# LAPTOP COMPUTER REVIEW

## by

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## SUMMARY PAGE

### THE PROBLEM

To evaluate certain laptop computers for possible purchase for use by corpsmen on submarines.

### THE FINDINGS

Five laptop microcomputers were evaluated in-house, and seven laptops were evaluated through a survey of the current literature. Two laptops were recommended for those submarines with minimal medical storage space, and one laptop was recommended for those submarines with greater medical storage space.

### APPLICATION

The reader should be able to make a wiser decision concerning the use of small portable microcomputers aboard submarines using the information contained in this paper.

### ADMINISTRATIVE INFORMATION

# ABSTRACT

We tested five laptop microcomputers and evaluated seven others by surveying the literature. For submarines with minimal medical storage space, we recommend the GriDCase 3 Plus followed by the Zenith Z-183. For submarines with more medical storage space, we recommend the Compaq Portable III.

# Evaluation of Laptop Computers
## for Use by Corpsmen on Submarines

## INTRODUCTION

This report evaluates the suitability of a selection of laptop computers for use by independent duty corpsmen on submarines and specifies the characteristics which such a computer should have. Since any conclusions regarding state of the art in microcomputer technology will probably be obsolete by the time this report is published, we have extrapolated from our experience with some computers to others not available when the study began.

When we began the program to validate our computer-assisted medical decision aid at sea, the only computers which could have been made available to the corpsman were the Tektronix 4051 computers in the sonar and fire control spaces. In fact, we were not able to collect the data needed to validate the abdominal pain system. On some submarines the corpsman was simply denied access to the 4051; on other ships access was granted only on the infrequent occasions when it did not interfere with any other activity. Even when the 4051 was available, the need to shuttle between the computer and the patient in his bunk often discouraged corpsmen from using it. The only way those barriers can be overcome is to provide the independent duty corpsman with his own computer.

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# REQUIREMENTS

A microcomputer for use by the 8402 corpsman should have the following characteristics.

(1) <u>Dedicated to the Medical Department</u>. The Corpsman needs his own machine. In many, if not most cases, he will not be able to share a computer with another department.

(2) <u>MS-DOS Compatible</u>. The microcomputer should be compatible with the IBM-PC MS-DOS operating system. The medical decision support systems which NSMRL are developing for use by corpsmen aboard submarines are being written to run on computers with an MS-DOS operating system, as does SNAP Automated Medical System (SAMS), the medical administrative system being implemented aboard U.S. Navy vessels. Moreover, most microcomputer business software is written for MS-DOS. Having software available would decrease the overall cost. This, then, is the first requirement which the computer must satisfy.

(3) <u>Size</u>. It must be small enough to fit into the corpsman's storage space. However, the amount of space varies with the type of submarine. A full sized IBM PC/AT can be placed in the Sickbay/Pharmacy of a Trident submarine. On an older attack submarine, the corpsman has to use some of his bunk space to stow medical supplies. Other submarines have storage facilities ranging between these two.

(4) <u>Display</u>. The display must be legible in poor lighting. Even in good lighting, the usable field of view is very restricted in some machines. The computer must have a backlit "super-twisted birefringent" LCD display, electroluminescent screen, or plasma display.

(5) <u>Battery Power</u>. It must be capable of operating by battery power for at least 30 minutes. Casualty drills are held quite often, sometimes during every watch section. Ideally, these drills are unexpected. In many of these drills, power to lights and receptacles is turned off. Battery power would allow the corpsman to shut down the computer in an orderly fashion or to move to another location without losing data. The laptop's AC adapter should have some sort of Electro-magnetic Interference (EMI) filtering, since the AC power may have transients resulting from heavy electronic machinery switching in and out.

(6)  Hard Drive. It should be possible to add a non-bulky
     hard drive.  This is essential to accommodate the MS-DOS
     compatible medical administrative programs (SAMS) being
     developed.  SAMS now uses over 8 megabytes for the
     operating system and, therefore, cannot be run from a
     floppy-based system.  However, floppies are essential to
     allow data and program updates to be transported.

(7)  Processing Speed.  Speed is important.  Accessing
     programs and data bases as large as those planned for
     SAMS may be impractical with a 4.77 MHz 80C88
     microprocessor, which is slower than the 80286 and even
     the 80C86.  It should be noted that OS/2, the new
     operating system by Microsoft, which will be available
     in one or two years, will require an 80286 or newer
     microprocessor.

     Appendix A gives the results of the evaluations with
     various benchmarking programs.

(8)  Memory.  The computer's internal memory should be at
     least 512K, and preferably 640K bytes RAM.  Many
     commercial software packages today require 512K RAM.  As
     memory becomes cheaper, the size of programs becomes
     larger requiring more memory.

(9)  Clock.  The computer should have a built-in clock so
     that the corpsman does not have to enter the date and
     time each time he boots the machine.

(10) Communication Ports.  There should be both a serial and
     a parallel port so that the computer can communicate
     with printers and other microcomputers.

(11) Graphics Emulation.  NSMRL programs require that the
     computer emulate the Color Graphics Adapter (CGA)
     graphics.  Most laptops emulate CGA graphics, although
     they have a monochrome display.  A color monitor is not
     essential, but it is desirable to be able to connect the
     computer to a color monitor if one is available.

(12) Expansion Capability.  Some sort of adapter port is
     desirable to allow external drives, CD-ROM drives, etc.,
     to be connected when space is available.

(13) User Acceptance.  The computer must be acceptable to and
     operable by the corpsmen who are to use it.

