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Safety culture assessment and implementation framework to enhance maritime safety

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Abstract

Accident investigation reports attribute the majority of marine accidents to human and organizational factors. Significant efforts are made to eliminate these errors in the maritime industry, but after each catastrophic accident, the maritime industry adopts a reactive approach which results in new regulations and an excessive amount of paperwork. None of these efforts provide the desired safety level for the maritime industry. Currently, the maritime industry is starting to implement proactive approaches and has tried to avoid reoccurrences by implementing an appropriate safety culture. Safety culture is defined as "how an organization behaves when no one is watching". The safety culture approach describes humans as a means for improving safety rather than someone to blame for failure. A positive safety culture with commitment from all levels in the company can achieve the envisaged and required safety levels in the maritime industry.

This paper presents a novel safety culture assessment and improvement framework to enhance the maritime safety and introduces preliminary results of the safety climate assessment within a company. The proposed framework will collect seafarer's attitudes, leading/lagging indicators and key performance indicators to analyze a company's current safety culture level and address the weakest areas to enhance the level of safety accordingly. New strategies and action plans will be proposed to improve these vulnerable areas. The selection of safety indicators will be adjustable according to a company's specific needs and the available data types. Safety indicators have a crucial importance in gaining an insight into a company's safety performance. The safety culture improvement framework will provide a guided way for companies to perform gap identification on their safety level. A management tool will also be developed for shipping companies to analyze and observe their current safety culture level continuously. Implementation of the safety culture assessment framework is a long term process and it requires up to five years of continual effort to get the final results. The results section doesn't go beyond the assessment of safety climate and

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identification of the main differences between shore staff and crew members. In the next stages of the study, interviews and observations will be performed to validate the results of the questionnaire. More structured means of statistical analysis will be conducted to identify correlations between safety performance data and safety metrics.

1. Introduction

The term "Safety Culture" was first used after the Chernobyl accident in 1986 by the International Atomic Energy Agency (IAEA, 1986). Safety culture is a part of overall culture in organizations and it reflects shared belief and values amongst organizations. Safety Culture is basically defined as "how an organization behaves when no one is watching".

Safety Culture comprise of 5 significant level according to Taylor et al. (2011):
- **Pathological:** Employees only react to the safety matters not to get caught by regulatory compliance.
- **Reactive:** Employees do not follow the basic safety instructions. The importance of safety is understood only after a serious accident.
- **Calculative:** There is an effort within the company to collect the safety associated data and arrange regular audits. Employees have more understanding about "how the system works", but the data are not analysed to enhance safety.
- **Proactive:** This stage focus more on "what might go wrong in the future" instead of analysing occurrence data. The interaction between employers and employees increases.
- **Generative:** This is the most advanced stage a company can have. The company uses human errors to improve safety rather than apportion blame. There is a really good feedback and reporting system between all workers within the company. The company is always prepared for the unexpected.

Shipping is known as one of the most dangerous and international occupation in the world (IMO, 2012). The maritime industry has witnessed catastrophic accidents throughout the years such as Herald of Free Enterprise, Costa Concordia and Deep Water Horizon (Kurt, Arslan et al. 2015). Regulatory bodies developed the International Safety Management (ISM) code in order to avoid reoccurrence of these accidents. Unfortunately, the maritime industry traditionally adopted a reactive approach to eliminate these errors therefore none of these measures provide the desired level of safety. Recently, the maritime industry has started to adopt proactive approaches by developing an appropriate safety culture.

Some international bodies and associations have determined key specifications of safety culture and developed guidelines to improve it. The International Chamber of Shipping ICS (2013) defined three key features of an effective safety culture as below:

- A company can prevent all types of accidents and incidents which are an accumulation of unsafe acts or deviations from Standard Operation Procedures.
- Safety requires constant consideration by employees including all shipboard and shore personnel.
- Companies should target a zero accident policy and continually improvement.

