TAKING THE D86 MACHINERY CONTROL AND SURVEILLANCE SYSTEM INTO THE 21st CENTURY

BY

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ABSTRACT

The D86 Machinery Control and Surveillance System is fitted in the Type 23 Frigate to provide electronic control of the marine engineering equipment and systems. Conceived during the early 1980's, the distributed network of 8086 processors has limited processing capacity for accommodating new system management features, such as Condition Based Maintenance packages. A number of recent studies have examined the possibilities of replacing the 8086 processor with more modern variants, but these have required significant change to the system hardware and software. This article considers an alternative solution that minimizes system change by using embedded PC104 technology to provide an interface with CBM and other engineering management packages.

Introduction

The D86 Machinery Control and Surveillance (MCAS) System is fitted to the Type 23 Frigate to provide control and surveillance of the CODLAG main propulsion machinery and auxiliary systems. The system is driven by a number of distributed 8086 microprocessors that provide local and remote control of the plant operation, sending surveillance data back to remote units in the Ship Control Centre (SCC) for information display.

Since the introduction of the first D86 system into a Royal Navy vessel, HMS *Norfolk* in 1989, microprocessor technology has advanced significantly. Modern processors have greater capacity and faster data handling rates, which allow machinery information to be analysed and presented in a more 'user friendly' manner. With a limited processing capacity, the D86 system is unable to adequately store or analyse the channel data, it merely displays the sampled information in the SCC. Modern maintenance management facilities are now demanding more information from surveillance systems. The MoD is committed to the concept of Condition Based Maintenance (CBM), and has recently fitted the RN adopted CBM package, MIMIC, in a Type 23.

The MIMIC package fitted to the T23 was initially intended to manually record the equipment vibration readings only. There was no facility for recording the machinery channel data held within the D86 MCAS system. As channel information was available, it seemed logical that a method should be found for transferring this data into MIMIC for processing. A proposal to automatically capture this information was considered. This article examines the development of that proposal, and shows how PC104 technology may be used to increase the effectiveness of D86 by installing a PC104 card into the heart of the surveillance system. The card will allow direct access to the machinery control data held within D86 and being totally passive it will not increase the data handling requirements of the existing components. The information extracted from the D86 system may then be analysed by the MIMIC software, or by any other 'OPEN' standard processing package.

