The influence of resources on the implementation of quality procedures in MET systems and safety at sea (IRMETS)

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Abstract

The intensive development of various types of very important and useful regulations and standards in the shipping industry in recent years, in a lot of cases, is not sufficiently coordinated with the quantity and quality of resources to meet them and ensure their proper implementation. This paper presents the project sponsored by the Nippon Foundation describing some formal approaches in analysis of Human Element impact on safety and security in the shipping industry and MET efficiency.
Keywords: crew resources, fuzzy logic, Bayesian nets, safety, security.

1 Introduction

Application of such "catalysts of efficiency and safety" as ISO and ISM Code standards without granting the appropriate resources to meet their provisions has led to the emergence of some negative tendencies in which new terms and concepts are generated. These include "paper safety", "paper audit", "paper quality", etc. But the carrying out of many of such bureaucratic "paper procedures" to keep the "paper image" of the MET institution, shipping company or vessel, wastes the same resources and, in many cases, reduces the level of quality and safety. So, there is a vicious circle, and to escape from it, i.e. to raise the efficiency of the regulations and standards, we have only one possibility and that is finding the optimum balance between requirements and resources through the reasonable compromise between safety and economic efficiency of the industry. The shipping industry and MET field are linked in one system and in this Project we have tried to research such links using FIS and Bayesian nets.

2 Crew resources analysis

2.1 Fuzzy Inference System (FIS) application to regulation and crew resources analysis

The theory of Fuzzy sets, which basic ideas have been offered by American mathematician Lofty Zadeh, describe a qualitative, fuzzy concepts and knowledge of the world around and to operate with this knowledge and openly receiving new information. The methods of construction of information models based on this theory essentially expand traditional areas of computer applications and form an independent direction. Scientifically applied research has received the special name - Fuzzy modelling. The technique of modelling is described in [1]. The FIS flow-chart is presented on Figure 1. To make an FIS we used Gaussian membership functions distributed at regular intervals. These intervals and sets of linguistic variables are shown in brackets below. Input linguistic variables:

- manning (0-2; reduced, standard, increased);
- skill (0-2; low, medium, standard, high, excellent);
- regulations (0-4; lack, sufficient, functionally redundant, overlap, overregulation).

Output linguistic variables:
- workload (0-2; low, medium, standard, overload, extremely overload);
- task (0-2; not solved, almost not solved, almost solved, solved, little better solution, more better solution, the best solution).

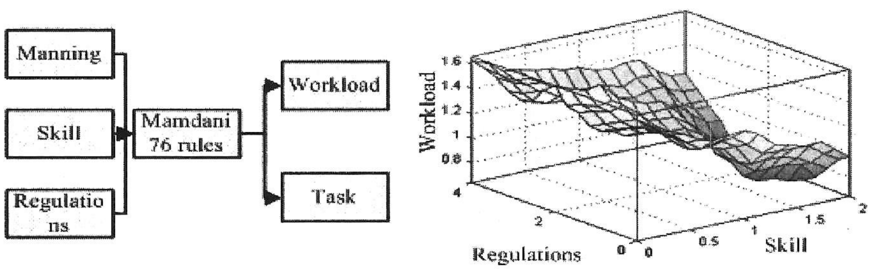

Figure 1: FIS and Workload surface.

All the standard (conventional) values in this model are equal to 1. So, if the value of workload is 1 it means that hours of rest meet the requirements of STCW 78, as amended and ILO 180 etc.

We used an adjustable model consisting of a set of 76 fuzzy *if-then rules* of the following type:

1. If (manning is standard) and (skill is standard) and (number of regulations is sufficient) then (workload is standard) and (level of task solution is standard)...76. If (manning is reduced) and (skill is low) and (there is an

overregulation) then (the crew is extremely overloaded) and (the task is not solved).

