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**AMENDMENTS TO THE CODE FOR THE INVESTIGATION OF MARINE
CASUALTIES AND INCIDENTS (RESOLUTION A.849(20))**

THE ASSEMBLY,

RECALLING Article 15(j) of the Convention on the International Maritime Organization concerning the functions of the Assembly in relation to regulations and guidelines concerning maritime safety and the prevention and control of marine pollution from ships,

RECALLING ALSO resolution A.849(20) by which it adopted the Code for the Investigation of Marine Casualties and Incidents,

CONSIDERING that practical advice for the systematic investigation of human factors in marine casualties and incidents will assist an effective analysis and promote the identification and implementation of preventive action,

RECOGNIZING the need for development and use, as appropriate, of practical guidelines for the investigation of human factors in marine casualties and incidents,

HAVING CONSIDERED the recommendations made by the Maritime Safety Committee at its seventy-first session and by the Marine Environment Protection Committee at its forty-third session,

1. ADOPTS amendments to the Code for the Investigation of Marine Casualties and Incidents incorporating the Guidelines for the Investigation of Human Factors in Marine Casualties and Incidents, as set out in the Annex to the present resolution;
2. INVITES Governments to implement the Guidelines as soon as practicable, as far as national law allows, with a view to improving the quality and completeness of casualty investigations and reports;
3. REQUESTS the Maritime Safety Committee and the Marine Environment Protection Committee to keep the Guidelines under review and to amend them as necessary.

ANNEX

AMENDMENTS TO THE CODE FOR THE INVESTIGATION OF MARINE CASUALTIES AND INCIDENTS (RESOLUTION A.849(20))

- 1 The existing appendix is renumbered as appendix 1.
- 2 A new appendix 2 is added as follows:

"APPENDIX 2

GUIDELINES FOR THE INVESTIGATION OF HUMAN FACTORS IN MARINE CASUALTIES AND INCIDENTS

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1 INTRODUCTION - PURPOSE OF THE GUIDELINES

1.1 The purpose of these Guidelines is to provide practical advice for the systematic investigation of human factors in marine casualties and incidents and to allow the development of effective analysis and preventive action. The long-term intent is to prevent similar casualties and incidents in the future¹.

1.2 Ships operate in a highly dynamic environment; frequently the people on board follow a set routine of shift work disrupted by arrival at, working in, and sailing from port. This is an existence which involves living in the place of work for prolonged periods, creating a unique form of working life which almost certainly increases the risk of human error.

1.3 Historically, the international maritime community has approached maritime safety from a predominantly technical perspective. The conventional wisdom has been to apply engineering and technological solutions to promote safety and to minimize the consequences of marine casualties and incidents. Accordingly, safety standards have primarily addressed ship design and equipment requirements. Despite these technical innovations, significant marine casualties and incidents have continued to occur.

¹ For the purpose of these Guidelines, the term "marine casualties and incidents" includes occupational accidents resulting in loss of life or serious personal injury.

1.4 Analyses of marine casualties and incidents that have occurred over the past 30 years have prompted the international maritime community, and the various safety regimes concerned, to evolve from an approach which focuses on technical requirements for ship design and equipment to one which seeks to recognize and more fully address the role of human factors in maritime safety within the entire marine industry. These general analyses have indicated that given the involvement of the human in all aspects of marine endeavours, including design, manufacture, management, operations and maintenance, almost all marine casualties and incidents involve human factors.

1.5 One way the maritime community has sought to address the contribution of the human factor to marine casualties and incidents has been to emphasize the proper training and certification of ships' crews. It has become increasingly clear, however, that training is only one aspect of the human factor. There are other factors which contribute to marine casualties and incidents which must be understood, investigated and addressed. The following are examples of these factors relevant to the maritime industry: communication, competence, culture, experience, fatigue, health, situational awareness, stress and working conditions.

1.6 Human factors which contribute to marine casualties and incidents may be broadly defined as the acts or omissions, intentional or otherwise, which adversely affect the proper functioning of a particular system, or the successful performance of a particular task. Understanding human factors thus requires a study and analysis of the design of the equipment, the interaction of the human operator with the equipment, and the procedures followed by crew and management.

1.7 It has been recognized that there is a critical need for guidance for accident investigators which will help them to identify specific human factors which have contributed to marine casualties and incidents. There is also a need to provide practical information on techniques and procedures for the systematic collection and analysis of information on human factors during investigations. These Guidelines seek to fulfil those needs. They include a list of topics which should be considered by investigators, and procedures for recording and reporting the results.

1.8 These Guidelines should result in an increased awareness by all involved in the marine industry of the role human factors play in marine casualties and incidents. This awareness should lead to proactive measures by the maritime community which in turn should result in the saving of lives, ships, cargo and the protection of the marine environment, improvements to the lives of marine personnel, and more efficient and safer shipping operations.

1.9 These Guidelines apply, as far as national laws allow, to the investigation of marine casualties or incidents in which either one or more States have a substantial interest because the casualty or incident involves a ship under or within their jurisdiction.

2 INVESTIGATION PROCEDURES AND TECHNIQUES

2.1 A systematic approach

2.1.1 The following is a process that provides a step-by-step systematic approach for use in the investigation of human factors. The process is an integration and adaptation of a number of established human factor frameworks. The process can be applied to any type of marine casualty or incident and consists of the following steps:

- .1 collect occurrence data;

- .2 determine occurrence sequence;
- .3 identify unsafe acts or decisions and unsafe conditions,

and then for each unsafe act or decision,

- .4 identify the error type or violation;
- .5 identify underlying factors; and
- .6 identify potential safety problems and develop safety actions.

This process is detailed in appendix 1.

2.1.2 A systematic approach to step 1 is crucial to ensure that critical information is not overlooked or lost and that a comprehensive analysis can be made.

2.1.3 Step 2 involves organizing the data collected in step 1 to develop a sequence of events and circumstances.

2.1.4 In step 3, the information gathered and organized is used to initiate the identification of occurrence causal factors, i.e., unsafe acts, decisions or conditions. Once an unsafe act, decision or condition has been identified, the next stage is to determine the genesis of that particular act, decision or condition.

2.1.5 Step 4 is initiated in order to specify the type of error or violation involved in each identified unsafe act or decision.

2.1.6 In step 5, the focus is on uncovering the underlying factors behind the unsafe act, decision or condition. Fundamental to the process is the notion that for each underlying factor there may be one or more associated unsafe acts, decisions or conditions. The re-examination of each step of the process may show where further investigation is necessary.

2.1.7 Finally, step 6 requires the identification of potential safety problems and the proposing of safety action based on the identified underlying factors.

2.2 General consideration

An occurrence may result in serious injury, illness, damage or environmental impact and sometimes all four. The purpose of a marine casualty or occurrence safety investigation is to *prevent* recurrence of similar occurrences by identifying and recommending remedial action. All minor occurrences of high potential in terms of credible result should be subjected to a full investigation. Studies have shown that occurrences can have many causal factors and that underlying causes often exist remote from the incident site. Proper identification of such causes requires timely and methodical investigation, going far beyond the immediate evidence and looking for underlying conditions which may cause other future occurrences. Occurrence investigation should therefore be seen as a means of identifying not only immediate causes, but also failures in the total management of the operation from policy through to implementation. For this reason investigations should be broad enough to meet these overriding criteria.

2.2.1 Timing of the investigation

An investigation should be carried out as soon as possible after an occurrence. The quality of evidence, particularly that relying on the accuracy of human recollection, can deteriorate rapidly with time, and delayed investigations are usually not as conclusive as those performed promptly. A prompt investigation is also a good demonstration of commitment by all those concerned.

2.2.2 The occurrence site

Where possible, the site of the occurrence should be left unchanged until the investigation team has inspected it. Where this is not possible, for instance because of the need to make essential and immediate repairs following serious structural damage, the scene should be documented by photographs, audio-visual recordings, sketches or any other relevant means available with the object of preserving vital evidence and possibly recreating the circumstances at a later date. Of particular importance is the recording of the position of individuals at the site, the condition and position of equipment, supervisory instructions, work permits and recording charts. Damage or failed components should be kept in a secure location to await the arrival of the investigation team, who may require detailed scientific examination of certain key objects. Such key objects should be carefully marked.

2.2.3 Witness information

Once the situation in the immediate aftermath of an occurrence has been stabilised and the threat to people, plant and the environment has been removed, everyone involved should commit their recollections to paper to assist in preserving their memory of events. In the event that local authorities take over responsibility for the investigation, the organisation/company involved should nominate a focal point to liaise with the authorities and to assist them in assembling the information they require. Where necessary, legal assistance should be provided.

2.2.4 Background information

Appropriate background information should be obtained before visiting the occurrence location. Such information might include, but is not necessarily limited to:

- procedures for the type of operation involved;
- records of instructions / briefings given on the particular job being investigated;
- location plans;
- command structure and persons involved;
- messages, directions, etc., given from base/headquarters concerning the work;
- ship particulars and plans; and
- any other relevant information that may enable the investigator to understand the context of the incident.

