Beyond the ethic case: a value proposition of proactive human factors management

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Abstract

This paper is based on the work presented in Österman, C. (2012), 'Developing a value proposition of maritime ergonomics', PhD thesis, Department of Shipping and Marine technology, Chalmers University of Technology, Gothenburg, Sweden.

There is a large body of knowledge available on the role of human factors for successful (and unsuccessful) systems. Domain specific handbooks, guidelines and standards can be found also for the maritime industry. Yet, the deteriorating figure of maritime casualties and the high incidence of occupational accidents suggest this knowledge is not utilised to its full potential.

The purpose of this paper is to present a value proposition of maritime human factors, positioning the potential core values that can be delivered to stakeholders within and outside the maritime transport system. The paper adopts an exploratory research approach, investigating the link between human factors and operational performance from several different angles. Methods for data collection include literature studies, individual and focus group interviews, and a case study involving a shipping company.

The synthesis of the results is presented in terms of a value proposition that describes the value for the employee in terms of improved health and well-being, learning, skill discretion and independence in life. Values for the company include increased operational performance and

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flexibility, advantages in recruiting and retaining personnel. Values for the sector include competitive strength, attractiveness of work and increased learning across the industry. Values for the society include reduced costs for health care and social security, reduced environmental impact, and a sustainable working life.

These results are a first step to make visible the effects of human factors management on overall systems performance in the maritime domain.

Keywords: *human factors, safety, participatory design, maritime, performance, value proposition.*

1. Introduction

The main theme of this paper is the value proposition of maritime human factors, positioning the potential core values of human factors that can be delivered to employees, customers, and other stakeholders related to the maritime transport system. Value propositions are not just about selling. They are part of operational strategy, guiding many levels of an organization towards satisfied constituents and sustainable value creation (Barnes et al., 2009).

The maritime transport system is the life-blood of the world trade and plays a key role in the global economy and in supporting economic growth. While basic economics of commercial shipping have remained largely unchanged through history, the ships and commercial infrastructure have gradually evolved towards a tightly knit global industry (Stopford, 2009). Continuously, the world fleet has expanded in number, size and sophistication. Technological developments of hull, propulsion and cargo handling systems have increased speed and improved capacity, versatility and reliability of maritime transports. Mechanization, automation and communications technology have made many manual tasks redundant, enabling efforts to perfect crew size and composition in order to curtail operations costs (Ding and Liang, 2005). However, there is yet an area of potential to develop in the effort to optimise maritime operations: human factors the interplay of human, technology and organization in the process of design and organization of tasks, technology and work environments.

As technological systems increase in complexity, the gap between the human operator and the technical system tends to increase as well. Increased automation and the introduction of new technology have reduced transparency of work operations on board. Out-of-the-loop unfamiliarity, automation induced errors, complacency, behavioural adaptation and loss of skills are but a few common problems associated with the introduction of novel technology (e.g. Lee, 2006, Stanton et al., 2010, Kaber and Endsley, 1997). These issues have also been observed within the maritime domain (e.g. Lee and Sanquist, 2000, Lützhöft and Dekker, 2002). The transformation of technologies place new demands on the human operators at work who must control, diagnose and solve new kind of situations. We need to learn faster, more actively, but also ethically in order to be economically, ecologically and socially sustainable in a global world.

There is a large body of generic knowledge available on the importance of human factors to successful (and unsuccessful) systems. Domain specific handbooks, guidelines and standards can be found also for the maritime domain (e.g. Grech et al., 2008, Ross, 2009, Rumawas and Asbjørnslett, 2010). Yet, it seems this knowledge, and the application of human factors principles and methods in practice, is not utilised to its full potential. Recent statistics show deteriorating figures for maritime casualties (IUMI, 2012), and despite significant changes in work tasks, towards more monitoring and administrative work, the industry is still suffering from a high level of occupational accidents and morbidity (Ellis et al., 2011, Rodríguez and Fraguela Formoso, 2007). This high incidence of occupational accidents and injuries means that many individuals are afflicted with aches, pains and sometimes lifelong disability and relegation from the labour market, but it also means disruptions of output and heavy expense to businesses and community.

In a world of competing financial priorities, human factors specialists have apparently not succeeded in selling the systems approach of human factors management as a tool towards improved overall systems performance and employee well-being (Dul et al., 2012). Rather, there are islands of knowledge and pockets of practice that still remain to be linked.

In order to achieve better communication between major stakeholders in maritime operations and human factors specialists, efforts must be directed towards an increased understanding of the relationship between commercial value generation and human factors.

2. Research design and overall aim

The purpose of the research work presented in this paper was to develop a value proposition of maritime human factors, describing the core values of a systematic human factors management from individual, organizational and societal perspectives.