To satisfy this criterion, 13 submarine corpsmen assigned to
Group 2 and Squadron 10 were asked to evaluate 11 characteristics
of the five computers available on a scale from 1
(unsatisfactory) to 5 (excellent).  Table 1 shows the results.
The decimal values are the mean evaluations; the values in
brackets show the ranking (1 = best; 5 = worst) of the computers
for each item.

## Table 1 - Corpsmen Evaluation Summary

|  | Grid * | Z181 | T1100 | DG | DTV |
|---|---|---|---|---|---|
| Keyboard Configuration | 2.8 [3] | 3.3 [1] | 3.2 [2] | 2.5 [4] | 1.8 [5] |
| Floppy Disk System | 3.8 [1] | 3.3 [2] | 3.2 [3] | 2.7 [5] | 3.2 [3] |
| Display, Ideal Lighting | 4.3 [1] | 3.2 [2] | 2.5 [3] | 2.3 [4] | 2.0 [5] |
| Display, Suboptimal | 4.5 [1] | 3.2 [2] | 2.4 [3] | 2.2 [4] | 2.0 [5] |
| Machine Speed | 3.4 [1] | 2.0 [3] | 2.1 [2] | 1.5 [4] | 1.5 [5] |
| Memory | 3.1 [1] | 1.7 [3] | 1.9 [2] | 1.5 [4] | 1.1 [5] |
| Running Programs | 3.2 [1] | 2.1 [3] | 2.2 [2] | 1.6 [4] | 1.2 [5] |
| Power Supply | 4.0 [1] | 2.8 [2] | 2.8 [3] | 1.5 [4] | 1.2 [5] |
| Expandability | 3.6 [1] | 1.9 [2] | 1.9 [2] | 1.2 [4] | 1.0 [5] |
| Portability | 4.2 [1] | 2.9 [3] | 3.2 [2] | 2.5 [4] | 1.5 [5] |
| Size | 4.5 [1] | 3.1 [3] | 3.7 [2] | 3.7 [4] | 1.8 [5] |
| All Characteristics | 3.8 [1] | 2.7 [2] | 2.6 [3] | 2.1 [4] | 1.7 [5] |

* The Gridcase 3, which has the old clumsy keyboard, was demonstrated
instead of the GridCase 3 Plus.

# Table 2 - Characteristics of the Five Microcomputers Evaluated.

| | Data General One/Model 2 | GRiDCase 3 Plus | Quadram Datavue 25 | Toshiba T1100 PLUS | Zenith Z-181 |
|---|---|---|---|---|---|
| Base Price | $3,835 | $3,280 | $1,695 | $2,099 | $2,399 |
| Minimum RAM | 256K | 128K | 256K | 640K | 640K |
| Maximum RAM | 640K | 640K | 1.35 Mbytes | 640K | 640K |
| Standard Disk Dr | 3 1/2" floppy 10 M hard disk | 3 1/2" floppy | 3 1/2" floppy 10 M hard disk | 2 3 1/2" floppy | 2 3 1/2" floppy |
| Processor | 80C88 | 80C86 | 80C88 | 80C86 | 80C88 |
| Speed (MHz) | 4.77 | 4.77 | 4.77 | 4.77/7.16 | 4.77 |
| Expansion Slots | 2 Proprietary | 1 Proprietary | 1 Proprietary | 1 Proprietary | None |
| Expansion Chasis | Yes | Yes | Yes | Yes | No |
| Monitor Ports | RGB | RGB | RGB,Composite | RGB,Composite | RGB |
| Serial Port | Yes | Yes | Yes | Yes | Yes |
| Parallel Port | Yes | Yes | Yes | Yes | Yes |
| Battery Operated | No | Yes | Yes | Yes | Yes |
| Hard Disk Options | 10 M stnd | 10 M, $975 20 M, $1175 | 20 M | None | None |
| Floppy Disk Options | 5 1/4" $795 | 3 1/2", $295 | 5 1/4" 3 1/2" | None | None |
| Carrying Case | Optional | Standard | Standard | Optional | None |
| Modem | $450 | Standard | Standard | $399 | $399 |
| Height (in) | 2.75 | 2 | 10.5 | 2.6 | 3 |
| Width (in) | 11.6 | 11.5 | 12.8 | 12 | 13.5 |
| Depth (in) | 13.6 | 15 | 6.3 | 12.1 | 11.75 |
| Bare Weight (lbs) | 12.6 | 13.1 | 16.23 | 9.90 | 11.5 |
| Handle | Yes | Yes | Yes | Yes | No |
| Screen Height (in) | 4.75 | 4 | 5.5 | 4 | 6 |
| Screen Width (in) | 7.75 | 9.5 | 11.5 | 10.5 | 8 |
| Screen Type | Electro-luminescent | Plasma | Backlit LCD | Supertwist LCD | Backlit Supertwist LCD |
| No of Keys | 80 | 71 | 84 | 81 | 75 |

All pricing displayed is retail.

## SUMMARY OF CRITERIA

Trade-offs must be made in selecting a microcomputer. Usually, the smaller the machine, the less the CPU speed, memory, and number of accessories. Choosing the same microcomputer for every submarine would be unwise. The small submarines have no room for a large microcomputer, but the larger submarines would be unnecessarily deprived of the capabilities of a larger machine. The critical factor in a standardized medical computing package is not that all submarines use the same computer, but that all computers use the same software. A small laptop computer is appropriate for submarines with very little storage space. A larger portable microcomputer is appropriate for submarines having larger storage capabilities.

