Marine Accident Investigators' International Forum

MAIIF Investigation Manual

Acknowledgments

The Marine Accident Investigators' International Forum acknowledges, with thanks, the contributions provided by the International Maritime Organization, the European Maritime Safety Agency and a number of national marine accident investigation authorities including the Australian Transport Safety Bureau, The UK Marine Accident Investigation Branch, The US National Transportation Safety Board and the Transportation Safety Board of Canada.

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1.1 INTRODUCTION

This manual is intended as support material for national marine investigation organizations which conduct investigations under the IMO Casualty Investigation Code (CI Code), which came into force on 1 January 2010[1]. It has been collated from various sources and contains examples of industry best practice to assist investigators and investigation organizations in carrying out their roles. The intention of the manual is to build on the guidelines agreed by the IMO, to provide investigators with a basic platform from which to develop the necessary skills to carry out efficient and effective investigations, and to provide a ready reference tool.

1.2 BACKGROUND TO THE INVESTIGATION MANUAL

The Marine Accident Investigators' International Forum (MAIIF) includes within its membership the chief investigators of many of the marine safety investigation organizations from around the world. One of its principal roles is to champion and promote best practice in marine safety investigation. The sole purpose of independent safety investigations into marine casualties and incidents is to improve future maritime safety and the prevention of pollution by ships by deriving the lessons that can be learnt following an accident.

The principle of investigating marine casualties has been included, for many years in international maritime conventions, including UNCLOS,[2] SOLAS[3] and MARPOL.[4] It should be noted, however, that the purpose of the various conventions may differ. While SOLAS does not provide for any sanctions that may result in court or disciplinary action, MARPOL (as implied in Article 4(2)) has provisions that may have adverse outcomes for individuals.

The CI Code incorporates and builds on the best practices in safety investigation and seeks the promotion of cooperation and a common approach to marine casualty and marine incident investigation between States. While the CI Code specifies some mandatory requirements, it also recognises the variations in international and national laws and includes many recommended practices as a result.

The thrust of the CI Code is not one of prosecution or sanction, rather it is solely focused on investigations that result in safety outcomes and which do not attribute blame or apportion liability. Safety investigations under the CI Code are primarily focused on understanding the reason why an unsafe action or condition leads to the casualty and the environment, physical and organisational, in which the casualty or incident occurred.

1.2.1 DEFINITIONS

Part I Chapter 2 of the CI Code contains definitions used in the CI Code:

Marine casualty means an event, or a sequence of events, that has resulted in any of the following which has occurred directly in connection with the operations of a ship:

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[1] International Convention for the Safety of Life at Sea (SOLAS) 08 amendment, Chapter XI-1, Regulation 6, additional requirements for the investigation of marine casualties and incidents
[2] United Nations Conventions on the Law of the Sea (UNCLOS), Article 94(7), Duties of the Flag State
[3] International Convention for the Safety of Life At Sea (SOLAS) 74, Chapter I, Regulation 21, Casualties
[4] The International Convention for the Prevention of Pollution from Ships, Article 12, Casualties to ships

a. The death of, or serious injury to, a person that is caused by, or in connection with, the operations of a ship; or

b. The loss of a person from a ship that is caused by, or in connection with, the operations of a ship; or

c. The loss, presumed loss or abandonment of a ship; or

d. Material damage to a ship; or

e. The stranding or disabling of a ship, or the involvement of a ship in a collision; or

f. Material damage to marine infrastructure external to a ship, that could seriously endanger the safety of the ship another ship or an individual; or

g. Severe damage to the environment, or the potential for severe damage to the environment, brought about by the damage of a ship or ships.

Marine incident means an event, or sequence of events, other than a marine casualty, which has occurred directly in connection with the operation of a ship that endangered or, if not corrected, would endanger the safety of the ship, its occupants or any other person or the environment.

A marine incident does not include a deliberate act or omission with the intention to cause harm to the safety of a ship, an individual or the environment.

Very serious casualty means a marine casualty to a ship involving the total loss of the ship, a death or severe damage to the environment.[5]

Marine safety investigation means an investigation or inquiry (however referred to by a State) into a marine casualty or marine incident, conducted with the objective of preventing marine casualties and marine incidents in the future. The investigation includes the collection and analysis of evidence, the identification of causal factors and the making of safety recommendations as necessary.

Serious injury means an injury which is sustained by a person, resulting in incapacitation where the person is unable to function normally for more than 72 hours, commencing within seven days from when the injury was suffered.

Substantially Interested State means a State:

a. Which is the Flag State of a ship involved in a marine casualty or marine incident; or

b. Which is the Coastal State involved in a marine casualty or marine incident; or

[5] Severe damage to the environment is a case of pollution which, as evaluated by the Coastal State(s) affected or the Flag Administration, as appropriate, produces a major deleterious effect upon the environment, or which would have produced such an effect without preventive action

c. Whose environment was severely or significantly damaged by a marine casualty (including the environment of its waters and territories recognized under international law); or

d. Where the consequences of a marine casualty or marine incident caused, or threatened, serious harm to that State or to artificial islands, installations, or structures over which it is entitled to exercise jurisdiction; or

e. Where, as a result of a marine casualty, nationals of that State lost their lives or received serious injuries; or

f. That has important information at its disposal that the marine safety investigating State(s) consider useful to the investigation; or

g. That for some other reason establishes an interest that is considered significant by the marine safety investigating State.

1.2.2 OBLIGATIONS TO INVESTIGATE

Each IMO Member State shall ensure a safety investigation is carried out into the causal factors of all very serious casualties involving ships flying its flag, irrespective of the location of the casualty (CI Code, Ch.6).

The safety investigation may be conducted by the Flag State or by another Substantially Interested State by mutual agreement or in cooperation with other Substantially Interested States, where a State other than the Flag State leads the investigation.

1.2.3 CONDUCT OF INVESTIGATIONS

In principle, each marine casualty or incident should be subject to only one investigation carried out by the marine safety investigating State(s) as detailed in the CI Code, Ch.7. This may involve the investigating State participating and cooperating with other Substantially Interested States. The State which leads an investigation needs to be agreed immediately after a casualty or incident to enable the investigation to commence as soon as possible. Member States must cooperate fully to progress the investigation and share evidence as far as possible with regard to national legislation on confidentiality as well as the potential risk of safety investigation findings being used in criminal and civil lawsuits. All measures shall be taken to ensure evidence is preserved by all the parties concerned in an investigation.

Nothing, however, prejudices the right of another Substantially Interested State to conduct its own separate marine safety investigation (CI Code, Ch.9).

1.2.4 INVESTIGATION BODIES

Ideally investigations should be conducted by independent specialist investigating bodies which are solely set up for this matter. It is acknowledged that not all States have such bodies. However it is important that investigators are independent to ensure the ability to fully investigate accidents unhindered (CI Code, Ch.11). Witness evidence, witness identities, as well as sensitive and private information should not be disclosed by the investigation body to any other party, unless the individual concerned wishes otherwise. (CI Code, Ch. 23)

1.2.5 INVESTIGATION OUTPUT

Safety investigations shall result in a published report, following consultation with interested parties and Substantially Interested States (CI Code, Ch.13, 14 and 25). Investigations of all but very serious casualties may result in a simplified report if deemed appropriate by the investigating body. Safety recommendations can be issued at any time when a serious safety issue is found following an investigation or as a result of abstract data analysis. In no circumstances shall they be deemed to determine liability or apportion blame. States should consider having a mechanism to ensure addressees take due account of recommendations made to them through follow up procedures.

1.3 PLANNING AND PREPARATIONS

The national Administration with responsibility for marine casualty and incident investigation, in accordance with the CI Code should plan in advance of any possible marine casualty or marine incident investigation, in order to assist the investigators, and to ensure that unnecessary delays are minimised.

1.3.1 INFORMATION SOURCES

Access to information is always important especially at the beginning of an investigation. Sources of information useful to investigators include:

- Contact details of worldwide Flag States (available through the IMO);
- 24-hour contact details for the investigating body in each Member State (GISIS – CI Code, Ch.4);
- National authority contact details, e.g. maritime Administration, coastguard, port authorities, police, and other emergency services;
- Ship and company details, e.g. Sea-web, SiReNaC, EQUASIS;
- VDR, ECDIS, GPS information resources, e.g. MAIIF/MAIB VDR Resource;
- AIS information sources, e.g. AISLive, SafeSeaNet;
- Environmental/hydrology conditions – National Meteorological Offices;
- Marine casualty information database(s), e.g. GISIS;
- Access to IMO Codes/Conventions/Regulations;
- Nautical publications, e.g. almanacs, charts, tidal data, pilot books;
- Airport/train/ferry timetables, hire car and/or travel agency contact details;
- Visa requirements and rapid visa application processes.

Some of these sources of information are freely available whilst others need to be purchased or require subscription fees. It may be useful to have pre-arrangements in place to ensure availability of these sources.

1.3.2 GENERIC TEMPLATES

To facilitate the collection and transfer of information it is beneficial to derive templates to enable the necessary data to be collated efficiently, for example:

- Notifications to interested parties of the start of a marine investigation (CI Code, Ch.5 and Ch.20);
- Ship's statutory and Class certificates/document lists;
- Information exchange between States;
- Information exchange between investigation bodies and national authorities.

1.3.3 GENERIC AGREEMENTS

To ensure ready access to information and that an Administration's role is fully understood, it is worth investing time and effort in producing generic agreements to enable:

- Cooperation between States;
- Cooperation between investigation bodies and other national authorities, e.g. police, coastguard, marine Administrations;
- Enabling contracts with specialists, e.g. fire investigators, metallurgists, translators, deep sea recovery etc.

1.3.4 SUPPORT FACILITIES

An office-based administrative supported structure is most suitable to provide the investigator with the basic tools and base from which to plan, organise and conduct an investigation on a 24 hour a day, seven day a week basis. The ability to print and publish safety investigation reports and other works, or organise the sub-contracting of the work, is an essential part of the support facilities.

Having the means to arrange travel is important if investigators are to be able to travel to the scene of an accident quickly. Having somebody other than the investigators themselves researching travel arrangements will enable them to deal with the immediate investigation issues.

Each Member State should determine its own needs sufficient to provide the necessary support to a marine safety investigation. The investigating body should ensure that any investigator is provided with accommodation and that any investigator has sufficient funds to cover travel, accommodation and access to funds for any support service that may be required.

1.3.5 INVESTIGATOR TRAINING AND COMPETENCE

Marine safety investigation is a specialised task, which should, ideally, only be undertaken by suitably qualified investigators consistent with the CI Code, Ch.15 and IMO Resolution A.1054(27) Annex Pt. 2, paragraphs 15, 16, 23 and 38 to 41 inclusive. However, some States will not have personnel dedicated solely to marine safety investigation. In these States, it may be appropriate that suitable personnel should be identified and trained in marine safety investigation techniques prior to being assigned to marine safety investigation duties. When assigned to a marine safety investigation, such personnel should be relieved of their regular duties and, in the context of the investigation, be free from external direction (CI Code, Ch.11). However, they must not conduct an investigation where they themselves may have a conflict of interest.

It is desirable that a marine accident investigator has, as a foundation on which to develop further specialist skills, an experienced professional maritime background (e.g. navigation officer, engineer officer, naval architect, marine authority official) all with a good, sound working knowledge of ship operations (IMO Resolution A.1054(27) Pt2. Para 38). Investigators do not need to be experts in all the areas likely to be encountered in their work. The expertise of specialists in areas such as human factors, metallurgy and forensic fire analysis can always be sought.

The experience and knowledge of investigators and their ability to effectively manage the investigation tasks, which can be substantial in a large investigation, determines the success of the investigation. At least one experienced investigator should be assigned to each investigation.

There are a number of personal and social attributes and skills required of an investigator that are beneficial during the investigation process including: integrity and impartiality in the recording of facts; logic and perseverance in pursuing enquiries, often under difficult and trying conditions; tact and the ability to relate with a wide range of people who have been involved in the traumatic experience of a maritime accident. Analysing and report writing skills are also very important in the investigation process. It cannot be assumed that an experienced mariner will already have the necessary skills to make a good investigator.

IMO Member States should develop their own systems of investigator training taking into account Part III of the CI Code, particularly Chapters 15 and 16.

The IMO recognises that training courses must be complemented with relevant work experience. Ideally, a new investigator should be able to act as an observer, before then being able to assist and finally lead investigations. Within small Administrations, it may be possible to arrange suitable work experience with another Administration.

1.3.6 INVESTIGATOR EQUIPMENT

The following equipment, depending on the type of casualty, is likely to be useful to investigators at the marine casualty or incident site:

- Suitable identity documents;

- High-visibility and protective waterproof jacket;
- Steel toe-capped, non-slip working boots;
- Safety helmet;
- Ear/hearing protection devices;
- Safety goggles/glasses;
- High-visibility vest;
- Automatic inflatable lifejacket;
- Working gloves;
- Overalls (reusable and disposable types);
- Dust mask;
- Latex type gloves for forensic evidence collection;
- Waterproof trousers;
- Safety torch;
- First aid/medical kit;
- Mobile telephone;
- VDR downloading equipment;
- Digital camera;
- Digital camcorder;
- Tape measure;
- Digital voice recorder;
- Laptop computer;
- Measuring and sampling equipment - sample containers;
- Spare batteries and other equipment accessories;
- Writing materials;

- $O_2/H_2S/CO_2$ gas analyser with in-date test certification;
- Personal escape hood, to enable evacuation from confined space;
- A basic tool kit for the removal of physical evidence;
- Clothing suitable for the expected on-site environmental conditions.

Consideration should be given to a readily available and suitably equipped 'go-bag' so that valuable time is not wasted in locating necessary equipment. In a team environment, the central location of less commonly used items, such as VDR downloading equipment, video equipment and basic test equipment maintained in a 'ready-to-go' condition, may be preferable. Additionally, stocks of regular use or disposal items, such as batteries and portable storage devices (e.g. SD cards and USB memory sticks) should be maintained. In this context it is also important to ensure that the investigator(s) have access to funding so that equipment can be supplemented locally.

Equipment such as atmosphere testing equipment, escape hoods and inflatable lifejackets must be maintained and certified in accordance with manufacturers' instructions to ensure their safe use. Equally, training in the use of atmosphere testing equipment, escape hoods and inflatable lifejackets must be completed before an investigator can use the equipment.

The nature of the casualty site being visited will determine the equipment to be carried by the investigator. It is a matter of the investigator's credibility that the investigation is approached in a professional manner. It is important, in the case of ships carrying hazardous material for instance, that all equipment is intrinsically safe and certified as such. There is little point in carrying a variety of equipment only to have to leave it at the terminal gate.

1.3.7 HEALTH AND SAFETY

1.3.7.1 General considerations

Health and safety are the responsibilities of everybody. However, an Administration/Investigating Body has a specific responsibility to ensure the health and safety of its staff. An Administration/Investigating Body should have a health and safety policy which among other things recognises the hazards, necessary procedures and other safety measures required to reduce the risk of injury to, or death of, their investigators. The policy should enable the investigators to remain aware of actual and potential hazards both to themselves and others on-site and take appropriate measures to prevent further casualties occurring. The responsibility that the investigator has for site safety will generally include the safety of contractors and others at the site, especially if the site is under the investigator's control.

Conducting an overall risk assessment of the likely hazards to be encountered by investigators will enable the necessary safety equipment and procedures to be developed. This means that investigators will need to be familiar with risk assessment techniques, which will aid the investigator once at the accident scene. This is important even if many of the common likely hazards have already been accounted for and mitigated against. Not all hazards can be foreseen and so there will be a further need for investigators to carry out a dynamic risk assessment at the scene of the accident.

1.3.7.2 Investigator health and inoculations

Investigators must be fit and able to carry out their duties. This does not necessarily mean they must have seafarer medical certificates. Duties required of investigators may include climbing pilot ladders and accessing confined spaces etc. and this must be borne in mind when considering an individual to be an investigator. Insurance for investigators while on duty should also be considered.

Depending on the location of the marine casualty, a number of inoculations should be considered and may even be required for entry into some countries. Some of the inoculations require a number of booster doses to ensure longevity and effectiveness. Pre-planning is therefore needed to prevent potential delays in attending casualty sites.

The inoculations that should be considered include:

- Yellow fever;
- Tetanus;
- Diptheria;
- Polio;
- Hepatitis A;
- Hepatitis B;
- Typhoid.

Administrations/Investigating Bodies should also be aware of prophylactic medicines to reduce the risk of illnesses such as malaria, and more mundane medicines to treat simple ailments and stomach upsets and sunburn. They should also consider the need for first aid training and certification.

1.3.8 MAJOR ACCIDENT RESPONSE

There will be some occasions when a marine casualty results in significant loss of life, severe damage or pollution with significant political implications. Having major accident response procedures in place will enable an Investigating Body to respond quickly and professionally and will ensure the safety investigation has the appropriate importance. Running drills and taking part in major accident exercises with the State's emergency services will help to ensure that a marine safety investigation organization is better prepared to deal with a major accident when it occurs.

1.4 ACCIDENT NOTIFICATION

Arrangements should be made to ensure prompt receipt of casualty and incident notification by the Administration/Investigating Body on a twenty-four hour basis (CI Code, Ch.5). It is vital

that prompt notification of an accident is provided to the Administration to ensure that important evidence is secured quickly.

1.4.1 TYPES OF NOTIFICATION

An investigator may become aware of an accident in a variety of ways, including: a message from the owners, the ship itself, by port authorities, in press and media reports, by notification from a Port State or a Rescue Coordination Centre (RCC). Underpinning legislation should detail who should report a marine casualty or incident, what is to be reported, how it is to be reported and under what timescale. The greater the number of organizations obliged to report, the better the chance of receiving early notification. It is sometimes advantageous to regularly review relevant press and media reports and coastguard logs to discover unreported casualties and incidents. Late reporting by ships and their owners can sometimes be used as a means to hamper an investigation.

1.4.2 NOTIFICATION INFORMATION TO INVESTIGATION BODY

The initial notification and subsequent fact-finding often takes place under time and resource pressures, but the following data is likely to be useful in assessing the seriousness of the casualty and therefore the most appropriate response:

- Source of notification;
- Time and date of notification;
- Time and date of marine casualty or incident;
- The name of the ship, ship type, and its Flag State;
- Name and contact details of owners and operators, the ship, the shipping company and other points of contact as may be applicable;
- Name and contact details of ship agents, if applicable;
- The IMO or ship number;
- The nature of the marine casualty;
- The location of the marine casualty, including latitude and longitude, where known;
- The number of any seriously injured, missing or killed persons;
- Consequences of the casualty to individuals, property and the environment;
- A brief description of the casualty event;
- The identification of any other ship or structure involved;
- Each ship's condition and intended movements;

- Contact details of anyone with information about the casualty or its victims;
- Details of VDR/SVDR, where fitted, and if the VDR data has been saved;
- The contact details of each involved ship, shipping company and point of contact;
- Contact information for the competent Authority of any Substantially Interested State, and their investigation body if applicable;
- Contact information and action taken by local first responders;
- Contact information for cargo details and location, e.g. loading company.

Other supporting initial information on the ship (e.g. tonnage, type of cargo normally carried, number of passengers onboard etc.) ship access details if in port (e.g. port authority security passes) and meteorological data can be located through the information resources made available during the planning stage. As part of the administrative investigation, the notification information should be recorded, and as further information becomes available, the record should be updated. The logging of telephone calls, in which the facts of the case are discussed, should also be considered, to aid the recollection of events and sources of evidence at a later stage.

1.5 ASSESSMENT

The information received during the initial notification should be sufficient for the marine safety investigation body to make an assessment on the seriousness of the incident and whether it warrants further investigation. Every effort should be made to gather the information necessary to determine the seriousness of the incident as soon as possible, as deciding to start an investigation too late can seriously limit its scope and thoroughness.

1.5.1 OBLIGATORY INVESTIGATIONS

The marine safety investigation body, in the Coastal, Flag or Substantially Interested State, must determine from the notification information if the casualty meets the criteria of a very serious casualty, as defined by the CI Code, Ch.6 and the definition of a 'very serious casualty' in Ch.2 (loss of a life, loss of ship or severe pollution). If so, a safety investigation must be conducted into that occurrence. At this early stage, close cooperation between the Flag, Coastal and any Substantially Interested State, identified during the notification phase, is needed to enable a decision on which State will be the marine safety investigating State. Although the Flag State has the ultimate responsibility under the CI Code to ensure that an investigation is carried out another Substantially Interested State can be the marine safety investigating state by mutual agreement. See Sect. **1.6** for further guidance on deciding the marine safety investigating State.

1.5.2 PRELIMINARY ASSESSMENTS AND NON-OBLIGATORY INVESTIGATIONS

If the notification data suggests that a casualty other than a very serious casualty or a marine incident has occurred, then a preliminary assessment must be conducted to establish if a safety investigation is warranted. The decision whether to investigate such casualties or incidents (CI

Code, Ch. 17 and Ch.2) should be made in the shortest possible time to ensure that potential evidence is not lost or contaminated. If a decision to undertake such a non-obligatory investigation is taken, the immediacy of response is just as important as that for a very serious casualty.

The following considerations for investigating a casualty other than a very serious casualty or an incident should be taken into account in deciding whether an investigation should be conducted:

- The seriousness of the marine casualty or incident;
- The type of ship and/or cargo involved;
- The potential safety value that may be gained by conducting an investigation;
- The public profile of the casualty or incident;
- Whether the casualty or incident is part of an identifiable trend, e.g. from GISIS database analysis;
- The potential (as opposed to actual) consequences of the casualty or incident;
- The extent of resources available and projected to be available in the event of conflicting priorities, including the extent of any investigation backlog;
- Any risks associated with not investigating;
- Serious injuries occurring to crew and/or passengers and/or third parties;
- The pollution of environmentally sensitive areas;
- Ships subject to significant structural damage;
- The disruption, or potential disruption, of major port operations or other activities.

The decision to investigate should also take into consideration whether a marine safety investigation by another Administration will be undertaken.

All the involved parties should be advised of the decision to investigate at the earliest available opportunity (CI Code, Ch.5 and Ch.20) and, where appropriate, their assistance obtained for the investigation process. The use of generic forms may assist in the efficiency of this part of the process.

1.5.3 DECISION TO NOT INVESTIGATE

A decision not to further investigate a marine casualty should be made within a reasonable timeframe. Interested parties should be informed of the decision, including the option to dispose of any initial evidence, which may have been requested to be retained.

1.6 COORDINATION

A notification of the casualty, to the Investigative Body of other Substantially Interested States, should be sent with a minimum of delay and by the most suitable and quickest means available (i.e. telephone, facsimile, or electronic mail). The notification information should contain all available information as provided to the initial Investigating Body and, as appropriate, further updates provided as more information becomes available.

1.6.1 COORDINATION WITH OTHER STATES (CI CODE, CH.21)

Initial notification will usually be received by the Coastal State or a ship's Flag State for an occurrence in international waters. Coastal or Port States are often the first to be notified of a marine casualty, particularly in cases of groundings or accidents to personnel occurring in or off a port. A Substantially Interested State may be informed first, for example in the case of a passenger on a cruise ship reporting an accident. It is important that whichever State receives the notification, it first coordinates with the other States involved to establish who will take the lead. The notification should also advise whether the notified Investigating Body is either conducting an initial examination or has already begun an investigation. Effective early and subsequent liaison will also enable a coordinated decision on whether to undertake a non-obligatory investigation, and for a productive cooperation in the event of an investigation.

Coordination between the notified Investigating Body and Substantially Interested State(s) should begin promptly to determine initial actions on:

- Whether to investigate;
- Who will be the marine safety investigating State (probably based on the Substantially Interested State with the relevant jurisdiction);
- The initial investigation strategy;
- The likely scope of the investigation;
- The initial practical measures and the Investigating Body best placed to carry them out;
- Access to a ship and crew;
- The use of another Investigation Body's powers of investigation.

In the case of very serious casualties, these and other issues must be discussed between the States involved to determine which Investigating Body will lead the investigation and be responsible for the safety investigation. In the exceptional cases, where it cannot be agreed who will lead an investigation, parallel investigations are permitted (CI Code, Ch.9)

1.6.2 ACTION BY A SUBSTANTIALLY INTERESTED STATE

When a Substantially Interested State has been informed of a maritime casualty, the appropriate Administration of the Substantially Interested State should take steps to communicate, coordinate and cooperate with other Substantially Interested State(s), as soon as

possible to agree the initial actions. The mutual sharing of points of contact information prior to a casualty event will further assist in the coordination and cooperation between States when a casualty occurs.

1.6.3 SUBSTANTIALLY INTERESTED STATE INVESTIGATIONS

Where it has been decided that a Substantially Interested State should conduct the investigation in accordance with the CI Code, Ch.7, the Administrations/Investigating Bodies of the Flag State(s) and other Substantially Interested States shall assist with the investigation as appropriate.

If in accordance with CI Code, Ch.7, it is agreed that a Coastal or other Substantially Interested State should conduct the investigation, it remains the responsibility of the Flag State to ensure that the IMO reporting procedure (CI Code, Ch.14 and MSC-MEPC. 3/Circ.4.) is completed and the final version of the marine safety investigation report is submitted to the IMO.

1.6.4 OTHER INTERESTED PARTIES

The notified Investigation Body should inform the ship, if possible, and other interested parties as appropriate, of their interest in the casualty, and of the requirement to retain and preserve potential evidence. The information provided should contain only the factual information which is pertinent to the interested party, the legislation under which the Investigation Body operates and the status of the Safety Investigation Body, and of any subsequent investigation.

