

ACQUISITION OF ALBION AND BULWARK LESSONS LEARNT

BY

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ABSTRACT

With HMS *Albion* now in service and HMS *Bulwark* due to enter service in 2005, it is perhaps opportune to look at some of the lessons we can take forward to other platform procurement projects. The two new ships offer significant enhancements to the capabilities offered in HM Ships *Fearless* and *Intrepid* and are indeed the first RN manned warship to adopt Integrated Electrical Propulsion (IEP) and widespread use of a Platform Management System (PMS). The article will assess at a high level a range of related issues, including:

- Standards.
- Design.
- IEP.
- PMS.
- Construction.
- Damage Control.
- Fire-fighting.
- Training.
- Support.

Introduction

The Replacement Landing Platform Dock (LPD(R)) Project has replaced the two decommissioned amphibious ships (LPDs) HM Ships *Fearless* and *Intrepid* with HM Ships *Albion* and *Bulwark*. The ship's primary function is to embark and transport, and to deploy and recover by air and surface means, troops, their equipment, vehicles and miscellaneous cargo forming part of an Amphibious Assault Force. The ship is also to act as the afloat command platform for the Commander Amphibious Task Force (CATF) which includes duties of naval Task Group Commander (CTG) and Commander Landing Force (CLF) while embarked. Major improvements over the replaced ships include more extensive command, control and communications and higher off load speed due to improved troop handling arrangements.

The contract for Design, Build and Initial Support of the 2 LPD(R)s was placed with VSEL (now BAE SYSTEMS Marine Ltd) in July 1996. The LPD(R)s are the first large surface ships for the Royal Navy to be built at Barrow since the completion of HMS *Invincible* in 1978, and the first warships to be dynamically launched from the berths since HMS *Talent* in 1988.

HMS *Albion* has already demonstrated that she is a very capable platform with many extremely good design features. The use of an IEP system and Platform Management System (PMS) is a great leap forward. The recognition that we have to keep up with technology in transition must continue in future classes. To list but a few:

- A dry spray system for communal and accommodation areas.
- Essential chilled water plants for specific weapon and sensor systems backed up by cross connections with non-essential plants.
- Lifts for victuals, bulk stores and magazines.
- The layout of the assault routes.
- No propulsion gearboxes.

Some of the shortcomings discussed in this article were caused by late changes to the design but if just a few of the points made in this article are taken forward we can expect an even better product next time.

Principal characteristics

Each ship will provide a military lift of over 300 troops (with over 400 additional troops in overload) together with a payload of main battle tanks and high and low vehicles, with four RO-RO Landing Craft Utility (LCUs) and four Landing Craft Vehicle and Personnel (LCVPs). A two-spot flight deck will support the operation of two medium support helicopters.

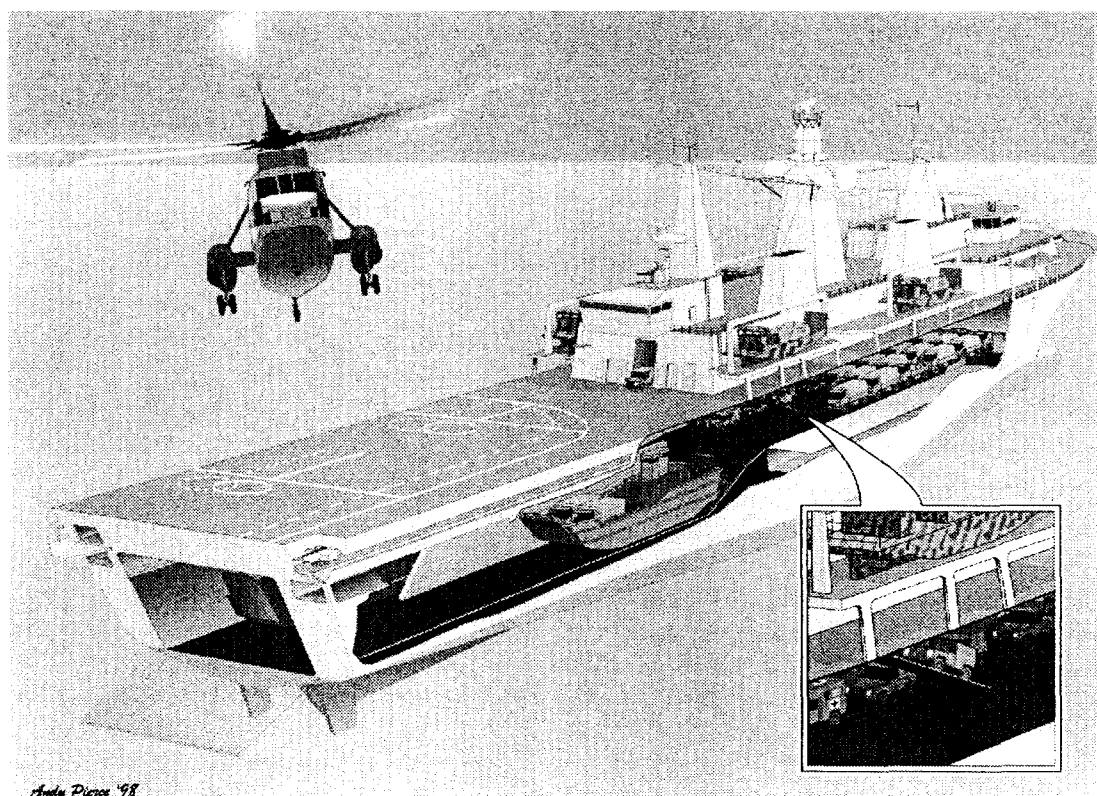


FIG.1 – GENERAL ARRANGEMENT OF THE LPD(R).

