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

The study reflected by this document surveyed the extent to which commercial automatic data processing (ADP) equipment is used in the ocean environment. The range of such applications and their relative success are surveyed, to assist in further decisions on such equipment in Operational Readiness Monitoring System (ORMS) uses.

This document is provided in two volumes. Volume One is the narrative overview of the study. It covers study methodology, ORMS background, study findings, conclusions and recommendations. Volume Two is a collection of user documents in appendix form. These user appendices are reproduced as provided by the various commercial ADP equipment users and present detailed descriptions of equipment applications.

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NOSC

NOSC TD 228
Vol I

NOSC TD 228
Vol I

Technical Document 228

COMMERCIAL DIGITAL/ADP EQUIPMENT IN THE OCEAN ENVIRONMENT

Volume I: Performance Study

JG Kammerer

Final Report: July — November 1978

15 December 1978

Prepared for
Naval Data Automation Command

NAVAL OCEAN SYSTEMS CENTER
SAN DIEGO, CALIFORNIA 92152

NAVAL OCEAN SYSTEMS CENTER, SAN DIEGO, CA 92152

AN ACTIVITY OF THE NAVAL MATERIAL COMMAND

RR GAVAZZI, CAPT USN
Commander

HL BLOOD
Technical Director

ADMINISTRATIVE INFORMATION

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The author of this technical document expresses his appreciation for the support provided by Mr J Gentry of SDC Integrated Services, Inc. Thanks are especially due for the cooperation and enthusiasm exhibited by the following personnel who were contacted (in order of contact): LCDR Dollard and CPO Pharr, USS GRIDLEY (CG 21); CAPT BS Little, USCGC GLACIER; CDR Miller, Messrs G DuPont, Jr, and H Meyers, NAVOCEANO; LT (JG) Reusch, USS KITTY HAWK (CV 63); CAPT Kothe, CDR Lonhorn, and ETCS Pinney, USCGC POLAR SEA; CDR Harshberger, COMNAVAIRPAC; Mr P Sutton, COMNAVSURFPAC; CDR Bolinger, NALC; Mr E Heaton, PRD Electronics; and Mr J Grant, NOSC.

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Surface Ship Systems Division

Under Authority of
HD Smith, Head
Communications Systems and
Technology Department

SUMMARY

OBJECTIVE

This Technical Document presents the results of a study to determine to what extent and degree of success commercial automatic data processing (ADP) equipment is being employed in the ocean environment. The main thrust of the study was to examine the reliability of commercial hardware applications and not to analyze the effectiveness of attendant software.

RESULTS

The TD consists of two volumes: Volume I provides information pertaining to the study methodology and results; Volume II provides detailed supporting documentation of the study. In essence, the study shows that commercial ADP is being employed successfully in the ocean environment. Shipboard users have found that commercial equipment is quite reliable, requires less initial investment (compared to MIL-STD equipment), and provides low-cost software packages and software support. In general, maintenance has not posed serious problems.

CONCLUSIONS

These findings indicate that the potential of commercial ADP equipment can be successfully exploited by the Navy in many nontactical roles aboard ship. The basic recommendation of the TD is that further analyses, utilizing the study results as a point of departure, are required. Further analyses should include a definitive life-cycle cost analysis to determine the full impact upon the Navy in employing commercial ADP equipment aboard ship.

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1.0 INTRODUCTION

1.1 OBJECTIVE

The objective of this study was to determine to what extent commercial automatic data processing (ADP) equipment and associated peripherals are being successfully used in shipboard ocean environments. The use of commercial ADP equipment allows the following advantages: (1) newer technology aboard ships in the near term, (2) the use of standard software support packages, and (3) lower initial system costs. However, these advantages must be traded off versus the true life-cycle costs of the commercial ADP equipment. This study does not address these trade-offs, but rather takes an overview at the experience of various ocean platform users (Navy and civilian) of this equipment. This is the first step in an overall feasibility analysis. It is designed to enable the Navy to either rule out the use of commercial ADP equipment, or to determine that there are definite benefits to be gained and that further analyses are warranted.

1.2 PURPOSE

The purpose of this study was to document the amount of use and the effectiveness of commercial ADP equipment aboard ships. This data, when coupled with trade-off studies, should enable valid decisions or recommendations to be made regarding the practicality of employing such equipment aboard US Navy ships for Operational Readiness Monitoring System (ORMS) uses, or other shipboard nontactical applications. This study was performed as part of the ORMS Project at the Naval Ocean Systems Center (NOSC).

1.3 SCOPE

The data contained in this document was gathered over a five-month period. The commercial equipments examined include computers and computer peripherals (e.g., printers, video display terminals, digital storage devices, data loggers, data acquisition units). Of prime interest was equipment designed for fixed shore usage that was being used aboard oceangoing vessels.

As in any study, the scope has been constrained by available time and money, thereby limiting the number of shipboard/ocean platforms and commercial ADP systems examined. However, the representative sampling used here is large enough for the key facts to be distinguished.

The following user classes were examined in the study:

- US Navy ships
- US Coast Guard ships
- Maritime ships, domestic and foreign
- Oceanographic and hydrographic research ships/platforms

Commercial ADP equipment utilized by the user classes for the following applications was particularly scrutinized:

- Training
- Personnel
- Logistics
- Maintenance
- Equipment monitoring and testing
- Navigation
- Scientific data processing

The factors examined to evaluate successful applications included:

- Availability and reliability (mean time between failure MTBF, mean time to repair MTTR, etc.)
- Maintenance requirements
- Duty cycle
- Ruggedization/mounting
- Environment
- Environmental modifications
- Logistics support

1.4 ORMS BACKGROUND

To effectively assess the readiness of today's complex ships, summary-type, command-oriented data must be available. This data must be presented in real time and must reflect the current condition of the ship's resources and environment. In addition, the functions of automation of testing; monitoring; data transmission; information presentation; and filing/reporting, presently performed manually, must be considered for the application of automation. Comprehensive and summarized data on the ship's resources must be made available where required. ORMS (refs 1 through 5) is a concept for a data system to meet these information requirements.

ORMS is a system for automatically acquiring, processing, and presenting operational-readiness data to shipboard command at various watch stations. It will provide comprehensive and continuous monitoring of all ship systems, with data transfer to a distributed data reduction and display processing system (fig 1).

---

1. NELC TN 3027: A distributed Microprocessor Architecture for the Operational Readiness Monitoring System (ORMS), by DC Eddington and D Harrison, Unclassified, 11 August 1975.
2. NELC TN 3065: Operational Readiness Monitoring System (ORMS), Monitor Requirements Analysis, by BB Briant and RJ Sullivan, Unclassified, 10 November 1975.
3. NELC TN 3158: Operational Readiness Monitoring System (ORMS) Test Bed Functional Description, by DD Hall and AC MacMurray, Unclassified, 17 May 1976.
4. NELC TN 3162: Operational Readiness Monitoring System (ORMS) Effectiveness Study, by JG Kammerer and AC MacMurray, Unclassified, 15 May 1976.
5. TECHNICAL REPORT: Conceptual Design and Interface Requirements of ORMS/ORTS Applied to a SEAMOD Frigate, by RCA/Government Systems Division, Unclassified, 2 June 1978.