There are likely to be a number of interested parties, who may be directly affected and have information or a role to play when a maritime casualty occurs including:

- The casualty ship owner/operator and legal representatives;
- The Flag State Administration;
- Police or other judicial authority;
- Search and Rescue/emergency response authorities;
- Port authority;
- Next-of-kin;
- P&I Club surveyors and lawyers;
- Classification Society;
- Salvage Association;
- Lawyers representing cargo interests;
- Lawyers representing individual crew members and salvors;

- Industry representatives, e.g. fishing;
- Equipment manufacturers;
- Maritime training centres and organizations;
- The media.

The respective interests and position taken by some of these parties will depend on a range of factors, litigation being one of the main ones. Depending on the national legislation of an Administration or agreements it has, the safety investigators may have primacy of evidence. However, it is usually worthwhile discussing and coordinating with some of the interested parties listed above, as soon as possible after starting an investigation, to ensure it can proceed unhindered.

1.7 EARLY PRESERVATION OF EVIDENCE

Within the constraints of any applicable national legislation, it is important to preserve the marine casualty or incident site in order to obtain undisturbed evidence. However, evidence can be disturbed through the process of retrieving human casualties, essential structural repairs, or bringing the ship to port - actions which are often carried out by the first responders to the casualty. In such circumstances every effort should be made to record what has been done so that can be taken into account when considering the evidence. The ship's crew and its company/operator, the local police, fire or port authority, or the relevant maritime Administration may be able to assist in securing evidence. The assistance of these authorities may be achieved through pre-arranged agreements.

1.7.1 INITIAL SITE PRESERVATION

Local police, fire or coastguard agencies will probably be the first officials to arrive at a casualty site or at a casualty's port of arrival. It is, therefore, important to enlist their cooperation on-site to ensure that vital evidence is not lost through interference with wreckage or other potential evidence. Such cooperation may also be facilitated through liaison at the headquarters level. Establishing liaison arrangements in advance of a casualty in the response plans and exercising the arrangements during exercise scenarios will help to further ensure the timeliness and effectiveness of site preservation when required.

In the event of a maritime casualty, any emergency or other response agency should be aware of the following essential tasks:

- Notifying the rescue coordination centre;
- Notifying the marine Administration and other authorities as necessary;
- Securing the casualty site from fire hazards and further damage;
- Checking for the presence of dangerous goods, where possible, and taking appropriate action;

- Placing barriers to ensure that potential evidence is not tampered with or disturbed;

- Taking steps to preserve, through photography or other appropriate means, any evidence of a transitory nature, such as floating debris;

- Obtaining the names and contact details of all witnesses whose testimony may aid in the investigation of the accident.

It has to be recognised that following most accidents the ship(s) involved remain operating units. In the case of personal injury and some other accident types, access to the casualty site should be limited to personnel necessary to rescue survivors, eliminate or mitigate hazards, maintain ship stability, and protect the public. Otherwise a ship will often be moved from the accident site to an anchorage or port. When notifying the ship of an investigation, it should be emphasised that all records must be maintained, and as little as possible disturbed, consistent with the continuing safe operation of the ship.

It should be noted that the role of investigators is to investigate the accident, not to fight fires, rescue survivors, organise body retrieval or remove hazardous material. The golden rule is to ensure the site has been 'made safe' before investigators board a ship or enter a localised accident site.

Where the occurrence site, or evidence, cannot be left undisturbed until investigators arrive, arrangements should be made to document the scene to later enable reconstruction of the circumstances. Damaged or failed components should be kept in a secure location until the appointed investigators have had the opportunity to examine them.

1.7.2 VDR – DATA PRESERVATION

Where a VDR is fitted, it is essential that the investigator ensures that the ship takes the necessary steps to preserve this evidence as soon as possible since, if no action is taken, the evidence is likely to be lost after 12 hours of the marine casualty or incident. If the ship carries a VDR/SVDR, the investigators are entitled (subject to domestic law) to obtain the information recorded on it. Obtaining confirmation from the ship owner/operator/ship that these steps have been undertaken is also recommended.

Supporting guidance on most common types of VDR/SVDR, their storage capabilities and information download methods is available on the MAIIF/MAIB web resource (www.maibresource.net) which is supported by MAIIF members. Advice can also be obtained from bodies such as the Australian Transport Safety Bureau (www.atsb.gov.au), the Transportation Safety Board of Canada (www.tsb.gc.ca), or the US National Transportation Safety Board (www.ntsb.gov).

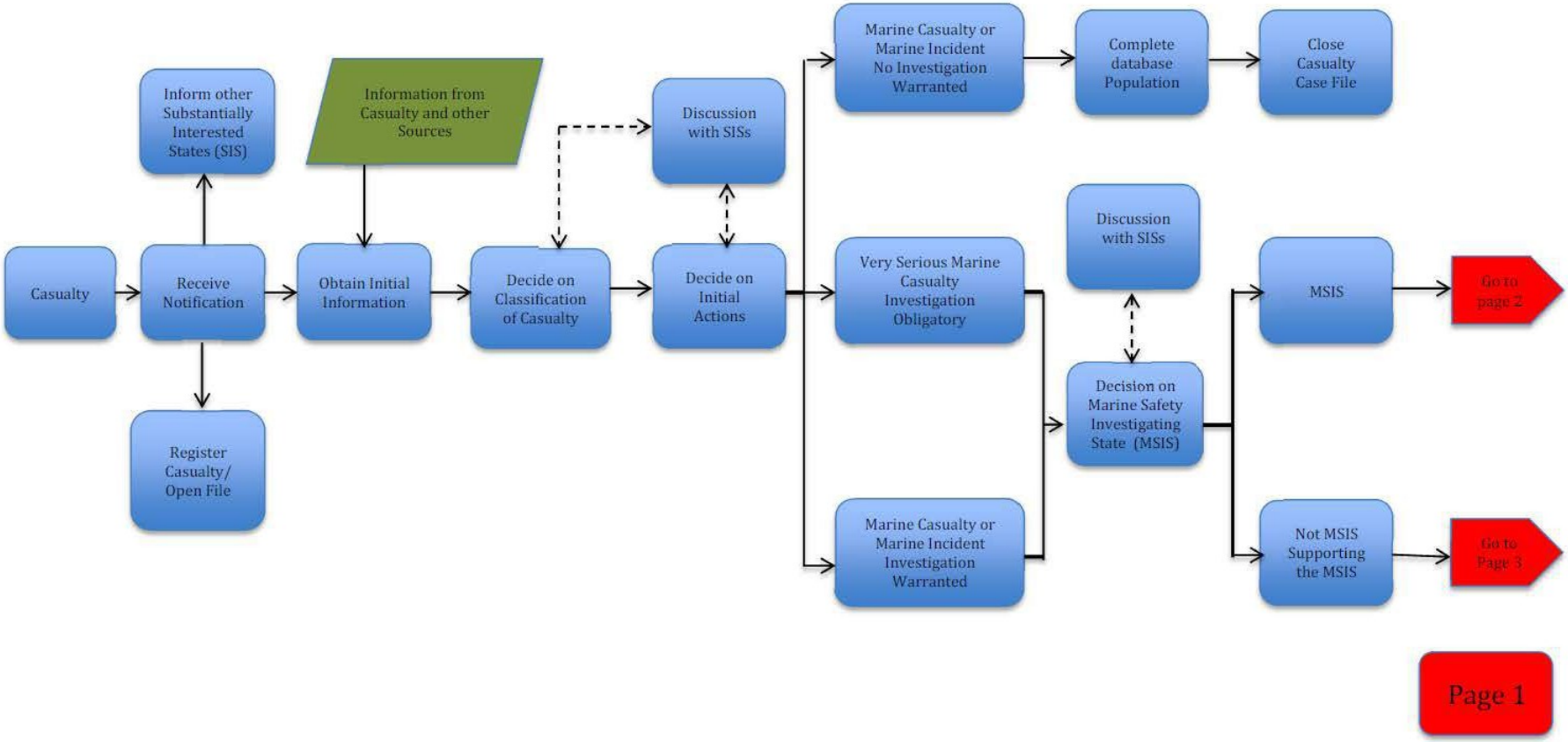
Where a VDR/SVDR is not readily accessible after an accident and information has not been retrieved prior to the abandonment of the ship, the Investigating and Substantially Interested States should decide on the viability and cost of recovering the VDR, balanced against the potential value of the information it contains. The possibility of the capsule having sustained damage should be considered and specialist expertise may be required to ensure the best chance of recovering and preserving the evidence. In addition, the assistance and cooperation of the ship owner, insurer, and the manufacturers of both the VDR and protective capsule may

be required. Prompt action is required given that the ability to locate a VDR/SVDR capsule will diminish rapidly with time.

APPENDIX 1 – CASUALTY REPORTING, ASSESSMENT AND INVESTIGATION PROCESS FLOW CHARTS (1- 3)

Casualty Reporting, Assessment and Investigation Process

1. Notification to Start of Investigation



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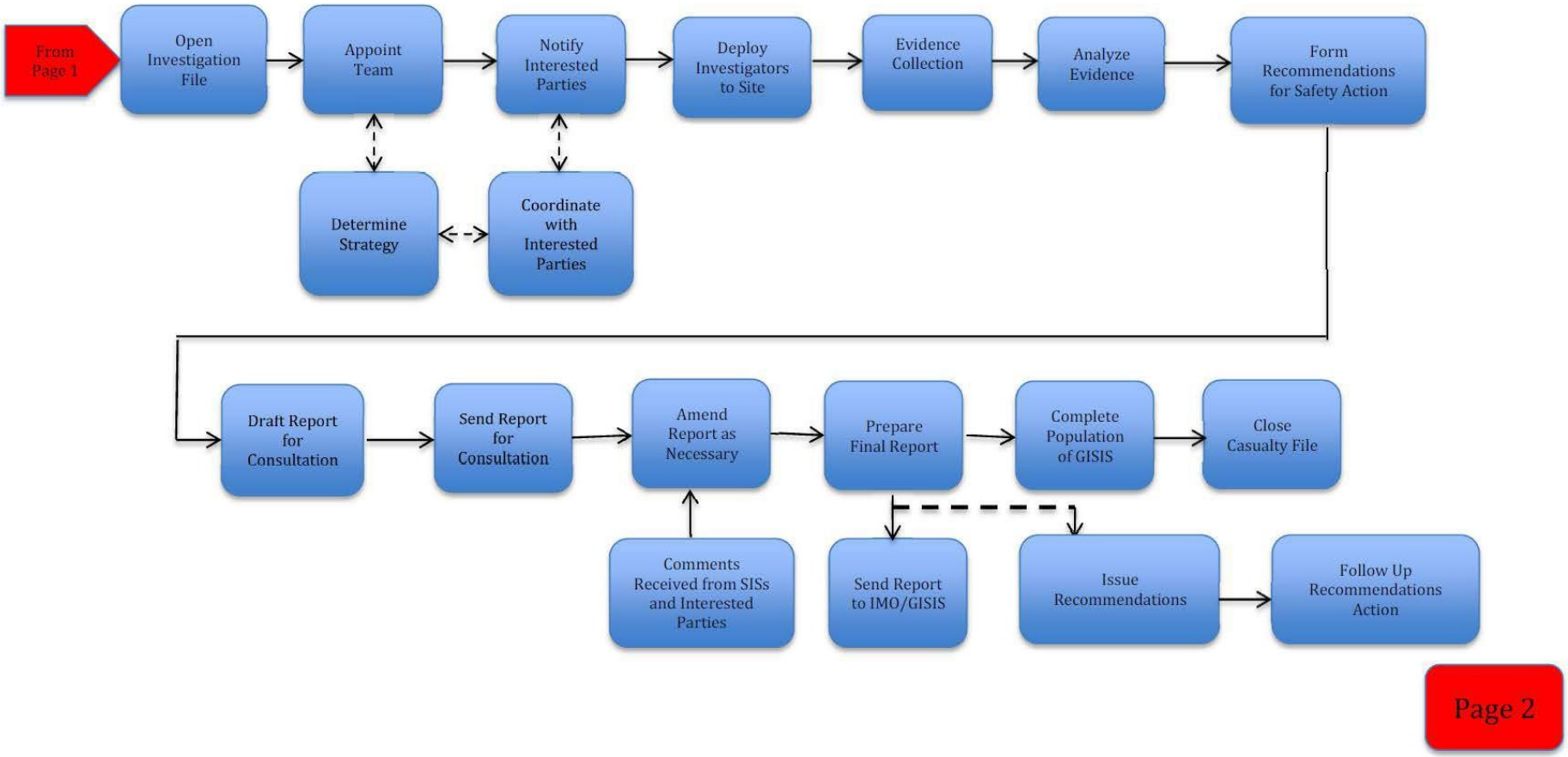
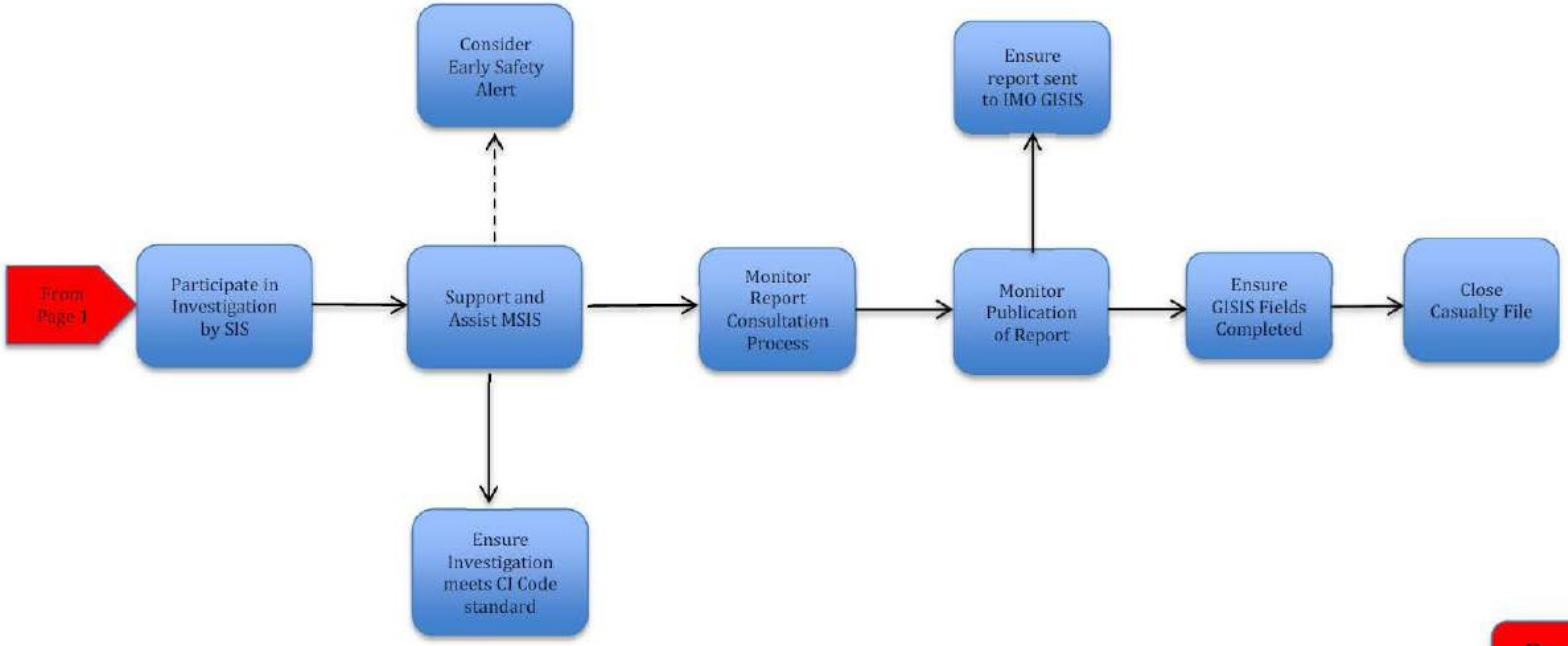
2. Investigation to Full Report



3. Support Investigation by other SIS



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2.1 STRATEGY CONSIDERATIONS

The investigation body of the marine safety investigating State, in close liaison with those of the other Substantially Interested States, should develop a strategy for the scope, direction and timing of the investigation, as quickly as practicable. The factors detailed below should be considered when deriving a plan to progress an investigation.

2.1.1 SCOPE OF THE INVESTIGATION

The scope of a safety investigation and the procedure to be followed should be sufficient to eliminate uncertainty and ambiguity to the maximum extent possible and so enable robust logical assessments to be made of what led to the marine casualty or incident.

Proper identification of causal and contributory factors requires timely and methodical investigation, going far beyond the immediate evidence and looking for underlying conditions, which may be remote from the site of the marine casualty or incident. It is these underlying conditions that may cause future marine casualties and marine incidents. Marine safety investigations should therefore be seen as a means of identifying not only immediate causal factors but also failures that may be present in the whole chain of responsibility.

A key discussion to have with Substantially Interested States is to agree on the scope of an investigation and specifically which areas may require examination. Agreeing what areas need to be examined and which State's marine safety investigation body is best placed to collect the necessary evidence will enable an effective plan to be developed.

2.1.2 TIMING OF THE INVESTIGATION

The quality of evidence particularly that which relies on the accuracy of human recollection, can deteriorate rapidly with time, which is why delayed investigations are usually not as conclusive as those performed promptly. Recognising that any ship involved in a marine casualty or incident may continue in service and that a ship should not be delayed more than is absolutely necessary, the investigation body of an investigating State should start the investigation or other examination as soon as practicable, without delaying the ship unreasonably (CI Code, Ch. 20.3). However detention of a ship should not be ruled out if it is believed that once the ship sails from its territorial waters, important evidence will be lost.

On some occasions, arriving swiftly at the casualty site will enable the safety investigators to establish themselves and progress their investigation ahead of other investigating authorities. This can often help in ensuring evidence has not been contaminated or is missing, having been taken by another investigating authority.

2.1.3 INVESTIGATION PLANNING

There is a need to plan an investigation in the short term and over the duration of the investigation process, up to the publication of the report and beyond.

Initially, given the potential deterioration of most evidence, it is important to plan what activities are needed to collect the necessary information, given the agreed scope of the investigation. During the early stages it may be impossible to have a full appreciation of the

likely scope of an investigation; however, the initial plan generated can be updated as the investigation progresses.

Part of the initial planning must also be to prioritise the collection of evidence. Key witness recollection will degrade over time and other witnesses will be repatriated or have to travel soon after the accident, so without careful planning their evidence may be lost or difficult to retrieve. IMO Resolution A.987(24) - *Guidelines on Fair Treatment of Seafarers in the Event of a Maritime Accident* - must be uppermost in the mind of investigators when considering the availability of crew members and the contribution they may make to the investigation (CI Code, Ch.22 and Ch.24). There is often a compromise to make between collecting one piece of evidence before another. For example, having a ship's GPS track from AIS, VDR or electronic chart can be immensely useful before interviewing a ship's bridge team, but often that information is not readily available when the crew are available for interview. Key pieces of evidence may only become available at certain times after a casualty and this must be factored into the investigation plan. Plans will have to remain flexible given the ever changing nature of an investigation.

As well as the initial planning, a longer term plan should be developed to enable the investigation report to be published within the shortest timeframe feasible. Communicating urgent safety issues prior to the completion of the report should also be taken into consideration; reports that are published long after the casualty date will often have less impact. However, report publication must not be rushed at the expense of quality and thoroughness. The plan should take account of issues such as the availability of investigators over a prolonged period, any requirement for external expertise, the possible costs of testing and simulation etc. and the time involved in drafting the report and the consultation process (CI Code, Ch.13, Ch.14 and Ch.25). Key events such as internal briefs, further interview, wreck examination, investigation report writing and report consultation should also be included. Again the plan should be reviewed and updated as the investigation progresses to ensure it is realistic.

2.1.4 COOPERATION WITH SUBSTANTIALLY INTERESTED STATES

The investigation bodies of all the Substantially Interested States should, to an agreed extent, provide mutual assistance in the conduct of a safety investigation (CI Code, Ch.10 and Ch. 21). Such assistance should include an investigation body, where requested by the marine safety investigating State and to an extent that is mutually agreed, using its respective powers for the purpose of acquiring information and evidence that would otherwise be unavailable to the investigation body of the marine safety investigating State.

Depending on the national arrangements of each Member State, it may be appropriate for investigation bodies and/or investigators to notify and discuss with the involved judicial investigation authority:

- The intention of the investigation body to progress a safety investigation;
- The respective jurisdiction;
- The need for, and methods employed in, evidence collection;

- Assistance that can be provided by both parties to ensure that factual evidence, and its quality, are maintained;

- The conditions under which the evidence may be shared (CI Code, Ch.23).

2.1.5 INVESTIGATOR DEPLOYMENT

The number of investigators appointed to conduct any investigation depends on the available resources, the size of the investigation, the need for speed, the impact of the investigation, the location of the accident, and the individual skills and strengths of the investigators. This will be a factor influenced by the investigation plan.

At one extreme, a large-scale safety investigation may require a multi-disciplined team of investigators, supported by technical and human factors specialists and an administrative staff. A small-scale safety investigation will normally require a lower level of response, typically at least two investigators in cases where an on-site investigation is justified and witnesses are to be interviewed. Although far from ideal, one investigator may be all that is available to deploy to the scene of an accident. If so, it is especially important that there is no pressing time constraint, as it will take longer to ensure the investigator has retrieved all the necessary evidence from the scene of the casualty.

Although more than one investigator may be deployed it is important that one investigator is appointed as the lead investigator. This enables a single point of contact for information during the investigation and a sense of ownership for that investigator. Proper planning and preparedness are essential in facilitating the prompt arrival of investigators at an accident site.

2.1.6 POWERS OF INVESTIGATION (CI CODE, CH.8)

The powers which can be exercised by an investigator will vary depending on the legal and regulatory system of the State conducting that phase of the investigation. In initial discussions between Substantially Interested States the different investigation powers should be explored to enable an appreciation of what evidence is likely to be able to be retrieved (CI Code, Ch.21).

When the casualty occurs in international waters (on the 'high seas') with no impact or foreseen consequences for any Coastal State, it will normally be the Flag State which has sole jurisdiction and power to investigate. This situation is modified when the event is a collision on the high seas with each Flag State involved having sole jurisdiction in the case of its own ship. Therefore, to make any reasonable investigation, there has to be an agreement between the two Flag State investigation bodies to cooperate.

The statutory powers granted to investigators to effectively discharge their duties should be used responsibly, with absolute fairness and reasonable consideration for those involved. Investigators should realise that during the initial part of an investigation their task is essentially one of gathering information which is best undertaken in an atmosphere of cooperation, rather than confrontation.

The investigator must know the full extent of his/her powers and his/her obligations under any legislation.

2.1.7 WORKING WITH OTHER AGENCIES AND JUDICIAL AUTHORITIES

Although it is recognised that the circumstances surrounding each casualty are different, the importance of proper planning and the need to establish good liaison with other authorities, particularly police, search and rescue, and firefighting services, cannot be over-emphasized. To achieve this the marine safety investigation body will find it beneficial to establish formal agreements (Memoranda of Understanding) with various government agencies involved in emergency response. With the aim of avoiding conflicts and duplication of work, the appointed investigator(s) should endeavour to hold one or more briefings with interested parties as soon as possible after arriving at the marine casualty or incident site. The briefings should seek to set out and explain, as appropriate:

- The objective and status of the safety investigation;
- The intended extent of cooperation with other investigations;
- The legal powers held by the investigator(s);
- The intended procedure for witness interviews;
- The intended procedures for dealing with witness and material evidence;
- The intended arrangements for updating next-of-kin and other interested parties, on the progress of the safety investigation.

An effective meeting early after arriving at the accident scene can go a long way to avoiding conflicts and unnecessary duplication of work.

2.1.7.1 Judicial investigations

All States have judicial authorities to enforce their domestic laws. How judicial investigations are conducted varies from one State to the next. Generally the purpose of any criminal justice system is to deliver justice for all, by convicting and punishing the guilty, while protecting the innocent. Importantly the punishment of an offender is also assumed to act as a deterrent. While this might not be in accord with a marine safety investigation, it is nevertheless an important process.

Often after a marine accident, both safety investigators and police will attend to investigate the casualty or incident. In most States the police will have primacy and will immediately seize evidence and conduct interviews with a view to a possible prosecution. This clearly is antagonistic to the safety investigation aims, which are not to apportion blame or liability but to prevent marine accidents and incidents in the future. Under these conditions, the safety investigation can become ineffective or impossible to conduct.

It is important to recognise that safety investigations must not take place to the exclusion of fair and thorough judicial proceedings. With consideration and formal understandings in place between authorities, it is possible to conduct both judicial and safety investigations in parallel (CI Code, Ch.16).

Having readily available information (such as pamphlets or flyers) explaining a safety investigator's role is one measure that can be considered to assist investigators while on scene. Prior to this it is beneficial to have developed agreements with the judicial services of an investigation body's State to ensure the two authorities can work in parallel and help each other where possible, e.g. seizure of physical evidence.

It should also be noted that the taking and keeping of original documents are not usually critical to a safety investigation. Under normal circumstances, once satisfied of the authenticity of a document, copies of documents are sufficient for a safety investigation. Furthermore, police usually use expert photographers. An agreement with the police to provide their photographs to supplement the safety investigation is very useful.

However, equipment which may need to be tested to destruction should be subject to an agreement to allow all parties access to such tests and that they are provided with factual data from those tests.

