Enabling Lean Manning through Automation

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Synopsis

Reduced manning has long been an aspiration for navies, due to manpower shortages and a desire to reduce through life costs, whilst the requirements for mission capable, effective and flexible vessels have continued to grow with the evolution of military operations. The challenge for industry is to provide a naval platform with increased capability and agility, whilst embracing sufficient automation to support a reduced complement.
An Integrated Platform Management System can provide the answer to many of the challenges posed by a lean manned platform. However, to fully exploit the benefits of such a system, the operator characteristics and supporting technology must be fully considered. In terms of Integrated Platform Management System design, a truly distributed architecture, extensive system integration, intuitive alarms and warning policies, and the inclusion of remote alarm panels with paging systems, can all help to tackle the reduced manning challenge.
As technology evolves so will the ability to optimize ships' operations and develop new ways of achieving mission objectives whilst addressing the reduced manning challenge. There are a number of themes currently driving innovation in the maritime market, such as remote support initiatives, most prevalent in the commercial maritime sector. Furthermore, the adoption of intelligent systems, such as smart valves, can offer significant benefits against the background of ever reducing manning levels.

Keywords: Reduced Manning; Automation; Type 31e; Integrated Platform Management Systems

1. Introduction

Reduced manning has been an aspiration within the Royal Navy for many decades, and continues to be with the recent announcement of the Type 31e Frigate which has evolved from the concept of a light general purpose frigate with export potential raised in the 2015 Defence Review [1]. Whilst a decline in the numbers of naval personnel and a desire to reduce through life costs have driven the need for reduced manning, the requirements for mission capable, effective and flexible vessels have continued to grow with the evolution of military operations. The challenge for industry is to provide a naval platform with increased capability and agility, whilst embracing sufficient automation to support a reduced complement. Against the backdrop of reduced manning, the Royal Navy has witnessed the development of her largest ever platform – the Queen Elizabeth Class Aircraft Carrier.

An Integrated Platform Management System (IPMS) can provide the answer to many of the challenges posed by a lean manned platform. However, to fully exploit the benefits of such a system, there are two main considerations - the operator characteristics and the supporting technology. An understanding of the operator roles and tasks enables the ship design and systems to be optimized to assist the vessel's crew in conducting their operational tasks. Bringing together corporate experience, tools and processes, role and task analysis can be conducted for a given ship design, with the mission objectives at the heart of this process.

This paper will consider that, while automation is an essential enabler in reducing manning demands, the optimization of data presentation to the crew is also necessary to maximize operational effectiveness within a lean manning environment. In terms of IPMS design, a truly distributed architecture, extensive system integration, intuitive alarms and warning policies, and the inclusion of remote alarm panels with paging systems, can all help to tackle the reduced manning challenge. This is all underpinned of course by a prime focus on human factors, compliant with Def Stan 00-251 [2], to ensure that the design solution fully meets the needs of the crew.

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[1] Authors' Biographies

Joe Chilcott BEng(Hons) MSc CEng L3 MAPPS Limited – Whilst working for L3 MAPPS Limited over the past 6 years, Joe has had a number of Engineering Roles, starting as a Software Engineer. He has developed a number of control systems for the Queen Elizabeth Class as well as working as the Integration Specialist for the platform. He is currently the Principal System Design Engineer for L3 MAPPS Limited working on solutions for the business development team, including the Type 26 and Type 31e platforms.

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As technology evolves so will the ability to optimize ships' operations and develop new ways of achieving mission objectives whilst addressing the reduced manning challenge. There are a number of themes currently driving innovation in the maritime market, most prevalent in the commercial maritime sector. Within the area of Integrated Logistic Support, remote support initiatives allow shore based expertise and associated infrastructure to enhance the effectiveness of both planned and corrective maintenance procedures so as to maximize equipment availability within the constraints of lean manning. Furthermore, the adoption of intelligent systems, such as smart valves, can offer significant benefits against the background of ever reducing manning levels. Finally, effective resource management utilities embedded within the IPMS can facilitate the considerable challenge of ensuring that suitably qualified and experienced personnel (SQEP) are in the right location during the most demanding ship scenarios.

2. Customer Requirements

The solution for an IPMS tailored to a platform will of course be largely derived from specific customer requirements within a Technical Equipment Specification. To this must be added various applicable standards mandated by the customer, such as those of classification societies (e.g. Lloyds Register Rules [3] and associated notations) and end user standards covering the specific systems and the associated human factors (e.g. Def Stan 08-111 [4] and Def Stan 00-251 [2]). Furthermore, if the results of Functional Hazard Analysis identify specific safety related control functions, then these functions must be implemented in line with the Naval Authority Group Software Integrity Policy [5] and an appropriate safety standard such as BS EN 61508 [6] to define the relevant Safety Integrity Level.

However, in developing an IPMS, these requirements must be delivered in conjunction with studies in role and task analysis and human factors to ensure that the system is optimized against the manning complement and the specific platform systems. Once these considerations have all been examined in detail, Functional Design Specifications can be constructed for the development of the Human Machine Interface (HMI) hardware and the Human Computer Interface (HCI) software.

3. Human Factors

The study of human factors is essential to the delivery of an effective IPMS. Operator consoles should be designed with due consideration to anthropometric data for both male and female operators, and the associated ergonomic factors. They should also be located with due regard to the necessary personal interaction required between different operators and the lines of sight to other information displays. Consoles should be orientated, wherever possible, to be forward facing to achieve the best correlation between the systems as represented on console displays and the physical orientation of the platform around them. However, damage control operators viewing Incident Board deck plan displays with forward to the right by convention, may face to port for the same reason.

In terms of the HMI, and in particular the HCI related to the IPMS, there are a number of clear guidelines to be followed. Panel controls and HCI display objects, along with their annotation and colour coding, must be consistent across all systems, and align with the established cultural conventions, whether innate (e.g. forward lever movement to increase power) or specific to the end customer expectation (e.g. 'odd' number labelling for starboard objects and 'even' numbers for port objects). The displays should provide comprehensive situational awareness of the status of systems under control, with clear and informative feedback regarding actions taken by the operator. They should be orientated with forward to the top or right or, in the case of process flow displays, with a natural progression from top/left to bottom/right (see the example process HCI Page in Figure 5 below). Where closely related, controls and data displays should be physically grouped together.

In line with an agreed alarms and warnings policy, it is essential that the operator is presented with clear, prioritized alarms and warnings, following system failures or occurrences requiring action, filtered as necessary of consequent alerts to prevent alarm 'flooding' during major incidents, to allow the correct restorative actions to be taken rapidly and efficiently.

4. Options for Automation

Automation embodied within control systems offers clear advantages with respect to reducing operator workload, thereby relieving the machinery watchkeeping burden and ultimately providing the opportunity to adopt a lean manned ship complement. Automation also allows control actions to be taken much faster than if a human is in the loop and eliminates the potential for human error. However, it is not well suited to scenarios where options need to be considered based on subjective assessments. Indeed, the truly optimized system will achieve the correct balance between automation and human intervention. Typical options for automation include semi-automatic task sequences and full automation at the system level, and Unattended Machinery Space (UMS) operation at the platform level.

