SEAHORSE Procedure Improvement System

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ABSTRACT

Standardisation of operating procedures has been used in variety of different sectors with the aim of achieving more reliable operations hence operational safety. Likewise, Standard Operating Procedures (SOPs) have been adopted by the maritime sector and enforced through the regulatory framework in an attempt to achieve safer shipping operations. Despite the fact that regulations enforce the SOPs, it is often observed that during shipping operations these procedures are not followed due to various reasons. One of the most common reasons for not following the SOPs is because shipping companies suffer from poorly designed procedures, which are impractical, unclear or sometimes factually wrong. These poorly designed procedures are disregarded by crewmembers, which prevent the practical implementation of these SOP's during shipping operations. 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 will be actively used by the crewmembers any time anonymously. In order to achieve this, over 400 questionnaires have been collected from seafarers across Europe where they were asked to report on impractical SOPs and common workarounds conducted on board ships. These questionnaires were organised and a risk benefit analysis was conducted. This paper will report the initial results, as well as demonstrating the overall methodology for the SEAHORSE Project's procedure improvement system.

INTRODUCTION

Maritime accident investigations indicate that human factors are attributed to most of the accidents. So far, the dominant approach taken to overcome and manage this root cause of accidents is the development of a set of Standard Operating Procedures (SOPs). These 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 aforementioned factors, together with poorly designed SOPs, 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. Deviations conducted by crew members to overcome a problem or limitation presented by the SOPs, are hereby defined as 'workarounds'. In some cases workarounds can present smarter means of carrying out duties; however, they may also result in higher risks. Thus, a methodology is required to collect workaround data and to inform decision-making about whether to make amendments to the SOP.

This paper presents a methodology to perform a risk-benefit analysis between a SOP and its workaround to support decision-making. The methodology can be summarised as follows. Seafarers anonymously submit workarounds in the form of a questionnaire. Seafarers identify and provide details of the workaround being practiced on-board vessels. To assess a SOP and a workaround, a group of experts are asked to rate the workaround based on a number of pre-defined attributes. The uncertainty and vagueness of the selection between alternatives (SOP or workaround) problem leads to the use of the Fuzzy Multiple Attribute Group Decision Making (FMAGDM) method to provide an assessment of the two alternatives (SOP and workaround). This method is employed to compare current SOPs and maritime workarounds and provide a value of how much better one alternative is over the other. The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) Method is utilised to find the best alternative between SOP and workaround. Results from the group of experts are provided to the administrator/decision maker. The administrator/decision maker considers the outcome of the comparison and a decision is made regarding the workaround. Feedback of the review is provided to every member of the organisation, thus closing the loop.

The methodology was tested on 107 workaround cases in a workshop. To date, the methodology has received positive feedback from experts in the maritime industry and the need for a methodology which collects, assesses and supports decision making in the organisation is clearly required.

Furthermore, the methodology can also be easily adapted and applied in other areas such as the aviation industry.

MARITIME STANDARD OPERATING PROCEDURES

Shipping is commonly regarded as one of the most dangerous industries in the world and according to the IMO, there is the necessity of a set of international regulations to be followed by shipping organisations, globally, to improve safety. Importantly, the IMO has taken steps to prevent ship operators cutting expenditure at the cost of shipping safety (IMO 2012). A series of incidents representing significant potential impact of shipping accidents is given in Hetherington et al. (2006). Most importantly they conclude that increased work load and deviations from standards may lead to huge repercussions.

In order to comply with International Safety Management (ISM), each shipping company has its own safety management system (SMS). SMS is widely used across industries to help direct companies to take a systematic approach to managing safety within their organisation. However, Mearns et al. (2013) recognise that a SMS without a suitable level of organisational culture does not fulfil the objective. Bhattacharya (2012) observes that there is a significant gap between the mangers' and seafarers' perceived meaning of the ISM code thus leading to a gap between the intended purpose of the code and the way in which it is operationalised in daily seafaring.

Mearns et al. (2013) note: "... *safety culture and safety management go hand in hand to achieve safe practices in an organisation. One is less tangible than the other is, but both are required. If there is only an SMS but no real commitment to safety, then the SMS will not be effective, as decisions will not really prioritise safety, and the SMS will be merely a 'paper exercise'. Similarly, if there is a good safety culture but no SMS, then in a complex organisation the way safety is applied runs the risk of being inconsistent, under or mis-resourced, and not seen as business driven (because it will not be part of the business plan)*". The aforesaid highlights that although processes can be formalised within a company, should the company not implement these processes properly, they are a waste of time and resources.

The above provides a basis for the necessity of a continual review of SOPs within shipping organisations. There is a fundamental need that this continual review is partnered with a good communication flow. Clearly, there is a need of communication between workers and management to discuss safety aspects and issues within the SOPs. Indeed, the involvement of seafarers in the review and development of SOPs will increase their respect and adherence to the SOPs. However, any rejection of proposed workarounds has to be adequately communicated to seafarers in order to avoid loss of interest and confidence in the system.

SEAHORSE PROCEDURE IMPROVEMENT SYSTEM (SPIS)

SEAHORSE procedure improvement system (SPIS) 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. 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. SPIS has been embedded in a software-based platform to ease the work of the managers and improve SOPs in a structured way.