2.1.7.2 Legal representatives

Investigators should bear in mind that, regardless of the type of casualty, there will likely be litigation, and the parties involved will be anxious to protect their interests. Depending on the State's legislation, representatives of the owner or other parties may have a right to be there, and many of them may well have arrived on-scene before the investigator. They can sometimes unknowingly create challenges for the investigator. For instance, the owner's lawyers will almost certainly wish to interview the crew and may well have started this process before the investigator arrives. They may be unaware of the existence of the marine safety investigation process in the investigating State. They represent their clients' interests and, when meeting with crew members to review the events leading up to the accident on behalf of the client, they may unintentionally bias or influence the crew members' recollections.

It may be necessary to brief legal representatives of the owner or other interested parties on the extent of an investigator's powers. It may also be important to remind the master or other officers of their rights in respect of legal representation, any protection against self-incrimination, and that P&I Club lawyers represent the interests of the owners and not necessarily those of individual personnel.

They may also seek to remove certain physical evidence for analysis by their own experts to support their clients' case. They will certainly attempt to obtain and hold documentary evidence. Unless the investigating State's legislation prohibits such removal of evidence, they will have a legal right to do so. However, by liaising with owners and the ship itself early on, it may be possible to minimise the potential conflict and enable parallel investigation processes.

2.1.8 DEALING WITH THE MEDIA

Most major accidents generate an initially high level of interest from both the public and the media, and a good rapport with the media can be an asset to the investigation. All administrations should have a media policy covering marine safety investigation. The dissemination of factual information, without prejudice to the investigation, can help to minimise speculation and rumours about the occurrence. If regular media reports are

considered necessary, then a single point of contact within the investigation body, preferably with media training, should be considered.

2.1.8.1 Press bulletins

A press bulletin should be brief and concise. It should recount only confirmed facts. It may be necessary to mention facts to journalists and broadcasters which would be self-evident to those who are in the know. Specialised terms and foreign words should be avoided. The issue date and, if necessary, the release date and time of day should be marked on the bulletin. The easiest method of delivery is by e-mail.

A first press bulletin should be considered once there is sufficient information available on the occurrence and the situation. The purpose of the first bulletin is to announce that the marine safety investigation body is aware of the situation and has launched an investigation. The following information where relevant could be considered for the first bulletin:

- What happened;
- Where it happened;
- When it happened;
- What the immediate consequences were;
- What can still be expected;
- Launch of an investigation;
- Time and location of any press conference.

The names of any victims, next-of-kin or other interested parties should not be disclosed in any bulletin issued by the marine safety investigation body.

Further bulletins may be issued as and when necessary. The content of further bulletins should consider reporting on the established sequence of events, the circumstances of the events and on the progress of the investigation. Care must be taken not to speculate on the causes of the occurrence. The marine safety investigation body should keep the interested parties, the injured parties, the next-of-kin (where possible) and, depending on the nature of the occurrence, the representatives of the authorities, the shipping company and the relevant labour organisations informed about the progress of the investigation. This may be best achieved by means of further bulletins or information events. Consideration should be given to allowing next-of-kin sight of a bulletin for their information before it is released to the press and other parties

A final bulletin may be issued when the investigation is completed. The summary of the investigation report can be a way that allows it to double up as a final bulletin.

2.1.8.2 Press conferences

Often the media seek further information from the marine safety investigation body by telephone or personal interview. Such requests should be treated in a positive manner and it is a good idea to arrange for questions after presentations and to allow for one-on-one interviews at the end of a press conference.

Before an interview, the investigator must decide which questions may be answered and which might not. If a question is refused, a clear and acceptable reason must be given for the refusal to answer. Interviews and telephone conversations must be conducted with care and it is important to keep to the facts. The investigator must also be prepared for the fact that the journalist may present his or her own assumptions or speculations on the matter. The investigator must take care not to make any assumptions or speculate on causes. If a television or radio interview is conducted in a foreign language in which the investigator is not fluent, they should consider using their own mother tongue.

Marine casualties always arouse the interest of the media. Journalists attempt to get photographs and information about the accident as quickly as possible. They also want to know the cause of the accident. Consideration should be given for photographers and journalists to be allowed the opportunity to visit the scene of the casualty. A single centralised visit, and consideration of making use one or two reporters and photographers who agree to share the information and footage with the rest of the media, poses less of a security risk and safeguards the integrity of any investigation material. It also allows for dissemination of information and corrections of misunderstandings at the same time. A location which gives them good shots of the accident site, without a direct view of victims or other sensitive material, may be suitable. If necessary, the reasons for any restrictions should be explained to the media representatives.

It should be recognised that the journalists and photographers will attempt to get shots of interesting subjects independently. Investigators may also be targeted with telephoto lenses from a long distance away. The media may try to get aerial photographs of the accident site. Cooperation with the aviation authorities can prevent any photography that is disruptive to the investigation or compromises safety. Alternatively, press photographs taken in the near vicinity of the accident site, or prior to the arrival of investigators, may add value to the investigation, and it may be useful to obtain copies.

2.1.9 NEXT-OF-KIN

The Administration, where relevant, or the Flag State should consider facilitating early contact with next-of-kin in the case of missing persons or confirmed death to keep them apprised of actions taken by the marine safety investigation body, as appropriate, basic casualty factual information, and any other pertinent information. Contact can be made through Substantially Interested States, local police intermediaries or, where relevant, fishing community missions - who are likely to have given the next-of-kin news of the casualty.

Early, and regular, contact can help to reassure the next-of-kin that the marine safety investigation body takes the casualty seriously, and can help prevent incorrect or misleading information from being given. It may be suitable to agree one point of contact within the next-of-kin to avoid mixed information being given. Effective, early contact may also provide an

opportunity for more background information on the casualty to be gained, but care should be taken not to probe too deeply into the background of those who have been lost too early on. Gaining the trust of the next-of-kin is important for a successful investigation.

2.1.10 FAIR TREATMENT FOR SEAFARERS

The marine safety investigation body should ensure that it complies in all respects with IMO's Guidelines on Fair Treatment for Seafarers in the event of a maritime accident (IMO Circular letter No.2711); in particular it should ensure that:

- The human rights and basic human dignity of seafarers are preserved at all times;
- Seafarers are informed of the basis on which the investigation is being conducted;
- Seafarers are not unreasonably detained;
- Seafarers are provided access to independent legal advice;
- Seafarers are provided with interpretation services as appropriate;
- All available means are used to preserve evidence to minimise the continuing need for the presence of any seafarer;
- Interviews are conducted promptly taking into account the physical and mental condition of any seafarer;
- Seafarers are permitted to be re-embarked or repatriated as soon as their presence is no longer required;
- It takes steps to ensure that no discriminatory or retaliatory measures are taken against seafarers because of their participation during investigations.

2.2 INITIAL CASUALTY OR INCIDENT SITE ASSESSMENT

On arrival at the marine casualty or incident site, the investigator(s) should consider the following:

- Meeting with representatives of the Flag State, Substantially Interested States, national authorities, and other interested parties, as applicable;
- Making an early overview of the ship/scene and gain a broad idea of the overall events, key timings and personnel involved from which to confirm/establish an initial plan of approach;
- Making/confirming arrangements for securing and preserving the marine casualty or incident site and for controlling access to and from the site;

- Identifying ‘safe’ areas before commencing any further examination;

- Making arrangements for a base ashore, if feasible, to enable witness interviews to take place on neutral ground;

- Making/confirming arrangements for access to witnesses and to VDR and other electronically recorded data.

A safety investigation will normally require ready access to telephone, fax and internet facilities; in the case of a large-scale safety investigation involving close cooperation with other national authorities, a command centre may need to be established with dedicated communication links and facilities for interviewing witnesses, storing material evidence, and conducting other meetings.

2.2.1 LOCATION AND EXTENT OF SCENE

Access to some casualty or incident sites may be problematic and require liaison or organisation with another authority. For example, if a ship is aground or at anchor, transportation by pilot boat or a workboat will need to be organised and a pick-up point arranged. In some cases the possibility of chartering a helicopter or float plane may be necessary. Even when a vessel is in port it is important to understand the requirements of the relevant ISPS legislation and the need to liaise with the port authorities concerned to enable the smooth deployment of investigators. However, the health and safety of the investigator must always be considered, as will be discussed in Section **2.3**, and this includes site access arrangements.

Once at a casualty or incident site, its extent must be determined to preserve the necessary evidence. In some cases the extent will be relatively small, such as a ship’s bridge, but on other occasions there may be damage and debris over a wider area which must be examined.

Depending on the legislative powers available to the investigator, it may be necessary to cordon off areas or declare exclusion zones to prevent anyone tampering with the evidence. In the case of a sunken ship it may be prudent to issue an exclusion notice to limit any disturbance of the wreck. These are best carried out in conjunction with relevant local authorities, who may be in a position to monitor the cordon.

Investigators will often arrive on-site long after the accident has occurred and after post- accident clean-up operations have taken place. The investigator should emphasize early on, to the authorities on scene, the need to leave the accident scene as far as possible untouched. Inevitably, for safety and operational reasons, post-action operations will be needed, but what has changed since the accident must be recorded to ensure the investigator can piece together what has happened. If a good work relationship has been established already with the authorities on scene, it may be possible to ensure the investigator is kept informed of the necessary actions taking place, as they happen.

In some instances, the first people able to board the vessel may be the salvors. In this case it will be necessary to develop good communications and understanding with the salvage company to ensure that the needs of the marine safety investigation are understood and, where practicable, interventions are made to ensure that evidence is preserved.

2.2.2 CONSTRAINTS AND RESOURCES REQUIRED

From the initial meetings with local authorities, interested parties etc., it will become evident what constraints an investigator will have to work within. These may include:

- Time constraints (ship scheduled sailing, crew departure, etc.);
- Tidal and weather conditions;
- Language difficulties;
- Access to the site;
- Procedures and processes to retrieve evidence;
- Requirements of other authorities conducting investigations;
- Specialist equipment and expertise required to progress the investigation;
- Ongoing salvage and corrective action/repair schedules.

Once these constraints have been assessed it will then be possible to establish what further resources may be needed. This may be as simple as further investigators travelling to the scene to help collect evidence before it is lost, or the need for specialist assistance.

In some cases specialist expertise may be required to progress one aspect of an investigation. Locating and engaging with specialist contractors early on will ensure that important evidence is not lost. Investigators should select specialist contractors carefully so that a significant conflict of interest does not occur. However, in the case of some pieces of equipment, it is impossible not to request the services of the manufacturer to assist in determining what has happened. In these cases it is important that the manufacturer's work is overseen or reviewed by an appropriate expert.

The equipment required to continue with an investigation should also become apparent from the initial meeting. For example, it may be necessary to seek a means of transport out to a ship or a crane to recover a piece of evidence. The marine safety investigation body should ensure the investigator has the necessary support to be able procure services at the accident site to enable the investigation to progress. At a major accident site it may be beneficial to deploy administrative staff to manage such activities.

It will be ideal to secure premises at an accident site or nearby in which witnesses can be interviewed on neutral ground and where investigators can hold their own discussions and briefings. Ideally this will be somewhere like the investigator's hotel or port authority office. Telephone and fax facilities and possibly photocopying would be beneficial. Often in reality, investigation operations will be based onboard a ship and, at best, a spare cabin is all that can be arranged. Investigators should go prepared to be as self-sufficient as possible and not expect resources to be readily available to them.

2.2.3 INITIAL ACCIDENT SCENE CAPTURE

An initial walkthrough of the marine casualty or incident site may be the only or best opportunity the investigators have before it is disturbed by others. The opportunity should therefore be taken to:

- Photograph the scene as thoroughly as possible;

- Make written and voice notes, photographs, sketches and diagrams, particularly of the positions of controls and switches, the location of used emergency equipment, the extent of damage, and the location and nature of other items of interest;

- Record exactly what any emergency response personnel are doing in order to work back to the state of the scene before they started their activities.

2.3 ACCIDENT SITE HAZARD IDENTIFICATION AND RISK ASSESSMENT

Although securing evidence before it perishes is an important aspect of conducting an investigation, it does not mean that investigators should take unnecessary risks or endanger themselves to retrieve it. Investigators should ensure they take a measured approach to the investigation, ensuring that they are well aware of the hazards before proceeding.

Where a ship remains wholly or partly in operation while an investigation is in progress, it is important to remember that the crew is operating under its ISM Code. Investigators should at all times ensure that any risk assessment and inspection planning, and the safety measures they adopt, are consistent with the ship's procedures.

2.3.1 RESPONSIBILITY

Safety does not just happen; it is a result of good management, proper training and effective procedures.

Safety is everyone's responsibility and investigators should ensure that they are familiar with the hazardous environment they are likely to work in, both for their own safety and for the safety of others. Ideally, investigators will come from a marine operations background so they should be aware of some of the more common hazards, but they must also be aware of the additional hazards that exist when investigating accidents. Investigators must also be familiar with the health and safety regulations applicable within their State. Investigators should ensure that they:

- Take reasonable care for their own health and safety, as well as for others who may be affected by their acts or omissions;

- Cooperate with anyone else carrying out health and safety duties – including compliance with control measures identified by other relevant authorities;

- Report any identified serious hazards or deficiencies immediately to the appropriate officer or other authorised person;

- Make proper use of plant and machinery, and treat any hazard to health and safety (such as a dangerous substance) with due caution;

- Do not interfere with or misuse anything provided in the interests of health and safety.

If there are any questions about safety matters, line managers within the respective marine safety investigation body should be consulted, and if in any doubt about safety, an investigator should err on the side of caution. It must be remembered that accidents that occur during a safety investigation may not only have serious consequences for the individuals concerned but will also significantly discredit and hamper the investigation itself.

2.3.2 RISK ASSESSMENT

Conducting a hazard identification and risk assessment is an important aspect for ensuring an investigator's safety. The concept of risk assessment is relatively simple and follows these basic steps:

- Identification of the hazards;

- Assessment of the chances of a hazardous event occurring;

- Assessment of the severity or consequences:

- If the combined risk and severity is of concern, taking some action (risk control) to eliminate or reduce the risk to as low a level as is reasonably practicable.

The priorities in the risk control process should be, in order of importance, to:

1. Eliminate the hazard;

2. Reduce the hazard level;

3. Provide safety devices;

4. Provide warnings;

5. Provide safety procedures and protective equipment.

The marine safety investigation body should ensure that a risk assessment is carried out by those appropriately trained to do so, that the appropriate measures to address the risks have been taken, and that the investigators have been made fully aware of the necessary precautions and procedures prior to entering the site.

A risk assessment should be carried out for each specific situation when an investigator arrives at an accident site. This need not necessarily be written down, but it requires pre-assessment of the situation together with a decision on what, if any, additional precautions are needed or, ultimately, a refusal to carry on when deemed unsafe to do so.

2.3.3 SITE HAZARDS

2.3.3.1 General hazards

The handling of, and working amongst, wreckage at a casualty site is inherently hazardous and requires the use of protective clothing, appropriate equipment, and a good understanding of the potential risks. There will be hazards not only associated with normal ship operations but also from equipments which have been subjected to conditions for which they were not designed.

Common hazards can include:

- Working at heights;
- Proximity to operating machinery;
- Confined or poorly lit spaces;
- Noisy environments;
- Chemical and/or biological hazards;
- Unstable, fragile or slippery ground.

Hazards can also come in many forms, including:

- Floating wreckage which may shift, sink or capsize;
- Fire damaged equipment such as pressure containers, flares, generators and accumulators;
- Electrical devices and chemicals (both ships' own and cargo);
- Those associated with fuel, including oils in bulk or in hand-portable containers.

2.3.3.2 Pressurised containers

Pressure containers include engine starting air receivers, fire extinguishers, flame cutting gas bottles and breathing equipment. All potentially hazardous items that have been exposed to the effects of the casualty should be considered to be in a hazardous state until rendered safe. Additionally, emergency equipment which has been used by the crew or by the emergency services to combat the accident, e.g. pressurised CO2 systems, should be considered to be in a potentially dangerous condition until confirmed safe, preferably by the manufacturer's representative or specialist.

2.3.3.3 Batteries

Batteries should be disconnected, and removal from the site should be considered where there is a risk of flammable gases or liquids in the vicinity from being ignited. Caution should be exercised when disconnecting and removing batteries due to the possibility of sparks. Additionally, battery acid is extremely corrosive.

2.3.3.4 Flammable liquids and gases

Flammable liquids and gases, which may be in bulk, can ignite or explode. The inhalation of fuel vapours, or direct contact with the skin, can be harmful. Where it is considered to be a hazard, advice should be sought from the emergency or specialist services on either the removal or the securing of the fuel from potential ignition. Smoking can be a significant hazard in some environments and should not be permitted.

2.3.3.5 Asbestos and composite materials

On older ships, asbestos was commonly used for insulation and for its fire resistant properties. Disruption of the asbestos and production of loose, floating material is very dangerous and suitable respiratory system protection should be worn.

Fibreglass and other composite material can be found in a variety of equipments, including life-saving apparatus, and can be hazardous to the eyes, skin and respiratory system, particularly if damaged by fire. If concerned about the potential asbestos hazard, consult specialists for advice.

Modern ships can often contain composite structures, which can form sharp and jagged edges when damaged. When handling the structures, robust leather gloves and reinforced protective footwear must be worn. Burning or smouldering composite materials create toxic gases. Only Self-Contained Breathing Apparatus (SCBA) will provide sufficient protection against such gases. Combusted composite structures emit fine dust and fibres that irritate the skin, eyes and respiratory passages, and penetrate unprotected skin.

When dealing with these materials in the wreckage, disposable overalls, overshoes and gloves should be worn, especially when there is a likelihood of asbestos contaminating clothing. The overalls should be of the type suitable for asbestos work and should have a hood and elasticated cuffs and ankles. They can be worn over normal clothing but should be carefully removed after use, by turning inside out, and be disposed of as asbestos waste. Care should be taken to prevent the spread of asbestos. With respect to asbestos, SOLAS II-1 should be taken in to account.

For some dirty or contaminated sites, wellington boots will be required, and these should be wiped or washed clean if they become contaminated, and/or after on-site activities are completed.

When handling fibreglass or composites, investigators should avoid the fibre dust by wearing goggles and a dust mask. As with asbestos, disposable coveralls may be needed, and contaminated clothing should be washed separately. If either fibreglass or composite materials have been damaged by fire, they should be sprayed with water before handling.

2.3.3.6 Hazardous materials

A ship's cargo may be combustible, toxic, corrosive or radioactive. The shipping company or the forwarding agent should have information on hazardous cargoes, but the accuracy of the details on the content may need to be reviewed with caution. Exposure-prevention is the primary aim with hazardous materials. Only where exposure cannot be prevented will there be a need to resort to personal protective equipment. If an investigator obtains advance information on the ship's cargo, reference may be made to the IMDG Code and its supplements for advice on particular hazards to health from that cargo. Otherwise, investigators should obtain information on the risks and precautions necessary from the ship's Master. Product data sheets, including Material Safety Data Sheets, where applicable, for all goods supplied to the ship, should be available. Investigators must not expose themselves to unknown risks and must seek advice before proceeding.

To avoid injuries, the following four steps are suggested:

1. **EXPECT** that hazardous materials may be present in any accident involving cargo damage until you have ruled out their presence. The investigator should always search for indications of the possible presence of hazardous materials in any accident. These materials may be indicated by warning placards or signs, labels on packages, shipping papers, or verbal information from people at the scene. You should recognize the warning placards and labels described in the regulations. Hazardous materials may be dangerous while they are still in their containers or if they have escaped from their containers. The principle is to scan the wreckage to rule out their presence; assume that hazardous materials can be present until you have conclusively established that they are not.

2. **WAIT** until potential energy transfers such as fires, explosions, vapours, breached radioactive materials containers etc. have been eliminated. Hazardous materials can be emitted in many ways for many reasons. Even worse, it is almost impossible to tell precisely when they will react and envelop the danger zone with you in it.

   Unless you have a compelling reason to go aboard the ship or enter the accident site while the hazardous materials containment systems are under mechanical or thermal stress, wait for those potential energy transfers to be eliminated. Alternative methods for acquiring evidence can be utilized. For example, aerial photographs, interviews with witnesses whose duties require them to go into the wreckage area, and subsequent examination of physical debris may provide the evidence you need. Consider the trade-off between the value of the data you need now from the accident site, and the risks to your safety. Stressed containers should be considered to have the potential for abrupt rupture. The contents should be considered to have the potential for an explosion until you have clear and convincing evidence to the contrary from experts.

3. **FOLLOW** others into the wreckage rather than leading others into the wreckage. A good rule of thumb is to stay away from the ship or accident site containing hazardous materials until a certified competent expert has certified the area as safe to enter. Check his/her credentials, and ask questions regarding the behaviour of the hazardous materials in the accident to satisfy yourself that he/she is truly knowledgeable. From his/her predictions, satisfy yourself that any expected problems pose no threat to your

personal safety. In those circumstances, you may wish to follow him/her into the wreckage area.

Your ability to predict how the hazardous materials will behave is poor, because this is not your role in a marine safety investigation. Obey any evacuation instructions from police and firemen. In no event should any investigator follow firemen or other emergency or rescue personnel into the wreckage area. A rule of thumb is to stay at least 600 metres (2,000 feet) away from any fires burning in wreckage where hazardous materials are present.

4. **DON'T** take chances. If you have any uncertainty about the behaviour of potentially destructive hazardous materials in an accident area, don't take chances by entering the wreckage. There is very little to be gained and much to be lost if you risk your own safety. Remember, your role is to determine what happened, and not to be a part of what is happening.

2.3.3.7 Permit to work schemes

On board ship, many hazardous operations require a permit-to-work, as a means of controlling operations, and to ensure that authorised personnel are aware of the hazards, have taken the basic safety precautions and have the approval of the appropriate competent person. Permits-to-work are usually given for a specific short period of time, are renewed daily if necessary and are cancelled when operations are completed. The investigator should ask if there are any permit-to-work (or permit-to-enter) systems in place, and should always follow instructions if they are.

Before working on or near equipment which may start unexpectedly, ensure that the suitable responsible persons have been informed, that the equipment has been isolated, that confirmation has been received, and warning notices put in place. The attendance of a responsible person while the investigator is working in the vicinity of such equipment will help prevent misunderstandings.

2.3.3.8 Entry in to confined spaces

The atmosphere of any enclosed or confined space is potentially dangerous. No tank or compartment that contains or contained dangerous (hazardous materials) cargoes or petroleum products, or other enclosed spaces which are not continuously ventilated, should be entered until the atmosphere has been tested for toxicity and flammable vapours and for sufficient levels of oxygen. Beware that seemingly innocuous spaces can be potentially hazardous, for example forecastle stores and chain lockers where the action of rusting has depleted the oxygen in the space. Consideration should be given to wearing personal oxygen meters and having escape hoods to evacuate from a space if the atmosphere is dangerous to human life.

2.3.3.9 Climate and working conditions

A rapid response to a casualty may preclude the chance to acclimatise to conditions that vary widely from those accustomed to. There are health hazards associated with physical labour in extreme temperatures, and the effects of fatigue on safety. The quality of the investigation is

best served by management awareness of the need for mental and physical fitness. Ideally, investigators should be given time to acclimatise and rest after potentially long journeys to ensure their safety is not compromised.

2.3.3.10 Biohazards

High speed ship collisions or accidents involving explosions may result in an accident scene that is contaminated with human blood, body fluids or tissue remains. Upon entering such a scene, the investigating team must take proper precautions to protect themselves from exposure to blood borne pathogens. When handling potential blood borne pathogens, universal precautions should be observed to minimize potential exposure. All human blood and body fluids should be treated as if they are infectious. The precautions listed should be implemented for all potential exposures. Exposure is defined as reasonable anticipated skin, eye, mucous membrane, or potential contact with blood or other potentially infectious materials.

The existence of a biohazard in a certain area can be established by healthcare authorities. In urgent cases, a physician from a health centre can be asked to establish the fact. The following protective gear must be worn when entering a biohazard zone:

- Overall and, if necessary, a disposable overall;
- Protection over footwear;
- Latex, nitrile or rubber gloves;
- Leather work gloves;
- Goggles or a facemask;
- Respiratory protection - either a paper mask or a half-mask.

In a casualty investigation site a biohazard may be caused not just by the bodies of the victims, but also residues (such as blood) stuck to the ship. Consequently, protective gear must be used even if the bodies have already been removed. It must be replaced with new after every visit to the contaminated zone. All used protective gear must be taken off inside out, sealed in a plastic bag and collected for incineration, e.g. in the local hospital's incinerator. Washing facilities should be available near the contaminated zone. Smoking, eating and drinking should be forbidden in the contaminated area.

2.3.3.11 Wreckage involving radioactive materials

Shipment of radioactive materials may create hazards requiring special precautions and procedures in the course of marine safety investigations. For example, radio-isotopes used in nuclear medicine are potentially radioactive materials which may often be carried as container cargo. Where there is damage to cargo, it should be determined as soon as possible whether or not radioactive materials were involved in the accident. The ship involved should have a manifest that shows whether radioactive materials are involved.

When it is determined that radioactive material is in the damaged cargo, the lead investigator should be responsible for assuring that all investigators are so informed and that adequate precautionary measures are taken to avoid exposure to contaminated areas. Seek expert advice before entering or allowing anyone on the investigation team to enter an area of suspected contamination.

Also be aware of pieces of ship's equipment that may have a radioactive source contained within them. While preventing no hazard intact, after a fire or other damage the radioactive source may be exposed. It will be prudent to speak to the ship's Master and crew to establish any such potential sources, prior to examining the ship.