## EVALUATIONS

We have tested five lap-sized machines. A Gridcase 3 Plus and the Data General One/Model 2 were already owned by the Laboratory. The Toshiba T1100 Plus, Zenith Z-181, and Quadram Datavue 25 were obtained on a 90 day lease as specified in letter NAVMEDCOM to NMRDC 5232, Ser 01C(92)/1773, dated 12 DEC 1986 with endorsement from NMRDC to NSMRL dated 2 JAN 1987. Table 2 gives the characteristics of the five laptops. The benchmarks discussed are listed in Appendix A. The following is a synopsis of each machine.

### Grid Gridcase 3+

Our department has used this machine for approximately one year. We have been pleased with it. It has run all MS-DOS software without any difficulty. It is compact and has a durable magnesium case. It has a plasma display which is the best display of any lap-sized machine we have seen. Table 3 shows that the display contrast was second of the five computers. It is battery-powered, and its AC adapter is quite small. The newest model can hold a 20 Megabyte hard drive.

## Table 3 - Display Characteristics of the Five Microcomputers Evaluated.

| Computer | Character Height | | Maximum Display Contrast[1] | | | |
|---|---|---|---|---|---|---|
| | UC (in.) | LC | Lighted Room (%) 90° | 45° | Dark Room (%) 90° | Color FG/BKG |
| Datavue 25 | .144 | .109 | 62.1 | 40.0 | 63.3 | Red/Yel |
| DG One/ Model 2 | .167 | .120 | 92.4 | 91.1 | 98.3 | Yel/Blk |
| Gridcase 3 | .137 | .098 | 76.6 | 83.6 | 99.7 | Red-Orange/Blk |
| Toshiba T1100 Plus | .137 | .093 | 77.1 | 59.2 | .... | Bl/Wh |
| Zenith Z-181 | .208 | .148 | 70.1 | 22.8 | 70.1 | Bl/Wh |

[1] $\text{Contrast } (\%) = \dfrac{|\text{Luminance of Background} - \text{Luminance of Target}|}{\text{Luminance of Lighter Area}} \times 100$

The data in this table is taken from a study to be published by K. Laxar and D. Neri at NSMRL.

The computer uses the 80C86 microprocessor running at 4.77 Mhz and has room for the 8087 coprocessor. The 80C86 has a 16 bit data bus, while the 80C88 used in most of the other small laptops has only an 8 bit bus. The larger bus allows the processor to perform faster than the 80C88 processor. Table 4 shows the ranks of the benchmark tests (Appendix A).

Memory is expandable up to 1 Megabyte and there are four external sockets for custom ROMs. The computer has a built-in clock. It has RGB, serial, and parallel ports. It emulates CGA graphics and can be connected to an expansion chassis. If the hard drive is installed, the 3 1/2 inch floppy drive is external, but it is almost pocket-sized and attaches directly to the rear of the machine.

The corpsmen rated this computer first (Table 1).

**Table 4 - Rankings of Tested Microcomputers on the Benchmark Tests**

|                                | Grid | Z181 | T1100 | DG | DTV |
|--------------------------------|------|------|-------|----|-----|
| Processor Speed Benchmark      | 2    | 4    | 1     | 5  | 3   |
| Processor Speed Instruct Max   | 2    | 4    | 1     | 5  | 3   |
| Floating Point (No 8087)       | 2    | 4    | 1     | 5  | 3   |
| File Access Speed              | 1    | 3    | 4     | 5  | 2   |
| Disk Access Time               | 1    | 3    | 4     | 2  | 5   |
| Memory Access Speed            | 2    | NA   | 1     | 4  | 3   |
|                                |      |      |       |    |     |
| Totals                         | 10   | 18*  | 8     | 26 | 19  |

## Zenith Z-181

Although this machine is IBM PC compatible, the Microsoft
Quick Basic 2.0 compiler would not run correctly on the machine
tested.  It is relatively small.  The computer has the best LCD
display we have seen.  The display uses supertwisted LCD
technology and is backlit.  Table 2 shows that the display
contrast was fourth of the five computers.  The machine is
battery powered.  A hard drive cannot be added.

The processor is an 80C88 running at 4.77 MHz. Table 4 shows
the ranks of the benchmark tests (Appendix A).  Maximum memory is
640K.  The computer has a built-in clock and comes with a serial
port, parallel port, and RGB interface.  It emulates the CGA.
There is no expansion chassis.  The two 3 1/2 inch floppy drives
"pop up and down" and appear to be rather flimsy for use in an
operational setting.  Although the machine does have the best LCD
display seen to date, it is very difficult to read scrolling text
on the LCD screen.

The corpsmen rated this computer second of the five laptops
surveyed (Table 1).

## Toshiba T1100 PLUS

This relatively small machine is IBM compatible and emulates
all of the IBM PC keys except a few shift - number pad keys,
including the minus and plus keys.  The LCD display has the worst
screen viewed.  It is inadequate for any area not having
excellent lighting.   Table 2 shows that the display contrast was
third of the five computers.  However, the screen is not backlit,
and the contrast could not be measured in a dark room.  The
machine is battery powered.  Toshiba makes no hard drive for this
machine, but a third party vendor can replace one of the floppies
with a 10 or 20 Megabyte hard drive for about $1000.

The processor is an 80C86 running at either 4.77 or 7.16 MHz. Table 4 shows the ranks of the benchmark tests (Appendix A). Maximum memory is 640K. It has a built-in clock and comes with a serial port, parallel port, and an RGB interface. The machine emulates CGA graphics. The computer has an expansion chassis.

