Karahalios, H, Yang, Z and Wang, J

A risk appraisal system regarding the implementation of maritime regulations by a ship operator

http://researchonline.ljmu.ac.uk/1749/

Article

Citation (please note it is advisable to refer to the publisher's version if you intend to cite from this work)

Karahalios, H, Yang, Z and Wang, J (2014) A risk appraisal system regarding the implementation of maritime regulations by a ship operator. MARITIME POLICY & MANAGEMENT, 42 (4). pp. 389-413. ISSN 0308-8839

A Risk Appraisal System Regarding the Implementation of Maritime Regulations by a Ship Operator

Karahalios H., Yang Z.L., Wang J.
Liverpool LOgistics, Offshore and Marine (LOOM) Centre
School of Engineering, Technology and Maritime Operations
Liverpool John Moores University, L3 3AF, UK

Abstract

The shipping industry operates in a regulatory framework, where the International Maritime Organization (IMO) is the leading regulatory body. The role of the IMO is to propose maritime regulations to its member states. The successful implementation of a maritime regulation depends on how many member states adopt it. However, many maritime regulations are not adequately implemented worldwide. As a result, ship operators have found themselves in an uncomfortable position in developing their business. This paper proposes an extendable and applicable methodology involving a System of Hierarchical Scorecards (SHS) to measure the implementation cost and benefit analysis of a newly introduced or existing maritime regulation by ship operators. The regulators may use the results in evaluating newly introduced and/or existing regulations through taking into account the economical burden that will be generated to ship operators. In this paper, System of Hierarchical Scorecards (SHS) is extended to demonstrate its applicability on evaluating a stakeholder's organisation with regard to his regulatory implementation performance by the means of a case study.

Keywords: Maritime regulations, shipping industry, regulation implementation, hierarchical scorecards.

1. Introduction

The shipping industry consists of many stakeholders located worldwide. Therefore this industry should be bind by many international agreements allowing a stable regulatory environment. A legislative framework of numerous conventions is developed by the International Maritime Organization (IMO), which is the regulator of the shipping industry. However, the IMO lacks enforcement powers and does not directly monitor performance of its member states (Knapp and Franses 2009). The IMO's weak connection to the national maritime administrations has lead to a variety of interpretations and practices of implementing maritime regulations. Adding new rules is no panacea, as new rules in some cases negatively affect the functioning of existing regulations, and sometimes seem motivated mainly to show political alertness (Knudsen and Hassler 2011).

Some researchers such as Björn (2010) have argued that too much effort has been given by the IMO focusing on implementation of existing universal conventions, local action has been taken in areas where individual countries' interests are strong and consent within larger groups have not been indispensable (e.g. PSSA). Some safety issues could be more effectively dealt with using global conventions, whereas others seem to be more successfully managed at lower levels, involving only one or a small number of countries. Additionally a main issue for states that are willing to implement regulations is the cost-effectiveness of abatement measures (Heitmann and Khalilian 2011). The cost of a small firm in implementing regulations has been noticed in other business as well. For instance the approach that has been adopted by many governments is to incorporate the Regulatory Implementation Assessment (RIA), which is an OECD suggestion, into their existing policy-making processes (Staronova et al 2007). Furthermore, more broad issues are included such as "do nothing option” and “small firm impact”. Difficulties of companies to implement a regulation may need additional regulation to be involved by producing a vicious circle. The “small firm impact” is also a fundamental issue since every industry should be open to anyone who wants to get involved (Vickers 2008).

A very promising tool for regulatory implementation was the concept of port state control (PSC). Following a series of major oil tanker accidents in the 1970s, the PSC evolved to allow port states to conduct safety inspections on foreign flagged vessels entering their ports. The countries participate on Memoranda of Understanding (MoU) and today, 10 PSC regimes exist, covering most port states. These regional MoU’s enforce international legislation and act as a second line of defence against substandard shipping where the first line of defence is the flag state itself (Perepelkin et al 2010).

However the efficiency of port state control has been criticized. Tzannatos and Kokotos (2012) in their study remarked that recorded deficiencies, being the result of a PSC inspector’s opinion, are easily influenced by a host of subjective issues, such as the attitude of the crew, the ease of inspection, the inspector’s mood. Furthermore Cariou et al (2009) found that the factors that could lead to a detention of a ship following a PSC inspection would mainly be the age of the vessel at inspection (40%), the recognised organization (31%) and the place where the inspection occurs (17%). Although that detention rates are essentially explained by differences in the characteristics of vessels calling in a specific country rather than by differences in the way inspections are done. Another main issue with PSC is that its main focus is to increase safety standards onboard and pollution prevention while other regulatory issues such as ILO Conventions about the daily life of those persons living and working on the vessel are of lowest significance (Silos et al 2012).

The IMO having identified problems in willingness from some states to enforce regulations either as flags or port states adopted a Formal Safety Assessment (FSA)methodology that was developed targeting the improvement of maritime regulations. FSA is a rational and systematic process for assessing the risks relating to maritime safety and the protection of the marine environment and for evaluating the costs and benefits of IMO’s options for reducing the risks (Knapp and Franses 2009). A main limitation in the FSA methodology, the costs and benefits that may be generated by a regulation are addressed in a partial and very generic way. For instance, Vanem et al (2008) noted that in the FSA studies, the cost-effectiveness criteria do not take any particular stakeholders’ view, and they do not concern who would have to pay for the elimination of an identified hazard. It is not designed to assist a stakeholder such as a ship operator in improving his management or in implementing a new regulation although some shipowners have used this concept to develop their own safety cases (Wang 2006). Psarros et al (2010) have also have argued that the validity of historical data may be undermined by uncertainties which will considerably affect FSA studies.

An alternative approach suggested by Karahalios et al (2011) is that the successful implementation of a maritime regulation is by measuring the implementation cost of main stakeholders. A System of Hierarchical Scorecards (SHS) was developed to assist regulators in evaluating any proposed and/or existing regulations. A main group of stakeholders include ship operators,ship managers and shipowners. The aim of this paper is to demonstrate the applicability of a SHS tool in assessing potential challenges of a ship operator when he has to implement a maritime regulation. Such challenges include human resources, training, risk analysis and costs. By using the SHS a regulator will be able to measure areas where a ship operator will face difficulties in order to achieve compliance with a regulation. The structure of this paper consists of two parts. The first part (Sections 2 and 3) gives a brief description of the current status in which a ship operator run his business daily and the risks that he is exposed from not adequately implementing a maritime regulation. At the second part which includes Sections 4, 5 and 6 a case study is carried out regarding the use of the SHS by a ship operator.

2. Literature Survey in the Implementation of Maritime Regulations by Ship Operators

One main approach to improve regulatory implementation is to improve the administration of a ship operator. The IMO encouraged the establishment of a safety management system (SMS) in ship operators in accordance with the international management code for the safe operation of ships and for pollution prevention (ISM Code) that was a critical milestone for maintaining a legislative control in shipping (Celik et al 2010). The ISM Code required the managers to lay down systems of work involving management of risk along with self-checking and self-critical measures for the purposes of verifying and continually improving its performance (Bhattacharya 2012). The limitations of these systems are that they require a great deal of paperwork, which sometimes leads to a paper chase exercise. Lack of deficiencies in a management system may mislead a ship operator and makes him believe that his company met the objectives of a regulation. Furthermore the concept of management systems was introduced, mainly from the USA, together with new technologies (Hofstede 1983). Many researchers argued that a significant limitation of these systems is that they may not be appropriate for other national cultures (Hofstede 1983), (Brock 2005), (Pagel et al 2005), (Dimitriades 2005). The findings from Tzannatos and Kokotos (2012) show a considerable disparity between managers' and seafarers' understanding of the use of the Code resulting in a wide gap between its intended purpose and practice.

