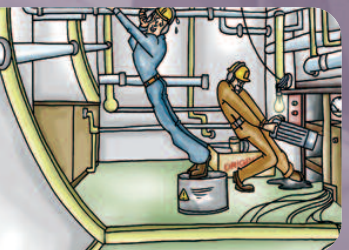


- THE HUMAN ELEMENT

An introduction



Lloyd's
Register
LIFE MATTERS

THE HUMAN ELEMENT

An introduction

Modern commercial shipping is, in overall terms, highly reliable and safe. Nevertheless, the industry still seeks to improve, and it faces increased external pressure to reduce the number of casualties. The record of safety improvement over the recent past is impressive, despite the increasing age of the world fleet.

Improved technical standards, including more demanding survey regimes and stronger regulation enforced through a rigorous port state control system, have had a strong positive influence on safety. However there is a limit to how much additional improvement is possible if attention is only focused on the structural, mechanical, electrical and electronic components. Further improvements will require a focus on the way that a ship is used; in other words, considering the overall ship system. This can't ignore the people operating it, often known as the 'human element'.

The human element is increasingly accepted as the greatest source of risk to safe and effective shipping. Lloyd's Register has developed this booklet to give an overview of the issues that the human element brings.

It introduces many of the issues of which shipowners, ship managers, designers, naval architects, and other stakeholders in marine safety need to be aware. Perhaps most importantly, it also introduces the types of activities that can be carried out to address the human element.

Lloyd's Register, its affiliates and subsidiaries and their respective officers, employees or agents are, individually and collectively, referred to in this clause as the 'Lloyd's Register Group'. The Lloyd's Register Group assumes no responsibility and shall not be liable to any person for any loss, damage or expense caused by reliance on the information or advice in this document or howsoever provided, unless that person has signed a contract with the relevant Lloyd's Register Group entity for the provision of this information or advice and in that case any responsibility or liability is exclusively on the terms and conditions set out in that contract.

Contents

1. The human element – what is it?	4
2. The importance of meeting the needs of people	6
3. Human factors and human resources	8
4. Ship, system and equipment – design and build	10
5. Education, training and competence	14
6. Regulation	16
7. Effective communication	18
8. The effects of modern technology	20
9. Integrating the human element	22
10. Further information	24

1. The human element – what is it?

There is no accepted international definition of the human element. In the maritime context, it can be taken to embrace anything that influences the interaction between a human and any other human, system or machine on board ship.



Although the phrase ‘human element’ may be fairly new, the effects of people on maritime safety have been with us as long as mankind has sailed the seas. Nevertheless, the particular issues that this presents are not constant. The people, systems and machines have changed, not only through the increase in technology, but also because of the need for shipping companies to maintain the competitive edge by reducing operating costs. This has resulted in a reduction in manning scales and the employment of multinational, multicultural and multilingual crews.

Furthermore, the increasing reliance upon complex systems in ship operations places certain demands and constraints on the human element, not least in terms of the competence of the user and of the organisational and physical environment in which he/she is required to operate.

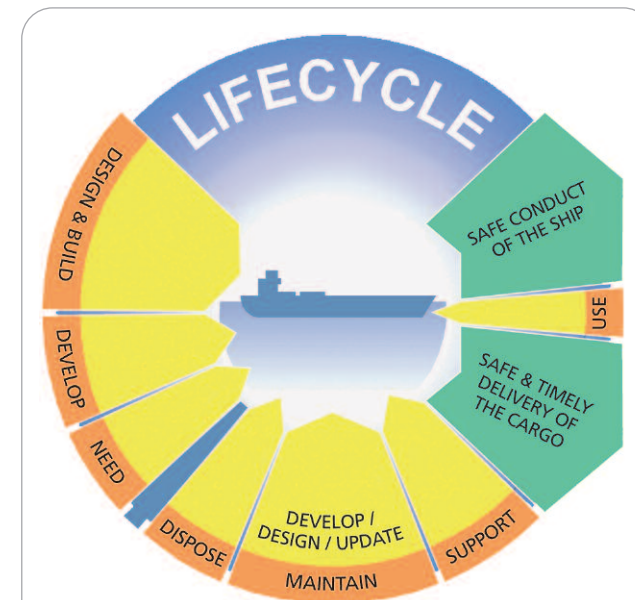
The International Maritime Organization (IMO), through its Resolution A.947(23) – *Human Element Vision, Principles and Goals for the Organization* – recognises

