The Importance of Non-Technical Skills in the Maritime Education

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Abstract In many high reliability organisations safe and effective crisis management is dependent on both, technical and non-technical skills. The importance of non-technical skills, such as leadership, teamwork, communication, stress management/personal limitations, decision making and situation awareness, is now being realised in addition to subject knowledge and technical expertise to deal with emergency situations. Response to escalating emergencies in large organisations and industries require co-ordination of actions, communications, and a high level of decision making under pressure. The significance of technical skills is accepted; the importance of non-technical skills is now being recognised.

The need for the training and assessment of main non-technical skills of co-operation, leadership and management skills, situation awareness, and decision making in MET is to be established. The distinction between technical and non-technical skills is accepted in the aviation industry where European legislation now requires that pilots in multi-crewed cockpits are trained and assessed in technical and non-technical skills. Critical incident reporting has identified nontechnical skills to be major determinants of successful anaesthesia crisis management. Most literature in this subject has focused on assessment of knowledge and technical skills during anaesthesia simulation, nontechnical skills have become a recent area of interest for researchers and now a comprehensive and reliable nontechnical skills assessment tool called the Anaesthetists' Non-Technical Skills (ANTS) has been developed. In commercial shipping individual companies like Maersk send their Chief Officers for a three day leadership course before promoting them to take the responsibility of the command of a ship, but there is no legislative requirement of such training.

A review of the maritime accidents databases from UK, USA, Norway and Canada conducted by Professor Michael Barnett and others in 2006 confirms that human error is the main contributing factor in the maritime accidents. This study illustrates that major maritime accidents are not caused by technical problems but by non-technical skills failure. The Crew Resource Management (CRM) course has been developed to address the non-technical aspects of ship operations. The course contents are focused towards those skills assumed to be essential in assisting in the detections and management of errors in the crisis. Barnett et al (2006) think that one week's course provided by a training college is not enough to fix the "problem employee". A greater need is realised to follow up the training after effects, by seeing how effective it has been on board the vessel itself.

A review of other safety related industries' recent involvement towards non-technical skills training and assessment will be carried in this paper and a comparison will be made with current maritime education.

Keyword :

1. Introduction

Accidents in maritime industry are not new and a major contributing factor to most of these accidents is human error. In 1997 a P&I club reported that human error was responsible for 58% of all claims made. This figure has not reduced since but the other major contributing cause to accidents, the technical failures, has reduced by two thirds since then [1]. Human error cannot possibly be eliminated altogether but measures can be taken to reduce it. Many safety related industries, such as aviation, medical, nuclear power and fire fighting, are now focusing on integrating non-technical skills into the main technical training. The present maritime education system is heavily focused on technical skills and we have to learn lessons from other safety related organisations.

2. Aviation - Crew Resource Management (CRM)

The concept of non-technical skills generated from the aviation industry when the National Transportation Safety Board in USA investigated a number of airline accidents in 1960s and 1970s. As a result of the following accident and others, the concept of Cockpit/Crew Resource Management (CRM) was born [2].

"On December 28, 1978, as a result of a relatively minor landing gear problem, a United Airlines DC-8 was in a holding pattern while awaiting landing at Portland, Oregon. Although the first officer knew the aircraft was low on fuel, he failed to express his concerns convincingly to the captain. The plane ran out of fuel and crashed, killing 10."

A workshop was held in 1979 called, Resource Management on the Flightdeck, sponsored by the National Aeronautics and Space Administration (NASA). Human error aspects of a majority of air crash accidents were identified in this meeting as failures of interpersonal communication, decision making and leadership. It was suggested that the training of non-technical skills of pilots was required to reduce the "pilot error" by making better use of human resources on the flight deck. Since that time Crew Resource Management (CRM) training programmes have evolved in the United States into five generations [3].

CRM training can be defined as "a set of instructional strategies designed to improve teamwork in the cockpit by applying well-tested tools (e.g., performance measures, exercises, feedback mechanisms) and appropriate training methods (e.g., simulators, lectures, videos) targeted at specific content (i.e., teamwork knowledge, skills, and attitudes)"[4]. CRM training is mainly non-technical skills training integrated into a technical training course of the flight crew. The CRM or non-technical skills include situation awareness, decision making, leadership, teamwork and communications.

