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Human Factors and Safety Culture in Maritime Safety (revised)

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ABSTRACT: As in every industry at risk, the human and organizational factors constitute the main stakes for maritime safety. Furthermore, several events at sea have been used to develop appropriate risk models. The investigation on maritime accidents is, nowadays, a very important tool to identify the problems related to human factor and can support accident prevention and the improvement of maritime safety. Part of this investigation should in future also be near misses. Operation of ships is full of regulations, instructions and guidelines also addressing human factors and safety culture to enhance safety. However, even though the roots of a safety culture have been established, there are still serious barriers to the breakthrough of the safety management. One of the most common deficiencies in the case of maritime transport is the respective monitoring and documentation usually lacking of adequacy and excellence. Nonetheless, the maritime area can be exemplified from other industries where activities are ongoing to foster and enhance safety culture.

1 INTRODUCTION

The strengthening of safety culture in an organization has become an increasingly important issue for all high risk industries. A high level of safety performance is essential for business success in intensely competitive global environment. The most important objective is to protect individuals, society and the environment by establishing and maintaining an effective protection against the respective hazards.

This is achieved through the use of reliable structures, systems and components as well as adequate clear procedures, and acting people which are committed to a strong safety culture.

The term 'safety culture' first appeared in the International Atomic Energy Agency's initial report following the Chernobyl disaster. In the early investigation of this accident, the initial emphasis was focussed on plant deficiencies.

However, more thorough analyses also identified organizational, cultural, and managerial issues and showed a lack of an adequate safety culture.

In the nuclear industry, international organizations such as the International Atomic Energy Agency (IAEA) recognized the important role that all regulators should play in monitoring safety performance in the nuclear industry. Following the Chernobyl accident, the IAEA published two guides on safety culture (IAEA 1991 and 2002).

More recently, the IAEA developed the following definition for safety culture (IAEA 2006): "The assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, protection and safety issues receive the attention warranted by their significance."

According to (IAEA 2009), safety culture should be based on a set of safety 'beliefs' (assumptions) and on a code of conduct that reflects the right attitude to safety which is held in common by all individuals in the organization. Ultimately, the safety culture is manifested in individual and collective behaviour in the organization.

In the meantime, inquiries into many major accidents such as the King's Cross fire, Piper Alpha and the Herald of Free Enterprise and more recently the accidents in the Mexican Gulf (Deepwater Horizon blow-out) in 2010 have found faults in the organisational structures, safety management systems and the prevailing cultures, throwing the importance of safety culture into the spotlight.

The most recent event in the nuclear industry was in March 2011 when a magnitude 9.0 earthquake off the coast of Japan and the resulting tsunami caused extensive damage at the Fukushima Daiichi nuclear power plant. A full understanding has yet to emerge of what Japanese authorities and the nuclear industry have learned about safety culture implications at the Daiichi plant, as facility and equipment damage from the earthquake and resulting tsunami has been the initial focus of event studies. As with all major events, getting to the underlying safety culture issues requires more time and further analysis before all root causes can be identified, but a recent report by the Japanese Government strongly points to safety culture issues (NAIIC 2012).

Furthermore, an international experts' meeting in May 2013 on human and organizational factors in nuclear safety in the light of the Fukushima accident recommended to strengthen human including organizational aspects and to improve the synergy between technology and human factors (e.g., Ryser 2013). Moreover, a safety culture training course has been described with the main goal to develop awareness of the importance of each individual's personal contribution to safety culture improvement among workers and managers (Rusconi 2013).

Although there is a wealth of information, articles and reports relating to safety culture, there is still no universal definition or model. Safety culture has been defined in a variety of ways including (Berg 2011):

- The ideas and beliefs that all members of the organisation share about risk, accidents, and ill-health,
- A set of attitudes, beliefs or norms,
- A constructed system of meaning through which the hazards of the world are understood,
- A safety ethic.

The assessment of safety culture is key to identifying a companies current level of safety culture (known as its maturity or development level) in order to identify how to learn and improve. There are a number of different assessment methods including:

- safety attitude surveys (using questionnaire to elicit workforce attitudes),
- safety management audits (using an audit process and trained auditor to examine the presence and effectiveness of safety management systems)
- safety culture workshops (involving a cross-section of the workforce to consider perceptions of the safety culture and elicit improvement ideas)
- safety performance indicators (analyzing data on indicators such as the number of safety tours performed or near miss data).

Such a questionnaire which is often used as a first step has to be carefully developed for the respective needs and area. In the nuclear field, a so-called IAEA safety culture perceptions questionnaire has been elaborated with 132 questions in this survey. The purpose of this survey is to refine the current pilot version of the IAEA safety culture perceptions questionnaire for future use in conducting safety culture assessments in the nuclear industry. This will be the topic of a meeting in August 2013 with invited experts.

An explorative study of Swedish masters' perception of the concept of maritime safety including safety culture is provided in (Mauritzson 2011).

In Finland, a maritime transport strategy is under preparation, where also the safeguarding and development of the expertise in maritime industries, in particular from the viewpoint of maritime safety culture (Ministry of Transport and Communications 2013).

A safety culture assessment allows an organisation to better understand how its people perceive safety and the company's approach to safety management. It allows the organisation to identify both strengths and weaknesses that then enable it to continuously monitor and improve its approach to safety.

As in every industry at risk, the human and organizational factors constitute the main stakes for maritime safety. Furthermore, several events at sea have been used to develop appropriate risk models (Chauvin 2011). Operation of ships is full of regulations, instructions and guidelines also addressing human factors and safety culture to enhance safety. However, management ashore and on board need not only to ensure that the formal skills are in place but also ensure, encourage and inspire the necessary attitudes to achieve the safety objectives.