“the need for increased focus on human-related activities in the safe operation of ships, and the need to achieve and maintain high standards of safety, security and environmental protection for the purpose of significantly reducing maritime casualties”;

and that

“human element issues have been assigned high priority in the work programme of the Organization because of the prominent role of the human element in the prevention of maritime casualties.”

The human element is a critical feature of all aspects of ship and system design and operation. Human element considerations do not just start when a ship is launched and end when it is sold on or scrapped – they exist throughout its lifecycle, including at the conception, design and build stages. This means that the company ashore, at all levels of management, is as important as the seafarers themselves in ensuring that the human element is addressed effectively. Properly addressing the human element requires genuine, demonstrable commitment from the very top of the company. This booklet introduces some of the requirements associated with this commitment.



Human element considerations must be applied throughout the lifecycle of a ship, and at all levels of a company.

2. The importance of meeting the needs of people

The maritime industry needs good, qualified, and motivated shore and sea staff to operate effectively. People are important. They need to be provided with the proper tools and be adequately trained to be able to conduct their business in a safe and efficient manner.



In terms of the seafarer, the quality of the end product depends not only on the standard of education and training provided, but also on how well the basic human needs of the **mind**, the **body** and the **spirit** are met:

The Mind

- **Competence.** The level of competence depends on good education and effective training based on realistic objectives, a personal ability to absorb knowledge and to understand the subject, and individual skill and proficiency.
- **Attitude.** Attitudes to education and training are driven by mental ability, intelligence, personality, character and sensitivity, through self-awareness and self-evaluation.
- **Motivation.** Fair terms of employment and reward structures, good communication, direction, clear responsibilities, teamwork, empowerment and character building lead to motivation and a sense of leadership, interoperability and adaptability.

The Body

- **Happy and healthy lifestyle.** Encouraging a balanced diet, good hygiene, exercise, rest and recreation, together with acceptable standards of habitability and regular medical screening ensures that the person has sufficient energy, physical fitness, physical strength, stamina and wellbeing to enable him or her to do the job.
- **Safe and secure working environment.** Good ergonomics, safe working practices and the provision of protective equipment, together with proper physical security, will lead to an improved safety culture and greater security awareness.

The Spirit

- **Self-actualisation.** Personal ethics, conscience, cultural integration and leadership, together with proper supervision and adequate remuneration, generate a sense of pride and purpose, identity, loyalty, fellowship and personal job security.
- **Moral values.** Decency, honesty and integrity, together with an appreciation and tolerance of the beliefs of others, are key moral values to be displayed. Personal faith and self-discipline are drivers towards cultural awareness.

Some of these attributes can be taught, and some are developed through self-education, while others fall to the shipowner or shipmanager to develop and encourage.

The shipowner or ship manager has a duty to employ quality people, and provide them with a safe and secure working environment, together with decent working and living conditions and fair terms of employment.

3. Human factors and human resources

Human factors is concerned with the task people do and the environment they do it in – fitting the job to the person.

Human resources are concerned with the supply of people – fitting the person to the job.



Human factors, when applied to the design and operation of a ship and its systems, means taking account of human capabilities, skills, limitations and needs, and the use of people as a component of the system in terms of:

- the job – what people are required to do;
- the person – who is doing the job;
- organisation and management – organisation and control of the job.

Human resources, when applied to the design and operation of a ship and its systems, concerns the selection, development and preparation of suitably qualified and experienced staff for the required work.