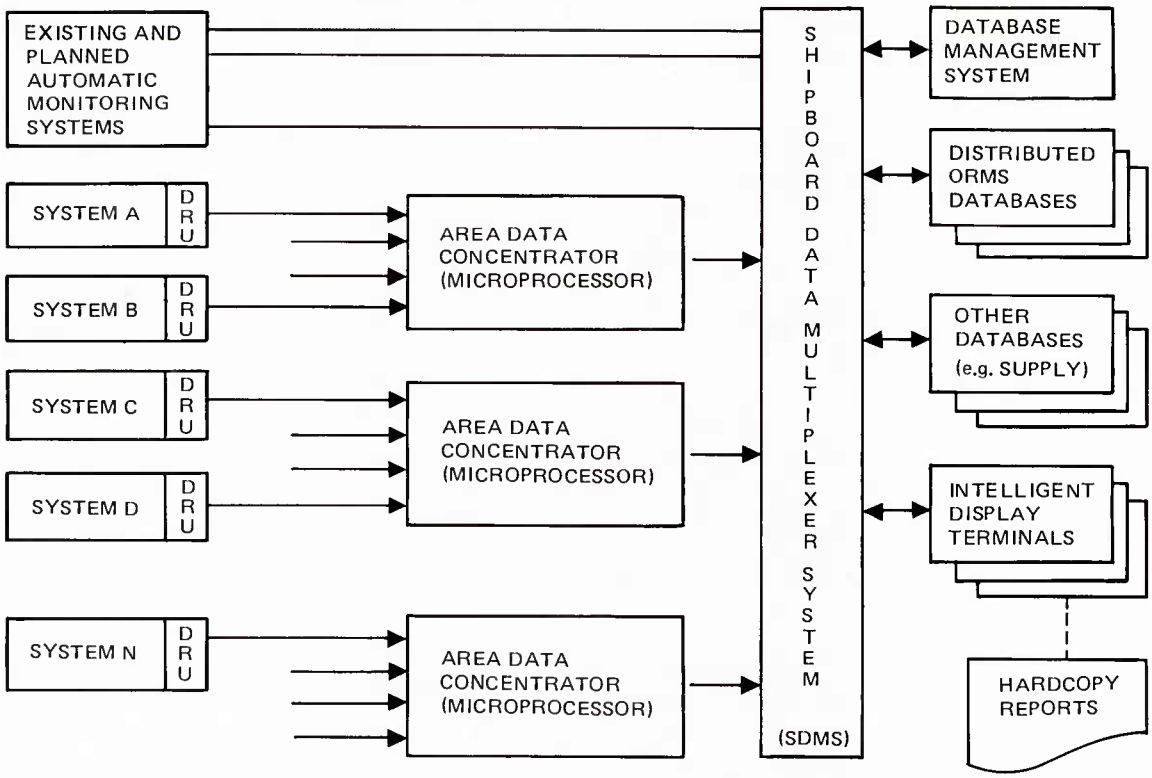

Figure 1. ORMS system concept.

ORMS has the following performance objectives:

(a) Subsystem Readiness

- Provide subsystem status monitoring
- Determine operability and performance capability

(b) Mission Readiness

- Determine system and mission performance capability

(c) Personnel Readiness

- Provide centralized training interface
- Schedule and evaluate individual, team, and multiunit training

(d) System Test and Evaluation

- Schedule and evaluate all testing
- Schedule maintenance activities

(e) Configuration Management

- Display casualty reconfiguration alternatives
- Display repair and recovery status

The ORMS project was initially funded by the Naval Material Command (NAVMAT) and Naval Sea Systems Command (NAVSEA) in February 1975. It is presently an exploratory development project under the management of NAVSEA, with NOSC providing technical support as required in the areas of system engineering and analysis, operations analysis, human factors, test and evaluation, etc. The project is scheduled for transition to the advanced development stage in fiscal year 1980 (FY 80).

1.5 METHODOLOGY

To implement this study, the definition of specific research tasks and their interrelationships was necessary. Figure 2 is an overview of the investigative methodology that was adhered to throughout the performance of this study. The basic principles of the investigation are discussed below.

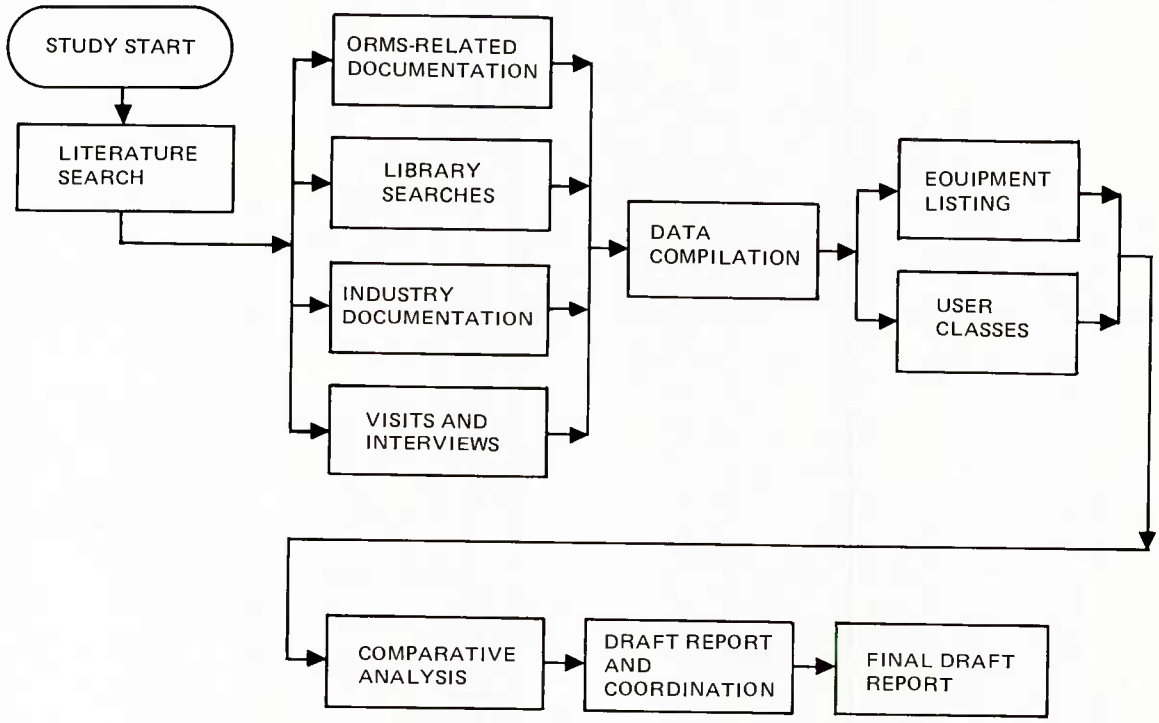

Figure 2. Study methodology.

1.5.1 Literature Search

The initial step of this investigation was to gather enough information to enable the examination of commercial ADP equipment used in the ocean environment. This required, initially, an extensive investigation of available library information to identify further data sources. Examination of ORMS-related documentation and the NOSC library revealed initial identification of possible sources of information to support this study. Other libraries visited and researched in the San Diego area were:

- San Diego State University (SDSU)
- Scripps Institution of Oceanography
- University of California at San Diego (UCSD)

1.5.1.1 ORMS-RELATED DOCUMENTATION. The ORMS project files provided an initial set of 15 documents. A listing of these documents is provided in Volume II, bibliography. This information established the baseline for the initiation of the literature search.

1.5.1.2 LIBRARY RESEARCH. The information obtained from the library searches identified manufacturers of commercial digital/ADP equipment being employed in the ocean environment. This information led to points of contact to obtain the required data. The organizations contacted are listed in table 1 along with their responses to requests for information.

Table 1. Industrial organizations contacted during investigation.

