Using simulation to determine a framework for the objective assessment of competence in maritime crisis management.

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A lack of competence in crisis management has been shown to be a causal factor in a number of recent maritime accidents. In safety critical industries other than commercial shipping, such as civil aviation, nuclear and petrochemical, research is being undertaken to identify behavioural markers that can be used to assess competence in crisis management. Although there is now a general acceptance of the core concepts for the non-technical or resource management skills required for competence in crisis management, there is also an acceptance that the behaviours associated with these skills are context specific. This paper gives details of a research programme that is working to improve the understanding of how a behavioural marker system could be used as a framework to objectively assess the competence in crisis management of merchant marine engineering officers within the context of a merchant vessel engine control room.

Introduction: Emergency or Crisis?

Evidence from some recent investigations into maritime accidents has shown severe shortcomings in the competence of some merchant marine engineering officers to manage both resources and crises (MAIB, 1996; MAIB, 1999). Data from research undertaken by the UK P&I Club (UK P&I, 1997) indicates that human error directly accounted for 58% of all shipping incidents that led to major insurance claims. The United States Coastguard (1995) states that the human element was a root causal factor in 70% of all shipping incidents. Although not all of these incidents led to a crisis situation, all had that potential. Accepting that human error is inevitable, there is a need to understand the behaviours of effective error detection and management in order to ensure safe and efficient operations (Helmreich et al., 1998).

Within many safety critical industries, and the military, the training and assessment of resource management skills is taking on a high level of importance (Flin & Martin, 2001; Cannon-Bowers & Salas, 1998; Brabazon & Conlin, 2000; Flin et al., 2000). Within the civil aviation industry the training and assessment of crew resource management skills is being introduced and is seen as a way of improving safety performance.

Helmreich et al. (1998) suggest that the optimal implementation of resource management skills is dependent upon the cultural context in which they are applied. If this is the case, then in order to effectively assess the application of resource management skills, assessment should, as far as possible, be undertaken within a cultural context close to that in which the skills would be applied. They discuss the influences of three cultures, professional, organisational and national, on the application of resource management skills in the cockpits of civilian airliners. They argue that resource management skills form a fundamental part of any error management philosophy and that these skills are highly applicable to any domain where teamwork and technology are required.

There is a growing recognition that resource management skills form an essential part of any error management philosophy. In the European Union and the USA, the assessment of non-technical skills is a mandatory part of the licensing process for civil aviation pilots.

Within the maritime domain the only mandatory non-technical skills requirements are those of the International Maritime Organization's 'Seafarer's Training, Certification and Watchkeeping Code (STCW Code)'. 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 the existence of these standards of competence indicates that the International Maritime Organization recognises the need for non-technical or resource management skills, both the standards and their assessment criteria are immature in comparison with the understanding of non-technical skills, and their assessment, within the civil aviation domain.

Within the context of the civil aviation domain the behavioural marker systems for the assessment of non-technical skills are still the subject of research. Within the context of the commercial shipping domain the literature review has not found any such research being undertaken.

When considering the assessment of crisis management skills a distinction should be made between emergencies and crises (Habberley et al, 2001).

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 main engine failure. Training in emergency procedures can be undertaken both onboard and at onshore training establishments.

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 (Barnett, Gatfield & Pekcan, 2003)

A recent casualty in British coastal waters is given to illustrate the need for training providers and purchasers of crew resource management training to be clear about whether they need to provide opportunities for their employees to learn crisis management or emergency preparedness.

Case Study: The "Green Lily" - An Unnecessary Tragedy?

On 18th November 1997, the 3,624 grt Bahamian registered vessel "Green Lily" sailed from Lerwick in the Shetland Islands with a cargo of frozen fish for the Ivory Coast. The weather on departure was bad with wind speeds increasing to severe gale force 9. The following morning, while hove to about 15 miles south-east of the island of Bressay in the Shetland Isles in storm force 10 winds, a sea water supply line fractured in the engine room. The engineers controlled the flooding, and pumping out had begun when the main engine stopped. Unsuccessful attempts were made to restart the engine while the vessel drifted northwards towards Bressay. Shetland Coastguard was advised and three tugs, the Lerwick RNLI lifeboat and a coastguard helicopter prepared to proceed to the casualty.