The domains of human factors and human resources both contain a number of sub-domains:

- **Human Factors (fitting the job to the person):**

- **Human factors engineering** – the integration of human characteristics into the definition, design, development and evaluation of a system to optimise human-machine performance.
- **Health hazards** – the identification, assessment and removal or reduction of short or long-term hazards to health.
- **System safety** – the removal or reduction of the human contribution to the risks from doing the job.

The next part of this booklet (Section 4) outlines ergonomics and human-centred design, which are two methods of putting human factors principles into practice, especially during design and build.

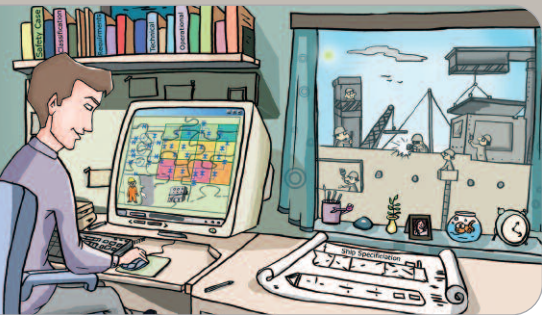
- **Human Resources (fitting the person to the job):**

- **Manpower** – the number of personnel required, and potentially available, to operate, maintain, sustain and provide training for a system.
- **Personnel** – the capabilities required of people to train for, operate, maintain and sustain a system and to provide optimum quality and quantity of the crews to man the ship.
- **Competence** – the instruction or education, and prior or on-the-job training, required to provide personnel with their knowledge, essential job skills and experience, values and attitudes.

An appropriate balance between the job (including equipment and tasks) and the people (including quality and number) is required to operate a ship safely and effectively.

4. Ship, system and equipment – design and build

The human element is a critical feature of all aspects of ship and system design. User input can ensure that the operational parameters and the layout, crewing and procedures for the operation of shipboard systems are optimised for the specific role or trade of the ship.



A ship is unique in that it is not only a place of work, within which there are a number of discrete workspaces, each of which may have different operational criteria, but it is also a 'home' to those who work on board.

It is a floating platform which can be affected by external and internal environmental conditions, such as weather, temperature, humidity, noise, vibration and ship motion (pitching, rolling and slamming). Any of these can be detrimental to the safety and performance of those who work and live on board.

Seafarers expect a ship to be fit for purpose in every respect. This is not always the case as often neither the seafarer nor any of his or her predecessors or representatives will have been involved in the design of the ship or any of its systems or equipment. They may also have had no opportunity to contribute to the procedures and instructions which control the operation of the ship, not only in the initial phase, but throughout its life.

The end product is generally a compromise between what is needed to satisfy the regulations, what is absolutely necessary to fulfil the operational role, what is affordable and what the design team perceives to be acceptable to the 'generic' seafarer.

To ensure a satisfactory compromise, effectively addressing the human element in the design and build of a ship and its systems requires consideration of ergonomics and the concept of human-centred design.

Ergonomics is the study and design of working environments for the benefit of the workers' safety, efficiency, effectiveness, health and comfort. Working environments include ship bridges, machinery control rooms and galleys, and their components, work practices and work procedures.

For any ship to operate safely and effectively, it must be designed to support the people who work it, without detriment to their health, safety and overall performance. This applies particularly in respect of:

- **Habitability** – the provision of adequate and comfortable accommodation, including furnishings and washing facilities, such as galleys, messrooms and recreational spaces. This provision must have due regard for the variations in the size, shape and gender of the seafarer, and for the various environmental stressors such as noise, heat and vibration.
- **Maintainability** – designing operational maintenance tasks to be rapid, safe and effective, to allow equipment and systems to achieve a specified level of performance. This includes consideration of access, removal routes, tools, expertise, disposal and through-life support.
- **Workability** – due consideration must be given to the users, tasks, equipment (including any software), materials and procedures, and the physical and social environments in which a system is used. The level and amount of information provided in handbooks must be appropriate to the required technical skills of the user, and be written in languages understood by all users.
- **Controllability** – designing the layout of ship control centres, machinery control rooms, cargo control rooms etc, bearing in mind the integration of people with equipment, systems and interfaces, such as communication facilities, controls, displays, alarms, video-display units and computer workstations.