ORGANIZATION	INFORMATION RECEIVED AND REMARKS
Control Data Corporation (CDC), San Diego CA	Visited to discuss the commercial equipment employed aboard the USS KITTY HAWK during the OUTLAW HAWK test at sea. Performance was judged to be excellent. (For more information on OUTLAW HAWK, see section 2.)
Bunker-Ramo Corporation, Westlake Village CA	Received information on the AN/GYQ-21(V) (PDP-11 series central processing unit [CPU] plus peripherals) being employed on various mobile platforms.
Plessy Environmental Systems, San Diego CA	Forwarded material for use on the day contacted; received information on oceanographic survey equipment.
Cubic Western Data, San Diego CA	Received information on July 17, 1978 regarding position location, navigational support, and stationkeeping equipment.
Kent Navigation Systems, San Diego CA	Received information on July 17, 1978 which included • Oceanographic survey equipment • Navigation data processing equipment
Honeywell Commercial Marine Operations, Seattle WA	Contacted July 14, 1978; received information on July 17, 1978 which included • Position location equipment • Navigation support equipment • Stationkeeping
Motorola Position Determining Systems, San Diego CA	Contacted July 14, 1978; received information on July 17, 1978. Position location equipment for ships, aircraft, and vehicles.
Hydro Products, San Diego CA	Contacted July 14, 1978; received information on July 18, 1978 pertaining to oceanographic survey equipment.
Hewlett-Packard (HP), San Francisco CA	Contacted July 24, 1978; received standard equipment descriptions in 1 week.
Digital Equipment	Contacted July 24, 1978; material received on July 28, 1978 included a listing of DEC ADPE.

1.5.1.3 INDUSTRIAL LITERATURE. Upon receipt of the information from the firms contacted, the data was evaluated and compiled. This compilation led to the creation of a format to identify various commercial capabilities that are being employed in the ocean environment and their possible naval applications. The details of the evaluation/compilation are presented in Volume II, appendix F.

1.5.2 Field Visits

To examine applications of commercial ADP equipment in the ocean environment, several ships were visited to obtain first-hand information. Other visits were also made to institutes and universities, as well as commercial field offices, to secure further information pertinent to this effort. The visits made were as follows:

1. USS GRIDLEY (CG 21), Long Beach Naval Shipyard, Long Beach CA
2. USS KITTY HAWK (CV 63), North Island Naval Air Station, San Diego CA
3. USCGC GLACIER, Long Beach CA
4. USCGC POLAR SEA, Seattle WA
5. Naval Oceanographic Office (NAVOCEANO), Bay St. Louis MS
6. Scripps Institution of Oceanography, San Diego CA
7. University of California at San Diego CA
8. San Diego State University, San Diego CA
9. Field Office, Digital Equipment Corporation, San Diego CA
10. Field Office, Wang Laboratories Corporation, San Diego CA
11. Field Office, Control Data Corporation, San Diego CA

In addition the following contacts were made at NOSC or via telephone:

12. NOSC OUTLAW HAWK Project Manager
13. Naval Aviation Logistics Center (NALC), Patuxent River MD
14. Harris Corporation, PRD Electronics, Syosset NY

Details of the results of these visits/contacts are presented in the following section.

2.0 STUDY FINDINGS

Visits and contacts with commercial vendors, as well as discussions with shipboard users, have revealed that commercial ADP equipment can be employed in an ocean environment to advantage. This advantage lies in the fact that commercial ADP hardware/software can be obtained off-the-shelf to perform various shipboard functions. It was determined, as the investigation progressed, that the employment of data processing provided the following capabilities:

- Logistic support for recordkeeping and cost accounting
- Personnel recordkeeping
- Navigational support
- Collision-avoidance support in congested waters
- Training support for the ship's complement
- Monitoring of critical equipment
- Force status reporting
- Operational planning support

The list of employment goes on, and the use of commercial ADP equipment in the ocean environment is an approach that has potentially large cost benefits for the Navy. The major question related to the employment of this equipment aboard US Navy ships is, what are the life-cycle costs of commercial versus military ADP equipment?

Some other areas to be further defined are as follows:

1. What are operational support needs?
2. What are the interrelationships of functions that can be supported by commercial ADP equipment aboard ship?
3. What are the interface requirements aboard ship that fulfill operational readiness support requirements?
4. What is the life-cycle cost of commercial ADP equipment aboard ship?

2.1 INVESTIGATION BASELINE

Using the literature search, a set of guidelines was established to further the investigation. These fell into the following major categories:

- Shipboard employment to provide information needed to determine overall operational readiness
- Navigational and engineering support functions
- Maintenance and supply support requirements

2.2 USER CLASSES EXAMINED

In the performance of this study as many platforms as possible were examined that employ commercial ADP equipment in the ocean environment. The information collected was compiled and listed by the following categories of user:

A. Naval ships
B. Coast Guard ships
C. Oceanographic ships
D. Commercial shipping
E. Other military platforms

Table 2 presents a summary of information collected from user classes during the study.

Table 2. Activity summary of information collection.

COMMAND/ ORGANIZATION CONTACTED	VISIT/INTERVIEW/DATA COLLECTION RESULTS	AMPLIFYING REMARKS
1. US Naval Ships a. USS GRIDLEY (CG 21), Long Beach Naval Shipyard, Long Beach CA	Extensive experience in use of commercial ADP equipment aboard ship. Employment of equipment is most favorable. Employment is in a nontactical administrative role aboard ship. Old system, which is to be replaced to provide for a system to have an ever greater role aboard ship consists of: • NOVA 1200 computer • Diablo disk system • Data General tape unit (2) • Teletype • Dataproducts line printer (2) • Mohawk card reader • Infoton video terminals (4)	System had been dismantled at time of visit. A new system consisting of basically DEC equipment (PDP 11/60) and peripherals will be installed. This system is currently van-mounted and has been driven to and from San Diego, Long Beach, and China Lake with no reliability problems.
b. USS KITTY HAWK (CV 63), North Island Naval Air Station (NAS), San Diego CA	Commercial ADP equipment has been in use aboard the KITTY HAWK for approximately 1½ years in the LINDA system. The system has performed extremely well with little downtime. The system in use is basically a DEC configuration consisting of the following:	The commercial ADP system has, in the opinion of the ship's ADP officer, performed better than the military standard (MIL-STD) equipment in its availability, reliability, and maintainability. When at sea, there are

Table 2. (Cont).

COMMAND/ ORGANIZATION CONTACTED	VISIT/INTERVIEW/DATA COLLECTION RESULTS	AMPLIFYING REMARKS
USS KITTY HAWK (Cont)	• PDP 11-34 computer • DH 11 serial interface • DEC RK 05 disk controller • DEC RK 05 disk • DEC hardcopy terminals • 16 ADM-3 cathode-ray tube (CRT) terminals	at least 20 jobs running on the system simultaneously. When in port, there are 5-8 jobs being performed at the same time. The basic software package for system support is RSX-11D. It was also learned that the Wang 2200 system was being employed in support of the "air boss" aboard ship. For further details, see 2.b below.
2. Other US Navy Commands/Activities		
a. NAVOCEANO Laboratory, National Space Technological Laboratories, Bay St. Louis MS	Extensive experience in the use of commercial ADP equipment aboard ship. The shipboard systems are used primarily as data collectors for subsequent reduction at the lab. The employment of the equipment is most favorable. The current basic configuration, Bathymetric Survey System (BASS), consists of the following: • HP 2100 computer • Calcomp plotter 936 • GE Terminet 300 • HP 2895A punch • Calcomp plotter 502 • HP 7900A disk • HP 2748B tape reader • North Atlantic 546/20 B/D converters • Line printer • Input/output (I/O) terminal	The operating schedule of the USNS BENT and WYMAN did not permit a visit on board. However, a duplicate BASS was in the lab, and a tour was made of the installation. The major difference was the use of the DEC PDP 11/9 computer, which was previously used aboard ship with a great deal of success. The GE Terminet was considered the most unreliable part of the system.
b. Comander Naval Air Pacific (COMNAVAIRPAC) North Island NAS, San Diego CA	It was found, via interview with CDR Harshberger, that a Wang 2200 system was being used on all carriers. The unmodified commercial system has been performing reliably with no major problems being reported. The equipment, basically, is being employed as an aircraft status "tote board" to launch, retrieve, etc., and to support operational planning.	

Table 2. (Cont).