The weaknesses of the International Safety Management (ISM) Code have lead organizations in proposing other management tools. For instance the Tanker Management and Self Assessment (TMSA) is being seen as a means of reinforcing the implementation ofthe ISM Code , with particular emphasis on self-assessment and continuous improvement (Plomaritou et al 2010). However TMSA has been designed for tanker operators and therefore its applicability is limited. Some major industrial organizations suggest that quality systems such as the ISO 9001:2008 quality standards by the International Organization for Standardization (ISO) should be the next step after the ISM Code. Celik (2009) proposed a systematic approach for exploring the compliance level of the ISM code with the ISO 9001:2008 in order to structure an integrated quality and safety management system (IQSMS) for shipping operations. The adaptation of ISO quality standards in shipping business provides invaluable benefits with regard to the technical management of merchant fleet, and is also very useful for both improving the service quality and enhancing customer satisfaction in the market. However, in the same research (Celik 2009) problems have appeared on ensuring the compliances of the ISO quality standards with the relevant maritime regulations while structuring an integrated management system in practice.

A ship operator should be able to implement a maritime regulation with reasonable costs when there are strong evidence that such regulations are for the benefit of the shipping trade, environment and/or safety at sea. Such a move should not be heavily criticized since the aim of a ship operator is not different from any other company in business world, which is to ensure that his business will remain profitable. Ship operators are always searching ways for the minimisation of their unit cost in all possible areas (Progoulaki and Theotokas 2010). Evidence of ship operators trying to minimize regulatory costs could be traced in the past. In late 60's the economic globalization lead many ship-owners to move away from their national jurisdiction and chose to transfer the registry of their ships to countries such as Panama, Liberia and Cyprus (Bhattacharya 2012). The more relaxed regulatory standards required by such states q were found by ship-owners less costly. Ship operators continue to operate with deficiencies because of poor implementation since 1996 for the same basic reasons mainly the inadequate implementation (Knudsen and Hassler 2011).

3. Overview of Hierarchical Scorecards

The benefits for a ship operator from implementing a regulation should be linked with his commercial gains. For instance every maritime regulation was introduced by the IMO to enhance safety at sea and/or to protect the environment. Any failure to effectively implement a maritime regulation may have adverse effect in terms of safety, pollution and business damage for the violated parties. Additionally a shipper requires from a carrier to care for the suitability of his/her vessel in order to fulfil the transportation of cargo with safety. The carrier is obliged to provide a ship constructed, equipped, supplied and staffed according to the international regulations on the design and operation of vessels in order to execute the voyage safely and to overcome those risks it is anticipated to meet during the charter (ordinary perils of the sea) (Plomaritou et al 2010).

A ship operator normally implements a regulation through a main process, which consists of the following targets:

1. Monitoring the regulation implementation performance of his organization.
2. Monitoring the regulation implementation performance of each division.
3. Apply a self-assessment tool with regard to his implementation performance.

A ship operator needs a tool that will allow him to monitor the regulatory implementation process at all levels within his organisation. To meet the above steps/objectives the SHS has been introduced by Karahalios et al. (2011a) as a cost benefit tool to measure the commercial impact of a maritime regulation to the main stakeholders of the shipping industry. It consists of five main steps, which are separately presented below.

Step 1. Identify Cost and Benefits Indicators

The BSC is used as the foundation of SHS because compared to other performance measurement methods it has a broad applicability in many business sectors (Punniyamoorthy, and Murali 2008), (Shafia et al 2011). The BSC is the most recognized and utilized contemporary performance measurement systems (Tung et al 2011). Håvold and Nesset (2009) have applied BSC in the shipping industry since many business executives demand simple, low cost measures for benchmarking purposes or for use as measures in a balanced scorecard. Perepelkin et al (2010) has established a system for measuring the performance of flags by developing a methodology to measure flag state performance which can be applied on the regional or global level and to other areas of legislative interest (e.g. recognized organizations, Document of Compliance Companies). According to the BSC method four performance perspectives can be identified as: (a) financial, (b) learning and growth, (c) customer and (d) internal business (Kaplan and Norton, 1996a,b). In order to achieve the best solution for these considerations, the users have benefited from a customized BSC.

Step 2. Ranking of Cost and Benefits Indicators

For a ship operator each of the four perspectives of BSC may have different weights. Therefore, it is appropriate to provide the means of ranking the four perspectives according to their priorities. As the analytic hierarchic process (AHP) has been developed and used more and more widely in practice, it appears to be a popular tool for decision support (Huoa et al 2011). Zheng et al (2012) suggest that one of the main advantages of the AHP method is its simple structure. The AHP is designed in a way that represents human mind and nature. The use of AHP does not involve cumbersome mathematics, thus it is easy to understand and can effectively handle both qualitative and quantitative data.

The AHP established by Saaty (1977) is a theory of measurement through pair-wise comparisons and relies on the judgement of experts to derive the priority scales. These scales measure the intangibles in relative terms. The comparisons are made using a scale of absolute judgement that represents how much more one element dominates another with respect to a given attribute. The main concern of AHP is dealing with inconsistencies arising with the judgement and improving this judgement (Vinodh et al 2012). The application of the AHP to a complex problem consists of the following four steps (Cheng et al 1999):

1. Break down the complex problem into a number of smaller parts/elements and structure them in a hierarchy.
2. Make pairwise comparisons among the elements.
3. Evaluate the relevant weights of the elements.
4. Aggregate these relevant weights and synthesise them for the final measurement of the given decision alternatives.

When the numerous pairwise comparisons are evaluated, some degree of inconsistency could be expected to exist in almost any set of pairwise comparisons. The AHP method provides a measure of the consistency for pairwise comparisons by introducing the consistency index (CI) and consistency ratio (CR) (Ung et al 2006). The λ_{max} is the principal eigenvalue of an $n \times n$ comparison matrix and is calculated by Equation 1 (Vargas 1982). RI is the random index for the matrix A and depends on the number of items being compared, which is shown in Table 1 (Saaty 1994).

$$w_i = \frac{1}{n}\sum_{j=1}^{n}\frac{a_{ij}}{\sum_{k=1}^{n} a_{kj}} \qquad (1)$$

If CR is valued less than or equal to 0.2 then a consistency is indicated and the pairwise comparisons are assumed to be reasonable and any attempt to reduce this value will not necessarily improve the judgement (Dadkhah and Zahedi 1993), (Wedley 1993).

Table 1. Average Random Index Values

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Step 4. Fuzzy set theory

As this research is based on a new approach, there is lack of data for analysis and the level of uncertainty of data could be very high. Thus, fuzzy set modelling may be effectively used as a useful approach to facilitate the decision making of a stakeholder. Specifically, the major contribution of fuzzy set theory is its capability of representing vague data. In general, a fuzzy set is characterized by a membership function, which assigns to each object a grade of membership ranging between zero and one (Naghadehi et al. 2009),(Lee et al. 2012).

The triangular fuzzy numbers are used due to their simplicity. A fuzzy number is a special fuzzy set $\tilde{M} = \{(x, \mu_{\tilde{M}}(x)), x \in R\}$ where x takes its values on the real line $R: -\infty < x < +\infty$ and $\mu_{\tilde{M}}(x)$ is a continuous mapping from R to the close interval [0,1]. A triangular fuzzy number $\tilde{M}$ can be defined by a triplet (a, b, c) as (Cheng et al 1999):

$$\mu_{\tilde{M}}(x) = \begin{cases} 0 & x < a \\ \dfrac{x-a}{b-a} & a \le x \le b \\ \dfrac{c-x}{c-b} & b \le x \le c \\ 0 & x > c \end{cases}$$

The addition and division operations of triangular fuzzy numbers are expressed below (Kwong and Bai 2003), (Chen and Chen 2005):

1. Fuzzy number addition

$(a_1, b_1, c_1) + (a_2, b_2, c_2) = (a_1+a_2, b_1+b_2, c_1+c_2)$ (2)

2. Reciprocal fuzzy number

$(a_1, b_1, c_1)^{-1} = (1/c_1, 1/b_1, 1/a_1)$ (3)