- **Manoeuvrability** – having the most appropriate manoeuvring capabilities consistent with the intended role, manning and operating pattern of the ship. These should include the type, number and power of propulsion systems, steering systems and thrusters, all having due regard for the environment and fuel economy.
- **Survivability** – the provision of adequate firefighting, damage control and lifesaving facilities (including manpower), and of security arrangements, to ensure the safety and security of the crew, visitors and passengers.

Human-centred design is a relatively new concept in ship design, which focuses on making systems usable. It is the means of exploiting the knowledge and operational experience of the various users to mitigate the risks from mismatches between seafarers, their ship, its systems and its operational procedures.

The aim of human-centred design is to develop an effective combination of the people and the machines. The process recognises that these two components of a system cannot be treated entirely separately, as the interrelationship is vital to the overall effectiveness of the ship. It is a process of systematically applying human factors and ergonomics knowledge and techniques in order to minimise human error, enhance effectiveness and efficiency, improve human working conditions, and counteract possible adverse effects of use on the health, safety and performance of the mariner.

Being human-centred entails an early and continued focus on the requirements of the people who will use a system throughout its life. User requirements are derived from human factors data considered in the context of the particular ship, its manning, outfitting and operation.

A large amount of human factors data is already captured in regulation, standards and organisational knowledge. However, the operational experiences of the various users and the expert knowledge of human factors professionals must also be exploited by designers to ensure that the number of design errors, so often identified during the late stage of build, or even when the ship enters operational service, is minimised.



To ensure a design being appropriate to the context in which it will be used, the designer must involve the seafarers. They will have either used similar systems before and have valuable experience, or they will have a full appreciation of the environment in which an entirely new system will be used.

The designer should keep in mind that it is the crew members – and not just the senior officers – who will first spot those irritating design errors, some of which may not be readily identified until sea trials, but which could so easily be rectified before bringing the ship into service.

Regardless of how well the principles of ergonomics and human-centred design are applied at the design and build stage, it is crucial that all crew members are familiar with their ship well before it leaves the builder's yard. This applies equally to the first voyages of old ships taken over by a new company.

Those who have to operate the various systems must be properly trained to use them. They should not be expected to 'pick it up' after they have joined the ship, or accept a quick briefing on it from the commissioning engineer, or simply read the handbook, which may in itself be technically complicated, difficult to understand, and possibly not even written in a language they understand.

Those who are involved in designing, building and updating ships and their systems, and in their operation, must always keep in mind the problems associated with onboard operations. This relates not only to workplace design but also to crew habitability and the education and training needs of the seafarer. The people who use a system know best what works and what does not work.

5. Education, training and competence

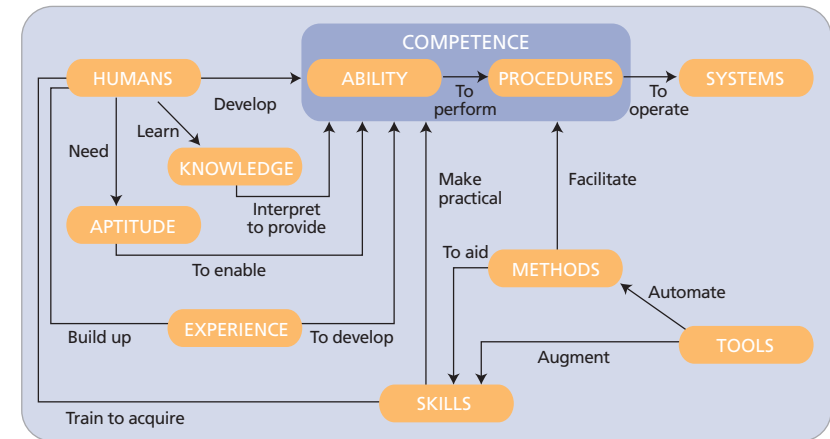
Education is the gradual process of acquiring knowledge through learning and instruction. Training is the development of skills or knowledge through instruction or practice.