2 HUMAN FACTORS IN MARITIME SAFETY

2.1 *Role of human factors*

Regulations and systems have not achieved the desired effects in averting marine accidents which are a result of human errors and account for 80% of those occurring worldwide.

Studies have shown (Rothblum 2000) that human error contributes to:

- 84-88% of tanker accidents,
- 79% of towing vessel groundings,
- 89-96% of collisions,
- 75% of fires and explosions.

These estimations are still valid. Thus, the maritime transport system is 25 times riskier than the air transport system according to the accounts for deaths for every 100 km. Intensification of sea trade for last ten years causes the increasing of potential risk to the ship safety.

The implementation of the International Safety Management Code (IMO 2008) has played a significant role in addressing this issue through training and education of crew members but to some extent casualties can be prevented by eliminating other indirect causes including hardware, such as equipment systems.

It must be noted that if the possible cause of an accident is human error, finding and eliminating the root cause of such errors is vital for preventing recurrence - whether it is related to human element, hardware factors, organizations and management factors.

However investigation in human factors, main cause of such accidents, is increased nowadays and the methodologies to carry out such an investigation are being developed by several institutions. These methodologies, adopted from the investigation on risk analysis are frequently based on the estimation of risk levels, whose values, in the case of human factor investigation are not always clear.

In any case, a comprehensive risk assessment consists of:

1 Identifying the hazard in the system;
2 Evaluating the frequency of each type of accident;
3 Estimating accident consequences;
4 Calculating various measures of risk, such as death or injuries in the system per year, individual risks or frequency of accidents of a particular kind.

For improvements in operability and working environment it is necessary to ensure that the operability is not poor or inconvenient or is encountering obstacles during operations. Since it heightens the risk of an accident, it is important to pay attention to the arrangement and layout of equipment. Hence it is important that operators work in congenial and safe surroundings.

It is clear that total safety over ships operation can not be achieved, but it is possible to obtain a high degree on it. Research on the influence of human factors over maritime accidents is, also, very difficult. On the one hand we find that an accident involves the interaction of individuals, equipment and environment, as well as unforeseen factors (Caridis, 1999), and on the other hand, human factors comprise operative human errors –derived from personnel own qualifications, or from their physical, mental and personal conditions- and situational errors– derived from work environment design, management problems, or human-machine interface, amongst others

Being aware that risk is an inherent factor of maritime activity which can not be totally removed and that errors are part of human experience, it is expected that elements such as good management policies, effective training and having suitable qualifications and experience, can reduce the occurrence of human errors.

The practical application of this kind of analysis seems clear: obtaining the cause parameters, both direct and indirect parameters, from the studied factor, one can better understand the root of the presence of such a factor, and one can take specific and direct corrective actions to try to minimize the accident risk. The main weakness of this method lies in the lack or shortage of data related to accidents and incidents on maritime domains.

Even though the roots of a safety culture have been established, there are still serious barriers to the breakthrough of the safety management (Lappalainen & Salmi 2009).

The poor reporting practises cause further problems. The information about the non-conformities, accidents and hazardous occurrences does not cumulate at any level of the maritime industry. The personnel of the other ships cannot learn from the experiences of the other vessels. There are no possibilities to interchange information about incidents between the vessels. The company cannot utilize the cumulative information when improving its safety performance. Companies do not have the opportunity to learn from other companies' mistakes (Lappalainen & Salmi 2009). Under these circumstances the national maritime administrations are powerless in their attempts to further develop the maritime safety

The fundamental philosophy of the IMS Code (IMO 2008) is the philosophy of continuous improvement. The procedures for reporting the incidents and performing the corrective actions are the essential features of the continuous improvement. If this information is not provided the successful cycle of continuous improvement cannot function (Lappalainen & Salmi 2009).

Operation of ships is full of regulations, instructions and guidelines which officers and crew are expected to know and adhere to. A culture of safety may perhaps be achieved through written instructions, but in the end it is a question of a common mind-set throughout the organisation. Management ashore and on board need not only ensure that the formal skills are in place but also ensure, encourage and inspire the necessary attitudes to achieve the safety objectives. Statistics prove beyond doubt that investing in a good safety culture provides results and pays off in the long term.

The effort of allocating various forms of human error as verified accident causes is surely not a trivial task. Moreover, this difficulty is augmented in the case of maritime transport, since the respective monitoring and documentation is usually lacking of adequacy and excellence. Nonetheless, marine industry can be exemplified from other sectors of industry (e.g. civil aviation, nuclear plants), where considerable load of attention is already given in pinpointing and revealing various involved aspects of human element extracted from comprehensive databases of safety relevant events.

Human behaviour and performance can be the prevailing factors that prescribe the level of safety for numerous maritime transport procedures and practices of management (Martínez de Osés & Ventikos 2006). This means that they can also influence, in a considerable degree, the protection of marine and coastal environment. Thus, a feasible way to reduce the frequency and severity of naval accidents is, by identifying the contributing factors to the so-called human error, and by investigating for methods, which will either eliminate or mitigate these mistakes.

Over the last 40 years the shipping industry has focused on improving ship structure and the reliability of ship systems in order to reduce casualties and increase efficiency and productivity. Improvements can be seen in hull design, stability systems, propulsion systems, and navigational equipment. Today's ship systems are technologically advanced and highly reliable (Rothblum 2000).

Therefore, one further important aspect to reduce marine accidents is the collection and investigation of near miss data as it is practice in other transport industries like aviation.