Attempts were made by two of the tugs to secure a line and tow the "Green Lily" away from land but although initially successful, each line parted. The starboard anchor was released and the third tug attempted to snag the cable and pull her head to wind, but the cable parted. At this time, the lifeboat rescued five crewmen, including two injured, from the ship's deck. The ten remaining crewmembers were rescued by the Coastguard helicopter but the winchman, who had remained on the deck of the ship, was swept into the sea and lost. The "Green Lily" went aground and started to break up. The investigation by the United Kingdom Marine Accident Investigation Branch (MAIB), published in June 1999, advised the cause of the grounding was:

> *"the lack of propulsion and failure to restart the main engine to arrest the drift of the vessel towards the shore in the prevailing environmental conditions. Contributory causes included flooding of the engine room, failure to reset the mechanical over-speed trip, inadequate knowledge of the cooling water system, failure of the towage attempts and inadequate teamwork"* (MAIB, 1999; pp. 9)

Analysis

- An initial technical failure precipitated events and was compounded by a hostile environment and further technical problems and failures. The situation escalated in severity. An emergency became a crisis, but the actors in this tragedy did not have the benefit of hindsight to read the 'script'.

- The available emergency plans, which tended to be procedures based on single failures, were not applicable. The individuals involved were forced to fall back on their experience to cope with an increasingly complex and unpredictable set of circumstances.

- Initial diagnosis of the technical failure was incorrect and led to a faulty but persistent mental model of the situation. In this case, the chief and second engineers, together with the electrical engineer, failed to understand why the main engine stopped and were consequently unable to restart it. They believed that the main engine failure was due to the effect of the flooding, previously caused by the fracture of the sea suction pipe. The probable reason for the main engine stoppage was actually due to the mechanical over-speed trip either not being reset or reset incorrectly.

- Awareness of the overall situation by individuals was based on incomplete or inaccurate information. In this case, both the Master, based on his calculation of drift, and the engineers, were over optimistic in their belief that a tow would be available before the ship ran aground. Meanwhile, the skippers of the rescue craft had unexpressed reservations about various aspects of the operation including the appropriateness of some of the towing gear, the weather conditions and sea room, and the ability of the ship's crew to handle the towlines.

- Individuals and units were separated physically and several agencies were interacting through various forms of communication. In these circumstances, it was very difficult for the key players to communicate meaningfully and maintain a shared and agreed awareness of the rapidly changing situation.

In crisis situations, just when the expert needs to draw on a reliable repertoire, the situation is unpredictable and atypical, so no repertoire can be called upon. The crisis handler has to revert to a creative response i.e. they have to think their way through the novel situation. The primary justification for the direct training for crisis management is based in the belief that by exposing individuals or teams to a variety of potential crisis scenarios, their 'patterns' or mental models of situations will be enriched, thus enhancing their situational awareness techniques and their repertoires of decision making. The key to this approach is in the 'richness' of the mental models developed by the individual or team, but paradoxically, the problem is that if the training scenarios are too prescriptive, then the learned repertoires may be inappropriate to the real emergency encountered.

This repertoire driven process can lead to dangerous consequences when facing an unpredictable situation. On the one hand, the decision-maker may derive increasingly bizarre hypotheses to explain the available information cues – the "kaleidoscopic" effect; or the decision-maker may become fixated on one pattern, refusing to change repertoires in the face of obviously conflicting information – the "mind-set" problem as exhibited by the "Green Lily" engineers. (Barnett, Gatfield & Pekcan, 2003)

In 2000, the United Kingdom Maritime Coastguard Agency (MCA), following a recommendation of the United Kingdom 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 of escalating emergencies. This project enabled the researchers to review current concepts and models in the field of crisis management across a range of safety critical industries and to conduct a survey of expert opinion on the optimal training and assessment regimes for handling escalating emergencies (Barnett, Gatfield & Habberley, 2002).

