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Effective safety culture modelling in the maritime industry; an assessment of the Tanker ship subsector

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Abstract: The work reviewed the several approaches to safety culture procedures applied in the maritime industry with a view to creating the best model for the sector. In this study, the importance of the international safety management code otherwise known as the ISM code were reviewed vis a vis the development of a proactive safety management culture by the entire tanker sub sector of the maritime industry. Comparison were made between different sources of maritime incidents such as design errors, human errors and organizational commitment to safety in a bid to model an effective safety culture for the entire maritime industry. Finally, the need to evolve safety measurement metrics best suited to analyze the safety demands of the maritime sector was emphasized. The developed model emphasizes an approach of safety orientation as part of the organization's safety philosophy. The adaptability of the model in the entire maritime industry as well as measurement procedures was also proposed.

Keywords: Safety Culture Modeling Safety Orientation, ISM Code, Maritime Incident Reporting, Human Errors

1. Introduction

Modeling of safety culture in the maritime industry to date has been based on the safety criteria recommended by the ISM code. The safety criteria set up by the ISM code provides three indicators presently used for safety analysis and evaluation. These criteria includes

i. An active and established working process of continuous improvement.
ii. Commitment from the top management of the company towards safety improvement.
iii. Motivated and encouraged personnel on board to actively initiate safety improvements.[1][2]

Some works stated above have found out barriers existing in different cultures which prevent the execution of the safety process. Another suggestion in the sector includes the demand for a move from a reactive approach to a proactive approach in the tanker sub sector of the maritime industry[3] This work had argued that most decisions of the International Maritime Organization (IMO) was based on lessons learned from previous accidents beginning from the Titanic which created SOLAS even up to the case of Herald Enterprise, which created the ISM code. See also [4]. Finally, (Havold, 2007)[5] argued in his doctoral thesis for the need for the maritime industry to move from the reactive approach to the approach of safety orientation . All of the above are pointers to the need for the right modeling approach to safety culture in the maritime industry.

1.1. Objective

The objective of this paper is to review the safety modeling approach in the entire maritime industry and thus create an effective safety model for the sector.

2. Literature Review

Assessment of safety culture in the maritime industry has generally lacked instruments of measurement over the years.[5] The safety orientation approach is actually a practical safety culture assessment instrument that indicates the degree of orientation by a group or an organization towards safety.

Three regimes/cultures of development have been associated with safety regulation in recent times.[2] They include firstly, the regime of punishment where responsible parties are assigned by law to pay compensation for their safety liabilities. A good example is American's Oil Pollution Act of 1990 (OPA '90). The second regime has been described as the regime of compliance. Under this regime prescriptive rules concerning ship construction and other safety matters are required to be complied with. The concept of continuous improvement was established by the "quality gurus" in the fifties and sixties of which the American businessman Philip Crosby was one of the best known.

He stated that in order to reach the objectives of a quality management system it is of importance to look into the task as a continuous process where nonconformities continuously are reported and corrected. This process was described in his work Quality is free where he wrote about this process as the 14-step program for continuous improvement. This program was implemented in the American company ITT which by then had revenues of USD 15 billion and 350.000 employees, which made them to be one of the largest companies in the world .The theory of continuous improvement as a never ending process as a system for Quality/Safety Management is well established within all kind of industries and one of the best known is the Kaizen model developed by Toyota in Japan during the fifties. Kaizen is the Japanese word for continuous improvement and is a policy of constantly introducing small changes in order to improve quality/safety. This was assumed, because of their presence, that it is the people within the business who are the ones to best identify where there is room for improvements.

The system can be operated at the individual level or by Kaizen Groups or Quality Circles which are groups for identification of improvements. One issue of importance in order to make Kaizen effective, is the culture of trust between staff and manager including good communication both ways, and an open-minded and democratic view of the employee .

This can be related to the cornerstones of the ISM Code, "Commitment from the top" and continuous improvement by reporting, analyzing and implementing corrective actions as described in section 9 of the ISM Code.

In the work of Sagen [4] he describes a theory developed by Heinrich who stated that the relation between serious accidents and minor accidents is 1 to 30 and minor accidents and near accidents (near misses) is 30 to 300, i.e. 300 near accidents results in up to 30 minor accidents and 30 minor accidents results in 1 serious accident. This theory is commonly accepted within the science of safety research (Sagen, 1999)[4].

Good examples of safety regulations made during this regime include: International Convention for Safety of Life at Sea (SOLAS) and the International Convention on Standards of Training, Certification and Watch keeping for Seafarers (STCW) [6].The third regime or culture is known as the regime or culture of self regulation, this regime is based on standards established by the industry itself. The ISO 9001 Quality standard and the ISM code are good example of this safety culture regime. [6]

The ISM code itself did not specify statistical measures of performance like its counterpart ISO 9001. However; it literally demands the implementation of the process of continuous improvement regularly. [2] In handling this problem, (Mejia, 2001)[7] suggested the use of qualitative assessment instruments that measures system effectiveness. Mejia defined effectiveness to mean`` the issues of whether desired results are actually achieved". Coming from the backdrop of Policy Management, an evaluation of the ISM code was made categorizing them into outputs and outcomes. The outcomes are the desired goals of the policy. For the ISM code these include:

(i) The requirement to provide safe practices in ship operation and a safe working environment and the requirement to establish and safeguard against all identified risks.
(ii) The requirement to continually improve safe management skills of the personnel ashore and aboard including preparation for emergencies and environmental protection.
(iii) The requirement to develop a safety culture. [7].

