Recent Developments in Crew Resource Management (CRM) and Crisis Management Training

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1. What is CRM and how has it developed?

Crew Resource Management (CRM) can be broadly defined as:

> *"the utilisation of all available human, informational and equipment resources toward the effective performance of a safe and efficient….. operation"*.
> (Helmreich et al 1999)

CRM training was originally conceived over 20 years ago as a response to a number of air crashes in which human error, specifically pilot error, was identified as the primary cause of the accident. It is a form of training that is designed to focus on the non-technical skills of operation. Since the 1980's, CRM training has been expanded and adapted for a number of purposes and has been adopted by a number of other industries, including the nuclear and offshore industries, and more latterly, the medical profession. (Edkins, 2002; Helmreich and Merritt, 1998).

Similar training, especially involving the use of full mission simulators, also has a long established pedigree in the shipping industry. As early as 1974, it was apparent from the casualty of the Very Large Crude Carrier (VLCC) "Metulla", in which the vessel grounded in the Magellan Straits with two pilots and watch keepers present on the bridge, that bridge teams were not working effectively in supporting each other or the pilot. Simulator-based training courses were introduced primarily to train the skills of passage planning and the importance of the Master/Pilot relationship (Gyles and Salmon 1978). This training initiative developed into the Bridge Team Management (BTM) courses that are conducted today on many simulators world-wide and contain many of the elements to be found in CRM courses. Bridge, Engine and Crew Resource Management courses are a more recent initiative, adapted directly from the aviation model for training the non-technical skills of resource management, and are not always based on the use of simulators.

The 1980s saw the introduction of Engine Room simulators and towards the end of that decade, cargo operations simulators also became available. These types of simulator have primarily been used to train officers in the handling of operations, including fault finding and problem diagnosis, and increasingly to train teams in the skills of systems, resource and risk management. Many types of simulator: bridge, engine and cargo control room, have tended to emphasise a physically realistic environment in which these exercises occur, although the use of PC-based simulators for training some tasks is increasingly widespread. The most recent developments in CRM training are exemplified in the course now being conducted at Warsash, in which bridge and engine room simulators are linked to provide the opportunity for joint training of bridge and engine teams.

The only mandatory requirements in the maritime domain for the development of the non-technical skills of resource and crisis management are those of the International Maritime Organization's (IMO) Seafarer's Training, Certification and Watchkeeping Code (International Maritime Organization, 1995). Table *A-V/2* of this code specifies the minimum standard of competence in crisis management and human behaviour skills for those senior officers who have responsibility for the safety of passengers in emergency situations. The competence assessment criteria detailed within the Code are not based on specific overt behaviours, but rather on generalised statements of performance outputs, and as such are highly subjective and open to interpretation. Although these standards of competence indicate that IMO recognises the need for non-technical management skills, both the standards and their assessment criteria are immature in comparison with the understanding of non-technical skills, and their assessment, within an industry such as civil aviation.

In summary, resource management training to mitigate risk has become established in the curricula of many maritime training establishments. Courses take a variety of forms and cover both deck and engine room disciplines. The courses are often simulator-based, but not always, and their syllabuses reflect CRM training in other industries.

2. What are the skills required for effective CRM and crisis management?

Table 1 indicates the skills required for effective resource management and that these may be seen as being both social and cognitive in nature.

SOCIAL	COGNITIVE
Co-Operation and Communication • Team building and maintaining • Consideration of others • Support of others • Conflict resolving	***Situational Awareness*** • System awareness • Environment awareness • Anticipation of future
Leadership and Managerial Skills • Use of authority and assertiveness • Planning and co-ordinating • Workload management	***Decision Making*** • Problem diagnosis • Option generation • Risk assessment • Option selection

Table 1: CRM skills

So are the skills required to handle crises any different? Before looking at the specific skills requirements, a distinction needs to be drawn between emergencies and their management and crisis management. This distinction may be summarised as follows:

An emergency can be defined as a situation outside normal operating parameters where corrective decisions and actions are based on documented procedures. In the maritime context, examples might be “Man overboard”, steering gear failure or a report of a fire in a cabin. Emergency procedures can be trained both at onshore training establishments and on board.

A crisis differs from an emergency in that successful decisions and actions may not necessarily be based on documented procedures. Appropriate pre-defined responses may not exist, and even if they do, in practice they may have conflicting requirements. Those responsible for handling crises will have to think through the situation, and respond in creative and flexible ways.