2.2.5 The investigation sequence

2.2.5.1 The method for fact-finding while conducting an investigation includes, but is not necessarily limited to, the following activities:

- inspecting the location;
- gathering or recording physical evidence;
- interviewing witnesses taking into account cultural and language differences (on-site and external);
- reviewing of documents, procedures and records;
- conducting specialised studies (as required);
- identifying conflicts in evidence;
- identifying missing information; and
- recording additional factors and possible underlying causes.

2.2.5.2 Following the fact-finding a typical marine casualty or incident investigation includes analysis of the facts, conclusions and safety recommendations.

2.2.6 Fact-finding

2.2.6.1 The objective of this stage of the investigation is to collect as many facts as possible which may help understanding of the incident and the events surrounding it. The scope of any investigation can be divided into five areas:

- people;
- environment;
- equipment;
- procedures; and
- organization.

2.2.6.2 Conditions, actions or omissions for each of these may be identified, which could be factors contributing to the incident or to subsequent injury, damage or loss.

2.2.6.3 During the initial stages of every investigation, investigators should aim to gather and record all the facts which may be of interest in determining causes. Investigators should be aware of the danger of reaching conclusions too early, thereby failing to keep an open mind and to consider the full range of possibilities. With this in mind, it is recommended that the fact-finding stage of the investigation process itself be kept separate from the complete analysis of the collected evidence leading to conclusions and recommendations, and that a structured methodology be adopted to ensure the effectiveness of that analysis. The analysis may well help to identify missing pieces of evidence, or different lines of enquiry that may otherwise have gone undetected.

2.2.6.4 Investigation checklists can be very useful in the early stages to keep the full range of enquiry in mind, but they cannot cover all possible aspects of an investigation, neither can they follow all individual leads back to basic causal factors. When checklists are used, their limitations should be clearly understood.

2.2.6.5 The initial stages of an investigation normally focus on conditions and activities close to the incident and only primary causes, also called "active failures", are usually identified at this stage. However, conditions or circumstances underlying these causes, also called "latent failures", should also be investigated.

2.2.6.6 A factor to consider during an investigation is recent change. In many cases it has been found that some change occurred prior to an occurrence which, combining with other causal factors already present, served to initiate the occurrence. Changes in personnel, organisation, procedures, processes, and equipment should be investigated, particularly the hand-over of control and instructions, and the communication of information about the change to those who needed to know.

2.2.6.7 The effect of work cycles and work-related stress could have an impact on an individual's performance prior to an occurrence. The impact of social and domestic pressures (so-called error-enforcing conditions) related to an individual's behaviour should not be overlooked.

2.2.6.8 Information should be verified wherever possible. Statements made by different witnesses may conflict and further supporting evidence may be needed. To ensure that all the facts are uncovered, the broad questions of "who?, what?, when?, where?, why?, and how?" should be asked.

2.2.7 Conducting interviews

2.2.7.1 An interview should start with the introduction of the interviewing party, the purpose of the investigation and of the interview, and the possible future use to be made of the knowledge and material obtained during the interview. Investigators should be guided by the requirements of national law regarding the presence of legal advisers or other third parties during an interview.

2.2.7.2 People should be interviewed singly and be asked to go step-by-step through the events surrounding the occurrence, describing both their own actions and the actions of others. The interviewer should take into account the culture and language of the interviewee.

2.2.7.3 Notwithstanding any previously made written statements, the value of a witness's statement can be greatly influenced by the style of the interviewer, whose main task is to listen to the witness's story and not to influence him/her.

2.2.7.4 If the investigation is a team effort, great care should be taken not to make a witness feel intimidated by too many interviewers. Experience has shown that interviews can be effectively conducted by two interviewers and if appropriate, the witness could be accompanied by an independent "friend".

2.2.7.5 It should be remembered that an investigation team is often seen as having a prosecuting role, and there may be reluctance to talk freely if interviewees think they may incriminate themselves or their colleagues. An investigator is not in the position to give immunity in return for evidence, but should try to convince interviewees of the purpose of the investigation and of the need for frankness.

2.2.7.6 In addition to requiring both patience and understanding, successful interviewing requires the existence of a "no-blame" atmosphere in which the witness can be made to feel comfortable and is encouraged to tell the truth. It is not the role of the interviewer, or indeed the investigation team, to apportion blame. Their role is to establish the facts and to establish why the occurrence happened.

2.2.7.7 At the end of an interview the discussion should be summarised to make sure that no misunderstandings exist. A written record may be made of the interview and this may be discussed with the witness to clarify any anomalies. Subject to any national law, it may be possible to provide the interviewee with a copy of the written record.

2.2.8 Selection of interviewees

Established marine casualty and incident investigation procedures should be taken into account when determining whom to interview following a marine casualty. Safety concerns should be paramount in the scheduling of interviews.

The aim should always be to get the investigation team to the site of the occurrence as soon as possible and to interview those most closely involved, which in the marine sense will always be the ship first. When that is not possible due to external factors such as the geographical location of the occurrence or political considerations, it may be possible to nominate a local representative to carry out an interim investigation. From an investigation management point of view, it should be possible to start the process by carrying out at least some interviews of individuals ashore.

It may not be possible to speak directly with port or pilotage authorities in some parts of the world. Where that is so, every effort should be made to obtain at least a transcript of the pilot's statement if one is involved. In the event of a collision in enclosed waters, evidence from the operators of shore-based electronic surveillance equipment can be particularly useful.

There are no "hard and fast" rules for selecting whom to interview, and the following is offered as an example only:

2.2.8.1 On site (those nearest the incident)

Generally it is beneficial to begin the interview process with the ship management team, including the master and chief engineer, who typically can provide an overview of the occurrence.

- First-hand witnesses present at the occurrence site at the time of the occurrence itself, regardless of rank/position in the organization.
- First-hand witnesses present at the occurrence site at the time of the occurrence itself, but from outside the organization, for instance berthing or mooring assistants, or visiting personnel such as agents or contractors.
- First-hand witnesses present at the time of the occurrence but not at the occurrence location itself, for instance ship's staff on the bridge of a ship witnessing a mooring occurrence on the main deck below.
- First-hand witnesses present at the time of the occurrence but not at the occurrence location itself and from outside the organization, for instance a pilot on the bridge witnessing a mooring occurrence on the main deck below.
- Those not involved with the occurrence itself but involved in the immediate aftermath of an occurrence, for instance those engaged in damage control, shipboard fire-fighting or first-aid medical treatment.

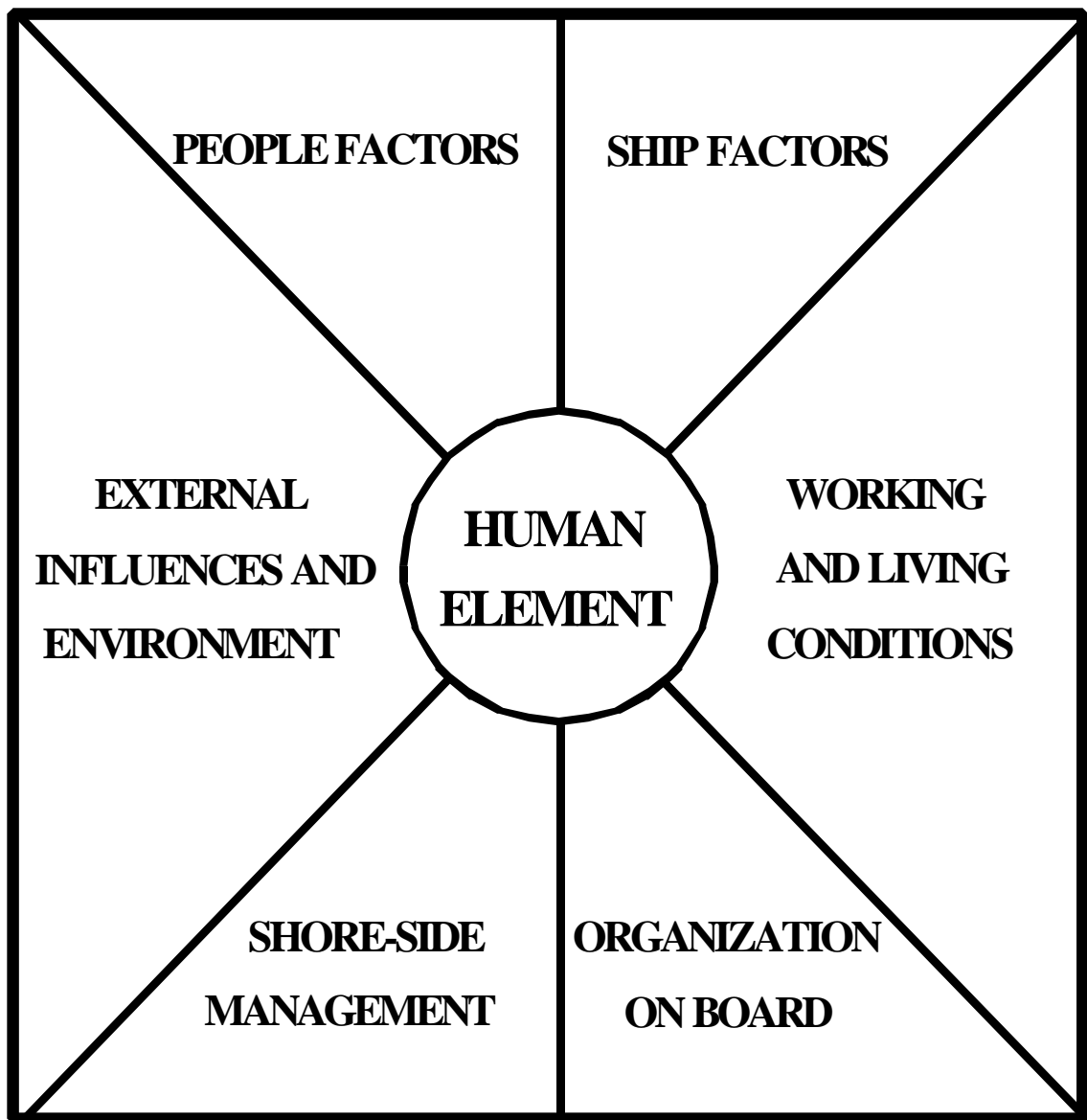
- Tug, mooring boat or pilot cutter crews.
- Search and rescue personnel including helicopter crews.
- Shore-based fire-fighters.
- Jetty/terminal staff.
- Other vessels in the immediate vicinity.
- Operators of Vessel Traffic Services (VTS) or monitoring systems.