A general overview of SPIS is shown in Fig. 1. It consists of three main stages: 1) gathering of workaround data and development of attributes, 2) ranking and selection of alternatives using FMAGDM and TOPSIS and 3) final decision-making by administrator and feedback provided to seafarer and reviewers.

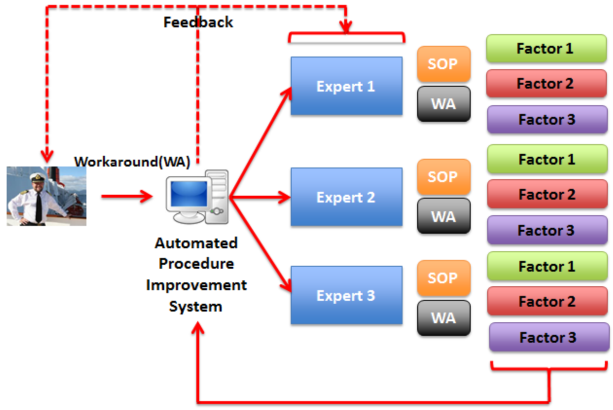

Fig. 1 Overview of SEAHORSE Procedure Improvement System (SPIS)

SPIS is a pioneering system that could also be applied to other kinds of problems already existing in the maritime industry. Additionally, it could also be utilised within other domains such as the aviation industry.

Stage 1: Identification and Review of Workaround

The blame culture is still a predominant factor in the maritime industry and seafarers are reluctant to share information about workarounds because they fear of negative repercussions (Ek* & Akselsson 2005). A questionnaire was developed to anonymously collect appropriate data related to the workaround and SOP from the seafarer. SPIS questionnaire composed of two distinctive parts: 1) demographics and attitude section and 2) workaround section. The structure of workaround section within SPIS questionnaire is shown in Fig. 2.

To begin with, seafarers are expected to give a brief description of the SOP from which they deviate, also the participant is required to provide a description of the workaround being practiced. This is done to provide a written account of the alternative means of carrying out the task to facilitate reviewers in comprehending and assessing the workaround.

The workaround frequency question aims to identify how often a workaround happens amongst seafarers. The identification of common deviations is a clear warning that a SOP is not being followed, suggesting that there are potential issues with the SOP. At the same time, this question also provides insight into whether there may be challenges if the workaround needs to be prohibited.

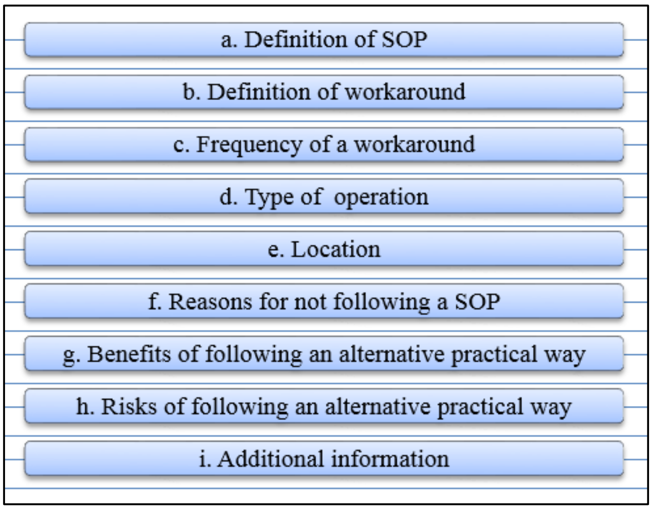

Fig. 2 Structure of workaround question within SPIS questionnaire

It was expected that certain type of operations may incite workarounds, thereby seafarers were expected to identify it along with the location onboard where such operation was being undertaken. There are always several reasons why SOPs are not working effectively in the maritime industry. Therefore, it is vital to capture the reasons behind the deviations from SOPs. This allows insight into the seafarer and potential issues with the existing SOP.

Presumably, SOPs are designed to describe the best way of working, however, sometimes seafarers may identify smarter, more efficient ways of performing the same task without compromising safety. The identification of the benefits allows the seafarers to express why the workaround is being deviated from, showing the positive reasons.

Naturally, there are possible risks associated with performing the task in the alternative way. In order to gain insight into the risks, the seafarers are asked to give their own account of the possible risks associated with the workarounds. Lastly, any additional information worth considering for the review of SOP is enquired.

To summarise, the above questions allow seafarers to provide a description of both workaround and SOP along with associated information including their perceived risks and benefits of performing the workaround. Open-ended questions were determined as most suitable for this questionnaire as it was identified that seafarers would have to detail many aspects to allow assessment in the second stage of the methodology by the experts. The questionnaire purposely has a limited number of questions to encourage the reporting of the workaround and reduce the time required to complete the questionnaire. It however does elicit sufficient information needed for the subsequent assessment.