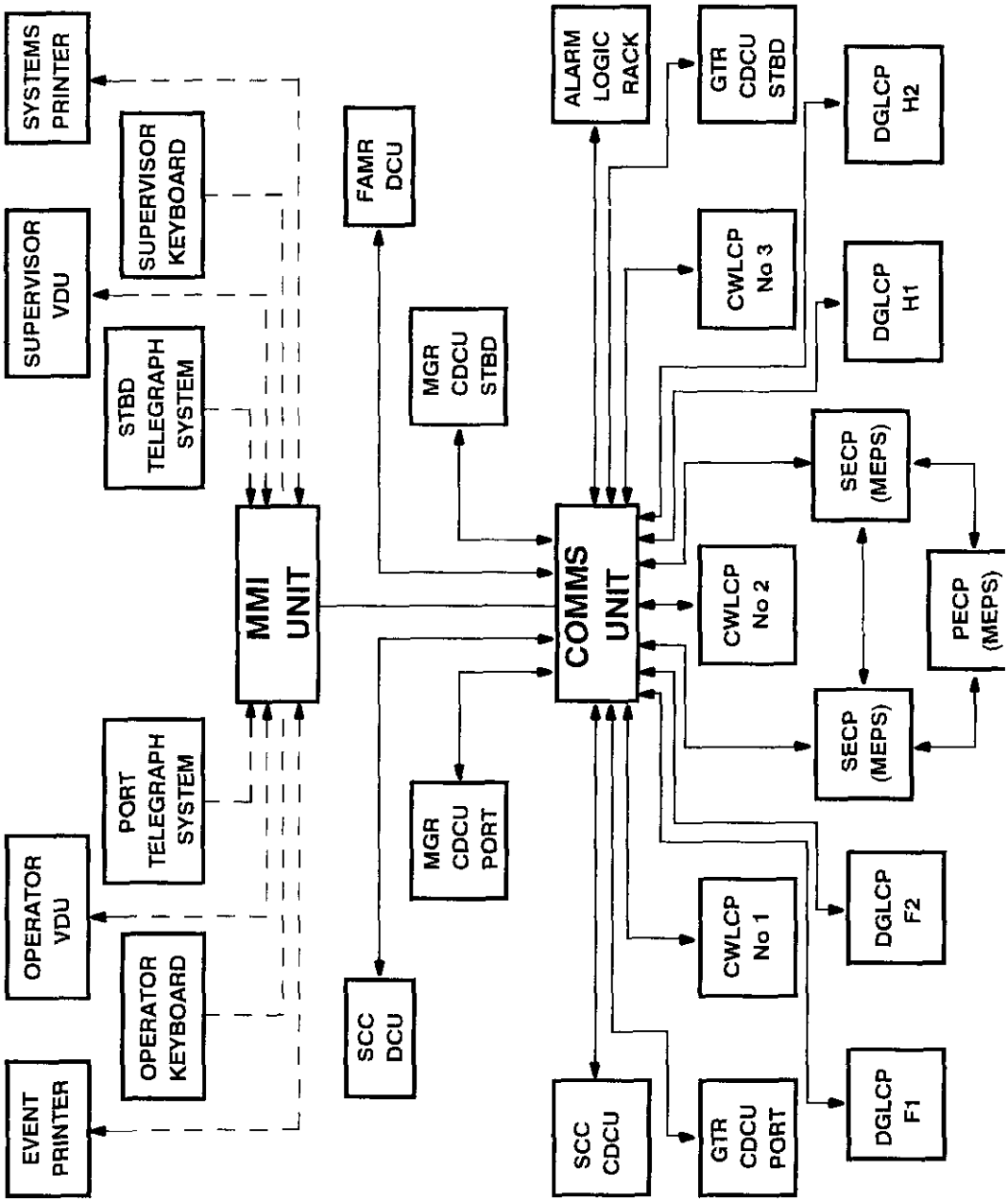

FIG.1 - T23 MACHINERY CONTROL AND MONITORING SCHEMATIC

Background

The D86 MCAS system was developed from the D77 system used in the RN's Huntsman training simulator situated at HMS *Sultan*. The improved D86 variant was fitted with an Intel 8086 processor instead of the ageing F100L type used in the D77. D86 was first used in a high-speed vessel built by Lurssen in West Germany. After successful sea trials on this vessel the system was chosen for the machinery control and surveillance system in the Type 23, Single Role Mine Hunter (SRMH), Trident class and T2400 submarines.

A schematic diagram of the D86 system fitted to the Type 23, is shown in (Fig.1). This shows a number of distributed 8086 microprocessor units, installed throughout the main machinery spaces and within the consoles in the SCC. The outstation units interface with the propulsion and auxiliary machinery, gathering channel information and providing control functions.

The units fitted in the SCC provide a more primary role, and can be described under the following heading:

Central Unit (CDCU & DCU)

- Monitors the outstations providing secondary surveillance
- Generates the visual and audible warnings
- Formats the MMI displays
- Short term storage of information.

Alarm Rack

Outputs an alarm when a parameter exceeds its specified range or when a CDCU failset is detected.

MMI Rack

Provides an interface with the keyboard, VDU, printers and conditions secondary group warning.

Comms Rack

Services the MMI rack requests, MCAS SDLs to CDCU/DCU, maintain the MCAS system database, constantly updating the information with fresh data from the CDCU/DCUs.

Channel data is passed from the CDCU/DCUs to the SCC and between the Comms and MMI racks via Serial Data Links (SDLs). The SDL's provide a high data rate, high integrity link between the units using HDLC protocols at 375K baud. Control signals and Alarm Channels, commonly referred to as Critical channels, are hard wired and are independent to the operation of the SCC CDCUs.

This existing D86 arrangement provides an adequate level of control and surveillance for routine plant operations, but offers limited capacity to incorporate enhancements into the system. The installation of a PC104 card into the D86 unit will significantly enhance the data capture capabilities of the system and provide further opportunities for system improvements. The card will fit into the communications rack and monitor data transmitted along the backplane. This information will be made available to external workstations, where it may be conditioned by various software packages.

PC104 Technology

The PC104 offers a COTS solution to the data capture problem. It is a compact ruggedized card, developed to allow easier installation of PC technology in limited spaces. The term 'PC104' is derived from the cards unique physical properties designed for embedded system applications. It has 104 signal contacts on two PC/104 bus connectors, a typical PC104 card is illustrated in (Fig.2).