For fuzzy numbers a defuzzication process follows to obtain crisp numbers (M_crisp). The method to calculate the crisp number for a triangular fuzzy number is to compute the centre of the fuzzy number's triangular area by Equation 4 (Wang and Parkan 2006):

$$M\_crisp = \frac{(b+a+c)}{3} \qquad (4)$$

3. Evaluation Methodology

As aforementioned, the aim of this paper is to design a strategy, which will lead to the implementation of a maritime regulation by reducing the implementation costs to an affordable level for ship operators. The terms "Benefits" and "Costs" are used in a broad sense reflecting the needs of modern shipping business rather than the old-fashioned financial values such as profit and expenses. A ship operator can measure the implementation performance of a maritime regulation by focusing on the four perspectives of BSC mentioned in Section 3. An appropriate framework for evaluating a regulation performance can be set by using the following seven steps:

1. Set the hypothesis that will be tested.
2. Identify the divisions of a stakeholder's organization.
3. Identify the perspectives and measures that can evaluate the costs and benefits of the implementation of a regulation for a division.
4. Develop a hierarchy for evaluating maritime regulations performance from a stakeholder's perspective.
5. Evaluate the weight of each division and its perspectives and rank them for their burden in the regulatory process.
6. Design a stakeholder's tool capable of evaluating the implementation performance of a stakeholder in terms of compliance with a maritime regulation.
7. Selecting the perspectives and measures with the highest weight

3.1 Set the hypothesis that will be tested.

The hypothesis is that it is very challenging for a small ship operator to comply with a newly introduced maritime regulation.

3.2 Identify the Divisions of a Ship Operator

A ship operator is running his daily business in a complicated business and regulatory environment. Therefore, the organizational structure of a ship operator may consist of various divisions with specific activities. Each ship operator may have a different structure. Therefore, the divisions' activities are verified by the literature review as shown in Table 2 (Chu and Liang 2001), (Lyridis 2005), (Panayides 2003), (Panayides and Cullicane 2002), (Jensen and Randoy 2002, 2006), (Karahalios et al 2011b).

Table 2. The Organizational Structure of a Ship Operator by Divisions and their Activities

Division	Symbol	Activities
1. Managing Director	D_1	Overall management, hiring employees, ships purchase and scrapping
2. Operation Department	D_2	Operation and performance of a ship in accordance to its commercial and legal obligations
3. Technical Department	D_3	Operation, performance and maintenance of the engineering and technical systems of a ship, dry-docking and repairs
4. ISM Department	D_4	Safety management, implementation of safety and pollution regulations
5. ISPS Department	D_5	Implementation of security regulations
6. Chartering Department	D_6	Chartering and charter compliance
7. Accounting Department	D_7	Budgetary control
8. Crew Department	D_8	Crew recruitment and manning of ships
9. Supply Department	D_9	Supply of deck stores, provisions and paints inquiries
10. Ship	D_{10}	Operation of ship with the highest level of safety in accordance with the company's stated principles, policies and objectives

3.3 Identify the Perspectives and Measures for Evaluating the Costs and Benefits of the Implementation of a Regulation for a Ship Operator

3.3.1 Perspective Definition

A ship operator should select the appropriate perspectives in order to assess his performance of implementing a maritime regulation. The perspectives chosen in this paper are those proposed by Kaplan and Norton (1996a, b) since they address fundamental and common acceptable aspects of a modern management system. However, their meanings need to be modified in order to fit in the needs of successfully implementing a maritime regulation. The selected perspectives and their definitions are shown in Table 3. A proposed generic scorecard for a ship operator, which includes the perspectives, is shown in Table 4.

Table 3. Perspectives and their Definitions

Perspective	Definition
Financial Perspective	Costs and profits that will result from the implementation of a regulation
Customer Perspective	The satisfaction of a stakeholder's customers as an outcome of the implementation
Internal Business Perspective	The procedure that should be followed to implement a regulation. Training, planning and review are considered as key elements of this perspective
Learn & Growth Perspective	The required resources in order to implement a regulation. These resources include technology, human resources and knowledge.

In Table 4, $m^{a}_{b^{a},c^{u}}$ is a given measure, a is the indicator of the measure' parent perspective (a =1, 2, 3, 4 since there are only four perspectives), b^{a} is the indicator of the bth measure associated with the ath perspective, u is the indicator of the relevant division (u=1, 2, 3, .., l)

Table 4. A Detailed Scorecard for a Ship Operator Including his Divisions

Division (D_u **)**	**Perspectives (** $P_{a,u}$ **)**	**Measures (** $m^{a}_{b^{a}}$ **)**
D_1	$P_{1,1}$ Financial Perspective	$m^{1}_{1^{1}}, m^{1}_{2^{1}}, \ldots, m^{1}_{g^{1}}$
	$P_{2,1}$ Customer Perspective	$m^{2}_{1^{2}}, m^{2}_{2^{2}}, \ldots, m^{2}_{g^{2}}$
	$P_{3,1}$ Internal Business Perspective	$m^{3}_{1^{3}}, m^{3}_{2^{3}}, \ldots, m^{3}_{g^{3}}$
	$P_{4,1}$ Learning & Growth Perspective	$m^{4}_{1^{4}}, m^{4}_{2^{4}}, \ldots, m^{4}_{g^{4}}$

3.4 Develop a Hierarchy for Evaluating Maritime Regulations Implementation Performance from a Ship Operator's Perspective

The organisational structure of a stakeholder can be shown by the diagram in Figure 1 where the scorecard is divided into four levels. However, each division contributes to the operation of a ship operator's structure with a unique way. Therefore, the divisions of an organisation may not be of equal weight. By making pairwise comparisons of the divisions in Level 2, their relevant weights in the maritime regulation implementation process can be estimated. By ranking the elements of Level 3 in terms of their importance, it is possible to identify which perspectives are more important for a division.

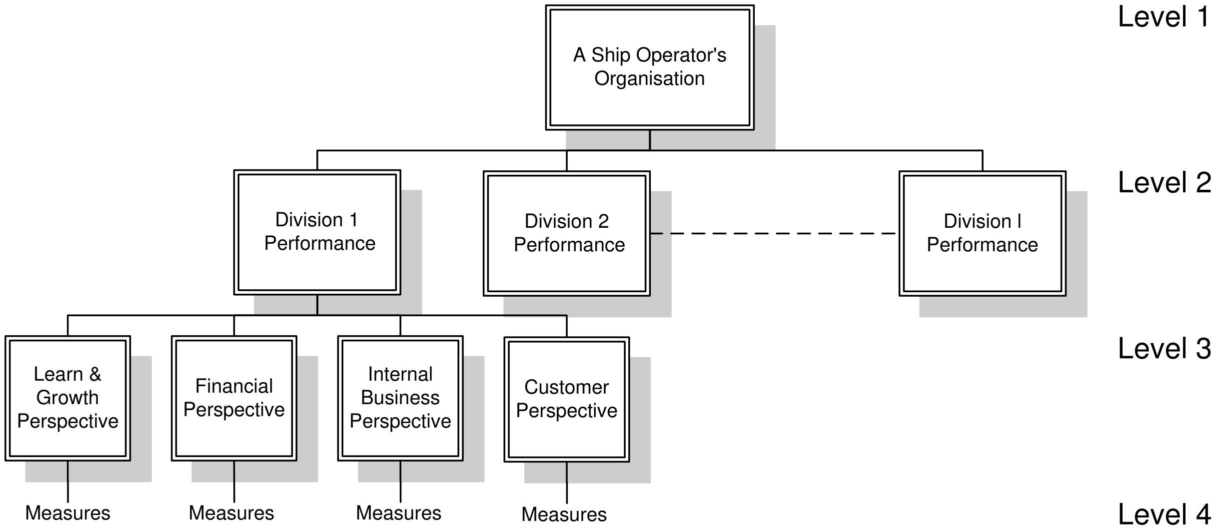

Figure 1. The Hierarchy Diagram for Evaluating Maritime Regulations Performance from a Ship Operator's View

It is expected that due to the size of the proposed hierarchy, a large number of pairwise comparisons will be carried out. The pairwise comparisons required at Level 4 of the proposed hierarchy will be too large in number. Nevertheless, if the unequal weights of measures in Level 4 are required in some cases by the stakeholders, the model is still applicable to use the procedure similar to the one for calculating the weights in Levels 2 and 3.