Incident and near miss reporting is used as a proactive tool of safety management in many risk-prone industries. The ISM Code requires shipping companies to establish a system for reporting incidents and near misses. However, it has been stated in several studies that incident and near miss reporting is deficient in the shipping industry. Near miss reporting has been seen as the failing part of ISM code's implementation and received resistance from the users (Lappalainen, 2011).

The aim of a recent report is to present experiences and best practices of incident reporting in order to offer information for improvement (Storgård et al. 2012). It is concluded in (Storgårdet al. 2012) that - although some progress has been made in connection with shared incident reporting systems in the shipping industry in the Baltic Sea area - the sharing of experiences and lessons learnt at industry level is still in its infancy.

The main objective of another report (Erdoğan 2011) was to identify some best practices about near-miss reporting from the companies that are active in Swedish and Finnish shipping industry and believed to have high level of safety within their organization The majority of the participants believe that near-miss reporting in principle has a significant effect creating and enhancing the safety culture. However, the actual benefits of the near-miss reporting are reported as being limited. Further, it seems that the companies are not yet utilizing the reported data for establishing trends to improve the follow-up and the awareness within the organization

Yet, the maritime casualty rate is still high. Why, with all these improvements, was it not possible to significantly reduce the risk of accidents? It is because ship structure and system reliability are a relatively small part of the safety equation. The maritime system is a people system, and human errors figure prominently in casualty situations (Rothblum 2000).

A recent analysis (Chauvin et al. 2013) shows that most collisions are due to decision errors. At the precondition level, it high-lights the importance of the following factors: poor visibility and misuse of instruments (environmental factors), loss of situation awareness or deficit of attention (conditions of operators), deficits in inter-ship communications or Bridge Resource Management (personnel factors). At the leadership level, the analysis reveals the frequent planning of inappropriate operations. In other words, instructions given to the bridge team were inappropriate, given the situation requirements (poor visibility or heavy traffic) and also constitute supervisory violations. They may reveal some difficulty for leaders to adapt their instructions to a changing situation may also reveal a poor safety culture (Chauvin et al. 2013).

Human reliability also influences the overall system reliability in automatic systems. This influence can both be negative (e.g. human working error) or positive (e.g. controlling system breakdowns or system problems). Human performance could be defined as the human being's execution of an action with the purpose of accomplishing a given task.

2.2 *Example of an accident*

The example provided in the following (Gard 2012) deals with the accident grounding. A vessel is under way on an ocean crossing with course set out from start to end. The course is set out and the voyage planned on a small scale planning chart. The course is set to pass some small groups of mid-ocean islands and the CPA (Closest Point of Approach) is considered and thought to be well on the safe side. On a nice tropical night with calm seas and good visibility, the vessel makes its approach to pass one group of islands well on the port side some time after midnight.

The chief officer observes during the last two hours of his 1600-2000 hrs watch that a slight breeze and current are working together to set the vessel slightly off course and towards the islands ahead. He therefore makes a correction to the course to compensate for the drift and setting to keep the vessel on its intended course. When handing over the watch at 2000 hrs, the chief officer makes the second officer aware of this.

The second officer continues to plot the positions throughout his watch and observes that the vessel is still drifting somewhat off course to the effect of making the CPA to the islands ahead less safe than planned. He therefore makes some minor course adjustments to compensate for drift and setting. At midnight the watch is handed over to the first officer, who is also made aware of the drift and the course adjustments. At 0040 hrs the vessel runs aground at full speed on the beach of a small low atoll. The beach is mainly sand and pebbles and slopes at a low angle into the sea so the vessel suffers minor damage but can not be re-floated with its own power. A costly salvage operation follows.

The human aspect of this accident is discussed in the following. The positions were plotted in the same small scale planning chart covering the entire ocean where the voyage was planned and the course set out. In a small scale chart it is difficult to accurately measure small distances and observe small deviations from the course between hourly plots. The reason for using a small scale chart was probably that it was not considered necessary to conduct "millimetre" navigation when crossing the ocean. The island on which the vessel grounded was marked on the chart in use, but only as a small dot and the course was set to pass at what seemed to be a safe distance.

The drift and current, however, worked together to set the vessel off course towards the island and it is painfully obvious that the corrective actions taken by the navigation officers were not adequate.

It can be concluded that the grounding would not have happened if:

- a large scale chart had been used for position plotting since it would then have become apparent that the course was heading gradually towards the island, and/or
- a much wider passing had been planned in the first place, and/or
- a considerable safety margin had been applied when the corrections were made to compensate for drift and setting.

It is also possible that proper look-out and use of radar could have been an issue. On the other hand, the island was very low and it is arguable that it could not have been spotted visually in time in the dark tropical night. It is unclear whether and why the island was not seen on the radar, but it is a known fact that radars are subject to a lot of interference in tropical waters and it could be that both the rain and sea clutter settings had been adjusted to deal with that, thus at the same time removing or diminishing the radar image of the island.

One further example is the cruise ship Costa Concordia's grounding at the Italian island of Giglio in January 2012 which will probably labelled as human error (Porathe & Shaw 2012).

3 MARITIME SAFETY CULTURE

3.1 *General aspects*

Safety culture can be viewed from many angles (Berg 2011). Typically, the environment close to safety managers of the organizations provides most of the research material, and consequently the middle management view dominates. Similarly, employee perspective is strong in internal material of the organizations, typically work instructions and safety management documentation. From the top management viewpoint, lesser amount of practical information is available.

However, in shipping, and especially on board ships the organization is hierarchic, due to tradition and the need for clarity in emergency operations. Therefore, safety considerations depend strongly on the actions of the masters and the officers of the ships, and the interactions of the land-based organization (Räisänen 2009).