This distinction between emergencies and crises has a significant impact on the training requirements for their management. Training in handling emergencies may simply be training in following pre-prescribed procedures and drills. Training in crisis management is likely to require a much more demanding approach to practise the skills required in these situations.

There is now considerable evidence from both military and civilian sources that the main requirements for crisis management are the high-level cognitive skills of problem solving and decision making. Crichton and Flin (2002) suggest that, at its most simplified, there are two fundamental and inter-related skill requirements:

- Situation assessment – “what’s the problem”
- Decision making – “what shall I do”.

A recent review of accident databases from the USA, UK, Canada and Australia confirms that human error continues to be the dominant factor in maritime accidents and reveals that in 70% of recorded incidents attributed to human error, failures in situation assessment and awareness predominate (ABS, 2004).

Decision-making is a skill. Like all skills, it may be honed through practice. By reducing cognitive load through practice, experts will be less stressed than novices in threatening situations. In addition to specific contextual skills, there is a set of more general cognitive skills involved in situational awareness and decision making. The direct development of such generalised critical thinking skills, which encourage team members to question their assumptions about their assessment of situations, will help individuals to counteract the consequences of stress, and make them more effective crisis managers.

In summary, research would suggest that the handling of crises places greater emphasis on the cognitive aspects of CRM skills; namely situational awareness and decision-making. Moreover, the nature of crisis situations suggest that there are at least two specific training requirements for the development of these cognitive skills:

1 To provide exercise scenarios in which the individual’s mental models of systems, situations and the cues by which they recognise them, may be enriched;

2 To develop a general critical thinking skill which resolves conflicting information and tests the assumptions on which decisions are based.

3. What are the most effective ways of training CRM skills?

In the year 2000, the Maritime Coastguard Agency (MCA), following a recommendation of the Marine Accident Investigation Branch (MAIB) in response to the loss of the "Green Lily", awarded a project to a research team at Warsash Maritime Centre. The remit of the project was to investigate the potential use of simulators for training in the handling crises and escalating emergencies. This project enabled the researchers to review current concepts and models in the field of resource and crisis management across a range of safety critical industries and to conduct a survey of expert opinion on the optimal training and assessment regimes (Barnett et al 2002).

In order to ascertain the optimal types of simulation to provide training and assessment of non-technical skills , the Warsash research team used a panel of 15 experts drawn from marine simulation resources as well as researchers and practitioners from other similar safety critical industries. Within this project, the Policy Delphi Method (Turoff 1970) was used . The Policy Delphi process is a form of policy analysis that provides a decision maker with the strongest arguments on each side of the issue. A range of future implementation scenarios were proposed as training policies that could meet the perceived training requirements relating to the exercising of resource management skills. These policies were presented to the panel of experts. A subsequent workshop involving some of the panel experts was also used to confirm and develop their responses.

The following is a summary of the responses received from the panel of experts in reply to 19 questions sent to them in order to further clarify the main arguments for and against the proposed training policies.

Training Policy 1: The Use of Full Mission Simulators for Team Based Exercises

The panel of experts believed that the strength of this option was the ability to undertake team-based activities in an environment that provided realism. However, the experts also thought that the cost of full-mission simulators was a significant disadvantage. The experts also made some important observations regarding team based activities and these were that:

- training and assessment of resource management skills should only ever be undertaken separately, and
- the tutor should never also be the assessor within the same time-frame

Training Policy 2: The Use of Full Mission Simulators for Single Trainee Exercises

There was agreement that this policy option was not generally beneficial, but could be useful in special circumstances such as remedial and pre-team training.

Training Policy 3: The Use of Virtual Environments

Although there was still a very positive response to this policy option, little empirical evidence was cited to support the opinions given.

There was general agreement that the communications systems used within this policy option could be embedded, as long as they allowed actual voice communications, and this could be used in a similar way to real communication systems.

Most responses indicated that the co-workers within virtual reality training environments should be real and not simulated in order to facilitate effective team training. However, the possibility was raised that simulated co-workers could be used to afford a greater variety of training opportunities for team members.

There was general agreement that a high level of fidelity was required for certain elements of the virtual environment, but there was a wide diversity of opinion as to what these elements were. The elements discussed were all part of the functional representation of the real environment, both physical and procedural. One response stated that virtual environment did not have to have a high degree of fidelity as long as it allowed for the replication of the skills inherent in the task being trained.

Training Policy 4: The Use of Desktop Computer Simulations

There was agreement that this policy option required a certain level of interactivity to be effective and that an increase in interactivity could improve effectiveness and efficiency up to a point, beyond which the trainee may start to feel confused.