The corpsmen rated this computer third (Table 1).

Data General One/Model 2 (Electroluminescent [EL] Display)

This machine is not "100% IBM compatible" like the other machines listed. The asynchronous adapter integrated circuit (IC) forming the serial port is different from the one that is in the IBM PC. None of the communication or serial printing software that we have available at the Laboratory will run on this machine. With its AC power supply adapter, it is one of the larger of the laptops. The keys are also quite small and more difficult to use than some of the other keyboards and the machine itself has a plastic swing-down rear support which is rather flimsy. The EL display is good. Table 2 shows that the display contrast was the best of the five computers. The EL display limits this machine to AC power only. If the LCD display is chosen, battery power may be used. The machine comes with a 10 Megabyte hard drive.

The computer's processor is a 80C88 running at 4.77 or 7.16 MHz, although on our test machine, an early model, the speed could not be changed from 4.77 MHz. Table 4 shows the ranks of the benchmark tests (Appendix A). The computer has a maximum memory of 640K. The computer does have a built-in clock and comes with a (nonstandard) serial port, parallel port, and a RGB port. The computer emulates the CGA and can be connected to an external chassis.

The corpsmen rated this computer fourth.

## Quadram Datavue 25

This machine is IBM PC compatible and runs MS-DOS 2.11. It is by far the bulkiest machine evaluated. The display is a backlit LCD display which is readable, although portions of the screen appear to change colors when the viewing angle is changed. The display contrast was fifth of the five computers (Table 1). A "gas-light" display is available at a higher price than the LCD model. We chose to evaluate the LCD machine to make direct comparisons with the Zenith Z-181. The machine can be battery powered, but has to be turned off to swap the battery pack for the AC adapter pack and vice versa.

The processor is an 80C88 running at 4.7 MHz. Table 4 shows the ranks of the benchmark tests (Appendix A). The maximum memory is 1.25 Megabytes. The machine contains a built-in clock, a serial port, parallel port, and an RGB interface. The computer emulates the CGA adapter. The keyboard is separate from the main unit and uses either an infrared (IR) link or an optional cable to communicate with the main unit. The keyboard needs 2 AA dry cell batteries whether the keyboard is operating in the IR mode or attached to the main unit by an optional cable. This keyboard drops characters when a user types moderately fast. If a character is dropped, the computer does not notify the user. The user is forced to watch the screen for each character to make sure the computer receives it.

The corpsmen ranked this computer fifth.

# COMMENTS ON THE NEW LAPTOPS

Since the evaluation of the original five machines was begun, both newer models of the originals and new computers have been released. We have not been able to evaluate these computers, but seven of these machines offer improvements that warrant considering them in the final selection of microcomputers for corpsmen aboard submarines.

"PC Magazine" in its July 21, 1987 issue (vol 6 #13) has published several comparisons of laptops recently. Information about the seven computers abstracted from "PC Magazine" is summarized below. Several characteristics of the machines are tabulated in Appendix B and "PC Magazine" benchmarks for these machines are listed in Appendix C. The benchmarks are generally different from those used for the five evaluated computers. Not all of these new benchmark programs were available when the benchmarking was performed on the evaluated computers.

(1) Compaq Portable III

This computer is IBM PC/AT compatible. It is the largest computer in the group. Its volume is approximately twice that of the average of the other computers, but it is well balanced and stores nicely. The computer has a plasma display. The computer is AC powered with no provision for battery power. Emergency power could be supplied by an uninterruptible power supply (UPS) at an additional cost of approximately $500. The standard model of this computer is equipped with a 20M hard drive. A 40M hard disk is optional. The processor is an 80286 running at 8 or 12 MHz. This computer has the highest clock speed of any of the eleven computers. The Compaq placed first overall in the benchmark tests. It will run the OS/2 operating system.

Maximum memory is 6.6 Megabytes. The computer comes with a serial port and a parallel port. It supports the CGA graphics and has an external RGB connector. There is room for two full-size AT peripheral cards in the expansion chassis.

(2)  <u>Toshiba T3100</u>

This microcomputer is IBM PC/AT compatible.  It is
relatively small and has a plastic case.  Its plasma display is
not as good as that of the Gridcase 3 Plus, but it is better than
any LCD display.  It is AC powered.  However, "PC Magazine"
reported that an external battery supply may be purchased from
Product R&D Corp. for $399.  The 10 Megabyte hard drive in this
machine is relatively slow, but faster drives may be purchased
from third party vendors.

The machine uses the 80286 microprocessor at 8 MHz.
This processor is used in the IBM PC/AT and is a generation ahead
of the 8088.  Only three benchmark test results were located and
this machine placed third overall in those tests.

Maximum memory is 2.6 Megabytes.  The computer has a
built-in clock, a serial port, and a parallel port.  It emulates
the CGA and has an external CGA adapter.  The computer can be
connected to an expansion chassis.

(3)  <u>Zenith Z-183</u>

The computer is IBM PC compatible.  It is relatively
small, but is larger than most of the other true laptops
discussed.  The display is the best of any of the LCD laptops,
but is still not as good as the plasma displays.  It is an
improved version of the Z-181 display.  The Z-183 is battery
powered.  The computer comes standard with a 10 Megabyte hard
drive.

The processor is the 80C88 running at 4.77 or 8 MHz.  In
the benchmark tests, the Z-183 placed fifth among the seven
computers.