2.1 First Generation of CRM

The first comprehensive CRM (Cockpit Resource Management) programme was initiated and developed by United Airlines in 1981 in the US and the course was called Command, Leadership and Resource Management [5]. The consultants who had developed training programmes for corporations trying to enhance managerial effectiveness were part of the

development of the CRM. This was a seminar style training programme where participants diagnosed their own managerial style. First generation CRM training programmes were psychological in nature. The focus was on general concepts of leadership and general strategies of interpersonal behaviour but failed to provide definitions of appropriate behaviour in the cockpit. It was recognized that annual recurrent training in CRM was necessary. However, many of these courses encountered resistance from some pilots who accused these courses of seeming to manipulate their personalities [3] [6].

2.2 Second Generation of CRM

NASA held a workshop in 1986 to discuss the progress of the CRM training programmes offered by that time by many airlines in the United States and around the world that had initiated the CRM training. One of the conclusions drawn at this meeting was that CRM training would disappear as a separate component of training when it became part of flight training and flight operations [7]. At this time a second generation of CRM training programme emerged. The name was changed from cockpit to crew to focus on cockpit group dynamics [3].

2.3 Third Generation of CRM

In the early 1990s a new shape of CRM introduced which integrated CRM with standard technical training. The idea was to focus on specific skills and behaviours that pilots could use to operate in a more effective and safe manner. Many airlines at this stage included modules focusing on CRM issues in the use of flight automation [3]

2.4 Fourth Generation of CRM

The Advanced Qualification Programme (AQP) was introduced by the Federal Aviation Administration as a major change in the training and qualification of the flight crew. AQP was a voluntary programme which required carriers to provide both CRM and LOFT (Line Oriented Flight Training) for all flight crews. This also required integrating CRM concepts into technical training. To complete the shift to AQP, carriers had to complete detailed analysis of the training requirement for each aircraft. The carriers were required to develop programmes that address the human factors (CRM) issues in each aspect of the training. [3]

It would seem that the Fourth generation of CRM has solved the problems of human error by making CRM an integral part of all flight training. There was general consensus among US airlines that AQP approach has produced improvements in the training and qualification of flight crews [6].

2.5 Fifth Generation of CRM

The Fifth generation of CRM outlines the fact that human errors are inevitable and CRM can be seen as a set of error countermeasures with following three lines of defence;

1. The avoidance of error.
2. The trapping incipient errors before they are committed.

3. Mitigating the consequences of those errors that occur and are not trapped.

In addition to error management, organizations were required to take steps to identify the nature and source of error in their operations. An Aviation Safety Action Programme was announced by US FAA to encourage incident reporting within organizations to deal with safety issues proactively [8]. The programme proved to be a success with about 6000 incident reports received in first two years. The data generated by the system helped companies to take steps to prevent or minimize the recurrence of the incidents. [3][6].

2.6 NOTECHS

The international aviation regulators have generally dictated CRM courses. The Federal Aviation Administration in the USA introduced the Advanced Qualification Program (AQP) in 1990s and in the UK Civil Aviation Authority required a formal incorporation on non-technical (CRM) skills evaluation into all levels of flight crew training [9]. The European Joint Aviation Authorities (JAA) has introduced the regulation, *"The flight crew must be assessed on their CRM skills in accordance with a methodology acceptable to the Authority and published in the Operational Manual. The purpose of such an assessment is to: provide feedback to the crew collectively and individually and serve to identify retraining; and be used to improve the CRM training system"* [10].

Based on this legislation a research project, JARTEL (Joint Aviation Translation – Translation and Elaboration of Legislation) was initiated by the JAA Human Factors group in 1996 to identify or develop a feasible and efficient method for assessing an individual pilot's non-technical (CRM) skill. The project was sponsored by four European CAAs, a research consortium consisting of pilots psychologists from Germany, France, Holland and the UK was established to work on the NOTECHS (Non-Technical Skills).The system was to be used to assess the skills of an individual pilot and it was to be suitable for use across the Europe [5].