COMMAND/ ORGANIZATION CONTACTED	VISIT/INTERVIEW/DATA COLLECTION RESULTS	AMPLIFYING REMARKS
c. Command Naval Surface Pacific (COMNAVSURF-PAC), Coronado CA	Commercial Wang equipment is being employed aboard most DDG, FFG, and LHA ship classes of the Pacific Fleet. The equipment is being used in a non-tactical support role, primarily oriented to supply function requisition tracking, and spare parts accounting. The equipment has performed well and has proven to be most reliable.	The employment role of this commercial ADP equipment aboard these surface ships can be found in detail in a thesis presented to the faculty of SDSU, a copy of which was provided and is included (in part) in appendix D.
d. NALC, Patuxent River NAS MD and Harris Corporation, PRD Electronics, Syosset NY	Contacted both NALC and PRD regarding the Status Inventory Data Management System (SIDMS) presently aboard the USS JOHN F KENNEDY (CV 67). The system has been aboard since 1976 and is primarily a logistics and maintenance tool to service the Aircraft Intermediate Maintenance Department (AIMD) with extensive interface with the Supply Department. The system was developed by PRD under the direction of NALC and consists of the following equipment: 1 CPU – Varian 76 2 Disk drivers/controllers – Calcomp (46 Mbytes) 2 Tape drives – PERTEC 1 Card reader – Documation 1 Printer – Centronics (100 char/sec) 2 Thermal printers – HP 1 Teletype terminal – RO 35 14 Teletype terminals – RO 33 32 CRT terminals – ADDS 980 Over 27,000 feet of shielded twisted pair cable was used to connect the 32 CRT terminals (9600 baud on short runs, 4800 baud on longer), that were located all over five different deck levels. CDR Bolinger of NALC reports that the availability of the hardware has been truly outstanding (about 95 percent) considering that it is in use 24 hours/day and is generally located in spaces with unfavorable environment.	Latest cruise report of the USS JOHN F KENNEDY will be available in February 1979. The first cruise was not very successful as far as SIDMS software was concerned; the software package did not perform as advertised. This has been corrected. The only major hardware failures were 2 head crashes in 2 years.

Table 2. (Cont).

COMMAND/ ORGANIZATION CONTACTED	VISIT/INTERVIEW/DATA COLLECTION RESULTS	AMPLIFYING REMARKS
e. NOSC, San Diego CA	Contacted Mr J Grant, NOSC manager of the OUTLAW HAWK project. OUTLAW HAWK was a system that was aboard the USS KITTY HAWK (CV 63) during 1974-1975 for the overall evaluation of ship/shore interaction. The system provided for the real-time input, processing, correlation, and display of multi-source data ashore, with the results transmitted to the USS KITTY HAWK for correlation with shipboard data and display to the Flag. The Flag Command and Correlation Facility (FCCF) was made up of commercial equipment interfaced, where appropriate, with existing shipboard Government Furnished Equipment (GFE) such as the Naval Tactical Data System (NTDS) and communications systems. A listing follows. 1 CPU – CDC 1784-2 1 CPU – Microdata Reality 1 Disk system – CDC cartridge type (4.4 Mwords) 2 Disk systems – Microdata 2 Tape drives/controller – CDC 1 Line printer – Microdata 2 CRT terminals/keyboard – ADDS 6 TV monitors – CONRAC 1 Hardcopy device – CDC (525 lines) 1 Hardcopy device – CDC (1029 lines) 1 Line printer – CDC 1 Large group display system – GE 2 CRT terminals with fixed function keyboards and typewriter keyboards – PEP 801 6 CRT terminals with typewriter keyboards – Hazeltine 2000 1 Flatbed plotter – Wang	The OUTLAW HAWK FCCF performed the following functions: • Provided integrated war-room display of all information sources available to Flag. • Near real-time correlation of ocean surveillance information from shipboard sensors and the shore-based Multi-source Correlation Facility (MSCF) at Sunnyvale CA. • Demonstrated and evaluated a Flag decision oriented integrated tactical information processing system composed entirely of commercial ADP and associated peripherals. Commercial ADP equipment performed excellently over the period of deployment (approximately 6 months) and also during the major at-sea multi-nation RIMPAC '75 exercise. Hardware reliability was outstanding.
3. US Coast Guard Ships a. USCGC GLACIER, Long Beach Naval Shipyard, Long Beach CA	The GLACIER is an icebreaker with extensive experience in the use of commercial ADP equipment. The performance of the equipment was considered to be unsatisfactory. The three computers aboard were	The systems, at the time of the visit, had been dismantled and placed ashore. The user stated that he was to receive a new system but did not know the make or model. He

Table 2. (Cont).

COMMAND/ ORGANIZATION CONTACTED	VISIT/INTERVIEW/DATA COLLECTION RESULTS	AMPLIFYING REMARKS
USCGC GLACIER (Cont.)	used to support navigation and wet lab research. The systems are as follows: • Navigation – 2 Honeywell 516 computers and 1 Tektronix I/O terminal • Wet lab – 1 Honeywell 516 and a card punch/reader	recommended a visit to either the USCGC POLAR STAR or POLAR SEA, which are newer automated icebreakers. Subsequent discussions with POLAR SEA personnel, regarding the GLACIER's commercial ADP equipment problems, indicated that improper maintenance could have been a key contributing factor.
b. USCGC POLAR SEA, Todd Shipyard, Seattle WA	The POLAR SEA is a fully automated ship using commercial ADP equipment to perform the following: • Navigation support • Collision-avoidance support • Critical equipment monitoring support The data processing equipment being used to perform the foregoing was the Honeywell 516 computer, the SPERRY UNIVAC 16/40, and a General Automation system. The details of application can be found in appendix E of this study.	Personnel interviewed were most enthusiastic about the capabilities of the hardware to perform many watchkeeping functions, also, the reduction of many manually produced reports required for resupply, etc. The reliability of the equipment is excellent, and no major problems have been encountered.
4. Commercial ADP Equipment Field Offices		
a. CDC, San Diego CA	CDC has supplied its 1784-2 computer as the central processing unit for the OUTLAW HAWK FCCF aboard the USS KITTY HAWK. CDC reported that the system performed well at sea.	During the visit, the field representative stated that the CDC 1784-2 had been replaced with the CDC Cyber 18 series. For more details, refer to 2.e of this table.
b. Wang Laboratories, Inc., San Diego CA	Wang is supplying its 2200 system to the Navy. The field office did not have a listing of where and on what ships the equipment was being employed. When questioned about its performance record, the unofficial feedback was that the Wang equipment had been highly reliable in its use by the Navy.	One of the systems was located in World War II wooden barracks on Point Loma at NOSC, and in a non-airconditioned room. The windows are left open, which exposes the system to salt air and fog. When the users of the system were queried about the system's performance, they had only the

Table 2. (Cont).

COMMAND/ ORGANIZATION CONTACTED	VISIT/INTERVIEW/DATA COLLECTION RESULTS	AMPLIFYING REMARKS
Wang (Cont.)		highest praise. The one major complaint was not about the system but rather problems with commercial power variations.
c. DEC, San Diego CA	The field representative stated that he knew that DEC equipment was being employed by the Navy but didn't know in what capacity or role.	DEC equipment will be employed aboard the USS GRIDLEY (CG-21). See paragraph 2.2.1.1 of this study for details.
5. Institutions Visited		
a. Scrips Institution of Oceanography, La Jolla CA	Scrips has had extensive experience in the use of commercial ADP equipment aboard ship (more than 10 years). The employment of equipment is most favorable. The system is utilized for navigation and wet lab support and consists of the following: • IBM 1800S computer • Tektronix terminal • Drum, disks, card reader, line printer (IBM) • Calcomp plotter	The two Scripps' ships were out to sea. A duplicate system was available at the institute, which is exposed to the ocean environment. The system is still in use, and there are no immediate plans for replacement.
b. UCSD	No direct experience, or ADP oriented toward oceanography.	Extensive library search performed. Some limited information on possible contacts.
c. SDSU	No direct experience, or ADP oriented toward oceanography.	Extensive library search performed. Some limited information on possible contacts.