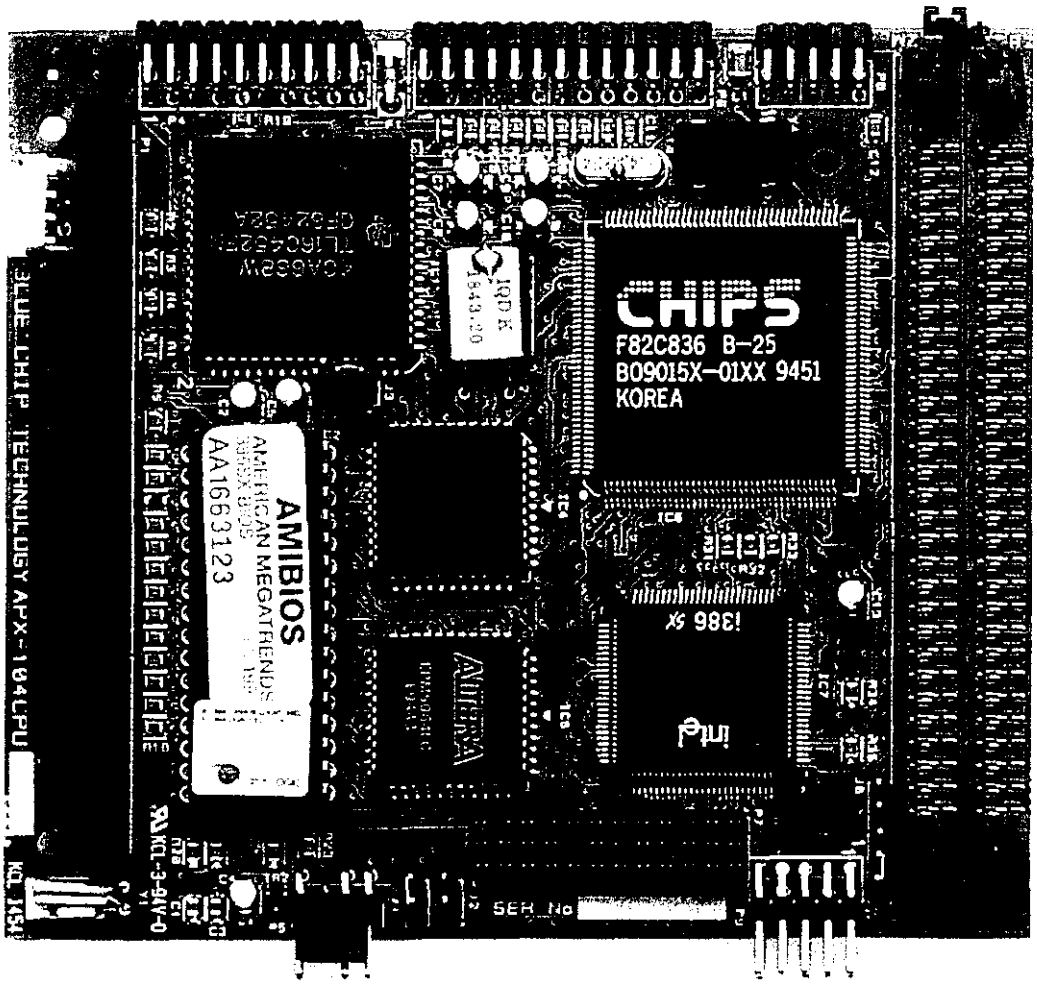

FIG.2 - A TYPICAL PC104 CARD

The cards have a reduced form factor (size), and offer full architecture, hardware and software compatibility with standard PC bus. A selection of PC modules is available to suit specific applications. In this application the PC104 will be used in conjunction with an existing D86 PCB, shown (Fig.3), to extend system capabilities and improve performance.

Development of PC104 for D86 system

A number of MoD sponsored studies have examined various ways of improving the performance of the T23 D86 MCAS system to facilitate a Condition Based Maintenance (CBM) package. These studies focused mainly on the replacement of the ageing 8086 based Processor 2's with either multiple Processor 3's (8086 based), or, the newer 486 based Processor 5's. This would have required the conversion of the Coral programme to a more modern language, such as ADA. Such designs required considerable change to the system hardware and software, making any modification proposal a high-risk strategy.

