, the proverbial nail has been replaced by the small, modern, non-tactical computer.

Since the late 1970's, there has been a proliferation of computers on board the ships and vessels of the U.S. Navy, which has served to revolutionize the processing of information at sea These small processers have generally increased the productivity of ship's administrative personnel by allowing each man to produce more information of a higher quality than was previously possible in a manual mode. They have also provided the Commanding Officer and his key assistants with more timely information on which to base their everyday management decisions.

Along with these benefits, the introduction of the small non-tactical computer into the shipboard environment has exacerbated the ongoing concerns of security and standardization, while introducing many new issues that must be dealt with, such as control of computer resources and dependency on systems that could cease to function at any time in the harsh at-sea environment of a ship.

The objective of this thesis is not to identify and analyze all the systems presently implemented on board Naval ships, but to survey a few of them in regards to their architecture, benefits, and unique technical and managerial problems.

This thesis focuses on three distinct computer installations that are currently implemented on board U.S.

Naval ships. Chapter Two looks at a system of Perq minicomputers installed on board the U.S.S. Carl Vinson that run an experimental menu-driven, distributed database called ZOG. ZOG was developed at Carnegie- Mellon University with support from both the Office of Naval Research (ONR) and the Defense Advanced Research Agency (DARPA). Chapter Three addresses the WANG VS-100 which is also installed on board the U.S.S. Carl Vinson. It was selected for inclusion in this thesis because it is an off-the-shelf commercial system that has been installed and operated without being specifically designed or altered for the shipboard environment. This system was also developed without the benefit of government support. Chapter Four discusses the SNAP system, which is presently being placed on board all naval ships. This system comes in two versions, the Honeywell SNAP I system is for large ships, and the Harris SNAP II system is for smaller ones. Both of these systems, which are centrally procured and managed by the Navy, have been specifically ruggedized for a shipboard environment. Chapter Five consolidates some of the conclusions that have been drawn from the other chapters.

While this thesis does not attempt to analyze the whole spectrum of problems concerning non-tactical automation that is now being addressed in the fleet, it does attempt to survey many of them from the viewpoint of the professional naval officer. However, a concerted effort has been made to define or describe terms unique to the Navy or shipboard life for those readers without an appropriate naval background.

II. PERQ

A. INTRODUCTION

In 1981, a non-tactical computer system consisting of twenty-eight Perq minicomputers and the prototype software called ZOG was installed on board the Navy's new aircraft carrier, the U.S.S. CARL VINSON. These minicomputers were state-of-the art technology, offering the user a choice between mouse technology or a detachable keyboard for accessing the ZOG system. Each Perq minicomputer was also configured with a hardware graphics tablet for the mouse, one megabyte of random access memory, four thousand bytes of writable control storage, and a twenty-four megabyte Winchester hard disk storage drive. All the Perq minicomputers were connected in a local area network by a 10mz Ethernet.

The heart of this system was ZOG, an experimental, human-computer interface conceived and developed at Carnegie-Mellon University in the early 1970's. It is the transfer of ZOG technology from the research laboratory of academe to the operational shipboard environment of the U.S.S. CARL VINSON that will be the focus of this chapter.

B. BACKGROUND

ZOG was initially conceived and developed in 1972 as part of a summer workshop held at Carnegie-Mellon University (CMU) for cognitive psychologists studying simulation [Ref. 2]. The original intent of ZOG was to provide a system that would allow new users to access and explore large complex programs. Although the concept proved workable, lack of a fast terminal input/output device made

the actual system too slow. At that time, state of the art terminal technology was limited to 300 baud with hardcopy output. Hence, the system was shelved until more advanced hardware and communication technology became available.

In 1975 Alan Newell and George Robertson, two of the original developers of ZOG, served on a technical advisory committee for PROMIS (Problem Oriented Medical Information System); a system strikingly similar to the ZOG concept, but which utilized the latest in hardware technology. PROMIS was conceived by DR. Lawrence Weed of the University of Vermont Medical School. It was a combination of a management information system and a menu guidance system that was billed as a comprehensive approach to health care. [Ref. 3] PROMIS used a Sperry-Univac V77-600 minicomputer with 250k ram, three Control Data Corporation Storage Module Drives (250 megacharacters per spindle) and associated peripherals per node. The user interfaced the computer via a high speed (approximately 1/2 second access time) CRT terminal, which incorporated a touch sensitive screen as well as a standard keyboard [Ref. 4].

This demonstrated use of modern high speed terminal technology in the PROMIS system resulted in revived interest in ZOG at Carnegie-Mellon University. With support from both the Office of Naval Research (ONR) and the Defense Advanced Research Agency (DARPA), newer versions of ZOG were developed and brought up on the university's PDP-10, first using a Tops 10 and then a TOPS 20 operating system. ZOG was also installed on the university's experimental multiprocessor, C.MMP. By 1980 Carnegie-Mel[illegible] esearchers were successfully running ZOG on a new Et[illegible] local area network, which connected the university's [illegible]0s, Xerox Altos, and new DEC Vax computers. [Ref. 5]

There were two occurrences in 1980 that had major impact on ZOG's development. One was the implementation of SPICE,

(Scientific Personal Integrated Computing Environment) as a research project at Carnegie-Mellon. Since several of the researchers working on SPICE had also worked on ZOG, it was inevitable that the two systems would be closely affiliated. Informal relationships that occurred because of this close affiliation were reinforced as a result of a conscious decision made by researchers at Carnegie-Mellon to eventually integrate all software projects at the university with SPICE. As a direct result of this decision, the Perq minicomputer from the Three Rivers Computer Corporation that was selected for initial SPICE implementation, was ultimately selected for ZOG when it was moved from the research to the operational arena. [Ref. 6]

The other occurrence was a visit to Carnegie-Mellon by Navy Captain Richard Martin, the prospective commanding officer of the nuclear powered aircraft carrier, U.S.S. CARL VINSON, then under construction in Newport News, Virginia.

Captain Martin was visiting several ONR research sites throughout the country to familiarize himself with the latest developments in various technical areas. His purpose at Carnegie-Mellon was to ascertain what advanced computer technology was available that might prove useful on board the U.S.S CARL VINSON. His initial encounter with ZOG at Carnegie-Mellon convinced Captain Martin that a marriage between the new software technology and the U.S.S. CARL VINSON would serve two purposes.

1. It would supply the ONR/DARPA supported research at CMU with an operational test bed, and
2. It would give U.S.S CARL VINSON the latest in computer technology to help manage the carrier's extensive administration requirements in the areas of management, maintenance, and planning.

To evolve ZOG to a point where it could be implemented on board U.S.S. CARL VINSON, a formal ZOG Technological Demonstration Project was established in March 1981. Its goals were to get fleet personnel involved as soon as possible in the ZOG project, to accelerate application development to more closely conform with U.S.S CARL VINSON's commissioning and trial schedules, and to expand the functional span and quality of the final product [Ref. 7]. Three shipboard areas were initially selected to use ZOG. These included on-line creation of the Ship's Organization and Regulations Manual (SORM), administration planning and evaluation, and weapons elevator maintenance training.

C. THE NATURE OF ZOG

Thus far, we have only briefly described the evolution of the Perq/ZOG system from its beginnings at Carnegie-Mellon University in the early seventies, to the establishment of a formal ZOG Technological Project in March 1981. We have not specifically defined nor completely described ZOG. What is ZOG? How does it differ from the numerous other software concepts that were being discussed and developed in universities, research institutions, and commercial laboratories throughout the 1970's and early 1980's? These and similar type issues must be discussed before ZOG's potential impact can be analyzed and evaluated.

1. Essence of ZOG

ZOG has been described as "a rapid-response, large-network, menu-selection computer interface" [Ref. 8]. In less succinct words, it is an extremely fast, distributed data-base that is driven by menus called display frames. These display frames are the essence of ZOG. The function of a display frame is to present information to the user and

allow him to jump to another frame when finished with the one he is currently on. With few exceptions, the degree of information that can fit on the standard terminal screen is the maximum amount of information allowed in one display frame. This limitation does not present many problems, however. Since the Perq's high resolution screen actually allows two full frame menus to be displayed at a time, the user does not require a scrolling function when viewing data. The first information item on a display frame is the frame's title line. It can consist of a variable length title and a short summary of the frame's contents. The second information item is the frame's text. It further expounds on the frame's main point of information. The third information section constitutes a list of numbered options. An option can consist of the title of a subsequent frame, which when activated will move the user to that particular frame. Options can also be used like subpoints of the frame text as in an outline [Ref. 9]. If we envision the entire database as a tree structure, and each menu as a parent node, we can view the children of each parent node as frames accessible through options. A fourth information item on the frame is the set of local pads. Local pads are used to invoke programs or point to extrinsic information. Using the tree analogy, local pads on the menu could point to frames or nodes in a totally different tree vice that of the frame's children. They are cross reference links. The final information item on a display frame consist of the global pad set. These pads perform often repeated actions e.g. go into edit, go to the previous frame, find information, help, etc.

Thousands of these frames can be connected together to form what is called a "subnet". Subnets are functional groupings of menus that form some report, program, or other entity when interconnected.

2. ZOG and User Integration

When interacting with ZOG, the user is in one of three modes. He is either navigating, invoking a program, or editing [Ref. 10]. Navigation is the act of making a selection of an option, local pad, or global pad by way of the mouse pointing device or keyboard. The system reacts by replacing the current display frame with that of the new selection.

Embedded within ZOG are agents (application and utility programs) written in the Pascal language. These agents are used in planning and document writing, or as interface drivers for input/output devices. Because ZOG supports a programming environment these programs can be written and implemented into the database by the user himself.

If the user desires to invoke an agent embedded within ZOG, he usually navigates to a particular display frame on which the program is listed as an action item, fills in the required parameters, and then selects the action. McCracken and Akscyn describe an action item as:

> "A sequence of commands in the ZOG action language -- a simple programming language. This language contains commands for traversing the network, invoking intrinsic utilities, and entering the editor." [Ref. 11]

The third area of interaction between ZOG and the user is editing. Onboard the U.S.S. CARL VINSON, a user has the choice of two different editors. The principle editor is ZED (ZOG edit). ZED is a frame editor that is used for making changes to the database. Its main purpose is to provide an instrument for creating new frames, changing links between frames, or editing the contents of existing frames. ZED can be invoked from any frame via the "edit" global pad. A second editor called SLED (slot edit) is also

available within ZOG. This editor has proved much easier to use than ZED, but unlike ZED, it cannot be used to create frames. SLED is designed for use in applications that require fast, accurate input or editing of information. It is especially useful in running ZOG agents. SLED has a built in error-checking capability that matches input dates, times, frame, subnets, and other pertinent information against its data base to ensure their validity. With its pop-up type menu and default value display, SLED allows the user to quickly input required parameters for an agent by invoking electronic toggle switches with the mouse or keyboard. One application that relies heavily on SLED is the "expert" system called AIRPLAN. AIRPLAN is used by the air operations officer in monitoring and controlling aircraft. When aircraft data is loaded into the system it is checked against the ZOG database to ensure that relevant information concerning the pilot, aircraft, and mission correlates with what is in the database. These parameters, as well as the parameters required by all agents, are entered by using SLED. AIRPLAN will be discussed at a later point in this paper.

D. ZOG AND THE U.S.S. CARL VINSON

In evaluating a system such as ZOG, several criterion must first be established with which the system can be measured and compared. Still, regardless of how careful these criterion are chosen, a system can seldom be deemed either a total failure or a total success. More often than not it lies in the proverbial gray area in which it is a success in one arena, a failure in a second, and indeterminate in a third.

1. Criterion for Success

Criterion used in evaluating ZOG will vary with the perspective from which it is being viewed, the interpretation of common measures, and the individual's knowledge of the environment in which the system is utilized.

A battle group commander, for example, may consider the system a failure because it cannot use standard software already developed and distributed throughout the fleet. An individual commanding officer may view this same system as a success, because it gives him the information he requires at the time he needs it. The user/technician may view the system as unsuccessful, because it is difficult to operate and maintain. Each observation is valid, yet leads to different conclusions.

One common criterion heavily used in evaluating ZOG was usage. Newell stated that "ZOG is a success to the extent that it becomes used for actual operations, and to the extent that such use continues and expands" [Ref. 12]. This supposition was affirmed by Van Matre, Moy, and McCann as, "the best measure of system success is the use or non-use of the system" [Ref. 13]. While this premise appears reasonable, its use should be tempered with a thorough knowledge of the environment in which the system is utilized, otherwise, erroneous results may occur.

Low usage of the Perq/ZOG system may not be significant on board the U.S.S. CARL VINSON because the ship has other non-tactical computer systems that can duplicate many of its applications, e.g. WANG-Net, Snap, etc. Also there are other less apparent factors that could account for this low usage. An example of thes is evident in the SORM. (Ship's Organization And Regulations Manual).

The SORM is a ship's document that gives detailed instructions on the daily routine to be followed by a ship. It is developed and tailored by ship's personnel specifically for their ship. The SORM is a dynamic document that reflects the philosophy of the commanding officer, but follows the format and guidelines of the Navy's SORM, OPNAVINST 3120.32 (Operational Navy Instruction 3120.32). OPNAVINST 3120.32 can function as the ship's SORM with a few page insertions and some pen and ink changes, as is often done on smaller vessels. Consequently, development of a shipboard version is usually of low priority compared to more pressing documentation. Therefore, low usage on a SORM subnet could lead to an erroneous interpretation and conclusion about ZOG's suitability for developing this particular type of documentation. In reality, the usage or non-usage of this subnet might be more a function of command emphasis and priorities on SORM development, than a reflection on ZOG.

2. Evaluation of the VINSON/ZOG Project

Three areas were initially selected for ZOG's implementation on board U.S.S. CARL VINSON. These included the SORM, administrative planning and evaluation (management), and weapons elevator maintenance training. Later, an expert system called AIRPLAN was added along with several ad hoc applications. Each of these application areas would suffer common problems endemic to either ZOG or the Perqs. These problems include the following:

a. "Difficulty in using the ZED editor" [Ref. 14]. The editor has proven awkward and hard to use. Once mastered, it requires constant use to maintain proficiency.

b. "ZOG is biased too much toward a breadth-first view" [Ref. 15]. This is unnatural in relation to the

normal way one is taught to think and read. An analogy of this problem can be illustrated in reading a book. When reading a book, one is taught to read the first sentence on the first page, the second sentence on the first page, etc., until the first page has been read. The reader will then progress through the second page, third page and so fourth reading in this top to bottom manner. This is reading depth first. If one were to instead read the first sentence on page one of chapter one, the first sentence on page one of chapter two etc., until he progressed through the complete book, then return to the beginning and do the same for the second sentence, this would be breadth first. This type of thought process is what is asked of the user in reading ZOG subnets.

c. Hardware/Software problems. During the U.S.S. CARL VINSON's 1983 cruise, problems were continually experienced with the Perq minicomputers. These problems were partly due to the equipment being ill-designed for a shipboard environment, and partly due to equipment being installed without the benefit of shock absorbers to compensate for pitch and roll of the ship, or basic voltage protection to ensure clean power, e.g. isolation transformers, line regulators, line conditioners, uninterruptible power supply, etc. Consequently the Perqs and Ethernet experienced continual problems with electronic boards and other electrical components.

ZOG itself was a major source of frustration to members of the management department. Its personnel were expending an inordinate amount of time in debugging the system, indicating poor quality control of ZOG software received from Mellon Institute. This lack of quality control

was probably a direct result of transferring ZOG technology from the research environment to an operational environment too early in its development cycle. To exacerbate the problem even further, management personnel on board the U.S.S. CARL VINSON were attempting to integrate code being written at both the Mellon Institute development site and shipboard operational site. This difficult task was attempted under an inflexible set of time constraints with poor communication between the two sites. When the ship was at sea, it could take up to a month for a mail query to be answered.

a. The SORM

Nicholas Van Matre, Melvyn Moy and Patrick McCann concluded in their evaluation of ZOG that "The SORM was not suitable as an organizing element for all functional applications as was originally conceived" [Ref. 16]. They further found that there was a disproportionate usage of SORM subnets, i.e. some portions were meticulously developed and were providing extremely useful management support, while other portions of the SORM subnet remained nothing but shell.

The rational for this phenomenon was two-fold:

1. "Time was a limiting factor" [Ref. 17]. By this, they mean that Perq/ZOG development was performed by shipboard users collaterally with their primary responsibilities. These users had to develop SORM subnets in their own time after fulfilling their foremost shipboard duties. This is closely related to command emphasis, which was previously discussed.
2. The users had difficulty in "instantiating their job as a subnet" [Ref. 18]. The user who was an expert on the business side of the SORM, also had to perform the technical function of fitting and copying his

job into the ZOG database. This is a skill that requires some expertise in choosing meaningful levels of division and a good working knowledge of ZED [Ref. 19]. Without this skill, and with limited or non-recent training in this area, many users became extremely frustrated.

Besides the above, hardware and software problems had a discernible effect on SORM development. The management department on board the U.S.S. CARL VINSON had completed installing the ZOG shell for SORM subnets before the ship's initial cruise in 1983. Because of the size of these SORM subnets (over 10,000 frames), the SORM database was distributed over four host Perq minicomputers. Four other Perqs held read only secondary copies. The other twenty Perqs had the capability of accessing this SORM database through the Ethernet local area network. During the cruise, ship personnel experienced problems with both the Ethernet and the Perqs, which precluded reliable access to the SORM database by all except the four host computers. This in effect limited the number of locations and, therefore, the number of people that could access the SORM database at one time. To further frustrate the user, several other Perq minicomputers ceased to function as the cruise progressed. Fewer and fewer computers were available on which to run ZOG, thus further impacting SORM development. By the end of the cruise there were only nineteen functioning Perqs.

The combination of these problems has served to frustrate the user and inhibit online development of the SORM.

b. Weapons Elevator Maintenance Training

A complex application attempted with ZOG was an on-line technical manual for the ship's weapons elevators.

This manual was to provide maintenance personnel of the ship's weapons department with technical support in repairing, maintaining, and operating the ship's weapons elevators. Additionally, it was to serve as a training device for all members of the G-3 division. The manual itself was hosted on three Perq minicomputers that were connected to a laser video-disk player and CRT display monitor.

During ship construction in Newport News, Virginia, members of the weapons department G-3 division made detailed, multiple- view video tapes of each step in assembly and installation of the weapons elevators. On completion, more color video tapes were made showing the elevators in operation with appropriate motion and sound. These video tapes were then moved to laser video disks. Consequently, a complete pictorial history was made of each weapons elevator aboard U.S.S. CARL VINSON.

Once developed, the user of this system would read the on-line narrative portion of the technical manual, and then look at the picture display. Like the SORM, all material was categorized into three functional ZOG trees.