4.1. Semi-Automatic Task Sequences

Semi-Automatic task sequences delegate control of specific system tasks to the Platform Management System under operator authorization. Once a semi-automatic task sequence is selected by the operator, the system and IPMS collectively implement automated control actions to reach a pre-determined end state, without further intervention by the operator except to terminate the sequence prematurely. Such sequences are ideally suited to routine system evolutions such as fuel system transfers, whereby the operator would initially select source and destination tanks, select duty and standby transfer pumps, and specify the quantity to be transferred. Then, after operator initiation of the sequence, the control system would conduct all necessary control actions with appropriate operator feedback until the correct quantity of fuel is transferred and the sequence terminated.

4.2. Full System Automation

Full Automation takes this a step further whereby system control is delegated in its entirety to the Platform Management System with no operator input after initiation. Therefore, once an automatic mode is initiated by the operator, the system and IPMS collectively detect when control action is needed and implement the appropriate operations subject to protective interlocks, schedules and algorithms, without further operator intervention, until the point at which the operator chooses to adjust control settings or terminate the automatic mode. This mode is ideally suited to systems such as a ship's chilled water ringmain whereby the chilled water plants can be set to automatic mode such that they start and stop as required to maintain the ringmain temperature within set limits, operating indefinitely in this manner until the operator chooses to intervene.

Full automation can also be enhanced by 'Smart Valve' technology, delegating control logic to system nodes level or valve actuators. Using the example of the chilled water system ringmain, such technology can ensure that the ringmain can be automatically reconfigured to maintain the service after system damage, including rapid isolation around the damaged section, or indeed prior to damage in response to perceived threats [7].

4.3. UMS Operation

With extensive machinery automation across the platform, the opportunity arises for UMS operation [3], as a means of eliminating routine watchkeeping entirely, to be replaced by an on call 'duty engineer' system supported by an enhanced rounds system. Alarm panels incorporating both audible and visual indication of alerts are required in accommodation and recreation areas, supported by remote paging systems. Furthermore, the alarm count must be minimized to make the mode of operation viable. This mode of operation has the potential to drive significant manpower savings due to the fact that the duty engineers can also be employed on maintenance and other tasks, as has already proved the case in the commercial marine sector. In the naval sector, where the manpower complement tends to be driven by the needs of the action state in major surface combatants, its application has tended to be restricted to auxiliary vessels such as survey ships.

However, with more extensive installations of fixed firefighting systems and damage control sensors, there is potential for UMS operation to be extended to other vessels, particularly light frigates such as the T31e. Indeed, the practical implementation of UMS within the Holland Class Offshore Patrol Vessels is described in detail by Horenberg and Melaet [8]. They also describe how the co-location of command and control nodes, and the blurring of traditional marine and weapon engineering boundaries through advanced diagnostics and innovative HCI displays within IPMS, have also contributed to reduced manning.

5. Role and Task Analysis

This paper argues that the optimization of IPMS is a major driver in the reduction of manning levels in marine platforms, through the analysis of human tasks to devise the most efficient options for operator console location/functionality, HCI display, system automation and alarms policy, and through the exploitation of new technologies. As a first step in this process, it is necessary to study the proposed platform manning and operating environment through role and task analysis. This can be implemented most effectively by employing a modelling tool such as IBM System Architect with DoDAF or MoDAF frameworks. In particular, the following information sources are utilized as input data:

a. Watch and Station Bill – this details the deployment and function of personnel within the platform Operational State Manning Scenarios (i.e. States 1/2/3, Special Sea Dutymen (SSD), Harbour Stations, Sea Emergencies, Harbour Fire etc.);

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b. Compartment Layouts and Deck Plans – these will take the form of drawings showing the physical arrangement of key compartments, including system equipment and proposed operator positions, and their relative locations within the platform;
c. Operating Console Keyplan – this details the envisaged operator positions throughout the platform, including the functionality intended to be provided for operators at each position (note that if this information is not provided then it will be derived through the analysis, if it is provided then the analysis will identify any omissions or shortfalls in the intended configuration within the keyplan);
d. Customer Operating Doctrine – this information within customer manuals will provide context and detail to the expected means of ship operation, based on standard operating procedures, perceived best practice, traditional routines and organizational culture.

The process of role and task analysis is detailed in Figure 1. Firstly, by studying the manning roles identified within the Watch and Station Bill against a range of Operational State Manning Scenarios, it is possible to identify the specific manning roles that need to be Platform Management System operators (see an example hierarchy for a conceptual Light Frigate in the Action State (i.e. State 1) in Figure 2), and in turn generate a generic role hierarchy that can be hard coded into the system framework to permit operators to carry out particular functions associated with the human tasks for these roles. A similar hierarchy for capability reporting can also be developed for the reporting and prioritization of system defects or platform damage in the Action State.

