FINAL REPORT

Simulator Training
for
Handling Escalating Emergencies

MCA Project RP 467

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WARSASH MARITIME CENTRE

A REPORT TO THE MARITIME AND COASTGUARD AGENCY

ON

"SIMULATOR TRAINING FOR HANDLING ESCALATING EMERGENCIES"

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GRAPHS

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EXECUTIVE SUMMARY

Following the grounding of the "Green Lily", the Marine Accident Investigation Branch (MAIB) report recommended that the Maritime and Coastguard Agency (MCA) commission a research study into how bridge and engine room simulators can best be used for bridge and engine room resource management training that includes escalating emergencies and increasing levels of stress. Warsash Maritime Centre (WMC) was commissioned to carry out this research.

Objectives

The objectives of the research project were to:

- Investigate the availability of, and developments in, simulator technology applied to bridge and engine room resource management training, specifically that addressing escalating emergencies and increasing levels of stress.
- Taking into account the results of the above objective, determine how simulator technology may most effectively be used in the training of seafarers in the handling of emergencies.
- Applying these results, through a cost-benefit assessment or other suitable technique(s), quantify the efficiency of the simulation techniques on offer in addressing the training aims.
- In summary form, report on the simulator training regimes in place in other Certifying States including the identification of the underlying education levels, tasks and training aims.

Methodology

The methods adopted for the project included a literature review and questionnaires sent to Certifying States, Simulator Manufacturers, Shipping Companies, Maritime Organisations and Simulator Operators. An electronic discussion group, using the Delphi technique, was used and a number of experts from other industries were brought together for a two-day workshop.

Results

The literature review and returned questionnaires indicated that although simulation is often a preferred method of training it is not widely used for the training of handling escalating emergencies at sea.

Importantly, a distinction was noted between an emergency and a crisis. Emergency Management can be used in a situation where decisions and actions are based on documented emergency procedures. Crisis Management differs from Emergency Management insofar as decisions and actions do not necessarily have documented procedures and that the critical skills needed in these situations are predominately non-technical in nature. Although the training of these non-technical skills is being undertaken in other safety critical industries, the report shows that they have not yet been fully defined and recommends further research in this area. As these non-technical skills are, at present, not available it is suggested that a Training Needs Analysis (TNA) needs to be applied in order to determine the training requirement and identify the required instructional facilities in order to deliver the training and undertake trainee assessment.

The report also suggests that Crisis Management standards of competence are poorly defined as are their "behavioural markers", by which these standards may be assessed. Crisis Management training should be viewed as a long term process and embedded in the training of a seafarer throughout their career rather than as a set of added courses.

Recommendations (taken from Chapter 9)

9.1 A Training Needs Analysis (TNA) should be undertaken to analyse the training requirement and specify the functional requirements for the training equipment to be used within this training and assessment programme.

9.2 The main non-technical skills of co-operation, leadership and management skills, situation awareness, and decision making, that have to be mastered in order to handle escalating emergencies, need to be more fully defined.

9.3 A strategy needs to be developed to incorporate these skills into a training and assessment programme.

9.4 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.

9.5 Whatever training methods are used, crisis management training should be viewed as a long term process, embedded in the training of individuals from novice through to senior command, not as a set of "bolt-on" courses.

9.6 The most cost-effective training option will be determined by local factors. Therefore, no mandatory option should be considered. At present, until the research above is completed, assessment by Full Mission Simulator constitutes the only viable option.

1 INTRODUCTION

1.1 On 19th November 1997, the 3,624 grt Bahamian registered vessel "Green Lily" grounded on the island of Bressay in the Shetland Isles in Force 10 winds and subsequently broke up. All crew members were rescued by a Coastguard helicopter but the helicopter winchman, who remained on the deck of the ship, was swept into the sea and lost. The investigation by the 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 page 9)

1.2 One of the reasons for this tragedy was that 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 flooding, previously caused by a fracture of the sea suction pipe. The probable reason for the main engine stoppage was due to the mechanical over-speed trip either not being reset or incorrectly reset.

1.3 The MAIB report, recalling previous investigations and noting the "Green Lily" investigation, advised that many of the accidents investigated showed that team cohesion failed when non standard emergency situations occurred, leading to rising levels of personal stress. Under this,

> *"engineer officers often show a lack of diagnostic skills while deck officers fail to operate as an effective bridge team*" (MAIB, 1999).

1.4 One of the MAIB recommendations to the Maritime and Coastguard Agency (MCA) was

> "*to commission a research study into how bridge and engine room simulators can best be used for bridge and engine room resource management training that includes escalating emergencies and increasing levels of stress. The results should be used to develop effective training for handling emergencies at sea*" (MAIB, 1999)

1.5 The MCA responded with an invitation to tender – RP 467 – "Simulator training for handling escalating emergencies" in February 8th 2000, to which the Warsash Maritime Centre (WMC) was invited to submit a proposal. Following their submission and a meeting with the MCA, WMC was awarded the contract on 6th April 2000.

1.6 **Reference**:

Marine Accident Investigation Branch (MAIB) Marine Accident Report 5/99 "Report of the Inspector's Inquiry into the loss of mv Green Lily on 19 November 1997 off the East Coast of Bressay, Shetland Islands".

2 PROJECT OBJECTIVES

2.1 The objectives of the research project were to:

2.1.1 Investigate the availability of, and developments in simulator technology applied to bridge and engine room resource management training, specifically that addressing escalating emergencies and increasing levels of stress.

2.1.2 Taking into account the results of objective 2.1.1, determine how simulator technology may most effectively be used in the training of seafarers in the handling of emergencies.

2.1.3 Applying these results, through a cost-benefit assessment or other suitable technique(s), quantify the efficiency of the simulation techniques on offer in addressing the training aims.

2.1.4 In summary form, report on the simulator training regimes in place in other Certifying States including the identification of the underlying education levels, tasks and training aims.

3. METHODOLOGY

3.1 Introduction

To achieve the four objectives outlined in section 2.1, the project team adopted a general methodology which had the following elements:

- a literature review;
- questionnaires and analysis;
- an electronic discussion group using Delphi techniques;
- a cost benefit analysis.

3.2 Literature review

A literature review was conducted with the following three objectives:

- Provide an update on work in the psychology of emergency handling under stress, based upon recent published research reports and papers;
- Identify the current available training options in handling escalating emergencies;
- Identify the ability of current specific simulators to meet these requirements.

3.3 Questionnaires

A series of questionnaires was developed and distributed to establish how simulator training in handling emergencies is undertaken by leading national bodies and simulator-training facilities across a range of safety critical industries.

The questionnaires sought to establish:

- the range of existing simulators used in the training of handling escalating emergencies;
- the extent to which these simulators are used for mandatory training and / or assessment of competence;
- evidence of their effectiveness in training and / or assessing handling escalating emergencies;
- limitations in their use in training and / or assessing handling escalating emergencies.

A number of groups were selected to respond to the questionnaires:

- Certifying States as represented by delegations to the STW Sub-Committee at IMO;
- Simulator manufacturers;
- The users and sponsors of simulator-based training ie shipping companies;
- Maritime organisations with an interest in the use of simulators;
- Simulator operators i.e. maritime colleges.

3.4 An electronic discussion group using Delphi techniques

The Delphi technique was used as a method for producing a detailed critical examination and discussion among the major stakeholders and experts in the field of training on how to handle escalating emergencies leading to conditions of psychological stress. Expert judgement was sought from the maritime industry and other safety critical industry sectors in order to document and analyse their experiences in crisis management training.

The project team facilitated the process and undertook an analysis of the results of each round of the discussion in order to achieve the following specific objectives:

- collate and analyse the subjective judgements of discussion group participants to produce a clear presentation of the range of views and considerations;
- detect hidden disagreements and judgmental biases and expose these for further clarification;
- detect missing information or cases of ambiguity in interpretation by different participants;
- clarify patterns of information and sub-group positions;
- identify critical items that need to be focused upon.

The results of the activities were used to identify training options that will be effective in the transfer of necessary skills to seafarers to enable them to respond to emergencies under conditions of psychological stress, with relation both to the individual and to teams.

The analysis also produced a set of specific requirements that simulators would need to satisfy in order to meet the identified training options.

A list of “experts”, who could be invited to take part in the Delphi process was drawn up encompassing expertise from classification societies, simulator manufacturers and users, academics with expertise in simulation, and maritime national and international bodies. Invitations were sent out to 32 representatives. Of the 15 who agreed to take part in the first round, 9 represented organisations operating outside the UK.

3.5 Cost benefit analysis

Once the training options and specific simulator requirements to meet these training options had been identified, expert opinion and empirical evidence from simulators currently in use were used to evaluate and rank the training options in terms of cost benefit. A number of metrics were considered in order to evaluate cost benefit including:

- training effectiveness;
- simulator system costs;
- trainer costs;
- trainee costs.

The cost benefit analysis was conducted at a two day workshop using a small group of simulation and training experts, drawn from the participants in the electronic discussion group described above. The expert judgement from this exercise was then used to provide conclusions and recommendations.

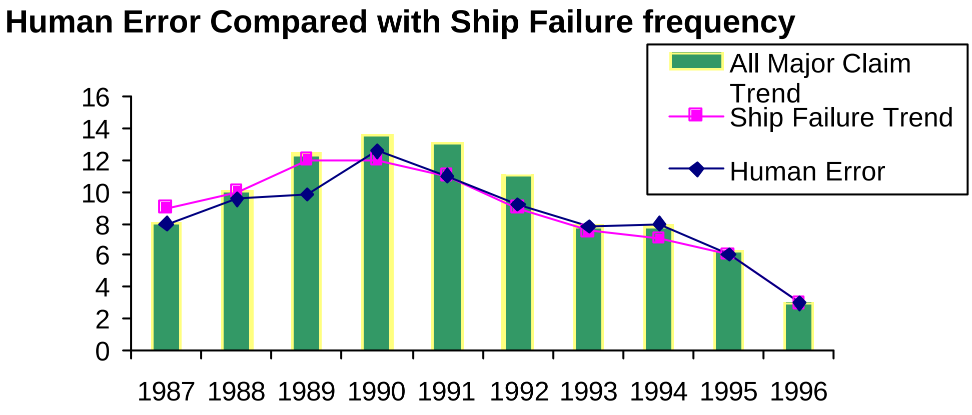
4 LITERATURE REVIEW

4.1 Introduction

One of the axioms of emergency and crisis management is that we can learn lessons from past accidents and prevent their re-occurrence. While this is undoubtedly true, it is also true that one of the more difficult aspects of the study of crisis management, and certainly of training for handling emergencies, is that no two situations are exactly alike. In this context, strategies and procedures that are too prescriptive may be counter-productive.

So what do the data on casualties tell us? Many people will be well acquainted with the statement that 80% of all accidents are attributable to human error. In the maritime context, this statistic was first noted by the Panel on Human Error in Merchant Marine Safety in 1976 (Maritime Transportation Research Board, 1976). Other safety critical industries such as aviation and nuclear power have reported similar statistics. Increasingly though, it has been recognised (Reason,1999) that all accidents may be attributed in some way to human fallibility, and that such broad statistics need further definition and analysis.

The UK P&I club (UKP&I, 1997) regularly publish their casualty and incident trends (see graph below), which indicate an overall decrease in major claims and human error from 1987 to 1996. Their categories of incidents include mechanical, structural and equipment failure which is indicated by the ship failure trend, major claims and human error, as indicated on the chart below:



Graph 1: Comparison of the percentage of recorded incidents from 1987 to1996.

This complete study was based on 3719 large (i.e. >$100,000 per claim) marine claims over the 10 year period from 1987 – 1996. Cargo claims accounted for 40% of all large claims and represented 27% by value. Personal injury claims accounted for 30% of the larger claims and 20% by value. Collisions accounted for 8% by number and 11% by value. It was noted that there has been an increase in pollution claims since 1993, against the general trend and in contrast to the previous two years when they were in decline.

Human error as an overall trend, as distinct from ship failure, accounted for 58% of major claims. The main trends noted in human error are that crew, deck and engine room errors have shown a considerable decrease since 1989, but shore personnel and especially pilot error are seen as playing a significant part in major claims. The digest of the report sums up the human error aspect as

> *"Although claims resulting from human error are decreasing slowly in absolute terms, their relative importance is increasing in a climate where ship failure is significantly reducing. Three out of five major claims are directly related to human error" (UKP&I Club Digest report, 1997)*

Casualties like the loss of the "Green Lily" have highlighted that there are problems in the handling of escalating emergencies, particularly in stressful circumstances (MAIB, 1999). In common with other industries, such emergency situations share a number of characteristics:

- They involve complex, dynamic and sometimes fast-moving situations;
- They require decisions to be made under stress;
- The consequences of bad decisions can be catastrophic;
- They often involve teams rather than individuals;
- Decision-makers in these situations are often experienced personnel.

The following sections describe the relevant literature on research and current thinking on some of the issues raised by these characteristics. The sources of these findings stem from a variety of industrial sectors and academic disciplines.

The literature review is described in four parts:
- The Psychology of Decision Making Under Stress;
- Training for emergencies;
- Virtual Reality Training Environments (VRTEs);
- Simulator Technology.

4.2 The Psychology of Decision Making Under Stress

The psychology of decision making under stress is considered under the following headings:
- Models of decision making
- Types of decision making

- Errors in decision making
- Naturalistic decision making

Decision-making has long been studied by industrial or organisational psychologists. It can be defined as the process by which individuals or members of a group choose a specific course of action in response to changes in the environment.

4.2.1 **Models of Decision-Making**

Initially, decision making was seen essentially as problem solving. The classical decision making model, known as the prescriptive model, began with the assumption that people had access to all the information they need to make a decision. People make decisions based on choosing the best possible solution to a problem or a response to an opportunity (Edwards, 1954; Simon, 1955). Therefore, decision making was seen to follow four steps:

1 List alternatives
2 List consequences of all alternatives
3 Consider preferences for each alternative and rank them in order
4 Select an alternative that has the most preferred set of consequences and follow that action.

Thus, optimal decisions could be followed if these four rules are followed. However, the model is flawed on several counts. As an application to the real world, there are three fundamental problems:

1 <u>Not all information is present in every situation.</u>

Even with improved feedback from machines and increased data handling capacity of computers, it is very unlikely that all relevant information is present in every situation. The consequences of alternative courses of action may also not be known, leading to estimation and prediction which varies in degree of certainty. Individuals themselves often do not know exactly what they want from a situation. Thus, criteria for ranking may be difficult to develop.

2 <u>Cognitive overload.</u>

It is impossible for individuals to compute and interpret all relevant information when making a decision. People are limited in their capacity to process information. Decisions are therefore made on the most salient or obvious aspects of feedback in the environment. The decision to concentrate on a certain source of information for feedback is not always rational.

3 <u>Social behaviour</u>.

Such early models were based on decision making of individuals. They fail to take into account the strong influence found within group situations such as "group conflict" and "group polarisation" (see below). Furthermore, such models assume people can be totally rational and objective when making decisions and follow problems logically.

The model also fails in that it demonstrates the importance of 'what can be known' rather than 'how can it be known'. The emphasis is on information and what can be done with such information rather than the complex interacting web of processes that is involved in decision making.

The above limitations of the classical model are even more important in the following situations that regularly occur in real life:

- Negative states such as being under high stress or great anxiety;
- Unusual, ill-defined or ambiguous context;
- Where decisions must be made 'on the spot' or under increased time pressures.

The classical model assumes that decision making is based on having complete information in order to make that decision. In reality this is often not the case. As mentioned above, it may not be possible to determine whether all relevant information is present. Thus, in reality, decision making has more to do with 'making the best of the information *found*' rather than 'making the best of *all possible* relevant information'. Thus decision making is a "satisficing" rather than an optimal process.

Thus, the classical model is rejected in most modern decision making research. This is particularly true of research that concentrates on critical decisions being made in ill-structured and dynamic environments. This has led to a new approach such as March and Simon's (1958) Administrative Decision Making Model and more recently Naturalistic Decision Making (NDM) models (as reported by Skriver, 1996). These models look at decision making in real life contexts. Many of these involve studying critical and important safety decisions within safety critical industries such as aviation, nuclear power plants, offshore installations, military command and control and fire-fighting incident command. These models are descriptive and highlight how people make decisions. They stress how individuals deal with incomplete information and highlight the psychological and sociological processes involved. The emphasis in this model is on making decisions that are satisfactory, not optimal. Individuals search for and then choose an acceptable response or solution which is not necessarily the 'best' one (George and Jones, 1996). These models emphasise that individuals do not have all the information and, even if they did, they are bounded by cognitive rationality, i.e. there is a limitation on the capacity of the human mind, making it impossible to consider all information relevant to a decision.

The classical model also assumes that a poor outcome is entirely based on poor decisions made by individuals. NDM models suggest that good decisions may lead to poor outcomes for a number of reasons. These include limitations in the ability to reduce the effect of that information which is readily available, the cognitive load and social factors placed on individuals interpreting information and the contextual and time constraints placed on individuals when making decisions.

The NDM model is discussed in more detail in para 4.2.5 but prior to that, a short description of the types of decision making and errors involved in decision making will be outlined.

4.2.2 **Types of Decision Making**

Seafarers of all ranks have to make a number of important decisions for the effective and smooth operation of the vessel. Often decisions are going to be made under great stress and, on occasion, decisions need to be made at times of crisis or emergency. Previous research in decision making and NDM, both for individuals and in teams, seeks to investigate the processes that occur in making decisions under stress or at times of crisis or emergency in a wide variety of safety critical disciplines.

By definition all decisions involve choice among alternatives. There are different types of choice. Orasanu (1993) identifies four areas of choice with regard to cockpit crew on aircraft, which are also relevant to seafarers:

- Invisible choice - this situation is where no choice was made since only one option is actually considered;

- Stopping action - this situation occurs when choice may involve stopping something in progress;

- Choice within action - this is the situation where an appropriate choice may be identified by the way an action is carried out;

- Temporal choice - this situation may be recognised when the sequence and timing of a set of actions is important.

With regard to these four areas, although one type is no more important than another, very different cognitive strategies are adopted for each one. Orasanu (1993) suggests that each of the four areas of choice are so different that different areas of training are required for each.

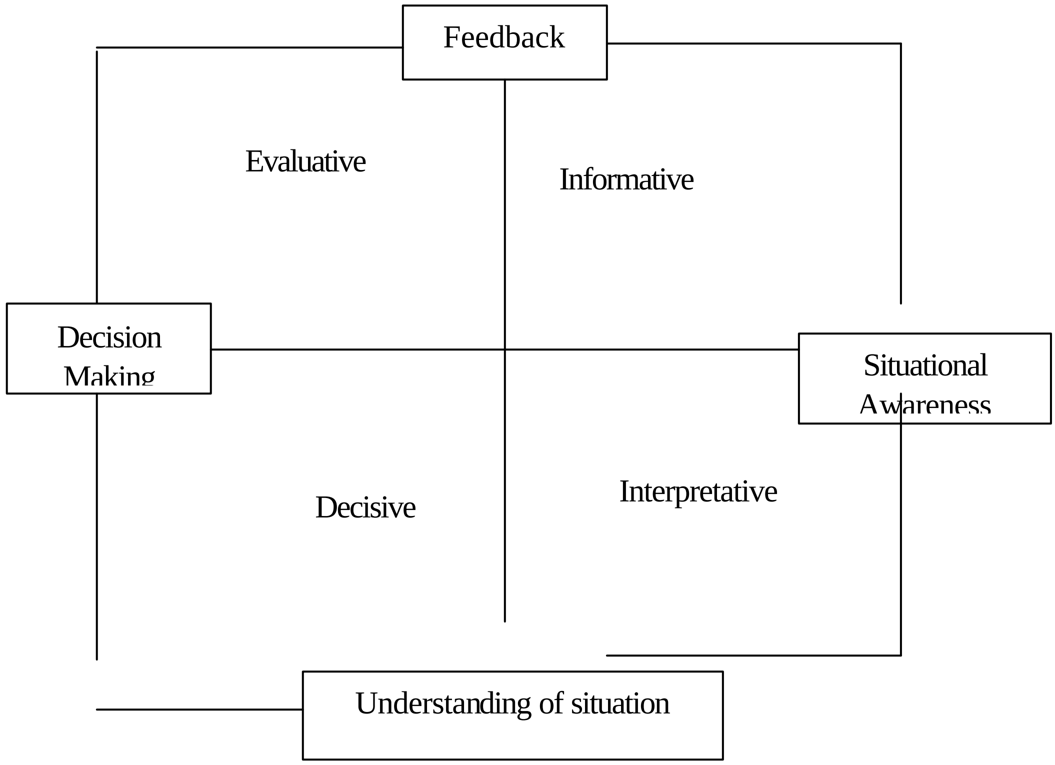
4.2.3 **Errors in Decision Making**

With regard to decision making under stress at sea, there are a number of errors that may be encountered that lead to less than satisfactory decision making. These can be identified in four main areas of human cognitive processing:-

- the informative level;
- the interpretative level;
- the decisive level;
- the evaluative level.

These four levels are shown on Figure 1, overleaf.

Figure 1: Main cognitive areas where human error is encountered.



4.2.3.1 **The informative level**

The informative level is the level at which information about a situation is gathered. This level relates to an individual's or group's situational awareness. Information can be seen as feedback from the machine being operated, in this case the ship, and from both the physical and social environment. At this level no interpretation of the data is necessary but there must be an awareness that there is feedback present. Thus, failures occur where there is no perception of feedback. This may be due to:

<u>Physiological barriers.</u>

Physiological barriers include poor senses which are not able to gather information properly, for example, bad eyesight or reduced hearing. Studies that have looked at seafarers health (e.g. Horbulewicz, 1973) have suggested that, amongst other factors, many serving seafarers have poor hearing.

Physical barriers.

Modern ships, like modern cars, are built with individual comfort in mind. Furthermore, the introduction of increased mechanisation and computerisation means the ship's crew are becoming more physically isolated from noticing changes in the ship's performance. Engineering officers used to be able to detect and analyse changes in engine noises but this is more difficult in modern ships with self-contained control rooms. Another shipboard example is provided by the introduction of cargo control rooms which separate personnel physically from pumps, valves and machinery.

Physical characteristics of the ship can also hamper vision. It is well-known that visual blind spots are inherent on some ships as a result of the foredeck configuration caused by masts or other high rising structures.

Mechanical barriers.

Due to the increase in the physical isolation of crew from the ship, modern technology provides feedback in terms of lights, dials, buzzers and, in more modern examples, the marine equivalent of the 'glass cockpit' (ie menu driven computer warning displays). Unfortunately most 'categorical' displays indicate nothing for normal, only lighting up or sounding when something is wrong. There have been incidents where no feedback has been experienced and thus everything has been assumed to be correct, when in fact buzzers and lights have broken or have failed to light. Feedback may also be erroneous causing the right decisions to be made but for the wrong reasons.

4.2.3.2 **The interpretative level**

Decision making problems are also found at the interpretative level. Even if feedback is correct at the informative level, further barriers to the success of decisions are found in the way individuals and groups interpret the information presented:

Mechanical barriers.

It may be the case that the ship's machinery presents correct feedback, but has been designed in such a way that it is open to misinterpretation. There have been examples in the aviation world of lights or buzzers being more obvious than other lights or buzzers that are actually more important. For example, during an Eastern Airlines flight in the Florida Everglades (29/12/1972 reported in Kayten, 1993), a light in an aircraft cockpit, showing that the landing gear had failed, was much brighter and in a much more often observed place, than a smaller light indicating that the auto-pilot had been disengaged. This resulted in the crews' attention being directed to solve the initial, less dangerous problem without noticing the more important problem until too late. Thus, the design of the ship's bridge and engine control room is very important and needs to be examined ergonomically with regard for human needs.

Availability heuristic bias.

The availability heuristic is the tendency to interpret an event by the frequency of its occurrence. Thus, events that are easily remembered are thought to occur frequently. Likewise, if a potential cause comes to mind quickly, people are likely to think it is an important causal factor. This is a useful process for events that do occur frequently but not for unusual stressful situations like emergencies. Since other factors such as vivid, extreme events or recent events come to mind quickly, these are easier to remember and may be interpreted as the cause. Thus, the wrong interpretation is placed on the situation and bad decisions made.

Representative heuristic bias.

The representative heuristic is the notion that similar kinds of events that happened in the past are good predictors of the likelihood of future events. The bias comes in the individual's interpretation of 'similar'. Thus, assumptions that an event is similar can cause problems. A master's decision to sail in a Force 10 storm may be based on the fact that once before he may have successfully sailed in similar conditions. The problem arises in that every situation is actually different and whereas all available information may appear similar, over reliance on its similarities occurs and differences are not highlighted. This is particularly true in situations where there is not a great deal of time to establish a true base, such as in times of emergency. Assumptions that are made without gathering the facts seem to be a major problem in decision making at sea. MARS (200001, January 2000) cites an example where a master altered course at a waypoint without appreciating the close proximity of another vessel. His decision resulted in a collision. MARS (200022, June 2000) shows how some commercial yacht seafarers have a potential problem in that they assume all ships of whatever size alter course at a certain distance from them and find it difficult to make allowances for different types of ship.

Anchoring heuristic bias.

The anchoring or adjustment heuristic is the taking of a current situation and making decisions based on the simple addition or multiplication of the current factors. Such a bias is increased where there is little time for correct calculations or information search as in emergency situations.

Optimism bias.

There is a likelihood of an individual being over optimistic about a situation. Thus, feedback suggesting emergency conditions may be interpreted more optimistically than is necessary. This is heightened by previous false alarms, for instance the 'cry wolf' situations where danger is often expressed by oversensitive control and alarm systems, but turn out to be false alarms.

Denial.

This is a tendency that occurs in true emergency situations when an individual may not believe that an emergency is happening.

Risk taking personality.

It has been suggested (Jonah, 1986) that there is evidence of a risk taking personality. Thus, risk taking is a measurable trait that has influence over the way such feedback is interpreted. Individuals with a high risk taking personality would fail to see strong winds and high seas as being as dangerous or as hazardous as an individual with a low risk taking personality. Airplane pilots are selected using psychometric tests on the basis of being calm, conscientious and emotionally stable characters (Rathus, 1990). Some shipping companies also select personnel using psychometric tests but it is less clear whether risk taking personality and emotional stability is considered in their selection techniques.

4.2.3.3 **The decisive level**

As interpretation of information from feedback and increasing situation awareness occurs, decisions are constantly being made. Since working on a ship during an emergency invariably involves team work, it is important to look at problems that face decision making in a group.

Physical and psychological boundaries of group membership.

The concept is that all workers should be members of a group during emergency crisis with the explicit emphasis of working as a team. Sub-groups and other groups that do not interact either socially or in a working group can cause disorganisation and problems, particularly at times of stress. Literature is divided as to whether stress brings together such groups or separates them further. There is disturbing evidence that on certain ships which are required to give way under the collision regulations, a red-blinking light is switched on at the Christmas tree; the inference being that the stand on vessel should give way. The MARS report 99038 (*Seaways*, October 1999), suggests that in one particular case this was due to bad relations with the Master which led to the ship's bridge officers not wanting to call him to the bridge. Thus, the OOW displays a red-blinking light and continues their passage.

Role conflict.