1. UNDERSTAND: This section breaks the elevator into components, and describes their location and function. While this section was easy to comprehend, it was very difficult to actually construct a tree.
2. OPERATE: This is a combination description and demonstration of elevator operation.
3. EVALUATE/MAINTAIN: This provides the technicians with preventive maintenance procedures, specification and electrical schematics.

While the on-line elevator maintenance manual proved an excellent use of the new ZOG technology, it was plagued with both software and hardware problems. The Perq computers suffered electronic circuit board problems due to

power fluctuations, while the laser video disk player experienced alignment problems due to the motion and vibration inherent on board ship. In the software arena, a great deal of effort was expended in continually debugging due to problems between the operating system and ZOG. One other area in which the weapons elevator program proved deficient was video disk expansion capability. It proved too expensive to add to the current disk or make more disks. Hence, before completion of the on-line technical manual, the video disk literally ran out of space, resulting in later additions to the technical manual being narrative only [Ref. 20].

c. AIRPLAN

AIRPLAN is an "expert" system that was developed as an aid and tool for the air operations officer in monitoring and controlling carrier aircraft. It is not a part of ZOG, but uses ZOG as an interface system between itself and the user.

The AIRPLAN program is a rule-based, decision support system that maintains a summary status on all aircraft operationally controlled by the U.S.S. CARL VINSON, and recommends actions to be taken as different situations arise, e.g. emergency procedures. It is also capable of modeling aircraft scenarios without requiring actual aircraft launch.

Before flight operations, daily flight schedules and initial status of all aircraft are loaded into the AIRPLAN net. This includes such information as mission, pilot name, primary and secondary buttons (communication frequencies), and initial fuel and ordinance loads for each aircraft. These inputs are loaded using SLED and are automatically checked for errors. Output includes a hardcopy flight schedule, ordnance loading plan and an emergency

landing plan. Once airborne, each aircraft is monitored and its real time status is summarily displayed on a Perq minicomputer. Included in this display is the amount of remaining fuel in pounds and time remaining before certain critical decisions must be made, i.e. land, refuel from an air tanker, etc. The AIRPLAN net is also comprised of emergency subnets for each aircraft which display a procedural check-off list for different types of emergencies.

On a success/failure continuum, AIRPLAN has proven to lie toward success for two reasons.

1. It is an alternative to the slower, manpower intensive, manual systems that are used on all other aircraft carriers.
2. AIRPLAN displays can be channeled to the ship's secure closed circuit television system, as well as the Perqs. This allows monitoring of air operations from many compartments aboard ship including all squadron ready rooms, the bridge, lower and hanger deck control.

Although AIRPLAN is popular among personnel concerned with flight operations it cannot be relied on in an emergency, because it suffers from the same hardware and software reliability problems that afflict the SORM and Weapons elevator programs.

d. Planning and Evaluation Subnets

Planning and Evaluation (P and E) subnets complete the triad of original ZOG applications first envisioned for implementation on board U.S.S. CARL VINSON. These subnets were intended to support both SPECIFIC PLANS (one-time activities), and GENERIC PLANS (iterative activities) at the department head level and above. Newell, McCracken, Robertson and Akscyn described this on-line planning as follows:

"Plans will exist in an integrated ZOGnet, which will be updated and modified continually as each plan is extended and changed. Exploration of plans from different perspectives will be possible, e.g. by task, by persons or by resources. Some automatic monitoring of plans for consistency and critical events, and some propagation of status through plans will be possible." [Ref. 21]

Within each of these subnets, two basic types of ZOG developed plans can be displayed. These are Specific Responsibility Task Nets and Specific Responsibility Time Line Nets. The Task Nets show the hierarchical relationship of the tasks to be performed, i.e. it breaks them down into components and subcomponents, but not in the chronological order for completion. It also indicates the person or group responsible for accomplishing the task, the required date of completion, and the expected amount of time to complete the task. The Time Line Nets exhibit time relationships between the tasks. These tasks could be sorted by starting date, completion date, and over time periods varying between one day and eighteen months. By making a selection from the Time Line Net, the related task frame of the Task Net along with its detailed information will also be displayed. A hardcopy of these timeline charts could be printed if desired. The format of these plans is generally that of a standard Gantt chart.

With the installation of ZOG on board U.S.S. CARL VINSON, many formally structured P and E subnets were established for ship's departments and personnel. See table I for assigned machines and locations.

Although these planning and evaluation subnets suffered from the same hardware and software problems as did the SORM, they appear to have been used much more extensively. During the U.S.S. CARL VINSON's 1983 cruise, 108 subnets were created besides the formal ones enumerated above. Of these subnets, 95 can be classified as primarily supporting planning. [Ref. 22]

TABLE I

Assigned Subnets and Machine Locations

ASSIGNED TASK SUBNETS		MACHINE LOCATION
Air Officer	(AOPS TASK)	Air Ops office
Aviation intermediate Maintenance Department	(IMDO TASK)	AIMD Office
Management Department	(MGTO TASK)	Conference room
Engineering Department	(ENGO TASK)	Engineers logroom
Medical Department	(HMED TASK)	Medical office
Navigation Department	(NAVO TASK)	Ship's bridge
Operations department	(OPSO TASK)	Ops office
Personnel Department	(PERS TASK)	PERS office
Reactor Department	(REAC TASK)	REAC office
Strike OPS Department	(OXOE TASK)	Strike OPs Office
Supply Department	(SUPO TASK)	Supply office
Senior Chaplain		Chaplain's office
Weapons Department	(WEPS TASK)	Weapons office
Executive Officer	(YYXO TASK)	XO's office

Van Matre, Moy, and McCann attribute this proliferation of activity in creating subnets midway through the cruise to two factors.

1. The users had gained two months additional experience with ZOG, and were therefore becoming more proficient.
2. ZOG became easier to use because an update to the software "enabled a user to be presented with his own unique 'top frame ' when first logging on, instead of the ZOG data base top frame" [Ref. 23].

While these two factors undoubtedly contributed to expansion of P and E subnets, the cruise itself was probably the primary reason for this noted increase. Personnel who actually developed and used these subnets were on board the ship 24 hours a day with no interruption from land-line telephones or ship visitors. This translates into increased manhour availability for creating these subnets. The cycle of the cruise is also partly responsible for the development of these planning nets. When a ship first gets underway for a major cruise, its operational tempo is one of training and operational commitments. Its near term planning consist primarily of fulfilling these commitments. About halfway through a cruise, the ship will shift its planning emphasis from an almost pure operational mode, to one that will prepare it for the myriad of inspections, training requirements, maintenance, and other demands that will inundate it on its return to the United States. It is a combination of all these factors taken together that impacted on the proliferation of P and E subnets during U.S.S. CARL VINSON's first world cruise.

One specific task that consistently used one of these planning subnets was the development of U.S.S. CARL VINSON Greensheets. These are "plans of the day" (daily plans) that are universally used on all U.S. Navy ships. They list deviations from the daily routine of shipboard life, i.e. changes in meal hours, meetings and scheduled events along with times and personnel concerned. Onboard U.S.S. CARL VINSON, the department heads would give the Assistant Operations Strike Officer the information to be included in the daily Greensheets. It took him about two hours to prepare them after receiving the last input. This is about the same time it takes to prepare the plan of the day on other Navy ships. The main difference between these Greensheets and another ship's plan of the day is that the

Greensheets actually included a two day plan to allow for better planning, and could be electronically disseminated almost immediately to the Perqs. Hardcopy Greensheets still had to be run off and delivered newspaper style to the vast majority of the crew.

Another area where planning subnets were used frequently was in getting the ship underway. To get a ship underway requires a great deal of planning and coordination. Tugs must be scheduled, charts corrected, engineering equipment tested and brought on-line, food and supplies brought on board, etc. Preparations will usually start days and sometime weeks before actually taking in the lines and getting the ship underway. A ZOG planning and evaluation subnet was used on the U.S.S. CARL VINSON to provide an online and hardcopy checkoff list to ensure that all required tasks were completed at the proper time and in the order they were scheduled. By keeping this information on-line, an up-to-date date tailored plan could be automatically created, and task relevant information displayed for either a specific person or billet (specific assigned shipboard job). The status of overall underway preparations was also available for concerned personnel.

A third area where this type of subnet proved useful was in preparing for the ORSE (Operational Readiness System Evaluation). This is an involved inspection of the engineering department on board a nuclear vessel. Both the engineer and reactor officers used planning and management nets to assimilate and correlate information concerning personnel availability, training, checkoff list, schedules, etc.

It appears that planning and evaluation subnets were used extensively on board the U.S.S. CARL VINSON despite hardware and software problems. One possible reason for this is that the only alternative solution was often manual mode.

E. A CRITIQUE OF TECHNOLOGY TRANSFER

If the sole objective of the ZOG technology transfer concept was to expedite the transition of technology from the research laboratory of Carnegie-Mellon to the operational environment of the U.S.S. CARL VINSON, then it is an unqualified success. Success, however, is a nebulous term that varies with time and the perspective from which the system is being judged. For the U.S.S. CARL VINSON, it hinges more on the future prospects of ZOG and its progeny than its past. This is as it should be, because the Perq/ZOG system as implemented on board the U.S.S. CARL VINSON has been fraught with problems. The reason for this is four-fold.

1. ZOG was originally designed to run on the SPICE operating system. Two months prior to the ship's 1983 cruise this operating system was deemed inappropriate and its planned implementation on board the U.S.S. CARL VINSON canceled. The standard Perq operating system was designated to take its place.
2. ZOG, when first implemented in an operational environment was a first generation system undergoing constant development at a rapid pace. In July of 1983, version 19.1 was being used on board U.S.S. CARL VINSON. By October of 1983, the ship had installed version 23.1. Each version represented a major improvement over its predecessor, representing everything from implementation of an electronic mail system to installation of the new personalized ZOG frame previously mentioned.
3. ZOG had been installed too fast. As a direct result of the rapidity of ZOG's implementation, many problems occurred that could have been minimized or prevented. One example of this is in the area of

hardware. Both the Perq minicomputers and Ethernet system experienced a great deal of problems with electronic components as a result of voltage fluctuations. These problems were a direct result of utilizing ship's power without the benefit of voltage protection devices. When surge suppressors (voltage line filters) were finally installed three months into the cruise, electronic fault problems decreased [Ref. 24]. While voltage spikes can increase fail time on electronic equipment, a major power surge will really wreak havoc on computer electronics. In starting a large induction motor for example, a tremendous amount of current draw will be experienced; a 300 AMP electric motor will initially draw approximately 1500 amps of current. On some ships, depending on the power source, this can result in severe damage to any computer or other electronic equipment that is not protected with something more than a simple surge protector.

4. A fourth reason the Perq/ZOG system appeared to have so many problems is simply because the users gave the system a good workout. If the system had not been relentlessly used, then many of these problems could have gone unnoticed.

1. Disadvantages of ZOG

ZOG exhibits many disadvantages as it is presently installed on board U.S.S. CARL VINSON. These include the following:

a. "ZOG sacrifices efficiency of particular applications to get integration" [Ref. 25]. ZOG makes many compromises because it is attempting to be all things to all types of users. This results in high processing time and memory overhead within the computer itself.

b. "ZOG doesn't support a fast database query language" [Ref. 26]. To achieve flexibility and portability of the database ZOG data is stored in mass storage as text files. This requires a great deal of computer overhead when parsing and unparsing ZOG frames.

c. ZOG is "Biased too much toward a breadth-first view" [Ref. 27]. This was discussed in an earlier part of this chapter.

d. "ZOG cannot be used over standard telecommunication lines." [Ref. 28] A 1200 baud transmission rate is too slow for using ZOG. It should be more than 9600 baud to obtain the full benefit of this type of database.

e. ZOG experiences decreasing speed as the database grows. The U.S.S. CARL VINSON experienced a response time of .5 seconds when accessing data that was resident on the machine being used. If the data had to be brought in from a part of the database resident on another machine, then access time was increased to 1.5 seconds when both machines were running normally. [Ref. 29] The original design goal for ZOG was near .25 seconds, and was regularly reached in the laboratory. As database use and size increase, speed can expect to decrease even more.

2. Advantages of ZOG

Strictly from a user's viewpoint, a ZOG type system has several advantages over a more conventional mainframe architecture, or even a network of mini/microcomputers that use non-database type software. Some of these advantages are as follows:

a. Redundancy of hardware. Those who have experienced shipboard life quickly realize that equipment wears faster, breaks quicker, and has a shorter life span

than equivalent equipment that is used in a less hostile environment. This is especially true of computer equipment. It must be designed to contend with high humidity, temperature variances, salt air corrosion, power fluctuations, and structural movement of the ship itself. Even then, all other things being equal, shipboard installed equipment will still have a shorter life expectancy and greater failure rate than equivalent equipment ashore. A redundant hardware architecture, such as the Perq system, means that the entire system will not come to a crashing halt as a result of the loss of one, two or even more computers.

b. Redundancy of data. This principle carries over into the software area as well. By using a distributed database the loss of one or more nodes does not bring the whole system to a screeching halt.

c. Ease of use. This is especially important in a shipboard environment where high rates of personnel turnover often occur. A computer novice can be taught to navigate through ZOG in less than thirty minutes. In two hours he can be taught to add new material to the database with ZED. [Ref. 30]

d. Browsing capability. Closely tied to ease of use is browsing capability. Instead of having to search the database using query methods, the new user can jump right in and start exploring the database through random browsing. This capability in effect functions as a tutor allowing the new user to explore the database and familiarize himself with how it is set up. The ZOG system defaults to the browsing mode when it is entered.

e. Large database. A fifth advantage of ZOG is that it supports a large database,e.g. the U.S.S. CARL VINSON

had over 30,000 frames. Theoretically, the only limit on size is mass memory of the hardware device, and possibly some operating system constraints.

f. Allows more information to be produced from a given amount of data. In effect, a database allows a piece of data to be entered once and used by everyone, instead of everyone entering that same piece of data in a personalized file. Thus, one piece of data is supplying more information to more people. This is especially important on board ship. For example, if a supply officer were to keep his complete requisition status (status of items on order) in a database, the engineer, operations officer, or other interested personnel could obtain the latest information simply by addressing the database. This would free up the supply officer and his men for more constructive tasks, as well as keeping appropriate personnel apprised of their requisition status. The checkoff sheet for getting the ship underway is a working example of this concept. Assignment of task and times which will result in the completion of required activities needed to get the ship underway are loaded into the ZOG database. This information is then used by anyone on the ship with access to a Perq who has need of this data.

g. Elimination of data duplication. By using a database system, many artificial partitions used to separate data in a conventional file system are eliminated. This allows a specific piece of data to be entered once, yet used over and over by many different programs. Consequently, the number of times that a specific piece of data is entered into the database is reduced, while at the same time the amount of information that can be derived from that particular piece of data is increased.

Additional advantages derived from ZOG's distributed database include data integrity, data independence from embedded programs or agents, and the capability for better data management.

F. CONCLUSIONS

ZOG appears to be much more flexible in areas which can use the system primarily as an interface for embedded programs or other technology such as AIRPLAN and the weapons elevator technical manual. It is inflexible in areas where it must function as an organizing element, i.e. used as the primary tool for creating and arranging difficult structural documentation, such as the SORM. While it can be made to support planning and evaluation subnets, much of this support is really done with the brute force method. Most of the planning functions could be done more efficiently by use of a standard turnkey system with an electronic mail capability. Technology transfer does offer more reliability than the other systems presently on U.S.S. CARL VINSON primarily because of its distribution features. It is less prone to total failure due to fire, water or other catastrophe than is a centralized system.

With the influx of new personnel, ZOG usage will probably go down. This is because many of the new people, while just as dedicated as the older personnel, will not have benefited by such a close association with the developers as did the original personnel. They will also have more systems to chose from.

While this will probably mean that ZOG is used on a less frequent basis, it should not be abandon. Instead, it should be utilized in those areas in which it has proved the most feasible.

III. WANG

A. INTRODUCTION

Some of the more common computing equipment found on board Naval ships and installations in recent years has been manufactured by WANG Laboratories Inc.(WANG). This phenomenon is a direct result of WANG's strategy of marketing its products as "word processers" vice "data processers", as most other vendors have done. While an off-the-shelf WANG word-processing machine is configured primarily to perform word processing functions, it can be turned into a powerful data processor with just a few minor adjustments and the installation of the appropriate software. Nevertheless, up until 1982, WANG word-processing products had been listed and procured under the GSA (General Services Administration) contract schedule as office equipment (federal supply class 74) instead of under the more restrictive GSA contract schedule for automatic data processing equipment (federal supply class 70). In 1982 the Navy issued an instruction defining automatic data processors and equipment by purpose instead of by class [Ref. 31]. With the issuance of this instruction Navy commands could no longer purchase a WANG word processor and convert it into a data processing machine without having to go through the extensive and complicated acquisition procedures required for procuring automated data processing equipment.

While the majority of WANG processers on board naval vessels are used strictly for word processing, there are six noted exceptions. Five of these exceptions are the WANG VS-80 prototype SNAP II systems installed on board the

U.S.S. David R. Ray, U.S.S. Kidd, U.S.S. Scott, U.S.S. Chandler, and the U.S.S. Callaghan. The U.S.S. Fife and the U.S.S. New Jersey were originally outfitted with these WANG VS-80 prototypes as well, but have since had them replaced with the Harris SNAP II system. The WANG systems originally installed on the U.S.S. Fife and the U.S.S. David R. Ray were implemented as SNAP II prototypes by the Commander Naval Ships Engineering System Command (COMNAVSEASYSCOM), while those installed on the remaining five ships were procured, implemented and designated as interim SNAP II systems by Commander Naval Surface Forces Pacific (COMNAVSURFPAC). This was done before the selection of the Navy's standard SNAP II computer system to get non-tactical automation capability on board each of these newly commissioned ships. Software was jointly developed and implemented by NAVSEA (PMS-389) and Navy Management Systems Support Office (NAVMASSO) Norfolk. In July 1983 NAVMASSO placed a moratorium on further software development for the WANG VS-80 system. This was followed in August 1983 by COMNAVSURFPAC making known his intentions to replace the WANG prototype system with the standard Harris SNAP II as they become available. [Ref. 32]

The other installation which uses a WANG system for more than simple word processing is on board the U.S.S. CARL VINSON. It is this system that will be the focus of this chapter.

B. WANG AND THE U.S.S. CARL VINSON

In June 1980, a WANG System-20 computer was leased and installed in a naval office building being used by the precommissioning crew of the Navy's aircraft carrier, U.S.S. Carl Vinson, then under construction at the Newport News Shipbuilding and Drydock Company in Newport News, Virginia.