Some formal findings and results within the model frames are given below:

a) If even the number of regulations is functionally sufficient and manning and skill of the crew is conventional, then to make the 0.9 of conventional work the probable crew overload of 0.12 is a common thing.
b) If in “a” conditions the crew is reduced to 0.8 then the workload increases to 0.24, and crew performance falls to 0.85.
c) If the qualification of crew leaves much to be desired then it practically means that workload is at the same level as in result “b” and in this case the crew performance level is reduced to 0.71.
d) If there is a functional lack of regulations then even with the complete crew and their standard qualification, the crew performance level is 0.7.
e) The overregulation impact is very similar to the situation “d”. Overregulation is dangerous, as it distracts seafarers from performance of their direct official duties frequently to please the ship inspectors. This is the main reason of «paper image».
f) Overregulation is catastrophic for ship (company) when there is a shortage of crew especially if the crew is low qualified. In this case crew performance is only 0.58. It is accompanied by an enormous overload. Overregulation, unskilled seafarers and overload go together and they create the vicious circle to increase regulation even more.
g) Improvement of crew skill by 0.1 enables to give standard level of crew performance with its possible insignificant overload of 0.1.

The results "a-e" show low crew performance. In other words, in these cases there is a *constant hazardous atmosphere* originating with the high probability of incidents, accidents or catastrophes.

Analyzing the output linguistic variables, Workload and Task (Crew performance), we received some findings and results, which are partially submitted below:

h) Even in conditions of keen competition, the overregulation in the shipping industry could be avoided or its negative impact could be reduced by educating and training of highly qualified seafarers and the company’s shore based staff and ship inspectors.
i) Decrease in seafarer’s qualification is equal to increasing of his/her workload. It means an increase in the fatigue and reducing the level of safety as well as the attractiveness of shipping industry.
j) Non-compliance with the rest-hours required by STCW 78 and ILO 180, as well as the level of safety and security, is originated in MET institutions. For example, wrong and very formal implementation of ISO standards in MET institutions in lack of human resources could result in increasing of paper work and promote the outflow of teaching personnel from this bureaucratic work. In its turn this promotes the possible non-compliance with the MET

standards, and further such hazards block to meet the STCW, ISM, ISPS, ... provisions.

k) One of the reasons of overregulation in shipping industry is cheap, low qualified and often multinational crews. Using non-native language for communication on board ship and while training and educating promotes a decrease in professional skill level of seafarers, at least in the very beginning of his/her maritime career.

l) Situational awareness is impossible without serious education, training and maritime experience.

m) Functional overlap in regulations (in a context of model) gives essentially a smaller workload on a qualified crew, than overregulation.

n) The functional redundancy in regulations (we use the term in a sense of functional integration of regulations) operates to improve the reliability and consistency of them if the crew resources are not lower than standard. If functional redundancy reaches the level not appropriate to crew resources (manning, skill) then there comes the situation similar to impact of overregulation.

o) Education and training of highly skilled seafarers, shore based company's personnel and ship inspectors using an identical system of high standards will reduce the burden on seafarers and raise the level of safety and industry attractiveness as well.

p) The high absolute value of workload gradient (Figure 2) or task complexity gradient (short transitional periods) are most dangerous to the safety and security of the ship. These include the handover of the watch, the change of a crew, reducing or even increasing the number of crew, new regulations entering into force, approaching and leaving port, increasing or reducing the security level... etc.

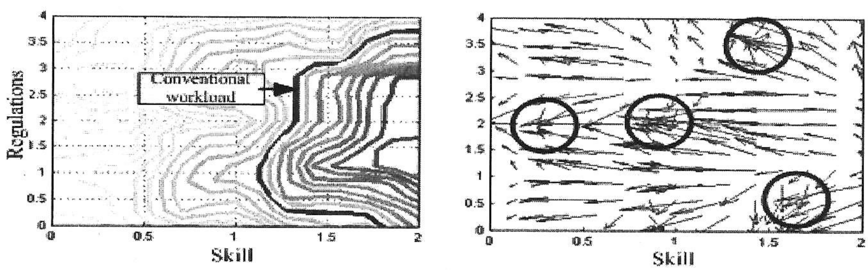

Figure 2: Workload contours and gradients.

q) Circles cover gradient variation areas. They show the lack of coordination in different activities in industry, for example when new regulations entering into force, the ship owner reduces the number of crew and degrades its skill; it may be the security drill while loading the ship, etc.

r) Increasing the complexity of the task is equivalent to degrading the crew skill.

s) The conventional (standard) workload level contour is marked on Figure 2. We can observe the area where "the unit workload" is not possible even if the crew is super qualified.