One of the conclusions of this project was that within any framework currently in use for the assessment of the non-technical skills of maritime crisis management, the behavioural markers were ill defined. The project recommended that research be undertaken to understand how behavioural markers may be used for the assessment of crisis management standards of competence within the commercial shipping domain.

> *"Crisis management standards of competence are ill defined and consequently so are their 'behavioural markers' by which the standard may be assessed. More research is needed in this area, particularly in assessing the team working competencies."* (Habberley et al, 2001)

Behavioural Markers

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. 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. Confirming the experience of researchers in other domains, Tollcott (1992) states that the two primary components of military decision making are:

- situation assessment (what is happening); and
- action selection (what to do about it).

The first of these components requires crisis managers to generate hypotheses to account for the information that is being received. The second of these components requires the generation and evaluation of alternate actions. During a crisis these tasks have to be performed within a highly demanding decision-making environment. In certain circumstances this demanding decision-making 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."*

So 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.

Military Behavioural Markers

Following their participation in a major US military research project, "Tactical Decision Making Under Stress", Cannon-Bowers and Salas (1998) proposed a set of twenty knowledge, skill and attitude requirements for teams to work effectively during crisis situations. If indeed there are so many requirements for an effective crisis management team, the assessment of competence in crisis management based upon these requirements is a daunting task. If assessment should be undertaken in an environment that closely resembles the real world situation, in order to ensure that, as far as possible, all of the required cues for decision-making are available; the capture of data to evaluate against assessment criteria relating to all of these requirements is a truly enormous task.

Through their use of war games, the military attempt this task. During the attendance of a major war game exercise onboard HMS Iron Duke, the author was able to observe a military 'crisis management' assessment. A large number of assessors are 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 given in Table 1.

Command and Control
Did the Command team quickly close up at HQ1.
Was a comprehensive set of check cards / aide memoirs provided and used.
Were smoke boundaries established and effectively maintained.
Was there a good flow of information into the control position at all stages.
Was the incident picture well kept.
Was an alternative control position considered.
Were hands piped to emergency stations in good time.

Table 1. Examples of Military Command and Control Assessment Criteria (Royal Navy, 2002)

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, subjective assessments are inevitable, because of the operational requirements of the military, and the sheer complexity of the war-gaming environment. However, because of the large number of assessors used, fair and effective assessments can be achieved through moderation. Anecdotal evidence from military personnel who have been assessed by such a process tends to confirm this fairness and effectiveness.

Civil Aviation Behavioural Markers

Within the civil aviation industry the training of crew resource management skills has been introduced as a way of improving safety performance. The civil aviation industry has recently been undertaking research into the possibility of assessing the non-technical skills of aircrew. Non-technical skills can be defined as those skills, in addition to technical skills, required for competence in crisis management. There are four main categories of resource management skills, or non-technical skills, being used within behavioural marker systems within the civil aviation industry (Flin & Martin, 1998):

- Co-operation
- Leadership and Management
- Situation Awareness
- Decision Making

The European Union research project 'Joint Aviation Requirements Translation and Elaboration of Legislation' (JAR TEL Consortium, 2001) has evaluated the use of such a behavioural marker system for the assessment of resource management skills of commercial flight crews. The JAR TEL project consortium concluded that their assessment framework: "is capable of proving itself a valid and reliable method for assessing non-technical skills."

Although the non-technical skills or 'NOTECHS' framework has moved the assessment of competence in crisis management, 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 some 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 JAR TEL research project, a methodology for assessing the non-technical skills of aircrew, by observing individual overt behaviours, has been proposed. Some examples of the behavioural markers used in this assessment framework are shown in Table 2.

Non-Technical Skill Category – Cooperation *Element – Consideration of others.* Consideration of others is about acceptation of others and understanding their personal condition.	
Behavioural Markers indicating poor practice:	*Behavioural Markers indicating good practice:*
Ignores suggestions of other crewmembers.	Takes notice of the suggestions of other crewmembers even if s/he does not agree.
Does not take account of the condition of other crewmembers.	Takes condition of other crewmembers into account.
Shows no reaction to other crewmembers.	Gives personal feedback.

