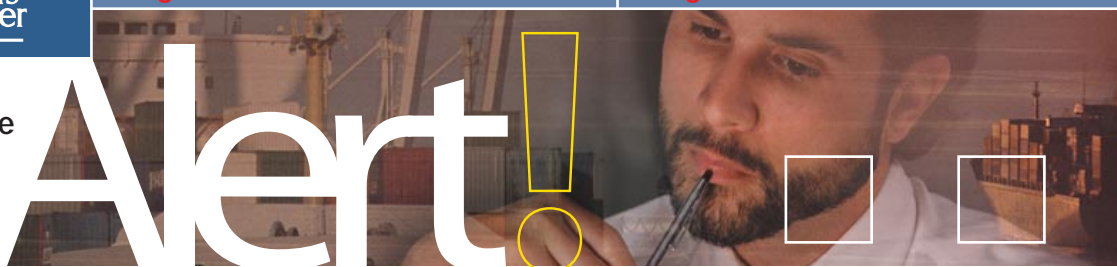




The International Maritime Human Element Bulletin

Issue No.1 October 2003



Welcome to the first edition of *Alert!*, and the start of a campaign to raise the awareness of Human Element issues as they apply to the commercial maritime industry. This campaign is a 3 year project run by The Nautical Institute and sponsored by Lloyd's Register.

Developing technology has revolutionised the way in which ships and their systems are designed and operated, but there still remains the need for human involvement at some stage or other, no matter how much 'automation' may be introduced. It is often stated that 80% of all accidents at sea are attributable to human error (or more correctly operator error). But while operator error may be the immediate cause of an accident, the root cause can often be traced back to the human influences on the design or operation of a ship or its systems. The human element is a critical feature of all aspects of ship or system design and operation.

Through these quarterly Bulletins, we aim to capture the attention, and raise the awareness, of maritime professionals across the industry, to human element issues. Through our website we seek to add greater depth to the features in each Bulletin and to establish a common repository for all maritime related human element research, focusing attention on areas of weakness that may lead to new research projects while offering a vehicle for distributing and applying the results.

The reason why The Nautical Institute has taken the lead in promoting the human element is because ultimately its members are responsible for taking ships to sea. The Institute provides an independent professional forum for linking seagoing staff with other maritime disciplines.

The project is international in scope and seeks to represent the views of all sectors of the maritime industry, ie from mariners, engineers, naval architects, port operators, regulators, insurers etc.

All comments are welcome.

Improving the awareness of The Human Element in the Maritime Industry

Wherever there is a human interacting with a system there is a Human Element issue. Modern technology has revolutionised the way in which a ship is operated, but lack of attention to the human-system interface, in terms of the design, layout, and integration of systems, and training in their use, is the root cause of many accidents today.



Captain Robbie
Middleton, FNI
President of
The Nautical
Institute

The key to improvement is in the close involvement of all stakeholders to ensure that a ship is 'fit for purpose', and that the master and his crew are provided with the proper tools and are adequately trained to be able to conduct their business in a safe and efficient manner.

I welcome this initiative of The Nautical Institute, supported by Lloyd's Register, which - through these quarterly editions of *Alert!* and the associated website - aims to create a common understanding amongst operational decision makers, both ashore and afloat, of what the Human Element is and how it can be applied in practice.

The maritime industry recognises that many accidents are the direct consequence of human failings and that in reality many of the others have a strong element of human involvement. We rely on people, working in an increasingly demanding, technically complex system. The industry cannot afford to simply accept that this situation is inevitable. Lloyd's Register has carried out a structured programme of research and development work investigating the human element and has developed approaches that can assist in reducing the risks due to human factors. However, we recognise that we, from our standpoint of Classification, cannot solve this complex problem.



David G
Morrhouse, The
Chairman
Lloyds Register

Lloyd's Register has a long tradition of providing support to safety initiatives, particularly in the marine industry. We have worked with The Nautical Institute on a number of projects and I was encouraged to receive their proposal for a project to improve the awareness of the human element. I believe that this awareness initiative is an important first step in a campaign to improve maritime safety. I am delighted that Lloyd's Register has been able to provide funding for this initiative and I give it my full support.