It consisted of a single terminal, a floppy disk drive, and one printer. The system-20 ran what is called "Glossary Language" besides standard COBAL.

Glossary language is a key word oriented language that can be used for calling a library of routines, utilities, or series of keystrokes. It is an integral part of the word processing package available on the System-20. While using this language is analogous to programming a PF key on an IBM System, it will do much more. For example, the glossary function can be programmed to format standard documentation such as a form-letter. When activated, it will print required information like a letter head, place in an automatic return and jump down to the address area. The user will input the name and address of the intended recipient and hit the return key. At that time the glossary language will print out the remainder of the letter.

The primary purpose for obtaining the System-20 was to enumerate and track the thousands of tasks requiring completion before the ship could be commissioned. This planning and control function was to be the precursor of the planning and evaluation subnets that would later be developed and used on the Perq/ZOG system.

Once installed, the System-20 proved to be extremely useful. As a result, Captain Richard Martin, the prospective commanding officer of the U.S.S. CARL VINSON, decided to expand its users to include the ship's department heads. By March, it had become apparent that the system was too small to perform all the functions and tasks now required of it. Consequently, in April 1980 the System-20 was traded in for a System-30 that was also leased from WANG. The System-30 was configured with 10 terminals, 3 printers, and a 30-MB (megabyte) hard disk drive.

Shortly after the WANG System-30 was installed, it became apparent that computing demands for both the

precommissioning planning and control requirements and the department heads had been greatly underestimated. With the inclusion of department heads in the coterie of WANG users, the proverbial door had been opened for personnel within the various departments themselves to access the system. Once this occurred, contagion for the WANG System-30 began to run rampant throughout the ship. Personnel from the administrative, medical, engineering, personnel and other departments began to find new and innovative ways to use the WANG to make their own work more efficient and effective. As a direct result, a WANG VS-80 system was leased in July 1980 to upgrade the System-30. The System-30 was retained on board the ship for use by the engineering department until September 1983, when its lease ran out and it was returned to WANG. The VS-80 leased from WANG increased the size of the hard disk drive from 30-mb to 90-mb of storage. To ensure that enough memory was available, an additional 75-mb was procured and added to the VS- 80 specifically to upgrade the planning and control functions.

Although the VS-80 system with additional memory was adequate for the needs of the U.S.S CARL VINSON's precommissioning crew, it again proved too small once the ship was commissioned and became an operating unit of the U.S. Navy. Captain Martin then decided the ship should obtain the largest processor system made by WANG, a super mini computer called the VS-100. This would meet the ship's present needs while allowing for future expansion. In July 1981, the VS-80 system was returned to WANG in exchange for a leased VS-100 system. The VS-100 was configured with a spider network of 28 smart terminals directly wired into the mainframe, two 288-mb disk drives, one magnetic tape drive, one telecommunications channel, and a 2-mb main memory. By October 1984, the WANG VS-100 System was purchased outright by the ship and upgraded to include 86 terminals, 21

printers, 4 disk drives, 11 telecommunications channels, 8-MB of main memory, and a prototype WANG Net.

C. A SECOND WANG VS-80 SYSTEM

In January of 1982 the management department of the U.S.S. CARL VINSON obtained a second WANG VS-80 System, which had originally been procured by the U.S.S. Lexington (AVT-16). While on board the U.S.S. Lexington, the 110 Volt Alternating Current (VAC) VS-80 System had inadvertently been connected to a 220 VAC power source, which resulted in damage to a majority of the internal electrical and electronic components. Once in the possession of the U.S.S. CARL VINSON's management department, repair parts were procured from WANG. Within six months, technicians on board the U.S.S. CARL VINSON had made the system fully operational.

This particular system was installed in the ship's Combat Information Center (CIC). It is configured with one 288-MB disk drive, a printer, and five smart terminals connected to the CPU in a spider network. Neither the VS-80 System nor any of its five workstations have external communication capabilities outside the tempest certified space. The system is being used to handle highly classified intelligence information.

D. WANG NET

In 1983, the U.S.S. CARL VINSON was selected as a beta-test site for a prototype WANG Net. The WANG Net implemented on the ship actually consisted of two separate nets (one upper, one lower) of the dual cable, broadband, active headend type design. This means the equipment uses two cables to connect into the main trunk line. One cable is used for transmission and one cable is used for reception,

thus eliminating the need for two different frequencies. The upper net serves all terminals located above the hanger deck, while the lower net serves all terminals located below the hanger deck. It is this lower loop that presented an interesting engineering problem that required three iterations of installation before the net became fully operational.

The main deck on board a ship is called the "damage control deck". All compartments located below the damage control deck must maintain watertight integrity, which means that no new penetrations or openings can be made in bulkheads (walls), overheads (ceilings), or decks (floors). Provisions are made during the construction of a naval ship to provide a path for cables and wires to pass through these inviolate partitions. These paths are then sealed with a pliant material to maintain the compartment's watertight integrity. This close grouping of different types of cables can present problems. High voltage lines, telephone wires, and computer cables are all joined together and run through compartments and partitions as a single group in what is called a cablerun. These cableruns are often routed near light fixtures, generators, and other sources of electromagnetic interference. It was these cableruns which proved troublesome in the initial attempt to install the WANG Net. The first attempt to implement the system used unshielded RG-11 coaxial cable which simply did not work. CATV-type amplifiers installed at intervals along the net were also insufficient to keep signal attenuation less than 40 DB. As a result, a second attempt was made using single shielded RG-11 cable and a special amplifier designed to keep signal loss to less than 40 DB. While this mitigated the problem somewhat, it still required a third attempt before the system was fully operational. On this last attempt RG-11 double shielded cable was installed along with

some minor adjustments to the special amplifiers, before the system became operational.

The current configuration of the WANG Net uses a branching- tree topology to connect the processing equipment to the two single trunk lines that run throughout the ship. Several amplifiers and netmuxs (network multiplexers) are attached to the network cable at different points. A netmux is simply a device which permits the simultaneous transmission of many independent channels into a single high-speed data stream by dividing the signal from different device channels (terminals)into successive alternate bits. In a nutshell, a netmux can be compared to a black-box that takes input data supplied by anywhere from 1 to 8 terminals and outputs it to the main trunk line of the WANG Net, or vice versa. By using a network system such as this, terminals and personal computers can be easily attached to the mainframe without the necessity of stringing a new cable each time. This results in smaller cableruns and better watertight integrity between adjoining compartments, because fewer cables penetrate common watertight bulkheads. It also permits the WANG VS-100 system to run more than the 96 workstations it would have been limited to had it operated with only the spider configuration. For each netmux installed in the WANG Net an additional 8 workstations can be added to the system. While there is no limit to the number of netmuxs that can be installed, the present operating system (VS-OS, revision 6.2) on the WANG VS-100 restricts the system to a total of 128 terminal nodes.

E. ESSENCE OF WANG

Except for the WANG Net, the Wang VS-100 system as presently configured on board the U.S.S. CARL VINSON is the same system being used in numerous commercial and industrial

applications. The essence of this system is its ability to perform diverse tasks of both a general and specific nature. It can be used to perform data processing, word processing, and electronic mail, yet still be adapted to specialized use. An example of this specialized use on board the U.S.S. CARL VINSON is the WANG's backup function as the ship's message processing distribution system (MPDS). The MPDS is a system unique to Nimitz class aircraft carriers and communication, command, and control ships (LCC's). It is a system that takes a message received in the ship's communication center, reads the standard subject identification code embedded in the header of each message, and routes it to the action officer or department that has cognizance over that particular subject area. For example, if the subject concerns fuel for the ship's emergency diesel generation system, the engineering department would automatically be routed a copy as the message arrives on the ship. What distinguishes this system from similar procedures on other ships is that MPDS is done electronically without human intervention. MPDS actually consist of a small processor in the communications center that is linked to several hardcopy terminals dispersed to various functional areas throughout the ship, i.e. engineering, supply, operations, etc. Although MPDS fully automates the communication center on board the U.S.S. CARL VINSON, a separate paper tape punch creates a record tape of each message transaction. If the MPDS were to fail, the information on these paper tapes could be uploaded to the WANG VS-100 with an attached paper tape punch and distributed to the appropriate departments and personnel through the WANG terminals. Messages can also be composed on the WANG VS-100 and output on a paper tape. This paper tape can then be taken to the ship's communication center and transmitted with regular teletype communications equipment.

The WANG VS-100 is, therefore, a complete backup system to MPDS.

1. The User and the WANG VS-100

A majority of present and former personnel of the U.S.S. CARL VINSON interviewed about the ship's WANG installation consider the VS-100 to be user friendly. This particular system is completely menu driven and appears to be easy to use. One reason for this is because it is a commercial system that was designed to be used by a multitude of different users. A shipboard technician summed it up when he said "if you can read, you can use the system".

2. Evaluation of WANG on board the U.S.S. CARL VINSON

The WANG VS-100 capabilities that are used the most on board the U.S.S. CARL VINSON are the word-processing package and the electronic mail feature. One member of the ship°s management department estimated that 90% of all jobs performed on the WANG VS-100 involve interactive word-processing, while only 10% involve data processing. This is in consonance with one of the two original reasons for procuring the VS-100 in the first place, i.e. to provide the ship with a powerful, versatile word processing capability. The other reason, which was discussed briefly in an earlier part of this chapter, was to aid in the area of planning and control.

Although the WANG VS-100 is a centralized unit, it has proven much more reliable than the Perq distributed System discussed in Chapter Three. There are four primary reasons for this phenomenon:

a. The WANG VS-100 is a rugged machine. It is designed to operate between 196 vac (volts alternating current) and 253 vac without sustaining electronic

damage. Additionally, a dedicated w/30a circuit breaker is installed with all WANG VS-100 installations to shut the system down in case of electrical overload. [Ref. 33]

b. Members of the management department ensured that an isolation transformer was properly installed on the ship's power outlets that supplied the WANG VS-100. Although the rational for an isolation transformer on board ship is really for electrical safety and electrical ground isolation, it has an added capability of attenuateing electrical noise in electronic equipment. In addition, the ship's force installed a low voltage protection device to shut down the system if voltage dropped too low. This prevents the system from voltage surge if power is suddenly restored after a loss of the electrical load.

c. A third reason the WANG VS-100 proved so much more reliable than the Perq System is because it is enclosed within its own air conditioned space. While most of the Perq's were also located in air conditioned spaces, their spaces were more likely to be kept at a temperature and humidity conducive to human comfort than that for optimum machine performance.

d. The final reason the WANG fared so much better than the Perqs was because the WANG mainframe was located in a limited access area where it was constantly monitored by trained technical personnel. If an abnormal situation began to develop, it could be quickly detected and appropriate corrective action taken. With the Perq System, the computers were distributed throughout the ship where abnormalities were more likely to occur and less likely to be

detected by qualified technical personnel. This situation ultimately resulted in more equipment casualties to the Perqs.

Before October 1984, the ship had experienced only one significant problem with the WANG VS-100. A clock circuit had failed, which in turn caused a cache memory problem. Ship's technicians corrected this problem within two hours of its occurrence. The Perq computers on the other hand had suffered numerous equipment problems throughout this same time period.

a. Electronic Mail and Word Processing

The combination of electronic mail and word processing on the WANG VS-100 have served to reduce the ship's administrative work-load considerably. One particular area in which this is evident is in the preparation of personnel evaluations. Onboard most Navy ships, a chief petty officer would make the first handwritten draft of an enlisted person's evaluation. He would then submit it to his division officer who would either send it back to the chief for revision, or submit it to his department head. The department head would then review the evaluation and either send it back to the division officer for further revision or submit it to the executive officer for final review and signature approval. At any point in this process, changes can be made before it is submitted to the next person in the chain of command, or it can be sent back down the chain for partial or total revision. It is not unheard of for an evaluation to traverse through this procedure two or three times before it is finally approved and signed. After one iteration of this traversal the evaluation oftentimes must be completely rewritten or retyped. Officer's fitness reports follow a similar procedure except they are initiated by the next senior officer in the chain of command and

signed by the commanding officer. Some personnel are required to have evaluations submitted on them every six months, while everyone receives at least one a year and two if they are being transferred off the ship. Multiply this simple evaluation process to include the thousands of personnel that make up the crew of the U.S.S. CARL VINSON and the task quickly becomes non-trivial. Envision this task being performed on paper and it becomes overwhelming. With the WANG VS-100 this same evaluation process is greatly simplified. The chief petty officer can type in the twenty or thirty evaluations he is required to initiate into the WANG System and send them electronically to his division officer. The division officer will add his comments to those evaluations he feels are correct and forward them electronically to his department head. Those that he rejects are returned electronically to the same chief petty officer who initiated them for revision and resubmission. This same process is performed between the department head and the executive officer, and between the executive officer and the commanding officer for officer fitness reports. Once the evaluation has received final approval from either the Commanding Officer or the Executive Officer, the WANG will perform a final spelling check, automatically format, and print a hard copy.

Although this example concerns only the shipboard evaluation process, the method of electronically creating and routing all sorts of correspondence and reports is used extensively on board the U.S.S. CARL VINSON. One particular area where it is used on a daily basis is in the creation and release of Naval messages. The drafter will initially create a Naval message using the word processing capabilities of the WANG VS-100. These capabilities include a spelling checker, standard fill in the blank type formats for the most commonly sent messages, and a plain language

address (PLAD) look-up program besides other standard word processing features. The VS-100 will look up the correct PLAD and insert it in the header of the message. Once this is done, the message will be routed to the commanding officer for his review and release. The Commanding Officer can then review and release the message from the bridge, his cabin, or any place on the ship where a WANG terminal is located. This precludes his having to carry around a stack of paper when dealing with routine messages, or having to be chased down to get a release signature in the case of more urgent ones, thereby saving uncountable numbers of manhours. Once these messages are released by the Commanding Officer, they are printed out on a paper tape and taken to the ship's communication center for transmission. The combination of electronic mail and word-processing has proven highly successful on board the U.S.S. CARL VINSON.

b. Data Processing

The VS-100's data processing capabilities are not being fully used on board the U.S.S. CARL VINSON. One reason for this is because other non-tactical automated systems are performing the majority of the ship's required data processing tasks. As of October 1984, a Durango Computer was being used for maintaining records and creating reports in the food service management area, while the Honeywell Snap I System was being used as an interface between maintenance and supply functions, ordering parts, printing paychecks, etc. This leaves very little data processing actually being performed on the WANG VS-100. There are some exceptions, however. One particular area on board the ship in which the WANG's data processing capabilities are being used is to create customized reports of ship's personnel who are eligible to vote in different states and elections. For example, If the voting officer

needs to know how many members of the ship's engineering department are eligible to vote in a special election in Michigan, he can process this data on the WANG and create a customized report enumerating this information. The voting officer can then disseminate the needed information to the appropriate personnel.

The career counselor is another person who uses the data processing capabilities of the WANG VS-100. He is responsible for maintaining a current list of regulations and guidelines concerning reenlistment incentives, Navy schools, and general career path information. The career counselor will also maintain a master schedule of career interviews, which can be disseminated to division officers on a monthly or weekly basis. This is simply a list of ship's personnel who are scheduled for division officer reenlistment interviews. With the WANG VS-100, he is able to maintain his data, process it, and create required reports and interview schedules quickly and easy. For example, if entrance requirements for a specific Navy school are lowered, the career counselor can quickly produce a list of ship's personnel who had previously expressed an interest in that school, but until now had not met the entrance requirements. He can then contact the individuals concerned and ascertain if they are still interested in attending the school.

The ship's Damage Control Assistant (DCA) officer also uses the data processing capabilities of the WANG VS-100 to maintain the ship's master compartment check off list (CCOL). Each compartment on the ship has a CCOL posted in a conspicuous location near its access, which lists and describes all fittings and systems within that particular compartment. The CCOL also gives the damage control classification, which tells when the fittings or systems should be activated or secured, and indicates the

ship's division that is responsible for their maintenance and closure status. If a division needs to have a complete list of all the deck drains it is responsible for maintaining, the DCA can produce such a list from the master using the data processing capabilities of the WANG. Using the WANG's database, the DCA can also produce a customized report of compartment material and equipment deficiencies for each of the last four zone inspections. Zones are nothing more than artificial divisions or groupings of equipments and compartments to facilitate their inspection, hence the term zone inspection.

Other areas that use the WANG VS-100 for data processing include the medical and dental departments. The medical department uses the system to identify personnel who are due for shots and to monitor urinalysis testing for drugs, while the dental department identifies personnel requiring dental exams. While there is some data processing being performed on the WANG VS-100, it is not enough to justify the systems existence on that basis alone. Current justification relies on the areas of word- processing and electronic mail. It has been these two areas that have been the driving force for increasing both the efficiency and effectiveness of numerous administrative functions on board the U.S.S. CARL VINSON.

c. Specific Applications

With the implementation of the WANG VS-100 on board the U.S.S. CARL VINSON, an abundance of computing power was suddenly made available to ship's personnel. While most of the applications run on the WANG by these shipboard users is of a general nature, many of them proved to be quite innovative. One of the more novel uses of the WANG VS-100 was developed by the ship's first Commanding Officer, Captain Richard Martin, but is actually employed

by the ship's embarked airwings. An airwing is a separate organizational entity that is temporarily assigned to the ship for an operational deployment or exercise. The airwing is made up of different squadrons, which consist of the pilots and support personnel required to operate and maintain a group of like aircraft. These support personnel include mechanics, plane-crews, and administrative personnel. When an airwing is assigned to the ship for an extended amount of time, it will move all its aircraft, personnel, and records on board the ship. These records are quite comprehensive. They include everything from the complete maintenance history of each aircraft to the medical and dental records of the airwing's assigned personnel. When assigned to the U.S.S. CARL VINSON, these records are carried on board electronically filed in the airwings portable WANG Professional Computer (PC), which they carry with them. Each of these portable computers is configured with two duel 5 1/4 inch floppy disk drives, a 10 megabyte hard disk drive, 640-KB of random access memory, its own operating system, and a serial printer. Once on board, the WANG PCs are connected to the VS-100, and all its data is uploaded to the mainframe. While attached to the U.S.S. CARL VINSON, the airwing uses the capabilities of the WANG VS-100 to maintain files and meet its data processing requirements. When the airwing is ready to depart, it downloads its data to the WANG PC, and returns to its home base with the PC and all it's files electronically recorded. This innovative use of the ship's Vs-100 and a WANG PC has permitted the different airwings to automate their own administrative functions and quickly integrate them into those of the ship when embarking.

