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HP-9020C/AN/UYK-43 STUDY BY: SYSTEMS EXPLORATION

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NAVAL OCEAN SYSTEMS CENTER San Diego, California 92152-5000

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# HP-9020C/AN/UYK-43 Study

Systems Exploration, Inc.

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The purpose of this analysis is to provide a high level presentation of the issues of performance reliability, maintainability, availability (RMA), and survivability as they pertain to the procurement of commercial desk-top computers (DTCs) for mission critical applications.


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# SECTION 1

# INTRODUCTION

## 1.1 PURPOSE

The purpose of this analysis is to provide a high-level presentation of the issues of performance reliability, maintainability, availability (RMA), and survivability as they pertain to the procurement of commercial desk-top computers (DTCs) for mission critical applications.

## 1.2 SCOPE

The analysis will describe the basic characteristics of the Navy standard computer (AN/UYK-43) and a commercial DTC, the Hewlett-Packard HP-9020C. An overview of the MIL-STDs, MIL-SPECs, and MIL-HDBKs, that establish requirements for developing digital equipment that qualify for full-MIL designation is presented. Issues such as RMA and survivability are examined. Finally, candidate environmental tests that are applicable to DTC's qualifying as Type III, Class IV, enclosure style B equipment are described.

## 1.3 BACKGROUND

In 1982, the Chief of Naval Operations (OP-945D) sponsored a Desk-Top Computer (DTC) program to provide a common Fleet standard hardware system for tactical decision support. The program was non-developmental and therefore; TEMPEST certification and adherence to MILSPEC were waived for the hardware. These actions were taken because large numbers of DTCs were already employed in the Fleet to support operations planning and to provide tactical decision aids. Also the need to standardize became apparent. A contract was awarded during FY84 by NAVELEX (N0039-84-D-0370) for the lease and/or purchase of DTCs. The selected hardware was the Hewlett-Packard 9000 family of compatible workstations. The HP-9836U and the HP-9020A were authorized for procurement, but the HP-9020C, a newer more capable DTC of the same family is becoming more prevelant in the Fleet and test bed sites, and therefore, was chosen for this analysis.

The Navy's use of standard digital computers at sea began in the late 1950's with the installation of the Naval Tactical Data System (NTDS) featuring the AN/USQ-20(V) [CP-642]. Over the past three decades additional Navy standard computers such as the AN/UYK-7(V) and the AN/UYK-20(V) have been introduced to meet the Navy's tactical and strategic data processing needs. These computers and their newest replacements, the AN/UYK-43(V) and the AN/UYK-44(V), attained the status of Navy standard computers by meeting government specified requirements for program management, configuration management, design, development, construction, testing, maintenance and documentation as described in applicable Military Standards (MIL-STD), Military Specifications (MIL-SPEC), Federal Standards, Department of Defense (DoD) requirements and TEMPEST requirements.

The U.S. Navy is continuing to expand its use of standardized computer technology in support of tactical operations. There are many major programs such as the Flag Data Display system (FDDS), Advanced Combat Direction System (ACDS), Antisubmarine Warfare Module (ASWM) and a number of others that currently or in the future will employ standard computers (e.g., AN/UYK-43). All of these programs are directed toward meeting specific Fleet requirements today and in the future.

The process of complying with government requirements adds significantly to the time and cost of developing a computer system and to its introduction into the Fleet. In order to expedite the introduction of Automated Data Processing (ADP) to support tactical operations, the Hewlett-Packard 9000 family of DTCs and a variety of software packages have been and are being developed for specific tactically related applications. Examples are the Prototype Ocean Surveillance Terminal (POST), the Joint Operational Tactical System (JOTS), the Communications and Planning Support (COPS) program, and the Integrated Tactical Decision Aid (ITDA) system.

The current high level of technological development and capabilities of the DTCs, their comparative low cost and their ease/quickness of deployability has lead program managers to consider their suitability for critical missions. One major obstacle to their deployment is the issue of survivability. Computer systems supporting critical missions are required to meet specified levels of survivability. These levels have been defined as full-MIL qualified systems. Obviously, commercial DTC's either do not meet these requirements or are not tested to prove their compliance with MIL standards. Some proponents of the DTC's question whether the MIL-SPEC levels of survivability are excessive. They ask, why pay extra in terms of dollars, effort, and time for survivability features that enable the equipment to withstand battle conditions that their human operators cannot endure? The DTC's are an unknown quantity. No independently verified data exists that quantifies a level of survivability for DTCs. If the DTCs are to be considered for use in critical missions this data must be obtained so that rational fact based decisions can be made about DTC viability in mission critical applications.

## 1.4 ASSUMPTIONS

a. The AN/UYK-43 has met all MIL-STD and MIL-SPEC requirements pertaining to its acceptance as a Navy standard computer.

b. The HP-9020C is a commercial "off-the-shelf" product. Its characteristics and capabilities have not been independently verified, and therefore; all statements of fact made about the HP-9020C are drawn from vendor promotional materials.

## 1.5 ISSUES

A number of issues surfaced during the preparation of this study. On the whole they relate to the impact of using or not using DTCs for specific developmental programs and the resulting budget, schedule, and risk impact. Programs already using DTCs have proven that they are cost effective, rapidly deployable, and easily modified to accommodate new operational requirements.

The DTC reliability, maintainability, and availability have been satisfactory in today's peacetime environment. Therefore, DTC-based efforts are loath to change to MIL-STD equipment. It is plausible that lessons and program logic from DTC applications may transition to MIL-STD systems.

On the other hand, MIL-STD programs with mission critical functions raise the unanswered questions of DTC reliability in a shooting environment. These developers are willing to use DTCs as interim augmentation measures, but not as the core system for mission critical functions.

An issue that delayed the study and reduced its impact is the proprietary nature of DTCs. Several attempts were made to obtain DTC test data and RMA statistics from the DTC maker and its Navy vendor, without results. Researchers were advised that both the original test data and current RMA data (if available) were considered properietary. Therefore, even though the manufacturer's tests are discussed below, there is no assurance as to the independence, verifiability, repeatability, or sufficiency of the testing.