Decision making is difficult for individuals if they experience role conflict. Intra-sender role conflict is where one person gives two or more conflicting signals. Inter-sender role conflict is where two or more individuals send conflicting signals about what is expected of an individual. There can also be inter-role conflict where a person holds two roles that become conflicting. Finally, there is person-role conflict in which personal values or experiences are thrown into conflict by tasks given by another person. All these examples tend to be heightened at times of emergency and unfortunately also all lead to increased problems when decision making.

Role ambiguity.

Role ambiguity is where expectations about the role are not fully known. In stressful situations individuals' roles tend to become more ambiguous. Again, such role ambiguity can lead to problems in decision making.

Norms.

Norms are powerful informal rules found within a group. These are not often discussed, hardly ever written down, but have a huge influence. Such rules are generally picked up through a variety of social cues, such as non-verbal communication and 'reading between the lines' in verbal dialogues. Norms will effect who can make decisions and what effect individuals may have on the decision making process. Many examples from aircraft disasters highlight the role of 'norms'. Such expectations and assumptions that certain people will act and behave in a certain manner continue during stressful conditions. Unfortunately, some deviations from norms would be beneficial during times of novel situations. However, norms can be so strong that this does not happen.

Authority.

The staffing of ships is traditionally very hierarchical. The concept of the omnipotent Master able to decide what should happen, and when, is only recently being questioned with training in Bridge Team Management (BTM) and Bridge Resource Management (BRM) being provided by training institutions. For daily routine procedures, this system may be seen as an efficient and effective way of running a ship. However, in times of unusual situations the hierarchical structure can cause problems. In aviation, the hierarchical nature of the cockpit meant that unwritten rules about acceptance of the captain's decision resulted in a large number of accidents. In several of these, it was clear that the flights' First Officers were not entirely happy with the situation but went ahead anyway because they were told to do so by their senior officer (see Kayten, 1993, for aviation examples). There has been a shift in increased empowerment for lower ranks to be involved in decision making with authority figures, particularly with regard to safety critical issues, but there is still evidence that this is the exception rather than the rule. On other occasions it is lack of assertiveness by the First Officer, rather than authoritarianism by the Captain that has been the problem (Ginnett, 1993). Harper, Kidera and Cullen (1971) found, on a simulator trial, that only 25% of First Officers landed a plane successfully when a Captain feigned incapacitation. Many of the First Officers failed the landing because it took too long for them to take responsibility for themselves. All the First Officers were selected on the fact that they could, in practice, land a plane successfully. Thus, it was concluded that the only reason they did not was a social attitudinal problem and not a skill-based problem.

Social Facilitation.

Social facilitation is the term given to the tendency for individuals to perform better in the presence of others than when alone. This works well for simple and well-rehearsed tasks. However, in non-rehearsed, novel, unusual and stressful conditions (i.e. emergency conditions) the presence of others can inhibit rather than facilitate performance.

Diffusion of responsibility.

Generally, groups tend to be characterised by a diffusion of responsibility. The group as a whole becomes responsible for the decision rather than one individual. Thus, one individual is not blamed for the outcome and decision making is placed on all individuals. However, in strong hierarchical situations, responsibility rests normally on one or two individuals. Thus, the decisions they make can place them under huge stress, which means decision making is not as effective as it could be. Should all members have more share of responsibility, there is then the problem of social 'loafing', whereby some individuals can do very little during the decision making but reap rewards afterward if the decision is successful.

Group polarisation.

There are both positive and negative aspects of group polarisation. This is where a group tends to be more extreme in its answer than individuals. On a ship in response to a safety critical situation groups would either make a very conservative and safety first decision or make an extremely hazardous decision. Which way depends very much on the views of the group, the ranks of those with certain views and how good people with certain views are at presenting evidence for their decision.

Group conflict.

There is always potential for conflict in decision-making groups. Group members differ in their backgrounds, attitudes, beliefs, skills, knowledge and expertise. This can be useful if it means decisions are evaluated in a number of ways but not beneficial when individuals become more concerned about winning rather than making a good decision (George and Jones, 1996).

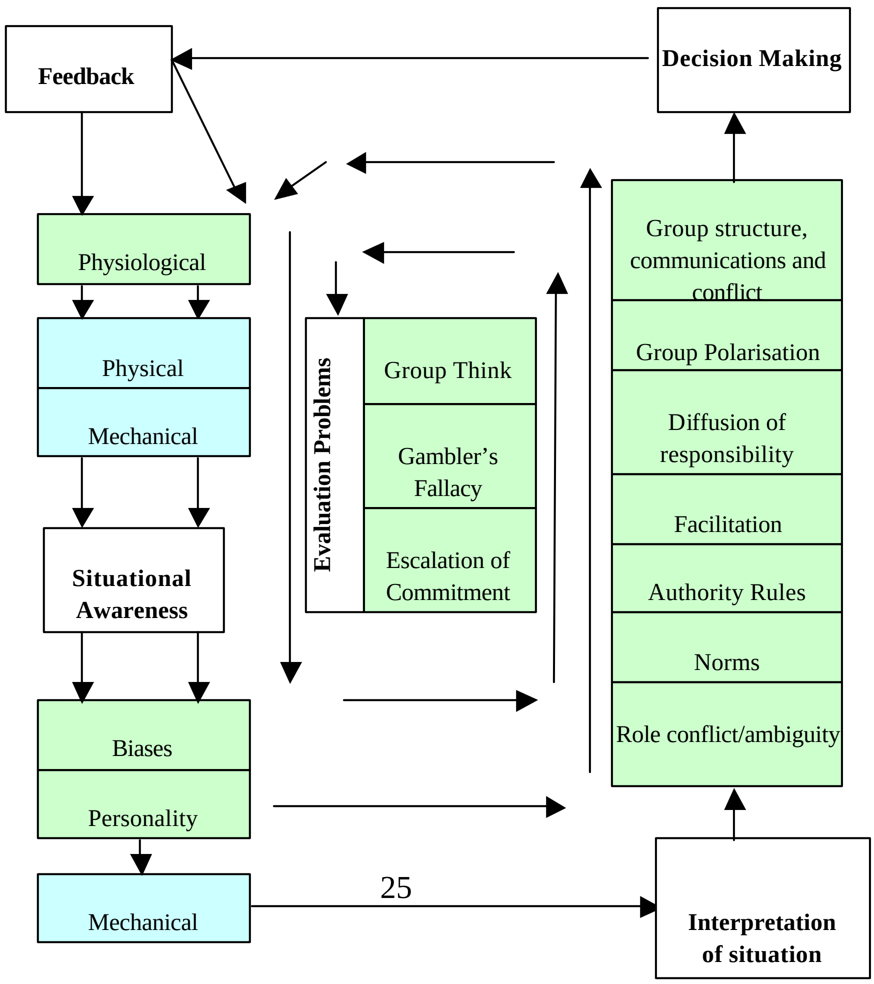
Group communications.

Another fundamental problem seen in a number of shipping and aviation accidents is difficulties in communication between group members. Often one member of the team will see a problem and fail to communicate it effectively. Instructions given have led to confusion where individuals have different perceptions about the meaning of the terms (see MARS 99010, March 1999; 99029, June 1999; 99046-99048, November 1999). Also, a number of assumptions are made with regard to how others are seeing the situation. The egocentric bias is the assumption by an individual that everyone is thinking along the same lines as they are. However, as accident investigations clearly recognise, poor communication of one's thinking, or no communication at all, can result in serious consequences.

4.2.3.4 The evaluative level.

The final level sees an evaluative framework in place. Once a decision has been taken evaluation of the decision begins to take place automatically. However, once again there are a number of biases associated with the evaluation technique that could lead to poor evaluation and possible escalation of the problems faced. Figure 2 demonstrates how these barriers can lead to escalation of problems.

Figure 2: Errors in decision making made in stressful situations leading to escalation of problems



None or poor perception of feedback

In a similar way to the informative level, physiological, physical, and mechanical barriers mean that feedback is not always detected.

Wrong interpretation.

Wrong interpretation of the feedback at the evaluative level may occur due to mechanical barriers, the various heuristic biases, optimism bias, denial or having a risk taking personality.

Group-Think.

Janis (1982) found that in a highly cohesive group, people tend to strive for unanimity rather than appraising different courses of action. Cohesive groups are seen as being hugely beneficial and sought after by individuals. This is often synonymous with exaggerated beliefs about the group's capabilities and morality. Thus, they believe they are acting morally and ethically and that they never could do otherwise. As a result, the group closes their minds and fails to pay attention to information that the decisions may be the wrong ones to follow. Any members that do have doubts may not mention them to others in order not to disrupt the cohesion of the group. This would be particularly true of groups who live and work closely together, as they do on ships. Thus, actions following escalating emergencies could easily occur without any member of a group questioning such actions.

The Gambler's Fallacy.

Bernstein, Roy, Srull and Wickens (1988) highlight the idea of the Gambler's Fallacy. This is the belief that a sequence of similar events will mean the next event is bound to be the opposite. Thus, a run of bad luck will eventually be overturned by good luck. This is particularly true of gamblers under high stress and with regards to a sequence of negative events. Thus, a gambler who gambles each time on winning 'heads' on a coin and it turns up 'tails' ten times in a row will believe the next must be 'heads' almost certainly. However, the same chance exists as at the beginning, making their perception a fallacy. Thus, in escalating emergencies, it may be perceived that a string of negative events or failures must mean something positive is about to happen.

<u>Escalation of Commitment.</u>

George and James (1996) state that an escalation of commitment occurs in decision-making processes. This is the tendency for decision makers to invest additional time, money or effort into what are essentially bad decisions or unproductive courses of action. That is, although the decision may provide negative feedback, more of the same decisions are made to reverse the negative feedback. Thus, escalating bad decisions can occur. This is likely to happen when decision makers do not want to admit to themselves or to others that they have made a mistake and when they wish to justify the time and effort they have already put into the decision. Thus, this can happen when a powerful, highly regarded, member of a group, responsible for time and costs, such as a ship's Master increases the commitment to a certain poor course of action.

4.2.4 **Naturalistic Decision Making (NDM)**

Modern concepts for understanding decision-making have progressed from classic rational choice models to ones that try to reflect the way decisions are actually made in the real world. The most influential of these models is called the naturalistic decision-making (NDM) model and has been defined as follows:

> *"The study of NDM asks how experienced people, working as individuals or groups in dynamic, uncertain, and often fast-paced environments, identify and assess their situation, make decisions and take actions whose consequences are meaningful to them and the larger organisation in which they operate." (Pruitt et al, 1997)*

This definition reveals a number of characteristics of the situations in which NDM takes place. These characteristics suggest that NDM is an appropriate model for the understanding of decision making under stress in escalating marine emergencies. These characteristics are:

1 The situations in which decisions are made are uncertain, unpredictable and dangerous.

2 Knowledge of the situation is incomplete, and constantly changing.

3 The consequences of decisions and actions based on poor situational awareness are potentially catastrophic.

4 Experienced people, not novices, generally conduct decision making in such situations.

Another important feature of NDM, which reflects its value in understanding real world decision making, is that, unlike classical models of decision making, where the objective is to provide optimal decisions, the objective for real world decision makers is to arrive at actions based on decisions that will satisfy the immediate concerns of the situation, without those decisions necessarily having to be the best ones. There are a number of different models within an NDM approach to describe the process by which decisions are made. The dominant model is known as the Recognition-Primed Decision (RPD) model. Orasanu (1997) provides a comprehensive description of the process:

> *"Its basic principle is that experts use their knowledge to recognise a problem situation as an instance of a type, and then retrieve from their store of patterns in memory an appropriate response associated with that particular problem type. The response is evaluated for adequacy in the present context, and if it passes, it is adopted. If it is found wanting, either another interpretation of the situation is sought or a second level response is retrieved and evaluated."*

A number of conclusions may be drawn from this description of the RPD process, which are relevant to the handling of emergencies in stressful circumstances.

1 Normal control of operations is managed through a series of approximating or satisfying decisions, i.e. a situation is recognised as being typical and a number of decisions and actions taken. The situation is then monitored and further decisions and actions taken to refine the original response.

2 The more experienced the decision-maker, the richer the store of experiences to draw from and the more extensive their repertoire of actions. Orasanu (1997) records a number of research studies that confirm that this is one of the most consistent differences between novices and experts.

3 The most critical aspect of the decision making process is awareness of the situation, not the generation of options. Orasanu (1997) also records that in most aviation accidents, crews have exhibited poor situation assessment rather than faulty selection of a course of action.

RPD works well when the situation can be recognised, i.e. in normal situations. The paradox is that in emergency 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 emergency handler has to revert to a creative response i.e. they have to think their way through the novel situation.

It is this requirement to think through the situation that creates stress, which in turn may affect the quality of decision making. If decisions need to be made quickly, then time pressure also becomes an additional stressor. Orasanu (1997) describes the situation thus:

> *"In situations that support perception-based memory retrieval, stress effects should be minimal. These situations tend to be those that deal with familiar and unambiguous problems for which rule-based responses are available. Situations that require attentional scanning and impose demands on working memory are ones that are either unfamiliar or for which cues indicating a problem are ambiguous, thus requiring information search or diagnostic strategies."*

Given the nature of decision making under stress, the challenge is how best can we prepare individuals and groups for the unpredictable or as Orasanu (1997) puts it – how might we strengthen the weak links? She provides three possible answers: through training; through better procedures; and through the design of better decision making aids.

This study is concerned with the effectiveness of training to enable seafarers to handle escalating emergencies, so what are the implications of NDM and RPD theory for training?

NDM and RPD theories raise a number of issues that suggest ways in which training may be enhanced to prepare people for handling escalating emergencies under stress (Orasanu 1997):

1 Decision-making is a skill. Like all skills it may be learned through practice. By reducing the cognitive load through practice, experts will be less stressed than novices in threatening situations.

2 In addition to specific skills, there is a set of more general decision making skills, known as metacognitive skills. The direct development of such generalised situation awareness skills might counteract the consequences of stress.

3 Educating people about stress, and providing them with techniques and strategies to cope with stress may be helpful.

4 Stress effects of decision making may be reduced by sharing the decision making process within the members of a team.

The primary justification for the direct training for emergencies is based on the belief that by exposing individuals or teams to a variety of potential emergencies, they will enrich their mental stores of situations, thus enhancing their repertoires of decision making. A secondary justification is that by exposing people to such situations it provides them with the self-confidence that they can handle future unknown situations.

The problem with this approach is that if the emergency training scenarios are too prescriptive, then the learned repertoires may be inappropriate to the real emergency encountered. Crego and Spinks (1997) express this dilemma in their description of the "Minerva" simulation, which is the command and control system for senior police officers:

> *"It is vital that any patterns presented to the learner should not be reduced to individual cues…at various periods during the unfolding event. This behaviourist approach may well be successful in engendering recognition of a particular pattern set, but this recognition may not be transferable when the learner is faced with similar patterns in different contexts. What is needed is a more fluid, flexible simulation that is responsive to decisions made and, as a result, is very much driven by the actions (or indeed the inactions) of the participants. At the same time, unfolding incidents must be multi-threaded and at times parallel, if the impression that the learner is being led through prescribed problems towards pre-*

> *planned outcomes and solutions, is to be avoided. Only through such patterning and sequencing, combined with effective team driven communication, will the command team gain a real sense of 'situational awareness' and fidelity with the real world of command be sustained."*

Clearly, some form of simulation offers one of the most beneficial training mediums for the direct learning and practice of situational awareness and decision making skills in a safe environment. In the short extract above, Crego and Spinks also highlight the major issues to be addressed in the use of simulation for the training of emergency handling:

1. To what extent will RPD type skills, learned in a simulated environment, *transfer* to the real emergency?

2. What level of context or *fidelity* has to be provided in a simulated environment to provide the sort of fluid, responsive simulation that is required?

These issues of transfer and fidelity are addressed in section 4.3.

4.3 Training for emergencies

4.3.1 Introduction

Previous research (MSA Project 340, 1994) suggests that there are a number of significant issues which need to be considered when assessing the practical application and cost-effectiveness of simulators. These may be summarised as:

- The Application of Training Needs Analysis and related Pedagogical Issues;
- The Transfer of Training to the Workplace;
- The Relationship between Fidelity and Transfer.

This section describes the current thinking on such concepts. In addition, a separate section, paragraph 4.4, addresses these issues in the context of the latest technological advances in the development of Virtual Reality Training Environments (VRTE).

4.3.2 The application of Training Needs Analysis and related pedagogical issues

It has long been recognised that simulators and the training benefit they provide should not be considered in isolation. Simulators, like all other training aids, are part of a training system. The system comprises trainees and instructors as well as the training equipment itself, and it is an axiom of simulator training that the single most important component is the instructor and not the hardware (Hammell, 1981).

In order to match the training equipment to the training requirement it is necessary to apply a rigorous Training Needs Analysis (TNA) and other associated human factor disciplines. TNA may be defined as "a systematic method for analysing a training requirement and specifying the functional requirements for the training equipment" (Jackson, 1993). As part of this method, TNA can also identify the required instructional facilities to monitor trainee performance for any assessment purposes.

Jackson describes a typical TNA sequence as:

1 Mission Objectives
2 Mission Critical Segments
3 Functions
4 Skills
5 Training Cues

The mission can represent any training requirement but the TNA should provide unambiguous implementation goals (Zeltzer and Pioch, 1996). Skills may be perceptual, cognitive, psychomotor or procedural.

Of particular significance to simulator-based training, Jackson asserts that TNA can identify and give priority to the required simulation cues for each training task. This in turn determines to what level of fidelity each cue needs to be created in a given system.

This is significant because, depending on the training objectives identified, it will not be necessary to simulate every cue. Zeltzer and Pioch (1996) express this idea in relation to a navigational task:

> *"It is not necessary to account for every behaviour performed by an officer during the harbour navigation task since, from a training standpoint, the majority of these actions are irrelevant to the task being trained, and hence add no value to the simulation. In the same way, low-level actions that are necessary in the real world to carry out a sub task but are not in themselves directly important to the overall task may be omitted, especially if their inclusion would incur significant additional equipment or programming overhead."*

The goal is to concentrate on task-level interactions that are important for training effectiveness in the particular task.

Previous maritime research (MSA Project 340, 1994) has highlighted further issues raised by taking a formal analytical view of training:

1 If the training goals are expressed as performance criteria, then training can be targeted, for example, by continuing training, or providing remedial training, until the required level of proficiency is achieved.

2 Systematic testing of trainee performance prior to and after training, as well as subsequently in the work place, is necessary to evaluate the effectiveness of the training.

3 Conditions in the work place must be conducive to the transfer of trainee performance. Criticism of the effectiveness of training is misplaced if the policies, practices and

attitudes of an organisation inhibit transfer to the work place. Indeed, the positive commitment of an organisation to the objectives of the training is vital if transfer is to take place. (MSA Project 340, 1994)

A number of pedagogical issues also need to be considered in the design of training systems:

1 The design of the instructional overlay for any simulation should ensure that the learner is not overloaded. The real situation is usually quite complex, with many variables to consider for successful performance. For such situations, to begin with so many variables in the underlying model will clearly impede learning and motivation. (Reigeluth and Schwartz, 1989)

2 Where there are many uncontrolled variables that may account for learning effects, it is often difficult, to effectively evaluate a multivariate, dynamic training environment; for example, evaluating the effectiveness of team co-ordination. (Caird, 1996)

3 Practical constraints of time, opportunity and cost often conspire to produce a less than optimal learning environment: (MSA Project 340, 1994)

- Little may be known of a trainee's prior experience until the course starts. Trainees may lack the pre-entry requirements of knowledge and skill for which the course was designed.
- A course may not comprise the optimum number or necessary experience level of trainees.
- In limited time, it is not possible to allow trainees to repeat exercises until they are proficient.
- There is also little opportunity to take account of individual differences in learning style.

4 Team training is often conducted in simulator courses, but the effort is wasted if on return to sea, an individual fails to put knowledge, skills and attitudes into practice through peer pressure or the attitudes of senior staff.

4.3.3 **The transfer of training to the workplace**

Classic definitions of transfer (MSA Project 340,1994) refer to the degree to which learning to perform one task is made easier by the *prior* learning of *another* task. Simulator based training involves the systematic development in a simulated environment of the knowledge, skills and attitudes required to perform a task *in the real world*. In this context, transfer refers to the degree to which learning in the real environment is made easier by prior learning in the simulated situation. If the learning situation facilitates performance in the second situation, positive transfer has occurred. If the learning situation impairs subsequent performance, negative transfer has taken place.

Three complementary models of transfer are to be found in the literature. (Rolfe, 1991). One of the earlier explanations of transfer argued that positive transfer would occur to a second task if that task contained component activities which were present in the first task. Transfer is thus dependent on *identical* elements within both tasks.

A later model argues that transfer is dependent on the extent to which there is similarity between the *representation* of a stimulus and the response demands of the learning and actual performance situations. The importance of this model is that it introduces the idea that transfer can be obtained with simulators which are not *replicas* of the real situation.

More recent approaches to transfer stress the importance of the trainee in the learning process. Therefore, one of the pre-requisites for positive transfer is the *motivation* of the trainee to acquire new skills.

Total transfer is rare; i.e. some further learning in the operational setting is usually necessary. Transfer is not *uniform;* some skills will transfer more readily than others. Some aspects of the learning situation may transfer inadvertently. By deliberately omitting some tasks, trainees might infer incorrectly that these tasks are not considered important, and then neglect them in the real situation. Equally, beneficial aspects may transfer even though they were not specific training objectives. Training in teams may also influence the transfer of learning of individuals, for better or worse. For example, if one team member dominates, others may not learn so much. Equally, collaboration may enhance individual learning and transfer.

The importance of transfer in simulator training is that it is the key measure of the effectiveness of that training (Barnett, 1996). However, there are few recorded transfer experiments in the marine simulator literature. (Muirhead, 1991)

The most abundant source of transfer study experiments are in relation to flight simulators, and even here, results from studies are surprisingly inconclusive in providing hard evidence of positive transfer. (Billings et al, 1975; Rolfe, 1991)

Findings from these studies stress that transfer experiments need to be carefully designed. Transfer of training experiments are notoriously difficult to control (Caird, 1996). Problems involve the lack of experimental control, insufficient sample sizes, insufficient time in the simulator, insufficient time for evaluating transfer in the operational setting, and insensitive measures (Waag, 1991).

One implication of the classic models of transfer is that to be cost-effective, any simulator should be designed so that it simulates the operational situation *only to the extent necessary* to provide transfer of the skills required by the TNA. As Jackson (1993) puts it:

> *"It is desirable that simulation fidelity and capability is sufficient to ensure the required transfer of training, but not to grossly exceed it since this would generally increase system cost with no return.*
>
> *The result of the training needs analysis will be a specification of the cues required and their minimum fidelity in order to achieve the required transfer of training."*

This concept establishes the linkage between transfer and the level of *fidelity* required in order to provide that transfer.

4.3.4 **The relationship between fidelity and transfer**

In the simulation literature, there are a confusing number of definitions of fidelity in terms of realism, equipment fidelity, environmental fidelity, behavioural fidelity, psychological fidelity, physical similarity and total context fidelity. (Allerton and Ross, 1991)

Hays and Singer (1989) reduced these multiple definitions to two main dimensions:

> *"Simulation fidelity is the degree of similarity between the training situation and the operational situation which is being simulated. It is a two dimensional measurement of this similarity in terms of: (1) the physical characteristics…and (2) the functional characteristics."*

Caird (1996) provides a similar definition:

> *"Physical fidelity has been defined as the degree that the physical simulation resembles the operational environment, whereas psychological fidelity is the degree that a simulation produces the sensory and cognitive processes within the trainee as they might occur in operational theatres."*

Early simulator design and training development progressed in the belief that by producing the highest level of physical fidelity possible, such realism alone would lead to effective transfer. As Caird (1996) puts it:

> *"For decades, the naïve but persistent theory of fidelity has guided the fit of simulation systems to training."*

Consequently, more modern thinking recognises that the level of fidelity required depends on the nature of the skills being trained. Both Jackson (1993) and Caird (1996) point out that greater degrees of physical fidelity are needed where physical or manual tasks are required, whereas functional or operational fidelity is required for cognitive tasks.

Furthermore, and this is the crucially important point, the *level* of fidelity required depends on whether physical or cognitive tasks are being developed, to the extent that in some cases, the lack or *distortion* of realism may provide increased training benefit:

> *"For cognitive and procedural training there need be less emphasis on realism, indeed it may be advantageous from a training transfer aspect to remove distracting 'realistic' features. It may even be advantageous to actively distort the reality in order to better demonstrate the subject matter"* (non Euclidean environments i.e. outside of the normal laws of geometry). (Jackson, 1993)

> *"…there is some evidence from flight simulation that higher levels of fidelity have little or no effect on skill transfer and reductions in fidelity actually improve training. Reductions of complexity may aid working memory and attention as skills and knowledge are initially acquired.……Perhaps errors on the side of more fidelity reflect failed attempts to completely understand the underlying physical to cognitive mappings.* (Caird, 1996)

4.4 Virtual Reality Training Environments (VRTE)

4.4.1 Introduction

A Virtual Reality Training Environment (VRTE) is commonly considered to be a computer-generated representation of a real world environment with which a trainee can interact in order to achieve their training objectives. The forms of this interaction can be wide ranging, from trying to faithfully simulate the trainees interactions with the real world, through to totally non-Euclidean (outside of the normal laws of geometry) forms of interaction. Different forms of interaction can be used within a VRTE depending upon their effectiveness in allowing trainees to achieve their training objectives. Events within the environment, and the response of the environment to trainee interaction, can be pre-programmed or controlled by tutor or assessor intervention.

There are currently three main types of VRTE:

- 'Window on the World' in which the representation of the training environment is displayed on a personal computer monitor and the trainee uses the computer keyboard, mouse or joystick in order to interact with the environment.

- 'Cave' in which the trainee is either partially or totally surrounded by projection screens onto which the representation of the training environment is displayed. The trainee interacts with the environment by means of a joystick, or a high fidelity control console.

- 'Full Immersion' in which the trainee is fully immersed within the training environment by virtue of the interfaces used. Interfaces can include head-mounted displays, haptic and force feedback gloves, locomotion trackers and even force feedback exoskeletal suits.

4.4.2 **Technical Issues**

Within the design and development of current VRTE's there is a move towards the requirement for a high level of visual fidelity. This move has been prompted by the hypothesis that the more the virtual training environment looks like the real work environment, the more will be the trainees sense of presence and therefore the more effective will be the training and training transfer. There is, as yet, no empirical evidence to support this hypothesis. It is still the case that the computational burden placed upon a VRTE in order to produce a photorealistic environment is, in most cases, too great for current technology, and the end result is often the introduction of time lags within the visual system. These lags have been known to cause nausea within trainees and even negative transfer of training (Caird, 1996). Currently it is the case that, the greater the level detail displayed within a VRTE, the less seamless the movement within the environment will appear.

Some VRTEs have active objects or agents within the environment that behave with a level of autonomy. It has been recognised that the behavioural models for these types of objects must be rigorously validated if they are to be effective within the training environment (Zeltzer and Pioch, 1996).

Task-level analyses of the functional requirements of a VRTE should be undertaken to ensure that the specific training objectives, for which the system is to be used, can be met. In order to ensure that each task-level command within the VRTE will elicit the required response it has been suggested that the following guiding principles be used:

- support just those trainee actions required for the task;
- hide the virtual environment system from the trainee;
- evaluate inherent hardware and software tradeoffs where necessary and implement carefully to avoid negative transfer of training (Zeltzer and Pioch, 1996).