One typical feature of shipping is that ships are manned with crews of multiple nationalities, and the much of it is carried out in international setting, outside national legislations. These issues complicate the communication and interactions within the ships, between them, and with the land-based stakeholders.

Moreover one has to emphasize the effects of national culture, which is less prominent in related safety discussions of other fields (Håvold 2005, Håvold 2007).

The prevailing goals, principles and procedures in an organisation, which can safeguard against errors and when errors are encountered through which it is possible to react with subsequent changes in practises before serious incident or accident occurs. Accident investigation is part of the maritime safety culture - a reactive one - but an excellent observer point.

In the Baltic Sea the maritime traffic is rapidly growing which leads to a growing risk of maritime accidents. Particularly in the Gulf of Finland, the high volume of traffic causes a high risk of maritime accidents. The growing risks give us good reasons for implementing the research project concerning maritime safety and the effectiveness of the safety measures, such as the safety management systems. In order to reduce maritime safety risks, it is recommended in (Lappalainen et al. 2010) that the safety management systems should be further developed.

The purpose of the METKU Project (Development of Maritime Safety Culture) which started 2008 was to study how the ISM Code has influenced the safety culture in the maritime industry, to evaluate the development of safety culture in maritime industry and to examine the weaknesses found in the safety management systems of shipping companies (Lappalainen et al. 2010). The main results found were that maritime safety culture has developed in the right direction after the launch of the ISM Code in the 1990´s (Heijari & Tapainen 2010). In this study it has been discovered that safety culture has emerged and it is developing in the maritime industry. Even though the roots of the safety culture have been established there are still serious barriers to the breakthrough of the safety management (Lappalainen 2008).

The ISM Code is seen as been effective over a decade. However, the old-established behaviour which is based on the old day's maritime culture still occurs, e.g., there are still serious barriers to the breakthrough of the safety management. These barriers could be envisaged as cultural factors preventing the safety process. For more details see (Lappalainen et al. 2010).

However, experience has shown that there are perceived gaps between the desirable leadership qualities, and what is currently being delivered. These primarily concern:

- Clear two-way communication,
- "Tough empathy",
- Openness to criticism,
- Empathy towards different cultures,
- Ability to create motivation and a sense of community,
- Knowing the crew's limitations,
- Being a team player.

Moreover, there are other important explicit barriers to effective safety leadership that relate to the current structure of the industry, standards, practices and economic pressures. These barriers would need to be addressed irrespective of the personal qualities and skills of the Master.

Therefore, workshops on leadership and safety culture for senior experts are regularly provided by the IAEA in the nuclear field, the next one in September 2013. This workshop will focus on the topics such as international standards for leadership and safety culture; lessons learned from severe events and their relation to leadership and safety culture, methods and tools for improving leadership and safety culture.

Such training workshops are also helpful in the maritime field. Experience has shown that the transformation of safety culture works being aware that this process needs time (Goldberg 2013).

Operation of ships is full of regulations, instructions and guidelines which officers and crew are expected to know and adhere to. The ISM Code has to a large extent codified what is known as good seamanship.

A culture of safety may perhaps be achieved through written instructions, but in the end it is a question of a common mind-set throughout the organisation. Management ashore and on board need not only ensure that the formal skills are in place but also ensure, encourage and inspire the necessary attitudes to achieve the safety objectives.

The safety culture aboard vessels trading in the Baltic Sea is depicted in (Hjorth, 2013). The investigation shows deficiencies in the safety culture that prevails aboard and in shipping as a whole. The safety culture aboard is influenced not only by the crew and their shared agreements but also by the surrounding systems, which are in turn influenced by other surrounding systems.

It is slightly worrying that documents related to leadership, just culture, etc., submitted in recent years have not received the attention they should. One critical step to evaluate how proactive IMO is will certainly be the follow-up to the Costa Concordia accident last year (Schröder-Hinrichs et al. 2013).

3.2 *Examples of safety culture approaches*

The extent of good safety leadership (and more broadly good safety management arrangements) appears to be highly variable across companies. Safety management arrangements are generally most highly developed in the tanker sector, and least highly developed in the dry cargo sector.

However, the research results (Little 2004) confirm that a good safety performance can be achieved with a committed leader who has the key qualities described above, without necessarily having the most sophisticated management arrangements.

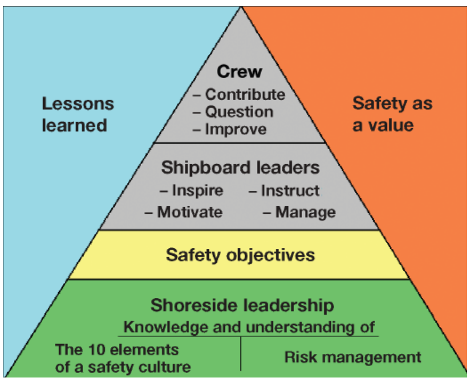

Figure 1. Safety culture pyramid for the maritime area according to Drouin (2010).

For the maritime area, one safety culture approach can be illustrated by a pyramid as shown in Figure 1, accompanied by the elements "lessons learned" and "safety as a value" which are important for the entire organisation to succeed in a sound safety culture (Drouin 2010).

A further safety culture approach is illustrated in Figure 2.