3.5 Evaluate the Weight of Each Division and its Perspectives and Rank them for their burden in the organisation's regulatory implementation process

In this study a Delphi survey was included for the evaluation of the scorecards, where a group of industrial experts is chosen to validate the scorecards perspectives and measures through surveys (Sii and Wang 2003). The Delphi technique is a structured process which allows experts to deal systematically with complex tasks, by means of controlled feedback and statistical response, and is recognized as an appropriate research tool where exploration of ideas and production of suitable information for decision making are required, and its adoption is particularly indicated in case of complex, interdisciplinary problems involving several new concepts (Bigliardi 2012). The Delphi method is not only used in forecasting, but also widely adopted in criteria system construction (Zhu et al 2011). The Delphi method consists of many rounds of surveys until experts reach an agreement for their judgments. In the classical Delphi a statistical aggregation of group response is used for a quantitative analysis and interpretation of data (Skulmoski et al 2007), (Chen and Chen 2005).

Following the Delphi method each expert received the scorecards in a form of a questionnaire for evaluation and comments. The experts rate the importance of each scorecard item in a scale of nine linguistic terms, where each term will correspond to a fuzzy number as it is shown in Table 5. The scale of 9 fuzzy numbers is used according to the Saaty's scale in the AHP theory as Saaty justified that individuals find it easier to compare items in a 9-point scale (Harker and Vargas 1987). Fuzzy numbers of Table 5 represent linguistic terms from equal to absolute importance. A triangular fuzzy numbers n = (a_z, b_z, c_z) where z = 1, 2,...,9 and a_z and c_z are the lower and upper values of the fuzzy number $\tilde{M}_z$, respectively. The b_z is the middle value of the fuzzy number $\tilde{M}_z$ with a membership value being equal to 1. The membership functions of fuzzy numbers are determined by experts. According to expert opinions (E_i) each linguistic term should be represented by a triangular number $\tilde{M}_z$ (z=1,2,..,9) where the value that is nearest to his understanding for that term will be the middle value b_z. By repeating the process there will be a last round where after that the data will not change because either they are very similar or the experts do not want to change their views further. After this last round of the Delphi method each expert will have concluded to a set of triangular numbers. It may be very difficult for those experts to choose the same set of numbers. Therefore, the final sets that experts provide will be averaged in order to determine the appropriate membership functions of the linguistic terms. The average of r experts' opinions, $E_{\tilde{M}_z}$ will be used to determine the fuzzy number for each linguistic term (Ung et al 2006):

$$E_{\tilde{M}_z} = \frac{\sum_{i=1}^{r} E_i}{r} \tag{5}$$

Table 5. The 9-Point Scale of AHP with Fuzzy Numbers

Intensity of Membership Importance	**Fuzzy number**	**Definition**	**Membership function**
1	$\tilde{M}_1$	Equal Importance	$(a_1,b_1,c_1,)$
2	$\tilde{M}_2$	Equal to Weak Importance	$(a_2,b_2,c_2,)$
3	$\tilde{M}_3$	Weak Importance	$(a_3,b_3,c_3,)$
4	$\tilde{M}_4$	Weak to Strong Importance	$(a_4,b_4,c_4,)$
5	$\tilde{M}_5$	Strong Importance	$(a_5,b_5,c_5,)$
6	$\tilde{M}_6$	Strong to Demonstrated Importance	$(a_6,b_6,c_6,)$
7	$\tilde{M}_7$	Demonstrated Importance	$(a_7,b_7,c_7,)$
8	$\tilde{M}_8$	Demonstrated to Extreme Importance	$(a_8,b_8,c_8,)$
9	$\tilde{M}_9$	Extreme Importance	$(a_9,b_9,c_9,)$

3.6 Design a Ship Operator's Tool Capable of Evaluating his Implementation Performance in Terms of Compliance with a Maritime Regulation

The feedbacks will be entered in the system as values of the measures. However, the values of some measures may be different such as the number of accidents or amount of money. Thus, it is necessary to normalise these values in the same scale e.g. 0 to 10. By adopting this approach, the input of the system will be the relative success of each measure in terms of achievement. Then by using the weights of the parent perspectives it is possible to calculate the impact of each measure to the overall performance of the ship operator.

The process of developing the SHS tool for a ship operator can be carried out by following the five tasks:

Task 1: Rate the measures $Rm^a_{b^a}$ with values from 0 to 10.
Task 2: Calculate each perspective rate $RP_{a,u}$ by multiplying its weight $wP_{a,u}$ with the average rate of its measures.
Task 3: Sum the perspectives rates of each division to find its performance pD_u
Task 4: Multiply a division's weight wD_u with its performance pD_u to find its rate RD_u.
Task 5: Sum the divisions' rates RD_u to calculate the ship operator's total rate S_{TR}.

The above procedure can be presented by the following equations:

$$RP_{a,u} = \frac{1}{g^a}\sum_{b=1}^{g^a} Rm_{b^a,c^u} \times wP_{a,u} \tag{6}$$

$$pD_u = \frac{1}{g^a}\sum_{a=1}^{4}\sum_{b=1}^{g^a} Rm^a_{b^a} \times wP_{a,u} \tag{7}$$

$$RD_u = pD_u \times wD_u \tag{8}$$

$$S_{TR} = \frac{1}{g^a}\sum_{u=1}^{l}\sum_{a=1}^{4}\sum_{b=1}^{g^a} Rm^a_{b^a} \times wP_{a,u} \times wD_u \tag{9}$$

The rating of each scorecard measure should be valued from 0 to 10 where the value 0 represents lack of any achievement and 10 the absolute success.

3.7 Selecting the perspectives and measures with the highest weight

A survey where a company would have to rate its performance for all the measures for all its ten divisions would be unrealistic. Furthermore in the real world fast information is an advantage. This proposed reduction is also practical because for a manager it is of high significance to be able to have accurate and fast results of his company's performance with a minimum effort. Otherwise, he is uncertain about the level of risk that he is exposed until all the 160 measures are assessed. An indication for possible failures at the early stages of implementing a regulation can help a manager to make a decision if any corrective or additional actions are required.

The first concern in minimizing the measures of the hierarchy for a ship operator is to calculate the acceptable values that each measure, perspective and division should achieve. Equation 9 can be rewritten as a sum of division rates as below:

$$S_{TR} = RD_1 + RD_2 + RD_3 + ... + RD_u \tag{10}$$

In Equation 10 each RD_u can be replaced by its weights wD_u and its performance rates pD_u as follows:

$$S_{TR} = wD_1 \times pD_1 + wD_2 \times pD_2 + ... + wD_u \times pD_u \tag{11}$$

In order to identify the most valuable divisions with the highest weights it is assumed that there is a division value RD_x where after that all other divisions' contribution is numerically insignificant. Hence, Equation 11 will be:

$$S_{TR} = wD_1 \times pD_1 + wD_2 \times pD_2 + ... + wD_x \times pD_x + ... + wD_{u-1} \times pD_{u-1} + wD_u \times pD_u$$

Since the lower ranked divisions' contribution may be numerically insignificant even if they excel, the pD_u values can be replaced by the value 10 which is the highest value that can be achieved by any division:

$$S_{TR} = wD_1 \times pD_1 + wD_2 \times pD_2 + ... + wD_x \times pD_x + ... + wD_{u-1} \times 10 + wD_u \times 10 \Rightarrow$$

$$S_{TR} = wD_1 \times pD_1 + wD_2 \times pD_2 + ... + wD_x \times pD_x + 10\left(wD_{x+1} + ... + wD_{u-1} + wD_u\right)$$

It is known that the sum of all the weights is equal to 1. The sum of the smaller weights can be found from deducting their sum from the value 1. Hence, Equation 11 can be rewritten:

$$S_{TR} = wD_1 \times pD_1 + wD_2 \times pD_2 + ... + wD_x \times pD_x + 10\left(1 - wD_1 - wD_2 - wD_x\right)$$