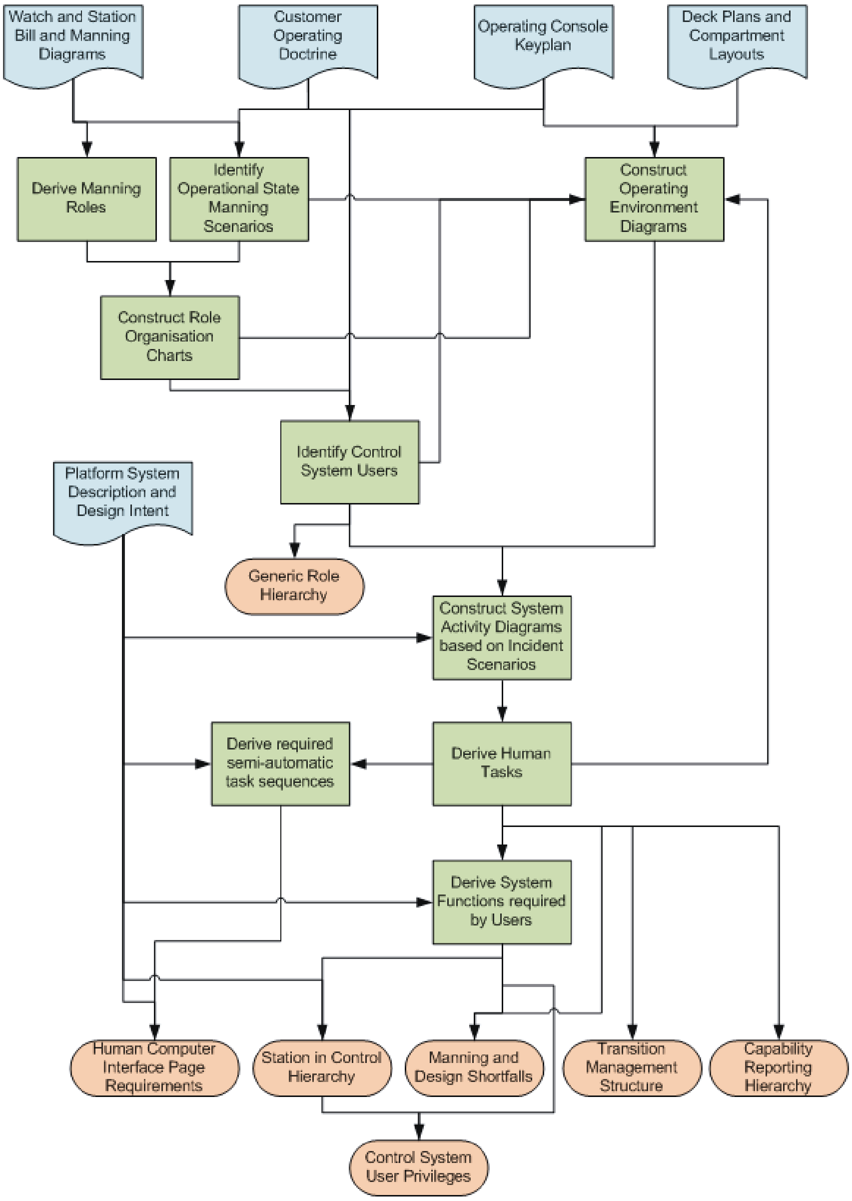


Figure 1. Role and Task Analysis Process

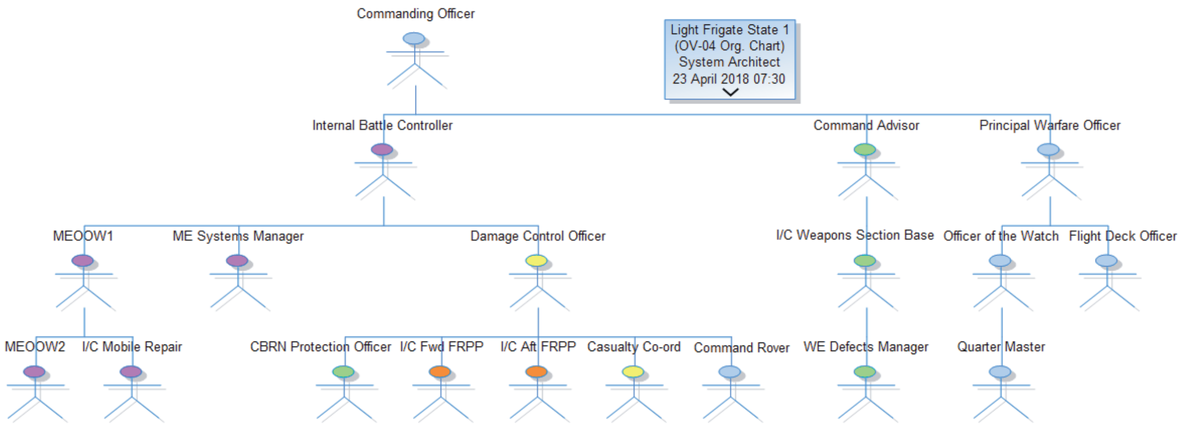


Figure 2. A conceptual Light Frigate IPMS Role Hierarchy for the Action State

The human tasks referred to above are derived by examining specific scenarios in the context of the operating environments within compartments associated with the control of systems and the operational management of personnel and other resources (see an example based on a Ship Control Centre (SCC) for a conceptual Light Frigate in Figure 3).

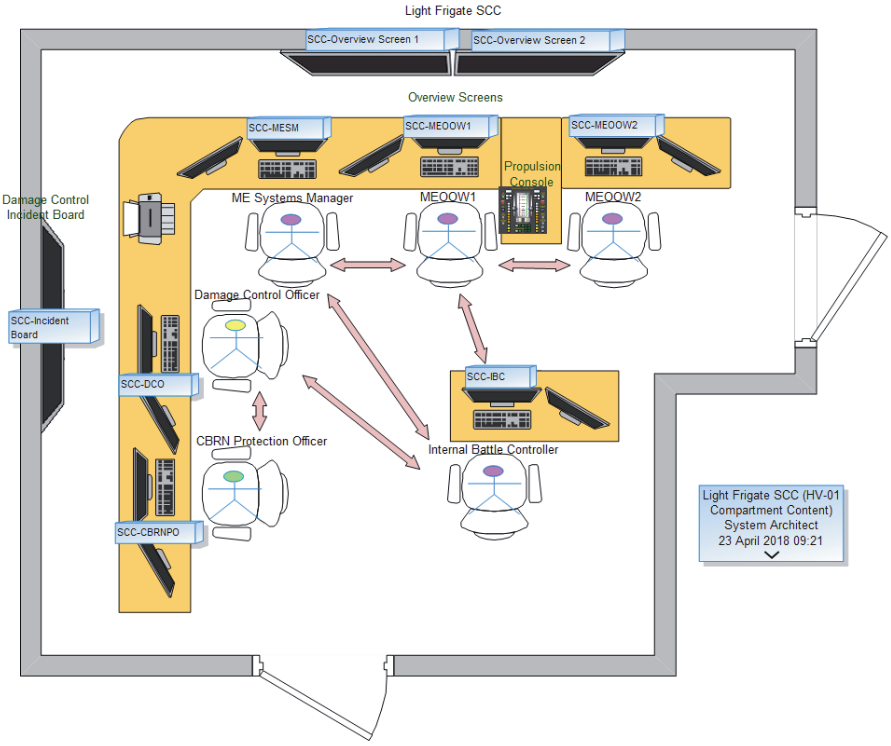


Figure 3. A conceptual Light Frigate SCC Operating Environment

The tasks can be examined along with the platform system data to examine options for automation and, in particular, for semi-automatic task sequences (see the example in Figure 4 below) or Smart Valve technology to minimize both operator workload and the potential for human error. Engagement with key stakeholders, including the end user, at various points during the process, ensures that consensus is achieved over the outputs, thereby minimizing project risk over subjective operability assessments.

