SEAHORSE PROCEDURE IMPROVEMENT SYSTEM - DEVELOPMENT OF INSTRUMENT

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ABSTRACT: Standard Operating Procedures (SOPs) have been used in almost every sector in order to improve operational safety and efficiency. The situation is not different in maritime sector, where SOPs are enforced through the regulatory framework in order to achieve safer shipping operations. Even though it is a regulatory requirement to develop and implement SOPs, it can be seen that during shipping operations these procedures are not followed due to various reasons. It was observed that one of the most common reasons for not following an SOP is due to poorly designed procedures, which are impractical, unclear or sometimes factually wrong. Therefore, these poorly designed procedures are disregarded by crewmembers, which not only prevent the practical implementation of SOP's during shipping operations but also devalue the importance of using SOPs. Therefore, it is of key importance that a systematic approach is needed to identify and improve the current SOP's as well as preventing potentially harmful workarounds. The EU FP7 SEAHORSE project is developing a "Procedure Improvement System" which can be actively used by the crewmembers any time anonymously. In order to achieve this, a comprehensive questionnaire has been developed and used to collect data from seafarers across Europe where they were asked to report on impractical SOPs and common workarounds conducted on board ships. This paper presents the instrument and initial results.

Keywords: SOP, Workarounds, Common Factor Analyses

1 INTRODUCTION

It was stated that maritime transport is 25 times riskier than air transport according to the accounts for deaths for every 100km travel (Berg, H. P., 2013). In the same paper, it was stated that operation of ships are subject to full of regulations, procedures and guidelines, which are expected to be adhered to by crew and officers. However, in some situations, instruction given to the bridge team may not be appropriate and may constitute supervisory violations as leaders find it difficult to adapt their instructions to changing situations due to possible poor safety culture. Similarly, (Darbra, R. M., et al, 2007) reports that coastal pilots in Australia and New Zeeland could not report hazards as much as they would like to due to the commercial pressure from the client shipping companies. Furthermore, a survey conducted reveals that 71% of port pilots in New South Wales and 62% of port pilots in Western Australia agreed that commercial pressure forces pilots working out-side established rules (Darbra, R. M., et al, 2007).

Moreover, International Safety Management (ISM) code, introduced in 1998, is aimed to bring self-regulation to the maritime industry. ISM is criticised due to it's bureaucratic nature as it forces seafarers to fill many forms and checklist resulting in seafarers' time and focus are taken away from working safely (Bhattacharya, 2012). ISM requires shipping companies to develop work procedures involving management of risks, maintenance of ships and equipment, emergency preparedness as well as reporting incidents, accidents and near misses while auditing the current systems. On the other hand, due to downsizing of workforce, seafarers are expected to be multi-tasking and work longer hours while having fixed and short term contract. In the same paper, however, survey with managers indicated that most common cause for accidents at sea was seafarers' non-compliance with SMS indicating seafarers' apathy towards following procedures (Bhattacharya, 2012). On the other hand, seafarers claimed that it is not the SMS but their skills gained through their long experience helped them to maintain shipboard safety.

Three types of errors identified by Reason (Reason, 1990) can be listed as Skill Based Performance, Rule Based Performance and Knowledge Based Performance. Rule based performance is the riskiest of all since rule breaking is seen as the contributory factor in most of serious incidents/accidents (Skalle, P. et al., 2014). Rule Based mistakes are done by the crew for a good reason as they do not intend to cause damage; people fail to apply the correct rule or procedure or expressed in another way, or implement an inappropriate rule and mostly caused by misjudging the problem (Skalle, P. et al., 2014). In same paper, following a procedure is classified as both rule based and knowledge base, and therefore requires a lot of judgement to adjust the procedure to specific situations.

Knudsen, F (Knudsen, F, 2009) states that efforts to improve safety resulted in increasing volume of regulations, control and paper work such as check-list, workplace assessment and risk assessment, and many seafarers view that these demands on seafarers are

imposed by people who do not understand anything about seafarer's life and work. Rule following in several cases is seen as counteracting work against the proper seamanship. This may be due to the not well-developed rules/procedures. Since humans are logical actors, deliberate additions and subtractions may be conceded irrespective of perceived risks in order to satisfy employers' demand for efficiency and productivity (El-Ladan, S.B and Turan, O., 2012).