The development method included a detailed examination of existing behavioural marker system to assess pilot's CRM skills. The experts who advised on the final design on the NOTECHS systems were airline captains who had considerable experience of using behaviour rating methods. The resulting NOTECHS system has four categories, each with component element of behaviour as shown in the following table;

Category	Element
1. Co-operation	Team-building and maintaining Considering others Supporting others Conflict solving
2. Leadership and Managerial Skills	Use of Authority and assertiveness Providing and maintaining standards Planning and co-ordination Work load management
3. Situation awareness	Awareness of aircraft systems Awareness of external environment Awareness of time
4. Decision Making	Problem definition and diagnosis Option generation Risk assessment and option selection Outcome review

Source: [11]

Table 1. NOTECHS system

The four primary categories subdivide into two social skills (Co-operation and Leadership and management) and two cognitive skills (Situation awareness and decision making). Social skills' behaviours are generally observable in the form of communication but cognitive skills are non-observable since they do not directly materialise. Hence for evaluation purpose, these cognitive processes must be inferred from observable behaviour (eg. Specific actions or verbalisation) [11].

Five operational principles were established with the aim of ensuring that each crewmember would receive as fair and as objective an assessment as possible with the NOTECHS system as follows;

Design Principles for NOTECHS

1. *Only observable behaviour is to be assessed – The evaluation must exclude reference to a crewmember's personality or emotional attitude and should be based only on observable behaviour. Behavioural markers were designed to support an objective judgement.*
2. *Need for technical consequence – For a pilot's non-technical skills to be rated as unacceptable, flight safety must be actually (or potentially) compromised. This requires a related objective technical consequence.*
3. *Acceptable or unacceptable rating required – The JAR-OPS requires the airlines to indicate whether the observed non-technical skills are acceptable or unacceptable.*
4. *Repetition required – Repetition of unacceptable behaviour during the check must be observed to conclude that there is a significant problem. If, according to JAR paragraph concerned, the nature of a technical failure allows for a second attempt, this should be granted, regardless of the non-technical rating.*
5. *Explanation required – For each Category rated as unacceptable the examiner must: (a) Indicate the Element(s) in that Category where unacceptable behaviour was observed. (b) Explain where the observed NTS (potentially) led to safety consequences. (c) Give a free-text explanation on each of the Categories rated unacceptable, using standard phraseology.*

Source: [5]

Table 2. Design Principles for NOTECHS

The main JARTEL study was an experimental rating task using NOTECHS based on eight video scenarios filmed in a Boeing 757 simulator. The scenario simulated realistic flight situations with predefined behaviours from the NOTECHS element. The pilots' behaviours were rated ("very poor" to "very good") using NOTECHS system by 105 instructors, recruited from 14 airlines in 12 European countries. Each session began with a briefing on the NOTECHS method and a practice session. The instructors were asked to rate captains' and first officers' behaviours in each of the eight cockpit scenarios using the NOTECHS score forms [5] [11]. In the evaluation questionnaire, the instructors were very satisfied with the NOTECHS rating system [12].

The users of NOTECHS are expected to be certified flight instructors and authorised examiners, who have been trained in the application of the method for rating performance. NOTECHS was designed as a professional tool for instructors and authorized examiners. It was written in common professional aviation language with the intention of debriefing pilots and communicating clear advice for improvements. From the experimental and operational trials of NOTECHS system it was indicated that the basic psychometric properties were acceptable and that the method was accepted by practitioners [11].

Clearly, a more extensive test of the psychometric quality of NOTECHS would be desirable but this would require a large set of data collected under standardized conditions. An observational study was carried out for Southeast Asian Airlines involving crews from 323 flight sectors. A set of four categories and 16 behavioural markers was adapted from the existing LOSA (Line Operation Safety Audit) and the NOTECHS methods to evaluate the crews' non-technical performance and to compare them against error and threat management. It was found that crews who showed better decision-making skills were more likely to trap errors during the flight. A higher level of error trapping during the flight was found in the crews who showed an increased co-operation in pre-departure phase. In the pre-departure phase the vital behaviour for threat management were briefing and planning [13].