One method is resolving these issues of DTC capabilities would be to conduct some independent, verifiable and fully documented experiments and testing. At a minimum, the tests completed by the manufacturer can be completed. Another approach to determining DTC RMA would be a centralized effort to collect current performance and maintenance data. This would identify common failures, necessary preventive procedures and an estimated measure of availability. A third approach to resolving DTC RMA issues would be to ruggedize the DTC system so that it can demonstrate compliance with a number of environmental and electromagnetic interference issues.

Several lessons are clear. The DTC is here to stay due to its rapid response to Fleet needs and reasonably portable nature. As DTCs become ever more powerful, they will eclipse the current generation of MIL-STD computers in terms of both cost and performance. There are impressive gains to be made in using DTCs as interim prototype systems until formal acquisitions provide similar MIL-STD capabilities; however, if DTCs are susceptible to shock, vibration and other environmental problems of a shooting war, then it may be unwise to rely on them for mission critical functions.

# SECTION 2

# HP-9020C AND AN/UYK-43 CHARACTERISTICS

## 2.1 GENERAL

The physical characteristics and functional capabilities of the full-MIL AN/UYK-43 standard computer and the HP-9020C commercial DTC are summarized in Table 2-1. The table enables a side-by-side comparison of the two types of computers. More detailed descriptions are provided in subsequent paragraphs.

## 2.2 HP-9020C DESCRIPTION

The HP-9020C is a commercially available multiple (3) processor, 32-bit desktop computer designed to support scientific and engineering applications. It is packaged as an integrated workstation complete with keyboard, printer, mass storage, and graphics display all mounted in a desktop configuration. Figure 2-1 is a typical HP-9020C configuration.

This basic configuration can be enhanced by adding any of several peripheral devices offered by Hewlett-Packard. These include: disc drives with 24 and 55 Mbytes of capacity, a series of ink-jet printers (recommended for applications which require a large volume of printing), a 1/4" tape cartridge system, a color graphics terminal, and a 6-pen color plotter. Hewlett-Packard also provides the capability to link HP-9020Cs together via local area networks (LANs) and to host computers (IBM, DEC) via terminal emulators.

### 2.2.1 <u>HP-9020C System Architecture</u>

The system architecture of the HP-9020C has four main components; the Central Processing Unit (CPU), a 128 Kbit Random Access Memory (RAM) chip, a 256 Kbit Dynamic RAM (DRAM) chip, and an I/O Processor (IOP) chip. These four components communicate via a 36 Mbyte/sec common Memory-Processor Bus (MPB). The chip set has self-test logic which automatically tests 99% of its devices at power-up.

Table 2-1. HP-9020C / AN/UYK-43 Characteristics Comparison

| PROCESSOR CHARACTERISTICS | AN/UYK-43 | HP-9020C |
|---|---|---|
| Net size h,w,d in inches | 72 x 19.8 x 22.32 | 24.5 x 21.75 x 29 |
| Net weight | 1470 - 1670 lbs. | 137 - 163 lbs |
| Power requirements | 5.5 kw (air), 4.7 kw (water) | 15.0 @ 108 VAC, 11.0A @ 198 VAC |
| Modularity | yes | yes |
| Word Size | 32-bit | 32-bit |
| Number of instructions/ second | 1520-4500 (2 CPUs) | 1 micro-instruction/55 NSEC |
| Memory Types | Semiconductor (SC) and Magnetic Core (MC) | Standard Speed Ram (SSR) and High Speed Ram (HSR) |
| Memory Size | MC 32K, 32-bit words SC 64K - 512K, 32-bit words | SSR max 1 mbyte HSR max 512K |
| Access speed | 750 NSEC for MC 450 NSEC for SC | 550 NSEC |
| Hard Mathematics | Binary integer, FP, Trig, Log, Trig Vector Ord | FP |
| CPUs | 2 per enclosure, | 3 per enclosure |
| I/O Controller | 1 per CPU with 32 I/O channels | 3 per CPU with 8 I/O channels (expanders allowed) |
| I/O Chaining | yes in IOC | |
| Intercomputer Comm Capability | yes w/CIS | yes w/CPU finstrate board |
| Interfaces supported: | | |
| o MIL-STD 1397A (NTDS slow) | yes | --- |

Table 2-1. HP-9020C / AN/UYK-43 Characteristics Comparison (Cont)

| PROCESSOR CHARACTERISTICS | AN/UYK-43 | HP-9020C |
|---|---|---|
| Interfaces supported: (Cont) | | |
| o MIL-STD 1397B (NTDS fast) | yes | --- |
| o MIL-STD 1397C (ANEW) | yes | --- |
| o MIL-STD 1397E (NTDS Low Level) | yes | --- |
| o RS 232C | yes | yes |
| o MIL-STD 1553B | yes | --- |
| o RS 449 | yes | --- |
| Disk Support | CDC 9760 (MPP), RCA, CDC MD40, Disc File 1840 M Dual | HP 7945A, 55 mbyte Winchester disk w/5 1/4" 630 Kbyte double-sided micro floppy |
| Tape Support | 1240/1250 Mag, 1232/1532 paper, RD-358/UYK | HP 9144A 1/4" tape cartridge |
| Mean time to fault | 1050 hrs | --- |
| Mean time to repair | less than 15 min | --- |
| Mean time between failures | 1650 hrs | --- |
| Operator interface | system control panel | keyboard |
| Hardware breakpoint registers | 8 internal | N/A |
| Language | ADA-(no data set) CMS-2L, Macro/L Assembler | Fortran 77, C, HP Pascal, HP Basic |
| Development support | MTASS/L | * |

Table 2-1. HP-9020C / AN/UYK-43 Characteristics Comparison (Cont)

| PROCESSOR CHARACTERISTICS | AN/UYK-43 | HP-9020C |
|---|---|---|
| Utilities | Error logging, online fault detection | * |
| Debug capabilities | P-History file, break point registers | * |
| Operating system | SDEX/43 | Unix multiple-user/single user or HP Basic Language System |