Standard Operating Procedures (SOPs) are intended to provide a standardised means of working within a given organisation and is an attempt to make the system less dependent on human operators. However, to date, the envisaged impact of SOP's upon safety/accidents has not been achieved in the maritime industry. This may be attributable to the lack of standardisation between vessels, operations, environmental conditions, crew numbers and so on. Due to the lack of standardization between vessels and poorly designed Standard Operating procedures, measures introduced to eliminate the errors fail to sustain desired level of safety. Standardization is described as the accumulation of the efforts to prevent failures, which were revealed, based on accident investigations and the aggregations of learnt lessons from these accidents (Bieder and Bourrier, 2013). It is known that within the shipping industry the SOPs do not always match with operational realities and as such, seafarers, in some cases, deviate from the SOPs to complete their duties. These deviations conducted by crewmembers to overcome a problem or limitation presented by the SOPs, are hereby defined as 'workarounds'. In some cases workarounds can present more practical, clever and even sometimes innovative means of carrying out duties; however, they may also result in significant risks. Hence, a methodology is required to collect workaround data and to inform decision-making about potential improvements to the SOP.

This paper presents the instrument developed, as part of SEAHORSE project, for the collection of SOPs and their workarounds and demonstrates its validity for the purpose.

2 SEAHORSE QUESTIONNAIRE

The SEAHORSE project aims to capture current maritime workarounds through application of anonymous surveys. In the context of SEAHORSE project, a workaround is defined as a non-standardized shortcut of performing a given task. For the purpose of establishing the workarounds being practiced by seafarers, a SEAHORSE Questionnaire was carefully developed with an interdisciplinary group to ensure that it captures the information needed for further analyses. It consists of three main sections as depicted in Figure 1 and briefly explained in subsequent paragraphs.

Figure 1. Main Sections of SEAHORSE Questionnaire.

2.1 Section-1: Demographics

The first section of the questionnaire aims to collect demographic information about the respondents. However, it was ensured that anonymity of respondents is maintained, therefore, no personal information was collected which could lead to identification of the person. This section consisted of the questions related to:

- Role/ rank
- Seagoing experience
- Type of vessel on which service is being/ was rendered
- Type of shipping company operation
- Number of SOPs dealt with on daily basis
- Nationality

2.2 Section-2: Perceptions and Attitudes

The second section focused on capturing the perception and attitudes of seafarer where respondents were asked to agree or disagree with the given statements on a Likert Scale (i.e. never, rarely, some-times, often, always). All questions in this section had the option of 'Do not know'. In the subsequent analyses, this option was considered as missing value. The perception and attitude section is had questions related to:

- Design aspects of the SOPs
- Efficacies of the SOPs
- Training, competence
- Safety culture
- Employee-employer trust
- Matching procedures to operational reality

2.3 Section-3: Workarounds

The third and last section of the SEAHORSE questionnaire aims to collect the data of workarounds opted by the respondents, if any. The following questions are presented to the respondents in this section:

- Define existing SOP
- Define alternative adopted (workaround)
- Commonality of workaround
- Operation type
- Operation location
- SOP Impracticability

- Benefits of workaround
- Risks of workaround
- Risks of workaround

3 SUMMARY OF DEMOGRAPHICS

The SEAHORSE questionnaires were distributed to a wide range of seafarers by the project partners. A total of 453 survey questionnaires were returned by the respondents with 294 workarounds reported.

More than 65 % of participants who joined our survey reported workarounds and 65% of the workarounds reported stated that most or all crew members do the same workaround. More than 50% of workarounds were reported in deck operations while most workarounds reported are applicable to whole ship followed by Engine room and Navigation /communication control space workarounds. The workarounds were categorized under 108 group of workaround. Initial scan of the survey indicated that the most common workarounds are located in the areas of reporting paperwork, personal protective equipment, Work-Rest hours, navigational rules and standards, and Hot-Work and permit to work.

This section summarizes the demographic data collected through the SEAHORSE smart procedure survey.

3.1 Role/ rank summary

The role/rank distribution of the SEAHORSE smart procedure survey respondents is shown in Figure 2 below. It can be seen that most of the respondents are of officers' cadres with the majority being ships' masters.

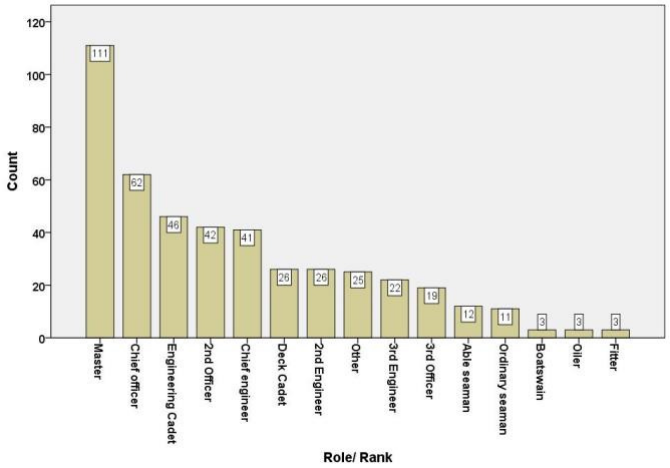

Figure 2. Role/ rank distribution of the SEAHORSE survey respondents

The above distribution may not be reflecting an unbiased sample (accounting for all seamen), but is a good representation of the seafarers dealing with SOPs most of the time.