Shipping is the most prevalent transportation type worldwide and accounts for 80% of all transportation (UNCTAD, 2012) and it plays a crucial role in maritime safety culture. Several efforts have been made to identify and analyze safety culture within the industry. They utilized different types of approaches to measure it. 1158 questionnaires were collected from Norwegian-owned tankers and analyzed by factor analysis (Håvold, 2010b). The study indicated that safety culture is affected by the ship owner, the vessel's flag, seafarer's occupation,

vessel's age and country of origin. However there was no significant difference between types of tankers. Studies showed that cultural and organizational factors have a significant impact on safety culture.

Håvold (2010a) developed a safety culture questionnaire in order to analyse the level of safety on fishing vessels by utilizing Principal Component Analysis (PCA). 209 fishermen participated in the survey and the results of the questionnaire demonstrated that the safety attitude of management has a crucial impact on a company's safety policy and age groups, vessel types and occupations have an influence on the safety attitudes of the fishermen.

Berg, Storgård, and Lappalainen (2013) demonstrated that communication, fatigue, language skills and intercultural cooperation have a crucial impact on shipping safety at an individual level. The study indicated that seafarers need proper training to understand other cultures and learn how to communicate with them effectively to enhance the maritime safety.

In another study, which was performed by Håvold (2005), a safety culture questionnaire, which included 40 items, was developed and distributed to seafarers and to attendants of a seminar in Manilla. Principal component analysis was performed on the collected 349 questionnaire data; results demonstrated that management attitude to safety, safety behaviour, knowledge, attitudes towards safety rules/instructions and employee satisfaction were the most crucial factors between 11 factors.

2. Methodology

The aim of the safety culture assessment and improvement framework is to identify the safety related problems of any shipping company, address the vulnerabilities and develop improvement strategies to enhance the maritime safety. After a detailed review of assessment tools in the maritime industry, ABS's safety culture assessment methodology was selected as the most appropriate method within the maritime domain to assess a companies' safety culture (ABS, 2011). Even though it was a successful implementation, several gaps in ABS's model were identified which should be developed further. Therefore, ABS's model has been accepted as a basis for our methodology and several modifications have been implemented to fill these gaps in order to capture the full picture. The main objective is to develop a safety culture assessment tool which covers all of the safety related aspects in a shipping company and measures will be taken proactively and reactively in order to enhance safety of the shipping industry. An overview of the assessment methodology can be seen in Figure 1.

There are four main levels in the proposed methodology:
- Questionnaires and interviews
- Objective proactive measure assessment
- Subjective proactive measure assessment
- Improvement methodologies and action plans

2.1. Safety climate assessment

Two online questionnaires have been developed to analyze the attitude of the employees in the company. Overall safety attitudes per demographic feature (age, gender, rank, and experience), ship, fleet and business unit are calculated at this stage. As part of the framework to improve the safety culture, the same questionnaires will be implemented in the company annually to see overall improvement and identify the problematic areas.

The overall results of each question and each factor will be compared between shore staff and crew members to identify the significant differences between them. Demographic analysis will be performed by utilizing the statistics software SPSS. The basic algorithm about question assessment is as shown below:

- Calculate the arithmetic mean of each statement for each vessel
- Calculate the arithmetic mean of each statement for shore-side
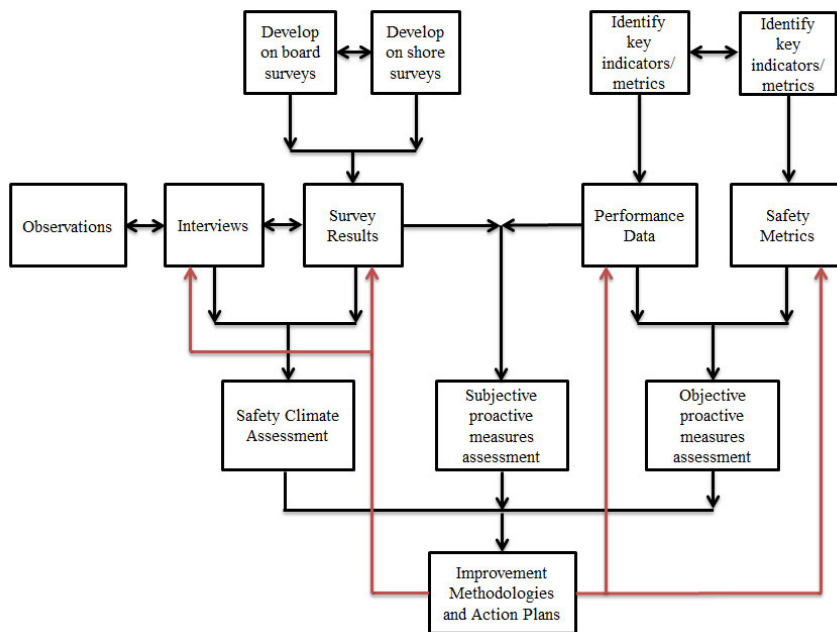- Calculate the arithmetic mean of each statement overall