2.3.3.12 Personal safety equipment

In addition to the basic personal protective equipment that should be worn while on-site, other specialized equipment may be necessary when working aloft or overboard during an investigation. Suitable safety harnesses, lifelines, safety nets, lifejackets and waterproof clothing should be used, as appropriate. Additionally, lifebuoys with sufficient line should be available for ready use and an observation watch maintained while the investigator is in a potentially hazardous location. The risks in the use of portable ladders, cradles, staging or bosun's chair to access difficult locations should be carefully considered and balanced against the potential gain in evidence.

2.3.3.13 Working alone

In trying to conduct an investigation as expeditiously as possible there may be occasions when an investigator will work alone in examining a scene. It may be perfectly safe to do so but it is worth stopping and thinking whether there is a need for another person to watch out for you and to be able to raise the alarm. Often two people examining a scene will be more thorough and enable one investigator to direct the other to take specific photographs. Investigators should also familiarise themselves with escape routes to ensure they can reach a muster point or safety in an emergency.

2.3.3.14 Fire scenes

Fire scenes can be particularly hazardous and should be approached with caution. Ideally, an investigator should be trained in fire investigation. Investigators must be vigilant at all times to protect themselves from the hazards that may be hidden by the charred debris, ashes and damage. Hazards may include live electrical wiring, sharp objects, hazardous materials and biohazards. Investigators must also make sure the scene is structurally safe to enter.

2.4 EVIDENCE GATHERING

In the context of this Manual, evidence is anything that helps to establish what, when, why, where and how a casualty or incident has occurred.

Collecting data is a critical part of the investigation. The detailed information collected by the marine safety investigation team is the foundation for the entire investigation, including the analyses and conclusions. These in turn become the basis for identifying preventive measures

to prevent recurrences. Consequently, it is important to ensure that all relevant information is collected and that the information is accurate.

Gathering and analysing information is an inter-dependent iterative process that takes place throughout the first few weeks of the investigation cycle. As early analysis is conducted on the initial evidence and gaps will become apparent, requiring the team to collect additional evidence. Generally, many data collection and analysis iterations occur before the team can be certain that all pertinent evidence has been gathered and analyses are finalised.

Evidence can be split into four main categories, each requiring different approaches:

1. Human or testament - witness statements and observations;

2. Physical - matter related to the accident, e.g. equipment, parts, debris, hardware etc.

3. Documentary - records, reports, procedures etc.;

4. Electronic - VDRs, electronic charts, VTS recordings, CCTV etc.

Collecting evidence can be a lengthy, time-consuming, and piecemeal process. Witnesses may provide sketchy or conflicting accounts of the accident. Physical evidence may be badly damaged or completely destroyed. Documentary evidence may be minimal or difficult to access. Thorough investigation requires that team members be diligent in pursuing evidence and adequately explore leads, lines of inquiry and potential causal factors until they gain a sufficiently complete understanding of the accident.

When evidence is acquired it is important that it can be accounted for from the time it is acquired to the time that the investigation is complete.

2.4.1 GENERAL APPROACH

The method for fact-finding while conducting a safety investigation can include, but is not limited to, the following activities:

- Interviewing witnesses (see Chapter 3, Section **3.5** - Witness Interviewing);

- Measurement;

- Photography;

- Examination of documentation including charts, plans and standing orders;

- Examination of material evidence at the marine casualty or incident site;

- Accessing computer records, replay and memory access from GPS, ARPA, electronic charts and machinery and other data records;

- Downloading and analysing Voyage Data Recorders;

- Examining course recorders and other automatic data recording devices;
- Listening to communication tapes and records;
- Viewing VTS recordings;
- Obtaining certificates, e.g. registry, competency, machinery, class, safe manning;
- Viewing cargo records;
- Checking invoices and other relevant documents;
- Viewing satellite photography;
- Obtaining weather forecasts and actual weather reports;
- Sampling;
- Referring to manufacturers' handbooks;
- Reading company annual reports;
- Obtaining ephemeral data from Almanacs – actual tides as opposed to predicted;
- Studying media reports;
- Examining standing orders, Statutory Instruments, Flag State instructions;
- Conducting specialised studies (as required);
- Looking at organisational matters;
- Identifying conflicts in evidence;
- Identifying missing information;
- Examining waste paper baskets and rubbish bins.

During the initial stages of a safety investigation, investigators should aim to gather and record all of the facts which may be of interest in determining 'who', 'what', 'when', 'where', 'how' and, importantly, 'why' the accident occurred. 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.

Information should be verified, whenever possible. Statements made by different witnesses may conflict and further supporting evidence may be needed to ensure that all of the relevant facts are uncovered and the most likely sequence of events is determined.

2.4.2 PHYSICAL EVIDENCE COLLECTION

The investigation team should proceed with gathering, cataloguing, and storing physical evidence from all sources as soon as it becomes available. The procedures for access to, and the controlling of, evidence may be subject to national legal requirements which vary from country to country. The most obvious physical evidence related to an accident or accident scene often includes:

- Equipment;
- Tools;
- Materials;
- Pre- and post-accident positions of accident-related elements;
- Scattered debris;
- Patterns, parts, and properties of physical items associated with the accident.

Less obvious but potentially important physical evidence includes fluids (liquids and gases). Ships use a multitude of fluids, including chemicals, fuels, hydraulic control or actuating fluids, and lubricants. Analysing such evidence can reveal much about the operability of equipment and other potentially relevant factors. It may be that specialists are required to perform the appropriate tests. Take the necessary precautions if biohazards are likely to be present.

2.4.2.1 Documenting physical evidence

Evidence should be carefully documented at the time it is obtained or identified. An Accident Investigation Physical Evidence Log (See **Annex 1** for an example) can help investigators document and track the collection of physical evidence. In a multi-investigator team investigation, the use of an Evidence Log will prevent several investigators asking for the same piece of evidence, thereby avoiding duplication of effort. Additional means of documenting physical evidence include sketches, maps, photographs, and videotape.

2.4.2.2 Sketching and mapping

Sketching and mapping the position of debris, equipment, tools and injured persons may be initiated by the team as soon as it arrives on scene. Position maps and the ship's plans convey a visual representation of the scene immediately after an accident. Evidence may be inadvertently moved, removed or destroyed, especially if the accident scene can only be partially secured. Therefore, sketching and mapping should be conducted immediately after recording initial witness statements. Precise scale plots of the position of elements can subsequently be examined to develop and test accident causal theories.

2.4.2.3 Photography

A good quality digital camera is an essential tool for all investigators and a thorough knowledge of the features and idiosyncrasies of the particular model used is important. Spare batteries and memory cards should always be carried. Photographs not only provide evidence, they assist people to recall events, and their inclusion in the investigation report will often add clarity to the text. They can also be used for presentation purposes.

Photographs of the general layout of the ship are important, preferably taken at such a distance that the whole can be accommodated in a single frame. Front or side lighting is advisable, and only use back lighting if there is no option. Photographs of damage areas are essential and this requirement means that the investigator should be on site as soon as possible after the event, prior to repair work. Damage should be photographed from as many different angles as possible. Pictures should have some means of determining scale; very often an easily identifiable reference point will provide this but in other cases a measuring rule, coin, pen or similar should feature in the frame. When a casualty occurs in view of a witness, a photograph of the line of sight should be taken, preferably in similar lighting conditions. If a casualty occurred at night, the investigator should endeavour to take photographs of the scene using both flashlight and natural light. A photograph of a scene taken in low light levels outside will require the camera to be set on a 'low light', 'night' or 'delay' setting; the use of a tripod or other solid support during the extended exposure period will be needed. Obviously there are limitations to what photographs can be taken in low light.

Photographs of instrument settings, fuse boxes, fractures, wires, electrical equipment and any small items may require close-up or macro-photography. Additionally, a method of steadying the camera is often necessary, as is consideration of the light source. Direct flash will often reflect back in to the lens making the finished product unacceptable. When photographing specific items of evidence, a better picture will result if a contrasting background is provided.

Consideration should be given to photographing key personnel (or substitutes) in the positions they were occupying at the time of the accident. This can be particularly useful when analysing the individual lines of sight and areas of influence.

If it has not been possible to attend the casualty site before the site has had to be disturbed in response to the casualty, then photographs by those involved or those attending the casualty should be requested, where possible. Once on-site, the investigator should determine the location and direction from which the photographs were taken, and should consider taking identical shots if useful for confirmation purposes.

Caution must be taken to ensure photographs do not misrepresent a scene and lead to false conclusions or findings about an accident. Investigators should take care to avoid this and if deemed necessary employ professional photographic services, which could include police forensic officers if there is a judicial investigation underway. Even if photographs are taken by a skilled photographer, the investigation team should be prepared to direct the photographer in capturing certain important perspectives or parts of the accident scene. Information about the scene/subject, date, time, direction and orientation of photos taken, should be documented.

2.4.2.4 Video recordings

Video can help an investigator recall the location and layout of an accident scene. It also provides a useful tool when reconstructing the position of people or equipment before, during and after the accident. The aim of video filming is to present a visual record of an accident scene in a technically useful manner. A thorough videotape allows the team to minimize trips to the accident scene. This may be important if the scene is difficult to access or if it presents significant hazards. An element of planning beforehand is necessary to get the best of video filming.

When videoing, investigators should consider what the end result will look like, and be aware that roaming randomly, panning endlessly and continually zooming in and out can be distracting to the viewer. A series of static wide-angle shots of the same scene from different positions is often better than random roaming. This should be followed up by static shots of points of interest. Almost certainly these will be close-ups of varying degrees.

When taking shots of a distant object, such as a navigation mark, always attempt to include some form of reference mark, perhaps background scenery, against which the viewer can orientate. It is important that voice-over descriptions of scenes, equipment etc. are made in all cases for future reference.

Health and safety should also be considered while taking video, as the investigator will be pre-occupied with the content and commentary of the video and is likely to be less aware of the site hazards while moving around. In these situations, the proximity or close observation of a colleague or responsible person will help ensure the safety of the camera operator.

2.4.2.5 Inspecting physical evidence

Following initial mapping and photographic recording, a systematic inspection of physical evidence can begin. The inspection involves:

- Surveying the involved equipment, vehicles, structures, etc. to ascertain whether there is any indication that component parts were missing or out of place before the accident;

- Noting the absence of any parts of guards, controls, or operating indicators (instruments, position indicators, etc.) among the damaged or remaining parts at the scene;

- Identifying as soon as possible any equipment or parts that must be cleaned prior to examination or testing and transferring them to a laboratory or to the care of an expert experienced in appropriate testing methodologies;

- Noting the routing or movements of records that can later be traced to find missing components;

- Preparing a checklist of complex equipment components to help ensure a thorough survey.

These observations should be recorded in notes and photographs so that investigators avoid relying on their memories. A small voice recorder can be useful for recording general descriptions of appearance and damage; however, the potential failure of a recorder, inadvertent erasure and limitations of verbal description suggest that verbal recorded descriptions should be used in combination with notes, sketches, and photographs.

2.4.2.6 Removing physical evidence

Following the initial inspection of the scene, investigators may need to remove items of physical evidence. To ensure the integrity of evidence for later examination, the extraction of parts must be controlled and methodical. The process may involve simply picking up components or pieces of damaged equipment, removing bolts and fittings, cutting through major structures, or even recovering evidence from beneath piles of debris. Before evidence is removed from the accident scene, it should be photographed and its position noted on an appropriate sketch of the scene. Remember, once it has been moved, it will never be able to be returned to exactly the same position that it occupied before it was moved. It should then be carefully packaged and clearly identified.

Equipment or parts thought to be defective, damaged, or improperly assembled should be removed from the accident scene for technical examination. If improper assembly is suspected, investigators should direct that the part or equipment be photographed and otherwise documented as each sub-assembly is removed.

Items that have been fractured or otherwise damaged should be packaged carefully to preserve surface detail. Delicate parts should be padded and boxed. Both the part and the outside of the package should be labelled. Greasy or dirty parts can be wrapped in foil and placed in polyethylene bags or other non-absorbent materials for transport. If uncertainties arise, subject matter experts can advise the investigator regarding effective methods for preserving and packaging evidence and specimens that must be transported for testing.

When preparing to remove physical evidence, these guidelines should be followed:

- Normally, extraction should not start until witnesses have been interviewed, since visual reference to the accident site can stimulate one's memory.

- Extraction and removal or movement of parts should not be started until position records (measurements for maps and photographs) have been made.

- Be aware that the accident site may have been sufficiently damaged to make it unsafe to collect the particular evidence required.

- Locations of removed parts can be marked with orange spray paint or wire-staffed marking flags; the marking flags can be annotated to identify the part removed and to allow later measurement.

- Care during extraction and preliminary examination is necessary to avoid defacing or distorting impact marks and fracture surfaces.

- There must be agreement with other interested parties before extraction takes place.

2.4.2.7 Sampling of physical evidence

Paint samples, books for forensic testing, materials etc. should be put in clean, sterile plastic bags. Where the evidence is too large for such a bag then alternative means of securing the sample may have to be made. A large plastic bin may be suitable; otherwise, the sample may have to be taken unsecured by a covering. If this is the case a note should be made in the investigator's notebook.

Any evidence sample that may give off hydrocarbons (oil samples, or samples of material that may contain some fire accelerant solution) should be secured in clean sample tins with a secure top as hydrocarbons can breathe through plastic. If necessary, paint suppliers may be able to provide such tins.

When evidence samples are sent for testing or analysis it is sensible to have a documentary trail to show who received what and when and who removed seals and resealed containers.

2.4.3 COLLECTING DOCUMENTARY EVIDENCE

2.4.3.1 Documentation in general

Documentary evidence can provide important data and should be preserved and secured as methodically as physical evidence. This information might be in the form of logbooks, equipment readouts, course recorder traces, chart (paper or electronic) licenses, documents, certificates, papers, navigation software version numbers, photographs, videotape, organizational charts either at the site or in files at other locations.

Some work/process/system records are retained only for the workday or the week so their swift identification is required to ensure they are secured. In some cases important documents may be in a language not familiar to the investigator; if so, it may be better to take more copies of documents to enable translation at a later stage. Some crew can also assist with pointing out the documents you have requested.

Marine safety investigation planning should include the identification of records to be collected, as well as the people responsible for their collection, since records are not always located at the scene of the accident. Clearly, the requirement for some documentary evidence will only materialise as the investigation progresses. If electronic copies of ship procedures and working instructions are available it is worth collecting them, but be sure to check the paper copies held onboard, which may have amendments or missing sections.

Documents often provide vital evidence for identifying causal and contributory factors to an accident. The evidence can be useful for:

- Thoroughly examining the policies, standards and specifications that shaped the environment in which the accident occurred;

- Indicating the attitudes and actions of people involved in the accident;

- Revealing evidence that generally is not established in verbal testimony.

Documentary evidence generally can be grouped into four categories:

1. Management control documents that communicate management expectations of how, when, where, and by whom work activities are to be performed.

2. Records that indicate past and present performance and status of the work activities, as well as the people, equipment and materials involved.

3. Reports that identify the content and results of special studies, analyses, audits, appraisals, inspections, inquiries and investigations related to work activities.

4. Follow-on documentation that describes actions taken in response to the other types of documentation.

Collectively, this evidence gives important clues to possible underlying reasons for errors, malfunctions and failures that led to the accident. Analysis of documents may involve cross checking documents from different sources that contain the same information, or scientific analysis. Analysis could include cross checking the bridge movement book with the engine room records.

It cannot be emphasised enough that contemporaneous records, i.e. those made at the time of an accident, are of greater value. Written up copies of log books, e.g. the scrap log copied out in a fair hand are of limited value. Of greater value is the cross checking of the ship's records with external sources such as VTS tapes, harbour control tapes or log books, cargo terminal records, police records, customs records or even TV or radio recordings.

Investigators must keep an open mind and think laterally by asking: 'Who else may have similar information?' to enable the evidence to be verified.

2.4.3.2 Organizational and management factors

Marine safety investigations must thoroughly examine organisational concerns, management systems and line management oversight processes to determine whether deficiencies in these areas contributed to the accident. The investigation team should consider the full range of management systems through all levels of management in accordance with the ISM Code. It is important to note that this focus should not be directed toward individuals.

The ISM Code documentation should be inspected as a matter of routine. It is important to ensure that the procedures in the Code have been adhered to. The ship operator's Documentation of Compliance is valid for 5 years, subject to annual verification. The ship's Safety Management Certificate is valid for 5 years, subject to periodical verification by the Administration. All aspects of the Code are important to an investigator and include but are not limited to:

- Training (ISM Code 6.3);

- Information and language of ISM Code (ISM Code 6.6);

- Plans, instructions and check lists for the safety of the ship and pollution prevention (ISM Code 7.0);
- Emergency preparedness (ISM Code 8.0);
- Reporting non-conforming incidents (ISM Code 9.1);
- Corrective action (ISM Code 9.2);
- Maintenance (ISM Code 10.1);
- Documentation (ISM Code 10.1);
- Critical equipment (ISM Code 10.3);
- Record of internal audits (ISM Code 12.3).

If there was a departure from the Code it is important to identify the non-conformity to establish whether the departure was consistent with reasonable decision making. Depending upon the casualty it may also be necessary to check the ship's reporting of non-conforming incidents (ISM Code 9.1) and the management receipt of such records and subsequent action, which may include a record of corrective action (ISM Code 9.3). Sometimes issues that arise in an accident may have been identified in previous audits; establishing why corrective action has failed to prevent the accident can be quite telling.

2.4.3.3 Photocopies

Investigators should be sensitive to the possibility that photocopies of documents may not truly depict the original document. Erasures and/or the use of 'white out' correction liquids, which may be apparent on the original document, may not show up on a photocopy of the document. Further, as in the case of logbooks, entire pages may be removed. If the investigator does not examine the original document, he will not know for sure that the photocopy provided is, in fact, a true and accurate copy. Before photocopies of documents are accepted, the investigator should compare the copy with the original to assure that there have been no alterations to the original.

With digital cameras it is often just as easy to take a photograph of the relevant pages of the document, which may show up the original better. Ship's photocopiers can also be of varying quality, and taking documents ashore for copying can present its own problems.

2.4.4 ELECTRONIC EVIDENCE - VDR

In the past, marine safety investigation was very dependent on traditional 'detective work', the keystone of which was interviewing witnesses to derive their account of what happened. Different witnesses would recount different stories on the same incident and it was the investigator's job to consolidate the different accounts into a likely sequence of events - an often difficult process. Now in the electronic age in which we live, we have far more 'hard evidence' that can be used to support/disapprove witness accounts. The key electronic tool

now available to marine accident investigators is the Voyage Data Recorder (VDR), the marine equivalent of an aircraft black box flight recorder.

The VDR records and stores ship's data in a protective capsule and usually also on a computer hard disc, namely:

- Date & time;
- Main alarms;
- Position;
- Rudder order and response;
- Speed;
- Engine order and response;
- Heading;
- Hull openings;
- Bridge audio;
- WT and fire door status;
- Communications audio;
- Accelerations and hull stresses;
- Radar;
- Wind speed and direction;
- Echo sounder.

Not all of these components are compulsory; some, such as hull stresses, are only if the ship is fitted with such equipment. In addition, in 2004 the IMO introduced the requirements for a simplified VDR (S-VDR), requiring less data to be stored. What is readily apparent in either the case of a VDR or S-VDR is the potentially vast amount of evidence that may be available to an investigator to assist in a marine safety investigation

Where a VDR is fitted, it is essential that the investigator ensures that the ship takes the necessary steps to preserve this evidence as soon as possible, since the evidence is likely to be lost after 12 hours of the marine casualty or incident if no action is taken. If the ship carries a VDR, the investigators are entitled to obtain the information recorded on it. Obtaining

confirmation from the ship owner/operator/ship, that these steps have been undertaken, is also recommended.

IMO Regulations require that passenger ships and ships other than passenger ships of 3,000 GT and upwards must carry VDRs to assist in accident investigations. In the case of cargo ships of 3,000 GT and upwards, this may be a S-VDR.

Supporting guidance on most common types of VDR, their storage capabilities and information on download methods is available through the MAIIF/MAIB VDR Resource (www.maibresource.net).

In the event that the State conducting the safety investigation does not have the necessary resources to recover, extract or evaluate the data, it should request assistance from other Member States, taking into account:

- The capabilities of the replay and analysis facility;
- The timeliness of the availability of the resources;
- The location of the replay facility;
- The equipment and knowledge required for downloading and replaying the data;
- Any additional information required to replay the data;
- The time required to analyse the recovered data.

If no immediate assistance is available by this method, contact the VDR manufacturers who should be able to assist, although perhaps incurring cost.

Where a VDR is not readily accessible and information has not been retrieved prior to the abandonment of the ship, the investigators should decide on the viability and cost of recovering the VDR, balanced against the potential value of the information it contains. The possibility of the capsule having sustained damage should be considered and specialist expertise may be required to ensure the best chance of recovering and preserving the evidence. In addition, the assistance and cooperation of the ship owner, insurer and the manufacturers of both the VDR and protective capsule may be required.

2.4.5 ELECTRONIC EVIDENCE - GPS DEVICES

GPS units will be found on many ships and potentially can provide vital clues to an accident. The GPS units need to be handled with care, depending on the state in which they are found, to maximise the chances of obtaining historical GPS information. The following guidance will assist in dealing with the various states in which you may find a GPS after an accident.

2.4.5.1 Wet GPS devices

GPS devices have two types of memory, volatile and non-volatile.

1. Volatile memory is usually used in older devices and all the data is lost once the internal circuits come into contact with water.

2. Non-volatile memory can theoretically be read after immersion, provided the device is opened, the circuits are rinsed with fresh water and the device is delivered to an appropriate technical centre capable of retrieving information from such devices. Although there are no guarantees, it is worth pursuing if the GPS can be recovered.

2.4.5.2 Dry or waterproof GPS devices

As a minimum, the last confirmed position of the device before the power was lost, or it was switched off, will be stored. In most cases this will be lost when the device is switched on again, unless this is done in a controlled environment. Therefore, if the last position is important, it is essential that the device is not switched on in the field by anyone.

What else is stored depends on the device and the way it has been set up. In the worst case nothing other than the last position or a 'snail trail' that can be zoomed in on with the cursor on the device to estimate the positions will be available. In the best case 24 hours or more of tracks including position, course-over-ground (COG), speed-over-ground (SOG), time and waypoints in a form that can be downloaded will be available.

If the device is physically damaged, it is likely that an appropriate technical centre will be able to read the memory chip and so the device should be returned to them. To prevent electrical damage, ensure that any batteries are removed before transport, and do not attempt to switch it on.

Where track data is stored, it may be possible to interface PCs to these devices and thereby download the data stored on them directly. It may then also be possible to access the data for analysis.

2.4.5.3 GPS devices that are still operating

In most cases, the unit will have to be brought back to the investigator's office to download this data if the device supports data transfer. In some instances it is possible to transfer the data to the device's memory card; in order to do this you may need to obtain a spare memory card from a local supplier.

2.4.5.4 GPS data retrieval summary

If it is wet inside, obtain expert advice. If it has not been in the water for more than 48 hours, then send it to an appropriate technical centre but be aware that the odds are against any data being recovered.

If it is dry inside, do not switch it on and try to ensure that no one else does either (warn the local police, maritime authority, coast guard, harbourmaster etc.).

2.4.6 OTHER ELECTRONIC EVIDENCE

Increasingly, digital information from electronic sources, both on the ship and ashore, is retrievable and can offer objective evidence to the safety investigation. Investigators should carry equipment that will record/copy and may even replay information, and be familiar with its operation. The required equipment can include, but is not limited to:

- A laptop computer;
- USB flash memory;
- USB and ethernet cables;
- Portable hard disc;
- CD/DVD player/burner and floppy disc drives (some ship systems still use floppy drives).

Equipment enabling investigators to perform screen captures is also useful.

It is important that investigators establish the software that is being used, and the operating system and version of the equipment from which any electronic data are being copied. On board, equipment that may record or hold digital information includes:

- Electronic Chart Display and Information Systems (ECDIS);
- Electronic charting systems;
- GPS devices;
- AIS transponders;
- Radars;
- Engine management systems;
- Fire protection systems;
- Communications systems;
- Security cameras;
- Electronic log books;
- Planned maintenance and safety management systems.

Ashore, ship traffic management systems (VTS and VTIS) record and store digital and AIS information. This information is routinely recorded by many Coastal States and commercial

organizations and, along with other commercial tracking services, can provide useful information. Through these systems, it can also be useful to determine whether other ships, which were in the vicinity of the casualty, and which carry a VDR, might be able to provide additional information. In port, security cameras may record video footage. Communication records (VHF and telephone) are often stored, as are weather records.

Where a device containing electronic information is required to be examined, which entails switching on, disassembly or some other examination, particularly where such action may materially alter the condition or state of the device, consideration should be given to consulting relevant stakeholders in advance and seeking specialist expertise if necessary.

2.4.6.2 ECDIS/IBS

ECDIS is a computer-based information system designed to replace paper charts on a ship. Its primary function is to display information from digital charting (from various different formats) and integrate it with position data. It can then be used in the same way as a paper chart, plotting a berth-to-berth course into the system, with the added benefit that the ship's position is automatically determined and always known. In addition, an ECDIS may also display data from radar, echo sounder, AIS and other on-board instruments. Approved ECDIS systems with a suitable backup system can now also be carried in lieu of paper charts. Typical electronic manufacturers that may be encountered could include TRANSAS on merchant ships and OLEX on fishing vessels.

An integrated bridge system (IBS) is defined as a combination of systems which are interconnected in order to allow centralized access to sensor information or command/control from workstations, with the aim of increasing safe and efficient ship's management by suitably qualified personnel. Performance standards for integrated bridge systems were adopted by IMO in 1996.