3.2 Seagoing experience summary

The overall seagoing experience of the survey respondents is summarized in Figure 3 below. It can be observed from the figure that approximately 40% of the respondents are relatively new to the maritime sector with less than 5 years of seagoing experience. On the other hand, almost 35% of the respondents fall under the category of veteran seafarer with more than 15 years of seagoing experience. Thus, the questionnaire database is representative of seafarers with a vast range of seagoing experience, which is typical of the modern maritime sector.

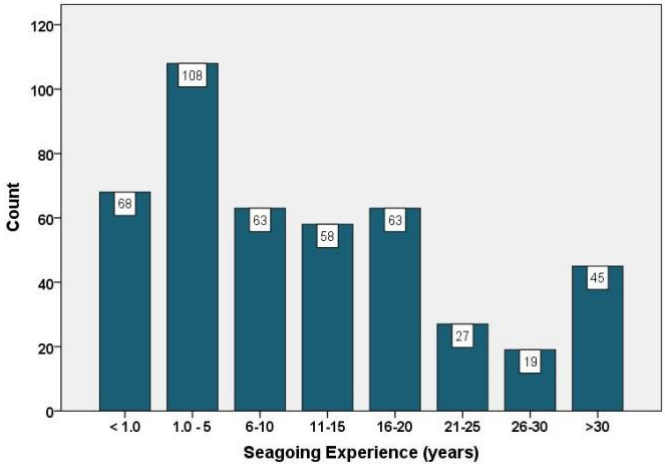

Figure 3. Overall seagoing experience of the respondents

3.3 Type of vessel summary

The distribution of most recent type of ship respondents were working on or had worked on previously is shown in Figure 4.

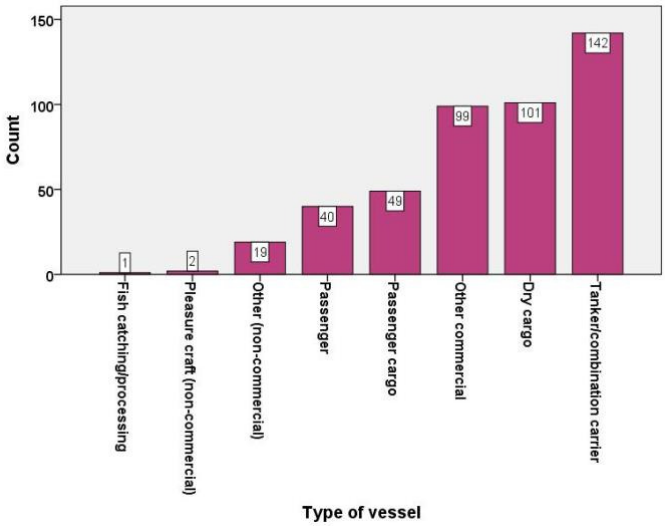

Figure 4. Distribution of respondents' vessel type

The majority of the respondents had experience of working on goods carriers. Almost 20% of the respondents returning the survey questionnaire have experience with working on passenger vessels. This distribution is also aligned with the typical distribution of marine vessels in the maritime sector.

3.4 Type of shipping company operation summary

Figure 5 depicts the distribution of type of shipping company operations. It can be observed from the figure that almost 55% of the respondents returning the survey questionnaire are involved in deep sea operations, which reflects prolonged stay at sea. Only, 35% respondents were involved in shortsea shipping operations.

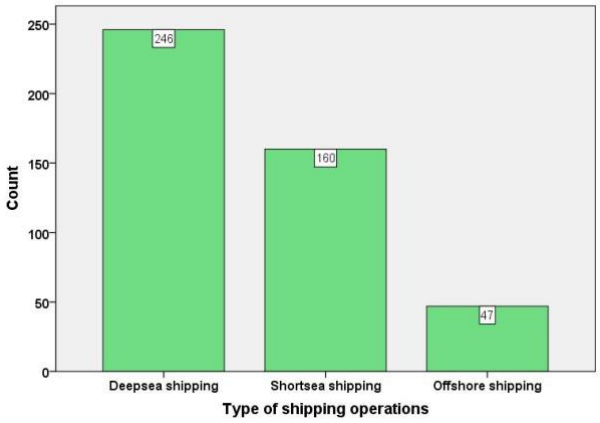

Figure 5. Distribution of type of shipping operations

The relationship between ship types and their typical operations can be seen in Figure 6 .