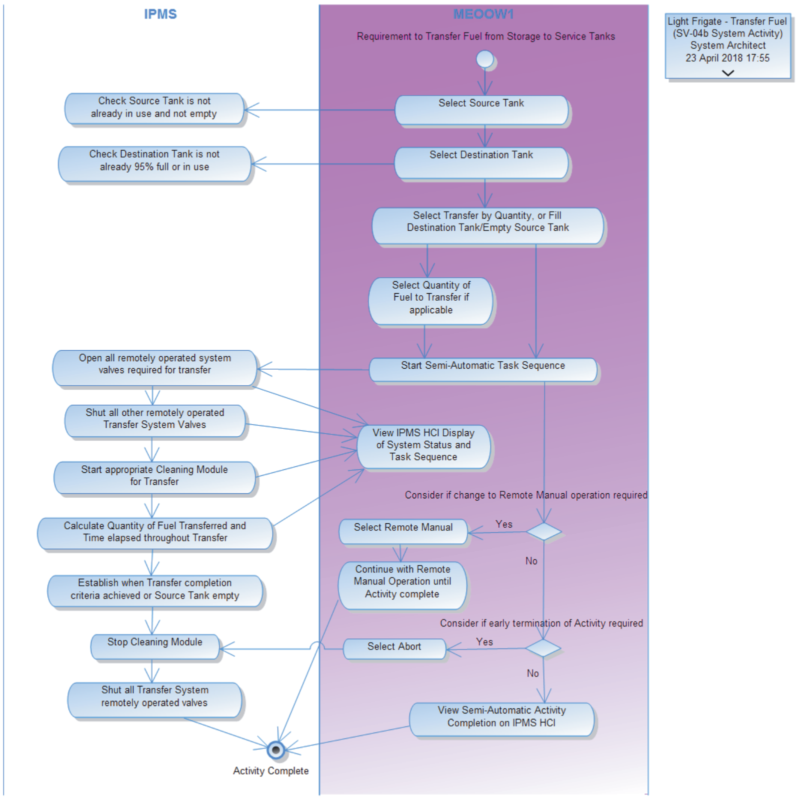
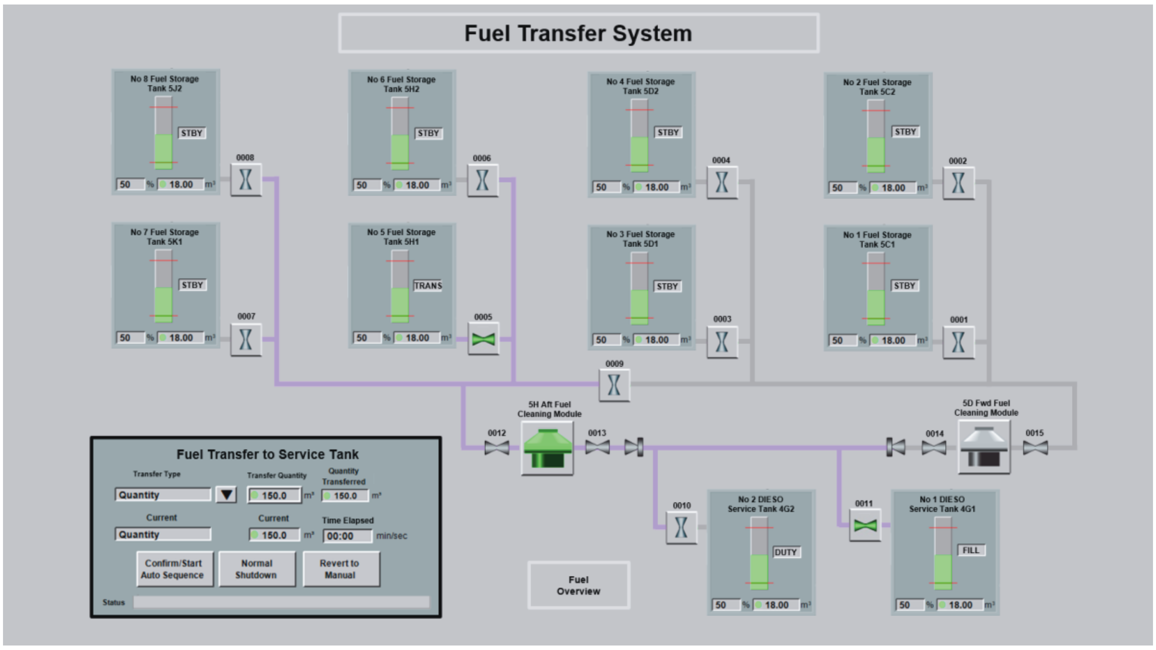


Figure 4. A System Activity Diagram for a simple Task Sequence for Fuel Transfer in a conceptual Light Frigate

From the study of the key human tasks associated with the control of platform systems, the HCI page requirements are deduced in terms of the page hierarchy, and for information display in terms of system mimic diagrams (status, process flow or ringmain types), task sequence operator sequence interfaces, damage control command and control displays, etc. Subsequent page design will embody the required information display and associated control objects within the constraints and guidelines detailed in an HCI Style Guide agreed with the customer (see the example in Figure 5 below). Generic information and navigation links for permanent display will be embodied within the HCI Framework surrounding the page display area.



Fuel Transfer to Service Tank

Transfer Type: Quantity
Transfer Quantity: 150.0 m³
Quantity Transferred: 150.0 m³
Current: Quantity
Current: 150.0 m³
Time Elapsed: 00:00 min/sec
Status:

Figure 5. An HCI Page for the Fuel Transfer System in a conceptual Light Frigate

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From the study of the particular system control and monitoring tasks of key operators in various Operational State Manning Scenarios, against the inherent platform system breakdown structure, the functional decomposition of the proposed Station in Control (SIC) Hierarchy for incorporation within the HCI Framework is deduced (see example in Figure 6 below). This is used to manage the allocation of system control in different scenarios between the various operator roles, based on login privileges linked to the SQEP levels of various IPMS users. By analysing the specific functions required by particular control system users against the proposed SIC Hierarchy, along with the appropriate supervisory and administrative tasks identified, the user privileges required by specific operators within their user account configuration is determined in matrix form.

Role and task analysis will also identify the tasks to be undertaken during transition between various Operational State Manning Scenarios relating to watertight integrity, readiness, radiated noise, emergency states, internal security etc. This will determine the requirements for embedded functionality within the HCI Framework for the effective management of these transitions. Finally, the analysis will identify perceived shortfalls within the manning philosophy, and the proposed physical design of platform systems and their control positions (including their embedded functionality), which can be passed back to the customer as recommendations for change.

These outputs will tailor the installed IPMS to the specific operating environment within the platform, ensuring that the system facilitates the human tasks required to be undertaken by the operators in the most effective manner, thereby minimizing operator workload. Indeed, they will also help identify beneficial interfaces with other associated systems such as closed circuit TV surveillance, stability application software, fire detection and suppression systems etc., as the integrated system will be far more effective than the sum of the parts. They will also help identify hardware criticality so as to inform the need for redundancy, maintained power supplies and shock resilience, in concert with the associated system Failure Mode, Effects and Criticality analysis (FMECA). By truly optimizing the system of both man and machine in this way through a finely tuned man/machine interface, in the form of the HCI and wider HMI, so manning levels within the platform can also be minimized. Therefore, when supported by the correct selection of technology to meet the operational needs of a platform, effective role and task analysis can be a major enabler in the drive towards lean manning within a marine platform.