The stakeholder must consider which should be the lowest acceptable value M for each division's performance. However, it is obvious that this value should not be less than 5, which is half of the maximum and desired achievement.

$$S_{TR} = wD_1 \times M + wD_2 \times M + ... + wD_x \times M + 10\left(1 - wD_1 - wD_2 - wD_x\right) \Rightarrow$$

$$S_{TR} = M(wD_1 + wD_2 + ... + wD_x) + 10 - 10(wD_1 + wD_2 + wD_x) \Rightarrow$$

$$S_{TR} - 10 = (wD_1 + wD_2 + ... + wD_x)(M - 10) \Rightarrow$$

$$M = \frac{S_{TR} - 10}{wD_1 + wD_2 + ... + wD_x} + 10 \qquad (12)$$

The above equation shows the relationship between the stakeholder performance S_{TR} and the sum of the highly ranked divisions' weights when all the other divisions excel. As was revealed by the

From the above calculations, it is shown that by examining the hierarchical organisation of a company, the performance of a division is lower than the value 5.91 it is harder for the company to achieve a S_{TR} value higher than 7. Therefore, by checking hierarchically a company with the above process it is possible to have a fast indication about the company's performance without needing to check all the 160 proposed measures.

4. Numerical Illustration

In this section, a numerical illustration is carried out in order to demonstrate the applicability of the proposed methodology by following the four steps below:

Step 1: Evaluation of the ship operator's divisions weights.
Step 2: Evaluation of perspectives' weights of each division.
Step 3: Evaluation of ship operator's implementation performance (SHS tool).
Step 4: Evaluation of a regulation from the ship operator's perspective

In this case study, the maritime regulation chosen to be investigated for its implication to a ship operator is The SOLAS regulation II-1/19.1, as amended by resolution MSC.216(82), Damage control information introduced by the IMO. To avoid numerous calculations, the Perspectives and measures with the highest weight have been included. With respect to the problem of decision making Gigerenzer (1996, 2007) suggested that in decision making problems where lack of both time and expertise exist it may be useful to examine a single criterion each time until all criteria are met. When there is evidence that one of the criteria is unsuccessfully met then corrective actions should be taken. In this research, it is suggested that the order of the criteria examined should follow a ranking order according to their importance.

In order to demonstrate the applicability of the SHS methodology to measure the implementation performance of a maritime regulation two surveys were designed. The aim of the first survey is to validate the indicators and measures from the scorecards by industrial experts. The second survey was carried out in order to carry a case study by comparing the performances of four companies regarding their performance towards the regulation II-1/19.1. The results of both surveys are included and explained during the steps in the methodology.

4.1 Evaluation of the Ship Operator’s Divisions weights

Eight experts were chosen in this study, each being with a reasonable mixture of academic qualifications, professional qualifications and industrial experiences. The first task for the experts was to determine the fuzzy memberships of the linguistic terms that intend to use. By following the Delphi method each expert was required to evaluate each linguistic term in a scale from 1 to 9. The average value of all experts determines the fuzzy number of each linguistic term. The results for the linguistic terms are shown in Figure 2 and Table 6. For example, given that eight experts are involved in the analysis of calculating the membership of strong importance, it can be obtained as follows using Equation 5.

$$\tilde{M} = \frac{\sum_{i=1}^{8} \text{[illegible]}}{8} = \frac{\text{[illegible]}}{8}$$

$$= (\text{[illegible]})$$

In a similar way, the membership functions of the other linguistic terms can be computed.

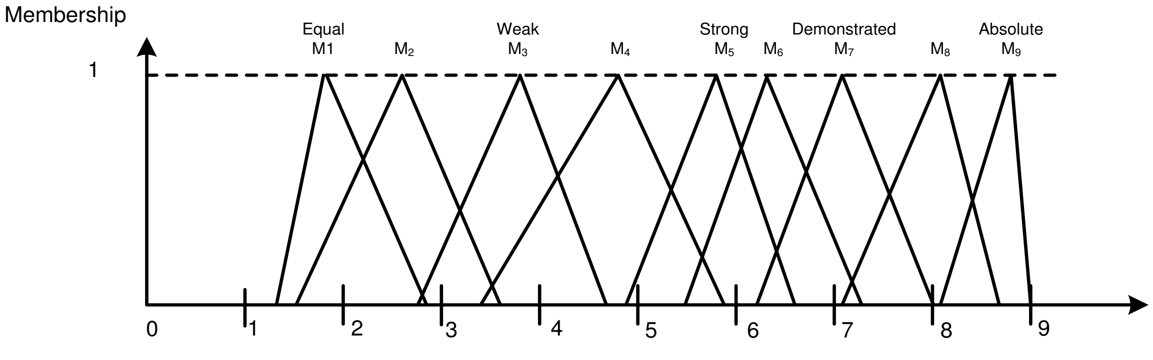

Figure 2. The Memberships of the Calculated Fuzzy Numbers

Table 6. The 9-Point Scale of AHP with Calculated Fuzzy Numbers

Intensity of Membership Importance	Fuzzy Number	Definition	Membership Function
1	$\tilde{M}_1$	Equal Importance	(1.250, 1.750, 2.750)
2	$\tilde{M}_2$	Equal to Weak Importance	(1.625, 2.750, 3.750)

3	$\tilde{M}_3$	Weak Importance	(2.750, 3.750, 4.625)
4	$\tilde{M}_4$	Weak to Strong Importance	(3.375, 4.750, 5.875)
5	$\tilde{M}_5$	Strong Importance	(4.875, 5.875, 6.625)
6	$\tilde{M}_6$	Strong to Demonstrated Importance	(5.500, 6.375, 7.250)
7	$\tilde{M}_7$	Demonstrated Importance	(6.250, 7.125, 8.000)
8	$\tilde{M}_8$	Demonstrated to Extreme Importance	(7.125, 8.125, 8.625)
9	$\tilde{M}_9$	Extreme Importance	(8.125, 8.750, 9.000)

A pairwise comparison matrix is completed for the chosen divisions in Table 2. The fuzzy numbers are then added and averaged with Equations 2 and 3. For the fuzzy numbers a defuzzication process follows to obtain crisp numbers (M_crisp) by using Equation 4. All the defuzzication results from the fuzzy matrix of the ship operator are shown in Table 7. For the ship operator's crisp matrix from Table 7, the CR value for the $n=10$ matrix is calculated to be 0.12 where the CR is below the value 0.2. By using Equation 1 the divisions are ranked in terms of their weighting in the regulatory process of a ship operator's organisation. In Table 9, the ranking order of the divisions is displayed in terms of their weighting in the regulation's implementation process by a ship operator. It appears that the most important division in the regulatory implementation process is the managing director followed by the operation department, the ISM department and the technical department.

Table 7. Defuzzification Results of Divisions' Pairwise comparisons

	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}
D_1	1.000	5.296	4.323	4.928	3.056	4.788	5.540	3.558	4.179	4.889
D_2	0.189	1.000	2.351	5.156	2.384	6.375	4.672	2.977	3.348	6.005
D_3	0.232	0.432	1.000	3.981	2.070	6.339	2.549	3.270	3.787	5.911
D_4	0.206	0.197	0.256	1.000	0.222	3.392	2.460	1.963	0.916	3.726
D_5	0.329	0.429	0.497	4.577	1.000	4.697	5.078	4.828	4.781	5.599
D_6	0.213	0.159	0.159	0.306	0.217	1.000	1.799	0.982	1.471	4.257
D_7	0.182	0.217	0.405	0.417	0.200	0.564	1.000	1.507	2.816	4.794
D_8	0.284	0.346	0.312	0.527	0.210	1.044	0.686	1.000	3.362	5.380
D_9	0.241	0.304	0.267	1.113	0.212	0.693	0.359	0.304	1.000	0.875
D_{10}	0.207	0.169	0.171	0.280	0.182	0.239	0.214	0.190	1.166	1.000

Table 8. The Weighting of Divisions

D_1	Managing Director	0.275
D_2	Operation Department	0.174
D_4	ISM Department	0.144

D_3	Technical Department	0.141
D_6	Chartering Department	0.061
D_5	ISPS Department	0.057
D_8	Crew Department	0.051
D_7	Accounting Department	0.044
D_{10}	Ship	0.031
D_9	Supply Department	0.022

4.2 Evaluation of the Ship Operator’s Perspectives

As it is required in the questionnaire, the experts make pairwise comparisons for the perspectives of each division, which are displayed in Table 9 for the operation department. The pairwise comparisons are first used to design a fuzzy matrix and then the defuzzication results of the fuzzy matrix are obtained as shown in Table 9. The $\lambda_{\max}$ value is calculated to be 4.267. The CR value is calculated to be 0.099 which is less than 0.2. The other divisions and their perspectives are studied in a similar way. The weighting from the fuzzy matrix is found under the column D_2 in the Table 10 together with the weights of the four perspectives for each division.