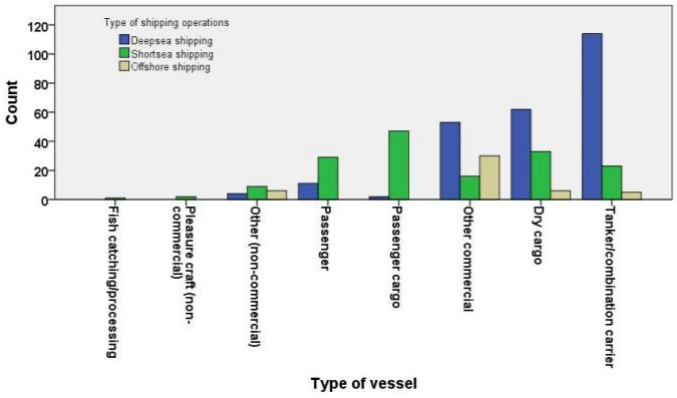

Figure 6. Ship type wise distribution of shipping operations

It appears from the above figure that goods carriers are mostly involved in deep-sea operations, whereas most of the passenger vessels are engaged in shortsea operations. This observation is also aligned with the typical operational profile of the ships in maritime domain.

3.5 Number of SOPs dealt with on a daily basis- summary

The distribution of SOPs handled on a daily basis by seafarers is given in Figure 7. It can be seen that around 40% of the respondents deal with more than ten SOPs on a daily basis.

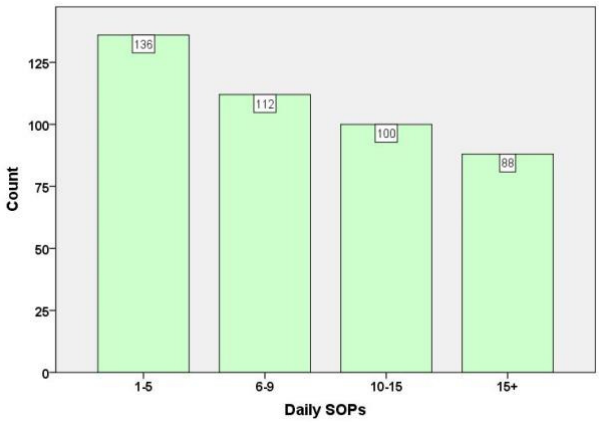

Figure 7. Distribution of SOPs handled on a daily basis

3.6 Attitudes Results

In the attitude section of the questionnaire, the intention was to measure the safety climate in the company. In total 48 attitude questions were asked and questionnaire was structured as below:

- Procedure Design
- Training, competence
- Safety Culture
- Employee – Employer Trust
- Matching Procedures to Operational Reality

Each heading has several questions to capture the general understanding of the seafarer about that specific area. There is a still big debate on what extend SOPs reflect the operational realities. Seafarers stated that majority of Standard Operating Procedures are factually incorrect. Also, seafarers are doubtful if SOPs really reflect the best way of working or even they make the operations less efficient as described in Figure 8 and 9

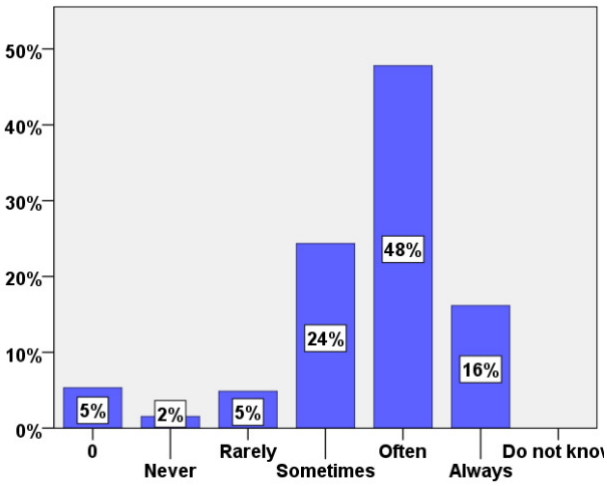

Figure 8 Job tasks and related procedures required to be followed on ships are factually incorrect

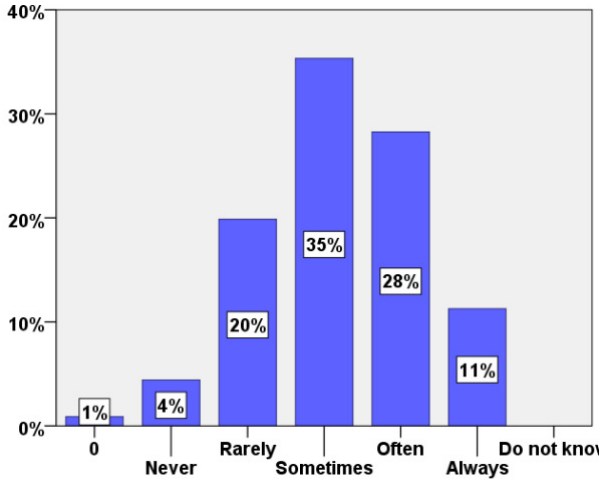

Figure 9 Some procedures that crew need to follow as part of their job tasks make the job less efficient

Significant efforts are invested to enhance competency of the crew members with appropriate and continues trainings by shipping companies to sustain desired level of safety. However, seafarers stated in the survey that they are not always trained on how to deal with unusual conditions, see Figure 10.