Fig. 1. The proposed safety culture assessment and implementation framework.

2.1.1. Interviews

Interviews are crucial to validate survey results and receive reliable feedback from the participants of the surveys. Especially, crew members are more willing to share their opinions about safety matters at face to face interviews instead of filling surveys. Only 10% of the participants will participate in the interviews. Similar questions about safety factors will be asked at interviews to compare the general attitudes between them. The basic algorithm for interview assessment is as shown below:

- Average responses given to each statement will be analyzed
- Average responses on each safety factor will be analyzed
- Interview results and survey results will be compared

2.2. Objective proactive measure assessment

Numerous safety metrics and extensive amounts of safety performance data are required to perform successful objective proactive measure assessment.

Examples of safety metrics are given below:
- Number of safety management meetings
- Percentage of safety reports on which feedback was provided
- Number of familiarization training provided to crew

Examples of safety performance data are given below:
- Near miss frequencies
- Lost time incident frequency for the fleet
- Class society visit frequencies

First of all, each safety metric should be correlated with each set of performance data in the organization by utilizing spearman's rho rank correlation test. After organization level, the same metric will be compared with other sets of performance data in the business unit and at fleet level. There is a requirement to use five years of data in order to assess safety culture at the organization level, while one year of data will be enough to assess a business unit or at fleet level. This methodology will be implemented for each safety metric step by step to find all of the key correlations within the company. The results of these correlations will highlight whether or not the safety metrics are useful for improving the safety culture of a company. The correlations will also help to identify the metrics which do not contribute to anything with regards to safety.

2.3. Subjective proactive measure assessment

Both survey results and safety performance data are required in order to perform subjective proactive measure assessment successfully. The arithmetic means of each statement will be calculated for the vessels, for the business units and for the organization. The results of each statement will be compared with the safety performance data. The correlation results identify the effects of each statement on safety performance data and how safety culture attitudes are related to the performance data.

2.4. Improvement methodologies and action plans

After the identification of the vulnerabilities in a company, improvement methodologies will be developed to enhance the level of safety. Training will be provided to increase seafarer's knowledge and awareness of the factors that the employees achieved lower scores on. Surveys will be implemented until the required level of safety for all of the factors has been achieved in a shipping company. According to the adopted correlation method, significant correlations will provide insight into companies' problematic areas. By focusing on the important safety metrics which have been identified to have crucial impact on performance data, the company will be able to decrease accident ratios. Companies will also reduce their accident rates by identifying questions on which employees achieved lower scores, with the help of the correlations on subjective data (questionnaire results).

3. The questionnaire

The questionnaires were carefully developed with an interdisciplinary group to ensure that they capture the right information to conduct a comprehensive analysis. A detailed litreature review was performed not only in the maritime industry but also in other industries to identify the requirements of an appropriate safety culture questioonaires and assessment methods. Two online questionnaires have been developed, one for crew members and one for shore staff, in order to assess the safety climate of a company. Within the concortium,feedback elicited from experts was taken into account and numerous discusions have been held to identify companies' strengths and weaknesses by asking the right questions. Once the questionnaire was finalized, it was distributed to the colleagues in the department of Naval Architecture, Ocean and Marine Engineering who had seagoing experience in order to test the questioonaires. The required time to complete the questionnaire was also considered as a vital factor in order to get more results within a shipping company because It is a well-known fact that seafarers deal with excessive amount of paperwork and they don't want to spend their free time by filling questionnaires.Anonymity is treated as a crucial aspect within the design of the questioonaires in order to overcome the existing blame culture problem in the maritime industry The Likert scale has been applied and answers were organized as strongly disagree, disagree, neutral, strongly agree and do not know in the questionnaire.