In all, seven exploratory studies were performed, investigating the link between maritime human factors and operational performance from different angles. The studies were structured around three themes:

2.1 ***Maritime human factors*** – investigating the key issues in the maritime domain from two perspectives. The theoretical perspective turned to the scientific literature to examine which major issues that have been addressed in previous research. The practical perspective turned to the industry to examine if the economics of human factors was known in the industry and which factors were considered important.

2.2 ***Effects of human factors*** – investigating the effects of human factors on operational performance in the maritime domain on individual, company and societal level respectively. A multi-metric approach was applied, adopting the concepts of productivity, efficiency and quality from the production industry paradigm. The concepts' relation to human factors were reviewed and further investigated in terms of availability and applicability in the setting of a real shipping company.

2.3 ***Knowledge of human factors*** – the development and transfer of human factors knowledge between stakeholders in the maritime domain. This part of the study was designed to explore how human factors knowledge can be developed and transferred within the industry. Specifically, the issue of crew participation during design and introduction of new workplaces or new technical systems on board.

Methods for data collection include literature studies, individual and focus group interviews, and case study. The research work is based on an overall triangulation of perspectives across studies to provide different images of understanding: from the macro perspective, studying the maritime transport system as a whole, to a micro perspective, studying one single technical system on board a vessel. Within the studies, methodological triangulation has been employed through the use of different methods for data collection and analysis. The gained understanding from each research activity has been reflected upon moving between multiple levels of abstraction during the research process.

The overall aim is to increase the knowledge base of the value of human factors in the maritime domain, thus contributing towards improved working conditions for seafarers in a safe and sustainable maritime transport system.

3. Science and practice of human factors

The science of human factors is multi-disciplinary systems and design oriented, sometimes referred to as the science of fitting the task to the human (Kroemer and Grandjean, 1997). It implies the design of tasks, artefacts, systems and environments to be compatible with our physical and mental needs, abilities and limitations (Chapanis, 1996). According to the International Ergonomics Association (IEA), human factors is:

'*the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance*' (IEA, 2012).

This definition demonstrates a holistic approach embracing all aspects of human work, indicating both an individual and social aim (human well-being) as well as an organizational and economic aim (overall system performance). Thus, human factors can be viewed as a way to ensure goals of improved system effectiveness, safety, ease of performance and the contribution to overall human well-being and quality of life (Karwowski, 2005).

Domains of specialisation embody deeper competencies, often grouped in physical, cognitive and organizational factors (IEA, 2012). Physical factors refer to anatomical, physiological, anthropometric and biomechanical characteristics related to human activity. Relevant topics include working postures, work-related musculoskeletal disorders, workplace layout, product design, safety and health. Physical human factors are also concerned with how the physical work environment (e.g. noise, vibrations, light, climate and hazardous materials) can affect human performance. Cognitive factors are concerned with mental processes such as perception (the process of interpreting information from our senses), cognition and motor response. It can be described as the science of designing tasks, artefacts and systems to fit the human mind. Relevant topics of cognitive human factors include mental workload and performance, decision making, human error, human reliability, work stress, and training. These topics all relate to operator performance in a human–machine system (Wickens and Hollands, 2000). Organizational factors establish the organizational context and are concerned with the optimisation of socio-technical systems, including their organizational structures, policies, cultures and processes for communication and decisions on who knows what, who will do what and who has done what. Relevant topics include communication, human resource management, teamwork, design of working schedules, participatory design, organizational culture, and quality management.

Poorly designed workplaces from a human factors perspective are known to have negative monetary and other effects for individuals, companies and for the society as a whole. At an employee level, poor working conditions can lead to accidents and illnesses that affect their income, lead to short term and long term costs such as treatments and rehabilitation and can affect their lifetime wages (Hendrick, 2003, Mossink and De Greef, 2002). On company level, the relationship between human factors and operational performance have been demonstrated in terms of increased production (Abrahamsson, 2000, De Greef and Van den Broek, 2004), improved level of quality (Axelsson, 2000, Falck, 2009), and reductions in work-related musculoskeletal disorders, personnel turnover and absenteeism (Goggins et al., 2008).

At societal level, the direct and indirect costs associated with occupational accidents have been estimated to 1–3 per cent of gross national product in the EU member states (Mossink and De Greef, 2002) and about 3 per cent of the US gross national product (Leigh et al., 2000). These societal costs consist of the total loss of resources and productive capacity, and reduction of welfare and health.