Another application that has proven highly successful on the WANG VS-100 is the ship's personnel information system. This is an on-line database. unique to

the U.S.S. CARL VINSON, that contains medical, dental, and personnel records for both ship's officers and enlisted crewmembers, as well as, other appropriate administrative records. To ensure that only properly authorized personnel can view information within this database, a Federated Management System (FMS) interfaces with the computers security program. The FMS assigns all users a special code. This FMS code identifies the files and protection classes (unprotected, execute-only, read-only or private file) that can be accessed by that particular user. When a user first logs on the WANG VS-100, he will enter his "user id" and "personal password". From this information the FMS will internally locate his FMS code and display a menu of data files that he is allowed to access. Within the Personnel Management System for example, only personnel authorized by the medical department along with those having "system administrative rights" are allowed to read medical records. All members within the WANG division of the management department have these "system administrative rights".

This system allows the personnel officer to maintain a mini electronic personnel record for each member of the ship's crew. In addition, the career counselor and voting officer can use this database to create customized reports as previously discussed, while the ship's division officers can use it as an on-line division officers notebook. A division officers notebook is nothing more than a record kept on each man within a division. It usually includes his name, present rate, educational level, Navy schools attended, noted achievements, etc.

Additional application areas of a specified nature performed on the WANG VS-100 include a messmen information system to keep track of messcooks assigned to the ship's messdecks, a management department utilities and muster list, the public affairs officer's datafiles, the

photographic departments equipment list and job order information, and a list of navigational aids used by the ship's navigator.

d. Unused Capabilities

Although the ship uses the VS-100's word processing and electronic mail applications extensively and its data-processing capacity to a limited degree, it is not taking full advantage of the WANG-Net itself. As previously discussed, the WANG-Net is of the dual cable active header type. Being a broadband network it is capable of multiple service analog transmission, i.e. it is capable of transmitting data, voice, video, etc. vice strictly serial digital signaling as in baseband nets.

This capability allows the WANG-Net to be used in the following four ways:

1. It can be used to support either WANG PC's or intelligent terminals as VS work stations. This is the mode in which it is presently being used on board the U.S.S. CARL VINSON. These workstations just input data to the VS-100 and output it to a CRT terminal.
2. The WANG-Net has a remote telecommunications interconnect band that allows it to function as a telephone line between different nodes on the net. Any protocol may be used as long as the WANG or non-WANG terminal devices using this band have industrial standard electrical interfaces, and the protocols operate at the same speed.
3. A special WANG PC band is also included which connects all stand-alone type WANG PC's into a distributed network. The WANG VS-100 cannot be part of this system, hence the distributed network will still function if there is a casualty to the VS-100

itself. This special band uses time division multiplexing and operates at 2.5 million bits/second. [Ref. 34]

4. The interconnect band allows Stand-alone PC's to talk to each other at either 64,000 bits/sec, 9,600 bits/sec, 4800 bits/sec, 2400 bits/sec or 1200 bits/sec. This particular band can also be accessed by small computers made by other vendors. [Ref. 35]

To use these capabilities more fully would require replacement of all intelligent terminals presently on the net with either WANG PC's equipped with appropriate expansion cards, or other vendor equivalents with appropriate protocols.

F. A CRITIQUE OF THE WANG VS-100 ONBOARD THE U.S.S. CARL VINSON

Being a commercial system designed to accommodate a wide spectrum of users, the WANG VS-100 installation suffers from the same faults common to most systems attempting to be everything to everyone. That is, it does a good job in all its shipboard applications and a superior job in a few. However, it may not be the best suited system for all the applications presently being performed on board the ship. To make a reasonable determination as to whether it is the best suited system would require a thorough cost/benefit analysis, which goes beyond the scope of this paper. To get a better feel for the direction such an analysis would take some advantages, disadvantages, and management issues will be considered below.

1. Advantages of the WANG VS-100 Installation

The WANG VS-100 System on board the U.S.S. CARL VINSON exhibits many advantages.

a. Versatile word processor. The word processor that is installed on the ship's WANG VS-100 offers the user several diverse capabilities. These include a choice of fonts, a documentation shrinker, and even the capability to print upside down if required.

b. User friendly. The management department on board the U.S.S. CARL VINSON holds a full three-day training session for new users once a month besides special classes in basic and cobol programming when the ship is on an extended deployment. The monthly training session itself consists of an indoctrination to computers along with specific tutorial exercises for the WANG VS-100 and the word processing editor. It has been the experience of some members of the management department that a student can perform basic applications on the VS-100 terminals after only an hours instruction. The reason for this is because the system is totally menu driven and therefore, extremely easy to learn to use. The system also employees a library of standard routines and utility programs which make code generation a simple task for the more sophisticated user.

c. Good response time. The WANG VS-100 is designed to be an extremely fast machine. In addition to its separate cache memory, the VS-100 uses a 64-bit data bus between the main memory and other major processor components, and a 32-bit central processor (CP) data bus. The combination of these three factors results in a rapid CPU cycle time (160 nanoseconds/micro-instruction). With up to 70 users on the system there is virtually no noticeable change in response time to the user. Of course, because the majority of applications being run on the processor concern word- processing vice data processing means

that the CPU is idle quite a bit of the time. Thus, the system usually runs near its fastest speed.

d. Equipment reliability. From the time the WANG VS-100 was installed on board the U.S.S. CARL VINSON in July 1981 until the end of the ship's first cruise in the fall of 1983, there was only one major equipment failure despite the fact that most of the equipment servicing was done on board by ship's technicians. Since the end of that first cruise there have been no significant equipment casualties reported for the ship's WANG VS-100.

e. Diverse selection of software readily available. Being a commercial system, the VS-100 can support a wide range of off- the-shelf software along with several multiple high-level languages, including ANSI COBOL, BASIC, FORTRAN, PL/1, and RPG II. In addition, it supports a macro assembler that uses an instruction set compatible with that used on an IBM 360, and an English-like command language called "PROCEDURE", which allows the user to create special text files that will perform many of the operations normally executed interactivily. It is similar to job control language. [Ref. 36]

2. Disadvantages of the U.S.S. CARL VINSON's WANG Installation

The WANG VS-100 System exhibits many disadvantages as it is presently installed on board the U.S.S. CARL VINSON. These include the following:

a. Lack of redundancy. Being a centralized system with a single CPU, the e is no backup if a major casualty were to occur to the equipment. This could be mitigated somewhat by replacing all the intelligent terminals on the WANG Net with self contained

personal computers configured with appropriate expansion cards to activate the distributed processing capacity of the WANG-Net as discussed above.

b. Requires a constant attendant 24 hours per day. Unlike the Perqs and the Snap II computers being implemented on smaller ships, the WANG VS-100 requires an operator to be on duty within the space at all times. This attendant is required for security as well as for equipment operation and monitoring.

c. Limited growth potential. The present system architecture is set, limiting flexibility for future growth to 128 terminals. While the present system cannot be expanded beyond these 128 terminal nodes, replacement of all intelligent terminals on the WANG-Net with stand-alone PC's configured with the appropriate expansion boards would increase the amount of processing that could be done with the present configuration. This would postpone if not preclude having to go to a larger machine as new uses for the VS-100 are developed.

d. Lack of an uninterruptible power supply (UPS).

e. Onboard a Naval vessel it is considered good engineering practice to rotate ship's service turbo generators (SSTG's) on a daily basis to ensure that all mechanical systems wear at approximately the same rate, as well as, to detect abnormal operating conditions in any of the equipment. While this shifting of generators is usually carried out in a smooth, orderly procedure, it is not uncommon to lose electrical power in all or parts of the ship. When this occurs, all electronic equipment that does not have an UPS must be secured to prevent internal damage. The WANG VS-100 does not have a UPS which

means that it will shut down in case of a power interruption. This results in the loss of any data then being input on the intelligent terminals, unscheduled down-time, and a time consuming procedure to reset the system and bring it back on-line.

f. Lost data if CPU shuts down. If the CPU should be inadvertently shut down through a power loss or some other mishap it loses the addresses of the terminals that are inputing data at that time. This means that all the data in the buffers of the intelligent terminals cannot be recovered.

g. Reliance on one vendor. The WANG VS-100 system and associated WANG Net as implemented on the U.S.S. CARL VINSON is a 100% WANG system. Since many commercial devices and peripheral equipments are not compatible with the VS-100, they must be purchased from WANG vice competitive bidding. Hence, the ship is locked into using WANG equipment with very few exceptions.

h. Lack of Navy parts support for the VS-100. Since the WANG VS-100 is not a standard system throughout the Navy, it is not supported by the Naval supply system. This means that the ship is required to purchase and carry numerous replacement parts and consumable items on its own. The ship is presently carrying an estimated one-time expenditure of $475,000 in repair parts and is expending $100,000 per year in consumables to support the WANG VS-100.

3. Management Issues

In addition to those advantages and disadvantages enumerated above, there are several issues that do not fit clearly into either category. These are issues that should be considered before the decision to acquire and install a processing system is even made. For the most part they are

management issues of which only five will be addressed in this chapter.

a. Need and purpose. Although the justification for installing the original System-20 on board the U.S.S. CARL VINSON was to satisfy a perceived need in the area of planning an control, a comcommitant purpose for the small WANG processor was never clearly defined. This failure to fix and control the specific applications that should be run on the WANG System-20 resulted in its being used in several ways that had little to do with planning and control. To complicate the situation even more, the coterie of users was expanded to include the ship's department heads. The combination of expanding the number of users and allowing new applications to be placed on the system resulted in an increase in demand that was beyond the capability of the System-20 to fulfill. To meet these demands, the ship began a series of upgrades. Each upgrade replaced a predecessor that had failed to satisfy the ship's insatiable demand for processing, until the VS-100 was installed in July 1981. If a thorough requirements analysis had been performed on board the U.S.S. CARL VINSON before the procurement of the first System-20, the true needs of the ship could have been recognized. This in turn would have resulted in a more efficient and effective method of acquiring a suitable processing system for the ship.

b. Life Cycle cost. Prior to investing in an actual processing system such as the WANG VS-100, an economic feasibility study should be conducted in order ascertain if the system is too expensive for the benefits it will provide. This is usually determined by a thorough cost/benefit analysis.

There is no evidence that a cost/benefit analysis was ever performed on any of the WANG Systems installed on board the U.S.S. CARL VINSON. Two different members of the ship's management department made the comment during an interview that much of the software for the VS-100 was free, i.e it was provided by WANG when the system was installed. While initial cost may have been zero, the maintenance cost must still be considered. Another member of the management department indicated that consumable supplies (Disk packs, tapes, etc.) are costing approximately $100,000 a year. In addition, $475,000 in repair parts were bought for the WANG VS-100 during FY 1984. These parts were not used, but placed in storerooms in the event they are needed. These are just a few of the cost that should have been considered before system implementation. Although other cost figures were unavailable it would not have been difficult to work up a reasonable life-cycle cost estimate before making the decision to implement the system. The benefit side is much more difficult to quantify. In addition to the advantages discussed earlier in this chapter, the WANG VS-100 System has undoubtedly streamlined several operations on board the ship which has resulted in the savings of thousands of manhours. Some of these manhours could be quantified and translated into dollars, while others that cannot be identified result in improved administrative operations for the ship as a whole. It would not be unreasonable to find that the savings were actually as high or higher than the cost.

c. Operational feasibility. This is concerned with the effect the system will have on the people who are going to use it, and in turn the effect the people

will have on the system. The effect that ship's personnel had on the expansion of the WANG Systems on board the U.S.S. CARL VINSON has been discussed throughout this Chapter. However, the effect the system had on ship's personnel and other systems is just as dramatic. For example, two major concerns in this area are job displacement and manning considerations. As of October 1984, there were 11 personnel assigned to the WANG division within the management department. Three of these personnel were petty officers and two of them were designated strikers in the data processing rating. This means that six of the eleven personnel were recruited from other divisions within the ship to work in the WANG division, three personnel that had been assigned to the ship for the Snap program had been placed in the WANG division, and two personnel were either recruited from another division on board the ship or taken out of the ship's Snap II manpower complement. This raises an interesting question as to whether the Snap division on the U.S.S. CARL VINSON is being adversely affected by having five technicians that were originally assigned to the ship as part of the Snap I program actually working in the WANG division. Whatever the case, this type of manning decision was dictated as a direct result of the WANG's rapid expansion and lack of Navy manpower support for the WANG system. The issues to be considered under operational feasibility must therefore address the impact a particular system will have on other shipboard systems by creating an increased demand for scarce resources such as technical manpower.

d. Security issues. Security issues must be addressed and dealt with throughout the life of the system. In

an environment such as exist on board the U.S.S. CARL VINSON, where sensitive and classified information is prevalent in virtually every department, security of information is paramount. The engineering department, which had originally been using the VS-100, has moved most of its files to a WANG PC to prevent a possible compromise. Likewise, the VS-80 System located in the combat information center is completely isolated to prevent the compromise of highly classified information.

Security of unclassified information must also be considered. While the WANG VS-100 has an extensive security system that requires both a code and a password, besides the federated management system previously discussed, the system has two ways in which security can be bypassed. The first way is to obtain system administration rights. All members of the WANG division are granted these rights, which allows them to access any files within the system. To reduce the potential for abusing this privilege, certain precautions can be taken. One such precaution is to ensure that all personnel given system administration rights come under the purview of the Navy's Personnel Reliability Program (PRP). This is a program which certifies personnel who are required to work with sensitive information or equipment. It is not clear whether the PRP was used within the management department on board the U.S.S. Carl Vinson. The second way that unauthorized entry to sensitive information could occur is by monitoring the cables connecting the peripheral devices and terminals to the CPU. Since all cables connecting remote terminals or PC's run in open cableruns, often through unmanned compartments, they could be monitored at numerous points with equipment that is readily available on board ship. Using this technique, someone bent on malicious destruction or sabotage of

information could easily obtain the frequencies generated by authorized users logging into the system, and later duplicate these same frequencies to access files. Security is an issue that must be addressed before a system is procured, as well as, throughout its entire life-cycle.

G. CONCLUSIONS

The implementation of the WANG VS-100 System on board the U.S.S. CARL VINSON was perhaps done too quick. Instead of doing a requirements analysis and then selecting the system, the system was selected and applications developed after the fact. While backwards, this method does have its advantages. The primary one is that it allows the user to experiment with novel ways in which to use the system. Sometimes a new and innovative application is developed that serves to justify system cost better than those applications for which the system was intended.

Many of the disadvantages of the VS-100 are disadvantages only because the system is not standardized and supported by the Naval supply system. This is the reason the ship had to procure and stock repair parts costing $475,000. Had the WANG VS- 100 been a common system within the fleet supported by the Naval supply system, the ship would not have had to tie up so much money in repair parts.

The WANG is a reliable system as demonstrated by its lack of significant casualties on board the U.S.S. CARL VINSON, but this very reliability could result in future problems for the ship. Personnel on the U.S.S. CARL VINSON are becoming too dependent on the system. As more applications are added to the system, it will become even more indispensable to the ship. On the other hand, as the system ages it will likely become less reliable. Parts will begin to wear or deteriorate and the system will likely experience increased downtime.

IV. SNAP

A. INTRODUCTION

The Shipboard Non-tactical Automated Data Processing Program (SNAP) was designed to provide surface ships and submarines of the U.S. Navy with a standard, information management system. This program has three primary purposes:

1. Reduce the ever growing administrative work-load associated with maintenance, supply, financial management, and personnel administration.
2. Provide a responsive, flexible facility for shipboard management.
3. Improve the accuracy and timeliness of ships' reports to other commands, without increasing the ships' administrative work-load.

The original goal of the SNAP program was to meet the Chief of Naval Operation's (CNO's) Objective Number 5 of 1980. This objective was intended to alleviate "the administrative burden on fleet units." [Ref. 37] The SNAP concept has been developed as two separate programs. SNAP I for larger ships of the fleet, and SNAP II for smaller surface ships and submarines.

1. SNAP I System

The SNAP I non-tactical computer system is the replacement for the AN/UYK-5(V) system which has been in use in the fleet and in Marine Air Groups since the mid-1960's. SNAP I is designated the AN/UYK-65(V), non-tactical ADP system. Eventually all the larger ships of the Navy will have SNAP I systems installed, including the carriers, repair ships, supply ships, and amphibious ships, and the Marine Air Groups (MAG).

SNAP I started in 1974 when a plan was approved for the replacement and upgrade of the AN/UYK-5(V) system, which by then was obsolete and experiencing maintenance problems. A two stage implementation plan was finally approved in May 1977.

The first step included the replacement of several hardware units, including tape drives and line printers that had been experiencing many maintenance and operational problems. This step was completed in May 1980. The second step in the implementation process included the replacement of the remaining hardware with commercially acquired, off-the-shelf, processing equipment. This was paralleled by an upgrade in application software to handle on-line, real time processing.

Honeywell Information Systems International Inc., was selected as the prime contractor for SNAP I in June 1982. The Honeywell DPS-6 series computers are installed as a distributed processing system and are arranged in one of four basic configurations depending on the mission and type of each ship. [Ref. 38] A total of up to 221 DP-6 systems are to be purchased for installation on 67 ships, 17 MAGs, and 26 selected shore sites (SIMAs, training sites, Naval Air Stations, etc.) All the shipboard equipment installations are to be completed during fiscal year 1985 [Ref. 39]. The projected life-cycle costs for the SNAP I system are estimated to be:

1.	Software Development Costs	$127,389,000
2.	Software Maintenance Costs	$319,914,000
3.	Hardware Acquisition Costs	$420,600,000
4.	Ship Alteration/Installation Costs	$ 74,307,000

[Ref. 40]

By October 1984, seventeen of the eighty-five phase two equipment replacements had beed completed. Many of the real-time (RT) application programs were being tested in

fiscal year 1984 and were scheduled to be implemented during the following two years. Until these programs are ready, the AN/UYK-65(V) systems have been emulating the AN/UYK-5(V) computers, processing data in batch mode, with key to disk data entry. [Ref. 41]

2. SNAP II System

SNAP II systems are scheduled for installation on 452 ships between the fiscal years 1983 through 1988. The basic philosophy behind SNAP II is to provide a system that is centrally procured, designed and managed, which can be operated and maintained by users who have little knowledge of computers. This is different from the SNAP I systems, which require a a staff of computer technicians and operators. The SNAP II systems are designed to be highly reliable, requiring a minimum of shipboard maintenance and repair. The premise underlying this concept is that no additional shipboard personnel are required for the operation and maintenance of the SNAP II system! Instead, personnel already assigned to the ship with appropriate technical backgrounds, i.e. Electronic Technicians (ET) will be trained to operate and maintain the system. They will perform these duties on a collateral basis along with their primary duties. Thus, SNAP II computers are designed to run without operators in an unmanned space, while users interact with the computer via remote terminals at various locations throughout the ship.