2.2.1 Naval Ships Visited

Visits were made to the USS GRIDLEY (CG 21) and the USS KITTY HAWK (CV 63) during the investigative effort. The findings of these visits are also presented in table 2.

2.2.1.1 USS GRIDLEY (CG 21). The commercial equipment that had previously been employed was centered around the NOVA 1200 with other commercial support peripherals. The equipment was used successfully aboard ship with little downtime because of part deterioration. The users aboard ship were enthusiastic about the equipment capability and reported that its reliability/availability was at maximum during its use at sea. The equipment's performance history is included in appendix A of this report. The current

system (NOVA 1200 and associated peripherals) will be replaced by DEC commercial equipment when overhaul of the GRIDLEY is completed. The system will consist of the PDP 11/60, DEC disks, card punch/reader, magnetic tape unit, and line printer. I/O stations will consist of 10 CRT displays (ADDS and ADM-3, 5 each) with keyboards, which will be interfaced with the computer facility and will share the compartment with the ship's Electronic Warfare (EW) positions. A mark-sense optical reader will also be used for test-scoring inputs. The support functional role of this system will fall within the following general categories of activity:

- File management information retrieval
- Personnel administration
- Training administration
- Operations planning support
- Logistics support
- Recreation games

The new system, consisting primarily of DEC equipment, is currently being used in a mobile van for training purposes. This is being performed to instruct shipboard personnel in the use of the equipment to support their responsibilities once the ship is at sea. The equipment mounted in the van has been driven within California between San Diego, Long Beach, and China Lake several times with no apparent equipment problems. The new system will be utilized to support those functional jobs, enumerated above, aboard ship when the USS GRIDLEY puts to sea. In discussion with CPO Pharr it was learned that, once the installation aboard ship was completed, its support role would be expanded to provide more timely and useful information upon which the commander can make decisions. A true physical layout of the equipment with subscriber stations is not presently available.

2.2.1.2 USS KITTY HAWK (CV 63). Arrangements were made to visit the USS KITTY HAWK while in port at San Diego. The visit was made on 6 November 1978, where the investigators were provided an extensive briefing on the use of the DEC PDP 11/34 and associated peripherals. The system has proven to be highly reliable with no major down-time problems at sea. The biggest problem area is with the I/O stations (ADM-3), which fail because of minor parts (such as resistors, capacitors, etc.) which can be easily replaced and immediately restore the station to operational use. The major concern here is the ability to obtain the necessary replacement parts, which are not within the current logistic pipeline for replenishment purposes. Other than these difficulties, the commercial system has been performing extremely well. The system is being used in an operation support role, which is not directly linked to the tactical command and control system. (The system configuration is contained in appendix B of this report.) A monthly performance status report is submitted to the Naval Weapons Center (NAVWPNCEN), China Lake. This report identifies any specific trouble areas, corrective action taken, and the system's availability during the reporting period. As can be seen from the information extracted from wage reports (in terminal hours) for 1978, the trend has identified a steady increase in the use of the system.

5,522 terminal-hours - May
6,277 terminal-hours - June
6,988 terminal-hours - July
7,694 terminal-hours - August
8,032 terminal-hours - September
8,567 terminal-hours - October

The PDP 11/34 processing system is not hard-mounted or shock-mounted. The computer, disk controller, and disk packs stand on lockable rollers and, through adjustment, can be lowered onto rollers and moved about the compartment. During periods of heavy seas, the system is secured by lashing the cabinets to a bulkhead. The system, as currently installed, services the following stations aboard the USS KITTY HAWK with CRT consoles:

2 CRT Pri-Fly
1 CRT Flight deck
2 CRT Air operations
2 CRT AIMD Ship 7
1 CRT Bridge
1 CRT Electronic Maintenance Officer (EMO)
1 CRT Weapons controls room
1 CRT Engineering
1 CRT Strike operations
1 CRT Dental compartment
1 CRT System control
2 CRT Spares

2.2.2 Naval Commands Visited

To gather additional information, visits were made to other Navy commands: NAVOCEANO, COMNAVAIRPAC, and COMNAVSURFPAC. The results of these visits are presented below.

2.2.2.1 NAVOCEANO. The visit to NAVOCEANO provided sufficient information to verify the use of commercial ADP equipment being employed aboard these ships. The equipment is being employed in three roles:

- Navigational accurcy support
- Oceanographic survey data collection
- Critical shipboard equipment monitoring

The latter use signifies the practicality of applying automation to the critical equipment aboard ship. The equipment has proven to be reliable and provides the required data for analytical reduction. The equipment is mounted over the engine room, which subjects the installation to considerable vibration. It was found that this equipment was initially hard-mounted but later shock-mounted to overcome vibration problems. The configurations being employed by NAVOCEANO are presented in appendix C of this report.

The two systems utilized by the NAVOCEANO ship centered around the PDP 11/9 (an old piece of equipment) and the HP 2100 systems. The two systems, BASS and BOTOSS (Bottom Topographic Survey System), collected data and duplicated the data on magnetic tape units for shipment back to the laboratory for reduction.

The scheduled maintenance approach has caused more failures than those caused during continuous use. It was learned that "better left alone" was a better philosophy than that of satisfying a maintenance schedule. Repairs are now made when a failure occurs with some routine maintenance accomplished when in port.

One of the critical factors of system availability was the training qualifications of maintenance personnel. It was determined that experience in the repair of the system was the best factor. Whenever a system is experiencing a failure, a technician (civilian) is dispatched to rectify the problem. Data System specialist (DS) personnel are so "short lived" aboard ship that they cannot become fully acquainted with the commercial documentation. This problem of training could impact seriously upon future employment of commercial ADP systems aboard ship.

The ship's electrical power proved to be a major problem in employing the commercial system; the constant surges and drops would put the system out of operation. Once the problem was isolated, and a special power supply was installed, the failures were overcome.

2.2.2.2 COMNAVAIRPAC. A visit and interview were held at this command which was employing shipboard commercial ADP equipment in a nontactical role. The personnel interviewed included CDR Harshberger, who had the operational responsibility of launching and retrieving aircraft as well as answering the commander's operational readiness questions. The Wang commercial system performed well when at sea and in port. It displayed to the operations officer the required information upon which a decision could be made. The support provided by this commercial ADP system, for aircraft operational commitment and retrieval, was applied with success for the following general purposes:

- Aircraft availability
- Ordnance loading availability
- Aircraft maintenance needs
- Determining location of aircraft for strike/retrieval purposes
- Determining the turnaround time of delivery systems aboard these aircraft.

The support role of commercial ADP equipment, in providing this information to the ship's complement and commanding officer while at sea, has been most successful.

2.2.2.3 COMNAVSURFPAC. Commercial ADP systems have been successfully used by SURFPAC ships. Mr PW Sutton was most enthusiastic about the extensive supporting role this equipment has played. Aboard a DDG and LHA, the systems were employed in a logistical support function that saved many man-hours in requisitioning, tracking, and accounting. Cost figures in savings are presented in appendix D of this report. The primary emphasis in the application of commercial equipment was to support supply, resupply, and pipeline status of requisitioned parts and other essential material.

2.2.3 Coast Guard Ships

Two Coast Guard ships (both icebreakers), USCGCs GLACIER and POLAR SEA, were visited during the investigation to obtain additional information on other applications of shipboard commercial ADP equipment.