Within the maritime domain it is common to use the term human element when referring to the interaction of human, technology and organization. In November 1997, the International Maritime Organization (IMO) Assembly adopted Resolution A.850 (IMO, 1997) that defines the human element as: '*a complex multi-dimensional issue that affects maritime safety and marine* *environmental protection. It involves the entire spectrum of human activities performed by ships' crews, shore based management, regulatory bodies, recognized organizations, shipyards, legislators, and other relevant parties, all of whom need to cooperate to address human element issues effectively*.'

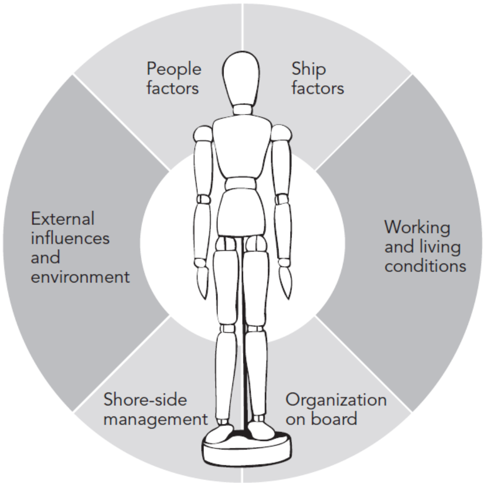

Figure 1. An overview of factors that have an impact on the human element

Over the years, the role of human element in maritime safety has evolved from what Reason (2000) labels the person approach, that focuses on the unsafe acts of people at the sharp end, to the system approach, that concentrates on the conditions under which individuals work. As a result, the revised IMO guidelines for investigation of marine casualties and incidents (IMO, 2000) provide a general overview of factors that have a direct or indirect impact on the human element (Figure 1). People factors include, but are not limited to, skills, knowledge (outcome of training and experience) and mental and physical condition. Ship factors include design, state of maintenance and availability and reliability of equipment. Working and living conditions include design of working, living and recreation areas and equipment as well as opportunities for recreation and adequacy of food.

Organization on board includes factors such as division of tasks and responsibilities, crew composition, manning level and workload, while shore-side management concerns safety and recruitment policies, management commitment to safety and ship-shore communication. External influences and environment factors include sea and weather conditions, port and sea traffic conditions, various stakeholder organizations, and national and international regulations and inspections.

4. Results and analysis

This section presents a cross-study analysis of the results structured around the three topics. It is followed by a section on the application of human factors management in the maritime transport system.

4.1 Key issues in maritime human factors

The literature review of the maritime human factors indicated a focus on physical human factors and occupational health issues from a medicinal perspective (Österman, et al., 2010). An explanation to the emphasis on physical factors is undoubtedly that seafaring still is a hazardous occupation with a high incidence of accidents and illnesses compared to many other industries (Ellis et al., 2011). Few studies report on organizational and psychosocial factors, indicating that the systems view of humans at work is scarce in maritime human factors research. However, a reason for the limited number of studies can be the practical difficulties in designing and carrying out studies on the maritime domain. Especially to arrange visits to the ships and meet the people working on board in their daily working situation and not only meet the shore based part of the organization.

Moreover, the literature shows a strong focus on the work performed in the deck and engine department while the catering department is largely invisible. Although the daily work of the catering personnel might not be perceived as immediately safety critical, it naturally affects customer satisfaction. Further, as demonstrated for instance in the sinking of the Costa Concordia, the catering crew plays a vital role in emergency situations where they are often responsible for the safe evacuation of passengers in case of fire or abandoning of ship.

The human factors emerging from the interviews were all organizational issues: leadership, knowledge, culture and values, human resource management, communication, and employee participation. Well managed, the informants consider these issues to yield fewer marine accidents, personal injuries and damaged equipment, or as an informant put it: '*fewer surprises*'. A motivated, skilled crew is thought to do a better job operating and maintaining the vessel, and if an accident occurs, to be better prepared for mitigation; thus limiting costs and time off-hire.

Several of the interviewed informants use the expression '*firefighting*' when describing safety and human factors, that priority is given to the most necessary tasks as they appear and that there is not sufficient time for proactive work. There is however a risk that solely being able to respond to what happens, being limited to reactive behaviour, will ultimately lead an organization to lose control. Irrespective of each other, two informants representing different marine insurers both maintained that the '*visible owners*' with a tight relationship with the crew and successful communication policies have fewer insurance claims. This statement corresponds well to conditions known to influence performance of an organization, and when and how an organization loses control. These conditions include defective leadership leading to unattainable demands, inadequate or overoptimistic planning, lack of knowledge and competence, and lack of resources (Hollnagel and Woods, 2005).