2.2.8.2 Remote from occurrence site

- Designated person under the ISM Code.
- Ship operators ashore.
- Technical superintendents ashore.
- Company general managers ashore.
- Specialists/consultants (relevant to the occurrence).
- Port State inspectors.
- Flag State inspectors.
- Regulatory authorities.
- Representatives of classification societies.
- Safety committee members including crew representatives.
- Designers, shipbuilders, manufacturers and repairers.

2.3 Topics to be covered by the investigator²

The diagram below shows a number of factors that have a direct or indirect impact on human behaviour and the potential to perform tasks.



The headings in the diagram are expanded below:

² Appendix 2 provides appropriate areas of inquiry and Appendix 3 provides definitions of common human element terms.

2.3.1 People factors

- ability, skills, knowledge (outcome of training and experience)
- personality (mental condition, emotional state)
- physical condition (medical fitness, drugs and alcohol, fatigue)
- activities prior to accident/occurrence
- assigned duties at time of accident/occurrence
- actual behaviour at time of accident/occurrence
- attitude

2.3.2 Organization on board

- division of tasks and responsibilities
- composition of the crew (nationality/competence)
- manning level
- workload/complexity of tasks
- working hours/rest hours
- procedures and standing orders
- communication (internal and external)
- on-board management and supervision
- organization of on-board training and drills
- teamwork, including resource management
- planning (voyages, cargo, maintenance)

2.3.3 Working and living conditions

- level of automation
- ergonomic design of working, living and recreation areas and equipment
- adequacy of living conditions
- opportunities for recreation

- adequacy of food
- level of ship motion, vibrations, heat and noise

2.3.4 Ship factors

- design
- state of maintenance
- equipment (availability, reliability)
- cargo characteristics, including securing, handling and care
- certificates

2.3.5 Shore-side management

- policy on recruitment
- safety policy and philosophy (culture, attitude and trust)
- management commitment to safety
- scheduling of leave periods
- general management policy
- port scheduling
- contractual and/or industrial arrangements and agreements
- assignment of duties
- ship-shore communication

2.3.6 External influences and environment

- weather and sea conditions
- port and transit conditions (VTS, pilots, etc)
- traffic density
- ice conditions
- organizations representing shipowners and seafarers
- regulations, surveys and inspections (international, national, port, classification societies, etc.)

2.4 Analysis

Once facts are collected, they need to be analysed to help establish the sequence of events in the occurrence, and to draw conclusions about safety deficiencies uncovered by the investigation. Analysis is a disciplined activity that employs logic and reasoning to build a bridge between the factual information and the conclusions.

The first step in analysis is to review the factual information to clarify what is relevant and what is not, and to ensure the information is complete. This process can give guidance to the investigator as to what additional investigation needs to be carried out.

In normal investigation practice, gaps in information that cannot be resolved are usually filled in by logical extrapolation and reasonable assumptions. Such extrapolation and assumptions should be identified and a statement of the measure of certainty provided.

Despite best efforts, analysis may not lead to firm conclusions. In these cases, the more likely hypotheses should be presented.

2.4.1 Fact-finding and analysis

After fact-finding and analysis it should be possible to give a description of the occurrence, its background, the time it took place, and the events leading to it.

The description should include such factual items as:

- the weather conditions;
- the operation(s) involved;
- the equipment in use, its capabilities, performance and any failures;
- the location of key personnel and their actions immediately before the incident;
- the pertinent regulations and instructions;
- uncontrolled hazards;
- changes of staff, procedures, equipment or processes that could have contributed to the occurrence;
- what safeguards were or were not in place to prevent the incident;
- response to the occurrence (first-aid, shut-down, fire-fighting, evacuation, search and rescue);
- medical treatment actions taken to mitigate the effects of the occurrence and the condition of injured parties, particularly if disabling injuries or death ensued;

- damage control including salvage;
- inventory of all consequences of the occurrence (injury, loss, damage or environmental damage); and
- general ship's condition.

It should also be possible to identify active and underlying factors such as:

- operational deviations;
- design aspects of hull structural failure;
- defects in resources and equipment;
- inappropriate use of resources and equipment;
- relevant personnel skill levels and their application;
- physiological factors (e.g. fatigue, stress, alcohol, illegal drugs, prescription medicine);
- why safeguards in place were inadequate or failed;
- role of safety programmes;
- problems relating to the effectiveness of regulations and instructions;
- management issues; and
- communication issues.

2.5 Safety action

2.5.1 The ultimate goal of a marine safety investigation is to advance maritime safety and protection of the marine environment. In the context of these Guidelines, this goal is achieved by identifying safety deficiencies through a systematic investigation of marine casualties and incidents, and then recommending or effecting change in the maritime system to correct these deficiencies.

2.5.2 In a report that clearly lays out the facts relevant to the occurrence, and then logically analyses those facts to draw reasoned conclusions including those relating to human factors, the required safety action may appear self-evident to the reader.

2.5.3 Recommended safety action in whatever form should clearly identify what needs to be done, who or what organization is responsible for effecting change, and, where possible, the urgency for completion of the change.

3 REPORTING PROCEDURES

3.1 To facilitate the flow of information from casualty investigations, each report should conform to a basic format as outlined in section 14 of this resolution.

3.2 Reports should be made to IMO in accordance with established procedures³.

3.3 Persons and/or organizations with a vested interest in a report should be given the opportunity to comment on the report or relevant parts thereof before it is finalized.

3.4 The final report should be distributed to relevant parties involved and should preferably be made public.

4 QUALIFICATIONS AND TRAINING OF INVESTIGATORS

4.1 A variety of contributory factors can play a significant part in the events preceding a marine casualty or incident. The question of who should be charged with the responsibility for investigating and analysing human factors therefore becomes important. The skilled marine casualty and incident investigator generally is the person best suited to conduct all but the most specialized aspects of human factor investigation.

4.2 An investigator should have appropriate experience and formal training in marine casualty investigation. The formal training should include specific training in the identification of human factors in marine casualties and incidents.

4.3 In some cases, a human factors specialist may be of significant value in the investigation.

³ Refer to MSC/Circ.827-MEPC/Circ.333 of 9 December 1997 on reports on marine casualties and incidents.

APPENDIX 1

THE IMO/ILO PROCESS FOR INVESTIGATING HUMAN FACTORS

The following is a process that provides a step-by-step systematic approach for use in the investigation of human factors. The process is an integration and adaptation of a number of human factor frameworks - SHEL (Hawkins, 1987) and Reason's (1990) Accident Causation and generic error-modelling system (GEMS) frameworks, as well as Rasmussen's Taxonomy of Error (1987).

The process can be applied to both types of occurrences, i.e., accidents and incidents. The process consists of the following steps:

- .1 collect occurrence data;
- .2 determine occurrence sequence;
- .3 identify unsafe acts/decisions and unsafe conditions;

and then for each unsafe act/decision,

- .4 identify the error type or violation;
- .5 identify underlying factors; and
- .6 identify potential safety problems and develop safety actions.

Steps 3 to 5 are useful to the investigation because they facilitate the identification of latent unsafe conditions. Step 6, the identification of potential safety problems, is based extensively on what factors were identified as underlying factors. At times, an unsafe condition may be a result of a natural occurrence; in that case, the investigator may jump from step 3 to step 6. At other times, an unsafe act or decision may result from an unsafe condition which itself was established by a fallible decision; in such a case, the investigator should proceed through steps 3 to 6.

Step 1 - Collect occurrence data

The first step in the human factors investigation process is the collection of work-related information regarding the personnel, tasks, equipment, and environmental conditions involved in the occurrence. A systematic approach to this step is crucial to ensure that a comprehensive analysis is possible and that the logistical requirements of collecting, organizing and maintaining a relevant occurrence related database are met.

For complex systems, where there are numerous interactions between the component elements, there is constant danger that critical information will be overlooked or lost during an investigation.