Paragraph 6 of SOLAS Chapter V, Regulation 19 - *Carriage requirements for ship-borne navigational systems and equipment* - states that 'integrated bridge systems shall be so arranged that failure of one sub-system is brought to the immediate attention of the officer in charge of the navigational watch by audible and visual alarms, and does not cause failure to any other sub-system. In case of failure in one part of an integrated navigational system, it shall be possible to operate each other individual item of equipment or part of the system separately.'

2.4.6.3 Bridge information recording equipment

These may include:

- Fire protection systems;
- Communications systems;
- Security cameras;
- Electronic log books;
- Planned maintenance;

- Safety management systems.

2.4.6.4 Engine room recording equipment

These may include:

- Engine management systems;
- Fire protection systems;
- Communications systems;
- Security cameras;
- Electronic log books;
- Planned maintenance;
- Safety management systems.

2.4.6.5 Mobile phones

Mobile phone records primarily concerning the time that the phone was used and, where possible, a triangulation position, can be of great use during a fatality or missing presumed lost investigation where no witnesses or other evidence are available.

Depending on the legislation of the State in whose jurisdiction the casualty occurred, it may be possible to obtain mobile phone records, possibly through the judicial authorities.

2.4.7 PRESERVING AND CONTROLLING EVIDENCE

Preserving and controlling evidence are essential to the integrity and credibility of the investigation. Security and custody of evidence are necessary to prevent its alteration or loss and to establish the accuracy and validity of all evidence collected.

If a judicial investigation is continuing in parallel to a safety investigation then the judicial authority concerned will require the preservation of evidence to their standard to ensure it can be used in court at a later date. If a marine safety investigation body cannot comply or meet this standard, it is highly likely the evidence will have to be seized by the judicial authority, and access to it will have to be negotiated. This may represent a significant hindrance to the investigation body's investigation and, in a worst-case scenario, access to the evidence may not even be granted by the judicial authorities.

Prior to investigators arriving at the scene, if necessary, a point of contact responsible for assuring that a chain of custody is established for all evidence removed from the accident should be established. Ideally, critical evidence should be left in situ until investigators arrive. Evidence control procedures similar to the following guidelines will help assure that evidence is

not adulterated, corrupted or lost, and that subsequent engineering and other relevant tests are valid:

- Evidence should be photographed and/or videotaped in its original location immediately following the accident, provided it does not interfere with rescue or relief activities.

- A log should be maintained stating the location, date and time that photographs and videos are taken.

- Create an evidence log including:

    - Lists of items removed from the scene;

    - Date and time items were removed from the scene;

    - Person who removed items from the scene;

    - Location where those items will be stored.

- Evidence should be controlled by signature transfer (signatures of the recipient and the person relinquishing custody) and made available only to those who need to examine and use the evidence during the marine safety investigation.

- Secure storage should be obtained immediately, and access to evidence controlled throughout the investigation.

- Access to the room or suite of offices used as an evidence room should be restricted.

Documentary evidence can easily be over-looked, misplaced, or taken. Documents can be altered, disfigured, misinterpreted, or electronically corrupted. Computer software and disks can be erased by exposure to magnetic fields. As with other evidence collected during the investigation, documentary evidence should be collected, inventoried (logged), controlled, and secured in locked containers, if necessary.

2.4.8 OTHER SOURCES OF EVIDENCE

The Investigator will often need to corroborate or cross check information available from the ship involved in an accident. VTS and port control centres may provide useful evidence. Pilot duty rosters and pilot company records, including safety management policies, may prove important. Investigators must keep an open mind on the sources of information that may include manufacturers' records, class society records, ISM audit records etc.

Other Substantially Interested States may have access to information that would be beneficial to the investigation.

2.5 SPECIALIST SERVICES

On some occasions there may be the need for specialist services to be used in the course of an investigation. This could include testing of faulty equipment, metallurgical testing of fractured components, underwater searches and even wreck salvage.

2.5.1 SPECIALIST TESTING

As alluded to in Chapter 1, it is beneficial to have contacts with test houses or companies that can provide specialist analysis of equipment or failed/faulty components. Specialists can include:

- Material test houses looking at fractured materials, material composition, fatigue analysis;
- Rope and wire testing:
- Prediction of load to cause failure, loss strength, failure mechanism, material composition;
- Equipment manufacturers, e.g. navigation equipment, main engines, auxiliary machinery, pumps, etc.;
- Independent test house for testing products against standards, e.g. liferaft, lifejacket and EPIRB testing;
- Forensic laboratories for microscopic and trace element examination, e.g. paint samples from collisions with unconfirmed ships, and wet document recovery;
- Electronic data recovery, VDR, GPS and computer hard drive recovery;
- Human factors specialists for voice recording analyses, fatigue and operator impairment analyses;
- Medical physicians, hospitals and laboratories for autopsies, drug and alcohol identification and medical issues.

Early on at the scene of an accident an investigator must assess whether specialist experts are needed as there may be very specific steps to be followed to enable the evidence to be preserved for testing. A quick telephone call to a manufacturer or test house will often determine whether a piece of evidence is worth retrieving or may be of little use, saving time in pointless recovering of evidence. When taking samples of materials for testing, ensure an adequate amount is retrieved for testing. Again, the test house should be able to advise how much material they need to enable satisfactory analysis.

When testing or faulty equipment has failed, every effort should be made to obtain a specialist that is not the manufacturer of the equipment to ensure impartiality and creditability of any testing. However, many pieces of equipment are highly technical and there is often no option

other than to take a piece of equipment to its manufacturer. In this case the investigator should assess the benefit of attending any tests or examination to ensure impartiality.

2.5.2 SEARCHES

In the case of a ship lost without trace, there may be the need to conduct a search to locate it if no survivors have been found or if initial accounts raise queries over the ship.

If people are missing, then invariably coastguard, navy or similar services will be conducting a search for survivors. If survivors are found, their position of recovery is important because given the tidal and wind conditions along with the time of the sinking, it may be possible to estimate a position where the ship was lost. In some instances the vessel may not have foundered. If this is thought likely, wind and tidal predictions can be used to derive where a ship may have drifted to and enable a search to be conducted in the most likely area. Maintaining close contact with the authorities conducting a search is therefore essential for an investigator to progress any investigation.

In some cases there may be the need to retrieve a VDR capsule. This could be a float-free capsule or, more likely, one that remains fixed with the ship. The VDR will be fitted with a sonar locating beacon, which will only transmit a signal for up to 7 days, so it is important to start a search quickly after an incident has occurred to maximise the chances of locating the device. Seek advice from MAIB or the Member State air accident investigation authority, which may have had experience recovering aircraft flight recorders (black boxes) from the sea, to establish how to home-in on the location signal.

It is unlikely an investigation body will have the facilities or resources to conduct a search for a missing ship themselves. Beyond what is conducted by emergency services, which will generally only search while there is a chance of finding survivors, it may be necessary to employ specialist contractors in hydrographic surveying to conduct a search. In some cases it may be possible to request the services of government or naval ships of a Member State to conduct a search. Sometimes port authorities have simple surveying equipment which might be suitable for simple searches. Searches conducted by such organisations should be carried in a methodical manner using standard search patterns to ensure a sea area is fully covered. Sometimes it is only possible to highlight several positions of interest on the seabed which require further investigation. This can only really be carried out by embarking on the next step of underwater surveys.

2.5.3 UNDERWATER SURVEYS

2.5.3.1 Diver surveys

Obtaining the services of divers to conduct an underwater survey needs to be carefully considered. A critical factor will be the depth of water in which a wreck has been found. For shallow water incidents less than 20m and simple searches it may be possible for divers in scuba gear to conduct an effective search as they will be able to stay on the bottom for 20-30 minutes at a time. For deeper water or more complicated cases, surface supply divers, or hard hat divers, will be required, which can involve decompression diving. In the latter case the logistics and team of people involved will be far greater and the cost much higher. In the case

of any diving it is essential to employ professionally qualified commercial divers that meet the local Member State's commercial diving regulations.

When employing divers ensure:

- They are briefed fully as to what is required (areas to look at etc.);
- The investigator understands the limitations of the dive, e.g. dive time, visibility, current;
- As much information is given on any known hazards of the wreck;
- Ideally that a head-mounted camera feeding back to the service is available with communications to allow some direction of the diver;
- That the diver is briefed not to interfere with the wreck any more than is required;
- The diver is interviewed after the dive, as to what was found, especially if no camera facility was available.

It is important to have realistic expectations of what a diver will be able to achieve. Deriving a priority list of what to look for first and then further tasks, if time allows, is a good way of maximising the dive's effectiveness. It must also be borne in mind that given current, visibility and weather conditions a dive may have to be aborted.

Occasionally, divers may have been brought to a scene to search and recover any missing persons. If this is the case, the diver(s) must be interviewed to determine what he has seen and what he has changed or tampered with in recovering any bodies. For example, pulling the body of a fisherman out of the wheelhouse of his fishing boat may dislodge controls like the engine throttle. The diver may also have had to open doors or windows to gain access.

Diver safety is of paramount concern. Investigators must not expect or request divers to endanger themselves for the sake of an investigation. Given that the investigators will have little or no experience of diving, the dive contractor must have the ultimate decision on whether it is safe to dive on a particular wreck. For more dangerous underwater surveys a remotely operated vehicle (ROV) survey may be the only option.

2.5.3.2 ROV surveys

ROVs can vary in size and capability depending on the demands of the underwater survey. If available, an ROV survey is in many ways preferable over a diver survey, as there is no limit on bottom time, operations can be directed from the surface and no diver's life is endangered.

In shallower water and areas where underwater current are not too great a small ROV which can pack down into two suit cases can be a very useful and inexpensive tool. Contractors will be able to mobilise quickly, arrive at a scene and within half a day be able to conduct an initial underwater survey. The ROV will have a camera and the investigator will be able to direct the ROV driver as to what he wants to examine. It is important to ensure the survey footage is

recorded to enable slow time examination at a later opportunity. The other advantage of the small ROV is that it can penetrate inside a wreck, an activity that should not be undertaken by divers because of the risk of entrapment. However, in some cases it may be beneficial to have divers available to open doors and hatches and to clear debris to allow an ROV to enter the site.

A small ROV has many advantages. However, in the case of complicated underwater surveys in greater depths of water (50-60 m) more capable and powerful ROVs will be required. The underwater current may be a critical factor as the drag on the umbilical cord from the ROV to the surface may be significant. The benefit of the bigger ROVs is that they may have a manipulator arm, or other tools, that can be useful in accessing a ship or retrieving important evidence or samples. However, the bigger the ROV the less likely it will be able to access inside a wreck. A solution to this can be to have a mini-ROV that deploys from a larger ROV, but clearly this brings far greater cost and complication.

2.5.4 SALVAGE OPERATIONS

In some cases it may be necessary to salvage a vessel. In most cases the salvage operation will be undertaken by a ship's insurers as they may have an obligation to remove the wreck. If a marine safety investigation body has decided to salvage a wreck then they will need adequate funding to do so, as salvage is usually an expensive operation. Salving a small fishing vessel or work boat may be less expensive but even so the potential expense and difficulty of salvaging a ship must not be underestimated.

In any salvage operation it is important to develop a close working relationship with the salvors as early as possible. This is because their priority will be removing the wreck, not preserving evidence or determining how the accident happened.

Before any salvage activities take place the investigator must insist on a thorough survey of the wreck, as found and, ideally, recorded on video. This should not be a problem, as the salvors also need to gain a good understanding of how the wreck sits and where are critical elements, such as watertight doors, vent pipes and any damage. It is very important that a good record of the ship is obtained so that once it is on the surface the actions of the salvors can be differentiated from damage caused during the accident. Having an investigator attend the salvage operation is ideal as he will be able to keep track of what the salvors are doing and can ask divers what they have found etc. Be prepared for the salvage to potentially take a significant amount of time as current, divers and weather can all delay progress.

Once a wreck has been recovered to the surface and after it has be determined to be safe to go on board, the investigator must make every effort to photograph and record the critical areas of the ship, such as ship controls, positions of switches, state of winches, doors etc. This is important as further savage operations to pump out a ship may contaminate or disturb the evidence and provide misleading clues to the investigator. Once the salvor has stabilised the wreck and is ready to hand it over, be sure, if it is the responsibility of the investigator, that facilities have been put in place to ensure the wreck stays afloat and can be stored securely.

ANNEX 1 - SAMPLE EVIDENCE/PROPERTY CUSTODY RECEIPT

Evidence/Property Custody Receipt

Activity number:	**Case explanation:**		
Name/Grade/ Title of Collector:	**Address:**		
Witness name:	**Witness address:**		
	Work phone:	**Home phone:**	
Location where property/evidence obtained:			
Reason for collection: ☐ **Safety Investigation** ☐ **Other (Explain):**		**Date/time collected:**	

Item	Qty	Disposal Action	Description of article/Model No. Serial No. etc.

Name of witness (if available):	**Name of receiving person:**
Signature:	**Signature:**

Chain of custody				
Items	**Date/time**	**Released by**	**Received by**	**Purpose**
		Name: Organization: Signature:	Name: Organization: Signature:	
		Name: Organization: Signature:	Name: Organization: Signature:	
		Name: Organization: Signature:	Name: Organization: Signature:	
		Name: Organization: Signature:	Name: Organization: Signature:	
		Name: Organization: Signature:	Name: Organization: Signature:	
		Name: Organization: Signature:	Name: Organization: Signature:	
		Name: Organization: Signature:	Name: Organization: Signature:	

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3.1 HUMAN FACTORS

Human factors form an integral part of virtually every investigation, and a formal and uniform approach to this part of an investigation is essential to develop an understanding of systemic technical, contextual and social parameters that influence human information processing and decision making within virtually every aspect of ship design, operation, management and regulation. Through this understanding, risk management processes at all levels of marine activity can be targeted to minimize the severity or likelihood of adverse outcomes.

The IMO defines human (people) factors as information related to ability, skill, knowledge, personality, physical condition, behaviour and attitude and its interaction with the assigned duties, organization on board, working and living conditions, ship factors, shore-side management, and external influences and environment.

Human factors, which contribute to marine casualties and incidents, may be broadly regarded as acts or omissions by any person(s), 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 capabilities of the people involved in the design of the equipment, the interaction of the human operator with the equipment, and the effectiveness of the procedures followed by crew and management.

3.1.1 OBJECTIVE OF THE HUMAN FACTORS INVESTIGATION

The objectives of the investigation of human factors in occurrences are to advance marine safety by:

- Discovering how mismatches between system requirements and human capacity could have caused or contributed to the occurrence.

- Identifying safety hazard (engineering, administration and personal protection) mitigation strategies that result in conditions that are likely to exceed human operational capacity, or reinforce behavioural risk adaptation.

- Making recommendations designed to eliminate or reduce the severity or likelihood of consequences resulting from mismatches between system operating requirements and human physiological, perceptual or cognitive abilities.

3.1.2 SCOPE OF THE HUMAN FACTORS INVESTIGATION

The collection and analysis of human factors information should be as methodical and complete as any other traditional area of the investigation. The investigation should extend beyond the examination of the actions of front-line operators such as masters, pilots, ships' officers, ratings, and maintainers, etc. to include an analysis of any individual or group involved in the occurrence, be it management, the regulator, or the manufacturer.

An investigation that focuses on only the front-line operators becomes a barrier to the identification of systemic safety hazards and to the opportunity to eliminate or reduce the consequence of safety hazards. (See also IMO Resolution A.1075 (28)).

The success of the human factors investigation depends largely on the type and quality of the information collected. As no two occurrences are the same, the investigator will need to determine the type and quality of data to be collected and reviewed. As a rule, the investigator should be over-inclusive in gathering information initially and set aside superfluous data as the investigation unfolds.

Information relevant to a marine occurrence can be acquired from a variety of sources.

1. Primary sources relating specifically to human factors include: hardware evidence, paper documentation, voyage data recorders, marine communications, traffic services and recordings, all of which will help identify 'what' happened. Interviews, direct observation of marine personnel activities and simulations, together with the factual information may help to explain 'why' people did what they did at the time.

2. Secondary sources include: marine occurrence data bases, reference literature and human factors/ergonomics professionals and those from associated disciplines such as psychologists, medical practitioners, and sociologists.

It is important to understand the difference between human error and human factors. Human error is a label we assign with hindsight to categorize the human behaviour that led to an occurrence or that contributed to increasing either the likelihood or severity of an adverse outcome.

Classifications include errors of action, planning, interpretation or observation. Human error has been identified as a causal aspect in about 80% of all marine accidents. The remaining 20% of accidents include classifications such as mechanical failure, environmental factors or, conceivably, an 'act of god''. However, all of these latter categories, including an 'act of god', also involve human behaviour. For instance where a safety valve has failed causing injury, human behaviour related to its design, usability and maintenance will play a large part in understanding why the mechanical failure occurred. Or if a ship is damaged by heavy weather conditions it is necessary to understand how the route of the vessel was planned, the suitability of the vessel's design, its maintenance and the operational routines on board which might have played a part. Even if a vessel is struck by lightning there will be questions about lightning conductors and the vessel's design and operation. It is therefore correct to say that virtually all accidents involve human factors and all physical factors involve a human dimension. The investigator must therefore consider the whole range of human factors including all those associated with mechanical failure and environmental factors as well those where human actions were closely associated with the accident.

The human factors investigation will include a wide spectrum of disciplines related to the performance of the ship, its people and its equipment. Section **3.1.3**, below, will explain what might be included in each of these areas; it is linked to the investigation process and analysing tools discussed in previous and subsequent chapters.

3.1.3 HUMAN FACTORS TO BE COVERED BY THE INVESTIGATOR

The Figure below shows a number of factors that have a direct or indirect impact on human performance and the potential to perform tasks:

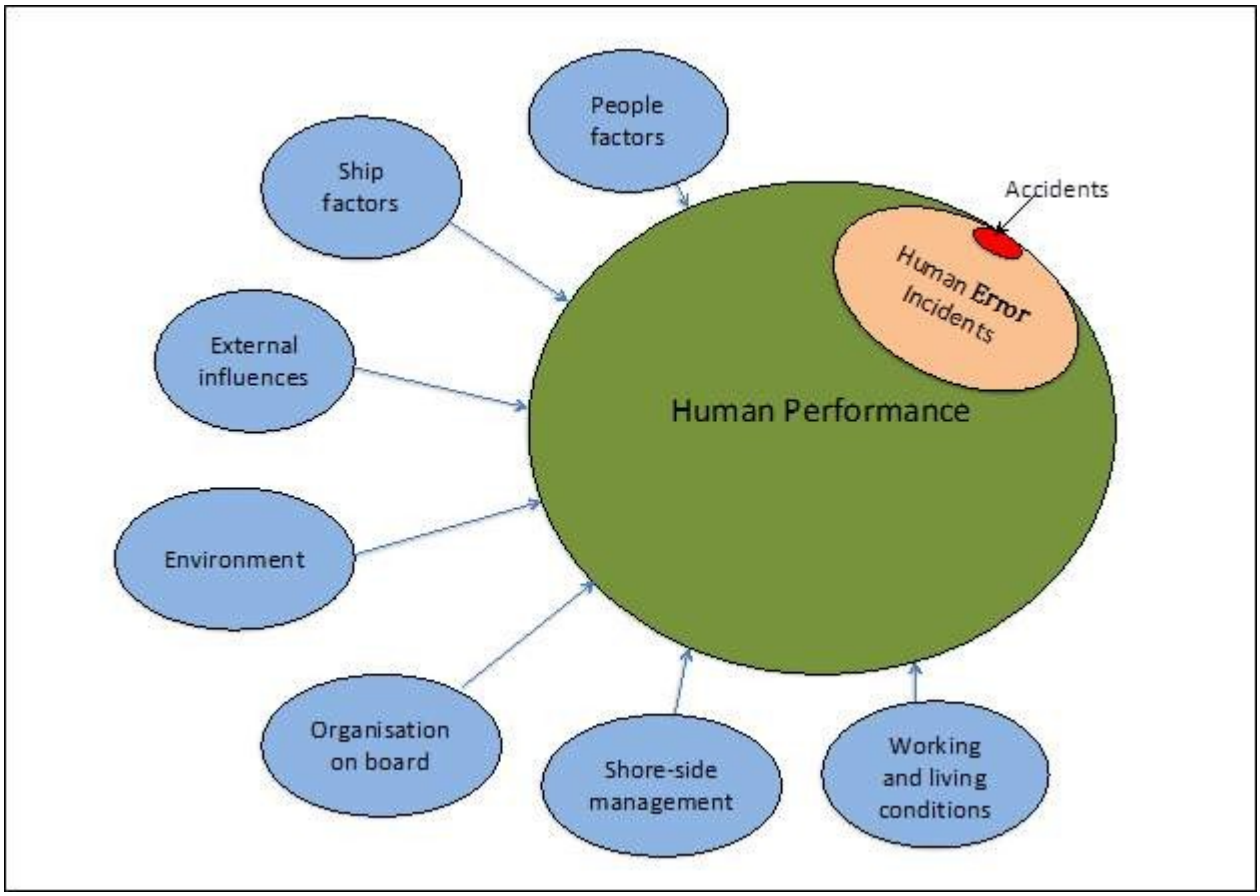


Figure – Factors influencing human performance

3.1.3.1 People factors

- Ability, skills, knowledge (outcome of training and experience);
- Personality (mental condition, emotional state, operational readiness);
- Physical condition (medical fitness, drugs and alcohol, and fatigue);
- Activities prior to accident/occurrence;
- Assigned duties at time of accident/occurrence;
- Actual behaviour at time of accident/occurrence;
- Attitude;
- Social interaction between people in work teams.

3.1.3.2 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);
- General application of safety management system;
- Vessel specific operations (bridge, engine room, holds, deck).

3.1.3.3 Working and living conditions

- Level of automation;
- Ergonomics of working, living and recreation spaces and equipment;
- Adequacy of living conditions;
- Opportunities for recreation;
- Adequacy of food;
- Level of ship motion, vibrations, heel and noise.

3.1.3.4 Ship factors

- Design;
- State of maintenance;
- Equipment (availability, reliability);
- Cargo characteristics including securing, handling and care;
- Certificates.

3.1.3.5 Shoreside 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.

3.1.3.6 Environment

- Weather and sea conditions;
- Port and transit conditions (VTS, pilots etc.);
- Traffic density;
- Ice conditions.

3.1.3.7 External influences

- Regulations, surveys and inspections (international, national, port, classification societies, etc.);
- Organizations representing shipowners and seafarers;
- Vetting companies;
- VTS.

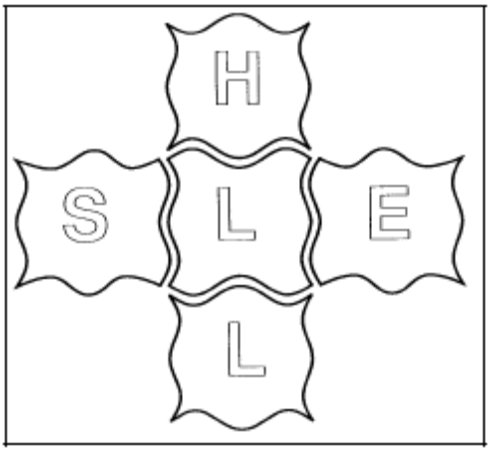
The above six groups of factors can be simplified further into just four categories and the acronym S H E L can then usefully be used as an easy aide memoire when collecting evidence and considering its analysis. This tool can be used throughout the investigation. It can help you plan your interviews and target physical and documentary evidence by prompting a clearer understanding of the whole range of information necessary for an in-depth human factors investigation.

3.1.4 DATA GATHERING GUIDELINES

3.1.4.1 Gathering evidence using the SHEL Model

The SHEL Model, which was originally developed by Edwards (1972) and modified by Hawkins (1984, 1987), provides a simple means of breaking down the various elements related to human factors.

The SHEL Model consists of four components:



- Software - S
- Hardware - H
- Environment - E
- Liveware - L

The model is commonly depicted as seen in the diagram. [1] It highlights not only the elements themselves but also the relationship between the key human component (Central Liveware) and the other components. The diagram attempts to highlight that the matches or mismatches of the interfaces are just as important as the components themselves, and are therefore just as important to investigate as the elements themselves.

3.1.4.2 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 has his or her own capabilities and limitations, be they physical, physiological, psychological, or psychosocial. This component can be envisaged as any person involved with the operation or in support of the operation under investigation. This person will interact directly with each one of the four other elements. The person and each interaction, or interface, represents potential areas of human performance investigation.

Consider the condition of the person involved – was he/she physically and mentally fit to do the job?

3.1.4.3 Liveware (peripheral component)

The peripheral Liveware refers to the human-human interactions of the system being investigated, including such factors as management, supervision, crew interactions, safety culture and communications.

Consider the interaction between the person at the centre of the investigation and the other people he/she was working with or otherwise who had influence over his/her work.

[1] From Hawkins, F.H. Human Factors in Flight 1987

3.1.4.4 Hardware

Hardware refers to the equipment involved in the accident. It includes the design and condition of workstations, displays, controls, seats, and all other physical parts of a ship or system.

Consider the interaction between the person (the central component) and the equipment he/she was using at the time, including its design and condition. Look for any incompatibility or mismatch.

3.1.4.5 Software

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

Consider the procedures, rules, regulations, documents and computer programmes that may have influenced the actions of the human at the centre of the investigation.

3.1.4.6 Environment

Environment includes the internal and external climate, temperature, visibility, vibration, noise and other factors which constitute the conditions within which people are working. The broad political and economic constraints under which the marine system operates, and the safety culture of the ship and the organisation, can be included in this element. The regulatory climate is also a part of this environment in as much as its climate affects communications, decision making, control and coordination.