Manning of ships is a pivotal element in the shipping industry, a topic touched upon by all informants in the study. Although the gap between the demand for seafarers and their availability has narrowed in the wake of the recent financial crisis, appropriately qualified seafarers are still high in demand (Drewry, 2012). Rather than shortage in number, the weak point seems to be the absence of competent seafarers, with good command of English and communication skills (Xhelilaj et al., 2012). A major concern is the future availability of senior management level officers, engineers and seafarers in specialist segments of shipping which normally require a higher level of competence (BIMCO/ISF, 2010). Moreover, it is just as important that people remain within the industry. Seafaring is no longer a lifetime employment, but rather a stepping stone for a future career ashore. Many organizations such as marine insurers, classification societies and maritime administrations regularly employ people with seagoing experience. These people bring not only factual, but vital contextual knowledge and skills of maritime operations and the work on board. Hence, it is fair to assume that it will be increasingly important to adequately address human factors that contribute to attractive workplaces to which people want to apply for a job and where they want to stay.

In sum, it seems research on the maritime domain so far has had predominant focus on physical rather than organizational factors. A shift towards a more holistic approach in future research, covering all dimensions of human factors (physical, cognitive and organizational) and encompassing all members of the crew should be appropriate to meet the needs of tomorrow's shipping industry.

4.2 *Effects of human factors on operational performance*

In order to be able to evaluate the effects of human factors management on performance, detailed modelling of maritime operational performance was needed. Three main productivity indicators were found to be under the control of the ship operator (Österman and Osvalder, 2012):

(1) accidents or injuries,
(2) operational disturbances of machinery and equipment, and
(3) inspections and detentions.

Accidents and injuries have a disruptive effect on operations both at the time they occur and in the aftermath with investigations, repairs, replacement of personnel, training and familiarization of new personnel. According to the European Maritime Safety Agency (EMSA, 2011), both the number of ships involved in accidents and lives lost increased in 2010 following a decline during 2009, suggesting a link between accident numbers and economic activity. During 2010, 644 vessels were involved in 559 accidents, and 61 seafarers lost their lives on ships operating in and around EU waters. The high occurrence of occupational injuries compared to other industries and the high costs for incidents involving crew members suffering from mental ill-health (NEPIA, 2006) implicate a high potential for improvements in this area.

Operational disturbances of machinery and equipment due to unplanned maintenance or breakdowns are costly in terms of direct costs for repairs, as well as for loss of productive time for ship, crew, and technical and administrative support ashore. Machinery damage and engine room problems remain the primary cause for serious losses, accounting for 35 per cent of all losses between 2006 and 2011 (IUMI, 2012). Alleged causes for these problems are found at the physical, psychological and organizational levels: the complexity of modern onboard systems that are not always fully understood, maintained or repaired, skill deficiencies among crew members, and neglect of technical inspection at management level. This phenomenon was illustrated also in Österman and Magnusson (2013) concerning design, installation and operation of selective catalytic reduction systems (SCR) to reduce the emissions of nitrogen oxides from ships. The paper reports numerous anecdotes of things falling apart, personal injuries and ineffective operation. Using Reason's (1990) analogy, within the *blunt end* of the SCR systems (where managers, system architects, designers, and suppliers of technology are found), there appeared to be a lack of sufficient factual as well as contextual knowledge of technical and environmental prerequisites for a well-functioning system. This lack affects both the technical functionality and maintainability. To continue Reasons analogy, in the *sharp end* (where the actual operation and maintenance takes place), the operators tended to view the SCR largely as a '*black box*' with no one to tell what actually happens inside. The restricted space for installation further implies that routine and repair work are performed with an increased risk for human errors and occupational accidents. The SCR is but one example of a technical system on board, but the above described phenomenon can be seen in many other systems as well. Due to large costs and logistical challenges associated with the development of new systems for marine applications, the ship operators and their crew routinely take active part in this development, both technically and economically. When various prototypes and preproduction models are installed on board, the ship operators and crew also carry part of the development costs in terms of necessary re-engineering, material, working hours, energy and waste.

Operational efficiency in shipping can be seen as a function of costs, time, and customer satisfaction. Crew costs are a significant part of the operating costs, along with the increasingly important fuel costs. Generally, crew costs are seen as one of the most flexible costs (Leggate and McConville, 2002, Stopford, 2009), making strategies to improve individual and team performance high on any shipping company's agenda. Knowledge, skills and structures for communication are internal determinants of efficiency depending on managerial functions (Barthwal, 2000). As such, it is related to organizational factors and the design of the socio-technical system, providing the work environment and prevailing conditions necessary for optimal crew performance.