Table 9. Defuzzication Results of Fuzzy Matrix for the Operation Department’s Perspectives

	Financial	**Customer**	**Internal Business**	**Learn & Growth**
Financial	1.000	3.888	5.329	3.329
Customer	0.260	1.000	5.931	6.012
Internal Business	0.189	0.169	1.000	1.227
Learn & Growth	0.306	0.167	0.846	1.000

Table 10. The perspective weights for each Perspective and its parent Division

	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}
Financial	0,579	0,502	0,462	0,503	0,237	0,603	0,365	0,197	0,461	0,573
Customer	0,229	0,328	0,305	0,294	0,324	0,215	0,364	0,370	0,261	0,210
Internal Business	0,098	0,081	0,130	0,118	0,106	0,108	0,126	0,165	0,121	0,143
Learn & Growth	0,094	0,089	0,103	0,085	0,333	0,074	0,146	0,268	0,157	0,075

The overall priority of the ten divisions of the ship operator is then displayed in Table 11. In Table 11 it is shown that the perspective with the highest weight for the divisions to implement the regulation is the financial perspective, followed by the customer perspective, internal business and the learn & growth. These results indicate that for a ship operator the most interesting issue is the costs that can be generated to each department by the implementation of the new regulation. The difficulties generated by additional workload to fulfil the regulation’s requirements and to improve his organisation functions are of second priority. It is expected that for some divisions their priorities may be different. For instance, in the ISM department the customer perspective is ranked higher than the financial perspective.

Table 11. Overall Priority of Perspectives

Divisions	**Financial**	**Customer**	**Internal Business**	**Learn & Growth**
Managing Director	**0.159**	**0.063**	**0.027**	**0.026**
Operation Department	**0.087**	**0.057**	0.014	0.015
Technical Department	**0.065**	**0.043**	0.018	0.014
Chartering Department	**0.031**	0.018	0.007	0.005
ISM Department	**0.034**	**0.047**	0.015	**0.048**
Accounting Department	**0.027**	0.009	0.005	0.003
Crew Department	0.019	0.019	0.006	0.007
ISPS Department	0.011	0.021	0.009	0.015
Ship	0.014	0.008	0.004	0.005
Supply Department	0.013	0.005	0.003	0.002
Total	0.460	0.289	0.109	0.142

4.3 Evaluation of ship operator’s implementation performance

As it was stated in Section 4 in the Survey 2 divisions with the higher the perspectives with the highest weight were included. With this practice 13 perspectives with 54 measures were selected as below in Table 12. The weight of the perspectives aggregate a total weight of 0.714 which indicates their significance in measuring the regulatory performance of a ship operator. Furthermore it is very clear that by selecting those perspectives it is shown the significance on the decision making of departments.

Table 12. Perspectives With Highest Weight

Division	**Perspectives**	**Overall Weights**
Managing Director	Financial	0.159
	Customer	0.063
	Internal Business	0.027
	Learn & Growth	0.026
Operation Department	Financial	0.087
	Customer	0.057
Technical Department	Financial	0.065
	Customer	0.043
ISM Department	Financial	0.034
	Customer	0.047
	Learn & Growth	0.048
Chartering Department	Financial	0.031
Accounting Department	Financial	0.027

The quality and safety managers from four companies with the characteristics presented in Table 13 agreed to participate in Survey 2. It is very clear that these four companies vary in size but also in organization as it is shown from the number of personnel ashore. In Table 14 is shown the scorecard of the four ship operators completed for the Damage control information requirement of SOLAS. Each scorecard related to the ship operator is filled in with values from 0 to 10 for each measure by reference to Table 15. The rates of Table 15 were obtained from the judgements of the eight selected experts.

Table 13. Ship Operators

Ship Operators	**Number of ships operated**	**Number of Personnel ashore**
Ship Operator 1	3	9
Ship Operator 2	4	15
Ship Operator 3	25	42
Ship Operator 4	55	17

Table 14. Implementation Performance of the Ship Operators

		Ship Operator 1			Ship Operator 2			Ship Operator 3			Ship Operator 4		
		$RP_{a,u}$	pD_u	RD_u	$RP_{a,u}$	pD_u	RD_u	$RP_{a,u}$	pD_u	RD_u	$RP_{a,u}$	pD_u	RD_u
Managing Director	Financial	1.447	3.675	1.011	2.315	4.908	1.350	0.868	2.264	0.623	1.447	3.833	1.054
	Customer	1.318			1.604			0.630			1.662		
	Internal Business	0.416			0.612			0.318			0.489		
	Learn & Growth	0.494			0.377			0.447			0.235		
Operation Department	Financial	1.757	3.725	0.648	2.511	4.970	0.865	1.506	2.654	0.462	1.130	2.769	0.482
	Customer	1.968			2.460			1.148			1.640		
Technical Department	Financial	1.618	3.603	0.519	1.965	4.332	0.624	1.387	2.380	0.343	0.578	1.876	0.270
	Customer	1.986			2.367			0.993			1.298		
ISM Department	Financial	0.651	2.873	0.405	0.710	5.458	0.770	0.651	2.786	0.393	0.710	5.458	0.770
	Customer	0.973			3.082			1.135			3.082		
	Learn & Growth	1.250			1.666			1.000			1.666		
Chartering Department	Financial	1.636	1.636	0.100	3.273	3.273	0.200	1.385	1.385	0.084	1.259	1.259	0.077
Accounting Department	Financial	1.207	1.207	0.053	4.072	4.072	0.179	1.207	1.207	0.053	1.508	1.508	0.066

Table 15. The Rating of Measures

Rate	Definition
9-10	Very High Performance
7-8	High Performance
4-6	Medium Performance
2-3	Low Performance
0-1	Very Low Performance

The next step of analysis is to compare the division rates of each ship operator in order to find which divisions face the most challenges. A list of the performance of the ship operators' divisions is shown in Table 14. In this table, it is shown that the ship operators agree about how their divisions can perform by implementing the regulation for damage stability information. From Table 15 the first conclusion is that all the divisions' rates are much less than the minimum values that should be achieved. Additionally, there is an imbalance of performance between the divisions. Therefore, the regulation implementation is believed to be challenging for most of the divisions.

The ship operators' perspectives and divisions' rates are calculated by using the measures rates from the Survey 2 and equations 6, 7 and 8. For instance the rate of the financial perspective of the operation department for Ship Operator 1 is calculated as following using Equation 6:

$$RP_{1,1} = \frac{1}{4}\sum_{g^1=1}^{4} Rm^1_{b^1} \times wP_{1,1} = \frac{1}{4}\left(Rm^1_{1^1} + Rm^1_{2^1} + Rm^1_{3^1} + Rm^1_{4^1}\right) \times 0.502$$

$$= \frac{1}{4}(8+2+3+1) \times 0.502 = 3.5 \times 0.502 = 1.757$$

By carrying out similar calculations as for the financial perspective the rates of the other perspectives of the operation department are obtained to be $RP_{2,1}$=1.476, $RP_{3,1}$=0.282 and $RP_{4,1}$=0.514. Then the operation department performance pD_1 is calculated as following using Equation 7:

$$pD_1 = \sum_{a=1}^{l} RP_{a,1} = RP_{1,2} + RP_{2,1} = 1.757 + 1.968 = 3.725$$

By using Equations 6 and 7 all the divisions' performances are computed and the results are shown in Table 14. Each division's performance is then normalized with its weight wD_u (Equation 8). For example, the operation department's performance is calculated as:

$$RD_1 = pD_1 \times wD_1 = 3.725 \times 0.174 = 0.648$$

These results for all ship operators which are shown at Table 14 where for each correspondent operator three columns are displayed indicating from the left to the right his rates perspectives' rates, division's performance and the divisions' rate respectively. For instance for the ship operator 3 the value of the managing director's financial perspective is 0.868. For the same ship operator the performance of his division is 2.264 and the division's rate is 0.623 which are shown in the second and third column respectively.