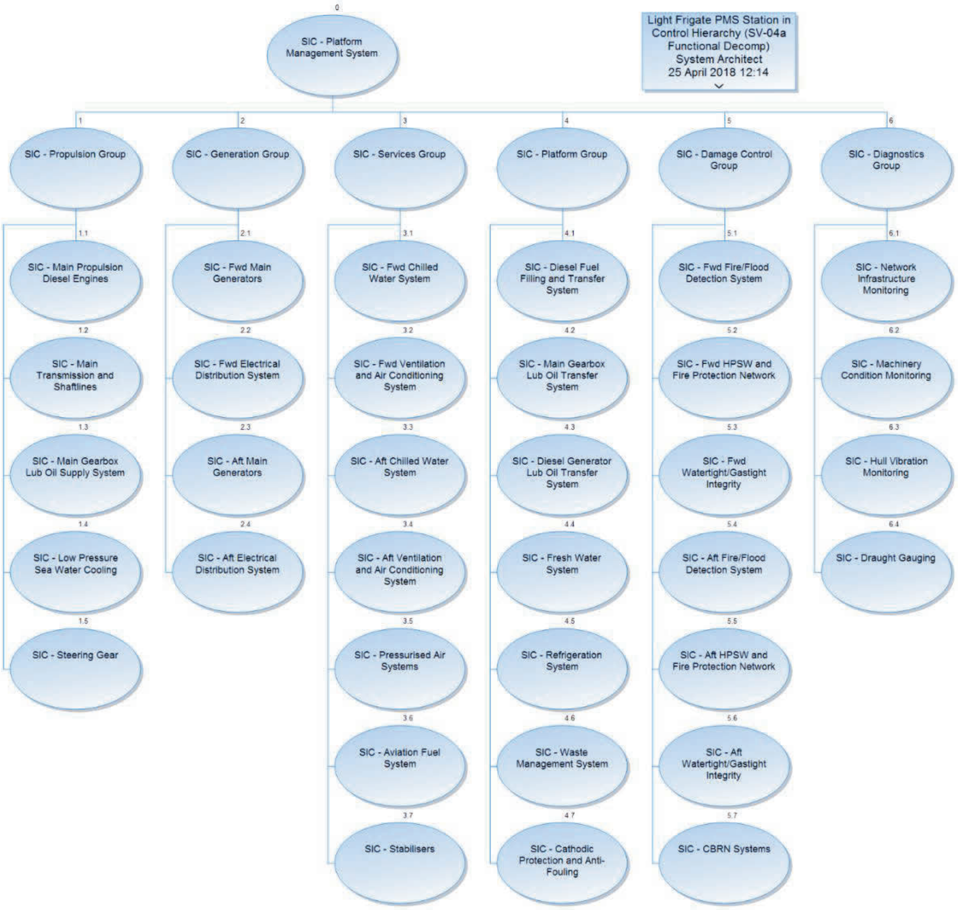


Figure 6. Conceptual Light Frigate IPMS Station in Control Hierarchy

6. Supporting Technology

The selection of appropriate technology is vital to optimizing vessel operations, supporting the operators in their daily tasks and mission objective. As a result, the selection of technology for ships’ automation and related systems must be driven by the output of operational analysis, as discussed in previous sections. The location of operating positions, availability of data, resilience to damage, and safety are all aspects that can drive the technology selected for a vessel. The following sections discuss some key areas of a system for consideration following the output of the role and task analysis.

6.1. Architecture

There are numerous architectures available for automation systems, however the survivability and availability requirements in the marine industry make peer to peer architectures appealing. Rather than hosting functionality centrally, typically with a redundant configuration, a peer to peer architecture ensures that the system functionality exists at the lowest levels in the architecture. Such an architecture supports the concept of damage control zone subdivisions by creating functional cells that can operate independently from one another. Defining the best location for IPMS functionality is a direct output from the role and task analysis. An example of a peer-to-peer architecture is shown in Figure 7.