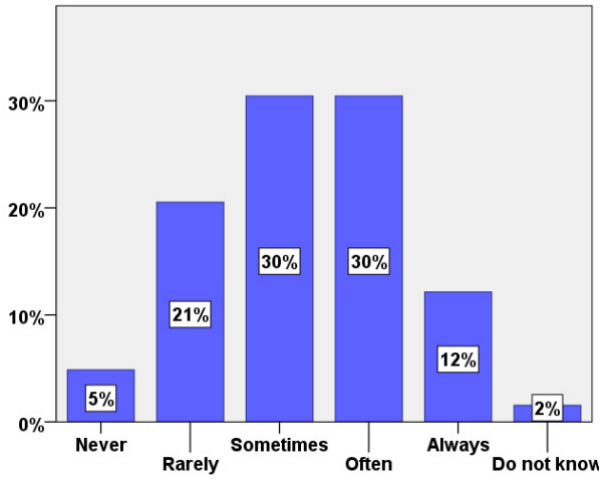

Figure 10 In our company crew members are trained on how to deal with unusual (infrequent) conditions

SOPs are introduced to maritime domain for every single task and for every crew member from different rank but many of them ignore following them and adopt their own alternative way due to many reasons.

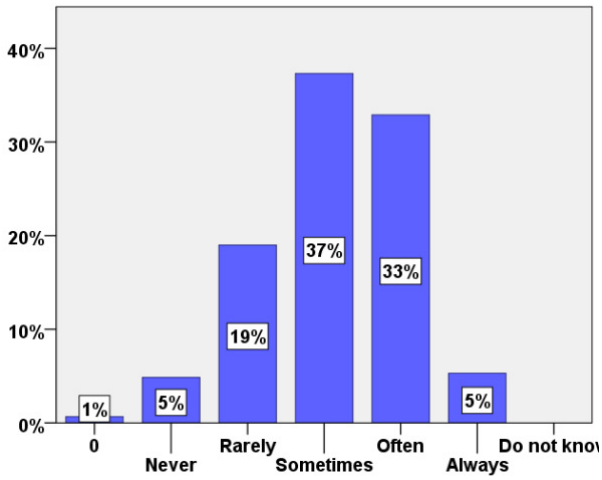

Figure 11 In shipping companies, it is common that procedures are not always followed.

Figure 11 illustrates that 37% of the crew sometimes follow the defined SOPs.

In order to establish a good employer – employee trust, there should be anonymous reporting system where crew member can report impractical SOPs to avoid possible risks to person, ship and environment. Figure 12 indicates that only 26% of the companies have this system in their SMS.

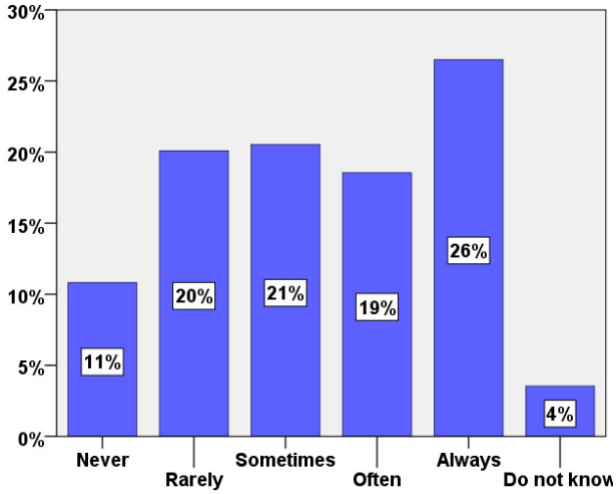

Figure 12. In our company, there are systems on board which allow crew members to report impracticable procedures anonymously.

Personnel Protective Equipment is extremely important for maritime operations to protect human from dangerous situations. Figure 3 shows that most of the people determined that they use PPE when it is required but workaround survey results show that ignoring the use of PPEs are very common in maritime domain.

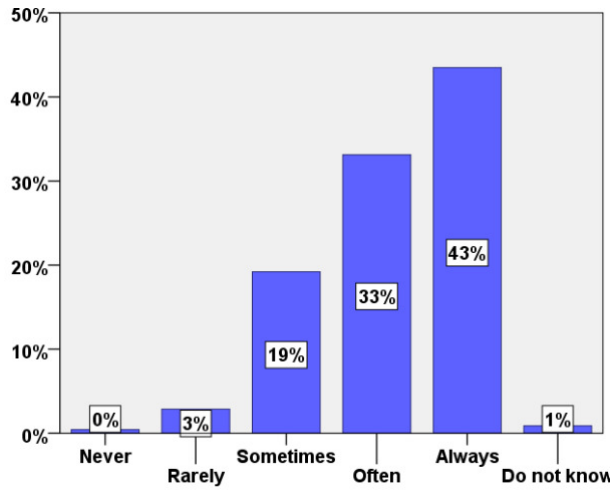

Figure 13 the members of our crew, use personal protective equipment when required.