Table 2. Examples of Civil Aviation Non-Technical Skills Assessment Criteria (JAR TEL Consortium, 2001)

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 in crisis management, are common to both. As with the military assessment framework, the JAR TEL criteria are assessed as having either been passed or failed.

A major difference between the assessment of competence in crisis management within the military context, and within 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.

Maritime Industry Behavioural Markers

Through the STCW Code Table A-V/2 (International Maritime Organization, 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 with 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 assessing competence. Examples of these assessment criteria are shown in Table 3.

Competence – Establish and maintain effective communications.
Information from all available sources is obtained, evaluated and confirmed as quickly as possible and reviewed throughout the emergency.
Information given to individuals, emergency response teams and passengers is accurate, relevant and timely.
Information keeps passengers informed as to the nature of the emergency and the actions required of them.

Table 3. Examples of Merchant Navy assessment criteria from the *Specification of minimum standard of competence in crisis management and human behaviour*. (International Maritime Organization, 1995)

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.

From the examples above, it can be seen that safety critical organisations undertake the assessment of competence in crisis management in very different ways. Based upon observations within various safety critical organisations, Table 4 provides a summary of their use of crisis management assessment frameworks. Within the merchant marine context, the STCW assessment framework for crisis management and human behaviour is too open to interpretation to be effective.

Table 4: Comparison of the Assessment Frameworks for Assessing Competence in Crisis Management Within Different Safety Critical Organisations

Context	Assessment Environment	Assessor(s)	Assessed	Assessment Criteria	Remarks
Military	High-fidelity War Game within real environment	Multiple Assessors Distributed throughout assessment environment	Team	Specific task orientated completion criteria.	Complexity of assessment environment leads to subjective interpretation. Fairness achieved through moderation.
Civil Aviation	High-fidelity simulator	Single	Individual working within team	Overt behavioural markers with examples given of good and poor practice.	Assessment framework difficult to use in complex scenarios leading to divergence of assessment.
Fire Service	High-fidelity simulator	Two	Individual working within team	Specific task orientated completion criteria.	Two assessors used to moderate subjectivity of assessment.
Offshore Oil/Gas	High-fidelity simulator and simulations onboard	Two	Individual working in a team	Specific task orientated completion criteria and some overt behavioural markers.	Two assessors used to moderate subjectivity of assessment
Merchant Marine	Simulations onboard and table top.	Single	Individual working within team	Prescriptive, but very open to subjective interpretation.	Assessment framework too open to interpretation by assessing authority.

Any framework for the assessment of competence in crisis management within the context of the merchant marine would not have the resources available to it that are available to the military. The civil aviation assessment framework for non-technical skills, although feasible to apply within the merchant marine context, has not yet been shown to be reliable in assessing competence in crisis management. However, the civil aviation industry is undertaking extensive research to address the issues of crisis management competence assessment. In contrast, very little research is being undertaken in this field with the merchant marine domain.

Within the context of the civil aviation domain the behavioural marker systems for the assessment of non-technical skills are still the subject of research. Within the context of the commercial shipping domain a literature review has not found any such research being undertaken, apart from that described in the following section.

Towards the Development of a Maritime Assessment Framework

A research programme is currently being undertaken at Warsash Maritime Centre that is intended to provide an understanding of how a behavioural marker system could be used to assess the competence in crisis management of merchant marine engineering officers within the context of a merchant vessel engine control room.

Behavioural markers that could be used to assess competence in crisis management within the context of a simulated merchant vessel's engine room control room are being determined. Experiments are being undertaken to investigate the efficacy of these behavioural markers to assess competence in crisis management, and it is intended that this research will then go on to show if these behavioural markers can be used as the basis for an objective competence assessment framework.

The aims of this research programme are:

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

2. To develop and validate an assessment framework that utilises specific overt behavioural markers to facilitate the objective assessment of competence in crisis management of merchant marine engineering officers.