The SNAP II systems use application programs written in COBOL, but allows the users to write and run their own programs in BASIC, MUSE IV word-processing language, or AZ-7 report/query generator language. The application software, provided and maintained by the Navy Management Support Systems Office (NAVMASSO), cannot be directly interfaced or accessed by user generated COBOL applications. This

limitation is intended to protect against intentional or inadvertent modification of the SNAP II application software and databases.

The hardware used in the SNAP II systems, designated AN/UYK-62(V), comes in one of four standard configurations depending on ship type and class. SNAP II systems use Harris series-300 minicomputers and other commercial "off-the-shelf" peripheral equipment ruggedized for shipboard use.

While the SNAP I and SNAP II systems have different hardware architecture, they have similar software design specifications, with some of the application software capable of running on both systems with only minor modifications. The application software is designed and developed by the NAVMASSO, who is the Central Design Activity (CDA) for both systems. Because of these similarities in the management and functionality of the two systems, only SNAP II will be reviewed in greater depth . It is the design, development and management of this SNAP II system that is the focus of this chapter.

B. BACKGROUND

SNAP II systems are intended to provide the smaller surface ships and submarines with an automated data processing capability.

One main problem faced by shipboard commanding officers, has been the ever-growing administrative and management burden placed on their ships.

> "The continued emphasis on decreased shipboard manning levels has traditionally addressed only the operational requirements and overall impact on shipboard combat readiness. The Commanding Officer, however, has few tools beyond personal leadership to cope with the administrative burden." [Ref. 42]

This problem has been the theme of several research studies over the past decade. The SNAP II system represents the culmination of that research for improving productivity in the fleet.

1. The U.S.S. DAHLGREN Study

In August 1972, the Chief of Naval Operations (OP-91) directed a study into the potential use of automated data processing on board combatant ships to support maintenance and material management (3-M), personnel administration, and supply. The U.S.S. DAHLGREN (DLG-12) was selected as the site for this study. [Ref. 43] The non-tactical ADP system installed and tested on U.S.S. DAHLGREN in January 1973 was a Data General NOVA 1200 "minicomputer" with a 32k-word core memory, one printer, one teletype, a disk system, and four CRTs. The operating system supported a limited multi-user environment, which used a swapping mode of time slicing. It also supported the BASIC programming language. The application software developed and implemented during the study was Computer Integrated Instruction (CII) and Shipboard Training Administration System (STAS). CII was an online training program for shipboard instruction in General Damage Control, while STAS was used to manage a personnel training database system as well as a Personnel Qualification Standard (PQS) tracking system. Both systems were developed off-ship by Naval Personnel Research and Development Center (NPRDC) and installed and prototyped on board the U.S.S DAHLGREN. [Ref. 44] From the study report, issued in December 1974, four primary conclusions can be drawn:

a. Commercial off-the-shelf hardware can effectively be used in the harsh environment of the small combatant.
b. The off-ship development of software by the Navy Personnel Research and Development Center (NPRDC)

proved to be a highly effective method of providing high quality application software without increasing the work load for shipboard personnel.

c. There were not enough CRT terminals and teletypes to adequately support the training and management applications.

d. The use of computer systems for shipboard non-tactical applications was shown to be an effective means to improve productivity in damage control training and in training management.

After several primary users of the NOVA 1200 system were transfered to other commands the system fell into disuse. As a result of this disuse and the lack of "command attention", the NOVA 1200 system was removed from the ship in December 1974.

2. The U.S.S. GRIDLEY Study

In early 1975, the U.S.S. GRIDLEY (CG-21) was chosen for a second study to be conducted under the direction of NPRDC. Using the Data General NOVA 1200 mini-computer system, NPRDC implemented 19 management applications that were previously developed for U.S.S. DAHLGREN. The programs were so successful that in 1978 the Data General system was replaced with a larger, more capable Digital Equipment Corporation, PDP 11/60 computer system. The new system supported Pascal, BASIC Plus, Fortran IV, and COBOL in a multi-user environment. Because the U.S.S GRIDLEY already had data systems technicians assigned in addition to the dedicated personnel working on the system, they were soon running ship developed applications, which included automating a 23,000 line item supply inventory, the crew's personnel records, and the Coordinated Ship's Maintenance Project (CSMP). [Ref. 45]

While several conclusions can be drawn from the lessons learned in the U.S.S. GRIDLEY study, one point was clear from the onset. Command "support and interest" made the difference between success and failure. Other conclusions of the study [Ref. 46], include:

a. Shipboard personnel are capable of developing applications that effectively reduce the manual work-load, but the time required to do so is prohibitive, and the results are not of equal quality for all commands. The real payoffs come in the transfer of operating application software to other commands, without additional development costs.

b. Off-the-shelf commercial hardware could be used to provide automated data processing on board small combatants despite the harsh environment of salt air and constant movement due to the ship's pitching and rolling.

c. Major supply functions, like inventory material management of on board repair parts, could be maintained on hard disk drives, requiring only 3-4 megabytes of disk memory.

3. The U.S.S. COONTZ and U.S.S. RADFORD Study

In March 1980, the Commander Surface Forces Atlantic Fleet (COMNAVSURFLANT) authorized a NPRDC study on the shipboard use of microcomputers for word processing and other data management applications. The U.S.S. COONTZ (DDG-40) and the U.S.S. RADFORD (DD968) were chosen as sites for the study. Alpha Micro AM-1031, microcomputers with 256 KB main memories, and 16-bit central processing units were leased and installed. The systems included Winchester 10 megabyte hard disks, video display terminals, and printers. All were connected with standard three pair shielded cable. A data management system, called AMS developed by Applied

Micro Systems LTD., and a word processing system, called ALPHAWORD, were provided with the leased systems. These systems used a multi-user, multi-tasking operating system, handling up to six users at a time. Power was provided by 60 Hz voltage transformers.

During the one year study there were no system malfunctions, even though both ships made extended six month deployments, subjecting the systems to high seas, temperatures of 85-95 degrees, and humidity between 75-85%. This demonstrated the high reliability of commercial, off-the-shelf hardware in the shipboard environment. Each ship had two maintenance men who had received only two weeks of training in system maintenance. [Ref. 47]

Although more than 80 data management applications and 200 word processing applications were developed, there was a significant difference in the use of the Alpha Micro systems by the two ships. On the U.S.S COONTZ, the Commanding Officer became heavily involved, acting as the head systems analyst. He had his data systems technicians chief (DSC) spending 45% of his time on the system. The ship made extensive use of both the data management system (DMS) and the word processing systems. On the other hand, U.S.S. RADFORD assigned a data systems technician second class (DS2) to maintain and operate the system on a collateral duty basis. Although the word processing application was well used, few DMS applications were developed, demonstrating that the quality of shipboard software development is proportional to the amount of attention and support provided by the command. [Ref. 48]

The conclusions of this study provided a valuable insight into the use of microcomputers for shipboard non-tactical automated data processing. The primary lessons learned were [Ref. 49] :

a. The use of computers has a significant impact on reducing the administrative work-load in the fleet and contributes to operational efficiency.

b. Data management applications can be developed by shipboard personnel, but only with significant command support and manpower.

c. Many commercially available microcomputers are reliable and compatible with the shipboard environment.

d. Six keyboard video display terminals (KVDT) provided with the systems were insufficient to adequately support data entry.

- Although the study was completed after much of the SNAP II planning had been done, it supported the viability of the SNAP II concept. It also addressed the need to deal with the proliferation of microcomputers in the fleet.

4. SNAP II Concept Development

In 1978, the conceptual idea of SNAP II was approved. The Mission Element Needs Statement (MENS) for the system was approved in May 1980. It outlined the requirement for an automated system to reduce the administrative burden on the fleet. The proposed program was to be a centrally managed and coordinated effort to provide non-tactical automated support to every ship in the fleet. The philosophy was that functional requirements and interface requirements were the "same" for all ship types, even though the hardware requirements might differ. Therefore, a standard Management Information System (MIS) could be created around these same functional specifications. [Ref. 50]

In 1979, the Automated Data System (ADS) development plan was written. It was reviewed by the various functional sponsors and fleet commands. Based on this ADS plan, SNAP

II was prototyped, using leased WANG VS-80 computer systems and peripherals, and application software developed by the Navy. The purpose of prototyping was: 1) to prove the viability of the SNAP II concept, and 2) to refine the "concepts and strategies preparatory to seeking authority to develop the Automated Information System (AIS)" [Ref. 51].

The Functional Description for the SNAP II, Shipboard Data System (SDS) was issued in March 1981, by NAVMASSO, with the overall goal of automating six primary functional areas. See Table II .

TABLE II

SNAP II Functional Areas

1. Supply	4. Maintenance
2. Pay/Disbursing	5. Personnel
3. Administration	6. Medical/Dental

Since SNAP II was designed to be run by users with minimal computer training, the decision was made to have the SDS operate on an interactive menu driven basis with on-line assistance available. Also, the databases were to be maintained and supported by an online mass storage (disk) system, with enough storage capability to hold the databases and still have enough reserve for future growth.

The initial release of the application software was an attempt at going for the "quick victory" to gain support of the user communities, while later releases were to include greater depth and scope in the applications provided. The first release of SNAP II SDS was developed

concurrently with the hardware acquisition so that it would be operationly certified by the time of the first hardware delivery. [Ref. 52]

One early problem encountered was getting concurrence on the functional specifications for the various SDS subsystems. This was primarily due to different procedures between the Atlantic fleet and Pacific fleet commands, as well as differences between ship types and sizes. The most difficult point to sell was that SNAP II was not just an automation of existing procedures, but rather a total replacement of existing procedures with an integrated, automated system. In the end, the functional sponsors for each of the subsystems designated the procedural requirements to be included in the initial release of SDS. In all, nine distinct subsystems were planned. See Table III [Ref. 53].

TABLE III

SNAP II SDS Subsystems

1) Systems Management	6) Pay/Disbursing
2) Corrective Maintenance	7) Personnel
3) Preventative Maintenance	8) Administration
4) Aviation Maintenance	9) Medical.
5) Supply Financial	

5. SNAP II System Acquisition and Selection

In November 1981, the Naval Sea System Command issued a contract to Systems Management American (SMA) Inc., "for the acquisition and logistical support of the ADP hardware, software, and related services for SNAP II" [Ref. 54]. This contract was expected to exceed $200 million over its 20 year life-cycle. It was issued to SMA as a Small Business Administration "8(a)" set-aside, which is part of a Minority Small Business and Capital Development program to "promote equal access to government contracts" for those who are both socially and economically disadvantaged [Ref. 55]. SMA Inc., is owned by Herman E. Valentine, who is president and corporate chairman. In 1982 SMA was ranked nationally as the 32nd largest, "black owned" company in the United States, with gross revenue of about $17 million. One year later, sales topped $31 million, with 75% of the revenue from Navy contracts. This changed SMA national ranking to 17th. [Ref. 56]

The Navy contract calls for SMA to act as the "system integrator" acquiring, ruggedizing, and integrating the computer system components. The acquisition of the system components was to be through a competitive selection process wholly controlled by SMA. The use of an integrating contractor for SNAP II had the advantage of reducing the extensive time delays and complexities of a major system acquisition, and gave the Navy a single contractor to deal with in resolving all hardware and system software problems.

The SNAP II selection process was conducted by SMA in November 1981, with seventeen vendors submitting proposals. See Table IV for the list of bidders. [Ref. 57] The selection was made by "SMA's technical and managerial staff, augmented by consultants from private industry and Old Dominion University" [Ref. 58].

TABLE IV

Vendors Bidding on SNAP II Requirements

C3 (Convergent Technologies)	Harris
C3 (Perkin Elmer)	Honeywell
CPT (Submarine Only)	IBM
Data General	WANG
Datapoint	Electronic Marketing
Digital Equipment	Hetra
Federal Data (TI)	Miltope
G. E. Aerospace	Wright Marketing
Memorex	

By December 1981, the field had been narrowed to three proposals which had been selected for further evaluation. These included Data General, Harris, and Honeywell. All other proposals evaluated by SMA were deemed unacceptable. [Ref. 59]

On December 23, 1981 SMA completed the evaluation process and announced the selection of the proposal bid by the Harris Corporation. The Harris 300 computer systems had been selected for SNAP II even though they had never been used in any major business system applications.

An interesting point here is that the functional specifications for the SNAP II system called for it to be fully compatible with SNAP I to allow the transfer data files between systems. Only a few months after SMA's selection of the Harris computers for the SNAP II system, Honeywell DP-6 computer systems were selected for SNAP I systems.

In January 1982, the performance validation testing was conducted on the proposed Harris system. The test results showed that the system was having problems with the Performance Validation Instruction Package Software. After a second revalidation test later that month only one discrepancy remained, which dealt with the interpretations of "response" and "response time" [Ref. 60]. The Harris system finally passed the benchmark tests in early February 1982, with 20 successful runs and an average response time of less than 3 seconds, as called for in the functional specifications. From their evaluation and analysis of the work-load requirements and data available from NAVMASSO, SMA recommended memory requirements for the Harris 300 computers to be used in three different configurations:

- small 384Kb
- medium 768Kb
- large 1.5Mb

Since the Harris equipment is expandable to 3.0Mb, it appeared to meet the system specification requirements. [Ref. 61]

In March 1982, the Commanding Officer of the Operational Test and Evaluation Force (COMOPTEVFOR) expressed concern about the hardware selected by SMA for the SNAP II system. After two demonstrations of the proposed hardware systems, it was clear that some of the specifications identified in the contractual Statement of Work (SOW) were not being met. The specific items identified included the following [Ref. 62],

a. The system had an inadequate diagnostic system for system maintenance.

b. The Harris 300 minicomputer had never been proven in a major business application.

c. There was no uninterruptable power source to assure power during outages.

d. The keyboard video display terminals were not provided with editing keys for text editing, or with user adjustable brightness/glare controls.

e. The response times were slower than called for in the specifications.

f. The system provided no "fail soft" protection for the subsystem levels of operation

g. There was no word processing capability.

h. The printers were all from different manufacturers, meaning that there was no printer family inter-operability and that there would be increased logistic requirements for repair parts.

While none of the deficiencies cited by COMOPTEVFOR were in themselves insurmountable, they pointed out a basic problem; the hardware specifications defined in the Statement of Work, USN Solicitation N00024-81-R-7165, were not being fully complied with by SMA.

The Harris 300 series minicomputer had been modified to meet size requirements of the design specifications. This required changing the circuit boards from their original vertical configuration, to a horizontal position and reducing the ventilation space above the computer circuit cards. A direct result of this was: 1) the natural ventilation past the circuit cards was lost, 2) the circuit boards warped in the horizontal position causing them to make poor contact with their connectors, and 3) they presented an excellent surface for the accumulation of dust from unfiltered air, further reducing heat transfer from the boards.

After extensive testing and evaluation, the first SNAP II system was installed on U.S.S SIDES (FFG-14) in January 1983.

6. Operational Test and Evaluation of SNAP II

During the period of March 7-18, 1983, an operational assessment of SNAP II was conducted on board U.S.S. SIDES. COMOPTEVFOR described the system as potentially operationally effective, but not operationally suitable for shipboard use, and recommended that it not be approved for fleet introduction. [Ref. 63] During the test, designated OT-IIA, the SNAP II system was thoroughly evaluated according to the performance standards provided in the systems test plan. The results of OT-IIA pointed out several problems with the SNAP II system provided by SMA. [Ref. 64]

a. The response time was slower than the design specifications.

b. Any user could use job control language to change the ownership and attributes of the files in the central database, without setting off an alarm or leaving an audit trail to indicate actual or attempted entry into the restricted files. While the SNAP II system's data files are unclassified, the database does contain information covered by Privacy Act regulations as well as financial accountability data for disbursing, ships' store, food service, and supply management.

c. The size and weight of the system installed on board U.S.S SIDES was far beyond the design specifications provided in the functional description. They called for a system which would be no larger than 26 inches wide by 60 inches tall (so it would fit through a standard hatch) and weigh no more than 130 pounds. The SNAP II system weighed an unbelievable 2257 pounds and was mounted in a dual cabinet that was 26 inches by 70 inches by 48 inches, thus presenting a

significant problem for installing these systems on submarines and smaller ships in the fleet.

d. Unfiltered air was being drawn through the computer cabinets and keyboard video display terminals (KVDT), causing dirt accumulation on the circuit boards and internal components.

e. The magnetic tapes and floppy disks produced on the SNAP I system could not be loaded into the Harris system. This data transfer was required for passing maintenance related job orders from the Current Ship's Maintenance Project (CSMP), as well as other supply related data.

f. The system operator/coordinator considered the SNAP II system too slow, and not user friendly. This situation could only get worse as more application programs are added to SNAP II. Also, there was insufficient space for the users at the work stations and around the computer itself.

g. The concept of providing system coordinators and maintenance personnel with only two weeks of training on the SNAP II system did not appear to provide them with a sufficient knowledge of the system and its capabilities. The users and system managers were unaware of a several functions and procedures available on the system.

h. The non-standard keyboards provided with the system were difficult to use, even for an experienced typist.

These issues, as well others, lead to the recommendation by COMOPTEVFOR that the Navy not procure any additional SNAP II systems until they have successfully passed an operational test and evaluation examination to ensure the system meets requirements. [Ref. 65]

Only two weeks before OT-IIA, the Naval Sea Combat Systems Engineering Station had conducted a First Article Test Afloat of the SNAP II system installed on the U.S.S. SIDES. This test was to verify the installation procedures, to establish a base line production configuration, and to verify many of the same functional requirements later inspected during OT-IIA. On March 1, 1982 they reported a successful First Article Test and recommended system procurement and implementation [Ref. 66]. Based on that recommendation, in May 1983, approval was granted for the procurement and installation of the first 40 SNAP II systems. Acquisition authority for the procurement of additional SNAP II systems was contingent on the successful completion of a second Operational Test and Evaluation, designated OT-IIB.