--- = Not available

* = Various commercial products available

N/A = Not applicable

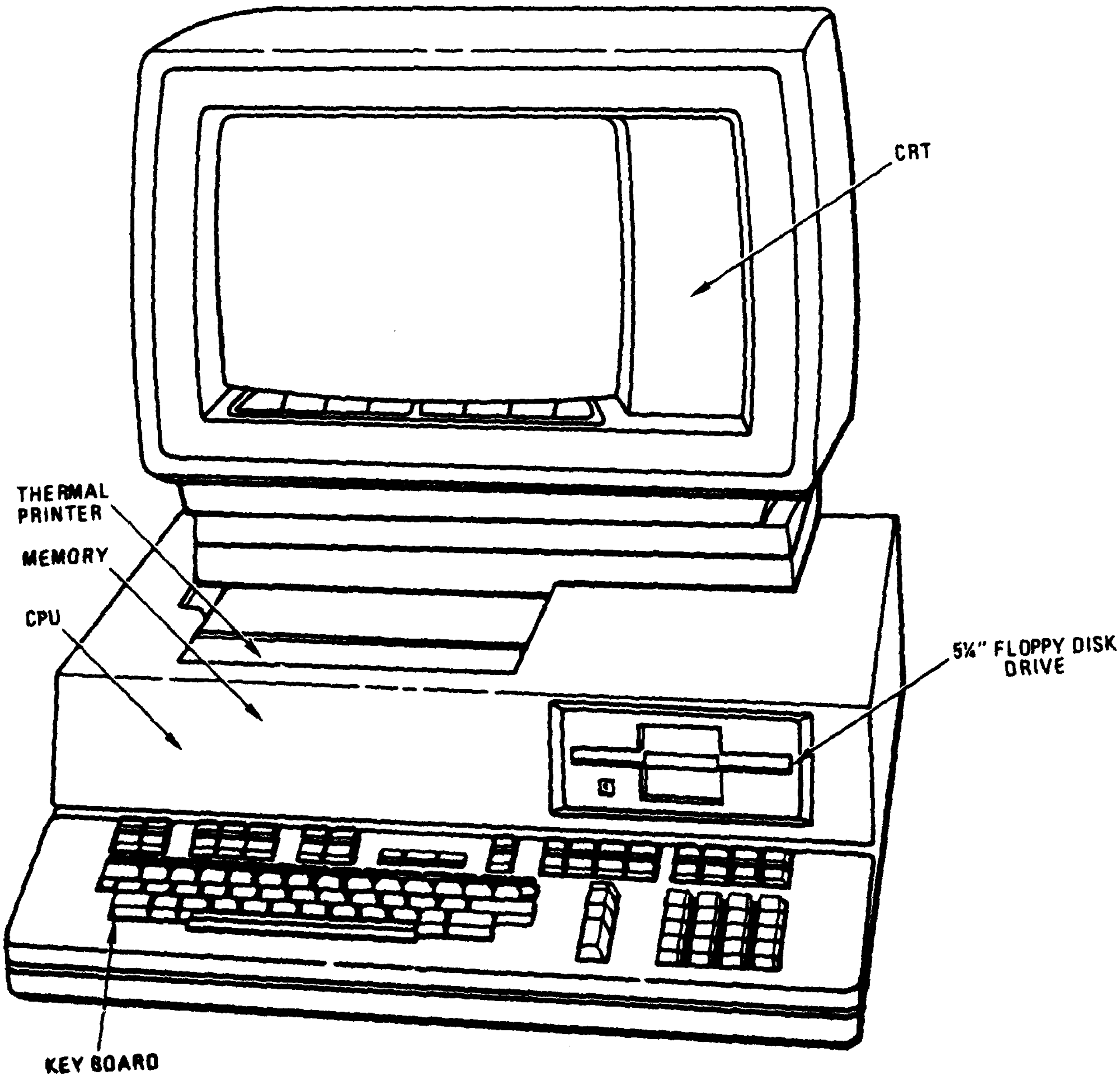



Figure 2-1. Computer Set Physical Layout

The CPU is a 32-bit single-chip microprocessor based on a stack architecture. It is enhanced by three floating point math chips and has a direct address range of 500 Mbytes. An instruction set of 230 operation codes provides operations for stack manipulation, code/data segmentation, shared code in memory and I/O processing. The 18 MHz clock rate enables the following cycle and execution rates specified in Table 2-2. The HP-9020C processing power can be increased by adding up to two additional CPUs to the basic configuration.

Two types of memory are supported by the HP-9020C; 512K high-speed NMOS RAM and 1 Mbyte standard-speed commercial RAM, and can be expanded to 10 Mbytes of RAM. Each memory address contains 32 bits for data and 7 bits which contain a code to enable the HP-9020C to detect and correct single, double, and most multiple bit errors.

The HP-9020C I/O Processor (IOP) controls the interface between the MPB and the eight I/O interface channels. The IOP can handle direct CPU I/O, generate CPU interrupts, and conduct simultaneous, independant direct memory access transactions on all 8 I/O channels. The IOP bandwidth is 5 Mbytes/sec when multiplexed across several channels. Two additional IOPs may be added to the HP-9020C configuration.

### 2.2.2 HP-9020C Operating Systems

The UNIX operating system (HP-UX), in single or multiuser versions, and Hewlett-Packard's (HP) BASIC Language System are the two operating systems available with the HP-9020C. The UNIX operating system is compatible with the programming languages: FORTRAN 77, C, HP-PASCAL, and HP-BASIC. The HP-BASIC Language operating system is compatible with HP-BASIC.