Each safety factor has specific questions which try to address the employee's attitudes and perceptions amongst crew members and shore staff. There are a total of 85 questions which are asked to the employees, under the headings of communication, employer employee trust, feedback, involvement, mutual trust, problem identification, promotion of safety, responsiveness, safety awareness and training and competence.

4. Preliminary results

The aim of the surveys is to analyze strengths and weaknesses in the company and perform benchmarking between crew and shore staff's attitudes towards safety. Participants of the surveys were asked questions about demography, safety factors and open ended questions about company policies. The process of data collection is still on going and questionnaires will be accessible until sufficient data has been collected. According to the preliminary results 44% of the 70 respondents consist of crew members whilst 56% of them are shore staff. The questionnaires were distributed to 300 people and return rate is 23%.

4.1. Demography

The demographic features of the survey change between shore staff and crew members. 76% of the participants are male amongst shore staff, whilst all of the participants of the crew members are male. Female crew members constitute the minority of seafarers in the maritime industry. They also tend to work in shore facilities instead of on board ships.

Crew members are mostly younger than shore staff in the shipping company. The majority of the seafarers are between 25 and 30 years of age on board ships and account for 35%. The larger part of the shore staff are between 41 and 45 years of age and account for 28%. This also reflects well-known phenomena in the maritime industry that when crew members get older they want to transfer to shore-based positions for the sake of a more regular life.

Demographic features such as age profile can have an impact on specific safety behaviours of an employee. 2 tailed statistical correlation tests have been performed to identify impact of the age profile on two selected questions. Results show that even though, age profile doesn't have any impact on the question 1 "Language/dialect related issues amongst crew members are not a threat to safety" (ρ value =0.154) but vice versa, significant correlation has been found between age groups and employee's perceptions on question 3 "There is good cooperation between the ship and shore" (ρ value =0.017). This result shows that it is very difficult to make an overall assumption about the impact of a demographic feature on an employee's attitudes but it was identified that the age profile has an impact on several safety related attitudes.

58% of the crew members who participated in the survey work in the engineering department and 48% of the shore staff work in the crew department.

The majority of the seafarers are 2nd engineers (21%) and 3rd engineers (21%). 71% of the crew members have worked on container ships whilst only 16%, 10% and 3% have worked on bulk carriers, tankers and general cargo, retrospectively.

4.2. Safety factors

This questionnaire was distributed as a trial study to test the efficacy of it. The feedback was provided by seafarers and mangers and no amendments were suggested.

Table 1 demonstrates the overall safety scores of the company according to the survey results. It can be seen from the given table that shore staff have better safety attitudes and perceptions on several safety related factors than crew members. Shore staff achieved the best score on employer-employee trust with the 84.5 and the lowest one on responsiveness with 74. Crew members achieved the best score on involvement with the 79.5 and the lowest one on responsiveness with 71.5. Both employees got the lowest scores on responsiveness and therefore the company needs to invest some time and money to this safety factor in order to enhance the level of safety in the company. The second obvious fact can be seen from the table that crew members' scores are lower on all of the safety factors than shore staff. The company needs to focus on enhancing crew members' level of safety in order to improve this situation. Another striking result which can be obtained from the survey results that the biggest difference between crew members and shore staff is recorded with 8.3 percent on employer-employee trust. This clearly identifies a significant issue that even though shore staff thinks that there is a good trust between workers and managers, crew member's opinions are totally significantly different in this case.

Statistical analysis to identify differences between shore staff and crew members has been conducted for the all statements. Due to the high number of questions asked in the questionnaire, all of the results won't be given in this

paper. Mann Whitney U Test, which is very common method to compare groups in a non-parametric data, has been performed in order to identify statistical differences between shore staff and crew members on the question 3. ρ value has been found as 0.02 with a two tailed test with 95% confidence level. It can be concluded as there is sufficient evidence to reject the null hypothesis and therefore, a statistical difference has been found between shore staff and crew member on the question 3. This result identifies very crucial problem that how crew members and shore staff have different perceptions about safety and how they interpret the cooperation levels between each other.