3. To provide the international maritime community with an understanding of how a behavioural marker system can be applied for the assessment of competence in crisis management of merchant marine engineering officers.

Data are being collected by observations undertaken during exercise scenarios within the Machinery Space Simulator at Warsash Maritime Centre. Patterns of interactions between engine room team leaders and other engine room team members are being compared to try and determine if there are any particular patterns that lead to the successful management of crises. The research is establishing and codifying the overt behavioural markers that define the successful patterns of interaction that are found. The research is restricted to overt behavioural markers. The research is not attempting to determine and analyse the cognitive processes underlying the patterns of interactions.

Groups of three experienced engineering officers are first given a familiarisation session within the Machinery Space Simulator. The groups are then given a briefing about the situation onboard the vessel, with each research participant given a team role. One participant takes on the role of the Chief Engineer, one as Second Engineer and one as Third Engineer. The simulator operator participates in the role of Extra Second Engineer, but only by radio. In this role the simulator operator can act as a facilitator for the not wholly scripted research exercise scenario. There is also a Mechanic available to work under the supervision of the Extra Second Engineer. Once simulator familiarisation has been achieved, team roles have been assigned, and the scenario briefing has been given, the research exercise is undertaken.

Observations are made with the researcher being an acknowledged observer. It is understood that there is the potential for reactivity effects using this method of observation. However, anecdotal evidence over many years from professional marine engineering officers using the Machinery Space Simulator at Warsash Maritime Centre has indicated that the closed circuit television and audio monitoring systems, used for observation, are unobtrusive, and do not cause any reactivity effects.

The initiating event for the research exercise scenario is seawater ingress into the diesel oil service and settling tanks. The diesel oil service tank supplies both main diesel alternator engines. This initiating event is based upon an actual incident that led to the loss of the motor tanker Braer at Garths Ness, Shetland on 5th January 1993, with associated massive oil pollution (MAIB, 1994). The significance of the observed behavioural markers in influencing the outcome of crisis development is being determined by statistical methods.

From the research exercises run to date a number of behavioural markers have been noted that may be shown to be significant. These are shown in Table 5. For those behavioural markers that are shown to be statistically significant, range statements are being proposed which codify the behaviour of the engine room team leader in relation to exemplars of behaviours associated with the effectiveness of the team leader's crisis management skills. Different assessors are then being asked to use these range statements to assess competence in crisis management. As these range statements are all nominal variables, the kappa statistic is being used as a measure of agreement between the assessors. The proposed assessment framework will be validated by determining the level of inter-rater reliability.

Behavioural Marker	Characterisation
Ratio of the degree of feedback control to the degree of predictive control.	Indication of the level of situational awareness.
The number of alternative hypotheses and actions communicated to team members.	An indication of teamwork and the building of a shared mental model.
Level of satisficing exhibited.	Considering only as many alternatives as needed to discover one that satisfies.
Communicating in a way that shares ones mental model.	Building, maintaining and refining the accuracy of the shared mental model of the team.
Relevance and timeliness of unsolicited information passed between team members.	A measure of the degree of congruence between the mental models held by individual team members.
Level of anticipation of other team members needs.	Indication of the level of situational awareness.
Level of anticipation of future actions and task requirements.	Indication of the level of situational awareness.
Focus is too much on the reduction of uncertainty.	Indication of a tendency towards analytical decision-making, and away from naturalistic decision-making.
Tendency to focus on one system at a time, thereby ignoring the dynamics of the complete system.	An indication of the lack of a situation overview.
Amount of sampling behaviour exhibited.	An indication of the updating of situational awareness and mental model.
Number of unfinished sentences.	A measure of uncertainty.
Delegation of work tasks.	A measure of the effective use of all team members, and the alleviation of overload.
Patterns of movement.	Interpretation of patterns of movement to determine degree of situation overview.

Table 5. Characterisation of observed behavioural markers.