### 2.2.3 HP-9020C Operational Characteristics

2.2.3.1 Portability. The HP-9020C is 24.5 inches high, 21.75 inches wide, 29 inches in depth and weighs between 137 and 163 pounds depending on the

Table 2-2. HP-9020C Cycle and Execution Rates

| | |
|---|---|
| o Micro-Instruction cycle time | 55 nsec. |
| o Load registar from memory | 550 nsec. |
| o 64 bit floating point multiply | 1.28 msec. |
| o 32 bit integer multiply | 1.25 msec. |
| o 64 bit floating point add | 1.17 msec. |

selected configuration. Its relative small size and low weight makes it highly portable.

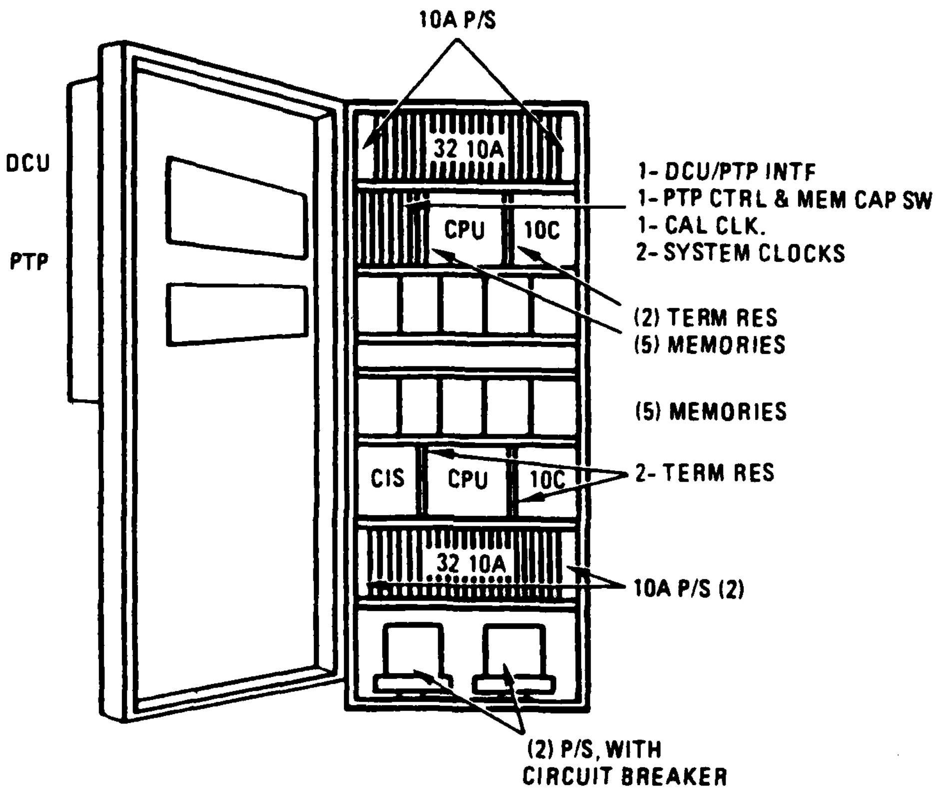
2.2.3.2 Cooling. The HP-9020C is air cooled and, according to vendor documentation, operates effectively at temperatures ranging between 10$^{o}$C and 40$^{o}$C and has a humidity tolerance of 20%-80% noncondensing. The two rear mounted cooling fans draw non-filtered room air into the rear of the display head with the exhaust exiting through the top. In non-ADP environments dirt and dust can collect. This (according to the POST land-based site) enables "circuit bridging" which causes the wiring to overheat and generate smoke. They indicate that monthly cleaning appears to alleviate the problem.

2.2.3.3 Fault Isolation. Hewlett-Packard provides diagnostic software routines for testing components of the system and to aid fault isolation. These include: a power-up self-test, hardware LED test, system integrity test, and function integrity test. Hewlett-Packard (according to the POST land-based site) does not provide sufficient documentation or training to enable users or technicians to effectively utilize these diagnostics.

## 2.3 AN/UYK-43 DESCRIPTION

The AN/UYK-43 is a DoD sponsored 32-bit Navy standard computer designed to support tactical and strategic data processing. It is a full-MIL standard modular computer which can be interfaced with a number of peripherals to configure a complete data processing system. These peripherals include: hard disks, papertape drives, magnetic tape drives, cartridge magnetic tape units (CMTU), printers, teletypes, terminals, graphic display devices, and plotters. These peripherals are available from number of manufacturers and come with a diverse range of capabilities.

The AN/UYK-43 is available in a Type A and Type B configuration. The Type A is not currently used by any Navy systems, therefore; the Type B configuration will be used in this study. Figure 2-2 illustrates the AN/UYK-43 basic Type B computer.




8 ENCLOSURE CONFIGURATION

Figure 2-2. Computer Set Physical Layout

### 2.3.1 AN/UYK-43 System Architecture

The system architecture of the AN/UYK-43 is partitioned into functional modules that can be assembled in varying configurations to suit the processing requirement of the target application. Table 2-3 specifies a fully populated Type B configuration which includes 2 central processing units, 2 input/output controllers, 64 input/output channels, 10 memory modules, 1 computer interconnect system (CIS), 2 power supplies (PS), 2 display control units (DCU), and 1 remote operator central unit (ROCU). These modules are described below.

The CPU is a general-purpose microprogrammable controller (MPC) which executes the AN/UYK-43 Instruction Set Architecture (ISA). The instruction set contains more than 220 basic whole and half-word instuctions providing operations for direct and indirect memory addressing, variable-length character addressing, and both privileged and non-privileged execution. Cache memory, which has up to 16,384 32-bit words, is used as a high-speed buffer between the processor and main memory. The CPU contains control, arithmetic, and timing circuits which are utilized to process executive functions and task programs. Nonvolatile programmable Read Only Memory (ROM) of 16K, 32K, or 65K capacity is available for each CPU.

