THE SUPPORT CHALLENGE FOR THE ROYAL NAVY'S ALBION CLASS LANDING PLATFORM DOCKS

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ABSTRACT

This paper outlines recent UK experience in the operation of the LPD HMS Albion and HMS Bulwark by the Royal Navy. It provides an overview of the particular challenges faced in maintaining Ship Control Systems based on COTS equipment fitted in the mid 1990s. It considers the ease of replacement of computing platforms, displays and networks and the reliability and performance of data acquisition. An important element of this is the overall portability and supportability of the existing software solutions.

As new equipment is introduced on board ship, the management of System Integrations and Systems Interoperability becomes significant. Contributory factors include the impact of lean manning on system design and operation, operator training and performance, the adequacy of maintenance training, supporting manuals and documentation. Consideration is given to the management of obsolescence, the ease of system update and the infrastructure required to maintain a through life capability. The nurturing of Suitably Qualified Experienced Personnel (SQEP) in the design, operation and support of COTS based systems is key to maintaining coherency between evolving COTS technology and cost effective support solutions.

The LPD class is fitted with the first Integrated Platform Management System to go to sea with the Royal Navy; and is supplied and supported by L-3 Communications MSUK on behalf of MoD MES ESG.

KEY WORDS

Human Factors, Platform Management Systems, Ship Control Systems Acquisition, COTS in a Marine Environment, Software Support Strategies, System Integrations and Systems Interoperability

1. INTRODUCTION

The 1st Ships Systems Control Symposium (SSCS) in 1986 extolled the advantages of integrated systems bringing together Machinery Control and Surveillance (MCAS), Electrical Power Control and Management Systems (EPCAMS) and Damage Surveillance and Control (DSAC) functionality. The integrated Platform Management System (PMS) provided increased opportunities for automation to support reduced manning in the Ship Control Centre (SCC)/HQ1, and a networked system of workstations enabled management of the damage control picture, locally, across the ship.

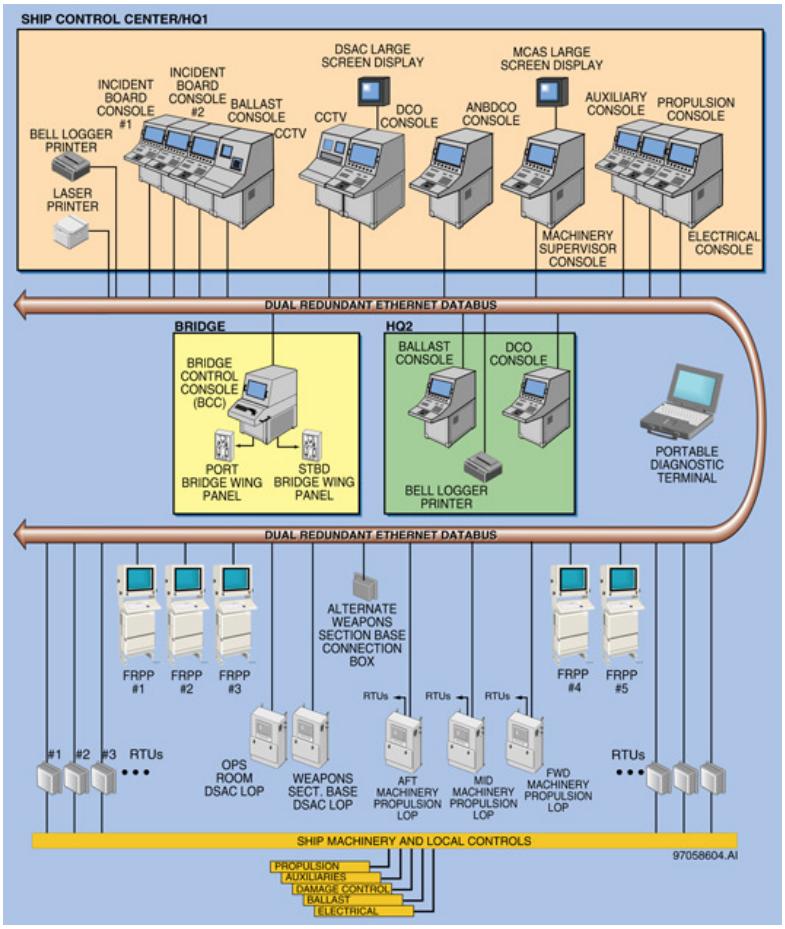
Adopting a PMS procurement approach to marine engineering systems and controls is now commonplace across global commercial ship operators, the oil & gas industry and the world's navies. Ideally this should be combined with whole platform, systems engineering process. Using targeted Human Factors Engineering (HFE) for a Human Centred design should ensure that risk to Ship "User Requirements" in PMS design is mitigated.