In order to compensate for some VRTE system technical limitations, some systems use methods to enhance their existing forms of perceptual cues in order to allow trainees to meet the task requirements. An example of this would be the use of selective compensational scalings to overcome poor resolution within a VRTE display system.

4.4.3 **Interface issues**

Issues relating to the interface of trainees with the VRTE are some of the most limiting in respect of the training effectiveness of these systems. How a trainee is to interact with the virtual environment to achieve a goal is not necessarily visually explicit, nor implicit, from prior computer experience. Frequently, users have difficulties learning how to accomplish tasks within virtual environments. These difficulties can be an impediment to skill and knowledge acquisition (Caird, 1996).

Simply moving around within a virtual environment can cause problems for novice VRTE users.

Until this skill has been mastered, trainees can spend an inordinate amount of time simply trying to move to the required locations within the environment. This tends to lead to frustration and this can seriously reduce the effectiveness of the training system. Navigation within the virtual environment has also been seen to be a problem unless the environment is equipped with readily recognisable cues.

Trainees using VRTE's have been observed completing part of a task, backing away from the objects associated with the task, then repositioning themselves in relation to these objects in order to complete the task. This is not a normal sequence of events when completing a task in the real world, yet very common in virtual environments, (Harmon and Kenney, 1994)

In order to minimise the effects of any lack of virtual environment interface skills necessary to perform a training task within the VRTE, the trainee needs to be made familiar with these skills before entering the actual training environment (Kozak et al., 1993).

VRTE system time lags are still an initial impediment to trainees interfacing with the training environment. Trainees have to learn to compensate for the inherent system time lags in order to complete training tasks. Some VRTE's offer variability in visual perspective and this has been shown to produce a lack of confidence within trainees, leading to poor performance. The poor performance of trainees within VRTE's has also been attributed to a lack of the following:

- visual feedback
- acoustic feedback
- haptic feedback
- force feedback

Harmon and Kenney (1994) suggest that because of difficulties related to interfaces with VRTE's, trainees experience cognitive overload in trying to deal with the experience of just being in the virtual environment and are unable to process the information to be learned.

Multi-user collaborative virtual environments have been developed where a number of trainees are present within the same environment. Each trainee is represented within the environment by an avatar (computer generated icon of a person) that can be seen by the other trainees. There are at present severe limitations with respect to the degree of interactivity that can be achieved between co-present trainees within virtual environments. No empirical evidence has been found to show that multi-user collaborative VRTE's can be used to effectively undertake any form of team-based training. In 1993 Jackson stated that:

> *"virtual reality is suitable for training domains where people operate equipment in isolation from other people, or by communication through voice."*

It is a reflection upon the difficulties that have been experienced in developing effective multi-user collaborative VRTE's that Jackson's statement is still generally true today.

A trainee's sense of presence or immersion within a training environment is dependent upon the level of interactivity there is, through the interface between the trainee and the virtual environment, to provide sensory data to the trainee. Increasing the modalities of sensory input in a virtual environment can increase both the trainee's senses of presence and memory for objects in the environment (Dinh et al., 1998). Experiencing a match between the trainee's internal representation of the training environment and the sensory data is important because it addresses the updating of the trainee's internal model to fit the virtual environment more closely. This is the actual process which makes the experience of presence occur (Tromp, 1997).

Where the type of training requires a trainee to develop and update a mental model of a situation, such as for the handling of escalating emergencies, the degree of immersion within the VRTE is seen to be a significant factor. Tromp (1997) distinguishes between physical immersion within a virtual environment and cognitive immersion. For some trainees all sense modalities need to be addressed before they will report a sense of immersion, others are capable of becoming totally immersed with very few sense modalities being addressed. This sense of total immersion is what Tromp defines as cognitive immersion. It therefore follows that the effectiveness of the training of cognitive skills within VRTE's will be dependent upon the trainees' level of immersion within the virtual environment and this has been shown to vary between different trainees.

4.4.4 **Application**

Currently VRTE's appear to facilitate spatial cognitive tasks and may be most applicable to spatial familiarisation training. Evidence of the effectiveness of VRTE's in this training domain has been provided by NASA who have used a VRTE to undertake procedural familiarisation training for the repair work carried out on the Hubble Space Telescope. The simulated actions of the hardware, provided trainees with rich mental images of tasks. The trainees felt this gave them a much deeper understanding of the tasks than by just memorising a list of event descriptions (Harmon and Kenney, 1994).

The U.S. Navy has used a VRTE to familiarise fire-fighters with the layout of a ship prior to them undertaking fire-fighting tasks onboard the actual vessel. Participants expressed their increased confidence in performing their fire-fighting tasks because of their familiarisation with the spaces and spatial situational awareness that they received through use of the virtual environment. They were able to concentrate on their fire-fighting skills, the most important part of their task, rather than the problem of navigating through unfamiliar spaces (Tate et al., 1995).

A further application of VRTE's is where two-dimensional interfaces are the constraint on presenting and using three-dimensional information, for example in air traffic control and geophysical data representations. To date these systems are only at the research phase, and little empirical evidence is available to show their training effectiveness.

New forms of feedback such as making the unobservable observable so that underlying functionality can be understood, and highlighting attentional priorities, offer new training opportunities (Caird, 1996). However, it is again difficult to find any empirical evidence to show the effectiveness of such new forms of feedback in the training of cognitive skills.

Kozak et al. (1993) put forward experimental results to show that what subjects learned during training within a VRTE was specific only to the context of virtual reality. They stated that a closer examination of aspects in the virtual reality environment reveals skills which are important for performance in this environment, but which are irrelevant to performance in the real-world task. This has important implications when considering issues relating to the transfer of training from VRTE's to the real world.

4.4.5 **Conclusions**

For spatial cognitive tasks and spatial familiarisation training VRTE's seem to offer a viable alternative to other forms of training within this domain. However, in most cases, VRTE's are only used as one part of an overall training regime and are not considered to be a replacement for other forms of training and documentation.

There is some evidence to show that a measurable improvement in the performance of trainees undertaking spatial familiarisation training is possible with the use of VRTE's.

The effectiveness of VRTE's for the training of team-based activities and cognitive skills, such as the handling of escalating emergencies, has yet to be proven.

4.5 **Emergency management and Crisis management**

This section aims to provide a very brief indication of the direction of training in other domains and to give an indication of some areas of instructional design which may prove fruitful. It is not intended as an alternative to the training needs analysis process.

Training of personnel for Emergency management and Crisis management has been the subject of various research studies in other domains. Flin and Slaven summarise the specific competencies required for incident command in a wide variety of domains such as the offshore industry, the prison service, and the aviation industry, (Flin and Slaven, 1995).

To take the aviation sector as an example studies have been concerned with the investigation of non-technical skills used by personnel co-operating as team members. For example the Non technical (NOTECHS) system has investigated the non-technical skills used by flight crew co-operating as team members (Flin, Goeters, Hormann, and Martin, 1998). These skills have been structured into four categories: co-operation, leadership and managerial skills, situation awareness and decision making. Within these categories behavioural markers indicating good and poor practice have been elicited using a European consortium[1]. The next stage (currently in progress) in the process is to ensure that all assessors are using similar standards to assess

[1] University of Aberdeen, UK, German Aerospace Centre (DLR), D, Institut de Medecine Aerospatiale du Service de Sante des Armes (IMASSA), F, National Aerospace Laboratory (NLR) NL.

competence.

The investigation into the non-technical skills required in the maritime domain should establish the type of skills which may be required in a crisis. Once these skills have been elicited the method and strategy for training can be established.

It has become apparent to the authors that a distinction should be drawn between Emergency management and Crisis management, the following working definitions are being used:

- Emergency management can be defined as a situation where decisions and actions are based on documented emergency procedures. These emergency procedures are trained both at onshore training establishments and on board. For example a report of a fire in a cabin will result in the pre defined emergency response for a fire being activated. Each crew member has been trained and taken part in drills in his or her role in the relevant team and should respond according to their training.

- Crisis management differs from emergency management in that decisions and actions do not necessarily have documented emergency procedures and there may not be pre-defined responses, or if there are emergency responses those responses may have conflicting requirements. For example multiple emergencies may occur which have conflicting resource requirements.

As an example, and in the case of the "Green Lily", it can be argued that when problems, for which there is an understood procedure for correction (such as a burst seawater main in the engine-room), does not constitute an emergency situation. It is an event for which engineers are trained and expected to have the knowledge to circumvent. An emergency situation can occur when a further problem affects an initial problem (the loss of power together with a broken water main). If these problems are not overcome within an acceptable timescale, then the consequence could be an emergency situation. If, within this scenario, the environment within which this occurs is unthreatening and time allows, there is no need for this situation to escalate to a crisis. If however, the ship is also being blown on to a close lee shore in a gale of wind, then a crisis situation has developed.

This distinction between training for emergencies, which can simply be the training in following pre-prescribed emergency procedures and crisis management which is likely to require a much more flexible approach is an important one. This is because the two types of management differ in their approach and the skills used. If the requirement is to train individuals to think about problems in a flexible way rather than just follow procedures then a method and strategy to facilitate flexible problem solving is required.

The objective concept of learning makes the assumption that teachers or technologies can transfer knowledge which can be acquired by learners. Alternatively the Constructivist concept makes the assumption that individuals construct their own knowledge based on their own interpretations of experiences within the world and the social context. Knowledge cannot of itself be transmitted so instruction should enable experiences that facilitate knowledge construction. Knowledge is something we construct as we learn, and learners actively construct knowledge revising and reinterpreting old knowledge to reconcile with new. Meaning is something which is personally and socially constructed from otherwise unordered unstructured sensation. In addition learning should take place in a social context which must be useful to the learner (Billet 96).

A development of this constructivist approach is that of cognitive flexibility (Spiro and Jeng, 1990), who define it as " the ability to spontaneously restructure one's knowledge in many ways, in adaptive response to radically changing situational demands. This is a function of both the way knowledge is represented (e.g. along multiple rather than single conceptual dimensions) and the processes that operate on those mental representations (e.g., processes of schema assembly rather than intact schema retrieval)."

Although the cognitive flexibility (CF) approach has been developed to accommodate technology based training, it may prove to be useful in other contexts. The CF approach uses information obtained from multiple perspectives, based on presenting many diverse case studies for discussion, in ways that avoid oversimplifying the content. Effective learning is considered to be context dependent and emphasizes knowledge construction by learner and not information transmission.

Taken together these approaches argue for an instructional design where individuals can work as a team using a wide variety of domain specific training scenarios, and discuss ideas from a variety of perspectives, a simulator may not be required. The anticipated training outcome will be a situation where the individual can think flexibly about the problem to hand by drawing on a variety of experiences of training exercises and alternative viewpoints, which he or she is then able to apply. It is expected that the trainee will be able to generate more flexible solutions and to be more open to alternative viewpoints from other team members. Research into the effectiveness of this and other approaches is required.

4.6 Simulator Technology

4.6.1 Introduction to maritime simulators

In general, all transport industries have access to the same computer and presentation technology whether the simulator is designed for aviation, maritime or process control training. The main differences in the finished product are the designed purposes of the simulator, the realism required and the fidelity, together with the money available to achieve the required product.

Today, most maritime training institutions possess radar and navigation simulators as part of their resource requirements for the obligatory radar training of their masters and officers. In 1996, 380 radar and navigation simulators were in use worldwide (Muirhead 1996) and the number of simulators with a visual scene totaled 106, which indicated a three-fold increase from 34 in

1988 (Habberley, 1988). Today, as a result of the need to be seen as a top ranking training institution and, in some cases, to maximise the opportunity for obtaining funding provision, most training institutions will have access to full mission ship simulators. Large numbers of these simulators have been bought by developing countries. There has also been a rapid increase in the number of engine room simulators, from the first one bought 20 years ago to 110 in use four years ago (Muirhead, 1996).

However, the inability to provide technical support to these relatively complex simulators, the lack of support funding and insufficient numbers of trained instructors, has meant that the provision of the simulators has, in some cases, been unfulfilled as a training aid, especially in the developing world.

Whilst the initial cost of the simulator has been driven down by the price reduction of computers, other less sophisticated and less expensive simulators have been developed. PC based simulators can now provide a wide range of training aids in different subject areas, for example, GMDSS, liquid cargo simulation, collision avoidance, and engine room control simulation. Companies such as Transas (UK), Sindel srl and PC Maritime are continually using the ever-increasing power of the computer to provide more sophisticated and wider ranging simulation training aids. These part task simulators can approach the complexity of the full mission simulator, as both use the same computer power at the heart of their system.

Other simulators available for the training of seafarers include a fire fighting structure for breathing apparatus training and fighting fires, mannequins for First Aid training, and bridge structures for the training of crowd control.

As the brochures of many simulator users and some conference papers point out (Barber, 1996; Smit Tak, 2000), the purchase of a simulator should only follow internal discussions about training objectives. Once the training objectives are agreed, a decision may be taken as to whether a simulator is the best resource to achieve those objectives. Unfortunately, often the simulator purchase precedes the debate about its use.

4.6.2 **Maritime Simulators and Emergency training**

Practicing for stated emergency scenarios is a training opportunity that can suit the input of a simulator. Courses that have been designed for Master and deck officer training in the event of a shipping emergency, including manoeuvres in stopping and holding in a narrow channel and a steering failure, are run by various training institutions on a fairly regular basis. These emergency scenarios can either be pre-prepared, involving an initial discussion of the emergency, followed by undertaking the emergency in the simulator or they can also be added to an exercise without any pre-knowledge to the team. These types of scenario are normally fairly basic and can involve only one failure. It is unlikely that a non pre-planned error-chain of events is run as an emergency training exercise, but rather a review of known casualties are provided which provides teaching points based on known decisions. It is well known that the majority of accidents or emergencies involve an error chain, as in the case of the "Herald of Free

Enterprise" or "Green Lily". One of the first main research studies on the development of emergency simulator training courses in the UK was run by the University of Wales in 1985 (UWIST, 1985). Although the project was interrupted by the inability to gain access to CASSIM, the Cardiff ship simulator, in the final year, the project did consider both the attributes of those in charge of the emergency and tested a number of emergency scenarios.

Some total ship risk assessment and risk management courses (Warsash Maritime Centre, 1999), which introduce the practical tools necessary to evaluate risk, do not use a simulator. The main aim of the course is to learn how to assess and manage risk using various practical tools and techniques, involving both qualitative and quantitative analysis. Student critique forms, following these courses, indicate that the students felt there was no requirement for a simulator in order to teach this course. Smit Tak provides a 4-day course entitled "Managing Marine Emergencies", which is offered twice a year (Smit Tak, 2000). The course is an introduction to

> *"the essential skills and procedures necessary to control a shipboard emergency, pending the arrival of professional salvage assistance*".

A half-day module is supplied within the course, which uses a PC simulator to train students on liquid cargo transfers, maintaining inert gas, and the stability of the ship throughout the emergency.

The need for the concept of Crew Resource Management (CRM) to be used within maritime training was highlighted within the recommendations from the National Transportation Safety Board following the grounding of the QE2 in Martha's Vineyard (NTSB, MAR-93-01,1993). Organisations set up a maritime training course, stemming from the experiences of the Scandinavian Air Services, which is now available worldwide. This has had great success following the initial introduction in the aviation world (see Kayten, 1993 for a history). The course involves a number of exercises and training sets looking at group behaviour, responsibility, co-operation, co-ordination and resource allocation on the flight deck. As Helmreich, Wiener and Kanki (1993) point out there is a definite need for psychology to be involved in the merchant shipping domain and in particular crew resource management:

> *"There is probably no enterprise that could profit more from human factors considerations than merchant shipping…the potential for CRM and other human factors areas to contribute to the alarming situation in the maritime industry is great, but whether it will ever be realised is difficult to say. To date safety standards in the maritime world seem to be resistant to even the most potent forces: loss of life, loss of capital equipment, and financial liability."* (p 495).

Nijjer (undated) states that ship resource management:

> *"should become automatic…and be used for all critical tasks from the bridge to the engine room."* (p 3).

Such training would help highlight and perhaps diffuse some of the problems found in group-decision making. Thus, communications would be improved and group-think and escalation of commitment problems reduced, and role ambiguity, role conflict and group norms could be studied and addressed. This would be a radical way to reducing group problems and biases found in decision making during stressful and emergency procedures and at all times.

Bridge Resource Management (BRM) courses evolved out of the CRM concept and are provided by many training institutions and commercial companies throughout the world. Warsash Maritime Centre drew up the Bridge Operations and Teamwork course in the early 1970s mainly for the masters and officers of the large oil companies, including Shell and BP. This course later became the Bridge Team Management (BTM) course. The main difference between the two courses is that the BTM course uses a full mission simulator to provide a realistic platform for the training course and the BRM course uses Computer Based Training (CBT) aids without any other simulation. Both BTM and BRM courses are used for training mariners to handle emergencies.

As part of the European sponsored EURET programme, the Danish Maritime Institute undertook research in observing a simulated fire onboard a vessel (Clemmensen 1994). Observation indicated that there were considerable bottlenecks in communication, especially when requiring the person at the top of the hierarchical structure, the Master, to make decisions. The authors note that the recommended behaviour for the Master is to remain silent, listen to the communication, monitor progress and only advise if their experience and knowledge indicates a change of direction.

Pols and Aggevall (1996) argue that the reporting of maritime near misses should be obligatory without any sanctions on the reporters, unless gross negligence is involved. This request has been taken up the Nautical Institute's MARS (Marine Accident Reporting System) column published in their journal "Seaways". They also suggest that marine insurers should also receive training, as offered by MSI in Rotterdam for their Shipping Awareness courses.

4.6.3 **STCW 95 requirements pertaining to emergency scenarios.**

Many of the simulators purchased throughout the world over the last few years are used to train and assess seafarers under STCW 95. As a result of the requirements of this legislation (International Maritime Organization, 1995), there is, for the first time, an outline of the statutory requirements that any simulator used for training and assessment shall achieve. The following is an interpretation of the essential uses (Cross and Oloffson, 1996):

- Suitable for training/assessment objectives
- Physical realism appropriate to training /assessment objectives
- Sufficient behavioural realism
- Capable of producing a variety of conditions

- The learner can interact
- The instructor/assessor can control/monitor/record exercises.

A specification for the minimum standard of competence in crisis management and human behaviour is set out within STCW 95 (Table A-V/2). This includes organising shipboard emergency procedures, optimising the use of resources, controlling responses to emergencies, controlling passengers and other personnel during emergency situations and establishing and maintaining effective communications. Barnett (1996) makes the point that under STCW 95, any simulator used for non-mandatory training does not need to comply with the general performance standards, as defined in Part 1 of Section A-1/12 of the STCW Code. Thus, for example, any PC-based simulator may be used onboard for emergency training as part of an approved training programme for prospective officers in charge of a navigational watch.

Det Norske Veritas (DNV) has produced a "Standard for Certification of Maritime Simulator systems" in January 2000, which sets out a classification of simulator types to provide

> "*an appropriate level of physical and behavioural realism in accordance with recognised training and assessment objectives*". (Det Norske Veritas 2000)

4.6.4 **Conclusions**

Existing ship and machinery space simulators, especially those intending to maximise realism, are used for pre-set emergency training. The scenarios used are fairly basic and rarely examine more than one emergency at a time.

Risk management courses which involve the total ship, and bring together deck and engine room officers, do not use simulators, and provide a wider and more detailed course

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5 QUESTIONNAIRES

5.1 Introduction

The questionnaires were written and distributed to look at each group's perceptions and understanding of simulators for training and their effectiveness. A number of groups, as detailed below, were selected to respond to the questionnaires:

- Certifying States as represented by delegations to the STCW Sub-Committee at IMO.
- Simulator manufacturers
- The users and sponsors of simulator-based training ie shipping companies
- Maritime organisations with an interest in the use of simulators
- Simulator operators ie maritime colleges

The following subsections describe the results from the various questionnaires sent out to the various groups.

5.2 Certifying States.

Response to the 100 questionnaires distributed across the world to IMO member states was poor, with returns only from the UK, Hungary, Hong Kong, Thailand and Canada. A copy of the questionnaire is attached as Appendix A(1). The results are analysed under three main headings:

- Mandatory Training for Emergency Situations;
- Mandatory Training for Non-Emergency Situations;
- Training for Stressful Situations which should become mandatory.

5.2.1 Mandatory Training for Emergency Situations

Detailed below are the précised answers from the various member states that replied to the questions. Where no mention is made of any comment from a specified state, then no specific answer was provided.

<u>Survival at sea in the event of ship abandonment.</u>

This is mandatory for all staff onboard all types of ship. In the UK, simulation in the form of a life-raft in a swimming pool, accounts for 15% of training. Classroom based learning accounts for 40% as does practical work and 5% of learning is through textbooks. The training is assessed by written, practical and oral examinations and through observation by the trainer. In Thailand, training is mainly classroom-based (70%) with no training using simulation taking place.

To be able to respond to emergency situations involving fire.

This is mandatory for all staff on all types of ship. In the UK, simulation in the form of a ship's internal structure, accounts for 25% of the training. Other training is 40% practical, 30% classroom and 5% textbook based and is assessed by written and practical examination and observation by the trainer. Answers from the Marine Department in Hong Kong did not differ substantially. They also use a steel environment of a ship's internal structure for approximately 30% of the training. They place more emphasis on classroom based training (40%) rather than practical (30%). There is no textbook learning. A written exam and observation by the trainer is required but no practical examination is given. Thailand also uses a simulated steel environment of a ship's structure for around 30% of the training. Like Hong Kong they use classroom-based training (35%), the same amount of practical training (30%) and like the UK complement it with textbooks (5% of the training). Assessment in Thailand is written with oral examinations.

In Canada the competence requirements into reacting to fires are separated into different parts of the ship, including engine room and cargo hold, and different types of fire including oil fires in the engine room. Each exercise involves approximately 10% of training using simulation as a steel mock up of a ship which is altered depending upon where in the ship the fire is and what type of fire is being simulated. Assessment is made through written, practical and oral examination as well as by observation by the trainer.

To be able to respond to medical accident or emergency.

This is mandatory for all staff on all types of ship. In the UK, simulation in the form of a dummy human body, accounts for 10% of training. Other training methods include 60% classroom based, 20% practical and 10% textbook-based learning. Assessment is by written, oral and practical examination and observation by the trainer. Hong Kong also uses dummies or manikins for around 10% of the training for this requirement. They place more emphasis on practical training (50%) than the UK and less on classroom-based training (40%). Assessment in Hong Kong is by written and practical examination. Thailand uses dummies and medical equipment to account for around 20% of the training: the rest of the training is mainly classroom based (60%). Examination in Thailand is written only.

To be able to respond to emergency procedures.

This is mandatory for all staff on all types of ship. In the UK, simulation in the form of a shore building for drills, accounts for around 10% of all training. Most training is classroom -based (60%) and other training methods include practical training (20%) and textbook training (10%). Assessment is by oral exam and through observation by the trainer. Answers from Hong Kong highlight that they do not use simulation in such training relying on mainly classroom-based (70%) and practical-based (30%) training. Assessment in Hong Kong involves a practical exam and observation by the trainer. There is no oral examination as in the UK. Thailand similarly do not use simulation relying on classroom-based training (70%), practical-based training (25%)

and textbooks for 5% of the training. Canada also do not use simulation relying mainly on practical training (60%) and classroom-based training (30%) with back-up from textbooks (10%). Assessment in Canada is through written, practical and oral examination as well as observation by the trainer.

To be able to take charge of survival craft in an emergency.

This is mandatory for all staff on all types of ship. In the UK, simulation which represents a davit and lifeboat mock-up onshore, accounts for around 15% of the training. Most training is classroom-based (40%), with around 30% of training through practical means and 15% through textbooks. Assessment is through practical and oral examination as well as observation by the trainer. Hong Kong uses no simulation. Training for this requirement in Hong Kong takes place equally in classrooms and practically in a survival craft. Practical and oral examinations are used for assessment in Hong Kong as in the UK.

Crisis management and human behaviour training

This training is mandatory for all staff on passenger and Ro-Ro ferries. In the UK, a shore building acts as the simulator and is made up to be a ship's structure which accounts for around 25% of the training. Other training includes 40% practical, 30% classroom and 5% textbook. It is assessed through practical and oral examination as well as observation by the trainer.

Crowd management training and safety training

This training is mandatory of all staff on Passenger and Ro-Ro ferries. In the UK, only 5% of training is through simulation of a shore-based room mock-up of a ship's structure. The main training is through classroom-based learning (70%). Other training includes 15% practical and 10% from textbooks. It is assessed through practical and oral examination as well as through observation by the trainer. Hong Kong uses no simulation, relying on 80% classroom and 20% practical training. Hong Kong assesses using practical and oral examination as well as written examinations.

To be able to provide medical care to the sick and injured while they remain onboard.

This training is mandatory for deck officers on all types of ship. In Hong Kong, simulation, using a mannequin, accounts for 20% of the training. The rest of the training is 50% classroom and 30% practical. Assessment is by oral and practical examination and observation by the trainer.

To be able to take action following collision or grounding.

The UK mention it would be useful to learn to be able to react to hull damage as a result from either grounding or collision. They suggest that this should be mandatory for all staff on all types of ship and could involve training using simulation of a steel copy of a ship's structure including watertight doors. Thailand do carry out such training, which is mandatory for deck officers on all types of ship, but it does not involve simulation, being 90% classroom-based and 10% textbook based. The Thailand course is assessed through a written exam only.

To be able to react appropriately in the event of an emergency onboard tankers.

In Thailand this is mandatory for all tanker staff. 10% of training takes place using a Liquid Cargo Handling Simulator. The majority of training takes place in the classroom (85%) with textbook tuition (5%)

To be able to operate the Global Maritime Distress and Safety System (GMDSS).

This training is mandatory for deck officers on all types of ship. In Hong Kong a PC based simulation of the GMDSS is used. It is assessed by written, practical and oral examinations as well as through observation by the trainer. In Thailand a GMDSS simulator is used for around 30% of the time.

Other training.

In Canada it is interesting to note that a NorControl simulator is used for the mandatory training for all engineering officers on all types of ship, in starting fire pumps and reacting to blackouts and the flooding of the engine room. With regard to starting the fire pump, simulation accounts for 15% of the training. Other methods of training are practical and textbook-based (30% each) and classroom-based (25%). With regard to reacting to black outs, simulation takes account of 30% of the training with other methods being practical training (40%), classroom-based (20%) and textbooks (10%). With regard to reacting to flooding of the engine room, simulation is used 20% of the time for training. Other methods of training involve classroom-based (30%), textbook-based (30%) and practical-based training methods (20%). Assessment for each of these requirements is by written, practical and oral examination and observation by the State assessor.

Hungary mention that they use simulation, being a steel construction, for 90% of training to meet the requirements prescribed in IMO Model course 2.0

Table 1, overleaf, shows an overview of the training methods used for each competence requirement.

Table 1: All competence requirements involving training for escalating emergencies which are mandatory and the percentage of training taking place on simulators, by practical work and in the classroom.