2.2 Efficiency of ISO, ISM and similar quality management systems applied according to STCW as amended in MET institutions

The process approach had been used in creating of the questionnaire distributed at the 2004 IMLA Conference in St. Petersburg. It was based on an 11 point Likert scale from 0 (fully not sufficient) to 10 (fully sufficient). We understood that return could not be greater than 10% of a total number. There were 70 questionnaires spread among participants. Nineteen questionnaires were returned. We can extend other projects results from ISM implementation in the shipping industry to QS implementation in MET institutions. The main weak points found in shipping have to be rigorously surveyed in the marine education field. Such extrapolation being not so theoretically pure may lead researchers directly to crucial points. Some of the negative considerations found in ISM implementation:

1. too much paperwork;
2. voluminous procedures manuals;
3. irrelevant procedures;
4. bought off-the-shelf systems;
5. no feeling of involvement in the system;
6. ticking boxes in checklists (without actually carrying out the required task);
7. not enough people to undertake all the extra work involved;
8. not enough time to undertake all the extra work involved;
9. inadequately trained people;
10. inadequately motivated people;
11. no support from the company;
12. no perceived benefit compared with the input required;
13. ism is just a paperwork exercise;
14. no respect for external auditors;
15. no respect for classification societies;
16. no respect for port state control inspectors;
17. no respect for the shore management by the seafarers;
18. no respect for the seafarers by the shore management.

What lessons could be learned from those negative findings?

To answer it we have to organize them into groups and remove items, which are not directly tied with MET quality processes.

The result of grouping is the following:

- procedures and manuals unsatisfactory (1–4, 13);
- overload of personnel (often without extra payment) (1, 7, 8, 9);
- lack of pre-training and quality ideas dissemination throughout (5 ,6, 9–11);
- lack of adequate resources (financial, technical, etc) (11, 12).

All the following items were found in literature laid down in random order without any consecutive explanations.

- Port state control statistics already shows a steady trend of crew related deficiencies, many of which are based on previous training experience (or lack of it).
- General decline of marine education in Western Europe may lead to shift of education "centre of gravity" to countries with insufficient adherence to efficient quality systems [2].
- Lack of MET financial support in EU countries [2].
- Lack of benchmark data to compare QS results.
- Absence of the experience and knowledge of quality assurance system [3].
- Lack of commitment from the top [3].
- Negative attitude due to hazardous thoughts like "we've always done it this way – why changing" or "I am the expert – I need no control" [3].
- Measurement of service is completely new for MET [3].
- A difference in academic and marine proficiency standards lead to potential problems due to partial inconsistency [5].
- Inadequate facilities and shortage of qualified teaching staff to cope with the increased demand of competence standards had an obvious damaging effect on the quality of maritime education and training [4].
- Quality standards system itself does not guarantee the depth and the width of knowledge, understanding and proficiency required by the internationally binding regulations [4].

Considering the ISM implementation process and areas of difficulty of the shipping industry similar to those experienced by MET institutions, we have to make some remarks:

Remark 1. Insufficient resources and inadequacy of resource management is a common place elsewhere.

Remark 2. Traditional education and training are main processes of MET. All support processes are often considered of less importance.

Remark 3. QS certification is sometimes more important for a market achievement than the actual quality of MET.

Remark 4. As in the shipping industry, there should be resistance against what is perceived as another regulatory and paper burden. It may lead to wrong perception of ways to MET quality achievement, wrong resources dissemination and keeping areas of required improvement out of attention if they are positioned within supportive items.

Independent evaluation and self-evaluation results made by expert groups in the Russian Federation confirmed our assumptions both qualitatively and quantitatively.

2.3 Questionnaire

An extensive survey among seafarers was given to serve as a base for modelling. Questionnaire "Sufficiency of resources for performing conventional duties" with 86 questions was produced within the frame of this research. More than 150 people took part in this survey; all of them are Masters, Chief Officers or OOW. Some of the results are given below in diagrams.