The second operational test and evaluation for SNAP II (OT-IIB) was conducted on board the U.S.S. FAHRION (FFG-22) from October 17 to November 2, 1983, while the ship transited form Mayport, Florida to Rota, Spain. Once again, OPTEVFOR concluded that the SNAP II system was not operationally suitable for use in the fleet. This finding was based on the validation criteria provided in the SNAP II Test and Evaluation Master Plan 657 (CH-2) of August 8, 1983. During the evaluation they noted that only 12 of the 20 system discrepancies from the first test (OT-IIA) had been corrected. The SNAP II system problems noted during this evaluation included [Ref. 67], :

a. The response time still exceeded the three seconds maximum requirement of the contract specifications often taking 30 seconds or longer to respond.

b. The power backup system was not adequate, requiring the system operators to reboot the system after each power loss and reset the real-time clock.

c. 80% of the database applications could not view the data at the video display terminals, but could only provide hard copy printouts.

d. The system ran without an operator 75% of the time (criteria: 90%).

e. SNAP II was still overweight and oversized, though a 600 pound power supply had been removed from the system and the total system weight was reduced to 1496 pounds. (OT-IIA system weight was 2257 pounds)

f. The mean time between failures was 16.6 hours (OT-IIA was 43.1) while the criteria was established at 2000 hours between failures.

g. The external interface with the Radio Central message center did not work when paper tape message data was fed into SNAP II.

h. The security system still gave a user with access to the job control language the ability to change the ownership and or characteristics of a file without setting off an alarm or leaving an audit trail.

i. It was taking the maintenance personnel an average of three hours to find and repair casualties, based on eighteen trials (criteria: 45 minutes).

j. The printers jammed as the ship rolled underway.

k. Dirt still accumulation on internal circuit boards of the computer and KVDTs because of unfiltered air drawn through the systems.

l. There was no room to lay documents near terminals while typing, and the MUSE IV word processor could not provide OCR documents.

m. Changing circuit boards was extremely difficult because of the small amount of vertical clearance between circuit cards and most of interconnecting cables at the front of the cards.

The vision of an easy to operate/maintain, user friendly, highly reliable system was quickly fading. Many of the functions provided by the system were not used because of lack of on board expertise. Also, only a few applications were being programmed by on board users in BASIC or AZ-7 query/report generator languages.

The failure of the SNAP II system to pass the test and evaluation, OT-IIB, prompted Vice Admiral Baciocco (OP-098) to express his concern, and desire for a third operational test later designated OT-IIC. It was clear at this point that not all the functional design specifications provided in the contract with SMA could be met by the Harris Computer System. Also, the software provided by NAVMASSO would need a great deal more work, if all the application programs cited in the integrated functional description were going to be provided.

In December 1983, the Commander of the Naval Surface Forces Atlantic (COMNAVSURFLANT) consolidated comments from the thirteen ships of the Atlantic Fleet that had SNAP II systems installed. The command comments indicated an overwhelmingly positive response to the SNAP II system. While problems still existed with SNAP II, the users found it a significant improvement over manual processing.

> "All have praised overall system operation and effectiveness in achieving the program goal of reduced admin effort...SNAP II has dramatically eased the burden on a minimally manned ship...is unequivocally recommended for fleet introduction." [Ref. 68].

It seems a paradox for the system to be declared unsuitable for shipboard use and yet receive such strong endorsement from the shipboard users. The answer lies in the change from manual procedures to automated processing. While the statement of work (SOW) defined specific processing requirements, the users were just happy to have the SNAP

system on board, even if many of the functional subsystems of SNAP II were not working up to the technical design standards. The SNAP II system was providing the ships' Commanding Officers the tools needed to solve shipboard management problems.

In March 1984, after a great deal of discussion, the Vice Chief of Naval Operations directed that the Master Test Plan for OT-IIC be modified to include only those "system requirements and characteristics required for fleet introduction." [Ref. 69] Only 45 of the 210, specific requirements, from the integrated functional description, were included in the revised test plan for OT-IIC. Many of the specific performance requirements had been eased. (For example, the response time requirement was increased from, less than three seconds, to not less than 6 to 30 seconds depending on the situation. Also, the mean time for repairing the system during hardware failures was increased from 45 to 90 minutes.

The third Operational Test and Evaluation was conducted in early May 1984 on board the U.S.S. Arthur W. RADFORD (DD-968). Of the 20 deficiencies from the previous test, 10 were still unresolved and of the 44 application software problems, only four were reinspected. The response times were still slow with an average of 7.7 to 11.5 seconds with various system loads, and a 41.9 seconds average time to sign-on the system. Most of those discrepancies from the previous evaluation OT-IIB remained, except for system security, which had been improved with software traps to prevent unauthorized or inadvertent access to system files. The system's maintenance men easily passed the new standard of 90 minutes for making system repairs.

Based on the findings of OT-IIC, COMOPTEVFOR, stated "If satisfying the requirements set forth in the revised Master Test Plan are adequate for supporting full

production, then operational effectiveness and operational suitability support recommendation for full production of SNAP II." [Ref. 70]

The Deputy, Under Secretary of the Navy for Financial Management granted approval for full production of the SNAP II systems in June 1984, based on the findings and recommendations of COMOPTEVFOR from the third evaluation, OT-IIC. As of September 1984, 56 SNAP II systems had been installed on surface ships. The rate of installation was scheduled to be eight SNAP II systems per month until all 452 ships [illegible] completed. One problem being encountered by the fleet [illegible]mmanders has been matching ships' operational schedules to the dates available for installation. This problem has been compounded by the lack of authorized Ship Alterations (SHIPALTS), which must be completed and authorized before installation of the SNAP II hardware. As of December 1984, only five of 38 SHIPALTS had been completed, representing 145 ships. [Ref. 71]

C. ESSENCE OF SNAP II

The SNAP II program was the second part of of a two phase program for modernizing and expanding the automated data processing capability in the U.S. Navy. SNAP I was to replace the AN/UYK-5(V) computer systems installed on the larger ships of the fleet since the mid-60s, while SNAP II was to provide an ADP capability to the smaller ships which were primarily non-automated. With the advent of large scale integration of computer components with their increased reliability and declining cost, it was now economically feasible to provide non-tactical computer systems to every command in the fleet.

The philosophy of the SNAP program was to provide every surface ship and submarine in the fleet with an automated data processing capability to support shipboard management and reduce the manual work load requirements on the crew used in processing data and directing shipboard activities. By centrally procuring the system hardware and software, logistic problems, training requirements, and overall life-cycle costs would be minimized. Each ship or submarine would have one of four authorized hardware configurations depending on ship class and type. These initial configurations give each command a base-line capability which can be expanded later.

The primary gains from SNAP II, as reported by Pacific fleet commands include: 1) better use of assigned manpower, 2) increased accuracy of data sent to shore support activities, 3) improved ships configuration management, and 4) efficient administrative support [Ref. 72]

The SNAP II is made up of three primary systems joined together under the control of a Harris minicomputer. These include the hardware, the system software, and the application software. The hardware and system software are provided under contract with Systems Management American (SMA) Inc., while the application software is developed, designed, and installed by NAVMASSO in Norfolk, Virginia. NAVMASSO is also the central design activity for the SNAP II system. The application software is primarily written in COBOL, using a hierarchical modular design to improve its maintainablity and to support the introduction of later software releases and additional application program modules.

The systems have on-line user manuals, documentation, and diagnostic systems providing the users and system operators with easily understood English-like information. This is necessary because SNAP II systems are designed to be

installed on ships that do not have ADP experts specifically assigned for running or maintaining the systems. Instead, each ship sends crew members to system coordinator and system maintenance schools, which are about two weeks in length. The individuals in turn provide the training for the rest of the users and functional area supervisors.

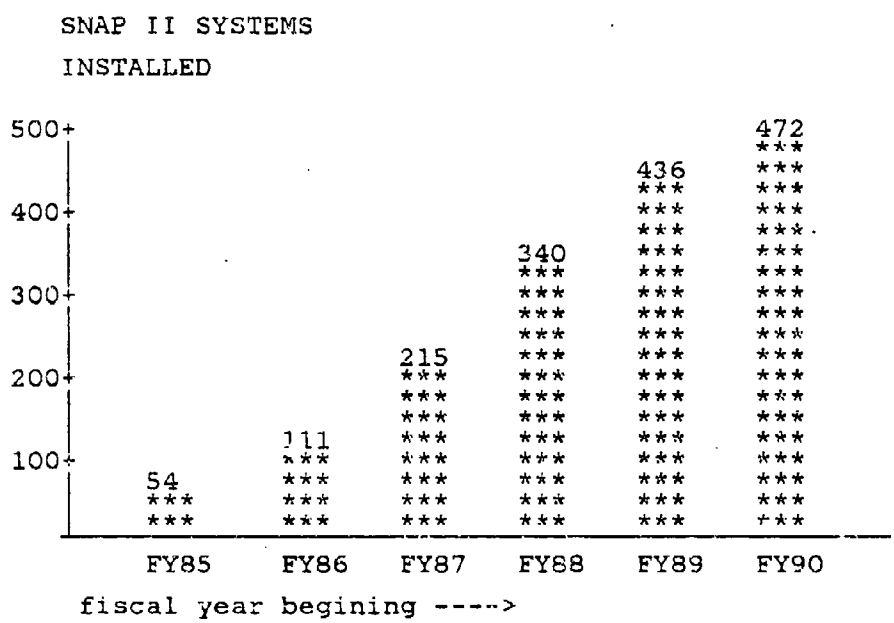
The schedule for SNAP II installations runs through 1989 and includes 472 sites, both afloat and ashore. The planned delivery schedule requires the installation of about eight systems per month during that five year period, and presents a scheduling nightmare matching available ships with installation teams, and authorized SHIPALTs. See figure 4.1 [Ref. 73].

Based on the modified requirements from the OT-IIC test plan, SNAP II is now considered to provide:

1. response times from 6 to 30 seconds
2. mean time for component failure of 2000 hours
3. less than five reboots per day
4. mean time for repairing casualties of 90 minutes
5. 85% system availability
6. unattended operations 65% of the time

The SNAP II system is limited to unclassified data and programs because of the stringent security requirements required to store and process classified data on a shared computer system. This limitation seriously restricts the amount of operational planning and reporting that can be done on SNAP II. A possible solution would be to use stand-alone Zenith 150 series microcomputers with 10 Mb hard disks which are TEMPEST certified for processing classified data, but no hard copy would be possible unless the printer was also TEMPEST certified.

At the time of this writing, the Zenith 120/150 microcomputers were well on their way to becoming a fleet standard. Because of delays in the development of some



New Installations				
FY85	FY86	FY87	FY88	FY89
57	104	125	96	36

Figure 4.1 SNAP Installation Schedule

software applications for SNAP II, several application programs have been produced for the Zenith systems including retail operations, food service operations, and disbursing. These applications do not interface other parts of the SNAP II database and are thus appropriate for the stand-alone systems, especially since these are all areas of financial accountability. [Ref. 74] These application programs are not scheduled for implementation on SNAP II until after fiscal year 1986.

There has been much discussion about providing better system response time and up-grading the hardware for the SNAP II system. These areas are discussed in later sections of this chapter. Other future plans include using microcomputers to access the Harris computer, instead of the KVDTs now used. This would permit some of the processing functions to be off-loaded as well as providing the capability of running commercial software packages on the SNAP system.

So far SNAP II has been well received in the fleet, with most commands concluding that the "economic benefits of the centralized system outweigh its limitations" [Ref. 75]. Other comments though indicate: 1) there is a general feeling that there are not enough KVDTs (at least two more needed), 2) there are some problems with circuit cards vibrating loose during underway operations, and 3) there is the need to power the SNAP II system with a "vital" power source, so it doesn't have to be shut down every time non-vital power sources are lost.

1. SNAP II Hardware

The Automated Data Processing Equipment (ADPE) for the SNAP II system is designated AN/UYK-62(v). It is provided by Systems Management American (SMA) Inc., under a Navy contract which requires them to purchase, integrate, and ruggedize the system components. The components are arranged in one of four configurations, large, medium, small, and small (submarine). See Table V [Ref. 76]. Each configuration is nearly identical, except for the number of peripheral units attached.

a. Processor Subsystem

The Harris 300 super-mini computer is the heart of the the SNAP II system. Ith uses a 48 bit word-size, plus

the address and control bits. Internal data is transmitted in parallel at a speed of 19.2Mb per second. The main memory is expandable to 3.0Mb, though the current SNAP II configuration uses only 1.5Mb of random access memory (RAM). With the addition of a 70 nano-second cache memory and the expanded memory, the system can be converted into a Harris 500 computer, with operating characteristics similar to an IBM 370/158 computer. [Ref. 77]

The commercial version of the Harris computer mounts in an equipment rack that is 80"high by 44"wide by 32"deep and weighs 1050 pounds. The contract specifications for the SNAP II system called for SMA to provide a computer system that was proven in business applications, no larger than 26 inches wide by 60 inches tall (so that it could fit through a standard shipboard hatch), and about 130 pounds in weight (to meet small ship weight limitations). [Ref. 78] The SNAP II model of the Harris computer required significant modification of the "off-the-shelf" version, since it did not meet any of these criteria. At present the Navy's SNAP II system is the beta test site for modifications and changes to the Harris system hardware and software.

Additionally, the central processing unit (CPU) of the processor subsystem includes the communication network processors, a power distribution system, and the programmers control panel.

TABLE V

SNAP II Shipboard Configurations

Equipment	Large	Medium	Small	Small(sub)
Mainframe				
Harris 300 Main Memory	1.5 Mb	1.5 Mb	1.5 Mb	1.5 Mb
Virtual Memory	12 Mb	12 Mb	12 Mb	12 Mb
Winchester 80Mb Hard Disk	4	3	2	2
Nine Track Mag Tape Drive	1	1	1	1
Paper Tape Reader/Punch	1	1	1	1
Terminals				
User Terminals	16	8	4	1
Operator Terminals	1	1	1	1
Printers				
300 LPS Line Printers	2	2	1	1
Display Printers	8	2	2	1
Word Processing Printers	4	2	2	0
Other				
8" Floppy Disk Drives	2	2	2	1
Card Reader	1	1	1	0

b. Input/Output Subsystem

The I/O Subsystem provides the primary interface with the SNAP II users. It includes display terminals, printers, and other I/O devices.

The systems include KVDTs which have an 80 column, 24 line display, and are capable of handling graphics.

There are three kinds of printers provided with SNAP II, including: 1) display printers for making hard copies of KVDT screen displays, 2) line printers, which run at 300 lines per minute for volume printing jobs using continuous forms (5" to 16" wide) and 3) work processor printers for letter quality printing, capable of using a variety of different fonts.

Other I/O devices include a paper tape punch/reader for the interface with the ships' communication center and a card reader for inputing supply requisition status cards provided by shore commands. (The tape and disk drives are listed with the storage devices.)

c. Mass Storage Subsystem

This subsystem includes the devices used to store the data and software programs for the SNAP II system. Since the SNAP II system is designed to run without an operator, most of the storage is on hard disks. The various configurations provide for two to four Winchester sealed hard disk drives, with four 8 inch disks and seven read/write heads. For system back-up there are 9-track magnetic tape drives, which run at an average speed of 75 inches per second with a density of 1600 bits per inch. Finally, there are 8 inch floppy disk drives which are used to receive or provide data with external sources, i.e. SNAP I systems.

d. Power Subsystem

The power subsystem is provided to ensure an orderly shut-down of the SNAP II system when there is a power failure. It includes four types of electrical line-filter used to regulate the line voltage to the SNAP II system.

e. Future Hardware Plans

The future plans for ADPE improvement look promising, and should solve many of the early problems with reliability, speed and system size. These plans include

1. expanding the Harris main memory and increasing the size of the virtual memory addressed by the operating system
2. using denser hard disks to provide 160Mb per disk pack
3. reducing both the size and weight of the components and the equipment rack
4. increasing the number of terminals
5. using portable microcomputers in place of terminals, fitted with hard disks and up to 600K of RAM, to allow off-loading of some applications

A current listing of SNAP II equipment manufacturers and vendors is provided in Appendix A.

2. SNAP II System Software

SMA provides the system software for the SNAP II system. The system software includes the operating system, utility software, and compilers. The Harris 300 minicomputer uses the Vulcan Operating System (VOS), which is capable of addressing 12Mb of virtual memory. VOS supports nine high level languages, including: 1) COBOL, 2) FORTRAN 77, 3) Pascal, 4) TOTAL DBMS, 5) AZ-7 query

language/report generator, 6) T-ASK information retrieval system, 7) APC, 8) SORT/MERGE, and 9) MUSE IV word processing language. Not all these languages are provided to the ships with the SNAP II systems. The shipboard version of SNAP II only comes with AZ-7, SORT/MERGE, MUSE IV, and a BASIC language compiler. Since the application software provided with the system is written in COBOL, shipboard users are not allowed to use COBOL. This is done to protect the programs and database provided with the system. [Ref. 79]

Since the selection of the Harris computer for the SNAP II system, there have been problems with the operating system. The primary complaint has been that,

> "the current SNAP II system suffers from inefficiency in both run-time throughput and response time. Specifically shipboard users have voiced concerns regarding the excessive amount of time required to perform routine functions while utilizing SNAP II." [Ref. 80]

The main difficulty lies with the operating system itself. VOS supports an indexed sequential file management system called VISP, which does not allow file sharing. With several users trying to access the same files, the system soon slows to a crawl. Other problems cited in one report provide an insight into some of the VOS problems. [Ref. 81]

a. Alternate indexed files are not efficiently processed during read and write operations.

b. There is no multiple character suppression in the indexed files, so large blocks of data must be moved between the record buffer in the server and the pseudo buffer in the application programs. This requires the operating system to allocate large blocks of dynamic memory, causing a significant degradation in the system response time.

c. The lack of multiple character (blank) suppression, also causes large amounts of disk space to be wasted.

d. Because alternate-key data retrieval slows the system down so much, programs have been developed which artificially eliminate the use of the duplicate keys. This inturn increases the record size and complexity of the programs.

e. The multi-user version of VISP seems only to be an kludge of the basic system.

In July 1984 SMA announced a new release of the operating system, VOS 3.1.1, to address many of the issues discussed above. In particular, the new release would provide a new multi-user VISP package and multi-character blank suppression. That announcement led to the suspension of almost all new application software development for SNAP II, while the new operating system was being integrated. [Ref. 82] This caused a delay in software development of nearly eight months, until about February 1985. The new version of VOS improves the response time and performance of the SNAP II system.

3. SNAP II Application Software

The application software for SNAP II is designed, developed, and maintained by NAVMASSO. It has a modular design so that additional software releases and new application software modules can be easily added to the system. This significantly reduces the cost of software maintenance. The SNAP II Shipboard Data System (SDS) implementation has been broken up in two distinct phases. The initial release was designed as a first effort at reducing the administrative work-load on the ships, while the follow-on releases are phased enhancements of the basic system or new functional applications defined by the system sponsors.