4 RISK BENEFIT ANALYSES OF WORKAROUNDS

A workshop was held at the University of Strathclyde to facilitate evaluations of the collected workaround, by field experts. A total of 34 field experts participated in the workshop and were randomly divided into four groups to assess 107 valid workarounds

4.1 *Workarounds' evaluations by the field experts*

Each expert of a given group was asked to rate (using five-point Likert scale) the SOPs and their workarounds allocated to the group on the following:

- Efficacy of the workarounds
- Evaluation of SOPs' and workarounds' benefits in terms of (1) Practicality (2) Time efficiency (3) Cost efficiency (4) Regulatory compliance and (5) Safety
- Evaluation of SOPs' and its workarounds' risks in terms of (1) Risk to Person (2) Risk to Ship (3) Risk to Environment (4) Risk to Operation

4.2 Common factor analysis of risks and benefits of SOPs/workarounds

In order to condense the number of factors representing risks and benefits associated with the SOPs/workarounds, common factor analysis was carried out. A total of three latent factors of experts' evaluation of SOPs/workarounds were identified as summarized in Table 1 below:

Table 1 Latent factors of experts' evaluations.

S.No.	Factor	Subscale]
1.	Procedure pragmatism	a. Time Efficiency b. Cost Efficiency c. Practicality
2.	Procedure statutory compliance	a. Regulatory Compliance b. Safety
3.	Risk	a. Risk to Person b. Risk to Ship c. Risk to Environment d. Risk to Operation

4.3 *Summary of experts' evaluations of workarounds*

Experts' opinion on the following aspects of each workaround in comparison to corresponding SOP were analysed:

- Efficacy
- Pragmatism
- Statutory compliance
- Risks

It is worth mentioning that workaround efficacy was calculated as the percentage difference between the 'yes' and 'no' replies of all experts of relevant group. Also a studentised t-test was conducted to statistically validate the observed differences. For the remaining three aspects of SOP/workaround i.e. 'pragmatism', 'statutory compliance' and 'risks', the difference between mean scores of workaround and associated SOP was calculated and divided by 4 [5 (highest value) – 1(lowest value)] to establish percentage difference in the opinions of experts.

The percentage summary statistics of workaround efficacies are graphically presented in Figure 14 below. It can be seen from below figure that majority of workarounds (57.9%) were considered by the field experts to be beneficial. Around 40% were thought to be non-beneficial and only 2% were benign in nature.

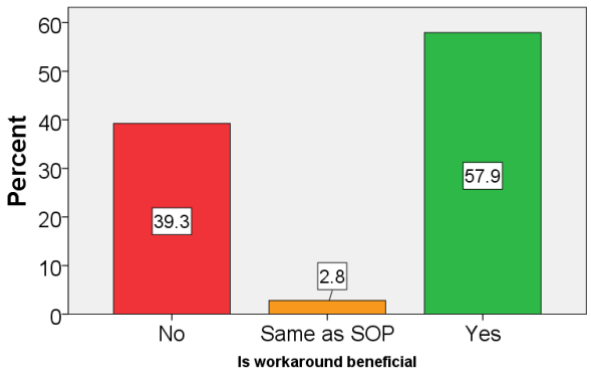

Figure 14. Efficacies of workarounds [N=107]

Figure 85 is depicting the percentage distribution of pragmatism of workarounds in comparison to SOPs.

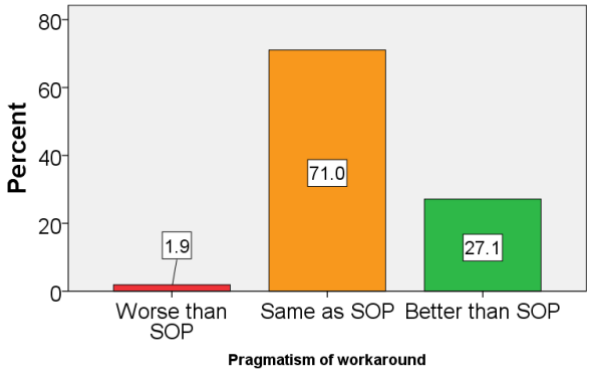

Figure 85. Pragmatism of workarounds in comparison with SOPs [N=107]

It is evident from above figure, that majority of workaround (71%) were considered by field experts to have similar practicality features as the original SOPs. Nevertheless, a reasonable number of workarounds (27%) did display better pragmatism than SOPs. The best workaround, displaying 61% improvement over SOP is summarized below:

Table 2 Example workaround reported against the SOP.