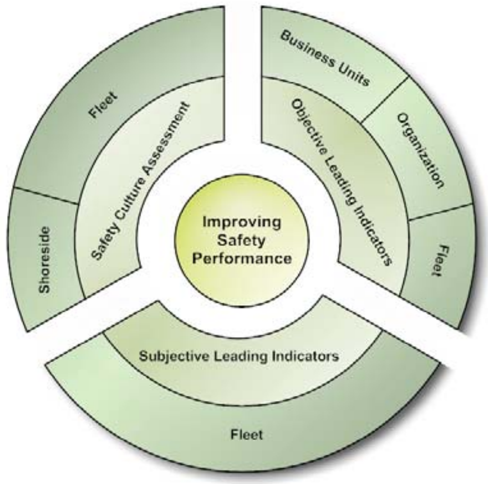

Figure 2. The ABS safety culture and leading indicators model according to ABS (2012).

The central premise of this model, discussed in more detail in (ABS 2012) is that improvements in organizational safety culture can lead to enhanced safety performance.

The first step is an assessment of the existing safety culture to identify areas of strength, weaknesses of defences, and opportunities for improvement against operational incidents, personal injuries, etc.

This model also incorporates a process for identifying an organization's potential leading indicators of safety. There are two ways of conducting this process:

1) By the identification of objective leading indicators. This is done by correlating safety culture metrics with safety performance data. This is the preferred approach because of its objectivity; because it utilizes metrics that the organization has collected; and it does not require a survey of the workforce which can be time-consuming.

This can be done at three levels:

– At the Organizational level,
– Across Business Units,
– Across the Fleet.

2) By the identification of subjective leading indicators from a safety culture survey. These indicators are based on the values, attitudes, and observations of employees. This method may identify potentially beneficial safety culture metrics not yet tracked by the organization. This approach may be used when the organization lacks sufficient metrics to use the objective leading indicators process. There are a number of criteria for undertaking a leading indicators programme, and for each type of assessment.

4 CONCLUDING REMARKS AND OUTLOOK

In general, safety culture has been found to be important across a wide variety of organizations and industries. While initial studies of safety culture took place in jobs that have traditionally been considered high-risk, organizations in other areas are increasingly exploring how safety culture is expressed in their fields. Overwhelmingly, the evidence suggests that while safety culture may not be the only determinant of safety in organizations, it plays a substantial role in encouraging people to behave safely.

The essence of safety culture is the ability and willingness of the organization to understand safety, hazards and means of preventing them, as well as ability and willingness to act safely, prevent hazards from actualising and promote safety. Safety culture refers to a dynamic and adaptive state. It can be viewed as a multilevel phenomenon of social processes organizational dimensions, and psychological states of the personnel.

In the nuclear field safety culture is still seen as an important task (CNSC 2012), and also the German activities are ongoing (Berg 2008, Berg 2010, Kopisch & Berg 2012).

In February 2011, i. e. one month before the Fukushima accident, a further international activity in the nuclear field on safety culture started. The general objective is to establish a common opinion on how regulatory oversight of safety culture can be developed to foster safety culture. It is intended that the output of the meeting will form the basis for a Safety Report Series document providing guidance on how regulators and licensees can deal with the safety culture components in order to continuously foster a positive safety culture. Moreover, the IAEA is also working on a document how to perform safety culture self-assessments.

A recent publication (IAEA 2013) addresses the basics of regulatory oversight of safety culture, describes the approaches currently implemented at several regulatory bodies around the world and, based on these examples, proposes a path to develop and implement such a strategies and processes.

In the meantime, there are many demanding aspects of seafaring such as the inability of employees to leave the worksite, extreme weather conditions, long periods away from home, and motion of the workplace. Some of these are unchangeable and are a reflection of the nature of the domain.

However, it is possible to modify, supplement, and introduce new strategies or interventions to potentially reduce the impact these factors have on the health and welfare of the individual seafarer (Parker et al. 2002).

There are many human factors influencing safety in this domain as have been presented in this review: fatigue, automation, situation awareness, communication, decision making, team work, and health and stress. These issues were reviewed within a framework that proposed that these individual factors can be contributory causes in accident causation, however the safety climate on ship will also influence whether or not an individual engages in safe behaviours or not. The review also considered the current status of attempts to address these human factors issues prevalent in the maritime industry. The review demonstrated that there are many "gaps" in the maritime literature, and a number of methodological problems with the studies undertaken to date.

Maritime transportation is characterized by a level of safety of the order of 10^{-5} per movements which is inferior to that of air transportation (10^{-6}), however it is comparable to the level of safety of rail transportation and much higher than the level of safety of road transportation. Thus, for passenger transportation in Europe, the risk of fatality is estimated at 1.1 for road transportation (for 10^{8} person kilometre) and at 0.33 for ferry transportation (Mackay, 2000).

Within this context, the risk of accident and - more precisely - the place of the human factor in this risks, are central issues. The human factor, indeed, seems to be the main cause of incidents at sea (Hetherington, Flin & Mearns 2006) describing the factors that contribute to incidents and accidents: factors which cause a decrease in performance (fatigue, stress, and health problems), insufficient technical and cognitive capacities, insufficient interpersonal competencies (communication difficulties, difficulties mastering a common language), organizational aspects (safety training, team management, safety culture).

A closer look at the questions of human-machine cooperation and at the role of automation in maritime accidents is taken in (Lützhöft & Dekker 2002).

In the case of a crew or team working together, the shared mental representation is one of the elements at the heart of the performance. The methods developed in cognitive psychology to analyze this mental structure can be used to evaluate the impact of Bridge Resource Management (BRM) on the work of a crew (Chauvin 2011). A study of this type was carried out some years ago (Brun et al. 2005).

However (see Salas et al. 2006), these studies remain marginal and recent in the maritime field, even though they are numerous and have been developed for several years in the field of air transportation.