SDS has four functional components in its design: 1) The System Management Subsystem (SMS) directs the overall operation of the application software for the SNAP II system. 2) The Organizational Maintenance Management Subsystem (OMMS) handles all administrative aspects of the shipboard maintenance program. 3) Supply and Financial Subsystem (SFM) manages the administrative functions of shipboard supply and inventory management. 4) The Administrative Data Management Subsystem (ADM) used in supporting shipboard personnel and administrative functions. Additionally, SDS accesses the word processing system software which has been described by the users as "easy to use " and a "real time saver". Figure 4.2 [Ref. 83]. shows the relationships of the primary four subsystems.

a. System Manager Subsystem

The SMS is the control module for the shipboard data system. It includes functions dealing with overall system management, system integrity, menu selection, on-line user manual, and queuing of reports. It is this menu-driven module that the users must first deal with when logging on the SNAP system. It not only provides system security, but also has the back-up and recovery modules required to ensure the integrity of the databases. A diagram of the major functions of SMS is displayed in figure 4.3 [Ref. 84].

b. Supply and Financial Management Subsystem

The SFM subsystem provides the basic tools to eliminate much of the manual supply record keeping and reporting functions, as well as providing an extensive inventory management capability. As the systems are currently implemented, when maintenance data is entered the status of on board repair parts is provide to the user by SFM. If the parts are carried on board, documents are

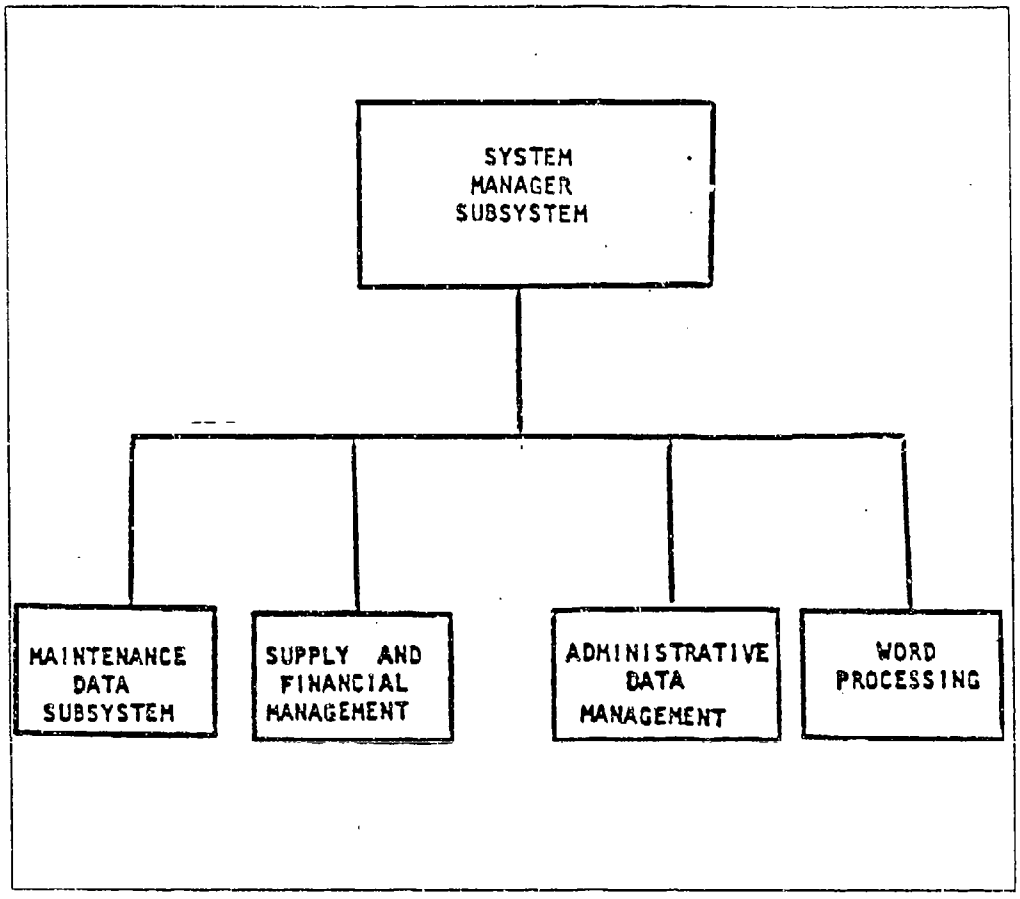


Figure 4.2 Shipboard Data System (Initial Release)

created to draw the parts from the ship's Supply Support Center along with the requisition documents necessary to order replacement parts. If replacement parts are not carried on board, the documents are created to order them from other activities, and the system tracks the status of those parts by work order number, and provides the status information to the user. The beauty of SFM system is that it also maintains the financial obligation accounting records required to manage the expenditure of ship's funds and the

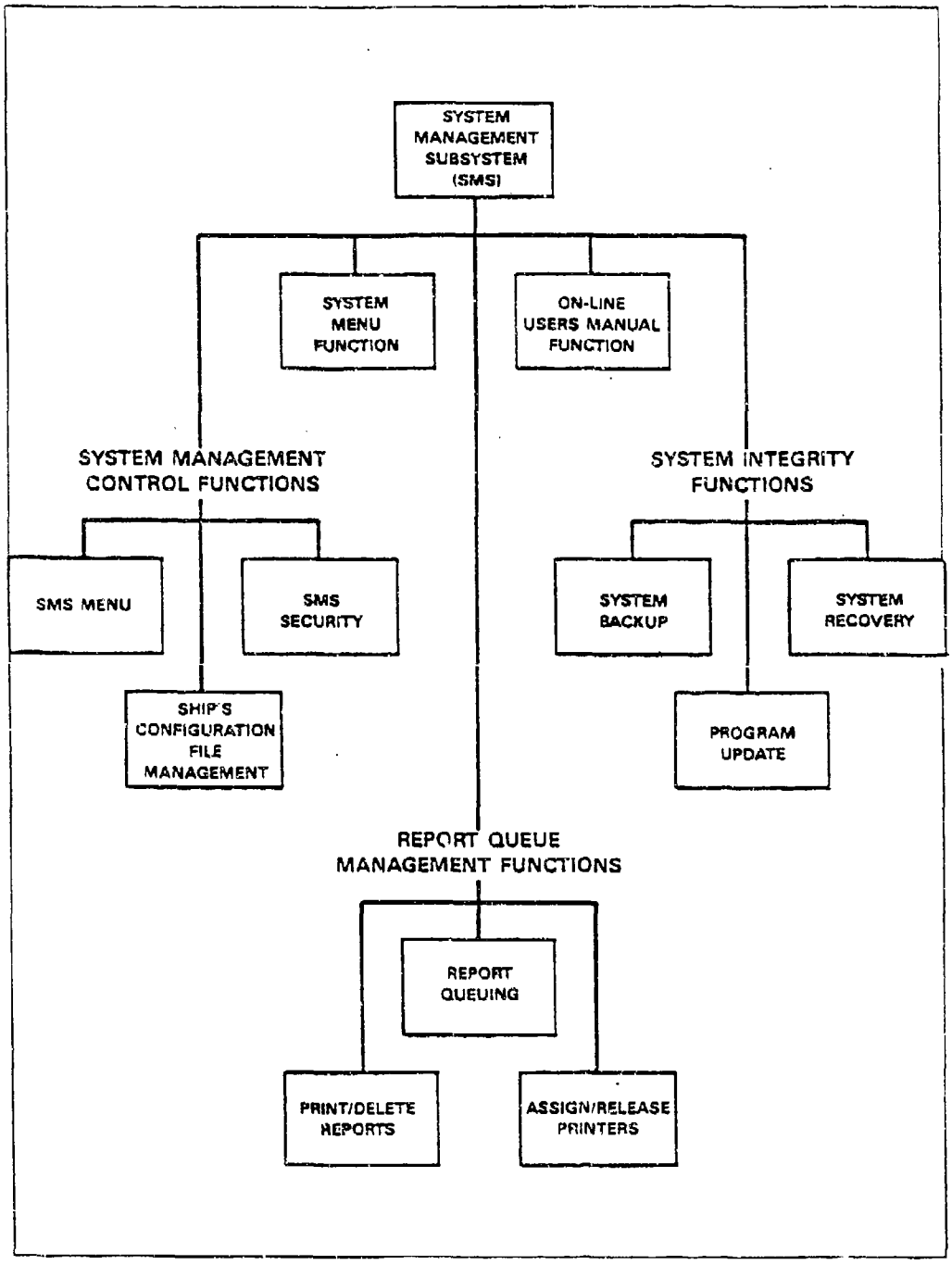


Figure 4.3 System Manager Subsystem

consumption expense accounting records, needed for internal and external reports. Figure 4.4 shows the major functions provided by the SFM subsystem [Ref. 85].

When parts, consumeables, or services are purchased through the SFM system, the MILSTRIP data used in ordering them, is queued and later punched in message format on paper tape for radio transmission through the ship's communication center. This feature has saved countless man-hours and has significantly increased the accuracy of the MILSTRIP messages. SFM also provides access to the ship's Consolidated Ships Allowance Listing (COSAL) which includes lists of the repair parts and components for the equipment installed on board a specific ship. The automated COSAL is arranged by Allowance Part Lists (APL), which reflect the repair parts that a ship is supposed to carry on board to support repairs. One weakness of the SNAP II system, cited by many of the users, is its failure to provide an automated interface with shore commands that provide the APLs and the COSALs that go into the ship's COSAL database. In general, the COSAL data have not been accurate when first installed with SNAP II systems, and the updates and modifications have to be entered by hand, one part at a time using the KVDTs. This can be an incredibly slow process for an APL that lists a thousand repair parts. This interface problem has been addressed and will be resolved by 1986 when APL data will be provided to the ships on magnetic media. [Ref. 86]. There is a certain amount of duplication in maintaining the COSAL data in the on-line database, because separate paper copy must also be maintained, for periods of time when the SNAP II system is not operational. The functional modules of SFM are displayed in figure 4.4 [Ref. 87].

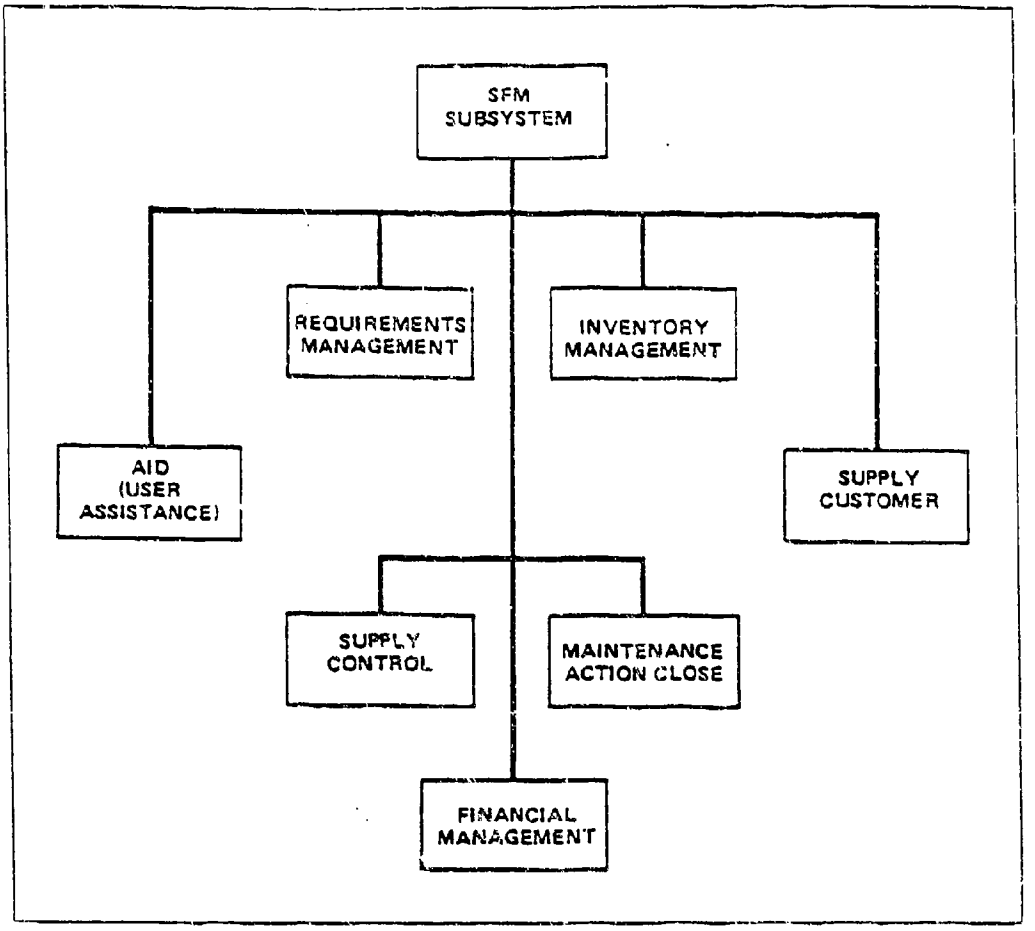


Figure 4.4 Supply and Financial Management Subsystem

c. Organizational Maintenance Management Subsystem

OMMS is is intended to provide ships with an automated maintenance management capability. All 3-M maintenance actions are recorded on-line and merged with the ship's current CSMP. This data combined with repair part ordering and status from the supply subsystem can then be used in the planning and management of maintenance work. Because of this automated capability, an average of more

than 50 man-hours can be saved for each repair availablity. OMMS supports on-line entry and display of maintenance actions, as well as management reports and scheduling aids. It provides for work-package processing, work-load planning, and on-line ordering of repair parts. The functional modules included in OMMS are presented in figure 4.5 [Ref. 88].

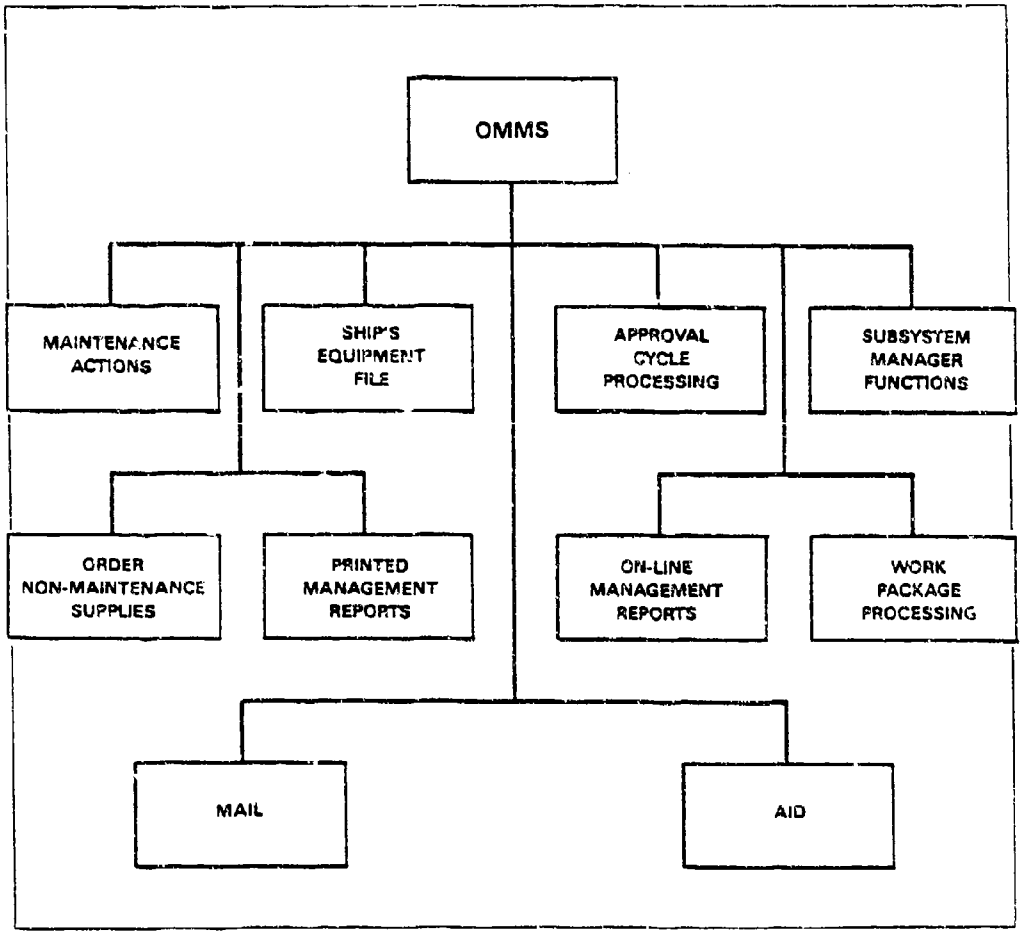


Figure 4.5 Organizational Maintenance Management Subsystem

d. Administrative Data Management Subsystem

The ADM subsystem will eventually contain all aspects of personnel management and administration (except classified information management). The initial release of ADM included functions for monitoring personnel assignments, training, and career development. In addition the database supported by ADM is used to track health & morale programs and retention programs. The primary complaint from the ADM users has been the time required to maintain the files for ADM. The functions provided by the initial release of ADM are presented in figure 4.6 [Ref. 89].

e. Future Application Software for SNAP II

Over the next three years, there will be additional application software modules added to the shipboard data system, as well as improved or modified releases of the existing programs. The present plan calls for the following application programs to be added to the system [Ref. 90] :

Organizational Maintenance Management Subsystem

- 3M for Helo Detachments
- PMS Scheduling & Admin Support
- Technical Publication Library
- Test Equipment Support

Supply and Financial Management Subsystem

- Financial Management
- Food Services
- Retail Operations
- Mobile Logistic Support Force
- Supply & Financial Reports

Administration Data Management Subsystem

- Disbursing & Personnel Management
- Medical and Dental Management
- Training Management

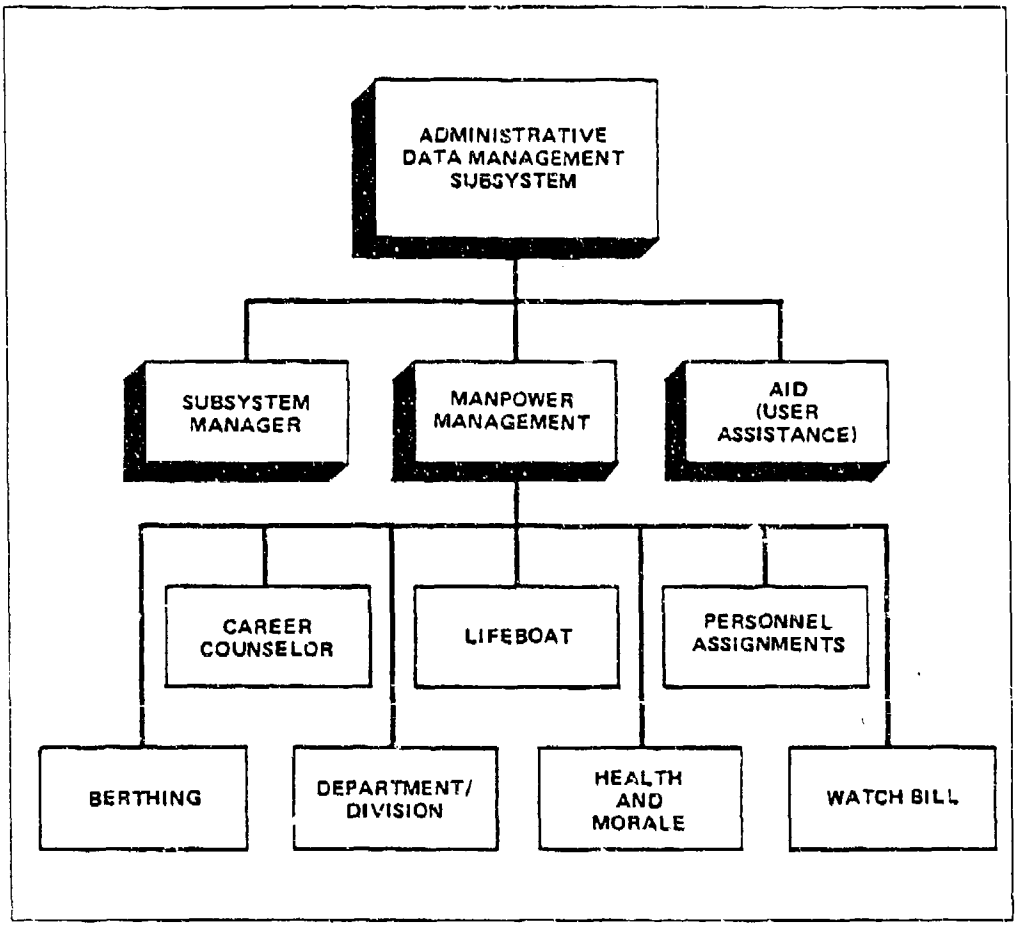


Figure 4.6 Administrative Data Management Subsystem

D. ADVANTAGES OF SNAP II

If the success or failure of a shipboard non-tactical computer system is measured solely in meeting primary design goal, then SNAP II would have to be considered an unqualified success, since it has served to significantly reduce the administrative burden on the fleet. As the SNAP II system is further developed and deployed over the next several years, its success will become even more evident.