The Input/Output Controller contains a programmable microprocessor dedicated to performing nonbuffered operations and a Buffer Control Unit (BCU) dedicated to performing buffered operations. A single IOC can control up to 32 full-duplex channels with an aggregate data throughput of three million words per second. The IOC has the capability of addressing to four billion words of memory (32-bit addressing). It also provides interrupt processing, data manipulation, and channel processing external to the CPU. The input/output adapter components of the IOC enables handling of a variety of channel/protocol types (e.g., NTDS Slow/Fast, 1553B).

Table 2-3. Fully Populated Computer Configuration

| MODULES | ENCLOSURE TYPE B |
|---|---|
| CPU[1] | 2 |
| IOC[2] | 2 |
| I/O Channels (IOAs) | 64 |
| Memory Modules[3] | 10 |
| CIS | 1 |
| PS | 2 |
| DCU (1 resident in the enclosure, 1 bulkhead mounted) | 2 |
| ROCU | 1 |

[1]Each CPU is capable of being configured with the computer program debug aids and performance monitoring interface.

[2]Each IOC is capable of being configured with the performance monitoring interface.

[3]Each memory module is capable of being either a 32K core or a 64K, 128K, 256K, or 512K SCM.

Two types of memory modules are available with the AN/UYK-43; 32K 32-bit words of nonvolatile magnetic core (MC) memory and 64K to 512K 32-bit words of semiconductor memory (SC). The MC and SC modules are interchangeable in form and can be mixed to conform with processing requirements.

The Computer Interconnect System (CIS) extends the internal computer bus outside the enclosure to allow a CPU in one enclosure to access memory, IOCs, and CPUs in another enclosure without using I/O channels.

The Display Central Unit (DCU) module provides a man-machine interface, operator panel, and display. It provides continuous status displays of each functional module in the enclosure. It also performs a variety of tasks such as maintenance support, operating support, and software debug support.

The Remote Operator Control Unit (ROCU) module provides operator controls and indicators to operate the CPUs and monitor the IOCs contained in the enclosure.

### 2.3.2 AN/UYK-43 Operating System

Real-time system coordination of computer resources can be provided by the Standard AN/UYK-43 Executive (SDEX/43) Operating System. SDEX/43 is coded and maintained using the Navy standard MTASS/L program generation package. MTASS/L is documented to MIL-STD-1679 requirements. Two other available operating systems are RSS and ATEX. The system has two language processors: the CMS-2L Compiler and the MACRO/L Assembler.

### 2.3.3 AN/UYK-43 Operational Characteristics

2.3.3.1 Portability. The AN/UYK-43 is 72 inches high, 19.8 inches wide, 22.32 inches in depth, and weighs between 1470 to 1670 pounds depending on the selected configuration. The AN/UYK-43, due to its large size, weight, and installation requirements does not lend itself towards portability without the use of heavy-equipment (i.e. forklift).

2.3.3.2 Cooling. As previously noted, both air and water-cooling methods are available for the AN/UYK-43. The effective operating temperature for the AN/UYK-43 ranges from -0°C to +50°C with relative humidity of up to 95%.

2.3.3.3 Fault Isolation. Fault detection is automatic with up to 99% of the computer faults repairable by Line Replaceable Unit (LRU) replacement. Detected faults fall into three categories: power, temperature, and logic. Power faults are detected by monitoring main power at the primary power supply and by monitoring functional module power at the secondary power converters. Temperature faults are detected at each functional module (including the DCU's, ROCU, and the primary PS's). Logic faults are detected by monitoring circuitry commonly referred to as BITE (Built-In Test Equipment). In addition to the continual monitoring of the BITE circuitry, faults can also be detected by macroconfidence instructions and isolation can occur by use of resident diagnostic programs. The AN/UYK-43 also has the ability to detect and log intermittent faults.

# SECTION 3

# MEASURES OF EFFECTIVENESS

A Measure of Effectiveness (MOE) constitutes a quantitative means of comparing the capabilities of various design options to enhance the mission-related performance of a system. Reliability, maintainability, and availability (RMA) are performance characteristics of a system that can be used to measure the effectiveness of a system. The following paragraphs describe these characteristics for the AN/UYK-43 and the HP-9020C.

## 3.1 RELIABILITY

Reliability is a measure of a system's ability to perform its mission despite the failure of individual components within the system. Normally, this is characterized by the "Mean Time Between Failures" (MTBF). As such, this MOE indicates the expected duration of operation after each startup. The longer the duration, the more reliable the system. The AN/UYK-43 has an established MTBF of 1650 hours. The HP-9020C does not have a published MTBF.

## 3.2 MAINTAINABILITY

Maintainability is a measure of the ease and speed with which a system can be restored to working order after failure or system shutdown. Qualitatively, this takes into account such human engineering concerns as access to failed parts and technician training. Quantitatively, this MOE is characterized by "Mean Time to Repair" (MTTR) which is the expected time before the system can be made operational. This assumes that the system has failed and that both necessary repair parts and trained technicians are available. The established MTTR for the AN/UYK-43 is 15 or less minutes. The HP-9020C does not have a published MTTR.

Navy technicians are trained to repair standardized computers like the AN/UYK-43. These personnel are not trained to perform repairs on the HP-9020C. A standard repair/part kit, intended to suport the HP-9020C at sea for up to 180 days, is available from Hewlett-Packard. If a system failure can be rectified by a board or power supply swap-out, a Navy technician should be able to accomplish the repair. MTTR will be dependant on the Navy technician's ability to transfer repair knowledge of other systems to the HP-9020C, as Hewlett-Packard does not supply training in this area. Hewlett-Packard does provide service contracts and/or will make service calls. The land based test site in San Diego, CA for the POST system indicates that Hewlett-Packard's response time to a call for service amounts to a few hours, although it can take days to accomplish the issuing of the purchase order necessary to receive this service.