Education is as much about the development of personal attributes through upbringing and observation as it is about gaining knowledge through textbooks. It is a lifelong process; we never stop learning, whether through formal education (such as degree courses and professional development) or through the 'University of Life' (observation and experience).

If correctly applied, training is a planned systematic development of the aptitude, knowledge, understanding, skill, attitude and behaviour pattern required by an individual so that he or she can adequately carry out a given task or perform in a particular job.

The level of competence of the seafarer will depend not only on good education and effective training based on realistic objectives, but also on his or her ability to absorb knowledge and to understand the subject, and on the availability of opportunities to develop his or her skills and, ultimately, experience.



The education and training of people such as designers, surveyors and trainers is equally important, not least in ensuring knowledge of how to specify and deliver the human component of ship systems and an up-to-date awareness of 'the ways of the sea'.

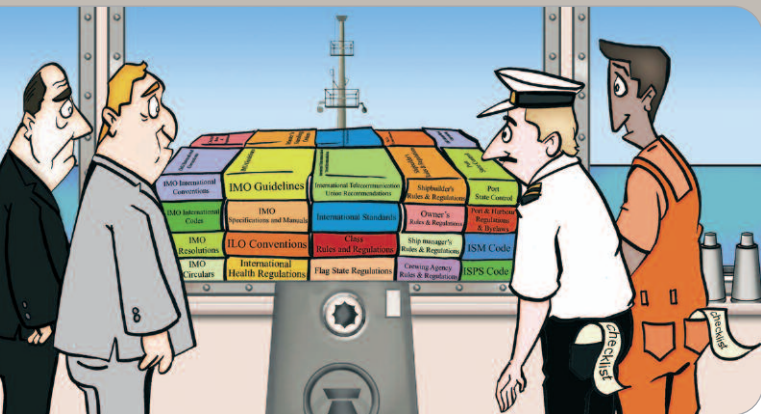
The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) recognises the importance of establishing detailed mandatory standards of competence to ensure that all mariners are properly educated and trained, and adequately experienced, skilled and competent to perform their duties.

The standards of competency laid down in the STCW Code are a minimum set. Furthermore, because of the multinational nature of the maritime workforce there may be differing interpretations of the Code, which can lead to inconsistencies in standards of training and education. It is important that shipowners and ship managers evaluate the standards that they apply to ensure that they truly deliver the quality of manning appropriate to their ship operations, as the spirit of the STCW Code intends. Unthinking reliance on compliance for its own sake will rarely be enough.

A range of factors affect the overall competence of seafarers. The highest standards of education and training must also be applied to all other industry stakeholders, in order to encourage and promote a universal spirit of professionalism throughout the maritime community.

6. Regulation

Rules and regulations set common minimum standards, for ship and system design and build, for education and training of the various stakeholders, and for operational procedures. However, their implementation needs to be sensitive to the human element.



Regulations generally specify a minimum level of assurance of quality, safety and security. While this minimum may on occasion be wholly sufficient in all situations, this should not be assumed. Ship operators should always establish what is appropriate and necessary for the way they run their ships, and develop their policies on, for example, manning, safety management and equipment selection accordingly.

It can be argued that all accidents at sea are a result of human error, because invariably the human input to the design, manufacture or operation of a system is a contributory factor. Many of these human failings result from unintentional mistakes, but some are due to intentional violations of the rules and regulations put in place to prevent such risks. Others result from complacency, which leads to a lack of awareness or concern regarding real dangers or deficiencies.