Use of the SHEL model as an organizational tool for the investigator's workplace data collection helps avoid downstream problems because:

- .1 it takes into consideration all the important work system elements;

- .2 it promotes the consideration of the interrelationships between these work system elements; and
- .3 it focuses on the factors which influence human performance by relating all peripheral elements to the central liveware element.

The process initially attempts to answer the more simplistic questions of "what, who, and when" and then moves to the more complicated questions of "how and why". The resulting data becomes, for the most part, a collection of events and circumstances comprised of acts and conditions. Some of these will be of interest as unsafe acts and unsafe conditions.

There are four components to the SHEL model:

Liveware - L

Hardware - H

Software - S

Environment - E.

The SHEL Model is commonly depicted graphically to display not only the four components but also the relationships, or interfaces, between the liveware and all the other components. Figure 1 attempts to portray the fact that the match or mismatch of the interfaces is just as important as the characteristics of the blocks themselves. A mismatch can be a source of human error and identification of a mismatch may be the identification of a safety deficiency in the system. Figure 2 also depicts how this model can be applied to a complex system where multiple liveware, hardware, software and environmental elements exist.

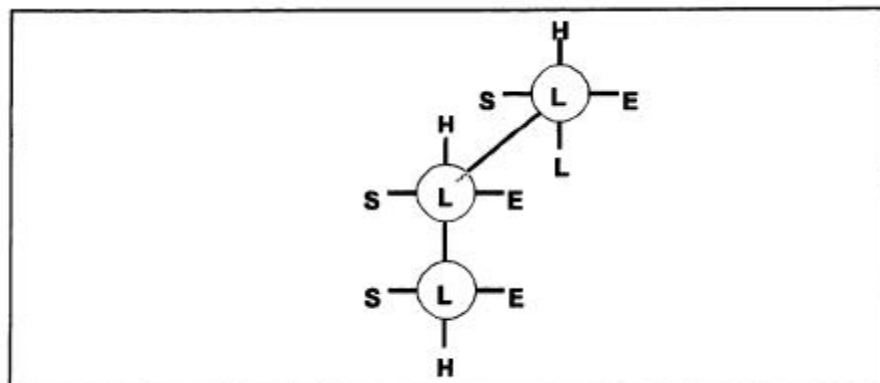


Figure 1.
(Adapted from Hawkins, 1987) SHEL Model

Liveware (central component)

The most valuable and flexible component in the system is the human element, the liveware, placed at the centre of the model. Each person brings his or her own capabilities and limitations, be they physical, physiological, psychological, or psychosocial. This component can be applied to any person involved with the operation or in support of the operation. The person under consideration interacts directly with each one of the four other elements. Each person and each interaction, or interface, constitute potential areas of human performance investigation.

Liveware (peripheral)

The peripheral liveware refers to the system's human-human interactions, including such factors as management, supervision, crew interactions and communications.

Hardware

Hardware refers to the equipment part of a transportation system. It includes the design of work stations, displays, controls, seats, etc.

Software

Software is the non-physical part of the system including organizational policies, procedures, manuals, checklist layout, charts, maps, advisories and, increasingly, computer programs.

Environment

Environment includes the internal and external climate, temperature, visibility, vibration, noise and other factors which constitute the conditions within which people are working. Sometimes the broad political and economic constraints under which the system operates are included in this element. The regulatory climate is a part of the environment inasmuch as it affects communications, decision-making, control, and co-ordination.

Step 2 - Determine occurrence sequence

As the investigator moves to addressing questions of "how and why", there is a need to link the data identified in the first step of the process. Reason's (1990) model of accident causation, utilizing a production framework, can be used by an investigator as a guide to developing an occurrence sequence. Reason's model facilitates further organization of the work system data collected using the SHEL model, and an improved understanding of the influence of that data on human performance. The occurrence sequence is developed by arranging the information regarding occurrence events and circumstances around one of five production elements, i.e., *decision makers, line management, preconditions, productive activities, and defence*.

The production elements themselves are basically aligned in a temporal context. This temporal aspect is an important organizing factor since the events and circumstances that can lead to an accident or incident are not necessarily proximate in time, nor in location, to the site of occurrence. By establishing a sequential ordering of the data, Reason's (1990) concept of *active* versus *latent* factors is introduced.

Active factors are the final events or circumstances which led to an occurrence. Their effect is often immediate because they occur either directly in the system's defence (e.g., disabled warning system) or the site of the productive activities (i.e., the integrated activities of the work system's *liveware*, *software* and *hardware* elements), which would indirectly result in the breaching of the system's defence (e.g., use of the wrong procedure).

Underlying factors may reside at both the personal and the organizational levels; they may be present in the conditions that exist within a given work system (referring to the preconditions element in the model). Examples of *underlying factors* include inadequate regulations, inadequate procedures, insufficient training, high workload and undue time pressure.

In practice, steps 1 and 2 may not be mutually exclusive. As the investigator begins the data collection step, it would be only natural that an attempt be made to place the information, albeit often fragmentary in the preliminary stages of an investigation, into the context of an occurrence sequence. To facilitate this concurrent activity, the SHEL and Reason models can be combined as illustrated in figure 2.

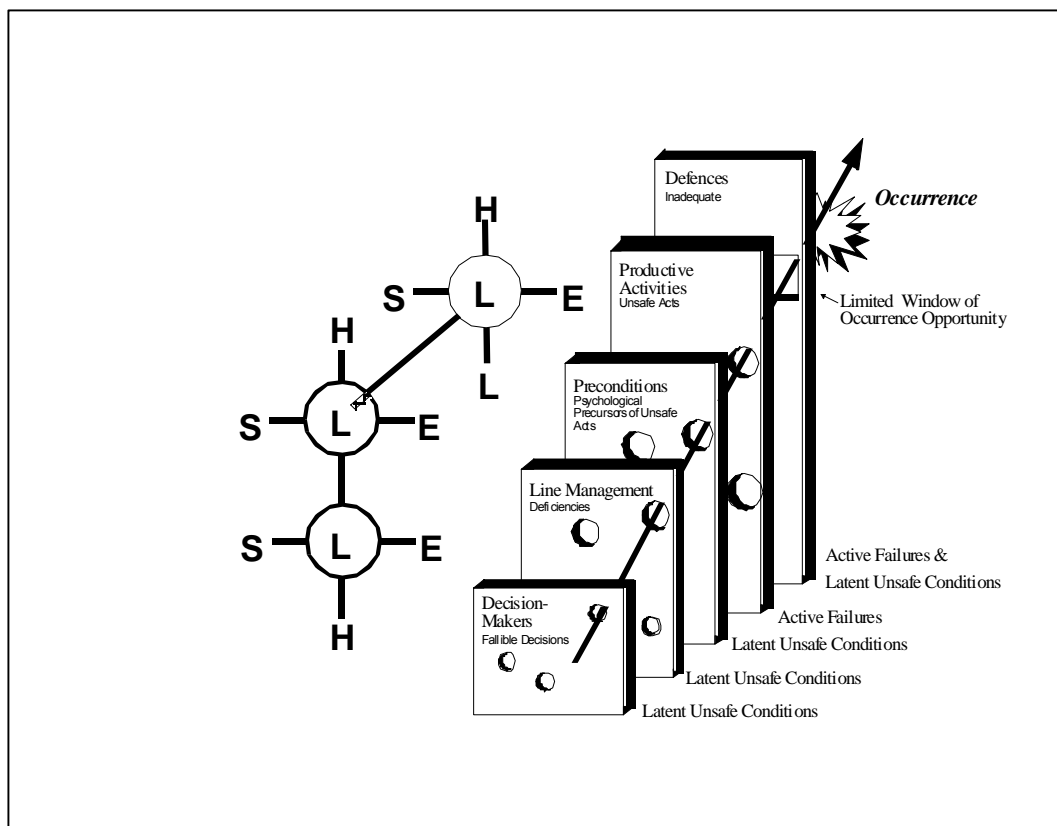


Figure 2
SHEL and Reason Hybrid Model

The data collected during an investigation (i.e. events and circumstances) can be organized, using multiple components of the modified SHEL model, into a framework surrounding an occurrence template (in this case the occurrence scenario), based upon the Reason model. Causal factors, i.e. the unsafe acts/decisions and conditions, are thereby identified.

Steps 3 to 5 - An overview

Steps 3 to 5 are based upon the GEMS framework. The framework provides "pathways" that lead from the identification of the unsafe act/decision (Step 3) to the identification of what was erroneous about the action or decision (Step 4) and finally to its placement within a behavioural context (i.e., a failure mode within a given level of performance in Step 5). The GEMS framework illustrated in figure 3 is particularly useful in exploring hypothetical reconstructions of the occurrence.

Step 3 - Identify unsafe acts/decisions and conditions

In step 3 of the process, the information gathered and organized using the SHEL and Reason frameworks is used to initiate identification of causal factors, i.e., unsafe acts/decisions and conditions. An unsafe act is defined as an error or violation that is committed in the presence of a hazard or potential unsafe condition. Decisions where there are no apparent resultant actions but which have a negative impact on safety should also be considered as unsafe acts. An unsafe condition or hazard, as noted above, is an event or circumstance that has the potential to result in a mishap. There may be several acts, decisions and/or conditions which are potential unsafe candidates, thus necessitating iterative assessments of the occurrence facts. The SHEL and Reason hybrid tool (refer to figure 2) can provide a useful base for conducting such iterative assessments.