Percentage of time spent training using	**Simulation**				**Practical**				**Classroom**			
Country	**U**	**H**	**T**	**C**	**U**	**H**	**T**	**C**	**U**	**H**	**T**	**C**
Survival at sea in the event of ship abandonment	15	/	0	/	40	/	25	/	40	/	70	/
Respond to emergency situations involving fire	25	30	30	10	40	30	30	50	30	40	35	30
To be able to respond to medical accident or emergency	10	10	20	/	20	50	20	/	30	40	60	/
To be able to respond to emergency procedures	10	0	0	0	20	30	25	60	60	70	70	30
To be able to take charge of survival craft in an emergency	15	0	/	/	30	50	/	/	40	50	/	/
Crisis management and human behaviour	25	/	/	/	40	/	/	/	30	/	/	/
Crowd management and safety training	5	0	/	/	15	20	/	/	70	80	/	/
Provide medical care to sick and injured while onboard	/	20	/	/	/	30	/	/	/	50	/	/
To take action following collision or grounding	/	/	0	/	/	/	0	/	/	/	90	/
To take appropriate action in emergencies on Tankers	/	/	10	/	/	/	0	/	/	/	85	/
To operate GMDSS	/	/	30	/	/	/	30	/	/	/	35	/

Key:- U = responses from the UK
H = responses from Hong Kong
T = responses from Thailand
C = responses from Canada
/ = Did not mention that specific competence

5.2.2 Mandatory training for non-emergency situations

Plan and conduct a coastal passage and determine position

This is mandatory training for all deck officers on all types of ship. In the UK, Hungary, Thailand and Hong Kong, training involves radar navigation and Automatic Radar Plotting Aids (ARPA) simulation. In the UK and Hungary, it is assessed by written, practical and oral examination as well as observation by the trainer. In Hong Kong and Thailand assessment is by written and practical examination only.

To maintain a safe navigational watch.

This is mandatory for all deck officers on all types of ship. In the UK, simulations used include radar and ARPA. It is assessed through written, practical and oral examination.

Manoeuvre and handle a ship in all conditions.

This training is mandatory for all officers on all types of ship. In the UK, simulations used include ship models and full-mission bridge simulators. It is assessed through written, practical and oral examination as well as observation by the trainers themselves.

Other training.

Canada has mentioned many uses of simulation requirements related to engineering watch-keeping certificates. NorControl-based simulation is used for half the training for preparing main machinery and auxiliary equipment for sea, shutting down main machinery, manoeuvring main machinery and preparing, starting, coupling and changing over alternators and generators.

5.2.3 Training for stressful situations which should become mandatory.

Hong Kong mention stress management training should become mandatory for all staff on all types of ship. They see this as being 100% trained in classrooms and assessed by observation by the trainer with group discussions and role-playing.

Thailand mention that bridge and engine room resource management training should be mandatory for all staff on all ships. They state that it should involve psychology, multi-cultural society, internal communication and teamwork. They state that 20% should be trained on a simulator, but do not mention what type. They believe the majority of training should be classroom based (60%). Assessment of competence should be completed through oral and practical examination as well as observation by the trainer.

5.2.4 Future changes

Canada mention that distance learning is being investigated as an alternative to many people travelling long distances to train due to the geographical vastness of Canada

Canada also mention that 30% to 40% of their existing written and oral examinations may well be replaced by assessments on simulators. They mention a pilot project running at present looking at the technical competence of engineering candidates being assessed on simulators.

5.2.5 Conclusions based on 5% response

Despite its widespread popularity for training purposes, simulation is used in relatively small amounts in training for emergency procedures at sea. It is unknown whether this is due to a lack of resources or whether it is considered that emergency training is best learned using other methods.

Thailand and Hong Kong do not use simulation or practical training as much as the other countries. They rely very much on classroom based learning.

UK and Canada use simulation more than Thailand and Hong Kong and rely about equally on practical work and classroom based work.

None of the countries use any distance learning packages in the course of their training, although Canada is considering the concept.

Assessment of competence tends to be based around written exams in Hong Kong and Thailand whereas the UK and Canada tend to use oral and practical examinations. This could be due to lack of resources or a feeling that, in certain parts of the world at least, the best methods of assessment tend to be written examinations.

There are calls from Thailand and Hong Kong to introduce a much more psychologically based module into the obligatory training for seafarers. Such a model could involve bridge or engine room resource management strategies including communication, coping with stress, team-work and group behaviour.

5.3 Simulator manufacturers

5.3.1 Introduction

Nine large international simulator manufacturers were sent a questionnaire to advise on the types of maritime simulators they have developed (see Appendix A(2)). A total of 5 companies returned the questionnaires (55% return rate), representing companies based in Italy, the UK, Germany, the USA and one anonymous response. The results are briefly outlined below.

5.3.2 Types of simulator developed for the maritime industry

The five companies that responded develop a number of different simulators for training merchant marine personnel. These are highlighted below:-

- **Ship's bridge –** All the respondents mentioned developing a ship's bridge simulator. Most mentioned that the most important aspects of the simulator should be that it reacts realistically and operates in continuous real time. The 'feel of controls' and 'looking as realistic as possible' were seen as being fairly important. However, aspects such as movement and noise were reported as being not very important. The simulator developers mentioned that they considered such simulators were good at teaching most skills. In particular they mentioned the success of such simulators in teaching communications, teamwork, emergency procedures and early error detection. Initial cost of the simulator varied between £250,000 and £5,000,000 depending upon actual design specifications.

- **Radar/ARPA –** The response from Italy advised that they manufactured a simulated radar and ARPA system. This involved real and emulated radar with full environmental simulation. They state such a simulator should react in realistic ways to input from users and should operate in continuous real time. They also stated that the simulator should include fairly realistic controls and must look fairly realistic. Once again noise and movement were seen as being less important. They stated it was successful in training individuals for specific technical skills and for picking up basic errors.

- **Global Maritime Distress and Safety System (GMDSS) –** Developers from Italy and the USA mentioned that they have developed a GMDSS simulator. This is a fully equipped bridge radio station and console. Once again the most important aspects were 'reacting realistically' and 'being in continuous real time'. Again, least important were noise and movement. They believe that this simulator is most effective at teaching technical skills, general teamwork and for picking up basic errors.

- **Cargo handling –** Developers from Italy, the UK and the USA have all developed cargo handling simulators. Again the most important aspects for the developers are that the simulator reacts in a realistic way and is in continuous real time and least important are noise and movement of the simulator. These simulators are seen as being very important in teaching emergency procedures and general teamwork and least effective at teaching leadership.

- **Engine room and Engine control room –** The developer from Italy, UK and Germany have produced a simulation of an engine control room. Again the most important aspects for the developers are that the simulator reacts in a realistic way and is in continuous real time and least important are noise and movement of the simulator. It is seen as being most effective at teaching technical skills, general teamwork and early error detection and least effective at teaching the ability to cope with stress. Developers from Germany and the

UK mention simulating engine controls and engine rooms. In this particular case they view background noise as being as important as realistic reactions and real time.

- **Vessel Traffic Services (VTS) –** A VTS simulator has been developed. They mention it has high fidelity of all aspects and they claim it is extremely good at teaching a large variety of skills.

- **Others.** The USA developer also mentioned that the Merchant Marine use their simulation of a crisis management and operations centre. This is a highly realistic centre to teach communications, emergency procedures, and ability to cope with stress and general teamwork. They also mention that they have developed crane simulators which are sometimes used for the training of maritime personnel. These are motion based and have very realistic controls and a wide field of view. These are considered more important for teaching ability to cope with stress, technical skills and emergency procedures and are believed to be least effective at training communications, leadership and teamwork.

5.3.3 Industries using simulation

The developers were asked which industries believed simulation was useful for training. In particular they mentioned the nuclear power industry, commercial airlines, the RAF and the Army as viewing simulation as being useful. The Royal Navy and the merchant marine companies were considered to view simulation as being less important.

5.3.4 Factors considered in developing simulation

The developers were asked to rank in order of importance six factors they consider when designing a simulator. These factors were low cost, high fidelity, high training transfer, low amount of upkeep required, high flexibility of customising simulator, and large amount of skills that the simulator can train. The most important aspect overall was that there should be high training transfer. This was very closely followed by high fidelity. This shows the level of priority given to achieving a high level of fidelity in simulation. It is viewed as being nearly as important as training transfer itself. Thus, it seems that the developers believe that high fidelity is needed for highly effective and successful simulation. Research results are ambivalent on this assertion.

5.3.5 Effectiveness of simulators

It was established that the majority of the developers were not involved in validating their simulators, stating that they were made to demand and that it was the training centres' responsibility to check their effectiveness and training transfer. They stated that a good simulator should create better knowledge, performance and skills than the trainee had before the simulator based course. Much less important was that simulators should be more effective than other methods of training and that the trainee should enjoy the experience. Perhaps it is assumed that training on simulators is better than training on other methods. However, to be effective it is important that the trainee learns more than before and, due to the large financial resources required of simulator training, is a better training method than other methods.

5.3.6 Conclusions

Simulator developers from across the world are, unsurprisingly, very positive about simulation as a training method. They emphasise that high fidelity simulation is very important. In particular, they emphasise realistic reactions, and real and continuous time. They do not place as much emphasis on movement and noise. However, some simulators do include either or both. As a rule, they are not involved in testing the effectiveness of their own simulators leaving that to the training centres. They believe that effectiveness of training on simulators can be shown through the trainee having learnt more skills and gaining more knowledge as well as performing better following such training. However, they see having to study simulation against other methods of training as being relatively unimportant with regard to effectiveness. This may be due to their belief that simulation is undoubtedly a better method of training than other methods and therefore does not need testing.

5.4 The users and sponsors of simulator-based training i.e. shipping companies

5.4.1 Introduction

Questionnaires were sent out to the users of simulators for maritime training (see Appendix A(3)). For the purposes of this research project it was established that the shipping companies themselves should be contacted, rather than staff who take the courses, since they are effectively the decision makers with regard to the amount and type of training that their seafarers receive. A total of 63 companies were sent a questionnaire and 11 replied (response rate of 17.46%).

5.4.2 Simulator courses which seafarers attended

Companies were asked what simulator based training seafarers attended. The following is a list of the compiled answers from the 11 responses:-

- **Basic and advanced fire-fighting course** – most training companies use the steel environment of ship's internal structure as the simulator. Some companies also use 3-D models of the internal structure of various ships. All are of a relatively low level of fidelity with only a basic resemblance to a real ship.

- **Basic sea survival courses** – simulation of survival at sea replicated in a swimming pool, which can involve high fidelity with waves, wind and real equipment such as survival craft.

- **General ship handling** – using a variety of simulation methods including replica scaled manned models and bridge mock-ups. Most companies use more than one type of simulation technique for this training.

- **Bridge Team Management** – using simulation of the bridge of a ship. Most companies reported very high fidelity is found on these simulators which can include sound, vibration and environmental realism.

- **Bridge Resource Management** – similar to Bridge Team Management, but uses CBT instead of full mission simulation. Companies mention it is more important
- that all aspects of the bridge operation are simulated in fairly good fidelity since training invariably involves teamwork.

- **Engine Room Resource Management** – using simulation of engine control rooms and engine rooms found in a ship. Once again high fidelity is often found with real time scenarios, high temperature, noise and vibration adding to the realism.

- **Engine room courses** – actual simulation of a 4-stroke diesel engine is used for engine operation, watchkeeping, troubleshooting and fault finding for many companies. Once again the fidelity is very high being an almost exact replica of an engine room.

- **Global Maritime Distress and Safety System (GMDSS) training** – using simulated GMDSS radio and system. Often this involves low fidelity classroom based training but helps the trainees to see the chain of events in the whole GMDSS system.

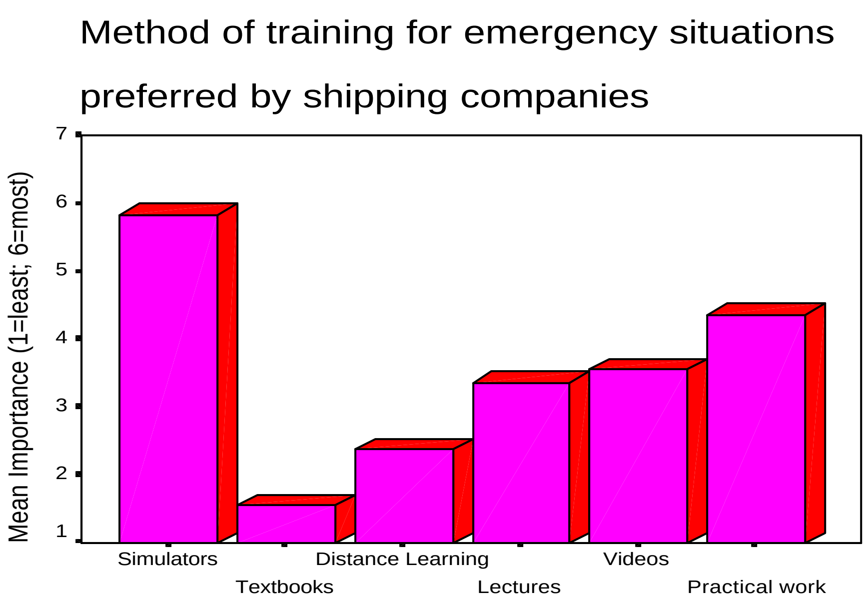
- **Liquid petroleum gas courses** – using a computerised simulation of loading and discharging of LP gases and their carriage. Fidelity is fairly good on simulators and companies mention particular use in such a system is fault identification and rectification.

- **Radar plotting courses** – using simulation of radar systems, radar plotting aids and ARPA. Fidelity is good.

5.4.3 Training situations

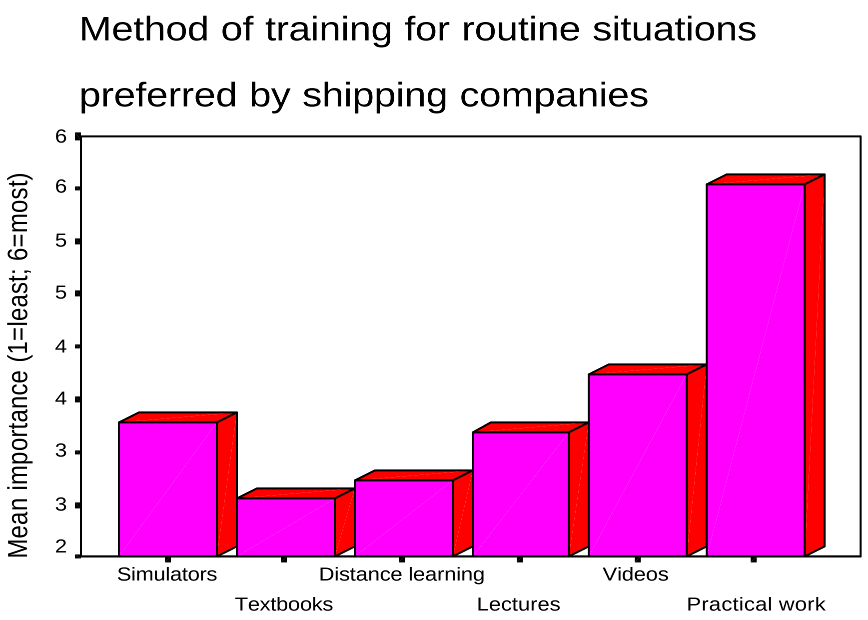
Shipping companies were asked to place a selection of training methods in order from most appropriate to least appropriate for four different training scenarios. With regard to training for emergency procedures, graph 2 shows simulation was clearly the most popular mode of training, practical work being second best with textbooks being worst.

Graph 2



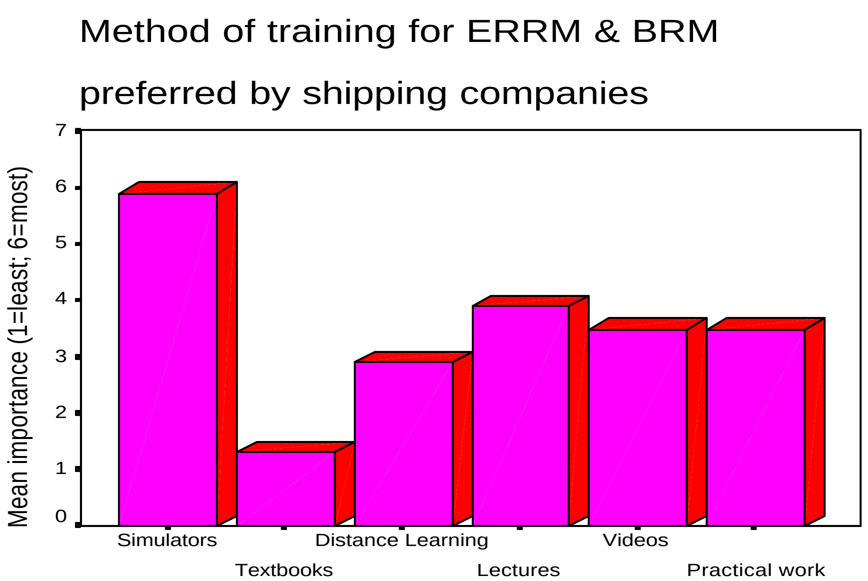
Using simulators for the training of routine procedures, however, as graph 3 shows, is relatively unimportant. Practical work is by far the most popular choice by shipping companies for this training. Distance learning and textbooks are relatively unpopular.

Graph 3



Simulators are the most preferred method of training for both Bridge Resource Management (BRM) and Engine Room Resource Management (ERRM) training (see graph 4). Lectures and practical work are also fairly popular and, once again, textbooks are least popular.

Graph 4

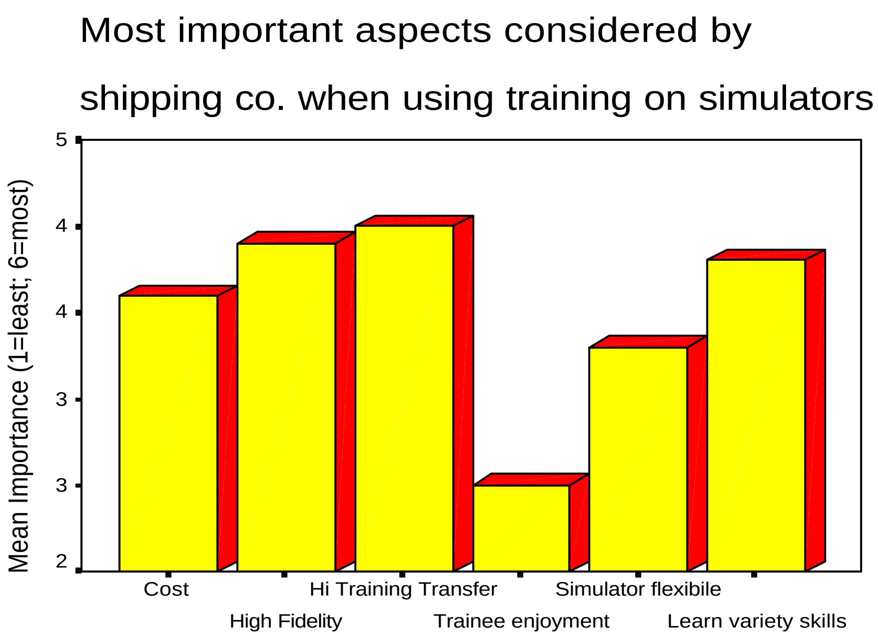


Thus, shipping companies see simulators being important when learning non-routine emergency handling skills and in group learning situations such as BRM and ERRM.

5.4.4 **Important factors in considering a simulator course**

Shipping companies were asked to rank in order of importance six factors that they take into account when deciding to send their staff on a training course using simulators. These factors include cost, high fidelity or realism of the simulator, high training transfer to real world, trainee enjoyment, flexibility of simulator to be tailored or customised, and the variety of skills that the simulator can train. Graph 5 shows the order of importance given on average by the shipping companies.

Graph 5

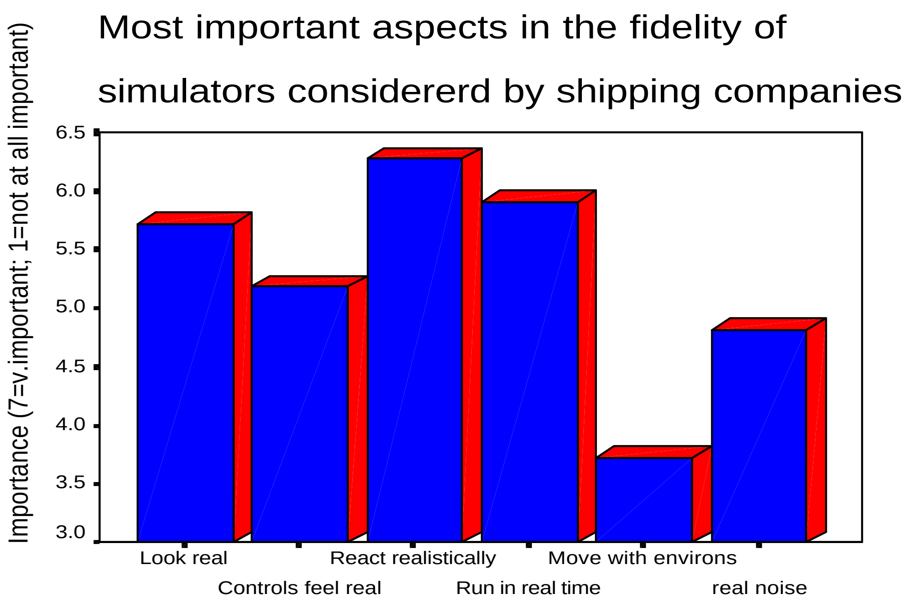


As can be seen, and as would be expected, the most important factor is high training transfer to the real world. Shipping companies also believe that the fidelity of the simulator is almost as important as training transfer. For just under 50% of responding shipping companies it was more important than training transfer. Furthermore, it was the most important factor for 3 of the 11 respondents. It is interesting to note that cost of training is a relatively unimportant factor meaning that shipping companies accept that good training may well cost a lot of money and that they are prepared to pay. Trainee enjoyment is the least important factor and with regard to the factors mentioned which is not necessarily unexpected.

5.4.5 **Importance of characteristics of simulators**

Shipping companies were asked how important different characteristics of simulation were in emergency situation training. As graph 6 shows, shipping companies replied by stating that the most important characteristics of simulation are that simulators should react realistically, run in real time and should look real. The least important are that simulation should include real noise and should move in accordance with the simulated environment. This tends to reflect a large number of simulators that are currently provided in maritime training organisations where concentration has been placed on making them look real and react realistically rather than provide the actual environmental envelope.

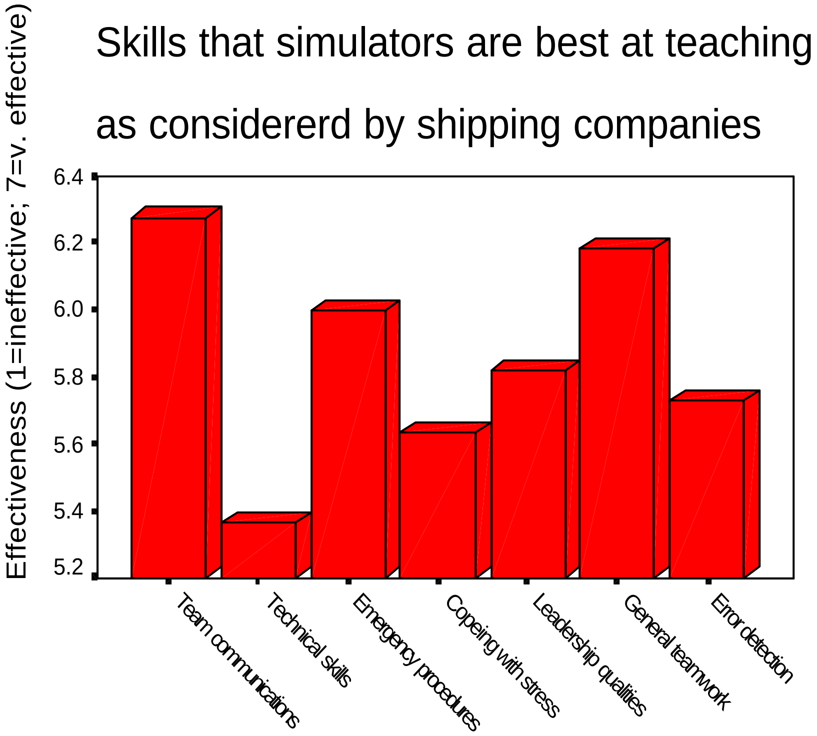
Graph 6



5.4.6 **Simulators and skills teaching**

Shipping companies were presented with seven skills that seafarers need for effective working. These were communications in a team, technical skills, emergency procedures, how to cope with stress, leadership qualities, general teamwork, and early error detection. Most companies responded positively to the fact that simulators could help teach all these skills. As graph 7, overleaf, shows, shipping companies are particularly positive about training of team communications and teamwork using simulators. Technical skills are shown to be less effectively trained in simulators.

Graph 7



Shipping companies also mention that they believe that simulators are best for senior officers rather than cadets. This possibly suggests that shipping companies believe that the more procedural routines that are more important in cadet training, are best learnt elsewhere initially. It may be that higher-level skill acquisition for senior officers is best taught in simulators suggesting they are most suitable for the acquisition of training complete teams.

5.4.7 **Simulation effectiveness**

Shipping companies state that good training on a simulator will be shown through trainees having better skills and better performance than before the training. On the whole, they believe that the trainee enjoyment factor of a course has little to do with the effectiveness of a simulator. Shipping companies appeared convinced that simulator-based training is better than other methods. Only two shipping companies mentioned that they had ever carried out such a test of effectiveness and both mentioned that this was done infrequently. All other shipping companies mentioned they had never carried out such testing. They accept that training centres are best able to provide an opinion and they readily accept that training centres believe simulators are the best training method. Shipping companies do very little formal face-to-face debriefing of their seagoing staff following a training course and rely upon the completion of the company critique form. They leave the judgements of the success or otherwise of the course to the assessments of trainees at training colleges, again normally through the training institute critique form. The shipping companies also carry out judgements based on interviewing staff and based on opinions of senior members of staff. Shipping companies mention that most individuals feel they have been better trained on simulators than other methods.

5.4.8 **Simulation effectiveness discussion**

Results of the questionnaires suggest that the effectiveness of a simulator is measured by studying performance and skills of the trainee after training with simulators and comparing with performance and skills the trainee had before using the simulator. Whereas this method certainly validates the training transfer aspects of simulators, there is no benchmark of the effectiveness of simulators against other methods of learning (e.g. classroom based lectures or practical work). The lack of need for comparing simulators to other methods shows the acceptance of simulation as being a better method than other methods. Since training centres are experts in training and they use simulators, companies believe that this must be the best method of training. However, as will be discussed in the simulator operator (i.e. training centre) section, the training centres that answered this questionnaire do not carry out such testing. Thus, it seems that simulators are used because they seem, or appear to be, the best method of training and are accepted as such. This is known as face validity which is the assumption that because something looks like it should be correct, or be the best, it is correct or the best. However, face validity is a large source of human error. Therefore, although simulators do seem to teach correct skills and good performance, little is known about whether they are the most appropriate measure for various types of training. The second most popular way that shipping companies believe simulators to be effective is the fact that other shipping companies send their trainees on courses run on simulators. Thus, the effect becomes a circular process and it may be the case that all companies are sending their staff on simulator courses that although certainly are effective at training may not be the most effective method of training.