Because human error (and usually multiple errors made by multiple people) contributes to the vast majority of marine casualties it is necessary to prevent human error of paramount importance in order to reduce the number and severity of maritime accidents. Many types of human errors were described, the majority of which were shown not to be the "fault" of the human operator. Rather, most of these errors tend to occur as a result of technologies, work environments, and organizational factors which do not sufficiently consider the abilities and limitations of the people who must interact with them, thus "setting up" the human operator for failure.

This general problem is also discussed for CRG casualties (Kobylinski 2009).

Human errors can be reduced significantly. Other industries have shown that human error can be controlled through human-centered design. By keeping the human operator uppermost in our minds, we can design technologies, work environments, and organizations which support the human operator and foster improved performance and fewer accidents.

There is often a delay between the development of weaknesses in safety culture and the occurrence of an event involving a significant safety consequence. The weaknesses can interact to create a potentially unstable safety state that makes an organization vulnerable to safety incidents. Within the nuclear industry, there have been a number of high profile cases in different parts of the world that have been linked to a weakened safety culture.

By being alert to the early warning signs, corrective action can be taken in sufficient time to avoid adverse safety consequences. Both the organization (which could be a specific plant or utility) and its regulators must pay attention to signs of potential weakness.

Some organizations that have encountered difficulties with their safety culture have previously been regarded as good performers by their industry peers. Good past performance is sometimes the first stage in the process of decline.

The investigation on maritime accidents is, nowadays, a very important tool to identify the problems related to human factor that, studied with attention can be one mainstay to accident prevention and to the improvement of maritime safety.

The long-term positive trend in ship safety, with year-on-year improvements, has now been reversed (Madsen 2011). This is worrying. It's time to take a new look at the maritime industry's safety culture. A stronger focus on safety culture, safety training and competence assessment is needed.

Statistics show that the shipping industry's accident frequency rate has started to rise from a historically low level. Technology, rules and compliance will never achieve the expected level of safety unless there is a greater focus on the human element.

Historically, the safety focus in shipping has been on technical improvements. Most shipping company employees dealing with the operation of vessels have a technical background. Audits and inspections pay great attention to technical compliance. This technical focus has resulted in major improvements to ship safety. But now it is time to focus more on the soft issues. To improve maritime safety one needs to adopt a threefold approach:

1 Improved safety culture,
2 Improved training schemes,
3 A formal competence assessment programme.

The last two aspects are also addressed in (Chirea-Ungureanu & Rosenhave 2012) recommending a cross cultural training to deal with the specific situation onboard.

An organisation that decides to improve its safety culture should follow a systematic, closed-loop process. A typical enhancement process is presented in Figure 3.

The first step consists of defining what safety culture is and understanding what is meant by safety culture in the respective management organisation. This requires identifying the characteristics of safety culture to look at, and their sub-components. These first two steps are important because to measure safety culture effectively, an organisation must define and describe what it is attempting to measure.

The next (3rd) step of the process enters the assessment stage, where the organisation carries out or commissions a survey to measure its own safety culture. Surveys and other techniques contribute to the identification of strengths and weaknesses of the safety culture (4th step). On the basis of this assessment an action plan is developed (5th step).

The actions are effected to improve safety culture (6th step).

After a reasonable period (e.g. at least two years), safety culture can be assessed again iteratively to determine if the situation has improved.

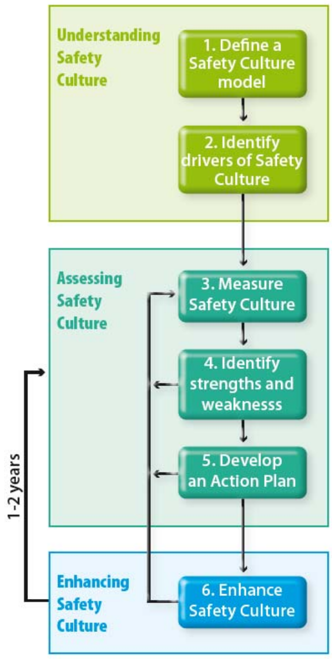

Figure 3. Safety culture enhancement process

The iteration timeframe depends on the time required to carry out the assessment, define the plan and put in place all planned actions and mature the enhancement. The iteration should not occur too quickly, as safety culture takes time to change.

Maintaining and enhancing safety culture needs regular training, continuous awareness of cultural transformation and an ongoing process of continuing improvement (Goldberg 2013).

Results of a recent study (Oltedal 2011) indicate several deficiencies in all parts of a traditional safety management system defined as:

– reporting and collection of experience data from the vessel;
– data processing, summarizing, and analysis;
– development of safety measures and
– implementation.

The underreporting of experience data is found to be a problem, resulting in limitations related to the data-processing process. Regarding the development of safety measures, it is found that the industry emphasizes the development of standardized safety measures in the form of procedures and checklists. Organizational root causes related to company policies (e.g., crewing policy) is to a lesser degree identified and addressed (Oltedal 2011).

The most prominently identified organizational influential factors are the shipping companies crewing policy, which includes rotation systems, crew stability, and contract conditions, and shipboard management. The companies' orientation toward local management, which includes leadership training, educational, and other managerial support, are also essential. The shore part of the organization is identified as the driving force for development and change in the shipboard safety culture. Moreover, management ashore and on board need not only to ensure that the formal skills are in place but also ensure, encourage and inspire the necessary attitudes to achieve the safety objectives.

In order to support the identification of individual, structural and organisational factors affecting safety in the maritime transport sector, a project with a time schedule until October 2015 has been launched (The Research Council of Norway 2012) which should address questions such as:

- Can individual differences in personal factors such as personality boost motivation for safety behaviour and thus reduce the occurrence of undesirable incidents?
- How much of the variation in undesirable incidents can be traced back to individual differences and how much is due to organisational factors (such as the safety culture)?
- What role do group factors such as the crew's shared knowledge of one another play in safety behaviour and undesirable incidents?