An alternative approach was investigated by VTC, and a more acceptable solution found. This solution provided a much lower risk, and could meet the interface requirements without the need for any alteration to the distributed parts of the system. It requires only the installation of an additional D86

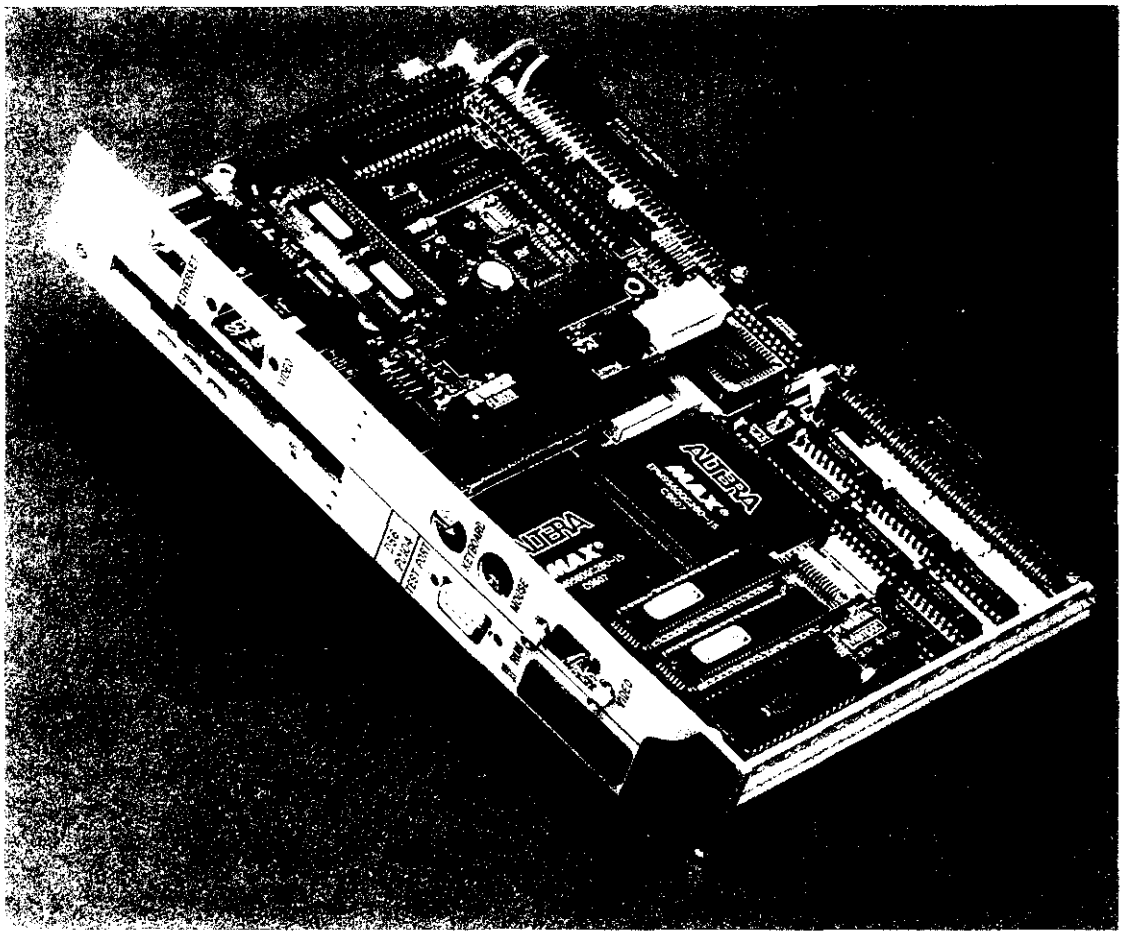

FIG.3 - THE D86 PC104 CARD

PCB into the system, but allows the use of 'OPEN' Standard interfaces. This will give improved data handling rates for application software, which may be run from any number of independent outstations.

By stacking a number of PC104 cards onto an existing D86 board, to form a powerful programmable unit, the processing capability of the system can be increased to provide the link between CBM and D86. Further control and surveillance applications, that have required increased processing power, may now be considered for T23 or other vessels using D86 boards (considered in more detail later in this article).