S.#	Description	Details
1.	SOP	Company procedure for agitating mud was not based on type of mud agitators and tank configuration on board with result procedure could not be used.
2.	Workaround	Used manufacturers' instructions along with a method of circulating mud that worked in practice.

It can be seen that this particular workaround is rather related to improvements that can be applied to the existing SOP. On similar lines, the workarounds displaying better practicality are mainly related to improvements in existing SOPs. Interestingly, around 2%

workarounds were considered to be worse than actual SOPs by the field experts. The summary statistics of statutory compliance features of workarounds in comparison to relevant SOPs is shown in Figure 16 below.

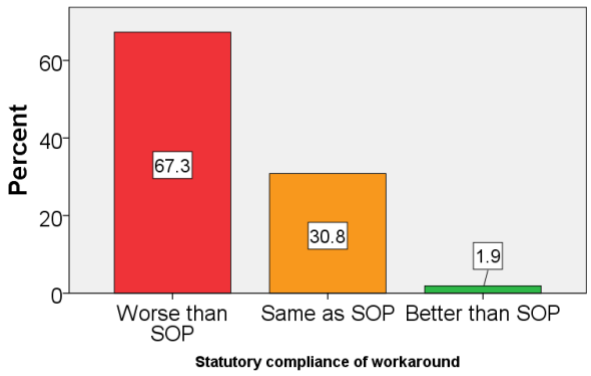

Figure 96. Statutory compliance of workarounds in comparison with SOPs [N=107]

It can be seen from above figure that more than 2/3 workarounds were considered to be worse than corresponding SOP when it comes to compliance with statutory regulations. Here, the worst case (83% decline) is reproduced below:

Table 3 Example workaround reported against the SOP

S.#	Description	Details
1.	SOP	Enclosed space entry requires SCBA (self-contained breathing apparatus), harness and resuscitator to be placed at entrance.
2.	Workaround	Crew often disregard placing SCBA, harness and resuscitator at entrance.

It goes without saying that this procedure is likely to be a serious safety hazard for the crew members and must be avoided on all cost.

Lastly, the risks' comparison of workarounds with SOPs are summarised in Figure 107 below.

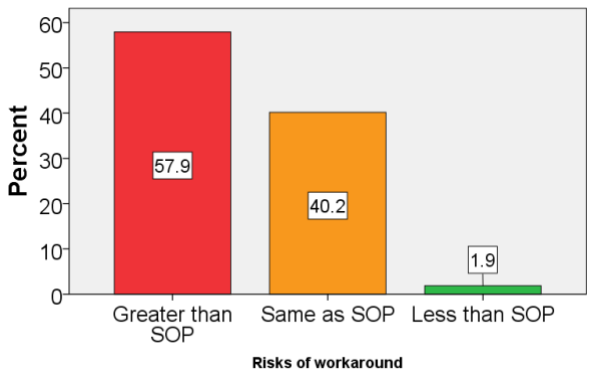

Figure 107. Risks of workarounds in comparison with SOPs [N=107]

It is evident from above figure that in the opinions of field experts, more than 57% workarounds pose greater risks than the actual SOPs. Here, the worst case (46% decline over SOP) is reproduced below:

Table 4 Example workaround reported against the SOP

S.#	Description	Details
1.	SOP	Drills should be conducted as per schedule
2.	Workaround	Drills often are not conducted

Various drills on board marine vessels play vital role for life saving in case of any unfortunate event. Thus, it is not surprising that evaluators found this workaround to SOP as a great increase in risk for the crew, especially, considering the modern trend of frequent crew rotations. Almost, 40% workarounds were considered by the field experts to have similar risks level as those of the original SOPs.

5 SEAHORSE PROCEDURE IMPROVEMENT SYSTEM

The improvement of SOPs is one of the main focal points in many sectors and companies have made considerable efforts to do so. Several shipping companies regularly review their SOPs and try to identify impractical SOPs and appropriate means to improve them. However, the maritime industry, to date, has not developed any workaround management tool in the maritime industry.

SEAHORSE Procedure Improvement System (PIS) Methodology aims to develop a comprehensive methodology to capture workarounds performed by seafarers within a company, assess them and compare them to SOPs in order to find the most effective and safe way of working. A small group of expert reviewers is assigned by the company to assess the workaround and SOP as described in section 6. All assessments are aggregated into a result that captures how much better (or worse) a specific workaround is than the SOP. These results are then distributed within the company.

The SEAHORSE PIS has also been developed in a software-based platform for the purpose being to ease the work of the managers and improve SOPs in a structured way. Its implementation will facilitate the improvement of SOPs and identify the number of impractical SOPs. Considering that the maritime industry is based heavily on SOPs, the adoption of this methodology will have a significant impact in terms of safety.