5.4.9 **Conclusions**

The use of simulators as a method of training is popular with shipping companies. They believe that training on simulators is particularly effective at training for emergencies. They believe that simulators are less effective for procedural and technical skills. Also they believe that simulators are more effective at training for senior staff rather than junior staff or cadets. However, they reiterate that high fidelity of simulators is almost as important as training transfer itself when shipping companies consider a simulator should be used for a specific training course. Thus, it is assumed that reality is needed to transfer skills other than those overtly mentioned on the training course. It is believed that shipping companies acknowledge simulators as being a useful training tool at building teamwork and communications skills in novel, unusual or emergency situations. Shipping companies tend to base this notion on observing better skills and performance in their staff after the training courses compared with before training. This is done through interviewing the staff member and observations made by senior staff. It is recognised that these are fairly subjective methods of assessment. Shipping companies rely on advice from training centres and observation that other shipping companies send staff on such courses. However, since training centres included within this survey have not carried out research to compare training methods, it is not known whether the use of a simulator is the most appropriate training resource for the course.

5.5 Maritime organisations with an interest in the use of simulators

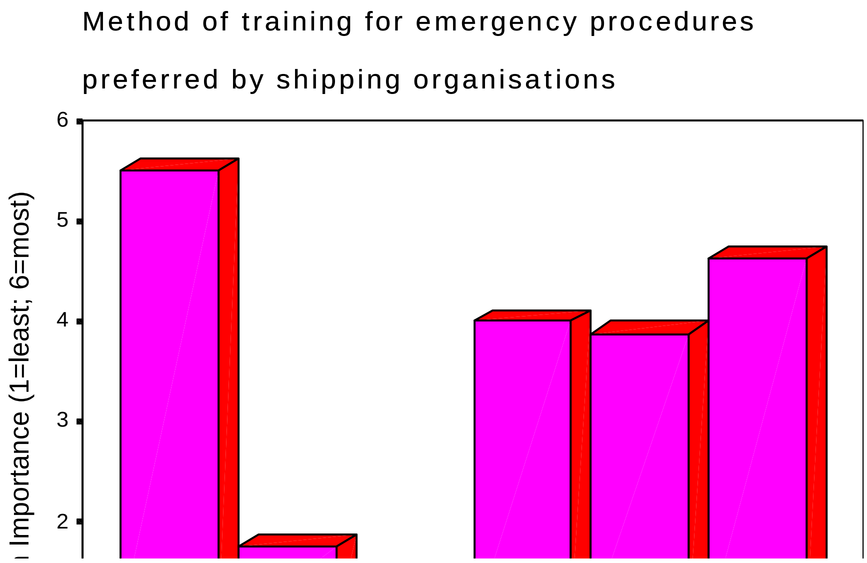
5.5.1 Introduction

A questionnaire was sent to 16 UK shipping organisations of which 8 (50%) were returned (see Appendix A(4)). The results are summarised below.

5.5.2 Training situations and appropriate methods

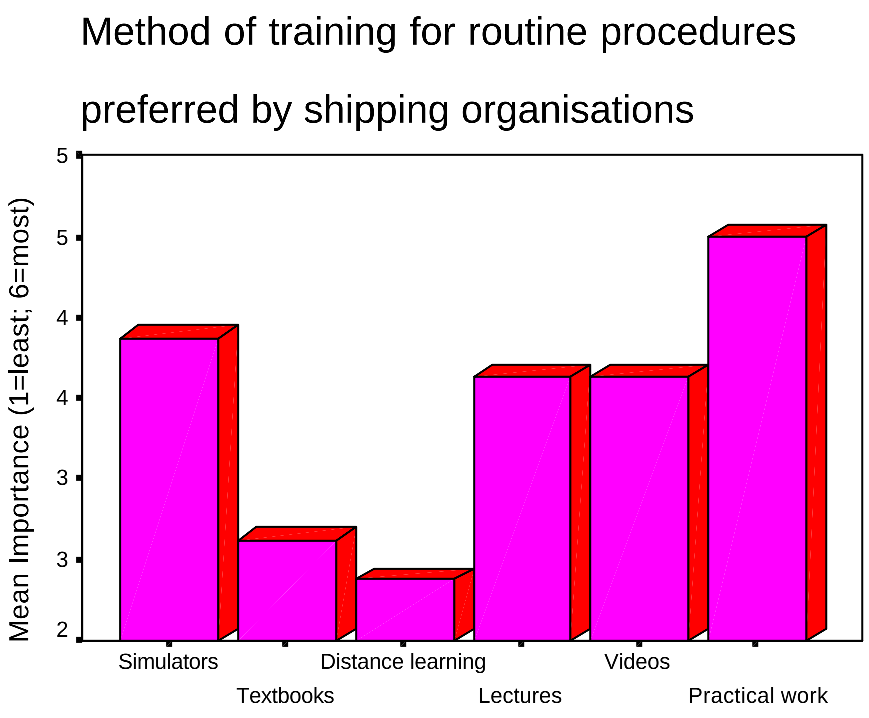
Shipping organisations were asked to place different methods of training in rank order for four different training scenarios. With regard to emergency procedures, shipping organisations believe they are best taught using simulators (see graph 8). Practical work is also a popular method. Least popular was distance learning with many feeling a need for some sort of hands-on experience with a degree of reality for emergency situation training, which could be replicated safely on simulators.

Graph 8



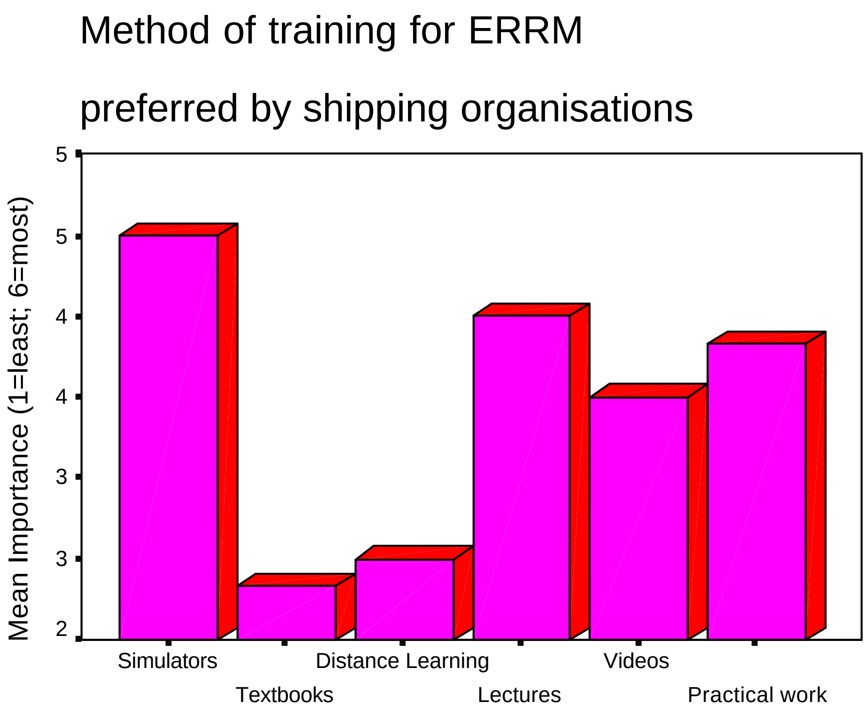
Graph 9, overleaf, shows that for more procedural routine training they believe practical work is the most preferred method of training, closely followed by simulation. They state that actual practical experience helps with familiarity and reduces ambiguity in learning such routine tasks. Once again they remain very sceptical about distance learning packages.

Graph 9



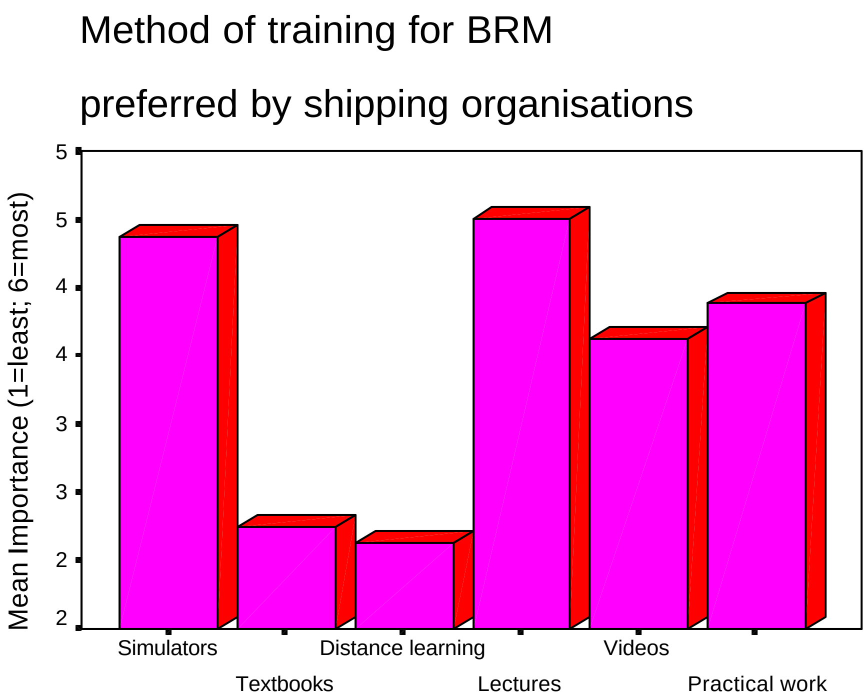
With regard to Engine Room Resource Management (ERRM) training, they believe simulation is the best method of training (graph 10).

Graph 10



However, as graph 11 shows, they believe a lecture is just as good as simulation for Bridge Resource Management (BRM) training. They rate a lecture as being much less effective for ERRM. The differences may be due to differences in the skills being learnt in each domain, with skills learnt in ERRM training being more effectively trained on simulators than those learnt in BRM. Overall, there does seem to be quite a favourable opinion towards simulators being used in a variety of training scenarios.

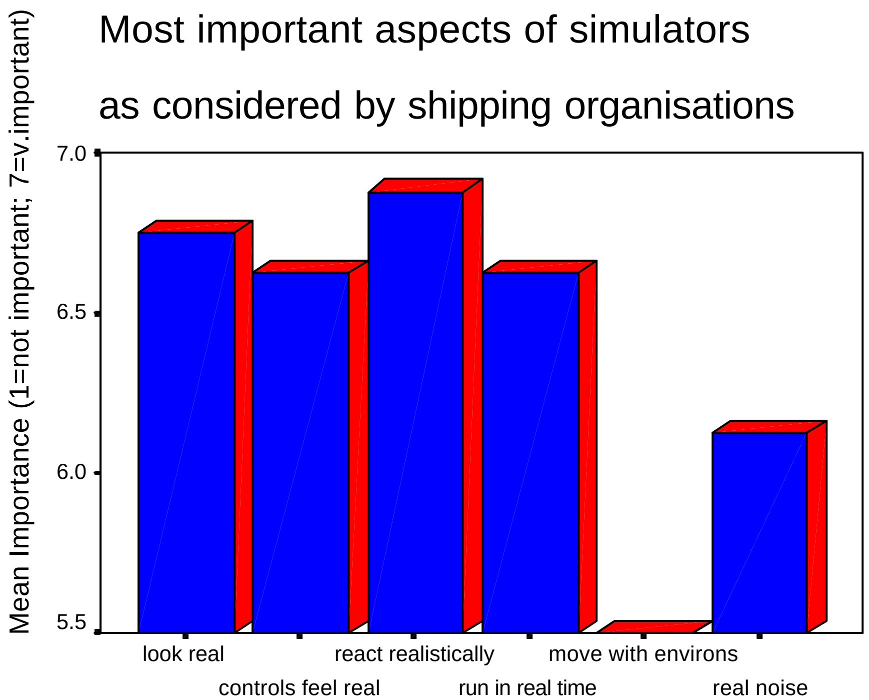
Graph 11



5.5.3 **Importance of characteristics of simulators**

Graph 12, overleaf, shows the amount of importance placed by shipping organisation on the high level of simulator fidelity. All aspects of fidelity studied in the questionnaire received on average over 5 out of 7 (with 7 being most important) on the scale of importance. Furthermore, nearly all the respondents noted that the simulator must both react in a very realistic way to input from users and look as real as possible.

Graph 12

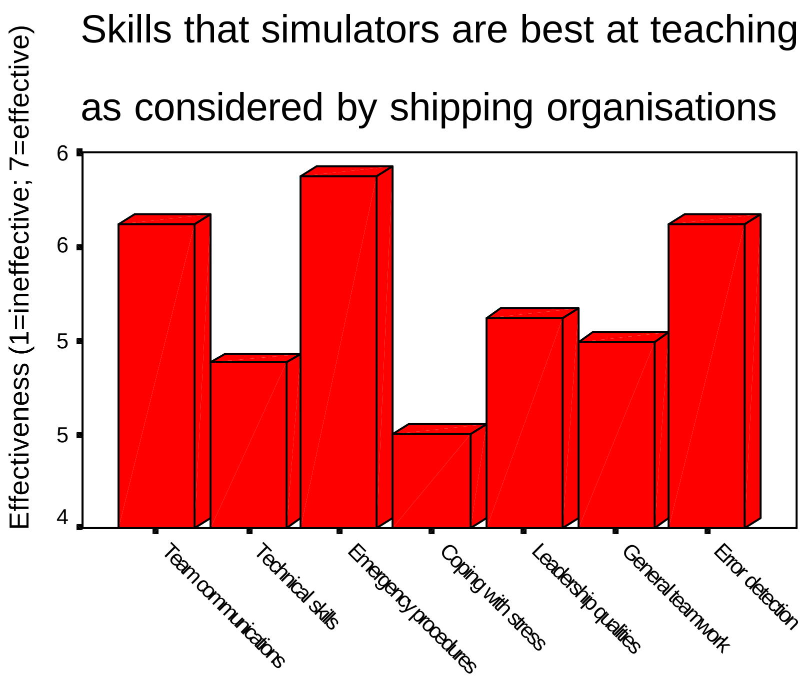


Once again it is interesting that these two aspects of fidelity are noted as being important. As with the general pattern of results to these questions the least important areas for fidelity of simulators are to include real noise and movement.

5.5.4 Skills that simulators are best at teaching

As graph 13 displays, shipping organisations believe that simulators are very good at training for emergency situations and also for early error detection. This shows that they undoubtedly feel simulators have a lot to offer in the realm of training for both the avoidance of problems and what to do when problems occur. They also see simulators are good for training teamwork, communications and leadership skills. They do, however, see that coping with stress is relatively not as effective as other skills. Also simulator training, in their opinion, is much more useful for senior officers than it is for cadets.

Graph 13



5.5.5 **Judging simulator effectiveness**

Shipping organisations were asked how they believed it was possible to assess the effectiveness of simulators as a method of training. They stated that they saw better skills, performance and knowledge after the training compared to before the training as the main measure of effectiveness. Comparisons with other methods were mentioned as being fairly important but not as important as simply judging what individuals have learned. Very few of the shipping organisations were involved in tests of effectiveness of simulators. Some had carried out interviews with trainees and some had asked senior officers or training centres. Very few organisations were involved in any formal assessments and none had conducted formal tests before and after using the method or formally tested against other methods.

5.5.6 **Conclusions**

There is a general favourable impression given by shipping organisations towards the use of simulators in training. This is particularly true in training for more unusual emergency situations or error detection rather than training for the more procedural, technical or routine skills needed. There is a very strong belief by shipping organisations that the higher the fidelity of the simulator the more effective is the simulator. They mention in particular that simulators should react realistically and look real. Finally, it is admitted that shipping organisations have very little to do with judging or testing the effectiveness of simulators as a training method. They do state that individuals should have better skills and knowledge and perform better following training on simulators but few said that this has to be better than other methods and once again it seems that this is assumed rather than tested.

5.6 **Simulator operators**

5.6.1 **Introduction**

Questionnaires were sent out to simulator operators in maritime training (See Appendix A(5)). These training centres were located around the world. A total of 65 such centres were sent a questionnaire of which 14 returned them (response rate of 21.54%). These came from a widespread collection of countries including the UK, the Netherlands, Australia, Denmark, Japan, Korea, New Zealand and Norway.

5.6.2 **Simulators on offer**

At present there are a large variety of simulators available for maritime training across the world. These responses highlighted the following different types:

- **Ship's bridge –** These varied from being generic simulators to specific ship types and from full mission with realistic controls and high fidelity to smaller PC run simulators. For ship operations training, some colleges use several smaller PC mock-ups of the bridge.

- **Engine room –** These include full mission and can include the machinery space. Many are of high fidelity and include realistic feel and controls: others are run via PCs.

- **Ship models –** Manned models that are built to scale and include logic circuits for steering and engine controls such that they handle realistically.

- **Cargo handling –** These include liquid cargo control room simulations

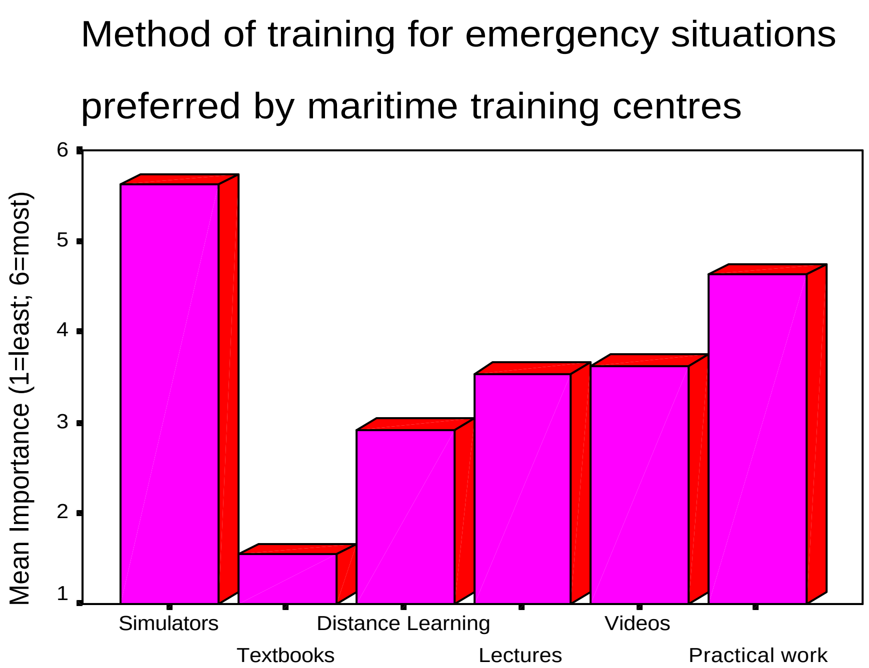
- **Radar and ARPA simulators –** These are simulations of radar and are run from small "own ship" cubicles.

- **GMDSS station –** These simulators are found in small cubicles within classrooms. Some of these simulators may run from a computer.

5.6.3 Training situations

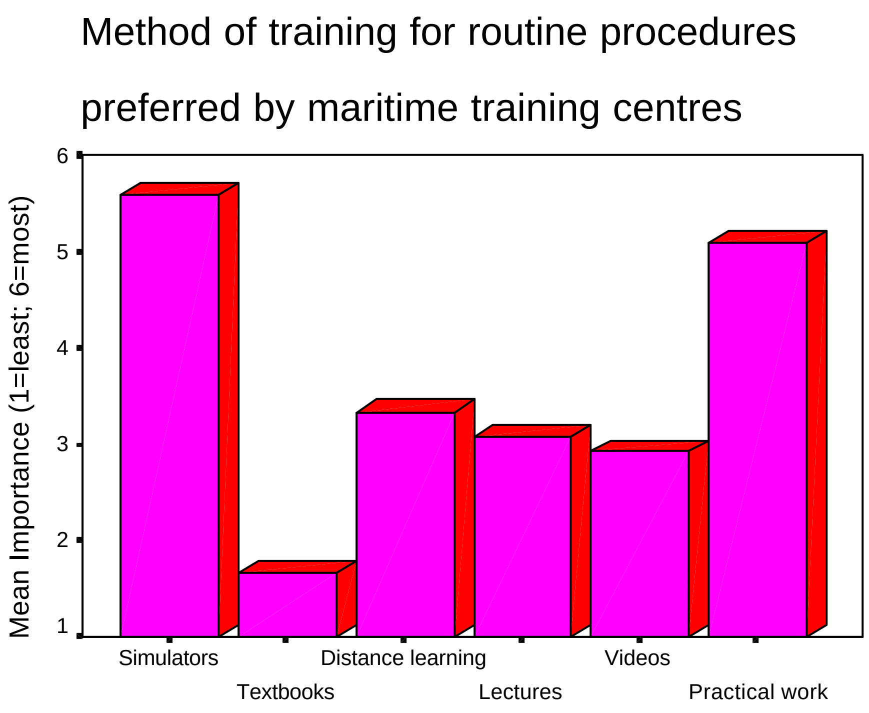
Training colleges were given four training scenarios and for each were asked which methods of training were best. Graph 14 shows that simulation is clearly thought of as the most appropriate method of training people in emergency situations. Practical work is also thought of as being fairly useful. However, the use of textbooks is thought of as being a relatively poor method. Interestingly the graph is almost an exact replica of that shown for shipping companies.

Graph 14



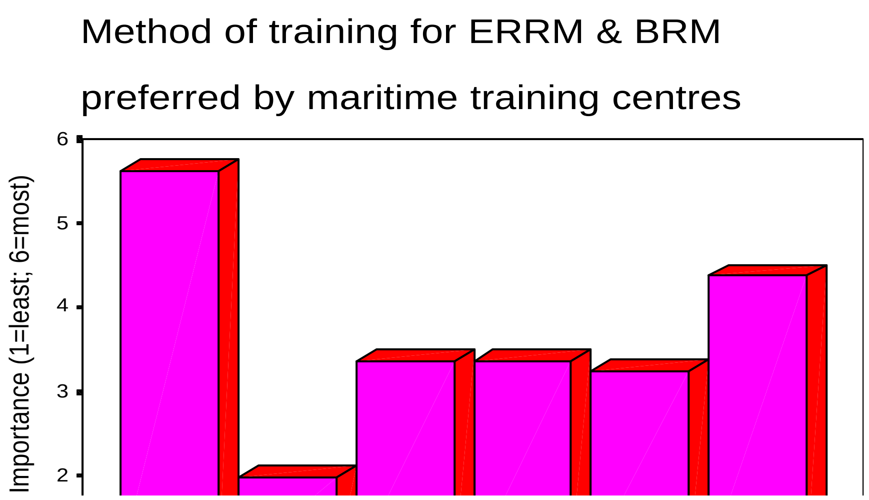
Graph 15 shows that training centres believe that simulators are the most effective method of training for routine situations, closely followed by practical training. Shipping companies thought simulator training to be much less effective for learning routine procedures than did the training centres. Training centres also advocate that distance learning for routine procedures is fairly feasible, and is much higher than the shipping companies and shipping organisations believe.

Graph 15



Graph 16 shows that Bridge Resource Management (BRM) and Engine Room Resource Management (ERRM) training is best carried out in simulators according to training centres. Therefore, training centres think simulators are useful for all four types of training.

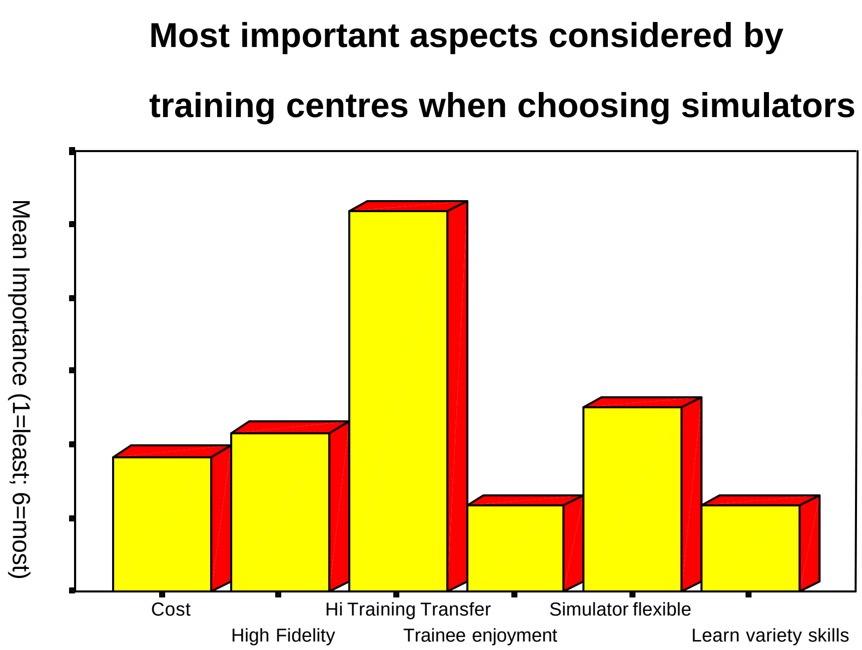
Graph 16



5.6.4 **Important factors in running a simulator course**

It was investigated what were the important factors in training centres deciding to purchase and run simulator courses. Six factors were presented for training centres to rank in order of importance to their decision as to whether or not to purchase and then run simulator courses. These factors include cost, high fidelity or realism of the simulator, high training transfer to the real world, trainee enjoyment, flexibility of the simulator to be tailored or customised to customer response and the large variety of skills a simulator can train. Graph 17, overleaf, shows the order of importance given on average by the training colleges.

Graph 17

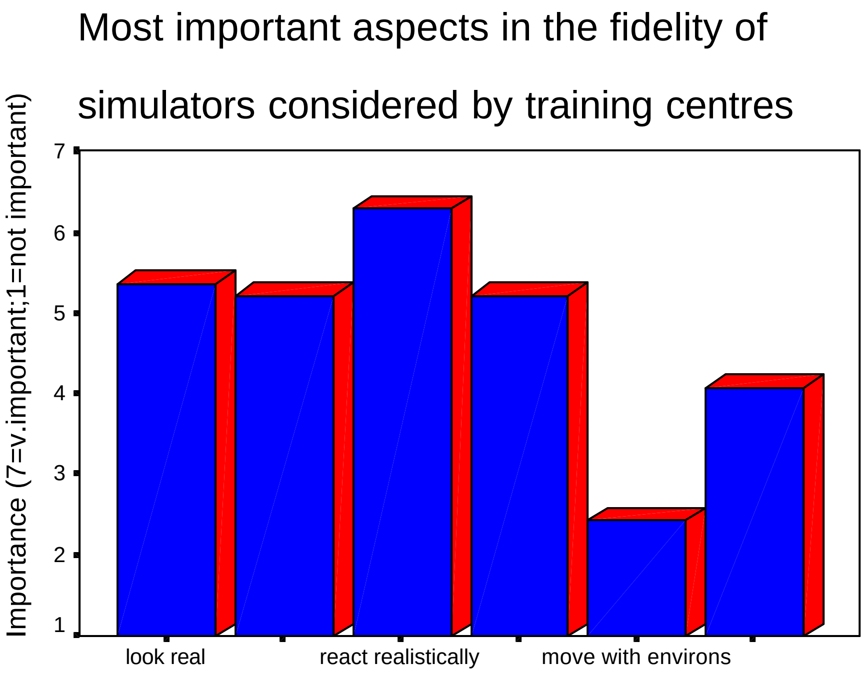


The training centres' main concern was whether the simulator has high training transfer to the real world. The second most important criteria is that the simulator should be flexible and can be used for a number of different courses. This is obviously a useful idea to reduce costs and is not surprisingly an important factor. Next important is high fidelity. Two factors stand out as being of little importance, namely trainee enjoyment and the teaching of a variety of skills.