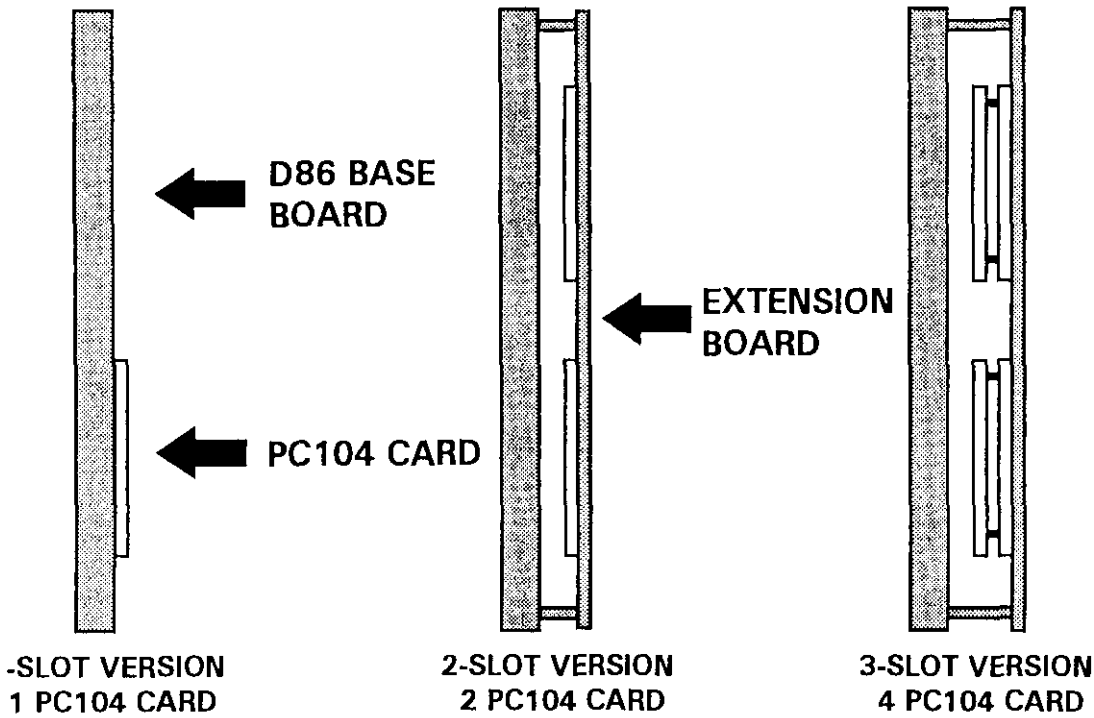

FIG.4 - D86 PC104 CARD CONFIGURATION OPTIONS

The D86 PC Card will provide all the benefits of a modern PC on an existing D86 board. The processing capability and board configuration may be optimized to suit specific applications. In this case the D86 PCB will be able to take up to four childboards, configured as shown in (Fig.4). This card is then simply plugged into the Communications rack, where it will monitor all the data transmitted on the D86 Motherboard (including both serial and I/O data). The data will be passed to the PC part of the board and converted into meaningful MCAS data. It may then be stored locally on a hard disk or PCMCIA, or transferred by serial link to a logging unit, as shown in (Fig.5).