On a political level the intrinsic manning structures in the global manning industry can be seen as a risk factor in itself and have a negative impact on the efficiency of operations at sea. Commonly, seafarers have longer tours of duty on board than time off ashore. This leads to an inevitable turnover of crew and in turn an increased risk for accidents and operating errors. Contrary, stable crews returning to the same ship show reduced risk for accidents (Bailey, 2006, Carter, 2005, Hansen et al., 2002), findings that are consistent with research from other domains on temporary workers (Quinlan et al., 2001). A constant flow of new crew members also poses a psychosocial stressor on the individual in having to adapt to new colleagues on and off working hours on board. In addition, it can involve a perceived sense of inequality due to differences in wages, length of tours of duty, and employment benefits. In addition, crew turnover is also associated with substantial costs.

Quality systems in the maritime industry have emerged principally from regulation, such as the International Safety Management (ISM) code (IMO, 2010), rather than from a company-centric or product-based mindset (Bichou et al., 2007). A ship is regularly subjected to inspections by various regulatory regimes and customers. Depending on executor, a failed inspection can result in the ship, or ship operator, being excluded for certain business opportunities, detention of ship, conditions or withdrawal of class, or a ban to enter certain ports or regions. In 2011, the Paris MoU reported deficiencies in 56 per cent of the inspections and 20 ships were banned from the region (Paris MoU, 2012a). A detained ship has significant cost implications for the shipowner in terms of loss of revenue and schedule disturbances, and because unplanned work undertaken at short notice is more expensive. Paris MoU regularly publishes a list of deficiencies and detentions along with photographs and particulars of ships in poor condition which have been '*caught in the net*' (Paris MoU, 2012b). Thus, even if a ship is not delayed, a failed port state control reflects poorly on both vessel and its operator and can imply commercial consequences on customer relations and loss of future employment.

Over the years, several shipping sectors have initiated self-regulating vetting systems to enhance quality driven by commercial interests. This especially applies to the liquid bulk market due to the high media profile of tanker accidents and associated corporate image repercussions for any well-known brand involved. Notorious examples are the grounding of the supertanker Exxon Valdez in 1989, and the tanker Erika that broke in two and sank off Brittany in 1999. Due to a perceived absence of economic incentives, similar market driven systems have been less prominent and have taken longer to develop within other segments (Tamvakis and Thanopoulou, 2000). But, in recent years there has been an increased customer interest for safety and environmental issues also within other shipping markets. Spurred by a combination of international pressure and separate incentives from a range of stakeholders, such as port state control regimes, classification societies and labour unions, the safety and quality standards are continuously raised (DeSombre, 2008).

In sum, effects of human factors on operational performance are found at all interrelated system levels. In the sharp end, crew performance benefits from a decreased risk for occupational and maritime accidents, improved individual health and well-being and increased learning. At an organizational level, the effects on company performance are related to the productive time at sea in terms of accidents, operational disturbances and inspections, operational efficiency, and quality of the sea transport service. Several effects at company level ultimately spill over to the entire maritime sector, for example, costs for insurance claims are carried by all policyholders in a mutual insurance company. Less tangible are the effects of maritime accidents, pollutions and other high-profile events that influence the image and perception of the industry in the eyes of policy makers and the general public with consequences for competitive strength towards other modes of transport and recruiting of new personnel to the sector. At a societal level, immediate effects of occupational injuries and ill-health can be seen in costs for medical treatment, health care and social security. Poorly managed and operated *green technology* systems may also have societal environmental effects through unnecessary emissions to air and water (Österman and Magnusson, 2013).

4.3 ***Development and transfer of knowledge***

Seafarers seldom participate in workplace design and development projects on board. Among the reasons given for this are the absence of an appointed crew when the ship is built, the different challenges of time and place that comes with the globalised nature of shipping, and a perceived lack of value of crew participation to a design team. Crew participation is further complicated by the differences in professional background, command of technical drawings and the ability to communicate in engineering terms with a design team.

When designing new workplaces or introducing new technical systems on board, there are many functional, technical and legal aspects regarding a ship’s seaworthiness and operation to consider that demand special areas of expertise. Thus, the participatory approach and the inclusion of the crew as operators and maintainers of the working and living conditions on board is not a substitution, but a complementary resource to the multi-disciplinary design team.