5.6.5 **Important characteristics of simulators**

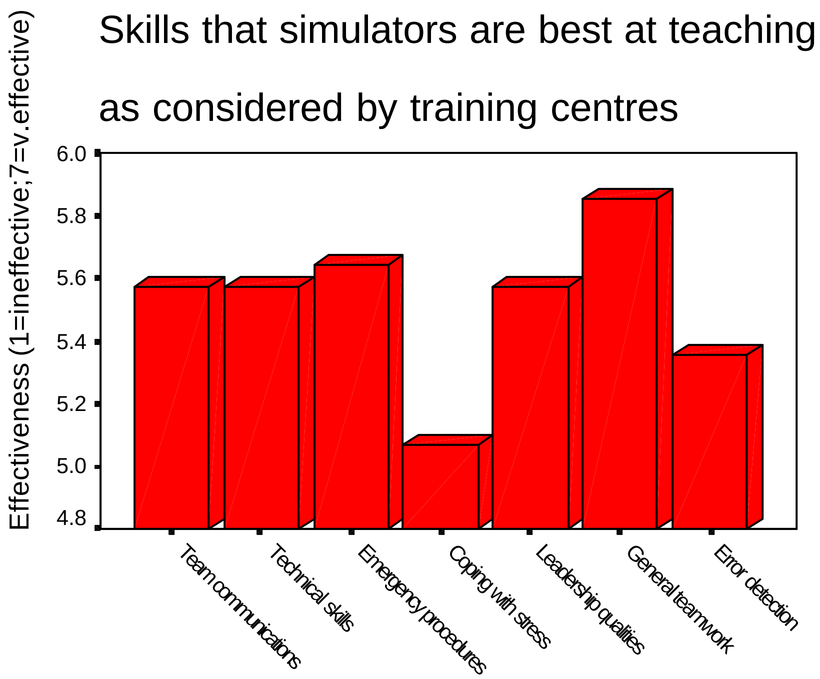
Training centres were asked the importance of a variety of simulator characteristics. Graph 18, overleaf, shows the results. Overall they felt that a simulator must react realistically as being most important. The second most important aspect noted overall was that the simulator must look real. Least important, as mentioned by the shipping companies, is that the simulator should include real noise and move rather than being fixed base. The high ratings given to these realistic characteristics shows the importance that training centres place on high fidelity and that reacting in a real way and looking real are the most important aspects of fidelity.

Graph 18



Training centres, on average, believe that many skills can be taught on simulators (see graph 19). In particular, they state general teamwork as being easily taught. They also rate emergency procedure training, team communications and technical skill training as being effectively taught on simulators. Coping with stress was seen as being the least effective method from the seven presented. However, the average score given was still over 5, well over halfway, meaning they still see simulators as being effective for teaching these skills.

Graph 19



Whereas shipping companies saw simulator training being most effective for senior officers from both the deck and engine disciplines, training centres see simulator training as being most effective for senior deck officers, followed by deck cadet, senior engineering officers and then engineering cadets.

5.6.6 **Effectiveness of simulation**

Training centres must attach importance to ensuring their methods of training are producing good effective results. The questionnaire investigated how they know simulators are a good method of training and what measures are taken to examine this. They believe that trainees should have better skills and performance after the training than they had before. Whereas this is undoubtedly true, further investigation is needed to examine effectiveness of simulators compared to other methods of learning. Very few training centres recognised this as being important. Shipping companies rely on training centres to know which are the best and most effective methods of training. However, whereas training centres believe that simulators are effective no check of whether they are the most effective method appears to be carried out.

The most popular method of testing for effectiveness was that trainers observe skill, knowledge and performance improvement. The second most popular method was to ask the trainee to answer a questionnaire and the third most popular involves formal testing following training. Very few mentioned formal testing of trainee before and after and even less mentioned formal testing against other methods. Once again these methods ensure that the trainee is learning some skills but not that simulators are the most effective method of training. It may also be noted that trainer's observation and questionnaires to the candidate although useful may be biased and possibly too subjective in nature. It is in the interests of the trainer to assume the candidates have learnt from the training sessions and it is important that the trainee states he or she is learning if he or she wants to progress in their career. Whereas such methods are very useful for highlighting specific problems in the training they do not include a formal and more objective testing of standards gained from training in this way.

5.6.7 **Conclusions**

Training centres across the world offer a large variety of simulators. These are of a number of different types and fidelity. They are used in a wide variety of training situations including procedural training and emergency situation training. They are important for both deck and engine room training. However, it is noted that simulator based training is given to more deck officers than engine officers. Training centres mention that high fidelity is very important in their simulators. This should consist of reacting realistically and looking real. Research has not proved that high fidelity is needed for all training. Training centres are concerned that simulators have high training transfer to the real world. This is measured, on the whole, by trainers' observation of any enhanced skills and performance shown by the trainee. However, given the cost of simulators it is surprising that formal testing against skills learnt and performance shown on other methods does not appear to take place.

Table 2 – Summary of questionnaire results:-

Question	Shipping Companies	Simulator Operators	Simulator Developers	Shipping Organisations
Simulators are best for	*Emergency procedures, ERRM, BRM.*	*Emergency procedures, ERRM, BRM, Routine procedures.*	*N/A*	*Emergency procedures, ERRM.*
Most important aspect of simulators	*High training transfer, High fidelity (realism)*	*High training transfer, simulator can be tailored, high fidelity (realism).*	*High training transfer*	*N/A*
Most important characteristic of simulator	*React realistically, run in real time.*	*React realistically, look real, run in real time, controls feel real.*	*N/A*	*React realistically, look real.*
Least important characteristic of simulators	*Movement.*	*Movement, noise.*	*N/A*	*Movement.*
Simulator most effective at teaching:	*Communications, teamwork.*	*Teamwork, emergency procedures.*	*N/A*	*Emergency procedures, error detection, team communications.*
Simulator not so effective at teaching	*Technical skills*	*Stress situations.*	*N/A*	*Stressful situations.*
An effective simulator must teach:	*Better skills and performance than before.*	*Better skills and performance than before.*	*Better knowledge, performance and skills than before.*	*Better skills, performance and knowledge than before.*
Testing effectiveness	*Ask training centres.*	*Trainers observe skills learnt, questionnaire to trainee.*	*N/A*	*Not involved.*

Key:-

N/A - not asked.

ERRM - Engine room resource management training.

BRM - Bridge resource management training.

6 ELECTRONIC DISCUSSION GROUP

6.1 Introduction

The research project proposal outlined the use of seminars to discuss the issues concerning the use of simulator training for handling escalating emergencies. It was the aim of these seminars to produce a detailed critical examination and discussion among the major stakeholders and experts in the field of training on how to handle escalating emergencies leading to conditions of psychological stress. Expert judgement was sought not only from the maritime industry, but also from other safety critical industry sectors in order to document and analyse a wide range of experiences in crisis management training.

A panel of recognised experts within the fields of simulation training and crisis management were invited to participate within the seminars. Of an original invitation list of 32 experts, 15 agreed to participate within the project as part of a panel of experts. These included experts from the following sectors:

- Maritime
- Nuclear
- Aviation
- Academia

The Delphi Method was chosen as a method for structuring group communication processes across the seminars. The reasons for this is that informed group judgements, achieved through the methodological procedures associated with the Delphi Method have been shown to be more reliable than individual judgement (Helmer, 1963 and 1964; Brown and Helmer, 1964; Dalkey, 1969a and 1969b). There is experimental evidence to show that for subject matter where the best available information is the judgement of knowledgeable individuals, the Delphi Method has distinct advantages over traditional group discussions, conferences, brainstorming and other interactive group processes (Dalkey, 1969a, 1971 and 1975; Dalkey and Rourke, 1971). The Delphi Method is more advantageous because it involves a systematic process of querying and aggregating experts' judgements (Zigilo, 1996).

6.2 Policy Delphi: A method for exploring and evaluating policy issues.

Within the project the Delphi Method was used in a particular way termed Policy Delphi. 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. Within the project a range of future implementation scenarios were proposed as training policies that could meet the perceived training requirements relating to the handling of escalating emergencies. These policies were presented to the panel of experts who were participating in the Policy Delphi process.

The proposed training policies are attached to this report as Appendix B.

The way in which the Policy Delphi process was structured allowed any of the participating panel of experts to add possible resolutions to the basic policies, or to argue for or against any possible resolutions. The panellists were asked to view the scenarios as possible policy options that could be introduced as a worldwide mandatory training standard within 10 years into a safety critical industry that currently had no such standard. The panellists were asked to use voting scales to indicate their opinion of the:

- likelihood of each proposed policy being adopted
- desirability of each proposed policy
- feasibility of each proposed policy
- cost effectiveness of each proposed policy.

When presenting arguments for or against any of the proposed policies the panellists were asked to justify the importance and validity of their arguments.

When making a response, panellists were also asked to indicate how this related to any existing items within the policy.

The structure of the Policy Delphi process implemented is shown below in Table 3.

TYPE OF ITEM	VOTING SCALES	RELATIONSHIPS
Resolution	Likelihood Desirability Feasibility Cost Effectiveness	Alternatives
Argument	Importance Validity	Pro or con to a given resolution. Opposing to other arguments.

Table 3: Policy Delphi Structure (After Turoff and Hiltz, 1996)

The responses from the first round of the Policy Delphi process were analysed in order to achieve the following specific objectives:

- collate and analyse the subjective judgements of Policy Delphi process participants to produce a clear presentation of the range of views and considerations
- detect hidden disagreements and judgmental biases and expose these for further clarification

- detect missing information or cases of ambiguity in interpretation by different participants

- clarify patterns of information and sub-group positions which will identify critical items that need to be focused upon. (Turoff and Hiltz, 1996)

Following this analysis, a set of 19 questions was sent to all of the round one respondents which sought to further clarify the main arguments for and against the proposed policies. These questions formed round two of the Policy Delphi process.

A copy of these questions is attached to this report as Appendix C.

Throughout the Policy Delphi process the identities of the participating experts were kept anonymous from the rest of the panellists. The objective of this anonymity was to allow the unrestricted introduction and evaluation of ideas and concepts by removing some of the common biases normally occurring within group interaction processes.

6.3 **Policy Delphi Results - Round 1**

The following is an analysis of the responses received from the panel of experts during round 1 of the Policy Delphi process, along with specific comments made in relation to the different training policies. The voting scales used ranged from 1 – 7, where 1 was MOST likely, desirable, feasible or cost-effective and where 7 was LEAST likely, desirable, feasible or cost-effective.

Training Policy 1: Full Mission Simulator with Team Based Exercises

	Range	median	mean
Likelihood of Adoption	1-7	3	3.5
Desirability	1-7	2	3.3
Feasibility	1-7	3.5	3.9
Cost Effectiveness	3-7	4	4.2

Views expressed in relation to Training Policy 1:

- Number of trainees can be increased but exercise becomes less controllable.
- A number of scenarios could be used in teaching one set of skills.
- Assessment is very subjective.
- Best method for assessment.
- Very likely but not very effective.
- Very high workload for assessor and simulator operator.
- Validation of set criteria is needed. Also, definitions of assessment/criteria are a problem.
- Set criteria maybe only on observed not on non-observed.
- Use of such equipment is very costly.
- High fidelity is good. Only real facilities better.

- Good to create feelings of stress.
- Can be used to highlight failures in a number of areas (design, human communications etc).
- Can be used to study interpersonal relationships (human interactions in groups and effects of peer pressure etc).
- This scenario creates most realistic situation.
- Do not need hi-fidelity simulator since main thrust is on team playing. Operating procedures should already have been learned.
- May also be used as an environment for qualification process i.e. certifying team's procedures in some formal manner.

Training Policy 2: Full Mission Simulator with Single Trainee Exercises

	Range	Median	mean
Likelihood of Adoption	4-7	6	5.9
Desirability	3-7	5	5
Feasibility	2-6	4	3.9
Cost Effectiveness	5-7	7	6.5

Views expressed in relation to Training Policy 2:

- Still subjective, but more objective than training policy 1.
- Not cost-effective at all.
- Training one person is a poor idea, need to train teams.
- Stops interpersonal skills being tested under pressure.
- Validation of set criteria is needed.
- Useful perhaps for very special purposes only.

Training Policy 3: Virtual Environments

	Range	Median	mean
Likelihood of Adoption	2-4	3	3.1
Desirability	2-7	2.5	3.2
Feasibility	2-6	2.5	3.2
Cost Effectiveness	2-4	3	2.8

Views expressed in relation to Training Policy 3:

- Without face to face interaction and communication is poor and unrealistic, although it is good for communications and interaction.
- Communications process is very different via multi-media than face to face.
- High investment is needed, though cost effective.
- Validity problem.
- Based on a team working together which is good.

- Tutor workload will be high.
- Virtual reality is not realistic enough.
- Number of trainees is too high.
- Good to simulate other team members.

Training Policy 4: Desktop Computer Simulation

	Range	median	mean
Likelihood of Adoption	1-6	3	3.22
Desirability	1-7	4	4.11
Feasibility	1-6	2	2.56
Cost Effectiveness	1-7	2	2.67

Views expressed in relation to Training Policy 4:

- Most objective method.
- Very cost effective.
- Very useful in combination with others.
- Brilliant for learning basics.
- Limitation in that no other players are involved.
- Limited in raising standard of sea staff.
- Low staff costs.
- Needs to be interactive and be team based.
- Not keen on totally technology based training polices.
- High cost investment.
- Benefits outweigh costs.
- Validity questions.
- Trainee can work through CBT package at own pace.
- Needs more interaction with peers and teams.
- It's the most objective method and surely feasible and cost effective.
- The desirability depends on the training goals.
- It should not be used in isolation. It could be useful in combination with one of the other training policies as a kind of introduction period.

Training Policy 5: Table-top simulation

	range	Median	mean
Likelihood of Adoption	1-5	3	3.1
Desirability	2-7	3	3.9
Feasibility	2-4	3	2.9
Cost Effectiveness	2-7	2	3

Views expressed in relation to Training Policy 5:

- Could be useful in conjunction with computer based training.
- Maybe too many trainees involved. Keep it to 4 trainees.
- Lots of acting and imagination required by trainees.
- May provide general answers and discussion.
- Will not lead to raising of the stress levels high enough to what they would be in reality.
- Very cost-effective.
- Used primarily for assessment. Can be used for self-assessment.
- Assessor must be very skilled in assessment since it is so subjective.
- Must be realistic and not predictable.
- Low cost investment, does not need a lot of resources.
- Not cost effective since it involves 2 or more trainers.
- More useful for strategic to tactical level decision making rather than operational command level personnel.
- Effectiveness depends upon the ability of the facilitator.
- Training can only be part of emergency management training.

Training Policy 6: Class Room Based Workshops

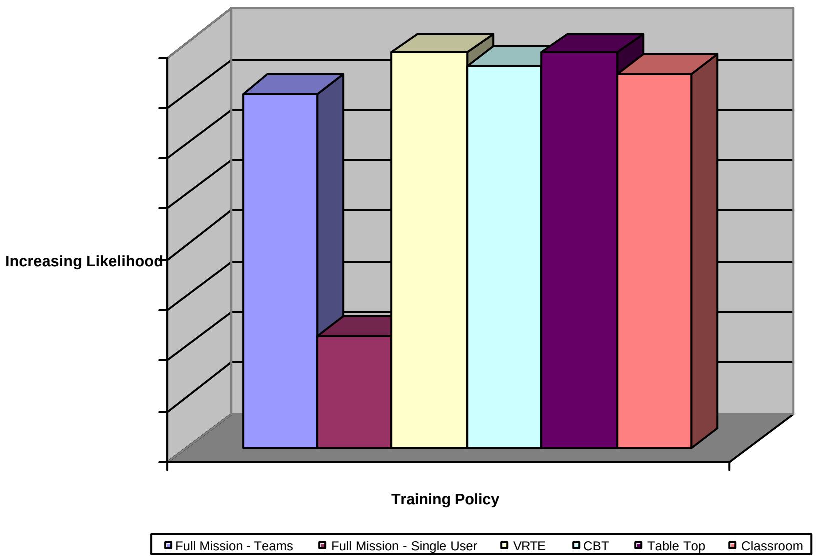
	range	median	mean
Likelihood of Adoption	2-6	2.5	3.3
Desirability	1-6	4.5	4.1
Feasibility	1-6	2.5	3
Cost Effectiveness	1-6	2	2.6

Views expressed in relation to Training Policy 6:

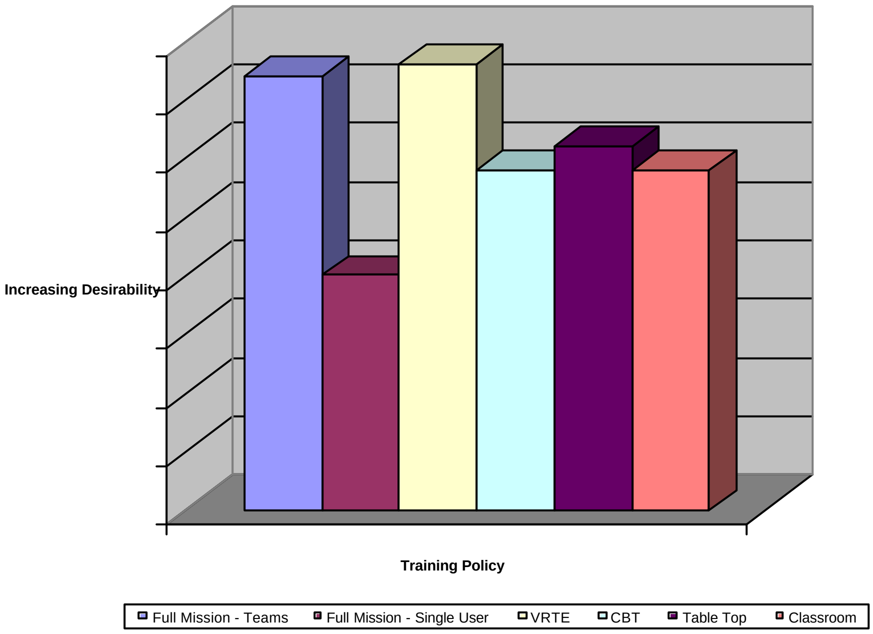
- Good to use before entering simulator or as part of a complete training scheme but not exclusively.
- Shorter time scale of training required and large number of trainees per assessor means low demands on equipment and resources therefore low cost.
- Little opportunity to simulate use of tools and techniques.
- Assessor may have high workload.
- Emphasis very much on the tutor. Success or failure depends upon them.
- Team leader should be rotated to avoid difficulties with assessments.
- Problems of repetition of scenarios inducing boredom.
- Good half way house -stress situations are a form of risk management.
- Difficulty arises as new technologies get introduced into the marine world.
- This is more knowledge based than the other scenarios and needs to address practical skills more.
- Maybe used to complement other training methods but never replace.
- Can be just as effective as new technology methods of training.
- Scenario is good for learning, less for assessment.

The following graphs plot the mean ranking of the responses received from the panel of experts for each of the four voting scales used.

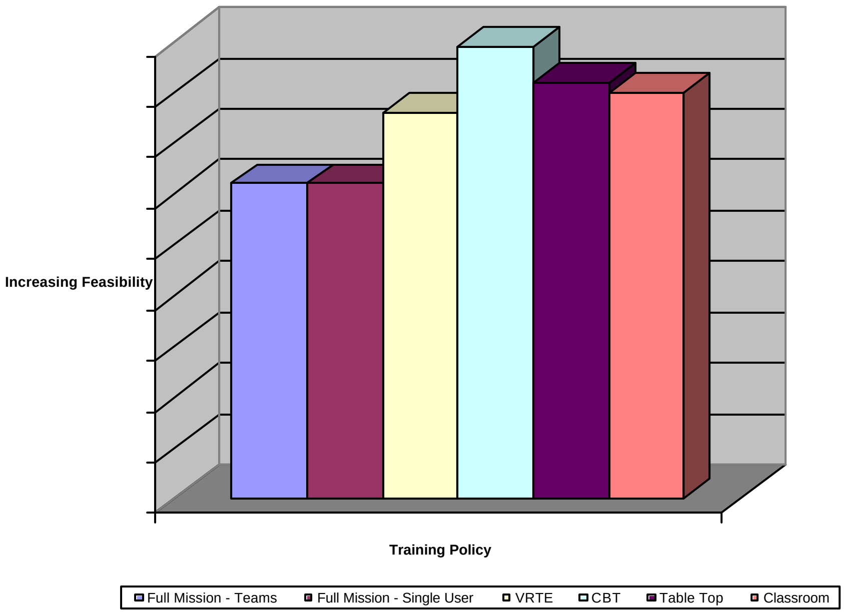
Graph 20 - Likelihood of adoption for future training policies



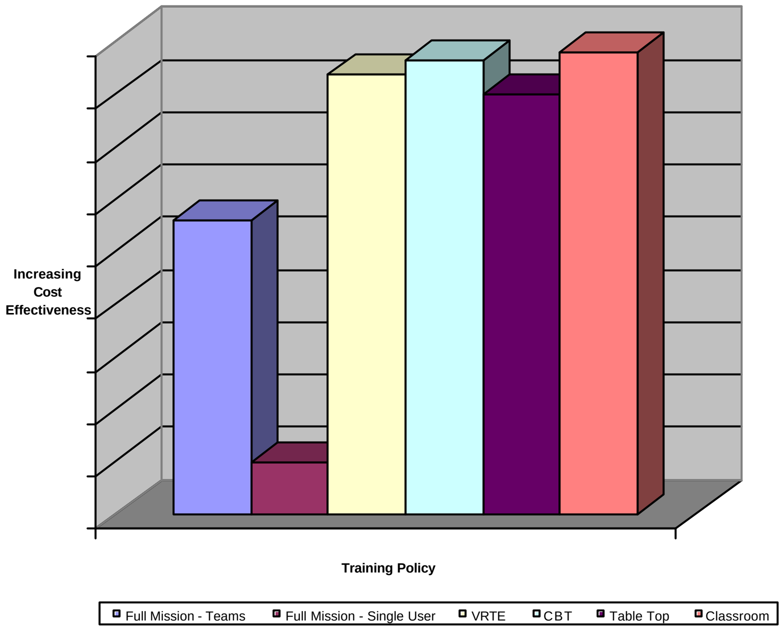
Graph 21 - Desirability of future training policies



Graph 22 - Feasibility of future training policies



Graph 23 - Cost Effectiveness of future training policies



Following an analysis of the responses from the first round of the Policy Delphi process the following summary could be made:

- For training policies 1 (full-mission simulator with team based exercises) and 6 (class room based workshop), there was a diversity of opinion. The issue with the biggest difference of opinion was the importance of high fidelity.

- For training policy 2 (full-mission simulator with single trainee exercises) there was a general negative consensus towards this option.

- For training policies 3 (virtual environment) and 5 (table top simulation), there was a general positive consensus.

- For training policy 4 (desktop computer training), there was a general positive consensus, except in the dimension of desirability where opinions were mixed.

6.4 Policy Delphi Results - Round 2

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

Training Policy 1: Full Mission Simulator with Team Based Exercises

There was general agreement that training and assessment should only ever be undertaken separately.

There were a number of concerns expressed about how any form of assessment would be undertaken in order to ensure objectivity.

Strengths of this policy option were seen to be the ability to undertake team-based activities and the greater fidelity of the training environment.

The main weaknesses of this policy option were seen to be the high cost of full mission simulators and the difficulties in carrying out assessments of individuals undertaking team-based activities.

There was general agreement that the tutor should never also be the assessor within the same time-frame.

Training Policy 2: Full Mission Simulator with 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.

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Training Policy 3: 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: Desktop Computer Simulation

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.

It was suggested that, within this policy option, team-based activity could be achieved by having a facilitator guide each training scenario.

There was general agreement that it would be difficult to use this policy option to undertake assessments at a distance, as this type of assessment would only be based upon the training outcome and not the process leading to it. The issue of ensuring the authenticity of a candidate was seen to be a further difficulty if undertaking assessment at a distance.

Training Policy 5: Table-top simulation

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.

There was general agreement that it is important to create stress during the training and assessment for handling escalating emergencies.

A number of ways of creating stress were proposed, the most common of these being to introduce time constraints into the simulation exercises. Other methods discussed for introducing stress were increasing information flows, increasing exercise complexity, introducing unexpected failures and malfunctions, increasing noise levels and the use of role playing facilitators.

There was a strong difference of opinion as to whether the level of fidelity correlates with the level of stress induced within a simulation. A number of responses suggested that, unless the simulation had a high level of fidelity, stress would not be induced. However, there were other responses that strongly opposed this view, suggesting that stress is psychologically induced and is therefore more dependent upon the exercise participant's perception of presence within the simulation scenario, than the level of fidelity of the simulation itself.

Training Policy 6: 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

6.5 References

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7 COST BENEFIT ANALYSIS

7.1 Introduction

The Delphi Process had brought together a number of specialist users of simulation from various process control areas, with various pertinent ideas of how simulators should be used. It was decided to contact specific researchers who had contributed to the Delphi process and ask them to come to a two day brainstorming session at Warsash, where the various benefits of specific simulation could be considered. Three persons were asked to come to Warsash from 29th to 30th January 2001 to discuss the agenda attached as Appendix D. The three were Margaret Crichton, from Aberdeen University, Dr Michael Pengelly from the University of Lancaster and Pieter Hemsley from the Aviation Training Association. Margaret Crichton is an expert in the use of simulators for training within the nuclear and offshore industries, Michael Pengelly is an educational expert with considerable knowledge of the nuclear industry and the use of simulators by the military forces, and Pieter Hemsley has considerable expertise in the use of aircraft simulation for training and assessment. The three guests were joined by two Inspectors from the MAIB and two persons each day from the MCA together with the Warsash research team.

7.2 Activities

The first day was devoted to understanding the methods used and the benefits of emergency handling and crisis management training in the nuclear, offshore and aviation industries and comparing them with the maritime industry. This was followed by looking at the training and assessment options for the types of training aid used in the Delphi process, namely:

- Full mission simulator
- Virtual Reality Training Environment
- Computer based training
- Table top simulations
- Classroom

7.3 Costs

These costs were determined from information already available in the maritime domain. As the VRTE system is not in commercial use at present, costs are unobtainable. As it is believed that CBT is not being used in any Crisis Management course, costs are also unavailable.

Detailed overleaf is a set of daily costs outlining possible maximum and minimum amounts. The maximum amount column considers rates for a simulator that is purchased by the operator for a cost of £1m over a 7-year useful life. The minimum column reflects a simulator purchased for the operator by another source, e.g. EU or government for a sum that does not have to be repaid.