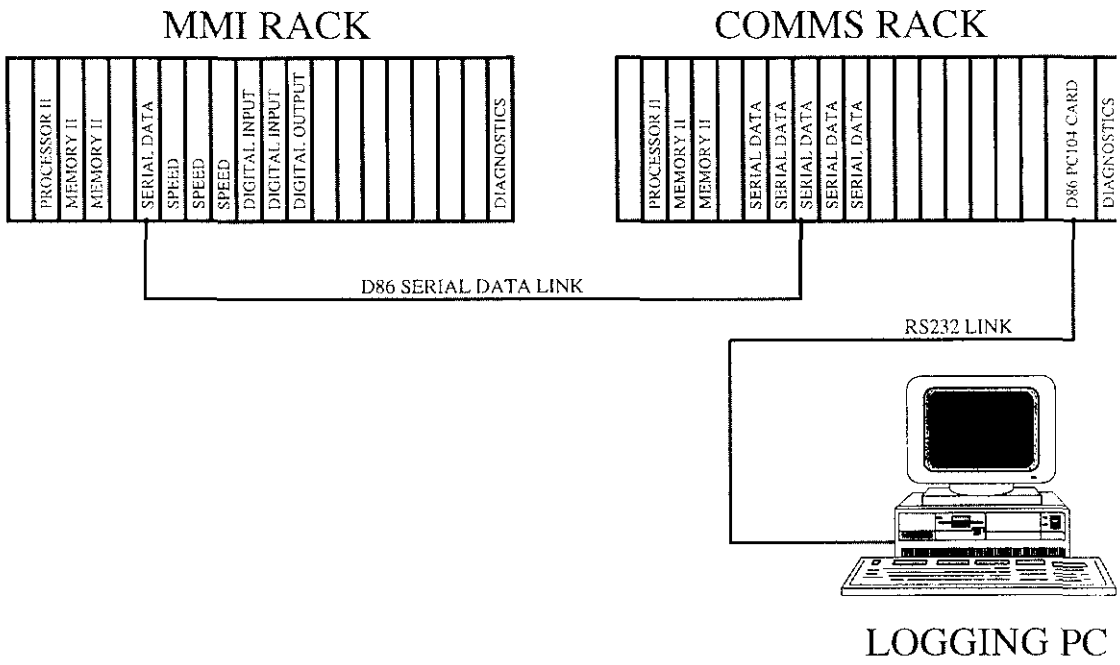

FIG.5 - DATA LOGGING USING D86 PC104 CARD

Software for the PC part of the board has been developed in two distinct parts. Firstly generic software that could be used on all future D86 PC104 boards was created. This includes the low-level baseboard interfaces and the external communications software. Secondly the application specific software, including a database, was created (Fig.6).

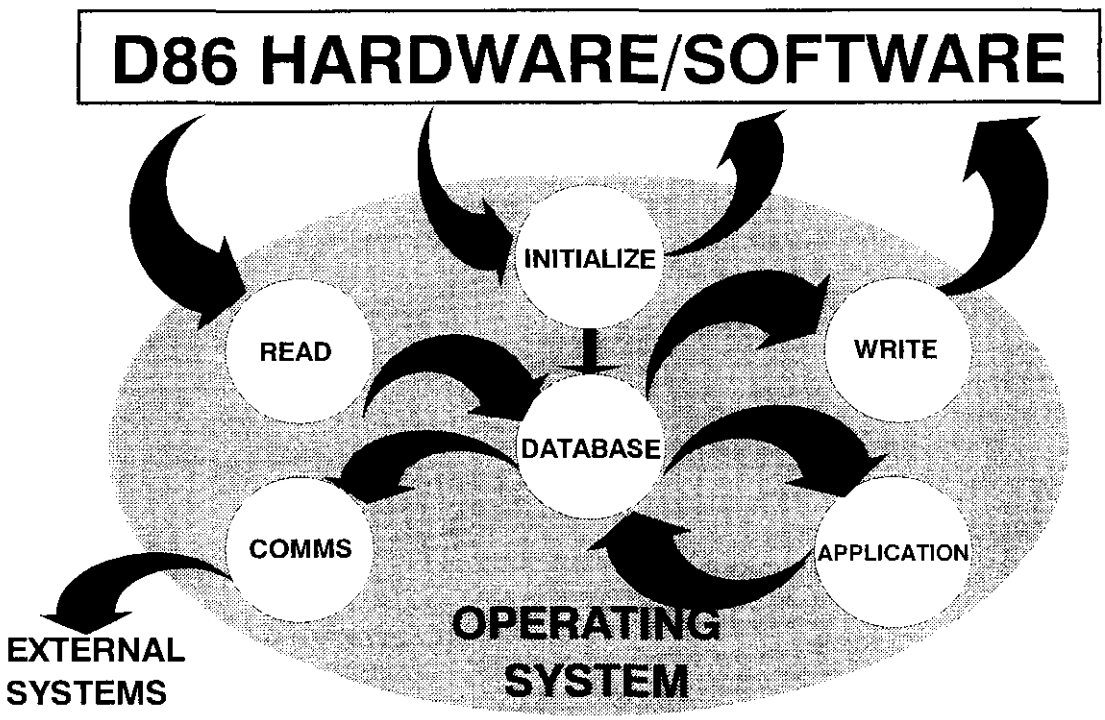

FIG.6 - D86 PC104 CARD SOFTWARE ARCHITECTURE

The first T23 application - Condition Based Maintenance with D86/ PC104

The CBM package, MIMIC, has been selected by the MoD to provide long term data recording on various ship systems. On non-T23 vessels this has involved interfacing MIMIC to hand held data recorders and serial links normally connected to a particular system's event printer. On the T23 it was recognized that the MCAS system contained a large proportion of the data required for recording. It was therefore decided to interface the MIMIC package to the MCAS system via a D86 PC104 card placed in the COMMS rack. The D86 PC104 card passively 'listens' to the main COMMS rack processor picking out data written to specific memory addresses. A serial link (RS422) provides the communications between the two systems.