Maximum memory is 640K.  The computer comes with a
serial port and parallel port.  It supports the CGA graphics and
has an external RGB connector.  The machine has no available
expansion chassis.

(4) Grid GridLite

The GridLite is a cheaper version of the GridCase 3 Plus. It is relatively small, has a plastic case, and is lighter than the GridCase 3 Plus by 3.4 pounds. The display is a supertwist LCD screen which is not backlit. It is battery powered. Currently you cannot add a hard drive to this machine.

The processor is an 80C86 running at 4.77 MHz. In the benchmark tests, the GriDLite placed sixth among the seven computers.

Maximum memory is 640K and the computer has a built-in clock. The computer has a built-in clock, a serial port, and a parallel port. It emulates the CGA and has an external CGA adapter. It has no expansion capabilities.

(5) Data General One/Model 2T

The Data General One/Model 2T is an "enhanced" version of the Data General One/Model 2. The main differences are that the display is a backlit supertwist LCD which is less readable than the Z-181 display, and the DG One/Model 2T has battery capability. We believe that the same nonstandard asynchronous adapter IC used in the Model 2 is used in the Model 2T. The keys are still small. The machine comes with a 10 Megabyte hard drive.

The computer's processor is a 80C88 running at 4.77 or 7.16 MHz. In the benchmark tests, the Data General placed fourth among the seven computers.

The computer has a maximum memory of 2.5 Megabytes. The computer does have a built-in clock and comes with a serial port and a parallel port. The computer emulates the CGA, has an external RGB connector, and can be connected to an external chassis.

(6)  <u>IBM PC Convertible</u>

This computer is IBM PC compatible.  It is relatively small, but its size and weight increase if the optional ports are added.  The display is a supertwist LCD which is difficult to read in less than optimal lighting.  In early July, IBM announced that the screen has been modified to increase its legibility.  The computer has a 6-8 hour battery life which is the longest battery life of any of the twelve computers.  The computer does not have a hard drive.

The processor is an 80C88 running at 4.77 MHz.  In the benchmark tests, the Convertible placed last among the seven computers.

Maximum memory is 640K.  The computer has a built-in clock.  A combination serial port and parallel port module comes separate as a plug-in extension to the rear of the machine.  A proprietary display adapter comes standard.  The machine supports the CGA.  An expansion chassis is available.

(7)  <u>NEC Multispeed</u>

The Multispeed is IBM PC compatible.  It is small and also has a plastic case.  The new display is a backlit supertwist LCD.  The computer is battery powered.  It does not have an internal hard drive.

The processor is CMOS V30, which is a faster clone of the 80C86.  At the faster of its two clock speeds, 9.54 MHz, the Multispeed placed second in the benchmark tests.

Maximum memory is 640K.  The computer has a built-in clock, a serial port, and a parallel port.  It emulates the CGA and has an external CGA adapter.  The computer can be connected to an expansion chassis.

## DISCUSSION

The primary criteria in the final evaluation were: size, screen legibility, availability of a hard drive, and provision for power during shipboard outages. These items are essential, but, unfortunately, also expensive. Together, a decent display and a hard drive will add approximately $2000 to the price of the laptop.

There are several computers which, although not ideal, may be adequate for the corpsman's use aboard submarines. Recommendations will first be made for the minimal medical storage situation and then the moderate medical storage situation. Again, it is stressed that even though the new computers may be recommended, we have not actually evaluated them, and conclusions are based on experience with earlier models and other reviews. Also, another review will be essential in about a year, since laptops are changing rapidly.

### Minimal Storage Computer

<u>Recommended</u>. For vessels with minimal storage space, two computers best meet our criteria. The first choice is the GridCase 3 Plus; second is the Zenith Z-183. Both are relatively small, battery powered, and have excellent displays. They have internal hard drives and have approximately the same processing power. They contain adequate memory and have the necessary ports. Both machines emulate the CGA.

The Grid is slightly preferable because it may contain a 20 M hard drive compared to the 10 M hard drive of the Z-183. The Grid's plasma display is easier to read than the Zenith's LCD display. The Z-183 does not have expansion chassis capabilities. Neither of these machines will run the new OS/2 operation system which will be released next year. The machines are comparable in price.

<u>Not Recommended</u>. The Toshiba 3100 was the original first choice for this category, but the recent political situation has eliminated both this machine and the T1100 Plus. The Compaq and the Datavue are too bulky. The Data General One/Model 2T is not IBM PC compatible, has small difficult-to-use keys, and its LCD display is less than optimal. The Z-181 has no hard drive, is slow, and has no expandability. The Multispeed is fast, but has no internal hard drive, and may be affected by the trade tariffs.

<u>Moderate Storage Computer</u>

For vessels with moderate storage space and a small semi-permanent working area, one computer best meets the criteria.

<u>Recommended</u>. The Compaq Portable III would be ideal, except its size limits it to vessels with ample medical storage space. It is IBM PC/AT compatible and has twice the volume of the average of the other laptops. It has a plasma display. The Compaq is not battery powered, but since the computer would be in a semi-permanent location, an UPS could be supplied. The UPS, however, would raise the price of the computer by approximately $300. The 20M hard drive is standard equipment for this computer; with it, the machine is well-suited to implement SAMS. The computer is the fastest of the machines reviewed, and it will run the OS/2 operating system when it is released. None of the other machines, except possibly the Toshiba 3100, will do so. The machine has the necessary ports and expansion capability.

<u>Not Recommended</u>. The closest competition the Compaq has is the Toshiba 3100 which has been eliminated. The other computers are a generation behind the Compaq Portable III.