This is an ongoing research project and statistical information will be provided to identify companies' strengths and weaknesses in detail for further improvement. The preliminary results given, identify the general perception and attitude differences between crew members and shore staff. In the objective proactive measures assessment section, safety related Key Performance Indicators (KPIs) will be correlated to gain insight into a company's significant safety performance drivers.

Table 1. Overall scores of shore staff and crew members.

Dimension	Scores for shore staff (%)	Scores for crew members (%)
1) Communication	82.56	75.7
2) Employer-Employee Trust	85.1	76.8
3) Feedback	84.5	77.3
4) Involvement	81.7	79.5
5) Mutual Trust	77.8	74
6) Problem Identification	77.2	76.6
7) Promotion of Safety	76.6	71.7
8) Responsiveness	74	71.5
9) Safety Awareness	78.7	77.1
10) Training and Competence	82.9	78.2
Av. score	80.11	75.84

5. The improvement strategies and action plans

The improvement strategies and action plan section focuses on the proper measures and methods which should be taken into account by every single manager and employee involved in a company. Regarding the weaknesses identified in the previous section for every single safety factor, measures and suggestions are proposed in order to enhance the level of safety culture in a shipping company. According to survey results the following actions are suggested on safety factors:

5.1. Communication

Both shore staff and crew respondents indicated that there are weaknesses regarding the language/dialect amongst crew members, which seems to be a threat to safety, as the exported score for this specific item, which is 54.8%, is nearly the half of the maximum score. This is a problem that many international shipping companies are suffering from, since they use multinational crews onboard the ships; and many past accidents occurred due to the inadequate communication and misunderstandings between the crew members. Thus, the company needs to take drastic measures in order to improve this weakness; in order to prevent any possible accidents or incidents from happening due to insufficient communication, enhancing in this way their safety culture.

- More sufficient training in understanding foreign culture is needed, for a more efficient cooperation and communication amongst crew members.
- Assessment of English language skills for crew members should be a prerequisite, before joining a ship.

5.2. Employer-Employee Trust

It is clear that the total average score of the shore staff responses is higher by 8.3% relative to the crew one. Generally, the results taken from shore staff responses are quite good, declaring that there is sufficient trust between the employer and his/her employees. On the other hand, a slight weakness seems to be apparent in trust between crew members and their managers. More specifically, this slight weakness is conspicuous to item 9 which corresponds to the existence of an effective system in place in order to fix procedures that are unworkable or impractical for crew use.

- In order to build trust between the employers and the employees, all crew members from different ranks and shore staff should be presented in safety meetings
- Establish a more effective workaround assessment system which will be able to fix all possible deficiencies in procedures which are unworkable or impractical for crew use.

5.3. Feedback

Shore staff seem to follow more faithfully the procedures required for an appropriate safety culture in the company, in comparison with crew members onboard.

- Managers of the company should encourage their crew members to report any unwelcome events in a timely manner, and to work together to find ways to avoid such events in the future, rather than inflict any heavy punishments on the responsible individuals.
- Seafarers should be provided with feedback about the results of the surveys which is a very common complaint by crew members

5.4. Involvement

This safety factor did not present any essential weaknesses except the fact that shore staffs from all departments and levels do not attend safety meetings. In order to overcome this issue;

- It should be established as a rule the compulsory involvement of all crew departments in safety meetings organized by the company. Possible infringements, without any serious excuse, should have some non-serious negative consequences (e.g. cutting bonuses).

5.5. Mutual Trust

Two important weaknesses have been identified through the analysis of "Mutual Trust" safety factor. The first weakness was "where the different background, culture and language of crew members seem to affect their performance" which shore staff and crew members scored 64.6% and 61.3% respectively. The second weak point was "when safety is concerned, junior crew members should not question a senior officer's decision" which had a score of 62.1% for shore staff and 56.8% for crew members.