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Alert!

The International Maritime Human Element Bulletin

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A Classification Society's view of Human Element issues

The design and operation of ships has evolved and continues to develop, driven by structural change in the industry, new technologies, new regulations and changes in manning. Lloyd's Register recognises the need for ship design to take account of the human element in order to ensure an acceptable level of marine safety.

When considering marine safety it is necessary to address both the human element and the technical solutions in the broadest sense, not just the immediate causes of actual or potential failures. Whilst this combined approach is taken in some incident analysis, whether after the event or as part of a proactive safety assessment, there is still a tendency to treat the human and the technical elements independently of each other. An integrated approach is required if full understanding is to be achieved. A simplistic technical approach tends to recommend local reactive solutions, such as the addition of more



alarms, which may assist but will add complexity and the underlying cause may not be resolved. A purely human element approach tends to promote administrative solutions, which may not be fully effective on their own.

Of course, there are many aspects of ship design that have a direct impact on human performance, such as ship motions, accessibility, lighting and noise levels and basic habitability. Classification Rules provide some cover for these aspects but the maritime industry needs to grasp human element issues at a higher, more integrated level to make

a real difference to safety.

There are many lessons to be learned from the experience of other sectors, to prevent the marine sector learning the same lessons the hard way. Much analysis of human error has been aimed at improving understanding, and its remedial value has not been fully exploited. Classification Societies have a role to play in the developing safety management culture of the marine industries and Lloyd's Register fully supports this initiative by The Nautical Institute.

Vaughan Pomeroy - Manager, Research and Development. Lloyd's Register

One Naval Architect's view of the Human Factor



My view on Human Factors as related to naval architecture was shaped by two distinct experiences: sailing dinghies and ocean racing yachts, starting at a very early age, and 2^{1/2} years at sea in a destroyer escort before I ever practiced any naval architecture.

These experiences convinced me that no naval architect should be allowed to design anything until he or she has been to sea for a sustained period, preferably both under sail and in a modern ship. Why is sea time so vital to better ship design and crew safety? I believe that lack of sea experience of ship designers is evidenced in many ways aboard far too many modern ships. For example, athwartship berths, king-size beds, and poor layout of mooring winches, bits, and chocks, which endanger sailors' lives, are all too common. Furthermore, the layout of segregated ballast tanks in some new double hull tankers, although complying with rule

minimums, often results in inadequate bow immersion while in ballast and questionable safety while carrying out at sea ballast exchange to meet new "invasive species" protection mandates. And, with large ships calling in harbours laid out for smaller ships, the close quarters manoeuvrability may be prejudiced by inadequate rudder size and/or power, often aggravated by very large windage.

Modern computer-run equipments, such as electronic chart systems, can also endanger a ship. No new officer joining a modern ship will be competent on the bridge, despite his past experience, until he has been trained in the multitude of equipment which confronts him - and even then it can lead to "information overload" in these days of small crews and quick turnaround.

Finally there is the inescapable fact that too many computer control systems are inherently LESS reliable than the manual control modes they replace.

So my advice to new naval architects is "Go to sea and stay awhile and ALWAYS listen to the mariners before you finish your designs!"

*William O. Gray
Life Fellow & Land Medallist, Society of Naval Architects and Marine Engineers (SNAME)*

Just waiting to happen ... The work of the UK P&I Club

Human error costs the maritime industry \$541m a year, according to the UK P&I Club. From their own analysis of 6091 major claims (over \$100,000) spanning a period of 15 years, the Club has established that these claims have cost their members \$2.6bn, 62% of which is attributable to human error.