(FIG.1) shows the general arrangement of the LPD(R). The superstructure contains the Command and Control areas with some accommodation. The vehicle deck is forward with a dock aft. The ship can therefore be best described as 'Polo' shaped in cross section, with one large void down the middle of the vessel from transom to bridge screen. Stores, offices and ballast tanks are located to either side of the vehicle deck and the dock with a deck above which is predominantly

accommodation for the Ship's Company and Embarked Forces with some office space and the galley. The compartments beneath the vehicle deck and dock consist primarily of machinery spaces, stores and tanks.

Standards

A number of the problems encountered by the shipbuilder during build and indeed a significant number of minor defects, which the WSA will now have to rectify, could have been prevented by using DefStans or other suitable standards. DefStans reflect best practice and lessons learnt, often the hard way:

- The joints in the small bore pipework needed much rework and are not supportable at sea.
- The HP air compressors and their compartment layout does not meet latest DefStans standards, which required considerable design rework to change the compressors to achieve clean air certification.

Hence DefStans are an extremely important part of the acquisition and support processes, providing the 'owner's requirements' to maintain effective integration, coherence, minimum design standards and minimum characteristics of Defence Systems. It is accepted that the move to Smarter processes has removed a significant amount of over-regulation in the specification, design and acceptance of maritime platforms, with the trend away from DefStans. In many cases DefStans were a mixture of standards, advice and guidance, often without sponsors and in need of review and it was generally accepted that the blanket application of standards was unaffordable. Recent equipment and platform experience has however shown that Commercial and Regulatory standards (predominantly focussed on safety, reliability and legislation) do not meet the Defence need and DefStans should now be used and applied in an informed and effective manner by Industry and the MoD.

If the use of DefStans is not appropriate then equivalent standards should be applied and that the QA process must bears close scrutiny. Extensive use of subcontractors in modern shipbuilding needs tight contracts and close supervision. Poor lagging and cabling in some areas shows how this can go drastically wrong. The use of Naval Authorities providing certification may provide a means to enforce customer requirements and will therefore require the use of Defstans/NESs/Policy documents/owner's requirements; call them what you will.

The Safety Case based on JSP 430 is a key element of any acquisition project but is not enough in itself to ensure that the final product is operable in a warship environment and not just safe. The ship's High Voltage system is an example of this.

Therefore:

Do

- **Use Owners requirements.**

Don't

- **Rely solely on JSP 430 to get an operationally capable platform.**

Design

The design strategy was supported by the use of state of a Computer Aided Design (CAD) 3 dimensional computer system. An example of one compartment, the Forward Auxiliary Machinery Room (FAMR) is shown in (FIG.2).

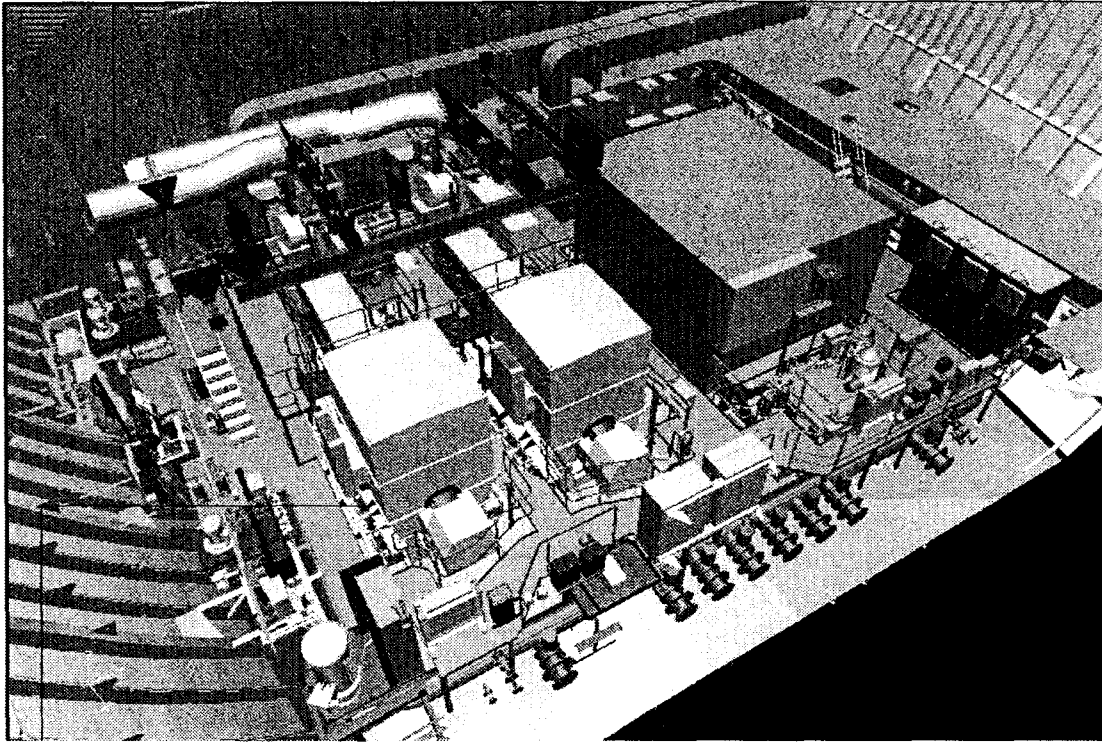


FIG.2 – FORWARD AUXILIARY MACHINERY ROOM CAD MODEL

Once the design was completed using the CAD package, the build commenced with construction of large blocks, partially outfitted, weighing up to 2,400 tonnes. The blocks were then transported to the berth where the blocks were welded together before launch. Final outfitting of HMS *Albion* took place afloat within the Buccleuch dock area (Fig.3).