The MCAS system supplies the MIMIC package with information on approximately 360 channels of data on an hourly basis. Channel information includes a unique identifier, channel descriptor and latest value.

A prototype D86 PC104 board and software started a six month Minor Trial in February 1998 on one of the T23s. Four months into the trial the system is still logging data to an external PC, no problems have been reported. Data collected from this trial will be analysed later in the year to confirm the board's functionality.

Further T23 applications

During the initial conception of the D86 PC104 board it was recognised that it would turn D86 from a 'closed' system into an 'open' system. Data acquired by the D86 racks and communicated to the COMMS rack could be re-used many times. This would allow the MCAS system to be expanded with new functionality without affecting the original software and thus reducing the risk associated with any software changes.

Previous studies have shown that the link between the Comms and MMI racks may be more susceptible to failure when the signal traffic is dense; encountered during periods of high activity, such as a Total or Partial Electrical Failure. The addition of another D86 PC card in the MMI rack will provide a Ethernet communication link that may run in parallel with the existing SDL. A dual redundant Ethernet link between D86 racks, extending further into the ship will allow a number of other system applications to be driven from the D86/PC104 interface (Fig.7).

It was therefore decided that whilst developing the CBM interface the database should be created to include a complete set of MCAS channels and not simply the 360 channels sent to MIMIC.

This, together with the modular approach to the software, has allowed for the rapid prototyping of several new MCAS functions including improvements to the MMI and the system diagnostics. Some of these systems have already been successfully demonstrated on the D86 Reference Facility at Vosper Thornycroft Controls Ltd. They include:

- Improved MMI
- Improved Diagnostics
- Dynamic On-Line Database
- Trials Logging (Dynamic Data Recording)
- Trend Analysis
- Scenario Generator
- On-board Training
- Links To Other Ship Systems.