During a course development project for seafarer safety delegates described in Österman (2011) the course assignments matured into a systematic method that could serve as an investigative toolkit during a real design process. The method draws on theories and principles of participatory design and work task assessment techniques such as task analysis and link analysis (Stanton et al., 2005) that enabled the safety delegates to take active part in a (fictional) ship design process, despite limited experiences of technical drawings. The group work presentations, as a symbol for a design proposal, had a strong focus on functionality and accommodated for actual tasks and processes in the workspace. The results illustrate the kind of contextual knowledge and understanding that comes of practical experience. This knowledge is vital when designing a workplace or work system in order to minimise risks and optimise performance during normal and emergency operations (Vink et al., 2006). The drawing review was performed on a conceptual level, limited to physical and social environment factors on board. Although not immediately recognised as safety-critical, the living conditions on board can have serious effects on operator and team performance. By ensuring adequate quality of sleeping and eating quarters, as well as possibilities for the crew to have an active leisure time on board, vital psychosocial stressors can be minimised, increasing crew well-being as well as operator performance (Carter, 2005).

In the absence of an appointed crew '*typical users*' can be employed. In a participatory design study including 18 nautical cadets from a maritime academy, Österman et al. (2011) showed that despite the cadets' lack of familiarity with the prototypical ship used in the study, they related their relatively short seagoing experience from other ships to the use scenarios and discussed both details regarding the physical design on the bridge and the interplay between operators on the bridge and on deck. Many anecdotes were triggered, indicating that the participants interpreted and evaluated the models and scenarios as real ship bridges during the discussions. The elicited comments from the participants generated tangible examples on workspace design, prerequisites for installation, use and service of equipment, transport and evacuation routes, maintenance and cleaning. This was achieved through relatively small resources for time, materials for low-fidelity mock-ups and training efforts – especially considering the costs for re-designing a workplace at a later stage.

Apart from illustrating how knowledge can be developed and transferred between users and designers of shipboard work systems, the outcome of these studies can be discussed in terms of empowerment of participants and inspiring confidence to embark on future design projects in real life. Empowerment does not come automatically from participation, but through a progressive process in which the participants can staircase their understanding of the remote and complex decision processes surrounding a design project. Relations to colleagues and skill discretion (the possibility for an employee to learn new things, utilize skills and creativity, and perform varying tasks) are closely related to perceived stress and mental health (Stansfeld, 2002, Karasek, 1979).

One of the most prominent findings to emerge was the importance of rapport (mutual understanding or trust) between the different actors– manufacturers of technical systems, shipyards making installations, owners and operators of ships, and cargo owners. This is consistent with Guinan (1986) who proposes that communication between designers and users is positively related to the outcome of the design, and Berlin (2011) who identifies rapport-building as an important strategy for influencing workplace human factors.

A participative design process involves an expansive learning of all actors involved. The operators convey experience and feedback regarding usage to the designers, and the designers provide understanding of the system’s function and operation. This knowledge flow helps to close the feedback loop between end-users and designers – linking the islands of knowledge. A mutual understanding supports the supplier in designing more operable systems, and the operators to operate them more efficiently and reliably (Launis, 2001). A collaborative installation process, involving both operators and technical management contributes towards a deeper understanding of how a technical system works, thus enabling a more efficient operation. This lead to less time and resources spent on problem-solving and maintenance. In times of increasing fuel costs, this phenomenon could also be linked to the contemporary discourse on improving energy efficiency on board. Among the identified patterns towards successful management of vessel energy efficiency are lack of knowledge and resources, low level of project management maturity, fragmented responsibilities and lack of communication (Johnson et al., In press).

Another challenge on the theme of development and transfer of knowledge is the institutional barriers that come with the prescriptive rules on knowledge and training within the regulatory regimes. The mandatory training courses included in the IMO convention for Standards of Training, Certification and Watchkeeping (STCW) are naturally prioritised before other training courses. However, the ISM Code requires each ship to be ‘*manned with qualified seafarers*’ and the establishing and maintaining of '*procedures for identifying any training which may be required in support of the safety management system and ensure that such training is provided for all personnel concerned*' (IMO, 2010, Chapter 6). This requirement and its relation to the safety management system undoubtedly leave room for interpretation and a question arises: when does human factors management become safety management?

No specific training is required for a technical system (or task) that is not regarded as safety critical. Training is possibly given to the operators who are on board at the initial start-up, and these operators are then supposed to transfer this knowledge to their colleagues and successors. Thus, successful operation of the system depends on the instructor's pedagogical as well as technical skills. Situations in the working life become the arena where the learning and the knowledge transfer occur. Depending on the extent to which a new situation resembles previously encountered situations, the learning process may be short and easy, or long and challenging (Eraut, 2004).

In viewing an organization as a knowledge system, knowledge is constantly generated and transformed through different types of bearers: people, machines, technical and administrative systems, documents, computer applications, and so forth (Wikström and Normann, 1994). Hence, for safe and efficient operation and maintenance, the installation in general and its user interfaces in particular, must be designed for good guessability, so it is easy to correctly guess how something works and what happens when for example a certain button is pushed. And further for learnability, so it is easy for the operator to learn how it works and remember correct actions (Jordan, 1998). This is especially important considering the high personnel turnover levels within the industry, with a constant influx of new crewmembers to train.