In its loss prevention work, the Club is placing a much greater emphasis on pinpointing root causes in respect of personal injury and other incidents. It recognises that investigators often identify the persons most responsible for incidents (active failures) without uncovering the underlying factors (latent failures). The Club asserts that latent failures frequently stem from decisions higher up, and that such failures can be hidden in one or more of 11 categories:

- Procedures • Hardware • Design
- Maintenance Management
- Error Enforcing Conditions
- Housekeeping
- Incompatible goals
- Communication • Organisation
- Training • Defences

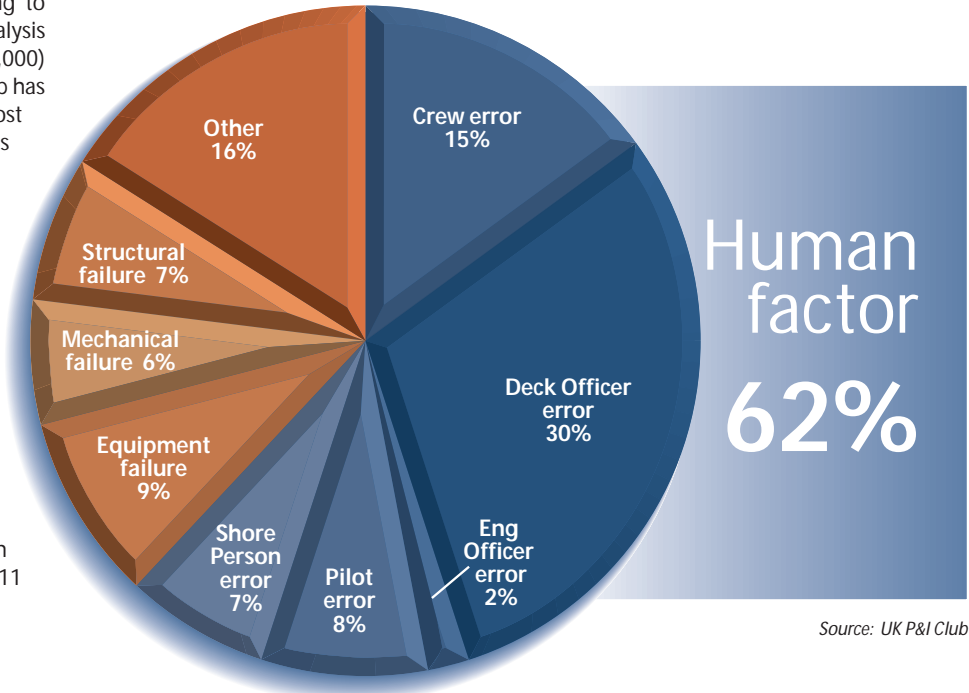
It is not surprising that each of these categories includes the human element!

One significant initiative on the part of the UK P&I Club, is to produce a video titled *No Room for Error*, which shines a wider spotlight on the causes of marine accidents. This involves extending

awareness beyond the immediate or proximate reasons for incidents to shortcomings in related procedures and actions which may well have contributed to their occurrence.

Karl Lumbers, the Club's Loss prevention Director says: "We must prevent the next incident occurring, not the last one. Latent failures are a greater threat as they create conditions in which accidents are more likely and more serious."

Further information on the Club's loss prevention work and on all loss prevention videos can be obtained through UK P&I Club's website at www.ukpandi.com.



A Marine Engineering perspective

The Human Element daily affects the lives of marine engineers in their personal and collective safety and in their work at sea, and can influence the success or failure of the ship's engineering team. Human factors relate to the behaviour of marine engineers as they undertake their work and what influences that behaviour either positively or negatively.

Human error can be brought on by such characteristics of the engineroom working environment as excessive heat, noise, vibration, lighting, equipment layout and

high workloads. Well designed, operator-focused work places and control room instrumentation display, and a strong and accurate operational and maintenance planning and procedures regime, together with a robust safety awareness ethos are all critical in reducing the occurrence of human error.