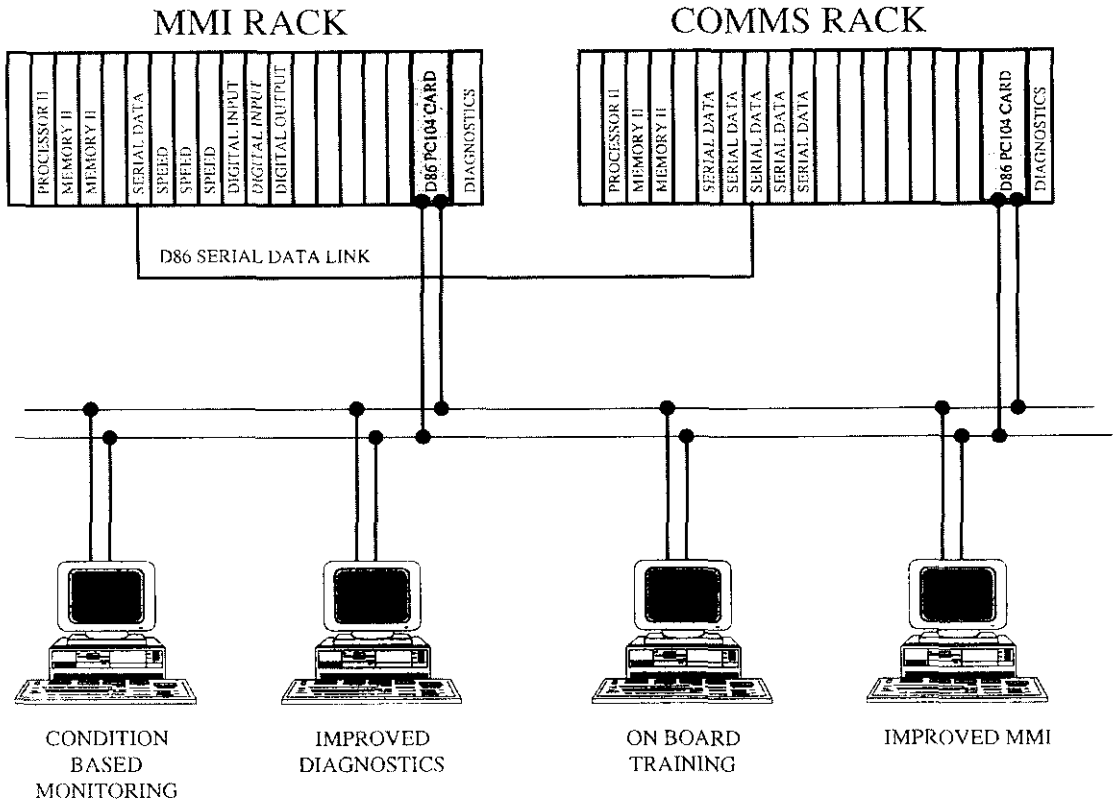

FIG.7 - POTENTIAL INCREASED FUNCTIONALITY WITH D86 PC104 CARD

Improved MMI

The current plasma displays and keyboards provide a limited MMI. The operator's interface will be enhanced by the use of colour graphics and an improved input method (trackerball, touch screen etc.).

Improved Diagnostics

The current D86 Handset provides limited diagnostics information in what is now considered a 'user unfriendly' way. Improving the MMI will allow the operator and maintainer to receive diagnostics information in a far more user-friendly way.

Dynamic On-Line Database

As part of the improved diagnostics a complete MCAS database will be available and include current channel values. The current channel database can be extended to include D86 board information, console wiring and ship's cabling data to provide a very useful maintenance aid.

Trials Logging (Dynamic Data Recording)

The D86 PC104 card can log data as quickly as it receives it at the COMMS rack. It can therefore provide additional logging to that offered for CBM. This includes trials logging and machinery health monitoring that would allow, for example, engine starts to be compared.

Trend Analysis

The current T23 MCAS system offers some trend logging, this could be enhanced to include the logging and some analysis facilities.

Scenario Generator

To assist in the setting up of machinery, the MCAS system, or fault finding with the D86 PC104 card can be used to run simulations of various parts of the ship. This will reduce trials time and save on manning. Real equipment would only form part of the final trial.

On-board Training

Leading on from above the simulations can also be used as part of ship's staff training. Additional workstations connected to the ship wide network can be used to observe the real ship actions, as they happen, or, play back previously logged data.

Links to other ship's systems

The T23 MCAS system now has the potential to be linked through to other ship's systems such that data can be passed to or from the other system.

Further Fleet applications

The D86 PC104 card can be used anywhere in the fleet a D86 rack exists. Several studies are already underway into the potential improvements that the PC104 board will bring. Some examples follow for the Machinery Surveillance System on the TRIDENT class submarine and the two systems on the SRMHs:

TmaSS

As with the T23 MCAS MMI the TmaSS MMI is plasma and keyboard based and is somewhat limited in its capability. By adding D86 PC104 cards to some or all of the D86 racks the quantity and quality of data presented to the operator will be greatly improved.

SRMH

The SRMH has three main D86 racks. Two, one port and one starboard, are associated with MCAS data, the other provides the automated Ship Positioning Control System (SPCS). Currently all three racks are independent. By adding a D86 PC104 card into each rack they can be networked together and their data shared.

The first SRMH application has been designed and tested and will undergo a Minor Trial in late 1998. It will provide data currently available only on the Bridge to ship's staff in the SCC. Further study work will generate prototypes providing:

- Enhanced Diagnostic Information
- A replacement to the SPCS plasma display
- A networked Dynamic Data Recorder.

Current development plan

Further development of the D86 PC104 card is being aimed at producing a board that is capable of both reading and writing to the D86 backplane. The write function will allow the card to complement or replace an existing D86 processor board.

Conclusions

The D86 PC104 module is a method of providing the RN and other D86 users with an Open System approach, capable of interfacing with the latest technologies. This will, along with the current planned development, provide an upgrade path, which is both relatively, low risk and supplier friendly. Although used initially to provide a link between D86 and MIMIC, the PC104 card will also allow integration with other ship's system giving the end user the means to have a retro-fitted Open System Integrated Platform Management System.