The Royal Navy's Landing Platform Dock (LPD) cost capability trade-off occurred before a human centred approach could be followed. The IPMS was cost capped on the initial Unit Production Cost (UPC) before Whole Lifecycle Costs (WLC) for COTS (Commercial Off The Shelf) based systems were evaluated or understood. However a tailored COTS IPMS solution did provide significant cost reduction in terms of UPC over that of a bespoke ship control system. This did however lead to a compromise on the extent and quality of ship and systems documentation. However, it is to the credit of the project engineers of the time, both in MOD and Industry, that a significant baseline was set from which all follow-on Royal Navy PMS solutions have evolved.

The purpose of this paper is to expand on the above issues, by discussion of constraints and benefits of the LPD PMS solution, and Learning From Experience (LFE) by the PMS supplier and the MOD support authority. The paper identifies key issues and promotes best practice for the through life acquisition and support of future PMS.

2. ALBION CLASS PMS SOLUTION.

In 1996 the UK specified a PMS for two new ships, the Landing Platform Docks (LPD), HMS Albion and HMS Bulwark. These were the first Royal Navy ships in the fleet to use this technology. Ship design was based on build practice for commercial ships of the time. A minimal programme of navalisation was used to make it suitable for its role in the Royal Navy; the principal feature being, the extensive use of COTS equipment throughout. It fell somewhere between an Royal Fleet Auxiliary (RFA) and a conventional warship. A dialogue was established during build, between the MOD Ship Controls Group (CG1), and PMS supplier CAE (now L3 Marine Systems UK Ltd.), through the MOD Project office, providing targeted HFE advice to influence Human Machine Interface (HMI) software design as there was no provision for this in the supply contract.



Albion Class Platform Management System

In 2000 a paper in The Journal of Naval Engineering written by the MOD Procurement Agency and PMS supplier, CAE Marine Systems[Ref.1] described the system architecture, operational philosophy and perceived benefit of using customized COTS equipment in the Royal Navy's First Warships with a Platform Management System. The anticipated benefits of PMS included a substantial reduction in the number of personnel required to operate the main and auxiliary machinery, a lower procurement and through life cost and a quicker reaction time to any incidents onboard.

3. INITIAL IN-SERVICE EXPERIENCE (2004 TO 2005)

HMS ALBION was first of Class of a new LPD design, featuring a new Integrated Electric Propulsion (IEP) and new COTS based PMS. In addition, it required new adherence to Lloyds Class Rules and a full Platform Safety Case,

In 2004 a design support team of ship build companies and waterfront support services had been established to aid the transition process, and to provide for design services at the platform level. By its very nature the design maturity and final acceptance of the PMS will inevitably be one of the last programme deliverables as all the other primary plant and interfaced systems that are operated through the PMS workstations and Local Operating Panels (LOP), must be set to work to allow acceptance of PMS.

The importance of the PMS to ship operations was not entirely understood by the existing support community such that the PMS was considered as traditional equipment. However at the time there was no precedent for COTS support on this scale; even as the ships entered service some COTS components had become obsolescent. CAE as the Original Equipment Manufacturer (OEM), with the Intellectual Property Rights (IPR) in the equipment design, was based in Montreal and had not, any previous experience with support service provision to MOD UK. Likewise, during build, MOD had not fully appreciated the industrial and commercial culture of the overseas PMS supplier.