## 3.3 AVAILABILITY

Availability is the maximum amount of time a system can be expected to be operational. This MOE is directly related to MTBF and MTTR. Availability goes up as MTBF is increased and MTTR is decreased. This MOE will be further modified when the "Mean Time to Start Repair" (MTTSR) is factored into the equation. MTTSR is a volatile factor dependent on a variety of variable logistics factors such as the time required to obtain necessary parts and to locate a technician. Operational availability can be calculated by computing an average based on historical data collected from a computer's service records. Neither the AN/UYK-43 or the HP-9020C have hard numbers on operational availability, but inherent availability can be calculated as:

$$\text{INHERENT AVAILABILITY} = \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR}}$$

The inherent availability of the AN/UYK-43 approaches 100% using this calculation. Since the MTBF and MTTR is not known for the HP-9020C, inherent availability can not be calculated.

## 3.4 HP-9020C RMA ISSUES

The primary issue concerning the HP-9020C RMA characteristics is that information about them does not appear to exist and if it does exist, it is not available for independent evaluation and comparison with other systems' RMA characteristics.

# SECTION 4
# MILITARY STANDARDS AND SPECIFICATIONS

The list of Military Standards (MIL-STD), Military Specifications (MIL-SPEC), Federal Standards, Department of Defense (DoD) requirements and other guidelines published by military and non-military sources (i.e., American Society for Testing and Materials) that may be applied to the procurement of electronic/digital equipment is extensive. All of these standards, specifications, and requirements may not be logically applicable to every procurement of electronic/digital equipment and therefore, may be viewed as advisory rather than absolute when developing the End Item Specification for the procurement of a particular system/equipment type. The requirements called out in the standards and specifications are intended to be tailored as required by governing regulations and as appropriate to particular systems or equipment type, magnitude, and funding. When accompanied by supporting rationale non-standard requirements may be modified or waived. Table 4-1 provides a partial representative list of the MIL-STDs, MIL-SPECs, and requirements that apply to the procurement of electronic/digital equipment. All of these and others were applied to the procurement of the AN/UYK-43, which added significantly to its procurement costs. These standards were developed to provide minimum standards for developing dependable equipment. As indicated earlier, there is some debate about whether this dependability is perceived or actual. And if it is actual, does the cost/benefit ratio justify implementation of these standards.

There are three core/basic standards that can be applied to the procurement of all electronic/digital equipment. These are MIL-STD-454, MIL-STD-810, and MIL-HDBK-217.

MIL-STD-454 is the technical baseline for the design and construction of electronic/digital equipment for the DoD. It covers the common requirements to be used in military specifications for electronic/digital equipment and calls out other documents applicable to specific requirements.

Table 4-1. Developmental Standards for Electronic/Digitial Equipment

| | |
|---|---|
| | Military Specifications |
| MIL-P-116 | Preservation, Methods of |
| MIL-B-117 | Bags, Sleeves and Tubing - Interior Packaging |
| MIL-S-901 | Shock Test, H.I. (High Impact) Shipboard Machinery Equipment and Systems, Requirements for |
| MIL-C-5015 | Connector, Electrical, Circular Threaded, AN Type, General Specifications for |
| MIL-C-915 | Cable and Cord, Electrical, for Shipboard Use |
| MIL-R-6130 | Rubber, Cellular, Chemically Blown |
| MIL-E-16400 | Electronic, Interior Communication and Navigation Equipment, Naval Ship and Shore: General Specification for |
| MIL-E-17555 | Electronic and Electrical Equipment, Accessories, and Repair Parts; Packaging and Packing of |
| MIL-S-19500 | Semiconductor Devices, General Specification for |
| MIL-C-28840(EC) | Connectors, Electrical, Circular, Threaded, High Density, High Shock Shipboard, Class D |
| MIL-M-38510 | Microcircuits, General Specification for |
| MIL-C-49142 | Connector, Tri-Axial, Radio Frequency, General Specification for |
| MIL-B-81705 | Barrier Materials, Flexible, Electrostatic-Free, Watervapor proof, Heat Sealable |
| MIL-P-81997 | Pouches, Cushioned, Flexible, Electrostatic-Free, Reclosable, Transparent |

Table 4-1. Developmental Standards for Electronic/Digital Equipment (Cont)

| | |
|---|---|
| | Military Standards |
| MIL-STD-129 | Marking for Shipment and Storage |
| MIL-STD-167-1 | Mechanical Vibrations of Shipboard Equipment |
| MIL-STD-454 | Standard General Requirements for Electronic Equipment |
| MIL-STD-461 | Electromagnetic Interference Characteristics, Requirements for Equipment |
| MIL-STD-462 | Electromagnetic Interference Characteristics, Measurement of |
| MIL-STD-681 | Identification Coding and Application of Hookup and Lead Wire |
| MIL-STD-690 | Failure Rate Sampling Plans and Procedures |
| MIL-STD-740 | Airborne and Structureborne Noise Measurements and Acceptance Criteria of Shipboard Equipment |
| MIL-STD-750 | Test Methods for Semi-Conductor Devices |
| MIL-STD-758 | Packaging Procedures for Submarine Repair Parts Utilizing Transparent, Flexible, Heat Sealable Film |
| MIL-STD-781 | Reliability Design Qualification and Production Acceptance Tests: Exponential Disribution |
| MIL-STD-790 | Reliability Assurance Program for Electronic Parts Specifications |
| MIL-STD-810 | Environmental Test Methods |
| MIL-STD-883 | Test Methods and Procedures for Microelectronics |
| MIL-STD-965 | Parts Control Tracking Program |
| MIL-STD-1310 | Shipboard Bonding, Grounding, and other Techniques for Electromagnetic Compatibility and Safety |
| MIL-STD-1326 | Test Points, Test Point Selection and Interface Requirements for Equipments Monitored by Shipboard On-Line Automatic Test Equipment |

Table 4-1. Developmental Standards for Electronic/Digital Equipment (Cont)

| | |
|---|---|
| | Military Standards (Cont) |
| MIL-STD-1397 | Input/Output Interfaces, Standard Digital Data, Navy Systems |
| MIL-STD-1472 | Human Engineering Design Criteria for Military Systems, Equipment, and Facilities |
| | Military Handbooks |
| MIL-HDBK-217 | Reliability Prediction of Electronic Equipment |
| | Military Publications |
| NAVSEA 0967-LP-597-1011 | Parts Application and Reliability Information Manual for Navy Electronic Equipment |
| | DoD Standards |
| DOD-STD-1399 | Interface Standard for Shipboard Systems |
| DOD-STD-1686 | Electrostatic Discharge Control Program |

MIL-STD-810 establishes uniform environmental test methods for determining the survivability of equipment when subjected to the effects of natural and induced environments peculiar to military operations. It provides environmental test methods in order to obtain, as much as possible, reproducible test results.