The second aspect of this stage is the development of a set of attributes to measure the workaround. Measuring the subjects like health, safety and environment is not easy and requires some measures to gain insight into company systems (Groeneweg et al. 2013). The performance of shipping companies is typically evaluated by key performance indicators (KPIs). Decision makers need several attributes to assess problems and come up with a result. In SPIS, nine attributes were selected to evaluate the performance of workaround according to safety critical performance drivers. An expert workshop was arranged to identify the most important attributes for SOP & workaround benchmarking process. In that, five attributes were defined as benefits, which try to identify advantages of performing a workaround. The other four attributes were defined as risks which may arise with the implementation of a workaround. The list of selected attributes is shown in Fig. 3.

Fig. 3 The list of attributes

Safety is paramount in the maritime domain. In order to maintain safety of shipping, many regulations came into force including: International Convention for the Safety of Life (SOLAS), International Convention for the Prevention of Pollution from Ships (MARPOL), Convention on the International Regulations for Preventing Collisions at Sea (COLREG), International Convention on Loadlines (LOADLINE), The International Ship and Port Facility Security Code (ISPS), The International Safety Management Code (ISM) International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, (STCW) and lastly, The ILO Merchant Shipping (Minimum Standards) Convention (ILO) (ICS 2015).

Practicality attribute aims to elicit the expert's opinion whether the proposed workaround may provide more benefits to the practicality of an operation compared to the existing SOP. Here, practically is "the quality or state of being practical". A SOP can be safe, cost effective etc.; however, it may not be practical and may induce operational difficulties. Seafaring is known as one of the hardest occupations with an excessive workload. Therefore, SOPs and work instructions should be prepared in a practical and user-friendly way to decrease the workload.

Time efficiency attribute is meant to establish the expert's opinion whether proposed workaround may make a shipping operation more time efficient compared to the existing SOP. Shipping companies operate at a very tight schedule and need to deliver their cargo in a limited time. Due to the long and exhaustive work hours, seafarers sometimes come up with time efficient solutions to ensure they have the specified rest hours.

Cost is a crucial parameter not only in shipping but also in other industries. Companies always try to decrease their investment or maintenance costs by implementing smarter technologies or conducting shipping operations effectively. Cost effectiveness can be achieved in a company by utilising fewer resources such as labour, time or equipment. Therefore, companies promote seafarers' cost effective solutions on daily basis without putting safety at stake.

Regulatory compliance is essential to maintain safety within the maritime industry. Shipping companies put enormous effort to comply with international regulations. Complying with the rules not only increases the safety and reputation of a firm but also protects from costly fines. Companies, who are successful at regulatory compliance, can avoid catastrophic accidents undoubtedly. The International Maritime Organization (IMO) is known as the biggest regulatory body in the maritime industry. The IMO made the International Safety Management Code (ISM) mandatory after the accident of Herald of Free Enterprise to avoid reoccurrence of these accidents (Goulielmos & Goulielmos 2005).

'Risk to person' attribute aims to extract the expert's opinion whether proposed workaround may create more risks to person's health and safety compared to the existing SOP. Numerous casualties and injuries occur because seafarers do not strictly follow the SOPs and are performing risky workarounds. All risks associated to human should be eliminated or reduced to a level that is as low as practicable on board ships to avoid such circumstances.

Around 90% of the goods transportation is seaborne and shipping is very complex and high risk environment. The shipping industry had catastrophic accidents throughout the years such as Herald of Free Enterprise, Costa Concordia and Deep Water Horizon. Risks to ships should be eliminated or reduced appropriately to avoid occurrences of such accidents. A total ship loss with numerous casualties is the worst scenario a company can have, therefore, there are various detailed SOPs to maintain safety on critical operations such as fire protection, manoeuvring, etc. A tragic accident can also affect company's image negatively and may even lead to bankruptcy. Considering the aforementioned factors above, risk to ship is a very important factor that affects SOP development.

Risk to environment attribute aims to elicit the expert's opinion whether the proposed workaround may create more risks to environment (such as oil spills, gas/chemical waste, garbage, etc.) compared to the existing SOP. Once there is an oil spill at sea, even though the prompt actions take place after these events, the residuals keep contaminating the marine environment. Scientists found subsurface oil residues twenty years after the Exxon Valdez accident (Boehm et al. 2011). Besides the oil spills, emissions of CO_2 emissions and other wastes also constitutes a great threat to the environment.

Shipping is known as a very complex occupation and in order to ease the complexity, the workload is broken down into different shipping operations such as manoeuvring, bunkering, cargo loading and mooring, etc. Each shipping operation require different types of expertise and high degree of situational awareness. It is crucial to consider all hazards a shipping operation might have. Risk assessment should be carefully conducted in order to address all types of risks of a specific operation.

Stage 2: FMAGDM Method for Ranking and Selection of Alternatives

In order to compare the workaround and the SOP, SPIS has adapted the Fuzzy Multiple Attributive Group Decision Making (FMAGDM) method proposed and outlined by Ölçer and Odabaşi (2005). This method consists of three distinct states, namely (1) the rating state, (2) the attribute based aggregation state and (3) the selection state. A visual representation of the FMAGDM methodology is shown in Fig. 4.