Consider how the internal, external, regulatory or safety environment may have affected the decision making of the person(s) at the centre of the investigation.

The investigator should use the acronym SHEL as a constant reminder throughout the investigation to prompt him to ensure all areas of enquiry should be pursued and the relevant evidence collected.

3.1.5 AREAS OF HUMAN AND ORGANIZATIONAL FACTORS INQUIRY

[*Taken from IMO Guidelines to assist investigators in the implementation of the Casualty Investigation Code, Resolution A 1075(28)*]

These areas of inquiry can be used in planning the investigation of human and organizational factors during an investigation. Some areas of inquiry overlap or indeed incorporate multiple interactions. The following guidance is not meant to be exhaustive, nor is it intended to be a checklist where each point must be investigated every time. Some areas may not be relevant in the investigation of a particular occurrence, while other areas may require deeper investigation. As new human and organizational factors/issues emerge, new areas of inquiry will need to be explored by the investigator.

3.1.5.1 Interviewing

Skilful interviewing can help the investigator eliminate irrelevant lines of inquiry and focus on

areas of greater potential significance. The order and manner in which questions are asked will depend on who is being interviewed and on his or her willingness and ability to recall and describe personal behaviour and personal impressions.

Training in cognitive interviewing techniques will assist investigators in eliciting accurate information from interviewees, and is highly recommended. Further, because human interactions, including interviews, are subject to misunderstanding, it will normally be necessary to verify, cross-check or augment information received from one person by interviewing others on the same subjects.

3.1.5.2 Additional information

While important human and organizational factors/information can be gained through interview, investigators must ensure that they also seek additional information through other means. For example, examination of rosters, procedures, personnel records, safety occurrence reporting records and risk assessment protocols may provide critical insights into practices, norms and attitudes potentially affecting safety.

3.1.5.3 Shipboard data types

1. Training and experience:
    - Position or rank held;
    - Certificate held; length of time the certificate has been held; where trained;
    - Experience in the position; both on this ship and over career;
    - Length of time on this contract and overall on board the ship;
    - Experience on other ships, both with this company and other companies.
2. Shipboard organizational structure and processes:
    - The management/department structure on board the ship;
    - The individual's position within the onboard structure; who they work for, who they work with, who they report to and who they assign duties to;
    - Normal day-to-day responsibilities, tasks and duties;
    - Description of any interworking with personnel ashore.
3. Nature of tasks:
    - Specifics of the task(s) being undertaken at the time of the occurrence, including:
        - Differences between the task at that time and normal operations;

- Description of the social dynamics of the working environment, e.g. alone/pair/team.

- Understanding of the task;
- Familiarity with the task: last time it was performed etc.;
- Available discretion relating to how the task was to be accomplished;
- Training provided for the task: what was the training?
- Procedures, documents and guidance for the task;
- Equipment used for the task: reliability, previous failures, problems, were the crew familiar with it?
- Physical environment: heat, humidity, noise, confined space, exposure to chemicals etc.
- Workload and/or effort required for the task:
  - To what extent was it within their capability at the time?
  - Were there any tasks that they did not do because of the workload on this task?
  - Physical effort involved: pushing, pulling, lifting etc.
  - Mental effort involved: thinking, deciding, calculating, remembering, looking, searching etc.
  - Time pressure involved: adequacy of time allocated to the task. Use of scaling questions may assist here, e.g. "On a scale of 1 to 10, where 1 is very easy and 10 is extremely difficult, how (physically) difficult was this task?"

4. Activities prior to occurrence:

- Actions and/or activities before coming on watch or reporting for duty;
- Individual's role in the operation being conducted by the ship at the time of the occurrence;
- Individual's location on board at the time of the occurrence;
- What was being observed immediately prior to the occurrence: what was seen, heard, felt, smelled, and thought about?

5. Work-period/rest-period/recreation pattern

    - Description of normal duty schedule, e.g. day worker or watchkeeper;
    - Description of duty schedule on the day of the occurrence, the day before and during the week before the occurrence;
    - Length of time awake and/or on duty at the time of the occurrence;
    - Overtime worked on the day of the occurrence, the day before and during the week before the occurrence;
    - Usual sleep/rest routine: what time to sleep and awake;
    - Sleep/rest routine in the three days (72 hours minimum) leading up to the occurrence:
        - 72-hour history of time to bed/time to sleep/duty times/nap times;
        - If there is an indication of reduced sleep beyond 72 hours, collect sleep information beyond 72 hours (as a guide, go back to two good nights' sleep prior to the occurrence);
        - Quality of sleep: disturbances, light sleep, waking, how refreshed when waking;
        - Time of day when sleep is taken: impact on quality;
        - Last extended period of off-duty time;
        - Operating conditions of vessel during sleep periods: impacts on noise, temperature, air quality.

6. Living conditions and shipboard environment:

    - Description of the adequacy of personal facilities: individual, shared or communal, noisy, cramped, vibrations, temperature, ship's motion etc.
    - Availability and consumption of alcohol and/or non-prescribed medications.

7. Physical health:

    - Symptoms of illness experienced within the 72 hours before the occurrence;
    - Medications taken (prescription, non-prescription);
    - Description of the last meal consumed prior to the occurrence: what and when;
    - Description of existence and regularity of exercise routine;

- Details of any recent medical examinations, illnesses or injuries;
- Details of any regular or irregular medication, both prescribed and non-prescribed;
- Description of quality of vision: corrective lenses etc.;
- Description of quality of hearing: hearing aids etc.;
- Name and contact details of personal physician.

8. Mental health:
   - Length of time spent away from family or loved ones;
   - Extreme emotions at any time in the days before the occurrence, e.g. feelings of extreme sadness, anger, worry, fear (use scaling questions (1 to 10) to determine level);
   - Important and/or difficult personal decisions made recently, e.g. financial or family worries;
   - Recent work performance: any concerns from others;
   - Stress and/or difficult situations whilst on board and how these were being managed;
   - Difficulties with concentration;
   - Any mental health issues recently and/or in the past;
   - Medications taken (prescription, non-prescription).
9. Working relationships:
   - Friendships and/or support from other crew members;
   - Conflicts and/or clashes with other crew members or supervisors;
   - Trust in other crew members;
   - Language barriers interfering with work performance;
   - Clarity of roles and responsibilities with other crew members.
10. Employment conditions:
    - Contractual arrangements;
    - Complaints or industrial action and systems for resolution of these;

- Recent changes to employment conditions.

11. Safety policy:

    - Awareness of the company's safety policy;
    - Ship's procedures for dealing with safety issues: methods of reporting and addressing safety concerns;
    - Safety training: type, nature of and frequency;
    - Emergency drills: type, nature of and frequency;
    - Personal protective equipment (PPE) provided;
    - Records and/or knowledge of personal accidents or injuries prior to the occurrence.

12. Staffing levels:

    - Sufficiency of staffing/crew levels on board;
    - Appropriate allocation of crew members to duties;
    - Changes to normal staffing/crew levels.

13. Standing orders:

    - Master's standing orders: for all or part of the crew;
    - How are the orders communicated?
    - Are the orders in accordance with the company policies?

14. Level of automation and reliability of equipment:

    - Complexity of machinery and automated systems;
    - Training provided for systems;
    - Competency of crew in using the systems;
    - Reliability of systems: any earlier failures?
    - Maintenance of systems;
    - Are the systems integrated with each other and the task needs?

15. Ship design, motion/cargo characteristics:

    - Ship design, motion or cargo characteristics: any features which interfere with human performance e.g. obstructed watchkeeper vision.

3.1.5.4 Shoreside management topics and sources

1. Management policies and procedures:

    - Existence (documented) and opinion of the effectiveness of the safety management system, including auditing, analysis, reporting and occurrence investigation;

    - Existence (documented) and opinion of the effectiveness of risk assessment and management policies and procedures relating to ships, personnel and the environment;

    - Existence (documented) and opinion of the effectiveness of the role of the Designated Person Ashore (DPA).

2. Scheduling of work and rest periods:

    - The company's work schedule, relief policy and fatigue risk management policy;

    - Adherence to these policies;

    - Recent changes to these policies.

3. Staffing levels:

    - The company's policies and practices for determining staffing/crew levels on board ships;

    - The effectiveness of these policies and practices.

4. Assignment of duties:

    - The company’s policies for determining watchkeeping practices and other duties on board the ship;

    - The actual watchkeeping practices.

5. Shore-ship-shore support and communications:

    - Means and level of support for the ship's master in conduct of operations;

    - The master's reporting requirements.

6. Voyage planning and port call schedules:

    - Policies, procedures and guidelines provided to the master to enable voyage planning;

    - Actual practices for voyage planning.

7. Recreational facilities:

    - The company's policies and practices for the provision of welfare and recreational services on board.

8. Contractual and/or industrial arrangements and agreements:

    - Contractual arrangements for all crew members;

    - Complaints or industrial action in the last year.

9. National/international requirements:

    - Appropriateness of the applicable international conventions and Flag State regulations;

    - Effectiveness of the Flag State's implementation of the requirements and recommendations of the applicable international conventions;

    - Compliance with the requirements and recommendations of the applicable international conventions and Flag State regulations.

3.2 HUMAN ERROR CLASSIFICATION

To understand why human errors occur, it is first essential to describe the possible error mechanisms. For the purpose of this manual, MAIIF has adopted the human error types or modes that are included in IMO's GISIS database (See MSC-MEPC.3/Circ.4). These in turn are broadly based on elements of the Cognitive Reliability and Error Analysis Method (CREAM) propounded by Erik Hollnagel.[2]

The classification includes errors of:

1. Action:

    a. Action at, or of, the wrong time:

        i. Timing too early or too late;

        ii. Duration too long or too short.

    b. Action of the wrong type:

[2] Hollnagel, E. (1998). *Cognitive Reliability and Error Analysis Method – CREAM*. Oxford: Elsevier Science

i. Force, too little or too much;

ii. Distance/Magnitude, too far or too short;

iii. Speed, too fast or too slow;

iv. Direction, wrong direction or wrong movement type (pulling instead of pushing).

c. Action at the wrong object:

i. Wrong object, a neighbour object, a similar object or unrelated object.

d. Action at a wrong place:

i. Sequence, action omitted, action skipped, action repeated, action order reversed, wrong action taken.

2. Observation:

a. Observation missed:

i. Overlook cue/signal;

ii. Overlook measurement.

b. False observation:

i. False reaction;

ii. False recognition.

c. Wrong identification:

i. Mistaken cue;

ii. Partial identification;

iii. Incorrect identification.

3. Planning/Intention:

a. Inadequate plan:

i. Incomplete plan;

ii. Wrong plan.

b. Priority error:

i. Wrong goal selected.

4. Interpretation:
    a. Faulty diagnosis:
        i. Wrong diagnosis;
        ii. Incomplete diagnosis.
    b. Wrong reasoning:
        i. Induction error;
        ii. Deduction error;
        iii. Wrong criteria.
    c. Decision error:
        i. Decision paralysis;
        ii. Wrong decision;
        iii. Partial decision.
    d. Delayed interpretation:
        i. No identification;
        ii. Increased time pressure.
    e. Incorrect prediction:
        i. Unexpected state change;
        ii. Unexpected side-effects;
        iii. Process speed misjudged.

To fully describe the error mechanisms involved in a particular human error, two or more of the above error types/modes may need to be identified. For instance, an error of action, such as pushing the wrong button, might have been influenced by an error of interpretation, such as wrong diagnosis.

In the context of this section investigators are also advised to undertake further reading about other error models including The Generic Error Modelling System (GEMS) (James Reason 1990), in which errors are subdivided into those which are intended actions (mistakes or adaptations) or unintended actions (slips or lapses) and further classified as resulting from skill, rule or knowledge based behaviours (Rasmussen 1982). The Internet is a good source of basic information about these and other error classification systems.

3.3 INVESTIGATING FOR FATIGUE

[*Taken from the TSB of Canada's document 'Investigating for Fatigue' – February 2001*]

3.3.1 INTRODUCTION

Fatigue has been recognized by the TSB of Canada, the NTSB in the United States, and other investigation agencies around the world as a contributor to many transportation occurrences. There have been many occurrences where fatigue has been suspected of contributing or causing transportation and industrial accidents; however, that connection was difficult to justify because the vital links between the unsafe acts and decisions which led to the accidents and the fatigue state of the people involved were not made.

The reasons for not making the links have varied. At one time, fatigue was discounted as a potential cause for human error; indeed, a common myth existed that fatigue could be prevented by characteristics of personality, intelligence, education, training, skill, compensation, motivation, physical size, strength, attractiveness, or professionalism. Also, the lack of scientifically accepted information on how fatigue affects not only mood and feelings, but individual and team performance as well, constrained investigators and analysts. Further, guidance on how to investigate for fatigue and build the links between a person's recent history and potential impairment has been lacking. Unlike alcohol and drugs which can be measured by, for example, blood tests, there is no unequivocal physical or chemical test which can tell us that a person was impaired to a certain extent by fatigue.

To discover whether fatigue is a contributing factor in an occurrence, the investigator needs:

a. Background information on the physiological bases of alertness and fatigue;

b. An understanding of how fatigue affects performance;

c. Guidance on how to investigate for fatigue.

3.3.2 OBJECTIVE

The aim of this package is to:

a. Provide a description of the basic concepts of sleep and fatigue;

b. Describe common fatigue-related performance effects;

c. Provide guidelines on investigating for fatigue; and

d. Achieve a common understanding about terms such as fatigue, sleep debt, circadian rhythm and other commonly used, but potentially ambiguous terms.

Note: In this guide, we will limit our concern to fatigue arising from two systematic physiological causes: sleep deficit and circadian rhythms - both of which can be affected by work and rest schedules.

3.3.3 SLEEP AND FATIGUE

Essentially every aspect of human performance can be degraded by sleep loss and sleepiness, including physical, psychomotor, and mental performance; mood can be affected, and attitudes toward risk-taking and safety can change. This section deals with issues relating to sleep and fatigue and includes the basic concepts of alertness, the biological clock, sleep/wake cycles, the nature and the function of sleep, quantity and quality of sleep, sleep disorders/disturbances, irregular schedules and their impact on alertness, circadian dysrhythmia, and the effects of fatigue on performance.

3.3.3.1 Alertness and fatigue

- Alertness and fatigue can be viewed as a continuum with peak mental alertness on one end and sleep on the other.

- Alertness is the optimal activated state of the brain.

- Fatigue has its basis in the combined interaction of the circadian rhythm in alertness/sleepiness and the effects of inadequate sleep. As fatigue increases the brain appears to fall asleep involuntarily, against the will of the operator, especially (but not exclusively) when the performance demands involve sustained attention and monotony; thus the effects of fatigue on performance are based on changes in brain function.

- Alertness enables us to make conscious decisions about what to attend to in our environment and what to exclude.

- Our level of alertness determines how well we perform our job.

- Whenever alertness is affected by fatigue, human performance can be significantly impaired.

- Alertness dramatically changes with time.

- Alertness cycles closely follow the body temperature cycle with peak alertness occurring when the body temperature is the highest (near midday) and low alertness occurring when the body temperature is lowest (between 3:00 and 5:00 am).

- The time of day that one works has far greater effect on alertness than the number of consecutive hours worked. People can work extended hours per day and maintain high levels of alertness and performance, as long as those work hours are between 7:00 am and 11:00 pm in their normal cycle.

- Alertness can be influenced by a number of factors: sense of danger, interest or opportunity; muscular activity; time of day on the circadian clock; sleep bank balance; controlled, strategic napping; ingested nutrients and chemicals; and environmental light, temperature, humidity, sound and aroma, as discussed below.

- Imminent danger or just surviving a near miss will pull us from a drowsy state; an interesting challenge, an exciting idea, and anything else that is new and different will

keep us awake. On the other hand, if the job is boring or monotonous, our alertness fades.

- Any type of muscular activity helps to keep us alert; running, walking, stretching or even chewing gum can stimulate our level of alertness.

- Our circadian clock makes us sleepy or alert on a regular schedule whether we are working or not.

- Sound and restful sleep makes deposits in our 'asleep bank' and sustained wakefulness makes withdrawals. When the bank balance is too low, the pressure to sleep has a dampening effect on our level of alertness.

- Controlled, strategic naps can improve alertness and performance.

- Alertness may be enhanced by the chemicals and nutrients we ingest or inhale.

- Bright lights can have dramatic effects on suppressing sleepiness and resetting our circadian clock.

- Cool, dry air can increase alertness while heat can bring on the desire for sleep.

- Music and other irregular sounds can help us stay alert while soothing sounds can put us to sleep.

- Some aromas such as peppermint seem to make us more alert.

3.3.3.2 Biological clock

- Our biological clock regulates the daily cycle of activity and inactivity.

- Virtually every function in the body is timed according to a day-night cycle.

- There are circadian rhythms for the following functions: activity, sleeping, eating, body temperature, digestion, kidney function and hormones in the blood.

- In normal conditions, our biological clock is locked to 24 hours by the onset of day and night, by clock times, and by social activities.

- Because of that, our body functions and energy levels are automatically higher after sunrise and lower after sunset.

- When freed from the usual daily time cues known as *zeitgebers,* the circadian rhythms are said to be free-running, exhibiting a periodicity of 25 hours.

- The intrinsic 25-hour cycle of the human biological clock is automatically reset forward by an hour each morning by the light of dawn so that it adapts to the 24-hour schedule of day and night. This process of synchronization is known as entrainment.

- In general, our 25-hour clock can be reset about 2 hours each day, allowing us to live comfortably on a 23 to 27-hour day.

3.3.3.3 Sleep/wake cycle

- In normal conditions, the sleep/wake cycle follows a 24-hour rhythm with approximately ⅓ of this time spent sleeping.

- The cycle isn't the same for everybody as the main peak of alertness can occur earlier or later in the day.

- Although individual rhythms vary, everybody's cycle has two distinct peaks and dips.

- The big dip is at night, with the time of our lowest alertness in the hours just before dawn between 3:00 and 5:00 am; the other dip occurs in the mid-afternoon between 3:00 and 5:00 pm.

- During the dips, it can be particularly difficult to maintain alertness.

- Proceeding these maximum sleepiness periods, people have maximum wakefulness periods or peaks.

- During the peaks, sleep is difficult and often of poor quality; that is, it does not provide the same restorative value as sleep during maximum sleepiness.

- The sleep/wake cycle can be thought of as a 'credit' and 'deficit' system in which a person is given 2 points for every hour asleep up to a maximum of 16 points and has 1 point deducted for every hour awake.

- You cannot store sleep; the fewer points you have, the more ready you are for sleep.

- Normally, a person will sleep when he or she has little or no sleep credit (zero points) and will then sleep for about 8 hours (16 points credit).

- This will be followed by a wakeful period of about 16 hours (16 points deducted).

- Thus, recuperative sleep makes deposits in our 'asleep bank' and sustained wakefulness makes withdrawals.

- When you have withdrawn too much and the sleep bank balance is too low, the pressure to sleep may become extreme, especially after 24 hours of sustained wakefulness, whatever the time of day.

3.3.3.4 The nature and function of sleep

- Sleep is an active process; when we are asleep, we are in an altered state of consciousness.

- Normally when we sleep, we move through sleep stages in specific cycles.

- The nightly pattern of light sleep, deep sleep, and rapid eye movement (REM) sleep episodes is called sleep architecture.

- Stage 1 sleep is a transitional phase between waking and sleeping. We spend about 10 minutes in Stage 1. If awoken during this stage, we would probably say we had not been asleep; therefore, we can be asleep without knowing it. Microsleeps and Automatic Behaviour Syndrome (ABS) occur during Stage 1 sleep.

- Stage 2 is a light level of sleep that, if awakened during it, we are likely to feel alert and refreshed. We spend about 15 minutes of sleep in Stage 2 (about 50% of sleep is in Stage 2).

- Stage 3 is the onset of delta sleep, a deeper stage of sleep in which we spend about 15 minutes.

- Stage 4 is the deepest stage of sleep and, if awakened from it, we are likely to feel groggy and disoriented and suffer from sleep inertia, a condition of impaired functioning which can last for 10 minutes to as long as one hour.

- REM sleep occurs after about 70 to 80 minutes of sleep. This is the dreaming stage. You are more likely to remember a dream if you awake during a REM sleep stage.

- The cycle of Stages 1 to 4 sleep and REM sleep repeats during the course of the night in 90-minute cycles, each succeeding cycle containing greater amounts of REM sleep.

- An 8-hour sleep will contain about 4 or 5 bouts of REM sleep. Most Stage 4 sleep is accomplished early in the night.

- Although little is known about the function of sleep, research has suggested that Stages 3 and 4 may be related to body restoration and REM may be related to strengthening and organizing memory. Intense physical activity may result in more Stage 3 and 4 sleep; whereas learning new tasks may result in an increased proportion of REM sleep.

- If deprived of either Stages 3 and 4 and REM sleep, a person will show rebound effects, in that, that particular type of missed sleep will be made up in subsequent sleep, suggesting the body has some requirement for these types of sleep.

3.3.3.5 Quantity of sleep

- Everyone's sleep needs are unique; however, over 90% of the population needs between 7.5 and 8.5 hours of sleep per 24-hour day.

- Alertness and performance are directly related to quantity of sleep.

- Acute sleep loss results when one is awake without any sleep beyond the normal 14-to 16-hour waking day; the longer one is awake, the greater the effect on performance.

- Chronic undersleeping can lead to cumulative sleep debt. This occurs when insufficient quantity of sleep continues over several consecutive days. For example, if you lose one

hour of sleep a night over a one-week period, your sleep debt will be the equivalent hourly loss of a full night's sleep. The seriousness of even a small sleep debt can be significant for performance. Research data suggests that chronic undersleeping results in a performance deficit separate from that associated with the circadian pacemaker and with acute wakefulness.

- Once sleep debt or fatigue builds, only sleep can maintain or restore performance levels.

- A person deprived of sleep for an extended period, such as by staying up all night and then not being able to obtain any significant sleep the next day, will usually take 2 normal nights of sleep to fully recover.

- Sleep requirements do not change with age; sleep patterns do change with age.

- Typically, aging is accompanied by difficulty getting to sleep or maintaining sleep. Older people do not need less sleep than they did when they were younger, but they often have more difficulty getting enough sleep.

- As people age, they tend to become less able to tolerate changes in schedule; it is not unusual for such changes to become noticeable at age 40.

- Younger people often obtain less sleep; they tend to be more flexible and adjust more easily to irregular schedules.

- In general, there is no absolute amount of sleep that must be achieved. You should obtain enough sleep to be alert the next day.

3.3.3.6 Quality of sleep

- All sleep is not of the same quality and does not provide the same fully recuperative benefits.

- Quality sleep is restorative sleep. Alertness and performance are directly related to quality of sleep.

- Sleep is more likely to occur readily, be of better quality, and last longer when it is in harmony with our internal clock.

- In order to feel well rested and alert, the various stages of sleep have to occur in their proper proportions.

- When we are getting quality sleep, we move through the sleep stages in specific cycles, each of which lasts about 90 minutes.

- Quality, recuperative sleep requires 4 to 5 uninterrupted sleep cycles.

- The stage of sleep from which we awaken determines our condition on arousal (see ***3.3.3.4 The Nature and Function of Sleep***). Thus, the most effective length of time for a

nap is about 20 minutes, which does not allow us to reach a deep level of sleep (Stages 3 or 4) from which we emerge impaired.

- Naps of 30 to 60 minutes do not provide us more restorative sleep than 20-minute naps; however, a two-hour nap will more than double the restorative sleep of a single-hour nap because two hours is long enough to come out of deep sleep.

- Ideal sleep occurs regularly, in a soporific environment; a soporific environment is one that makes it easy to fall asleep. Soporific environmental factors include sleeping in one's own comfortable bed, in a dark room, in an environment which is quiet, has a comfortable temperature, an adequate flow of fresh air, and is free of interruptions.

- Just being tired is not enough to ensure a good sleep. It is the timing of sleep, not the amount of time awake, that is critical to sleep duration.

- If your time of sleep is out of synch with your body clock, it is difficult to sleep properly. Thus time of day is an important component of sleep quality because regardless of how long we have gone without sleep, our body continues to follow our circadian rhythm in ability to sleep.

- If insufficient quality of sleep continues over several consecutive nights, a cumulative sleep debt will accumulate, which adversely affects the level of alertness during the day.

- Similarly, reduced and disrupted sleep during the day severely reduces one's level of alertness on the night shift.

3.3.3.7 Sleep disorders/disturbances

- More than 5% of the population suffers from sleep disorders, and many of them are unaware of it.

- Sleep apnea is one cause of excessive daytime sleepiness.

- Sleep apnea is characterized by a repeated cessation of breathing during sleep. A person who suffers from sleep apnea can wake up several times during sleep, often without realizing it.

- Sleep apnea can be due to an obstruction in the airway or damage to part of the brain that controls respiration. It is often associated with obesity.

- Narcolepsy is a disease of uncontrollable sleep attacks that occur sometimes several times a day. The cause of narcolepsy is unknown, although it may be genetic.

- Insomnia, which is more of a sleep disturbance than a disorder, is believed to be a problem for 15 to 30 percent of the adult population.

- In some groups such as shift workers, the prevalence of insomnia is more likely to be closer to 65 percent.

- Insomnia sufferers complain about experiencing difficulty in falling asleep and staying asleep, about waking too early, and about poor quality of sleep. Daytime complaints include fatigue, sleepiness, poor performance, aches, and anxiety.

- Many cases of insomnia are made worse by psychological factors, including worry about inadequate sleep. It can also be caused by an overactive thyroid gland, diabetes, muscle-twitching or caffeine.