A number of ways of improving interactivity were proposed including the:

- creation of multiple training paths
- provision of training scenarios with more than one acceptable outcome
- use of a facilitator to guide the trainee.

If this policy option could be team-based there was general agreement that this would be more beneficial, because it would allow trainees to discuss alternative solutions. However, one response indicated that if the simulation were more team-based it would become more difficult to control and it would be more difficult to carry out assessments.

Training Policy 5: The Use of Table-top Simulations

All participants agreed that this policy option could be used for training. However, there were arguments made both for and against the use of this policy option for undertaking assessment.

The argument against was based on the lack of fidelity provided by this type of simulation and the difficulty in observing relevant competent behaviour in a context that is very different from the actual workplace.

The argument for was based on assessment being undertaken against those relevant behavioural markers that could be observed within the context of the simulation.

Training Policy 6: The Use of Class Room Based Workshops

There was general agreement that this policy option is best suited to training only.

The following strengths were associated with this policy option:

- cost beneficial
- flexible
- gives the opportunity to discuss operational / emergency problems with others
- tutor guided

The following weaknesses were associated with this policy option:

- there is no environment to manage
- not suitable for the assessment of competence

One response suggested that any weaknesses associated with this policy option could be overcome by providing a good tutor and ensuring interactivity. There was a wide spread of opinion regarding which other methods of training this policy option could be usefully used in conjunction with. The overall range of opinion covered all of the remaining five policy options. One response suggested that classroom-based workshops followed by practice in context would allow increased transfer.

The following were proposed as being suitable to be trained using this policy option:

- appreciation of technical risks
- knowledge of systems
- knowledge of procedures
- theoretical knowledge
- planning
- risk management
- problem solving

The workshop concluded that the inclusion of full mission simulation was the only viable assessment option. This method is used extensively by the nuclear and aviation industries. The argument is that it is the only safe method that guarantees that the majority of the cues that seem important are present and that the perceived required skills may be demonstrated.

The search for a single cost-effective training option to deliver the required standard of competence may be misplaced. The principle enshrined in STCW95 and National Vocational Qualifications (NVQs) is that once the standard of competence has been defined, how an individual reaches that standard is irrelevant. Among a number of variables, it is the motivation of the learner and the ingenuity of the trainer that will determine the most cost-effective training option. In an ideal world, the trainer would select the most appropriate method from his/her training “toolbox” to suit the

individual trainee, their learning style, and stage of development identified through continuous assessment.

Recent research by Crichton and Rattray (2002) describes the potential of Tactical Decision Games (TDGs) for crisis management training. TDGs are a low-cost, low fidelity classroom based simulation that focuses on improved decision making and heightened situational awareness. Evaluation of their effectiveness and their validity and reliability as a competence assessment tool is currently underway.

In summary, the most cost-effective training option will be determined by a number of "local" factors, including the ingenuity of the instructor. At present, however, the assessment of competence, particularly for marine certification purposes, through the use of currently available Full Mission Simulations represents the most viable option.

Based on the principles described above, an innovative CRM training course is currently being developed at Warsash. The course uses a number of forms of simulation, including role playing exercises and full mission simulator exercises, which combine both bridge and engine room teams. In addition to the specific development of critical thinking skills and the enhancement of situational awareness, the objectives of the course also include the development of the other non-technical social skills of CRM, ie, communication, team co-ordination and leadership development.

The course builds the learning experience from classroom lectures on theoretical aspects, followed by brief exercises to practice specific techniques, culminating in simulator-based scenarios in which the various elements can be brought together. The final exercises bring both bridge and engine room teams together, through linked simulators, where complex evolving situations have to be managed by both teams.

4. How can competence in CRM and crisis management be assessed?

All safety critical organisations consider how they would manage a crisis situation and undertake some form of preparedness training. This training concentrates mostly on how to deal with an emergency, where a laid down procedure can be put into action. Few of these organisations take their training into the realms of a crisis situation, where there is no procedure to call upon, and where lateral thinking and rapid decision making are required of their managers. Even fewer organisations try to assess their personnel's competence in managing a crisis.

In certain circumstances this demanding decision environment may become too demanding for the crisis manager, and they may find themselves unable to cope. This is described by Salas et al. (1996) as a situation when:

> "*environmental demands evoke an appraisal process in which perceived demand exceeds resources and results in undesirable physiological, psychological behavioural or social outcomes.*"

Therefore, it is important within any safety critical organisation to try and determine whether the personnel placed in the role of potential crisis manager will be able to cope when a crisis arises. So how do safety critical organisations assess the competence of their crisis managers? How do they do this objectively, and what are the assessment criteria they use?