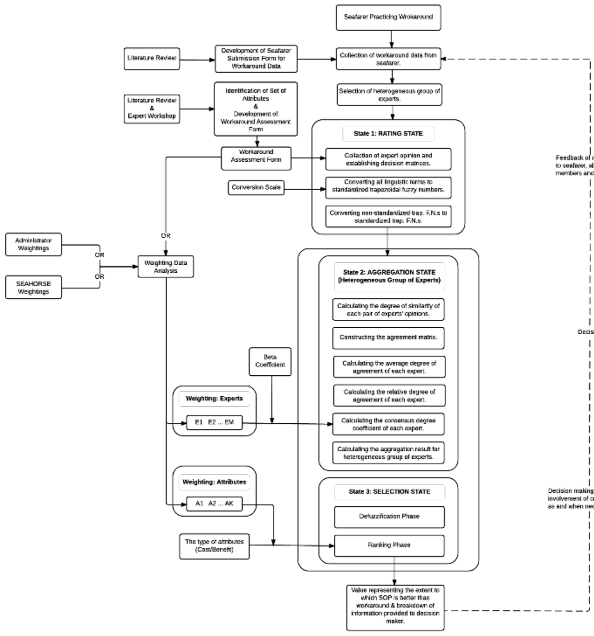

Fig. 4 Overview of FMAGDM methodology

This method leverages reviews by experts, which are elicited through an established workaround assessment form to provide an assessment of the workaround based on a number of attributes. Reviewers/experts are defined as individuals with substantive knowledge of a given area. In order to identify appropriate experts in the organisation the questionnaire completed by the seafarer categorises the workaround into one of four operations: deck operations, cargo operations, engine room operations and bridge operations. Experts are categorised as having expertise in one of the four categories and experts are internal within the organisation. Experts are given workarounds to assess based on their expertise decided by the administrator.

Table 1 Experts rank the attributes to determine the weighting of the attributes

	1. Very Unimportant	2. Unimportant	3. Neither	4. Important	5. Very Important
Practicality					
Time Efficiency					
Cost Efficiency					
Regulatory Compliance					
Safety					
Risk to Person					
Risk to Ship					
Risk to Environment					
Risk to Operation:					
Other:					

Experts are firstly asked to rate the workaround with respect to each attribute using a Likert-type scale (very unimportant, unimportant, neither important nor unimportant, important, and very important), thus giving an assessment in linguistic terms as shown in Table 1.

Naturally, each expert has different levels of expertise across the attributes (for instance one expert can have more knowledge about safety but has less knowledge about compliance). Therefore, it is important to have different knowledge levels on each attribute and to utilize heterogeneous group of experts in the aggregation. In the aggregation process, the person calculated as having the most expertise was weighted as "1" and others were compared and weighted relatively with this person. The linguistic terms were converted to standardised trapezoidal fuzzy numbers because linguistic terms are not mathematically operable. Established conversion scales exist in the conversion of fuzzy data to fuzzy numbers (Chen et al. 1992). The conversion scale used in SPIS is shown in Table 2.

Table 2 Selected Scale for Aggregation

Likert Scale Statements	Scale 3
1. Very Poor	(0, 0, 0.1, 0.2)
2. Poor	(0.1, 0.25, 0.4)
3. Fair	(0.3, 0.5, 0.7)
4. Good	(0.6, 0.75, 0.9)
5. Very Good	(0.8, 0.9, 1, 1)

The selected experts are asked to rate the workaround in a questionnaire format. Experts are required to assess the workaround based on a number of predefined subjective attributes, these attributes (Table 1) are generic and used for all workarounds regardless of their operation categorisation.

The second state is the attribute based aggregation state. Its purpose is to provide an aggregated result for the workaround. In this state, a score is calculated and assigned to each expert for each attribute capturing the expertise of each expert that is a potential means of weighting of each expert within the analysis. This calculation is performed to allow appropriate weighting of the expert opinion and then provide robust results and a higher degree of confidence in the calculations. The aggregation process of SPIS follows the sequence of Ölçer and Odabaşi (2005) and is paraphrased from their paper:

Firstly, the degree of agreement (degree of similarity) is calculated, this is denoted by S(R1, R2). In this stage, the method developed by Chen (1995) is utilised to calculate degree of similarity between all possible sets of experts. The degree of agreement is calculated as follows: given we have the opinion of Expert A who gives in trapezoidal number, say $A = (a_1, a_2, a_3, a_4)$ and then Expert B who gives $B = (b_1, b_2, b_3, b_4)$, S(A, B) is calculated as:

$$S(A,B) = 1 - \frac{|a_1 - b_1| + |a_2 - b_2| + |a_3 - b_3| + |a_4 - b_4|}{4} \tag{1}$$

An increase in S(A,B) corresponds to a higher degree of agreement between the experts with a maximum possible value of 1. After the calculation of degree of similarity is performed between all possible pairs of experts the agreement matrix (AM) is calculated. AM displays the degree of agreement between every pair of experts. The diagonal is the degree of agreement of an expert with themselves therefore values on the diagonal are always 1.