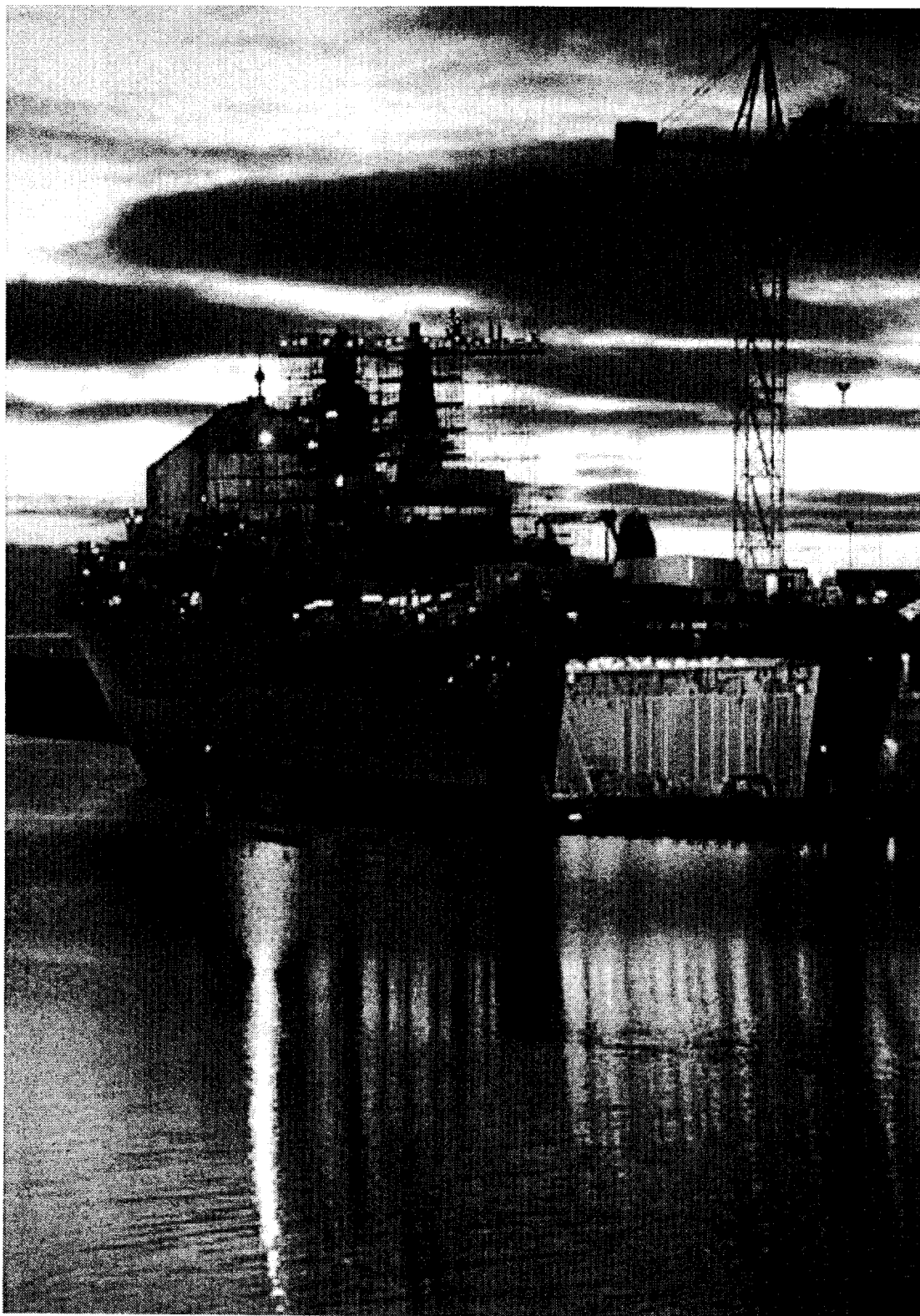


FIG.3 – HMS ALBION FITTING OUT

She arrived in Devonport in March 2003 (FIG.4).

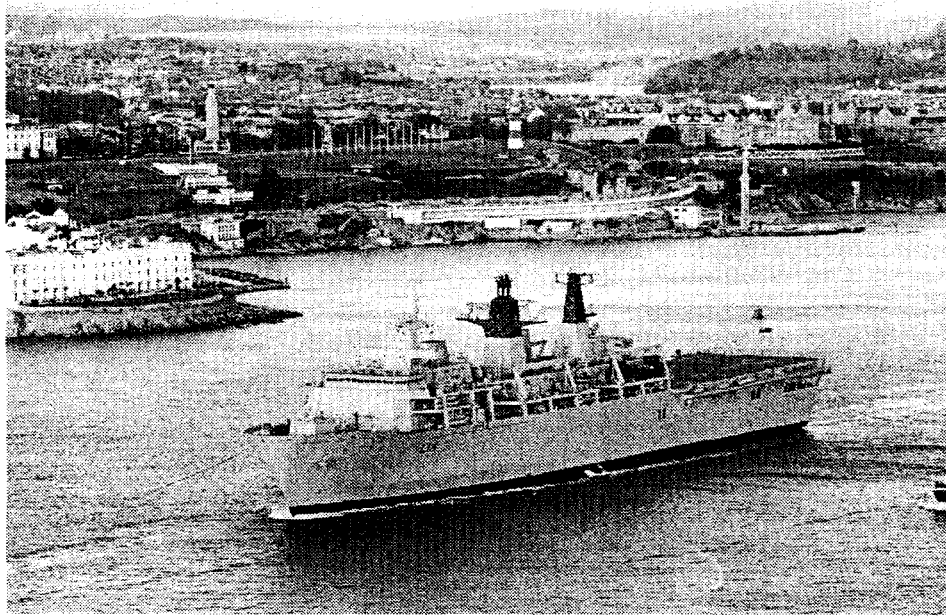


FIG. 4 – HMS ALBION ARRIVING IN DEVONPORT.

CAD is a very powerful design tool but beware at Formal Plan Approval stage that maintenance envelopes don't give a false idea of the accessibility, maintainability or operability of the equipment selected. The design is only as good as the draftsmen employed and the system and compartment layouts need to be carefully scrutinized by engineers in three phases concentrating on equipment, system and compartment.