Of all the safety critical organisations, the military have taken crisis management training and assessment the furthest. This is done for a very good reason, as all combat situations are, by their very nature, crises.

Through their use of war games, the military attempt this task. They use large numbers of assessors, dispersed throughout the war gaming environment during an assessment exercise. After the assessment exercise, the assessors meet to discuss their observations during the exercise, and to evaluate the actions of the team against set assessment criteria. Examples of these criteria are:

'was there a good flow of information into the control position at all times' and

'was the incident picture well kept'

These criteria are assessed as having been either 'met' or 'not met'. A discussion is then held between assessors to give an overall assessment of how the team performed. Due to the severe time restraints imposed on the assessment process, because of the operational requirements of the military, and the sheer complexity of the war gaming environment, subjective assessments are inevitable. However, because of the large number of assessors used, effective assessments can be achieved through moderation.

The civil aviation industry has recently been undertaking research into the possibility of assessing the CRM skills of aircrew. Through the Joint Aviation Requirements Translation and Elaboration of Legislation research project (JAR TEL Consortium, 2001), a methodology for assessing the non-technical skills of aircrew, by observing individual overt behaviours, has been proposed.

The cockpit environment is very different to that of a war gaming environment, but the non-technical skills of co-operation, leadership and management, situational awareness and decision making, as metrics for assessing competence are common to both. A major difference between the assessment of competence in CRM skills within the military context and the civil aviation context is that within the military context a team is assessed, whereas within the civil aviation context it is the assessment of an individual working within a team that is undertaken.

The JAR TEL non-technical skills or 'NOTECHS' assessment framework provides definitions of the non-technical skills to be assessed and gives the assessor examples of overt behaviours that indicate good or poor practice of these skills.

An example skill element under the category of 'Co-operation' is *"team building and maintaining"*.

An example of an overt behaviour indicating poor practice of this skill element is:

"Keeps barriers between crew members."

An example of an overt behaviour indicating good practice of this skill element is:

"Encourages inputs and feedback from others (lowers the barriers)."

Although the 'NOTECHS' framework has moved the assessment of competence in CRM skills, within the context of civil aviation, towards a more objective foundation, the experimental results of inter-rater reliability trials showed that in the more complex assessment scenarios there were significantly divergent assessments. The JAR TEL report states that there are some strongly held reservations by some members of the aviation fraternity about the very concept of the assessment of non-technical skills. One of the prime reservations being that:

"it is felt that the criteria on which assessment is based are largely subjective and thus cannot easily be monitored for fairness and accuracy"

Through the STCW Code Table A-V/2 (IMO, 1995), the International Maritime Organisation (IMO) has provided the competence specification of a minimum standard of competence in crisis management and human behaviour for those officers who have responsibilities for passengers. As within the civil aviation industry, these competencies relate to individuals working within a team. The required underpinning knowledge, understanding and proficiency, are stated for each competence, along with methods for demonstrating competence and criteria for evaluating competence.

IMO does not differentiate between crises and emergencies, and the Table A-V/2 relates primarily to the management of emergencies, citing the use of procedures and actions in accordance with established plans as a criterion for evaluating competence.

The assessment criteria given in Table A-V/2 of STCW 95 are also highly subjective, an example being:

"Information given to individuals, emergency response teams and passengers is accurate, relevant and timely."

From the examples above, it can be seen that safety critical organisations undertake the assessment of competence in crisis management in very different ways.
In order to provide the international maritime community with an understanding of how a behavioural marker system could be applied for the assessment of competence in crisis management of merchant marine officers, research is currently being undertaken at Warsash Maritime Centre.

The aims of this research are:

- To understand how behavioural markers can be used to objectively assess competence in crisis management of merchant marine officers.

- To understand the methods by which these behavioural markers can be elicited and assessed.

Data is being collected and analysed using ethnographic study techniques during simulated crisis scenarios within a high-fidelity ship's engine control room environment. It is hoped that this research will lead to the development of an assessment framework that can be applied within the merchant marine context for the fair and effective assessment of competence in CRM and crisis management skills.