Once an unsafe act, decision or condition has been identified, the next stage is to determine the genesis of that particular act or condition. Further investigation and/or analysis may reveal other unsafe acts/decisions or conditions antecedent to the causal factor that was initially identified.

As noted earlier, several unsafe acts and decisions may be identified throughout steps 1 and 2 of the process. The last unsafe act precipitating the occurrence often provides a convenient starting point for reconstruction of the occurrence. This last act or decision differs from the others in that it can be viewed as the definitive action or decision which led to the occurrence, i.e., the last act or decision that made the accident or incident inevitable - **the primary cause of the initial event**. Although it is usually an active failure, the last unsafe act or decision can be embedded in a latent unsafe condition, such as a flawed design decision which led to a system failure.

Step 4 - Identify error or violation type

This portion of the process is initiated for each unsafe act/decision by posing the simple question "What is erroneous or wrong about the action or decision that eventually made it unsafe?".

The identification of the type of error or violation involves two sub-steps (see figure 3):

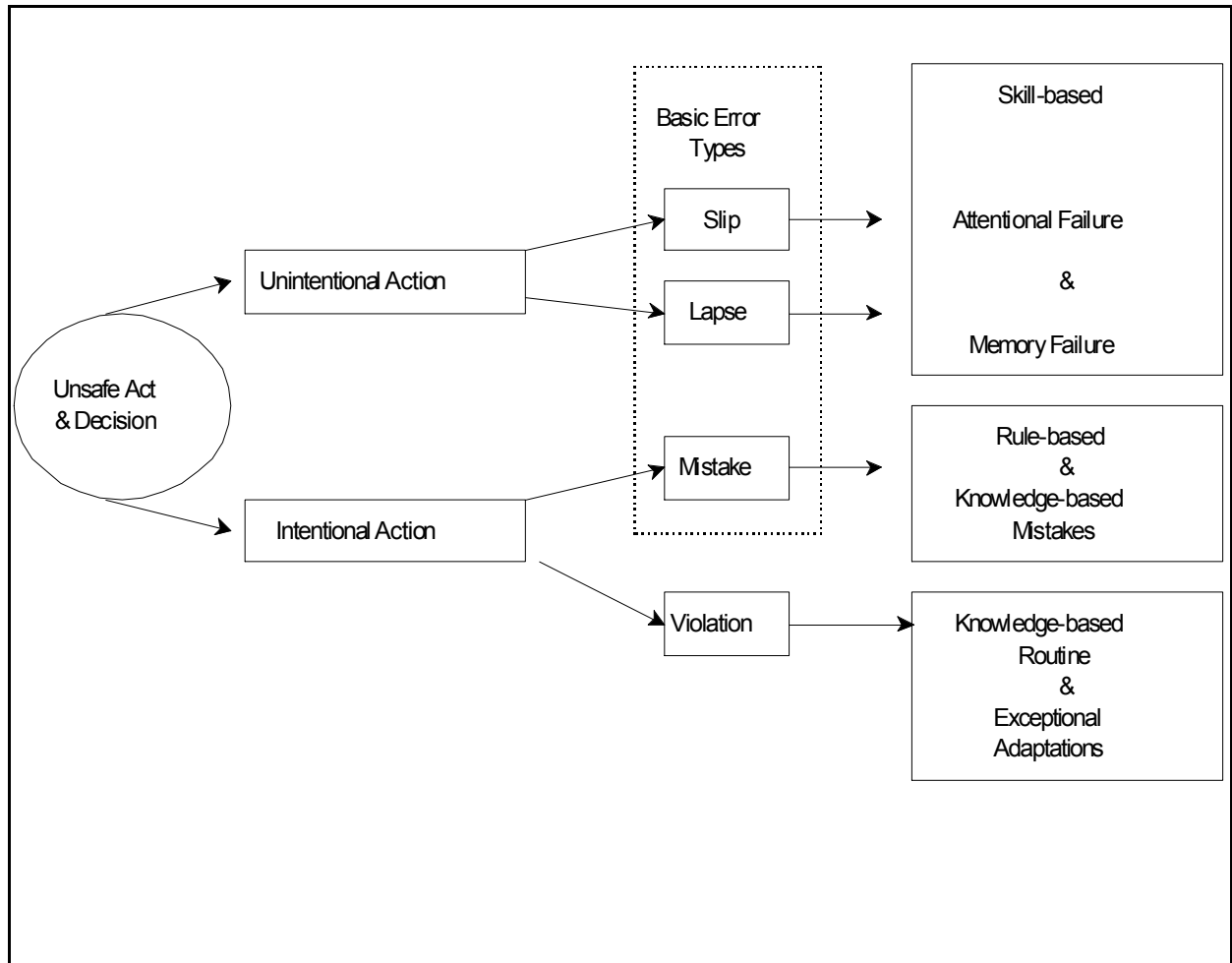


Figure 3.
The GEMS Framework
(Adapted from Reason, 1990)

The GEMS framework facilitates the linkage of an error/violation to an individual's level of performance at the time the failure occurred.

1) Unintentional or intentional action

First it is necessary to determine whether the error or violation was an unintentional or intentional action. "Did the person intend the action?" If the answer to that question is no, then it is an unintentional action. Unintentional actions are actions that do not go as planned; these are errors in execution.

If the answer to the question "Did the person intend the action?" is yes, then the action is intentional. Intentional actions are actions that are carried out as planned but the actions are inappropriate; these are errors in planning.

2) **Error type or violation**

The second sub-step is the selection of the error type or violation that best describes the failure, keeping in mind the decision regarding intentionality. There are four potential error/violation categories, i.e., *slip*, *lapse*, *mistake* and *violation*. A *slip* is an unintentional action where the failure involves attention. These are errors in execution. A *lapse* is an unintentional action where the failure involves memory. These are also errors in execution. A *mistake* is an intentional action, but there is no deliberate decision to act against a rule or plan. These are errors in planning. A *violation* is a planning failure where a deliberate decision to act against a rule or plan has been made. Routine violations occur everyday as people regularly modify or do not strictly comply with work procedures, often because of poorly designed or defined work practices. In contrast, an exceptional violation tends to be a one-time breach of a work practice, such as where safety regulations are deliberately ignored to carry out a task. Even so, the intention was not to commit a malevolent act but just to get the job done.

Step 5 - Identify underlying factors

The designation of separate activities implied by steps 4 and 5 may be somewhat arbitrary in terms of what actually occurs when an investigator attempts to reveal the relationship between the occurrence errors/violations and the behaviour that lead to them. In simplest terms, behaviour consists of a decision and an action or movement. In step 3, the action or decision (i.e., unsafe act or decision) was identified. In step 4, what was erroneous regarding that action or decision was revealed. In step 5, the focus is on uncovering the underlying causes behind the act or decision of an individual or group. To do so it is important to determine whether there were any factors in the work system that may have facilitated the expression of the given failure mode (and hence the error/violation and the unsafe act). These factors have been termed underlying factors. They can be found by examining the work system information collected and organized using the SHEL or Reason frameworks in steps 1 and 2. The re-examination of these data emphasizes the iterative nature of this investigative process in that it may even be deemed necessary to conduct further investigations into the occurrence.

Step 6 - Identify potential safety problems and develop safety actions

The identification of potential safety problems is based extensively on what factors were identified as underlying factors. Once again this underscores the importance of the application of a systematic approach to steps 1 and 2 of the process, which lays the foundation for the subsequent analysis steps. Where appropriate, potential safety problems can be further analysed to identify the associated risk to the system and to develop safety actions.

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APPENDIX 2

AREAS OF HUMAN FACTORS INQUIRY

The following questions are designed to aid the investigator while investigating for human factors. Skilful questioning can help the investigator eliminate irrelevant lines of inquiry and focus on areas of greater potential significance.

The order and manner in which the questions are asked will depend on who is being interviewed and on his or her willingness and ability to describe personal behaviour and personal impressions. It may be necessary to verify, cross-check or augment information received from one person by interviewing others on the same points.

These areas of inquiry can be used in planning interviews. The following questions are not meant to be exhaustive, or be used as a checklist, and some may not be relevant in the investigation of a particular accident. As new human factors issues emerge, new areas of inquiry will need to be explored by investigators.

SHIPBOARD ISSUES

1 Safety policy

- .1 Does the company have a written safety policy?
- .2 Is there a designated person to deal with shipboard safety matters in the company?
- .3 When did a company representative last visit the ship, or when were you last in contact with the company?
- .4 When were you last given safety training? What was the training and how was it provided?
- .5 When was the last emergency drill (e.g., fire, abandon ship, man overboard, pollution response, etc) and what did you do during the drill?
- .6 Was appropriate personal protective equipment provided and did you use it?
- .7 Are you aware of any personal accidents which occurred on board in the period prior to the accident?