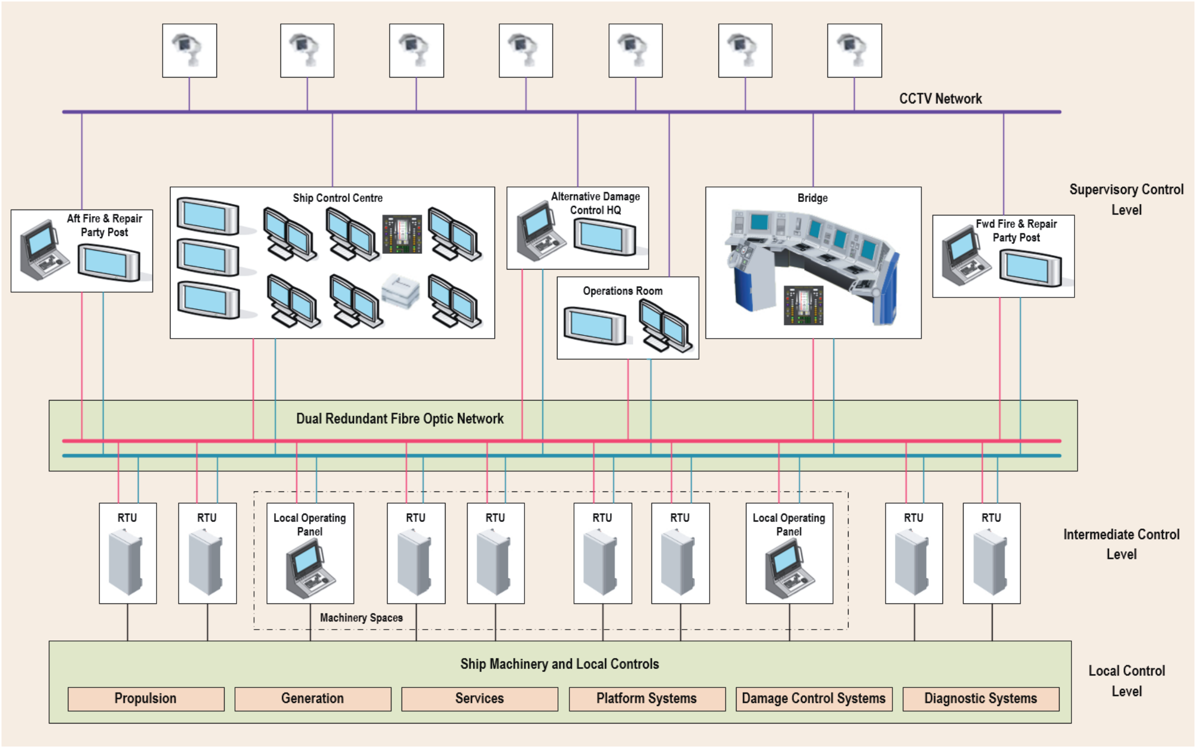


Figure 7. IPMS Peer to Peer Architecture for a Conceptual Light Frigate

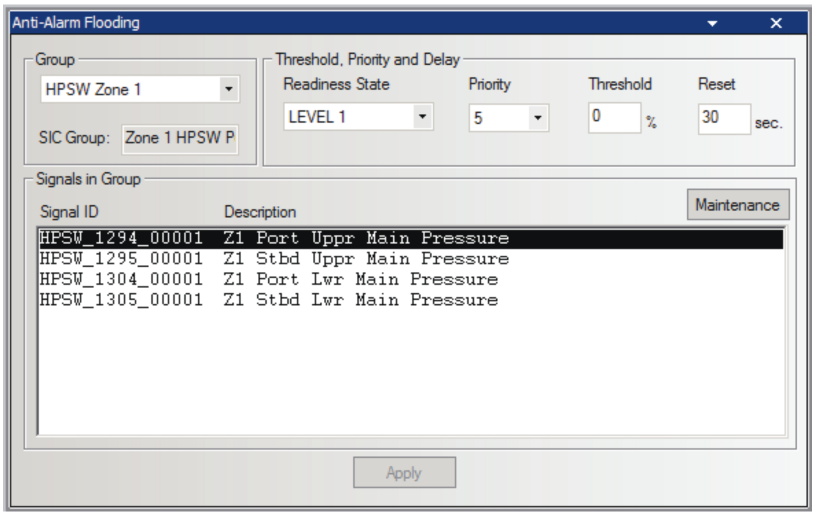
Within peer to peer architectures there are many options to tailor the solution to suit a vessel’s damage control philosophy and performance requirements. The control logic is hosted at the Remote Terminal Unit (RTU)/ which forms a functional cell. This ensures that even upon failure of the network or other functional cells, the remaining cells can still maintain critical functionality.

Under normal operating conditions, a vessel’s control and monitoring system must be continuously available. This is further emphasised in a lean manned ship since the crew are more dependent on the control and automation system compared to more heavily manned vessels.

6.2. Information Management

Ensuring the correct information is available to specific operators across all operator consoles allows the operators to access critical data throughout the ship. However, as discussed in Section 3 above, the amount of data available on modern warships is potentially overwhelming to an operator. In the design of an IPMS, the mechanisms to manage this data must be configured and reviewed to align to operational philosophy defined during role and task analysis. Processes are utilized to define the data that should be displayed on each HCI page and in which context. Additionally, each signal is accessed to determine whether it is an alarm, warning or neither, as well as its severity.

Alarm management provides the mechanisms to ensure operators are informed of alarms, but not overwhelmed by alarms that are either irrelevant or duplicate. Anti-Flood Alarm Groups allow IPMS to filter out multiple alarms which all have the same root cause. Sensors are configured into anti-alarm flooding groups such that, when the sensors from a group start going into alarm, the individual alarms are displayed in the alarm list and annunciated at the console that has SIC for these sensors. When the threshold value for a group is reached, the individual alarms are removed from the alarm list and are replaced by a single group alarm (see Figure 8).



Group: HPSW Zone 1
SIC Group: Zone 1 HPSW P

Threshold, Priority and Delay
Readiness State: LEVEL 1
Priority: 5
Threshold: 0 %
Reset: 30 sec.

Signals in Group

Signal ID	Description
HPSW_1294_00001	Z1 Port Uppr Main Pressure
HPSW_1295_00001	Z1 Stbd Uppr Main Pressure
HPSW_1304_00001	Z1 Port Lwr Main Pressure
HPSW_1305_00001	Z1 Stbd Lwr Main Pressure

Figure 8. Anti-Alarm Flooding Management Window

Alarm inhibits provide another mechanism for suppressing alarms in situations where the alarm is not warranted, such as a low pressure alarm on a fluid system where an inlet valve is intentionally closed. However, a mechanism such as this must be carefully managed throughout the IPMS design so that the design intent is achieved without inadvertently undermining the original function of the alarm.

Alarm annunciation is also controlled through the definition of SIC groups. Alarms not present in a particular SIC group held by an operator will still be visible in the alarm list, but no audible or flashing notification will be presented in this instance.

Damage Control in the action state provides an excellent example of a situation where information management is critical, requiring multiple aspects of IPMS to be utilized simultaneously by a number of operators. Automated information from the vessel's equipment and systems will be supplemented by manual inputs from operators around the ship. Not only is the anti-alarm flooding groups critical in this situation to reduce the amount of alarms being reported, the concise presentation of information as well as the ability to record local situational reports coming from crew is paramount. A layered incident board (such as that shown in Figure 9) can been tailored to this situation allowing operators to manage and access all of this information effectively, whilst maintaining a common operational picture throughout the vessel.

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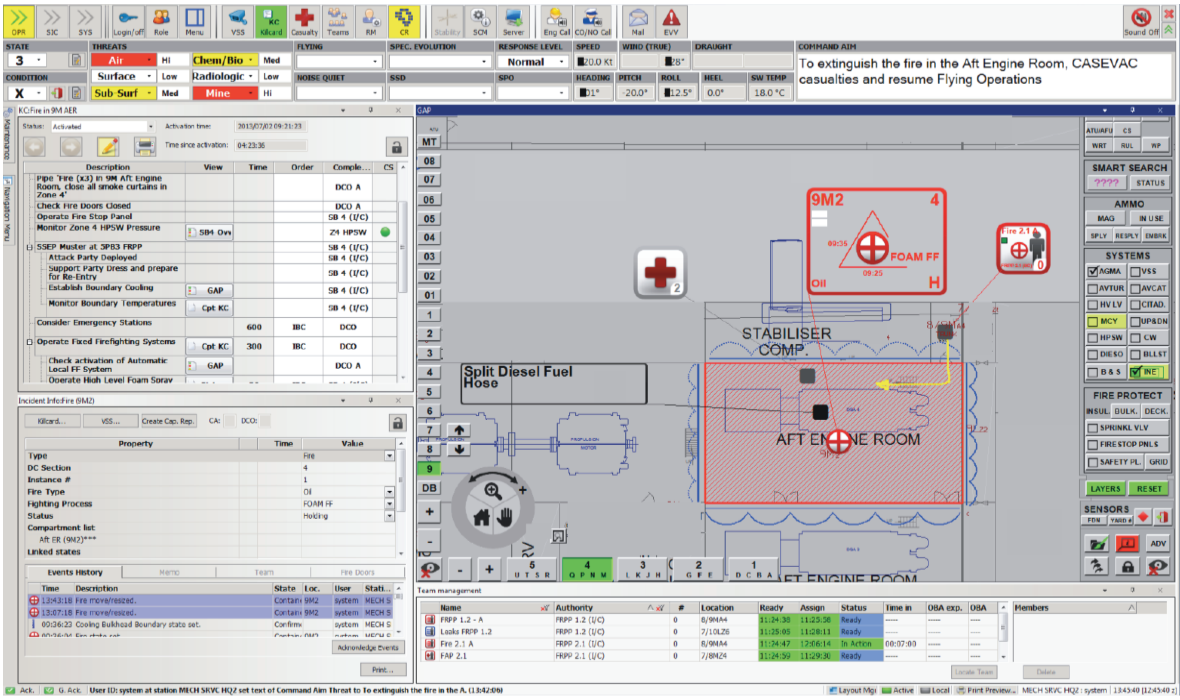

STATE	THREATS				FLYING	SPEC. EVOLUTION	RESPONSE LEVEL	SPEED	WIND (TRUE)	DRAUGHT
3	Air	Hi	Chem/Bio	Med			Normal	20.0 Kt	28°	
CONDITION	Surface	Low	Radiologic	Low	**NOISE QUIET**	**SSD**	**SPO**	**HEADING** / 01°	**PITCH** / -20.0°	**ROLL** / 12.5°
X	Sub Surf	Med	Mine	Hi				**HEEL** 0.0°	**SW TEMP** 18.0 °C	