- Clinical insomnia describes the condition when a person has difficulty in sleeping under normal, regular conditions and in phase with his body rhythm. It is an inability to sleep when the physiological system is calling for sleep.

- Situational insomnia describes the condition when a person has difficulty in sleeping in a particular situation, e.g. when the biological rhythms are disturbed, or one is trying to sleep in a strange environment. This often occurs when the brain and the body are not in the sleeping phase.

- There are wide differences between individuals in their ability to sleep out of phase with the biological rhythms and in their tolerance to sleep disturbances.

3.3.3.8 Irregular schedules

- The circadian clock is perfectly synchronized to the traditional pattern of daytime wakefulness and night-time sleep.

- Irregular schedules, which include rotation of shifts within a time zone and those which require time zone crossings, play havoc with that synchronization.

- The main problem with shift work is that it desynchronizes the body rhythms.

- Although our circadian clocks can adjust by an hour or two a day, they cannot immediately shift 8 or 12 hours as many schedules require.

- It takes several days for the body to adjust to a new schedule and during that time our bodies are out of synch with the world around us. Our body clocks are waking us up when we need to sleep and putting us to sleep when we need to be awake.

- Most rhythms resynchronize at a rate of about 1 to 1½ hours a day.

- The body can adjust slowly to successive nights of shift work and daytime sleeping.

- On the first two nights of shift work, there is a drop in alertness during the early morning hours

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- Within a few days, alertness is more easily sustained at night, and daytime sleep improves.

- However, at the end of a night shift period or a few days off, the circadian clock has to be reset all over again.

- Workers who are required to sleep during the day are more likely to experience shortened sleep and frequent awakenings.

- Daytime sleep has a greater proportion of Stages 1 and 2 sleep than normal, from which we are more easily aroused by disruptions.

- During daytime sleep, the more restorative types of sleep, that is, the deeper sleep stages 3 and 4 and REM sleep time are shortened. Therefore, reduction of time spent in Stages 3 and 4 and REM sleep means that the individual will still feel fatigued despite having spent 6 or 8 hours asleep.

- The individual may think that, because he or she has had 6 to 8 hours sleep, he or she must be well rested. That is why an individual's assessment of his/her alertness/fatigue level alone is insufficient when attempting to determine whether fatigue is an underlying factor.

- Work shift schedules that are ever-changing (shifting shift work) do not allow adequate time for an adjustment period and sleep deprivation occurs.

- If the shift work is not stable, that is, the person is not on the schedule long enough to adjust, then the individual will not resynchronize.

- Shift schedules should rotate forward (i.e. to later hours) in a clockwise direction.

- A clockwise rotation is compatible with the free-running rhythm of the biological clock.

- Work shift schedules that promote optimal performance are those where the rotation is clockwise (day to evening to night, back to days) where the night shift is short and at the end of a series of shifts, and where the rotation is slow; that is, it is of a duration that allows for circadian adjustment to the shift.

- Counter clockwise rotation forces workers to move their bedtimes to earlier hours.

- Where possible, critical safety tasks, overtime or double shifts should be scheduled during the hours when humans are most alert in the context of their circadian rhythm, i.e., between 7am and 11pm.

- Call-out schedules that have not taken the problem of sleep inertia into account have the potential to impair performance.

- Workers who are on straight night shift work, i.e. permanent assignment to an 8-hour night shift, typically never adjust to their biological clocks because each week during their time off they revert back to a day schedule.

3.3.3.9 Circadian dysrhythmia (Jet Lag)

- Jet lag, a mal-adjustment of body rhythms, occurs after travel across time zones. It occurs primarily because the internal circadian rhythm is out of phase with local time, creating de-synchronization and resulting in sleep deprivation.

- The extent and degree of jet lag symptoms depend upon the number, rate and direction of time zone changes. Another factor affecting the degree of jet lag is the influence of zeitgebers which, in the form of local time cues and signals such as meal, work and sleep schedules and the direct input of dark/light cycles, foster more rapid adjustment.

- We can more easily adjust to westbound travel, which extends our day because our internal biological clock naturally gravitates to a 25-hour day.

- It takes longer to resynchronize circadian rhythms after eastbound travel because they must be shortened (which is against their natural tendency to run long) in order to match the local environment.

- Travel in the same time zone does not produce any jet lag.

- Crossing several time zones, e.g. 5 time zones on an 8-hour flight causes moderate jet lag. Most people will adjust in 2 to 3 days. Extreme jet lag would be caused by crossing, for instance, 11 time zones on a 10-hour flight. Most people would require a minimum of a week to adjust.

- In general, the greatest difficulty in adjustment results from crossing 12 time zones, the least from crossing one time zone.

3.3.3.10 Effects of fatigue on performance

- When a person is suffering from fatigue, his or her performance on the job will be affected.

- During night-time hours, and to a lesser extent during the mid-afternoon dip, most types of human performance, whether manual dexterity, mental arithmetic, reaction time, or cognitive reasoning, are significantly impaired.

- The most extreme form of fatigue is uncontrollable sleep, i.e. falling asleep against the will of the individual. The sleep period can be a micro-sleep, a nap, or a long sleep episode. While asleep, a person is perceptually isolated, i.e. they are unaware of what is going on around them.

- Motivation can overcome the effects of fatigue for short periods, but motivational effect is limited and can end with little or no warning.

- Fatigue can affect a person's ability to respond to stimuli, from a failure to respond altogether to slowed reactions to normal, abnormal, or even emergency stimuli. In a fatigued state, it can take longer to perceive stimuli, longer to interpret or understand them, and longer to react to them once they have been identified.

- Fatigue affects the ability to judge distance, speed, and time.

- Fatigue can have a profound effect upon problem solving ability. In studies to determine the effects of fatigue on problem solving ability, it was found that after 18

hours awake, people showed a 30% decrement in performance and after 48 hours, the impairment averaged 60%.

- Fatigue can lead to forgetting or ignoring normal checks or procedures, reversion to old habits, and inaccurate recall of operational events.

- Mood is likely to be affected by fatigue, the effects of which are people are less likely to converse, are less likely to perform low-demand tasks, are more irritable, are more distracted by discomfort, and can display a 'don't care' attitude.

- Fatigue can reduce attention, the effects of which are people overlook or misplace sequential task elements, become preoccupied with single tasks or elements, are less vigilant and are less aware of their poor performance.

- When alertness is impaired, people may fix their focus on a minor problem, when there is a risk of a major one; may fail to anticipate danger; may display automatic behaviour syndrome; may fail to appreciate the gravity of a problem or situation; may display flawed logic; and may apply inappropriate corrective actions.

- Fatigue can result in reduced motivation to perform well. This can translate into a willingness to take risks and a laxity in safety that would not normally be tolerated when alert.

3.3.4 FATIGUE INVESTIGATION CHECKLISTS

3.3.4.1 Guidelines

Because of the pervasive nature of fatigue in our society, fatigue should be considered an underlying factor in virtually all occurrences. In support of this, four questions provide guidance as to the initial assessment of fatigue as a contributing factor to an occurrence:

1. At what time of day did the occurrence take place?

2. Was the operator's normal circadian rhythm disrupted?

3. How many hours had it been since awakening?

4. Does the 72-hour sleep history suggest a sleep debt?

If the answer to any of the above questions indicates a problem, then fatigue should be investigated in depth.

To establish fatigue as a contributing factor, it must be demonstrated both that:

1. The person or crew was in a fatigued state; and

2. The unsafe act or decision is consistent with the type of behaviour expected of a fatigued person or crew.

The following checklists: ***Checklist 1 - Establishing the fatigued state*** and ***Checklist 2 - Establishing the link between fatigue and the unsafe act/decision*** - have been developed to aid in the collection of fatigue-related evidence.

Checklist 1 consists of four columns: **Issue**; **Probes**; **Best-case Responses**; and **Notes**. The first column**, Issue***,* is a listing of significant factors relating to fatigue. Each one of these issues is described in Section **3.3.3** ***Sleep and Fatigue***. Each Issue is accompanied by a list of **Probes** - questions that examine various aspects of the issue. Probe questions are important in determining whether the Issue is pertinent to the occurrence. The third column, **Best-case Responses**, provides a foundation for analysis of fatigue; that is, any response different from the best-case represents a potential reduction in rested state. The fourth column, **Notes**, is for investigator notes.

Checklist 2 consists of three columns. The first two, **Performance Impairment** and **Indicators**, describe the possible effects of fatigue on performance. The third is for investigator notes.

3.3.4.2 Checklist 1 - Establishing the fatigued state

Issue	Probes	Best-case response	Notes
Quantity of Sleep	What was the length of last consolidated sleep period?	7½ to 8½ hours	
	Start time?	Normal circadian rhythm, late evening	
	Awake Time?	Normal circadian rhythm, early morning	
	Was your sleep interrupted (for how long)?	No	
	Have you had any naps since your last consolidated sleep?	Yes	
	Duration of naps?	Had opportunity for restorative (1½-2hrs) or strategic (20 min) nap prior to start of late shift	
Summary - establish whether or not there was a sleep debt	Describe your sleep patterns in the last 72 hours. (Apply Sleep Credit system)	2 credits for each hour of sleep; loss of one credit for each hour awake - should be positive value	
Quality of Sleep	How did the sleep period relate to the individual normal sleep cycle, i.e. start/finish time? (See 'Quantity')	Normal circadian rhythm, late evening/early morning	
	Sleep disruptions?	No awakenings	
	Sleep environment?	Proper environmental conditions (quiet, comfortable temperature, fresh air, own bed, dark room)	
Summary - establish whether or not the sleep was restorative	Sleep pathologies?	None	
Work History	Hours on duty and/or on call prior to the occurrence?	Situation dependent - hours on duty and/or on call and type of duty that ensure appropriate level of alertness for the task	

Issue	Probes	Best-case response	Notes
Summary - establish whether the hours worked and the type of duty or activities involved had an impact on the quantity and quality of sleep	Work history in preceding week?	Number of hours on duty and/or on call and type of duty that do not lead to a cumulative fatigue	
Irregular Schedules	Was he/she a shiftworker? If yes, was it a permanent shift? If no, was it rotating (vs irregular) shiftwork? How are overtime or double shifts scheduled? Scheduling of critical safety tasks?	No (Shiftworkers never fully adapt in terms of sleep quality) Yes - Days Yes - Rotating clockwise, rotation slow (1 day for each hour advanced), night shift shorter, and at the end of cycle. Scheduled when operators will be most alert in the context of their circadian rhythm. Scheduled when operators will be most alert in the context of their circadian rhythm.	
Summary - establish whether the scheduling was problematic with regards to its impact on quantity and quality of sleep	Work history in preceding week?	Number of hours on duty and/or on call and type of duty that do not lead to a cumulative fatigue effect	
Circadian Dysrhythmia (Jet Lag)	Number of time zones crossed? If more than one, at what rate were they crossed	One The slower the better	
Summary - establish whether the scheduling was problematic with regards to its impact on quantity and quality of sleep	In which direction was the travel?	East to West	

3.3.4.3 Checklist 2 - Establishing the link between fatigue and the unsafe act/decision

Performance Impairment	Indicators	Notes
Attention	Overlooked sequential task element Incorrectly ordered sequential task element Preoccupied with single tasks or elements Exhibited lack of awareness of poor performance Reverted to old habits Focused on a minor problem despite risk of major one Did not appreciate gravity of situation Did not anticipate danger Displayed decreased vigilance Did not observe warning signs	
Memory	Forgot a task or elements of a task Forgot the sequence of task or task elements Inaccurately recalled operational events	
Alertness	Succumbed to uncontrollable sleep in form of micro-sleep, nap, or long sleep episode Displayed automatic behaviour syndrome	
Reaction Time	Responded slowly to normal, abnormal or emergency stimuli Failed to respond altogether to normal, abnormal or emergency stimuli	
Problem-solving ability	Displayed flawed logic Displayed problems with arithmetic, geometric or other cognitive processing tasks Applied inappropriate corrective action Did not accurately interpret situation Displayed poor judgement of distance, speed, and/or time	
Mood	Was less conversant than normal Did not perform low-demand tasks Was irritable Distracted by discomfort	
Attitude	Displayed a willingness to take risks Ignored normal checks or procedures Displayed a don't care attitude	
Physiological Effects	Exhibited speech effects - slurred, rate, content Exhibited reduced manual dexterity - key-punch entry errors, switch selection	

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3.5 INTERVIEWING

3.5.1 INTERVIEW CONSIDERATIONS

At the outset of an investigation, the investigating team should try to establish a list of all the people who can provide a perspective on what happened and how the conditions of the occurrence were established. The list will almost certainly change as the investigation proceeds, but it is important that those who are required to give evidence are aware of it. When doubt exists, the names and contact details of potential interviewees should be obtained. As a rule, it is better to have an extensive list of possible interviewees than to miss the one person who really matters.

Interviews must be prioritized. Those that are expected to provide information regarding recent events, and where uncontaminated memory recall is important, should be conducted as soon as possible. Also, it is important that names and contact details are obtained, possibly by those first attending the accident site, of those who might be required to provide information before they leave the site. Some, or all, interviewees may have left by the time the investigating team arrives. However, it is worth bearing in mind that although interviewee recollection often provides the most insight, it is also of a fragile nature, and declines rapidly in the first 24 hours following an accident or traumatic event. Where a passenger ship is the subject of a marine safety investigation, the circulation of passenger questionnaires (see **Appendix 1**), preferably before the passengers have left the ship or shore receiving facility, will aid the identification of useful additional interviewees.

A valuable technique is for the investigator to introduce himself as soon as possible to actual and potential interviewees, explain that there will be an opportunity for the interviewee to give an account of what happened at a more appropriate time, but ask the interviewee if they have any views about why the accident happened. Appropriate questions can then be asked at the main interview, but revelations at this early stage are highly likely to be accurate and will enable a suitable line of questioning to develop. This could well be at a later stage, but investigator should use his own judgement as to whether to proceed with the main interview at that juncture. It is important for the investigator to make a record of what was said at this preliminary interview, with best practice being an audio or video recording.

The investigator should bear in mind that the venue of the interview can be important. As far as possible, the interviewee should feel comfortable in the environment, and the investigator must use his discretion, taking in to account the circumstances. An interviewee interview is also not an interrogation. The investigator should convey the sense of a cooperative, informal meeting. The interview needs to be conducted in a quiet area where there will be minimal distractions. Ideally there should be a table for writing and enough chairs for all who will be present. In some cases having the interview on ‘neutral ground’ might be beneficial but there are advantages in being able to visit the scene of the action at an appropriate time in the interview in order to recreate the context and help the interviewee to recall the events. Often ships’ masters and other crew will need to stay on board their ship to manage the aftermath after an accident.

The investigator should also consider interviewing people not apparently connected with the accident but who were on board the ship at the time. Off-watch members of the crew or those on duty elsewhere on the ship can often produce revealing background information about a

situation. Additionally, passengers will see things in a different way to a professional mariner. Sometimes the innocent passenger will provide the vital piece of evidence in a complex chain of events. Children between about 10 and 14 years old often make excellent interviewees.

As a general rule, the sooner an interview can be carried out, the better. However, a fine line has to be drawn between speaking to an interviewee who is still suffering from trauma, and delaying it by several hours or even days to enable the interviewee to recover. Very often, their memory may be faulty and the immediate (and usually very accurate) recollection of events has been replaced by an interpretation of what occurred. Sometimes third parties have had the opportunity to intervene and this can distort the witness's perspective.

3.5.2 INTERVIEW APPROACH AND PLANNING

Interviewees should be given the option to have legal advice concerning the interview process and they should be allowed to be accompanied by a 'friend' of their choice. The additional person's role is very much for moral support; they are not permitted to interfere in the interview and must be informed of this at the start. If they do repeatedly interfere, the interview should be stopped and the 'friend' asked to leave. The 'friend' should not be another key interviewee to avoid collusion or a member of the interviewee's chain of command, such as the master or company boss. The interviewee may want a lawyer with him. This is perfectly acceptable but it is worth confirming with the interviewee if the lawyer represents them, or actually represents the company they are employed by. If the lawyer really represents the company it should be made clear to the interviewee so that he can seek another 'friend' if he wishes (in some jurisdictions any legal advisor with an actual or perceived conflict of interest will be barred from representing a seafarer or other party). Interviewing is best done with two investigators present to ensure that as many angles of the interviewee's testimony are considered.

Seating should be carefully considered. 'Confrontational' seating should be avoided. Two investigators sitting one side of a desk while the interviewee is on the other is not optimal. Sitting at an angle with a low table, or no table, may be beneficial in enabling an interviewee to relax. The idea of the support interviewer sitting further away out of direct line of sight can reduce any appearance of a 'power' gap between the interviewee and the investigators.

It is beneficial to produce a short plan before each interview including the topics and questioning areas you would like to cover. Discuss this with your interview team and ensure it is clear who is leading the interview. The second investigator can listen to the answers being given and will often be able to ask additional questions to seek greater clarity to a point already made. It can also be beneficial if the second investigator takes the notes of the interview allowing the lead interviewer to concentrate on listening and asking the right questions. Every effort should be made to avoid leading the interviewee. Short open questions requiring descriptive answers are the most effective.

Potential interviewees include:

- Persons directly involved in the marine casualty or incident or its consequence;
- Eyewitnesses to the marine casualty or incident;

- Emergency response personnel;

- Company personnel, port officials, designers, repair personnel, technical experts.

During the course of an interview, it may be useful to ask the interviewee to list any others who were in the vicinity or who were seen near the time. It may also be useful to ask the interviewee to make a sketch of the marine casualty or incident, setting out the positions of other persons and the location and nature of key items of interest.

A group interview may be beneficial in gaining an initial overall picture of the circumstances surrounding a marine casualty or incident. However, individual interviews will normally be necessary in order to gain independent accounts and to provide additional details that may otherwise not be revealed. It is likely that further interviews may be required as more information is obtained during the course of the safety investigation.

It is important to approach marine safety investigations with a set of 'people sensitive' tools or skills. These include an open mind and a genuine humanitarian concern for people. Suggested guidance or skills for conducting an investigation involving those close to, either directly or indirectly, an accident include:

- Show concern for the person's injuries or a hazardous incident, no matter how slight it may seem to the investigator;

- Conduct the investigation as soon as possible, bearing in mind any injuries and possible trauma sustained;

- Explain the purpose of the investigation, emphasising its safety-orientated nature;

- Use a friendly non-threatening approach;

- Discuss the accident near the scene to help in memory recall if appropriate;

- Get the interviewee's view of the incident before asking questions;

- Listen carefully, avoiding interruptions and distractions;

- Frequently restate facts to secure a correct understanding;

- Use tact in clarifying discrepancies in peoples' recollection of the incident;

- Eliminate sarcasm, casting blame or threats;

- Eliminate leading questions;

- Discuss the incident with other personnel and involve them in identifying ways to prevent recurrences;

- Recognise when personnel acted properly, and include in the investigation report.

It must also be recognised that views may differ; this does not indicate that somebody is not telling the truth. People give accounts of events from their perspectives, which, to them is correct. One of the investigator's tasks is to try and explain the differences in honest interviewee accounts and not just pick the account that is preferred.

3.5.3 TYPES OF INTERVIEWEE AND THEIR STATE OF MIND

Interviewees usually fall into one of several categories. There are those whose recollection is good and who generally give an accurate account of the events as they saw them. Others may genuinely forget the details or, more usually, accidentally distort timings of events. A third group will try and put a gloss on events and evade giving entirely accurate answers to any question which might show up their own failings. Finally, there are those who deliberately lie or cover up the truth. An investigator will have to use his/her own judgement as to which category an interviewee falls under, but the sequence of events is unlikely to be revealed by accepting only one version.

Occasionally, an interviewee's state of mind may affect the accuracy or validity of testimony provided. In conducting interviewee interviews, the investigator should consider:

- The amount of time between the accident and the interview; people normally forget 50 to 80 per cent of the details in just 24 hours;
- Contact between this interviewee and others who may have influenced how this interviewee recalls the events;
- Signs of stress, shock, amnesia or other trauma resulting from the accident;
- Details of unpleasant experiences, which are frequently blanked from one's memory.

The investigator should note whether an interviewee displays any apparent mental or physical distress or unusual behaviour; it may have a bearing on the interview results.

These observations can be discussed and their impact assessed with other members of the team.

3.5.4 THE INTERVIEW

The opening of the interview should reassure the interviewee about:

1. The purpose of the interview (safety investigation);
2. Interviewee's rights;
3. Your role as the interviewer;
4. The procedures to be followed.

Establish a rapport with the interviewee at the outset, and:

1. Be polite;

2. Behave in a natural manner; do not make the interview seem artificial;

3. Keep interruptions to a minimum;

4. Strive for an atmosphere of friendly conversation;

5. Intervene only enough to steer the conversation in the desired direction;

6. Display a sincere interest;

7. Frequently summarise the information being given (this indicates an interest and avoids later misunderstandings).

Often the investigator will open an interview by inviting the interviewee to describe the events as they saw them. This allows certain questions to be framed before the formal recorded interview is carried out. The success of the interview will depend on both the timing and the structure of the questions. Begin the interview with a 'free-recall' question, letting the individual talk about what he or she knows of the occurrence or subject matter. Alternatively ask them to describe their career and background, as you will need this information anyway.

A free recall allows the interviewee:

- To ease into the interview in a more relaxed manner;

- To feel that what he or she has to say is significant.

More importantly, it is a source of information which is uncontaminated by the interviewer.

Sequence the questions from:

1. Easier to harder;

2. General to specific.

As the interview progresses, use a mixture of other types of questions:

- Open-ended or 'trailing-off' questions evoke rapid and accurate descriptions of the events, and lead to more participation by the interviewee. (For example: "You said earlier that your training was…?");

- Specific questions are necessary to obtain detailed information and may also prompt the person to recollect further details;

- Closed questions produce 'yes' or 'no' answers (providing little insight beyond the response);

- Indirect questions might be useful in delicate situations. (For example, “You mentioned that the first officer was uneasy about that approach. Why?”).

The following are some of the common traps interviewers may encounter:

- Avoid questions with the definite article unless the object in question has already been mentioned by the interviewee, e.g. use: “Did you see a broken lever?” not “Did you see THE broken lever?”

- When asking a question, avoid leading questions, i.e. any question that contains the answer. Instead, use neutral sentences without adjectives or figurative verbs, e.g. use: “Which way was the other ship heading?” not “Was the other ship heading west?”

- A question which mentions some object (whether the object existed or not) causes a tendency for an interviewee to assert that he/she saw the object. Design your questions so that they do not mention objects before the interviewee mentions them;

- If you have to ask questions of a personal nature, it is even more important to ask indirect questions, e.g. use: “Was there anything upsetting you on the day of the occurrence?” not: “How did your marital situation affect you that day?” or “Did you have a row with your wife/partner?”

The following are some additional hints for effective interviews:

- The interview is a dynamic process which requires continuing adaptation to the situation and to the interviewee;

- People approach any occurrence or situation from different perspectives;

- Remain objective and avoid making evaluations early in the interview; concentrate on the questions to be asked;

- Be aware of possible biases when assessing what was said during the interview;

- Do not allow the interviewee’s personality to influence interpretation of the interview;

- Do not accept any information gained in an interview at face value. Use it to confirm, clarify, or supplement information from other sources;

A good closing to the interview includes:

- Summary of the key points;

- An opportunity for the interviewee to expand on any points previously covered, or to add further points;

- Reassurance to the interviewee and thanks for cooperation;

- Determination of availability for further interviews (if required).

In some circumstances there may be many interviewees to be interviewed. The resultant (often conflicting) information must be summarized, sorted and compiled in a useful format. For example:

- Prepare a summary of each interview;
- Summarize each interview by consolidating information under meaningful headings;
- Write an overall description from each set of summaries;
- Do not draw conclusions from evidence which is too inconsistent to support them.

3.5.5 TEN COMMANDMENTS OF GOOD LISTENING

Good interviews require good listening skills:

1. **Stop talking**. You cannot listen if you are talking.
2. **Put the talker at ease**. Help interviewees feel that they are free to talk.
3. **Show them you want to listen**. Look and act interested, e.g. do not review documents while they talk.
4. **Remove distractions**. Do not doodle, tap or shuffle papers.
5. **Empathize with them**. Try to put yourself in their place so that you can see their points of view.
6. **Be patient**. Allow plenty of time. Do not interrupt.
7. **Hold your temper**. An angry person gets the wrong meaning from words.
8. **Do not criticize or embarrass**. Criticism puts respondents on the defensive. Do not embarrass interviewees by commenting on their lack of technical knowledge, education or choice of words. They may 'clam up' or get angry. Do not argue - even if you win, you lose.
9. **Ask questions**. Asking questions encourages the respondent and shows that you are listening. It also helps to develop points further.
10. **Stop talking**. This is first and last because all the other commandments depend on it. You cannot do a good listening job while you are talking or writing notes.

3.5.6 COGNITIVE INTERVIEWING

Cognitive interviewing is a particular interviewing technique that was developed in the 1980s. Its general aim is to help the recall of an interviewee and it is particularly useful with cooperative interviewees. The key to cognitive interviewing is letting the interviewee do the talking, which is quite an unnerving experience when the interviewer's natural desire is to keep

control of the interview. There are several techniques and steps to cognitive interviewing as briefly summarised below.

The first technique very simply focuses on asking the interviewee to tell the interviewer everything they can remember about the incident, not leaving anything out and not editing anything. This is often referred to as the free recall. When people are asked about an event they will often filter the information out that they thing is unimportant or is assumed known by the interviewer. The key to this approach is emphasising at the start the importance of just recalling everything and to tell the interviewee to take their time.