3. Anaesthesia - ANTS (Anaesthetics non-technical Skills)

Critical incident reporting has identified nontechnical skills to be major determinants of successful anaesthesia crisis management. Most literature in this subject has focused on the assessment of the knowledge and technical skills during anaesthesia simulation, nontechnical skills have become a recent area of interest for researchers and now a comprehensive and reliable nontechnical skills assessment tool called the Anaesthetists' Non-Technical Skills (ANTS) has been developed [14] The system of anaesthesia non-technical skills, a behavioural marker system, was developed in a project between the University of Aberdeen Industrial Psychology Research Centre and the Scottish Clinical Simulation Centre. The system includes the main non-technical skills linked with good anaesthetic practice [15]. The programme was developed after reviewing Crew Resource Management (CRM) designed to increase the use non-technical skills to improve the safety in the aviation industry [16].

The project was commissioned by the Scottish Council for Postgraduate Medical and Dental Education to investigate non-technical skills in anaesthetists, 'The Identification and Measurement of Anaesthetists' Non-Technical Skills'. The main aim of the project was to discover the non-technical skills, both cognitive and social skills, required by the anaesthetists during the operation. The project was divided into the following seven work packages;

1. Review of Human Factors Research in Anaesthesia. Review of Behavioural Marker Systems in Anaesthesia.
2. Interview study to Identify Anaesthetists' Non-Technical Skills.
3. Review of Incident Data - Confidential
4. Development of a Prototype Behavioural Marker System for Anaesthetists' Non-Technical Skills (ANTS).
5. Preliminary Evaluation of the Prototype Behavioural Marker System for Anaesthetists' Non-Technical Skills (ANTS).
6. Experimental Report.

The first work package [17] of the project reviews the human factors in anaesthesia. It describes the background of such study of human factors in anaesthesia as 80% of anaesthetic incidents are due to human error and up to a large degree avoidable.

In UK there were no formal obligations to report anaesthetic incidents, apart from death; hence not enough data was available. Confidential incident reporting programmes, where anonymous information is collected, have been set up in several countries such as Switzerland, Australia and The Netherlands. A Critical Incident Reporting System (CIRS) is found at the University of Basel, Switzerland; AIMS, the Australian National System; and Faults, Accidents and Near Accidents (FONA) at the University Hospital Leiden, The Netherlands [18].

The aim of the third work package of the University of Aberdeen's study of ANTS [17] was to collect the information from experienced anaesthetists to determine the non-technical skills being used in support of the clinical tasks. To do these three methods of collecting data were considered initially; surveys, simulation observations and interviews. The surveys or questionnaire method was immediately rejected as the data required were qualitative and not quantitative. Observations is a useful way of finding out about such skills, but a large component of anaesthetics' activities is cognitive, and therefore unseen and thus the only way to investigate these skills was through getting the experts to talk about them. Therefore, it was decided that most suitable method of collecting information regarding anaesthetics non-technical skills would be interviews.

A semi-structured interviewing technique was used out of many interviewing methods available. In a semi-structured interviewing technique there is more flexibility for interviewer to investigate issues that arise during the interview and questions can be adapted to individual circumstances. There is a disadvantage in this technique that interviewer need to have a good subject knowledge to be able to know when to probe further and what to ask. The researchers

working exclusively on the project had observed in the theatre and at the simulator a number of times and had attended an Advanced Trauma Life Support course and a Basic Obstetrics Life Support course. Thus it was considered that the researchers had a thorough subject knowledge and would not pose too much of a problem [17]

A review of Cognitive Task Analysis (CTA) methods was conducted and three main techniques were adapted; Critical Decision Method (CDM), knowledge audit and a sorting task. It was then decided that interviews would have three parts to cover each of the above chosen technique of CTA.

The first part of the interview was the main source for information about non-technical skills and was developed around the Critical Decision Method. The participants were asked to describe a challenging and difficult case from their past experience. A case could be a real incident or near miss or may be a normal case that just really tested their skills and for which their expertise was important for the outcome. This part of the interview was conducted in three stages: (i) the interviewee would tell the unstructured story, (ii) and then interviewer would repeat the case back to check everything was understood and finally (iii) the interviewee would represent the case again in more detail with probing used where more information was required. The time allowed for this part of the interview was 45 minutes.

A Knowledge audit formed the second part of the interview. In this part interviewees were asked what skills and behaviour they considered important for good anaesthetists. After compiling a list of skills they were asked how the skills are currently developed by trainees and if there were any differences in the skills needed for normal and crisis situations [17].