Transfer of PMS support responsibility to ESG within the Defence Equipment and Support directorate of MOD, was delayed for 12 months due to design changes to ship systems impacting on IPMS configuration. Unlike a bespoke system, the configuration baseline was not completed, and “MOD State Zero” could not be declared before PMS Design Sponsorship was finally transferred to CG1. However the delay enabled time for a new type of support contract to be placed with the OEM

4. HOW TO SUPPORT IPMS

There was no UK precedent for how PMS should be supported. There was no ILS knowledge at that time for the support of integrated COTS systems. Initial discussions with the OEM centred on “what does the PMS consist of” and “what is the design and configuration baseline”, “how will support be provided to the ship” and “how will PMS performance be maintained through life”?

Although it is in the interest of the OEM to maintain knowledge and SQEP for PMS, his primary business is innovation and supply of new systems.

A key lesson learnt is that MOD & ship owners need to ensure that SQEP can be maintained to ensure support to ship operations through life. CLS (Contractor Logistic Support) or CFA (Contracting For Availability) could not be considered at that time, due to perceived risk from incomplete documentation, lack of COTS software expertise or knowledge of PMS Key Performance Indicators (KPI), required to enable consideration for alternative support solutions.

To realise through life cost benefit, PMS must be considered in parallel with other marine engineering systems at the concept stage of any new platform. Ideally, a Whole Ship Control and Instrumentation Policy should be adopted.

5. LPD PMS SUPPORT CONTRACT (2005 TO PRESENT DAY)

The LPD PMS support contract builds on best practice for technical PDS (Post Design Services) and Logistic Support for Spares and Repairs.

A culture of openness between MOD and the OEM was adopted from the outset, to establish good communications and effective working relationships at the commercial and technical level.

A list of tasks to establish the technical baseline was produced by ESG1 PMS Cell, for review and prioritisation with the OEM and ship staff. Ship staff and the PMS Cell identified inadequate documentation; much of it being at a high level and not suitable to resolve PMS queries, as a major risk to the provision of adequate support. A stakeholder workshop and education event was organised by the PMS Cell to help mitigate the support risk.

6. STAKEHOLDER WORKSHOP & EDUCATION EVENT

Responsibility for systems, e.g. ballast, HPSW, propulsion, etc. interfaced, monitored or controlled through the PMS is distributed amongst their respective MOD equipment support groups. The workshop emphasised the fact that virtually none of these systems could be updated or expanded without considering the impact on ship operations, through PMS; and was a revelation to all stakeholders including members of the platform support group, representatives from the Royal Navy and the waterfront.

Workshop feedback helped to influence prioritisation of the first Post Design tasks and enabled a greater realisation that the IPMS Design Sponsor CG1 & OEM have to be brought into the planning stages of ship system upgrades at an early stage, to ensure signal capacity is available and that PMS software updates are produced, tested and installed onboard to maintain ship programme deadlines

A precedent has been set that has influenced recommendations for support of future PMS.

7. THE FIRST OEM SUPPORT TASKS

The OEM SQEP technical support office consists of a commercial engineer, dedicated LPD PMS engineer and technical services. Software expertise is applied from OEM headquarters, in Montreal and from other UK operations. Initial PDS tasks established a system baseline, a review of obsolescence and a telephone help-line for the “User Community”.

These tasks provided a coherent background to be shared with stakeholders and enabled key decisions to be made regarding COTS Obsolescence and PMS update.

8. OBSOLESCENCE REPORT RECOMMENDATIONS

COTS Obsolescence

Needs a Through Life Management Plan (TLMP) identifying funding and a programme of system updates to maintain LPD PMS performance through life:

Software

The typical life of a Microsoft product is not likely to exceed 7 years based on current experience. Even with a commitment to all time buys, the system may become non-operational beyond a 10 year lifespan.