Recognizing training as an investment rather than a cost in a longer time-perspective than the nearest tour of duty influences employability and attractiveness of work. The positive effects of improved individual and organizational learning will be seen right across the business, since many people in positions at classification societies, marine insurers, ship yards, manufacturers etc. have a background on board.

In sum, there is a large body of knowledge within the maritime domain on how to create successful systems. There is however an absence of formal structures for transfer of this knowledge between the various system actors that causes costly operational disturbances and unnecessary risks for occupational accidents. Strategies must be developed for bridging these islands of knowledge on several organizational and political levels: within international and national legislative regimes, trade organizations in the maritime sector and ship operators. These strategies include improved integration of human factors in the pre-operational planning phase of new vessels, workplaces, technical and administrative systems, and early involvement of the sharp end operators. Further, institutional and regulatory arrangements must be made for ensure quality crew training and the retention of maritime know-how, setting a level playing field across all operators and segments in the sector.

4.4 *Managing human factors in the maritime transport system*

The results show that an inherent potential for improvements can be found within the physical and cognitive workplace layout and design of the ship system and its sub-systems. Many human factors issues causing accidents and injuries can be solved early in the planning and design phase of new vessels or when planning changes in organization, work tasks or equipment. It is therefore suggested that traditional human factors and design engineering tools, such as methods for task and function analysis, user profiles, anthropometric and heuristic evaluations and user evaluations (e.g. Stanton et al., 2005, Wilson and Corlett, 2005), are used routinely. The use of these tools is equally important for designing the social environment on board. Seafarers of today have evolved into knowledge workers, operating in an increasingly complex socio-technical system that demands high level of concentration during planning, operation and administration of work. With long working hours and composition of watch systems with few hours of rest follows a need for physical and mental recuperation in order to promote personal health and safety and minimise the risks for use errors and accidents by stressed or fatigued operators.

The last resort for any remaining unsolved problems or issues that cannot be solved in the design and installation phase of new vessels, workplaces or equipment, lies in training. Adequate education and training is paramount to ensure that operators understand any risks associated with the work and how these risks can be avoided. Operators also need sufficient knowledge and training of the systems they are set to control so that complex or unexpected situations can be attended and perceived, adequate decisions made and correct actions taken during stressful conditions. In addition, it is important that not only the actual users receive training on how to operate a system and how to avoid accidents and injuries. It is just as important that any risks associated with a particular system or task are known by the nearest manager so the work can be planned and performed in a safe and efficient manner. The manager is responsible for ensuring that adequate work instructions and work permits are available and adhered to, and that necessary controls of exposures are carried out and that adequate personal protective equipment is accessible and used. Essentially, most crew positions and work tasks at sea can be seen as safety critical. Hence, poor crew performance, irrespective of cause, can lead to increased risks for accidents and damage to environment, cargo and ship.

5. Synthesis - a value proposition of maritime human factors

The following section consists of a synthesis of the results in relation to the purpose of the paper, tying the knot between human factors and operational performance in the development of a value proposition of maritime human factors.

While the ethical and moral cases for a systematic human factors management are clear, the preceding analysis shows a case also for business performance. A value proposition of maritime human factors is proposed (figure 2), positioning the potential core values that can be delivered at different levels within the maritime transport system: the employee, the ship operating company, the maritime sector, and society as a whole.

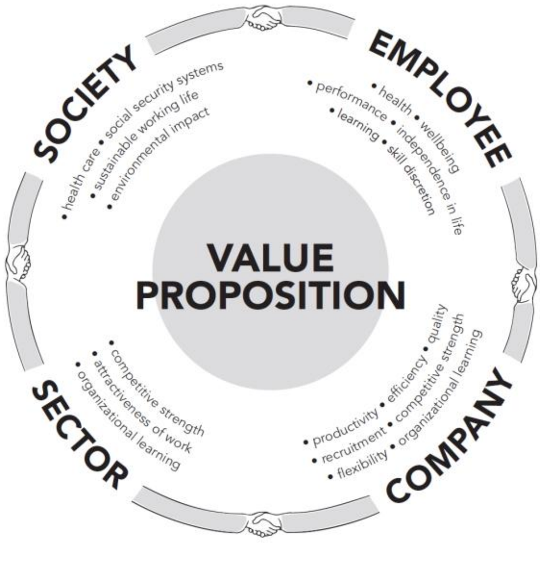

Figure 2. A value proposition of maritime human factors positioning core values at employee, company, sector and societal level.