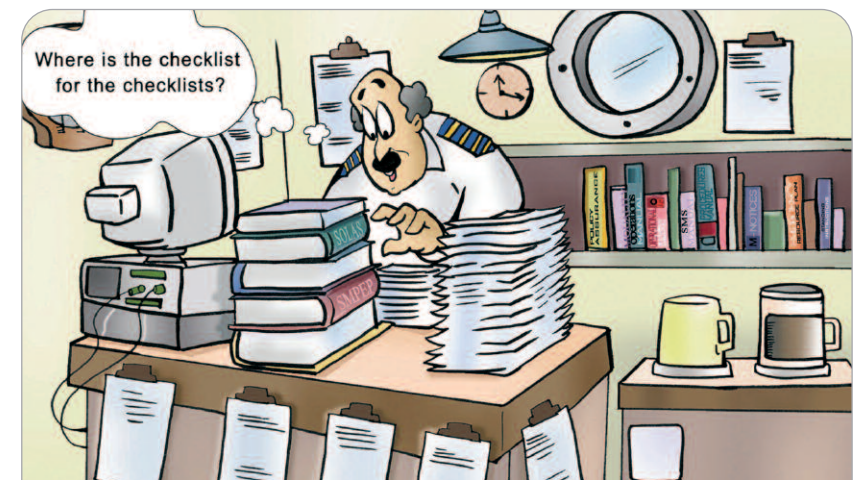
These violations or acts of complacency can be a result of resentment or frustration at the excessive administrative burdens that can accompany regulations, if inappropriately implemented. Almost all new regulations

will have administrative requirements of some sort, such as added documentation, more inspections, formalised procedures, or increased reliance on checklists. Moreover, recent legal judgements have made it clear that accurate and complete records must be maintained if due diligence by the shipping company and the master is to be demonstrated in a court of law.

If adjustments are not made to account for any such increased workload, the added pressures for the master and crew might cause them to make mistakes because they are too absorbed in the 'paperwork'. Furthermore, inappropriate or overly frequent use of checklists can mean they become a substitute for thought. This can lead to a 'tick in the box' culture that, in turn, can breed complacency.

A well designed management system, with support from the shore, will support the master and crew by enabling the amount of paperwork required to be kept to a minimum. Good computer software programs can provide valuable support for activities such as routine administration, recording of non-conformances, management of spare parts, and routine planned maintenance, although they must of course be used wisely, with appropriate IT training provided.

Those involved in the implementation of new or existing rules and regulations must take account of realistic human behaviour, and design the associated management systems and processes to minimise any unwanted side effects.



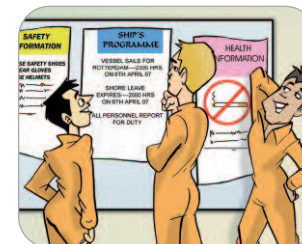
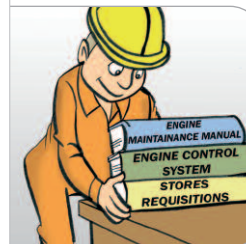
7. Effective communication

The ability to convey information properly, verbally or in writing, is important not only for the safety of ships' crews, visitors and passengers, but also for the wellbeing of crews, where the common working language may not be the first language of those on board.



Modern communications are supposed to make life easier for all. Today, some a ship's bridge may serve as the focal point for the whole operation of the ship, and as the communications hub. Here can be found not only the communications fitted to satisfy the requirements of SOLAS, but also fax machines, email reception facilities and mobile telephones. While all of these systems make communication easier, if they are misused they can negatively affect the safe operation of the ship. Ship owners and managers may wish to consider placing restrictions on the use of mobile telephones and personal computers on the bridge.

Communications both from and to the ship can have an effect. People who need to communicate with the ship from the shore, such as ships' agents, charterers' representatives or office clerks, must bear in mind that the master or crew will not always be able to receive communications easily. For example, if the master is busy overseeing the navigation of the ship, or is sleeping due to the time zone differences or watchkeeping patterns.



Effective communication onboard also involves the appropriate and clear use of signs to show passengers and crew escape routes, mustering stations, hazards and safety equipment.