2.2.3.1 USCGC GLACIER. A visit was made during September 1978 to discuss the use of commercial ADP and to determine their amount of experience in the use of such capabilities. Three systems have been employed onboard the GLACIER for approximately five years and are used to support navigation requirements and scientific research jobs in the ship's wet lab; the data processing requirements are performed on the Honeywell 516 computer. Upon

arrival at the ship, the systems had been dismounted and placed ashore. However, the data processing supervisor was available for discussion. When queried about the reliability/availability of the equipment at sea, he flatly stated that the computer was utterly unreliable and required constant maintenance to keep it operational. The computer in the Oceanographic Research Laboratory (wet lab) was also considered unreliable. It was originally installed to support scientists in performing their oceanographic/hydrographic research work. Because of computer unreliability, scientists coming aboard refused to use the capability and would bring aboard their own system for use. When asked if there was a reliability/maintainability report available, the answer was negative in that a requirement for such a report had never been stated. The Honeywell 516 computer was linked to several I/O stations utilizing the Hazeltine 2000. These were also unreliable and required continual attention to keep them running. When questioned about the ship's vibration effects upon the system, the user stated that the system had originally been shock-mounted but after a period of time the shock mounts were removed and the equipment hard-mounted to the deck; by doing this the problem was somewhat relieved. A new system was to be installed aboard the GLACIER prior to its departure to the Antartic in early November. A follow-up call to the Coast Guard revealed that the Honeywell 516 system was reinstalled and is being used on this deployment.

2.2.3.2 USCGC POLAR SEA. This ship was in dry dock to be refitted with new propellers; the old ones had been damaged during its last cruise. During the visit, the ship's personnel were most cooperative and provided a wealth of information about the reliability/availability of the ADP being employed aboard ship. The bridge, engine room, and navigational system are fully supported by commercial ADP equipment, which performed well in both the Arctic and Antarctic environments. Direct engine room watchkeeping has, for all practical purposes, been eliminated. The sensor system tied to the computer provides any indication of an impending failure or an item that must be looked into at the first opportunity. The applications of commercial ADP equipment aboard this ship were as follows:

- Navigational support output to the bridge
- Collision-avoidance output to the bridge by presenting the target's heading, speed, course, and where it will be in relation to time of warning
- Engine room performance and status to provide the information needed to perform the mission

Presented in figures 3 and 4 are examples of how the various commercial ADP capabilities are being applied aboard the POLAR SEA. The maximum shutdown experienced for equipment repair was 2 hours (to return a system to full operating capability). A new support system has been received and installed to support the navigation support requirements (a SPERRY UNIVAC 16/40). Since the equipment is new and has not been employed at sea, no reliability/maintainability information is available at present. However, system test and checkout while in drydock has indicated that it can perform the functional task in its support role. Training of personnel, to maintain and operate the systems being employed, is accomplished on-the-job.

2.2.4 Commercial Field Offices

To augment the commercial ADP literature obtained through the mail, several field offices were visited. The offices were most cooperative in their responses to requests for information. Information was provided during the visits and was compiled and added to the data sheets contained in appendix G.

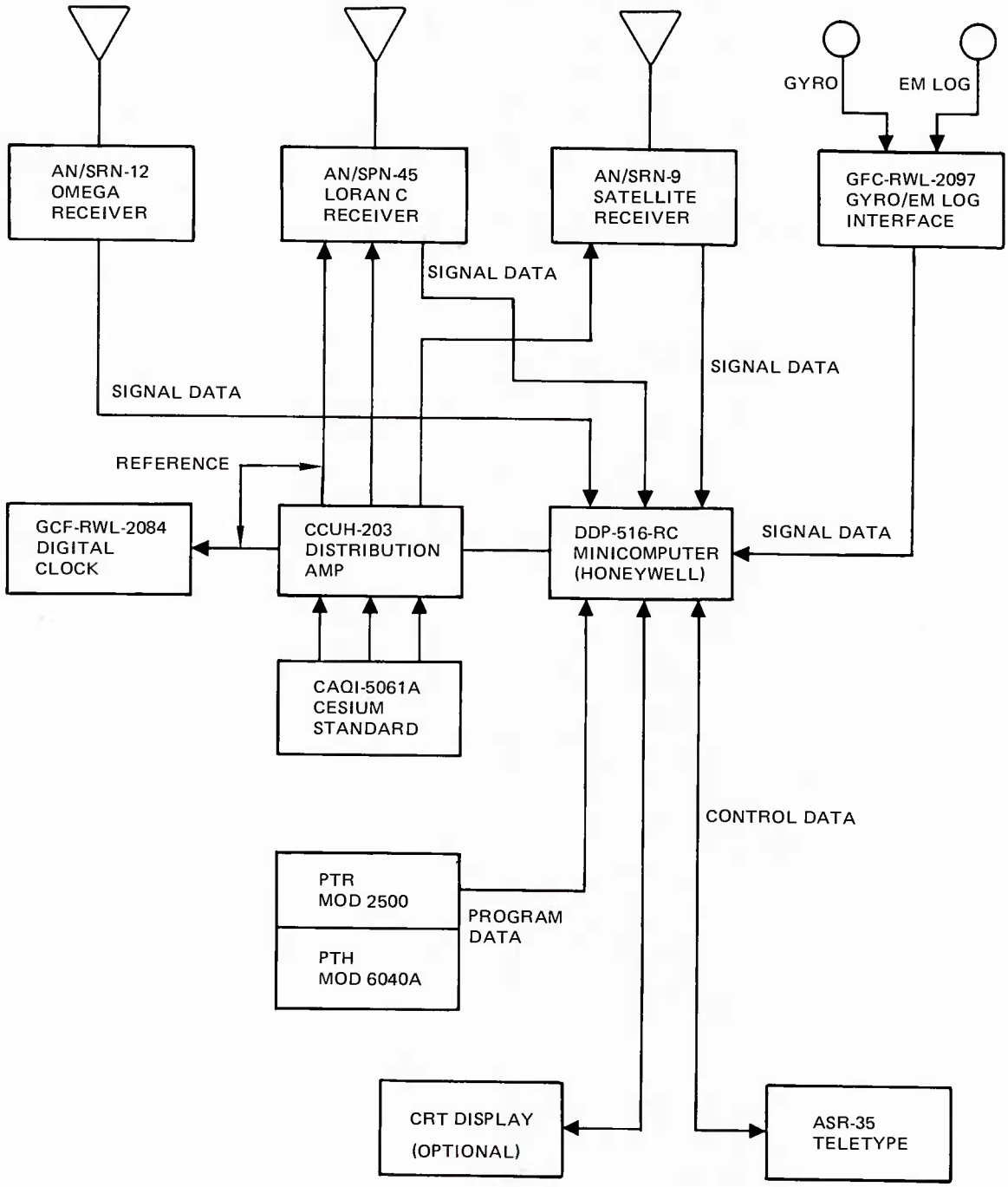

Figure 3. Precise navigation block diagram.