Deliberate deviations from rules, regulations, procedures, and instructions (violations) can arise due to, amongst others:

- The desire to cut corners to save time
- A perception that rules are too restrictive
- Lack of enforcement of the rules such that routine violations become the

norm, which particularly affects newly joining engineer officers

Any of these points or combination thereof can be brought about by various work place characteristics and working culture. In particular, during main engine or other maintenance which requires the ship to be out of service, commercial pressures to complete the job quickly can increase the likelihood of violations.

In order to minimise such violations, it is important to ensure that the mental attitudes and motivations of engineers are considered carefully in all aspects of engineering systems design and operation, by ensuring good work place design and environments, by ensuring rules and instructions are necessary, appropriate and relevant, by establishing appropriate supervision, and by monitoring and creating a positive health and safety culture.

Mark Hodgson
Deputy Fleet Manager, Shell International Trading and Shipping Company

WHO?

Exploring the human element

Stakeholders



There is no accepted international definition of the term Human Element, yet the IMO has been addressing these issues since 1991! The aviation world describes the Human Element as an alternative to the term Human Factors to 'avoid ambiguity and aid comprehension', and the US Coastguard defines it as 'human and organizational influences on marine safety and maritime system performance'.

In the maritime context, the term Human Element embraces anything that influences the interaction between a

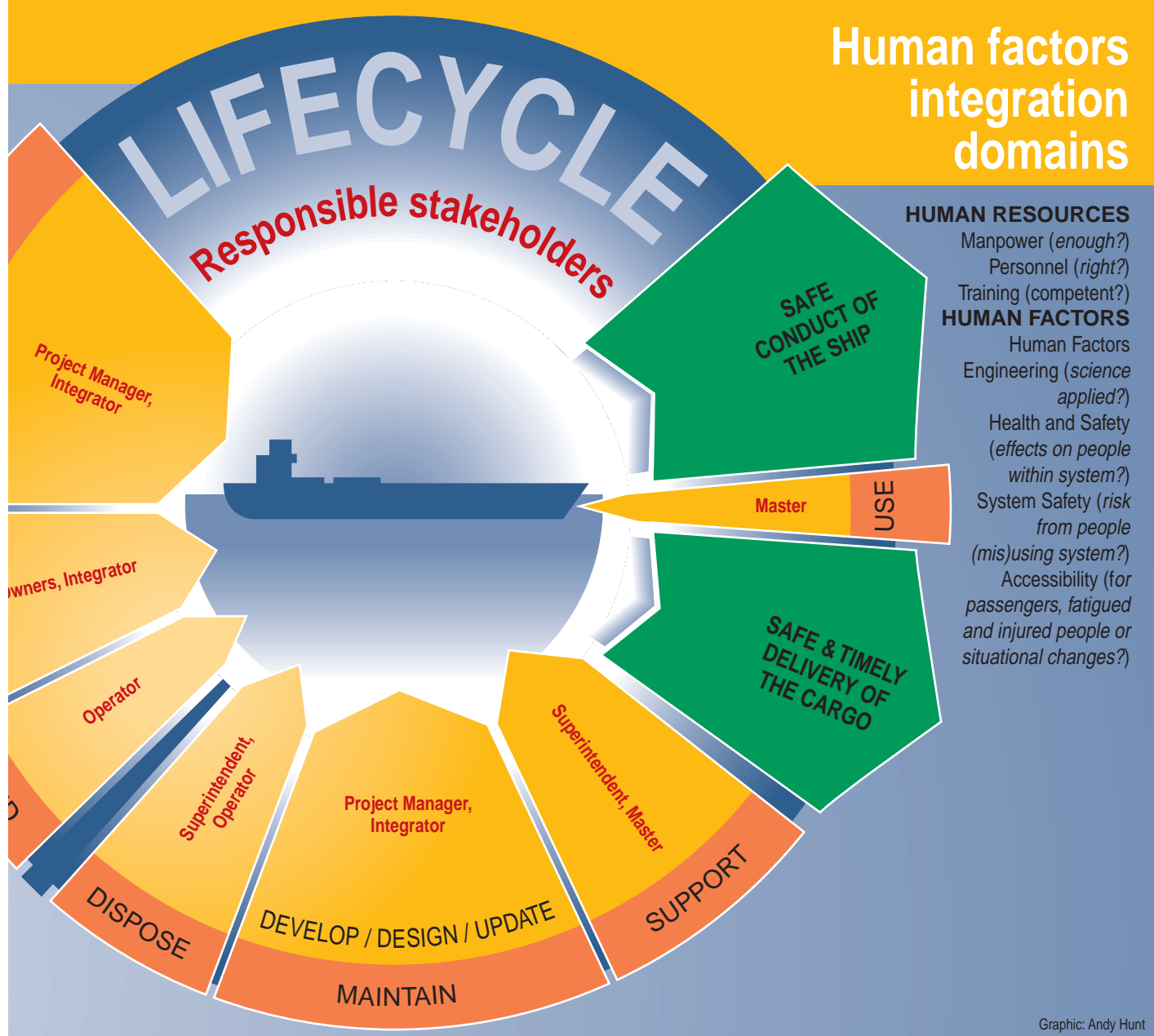
human and any system aboard ship. The Human Element has been with us since time immemorial, but it is the 'systems' that have changed, through the increase in electronic technology, which has caused the mariner to be less 'hands on' and driven more towards automation. Use of technology in general has replaced work teams with individuals, resulting in less checking, more lone work and a different social environment.