These diagrams prove that reduced crews are common nowadays, as most of the participants emphasize that the number of crewmembers is insufficient for safe operation. Additional workload, such as security duties under ISPS code, makes the situation even worse. Very often these additional duties result in distraction of OOW from his navigational duties, compromising safety (Figure 3A). Overall workload affects maintenance of the ship too, as the more time is spent for different duties less time is left for maintenance of the ship (Figure 4B).

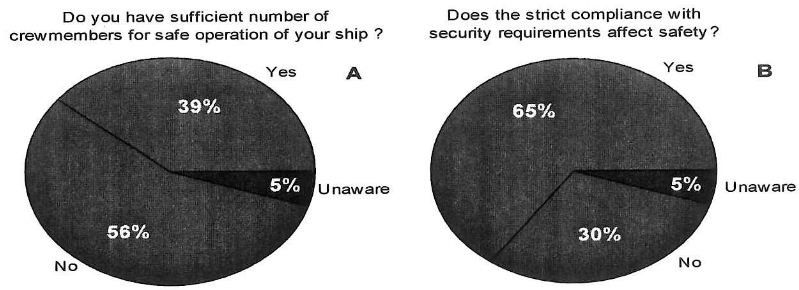

Figure 3: A. Safe ship operation B. Security and safety.

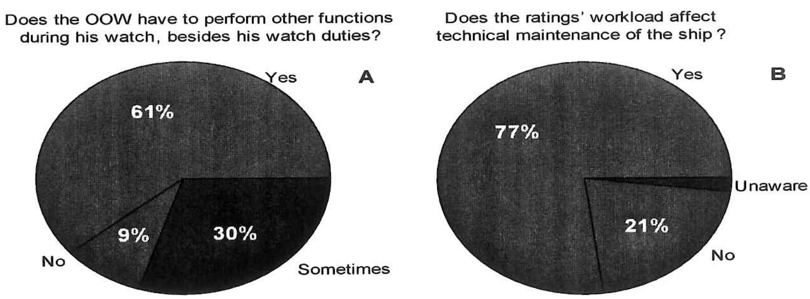

Figure 4: A. OOW distraction B. Ship maintenance.

The introduction of ISM and ISPS Code led to increased bureaucracy, extra paper work.

One of the most intriguing questions was about the factors preventing crew from complying with conventional requirements (Figure 5). The most common answers were: "Priority of records over actual compliance" and "under manning".

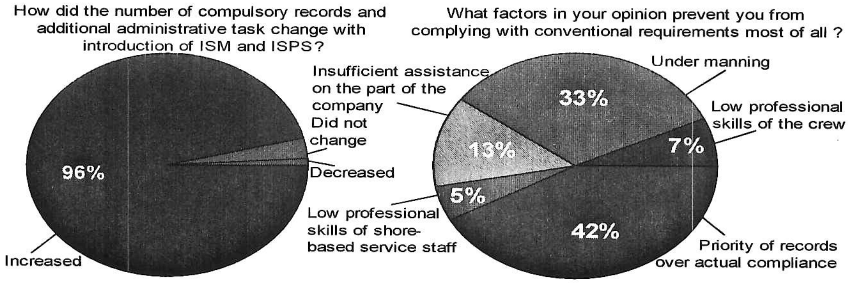

Figure 5: A. ISM and ISPS Code B. Crew performance.

2.4 IT Implementation onboard Vessels: crew resource study

This part of the project is devoted to analysis of modern navigational IT influence on crew workload and on the level of environmental protection and safety at sea. Bayesian networks are used as a formal background for the Research. New technologies in general have the most effect on the number of crewmembers, the job profiles, the workload, the work organization on board a ship, the safety on board the ship and the necessity of training. Safety aspects of new technologies appear to have counter effects. First of all, new technologies improve the safety of shipping. On the other hand, the different job functions require more technical people with less operational shipping knowledge. They might not respond adequately in an emergency situation. Indirect relationships between costs and new technologies, via human element, could appear in three different ways [6]:

- new technology resulting in a lower number of crew members;
- new technology resulting in a different composition of the crew with other wage levels;
- new technology resulting in a change of (overtime) working hours.

It needs to be evaluated by specific instruments during their implementation in the overall maritime sector. There have been specific tools based on Bayesian networks developed for assessing human factors' impacts on the implementation of new technologies. The results of analyzing the effects of IT on the human element, the main effects seem to be caused by navigation and communication related technologies.