5. What other factors affect successful CRM?

Two other research issues are of particular interest in the maritime context. The first is related to the sharing of situational awareness between members in a team and also between distributed teams. Video observations from our own simulator exercises suggest that team leaders can find it difficult to articulate their understanding of the situation to other team members. This difficulty is not limited to intra-team communication, but can work at an inter-team level too. In addition, it is apparent that one team can easily become oblivious to the information needs of a separate team when under stress, for example, bridge and engine room teams habitually fail to update each other as a training scenario unfolds. Measuring the effectiveness of synchronous training and the characterisation of behavioural markers for distributed teams represent interesting challenges to the maritime training community.

The international shipping industry shares with the offshore industry a similar working environment in that multi-national, multi-cultural crews work and socialise together in an isolated environment for months on end. Cultural and linguistic effects on team working is a particularly challenging area of research. Our experience from simulator training suggests that different national cultures do work together in noticeably different ways, for example, a UK/US team does display a more individualistic way of sharing situational awareness than those from a more "collective" culture (Hofstede, 1991). Questions that have yet to be addressed include: what effects are produced by cultural factors and how may they be characterised? What is the impact on the overall safety performance of a team, especially in stressful situations, by placing individuals from one culture into a different culturally based team?

In recent high fidelity simulator based studies two types of behaviour, which provide examples of both communication and cultural problems, have been noted that have had particularly adverse affects upon the team's performance. These behaviours have been categorised as "verbal disruption" and "cultural isolation".

5.1 Verbal Disruption

The behaviour has been noted where one team member has been so vocal during the simulation exercise that they have disrupted the team task. In an effort to be helpful to the team, these team members will continually verbalise the situational assessment, as they perceive it. They will offer many varied hypotheses for any perceived problem, they will continually offer advice to the other team members and they have also been observed thinking aloud. By continuously talking, they make it very difficult for other members of the team to communicate, and consequently the performance of the team suffers. When the team member who was causing the verbal disruption was given a non-participative role of observer within a simulator exercise, the performance of the remainder of the team was seen to improve dramatically.

Once the team members had been made aware of their verbal disruption behaviour, during subsequent simulator exercises, it was observed that they made a conscious effort to limit their utterances to the minimum required to maintain effective communications with the other team members.

5.2 Cultural Isolation.

In teams of three members or more, where one of the team members is the only one from a particular culture, and the rest of the team members are from a different culture, cultural isolation has been observed. The team member who is of a different culture to the rest of the team has been observed to be isolated within the team and ignored by the remaining team members. This behaviour has been observed even when this team member is known by the other team members to have expertise relevant to the team task. The behaviour then has serious consequences for the effectiveness of the team to successfully complete the team task.

From anecdotal evidence when debriefing the team, it appears that the isolation is not carried out at any conscious level. When the cultural isolation behaviour was discussed with those simulation exercise participants who were exhibiting it, they were unaware that they had been behaving in that way. It appears that the natural cohesion of the team members' culture was overriding the team working principle.

Again, once team members had been made aware of their cultural isolation behaviour, during subsequent simulator exercises they made a conscious effort to ensure that all team members were fully integrated into the team task.

These observations show that when undertaking crew resource management training courses within a full mission simulator, it is possible to detect behaviours that are detrimental to the team's performance. These observations also show that with debriefs, these detrimental behaviours can be changed, in the short term, for more beneficial behaviours. Further research would be required to ascertain how long these beneficial changes in behaviour would last.

6. Conclusions

As in similar safety-critical industries, the analysis of maritime accidents over the years has revealed shortcomings in the ability of operators to manage both resources and crises. CRM training has been seen increasingly as a fundamental part of the human error management philosophy. The International Maritime Organization recognises the need for non-technical or resource management skills, but both the standards of competence and their assessment criteria are immature in comparison with civil aviation. Studies of recent casualties involving human failures in resource, risk and crisis management confirms that lack of situational awareness is the predominant factor in operator error.

The results of a survey of marine and other experts in simulator training suggest that a variety of simulation based options have different strengths and weaknesses for resource and crisis management training. The most cost-effective training option, therefore, is likely to be determined by a number of factors. However, at present, the

only really viable option for the assessment of competence, for marine certification purposes, is in the use of full mission simulation.

These principles are now being incorporated in new simulation-based CRM courses at Warsash. The course uses a number of forms of simulation, including role playing exercises and full mission simulator exercises, which combine both bridge and engine room teams to develop the CRM skills of communication, team co-ordination and management and leadership development. In addition, research is currently being conducted in order to provide the international maritime community with an understanding of how a behavioural marker system could be applied for the assessment of competence in crisis management of merchant marine officers.

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