This illustrative diagram tells the story of the life of a modern ship in terms of the human element; it identifies the various

responsible stakeholders and their linkage, at each stage of the lifecycle, from conception to disposal. While every one of these stakeholders has an influence on the human-system integration on the ship, the degree of influence can be more, or less, direct. For example, someone on a ship who does not take account of health and safety issues will have a very direct influence on the operation of that particular ship, whereas someone in Government, who takes an interest in the health and safety of seafarers generally, could have a small but significant effect on all seafarers sailing under that country's

WHEN?

HOW?



Graphic: Andy Hunt

Human factors integration domains

HUMAN RESOURCES

- Manpower (*enough?*)
- Personnel (*right?*)
- Training (*competent?*)

HUMAN FACTORS

- Human Factors
- Engineering (*science applied?*)
- Health and Safety (*effects on people within system?*)
- System Safety (*risk from people (mis)using system?*)
- Accessibility (*for passengers, fatigued and injured people or situational changes?*)

flag. All responsible stakeholders need to work together to ensure that ultimately the master and his crew have the right tools in place, and are properly trained, to ensure the safe conduct of the ship, and the safe and timely delivery of its cargo.

But, in order to ensure that the ship is 'fit for purpose' in every respect, stakeholders must ensure that the key domains are fulfilled in terms of:

- Manning - numbers required, to do the jobs in both normal and emergency situations
- Personnel - ensuring the correct mix of people onboard to operate and maintain the ship and its systems
- Training - competency and familiarity with the ship and its systems
- Human Factors Engineering - the integration of human characteristics v optimisation of human/machine performance, including ergonomics
- Health and Safety - the effects on the people who are operating the system
- System Safety - the risks from people using (or misusing) the system
- Accessibility - for passengers, fatigued and injured people, or to take account of situational changes, which exceed human adaptation eg extreme motion or low or high illumination

This is a working diagram and it is inevitable that some of the stakeholders may have been left out; we hope to develop it further through the website, during the next three years.

In the next issue:
Exploring Human Factors

6 The International Maritime Organisation

...and the Human Element

In 1997, the IMO Assembly adopted a Resolution that indicated a step change in its approach to maritime safety by moving from a regulatory regime to that of a safety culture with a strong emphasis on the human element. Among its goals was the requirement to 'promote and communicate, through human element principles, a maritime safety culture and heightened marine environment awareness and to provide a framework to encourage the development of non-regulatory solutions and their assessment, based upon human element principles.' Thus today, all IMO Committees are instructed to consider the human element when developing new or amending existing performance standards.