Increased automation on board the ship has resulted in a shift from physical work demand towards mental work demand. Mental work demand is related to the perceptual-cognitive demands of monitoring the technical systems. Too much mental work demand may result in fatigue and stress for the seafarer.

The use of new technologies on board ships results in extra training needs for the crewmembers that have to work with these new systems. This means that with regular intervals the seafarer will be asked to take a course/training in working with new technological systems.

Automation reduces the number of repetitive tasks in a job, and makes it possible to perform the same tasks with fewer people. Because of the implementation of new technologies on board a ship, different functions are increasingly being integrated. This means that crewmembers must be able to perform different jobs on board. To be able to perform different tasks, the crewmember has to be multi-skilled.

2.5 Impact of international, regional and national instruments on navigational safety in restricted waters: Baltic Straits as particularly sensitive sea area – Case Study including crew resources

This part of the project is devoted to crew resources influence on navigational safety in the Baltic Straits. The increase in international shipping activity stimulates the development of new Associated Protective Measures (APMs). Only the complex of measures could produce desired tangible results. The following Crew Resources APMs were emphasized in the project:
Safety culture – Introduction of a safety culture on board ships should be a long-term goal of any shipping company. This not only enhances safety of navigation but also reduces risk of overall negligence and poor maintenance at a rather low cost. Moreover, it gives a good motivation for crew members to take an active part in SMS on board ship.
Simulator training – The training as required by STCW is a minimum, and it is further assessed that improved navigator training would have positive effect on the safety level of the vessel. An example of improved navigator training is advanced ship manoeuvring, including training of crisis situations, which can only be done safely in simulators. The training should be done with simulators to give a real life and **area-specific experience** of the given situations and thus prepare the navigators in case they face a similar incident. For example, Masters' training for Baltic Straits passage with appropriate certification, renewed at regular intervals.
BRM/BTM/CRM – BRM is designed to reduce errors and omissions in bridge operations through a simple system of checks and delegation of duties. BRM system emphasizes a coordinated effort among bridge personnel to ensure smooth, efficient and safe operation of the vessel. Similarly, Crew Resource Management (CRM) is designed to ensure teamwork and cooperation in emergency situations of the deck and engine crews. For communication and other responsibilities that are connected to the shore personnel, such training should also include key shore personnel.

The second group of APMs deals with shore based activities, such as VTMIS, pilots, DGPS, and buoyage. The main idea of this group is to facilitate ship handling process, either remotely via VTMIS or directly, by the pilot (compulsory pilotage), enhanced positioning accuracy, facilitate position control – DGPS, additional navigational marks, buoys, TSS, extra routeing measures, etc. In other words, this is a kind of outsourcing of some ship duties to shore.

2.6 ISPS code as a Bayesian node in general crew workload structure

Resources in this study were defined as available human power on board vessels. Detailed model descriptions could be found in proceedings of the same conference named "ISPS code as component of onboard resources in Bayesian Analysis". The main finding is that it is hardly possible nowadays to find one or two new effective measures, which allow us to raise the level of safety and security considerably and therefore, only the most complex of such measures could produce tangible results. The crew is limited in number as well as in other resources; to cope with numerous duties officers should be more competent and to be able to do more things within allocated time. For example, to keep ship's charts folios updated, an experienced Navigation Officer needs less time than his less experienced colleague. With unchanged crew, any increase in workload implies higher competency of crews to be able to complete their duties in time. The better the education, the better is the situational awareness. In other words, here we have a direct link between ISPS Code and MET. Crew competency is the measure of ship safety and security.

3 Conclusion

The part of findings and results of the Project is shown in the corresponding paragraphs and because of economy of a paper the authors do not see any sense in their recurrence. However we would like to emphasize the important idea, which has been clearly realized while executing the Project:

A globalized shipping industry is a very complicated system consisting of many interconnected active and passive components, of which activity could result in its stable or unstable state. To study and 'tune' the system by rules and regulations we need tools and models. To implement all the instruments we need resources, otherwise the high goals will never be achieved. The seafarer is the most important active component in this system, which is why the role of IAMU in MET field cannot be overestimated.

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