COTS hardware

New breakthroughs in design, technique and software can quickly render installed equipment obsolete and, therefore, not supported by the manufacturers. This design effort is born by the Manufacturer and the cost to the user is generally many times less than a bespoke design. Assessment of the supportability of the computer equipment needs to be made at least every two years, with an intention to re-equip with more up to date COTS equipment every 8 years.

PMS Reference Facility

The configuration of PMS on different ships is likely to diverge over a period of time due to modification of the systems under control and the replacement of COTS equipment. The ability to replicate a specific combination of software and hardware is vital in ensuring ship system integrity is maintained.

As a minimum the Reference Facility must be able to:

- Reproduce fault indications reported from on board ship.
- Test new software updates before installing on board ship
- Confirm compatibility of new COTS equipment with the rest of the system
- Allow ships staff, operators and / or maintainers to witness regression testing to ensure software functionality is meeting the needs of current users.
- Accommodate all the different variants of COTS equipment used by PMS across the fleet.

9. PMS COTS COMPONENTS AND UPDATE

Workstations Ship Control Centre PMS Workstations

The PMS workstations are substantial and bear a passing resemblance to ones from Warships, 15 or 20 years older. When supplied each console contained an “off the shelf” ruggedised computer in its base and was fitted with a 20 inch ruggedised colour Cathode Ray Tube (CRT)

Ship Control Centre PMS Workstation

There are two types of Local Operating Panels (LOP) distributed around the ship, used for DSAC and Machinery Control. For DSAC, the LOP is bulkhead mounted for operation in a standing position and is fitted with slightly larger (21 inch) CRT screens, the larger screen assisting in providing visibility to a group of people. In other compartments, where space is more limited, the LOP was fitted with 13 inch colour LCDs and slightly different computers. The Bridge and Propulsion workstations also contain levers for control of the bowthruster and propulsion levers capable of being used as an engine order telegraph.

Large Screen Display in SCC

Rear view of the Large Screen Display

The SCC was originally supplied with two 67”inch rear projection screens connected to the machinery supervisor console and Damage Control Officer (DCO) console. The SCC is directly above the Engine Room and subject to a significant level of low frequency vibration from the Diesel Generators rendering the screen image unreadable. The screens were hard mounted to the deck.
An alternative solution was devised by the shipbuilder used twin overhead projectors and fixed whiteboards provided a slightly improved picture; although still significantly affected by vibration.

View of LSD Mounting Framework

The latest solution uses 56” LCD Large Screen Displays mounted on a framework above the control consoles.
If these consoles had been designed to take LCD monitors and modern PCs they would be nowhere strong enough to support the Large Screen Displays with their substantial framework.
An added benefit was that this allowed us to use the existing shock mount arrangement of the workstations without any modification since the combined mass of the LSD and replacement LCD monitors was very close to that of the CRT monitors originally fitted.
Incidentally, physical stress testing for safety was not required; as a satisfactory result was achieved by computer using finite element analysis. The cost was approximately the same, but the frame and Large Screen was not put at risk during the exercise.

Hardware Design

The design of the workstation is heavily dependent on the computer and monitors available at the time. Modern consoles do not need to be anywhere near as robust as this “legacy equipment”. Remember, however that that these ships have been in service with the Royal Navy for less than 10 years. It is a reminder of just how far PC and displays have progressed in a short period of time.

Being able to use COTS computers and screens makes the task of finding replacement items a lot easier; since modern computers and screens occupy significantly less space and weigh less.

Console Computer -Before

The early PCs were quite vulnerable to shock and vibration. To counter this they were extensively ruggedized and therefore bulky. As you can see, there is no lack of room in the enclosures. The replacement computer and LCD screen now neatly fit in the space occupied by the original CRT.

Rear view of current installation

Hardware Obsolescence

Already the PCs in each ship have succumbed to obsolescence– a total quantity of 22.
Likewise the CRT screens have been replaced by LCDs.

DSAC LCD Screen mounting arrangement

These pictures of a new screen and PC fitted on a Damage Control workstation show how much extra space has been made available.