Average degree of agreement (AA) is then calculated by using AM. The average degree of agreement of expert u, denoted by E_u is calculated as

$$AA(E_u) = \frac{1}{M-1} \sum_{\substack{v=1 \\ v \neq u}}^{M} S(R_u, R_v) \tag{2}$$

M is the number of experts and E_v corresponds to expert v, $1 \leq u \leq M$ and $1 \leq v \leq M$.

The relative degree of agreement (RA) is next calculated as:

$$RA(E_u) = \frac{AA(E_u)}{\sum_{u=1}^{M} AA(E_u)} \tag{3}$$

Consensus degree coefficient denoted by $\mathrm{CC}(E_u)$ of expert E_u is calculated by

$$\mathrm{CC}(E_u) = \beta \cdot we_u + (1-\beta) \cdot RA(E_u), \tag{4}$$

$\beta (0 \leq \beta \leq 1)$ represents the relaxation factor. Naturally, when $\beta = 0$ all experts are considered equally and this will occur in a homogeneous group of experts. It is evident that β acts as a weighting of we_u, which denotes the importance of the expert and $RA(E_u)$ which is the relative degree of agreement of the expert. Ölçer and Odabaşi (2005) suggest that one way to assign weightings to experts is to use a moderator who assigns weights to each expert.

Lastly, the aggregation results, R_{AG}, of fuzzy opinions are calculated as

$$R_{AG} = CC(E_1) \otimes R_1 \oplus CC(E_2) \otimes R_2 \cdots \oplus CC(E_M) \otimes R_M \tag{5}$$

$\oplus$ denotes the fuzzy addition operator and $\otimes$ denotes the fuzzy multiplication operator.

To summarise, MAFGDM method aggregates the ratings provided by the group of experts for each alternative according to subjective attributes. All of experts' ratings for each alternative are aggregated according to subjective attributes and both attributes and experts are weighted according to their importance in the decision-making context expertise.

The third state is the selection state which aims to provide a ranking of the alternatives. After State 2, all aggregated trapezoidal fuzzy numbers are defuzzied to rank the best alternative. Fuzzy numbers are transformed into crisp numbers for evaluation by implementing fuzzy scoring approach (Chen et al. 1992). Weighting of the attributes is considered in this state.

Finally, TOPSIS is utilized as a MADM method in the ranking stage to rank the order of the alternatives. TOPSIS, developed by Hwang and Yoon (1981) is well-known with its broad acceptability in many problematic areas and effective for determining best alternatives quickly. The working algorithm of TOPSIS is given below (Ölçer & Odabaşi 2005):

- Attribute dimensions are converted into non-dimensional attributes in order to benchmark the attributes and obtain normalised weightings;
- The normalised decision matrix multiplied with its associated attribute weight is done in order to calculate weighted normalised ratings. There are several methods to calculate the weightings of the attributes such as Weighted Evaluation Technique (WET), eigenvector method and entropy method (Ölçer & Odabaşi 2005). Here, the WET has been adopted;
- Positive ideal and negative ideal solutions are calculated;
- Separation measures are calculated by Euclidean distance;
- Similarities to positive ideal solution are calculated;
- Preference order is ranked amongst alternatives.

Stage 3: Finalised Results and Feedback of Workaround Evaluation

It is recognised that decision making predominantly involves the consideration of more than one criterion or attribute (Pidd 2009). An interesting aspect of research investigates the way in which people make decisions, and the work of Kahneman and Tversky (1982) highlights that individuals do not make decisions in a systematic way and there are inherent biases in the decision making processes of individuals. In the decision making process the decision maker has to identify and consider the relevant stakeholders. The finalised decision ends up to be a compromise between needs and expectations of the different stakeholders identified and, sometimes, it needs to prioritise the wishes of the stakeholders with the most power (Pidd 2009). Indeed, decision-making is a challenging task, especially when there are varying criteria with which to measure the different alternatives. In order to ensure consistency across experts and facilitate a structured and repeated process of decision-making, the experts' judgments are elicited with a formalised means based on a questionnaire. This helps experts think through the problem based on agreed pre-defined attributes.

In order to allow the decision maker to make a judgment on the workaround a summary is provided to the decision maker to assist them. The decision maker is provided: a written summary of the workaround; a summary of the SOP which is being deviated from; a written summary of the risks; a written summary of the benefits; the aggregated results from the heterogeneous group of experts; a breakdown of the attribute based values from the experts' assessments; a breakdown of the experts' assessments. The decision maker is also given associated information about the calculation of the score.

Table 3 Guidance Scale (where x denotes the value produced by the FMAGDM method)

Value of Workaround	Guidance
$0 \leq x < 0.4$	SOP should be strictly followed. Value of the workaround highlights severe lack of adherence to key attributes. These types of workaround should be prohibited.
$0.4 \leq x < 0.5$	SOP should be kept as a template, but the information in the workaround can be considered and there is potentially a need for improvement in the SOP.
$0.5 \leq x < 0.6$	Workaround is better but requires discussion of amendments to SOP.
$0.6 \leq x < 1$	The workaround should be converted into SOP to enhance operational safety and meets both the operational realities on-board vessels as well as meeting desired safety levels.