It must also be remembered that communication is not just about talking, reading, writing and procedures etc. It is also about empowerment, inclusion, leadership and teamwork, through:

- the exchange of ideas, information and knowledge between individuals, and between crew and management ashore. This must take proper account of the diversity of different native language speakers likely to be working on any ship;
- the provision of telephone communications and e-mail and internet facilities to enable crew to keep in touch with their families;
- the dissemination of information through professional journals, company newsletters and notice-board bulletins, to inform the crew of important issues that have an effect on their professional life, health, safety and welfare;
- the recognition, interpretation and correct reaction to people, incidents or situations, which are open to misunderstanding due to cultural differences.

Effective communication is the key to the successful operation of any ship.

8. The effects of modern technology

Modern technology has revolutionised the way in which seafarers can work. They can be presented with an enormous amount of information, from a variety of standalone systems with differing user interfaces. This brings the potential for confusion and information overload, particularly if they are not properly acquainted with the operational parameters of one or more of those systems.



In principle, the more information about a situation that is available, the better a person's understanding should be, enabling them to make better decisions. However, this will not always be the case in practice, especially for the demanding and hazardous work of a seafarer during a complex task on board. For example, accident investigation reports suggest that some bridge watchkeepers are so absorbed in technology that their awareness of the situation around them is confined to the display rather than looking out of the window.

Furthermore, there is an increasing tendency for some seafarers to become overly reliant on electronic systems, with little regard for the vulnerability of those systems in terms of their accuracy, reliability, availability and integrity.

Although most equipment is required to be type approved to an IMO specification, there is a natural tendency for manufacturers to add special features in an attempt to distinguish their equipment in the marketplace. Often the distinction will involve the user interface. The seafarer can therefore be faced with joystick, trackball or menu-driven controls, depending on the equipment installed on the vessel on which he or she is serving. A badly designed interface, or an overly diverse range of interfaces, can lead to low usability, even when 'user-friendliness' was the designer's stated aim.

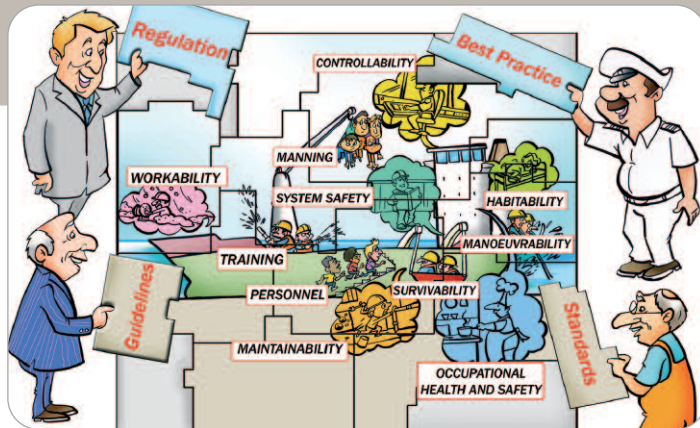
The different nationalities and cultures of today's mariners (and of those of the future) dictate a need for commonality of symbols, switches and control keys, together with appropriate education in the basic principles of new technology.

There is also a tendency for seafarers to move from one ship type to another, where each has different equipment fits. It can be impractical for them to be properly trained in the use of a variety of different manufacturers' equipment, so the resort to education through 'handbooks' can become a reality. This makes it all the more important for manufacturers to strive towards basic and common standards in the controls and operation of their different systems, in order to allow for a generic training programme.

Human element issues related to the use of technology and automation, particularly in regard to training, must be managed by the shipowner or ship manager. But there is also a need for greater awareness across the wider industry, including designers, manufacturers, engineers, trainers and educators, insurers, and regulators.

9. Integrating the human element

Integrating the human element into a complex system such as a ship is a bit like putting together a jigsaw puzzle. There are many component parts, some of which are readily identifiable and easy to link together so that an early impression of a picture soon begins to form. There are, however, others that are not so obvious, and it takes a certain amount of planning to fit them into the right slots until, eventually, the whole picture is complete.