Conclusions

Although not yet complete, this research programme is already starting to show how behavioural markers can be used as a basis for an objective assessment framework for the assessment of competence in crisis management within the domain of a merchant vessel engine room control room. The research has shown that it is possible to use sets of simple, clearly defined patterns of behaviour to assess competence in crisis management skills. The initial indications from the research are that the objective nature of these simple patterns of behaviour will lead to a more objective assessment of competence than the more complex patterns of behaviour used as markers within the assessment frameworks of some other safety critical organisations.

References

Barnett, M. L., Gatfield, D. & Habberley, J (2002). *Shipboard crisis management: A Case Study.* Proc Int. Conf. Human Factors in Ship design and Operation. pp 131-145 RINA, October 2002

Barnett, M., Gatfield, D. & Pekcan, C. (2003). A Research Agenda in Maritime Crew Resource Management. In: *Proceedings of International Conference on Team Resource Management in the 21st Century.* Embry-Riddle Aeronautical University, Daytona Beach, Florida.

Brabazon, P., & Conlin, H. (2000). *Assessing the safety of staffing arrangements for process operations in the chemical and allied industries.* Report for the Hazardous Installations Directorate of the UK Health and Safety Executive. London: HMSO

Cannon-Bowers, J.A., & Salas, E. (1998). *Making Decisions Under Stress: Implications for individual and team training.* Washington D.C.: American Psychological Association.

Flin, R., & Martin, L. (1998). *Behavioural markers for crew resource management.* UK Civil Aviation Authority Paper 98005. London: Civil Aviation Authority.

Flin, R., O'Conner, P., Mearns, K., Gordon, R., & Whitaker, S. (2000). *Crew Resource Management Training for Offshore Operations.* Factoring the Human into Safety: Translating Research into Practice. Volume 3 of UK Health and Safety Executive report HSE OTO 2000 063. London: HSE.

Flin, R., & Martin, L. (2001). *Behavioral Markers for Crew Resource Management: A Review of Current Practice. The International Journal of Aviation Psychology*, 11(1), 95-118.

Habberley, J., Barnett, M., Gatfield, D., Musselwhite, C. & McNeil, G. (2001). *Simulator Training for Handling Escalating Emergencies*. United Kingdom Maritime and Coastguard Agency Research Project 467. Southampton: The Maritime and Coastguard Agency.

Helmreich, R., Wilhelm, J., Klinect, J., & Merritt, A. (1998). *Culture, Error and Crew Resource Management*. Austin: University of Texas at Austin.

International Maritime Organization (1995). *Seafarer's Training, Certification and Watchkeeping Code (STCW Code)*. London: IMO.

JAR TEL Consortium (2001). *Joint Aviation Requirements: Translation and Elaboration of Legislation.* Final Report, Contract n° AI-97-SC.2037. European Commission, DG TREN.

Marine Accident Investigation Branch (1994). *Report of the Chief Inspector of Marine Accidents into the engine failure and subsequent grounding of the Motor Tanker Braer.* Southampton: MAIB.

Marine Accident Investigation Branch (1996). *Report of the Investigation into the Power Failure on Canberra.* Southampton: MAIB.

Marine Accident Investigation Branch (1999). Marine Accident Report 5/99. *Report of the Inspector's Inquiry into the loss of MV Green Lily*. Southampton: MAIB.

Royal Navy (2002). *Basic Operational Sea Training Assessment Form.* Plymouth: HMS Drake. Flag Officer Sea Training.

Salas, E., Driskell, J., & Hughes, S. (1996) *Introduction: the study of stress and human performance.* In: J. Driskell & E. Salas (Eds) Stress and human performance. Mahwah, N.J.: Erlbaum, 1-45

Tollcott, M.A. (1992). *Understanding and aiding military decisions.* In: S.C. Collyer (Ed) The 27th International Applied Military Psychology Symposium: A focus on decision making research. London: Office of Naval Research, ONR Europe Report 92-4-W, 33-48

UK P&I Club (1997). *Analysis of major claims – ten-year trends in maritime risk.* London: Thomas Miller P&I Ltd.

United States Coastguard (1995). *Prevention Through People,* Quality Action Team Report. Washington D.C.: USCG.