Probably the worst area of the design is the attention paid to ship's husbandry, in particular the upper deck and layout of internal passageways. For instance:

- The number of rustraisers on the weatherdecks should be reduced.
- There are too many doors (reduce by a minimum of 50% by having a single door into a lobby area).
- There are insufficient drains (more drains).
- The quarterdeck areas are festooned with drains and conduits (need to change internal layout of bathrooms).
- The upperdeck fittings use inappropriate materials (use composite conduit, pipes and connection boxes on upper deck).

The use of composite superstructure should be considered where possible and the number of inaccessible pipes, brackets, vents, brackets for walkways, which will produce rust streaks, should be designed out. The overboard discharges should be in boot topping area to reduce rust streaks down ship's side.

Therefore:

Do

- **Minimize upperdeck fittings, openings.**
- **Use non-metallic fittings where possible.**

Don't

- **Ignore the systems approach to compartment approval.**
- **Underestimate the lack of ship borne engineering knowledge of CAD draftsmen.**

IEP

Integrated Electric Propulsion (IEP) is now a reality in the Naval Service and has been discussed in a plethora of papers and seminars. The reality however brings to the fore a number of issues, for the design, support, operations and training communities; the main focus of which is the implication of High Voltage equipment and systems. In facing these challenges, the Naval community have sought to embrace the requirements of classification societies, operating experience, legislative bodies and best practice from the commercial sector. In doing so a High Voltage document has been produced which aims to capture a set of Naval 'Owner's Requirements'.

Originally designed as a direct drive mechanical propulsion system, IEP was introduced as the most effective power and propulsion design solution during the final stages of design premised on the inability of the mechanical solution to meet the performance requirements of the vessel, notably the loiter requirement and the cost of ownership benefits of the IEP configuration. The use of a common power system for both propulsion and ship's services is now an accepted norm for the commercial marine and offshore markets. Electric Propulsion brings together efficiency, flexibility, survivability and, perhaps most importantly, reductions in cost of ownership. Captured simply – reduced numbers of prime movers, integrated systems, flexibility in layout and proven commercial precedent make it a credible solution to the requirement. Whilst successful in the commercial sector, the exacting demands of the Naval environment mean that systems need to be survivable and have flexibility to operate in both peacetime and wartime scenarios. It is this framework of commercial solution, the Naval environment and legislative requirement, which bounds the successful introduction of IEP. As a result of the design studies and investment appraisal, the diesel electric IEP option was adopted for the LPDs but owner's requirements were not fully considered or appreciated at the time.

The LPD(R) main propulsion and power system (FIGs 5 and 6) was re-designed from an original diesel mechanical solution and hence was already subject to many design constraints. The power system was restricted to being sized and located such that it could be accommodated in the original footprint for machinery spaces and associated switchboard compartments. The design also specified that the main propulsion should consist of two independent shaft sets and the project itself was subject to severe timescale constraints, which dictated the use of readily available equipment.

The management system introduced has taken industry best practice with a degree of pragmatism to make a safe but manageable system. As with any new technology and the associated management processes associated with its introduction there will need to be a period of running, probably until both ships have undertaken BOST, after which FLEET will review the Safe System of Work introduced with the key stakeholders. The review will commence with a Ship Administration Check (E) (SAC(E)) HV inspection and small changes are likely to include the passes, QM's brief, etc.

Therefore:

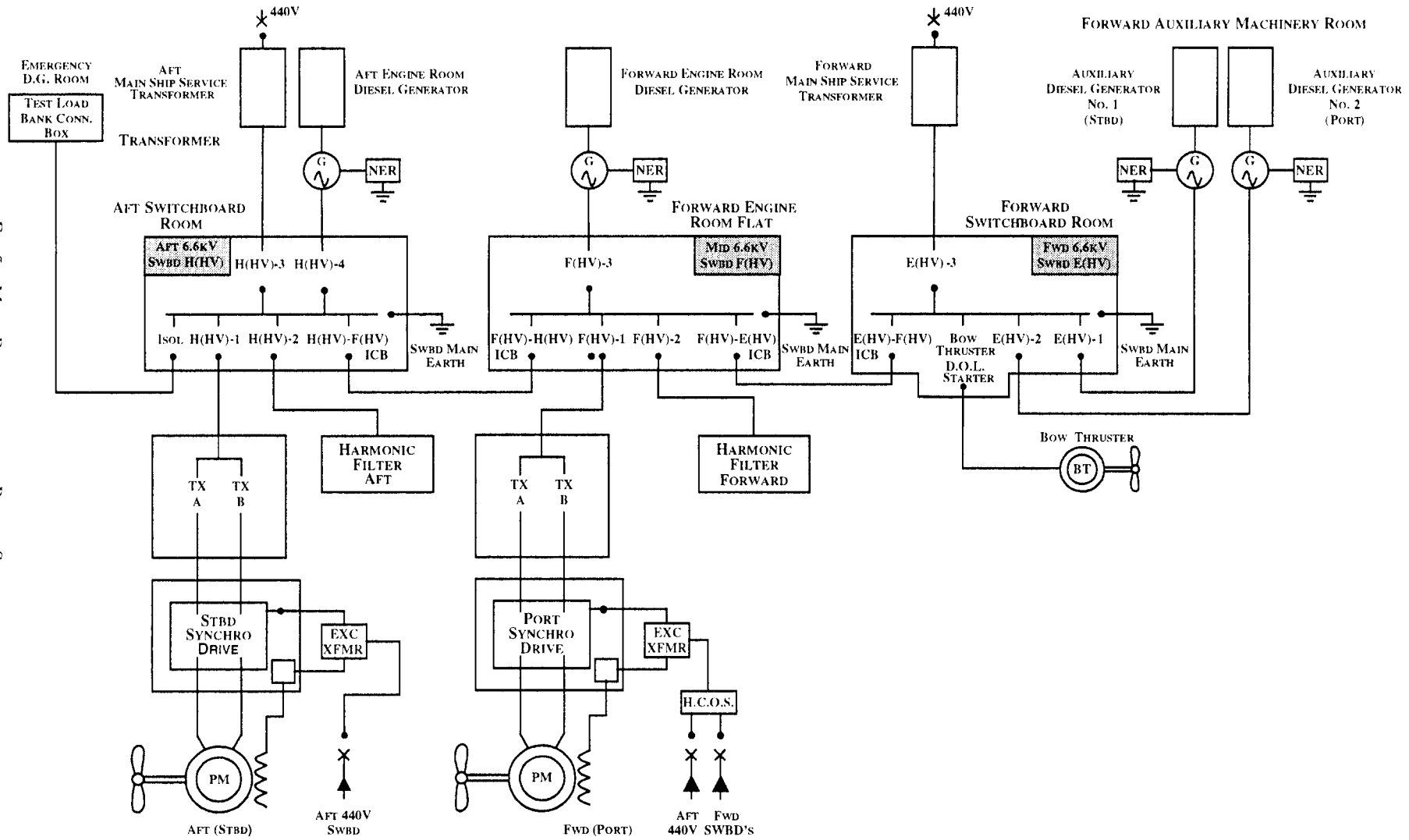
Do

- **Use IP 56 equipment if located in Main Machinery Space (MMS).**

Don't

- **Locate in MMS unless absolutely necessary.**

FIG.5 – MAIN PROPULSION AND POWER SYSTEM



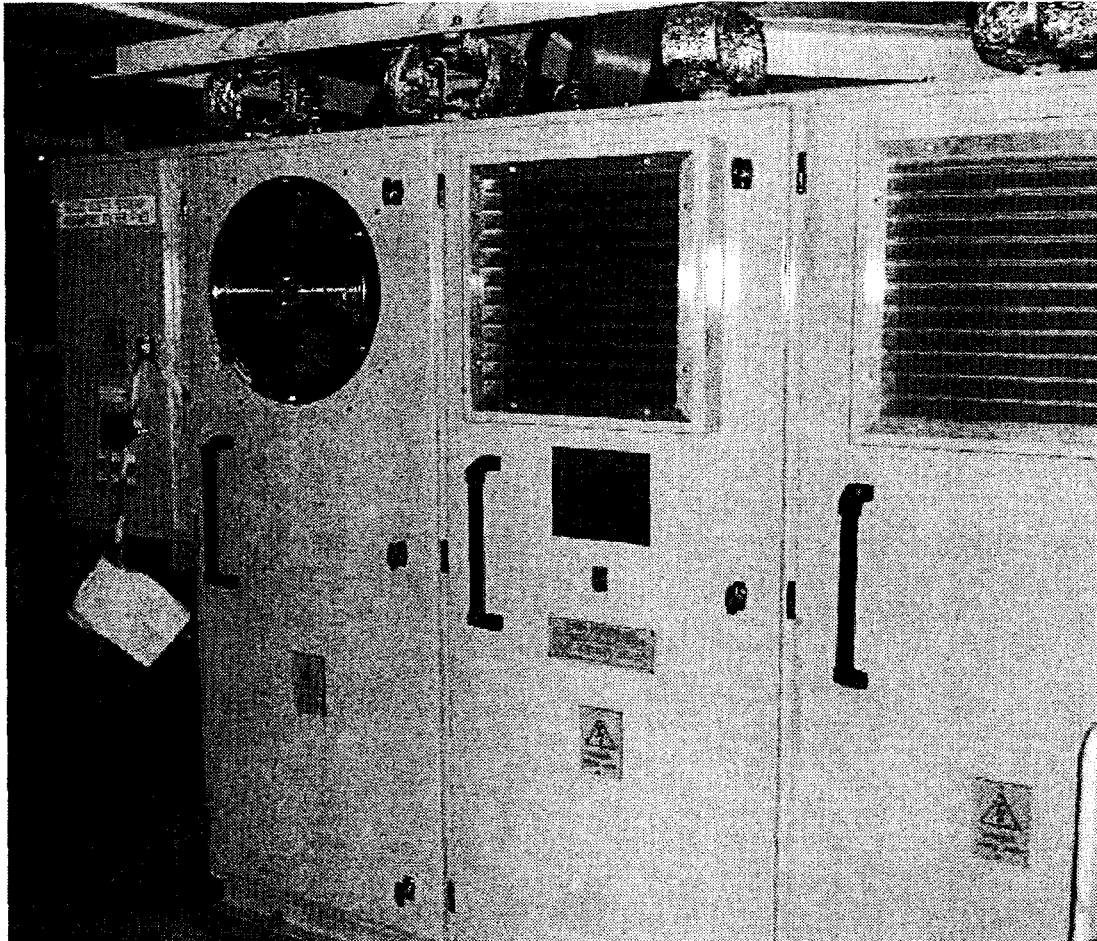


FIG.6 – FAMR HARMONIC FILTER

PMS

Though PMS is a considerable leap forward in technology, especially with regards to damage control, communication and information flow, some page layouts could be better. Updates for this system and future designs requires stakeholder input from the WEs, FOST, *Phoenix*, etc. As system suppliers for future platforms cannot be mandated, the MoD should look at standardizing page layouts and symbology where possible, working with stakeholders and industry to keep abreast of technology and changes in NBCD practices. The NBCD symbology used on the LPD(R)s has proven to be effective and clear during times of high activity. A screenshot is shown in (FIG.7).

A great strain has been placed on maintainers of the system with very little structured training for this equipment. The load of training the Ship's Company on the system has been OJT, instead of structured training at *Phoenix* and *Sultan*. Training for this system has yet to be fully addressed and must be fully scoped for future platforms. Full simulators may not be necessary so long that as a minimum the software is available and controlled for use within the training establishments and the platforms on stand alone hardware. This is probably best managed by MLS IPT CG within the WSA who would also ensure that software faults are rectified promptly.