Another example is the Canadian marine safety strategic plan (Transport Canada 2009) which shall identify key results to help realize its vision, mission and mandate by promoting a stronger safety culture within the marine community both domestically and internationally. Furthermore the marine community must commit to developing and maintaining a safety culture that continuously improves, learns, anticipates and becomes resilient to future changes and challenges.

The recent IMO symposium in June 2013 discussed a wide range of issues impacting the future of ship safety. The participants recommended to the Maritime Safety Committee to consider how to improve data collection and increase its availability in order to support monitoring and development of safety regulations and to consider ways of encouraging a safety culture beyond mere compliance with regulatory requirements (IMO 2013). As explained in the earlier sections both aspects are very important for improving maritime safety.

ERRATA

This paper is an updated and revised version of (Berg 2013). The update takes into account recent activities and insights regarding human factors and safety culture, in the nuclear field but especially in the maritime area. Moreover, it reflects questions which arise at the TransNav 2013 Conference in Gdynia in June this year.

The revision of (Berg 2013) refers to the references of J. Lappalainen and his colleagues provided in the list of references below. I apologize that these basic contributions to the needs for an appropriate maritime safety culture - for reasons that are not comprehensible - were missing in the original paper (Berg 2013).

REFERENCES

American Bureau of Shipping (ABS) 2012. Guidance notes on safety culture and leading indicators of safety, January 2012.

Berg, H.P. 2008. Safety management and safety culture assessment in Germany. Proceedings of the ESREL Conference 2008, Safety Reliability and Risk Analysis: Theory, Methods and Applications, Vol. 2, Taylor & Francis Group, London, 1439 – 1446.

Berg, H.P. 2010. Risk based safety management to enhance technical safety and safety culture. Transactions ENC 2010 – European Nuclear Conference, May/June 2010.

Berg, H.P. 2011. Maritime safety culture. Proceedings of the XV International Scientific and Technical Conference on Marine Traffic Engineering, 12 – 14 October 2011, Akademia Morska, Szczecin 2011, 49 – 59.

Berg, H.P. 2013. Human factors and safety culture in maritime safety. Human Resources and Crew Manning – STCW, Maritime Education and Training (MET), Human Resources and Crew Manning, Maritime Policy, Logistics and Economic Matters – Marine Navigation and Safety of Sea Transportation – Weintrit & Neumann (ed.), CRC, Press, A Balkema Book.

Brun, W., Eid, J., Johnsen, B.H., Labertg, J.-C., Ekornas, B. & Kobbeltvedt, T. 2005. Bridge resource management training: enhancing shared mental models and task performance? In H. Montgomery, R. Lipshitz & B. Brehmer (Eds), How professionals make decisions, 183–193), Mahwah: LEA.

Caridis, P. 1999 CASMET. Casualty analysis methodology for maritime operations. National Technical University of Athens.

Canadian Nuclear Safety Commission 2012. Safety culture for nuclear licensees, Discussion paper DIS-12-07, August 2012.

Chirea-Ungureanu, C. & Rosenhave, P.-E. 2012. A door opener: teaching cross cultural competence to seafarers. TransNav, the International Journal on Marine Navigation and Safety of Sea Transportation, Vol. 6, Number 4, December 2012.

Chauvin, C. 2011. Human factors and maritime safety. The Journal of Navigation 64: 625–632.

Drouin, P. 2010. The building blocks of a safety culture. Seaways, October 2010, 4-7.

Chauvin, C., Lardjane, S., Morel, G., Clostermann, J.-P. & Langard, B. 2013. Human and organisational factors in maritime accidents: Analysis of collisions at sea using the HFACS, Accident Analysis and Prevention 59, 26–37.

Erdoğan, I. 2011. Best practices in near-miss reporting. The role of near-miss reporting in creating and enhancing the safety culture, Department of Shipping and Marine