- More sufficient training in understanding foreign culture as well as English language assessment and courses where required for a successful and efficient safety culture improvement.
- The company's newsletters should emphasize the great importance of mutual trust and its significant role in building a strong safety culture.
- Junior members should faithfully adhere to senior officer's instructions and decisions concerning safety, without feeling uncertain about them.

5.6. Problem Identification

According to the weaknesses revealed regarding the "Problem Identification" factor, the company needs to perform to some improvements as required for enhancing its safety culture.

- Further training of shore staff and crew members needs to take place, and especially on their specific automated equipment within their area of responsibility, in order to render an empowered and competent workforce, capable of operating the required equipment and systems without any complications, to identify potential problems and find the proper solutions for them.

5.7. Promotion of Safety

Three essential weaknesses have been detected through the analysis under "Promotions of Safety". Proposed corrective actions and suggestions are mentioned below:

- The company needs to gradually increase its attention towards safety annually and, the safety department needs to set targets of improving safety. This is an effective way to improve the standard operating procedures and seafarers' attitudes.
- The company should get involved in actions continuously and not occasionally or only when an accident occurs. Continuous involvement in safety actions diminishes the possibilities of engagement in accidents or incidents.
- The company needs to make too much noise about safety on a daily basis, in order to effectively promote the feeling and belief to it.

5.8. Responsiveness

Several essential weaknesses have also been identified through the "Responsiveness" safety factor. The following measures and suggestions intend to improve identified weaknesses in the company.

- All seafarers should strictly adhere to their work/rest cycle and the company should provide them with adequate rest time and facilities for rest, preventing them suffering from fatigue.
- The company should encourage crew members through various means (e.g. newsletters, briefings, meetings, discussion forum) to monitor each other for signs of stress of fatigue, that might affect their attention to safety.

5.9. Safety Awareness

In comparison with the rest of the factors, analysis of "Safety Awareness" has resulted in only one weakness. More specifically, it was detected that sometimes the rules concerning safety are bent to ensure a sailing goes ahead, when an individual or a community needs it.

- The company should promote crew members who follow the standard operating procedures strictly.
- Safety should always be the first priority. Companies or crew members shouldn't compromise safety for any reason

5.10. Training and Competence

The assessment of "Training and Competence" has identified a weakness within this factor. More particularly, an essential number of shore staff members seemed to be unsure whether crew members are trained to cope with fatigue. All bodies within the company should be aware of the importance of that training for providing suitable skills and competencies to employees to be able to face any potential risks threatening the safety culture.

6. Conclusion

There is a requirement for continuous consideration, effort and action to enhance the safety culture in a shipping company. The safety culture assessment framework requires commitment from all of the bodies in a shipping company for successful implementation. The results of the study indicate that in general terms, the company has quite a good safety standard, but also highlights several weaknesses. According to the result analysis, shore staff seem to adhere more faithfully and efficiently to the appropriate standards, conditions, procedures and attitudes in terms of the ten examined safety factors, in comparison to crew members, who need further efforts and hard work in order to enhance their safety culture. Crew member overall scores for every safety culture are approximately 5 points lower than for the shore staff. Insufficient training, communication issues due to multicultural crews onboard, the inadequate manning levels on the ships as well as the unsatisfactory provision of time of rest to the employees are detected as the main weaknesses in this study. By following the appropriate required procedures and standards, and by adopting some of the proposed measures indicated in the previous chapters of this paper, the executives constituting the company can feel pride in their well-built safety culture.

7. Future work

The developed surveys will be sent to other shipping companies to benchmark to effects of the different operation types on safety. In addition to the collected survey results, structured interviews and observations will be arranged with the crew members and shore staff. By utilizing the results of the surveys, safety metrics and safety performance data will be collected in shipping companies Without performing objective proactive measures assessment, the overall action plans cannot be identified due to the limitations of the subjective judgments The objective proactive measure assessment and the subjective proactive measure assessment will be conducted to identify significant correlations within the company data. These analyses will reveal the vulnerabilities of the company for further improvements. The methodology will be utilized annually to observe the improvements and hence problematic areas will be improved.

Acknowledgment

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