The computer equipment selected must ensure that high resolution screens are used for both large and small screens with a minimum of two screens in any one location to obviate need for hard 'Incident Boards' as a backup. Screen design and layout is essential to ensure the operators can effectively use the systems in all

states. As FIG.7 shows colour selection is important, grey background with lighter shading of greys and black text will not take an operator to the essential information on the screen quickly. This colour scheme has lead to considerable discomfort by watchkeepers.

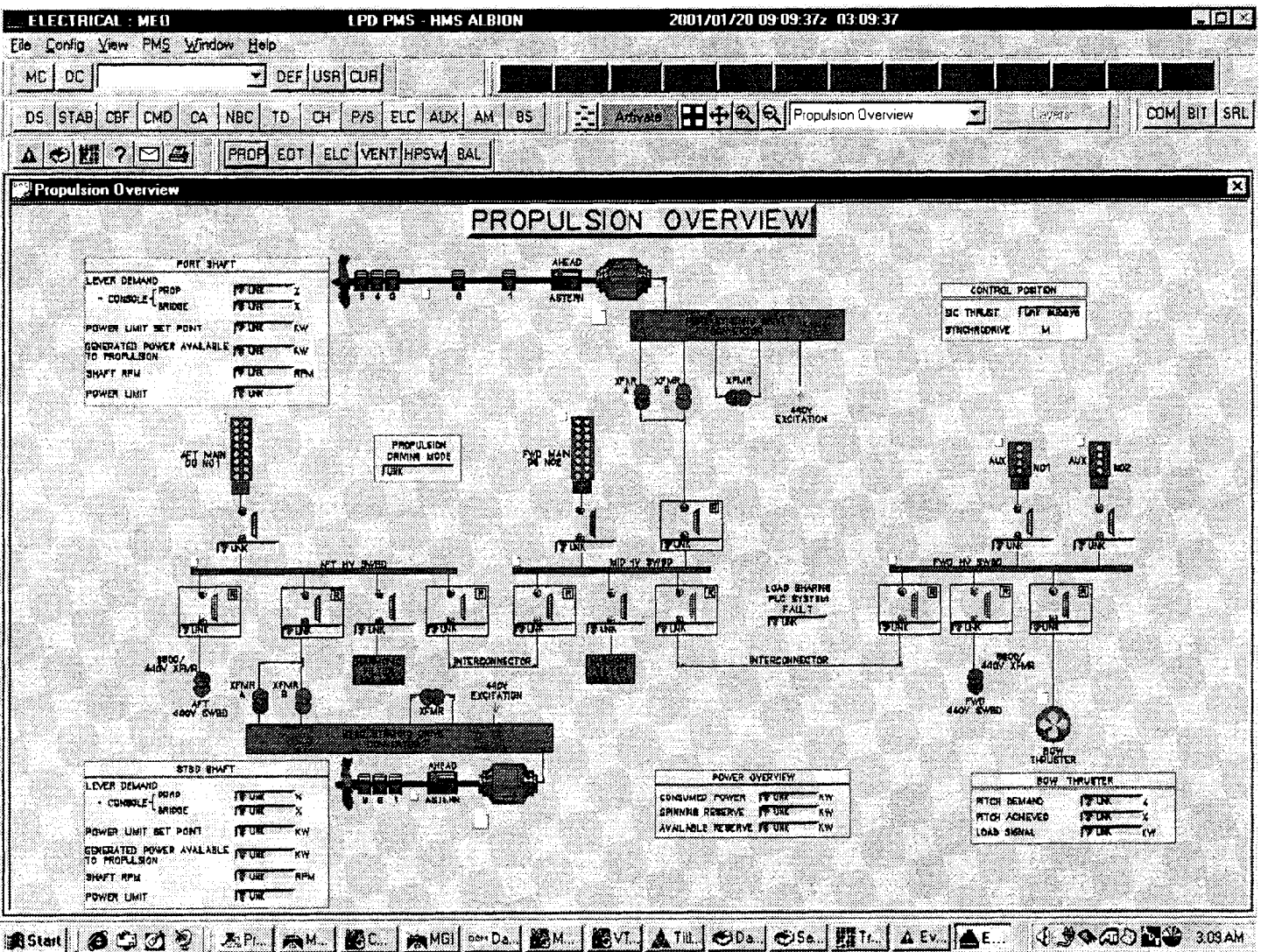


FIG.7 – PMS SCREENSHOT

The use of large screens to display overarching information is vital to provide immediate situational awareness to OODs, DCO, command rovers and ANBCDO in the heat of the moment. However screen design must be optimal not cluttering the display but also allowing immediate awareness of hazards Fwd, Aft and above and below an incident. Propulsion page design must draw the watchkeepers to the

important elements within the page. Incorrect orientation will cause confusion to operators (Starboard Shaft on the right hand side of a page and not the bottom).

Supervision of plant operators is not achieved via a separate MS terminal by the machinery supervisor (MEOOW1) but is achieved by looking over his shoulder at what he is doing and more importantly what the machinery operator is about to do! This operating procedure was also witnessed on the Dutch M class frigates who have a screen based machinery control system.

Therefore:

Do

- **Have sufficient high definition large screens.**
- **Have a minimum of two screens at any given location.**

Don't

- **Forget to involve all stakeholders in screen design process e.g. WEs.**

Damage Control and Fire-fighting

Whilst main machinery spaces are fitted with a fixed CO₂ drench system which may be operated with High Voltage equipment live within the space, the use of water based fire fighting equipment within a compartment containing live High Voltage equipment at IP23 presents an unacceptable risk to personnel. Main machinery spaces containing High Voltage equipment at IP23 therefore contain no water based Stored Pressure Extinguishers (SPEs). Other water based fire fighting equipment such as Centre Feed Hose Reels (CFHRs) are padlocked off with keys readily adjacent to prevent inadvertent operation until all High Voltage supplies to the space have been confirmed as 'disconnected'.

It is appropriate at this stage to define the difference between 'disconnected' and 'isolated'.