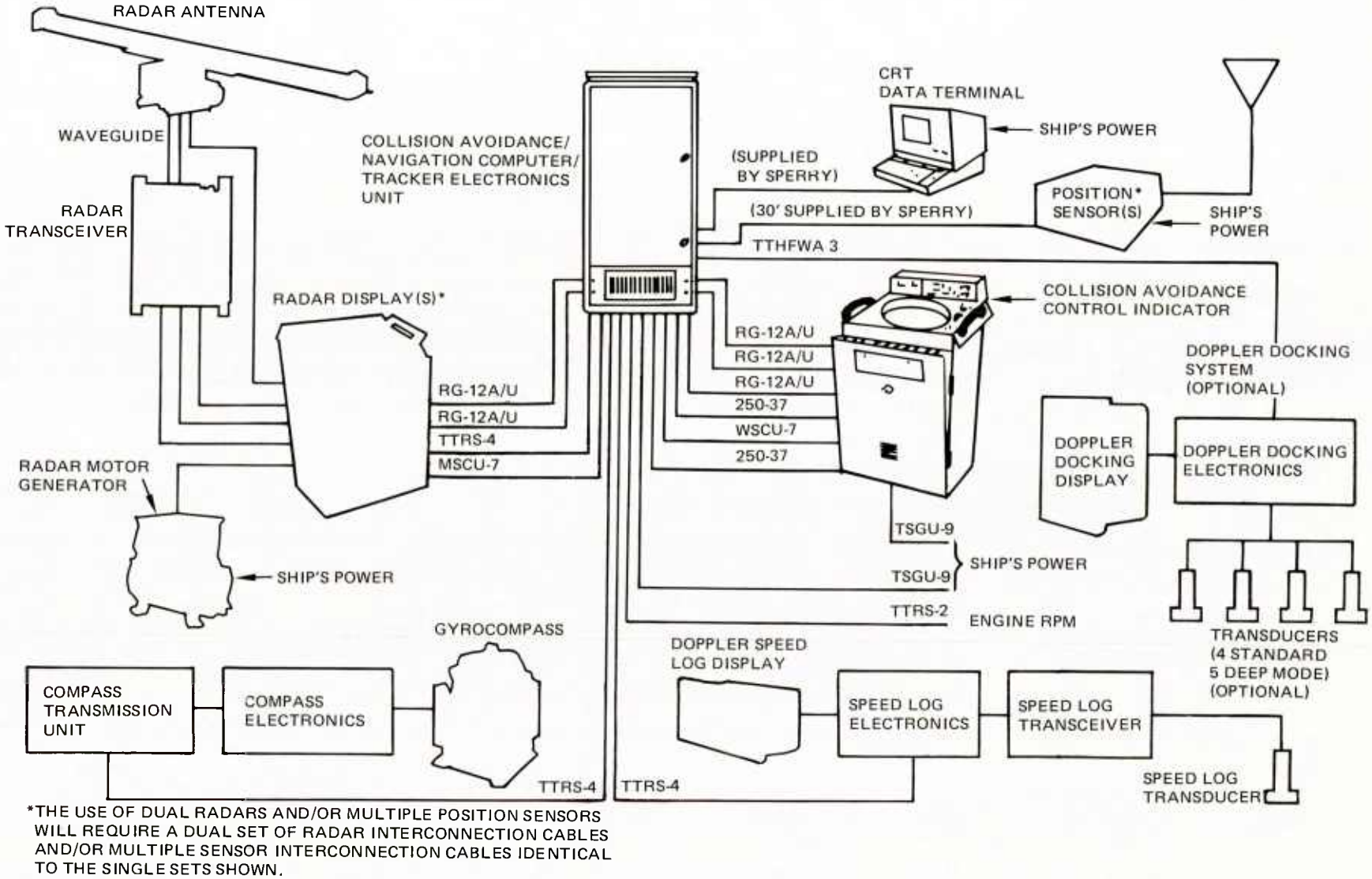

Figure 4. Equipment configuration, integrated navigation and collision-avoidance system.

The offices visited during the study were as follows:

Control Data Corp., San Diego CA
Wang Laboratories, Inc., San Diego CA
Digital Equipment Corp., San Diego CA

2.2.5 Institutions

2.2.5.1 SCRIPPS INSTITUTION OF OCEANOGRAPHY. Unfortunately, the two Scripps ships employing commercial ADP systems onboard had to put to sea and would be away from home port for about 18 months. However, the use of such commercial equipment has been highly successful with only negligible problems. The institution has been using IBM equipment for the past decade. The commercial data processing equipment consists of the IBM 1800S computer with associated peripherals. Initially, the equipment was hard-mounted to the ship deck and vibration caused some problems. Once the equipment was shock-mounted, the maintenance and repair problem was, for all practical purposes, eliminated. The commercial ADP system aboard these ships is used in two major roles:

- Navigation support
- Onboard scientific research support

The equipment configurations being employed onboard the Scripps ships, and which are duplicated ashore at the institution, consist of the following:

IBM 1800 computer
IBM card reader
Calcomp flatbed plotter
CRT/with keyboards (Tektronix)
IBM line printer
IBM disk drive and disk packs
IBM magnetic drum (sealed)

A tour was conducted by Mr L Abbott of the Scripps Institution. He said the system was being used to train students prior to their being sent to one of the ships. The students are also trained in troubleshooting, to identify problems and effect proper corrective action. He also remarked that, "if one were to query the shore-based system, it would react as if it were still navigating a ship."

2.2.5.2 UNIVERSITY OF CALIFORNIA AT SAN DIEGO. Early in the study phase, an extensive library search was performed to identify possible documentation dealing with commercial ADP in the ocean environment, but the results were limited. However, the library search did lead to identification of possible contacts with industry to obtain information. These leads were later followed-up with some success.

2.2.5.3 SAN DIEGO STATE UNIVERSITY. The same pattern of activity used at UCSD was followed while visiting the SDSU library, and the information secured was added to the list of contacts to be made with various manufacturers.

2.2.6 Commercial Shipping

An early consideration was the investigation of commercial ADP equipment employed by commercial ships. Contact was initiated early in the investigation, with

manufacturers supplying information equipment specifically designed to support ocean commercial activities. A compilation of such commercial applications is presented in appendix F.

2.2.7 Other Military Platforms

Other military services have been successfully employing commercial ADP capabilities for R&D support for the past several years (reference appendix F, sheets 1 through 4). The platforms involved include aircraft, armored vehicles, and other surface transport.

2.3 GENERAL TASK OBSERVATIONS

During visits and interviews, the overall consensus was that commercial ADP has performed well in the ocean environment. It was apparent that the use of such commercial equipment aboard ship could play a vital role in supporting nontactical shipboard ADP applications such as ORMS. Some of the more salient observations follow.

2.3.1 Ship's Electrical Power

One of the biggest complaints about commercial ADP equipment failure aboard ship is not of the equipment itself, but rather the variation in the ship's electrical power. However, once this problem is isolated and corrective action taken, these difficulties become minimal causes of downtime.

2.3.2 Training

The training of personnel, training status, and record-keeping is another area where commercial ADP provides a major support capability aboard ship. This functional application is of vital concern to the operational readiness of a ship and in providing timely and useful operational planning support.

2.3.3 Software

Software support of commercial ADP equipment was not to be investigated as a part of this study. However, it became increasingly evident that this was a significant area of commercial ADP success. Those interviewed were consistent in their answers that off-the-shelf software packages were well suited to perform the functional tasks required. Overall, only small programming changes had to be made to satisfy functional requirements. The potential savings in the performance of nontactical support functions is an area that should be further exploited. Reference is made to appendix D.

2.3.4 Applications

There are many applications that can be reliably performed aboard ship by commercial ADP capabilities. Some of the most significant are discussed below.

2.3.4.1 NAVIGATIONAL SUPPORT. Reliable ADP performance is the important operational requirement of navigation support. Oceanographic ships, Coast Guard ships, and commercial ships have, for a considerable time, successfully employed commercial ADP equipment to provide this information to the ship's command.

2.3.4.2 COLLISION-AVOIDANCE SUPPORT. This has been of major concern to ship's commanders for many years, particularly in congested waters and during hours of reduced visibility. The commercial systems that can perform the essential task are many. For details concerning these capabilities, see appendices E and G.

2.3.4.3 SHIPBOARD EQUIPMENT MONITORING. One of the major areas of consideration is the possibility of automating the monitoring of critical shipboard equipment and providing the necessary alarms, to either the bridge or watchkeeper, of an impending failure. Such areas aboard ship, for example, are the ship's engine room, early warning radar, and navigational aids. Foreign as well as US commercial ships are employing commercial ADP monitoring techniques to enhance their overall capabilities and are realizing a cost saving through such implementation. Figure 5 is an example of how commercial ADP might be applied to perform this type of monitoring application. This illustration is not provided as a design application, but rather to serve as an example of how commercial equipment can be employed to efficiently perform this essential task.

2.3.4.4 ENTERTAINMENT. The use of commercial ADP equipment for entertainment is beneficial to the Navy and ship's morale. It familiarizes personnel in the use of the equipment and increases the proficiency of those directly involved with the equipment during normal duty hours. It also serves to expand interest and confidence among personnel in the exercise of the equipment while on an extended cruise. Personnel aboard the USS RANGER (CV 61) utilize commercial equipment to play war games that are not only entertaining, but promote an interest, competence, and confidence in ADP equipment (ref 6).