Much of this change has been brought about by the Joint MSC/MEPC Working Group on the Human Element. The Group has also been directly involved in the development of the ISM Code, the guidelines on fatigue, and of the Human Element Analysing Process (HEAP). HEAP is a practical and non-scientific checklist to assist regulators in ensuring that all the human element aspects related to the ship and its equipment, and the master and his crew, have been taken into consideration when introducing or amending IMO instruments.



An integrated bridge system - Northrop Grumman Sperry Marine BV

Two recent updates to SOLAS clearly demonstrate the IMO's change in direction from a regulatory regime to that of a safety culture with a strong emphasis on the human element. Chapter II-2 (Construction - Fire protection, fire detection and fire extinction) part E deals exclusively with human element matters such as training, drills and maintenance issues, and part F sets out a methodology for approving alternative (or novel) designs and arrangements. Chapter V-15 features the decisions that affect bridge design, the design and arrangement of navigational systems and equipment on the bridge and bridge procedures. Bridge Resource Management, information processing and decision making, workload, human error, fatigue and distraction, together with clarity of controls, alarms, displays and status

indication are all addressed. Indeed in the light of the development of Chapter V-15, there is a feeling that the scope of the Regulations should be widened, to encompass everything that could influence the watchkeeper's function on the bridge.

Jorgen Rasmussen, the Chairman of the Human Element Working Group is not complacent; he believes that there is still much work to be done on the role of the human element in relation to maritime safety and pollution prevention, and adds: 'We shall only succeed in this work if all parties work within IMO and also on the national level, incorporating the entire industry.'

Further information on Human Element issues within the IMO can be found at <http://www.imo.org/en/OurWork/HumanElement/Pages/Default.aspx>



Kim Fisher

Harmonising the presentation of navigation related information

The requirements of the relevant IMO performance standards for the Electronic Chart Display and Information System (ECDIS), radar, plotting aids, Automatic Identification System (AIS), Integrated Bridge System (IBS) and Integrated Navigation System (INS) have caused serious human-system interface problems, in terms of the integration and presentation of navigation related information on the bridge.

These problems are, however, being addressed by the International Electro-technical Commission (IEC) on behalf of the IMO. Under the Chairmanship of Kim Fisher (UK MCA), a Working Group has been tasked with harmonising the presentation of all navigation related information, including consistency of colours, symbols, terms, abbreviations, units and controls. The Group is further tasked with developing a new generation of composite navigational display that integrates information derived from two or more systems and which could lead to a reduction in the number of screens on a bridge.

For those who are concerned that the mariner's view will not be heard, Kim Fisher assures us that 'the Human Element is considered to be extremely important in the work of the IEC, and operational mariner input is maintained in the Group so that final display arrangements will be acceptable to watchkeeping officers.'

Further information can be found on the website www.he-alert.org (refs HE00060 & HE00065)

SOLAS Regulation V/15, 2002 specifies seven goals for effective Bridge Resource Management (BRM), information processing and decision making. Workload, human error, fatigue and distraction are addressed, as are clarity of controls, alarms, displays and status indication. While these goals make good sense to the maritime community, it is necessary to be more specific about the ergonomic criteria for action by equipment designers, naval architects, software engineers etc.

Ships Control Centres vary widely in equipment, technology, layout constraints and operational requirements, and they will continue to be the recipients of new technology. This scale of variation means that a fully prescriptive approach to the installation and integration of new systems is not achievable, so safe and effective operation will depend on vigorous risk assessments, supported by sound ergonomic criteria.

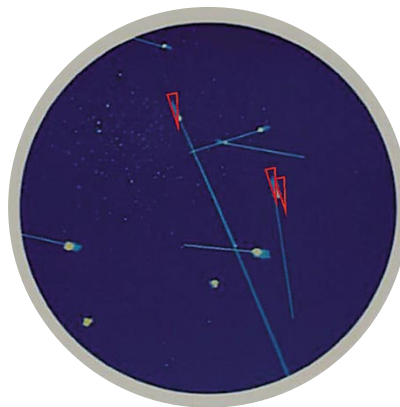
Recent work under the 'ATOMOS IV' project (<http://www.control.auc.dk/atomos/>) has brought about the development of a set of three templates for making submission statements to attest conformance to Regulation 15. These comprise of a laminated pocket card (for day to day changes in procedures or crew training), a short form template (for minor equipment changes), and a fuller template (for new bridge designs). A completed template, which adopts a User-centred Design approach, in effect provides an "operability case", drawing upon a wide range of information sources.