RTU (Remote Terminal Units)

The function of the 21 RTU's is to interface the PMS with the platform systems and equipment for monitoring and control via analogue, digital and serial interface cards. The RTU houses a Pentium based VDMC master processor card, which contains a replica of the ships database and equipment control software.

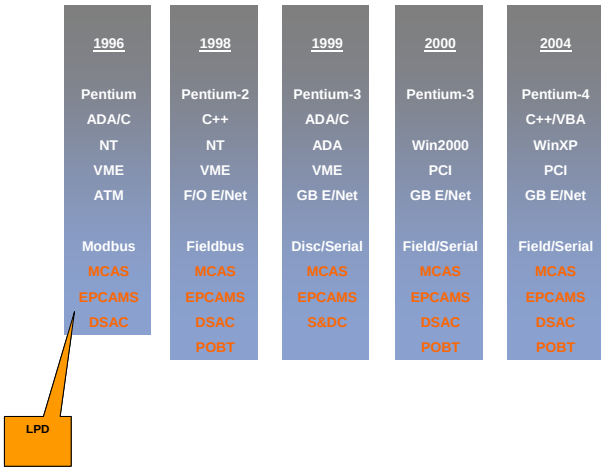
Ethernet "Thicknet" Data bus

The network is built in two sections using "Thicknet" coaxial copper cables. The sections are run port and starboard with, where possible, at least a deck separation between them to reduce system vulnerability to damage. If one cable fails the other LAN will continue to function and retain communication between the remaining stations. A Transceiver and drop cable completes the connection, to each PMS equipment.

This 5BaseT network is now obsolescent. Replacing the co-axial cable throughout the ship will only be possible during re-fit. Current support for the system uses "all time buy" Transceivers.

Software

The operating programme software was a tailored version of Windows NT running with CAE bespoke Application programmes developed through the ROSE & GRADE toolsets. Microsoft discontinued support for this in 2004.



PMS has now been migrated to Windows XP, support for which is due to cease in 2014.

10. ADVANTAGES & DISADVANTAGES OF COTS EQUIPMENT

Advantages

- No development lead time
- Design is already paid for and amortised in the price
- Delivery lead time is weeks, rather than months
- For computer and display equipment, physical size is reduced
- Operating System will be industry latest
- Designed to industry standard interface protocols
- Price for new item is not much more than the cost of repairing a failed one
- Type testing of militarized versions has already been carried out
- Replacement of obsolete items is straightforward because they conform to industry Standards.

Disadvantages

- Models are replaced on a regular basis
- Software drivers will not cover old equipment
- Operating System will be industry latest
- Repair becomes impossible for older models
- Standardisation of equipment across the fleet is difficult

11. OBSERVATIONS

- Where possible, a COTS based system design should incorporate the latest industry standards. This will ensure the most comprehensive choice of options when replacing obsolete equipment. The infrastructure of a LAN fitted to ships the size of HMS Albion and Bulwark makes the replacement of network cabling a big problem.

- Hardware selection should be made as late as possible, i.e. selection of processors, memory etc such that advantage can be taken of advances in technology between contract award and required delivery.

- For new ship projects, a key recommendation is that the equipment and system delivery package for COTS based systems should include an Obsolescence Management Plan. The customer authority should oversee the synopsis and final content of the plan to ensure its fitness for purpose; ideally the plan should also cover the in-build programme to ensure that the PMS is accepted with as high a state of technology currency as possible.

- PMS uses built in test (BIT) to identify failed components within the system. For faults originating from interfaced systems, i.e. earth faults, transients, sensor breakdown etc. no such information is available and Ship Staff had no access to detailed ship drawings.

- A maintainer training facility was not provided for the LPD Class and the PMS handbook did not include any procedural information about how to conduct software updates, fault finding or system administration etc.

- A telephone / email helpline for Ship Staff is invaluable for the quick solution of many PMS problems.