2 Activities prior to incident

- .1 (If the ship was leaving port at the time of the accident) In general, how did you spend your time while the ship was in port?
- .2 (If the ship was approaching port or at sea at the time of the accident) How long has the ship been on passage since its last port or terminal operation?
- .3 What were you doing immediately prior to coming on watch or reporting for duty, and for how long? Recreational activity? Physical exercise? Sleeping? Reading? Watching television? Eating? Paperwork? Travelling to vessel?
- .4 Specifically what were you doing approximately 4 h, 1 h, 30 min before the accident?
- .5 What evolution was the ship involved in when the accident occurred? What was your role during that evolution?
- .6 Immediately prior to the accident, what were you thinking about?
- .7 At any time before the accident, did you have any indication that anyone was tired or unable to perform their duty?

3 Duties at the time of accident

- .1 Where were you on the ship when the accident occurred?
- .2 What specific job or duty were you assigned at the time? By whom? Did you understand your assignment? Did you receive any conflicting orders?
- .3 How often have you performed this job in the past (on the specific ship involved in the accident)?

4 Actual behaviour at time of accident

- .1 Precisely where were you located at the time of the accident?
- .2 What specific task were you performing at the time of the accident?
- .3 Had you at any time since reporting for duty found that you could not concentrate (focus your attention/keep your mind) on a task you were trying to perform?

5 Training/education/certification/professional experience

- .1 How long have you been assigned to this ship? Have you requested that your assignment be lengthened or shortened?
- .2 How long have you filled your crew position? What other crew positions have you held on this ship?
- .3 How long have you held the certificate indicating your qualifications?
- .4 Before being assigned to this ship, did you work on other ships? If so, what crew positions have you held?
- .5 What is the longest time you have been to sea in a single voyage? How long have you been at sea on this passage? What was your longest single passage?

6 Physical condition

- .1 Were you feeling ill or sick at any time in the 24 hours immediately before the accident? If so, what symptoms did you have? Did you have a fever, vomit, feel dizzy, other? Also, did you tell anyone? What do you believe the cause was?
- .2 When was the last meal you had prior the accident? What did you eat? Was it adequate?
- .3 Do you exercise regularly while on board? When did you last exercise (before the accident)? How long was the session?

7 Psychological, emotional, mental condition and employment conditions

- .1 When was the last time you felt cheerful or elated on board the ship, and what were the circumstances that generated this emotion?
- .2 When was the last time you were sad or depressed or dejected, on board the ship? Why? Did you talk about it with anyone else?
- .3 Have you had to make any difficult personal decisions recently? Have you had any financial or family worries on your mind recently?
- .4 Have you been criticized for how you are doing your work lately? By whom? Was it justified?
- .5 What was the most stressful situation you had to deal with on the voyage (prior to the accident)? When did the situation occur? How was it resolved?
- .6 What are the contractual arrangements for all crew members?
- .7 Have there been any complaints or industrial action in the last (12) months?

8 Workload/complexity of tasks

- .1 What is the shipboard organization?
- .2 Is the shipboard organization effective?
- .3 What is your position in the shipboard organization (i.e., who do you work for, report to or assign duties to)?
- .4 What is the nature of your work? Sedentary? Physically demanding?
- .5 Was anyone involved in the accident impaired due to heavy workload?

9 Work-period/rest-period/recreation pattern

- .1 What is your normal duty schedule?
- .2 Are you a day worker or a watchkeeper?
- .3 What was your duty schedule on the day before the accident and during the week before the accident?
- .4 Were you on overtime at the time of the accident?
- .5 How long had you been on duty, or awake performing other work, at the time of the accident?
- .6 When was your last period of sleep? How long did it last? How often did you awaken during your last sleep period? Did you awaken refreshed? If not, what would have made your sleep period more restful?
- .7 How do you normally spend your off-duty time while on board? Play cards? Read? Listen to music? Watch television? Other?
- .8 When was your last extended period of off duty time when you were able to rest?

10 Relationship with other crew members and superiors/subordinates

- .1 Who among the crew would you consider to be a friend?
- .2 Do you find any members of the crew unpleasant to be with?
- .3 Do you have difficulty talking with any of the crew members because of language barriers?
- .4 Have any new crew members recently joined the ship? Have you had a chance to get acquainted with them?
- .5 Did you have any argument recently with another crew member?
- .6 In an emergency, would you trust your fellow crew members to come to your assistance?
- .7 Has another crew member ever offered to take your place on watch or perform a duty for you to let you get some extra rest?
- .8 What was the subject of your last conversation with another crew member before reporting for duty (when the accident occurred)?
- .9 Have you talked with any other crew members since the accident? If so, what was the subject of your conversation? Have you talked with anyone else about the accident prior to being interviewed?

11 Living conditions and shipboard environment

- .1 Do you consider your personal area on board the ship to be comfortable? If not, how would you like it to be improved?
- .2 Prior to the accident, did you have any difficulty resting as a result of severe weather, noise levels, heat/cold, ship's motion, etc.?

12 Manning levels

Is the manning level sufficient in your opinion for the operation of the ship?

13 Master's standing orders

- .1 Are there written standing orders to the whole crew complement from the master?
- .2 Did the master/chief engineer provide written or verbal standing orders to the watchkeeping personnel?
- .3 Were the orders in conflict with the company safety policy?

14 Level of automation/reliability of equipment

- .1 In your opinion, was the system reliable?
- .2 Were there earlier failures in the system?
- .3 Were the failures repaired by the crew or shore-based workers?

15 Ship design, motion/cargo characteristics

Did you observe anything out of the ordinary on this passage concerning ship design or motion or cargo characteristics?

SHORE-SIDE MANAGEMENT ISSUES

16 Scheduling of work and rest periods

What is the company's work schedule and relief policy?

17 Manning level

How is the manning level determined for your fleet?

18 Watchkeeping practices

- .1 Do you require the master to stand watch?
- .2 Do you leave the watchkeeping practices to the discretion of the master?

19 Assignment of duties

Do you leave this matter to the master?

20 Shore-ship-shore support and communications

How do you support the ship's master?

21 Management policies

Does the company have a written safety policy?

22 Voyage planning and port call schedules

How does the master plan the voyages?

23 Recreational facilities

Are welfare/recreational services and facilities provided on board?

24 Contractual and/or industrial arrangements and agreements

- .1 What are the contractual agreements for all crew members?
- .2 Have there been any complaints or industrial action in the last (12) months?

25 National/international requirements

Are the management and master complying with the requirements and recommendations of the applicable international conventions and flag State regulations?

APPENDIX 3

DEFINITIONS COMMON HUMAN ELEMENT TERMS

Human error: A departure from acceptable or desirable practice on the part of an individual or group of individuals that can result in unacceptable or undesirable results.

Diminished human performance:

Emotional: A physiological state of agitation or disturbance which can affect an individual's normal ability to perform required tasks.

Panic: A sudden overpowering fear that reduces the ability to perform required tasks.

Anxiety: A state of uneasiness and distress about future uncertainties which may reduce the ability to focus properly on a required task.

Personal problem: A problem which preoccupies the emotions and reduces the ability to perform required tasks. Examples include physical disabilities, death or illness in the family, marital and other relationship problems, health concerns, financial problems, anger, or poor interactions with shipmates.

Mental impairment: Diminished mental ability that can reduce or impede an individual's normal ability to perform the mental part of required tasks.

Alcohol use: Consumption of alcoholic beverages which diminishes an individual's abilities to perform required tasks. Examples include drinking on or too close to duty, which can impede an individual's abilities; drunkenness on duty; drinking off duty, which results in poor performance while on duty; and excessive drinking over a longer period of time, which results in a permanent decrease in mental abilities.

Drug use: Use of a medicine or narcotic which affects an individual's abilities to perform required tasks. There are many different effects on mental and physical capabilities that can result from the use of legal and illegal drugs, including extreme drowsiness, a false sense of competence, and hallucinations. The mental abilities of the user may also be distracted by the constant need to obtain more drugs. In addition, individuals may not be aware of the side-effects of legal drugs and may take them while on duty or forget to report taking them.

Inattention: The loss of attention, notice or regard; neglect. Examples include failing to monitor displays; not maintaining a proper lookout; forgetting to perform an assigned duty. Inattention may also be the result of other causes such as a personal problem, fatigue, drugs, boredom, or hearing problems.

Injury: Physical damage to the body which causes a decrease in mental or physical abilities. Examples include a head injury, other injuries such as a smashed finger, or a severe burn, where pain causes distraction and a loss of mental ability.