The fitting of the Minimum Keyboard Display (MKD) version of AIS would require the use of the short form template. There are a number of steps to be followed:

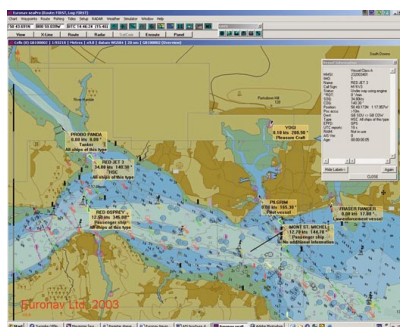
Step 1, which is completed by the owner's representative, defines the scope of the change and seeks to identify any known issues. In the case of AIS, the speed at which it has been imposed upon the mariner means that there is little operational experience to draw on, but some concerns have been raised in various papers and studies. For example, a recent Royal Institute of Navigation survey showed that the Minimum Keyboard Display (MKD) was strongly rejected by mariners, and that there was a (slight) preference for superimposing the AIS picture on ARPA rather than ECDIS. Other papers have highlighted the potential for a number of negative human element issues such as 'head down problems', OOW overload, distraction, inconsistent symbols, 'VHF madness', talking to pals, and making

A user-centred design approach to the fitting of AIS

Brian Sherwood Jones
Process Contracting Limited



AIS on radar - simulated
Maritime and Coastguard Agency



AIS on ECDIS



MKD display - McMurdo Ltd

private arrangements for collision avoidance. All these issues, no matter how trivial they may seem, will lead the person requesting the change towards **Step 2** - the Human Hazard Assessment.

The Human Hazard Assessment first seeks an assessment of the impact of the change on performance and then examines any hazards that it might create - either by itself or if something else goes wrong in terms of training needs, operational procedures, the equipment itself and the Bridge layout. For example, the fitting of AIS could lead to better traffic management and collision avoidance, but its safe and effective operation is dependant on proper training and correct procedures being followed.

Equally, it is important to ensure that conflicts or ambiguity between AIS and other bridge resources are resolved, that symbols or labels are not misinterpreted (especially if they differ from those used in other navigational equipments), and that the operator is aware of any other problems associated with the operation of the equipment.

Step 3 seeks information from equipment suppliers on selected topics covering provisions for training, controls and indications, installation guidance and manuals and documentation. For AIS, for example, evidence is likely to be sought on how it is integrated with ARPA or ECDIS, or on the use of a particular MKD, or on the implementation of alarms.

Step 4 provides a set of pre- and post-installation and operational checklists for the mariner to ensure the 'user friendliness' of the system.

Finally, there is an assessment of the residual risks which can be fed back and tracked. Not surprisingly, in the case of AIS, there are likely to be issues relating to workload, distraction and the application of the COLREGS.

Ultimately, although the fitting of an AIS MKD has potential hazards, applying HE issues during implementation, such as placement, integration, training and procedures for use, can minimize the risks and accentuate its usefulness aboard ship.