Values for the individual include benefits regarding physical and mental health and well-being, but also regarding individual learning and skill discretion. Ultimately, maintaining good health and having the opportunity for personal professional development and career opportunities on board and within the industry contributes to an employee's power to make a living, provide for family and independence in life.

Values for the company include improved operational performance in terms of increased productive time at sea, operational efficiency and improved quality of sea transport services that in turn result in increased operational flexibility and competitive strength. This is achieved through a motivated and well trained crew, more efficient movements in operation and maintenance with reduced costs and time lost for accidents, injuries and operational disturbances, reduced costs for recruiting, less use of energy and other consumables. It is further achieved through improved corporate image affecting the company's ability to keep and attract business, the position on the labour market and attractiveness of positions in the company.

Values for the sector include competitive strength towards other modes of transport on a national and regional basis, attractiveness of work and the sector's ability to recruit and retain competent personnel and recruiting of new personnel to the sector. Values further include increased organizational learning across the industry through a flexible workforce on board and within shore based organizations.

Values for the society include reduced costs for health care and social security. Well operated and maintained systems further reduce the risk for operational and accidental pollution to the environment. Improved physical and psychosocial working conditions, that preserve health and reduce the risks for occupational accidents as well as ill-health, affect the human's ability to perform well during the entire working life, thus contributing towards a sustainable working life.

The presented value proposition can be seen as a tool for supporting informed management decisions and a guide for developing operational strategies on political, inter- and intra-organizational levels. It increases the understanding of why human factors management is important, to whom it is important and how it is linked to core business values and overall performance of the maritime transport system. The value proposition is not presented as objectively assessed data. Nor does it pose as an absolute account. Due to the scarcity of previous work in this research area, it can rather be seen as a first piece in the puzzle, a first step to make visible the effects of human factors management on overall systems performance in the maritime domain. Increased knowledge of these effects has the potential to positively influence policy and decision making on political and organizational level towards improved working conditions for seafarers in a safe and sustainable maritime transport system.

There are many references in this work to measuring of various performance indicators and evaluation of effects. It is a human truism that what gets measured gets done, but it is obviously not the measuring and evaluation activities in themselves that improve performance or make seafaring a safer profession. The advantages of these activities lie in the increased understanding of the system that is achieved through a methodical definition, investigation and assessment of performance and objectives, justifying human factors and guiding management and operators on all levels to appropriate solutions.

There is a lack of complementary quantitative studies to empirically test the links between maritime human factors and operational performance proposed here. However, this research work constitutes a base for the design of future studies in knowing what to measure and how. Complementary studies are needed to investigate the feasibility in incorporating human factors methods and techniques in the toolboxes of naval architects, ship designers and suppliers of marine equipment. Continued research is also needed on the topic of crew participation on all stages in the development process when designing vessels, workplaces or other technical or administrative systems.

6. Conclusions

The research work presented in this paper proposes a link between human factors and the value creating process in the maritime transport system, and contributes with theoretical reflections and practical suggestions to the field of maritime human factors science.

The following conclusions are drawn from the work:

- Main focus of research on the maritime domain has so far been on physical and to some extent cognitive human factors, while an increased concern with organizational factors was noted among the practitioners that participated in the study.
- There is an absence of formal structures for development and transfer of human factors knowledge between the various stakeholders in the maritime domain. This absence increases the risk for accidents and operational disturbances.
- The following strategies for facilitating the development and transfer of human factors knowledge within the domain were identified:
    - Improved integration of human factors in the pre-operational planning phase of vessels, workplaces, and other technical and administrative systems
    - Early crew participation in design processes
    - Improved integration of human factors in the design of usable system documentation
    - Institutional and regulatory arrangements to ensure quality crew training and the retention of maritime know-how.

Finally, in order to support informed management decisions and highlight the potential value of maritime human factors, a value proposition was developed and structured around the employee, company, sector and societal levels.

Values for the employee include improved health and well-being, learning, performance, skill discretion and ultimately independence in life.

Values for the company include increased operational performance in terms of productivity, efficiency and quality, advantages in recruiting and retaining personnel, increased flexibility, and organizational learning.

Values for the maritime sector include competitive strength, attractiveness of work and increased organizational learning across the industry.

Values for the society include reduced costs for health care and social security, reduced risk for accidental and operational impact on the environment, and a systematic work towards a sustainable working life.

Suggestions for further work include complementary studies to investigate the feasibility in incorporating human factors methods and techniques in the toolboxes of naval architects and other system builders. Further work is also needed on the topic of crew participation when designing vessels, workplaces or other technical or administrative systems.

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