<i>Mental illness:</i>	Psychotic or erratic behaviour; depression; hallucinations; other forms of abnormal behaviour which are unexplainable.
<i>Physical illness:</i>	Sickness which produces a decrease in mental or physical abilities, but not generally considered as mental illness. Examples include: general disability accompanying colds and flu; hallucinations due to high fever; migraine headaches; seasickness and even severe indigestion and exposure to toxic substances.
<i>Diminished motivation:</i>	Lack of will or desire to perform well, resulting in a decrease of an individual's normal performance of required tasks.
<i>Deliberate misaction:</i>	Purposely taking an incorrect action or purposely failing to take the correct action. Examples include dereliction of duty; refusal to obey commands; sabotage, theft or ignoring procedures.
<i>Fatigue:</i>	A reduction in physical and/or mental capability as the result of physical, mental or emotional exertion, which may impair nearly all physical abilities including: strength; speed; reaction time; co-ordination; decision making, or balance.
<i>Low morale:</i>	A problem with individual or group motivation as shown by reduced willingness, confidence or discipline to perform assigned tasks. Examples/causes may include interpersonal conflict amongst the crew, officers with poor interpersonal skills, lack of a strong corporate or shipboard safety culture; excessively long tours of duty.
<i>Lack of self-discipline:</i>	Inadequate ability of an individual to control personal conduct. Examples include loss of temper or unprofessional behaviour.
<i>Visual problem:</i>	A reduced visual acuity due to a specific physical disability. Causes may include eye injury causing total or partial blindness; not wearing prescribed glasses or contacts; inability to adequately adapt to darkness.
<i>Excessive workload:</i>	Diminished physical or mental capability as the result of the sum total of all the mental and physical tasks a human must perform within a prescribed time resulting in a diminished job performance.

Marine environment:

<i>Hazardous natural environment:</i>	A situation in which the natural environment causes required tasks to become more difficult than usual. Examples include storms; high waves; shallow water; severe shoaling; strong currents or tides; ice, rocks, submerged wrecks, severe eddies, ship traffic, wind; fog; mist; rain; snow; sleet; haze; dust; airborne debris.
<i>Poor human factors design:</i>	Poor design of the ship, its subsystems, its environmental controls, engineering or its human-machine interfaces, which results in an increased difficulty to perform shipboard tasks. Examples of poor human factors engineering design include inadequate lighting; excessive noise; excessive vibration; inadequate heating, cooling, or ventilation systems; hazardous deck stair, ladder, bulkhead, or work surfaces; inadequate provision for foul weather or degraded mode operations; inadequate restraints, guards, or hand-holds; poor workstation orientation in regard to ship dynamics; poor

hull seakeeping characteristics; controls which allow accidental actuation; illegible or ambiguous control markings; illegible or ambiguous displays or display labels; poor layout, sizing, and colouring of controls and displays; inadequate design for operational or maintenance access; inadequate design for safety.

Poor operations: A situation in which individuals or groups of individuals degrade the shipboard environment making the performance of some required tasks more difficult. Examples include ship manoeuvres (e.g. increased speed, change in course, erratic manoeuvres) impact on ship dynamics, causing balance and restraint difficulties when personnel performing one task interfere with those performing another; or where storage of cargo impedes access or transit.

Poor maintenance: Failure to keep any part of the ship or its equipment in the condition in which it was designed to function within a designated lifetime or operational period, thus degrading the shipboard environment and making the performance of some required tasks more difficult. Examples of poor maintenance impacting on required tasks: inadequate replacement parts and tools to perform proper maintenance, resulting from a lack of commitment from management.

Safety administration:

Inadequate technical knowledge: Not having, due to inadequate experience and/or training, the general knowledge which is required for the individual's job on board. Examples include navigation, seamanship, propulsion systems, cargo handling, communications, and weather.

Inadequate situational communication/awareness: Not knowing, due to inadequate experience, lack of communication, co-ordination and/or training, the current status of the ship, its systems, or its environment. Examples include lack of knowledge of location, heading or speed and lack of knowledge of status of ongoing maintenance on board.

Lack of communication or co-ordination: Not making use of all available information sources to determine current status. This may be the result of a lack of initiative on the part of the individual or a lack of initiative and/or co-operation on the part of others. Examples of poor communication/co-ordination include: poor communication between bridge officers, poor communication with pilots, and poor deck-to-engine-room co-ordination.

Inadequate knowledge of ship operations: Lack of knowledge resulting from inadequate experience, ignorance of regulations, inadequate knowledge of procedures, inadequate training, and/or unawareness of role/task/responsibility. Examples of areas where an individual might lack knowledge: navigation, seamanship, propulsion systems, cargo handling, communications, and weather.

Inadequate knowledge regulations/standards: Lack of knowledge or understanding of required regulations due to inadequate experience and/or training. Examples of possible regulations; company policies and standards, national and international regulations, maritime regulations of other port States, local jurisdiction regulations, shipboard regulations, cautionary notices, chart notations, or labelling.

Inadequate knowledge of ship procedures: Not knowing due to inadequate experience and/or training the shipboard and company policies requiring adequate knowledge of your own ship's operation. Examples include emergency procedures, maintenance procedures, administrative procedures, and safety system procedures.

Unaware of role/task responsibility: Inadequate knowledge of the specific job required of an individual. Examples include a lack of understanding of command responsibilities, communications responsibilities, safety responsibilities, maintenance responsibilities and emergency responsibilities.

Inadequate language skills: A lack of the basic language skills necessary to communicate and perform duties as required. This includes total or partial inability to speak, read or comprehend the primary language and/or other required language sufficiently to understand shipboard commands, instructions, procedures, labels, warnings and regulations.

Management:

Failure to maintain discipline: Failing to ensure that personnel submit to authority, regulations and procedures. Examples include: tolerating unqualified or inept personnel, not enforcing regulations and procedures, tolerating insubordination.

Failure of command: Mistakes in giving commands. Examples of faulty command include: proper command not given, proper command not given at the appropriate time or out of sequence with other commands, incorrect commands, conflicting commands.

Inadequate supervision: Inadequate oversight of activities of personnel under an individual's supervision. Examples of faulty supervision include: not checking to see that a job was performed in a timely and correct manner, not providing proper resources to deal with problems brought to the attention of supervising individual, unequal treatment of personnel.

Inadequate co-ordination or communication: Failure to communicate and co-ordinate to address issues, problems and tasks both aboard ship and ashore. Examples include: poor communication between bridge officers, poor communication with pilots, poor communication with home office, poor deck-to-engine-room co-ordination.

Inadequate management of physical resources: Poor management of physical resources, namely the tools, equipment, supplies, facilities, food, water, fuel, etc., needed to perform tasks. Examples of faulty management of physical resources include: absence of physical resources, shortage of physical resources, inappropriate physical resources, physical resources stored improperly, physical resources difficult to obtain when needed.

Inadequate manning: Failing to ensure that all required tasks aboard ship can be properly performed and that there are adequate personnel of the proper skill level, physical and mental ability, experience, certification, and inclination to properly perform those tasks.

Inadequate manpower available: Not assigning, or not ensuring the availability of, adequate personnel with appropriate skill levels to a ship, or to a specific task aboard the ship, to ensure safe and efficient operation.

Poor job design: Specifying job or task requirements which are unreasonable, inefficient, impossible, excessive, or impractical. Examples include: excessive watch duration or frequency, requiring a single person to monitor simultaneously displays that are spastically separated, requiring exposure to hazardous materials without proper protective gear.

Poor regulations, policies, procedures or practices: Any problem with standards, regulations, policies, procedures or practices. For example: standards, regulations, policies, procedures, or practices may be conflicting, inaccurate, inadequate, lacking in sufficient detail, or outdated.

Misapplication of good regulations, policies, procedures or practices: The application of standards, regulations, policies, procedures, or practices at an incorrect time or in an inappropriate circumstance.

Mental action:

Lack of situational awareness: An incorrect understanding of the current situation which can lead to a faulty hypothesis regarding a future situation, or an understanding which is based upon incorrect beliefs, leading to compounded errors that can substantially increase the risk to the ship. Examples include arriving at a hypothesis without confirmation of which direction an oncoming ship will steer, incorrect interpretation of alarms on board ship (e.g. seawater contamination of a fuel system during high seas).

Lack of perception: When an individual does not properly understand that a problem or situation exists. Examples include misreading a dial, mishearing a command, misunderstanding a garbled radio message, thinking you smell engine oil when it's actually crude, not noticing a list to starboard, overestimating the distance to the dock.

Incorrect recognition: The misdiagnosis of a particular situation or problem once it has been perceived. While it may be perceived that a problem or situation exists, the identification is incorrect. Examples include misdiagnosis of a sounded alarm that sounds similar to other alarms on board ship, incorrect recognition of a visual display alarm on the bridge.

Incorrect identification: The incorrect identification of a problem or hazard once it has been recognized that a problem or hazard exists. The alarms on a display panel may have identified a particular hazard to the ship (e.g. low fuel oil pressure), but the individual may have misinterpreted the alarm and identified the problem incorrectly.

APPENDIX 4

SELECTED BIBLIOGRAPHY OF UNCLOS/ILO/IMO REQUIREMENTS AND RECOMMENDATIONS RELATED TO INVESTIGATION OF HUMAN FACTORS IN MARINE CASUALTIES AND INCIDENTS

UNITED NATIONS CONVENTION ON THE LAW OF THE SEA

Article 94, *Duties of the flag State*, provides, in paragraph 7:

Each State shall cause an inquiry to be held by or before a suitably qualified person or persons into every marine casualty or incident of navigation on the high seas involving a ship flying its flag and causing loss of life or serious injury to nationals of another State or serious damage to ships or installations of another State or to the marine environment. The flag State and the other State shall co-operate in the conduct of any inquiry held by that other State into any such marine casualty or incident of navigation.