SEAHORSE PIS, developed to support the collection, assessment and decision making related to workarounds

practiced in the maritime industry. A general overview of the methodology is shown in Figure 18. The methodology consists of three main stages: 1) gathering of workaround data and development of attributes, 2) ranking and selection of alternatives various techniques and 3) final decision-making by administrator and feedback provided to seafarer and reviewers.

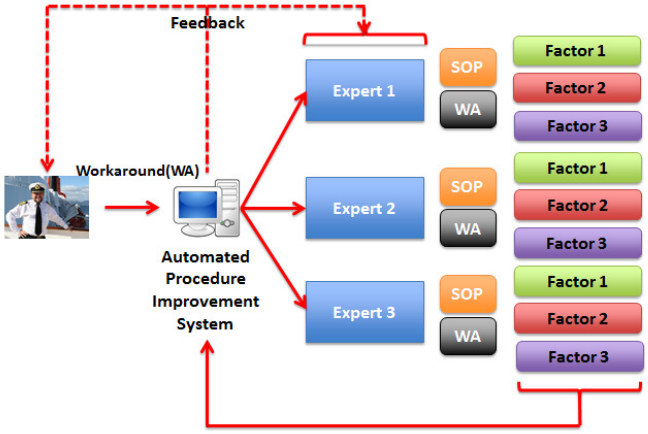

Figure 118. SEAHORSE Procedure Improvement SYSTEM

The SEAHORSE PIS is a pioneering methodology, which has been tested by shipping companies and are being utilised to improve and develop SOPs. System is available online and can be deployed using computer, tablets and smartphones, allowing shipping companies to bring the experts together in virtual environment. This allows very quick assessment, response and implementation opportunities. The tools could also be utilised within other domains such as the aviation industry

6 CONCLUSIONS

SEAHORSE project has developed a very comprehensive original survey instrument that could be easily used by maritime industry to evaluate and decide upon the workarounds being followed by seafarers on marine vessels.

In the absence, of a priori hypothetical factors being measured by the survey instrument, exploratory factor analysis (EFA) technique was used to unearth the underlying factors being recorded by the SEAHORSE smart survey questionnaire. EFA revealed that a total of nine latent factors (SOP Usefulness, SOP Accuracy, SOP Practicability, SOP Phraseology, Training, Safety SOP Implementation, Assuring Confidentiality, Abiding Rules, and Discipline) exist in the first two sections. Whereas, only three (Procedure pragmatism, Procedure statutory compliance, and Risk) could be identified in the last section.

The survey tools developed as part of SEAHORSE project can be used to assess and decide upon usefulness, pragmatism, statutory compliance and risks of workarounds being followed by seafarers. In case of positive outcome SOPs may be reviewed or measures to be undertaken to curtail workarounds in case these are found to be hazardous

REFERENCES

Berg, H. P., 2013 'Human Factors and Safety Culture in Maritime Safety, The International Journal of Marine Navigation and Safety of Sea Transportation, Volume 7, Number 3

Bhattacharya, S., 2012 'The effectiveness of the ISM Code: a qualitative enquiry', Marine Policy, 36, pp: 528-535, 2012.

Bieder, M. C., & Bourrier, M. (Eds.). (2013). Trapping safety into rules: how desirable or avoidable is proceduralization?. Ashgate Publishing, Ltd..

Danish Maritime Authority, 2013, 'Survey on Administrative Burdens Among International Seafar-ers', Final Report – International Seafarers

Darbra, R. M., Crawford, J. F. E., Haley, C. W., Morrison, R. J., 2007, ' Safety Culture and hazard risk perception of Australian and New Zeeland maritime pilots, Marine Policy 31, pP: 736-745

Delcore, H. (2009) Can't you just ask people? TheAnthroGuys. Retrieved 2014-08-08 Source: http://theanthroguys.com/2009/09/17/can%E2%80%99t-you-just-ask-people/

Dimitrova, D. N. (2010). Seafarers' rights in the globalized maritime industry (Vol. 75). Kluwer Law International.

El-Ladan, S. B. and Turan, O.,2012, ' Human relia-bility analysis—Taxonomy and praxes of human entropy boundary conditions for marine and offshore applications', Journal of Reliability Engineer-ing and System Safety, 98, pp: 43-54

Field, a. 2013. Discovering statistics using IBM SPSS statistics, Sage

IMO. "Maritime Safety." from http://www.imo.org/OurWork/Safety/Pages/Default.aspx

Knudsen, F., 2009, ' Paperwork at service of safety? Workers' reluctance against written procedures ex-emplified by the concept of 'seamanship', Safety Science, 47, pp: 295-303

Reason, 1990., 'Human Error, Cambridge Universi-ty Press, Cambridge

Skalle, P., Aomodt, A., Laumann, K., 2014, 'Inte-grating human related errors with technical errors to determine causes behind offshore accidents', Safety Science, 63, pp: 179-190

Wilcoxon, F. 1945. Individual comparisons by ranking methods. Biometrics bulletin, 80-83.