3.0 CONCLUSIONS AND RECOMMENDATIONS

In general, this study has revealed that commercial ADP can be applied successfully to a variety of functions in the ocean environment. Such equipment is currently being used aboard US Navy and Coast Guard ships, oceanographic research vessels, and commercial shipping with some of the equipment having performed well for as long as 10 years. Commercial ADP systems are utilized aboard ship in the following roles and other nontactical functions:

- Collision avoidance
- Navigation
- Critical shipboard equipment monitoring
- Personnel training support and record maintenance
- Shipboard logistics record maintenance

3.1 CONCLUSIONS

As a result of this study, it is concluded that commercial ADP equipment can be effectively used aboard naval ships for many nontactical applications. Much of the equipment is readily available off-the-shelf; the same is true for many software packages that can be obtained at minimal cost to the government. Commercial shipping has applied and is planning even greater utilization of commercial ADP aboard ship to perform the following tasks:

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6. NAVY TIMES: Playing War Games Aboard the RANGER, 23 October 1978.

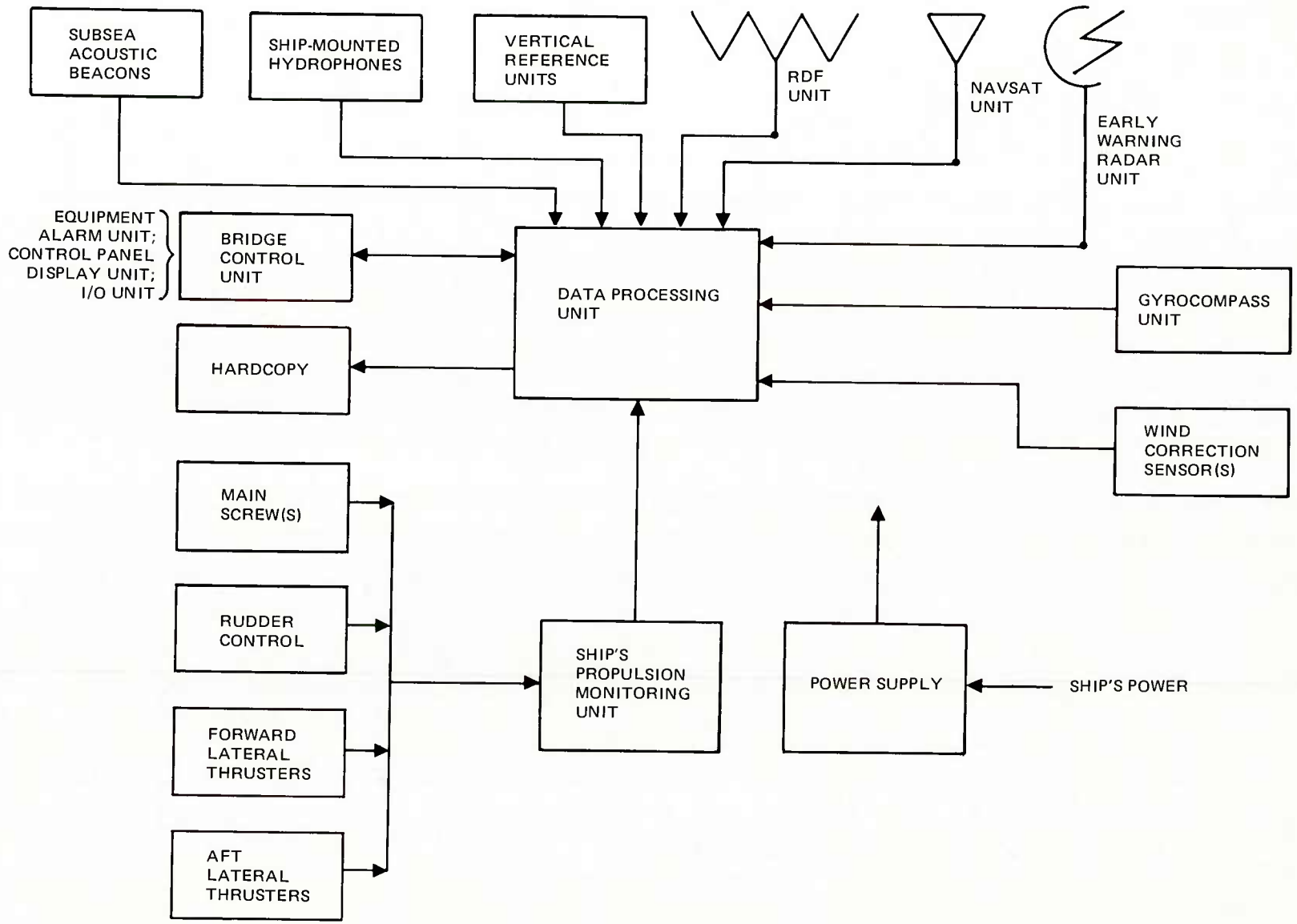

Figure 5. Ship's critical equipment monitoring configuration.

- Critical shipboard equipment monitoring
- Navigation/collision avoidance
- Positioning for resupply/exploration purposes

The success of exploiting commercial ADP to perform nontactical functions aboard the USS GRIDLEY, the USS KITTY HAWK, and NAVOCEANO ships is indicative that the Navy can use various commercial ADP systems effectively and advantageously.

3.2 OPERATIONAL READINESS SUPPORT

The execution of a course of action by a command must consider numerous basic principles of warfare. The application of these principles is largely dependent upon advanced information within the command itself. The use of commercial ADP equipment, not directly linked to the tactical execution phase, can more efficiently provide the information needed to support the tactical decision. The use of these capabilities aboard ship can result in man-hour savings, better maintenance procedures, improved operational planning, and logistic cost effectiveness. An excellent example of this is the application of commercial ADP aboard the USS GRIDLEY (CG 21). It is planned to employ a commercial ADP system aboard ship to perform the following functions:

(1) File Management

- File Management and Information Retrieval System (FMS)

(2) Personnel Administration

- Personnel Record System
- Public Affairs Officer File

(3) Training Administration

- Shipboard Training Administration System (STAS)
- Computer Integrated Instruction (CII)

(4) Operations

- Employment Schedule
- Weapons Publication Inventory System
- Combat Information Center (CIC) Publication Inventory System
- Intelligence Publication Inventory System

(5) Material Maintenance

- Deficiency Logs
- Inventory Maintenance Accounting (IMA) Job status
- Preoverhaul Test and Inspection
- General-Purpose Electronic Test Equipment (GPETE) Inventory and Calibration
- Gauge Calibration

(6) Logistics

- Material Requisition Status

(7) Recreation

- Games

3.3 RECOMMENDATIONS

It is recommended that the ORMS project consider implementing an expanding analysis effort as a follow-up to the findings of this study. The follow-up analysis would include the performance of life-cycle cost effectiveness trade-offs.

From the results of this investigation, the potential for cost savings due to the application of commercial ADP aboard US Navy ships appears to be great. The recommended life-cycle cost effectiveness trade-off analysis should include the following areas:

- Logistics
- Training
- Training impacts upon ship/training centers
- Engineering impacts upon ships
- Hardware costs
- Software costs

APPENDIX A. GUIDE TO VOLUME II, USER APPENDICES

A. USS GRIDLEY (CG 21), INFORMATION PROVIDED

B. USS KITTY HAWK (CV 63), INFORMATION PROVIDED

C. NAVOCEANO, INFORMATION PROVIDED

D. COMNAVSURFPAC, INFORMATION PROVIDED

E. COMMERCIAL MICROPROCESSORS IN OTHER MILITARY PLATFORMS

F. COMMERCIAL ADP EQUIPMENT IN SEABORNE EMPLOYMENT, DATA SHEETS

G. LISTING OF FIELD VISITS

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DEFENSE DOCUMENTATION CENTER	(12)