ILO (INTERNATIONAL LABOUR ORGANIZATION) CONVENTIONS AND RECOMMENDATIONS

Merchant Shipping (Minimum Standards) Convention, 1976 (No. 147)

Article 2 provides:

Each Member which ratifies this Conventions undertakes” “(g) to hold an official inquiry into any serious marine casualty involving ships registered in its territory, particularly those involving injury and/or loss of life, the final report of such inquiry normally to be made public.”

Prevention of Accidents (Seafarers) Convention, 1970 (No. 134)

Article 2 provides:

- 1. The competent authority in each maritime country shall take the necessary measures to ensure that occupational accidents are adequately reported and investigated, and comprehensive statistics of such accidents kept and analysed.*
- 2. All occupational accidents shall be reported and statistics shall not be limited to fatalities or to accidents involving the ship.*
- 3. The statistics shall record the numbers, nature, causes and effects of occupational accidents, with a clear indication of the department on board ship - for instance, deck, engine or catering - and of the area - for instance, at sea or in port - where the accident occurred.*
- 4. The competent authority shall undertake an investigation into the causes and circumstances of occupational accidents resulting in loss of life or serious personal injury, and such other accidents as may be specified in national laws or regulations.*

Article 3 provides:

In order to provide a sound basis for the prevention of accidents which are due to particular hazards of maritime employment, research shall be undertaken into general trends and into such hazards as are brought out by statistics.

Article 9 provides, in paragraph 2:

All appropriate and practical measures shall also be taken to bring to the attention of seafarers information concerning particular hazards, for instance by means of official notices containing relevant instructions.

Prevention of Accidents (Seafarers) Recommendation, 1970 (No. 142)

Paragraph 3 provides:

Subjects to be investigated in pursuance of Article 3 of the Prevention of Accidents (Seafarers) Convention, 1970, might include -

- (a) working environment, such as working surfaces, layout of machinery and means of access and lighting, and methods of work;*
- (b) incidence of accidents in different age groups;*
- (c) special physiological or psychological problems created by the shipboard environment;*
- (d) problems arising from physical stress on board ship, in particular as a consequence of increased workload;*
- (e) problems arising from and effects of technical developments and their influence on the composition of crews;*
- (f) problems arising from any human failures such as carelessness.*

Dissemination of information to shipowner and seafarers

In addition to the provisions referred to above, Convention No. 134 also includes provisions concerning the responsibility of the competent authority to disseminate information gained from accident investigations and research and to bring it to the attention of shipowners and seafarers. The competent authority also has the responsibility to promote and ensure the training of seafarers in the prevention of accidents and in to take measures for their health and protection. Recommendation No. 142 provides further guidance on these subjects.

IMO (INTERNATIONAL MARITIME ORGANIZATION) CONVENTIONS

International Convention for the Safety of Life at Sea (SOLAS), 1974, as amended

Regulation I/21, Casualties, provides:

(a) *Each Administration undertakes to conduct an investigation of any casualty occurring to any of its ships subject to the provisions of the present Convention when it judges that such an investigation may assist in determining what changes in the present regulations might be desirable⁴.*

(b) *Each Contracting Government undertakes to supply the Organization with pertinent information concerning the findings of such investigations. No reports or recommendations of the Organization based upon such information shall disclose the identity or nationality of the ships concerned or in any manner fix or imply responsibility upon any ship or person.*

International Convention on Load Lines, 1966

Article 23, Casualties, provides:

(1) *Each Administration undertakes to conduct an investigation of any casualty occurring to ships for which it is responsible and which are subject to the provisions of the present Convention when it judges that such an investigation may assist in determining what changes in the Convention might be desirable.*

⁴

Refer to the following resolutions adopted by the Organization:

- A.203(VII) - Recommendation on the conclusion of agreements and arrangements between States on the question of access and employment of foreign seaborne salvage equipment in territorial waters
- A.322(IX) - The conduct of investigation into casualties
- A.442(XI) - Personnel and material resource needs of Administrations for the investigation of casualties and contravention of conventions

Refer also to:

- MSC/Circ.70/Rev.1 Questionnaire on the maritime distress system
- MSC/Circ.224 Submission of damage cards and intact stability casualty records
- MSC/Circ.388 Fire casualty records
- MSC/Circ.433 Reports on investigations into serious casualties
- MSC/Circ.539/Add.2 Reports on casualty statistics concerning fishing vessels and fishermen at sea
- MSC/Circ.559 Guidelines to ensure the reporting to the Organization of incidents involving dangerous goods and marine pollutants in packaged form on board ships and in port areas
- MSC/Circ.621 Guidelines for the investigation of accidents where fatigue may have been a contributing factor

- (2) *Each Contracting Government undertakes to supply the Organization with the pertinent information concerning the findings of such investigations. No reports or recommendations of the Organization based upon such information shall disclose the identity or nationality of the ships concerned or in any manner fix or imply responsibility upon any ship or person.*

International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78)

Article 8, Reports on incidents involving harmful substances, provides:

- (1) *A report of an incident shall be made without delay to the fullest extent possible in accordance with the provisions of Protocol I to the present Convention.*
- (2) *Each Party to the Convention shall:*
- .1 *make all arrangements necessary for an appropriate officer or agency to receive and process all reports on incidents; and*
- .2 *notify the Organization with complete details of such arrangements for circulation to other Parties and Member States of the Organization.*
- (3) *Whenever a Party receives a report under the provisions of the present article, that Party shall relay the report without delay to:*
- .1 *the Administration of the ship involved; and*
- .2 *any other State which may be affected.*
- (4) *Each Party to the Convention undertakes to issue instructions to its maritime inspection vessels and aircraft and to other appropriate services, to report to its authorities any incident referred to in Protocol I to the present Convention. That Party shall, if it considers it appropriate, report accordingly to the Organization and to any other Party concerned.*

Article 12, Casualties to ships, provides:

- (1) *Each Administration undertakes to conduct an investigation of any casualty occurring to any of its ships subject to the provisions of the Regulations if such a casualty has produced a major deleterious effect upon the marine environment.*
- (2) *Each Party to the Convention undertakes to supply the Organization with information concerning the findings of such investigation, when it judges that such information may assist in determining what changes in the present Convention might be desirable.*

IMO ASSEMBLY RESOLUTIONS

Assembly resolution A.849(20) - Code for the Investigation of Marine Casualties and Incidents

ADOPTS the Code for the Investigation of Marine Casualties and Incidents;
INVITES all Governments concerned to take appropriate measures to give effect to the annexed Code as soon as possible;
REQUESTS flag States to conduct an investigation into all very serious and serious marine casualties and to report all relevant findings to the Organization;
REVOKES resolutions A.173(ES.IV), A.440(XI) and A.637(16).

Assembly resolution A.850(20) - Human element vision, principles and goals for the Organization

ADOPTS the human element vision, principles and goals for the Organization;
INVITES Governments to bring this resolution to the attention of their representatives who attend meetings of the Organization for appropriate action, and to encourage those responsible for the operation and design of ships to take the relevant principles into account when making design and operational decisions;
REQUESTS the Maritime Safety Committee and the Marine Environment Protection Committee to consider proposals for new or revised instruments of procedures relating to safety of life at sea or protection of the marine environment taking into account the annexed human element vision, principles and goals;
REQUESTS ALSO the Maritime Safety Committee and the Marine Environment Protection Committee to keep the annexed vision, principles and goals under review and take action as appropriate.

IMO MARITIME SAFETY COMMITTEE CIRCULARS

MSC/Circ.621 - Guidelines for the investigation of accidents where fatigue may have been a contributing factor

MSC/Circ.621, prepared by a Joint ILO/IMO Group of experts on fatigue, which finished its work in March 1993, provides guidance to those involved in determining whether, and to what extent, fatigue may have contributed to a maritime casualty or accident. The Guidelines cover such topics as investigator qualifications and training, criteria for selecting whom to interview and the sequence of interviews, and topics to be covered by the investigator. The Guidelines include forms for recording information for analysis at the national and international level.

MSC/Circ.827 - MEPC/Circ.333 - Harmonized reporting procedures - Reports required under SOLAS 74 regulation I/21 and MARPOL 73/78 articles 8 and 12

IMO CODE

Code for the Investigation of Marine Casualties and Incidents (resolution A.849(20))

The Code aims to promote a common approach to the safety investigation of marine casualties and incidents and also to promote co-operation between States in identifying the contributing factors leading to marine casualties. It provides that the result of a common approach and co-operation will be to aid remedial action and to enhance the safety of seafarers and passengers, and the protection of the marine environment. In achieving these aims, the Code recognises the need for mutual respect for national rules and practices and puts particular emphasis upon co-operation.

The Code further provides that the objective of any marine casualty investigation is to prevent such casualties in the future. Investigations identify the circumstances of the casualty under investigation and establish the causes and contributing factors, by gathering and analysing information and drawing conclusions. Ideally, it is not the purpose of such investigations to determine liability, or apportion blame. However, the Investigating Authority should not refrain from fully reporting the causes because fault or liability may be inferred from the findings.

The Code covers such topics as conduct of marine casualty investigations, responsibility to investigate casualties and incidents, responsibilities of the lead investigating State, consultation, co-operation (among States), disclosure of records, personnel and material resources, the issue and submission to IMO of marine casualty reports, the re-opening of investigations, contents of reports and contact between Administrations."