12. SUPPORT IMPROVEMENTS FOR LPD

- Support for LPD PMS has steadily improved since the start of the support contract in 2005, as both supplier and customer knowledge of ship fit and PMS use has increased over time. Use of an OEM bonded store for COTS non-pattern and codified stores has aided defect investigation and rectification.

- Provision of the Software Reference Facility allows full regenerative testing of new hardware and update software, within the UK and prior to update onboard. The facility is also used to aid diagnosis of fault or system defects and errors indicated on PMS screens when ships are in operation and unable to investigate faults until they return to port.

- The PMS handbook & IPC (Illustrated Parts Catalogue) has been updated in HTML format to include more detailed descriptions of PMS functionality, hardware details, HMI mimics and fault finding.

- Much of the original hardware has been updated by marine COTS equipment sourced from Europe to improve the supply chain.

- Provision of full wiring schedule for each RTU showing detail of sensors and inputs/outputs to aid ship staff fault finding

- Provision of one size TFT 19 inch LCD Screens to replace original 13 TFT, 20 & 21 inch CRT screens, with significant weight / space reduction, removal of inverter units and reduced heat output into compartments/spaces.

- Provision of new Large Screen Displays in place of Whiteboards/ Overhead Projectors.

13. LESSONS LEARNT & RECOMMENDATIONS FOR FUTURE IPMS

- Obsolescence is the major driver for support and update to PMS and must be planned for; during ship build, transfer to in-service and through life. The PMS supplier is best placed to produce an Obsolescence Management Plan, but it must be continually updated during life of the PMS.

- COTS updates must be planned for and to coincide with major upkeep periods or ship refits. The importance of PMS to the delivery of ship capability cannot be overstressed as the software must be adequately supported to ensure the integrity of ship operations.

- There will always be software snags to be overcome and is not a reflection on the integrity of the OEM supplied system. Software operating systems of COTS origin, i.e. Windows XP has many million lines of code that cannot be completely tested in the timeframe available for ship / system software updates. Use of software reference sets help to eradicate snags.

- Software reference sets must be procured at the same time as PMS procurement to ensure adequacy of system test requirements and early engagement of users / stakeholders in design, test and acceptance, prior to STW on board.

- It is essential to provide a configuration baseline of the PMS fit following acceptance from the shipbuilder into service.

14. CONCLUSION

Platform Management Systems should be introduced as part of a Whole Ship Control and Instrumentation Policy. This policy needs to be maintained throughout the life of the ship and in particular should be reviewed at the proposal stage for any changes to other ships systems. Obsolescence Management is vital to maintaining system performance. Operators and maintainers need to be fully informed on the functionality of PMS and its interfaces, in order to accurately identify and differentiate between all PMS and Non-PMS faults. It is essential to maintain good communications between ship / equipment owners, industry suppliers and ship staff in order to achieve the above.

- SQEP is a quality that should not be squandered but nurtured by the user community. It takes many years to build up system knowledge in both use of hardware and software functionality, which is vital under ship operations and fault conditions.

- Many stakeholders in PMS do not realise the importance or impact of PMS on the functioning of other platform systems and vice versa.

- Standardisation of COTS products across the fleet is difficult, when technology is changing every 2 to 3 years.

- A Whole Ship Control and Instrumentation policy should be adopted, when procuring PMS, to reduce risk to systems integration, interface management, operability and reversionary control.

- PMS are complex system's that will exhibit faults and failures despite high levels of system integrity and redundancy. It is imperative that operators and maintainers have access to adequate documentation to enable on board error diagnosis and system rectification. Ideally the provision of a software reference facility and /or PMS operator/maintainer trainer during build will allow adequate documentation to be made available, for STW and acceptance. It is vital that a full documentation package is agreed between PMS stakeholders and provided to ship staff and the In-service community as a precursor to viable and coherent support solutions.

REFERENCES

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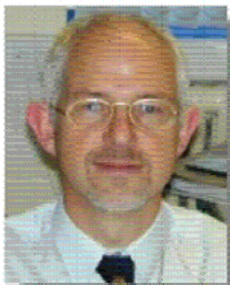
CONTACT INFORMATION



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