For some divisions the rates could not be much higher even if the regulation had fewer requirements since the improvement of safety is costly and time consuming. However, a small increase could make a difference. It is of high importance to underline that the results would be more accurate if the ship operators could provide numerical data such as the amount of money spent or the number of failures related to the regulation. Hence it is fairly reasonable to say that the opinions of the correspondents may be more negative than the real situation is.

For further analysis it is important to compare the perspectives since the survey was designed based on perspectives for more accuracy. The three perspectives, which achieved the higher values, are the customer from the division of Managing Director, customer from the division of Operation Department and customer from the division of ISM Department. This is an indication that the ship operators understand that their compliance with damage stability regulation is something that will improve their public image to many of the other stakeholders. In contrast, the three perspectives with the lower values are the financial from the division of Managing Director, financial from the division of the ISM Department and the financial from the division of Technical Department. This is an indication related to the cost that the regulation will produce to the ship operators.

4.4 Evaluation of a regulation from the Ship Operator's perspective

The performance of each ship operator was calculated and the results are presented in Table 16. For instance, all the divisions' rates are summed to find the total rate S_{TR} (Equation 9) for Ship Operator 1:

$$S_{TR} = \sum_{u=1}^{l} RD_u = RD_1 + RD_2 + RD_3 + RD_4 + RD_5 + RD_6 + RD_7 =$$

$$= 1.011 + 0.648 + 0.519 + 0.405 + 0.1 + 0.053 = 2.736$$

Table 16. Summary of Ship Operators' Performance

	Ship Operator 1		Ship Operator 2		Ship Operator 3		Ship Operator 4	
D_u	RD_u	S_{TR}	RD_u	S_{TR}	RD_u	S_{TR}	RD_u	S_{TR}
Managing Director	1.011	2.736	1.350	3.988	0.623	1.958	1.054	2.719
Operation Department	0.648		0.865		0.462		0.482	
Technical Department	0.519		0.624		0.343		0.270	
ISM Department	0.405		0.770		0.393		0.770	
Chartering Department	0.100		0.200		0.084		0.077	
Accounting Department	0.053		0.179		0.053		0.066	

From the above Table 16 is shown that ship operators are not very optimistic about their performance when they have to examine their performance regarding the regulation in more detail. Although among the ship operators the structure of the company varies the ship operator 2 who appears to have the highest performance has a high number of ships operated and staff ashore. This could be an indication that in order to implement a regulation a ship operator should have a significant number of people ashore.

This case study shows a detailed analysis of the factors that may affect the performance of the chosen divisions during the implementation of the regulation. It is very important to highlight that the total results from each ship operator are low. An indication of how a simple regulation that does not need structure changes to ships or purchase of new equipment still makes ship operators to achieve a low performance despite their size or the number of ships they operate.

6. Conclusion

As it can be seen from the above analysis, a variety of ship operators agree with the outcome of the regulation of Damage Control Information. Although the significance of the regulation is not in doubt the time consuming procedures, costs and potential errors result in that the ship operators may have a low performance in implementing the given regulation. Therefore, it can be concluded that even small simplified regulations may produce many challenges to a ship operator. These challenges should not be examined as an isolated situation but it should be added to the existing difficulties that are generated by the implementation process of all the previous regulations that a ship operator must follow.

A further contribution of this research is that a methodology and one tool are developed in order to evaluate the performance of a ship operator. Hence, it is introduced as an effective management system, which can assist the ship operators in improving their implementation performance. The proposed management system does not demand an excessive workload or excessive paperwork.

The proposed methodology is a unification of methods, which are brought together in an advanced mathematic model. The combination of sound methods such as AHP and the fuzzy set theory produced a decision-making methodology. Regulators can use this methodology as a tool that can justify their decision in introducing a regulation based on accurate and reliable results. This approach is in line with many governments that follow the OECD guidance for improving their regulations and so avoid unnecessary and overlapping regulations.

In the modern complex shipping industry, mistakes and omissions are often heavily punished. Therefore, a ranking of the priorities that a ship operator should consider when he implements maritime regulations is of great importance. In this research it was demonstrated how significant a detailed performance management system is for a ship operator when he evaluates his organisation regarding regulatory implementation.
The comparison between the detailed implementation of a tool and selective implementation of the tool reveals two significant points. Firstly, it is very costly for a ship operator to assess in detail his regulatory performance and keep monitoring. Secondly, a ship operator may end with misleading conclusions for his regulatory implementation performance if he fails to use a management system or a tool in detail. An inadequate operation of the proposed tools by a ship operator could produce a high degree of uncertainty for his organisation's implementation performance. This can be caused because the BSC's elements with small relative weight are numerous. I It is therefore suggested in this research that although the higher ranked elements can show fast an indication of a ship operator's performance the remaining elements should also be examined thoroughly.

References

1. Bhattacharya S. (2012). The effectiveness of the ISM Code: A qualitative enquiry. Marine Policy Vol. 36, pp. 528–535.
2. Bigliardi B., Dormio A.I., Galati F., Schiuma G. (2012). The impact of organizational culture on the job satisfaction of knowledge workers The journal of information and knowledge management systems Vol. 42(1), pp. 36-51.
3. Björn H. (2010). Global regimes, regional adaptation; environmental safety in Baltic Sea oil transportation. Maritime Policy & Management: The flagship journal of international shipping and port research. Vol. 37(5), pp. 489-503.
4. Brock D.M. (2005). Multinational acquisition integration: the role of national culture in creating synergies. International Business Review, Vol. 14, pp. 269-288.
5. Cariou P., Mejia M.Q., Wolff C.F. (2009). Evidence on target factors used for port state control inspections. Marine Policy Vol. 33, pp. 847-859.
6. Celik M. (2009). Designing of integrated quality and safety management system (IQSMS) for shipping operations .Safety Science Vol. 47,pp 569-577.
7. Celik M., Lavasani S.M., Wang J. (2010). A risk-based modelling approach to enhance shipping accident investigation. Safety Science Vol. 48, pp. 18-27.
8. Chen S.J., Chen S.M. (2005). Aggregating fuzzy opinions in the heterogeneous group decision-making environment. Cybernetics and Systems: An International Journal, Vol. 36, pp. 309-338**.**
9. Cheng A.C., Yang B.K., Hwang C. (1999). Evaluating attack helicopters by the AHP based on linguistic variable weight. European Journal of Operational Research, Vol. 116, pp. 423-435.
10. Chu T.Y., Liang G.S. (2001). Application of a fuzzy multi-criteria decision-making model for shipping company performance evaluation. Maritime Policy Management, Vol. 28(4), pp. 375-392.
11. Dadkhah K.M., Zahedi F. (1993). A mathematical treatment of inconsistency in the analytic hierarchy process. Mathematical Computing Modeling, Vol. 17(415), pp. 111-122.
12. Harker P.T., Vargas, L.G. (1987). The theory of ratio scale estimation: Saaty's analytic hierarchy process. Management Science, Vol. 33(11), pp. 1383-1403.
13. Håvold J.I, Nesset E. (2009). From safety culture to safety orientation: Validation and simplification of a safety orientation scale using a sample of seafarers working for Norwegian ship owners. Safety Science Vol. 47, pp. 305–326.
14. Heitmann N., Khalilian S. (2011). Accounting for carbon dioxide emissions from international shipping: Burden sharing under different UNFCCC allocation options and regime scenarios. Marine Policy Vol.35, pp. 682–691.
15. Hetherington C., Flin R., Mearns K. (2006). Safety in shipping: The human element. Journal of Safety Research, Vol. 37, pp. 401–411.
16. Huoa L.,Lan J., Wangb Z. (2011). New parametric prioritization methods for an analytical hierarchy process based on a pairwise comparison matrix. Mathematical and Computer Modelling Vol. 54, pp. 2736–2749.
17. Jensen J.I., Randoy T. (2002). Factors that promote innovation in shipping companies. Maritime Policy & Management, Vol. 29(2), pp. 119-133.
18. Jensen J.I., Randoy T. (2006). The performance effect of innovation in shipping companies. Maritime Policy & Management, Vol. 33(4), pp. 327–343.
19. Kaplan R.S., Norton D.P. (1996a). Linking the balanced scorecard to strategy. California Management Review, Vol. 39(1), pp 55-79.
20. Kaplan R.S., Norton D.P. (1996b). Using the balanced scorecard as a strategic management system. Harvard Business Review, January-February, pp. 75-85.
21. Karahalios H., Yang Z.L., Wang J. (2011b) A study of the implementation of maritime safety regulations by a ship operator‖, In Advances in Safety, Reliability and Risk Management, Ed. Berenguer, Grall and Guedes Soares, Proceeding of 2011. Annual European Safety and Reliability Conference (ESREL), Troyes, France, 18-22 September 2011, 2863-2869