Next, Mejia set to define outputs as those set of policies which attempt to ensure that the safety management systems of the shipping companies and vessels are compliant with the ISM code. According to him, output measures of the ISM code will include:

- Port sate control detention due to non-conformities and deficiencies in regard to the requirements of ISM code.
- ISM related port inspections carried out by the Flag state Re-Inspections due to major non-conformities observed in connection with external audits performed by the administration.
- ISM deficiencies and non-compliance reported by the ships personnel.[7]

3. Methodology

The method of principal component analysis was applied to measure the output side of the ISM code as presented in the tanker output report and barge output report for the years 2007 and 2008.The total score factor coefficients was calculated and the output result presented. Factor coefficients of the inspections carried out between 2007 and 2008 were computed as a basis for analyzing safety improvement in the tanker ship sub sector.

4. Result Presentation

Analysis of safety in the industry has focused mainly as exposed by the diagrams outlined below. Designs of safety in the system are usually controlled by policies that will eliminate the occurrence or likely occurrence of these errors. Safety result as analyzed by the diagram below reported casualties in percentage. Other measures are revealed subsequently by subsequent diagrams.

An assessment of the output aspects will be shown in this work applying the principal component analytical method to the next table.

4.1. ISM Code Output Analysis Using Principal Component Analysis

The table below contains output reports of inspections carried out on tankers and barges in two subsequent periods, the years 2007 and 2008.The variations in the number of reports requested and those submitted are reflected in the table as differences. The reports from barges were also reflected in the table.

Table 1. *SIRE Statistics (Source[8],)*

	Jan-Dec 2007	Jan-Dec 2008	Difference
Tanker reports submitted	15,730	16,452	+722
Tanker reports requested	52,527	59,736	+7,209
Total tanker vessels in the system	6,222	6,553	+331
Reports per tanker vessel per annum	2.6	2.6	
Barge reports submitted	4,576	4,879	+303
Barge reports requested	5,786	8,164	+2,378

Table 2. *Principal Component Analysis: C1, C2 Eigenanalysis of the Correlation Matrix*

Eigenvalue	1.9990	0.0010
Proportion	1.000	0.000
Cumulative	1.000	1.000
Variable	PC1	PC2
C1	0.707	0.707
C2	0.707	-0.707

Table 3. *Principal Component Analysis: C1, C2 Eigenanalysis of the Covariance Matrix*

Eigenvalue	868214156	423172
Proportion	1.000	0.000
Cumulative	1.000	1.000
Variable	PC1	PC2
C1	0.661	0.750
C2	0.750	-0.661

The percentage of variation explained by the analysis is thus 100%.In the correlation matrix the resultant equation of variation between the two years 2007 and 2008 varies accordingly as follows:

$$Y = .707X1 + .707X2$$

Likewise in the covariance analysis result obtained from the principal component analysis, a 100% variation was obtained from the first analysis and zero percent in the second. The resultant variation equation is as follows:

$$Y = 0.661X1 + 0.750X2$$

Table 4. *Factor Analysis: C1, C2 Principal Component Factor Analysis of the Correlation Matrix Unrotated Factor Loadings and Communalities*

Variable	Factor1	Factor2	Communality
C1	1.000	0.022	1.000
C2	1.000	-0.022	1.000
Variance	1.9990	0.0010	2.0000
% Var	1.000	0.000	1.000

Table 5. *Factor Score Coefficients*

Variable	Factor1	Factor2
C1	0.500	22.475
C2	0.500	-22.475

From the factor analysis we conclude from results that the output of tanker and barge reports submitted varies effectively with a variation of:

$$Y = .5000X1 + .5000X2.$$

Thus we conclude that the reports submitted called the output yielded a satisfactory result for the periods 2007 and 2008 based on principal component analysis. Thus we now have a means through which government institutions in control of maritime operations can measure the outputs of shipping firm’s compliance to instituted regulations like the ISM code.

5. Conclusion

The work analyzed safety measurement standards in the entire maritime industry and recommended new ways for assessing the outputs of safety regulations controlling safety in the industry such as the ISM code. A new way of applying new safety metrics such as the principal component analysis in assessing the outputs of the industry was demonstrated. The view of this work is that the culture of continuous improvement be adopted by all concerned as required by the ISM code while measurement metrics like the one prescribed in this work be used to ascertain the output efficiency of the industry from time to time.Modelling of safety culture in the tanker sector of the maritime industry from this work shows a way of analyzing the impact of inspections carried out in a given period.From the work ascertained the effect of these inspections carried out on both tanker and barges during the period of review.

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