The communication of uncertain information is a challenging task and decision-making is also somewhat difficult. In order to communicate clearly the results, the information is provided in a visual format to enable decision makers to better understand the variation between experts as well as variation between attribute scores. A generic scale has also been developed to assist the decision maker; the scale is used to determine which category the result of the experts' assessments belongs and provide guidance about the appropriate action for the decision maker to choose, this is shown in Table 3 above. The decision maker will formulate a decision based on the information.

TEST OF SPIS & INITIAL RESULTS

SPIS was tested in several stages and this section provides an overview of the various tests performed.

Collection of Workaround Data through Online Survey

The SEAHORSE Smart Procedures questionnaire was made available online via (http://seahorseproject.eu/) and distributed through partners of the SEAHORSE project. This was done so to gain a rich database of workarounds. In total, 451 responses were received. The survey is made up of two sections, the first section of the survey focussed on the collection of attitude data. The second section, pertaining to workarounds, was completed by 295 participants.

After a careful review/ cleansing of the workaround data, 107 distinct workarounds were identified. These 107 workarounds were identified as one of four operations: deck operations, cargo operations, bridge operations and engine room operations. The categorisation of the workaround assisted when assigning an expert to review the workaround in the second stage of the methodology.

It was noted that, despite asking seafarers to fill out both parts of the survey most of them missed workarounds part. The reasons for only one part of the survey being completed is unknown, however, the researchers identified that providing a large survey may lead to questions not being completed. Therefore, the decision was made that the survey to be administered to seafarers would only capture data about the workaround and some essential demographic and attitude data.

Initial Results of Expert Workshop Assessing Workarounds

A workshop was held in Glasgow on March 3rd, 2015. This reflects the testing of second stage of the methodology where experts are asked to assess the workaround based on a predefined set of attributes and an appropriate associated Likert-scale. At the workshop 40 experts from both air and maritime industry were present, these experts were assigned into one of the four groups (deck operations, cargo operations, bridge operations and engine room operations) based on their expertise.

Due to large in numbers, deck operation workarounds were divided into two different booklets while the cargo and bridge operations were consolidated as shown in Fig. 5.

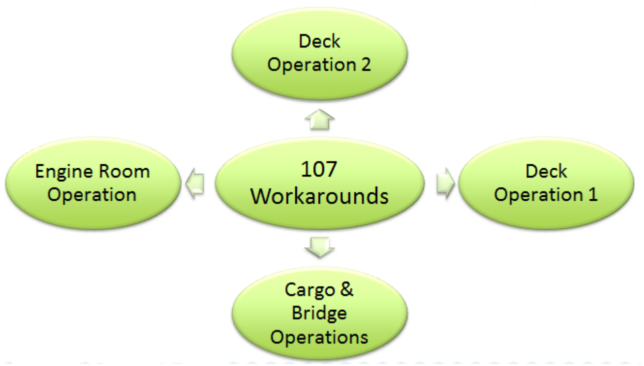

Fig. 5 The categorization of the booklets

In all of the working groups, different experts from different backgrounds were distributed equally and each working group consists of the given experts below in Fig. 6.

Fig. 6 Expertise of each working group

Experts were asked to self-assess their expertise in the workbook, thus differing a little from the proposed methodology. Nevertheless, this highlights how experts can be weighted in an alternative means should a moderator not be available.

The FMAGDM and TOPSIS method were implemented in Matlab to allow the assessment of the expert data and the outcome of the FMAGDM and TOPSIS were provided.

Even though SOPs are designed to reflect the best way of working, our results showed that in many cases the performed workaround is better than actual SOP (Fig. 7). In total 23 out of 107 (22%) workarounds were better than the actual SOP according to FMAGDM method.

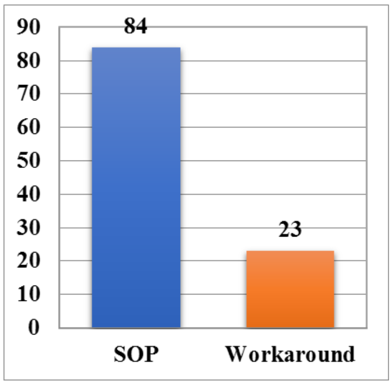

Fig. 7 Distribution of better procedure

In the following sample SOPs and associated workarounds, pertaining to each type of operations are presented:

Cargo & Bridge Operations

A sample SOP & Workaround data of cargo and bridge operations is outlined in Table 4. Here, as shown in Fig. 8, SOP is demonstrating as a better option for the first case with the ratio of 0.55 and workaround is showing a better option for the second case with the ratio of 0.76.

Table 4 Sample Cargo & Bridge Operations SOPs and Workarounds Data

No	a. Define the standard procedure (If you find it easier copy and paste the standard procedure)	b. Define the alternative practical way adopted by crew to perform same operation
1	Simple example - there are so many checklist for each navigational activity. This is to be done prior commencing the activity.	The alternative it is filled in with tick boxes and date only for recording / audit purpose. But not used as the objective in ensuring the actual checks have been completed.
2	Completing separate checklists for daily weekly and monthly tests for navigation and communication equipment	Consolidated checklists should be established for daily weekly and monthly tests for navigation and communication equipment

In the first case, crew members complain about filling an excessive amount of navigational checklists while they have other commitments. The workaround aims to prepare a checklist of a navigational duty before performing the actual duty just for the audit purposes. Checklists are very crucial for the operational safety and they have potential to prevent failures that can turn into catastrophic accidents. Even though workaround seems a wise idea, not following checklists can lead to the skipping of a crucial step and can create a dangerous situation in shipping operations.