MIL-HDBK-217 outlines a number of procedures that can be done to aid the process of predicting future reliability of equipment/systems and the components of which they are comprised.

# SECTION 5
# CANDIDATE TEST METHODS

The Candidate Tests in this section are uniform environmental test methods established by MIL-STD-810 and MIL-S-901 for determining the survivability of electronic/digital equipment subjected to the effects of natural and induced environments unique to military operations. It is important to note that when it is known that the equipment item will encounter more severe or less severe conditions stated in MIL-STD-810 and MIL-S-901 tests may be modified via the equipment specification.

The types of environmental tests to be performed on an equipment/system are determined by its design/construction type, environmental classification; and enclosure style. The HP-9020C is best described as a Type III, Class IV, enclosure style B equipment/system. These categories are described as follows:

- Type III - commercial off-the-shelf equipment/system which meets specific military requirements.

- Class IV - located in a protected area and environmentally controlled for human occupancy.

- Enclosure Style B - provides protection to contained equipment/system from mechanical damage. Ventilation openings in the side or rear are permitted when protected by suitable louvers. The enclosure is a integral part of the equipment/system.

Test results data on the HP-9020C are not available for the majority of the MIL-STD-810 and MIL-S-901 environmental test requirements; and there is no independant verification of the vendor conducted tests and published performance data. In order to verify manufacturer claims and rationally determine equipment suitability for shipboard use, a number of environmental tests could be performed the HP-9020C. The purpose of the tests is not to determine the total amount of abuse that the equipment can withstand, but to determine if the DTC will remain functional in a Class IV environment.

Table 5-1 outlines the environmental tests and required method, procedure, and test ranges applicable to Type III, Class IV, Enclosure Style B equipment/systems. The HP-9020C vendor published temperature, humidity, and altitude operating ranges are listed, as well as the results of vendor conducted environmental tests. The vendor literature indicates that the shock (pulse level) and Bench Handling tests were performed and results evaluated according to the MIL-T-28800 standard. These tests closely correspond to their equivilant in MIL-STD-810.

An abbreviated description of each of the environmental tests is provided in subsequent paragraphs. MIL-STD-810 and MIL-S-901 provide precise instructions for conducting the tests and evaluating the results.

## 5.1 TEMPERATURE NON-OP

The temperature test exposes an equipment/system to high and low temperature storage conditions for a period of time prior to operation.

The high temperature test is conducted to determine the resistance of equipment to elevated temperatures that may be encountered during service life either in storage (without protective packaging) or under service conditions.

The temperature chamber is raised to $71^{0}C$ ($160^{0}F$) for a period of 48 hours with a humidity of $\leq 15$ percent and then allowed to return to the highest temperature under which the test item is designed to operate. The test item is then operated and evaluated in accordance with MIL-STD-810, Section 3.2, General Requirements.

Table 5-1. Environmental Tests

| SPEC | METHOD | PROCEDURE | ENVIRONMENTAL CONDITIONS | CLASS IV MIN REQMTS | HP-9020C RANGES |
|---|---|---|---|---|---|
| STD-810 | Hi 501/ Lo 502 | I | Temperature Non-OP | $-62^{o}C$ to $85^{o}C$ | $-40^{o}C$ to $75^{o}C$ |
| STD-810 | 504 | I | Temperature/Altitude OP | $-54^{o}C$ to $55^{o}C$ | $10^{o}C$ to $40^{o}C$ |
| STD-810 | 507 | IV | Relative Humidity | 95 (+5, -0) | 20-80% Relative Non Condensing * |
| STD-810 | 500 | I | Altitude Non-OP | 40,000 ft | 15,000 ft OP *** |
| STD-810 | 514 | X, III | Vibration | 3g | ** |
| STD-810 | 514 | XI, Part II | Bounce, Loose Cargo | Note 1 | ** |
| STD-810 | 516 | I | Shock, Pulse Level | 30g | Passed Test |
| STD-810 | 516 | V | Bench Handling | Note 1 | Passed Test |
| S-901 | Grade A | --- | Shock, High Impact | Note 1 | ** |
| STD-810 | 508 | I | Fungus Resistance | Note 1 | ** |
| STD-810 | 509 | I | Salt Fog | Note 1 | ** |
| STD-810 | 516 | II | Transit Drop | 24" High, 8 Drops | ** |

*Vendor literature does not indicate whether this is a non-operating or an operating measurement.

**Data not available.

***Vendor literature does not provide a non-operating measurement.

Note 1: Test pass/fail determination will be in accordance with MIL-STD-810, Section 3.2 General Requirements.

The low temperature test is conducted to determine the effects of low temperature on equipment during storage without protective packaging and service use.

The temperature chamber is lowered to -57°C (-70°F) for a period of 24 hours. Then the test item is inspected. After the temperature chamber is adjusted to the lowest temperature under which the test item is designed to operate, the test item is operated and evaluated in accordance with MIL-STD-810, Section 3.2, General Requirements.

## 5.2 TEMPERATURE/ALTITUDE OP

The temperature-altitude test is conducted to determine the ability of equipment to operate satisfactorily under simultaneously applied varying conditions of low pressure and high/low temperature.

The rates of temperature and pressure changes inside the temperature-altitude chamber may not exceed 10°C (18°F) per minute and an 0.5 inch of mercury per second. Evaluation of the test item may be performed after each step of this test.