COMMAND AIM: To extinguish the fire in the Aft Engine Room, CASEVAC casualties and resume Flying Operations

KC:Fire in 9M AER

Status: Activated Activation time: 2013/07/02 09:21:23
Time since activation: 04:23:36

Description	View	Time	Order	Comple...	CS
Pipe 'Fire (x3) in 9M Aft Engine Room, close all smoke curtains in Zone 4'				DCO A	
Check Fire Doors Closed				DCO A	
Operate Fire Stop Panel				SB 4 (I/C)	
Monitor Zone 4 HPSW Pressure	SB4 Ovv			Z4 HPSW	●
SSEP Muster at 5PB3 FRPP				SB 4 (I/C)	
Attack Party Deployed				SB 4 (I/C)	
Support Party Dress and prepare for Re-Entry				SB 4 (I/C)	
Establish Boundary Cooling	GAP			SB 4 (I/C)	
Monitor Boundary Temperatures	Cpt KC			SB 4 (I/C)	
Consider Emergency Stations		600	IBC	DCO	
Operate Fixed Firefighting Systems	Cpt KC	300	IBC	DCO	
Check activation of Automatic Local FF System	GAP			DCO A	
Operate High Level Foam Spray					

Incident Info:Fire (9M2)

Kilcard... VSS... Create Cap. Rep. CA: DCO:

Property		Time	Value
Type			Fire
DC Section			4
Instance #			1
Fire Type			Oil
Fighting Process			FOAM FF
Status			Holding
Compartment list			
Aft ER (9M2)***			
Linked states			

Events History | Memo | Team | Fire Doors

Time	Description	State	Loc.	User	Stati...
13:43:18	Fire move/resized.	Contain	9M2	system	MECH S
13:07:18	Fire move/resized.	Contain	9M2	system	MECH S
00:36:23	Cooling Bulkhead Boundary state set.	Confirm		system	MECH S

Acknowledge Events
Print...

Team management

Name	Authority	#	Location	Ready	Assign	Status	Time in	OBA exp.	OBA
FRPP 1.2 - A	FRPP 1.2 (I/C)	0	8/9MA4	11:24:38	11:25:58	Ready	-----	-----	----
Leaks FRPP 1.2	FRPP 1.2 (I/C)	0	7/10LZ6	11:25:05	11:28:11	Ready	-----	-----	----
Fire 2.1 A	FRPP 2.1 (I/C)	0	8/9MA4	11:24:47	12:06:14	In Action	00:07:00	-----	----
FAP 2.1	FRPP 2.1 (I/C)	0	7/8MZ4	11:24:59	11:29:30	Ready	-----	-----	----

Members

Locate Team Delete

Ack. | G. Ack. | User ID: system at station MECH SRVC HQ2 set text of Command Aim Threat to To extinguish the fire in the A. (13:42:06) | Layout Mgr | Active | Local | Print Preview... | MECH SRVC HQ2 : system | 13:45:40 [12:45:40 z]

Figure 9. Layered Damage Control Incident Board

6.3. *Unattended Machinery Space*

UMS operation is a concept that has been utilized throughout the commercial marine market for some time. However, as discussed earlier in this paper, naval action state manning levels have largely negated the need for UMS in the past in most naval platforms. Despite this, with advancements in technology and confidence in the solution, such systems are seen as having more relevance. There are three key components to achieving UMS on a vessel, namely extended alarm panels, 'Deadman' systems and paging systems.

Figure 10. An example of an Extended Alarm Panel

Extended Alarms Panels, such as that shown in Figure 10, are located in accommodation and recreational areas of the ship. These panels display an alarm summary with audible annunciation upon alarm activation, where the panel is identified as holding duty status for a given alarm group. These panels provide indication to prompt immediate action from on duty crew and allow them to start processing the situation from their current location.

A paging system is used to ensure the duty engineer is alerted to the activation of pre-defined alarms from the IPMS. The paging system, consisting of a number of repeaters throughout the vessel, directly interfaces with the IPMS. When an IPMS alarm annunciates, it will be forwarded to the defined pager held by the relevant on call engineer for appropriate action.

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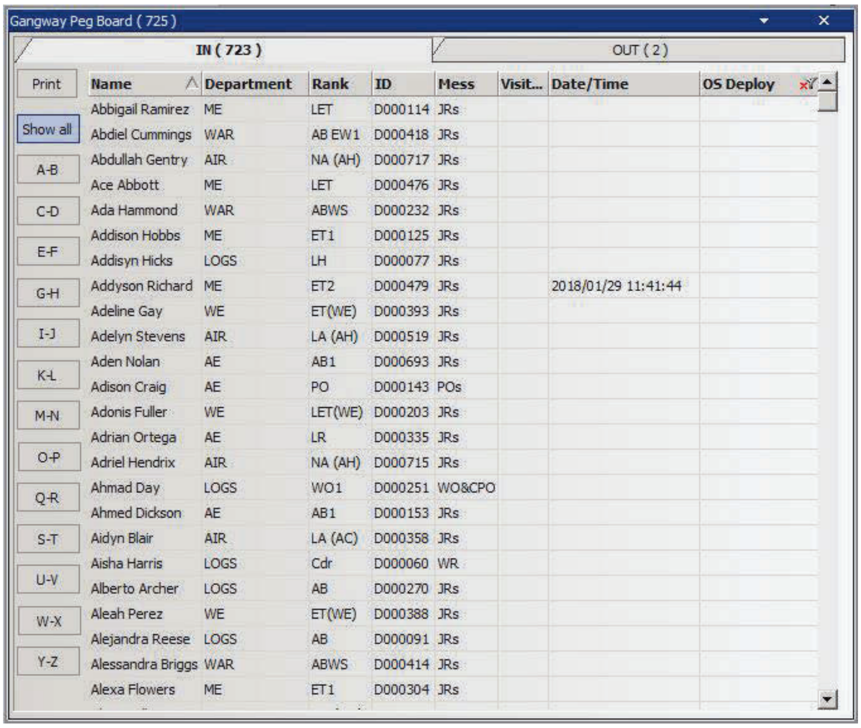
A ‘Deadman’ system is utilized by solitary roundsmen or maintainers in compartments such as machinery spaces where there are significant hazards. During lone working, the ‘Deadman’ system is activated and a watchdog timer starts which, if not manually reset, will initiate an audible alarm. This alarm will also be transmitted to the extended alarm panels and the duty engineer’s pager.

6.4. *Personnel Management*

There are various facets to personnel management. An electronic pegboard (see Figure 11) can be used to establish the status of souls on board by logging personnel movements at gangway access points in harbour and embarkation points at sea. This provides the ability to quickly muster personnel on a vessel, which is of great importance in a man overboard situation or a major emergency at sea. However, by interfacing this with the transition management functionality within the IPMS, the system enables personnel to be mustered and managed at all outstations during every conceivable scenario. Taking this a step further, the addition of an active personnel tracking system allows response teams to quickly build a picture of the exact location of missing crew in emergency scenarios.