Order of costs for a FMS operating in northern Europe in £s sterling

	Maximum rate	Minimum rate
Staff daily rate		
Lecturing staff	£500	£350
Technical staff	£250	£150
Simulator operating daily rate *	£200	£40
Simulator depreciation **	£835	0
Simulator interest on loan ***	£360	0
Total	£2145	£540
Profit / Contribution	As required by the Operator	

* Maximum rate based on costs for technical support programme from manufacturer (£20,000) plus re-equip all tubes (£20,000) over 40 week year. Minimum rate based on re-equip tubes every third year.

** Average Depreciation for a 40 week year to obtain £1.167m after 7 years

*** Interest on £1,000,000 loan borrowed at 5% and to be repaid over the 7 years lifetime of the simulator.

Order of costs for a Table Top Simulation using three lecturers per exercise

	Maximum rate	Minimum rate
Staff daily rate		
Lecturing staff	£1500	£1050
Table Top simulation	£5	0
Classroom	£50	0
Total	£1,555	£1,050

Order of costs for a classroom using one lecturer

	Maximum rate	Minimum rate
Staff daily rate		
Lecturing staff	£500	£350
Classroom	£50	0
Total	£550	£350

If comparing the various types of training aids, the staff daily rates could be discounted as these daily rates will apply across all areas of teaching whether or not simulator based

Hotel accommodation, travel and subsistence, course notes, course development costs, hire of room would all be a constant whether simulator, CBT or classroom is used.

7.4 Results

The starting point of these deliberations was to define more closely the differences between normal procedures, the ability to handle emergencies and crisis management. The three processes are connected and seen as an increasing deterioration in the situation. A definition of Emergency management and Crisis management is given in paragraph 4.5. It is possible to avoid crisis situations with knowledge and skilled handling of the emergency situation. Decision making skills are needed at all levels: as the problem(s) escalate through an emergency to a crisis, then the skill and rule based levels of thinking are replaced by the more time-consuming knowledge based level, i.e. the individual or team have to think through the situation (Rasmussen, 1983). In addition, the non-technical skills such as communication, motivation and leadership become paramount.

Although the MAIB Green Lily report (MAIB, 1999) refers specifically to handling escalating emergencies, it was considered that the skills of crisis management have the following features:

- The critical skills are predominantly non-technical in nature. They do not appear to be precisely defined, but they are probably general high-level cognitive skills, and involve the integration of other skills and system knowledge. Although a number of different skills are identified in the literature, significant ones include Co-operation, Leadership and Managerial skills, Situation awareness, and decision making (Flin, 1998). It is possible that certain elements of crisis management depend upon innate abilities, i.e. an individual may possess certain characteristics which enable him/her to handle crises.

- The inference that crisis management is, at least in part, made up of skills, suggests that it can be learned. Because it is a skill, (although it will also require knowledge) it is best learned through practice i.e. by doing. This in turn suggests that some form of role-playing through simulation is likely to be the most effective training method.

- It is often a group activity; possibly involving widely distributed groups and separate autonomous agencies.

- The critical skill in decision making is situational awareness as outlined in the literature review. Given the above features, shared mental models of the system are an important aspect.

- One of the main benefits of emergency management training would appear to be the strengthening or enhancing of these mental models which in turn would make situational awareness more resistant to stress.

- During the discussion on "behavioural markers", it was noted that a suitable definition for this is as follows:

  The term "behavioural markers" refers to a prescribed set of behaviours which have been identified as indicative of some aspect of skilled human performance. The typical behaviours or "markers" are listed in relation to the component skills and are then used for selection, training and competence assessment. (CAA, 1998)

A number of individual options for skills training were identified, ranging from full-mission simulation (FMS) to classroom role-playing. It is believed that the benefits of these training options have not been evaluated empirically. This is due to the many factors that may affect performance, and the difficulties of measuring transfer of training. It was agreed that an effective training strategy is likely to incorporate combinations of methods and, in order to achieve the best results, and will depend on a number of variables, e.g. the experience of students (and instructors), the frequency and regularity of training over time, etc. However, it was considered that if the best method of training for handling escalating emergencies had to be recommended then it is to use blocks of classroom based learning, followed by full mission simulator based exercises and then a further classroom based debrief session.

It was noted that the main method of assessment chosen by the Canadian regulatory authority is to use a dumb assistant in the engine room with the person being assessed. The dumb assistant will respond with correct answers to questions, but will neither prompt nor initiate. This process needs careful thinking out and rules need to be prepared for each set of assessments. For instance, if the person being assessed is a potential Chief Engineer and the dumb assistance is his Junior Engineer, and the Chief Engineer does not stipulate exactly the feedback he needs from the Junior Engineer, how much of a engine room team member is the Junior engineer allowed to be ?

It was believed that there is no empirical evidence that shows the effectiveness of current training and assessment strategies for the handling of escalating emergencies. In the nuclear and aviation industries the evidence put forward to support the effectiveness of their training and assessment strategies for handling escalating emergencies is that their industries are relatively safe.

Following the aviation industry, the offshore (Flin et al, 1999), nuclear (Crichton, 1999), and shipping industries are all adopting Crew Resource Management training (CRM). The topics covered by CRM courses are established through accident analysis, crew interviews, and observations of crews in simulators. Topics include: Situation Awareness; Decision-Making; Communication; Team Co-ordination; Fatigue and Shiftwork; and Stress. In this context, CRM gives the course members an insight into human interactions, but in most cases does not deal explicitly in crisis management.

- CRM is based on the premise that human error is ubiquitous and inevitable.

- CRM is a set of countermeasures with 3 lines of defence:
  Avoidance of error
  Trap errors in the course of development before they are committed
  Mitigate the consequences of any errors.

The level of fidelity required for effective training at each of the stages in development was discussed. It is probably true, but not verified, that high fidelity is wasted on novices and not totally necessary for experts. However, for personnel progressing from novice to expert, practicing the integrating skills necessary for crisis management would probably benefit from contextual training in high "behavioural fidelity" simulations.

Another issue was the over-arching certification process. For example, in the aviation world, it is the practice that once initially qualified, continued certification of a pilot is by a process of continuous professional development (CPD). This system reflects the value invested in the pilots. The important feature of the process is that each assessment, conducted frequently and regularly, on-line or in a simulator, is linked to updating and remedial training if necessary. Unless a similar system is adopted in the shipping industry, assessment by simulator will always be in the form of a "pass/fail" examination without on the job remedial training.

7.5 Conclusions

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 which 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.

The most cost-effective training option will be determined by local factors. Therefore, no mandatory option should be considered. At present, until research into standards of competence and "behavioural markers" is completed, assessment by FMS constitutes the only viable option.

The key to the certification process is the assessment of the trainee. The fidelity of the simulation must be such that the candidate can display the competencies to be assessed. Currently, it is unlikely that anything less than full mission simulation (FMS) can guarantee this. The cost of FMS assessment should be established, given the different issues identified above.

The main non-technical skills of Co-operation, Leadership and Management skills, Situation awareness, and Decision making that have to be mastered in order to handle escalating emergencies are not yet fully defined and implemented.

Whatever training methods are used, crisis management training should be viewed as a long term process, embedded in the training of individuals from novice through to senior command, not as a set of "bolt-on" courses.

7.6 Recommendations

The 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.

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8 SUMMARY OF CONCLUSIONS

The following summary of conclusions is detailed beneath the requisite objective.

Investigate the availability of, and developments in simulator technology applied to bridge and engine room resource management training, specifically that addressing escalating emergencies and increasing levels of stress.

The report has shown that the worldwide availability of simulators capable of being applied to bridge and engine room management training is approximately five hundred (Muirhead 1996). However, the returned questionnaires from member states indicated that despite the widespread use of these simulators for training purposes, simulation is not widely used in training for the handling of escalating emergencies at sea.

One of the major new developments in simulator technology is the Virtual Reality Training Environment (VRTE). Within the domains of spatial cognitive tasks and spatial familiarisation, VRTEs seem to offer a viable alternative to other forms of training. However, in most cases, VRTEs are only used as one part of an overall training regime and are not considered to be a replacement for other forms of training and documentation. The effectiveness of VRTEs for the training of team-based activities and cognitive skills, such as the handling of escalating emergencies, has yet to be proven.

Questionnaire respondents all emphasise that simulator fidelity is of high importance. This perceived requirement is being facilitated by the increase in computer power which has enabled a considerable improvement in the overall fidelity of visual presentation. Part task simulators can approach the complexity of full mission simulation as both use a similar hardware platform.

Taking into account the results of objective 2.1.1, determine how simulator technology may most effectively be used in the training of seafarers in the handling of emergencies.

The report has shown that a differentiation should be made between emergencies and crises.

Emergency management has been defined as a situation where decisions and actions are based on documented emergency procedures. These emergency procedures are trained both at onshore training establishments and on board. For example a report of a fire in a cabin will result in the pre defined emergency response for a fire being activated. Each crew member has been trained and taken part in drills in his or her role in the relevant team and should respond according to their training.

Crisis Management differs from emergency management in that decisions and actions do not necessarily have documented emergency procedures and there may not be a pre-defined response, or if there are emergency responses those responses may have conflicting requirements. For example multiple emergencies may occur which have conflicting resource requirements.

It is considered that the crew members of the "Green Lily" were in a crisis situation before the ship grounded.

The Literature Review indicated that the critical skills needed within crisis situations are predominantly non-technical in nature.

In the domain of Civil Aviation, Crew Resource Management has been used as a method to train non-technical skills. These skills have been structured into four categories: co-operation; leadership and managerial skills; situational awareness and decision making.
Within the four categories behavioural markers have been identified.

The key to the certification process is the assessment of the trainee. The fidelity of the simulation must be such that the candidate can display the competencies to be assessed. Currently, it is unlikely that anything less than full mission simulation (FMS) can guarantee this. The cost of FMS assessment should be established, given the different issues identified above.

Although the training of non-technical skills is starting to be used more widely within some safety critical industries, such as nuclear and aviation, the findings of the report raise concerns about a number of issues related to this training:

- The non-technical skills currently being trained have not been fully defined in relation to the needs of personnel handling of escalating emergencies in the maritime domain.

- The training regimes currently used for the training of crisis management may not have been developed in line with accepted best practice in instructional design.

In order to match the training equipment to the training requirement it is necessary to apply a rigorous Training Needs Analysis (TNA) and other associated human factor disciplines. TNA may be defined as "a systematic method for analysing a training requirement and specifying the functional requirements for the training equipment" (Jackson, 1993). As part of this method, TNA can also identify the required instructional facilities to monitor trainee performance for any assessment purposes.

The report has shown that most crisis management training that is undertaken using simulators has not been developed following the application of a rigorous Training Needs Analysis, but rather on a premise that by presenting as many of the functions of the real work environment as possible through a full mission simulator, the functional requirements required to meet any training requirement will be present.

Applying these results, through a cost-benefit assessment or other suitable technique(s), quantify the efficiency of the simulation techniques on offer in addressing the training aims.

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 which will determine the most cost-effective training option. Often this will be determined by local factors. Therefore, no mandatory option should be considered.

The cost benefit analysis workshop concluded that the inclusion of full mission simulation was the only viable assessment option. 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 skills perceived to be required may be demonstrated. The fidelity of the simulation must be such that the candidate can display the competencies to be assessed.

Currently, due to the lack of training needs analyses relating to the handling of escalating emergencies at sea, it is unlikely that anything less than full mission simulation can be guaranteed to allow the assessment of competencies required under the current certification process. Once a full training needs analysis has been undertaken, it may be possible to meet the training aims of handling escalating emergencies at sea with other, more cost beneficial training techniques.

In summary form, report on the simulator training regimes in place in other Certifying States including the identification of the underlying education levels, tasks and training aims.

Response to the 100 questionnaires distributed across the world to IMO member states was very poor, with returns received from UK, Hungary, Hong Kong, Thailand and Canada. No firm conclusions can be offered with this response, but returns indicated that Thailand and Hong Kong tend to rely upon classroom based learning, whereas the UK and Canada use simulation more than these other two countries. Assessment of Competence tends to be based around written exams in Hong Kong and Thailand whereas the UK and Canada tend to use oral and practical exams.

9 RECOMMENDATIONS

9.1 A Training Needs Analysis (TNA) should be undertaken to analyse the training requirement and specify the functional requirements for the training equipment to be used within this training and assessment programme.

9.2 The main non-technical skills of co-operation, leadership and management skills, situation awareness, and decision making, that have to be mastered in order to handle escalating emergencies, need to be more fully defined.

9.3 A strategy needs to be developed to incorporate these skills into a training and assessment programme.

9.4 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.

9.5 Whatever training methods are used, crisis management training should be viewed as a long term process, embedded in the training of individuals from novice through to senior command, not as a set of “bolt-on” courses.

9.6 The most cost-effective training option will be determined by local factors. Therefore, no mandatory option should be considered. At present, until the research above is completed, assessment by Full Mission Simulator constitutes the only viable option.

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11 **APPENDICES**

APPENDIX A (1)

QUESTIONNAIRE FOR MEMBER STATES

Warsash Maritime Centre is currently carrying out an investigation, on behalf of the UK MCA, into bridge and engine-room resource management training and in particular training that addresses escalating emergencies and increasing levels of stress in the working environment. It would be very useful to us if you, or an appropriate representative of your administration, could fill in the questionnaire below by answering the 6 questions and send it back to us in the enclosed addressed envelope. Any questions or further information can be obtained from Warsash Maritime Research Centre on +44 (0) 1489 556221. Below are a number of competencies that are required for seafarers to deal with emergency situations. If seafarers in your country are trained in any of these areas please complete the following table by entering the amount of percentage spent on each type of training method mentioned. If simulation is used what kind or type of simulation is used can be entered and finally, the method of assessment used can be entered to.

Competence requirement	**% of training time spent on a simulator**	**% training time spent in a classroom**	**% of training time spent doing practical work**	**Type of simulator used (if applicable)**	**Methods of assessment used**
EXAMPLE To be able to react appropriately when a fire occurs onboard	25	25	50	Steel environment of ship's structure	Practical exam
Survival at sea in the event of ship abandonment					
Respond to emergency situations involving fire					
To be able to respond to medical accident or emergency					
To be able to respond to emergency procedures					
To be able to take charge of survival craft in an emergency					
Crisis management and human behaviour					
Crowd management and safety training					

Provide medical care to sick and injured while onboard					
To take action following collision or grounding					
To take appropriate action in emergencies on Tankers					
To operate GMDSS					

If you have the time, please complete any thoughts or feeling you have on questions 2-5 below.

2. With regard to emergency situations, are there any other requirements that you believe training should become mandatory for?

3. With regard to working in stressful conditions on a ship, are there any other requirements that you believe training should become mandatory for?

4. Please write in any future plans that you may have of changing the methods used in mandatory training (e.g. perhaps you are looking into distance learning for some courses to replace classroom based learning, perhaps the use of a certain type of simulator may be considered for replacing practical elements)

5. Please write in any future plans that you may have of changing the way various requirements of training are assessed.

APPENDIX A (2)

QUESTIONNAIRE FOR SIMULATOR DEVELOPERS

Warsash Maritime Centre is currently investigating, on behalf of the UK MCA, bridge and engine-room resource management training and in particular training that addresses escalating emergencies including increasing levels of stress in the working environment. Since you are a renowned simulator developer we would very much value your expertise in answering for us the following 11 questions and return the completed questionnaire in the addressed envelope. Further details of the project are available from Warsash Maritime Research Centre on +44 (0) 1489 556221.

1. **What type of simulators do you currently offer? Or have had recently commissioned? Please write in results and/or include a current brochure if possible.**

SIMULATES WHAT?	FIDELITY (HOW REAL DOES IT LOOK, FEEL OR HANDLE?)	COST WHEN INSTALLED	PRIMARY PURPOSES	WHAT INDUSTRY SECTOR/S WAS THE SIMULATOR PRIMARILY DEVELOPED FOR?	TICK IF IS TO BE USED FOR EMERGENCY PROCEDURE TRAINING
e.g. Bridge of ship	Fixed base, realistic controls, dials, forward view of 120°	£200000	Training in General.	Merchant Navy	✓

2. What, in your opinion, are the advantages to using a simulator for training?

3. What are the disadvantages to using a simulator for training?

4. Place the following in order of importance (1= most important through to 6= least important) in your decision when developing a simulator:-

FACTOR TO CONSIDER	PLACEMENT OF IMPORTANCE (1=MOST IMPORTANT; 6 =LEAST IMPORTANT)
LOW COST	
HIGH FIDELITY (realism)	
HIGH TRAINING TRANSFER (to real world)	
LOW AMOUNT OF UPKEEP REQUIRED	
HIGH FLEXIBILITY OF SIMULATOR TO BE TAILORED OR CUSTOMISED TO DIFFERENT TRAINING NEEDS	
LARGE AMOUNT OF SKILLS SIMULATOR CAN TRAIN	

PLEASE COMPLETE 5 and 6 FOR EACH TYPE OF SIMULATOR SOLD
THESE QUESTIONS CORRESPOND TO WHICH SIMULATOR? (please write in name of simulator) ____

5. When training for emergency situations using a simulator how important are the following characteristics of the simulator?
(circle the appropriate number)

a. THE SIMULATOR MUST LOOK AS REALISTIC AS POSSIBLE

Very important 7 6 5 4 3 2 1 Not at all important

b. THE SIMULATOR'S CONTROLS MUST FEEL AS REALISTIC AS POSSIBLE

Very important 7 6 5 4 3 2 1 Not at all important

c. THE SIMULATOR MUST REACT IN A REALISTIC WAY TO INPUT FROM THE USERS

Very important 7 6 5 4 3 2 1 Not at all important

d. SIMULATION SHOULD BE IN CONTINUOUS REAL TIME

Very important 7 6 5 4 3 2 1 Not at all important

e. THE SIMULATOR PLATFORM SHOULD MOVE IN ACCORDANCE WITH THE OUTSIDE ENVIRONMENT

Very important 7 6 5 4 3 2 1 Not at all important

f. SIMULATION SHOULD INCLUDE REALISTIC NOISE

Very important 7 6 5 4 3 2 1 Not at all important

6. How effective are simulators for teaching:- (please circle your answer)

a. COMMUNICATIONS IN A TEAM?

Very effective 7 6 5 4 3 2 1 Very ineffective

b. TECHNICAL SKILLS?

Very effective 7 6 5 4 3 2 1 Very ineffective

c. EMERGENCY PROCEDURES?

Very effective 7 6 5 4 3 2 1 Very ineffective

d. HOW TO COPE WITH STRESS?

Very effective 7 6 5 4 3 2 1 Very ineffective

e. LEADERSHIP QUALITIES?

Very effective 7 6 5 4 3 2 1 Very ineffective

f. GENERAL TEAMWORK?

Very effective 7 6 5 4 3 2 1 Very ineffective

g. EARLY ERROR DETECTION?

Very effective 7 6 5 4 3 2 1 Very ineffective

7. To the best of your knowledge how useful do each of the following groups of people find simulator training?

a. SHIPPING COMPANIES

Very useful 7 6 5 4 3 2 1 Totally useless

b. COMMERCIAL AIRLINES

Very useful 7 6 5 4 3 2 1 Totally useless

c. NUCLEAR POWER INDUSTRY

Very useful 7 6 5 4 3 2 1 Totally useless

d. ROYAL NAVY

Very useful 7 6 5 4 3 2 1 Totally useless

e. RAF

Very useful 7 6 5 4 3 2 1 Totally useless

f. ARMY

Very useful 7 6 5 4 3 2 1 Totally useless

8. How much do you agree with the following statements about the effectiveness of simulators?

a. For a simulator to be effective it is important to establish how much a trainee enjoyed the experience

Very true 7 6 5 4 3 2 1 Not at all true

b. For a simulator to be effective it is important to establish that the trainee has better **performance** than before she or he started the training with the simulator

Very true 7 6 5 4 3 2 1 Not at all true

c. For a simulator to be effective it is important to establish that the trainee has better **performance** following using the simulator than she or he would have using a different method (e.g. lecture or text-book)

Very true 7 6 5 4 3 2 1 Not at all true

d. For a simulator to be effective it is important to establish that the trainee has better **knowledge** than before she or he started the training with the simulator

Very true 7 6 5 4 3 2 1 Not at all true

e. For a simulator to be effective it is important to establish that the trainee has better **knowledge** following using the simulator than she or he would have using a different method (e.g. lecture or text-book)

Very true 7 6 5 4 3 2 1 Not at all true

f. For a simulator to be effective it is important to establish that the trainee has better **skills** than before she or he started the training with the simulator

Very true 7 6 5 4 3 2 1 Not at all true

g. For a simulator to be effective it is important to establish that the trainee has better **skills** following using the simulator than she or he would have using a different method (e.g. lecture or text-book)

Very true 7 6 5 4 3 2 1 Not at all

9. How will simulators themselves change in the future?

10. Will the purpose of simulators change? What will their new primary functions be?

11. Will new industries be interested in simulation? If so, which ones?

APPENDIX A(3)

QUESTIONNAIRE FOR SIMULATOR USERS (SHIPPING COMPANIES)

Warsash Maritime Centre is currently investigating, on behalf of the MCA, bridge and engine-room resource management training and in particular training that addresses escalating emergencies including increasing levels of stress in the working environment. Since you are a shipping company that sends individuals on training we would very much value your expertise in answering for us the following 11 questions and return the completed questionnaire in the addressed envelope provided. Further details of the project are available from Warsash Maritime Research Centre on +44 (0) 1489 556221

1. What type of courses do you send your seafaring staff on that involve simulators?

NAME OF TRAINING COURSE	SIMULATOR SIMULATES WHAT?	FIDELITY (HOW REAL DOES IT LOOK, FEEL OR HANDLE?)	YEAR BEGAN USING SIMULATOR ON COURSE	WHAT TYPE OF TRAINING IS THE SIMULATOR MAINLY USED FOR	TICK IF USED FOR EMEREGENCY PROCEDURE TRAINING
Example Basic fire-fighting	Compartment within a ship	Steel environment of ship's internal structure.	1985	To learn what to do in a fire onboard a ship	✓

2. Below are four different training situations. Please place each training method in order of priority that in your opinion would be most effective for that situation. Please give comments on your reasons for choice in the space provided including any evidence you may have suggesting that method is best.

for example:- for training in basic fire-fighting if you believe simulators to be the best, then computer distance learning packages, then lectures, then videos, then practical work and finally text books to be the worst the following should be entered.

e.g. FOR FIRE-FIGHTING:-

METHOD OF TRAINING	PLACEMENT (1=BEST; 6 =WORST)
SIMULATORS	1
TEXT BOOK	6
COMPUTER DISTANCE LEARNING PACKAGE	2
LECTURE	3
VIDEO	4
PRACTICAL WORK	5

a. FOR EMERGENCY PROCEDURES

METHOD OF TRAINING	PLACEMENT (1=BEST; 6 =WORST)
SIMULATORS	
TEXT BOOK	
COMPUTER DISTANCE LEARNING PACKAGE	
LECTURE	
VIDEO	
PRACTICAL WORK	

Comments on reason for choice:-

b. FOR ROUTINE PROCEDURES

METHOD OF TRAINING	PLACEMENT (1=BEST; 6 =WORST)
SIMULATORS	
TEXT BOOK	
COMPUTER DISTANCE LEARNING PACKAGE	
LECTURE	
VIDEO	

Comments on reason for choice:-

PRACTICAL WORK	

c. FOR ENGINE ROOM RESOURCE MANAGEMENT

METHOD OF TRAINING	**PLACEMENT (1=BEST; 6 =WORST)**
SIMULATORS	
TEXT BOOK	
COMPUTER DISTANCE LEARNING PACKAGE	
LECTURE	
VIDEO	
PRACTICAL WORK	

Comments on reason for choice:-

d. FOR BRIDGE RESOURCE MANAGEMENT

METHOD OF TRAINING	**PLACEMENT (1=BEST; 6 =WORST)**
SIMULATORS	
TEXT BOOK	
COMPUTER DISTANCE LEARNING PACKAGE	
LECTURE	
VIDEO	
PRACTICAL WORK	

Comments on reason for choice:-

3. Place the following in order of importance (1= most important through to 6= least important) in your decision when deciding to send individuals on a course that is run mainly on simulators

FACTOR TO CONSIDER	**PLACEMENT OF IMPORTANCE (1=MOST IMPORTANT; 6 =LEAST IMPORTANT)**
COST	
HIGH FIDELITY (realism) OF SIMULATOR	

HIGH TRAINING TRANSFER (to real world) OF SIMULATOR	
TRAINEES SHOULD ENJOY TRAINING METHOD	
HIGH FLEXIBILITY OF SIMULATOR TO BE TAILORED OR CUSTOMISED	
LARGE AMOUNT OF SKILLS SIMULATOR CAN TRAIN	

4. When training for bridge or engine room emergency situations using a simulator how important are the following characteristics of the simulator?
(circle the appropriate number)

a. THE SIMULATOR MUST LOOK AS REALISTIC AS POSSIBLE

Very important 7 6 5 4 3 2 1 Not at all important

b. THE SIMULATOR'S CONTROLS MUST FEEL AS REALISTIC AS POSSIBLE

Very important 7 6 5 4 3 2 1 Not at all important

c. THE SIMULATOR MUST REACT IN A REALISTIC WAY TO INPUT FROM THE USERS

Very important 7 6 5 4 3 2 1 Not at all important

d. SIMULATION SHOULD BE IN CONTINUOUS REAL TIME

Very important 7 6 5 4 3 2 1 Not at all important

e. THE BRIDGE SIMULATOR PLATFORM SHOULD MOVE IN ACCORDANCE WITH THE OUTSIDE ENVIRONMENT

Very important 7 6 5 4 3 2 1 Not at all important

f. SIMULATION SHOULD INCLUDE REALISTIC NOISE

Very important 7 6 5 4 3 2 1 Not at all important

5. How effective are simulators for teaching:- (please circle your answer)

a. COMMUNICATIONS IN A TEAM?

Very effective 7 6 5 4 3 2 1 Very ineffective

b. TECHNICAL SKILLS?

Very effective 7 6 5 4 3 2 1 Very ineffective

c. EMERGENCY PROCEDURES?

Very effective 7 6 5 4 3 2 1 Very ineffective

d. HOW TO COPE WITH STRESS?

Very effective 7 6 5 4 3 2 1 Very ineffective

e. LEADERSHIP QUALITIES?

Very effective 7 6 5 4 3 2 1 Very ineffective

f. GENERAL TEAMWORK?

Very effective 7 6 5 4 3 2 1 Very ineffective

g. EARLY ERROR DETECTION?