An example assessment, based on the short form template, and the full set of templates can be downloaded from the website www.he-alert.org. (refs: HE00070 - Example Assessment; HE00075 - Template 1; HE00080 - Template 2; HE00085 - Template 3)

GROUNDING OF THE PASSENGER SHIP ROYAL MAJESTY ON ROSE AND CROWN SHOAL NEAR NANTUCKET, MASSACHUSETTS

JUNE 10, 1995

<http://www.nts.gov/investigations/AccidentReports/Reports/mar9701.pdf>



Andres Hernandez 1995

On June 10, 1995, the passenger ship Royal Majesty grounded on a shoal about 10 miles east of Nantucket Island, Massachusetts, whilst on passage from Bermuda to Boston. The report from the National Transportation Safety Board (NTSB/MAR-97/01 <http://www.nts.gov/publicn/1997/mar9701.pdf>) focuses on determining how this vessel could travel, unknown to the crew, more than 17 miles off course. The immediate cause of the grounding was clear - the failure of the officer of the watch to take corrective action, despite these warning signs - but it is the root causes, and the human element connotations, that are of interest.

The ship's Master and watchkeeping officers were competent and experienced in passenger ship operations, but they had not received any formal training in the operation of the Integrated Bridge System. The ship had been in service for 3 years

without incident. Pre-sailing checks had indicated that all navigation equipment was operating correctly; but the echo sounder alarm had been set at zero metres, to prevent it

from activating continuously during the pilotage out of Bermuda - it remained at zero throughout the rest of the passage.

Shortly after the Royal Majesty left Bermuda, the GPS receiver antenna cable - which had been re-sited some months previously and was openly routed across the deck - had separated, which caused the receiver to default to the 'Dead Reckoning' mode. For the next 34 hours no one detected the ship's errant navigation, despite a number of warning signs that the vessel was off course.

The Navigation and Command System (NACOS) autopilot was not configured to compare position data from other position receivers. The officers of the watch failed to recognise the warning signs on the GPS unit, which indicated that GPS position data was not reliable; the GPS receiver's brief aural alarm, the remoteness of the

Accident Investigation Reports

receiver's location (from the main console), and the fact that the GPS external alarm was not connected, all contributed towards this failure. The officers of the watch were relying almost solely on the GPS and the ARPA display to provide them with information about the vessel's position. This affected their situational awareness to the extent that they failed to properly identify buoys and other visual (and aural) warning signs immediately before the grounding.

The NTSB concluded that the probable cause of the grounding was:

- The over-reliance of the watchkeeping officers on the automated features of the integrated bridge system.
- The failure of the Company to ensure that its officers were adequately trained in the automated features of the integrated bridge system and in the implications of this automation for bridge resource management.
- Deficiencies in the design and implementation of the integrated bridge system, and in the procedures for its operation.

Reports & Studies



MANAGING THE HUMAN ELEMENT IN MODERN SHIP DESIGN AND OPERATION

This discusses how technological innovations may increase the potential for accidents, and some of the ways in which preventative measures may be put in place. An analysis of the Royal Majesty incident is presented as a vehicle to illustrate the issues to be resolved. The authors look at this incident from a systems perspective and identify the various failures in enabling systems, through a series of influence diagrams. They examine how the various stakeholders might improve the barriers against incidents, what sort of approach would be most appropriate, and the role that Classification Societies could play in supporting them. *This paper can be downloaded from the Alert! website www.he-alert.org (ref: HE00055)*

(R V Pomeroy and B M Sherwood Jones Lloyd's Register of Shipping, London, UK), Oct 2002:

ON YOUR WATCH: AUTOMATION ON THE BRIDGE

In this paper the authors discuss the grounding of the Royal Majesty, reconstructed from the perspective of the crew. They suggest that automation changes the task it was meant to support by creating new error pathways, shifting consequences of error further into the future and delaying opportunities for error detection and recovery. By going through the sequence of events that preceded the grounding of the Royal Majesty, they highlight the role that automation plays in the success and failure of navigation today, and point to future directions on how to make automated systems into better team players. *This paper can be downloaded from the Alert! website www.he-alert.org (ref: HE00050)*

(M. H. Lützhöft and S. W. A. Dekker Linköping Institute of Technology, Sweden)

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We make no apologies for featuring these papers which concern an incident that occurred some 8 years ago. Despite the good progress that has been made in the intervening years, the report, with its 30 recommendations, and these two papers, make essential reading for all those who are involved with the design, installation and operation of Integrated Bridge Systems.