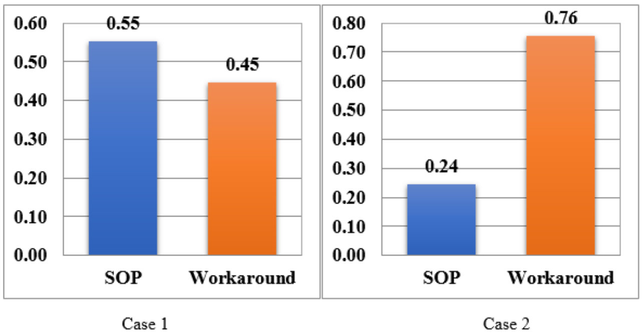

Fig. 8 Comparisons between sample Cargo & Bridge Operations SOPs and Workarounds

Second case is approved as an acceptable workaround by the majority of the participants in the workshop. A seafarer suggested a consolidated version of navigational checklist which can decrease the workload without putting safety at stake. Instead of performing a repetitive work, a seafarer found a better solution without causing any dangerous situation.

Deck Operation

Table 5, depicts a comparison between the SOP & Workaround data. As shown in Fig. 9, workaround is a better option for the case 32 with the ratio of 0.66 and SOP is a better option for the case 33 with the ratio of 1.00.

Table 5 Sample Deck Operations SOPs and Workarounds Data

No	a. Define the standard procedure (If you find it easier copy and paste the standard procedure)	b. Define the alternative practical way adopted by crew to perform same operation
32	Final reports are prepared At the end of each task. Reports will be prepared during the business work-related tasks. These reports are requested between 2 -24 hours	All reports are brought into a single report
33	Conducting risk assessment for a specific task	Crew often copy and paste risk assessments for other tasks - enter only 'standard' risks and control measures

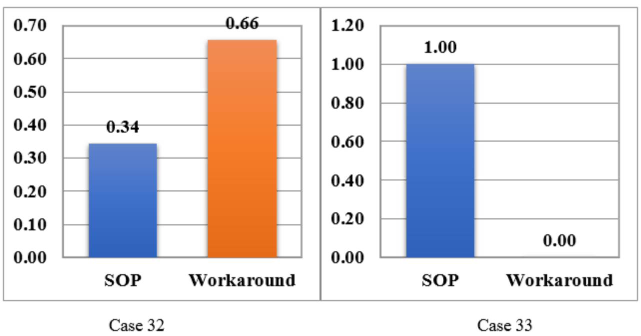

Fig. 9 Comparisons between sample Deck Operations SOPs and Workarounds

High workload is a well-known fact in the maritime industry. In addition to seafarers' heavy duties, they are also expected to fill in numerous papers for regulatory compliance purposes. Companies can work on this issue in order to decrease amount of paperwork, for instance by automating and collecting the same information just for once.

Risk assessment is a very crucial task to determine hazardous operations and foresee possible dangers related to them. Companies should provide sufficient training explaining the importance of conducting risk assessments and their impact on avoiding accidents and incidents. Copying and pasting from previous risk assessment data sheet is too dangerous for a shipping company.

Engine Room Operation

Table 6 gives a comparison between the sample SOP & Workaround data pertaining to engine room operation. As could be seen from Fig. 10, workaround is a better option for the case 93 with the ratio of 0.52 and SOP is a better option for the case 94 with the ratio of 0.72.

It is evident from case 93 that some of standard operating procedures do not comprise the details of a required operation. Therefore, crew members ask help from other seafarers who have higher ranks. Companies always review their operating procedures and update the one which are not operable by considering crew member's feedbacks.

Table 6: Engine Room Operation Workaround Data for Case 93 and 94.

No	a. Define the standard procedure (If you find it easier copy and paste the standard procedure)	b. Define the alternative practical way adopted by crew to perform same operation
93	When carrying out the task of checking flexible couplings between a pump and motor, the standard operating procedures differ in many ways to the equipment and isolating methods we have on-board. They are written as a general guidelines but do not apply specific procedures for that unit.	Common sense, obtain information from someone in a higher rank.
94	During bunker operations on large sea-going vessels the vessel crew need to visit the bunker delivery barge (which is at a lower height) and check their meters or do some paper work. After so many fatal accidents around the world in using monkey/embarkation ladders for this purpose, many shipping companies have adopted the procedure of using the ship's gangway for such operations.	On some ships the junior Engine crew members (particularity the rather shy ones) are encouraged to skip the gangway and accept climbing down a monkey/embarkation ladder!