technology, Chalmers University of Technology , Göteborg, Sweden, Report No. NM-11/21.
Gard 2012. Safety culture - incidents resulting from human error. Gard News 207, August/October 2012.
Goldberg, M. 2013. Proof that safety culture and training does work, April 29, 2013.
Håvold, J.I. 2005. Safety culture in a Norwegian shipping company, Journal of Safety Research, Vol. 36, 441-458.
Håvold, J.I. (2007) National cultures and safety orientation: A study of seafarers working for Norwegian shipping companies, Work & Stress, 21 (2):73-195.
Heijari, J., & Tapainen, U. 2010. Efficiency of the ISM Code in Finnish shipping companies, Report A 52, Centre for Maritime Studies, Turku.
Hetherington, C., Flin, R. & Mearns, K. 2006. Safety in shipping: The human element. Journal of Safety Research, 37, 401–411.
Hjorth, F. 2013. Safety culture in the Baltic Sea: A study of maritime safety, safety culture and working conditions aboard vessels, Baltic Sea Logistic and Transportation Problems – STCW, Maritime Education and Training (MET), Human Resources and Crew Manning, Maritime Policy, Logistics and Economic Matters – Marine Navigation and Safety of Sea Transportation – Weintrit & Neumann (ed.), CRC Press, A Balkema Book.
International Atomic Energy Agency 1991. Safety culture, A report by the International Nuclear Safety Advisory Group, Safety Series, No. 75-INSAG-4, IAEA, Vienna, Austria.
International Atomic Energy Agency 2002. Key practical issues in strengthening safety culture, A report by the International Nuclear Safety Advisory Group, INSAG-15, IAEA, Vienna, Austria.
International Atomic Energy Agency 2006. The management system for facilities and activities. GS-R-3 Safety Standards Series – Safety Requirements, IAEA, Vienna, Austria.
International Atomic Energy Agency 2009. The Management System for Nuclear Installations, Safety Guide No. GS-G-3.5, IAEA, IAEA, Vienna, Austria.
International Atomic Energy Agency 2013. Regulatory oversight of safety culture in nuclear installations. IAEA-TECDOC-1707, IAEA, Vienna, Austria, March 2013.
International Maritime Organization (IMO). 2008. International Safety Management (ISM) Code.
International Maritime Organization (IMO). 2013. Statement of the participants to the IMO Symposium on the Future of Ship Safety, 11 June 2013.
Kobylinski, L. 2009. Risk analysis and human factor in prevention of CRG casualties. TransNav, the International Journal on Marine Navigation and Safety of Sea Transportation, Vol. 3, Number 4, December 2009.
Kopisch, C. & Berg, H.P. 2012. The role of the regulator in the field of safety culture. Proceedings of the SSRAOC Workshop, Antwerp, Belgium, January 2012.
Lappalainen, J. 2008.Transforming maritime safety culture, Publications from the Centre for Maritime Studies, University of Turku , A 46, 2008, Kopijyvä Oy, Kouvola.
Lappalainen, J. 2011. Incident reporting in Finnish Shipping Companies. WMU Journal of Maritime Affairs, Vol. 10, no 2, pp. 167-181.
Lappalainen, J. & Salmi, K. 2009. Safety culture and maritime personnel's safety attitudes, Interview report, Publications from the Centre for Maritime Studies, University of Turku, A 48, 2009, Kopijyvä Oy, Kouvola.
Lappalainen, J., Vepsäläinen, A. & Tapaninen, U. 2010. Analysis of the International Safety Management Code, in: Efficiency of the ISM Code in Finnish Shipping Companies, Heijari, J. & Tapaninen, U. (Eds.), Publications from the Centre for Maritime Studies, University of Turku, A 52, 2010, Kopijyvä Oy, Kouvola.
Little, A. 2004. Driving safety culture, identification of leadership qualities for effective safety management. Final Report to Maritime and Coastguard Agency, Part 1, Cambridge, October 2004.
Lützhöft, M. H. & Dekker, S. W. A. 2002. On your watch: automation on the bridge. Journal of Navigation, 55(1), 83–96.
Mackay, M. 2000. Safer transport in Europe: tools for decision-making. European Transport Safety Council Lecture.
Madsen, O.M. 2011. A new look at safety culture. DNV Forum 2011 No. 2.
Martínez de Osés, F. X., & Ventikos, N. P. 2006. A critical assessment of human element regarding maritime safety.
Mauritzson, B. 2011. The masters' perception of the concept of maritime safety, an explorative study, Department of Shipping and Marine technology, Chalmers University of Technology , Göteborg, Sweden, Report No. NM-11/17.
Ministry of Transport and Communications. 2013. Preparation of a maritime transport strategy for Finland, Fact sheet 3/2013, January, 21, 2013
Oltedal, H.A. 2011. Safety culture and safety management within the Norwegian-controlled shipping industry, state of art, interrelationships, and influencing factors. PhD Thesis, University of Stavanger.
Parker, A. W., Hubinger, L. M., Green, S., Sargent, L., & Boyd, R. 2002. Health stress and fatigue in shipping. Australian Maritime Safety Agency.
Porathe, T. & Shaw. G. 2012. Working with the human element: human factors and technical innovation from EfficienSea and on to ACCSEAS, Proceedings of the International Symposium. Information on Ships, ISIS 2012, 30-31 August 2012, Hamburg, Germany.
Räisänen, P. 2009. Influence of corporate top management to safety culture, A literature survey. Turku University of Applied Sciences, Reports 88, Turku.
Rothblum A. 2000. Human error and marine safety. Maritime Human Factors Conference, Linthicum, MD, March 13-14, 2000.
Rusconi, C. 2013. Interactive training, a methodology for improving safety culture, International Experts' Meeting, on Human and Organizational Factors in Nuclear Safety in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant, 21 -24 May 2013, International Atomic energy Agency, Vienna.
Ryser, C. 2013. Implications of the Fukushima accident from a regulatory perspective, , International Experts' Meeting, on Human and Organizational Factors in Nuclear Safety in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant, 21 -24 May 2013, International Atomic energy Agency, Vienna.
Salas, E., Wilson, K.A., Burke, C.S., & Wightman, D.C. 2006. Does crew resource management training work? an update, an extension, and some critical needs. Human Factors 48 (2), 392–412.
Schröder-Hinrichs, J.-U., Hollnagel, E., Baldauf, M., Hofmann, S. & Kataria, A. 2013. Maritime human factors and IMO policy, Maritime Policy & Management: The flagship journal of international shipping and port research, 40:3, 243-260.
Storgård, J., Erdogan, I. & Tapaninen, U. 2012. Incident reporting in shipping, Experiences and best practices for the Baltic Sea, Publications from the Centre for Maritime Studies, University of Turku, A 59, 2012, Kopijyvä Oy, Kouvola.
The National Diet of Japan 2012. The official report of the Fukushima Nuclear Accident Independent Investigation Commission - Executive Summary. Available at: http://naiic.go.jp/wp-content/uploads/2012/08/NAIIC_report_lo_res5.pdf.
Transport Canada. 2009. The new wave marine safety strategic plan 2009–2015, TP 13111 (07/2009).