Very effective 7 6 5 4 3 2 1 Very ineffective

6. To the best of your knowledge how useful do each of the following groups of people find simulator training? (please circle your answer)

a. SHIPPING COMPANIES

Very useful 7 6 5 4 3 2 1 Totally useless

b. TRAINERS

Very useful 7 6 5 4 3 2 1 Totally useless

c. SENIOR DECK OFFICERS

Very useful 7 6 5 4 3 2 1 Totally useless

d. SENIOR ENGINE OFFICERS

Very useful 7 6 5 4 3 2 1 Totally useless

e. DECK CADETS

Very useful 7 6 5 4 3 2 1 Totally useless

f. ENGINE CADETS

Very useful 7 6 5 4 3 2 1 Totally useless

7. How much do you agree with the following statements about the effectiveness of simulators?

a. For a simulator to be effective it is important to establish how much a trainee enjoyed the experience

Very true 7 6 5 4 3 2 1 Not at all true

b. For a simulator to be effective it is important to establish that the trainee has better **performance** than before she or he started the training with the simulator

Very true 7 6 5 4 3 2 1 Not at all true

c. For a simulator to be effective it is important to establish that the trainee has better **performance** following using the simulator than she or he would have using a different method (e.g. lecture or text-book)

Very true 7 6 5 4 3 2 1 Not at all true

d. For a simulator to be effective it is important to establish that the trainee has better **knowledge** than before she or he started the training with the simulator

Very true 7 6 5 4 3 2 1 Not at all true

e. For a simulator to be effective it is important to establish that the trainee has better **knowledge** following using the simulator than she or he would have using a different method (e.g. lecture or text-book)

Very true 7 6 5 4 3 2 1 Not at all true

f. For a simulator to be effective it is important to establish that the trainee has better **skills** than before she or he started the training with the simulator

Very true 7 6 5 4 3 2 1 Not at all true

g. For a simulator to be effective it is important to establish that the trainee has better **skills** following using the simulator than she or he would have using a different method (e.g. lecture or text-book)

Very true	7	6	5	4	3	2	1	Not at all true

8. How often do you use the following methods of testing effectiveness?

a. Hand out questionnaire to trainee about effectiveness of simulator training

Often	7	6	5	4	3	2	1	Never

b. Interview trainee about effectiveness of simulator training

Often	7	6	5	4	3	2	1	Never

c. Formal testing of trainee before training and after training to assess what has been learnt

Often	7	6	5	4	3	2	1	Never

d. Formal testing of trainee only after training

Often	7	6	5	4	3	2	1	Never

e. Formal testing of trainees using simulator and compare results to trainees using a different method

Often	7	6	5	4	3	2	1	Never

f. Ask training centre for their opinions on standard of training with simulators

Often	7	6	5	4	3	2	1	Never

g. Senior officers observe knowledge, skills and performance of trainees using simulator

Often	7	6	5	4	3	2	1	Never

h. The number of shipping companies that send staff on training involving simulators suggest they are effective.

Often	7	6	5	4	3	2	1	Never

9. How much do you agree with each of these statements:- (circle the appropriate answer):-

a. Individuals trained using simulators have a better standard of training than those without training on simulators

Totally agree 7 6 5 4 3 2 1 Totally disagree

b. Training centres believe seafarers are better trained using simulators

Totally agree 7 6 5 4 3 2 1 Totally disagree

c. Some individuals benefit a great deal more than others do when being trained on simulators

Totally agree 7 6 5 4 3 2 1 Totally disagree

d. The usefulness of a simulator usually outweighs the cost of a simulator

Totally agree 7 6 5 4 3 2 1 Totally disagree

e. Most individuals feel they learn a great deal more on simulators than using other methods

Totally agree 7 6 5 4 3 2 1 Totally disagree

10. What are the main advantages to using simulators in training?

11. What are the main disadvantages to using simulators in training?

APPENDIX A(4)

QUESTIONNAIRE FOR SHIPPING ORGANISATIONS

Warsash Maritime Centre is currently investigating, on behalf of the UK MCA, bridge and engine-room resource management training and in particular training that addresses escalating emergencies including increasing levels of stress in the working environment. Since you are a leading organisation on all issues to do with shipping, we would very much value your expertise in answering for us the following 9 questions and return the completed questionnaire in the addressed envelope provided. Further details of the project are available from Warsash Maritime Research Centre on +44 (0) 1489 556221.

1. **Below are four different training situations. Please place each training method in order of priority that in your opinion would be most effective for that situation. Please give comments on your reasons for choice in the space provided including any evidence you may have suggesting that method is best:-**

for example:- for training in basic fire-fighting if you believe simulators to be the best, then computer distance learning packages, then lectures, then videos, then practical work and finally text books to be the worst the following should be entered.

e.g. FOR FIRE-FIGHTING:-

METHOD OF TRAINING	PLACEMENT (1=BEST; 6 =WORST)
SIMULATORS	1
TEXT BOOK	6
COMPUTER DISTANCE LEARNING PACKAGE	2
LECTURE	3
VIDEO	4
PRACTICAL WORK	5

a. FOR EMERGENCY PROCEDURES

METHOD OF TRAINING	PLACEMENT (1=BEST; 6 =WORST)
SIMULATORS	
TEXT BOOK	
COMPUTER DISTANCE LEARNING PACKAGE	
LECTURE	
VIDEO	
PRACTICAL WORK	

Comments on reason for choice:-

b. FOR ROUTINE PROCEDURES

METHOD OF TRAINING	PLACEMENT (1=BEST; 6 =WORST)
SIMULATORS	
TEXT BOOK	
COMPUTER DISTANCE LEARNING PACKAGE	
LECTURE	
VIDEO	
PRACTICAL WORK	

Comments on reason for choice:-

c. FOR ENGINE ROOM RESOURCE MANAGEMENT

METHOD OF TRAINING	PLACEMENT (1=BEST; 6 =WORST)
SIMULATORS	
TEXT BOOK	
COMPUTER DISTANCE LEARNING PACKAGE	
LECTURE	
VIDEO	
PRACTICAL WORK	

Comments on reason for choice:-

d. FOR BRIDGE RESOURCE MANAGEMENT

METHOD OF TRAINING	PLACEMENT (1=BEST; 6 =WORST)
SIMULATORS	
TEXT BOOK	
COMPUTER DISTANCE LEARNING PACKAGE	
LECTURE	
VIDEO	
PRACTICAL WORK	

Comments on reason for choice:-

2. When training for bridge and engine room emergency situations using a simulator how important are the following characteristics of the simulator?
(circle the appropriate number)

a. THE SIMULATOR MUST LOOK AS REALISTIC AS POSSIBLE

Very important 7 6 5 4 3 2 1 Not at all important

b. THE SIMULATOR'S CONTROLS MUST FEEL AS REALISTIC AS POSSIBLE

Very important 7 6 5 4 3 2 1 Not at all important

c. THE SIMULATOR MUST REACT IN A REALISTIC WAY TO INPUT FROM THE USERS

Very important 7 6 5 4 3 2 1 Not at all important

d. SIMULATION SHOULD BE IN CONTINUOUS REAL TIME

Very important 7 6 5 4 3 2 1 Not at all important

e. THE BRIDGE SIMULATOR PLATFORM SHOULD MOVE IN ACCORDANCE WITH THE OUTSIDE ENVIRONMENT

Very important 7 6 5 4 3 2 1 Not at all important

f. SIMULATION SHOULD INCLUDE REALISTIC NOISE

Very important 7 6 5 4 3 2 1 Not at all important

3. How effective are simulators for teaching:- (please circle your answer)

a. COMMUNICATIONS IN A TEAM?

Very effective 7 6 5 4 3 2 1 Very ineffective

b. TECHNICAL SKILLS?

Very effective 7 6 5 4 3 2 1 Very ineffective

c. EMERGENCY PROCEDURES?

Very effective 7 6 5 4 3 2 1 Very ineffective

d. HOW TO COPE WITH STRESS?

Very effective 7 6 5 4 3 2 1 Very ineffective

e. LEADERSHIP QUALITIES?

Very effective 7 6 5 4 3 2 1 Very ineffective

f. GENERAL TEAMWORK?

Very effective 7 6 5 4 3 2 1 Very ineffective

g. EARLY ERROR DETECTION?

Very effective 7 6 5 4 3 2 1 Very ineffective

4. To the best of your knowledge how useful do each of the following groups of people find simulator training? (please circle your answer)

a. SHIPPING COMPANIES

Very useful 7 6 5 4 3 2 1 Totally useless

b. TRAINERS

Very useful 7 6 5 4 3 2 1 Totally useless

c. SENIOR DECK OFFICERS

Very useful 7 6 5 4 3 2 1 Totally useless

d. SENIOR ENGINE OFFICERS

Very useful 7 6 5 4 3 2 1 Totally useless

e. DECK CADETS

Very useful 7 6 5 4 3 2 1 Totally useless

f. ENGINE CADETS

Very useful 7 6 5 4 3 2 1 Totally useless

5. How much do you agree with the following statements about the effectiveness of simulators?

a. For a simulator to be effective it is important to establish how much a trainee enjoyed the experience

Very true 7 6 5 4 3 2 1 Not at all true

b. For a simulator to be effective it is important to establish that the trainee has better **performance** than before she or he started the training with the simulator

Very true 7 6 5 4 3 2 1 Not at all true

c. For a simulator to be effective it is important to establish that the trainee has better **performance** following using the simulator than she or he would have using a different method (e.g. lecture or text-book)

Very true 7 6 5 4 3 2 1 Not at all true

d. For a simulator to be effective it is important to establish that the trainee has better **knowledge** than before she or he started the training with the simulator

Very true 7 6 5 4 3 2 1 Not at all true

e. For a simulator to be effective it is important to establish that the trainee has better **knowledge** following using the simulator than she or he would have using a different method (e.g. lecture or text-book)

Very true 7 6 5 4 3 2 1 Not at all true

f. For a simulator to be effective it is important to establish that the trainee has better **skills** than before she or he started the training with the simulator

Very true 7 6 5 4 3 2 1 Not at all true

g. For a simulator to be effective it is important to establish that the trainee has better **skills** following using the simulator than she or he would have using a different method (e.g. lecture or text-book)

Very true 7 6 5 4 3 2 1 Not at all true

6. How often are you involved in any of the following methods of testing effectiveness of simulators?

a. Hand out questionnaire to trainee about effectiveness of simulator training

Often 7 6 5 4 3 2 1 Never

b. Interview trainee about effectiveness of simulator training

Often 7 6 5 4 3 2 1 Never

c. Formal testing of trainee before training and after training to assess what has been learnt

Often	7	6	5	4	3	2	1	Never

d. Formal testing of trainee only after training

Often	7	6	5	4	3	2	1	Never

e. Formal testing of trainees using simulator and compare results to trainees using a different method

Often	7	6	5	4	3	2	1	Never

f. Ask training centre for their opinions on standard of training with simulators

Often	7	6	5	4	3	2	1	Never

g. Senior officers observe knowledge, skills and performance of trainees using simulator

Often	7	6	5	4	3	2	1	Never

h. The number of shipping companies that send staff on training involving simulators suggest they are effective.

Often	7	6	5	4	3	2	1	Never

i. Ask shipping companies if they believe simulators are effective

Often	7	6	5	4	3	2	1	Never

j. Sponsor research to carry out investigations into effectiveness of simulators

Often	7	6	5	4	3	2	1	Never

7. How much do you agree with each of these statements:- (circle the appropriate answer):-

a. Individuals trained using simulators have a better standard of training than those without training on simulators

Totally agree	7	6	5	4	3	2	1	Totally disagree

b. Training centres believe seafarers are better trained using simulators

Totally agree	7	6	5	4	3	2	1	Totally disagree

c. Some individuals benefit a great deal more than others do when being trained on simulators

Totally agree 7 6 5 4 3 2 1 Totally disagree

d. The usefulness of a simulator usually outweighs the cost of a simulator

Totally agree 7 6 5 4 3 2 1 Totally disagree

e. Most individuals feel they learn a great deal more on simulators than using other methods

Totally agree 7 6 5 4 3 2 1 Totally disagree

f. Shipping companies believe seafarers are better trained using simulators

Totally agree 7 6 5 4 3 2 1 Totally disagree

8. What are the main advantages to using simulators in training?

9. What are the main disadvantages to using simulators in training?

APPENDIX A(5)

QUESTIONNAIRE FOR SIMULATOR OPERATORS

Warsash Maritime Centre is currently investigating, on behalf of the UK MCA, bridge and engine-room resource management training and in particular training that addresses escalating emergencies including increasing levels of stress in the working environment. Since you are a renowned simulator operator we would very much value your expertise in answering for us the following 11 questions and return the answered questionnaire to us in the addressed envelope. Further details of the project are available by contacting Warsash Maritime Research Centre on +44 (0) 1489 556221

1. What type of simulators do you have?

SIMULATES WHAT?	FIDELITY (HOW REAL DOES IT LOOK, FEEL OR HANDLE)	YEAR INSTALLED	COST WHEN INSTALLED	PRIMARY PURPOSES	WHAT TYPE OF TRAINING IS THE SIMULATOR MAINLY USED FOR	TICK IF USED FOR EMEREGENCY PROCEDURE TRAINING
e.g. Bridge of ship	Fixed base, realistic controls, dials, forward view of 120°	1997	£200000	Training & Research	To teach bridge management & communication skills	✓

2. Below are four different training situations. Please place each training method in order of priority that in your opinion would be most effective for that situation. Please give comments on your reasons for choice in the space provided including any evidence you may have suggesting that method is best.

for example:- for training in basic fire-fighting if you believe simulators to be the best, then computer distance learning packages, then lectures, then videos, then practical work and finally text books to be the worst the following should be entered.

e.g. FOR FIRE-FIGHTING:-

METHOD OF TRAINING	PLACEMENT (1=BEST; 6 =WORST)
SIMULATORS	1
TEXT BOOK	6
COMPUTER DISTANCE LEARNING PACKAGE	2
LECTURE	3
VIDEO	4
PRACTICAL WORK	5

a. FOR EMERGENCY PROCEDURES

METHOD OF TRAINING	PLACEMENT (1=BEST; 6 =WORST)
SIMULATORS	
TEXT BOOK	
COMPUTER DISTANCE LEARNING PACKAGE	
LECTURE	
VIDEO	
PRACTICAL WORK	

Comments on reason for choice:-

b. FOR ROUTINE PROCEDURES

METHOD OF TRAINING	PLACEMENT (1=BEST; 6 =WORST)
SIMULATORS	
TEXT BOOK	
COMPUTER DISTANCE LEARNING PACKAGE	
LECTURE	
VIDEO	

Comments on reason for choice:-

PRACTICAL WORK	

c. FOR ENGINE ROOM RESOURCE MANAGEMENT

METHOD OF TRAINING	**PLACEMENT (1=BEST; 6 =WORST)**
SIMULATORS	
TEXT BOOK	
COMPUTER DISTANCE LEARNING PACKAGE	
LECTURE	
VIDEO	
PRACTICAL WORK	

Comments on reason for choice:-

d. FOR BRIDGE RESOURCE MANAGEMENT

METHOD OF TRAINING	**PLACEMENT (1=BEST; 6 =WORST)**
SIMULATORS	
TEXT BOOK	
COMPUTER DISTANCE LEARNING PACKAGE	
LECTURE	
VIDEO	
PRACTICAL WORK	

Comments on reason for choice:-

3. Place the following in order of importance (1= most important through to 6= least important) in your decision when purchasing or developing a simulator:-

FACTOR TO CONSIDER	**PLACEMENT OF IMPORTANCE (1=MOST IMPORTANT; 6 =LEAST IMPORTANT)**
LOW COST	
HIGH FIDELITY (realism)	
HIGH TRAINING TRANSFER (to real world)	
LOW AMOUNT OF UPKEEP REQUIRED	

HIGH FLEXIBILITY OF SIMULATOR TO BE TAILORED OR CUSTOMISED TO DIFFERENT TRAINING NEEDS	
LARGE AMOUNT OF SKILLS SIMULATOR CAN TRAIN	

4. When training for bridge and engine room emergency situations using a simulator how important are the following characteristics of the simulator?
(circle the appropriate number)

a. THE SIMULATOR MUST LOOK AS REALISTIC AS POSSIBLE

Very important 7 6 5 4 3 2 1 Not at all important

b. THE SIMULATOR'S CONTROLS MUST FEEL AS REALISTIC AS POSSIBLE

Very important 7 6 5 4 3 2 1 Not at all important

c. THE SIMULATOR MUST REACT IN A REALISTIC WAY TO INPUT FROM THE USERS

Very important 7 6 5 4 3 2 1 Not at all important

d. SIMULATION SHOULD BE IN CONTINUOUS REAL TIME

Very important 7 6 5 4 3 2 1 Not at all important

e. THE BRIDGE SIMULATOR PLATFORM SHOULD MOVE IN ACCORDANCE WITH THE OUTSIDE ENVIRONMENT

Very important 7 6 5 4 3 2 1 Not at all important

f. SIMULATION SHOULD INCLUDE REALISTIC NOISE

Very important 7 6 5 4 3 2 1 Not at all important

5. How effective are simulators for teaching:- (please circle your answer)

a. COMMUNICATIONS IN A TEAM?

Very effective 7 6 5 4 3 2 1 Very ineffective

b. TECHNICAL SKILLS?

Very effective 7 6 5 4 3 2 1 Very ineffective

c. EMERGENCY PROCEDURES?

Very effective 7 6 5 4 3 2 1 Very ineffective

d. HOW TO COPE WITH STRESS?

Very effective 7 6 5 4 3 2 1 Very ineffective

e. LEADERSHIP QUALITIES?

Very effective 7 6 5 4 3 2 1 Very ineffective

f. GENERAL TEAMWORK?

Very effective 7 6 5 4 3 2 1 Very ineffective

g. EARLY ERROR DETECTION?

Very effective 7 6 5 4 3 2 1 Very ineffective

6. To the best of your knowledge how useful do each of the following groups of people find simulator training?

a. SHIPPING COMPANIES

Very useful 7 6 5 4 3 2 1 Totally useless

b. TRAINERS

Very useful 7 6 5 4 3 2 1 Totally useless

c. SENIOR DECK OFFICERS

Very useful 7 6 5 4 3 2 1 Totally useless

d. SENIOR ENGINE OFFICERS

Very useful 7 6 5 4 3 2 1 Totally useless

e. DECK CADETS

Very useful 7 6 5 4 3 2 1 Totally useless

f. ENGINE CADETS

Very useful 7 6 5 4 3 2 1 Totally useless

7. How much do you agree with the following statements about the effectiveness of simulators?

a. For a simulator to be effective it is important to establish how much a trainee enjoyed the experience

Very true 7 6 5 4 3 2 1 Not at all true

b. For a simulator to be effective it is important to establish that the trainee has better **performance** than before she or he started the training with the simulator

Very true 7 6 5 4 3 2 1 Not at all true

c. For a simulator to be effective it is important to establish that the trainee has better **performance** following using the simulator than she or he would have using a different method (e.g. lecture or text-book)

Very true 7 6 5 4 3 2 1 Not at all true

d. For a simulator to be effective it is important to establish that the trainee has better **knowledge** than before she or he started the training with the simulator

Very true 7 6 5 4 3 2 1 Not at all true

e. For a simulator to be effective it is important to establish that the trainee has better **knowledge** following using the simulator than she or he would have using a different method (e.g. lecture or text-book)

Very true 7 6 5 4 3 2 1 Not at all true

f. For a simulator to be effective it is important to establish that the trainee has better **skills** than before she or he started the training with the simulator

Very true 7 6 5 4 3 2 1 Not at all true

g. For a simulator to be effective it is important to establish that the trainee has better **skills** following using the simulator than she or he would have using a different method (e.g. lecture or text-book)

Very true 7 6 5 4 3 2 1 Not at all true

8. How often do you use the following methods of testing effectiveness?

a. Hand out questionnaire to trainee about effectiveness of simulator training

Often 7 6 5 4 3 2 1 Never

b. Interview trainee about effectiveness of simulator training

Often 7 6 5 4 3 2 1 Never

c. Formal testing of trainee before training and after training to assess what has been learnt

Often 7 6 5 4 3 2 1 Never

d. Formal testing of trainee only after training

Often 7 6 5 4 3 2 1 Never

e. Formal testing of trainees using simulator and compare results to trainees using a different method

Often 7 6 5 4 3 2 1 Never

f. Ask shipping company for their opinions on standard of training with simulators

Often 7 6 5 4 3 2 1 Never

g. Trainers observe knowledge, skills and performance of trainees using simulator

Often 7 6 5 4 3 2 1 Never

h. Assessing the demand for simulator courses from shipping companies displays effectiveness of simulators

Often	7	6	5	4	3	2	1	Never

9. How much do you agree with each of these statements:- (circle the appropriate answer):-

a. Individuals trained using simulators have a better standard of training than those without training on simulators

Totally agree	7	6	5	4	3	2	1	Totally disagree

b. Shipping companies believe their seafaring staff are better trained using simulators

Totally agree	7	6	5	4	3	2	1	Totally disagree

c. Some individuals benefit a great deal more than others do when being trained on simulators

Totally agree	7	6	5	4	3	2	1	Totally disagree

d. The usefulness of a simulator usually outweighs the cost of a simulator

Totally agree	7	6	5	4	3	2	1	Totally disagree

e. Most individuals feel they learn a great deal more on simulators than using other methods

Totally agree	7	6	5	4	3	2	1	Totally disagree

10. What are the main advantages to using simulators in training?

11. What are the main disadvantages to using simulators in training?

APPENDIX B

ROUND 1 - DELPHI TECHNIQUE POLICY SCENARIOS

Scenario 1

Simulation	Full mission simulator with high fidelity environment.
Number of trainees / tutors	4 trainees 1 tutor
Duration of Training	4.5 days
Syllabus	Organise emergency procedures. Optimise the use of resources. Control response to emergencies. Control personnel during emergency situations. Establish and maintain effective communications. Team based exercises.
Assessment	Assessment exercise for each trainee as leader of the team. One assessor undertaking subjective assessment against set criteria. Assessor also operates the simulator.

Scenario 2

Simulation	Full mission simulator with high fidelity environment.
Number of trainees / tutors	1 trainee 1 tutor
Duration of Training	4.5 days
Syllabus	Organise emergency procedures. Optimise the use of resources. Control response to emergencies. Control personnel during emergency situations. Establish and maintain effective communications. Single trainee exercises.
Assessment	Assessment exercise for trainee as senior in charge with one 'dumb' assistant. One assessor undertaking subjective assessment against set criteria. Separate simulator operator.

Scenario 3

Simulation	Distributed multi-user collaborative virtual environment.
Number of trainees / tutors	6 1 tutor
Duration of Training	4.5 days

Syllabus	Organise emergency procedures. Optimise the use of resources. Control response to emergencies. Control personnel during emergency situations. Establish and maintain effective communications. Team based exercises.
Assessment	One assessor, subjective assessment against set criteria.

Scenario 4

Simulation	Desktop computer based crisis management training package.
Number of trainees / tutors	1 No tutor
Duration of Training	4 days
Syllabus	Organise emergency procedures. Optimise the use of resources. Control response to emergencies. Control personnel during emergency situations. Establish and maintain effective communications. Desktop computer based training exercises.
Assessment	Computer based assessment test.

Scenario 5

Simulation	Table top simulation using general arrangement plans of work environments.
Number of trainees / tutors	8 trainees 2 tutors

Duration of Training	4.5 days
Syllabus	Organise emergency procedures. Optimise the use of resources. Control response to emergencies. Control personnel during emergency situations. Establish and maintain effective communications. Team based exercises.
Assessment	One assessor, subjective assessment against set criteria.

Scenario 6

Simulation	Classroom Based Group Workshop / Seminar
Number of trainees / tutors	8 trainees 1 tutor
Duration of Training	2.5 days
Syllabus	Risk Management tools and techniques. Application of Risk Management tools and techniques to historic and predictive incident scenarios.
Assessment	One assessor, subjective assessment against set criteria.

APPENDIX C

ROUND 2 - DELPHI TECHNIQUE QUESTIONS

Scenario 1 (full mission simulator with team based exercises):

1 Would your opinion change along any of the dimensions if training only or assessment only was the purpose of this option. If yes, how would it change?

2 In order to support your original opinion, what would you consider to be the strengths and weaknesses of this option for training and for assessment? In your opinion, how could weaknesses be rectified?

3 Should a tutor ever be an assessor for the same people?

Scenario 2 (full-mission simulator with single trainee exercises):

4 In your opinion, are there any circumstances where training for emergency procedures alone or with one other "dumb" assistant might be more useful or better than training in a team?

Scenario 3 (virtual environments):

5 The consensus was positive for this option. Please justify further your opinions on this option, and on what evidence is this based?

6 Should communication systems be embedded in the VE or should real communications systems be used? What are the reasons for your choice?

7 Should the VE have real or simulated co-workers? Which is best and why?

8 How real does the VE have to be? What general aspects of the "real" world MUST be included?

Scenario 4 (desktop computer simulation):

9 Would your opinion change along any of the dimensions if the simulation was more interactive? If yes, in what ways would more interactivity make this option better or worse?

10 If your opinion has changed more positively, in what ways could more interactivity be achieved?

11 Would your opinion change along any of the dimensions if the simulation was more team-based? If yes, in what ways would more team-based activity make this option better or

worse?

12 If your opinion has changed more positively, in what ways could more team-based activity be achieved?

13 Do you think it is possible to conduct an assessment at a distance using this option? Please give reasons for your choice.

Scenario 5 (table-top simulation):

14 Should this option be used mainly for training or assessment or both equally? Please give reasons for your choice.

15 Do you think it is important to create stress during training or assessment? If yes, how can this be created with this option?

16 In general, do you believe that the level of fidelity correlates with the level of stress that is induced ie is it true that the more realistic a training method is, the more likely it is to induce stress on the trainees or candidates?

Scenario 6 (class-room based workshops):

17 Would your opinion change along any of the dimensions if training only or assessment only was the purpose of this option. If yes, how would it change?

18 In order to support your original opinion, what would you consider to be the strengths and weaknesses of this option for training and assessment? In your opinion, how could weaknesses be rectified?

19 The analysis suggested this option might be useful in conjunction with other methods of training. Which other methods could it be used in conjunction with and what specific skills should be trained with this option?

APPENDIX D

COST BENEFIT ANALYSIS WORKSHOP AGENDA

Monday 29th January — Morning session: Chairman/validator: MB/CM

0900	Coffee and Introductions in Griffin Room	ALL
0915	Background to research and purpose of workshop	MB
0930	Emergency handling and crisis management – the viewpoints	DG
1000	Emergency handling and crisis management – what are the benefits?	DG
1045	Coffee in Waterside Restaurant	
1100	Emergency handling and crisis management – what are the training and assessment options?	DG
1130	Full-mission simulator (FMS)	JSH
1200	Virtual Reality Training Environments (VRTE)	DG
1230	Computer Based Training (CBT)	GMcN
1300	Lunch in Waterside Restaurant	
1400	Tour of WMC simulator facilities — Afternoon session: Chairman/validator: JSH/CM	
1500	Table top simulations	JSH
1530	Classroom	MB
1600	Tea in Waterside Restaurant	
1615	Any other options?	
1645	The choice of options within a training strategy	MB
1715	Conclusions of the day	JSH
1730	Depart at leisure	

Tuesday 30th January

	Morning Session:	Chairman/validator:	DG/CM
0900	Introduction to Costs		JSH
0910	Industry experiences of:		
	Capital costs Revenue costs Overhead costs Depreciation costs Others? Consequence costs		ALL
1000	Industry-specific costs		
1030	Coffee in Waterside Restaurant		
1045	Summary of cost – benefits for the different options		
1100	Conclusions		DG/JSH
1200	Lunch in Waterside Restaurant or depart at leisure		

List of attendees

Margaret Crighton	University of Aberdeen
Pieter Hemsley	Aviation Training Association
Michael Pengelly	University of Lancaster
Stuart Withington	MAIB
Alan Rushton	MAIB
John Davison	MCA
James Thorpe	MCA
Mike Barnett (MB)	WMC
John Habberley (JSH)	WMC
David Gatfield (DG)	WMC
Charles Musselwhite (CM)	WMC
Gloria McNeill (GMcN)	WMC