## 5.3 RELATIVE HUMIDITY

The humidity test is conducted to determine the survivality of equipment exposed to the effects of exposure to a warm highly humid atmosphere. This is an exaggerated environmental test, accomplished by the continuous exposure of the equipment to high relative humidity at cycling elevated temperatures. These conditions impose a vapor pressure on the equipment under test which constitutes the major force behind the moisture migration and penetration.

The humidity-temperature chamber should be arranged so as to avoid condensation dripping on the test item and to prevent buildup of total pressure. Air flow inside the chamber should not exceed 150 feet per minute.

Distilled, demineralized, or deionized water having a pH value between 6.0 and 7.2 at 23°C (73°F) should be used to obtain the desired humidity.

## 5.4 ALTITUDE NON-OP

The altitude test is conducted to determine the effects of reduced pressure on equipment. This method is applicable for the purpose of determining the ability of equipment to withstand reduced pressure encountered during shipment by air and for satisfactory operation under those pressure conditions found at high ground elevations.

The pressure in the altitude chamber should be decreased to 429.1 of Hg (16.9 inches of Hg is 15,000 feet above sea level) at a rate not to exceed 2,000 fpm. This pressure is maintained for not less than an hour. The test item is then evaluated according to MIL-STD-810, Section 3.2 General Requirements. If a sudden loss of pressure in a cargo compartment could cause the test item to fail in a way hazardous to the transporting vehicle the test item is tested to withstand an altitude of 40,000 feet non-operating.

## 5.5 VIBRATION

The vibration test is performed to determine if equipment is constructed to withstand expected dynamic vibrational stresses and to insure that performance degradations or malfunctions will not be produced by the service vibration environment.

The test item is evaluated in terms of its survivability during transportation as secured cargo and as operating equipment aboard ship. The shipboard vibration test is conducted as outlined in Type I of MIL-STD-167.

## 5.6 BOUNCE, LOOSE CARGO

This test determines if the equipment, when prepared for field use, is capable of withstanding the vibrations normally induced during combat transportation as loose cargo. Equipment in this class is normally transported in a transit case, combination case, or special container from which it is removed just prior to use.

The test item is secured in its container and placed in the package tester prescribed for this test. The package is vibrated for 1/2 hour on each face for a total of 3 hours. The test item is then evaluated in accordance with MIL-STD-810, Section 3.2, General Requirements.

## 5.7 SHOCK, PULSE LEVEL

The shock test is performed to determine if equipment is constructed to withstand expected dynamic shock stresses and that performance degradations or malfunctions will not be produced by the service shock environment expected in handling, transportation, and service use.

This test calls for the test item to be dropped (outside of packing materials) from a height of 24" on each of its 8 corners. It is then operated and evaluated in accordance with MIL-STD-810, Section 3.2 General Requirements.

## 5.8 BENCH HANDLING

This test determines the ability of equipment to withstand shocks that may be encountered during servicing.

The chassis and front panel assembly is removed from its enlosure, as for servicing, and placed in a suitable position for servicing on a horizontal, solid wooden bench top at least 1-5/8 inches thick. The chassis is then lifted to form a 45 degree angle with the bench top, or one edge of the chassis is lifted 4 inches above the bench top. The chassis is then dropped back freely to the bench top. This procredure is repeated for each of the four pivot points. At the conclusion of the procedure the test item is operated and evaluated in accordance with MIL-STD-810, Section 3.2, General Requirements.

## 5.9 SHOCK, HIGH IMPACT

The purpose of this test is to determine the survivability of equipment/ systems when exposed to the effects of the severe shock which may be incurred in wartime service.

The test item is examined after each blow to determine if any damage occurred. The resulting data is recorded and the test continues. After the last shock, the equipment/system is operated to evaluate its level of performance.

## 5.10 FUNGUS RESISTANCE

The fungus test is used to determine the resistance of equipment to fungi and to determine if such equipment is adversely affected by fungi under conditions favorable for their development, namely high humidity, warm atmosphere, and presence of inorganic salts.

The test item is sprayed with a fine mist of mixed fungus spores. It is then incubated for 20 hours of relative humidity at 95 $\pm$ 5 percent at an air temperature of $30^{o} \pm 1^{o}C$ ($77^{o} \pm 2^{o}F$). After 28 days the test item is inspected for evidence of fungus growth and is operated and evaluated in accordance with MIL-STD-810, Section 3.2 General Requirements.

## 5.11 SALT FOG

This salt fog test is conducted to determine the resistance of equipment to the effects of a salt atmosphere. The specified concentration of moisture and salt is greater than is found in service.

This test is generally unreliable for comparing the corrosion resistance of different materials or coating conditions, or for predicting their comparative service life. It is acceptable for evaluating the uniformity (i.e., thickness and degree of porosity) of protective coatings, metallic and nonmetallic and different lots of the sample product, once some standard level of performance has been established.

The test item is placed in the test chamber and exposed to salt fog for 48 hours. At the end of this period the test item is operated and evalauted in accordance with MIL-STD-810, Section 3.2 General Requirment.

## 5.12 TRANSIT DROP

This procedure is used for equipment, in its transit or combination case as prepared for field use, to determine if the equipment is capable of withstanding the shocks normally induced by loading and unloading of equipment.

The test item is dropped from a height of 24 inches an each of its eight corners. Upon completion, the test item is operated and evaluated in accordance with MIL-STD-810, Section 3.2 General Requirements.

SECTION 6

CONCLUSION

## 6.1 TEST APPROACHES

Environmental testing facilites are currently available within Code 90 at NOSC, San Diego. It is capable of supporting all of the MIL-STD-810 - MIL-S-901 described in Section 5 of this document.

If HP-9020C DTCs or other commercial DTCs are going to experience expanded use by the Navy, it may prove prudent to independently evaluate and verify their performance capabilities under stressed environmental conditions that may be experienced in operational use. Implementation of the tests described in Section 5 would provide independent survivability data on DTCs and cause their operational capabilities to become a known rather than an unknown factor.

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