22. Karahalios H., Yang Z.L., Williams V., Wang J. (2011a). A proposed system of hierarchical scorecards to assess the implementation of maritime regulations, Safety Science, Vol.49, pp. 450-462.
23. Knapp S., Franses P.H. (2009). Does ratification matter and do major conventions improve safety and decrease pollution in shipping? Marine Policy Vol. 33, pp. 826-846.
24. Knudsen O., Hassler B. (2011). IMO legislation and its implementation: Accident risk, vessel deficiencies and national administrative practices Marine Policy Vol. 35, pp. 201-207.
25. Kwong K.C., Bai H. (2003). Determining the importance weights for the customer requirements in QFD using a fuzzy AHP with an extent analysis approach. IIE Transactions, Vol. 35, pp. 619-626.
26. Lee T.R, , Nha Le T.P., Genovese A., Lenny S.C. Koh L.S.C. (2012). Using FAHP to determine the criteria for partner’s selection within a green supply chain The case of hand tool industry in Taiwan Journal of Manufacturing Technology Management Vol. 23 (1), pp. 25-55.
27. Li K.X., Cullinane K. (2003). An economic approach to maritime risk management and safety regulation. Maritime Economics & Logistics, Vol. 5, pp. 268–284.
28. Linstone H.A., Turoff M. (1975). The Delphi method: Techniques and applications. Addison Wesley, Reading, MA.
29. Lyridis D.V., Fyrvik T., Kapetanis G.N., Ventikos N., Anaxagorou P., Uthaug E., Psaraftis H.N. (2005). Optimizing shipping company operations using business process modelling. Maritime Policy & Management, Vol. 32(4), pp. 403-420.
30. Panayides P.M. (2003). Competitive strategies and organizational performance in ship management. Maritime Policy & Management, Vol. 30(2), pp. 123-140.
31. Panayides P.M., Cullinane K.P.B. (2002). The vertical disintegration of ship management: choice criteria for third party selection and evaluation. Maritime Policy & Management, Vol. 29(1), pp. 45-64.
32. Perepelkin M., Knapp S., Perepelkin G., Pooter M. (2010). An improved methodology to measure flag performance for the shipping industry.   Marine Policy 34, pp. 395–405
33. Plomaritou E., Plomaritou V., Giziakis K. (2011). Shipping Marketing & Customer Orientation: The Psychology & Buying Behaviour of Charterer & Shipper in Tramp & Liner Market. Journal of Management, Vol.16(1), pp. 57-89.
34. Progoulaki M., Theotokas I. (2010). Human resource management and competitive advant age: An application of resource-based view in the shipping industry. Marine Policy, Vol. 34, 575–582.
35. Psarros G., Skjong R., Eide M.F. (2010). Under-reporting of maritime accidents. Accident Analysis and Prevention, Vol.42, pp. 619–625.
36. Punniyamoorthy, M. and Murali, R. (2008). Balanced score for the balanced scorecard: a benchmarking tool. Benchmarking: An International Journal, Vol. 15, pp. 420-43.
37. Saaty T.L. (1977). A scaling method for priorities in hierarchical structures. Journal of Mathematical Psychology, Vol. 15, pp. 234-281.
38. Saaty T.L. (1994). How to make a decision: the analytic hierarchy process Interfaces, Vol. 24(6), pp. 19-43.
39. Shafia M.A., Mazdeh M.M., Vahedi M. and Pournader M. (2011). Applying fuzzy balanced scorecard for evaluating the CRM performance Industrial Management & Data Systems Vol. 111(7), pp. 1105-1135.
40. Sii H.S., Wang J. (2003). A design–decision support framework for evaluation of design options/proposals using a composite structure methodology based on the approximate reasoning approach and the evidential reasoning method. Proceedings of the I MECH E Part E Journal of Process Mechanical Engineering, Vol. 217(1), pp. 59-76.
41. Silos J.M ,Piniella F., J.Monedero J.,J.Walliser J. (2012) Trends in the global market for crews: A case study. Marine Policy Vol.36, pp 845–858

42. Skulmoski G.J., Hartman F.T., Krahn J. (2007). The Delphi method for graduate research. Journal of Information Technology Education, Vol. 6, pp. 1-21.
43. Staronova K., Pavel J., Katarina Krapez K. (2007). Piloting regulatory impact assessment: a comparative analysis of the Czech Republic, Slovakia and Slovenia. Impact Assessment and Project Appraisal, Vol. 25(4), pp. 271-280.
44. Tung A., Baird K., and Schoch H.P. (2011). Factors influencing the effectiveness of performance measurement systems International Journal of Operations & Production Management Vol. 31(12), pp. 1287-1310.
45. Tzannatos E. Kokotos D. (2012). Analysis of accidents in Greek shipping during the pre- and post-ISM period. Marine Policy Vol. 36, pp. 528–535.
46. Ung S.T., Williams V., Chen H.S., Bonsall S., Wang J. (2006). Human error assessment and management in port operations using Fuzzy AHP. Marine Technology Society Journal, Vol. 40(1), pp. 73-86.
47. Vanem E., Endresen Ø., Skjong R. (2008). Cost-effectiveness criteria for marine oil spill preventive measures. Reliability Engineering & System Safety, Vol. 93, pp. 1354–1368.
48. Vargas L. (1982). Reciprocal matrices with random coefficients. Mathematical Modelling, Vol. 3, pp. 69-81.
49. Vickers I. (2008). Better regulation and enterprise: the case of environmental health risk regulation in Britain. Policy Studies, Vol. 29(2), pp. 215-232.
50. Vinodh S., Shivraman K.R. and Viswesh S. (2012). AHP-based lean concept selection in a manufacturing organization Journal of Manufacturing Technology Management Vol. 23(1), pp. 124-136.
51. Wang J. (2006). Maritime risk assessment and its current status. Quality and Reliability Engineering International, Vol. 22, pp. 2-19.
52. Wedley W.C. (1993). Consistency prediction for incomplete AHP matrices. Mathematical Computing Modeling, Vol. 17(415), pp. 151-161.
53. Zheng G., Zhu N., Tian Z., Chen Y., Sun B. (2012). Application of a trapezoidal fuzzy AHP method for work safety evaluation and early warning rating of hot and humid environments. Safety Science Vol.50, pp. 228–239.
54. Zhu Q., Du J.T., Meng F., Wu K., Sun X. (2011). Using a Delphi method and the analytic hierarchy process to evaluate Chinese search engines: A case study on Chinese search engines Online Information Review Vol. 35(6), pp. 942-956.