Disconnected

The power source is removed but not secure (breaker opened).

Isolated

The disconnection and separation of the electrical equipment from the source of electrical energy in such a way that the disconnection and separation is secure (breaker opened, racked out and access to busbars locked off).

Flooding within these spaces presents an even greater risk with the Command faced with immediately 'disconnecting' High Voltage supplies to the machinery space if the flood is to be attacked. Similarly, the laying of a foam blanket for a simple engine oil/fuel leak will necessitate the 'disconnection' of High Voltage to the machinery space. The requirement to clean deck plates or bilges with water based fluids may also necessitate the 'disconnection' of High Voltage to the machinery space.

The placement of IP23 equipment within the relatively volatile environment of machinery spaces has the potential to impact operational capability from State 1 through to State 3. For example, the requirement to lay a foam blanket or tackle a minor fluid leak in the FAMR during Special Sea Dutymen could lead to the temporary loss of the port shaft until excitation is provided from the alternative supply and to the temporary loss of 50% of ship service supplies. In the event of several spaces being affected at State 1 the possibility of losing all power supplies, both propulsion and ship service supplies, presents the ANBCDO with some real challenges.

Whilst the development of LPD(R) DC&FF SOPs has meant that the risk to personnel has been minimized and the Safety Case requirements have been met, the simple requirement to lay a foam blanket, tackle a small fire or tackle a minor fluid leak in these spaces will result in the loss of one shaft and the temporary loss of 50% of ship service supplies (subject to Command approval).

Table 2 identifies the supplies affected if a fire or flood incident requires the FAMR, FER or AER require HV supplies to be 'disconnected'. Some key LV supplies are provided via an ACOS (GOALKEEPER, Comms, SFCs, 1007, 996, UAT, SCOT and the Torpedo decoy); other LV equipment will have its supplies restored once the LV switchboards are cross-connected. This is part of the SOP for the MEOOW.

TABLE 2 – *Supplies affected.*

SUPPLIES AFFECTED	COMPARTMENTS AFFECTED		
	FAMR	FER	AER
Propulsion	Temporary loss of port shaft until excitation provided from HCOS in FER.	Port shaft unavailable until HV supplies restored to FER.	Starboard shaft unavailable until HV supplies restored to AER.
LV	50% until LV system reconfigured.	Not affected if both FAMR and AER DGs on load, otherwise 50% until LV system reconfigured.	50% until LV system reconfigured.

The propulsion configuration for peacetime cruising and during operations is similar. The running diesels operate in parallel with a minimum of 2 engines running for peacetime cruising and a maximum of 4 during operations. The practical implication is that the time to achieve a HV 'disconnection' is reduced during operations as additional engines do not have to be started (They are probably running at State 1) and brought on load to prevent a Total Electrical Failure. The requirement to 'disconnect' a MMS at State 1 may be reduced as they are manned and an experienced Senior Rate may decide that the incident (minor leak or fuel spillage away from HV equipment) can be dealt with whilst the compartment is kept live. This is not yet built into the SOPs.

Therefore:

Do

- **Ensure equipment fitted allows safe fire-fighting techniques without major changes to RN fire-fighting techniques.**

Don't

- **Leave HAT NBCD to the last few weeks before sea trials.**

Training

Training was an area of the project which went badly when it was cut as a savings measure. The key area from the author's perspective is training for future technology with electrical training in particular. Since the inception of Engineering Branch Development there has been a gradual but significant reduction in electrical expertise, particularly in the appreciation of electrical safety. This may have three primary root causes; the first is the dilution of electrical knowledge with the demise of the old MEA(L). The second is the lack of in-depth, coherent training for the new MEA(EL), where the training has remained biased towards the mechanical aspects of the training curricula. This has

not been helped, perhaps unknowingly, by the third cause, which is the lack of numbers of suitably electrically trained Marine Engineer Officers.

IFEP systems at sea may require voltages of 13.8 kV or higher to minimize fault levels and it is therefore essential that all marine engineering personnel are trained in safe working practices for these voltages. The electrical artificers must be fully trained to carry out maintenance and defect rectification on high voltage systems. Training will also need to be given to non-technical personnel to ensure everybody is aware of the dangers of these higher voltages. This will mean a considerable increase in the electrical content of all training.

A comprehensive Training Need Analysis involving all stakeholders is required for each acquisition project from the outset looking at how to provide such training:

- Career courses.
- Career updates.
- Specific to type/equipment training (PJT's).
- OJT.
- HMS *Sultan* or K Courses.
- Simulators ashore/onboard.

For electrical training we need to consider:

- Use of ESTD.
- Handbook of Marine Electrical Engineering.
- Electrical MSc (full or part time).
- Electrical content of training at all levels.

The authors are not convinced that the SMART Procurement Initiative has helped the situation with respect to longer term branch structure and training issues. We must ensure that future platform projects do not operate in isolation of other PIPTs and/or other training/manpower endeavours.

Support Issues

Sustainability has been the number one key concern with the Reliability Centred Maintenance System achieving functionality late, shortfalls in technical documentation and late delivery of tools and spares. Both delivery dates and quality of product require close scrutiny for future platforms, particularly if we envisage a greater number of documents being produced by contractors and ship's staff standing by for shorter periods.

Publications (BRs/EBRs) have been generally poor reflecting the need for a tighter specification with examples/proformas written into the contract (DefStans/NESs?) and a need for the customer to help the contractor where necessary or review the deliverable. With fewer IPT members and fewer ship's staff standing by the authors question who will be available to undertake this work.

There have been some very good initiatives for novel means of delivery of spares support including Vendor Managed Inventory and Contractor Logistic Support. These forms of support probably provide the only cost effective way ahead but we must be careful to ensure that spares and contractors are able and willing to go into theatre in time of conflict. In addition these initiatives must be in place prior to formal system handover to Ship's Staff.