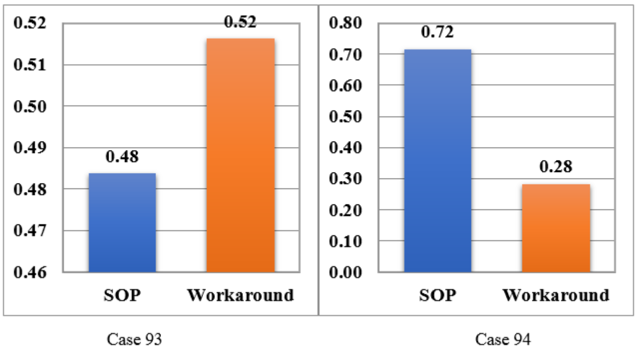

Fig. 10 Comparisons between sample Engine Room Operations SOPs and Workarounds

Case 94 demonstrates an unacceptable workaround which can create risks for performing the duty. Even though the companies advanced procedures and technologies, utilizing old and risky methods for fun should be eliminated and prohibited. The company procedure should be followed and the officers encouraging these kinds of behaviours should be stopped by the company.

DISCUSSIONS

The role of SOPs within the maritime industry are recognised as paramount in ensuring safety of shipping. Within the aviation industry SOPs have also been adopted and to date have had much success. The introduction of SOPs has not provided the same level of success as the aviation industry. Therefore, there is work to be carried out in improving SOPs and it is proposed here that the development of SOPs is to be an iterative process. SOPs are to be developed, then used in daily operations and based on the use seafarer's provide feedback on SOPs which are being deviated from. From this, it highlights which SOPs may need to be reviewed, this process is shown in Fig. 11.

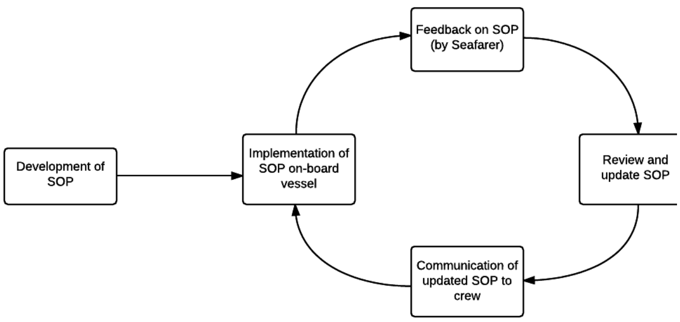

Fig. 11: Summary of iterative process of design, implementation and refinement of SOPs.

A key issue related to SOPs and shipping safety relates to the fact that seafarers may choose an alternative means of performing a task or operation, thus deviating from the SOP. It is assumed that managers in the organisation know a proportion of the workarounds being practiced, whilst others are unknown. To date, there is no methodology which captures workaround data from seafarers, yet the benefits and necessity of this are abundantly clear.

On-going engagement with several shipping organisations allows the demonstration of the proposed methodology, these industry partners explicitly expressed there is a significant need for a methodology such as SPIS. Without a formalised procedures to capture and assess workarounds, risky practices may be carried out in the daily operation of ships putting seafarers in even greater danger in their daily working life.

The unique contribution of SPIS is the development of a means to collect workaround data from seafarers, the identification of the key attributes by which to assess workarounds and the assistance provided for the decision making process and subsequent communication. It is a well-known fact that SOPs have crucial impact on operational safety and by utilising the SPIS presented here, companies are provided with a structured means for the elicitation of workaround data and the assessment of workarounds by experts in the organisation. In addition to the seafarer collection of data, the methodology provides a means to bring together the assessments of multiple experts to provide a value of the extent in which a SOP is better than the workaround.

In any case, the use of a workaround indicates an underlying issue in the organisation and even if the SOP is judged as the best alternative, decision makers need to review the underlying reasons as to why the workaround is being practiced. Also the decision making process is supported by the methodology. The recommendation may be to adopt the workaround as it is safer and more effective than the SOP. It will also identify risky workarounds which should be prohibited for operational safety. Usually these highlight an SOP which does not meet the operational realities on-board vessels, hence a review of the existing SOP or the design of a new one might be necessary.

The methodology was tested during the Glasgow SEAHORSE workshop by inviting 40 experts from the maritime and aviation industries to attend. The methodology received positive feedback on the real need of the proposed approach in the maritime industry as well as on the format of evaluation and the outcomes provided. The workshop enabled further refinement of the methodology as experts identified aspects causing issues in the assessment of workarounds.

The test of the methodology revealed that there are some workarounds which are conducted due to limitations in the design of the SOP, however the chosen workaround is not the best way to address the problem. Even though SOPs are designed with the intention of providing the best way of working, the results have shown that in many cases, performed workaround is better than actual SOP. In total, 23 out of 107 (22%) workarounds were identified as better than the SOP according to FMAGDM method.

CONCLUSION

Prevalence of workarounds shows that the maritime industry still has issues with regards to safety. Good practices are required to be turned into formalised procedures while bad practices should be eliminated. Identification of workarounds may also identify underlying reasons for the workaround being practiced and this may provide valuable insight into the limitations in the design of the SOPs.

To conclude, this paper provides a methodology to address the existence of workarounds in the maritime industry. It provides a structured way to support the identification, review and decision making related to workarounds and it can be easily transferred to other industries utilising SOPs such as the air industry where this gap in knowledge also exist.

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