## CONCLUSIONS

The GriDCase 3 Plus followed by the Zenith Z-183 are recommended for submarines having minimal medical storage areas and no set medical working area. The Compaq Portable III is recommended for submarines having at least a semi-permanent work space and ample medical storage space.

## ACKNOWLEDGEMENTS

# APPENDIX A

## Description of Benchmarking Programs

The benchmarking programs used in this evaluation, taken from PC Magazine, were the only ones available at the time. Each benchmark was run five times on each machine. Appendix 1 shows the mean times for each block of five runs. The "speed index" is the ratio of the benchmark time for the computer being tested to the benchmark time of a standard 4.77 MHz IBM PC or a standard 8 MHz PC/AT. The description of each benchmark is taken from the information given in the program; no other documentation was available.

Processor Speed Benchmark Test-- Version 1.30

The 128K NOP Loop, Do-Nothing Loop, Integer Add Loop, and Integer Multiply Loop tests were written in assembly language. The String Sort and Move test and the Prime Number Sieve test were written in Microsoft C 3.0.

Processor Speed Instruction Mix Test --   Version 1.00

This test executes a mix of assembly language instructions to measure processor speed.

Floating Point Test -- Version 1.00

This test was written in Microsoft C 4.0 and uses the math coprocessor emulation library for the first test. The second test was run if a math coprocessor was present in the evaluation unit.

File Access Speed Benchmark Test -- Version 1.00

This benchmark tests file creation, reading, and writing (random and sequential) for a 256K file with two buffer sizes. "BUFFERS=3" was set in the CONFIG.SYS file to ensure the same amount of file buffer space for each machine. Since floppy drives can vary on the PC, no "Speed Index" values are shown for this benchmark. All machines were tested with 3 1/2 inch, 720 Kbyte floppy drives.

Disk Access Time Test Using Sector Reads -- Version 1.00

This benchmark uses the DOS Interrupt 25H to directly read disk sectors.

Memory Access Speed Benchmark Test -- Version 1.10

This benchmark allocates 256 Kbytes of conventional memory and treats it as a series of 64 byte records. 16,384 random records are then read and written into this area from local memory.

## Benchmark Results

### Processor Speed Benchmark Test -- Version 1.30

| Trial Average | Time in Seconds | Speed Index Relative to 4.77 MHz PC | Speed Index Relative to 8.00 MHz AT |
|---|---|---|---|
| **128 K NOP Loop:** | | | |
| Data General One/2 | 12.52 | 0.8 | 0.3 |
| Grid Gridcase 3 | 7.40 | 1.4 | 0.6 |
| Quadram Datavue 25 | 10.11 | 1.0 | 0.4 |
| Toshiba T1100 PLUS | 4.96 | 2.0 | 0.8 |
| Zenith Z-181 | 10.59 | 1.0 | 0.3 |
| **Do-Nothing Loop:** | | | |
| Data General One/2 | 11.91 | 0.8 | 0.3 |
| Grid Gridcase 3 | 10.00 | 1.0 | 0.4 |
| Quadram Datavue 25 | 9.94 | 1.0 | 0.4 |
| Toshiba T1100 PLUS | 6.37 | 1.6 | 0.6 |
| Zenith Z-181 | 9.95 | 1.0 | 0.3 |
| **Integer Add Loop:** | | | |
| Data General One/2 | 12.41 | 0.8 | 0.2 |
| Grid Gridcase 3 | 8.20 | 1.2 | 0.3 |
| Quadram Datavue 25 | 9.89 | 1.0 | 0.2 |
| Toshiba T1100 PLUS | 5.40 | 1.8 | 0.4 |
| Zenith Z-181 | 10.19 | 1.0 | 0.3 |
| **Integer Multiply Loop:** | | | |
| Data General One/2 | 11.95 | 0.8 | 0.1 |
| Grid Gridcase 3 | 9.20 | 1.1 | 0.1 |
| Quadram Datavue 25 | 10.00 | 1.0 | 0.1 |
| Toshiba T1100 PLUS | 6.00 | 1.7 | 0.2 |
| Zenith Z-181 | 10.00 | 1.0 | 0.3 |
| **String Sort and Move:** | | | |
| Data General One/2 | 13.01 | 0.8 | 0.2 |
| Grid Gridcase 3 | 9.44 | 1.1 | 0.3 |
| Quadram Datavue 25 | 10.71 | 1.0 | 0.3 |
| Toshiba T1100 PLUS | 6.20 | 1.7 | 0.5 |
| Zenith Z-181 | 11.01 | 1.0 | 0.3 |

**Prime Number Sieve:**

| | | | |
|---|---|---|---|
| Data General One/2 | 19.03 | 0.8 | 0.2 |
| Grid Gridcase 3 | 13.80 | 1.1 | 0.3 |
| Quadram Datavue 25 | 15.37 | 1.0 | 0.3 |
| Toshiba T1100 PLUS | 8.58 | 1.8 | 0.5 |
| Zenith Z-181 | 15.95 | 1.0 | 0.3 |

## Processor Speed Instruction Mix Test -- Version 1.00

| Trial Average | Time in Seconds | Speed Index Relative to 4.77 MHz PC | Speed Index Relative to 8.00 MHz AT |
|---|---|---|---|
| 8086/8088 Instruction Set: | | | |
| Data General One/2 | 38.54 | 0.8 | 0.2 |
| Grid Gridcase 3 | 30.02 | 1.1 | 0.3 |
| Quadram Datavue 25 | 32.01 | 1.0 | 0.3 |
| Toshiba T1100 PLUS | 19.17 | 1.7 | 0.5 |
| Zenith Z-181 | 32.87 | 1.0 | 0.3 |