There is little commonality of equipment with previous ships in service. This is to be expected for a new class and indeed keeps the RN in line with technology in transition. It is probably not appropriate to revert to a Systematic Machinery and

Equipment Selection range, however we should learn from previous mistakes – The LPD(R) had similar overheating problems with the fitted air cooled HP air compressors which had to be removed from HMS *Ocean* post build.

Therefore:

Do

- **Ensure a pan platform Maintenance Management System is used.**

Don't

- **Deliver support packages late.**

The Future

It is the authors' view that with reduced IPT staff and no overseers the case for ship's staff standing by has never been stronger. The facilities for ship's staff must be factored into the build contract as must a formal process for the handover of compartments and more importantly systems and their maintenance. An 'ideal' joining profile would look something like:

- MEO + core team 18 months before Planed Acceptance Date (PAD).
- MEs 12 months before PAD.
- WEs + Logistics and Supply 9 months before PAD.
- Captain + XO 3 months before PAD.

If ship's staff do not stand-by for any length of time then expect 3 to 6 months to be added to Safety and Readiness Checks (SARC) process. Look at *Albion's* management plan (FIG.8) which started 2 years before PAD and covered over 2,000 items. The management plan proforma will be sponsored by Fleet with inputs from FOST and locally amended to reflect the new platform by Ship's Staff. Using a RN CST team of Emergency Party, chefs, OOW/NO reduces costs to company significantly and allows Ship's Staff to commence learning about operating the ship at an earlier stage.

5.19	<i>SCC State Boards</i>		
	Investigate the requirement for the following state boards and acquire/produce as necessary.		
5.19.1	HV System.	CC HV	1 May 02
5.19.2	RADHAZ/Underwater hazard.	P3	1 May 02
5.19.3	NBCD.	P5	1 May 02
5.19.4	Vent.	A4	1 May 02
5.19.5	Machinery.	CC Prop	1 May 02
5.19.6	Man Below.	CC HV	1 May 02
5.19.7	Firemain.	A3	1 May 02
5.19.8	Running hours board for diesels.	PI	9 Aug 02

FIG.8 – MANAGEMENT PLAN

The LPD(R) is 18,500 tonnes, and conservatively has over 900 metres of flats and passageways, 46 heads, 23 bath/shower rooms, 91 lobbies and more than 600 other compartments (including Main Machinery Spaces). The upper-deck also represents a significant workload, with in excess of 70 watertight doors and hatches to maintain. Whilst it is accepted that we must adapt to do things smarter with fewer people, standards of cleanliness and more importantly hygiene must be maintained. It would be counter-productive for cleaning tasks to dominate the

working hours of Junior Rates at the expense of their professional tasks. It would also contradict the principles of ReBalancing Lives (RBL), namely to encourage the development and improve the performance of all onboard.

Whilst it is not intended to remove the cleaning commitment from the Junior Rates totally, we must strive to reduce this commitment to an acceptable level and improve both the quality of life and level of hygiene within the ship. It is suggested that the provision of contract staff, both alongside and at sea be explored. These staff would be specifically employed for the potwash, conduct daily and deep cleaning of accommodation, flats and passageways, heads and bathrooms, dining hall, galley and other communal areas.

Use services and cabling trunks away from the main passageways to minimize overheads and cleaning requirements. Deckhead linings are then eliminated or minimized.

The formal process for feedback on design issues, concerns and defects from ship's staff was unsatisfactory. Whilst concerns over requirements growth are understood, approximately 80% of all priority 1 & 2 concerns raised by Ship's Staff during the early stages of build were raised again as Guaranteed Defects or OPDEFs which resulted in costly rework and delays to programme. Three documents were eventually produced covering general concerns, PMS concerns and HV concerns. An example is shown at FIG.9.

COMPARTMENT NO. AND LOCATION	DESCRIPTION OF CONCERN /DEFECT	PERSON REPORTING	PRIORITY	AREA	DATE TO IPT
Avcat Pump Room 7K	3-way valves FWF 3003 & FWC 3930 cannot be operated through their full range as the handles foul other pipes/flanges. The valves need moving.	CPO SWANSBURY	3		20/03/02
PMS	Valve numbering in PMS does not tally up with valve numbering on ships systems.	CPO MCCLUSKEY	2		20/03/02

FIG.9 – GENERAL CONCERNS

Therefore:

Do

- **Give Ship's Staff time to prepare.**

Don't

- **Underestimate the amount of documentation required prior to SARC process.**

Conclusion

There are of course a myriad of other issues but if just these few areas are taken forward we will end up with a better product.

The location of some of the High Voltage equipment at IP23 in the LPD(R) is not ideal, however SOPs have been produced which minimize the effect of these shortcomings. A study is being undertaken to investigate and scope the practicalities and funding issues associated with rectifying these shortfalls.

The Safe System of Work introduced is working well and will be honed after further operating experience. Our procedures are certainly more comprehensive

than those on some Cruise Liners, where these propulsion systems are now common place. The procedures need a degree of pragmatism but must also reflect our inexperience in this field of engineering. During a visit to a merchant ship in 2001, there was one small sign (crew only) on the route between the passenger areas and the High Voltage compartments. But we must not be complacent; a fatality in a MoD building and a serious injury at a shore test facility in the recent past demonstrate how serious the consequences can be when the Safe System of Work is not followed.

The work of the HVWG and the Lessons Identified in the LPD(R) have been invaluable to take forward for Type 45 and CVF, both of which are to have similar HV systems. It is vital that we learn from these lessons such that similar design faults are not inherent within the HV design/installation proposed for future platforms.

We need to be careful that the many sound initiatives to bring forward programme do not end up with a ship with more defects giving a tired ship and ship's company from the start. Whilst not mentioned above we must take note of the high exit rate of many key Senior Rates who are well trained and motivated but end up disillusioned with the poor product, poor documentation, poor tools, poor support and the long working hours to put it right.

The views expressed are those of the authors and do not necessarily represent those of the
Ministry of Defence or HM Government.