A ship comprises a number of component parts (systems) each of which will have some effect on its overall performance. The extent of this effect will depend on how critical it is to the safety of the ship and its crew.

Another variable is the extent of user involvement required in each system:

- some systems may be fully automated, but they will still require a degree of intervention from the seafarer, whether it is to set the initial tolerances or to respond to alarms;
- some may require direct seafarer input for their operation and for their maintenance;

- some will require people to interact with other people;
- some may be driven by 'outside influences' such as the environment, other people, or technology;
- others involve the procedures and work instructions, which require input from the seafarer to ensure they are complete, applicable and up-to-date.

Furthermore, the shipboard environment requires seafarers from a variety of cultural backgrounds to work, socialise and live harmoniously with one another.

The process of integrating the human element into this complex system starts at the conception of a ship, but it does not stop there. It is a dynamic process, which must be kept under review throughout the lifecycle of the ship to take account of changes in its operating pattern, system updates, improved technology and new regulation. Gathering and responding to input received from the people most closely involved in the operation of a ship and its systems is an essential part of this process.

Integrating the human element into an organisation does not 'just happen'. It requires the understanding and commitment of management at all stages of the ship's lifecycle, and the motivation and involvement of seafarers. By co-operating in this way, they can put into practice the principles embodied in this document, to increase the focus on human-related activities in the design and safe operation of ships.

Integrating the human element into ship operations requires understanding and commitment from both ship and shore staff. This enables effective balancing of the technological and human aspects of the ship's capability, in order to ensure its safe conduct, the safe and timely delivery of its cargo, and a safe, happy and healthy working and living environment for its crew.

10. Further information

This booklet introduces the scope of the human element, and suggests how it might be addressed. However, a single booklet cannot cover the entire range of human element issues in depth. Further information should be obtained before undertaking detailed action.

Much of the information in this document has been drawn from **Alert!** – *The International Maritime Human Element Bulletin*

This is a series of bulletins published by the Nautical Institute since 2003 with sponsorship from Lloyd's Register. These were intended to raise awareness of, and encourage action on, the human element. The associated website has also developed into a valuable resource: www.he-alert.org. **Alert!** is a useful starting point for further action.

Lloyd's Register has also published a guide that sets out best practice for ship operators in managing the human element – *The Human Element: Best Practice for Ship Operators*. Copies are available from www.webstore.lr.org

Lloyd's Register also offers training courses in various aspects of the human element. Please contact us for more information.

Cartoons used courtesy of **Alert!** – *The International Maritime Human Element Bulletin*

The human element is increasingly accepted as the greatest source of risk to safe and effective shipping. Lloyd's Register has developed this booklet to give an overview of the issues that the human element brings.

It introduces many of the issues that shipowners and shipmanagers, designers, naval architects, and other stakeholders in marine safety need to be aware of. Perhaps most importantly, it also introduces the types of activities that can be carried out to address the human element.

ISBN 1-900839-31-8

Lloyd's Register EMEA

T +44 (0)20 7709 9166
F +44 (0)20 7423 2057
E emea@lr.org

71 Fenchurch Street
London EC3M 4BS, UK

Lloyd's Register Asia

T +852 2287 9333
F +852 2526 2921
E asia@lr.org

Suite 3501 China Merchants Tower
Shun Tak Centre
168–200 Connaught Road Central
Hong Kong, SAR of PRC

Lloyd's Register Americas, Inc.

T +1 (1)281 675 3100
F +1 (1)281 675 3139
E americas@lr.org

1401 Enclave Parkway, Suite 200
Houston, Texas, 77077, USA

www.lr.org

February 2008

Services are provided by members of the Lloyd's Register Group. Lloyd's Register, Lloyd's Register EMEA and Lloyd's Register Asia are exempt charities under the UK Charities Act 1993.

**Lloyd's
Register**

LIFE MATTERS