## Floating Point Test -- Version 1.00

| Trial Average | Time in Seconds | Speed Index Relative to 4.77 MHz PC | Speed Index Relative to 8.00 MHz AT |
|---|---|---|---|
| Floating Point (no 8087): | | | |
| Data General One/2 | 195.66 | 0.8 | 0.2 |
| Grid Gridcase 3 | 118.66 | 1.3 | 0.3 |
| Quadram Datavue 25 | 159.23 | 1.0 | 0.2 |
| Toshiba T1100 PLUS | 76.94 | 2.0 | 0.5 |
| Zenith Z-181 | 165.09 | 0.9 | 0.2 |
| Floating Point (with 8087): | | | |
| Data General One/2 | 5.79 | 0.8 | 0.5 |
| Grid Gridcase 3 | 4.14 | 1.2 | 0.8 |
| Quadram Datavue 25 | N/A | N/A | N/A |
| Toshiba T1100 PLUS | N/A | N/A | N/A |
| Zenith Z-181 | N/A | N/A | N/A |

```
File Access Speed Benchmark Test -- Version 1.00

Buffer Size:                        512        4K
Number of Records:                  512        64

Trial Average                       Secs       Secs
                                    ------     -----

  Sequential File Creation:
        Data General One/2          114.20     34.56
        Grid Gridcase 3             109.56     26.56
        Quadram Datavue 25          108.86     27.68
        Toshiba T1100 PLUS          115.30     35.65
        Zenith Z-181                114.06     29.85

  Sequential File Reading:
        Data General One/2          113.55     33.89
        Grid Gridcase 3             108.70     28.70
        Quadram Datavue 25          107.96     28.47
        Toshiba T1100 PLUS          108.55     24.38
        Zenith Z-181                107.84     28.85

  Sequential File Writing:
        Data General One/2          216.00     34.09
        Grid Gridcase 3             211.40     29.26
        Quadram Datavue 25          210.86     27.90
        Toshiba T1100 PLUS          211.65     34.94
        Zenith Z-181                210.47     30.61

  Random File Read:
        Data General One/2           96.32     28.90
        Grid Gridcase 3              91.82     25.86
        Quadram Datavue 25          102.84     34.65
        Toshiba T1100 PLUS           93.56     24.23
        Zenith Z-181                 99.25     31.96

  Random File Write:
        Data General One/2          189.21     28.51
        Grid Gridcase 3             189.93     26.20
        Quadram Datavue 25          201.21     32.61
        Toshiba T1100 PLUS          192.59     37.66
        Zenith Z-181                193.94     37.84
```

**Disk Access Time Test using Sector Reads -- Version 1.00**

| Trial Average | msec | errors |
|---|---|---|
| Average Read Time of 1000 Sectors: | | |
| Data General One/2 | 259.79 | 0 |
| Grid Gridcase 3 | 256.66 | 0 |
| * Quadram Datavue 25 | 304.66 | 0 |
| Toshiba T1100 PLUS | 300.53 | 0 |
| Zenith Z-181 | 296.78 | 0 |

* Time averaged over four trials.  On first run, benchmark returned a negative time.


**Memory Access Speed Benchmark Test -- Version 1.10**

| Trial Average: | Time in Seconds | Speed Index Relative to 4.77 MHz PC | Speed Index Relative to 8.00 MHz AT |
|---|---|---|---|
| Conventional Read: | | | |
| Data General One/2 | 7.14 | 0.8 | 0.2 |
| Grid Gridcase 3 | 5.70 | 1.1 | 0.2 |
| Quadram Datavue 25 | 5.94 | 1.0 | 0.2 |
| Toshiba T1100 PLUS | 3.68 | 1.6 | 0.4 |
| Zenith Z-181 | not enough conventional memory | | |
| | | | |
| Conventional Write: | | | |
| Data General One/2 | 7.14 | 0.8 | 0.2 |
| Grid Gridcase 3 | 5.70 | 1.0 | 0.2 |
| Quadram Datavue 25 | 5.93 | 1.0 | 0.2 |
| Toshiba T1100 PLUS | 3.73 | 1.6 | 0.4 |
| Zenith Z-181 | not enough conventional memory | | |