Name	Department	Rank	ID	Mess	Visit...	Date/Time	OS Deploy
Abbigail Ramirez	ME	LET	D000114	JRs			
Abdiel Cummings	WAR	AB EW1	D000418	JRs			
Abdullah Gentry	AIR	NA (AH)	D000717	JRs			
Ace Abbott	ME	LET	D000476	JRs			
Ada Hammond	WAR	ABWS	D000232	JRs			
Addison Hobbs	ME	ET1	D000125	JRs			
Addisyn Hicks	LOGS	LH	D000077	JRs			
Addyson Richard	ME	ET2	D000479	JRs		2018/01/29 11:41:44	
Adeline Gay	WE	ET(WE)	D000393	JRs			
Adelyn Stevens	AIR	LA (AH)	D000519	JRs			
Aden Nolan	AE	AB1	D000693	JRs			
Adison Craig	AE	PO	D000143	POs			
Adonis Fuller	WE	LET(WE)	D000203	JRs			
Adrian Ortega	AE	LR	D000335	JRs			
Adriel Hendrix	AIR	NA (AH)	D000715	JRs			
Ahmad Day	LOGS	WO1	D000251	WO&CPO			
Ahmed Dickson	AE	AB1	D000153	JRs			
Aidyn Blair	AIR	LA (AC)	D000358	JRs			
Aisha Harris	LOGS	Cdr	D000060	WR			
Alberto Archer	LOGS	AB	D000270	JRs			
Aleah Perez	WE	ET(WE)	D000388	JRs			
Alejandra Reese	LOGS	AB	D000091	JRs			
Alessandra Briggs	WAR	ABWS	D000414	JRs			
Alexa Flowers	ME	ET1	D000304	JRs			

Figure 11. Electronic Gangway Pegboard

6.5. *Future Technologies*

There are a number of technology trends in the Marine Industry focussed on the management and value of data. This burst in innovation has been supported with the momentum that is being gained in the Big Data, Artificial Intelligence (AI) and Machine Learning paradigms that are being utilized in all market segments. Advances in these areas have produced solutions for advance medical diagnosis, home automation, autonomous vehicles, voice recognition in our phones and predication of the stock market. The obvious application in the marine industry is Autonomous vessels, which are a prime application for these technologies and will no doubt generate a raft of technological advances that can be utilized in manned vessels. Eventually, these technologies will be used on ships through advanced automation on ship and assisted decision-making, which will be driven by the increasing complexity of systems, the diverse operations of a given ship and lean manning. However, prior to applying these technological advances, the data currently available on a ship must be fully interrogated and understood to enable the application of the appropriate technology. Currently, data is typically in silos driven by the black box architecture that has been commonplace in shipbuilding. How do we combine this data to generated new information and utilise this in ship operations?

Remote diagnostic support is an area of technology that is also developing rapidly, providing remote management of machinery and the optimization of platform maintenance, both preventative and corrective. An

IPMS is well suited to interface with onboard condition monitoring and maintenance management software, and further integration with a platform external communications system allows specialist additional staff located at a shore facility, supported by equipment suppliers, to actively manage and monitor the status of a vessel's systems.

Further automation enhancements can be integrated into a vessel, such as Smart Valves as discussed by Doherty [7]. Flinch technology can improve the survivability of a vessel by using intelligent valves with the ability to detect leaks and reconfigure critical fluid systems to maintain critical functionality.

A modern vessel is teeming with data from sensors around the vessel. Sensors from combat systems as well as platform systems can offer a great deal of contextual information when combined within IPMS displays. One can imagine the ability to take preventative action upon the knowledge of imminent damage. All of this data can also be used for assisted decision making, providing the operator with contextual information but automating much of the decision making process throughout the command hierarchy, with the operator intervening only when necessary.

7. Conclusion

In this paper a pragmatic approach to supporting lean manning though automation has been discussed. Starting with the definition of the ship architectural design, operating philosophy and mission objectives through to role and task analysis, taking into account naval doctrine, which all drive the definition of the IPMS, utilizing advances in technology to support the ship's staff. IPMS is far more than an automation system and, with the correct definition early in a programme, the optimal solution can be designed to most effectively support ship operations. As technology trends continue, innovation paves the way for increased platform capability with consequent enhancement to ship operations. The challenge is to embrace the changes offered by advances in technology so as to maximize platform efficiency and drive down operating costs.

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9. References:

1. National Security Strategy and Strategic Defence and Security Review 2015, A Secure and Prosperous United Kingdom, HM Government, November 2015
2. Defence Standard 00-251, Human Factors Integration for Defence Systems, Issue 1 dated 5 Feb 2016
3. Lloyds Register Rules and Regulations for the Classification of Naval Ships, January 2018
4. Defence Standard 08-111, Requirements for Damage Surveillance and Control Management Systems, Version 3 dated 24 Jul 2014
5. Naval Authority Notice 06/2018 Software Integrity, incorporating the Naval Authority Group Software Integrity Policy, Issue 2.0 dated Feb 2016
6. British Standard EN 61508, Functional safety of electrical/electronic/programmable electronic safety-related systems, dated Jun 2010
7. Doherty G. (2007) Increased survivability with Intelligent Fluid Systems (Proceedings EAAW II)
8. Horenberg S. C. and Melaet A. C. F. (2013). Uniting weapon and marine knowledge: from goal to reality (Proceedings EAAW V)

10. Glossary of Terms:

Term	Description
AI	Artificial Intelligence
BS	British Standard
CBRN	Chemical, Biological, Radiological and Nuclear
CBRNPO	Chemical, Biological, Radiological and Nuclear Protection Officer
CCTV	Closed Circuit Television
Co-ord	Co-ordinator

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Term	**Description**
DCO	Damage Control Officer
Def Stan	Defence Standard
DoDAF	Department of Defense Architectural Framework
EAAW	Engine as a Weapon
EN	comite europeen de normalization Standards
FMECA	Failure mode, effects and criticality analysis
FRPP	Fire and Repair Party Post
Fwd	Forward
HCI	Human Computer Interface
HMI	Human Machine Interface
HQ	Headquarters
HV	Human View
IBC	Internal Battle Controller
IPMS	Integrated Platform Management System
L3 MAPPS	L3 Marine Automation and Power Plant Simulation
ME	Marine Engineering
MEOOW	Marine Engineering Officer of the Watch
MESM	Marine Engineering Services Manager
MoDAF	Ministry of Defence Architectural Framework
OV	Operational View
RTU	Remote Terminal Unit
SCC	Ship Control Centre
SIC	Station in Control
SQEP	Suitably Qualified and Experienced Personnel
SSD	Special Sea Dutymen
SV	System View
T31e	Type 31 export
TV	Television
UMS	Unattended Machinery Spaces
WE	Weapon Engineering