A final part of the interview was the sorting task. The interviewees were given following 19 skill items to sort and rate. The skill items have been identified from the literature.

Communication style	Allocation of attention
Information sharing	Monitoring
Feedback	Recognition
Leadership	Situation Awareness
Team Building	Decision Making
Maintaining Team Climate	Re-evaluation
Preparation	Teaching
Planning	Initial Crisis Management
Workload Management	Declaring Emergency
Prioritisation	

Three pilot interviews were undertaken with a senior anaesthetist to support the development of the interview. The questions were structured after the first trial interview. The remaining two pilot interviews were conducted once a draft interview schedule was established. The recruitment of the participants was not a problem as many experienced consultants volunteered to take part in the project [17]

This project has identified the non-technical skills for successful operation of anaesthetics (ANTS) and outlined behavioural markers system for the assessment of the ANTS.

4. Non-Technical Skills for Surgeons (NOTSS)

Surgeons became interested in non-technical skills in 2003 after the analysis of adverse events in surgery found that many underlying causes originate from failures in non-technical aspects of performance. In one study it was observed that failure in communication was the main cause in 47% of cases in the surgery. It was deemed necessary in order to achieve and maintain high standards of the surgical performance attention must be paid to non-technical skills such as team working, leadership, situation awareness, decision making, task management and communication [19].

A research group at the University of Aberdeen has conducted a research to develop the Non-Technical Skills for Surgeons (NOTTS). The Cognitive Task Analysis (CTA) method was used by structured interviews, literature review, attitude survey, analysis of surgical mortality reports and observations in theatres. 27 consultants in general, cardiac and orthopaedic surgery, invited for the interview to draw up the taxonomy of non-technical skills for surgeons. The purpose of the interviews was to identify key non-technical skills from the discussion of real life critical incidents in the operating theatre [19]

The following sources were used to develop the NOTTS [20];

a) Questionnaire and interview studies with surgeons
b) Observational studies of Surgeos (Videotaped, simulated)
c) Surgical adverse event analysis
d) Surgical education, training and competence
e)

A STAR (Surgical Team Assessment Record) questionnaire was designed to study the role of human factors in surgical outcomes and measures the situational, organisational, team and personal factors thought to contribute the surgical performance. A survey instrument, OMRAQ (Operating Room Management Attitudes Questionnaire), was designed to measure the attitudes of the operating theatre personnel toward safety, error, teamwork, leadership and authority. Observations of 243 neonatal arterial switch operations performed by 21 cardiac surgeons in 16 UK centres as part of the study.

5. Maritime

From year 2001 to 2005, an average of 18 ships met accidents like collision, fire, explosion or grounding everyday and two of them sank every single day [1]. A research conducted by Professor Michael Barnett in 2006 confirms that human error is the main contributing factor in maritime accidents. This study illustrate that major maritime accidents are caused by failure of crew to respond to the situation appropriately. Following conclusions were drawn [21];

1. *While the total number of accidents is declining, human error continues to be the dominant factor in 80 to 85% of maritime accidents.*
2. *Failures of situation awareness and situation assessment overwhelmingly dominate.*
3. *Human fatigue and task omission seem closely related to failures of situation awareness.*

Warsash Maritime Centre, UK, has developed a Crew Resource Management (CRM) course to address the non-technical aspects of ship operations. The course curriculum is dedicated to social and cognitive aspects of seafarer's performance. The course contents are focused to those skills assumed to be essential in assisting in the detections and management of errors in the crisis. But the authors [21] think that the one week's course provided by a training college is not enough to fix the "problem employee". A greater need is realised to follow up the training after effects by seeing how effective it has been on board the vessel itself.

6. Conclusion

Although some major shipping companies have recently adopted crew resource management training for their crew there is no regulation for such training as yet. Presently the standard seafarer training is heavily focused on technical training. The '*application of team working and leadership*' has recently been included in the STCW Convention and the STCW Code which would mean that future seafarer training would benefit from non-technical skills. There still seem in depth research necessary in the area of the non-technical skills required by seafarers to deal with crisis and emergencies onboard ships.

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