# APPENDIX C

## Non-evaluated Microcomputer Characteristics

| | Compaq Portable III | Data General One/Model 2T | GRiDLite | IBM PC Convertible | NEC Multispeed | Toshiba 3100 | Zenith Z-183 |
|---|---|---|---|---|---|---|---|
| Base Price | $4,999 | $2,895 | $1,795 | $1,695 | $1,995 | $4,199 | $3,399 |
| Minimum RAM | 640K | 512K | 128K | 256K | 640K | 640K | 640K |
| Maximum RAM | 6.6M | 2.5M | 640K | 640K | 640K | 2.6M | 640K |
| Standard Disk Dr | 1.2M floppy / 20M hard disk | 3 1/2" floppy / 10M hard disk | 3 1/2" floppy | 2 3 1/2" floppy | 2 3 1/2" floppy | 3 1/2" floppy / 10M hard disk | 3 1/2" floppy / 10M hard disk |
| Processor | 80286 | 80C88 | 80C86 | 80C88 | CMOS V30 | 80286 | 80C88 |
| Speed (MHz) | 12 | 4.77/7.16 | 4.77 | 4.77 | 4.77/9.54 | 8 | 4.77/8 |
| Expansion Slots | 2 Proprietary | 2 Prop/2 Open | None | 1 Proprietary | None | 1 Short | None |
| Expansion Chasis | Yes | Yes | Yes | Yes | Yes | Yes | No |
| Monitor Ports | RGB | RGB,Composite | RGB | Proprietary | RGB | RGB | RGB,Composite |
| Serial Port | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Parallel Port | Yes | Yes | Yes | No | Yes | Yes | Yes |
| Battery Operated | No | No | No | Yes | No | No | No |
| Hard disk Options | 20M strnd / 40M | 10M strnd | None | No | 10M strnd | 10M strnd | 10M strnd |
| Floppy Disk Options | None | 5 1/4" $795 | 3 1/2", $295 | 3 1/2", $170 | None | None | 5 1/4", $399 |
| Carrying Case | Optional | Optional | Optional | Optional | Optional | Standard | Optional |
| Modem | $399 | $400 | $495 | $225 | $399 | $399 | $399 |
| Height (in) | 9 | 3 | 2.6 | 2.7 | 3.0 | 2 | 3.25 |
| Width (in) | 15.5 | 11.25 | 13.25 | 12.8 | 13.6 | 11.5 | 13.75 |
| Depth (in) | 7.5 | 14 | 11.25 | 14.7 | 13.6 | 12 | 13 |
| Bare Weight (lbs) | 20.88 | 13.30 | 9.70 | 12.67 | 11.45 | 14.6 | 15.40 |
| Travel Weight(lbs) | 20.88 | 15.27 | 11.60 | 14.29 | 12.81 | Info Not Avail | 17.01 |
| Handle | Yes | Yes | No | Yes | Yes | Yes | Yes |
| Screen Height (in) | 5.5 | 6.5 | 6.5 | 3.75 | 4 | 5.9 | 6 |
| Screen Width (in) | 8.5 | 8 | 8.5 | 10.25 | 10.5 | 7.7 | 8 |
| Screen Type | Plasma | Backlit Supertwist LCD | Supertwist LCD | Supertwist LCD | Backlit Supertwist LCD | Plasma - Non-Glare | Backlit Supertwist LCD |
| No of Keys | 84 | 80 | 71 | 78 | 85 | 81 | 78 |

# APPENDIX D

## Non-evaluated Microcomputer Benchmarks

| Computer | NOP | 8086 Instr Mix | Conv Mem | FP Calc | BIOS Disk Seek (ms) | DOS Disk Acces (ms) | Dir to Scrn | BIOS no scrol | BIOS with scrol |
|---|---|---|---|---|---|---|---|---|---|
| 1. IBM PC AT 8 MHz (1.2 MB floppy) | 4.2 | 9.0 | 1.3 | 36.0 | 37.0 | 180.5 | 4.9 | 4.5 | 7.6 |
| 2. COMPAQ Portable III (12 MHz) | 2.8 | 6.1 | 0.9 | 23.8 | 27.4 | 190.5 | 4.3 | 2.3 | 4.5 |
| 3. Toshiba 3100 (8 MHz) | 5.7 | 12.5 | N/A | 34.6 | N/A | N/A | N/A | N/A | N/A |
| 4. IBM PC XT 4.77 MHz (360K floppy) | 10.1 | 32.0 | 5.9 | 159.2 | 95.6 | 242.3 | 11.6 | 17.3 | 23.3 |
| 5. IBM PC Convertible (4.77 MHz) | 9.4 | 31.0 | 5.7 | 150.5 | N/A | 308.1 | 7.6 | 13.6 | 16.8 |
| 6. GridLite (4.77 MHz) | 7.0 | 28.3 | 5.5 | 113.8 | N/A | N/A | 10.1 | 11.5 | 15.6 |
| 7. NEC Multispeed (9.54 MHz) | 3.7 | 12.4 | 1.9 | 51.3 | N/A | 220.8 | 3.4 | 11.4 | 12.9 |
| 8. DG One/Model 2T (8 MHz) | 6.8 | 21.8 | 4.0 | 108.5 | 148.2 | 200.7 | 5.8 | 5.7 | 8.5 |
| 9. Zenith Z-183 (8 MHz) | 7.5 | 22.1 | 4.0 | 114.2 | 113.8 | 295.4 | 7.9 | 3.6 | 6.7 |

The results in this appendix were taken from "PC Magazine" Vol 5 Number 13, July ,1986, p34, "PC Magazine" Vol 6 Number 7, April 14, 1987, p34, and "PC Magazine" Vol 6 Number 13, July 21, 1987, pp 220-221.

The NOP and mixed instruction tests are the same as those in Appendix A. The remainder of the benchmarks in this appendix are different from those listed in Appendix A.

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This memo report is in response to NAVMEDCOM letter 5232, Ser 01C(92)/1773, dated 12 December 1986, with endorsement by NMRDC dated 2 January 1987, requesting that we evaluate certain laptops for possible purchase for use by corpsmen on submarines.

Five laptop microcomptuers were evaluated in-house, and seven laptops were evaluated through a survey of the current literature. Recommendations for

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placing appropriate sized microcomputers aboard submarines are given.
For those submarines with minimal medical storage space, there are two
computers of the twelve reviewed which best fit the criteria. The first is
the GriDCase 3 Plus, followed by the Zenith Z-183. For those submarines
with greater medical storage space, the microcomputer recommended is the
Compaq Portable III.