The eight points discussed below present some of the more significant advantages of the SNAP II system.

1. Centeralized Development. SNAP II can be thought of as a centrally managed, geographically distributed processing system designed for the U.S. Navy. Each of the 452 planned nodes of this distributed processing system will be located on different Naval ships, but will have similar processing configurations. Under this view of the system, the functional sponsors and the fleet commanders act as the steering committee, making system management recommendations to the CNO. Therefore, the decisions on how to manage the SNAP II system take on a more global, priority and policy, oriented view, than a system acquired and managed solely by the direction of one ship. Goals are established for the system at a high level, which are appropriate to the scope and cost of a corporate Information System.
2. Standardized System. The standardization that SNAP II brings the Navy will be far reaching in nature. A universal system such as SNAP II, results in many economies of scale over the system's life-cycle. The training requirements for users is minimized, because every system is functionally the same. When an individual has been trained on the SNAP II system, and is then assigned to a new ship, there is a direct transfer of his knowledge and skills. Both software and hardware can be managed so cost of changes and modifications are minimized. One can only imagine the chaos that would result if a major change in administrative procedures was required, and every command had to rewrite their application programs to incorporate the change. With a "single system" you don't reinvent the wheel each time a problem must be

solved. Instead the SNAP II concept provides a single point for the resolution of all problems. NAVMASSO serves in this capacity.

3. Improved Logistic Support. The logistics of providing world-wide support for a standardized system like SNAP II are obviously much simpler and more cost effective than attempting to provide for 30 or 40 different systems. Each ship will carry its own repair parts and expertise in maintaining the SNAP II systems, yet will be able to provide assistance to other ships if needed. Repair parts will be stocked in depth and not breadth, i.e. this allows the supply system to procure and stock parts that fit all systems vice unique parts for each system. This results in better inventory management and economies of scope.
4. Increased Accuracy. The increased accuracy, in reporting parts usage for both corrective and preventive shipboard maintenance, provides the Navy's material managers with the necessary data to improve inventory management. As a direct result the COSALs will more accurately reflect the ship's equipment configuration. This leads to better supply support and consequently improved fleet readiness.
5. A Management Tool. The manpower savings in going from a manual system to SNAP II, have been significant. While SNAP II does not provide many "bells and whistles", it does provide each command with the basic tools needed to manage shipboard administration, without requiring the assignment of additional crew members who are expert in the system.
6. A Control Mechanism. The SNAP II system has had a unifying effect on the entire U.S Navy. By providing a "single system" for all the ships, policy and

procedures have been standardized. No longer will there be the "air" Navy, the "surface" Navy, the "sub" Navy, and the "Atlantic and Pacific" Navies, all with different rules and procedures for maintaining records and processing reports. Now there will be only one system ... SNAP ! It provides the commanders of geographically disbursed organizations with an excellent control mechanism to enforce standards and implement policy. When a change has to be made in administrative procedures it needs only be developed as a software modification and released to the fleet.

7. Acquisition Strategy. One main advantage of the SNAP II acquisition methodology is the use of a prime vendor who sub-contracts, assembles, and integrates all the ADPE components and systems software. This allows the Navy to use one point of contact for addressing and resolving all system problems.
8. Contractor Leverage. The use of a small contractor, such as SMA or Harris, offers a distinct advantage over many larger contractors. When a contract such as SNAP II, makes up a significant portion of their total business, they tend to be much more responsive to the unique needs of the Navy in scheduling, modifications and other such concerns.

E. DISADVANTAGES OF SNAP II

The disadvantages of the SNAP II system can be argued from the point of view of the Commanding Officers and what it provides them in the way of a flexible management tool. Many of the traditional management issues of shipboard command involve the solving of dynamic, unstructured problems, that are not always supported by "canned programs"

provided by standard, management information system. The points that follow present some of the disadvantages of the SNAP II system from this prospective.

1. System Inflexibility. The application software for SNAP II is designed so the shipboard user cannot access the databases with locally generated programs. While this is done to protect the integrity of the information stored in SNAP II, it incorporates inflexiblity in a system that must also respond to dynamic changing needs. It makes little sense to limit the users to Basic, when Pascal and FORTAN are also supported by VOS. Also, without a dedicated SNAP II expert assigned to each ship, it is unlikely the fully potential of the system will ever be realized.
2. User Dependence. A growing dependence on the SNAP II system may not be evident until a major casualty occurs to the system. Such a casualty could result from anything from malicious destruction to wartime damage. This dependency is a huge liability because an architecture with a single CPU and little fault tolerance has been chosen for SNAP II. Unless manual procedures are reheresed and practiced on a routine basis, the ability to function without the computer may be quickly lost. Besides, hard copy COSALs and microfiche listings of repair parts, as well as technical manuals must still be maintained.
3. Lengthy Implementation. The slow development and implementation process for SNAP II creates a situation where there are have's and have-not's. Those ships where systems have been installed can exploit its usefulness and profit from improved management of people, time and money, while those not scheduled to receive system for several years are

like second class citizens relegated to operating in the manual mode. This, along with the usual problems with application backlogs has led to the proliferation and use of microcomputers in the fleet. Some applications scheduled for implementation on SNAP II, have already been programmed for the stand-alone microcomputers and are meeting user needs.

4. Classified Data. The issue of handling classified data in an automated environment was discussed earlier in this chapter. Since a good deal of shipboard information is of a classified nature, the issue must be addressed in meeting the information needs of the ships. At the present, SNAP II does not address this problem, other than to say that classified data will not be processed on the system without specific approval and appropriate security measures.

5. Contractor Vulnerability. As a result of the acquisition process, SNAP II is being integrated and provided by a small company whose primary business is that Navy specific contract. Also, the computer hardware comes from a company whose computers are primarily used by the Navy. This results in a situation where the government almost has to guarantee the success and continuance of these companies, to maintain the viability of the SNAP II systems. If they were larger corporations with established track records for performance, the risk of them closing their doors and going out of business would be greatly reduced. Once SNAP II is in place, users will grow to depend on the system and the information that it provides. The Navy will not be able to afford the disruption and expense of

developing another system. Fortunately, the application software has been developed so that it can be transported to other hardware systems.

6. Increasing system scope. Since new capabilities are often added to computer systems under the guise of software maintenance, the scope and complexity of the systems are constantly increasing. This situation is no different with SNAP, causing the programs to look as though they are growing without bounds as the maintenance tail of the life-cycle curve continues to widen, giving the perception of poor management. This makes it extremely difficult for those who must argue for funding the SNAP programs.

F. CONCLUSIONS

The SNAP systems have been developed as a tools to make better use of available shipboard manpower, to increase the accuracy of the information used in managing the Navy, and improve the quality and level of support to the fleet. These are issues that relate to the readiness of the U.S. Navy in meeting its commitments and in fulfilling its mission. The research, planning and development that was completed before SNAP II's implementation have led to its success in meeting these goals.

The philosophy of using a "single system" to meet the information and administration management needs of the Navy provides many interesting results. Not only are the systems life-cycle costs controlled, but also almost every aspect of providing logistics, training, and managing operations, are simplified. An additional and important feature provided by the "single system" concept is that of control. The standardization of procedures and policy, throughout the Navy as a result of SNAP I and SNAP II, could never have

been realized under a less centrally developed and managed system. Once fully implemented in the fleet, SNAP II will provide a mechanism of control never before possible under the manual system.

The primary risk inherent in systems like SNAP I and SNAP II, is the users growing reliance on the information and data stored on the computers. In a war time environment it is likely that there will be periods of time when the crew has to function without the SNAP computer system. Therefore, the capability to operate in a manual mode must be maintained if that risk is to be minimized. While the use of a system with a single CPU may make some sense in the business world, it poses some strategic problems to a war ship that is geographically separated and must rely on the information stored in the database.

Finally, while the acquisition process of major systems is not be perfect, it is the process we have to work with in the government arena. When a contract is bid on a lowest cost basis, you get what you pay for. The only mechanism to ensure that the system provides product that is needed, is through the accurate and specific design specifications. This is where the prototyping of the makes such a difference. Get the requirements "right" before contracting, and then stick with the specifications where they make sense. The objective must be in "getting the right system...and getting the system right." [Ref. 91]

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The systems discussed in this thesis have illuminated a spectrum of technical problems and managerial issues that should be addressed before introducing non-tactical computers into the shipboard environment. For example, the Perq minicomputers suffered many technical problems on board the U.S.S. Carl Vinson, because the hardware was neither designed nor specifically ruggedized for the oftentimes harsh shipboard environment it had to operate in. If the operational environment had been thoroughly examined before installation of the Perq computers, then different hardware might have been selected, or at least appropriate protective devices can be installed installed that would have minimized some of the equipment casualties that were experienced during the 1983 cruise. SNAP II, on the other hand, experienced several technical problems because design specifications were initially not adhered to i.e. size, weight, etc., or because they were changed to match equipment capabilities e.g. response time. Some of the managerial issues that should be considered if an implementation is to be successful include manning, security, applications, and the speed with which the system should be implemented, to name just a few.

Both the Perq and WANG systems, as installed on the U.S.S. Carl Vinson, demonstrate some pitfalls that can occur if implementation is done too fast and without the benefit of a thorough requirements analysis. In each case the wrong machines were initially installed. The Perq's were not hardy enough, and except for the VS-100, the WANGs were

not large enough. The SNAP system on the other hand, has suffered from a long, drawn-out implementation process, primarily because of the extensive procurement process required for compliance with public law 89- 306 regulations, often called the Brook's Bill. While the conceptual idea for SNAP was approved in 1978, only 56 of 452 planned implementations were installed as of October 1984. This slow process results in the SNAP design being constantly altered or adjusted to take advantage of new technology, or to correct deficiencies in the original design. This means the first units installed will have to be back-fitted with these design or operational changes to maintain system standardization.

Although the Perq computers suffered from equipment reliability problems, they did demonstrate the advantage of having a distributed processing capability. Despite casualties to several of the Perq computers during the U.S.S. Carl Vinson's 1983 cruise, the network was never completely disabled because of equipment redundancy. This redundancy is not provided for on either the WANG VS-100 or Harris SNAP II systems, because of their single CPU architecture. The risk of total system failure due to electrical power problems, malicious damage, or sabotage is therefore much higher in these systems than on the network of Perqs.

The term non-tactical is misleading, because it connotes a system of secondary importance. For shipboard non-tactical automation nothing could be farther from the truth. With applications such as the supply-maintenance interface, intraship communications, and general word and data processing, these non-tactical computers are becoming more critical to the everyday operations of the ship. As more applications are developed for these non-tactical computers, both system dependency and the penalty for system failure

increase in magnitude. Along with these increased applications the risk of a sudden and devastating capacity crunch becomes much higher. This is what happened on the smaller WANG systems before the VS-100 was installed. The Wang System-20, System-30, and VS-80 were too small to handle the ever increasing demands placed on them by the ship's users. Whenever a new system was installed it would reach its capacity limit, resulting in a discernible slow-down and the inability to satisfy the many new applications that were being developed by shipboard users.

Another area that must be closely looked at is life-cycle cost. This includes the original cost of the equipment, as well as operating and maintenance cost for the life of the system. Oftentimes, the original equipment cost is the least expensive part of the life-cycle cost. For example, a WANG VS-100 super minicomputer with 8 input, output processor interfaces, a 16 port serial I/O processor controller, a macroassembler, and one archive processor is listed for approximately $72,000 on current Federal Supply Contract schedules. Other vendors can supply comparable equipment at similar prices. Of course, when you start adding the cost for hard disk memory, terminals, printers and other peripheral equipments, the price rapidly increases. The majority of an information systems cost is spread throughout its lifecycle as maintenance, repair parts, wages for operating personnel, and software. These costs can exceed the original purchase price within a short time. Although the WANG was specifically used in this example, these cost hold true for any computer system.

While the WANG installation on the U.S.S. Carl Vinson has proven the feasibility of using off-the-shelf, commercial computer equipment in a shipboard environment, the Perq has demonstrated the necessity for choosing the equipment wisely. This equipment should include overload

protection, line protection, and the availability to operate at different ambient temperatures if a suitable controlled environment cannot be provided.

B. RECOMMENDATIONS

1. Before developing or purchasing a non-tactical computer system, regardless of size, a cost/benefit analysis should be conducted. This will help identify total life-cycle cost, as well as assist in identifying or justifying the need for such a system.
2. A requirements analysis should be conducted before committing to a system. This will help in deciding whether an information system should be purchased, and if so which one.
3. Both hardware specifications and site preparation must be well-thought out and defined before actual procurement of a system. They should address appropriate power requirements such as line filters, overload protection, and an uninterruptable power supply, as well as size and weight constraints, special environmental requirements, and security and safety considerations for both personnel and equipment.
4. Where available, both commercial hardware and software should be procured and used.
5. The user should drive application development whenever possible. Use of a fourth generation type language such as Nomad, Focus, or similar commercial products allows the user to develop his own applications. This is conducive to innovation, while also minimizing costly software development.
6. Ensure that system architecture is flexible enough to allow for growth and incorporation of new technology.

7. A shipboard non-tactical computer system should be developed under the same philosophy as other critical equipments onboard ship, i.e. redundancy. One way to do this is to use a distributed network whenever possible.
8. To encourage user innovation the system should have some excess capacity that can be used for locally developed programs. The SNAP concept does this, but uses the basic language instead of a more flexible, more user friendly language.

While these recommendations do not in themselves guarantee a successful system implementation of a non-tactical computer system, they reflect some successful aspects of the Perq, WANG, and SNAP II systems, which should be considered when designing computer systems for the fleet. Research programs like Perq/ZOG and commercial systems like the WANG have a definite place in the Navy, and should be continued, because of the ingenious and innovative ways in which they are used. These creative ideas can then be transfered to the more standardized systems like SNAP. As we view the future, we must continue to look for ways to use new technology to increase productivity in the fleet.

APPENDIX A

SNAP II MANUFACTURERS AND VENDORS

Device	Manufacture	Vendor
CPU	Harris	Harris
Mass Storage	Winchester	Harris
KVDTs	Harris	Harris
Prog I/O Channel	IPOC	Harris
WP Printer	NEC	Bartlett Associates
Line Printer	PRINTRONIX	PRINTRONICS
Display Printer	MPI	Engineered Control Systems
Paper Tape	REMAX	Harris
Card Reader	DOCUMENTATION	Harris
Streaming Tape	CIPHER	Harris
Floppy Dsk Drive	INSTOR	Harris

APPENDIX B

GLOSSARY OF TERMS

ADM	Administrative Data Management Subsystem
ADP	Automated Data Processing
ADS	Automated Data System
ADPE	Automated Data Processing Equipment
AIS	Automated Information System
APL	Allowance Part Lists
CCOL	Compartment Check Off List
CDA	Central Design Activity
CIC	Combat Information Center
CII	Computer Integrated Instruction
CMU	Carnegie-Mellon University
CNO	Chief of Naval Operation
COSAL	Consolidated Ships Allowance Listing
CPU	Central Procession Unit
CRT	Cathode Ray Tube
CSMP	Coordinated Ship's Maintenance Project
DARPA	Defense Advanced Research Agency
DCA	Damage Control Assistant
DMS	Data Management System
DS	Data Systems technicians
ET	Electronic Technicians
FMS	Federated Management System

GSA	General Services Administration
I/O	Input/Output
KVDT	Keyboard Video Display Terminals
MAG	Marine Air Group
MB	Megabyte
MENS	Mission Element Needs Statement
MIS	Management Information System
MPDS	Message Processing Distribution System
NAVMASSO	Navy Management Support Systems Office
NPRDC	Naval Personnel Research and Development Center
OMMS	Organizational Maintenance Management Subsystem
ONR	Office of Naval Research
ORSE	Operational Readiness System Evaluation
PC	Professional Computer
PLAD	Plain Language Address
PROMIS	Problem Oriented Medical Information System
PRP	Personnel Reliability Program
PQS	Personnel Qualification Standard
RAM	Random Access Memory
RT	Real-Time
SBA	Small Business Administration
SDS	Shipboard Data System
SHIPALTS	Ship Alterations

SFM	Supply and Financial Management Subsystem
SMA	Systems Management American
SMS	System Management Subsystem
SNAP	Shipboard Non-tactical ADP Program
SORM	Ship's Organization and Regulations Manual
SOW	Statement of Work
SPICE	Scientific Personal Integrated Computing Environment
SSTG	Ship's Service Turbo Generators
STAS	Shipboard Training Administration System
UPS	Uninterruptible Power Supply
VAC	Volts Alternating Current
VISP	VOS Indexed Sequential Package
VOS	Vulcan Operating System
ZED	ZOG edit

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