The next technique, which builds on the first, is context reinstatement. This gets the interviewee to think back in their mind's eye to the environment in which they witnessed the casualty event, by encouraging the interviewee to close their eyes or look at the floor to prevent distraction. The interviewer should then, with short statements and questions, encourage the interviewee to picture the scene. Ask simple questions like, the layout of the scene, the objects, colours and sounds that were present. Again tell them to take their time and follow their own pace. Simple short and relevant probing questions can be asked as the account is given, but try not to distract the interviewee from their train of thought.

Another technique is the reverse order recall method. This method requires pursuing with the interviewee the course of events by taking the last thing remembered or the most memorable aspect and working backwards and forwards in time. What this can help remove is the habitual behaviour that an interviewee routinely experiences and can mask what was actually different on the occasion of the incident. Interviewees will quite often revert to what normally happens in a routine event, but it may be that at the time of the accident the normal was not followed. The technique can also be quite helpful at detecting deceit. When an interviewee wants to lie they will tend to rehearse the lie in chronological order and, therefore, recalling the false events in reverse is difficult and hopefully easy to spot.

Applying cognitive interviewing techniques will not be appropriate in many of the interview scenarios encountered in a marine safety investigation when, for example, interviewing shipping managers and owners who were not at the scene of an accident. However, some of the elements of cognitive interviewing, like encouraging the free recall and minimising questioning early on in an interview, can be employed in interviews generally.

Applying the cognitive interviewing technique fully requires the recollection of the chain of events three times or more in order to gain greater detail. This amount of time will not always be available to the investigator but it is important to use the full technique when specific events are critical to the investigation. Ideally, the interview should take place away from distraction, and be free from interruption, in order to glean the best information. The technique will also not be appropriate with uncooperative interviewees and will be extremely difficult to conduct if significant language barriers exist.

3.5.7 CULTURAL DIFFERENCES

The investigator should also be aware of cultural differences that may be expected and the sub-cultures that may be on board a ship, particularly those with multi-national crewing.

Issues of status and loss of face may be encountered from time to time. There may be a tendency for an interviewee to provide answers that he/she thinks the interviewer wants to

hear, or a tendency to agree, just out of politeness. In other cases, the use of English or other common language may have different meanings or inferences. Under any of these circumstances an interpreter may prove really useful.

National culture differentiates the national characteristics and values system of particular nations. People of different nationalities differ, for example, in their response to authority, how they deal with uncertainty and ambiguity, and how they express their individuality. They are not all attuned to the collective needs of the group (team or organization) in the same way. In collectivist cultures, there is acceptance of unequal status and deference to leaders. Such factors may affect the willingness of individuals to question decisions or actions - an important consideration in crew resource management for example. Crew assignments that mix national cultures may also affect team performance by creating misunderstandings.

3.5.8 LANGUAGE DIFFERENCES

The language used for the interview will obviously affect the information provided. Being able to conduct an interview in an interviewee's mother tongue will be optimal. Unfortunately, given the international nature of shipping this is often not the case. English being the international language of the sea will often be used as the default but it is important to assess early on whether the language barrier is hampering the collection of information. If the interviewee's account is particularly important to the investigation, the use of an interpreter may be the only solution.

If the use of an interpreter is necessary, the investigator should ensure that the interpreter is fluent in the language and dialect spoken by the interviewee, has a proper command of the language spoken by the investigator and, preferably, has a sound understanding of technical marine terms. The availability of professional interpreters may be sought through local police at a scene.

Preferably an interpreter will be supplied by a government approved interpretation service. However, sometimes one must hire an interpreter on scene. Local embassies or consulates and universities are good sources to inquire about interpreter availability. If necessary, contact a commercial interpreter firm and arrange for an interpreter to travel to the scene. This is costly but without adequate interpreter services, the investigation cannot be properly conducted.

The interpreter must be able to grasp technical marine terms, and it may be necessary to arrange a prior meeting and/or have a list of common nautical terms available so that the interpreter has time to research the appropriate translation. The interpreter must be able to pass to the interviewee the information, as well as reflect the attitude and manner of expression you wish to convey. Further, the interpreter must be able to recognize any idiosyncrasies in the answers an interviewee may give and bring them to your attention, along with the reply.

The interviewee should generally be seated in a chair diagonally opposite you (not directly opposite) with the interpreter in between but slightly to one side, so that the interpreter may conveniently face either the investigator or the interviewee as the conversation flows. Questions should be directly to the interviewee using the first person. The questioner should not refer to the interviewee in the third person, or ask the interpreter to "ask him" or "tell him" anything. Further, attempt to keep questions short. However, should it be necessary to pose a lengthy question instruct the interpreter to translate the question in 'bite size' pieces. In such

instances, explain to the interpreter that you will pause occasionally to allow the interpreter an opportunity to translate incremental portions of the question.

An interpreter should:

- Merely act as a vehicle for accurately interpreting and passing information back and forth between you and the witness;
- Imitate your voice inflection and gestures as much as possible;
- Not carry on a conversation with the interviewee, other than directed by you;
- Faithfully pass on everything the interviewee said, including trivial remarks and exclamations;
- Not evaluate the conversation him/herself.

Using an interpreter complicates an interview and can often more than double the time it takes to complete the interview. Such interviews can be successful if they are well planned and controlled. At the conclusion of an interview, when the interviewee has left, it may be worthwhile seeking the interpreter's assessment of the witness.

3.5.9 INTERVIEWING NEXT-OF-KIN

Keeping the next-of-kin and close relatives of people who have died in an accident informed about the status and progress of the investigation should be an important aspect of conducting a safety investigation into a fatality. Next-of-kin will nearly always be sensitive to the person being criticised so the imparting of this information must be conducted carefully.

Other family members or friends will hopefully be present to support the next-of-kin, and in some cases it may be appropriate for a police liaison officer or other trained counsellor to be present. The investigator must of course demonstrate good empathy, be polite and be considerate to the next-of-kin's needs. If they become upset do not carry on regardless; pause and give them time to recover or even have a break. Building good relations with the next-of-kin, although difficult, can pay dividends in the investigation overall.

3.5.10 AUDIO RECORDING

The investigator should consider the use of audio recording when interviewing. The use of the audio recorder can save the investigator time and effort, and in the ideal situation he should record his questions and the answers, and any other information the interviewee gives him. Audio recordings can be used as the investigator's notes from which the key points can be drawn. Where required, the bullet points of the interview can then be written on to a suitable form and signed by the witness.

To ensure a recorded interview is as clear as possible, a minimum number of people should be involved. The room where the interview is to take place should be as quiet as possible, with minimal background noise, and where the progress of the interview is unlikely to be disturbed

by other people. As far as practical, only one person should speak at a time, and the investigator should request someone speak more loudly, slowly and/or clearly, as necessary.

Before the interview starts the investigator should introduce the recording in the following way:

- Name of ship to or on which the accident occurred;
- Date of the accident;
- File reference number (if known);
- Date and time of the interview;
- Place of the interview;
- Names of the investigator(s);
- Name of the interviewee, together with rank, rating or job title;
- Name of anyone else present.

The investigator should also verbally record the time when the interview concludes.

3.6 TYPICAL EVIDENCE FOR DIFFERENT CASUALTY EVENTS

There is no such thing as a 'typical' accident but there is similar information that needs to be retrieved for each casualty event type. An investigator's training, technique, use of tools and his own experience will assist him/her with asking the right questions and seeking out the appropriate supporting evidence; but on occasions, especially when faced with an accident of an unfamiliar type, it is useful to have some reminders. If further detailed questions or investigation is required, another investigator or specialist contractor can be called in.

The following sections are taken from the *MAIB Inspector's Aide-Memoire*. They provide a framework to ensure the pertinent evidence is collected by the investigator when faced with various accident scenarios. It is not the intention that all the possible accidents are covered and the investigator will clearly need to satisfy himself that he has covered all the necessary areas of interest for the case concerned.

3.6.1 NAVIGATION ACCIDENTS

Aspects for particular consideration for [collisions and near misses] are in square brackets and for (groundings and contacts) are in round brackets. The rest are applicable to all navigation accidents:

- Memory from VDR, ECDIS, ECS, GPS, ARPA, course recorders, engine data log.
- Navigation equipment: draw a plan or photo main consoles. What alarms could be set and what were actually set?

- Was navigation equipment working properly, when was it last checked, manuals?
- Familiarity of watchkeepers with the bridge equipment, training received.
- What was the OOW's experience of navigating in the area?
- Was chart in use corrected and up-to-date, were sufficient paper charts carried?
- Navigation methods being used, e.g. how were fixes obtained, what was the fixing interval, how was the ship's track monitored?
- Steering mode, manual follow up/non-follow up, autopilot normal/river pilot, rudder limits/weather helm set.
- Radars/ARPA in use, scale used, mode of display, EBL/VRM/parallel indexing used, alarm set, when was the radar index error last checked?
- GPS employed, correct datum in use?
- Passage plan- comprehensive? Was it used, who compiled and who approved it?
- Correct nautical publications carried?
- Company and Master's Standing orders and those for the conduct of navigation.
- Was the helm/rudder indicator used?
- Was the echo sounder used, alarms set, depth records kept?
- What was the gyro error, when was it last checked, were repeaters aligned?
- Magnetic compass deviation card posted up/available?
- What navigation lights and shapes were displayed?
- What were the watchkeeping arrangements?
- Content and standard of master/pilot briefing and liaison.
- Content and standard of handover between watchkeepers.
- Was information on squat and manoeuvrability available?
- Blind arcs/ranges for both visual lookout and ship's radar.
- Were clearing lines set and how?
- Was a watch alarm fitted, was it used, what was interval?

- Was the ship's whistle/horn operating correctly, manual and automatic modes?
- Propulsion information: shaft direction, rpm, pitch gauge.
- [Position of collision/near miss]. (Grounding/contact).
- [When and how was other ship first detected? E.g. position, course, speed, true bearing, relative bearing, range].
- [Courses, headings, speeds, and sound signals from first sighting]. (Height of tide).
- [Radio communications between the two ships].
- [Monitoring of other ship, was a radar plot kept, acquired on ARPA?
- (Draught of ship, forward, aft and amidships, last fix before grounding/contact).
- Weather, sea conditions, visibility, current and tidal flow.
- Weather forecasts obtained e.g. Navtex; obtain hindcast from Met. Office.
- Who was on the bridge, who had the con, where and what was he doing?
- Were the watchkeepers carrying out other tasks, distracted or fatigued?
- Was there a dedicated lookout?
- Lighting conditions and noise on the bridge.
- Machinery or equipment failure.
- General alarm sounded/broadcast on P/A system.
- [Compliance with collision regulations].
- State of watertight and weathertight doors.
- Point and angle of impact, sketches and photographs.
- [Chart of area showing position of collision/near miss]. (Grounding/contact)
- Engine movement book or computer readout of engine data log.
- [Post-collision action taken, degree of damage and repair, internal soundings].
- (Ship's draught, soundings taken around ship after grounding/contact).
- Extent of pollution, measures taken to minimise.

- [Paint deposit samples where it is not clear who collided with whom].
- (If applicable anchor details, length and scope of cable, holding performance).

3.6.2 FIRES AND EXPLOSIONS

The following evidence should be collected in the case of a fire or an explosion. However, it should be recognised that fire investigation is a specialist topic in itself for which additional training is required or specialist contractor assistance is recommended:

- Outfit of fire-fighting systems and appliances, fire plan.
- Fire-fighting appliances and systems properly serviced and maintained.
- Structural fire protection, e.g. insulation, fire doors, dampers, cable glands.
- Containment used, use of fire doors and hatches, boundary cooling.
- Sprinklers and gas drenching systems used.
- Instructions posted for fixed firefighting systems.
- Portable fire appliances used, e.g. fire hoses and extinguishers.
- Emergency fire pump use.
- Fire detection system, units activated, alarms given/noticed.
- Organisation and procedures for fire emergency control.
- Fire drills practised and logged.
- Seat of fire, source of ignition, material initially ignited.
- Spread of fire and smoke; was flashover involved?
- Means of escape.
- General alarm sounded, crew mustering, broadcast on P/A system.
- Deployment of fire parties.
- Fire dampers and fuel quick closing valves, shut down arrangements for fans and fuel pumps.
- Shore side fire brigade involvement.
- Hot work involved, permit to work procedure followed.

- Dangerous goods involved.
- Stability considerations with respect to fire-fighting water's free surface

3.6.3 CARGO SHIFT INCIDENTS

The following is applicable to cases in which bulk cargo has shifted:

- Port of loading, arrival date, departure date.
- Was cargo stowed in accordance with IMO Code of Practice for the Safe Loading and Unloading of Bulk Carriers?
- Loading start and finish time and when ship left port, crew supervision of loading.
- Cargo stockpiled before loading, condition of stockpiles, wet base, weather before and during loading.
- Damp cargoes, moisture content, flow moisture point, transportable moisture limit, drainage to the bilges during voyage.
- Method of loading e.g. belt conveyor, grabs, pneumatic conveying.
- How was the cargo trimmed? E.g. rotating nozzle, deflector plate.
- Number and dimensions of holds, cargo amount in each hold.
- Shape of loaded cargo, approximate depths and slope angles.
- Anything different about this shipment or how it was loaded.
- Stability condition before sailing, conditions calculated while on passage.
- Weather, sea conditions, speed of ship.
- Heel angle before shift, list angle after shift.
- Structural or other damage as a result of shift.
- Remedial action e.g. ballasting, change of heading.
- Did list cause problems with:
    - Running of main engine or generators?
    - Downflooding through ventilation pipes into fuel tanks?
    - Valves in vent heads preventing downflooding?

- Cargo samples if applicable.
- Roles and responsibilities for safe loading.
- Wave direction, wave height, encounter period.
- Weather condition (precipitation) at berth.
- Rolling period while on passage.
- Measurement method of moisture content, survey report.
- Stowage plan.
- Details of the shipper and consignee.

3.6.4 SHIFT OF TIMBER DECK CARGOES

A particular section containing additional evidence is included for timber deck cargo shifts given the issues that are particularly dangerous associated with this cargo:

- Timber stowed in accordance with IMO Code of Practice for Ships Carrying Timber Deck Cargoes, 1991, and the Cargo Securing Manual?
- Did crew supervise and approve the deck cargo when loaded?
- High friction coating used on hatch covers?
- Securing arrangements e.g. wire or fabric strops, chains, shackles, uprights, tensioning devices, slip hooks, hog wires (see IMO Code).
- Steel banding around timber packages. Did steel banding rest on the steel hatch covers (steel on steel has a low coefficient of friction)? Dunnage used to prevent steel on steel contact.
- Packages pre-slung. Packages resting on rope slings, dunnage used to prevent this.
- Timber packages covered in waterproof plastic. Plain plastic sheeting or high friction variety?
- Any structure helping to hold the deck cargo in place e.g. timber rails?
- Any cargo jettisoned? What method was used for jettisoning?

3.6.5 FLOODING

- Source of flooding, failure of hull, deck and superstructure plating or planking, sea water cooling systems, scuppers, windows, stern or rudder glands?
- How was flooding first detected, what action was taken?
- Any unusual ship motion before flooding discovered?
- What was the extent of flooding?
- State of watertight and weathertight doors and hatches.
- How was flooding limited by bulkheads, decks, doors and hatches?
- Condition of closing appliances, especially the seals.
- Freeing ports adequate?
- Downflooding arrangements. Any used?
- Bilge alarms, fixed bilge pumps, portable pumps.
- Stop cocks and non-return valves in pipe systems.
- Stability condition before and after flooding.
- Did floodwater cause significant hogging, sagging, list or loll?
- Did hogging or sagging cause structural damage?
- Did head of floodwater cause damage to e.g. bulkheads, decks?
- Cargo damage.
- Effect on propulsion machinery and electrical supply.
- Damage control measures, e.g. wood bungs and wedges, cement boxes, pipe clamps.
- Fishing vessel specifics:
    - Did bilge alarm and pumps meet requirements of relevant regulations/code?
    - Testing regime and maintenance of bilge alarm system.
    - Extended spindles employed on sea inlets?

3.6.6 FOUNDERING

Events leading up to the foundering:

- Voyage plan, course and speed.
- Stability condition before foundering.
- Stability performance, obtain stability book, last inclining experiment, computer models if available.
- Weather, sea and visibility conditions.
- Radio communications with coastguard, VTS, other ships.
- How long afloat after initial accident?
- How did the ship sink? E.g. by bow, stern or capsize.
- Location of wreck and water depth.
- Salvage intentions?
- Fishing vessel specifics:
    - Type of fishing e.g. beam trawling, stern trawling, potting, dredging. Recent changes to fishing gear.
    - Was vessel required to meet stability standard?
    - Sea bottom at wreck position, e.g. sand, mud, rock, wrecks nearby.

3.6.7 LIFESAVING APPLIANCES AND EVACUATION

- Required outfit of lifesaving appliances carried.
- Were lifesaving appliances properly fitted and in date for service etc.?
- Organisation and procedures for drills and emergencies.
- Boat drills, including evacuation and man overboard, practised and logged?
- Liferafts correctly secured with Hydrostatic Release Unit?
- SOLAS type approved liferaft, or other recognised body?
- Distress signals card and SOLAS manual.

3.6.8 STRUCTURAL/MACHINERY/EQUIPMENT FAILURE

- Correct operating procedure used?
- Machinery/equipment maintained and serviced in accordance with the manufacturer's instructions (see Manuals), maintenance and servicing records, experienced and qualified staff.
- Genuine replacement parts used or parts of correct specification.
- Recent repairs, onboard or ashore.
- ISM - any non-conformity reports on failed components.
- Design flaw, material defect, manufacturing or assembly fault.
- Operating within environmental tolerance, e.g. temperature, humidity.
- Item suitable for marine use, equipment designed for intended environment.
- Fatigue failure, indicated by beach marks, repeated loading cycles below the maximum stress.
- Fatigue life exceeded, number of cycles greater than assumed for design.
- Material overstressed, indicated by tearing or buckling, e.g. ultimate tensile stress exceeded, excessive shear force or bending moment.
- Components subject to wear, foreign material present, oil samples, magnetic plug residue samples, fresh water samples.
- Impact damage or abused in some other way.
- Retention of failed specimens.
- Previous failures and repairs.
- Vibration noticed prior to failure.
- Non-destructive testing, information available?
- Heavy weather damage. Obtain weather hindcast and wave information, photos of weather conditions at the time.
- Ship motions, e.g. pitching, rolling and slamming.
- Action taken to reduce motions, e.g. course change.

3.6.9 SHIP LOST OR MISSING

- Ship history from, e.g. owners, agents, stevedores, pilots, surveyors.
- Date and time of departure from last port.
- Voyage plan, estimated time and date of arrival at next port.
- Type of cargo, where and how stowed and secured.
- Any communications e.g. radio and mobile telephone calls.
- Contact or sighting by other ships, (coastguard incident log).
- Weather, sea conditions, visibility, current and tidal flow.
- Reports of surveys, port state and general inspections.
- History of equipment failures or structural defects.
- Photographs of ship from, e.g. owners, previous crew, harbourmasters.
- Fishing vessel specifics:
    - Fishing habits of skipper; normal fishing grounds. Ask previous crew, harbourmaster, agent, crews of other fishing vessels.
    - Did any of the crew inform next of kin of their intentions?

3.6.10 ACCIDENTS INVOLVING ENCLOSED/CONFINED SPACES

- Any definition of enclosed/confined spaces held on board ship?
- What procedures are in place, e.g. ventilation of space, atmosphere monitoring?
- What equipment is held on board (atmosphere meters, BA, extraction equipment)?
- Records and crew experience of drills on enclosed space rescue.
- If possible obtain independent measurement of atmosphere before ventilation after the accident.
- Do not enter enclosed space until certified safe by a chemist or other authority capable of ensure the atmosphere is safe, e.g. fire brigade.
- Check boundaries and penetrations of compartment for source of contamination.
- Check validity of the procedures in place.

- Establish familiarity of crew with the procedures.
- Establish the maintenance history of relevant equipment on board.
- Consider whether cargo handling or other work on board had an influence.
- Consider whether weather and sea conditions were influential.

3.6.11 COMMON ISSUES

The following will be common areas in which evidence will need to be collected for all accident scenarios but to varying degrees depending on the type of ship and accident involved:

3.6.11.1 Training and experience of crew

- Full name, date of birth and nationality.
- Certificate of competency, and discharge book.
- Marine experience since leaving school, e.g. training received including colleges attended, ranks held, types of vessels served on, companies employed by, fishing methods used.
- Training received.
- How long had they served on this ship and in what capacities?
- Fishermen's basic safety training courses, basic survival at sea, basic first aid, basic firefighting and prevention, safety awareness.
- Other qualifications, e.g. GMDSS, Bridge Resource Management, ECDIS, ARPA, dangerous goods, tanker safety, steering certificate, CPSC.
- Native language and proficiency in working language (documentation language).
- Attitude to safety.

3.6.11.2 Manning

- Safe manning certificate, number of crew, and crew list.
- Ship's schedule, long/short voyages, time in port, cargo work.
- Crew opinion, is manning sufficient, fatigue a likely issue (use MAIB FIT tool).
- Handover and familiarisation of joining crew.
- Crew contractual arrangements. Directly employed by the ship owner or crewing agency used.

3.6.11.3 Management and safety (shore)

- Relationship between owner, manager and crewing agency.
- Management effectiveness, e.g. planning, training, recording experience of crewmembers, supervision and control, monitoring crew health.
- Performance monitoring, e.g. staff reporting scheme.
- Management pressure, e.g. pressure to sail when crew tired, blame culture.
- Quality of communication, e.g. standard of company instructions.
- ISM Code implemented. Document of compliance, designated person ashore, audits, safety policy statement, methods for compiling/updating procedures.
- Safety representatives employed, last visit to ship.
- Random testing for drugs and alcohol.

3.6.11.4 Management and safety (shipboard)

- Shipboard organisation and standing orders.
- Safety management certificate, last audit.
- Procedures available, used and complied with; check understood by crew.
- Risk assessments carried out, control measure applied.
- Control measures applied, e.g. lifejackets, hard hats, safety boots, telling someone ashore.
- Safety officer on board.
- Safety meetings. Examine minutes for actions taken against issues raised.
- Safety training, emergency drills, personal protective equipment provided.
- Safety posters.

APPENDIX 1 - EXAMPLE OF A QUESTIONNAIRE FOR A PASSENGER SHIP EMERGENCY

The aim of the questions will need to be modified for any particular accident. The following outline reflects a questionnaire used when investigating a fire aboard a ferry. The fire was extinguished and passengers returned to their cabins, lounges etc. Most of the questions were phrased so the respondents could tick appropriate boxes.

The passengers were asked for the following information:

Q.1. What is your age bracket and gender?

Q.2. What is your first language?

Q.3 Are you fluent in any other language?

Q.4 Were you travelling alone or with others?

Q.5 If travelling with others, what were their names?

Q.6 How many times have you travelled on the ship?

Q.7 Did you read any safety leaflets that may have been handed out?

Q.8 Did you read the safety information on cabin door?

Q.9 Did you hear and understood any public address safety announcements?

Q.10 Do you recall hearing a demonstration of the emergency and fire alarms?

Q.11 How were you alerted to the emergency?

Q.12 Did you think it was a real emergency?

Q.13 If not, how long was it before you realised it was a real emergency?

Q.14 What were your first actions when you realised the emergency was real?

Q.15 Did you know where your muster station was?

Q.16 Did you go straight to your muster station?

Q.17 Did you have any assistance in guiding you to your muster station?

Q.18 Did the crew help you when leaving your cabin or saloon compartment?

Q.19 What did you take with you to the muster station?

Q.20 Were any difficulties experienced in reaching the muster station?

Q.21 Did you meet any passengers who were trying to go back to their cabin?

Q.22 How long did it take you to get to your muster?

Q.23 How were other passengers behaving?

Q.24 Describe the organization at the muster station?

Q.25 Were you told what the emergency was?

Q.26 Were you kept informed about what was happening?

Q.27 Do you know whether a 'head count' was taken?

Q.28 Were the announcements made over the PA while at muster stations?

Q.29 Were any announcements clearly audible?

Q.30 Was a crew member with you at all times at muster station?

Q.31 What did you do after the emergency was over?

Q.32 Please rate the crew performance.

Q.33 Please provide any more comments or information concerning the accident.

Note. The questions must be targeted, and superfluous questions eliminated. The questionnaire actually used can be seen, with the analysis in ATSB report No.165 Appendix 1 - http://www.atsb.gov.au/media/24717/mair165_001.pdf.

CHAPTER 4

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4.1 ANALYSIS

4.1.1 DEFINITION

In terms of safety investigations, we can define Analysis as the process where available data is reviewed, evaluated and then converted into a series of arguments, which produce a series of relevant findings. It is the link between the collected data and the findings of an investigation.

4.1.1.1 General Points

Analysis is at the centre of a safety investigation (see **Figure: The relationship between Analysis and other investigation tasks**, page 118, below)

Analysis is an iterative process, interacting with the other major tasks involved in an investigation. Analysis may lead to a requirement to collect further data, which then needs to be analysed. Even during report preparation, we may identify a need to conduct further analysis, which may change the content of the final report.

Analysis occurs throughout the investigation task. Analysis activities are more prominent after most of the data has been collected. However, analysis starts at the beginning of an investigation, when decisions and findings are needed to ensure efficient data collection - for example, findings even need to be made when inspecting an accident site to determine which components may or may not require further examination. Analysis also continues until the end of the investigation, as the investigation report is modified to address relevant concerns raised during a review of a draft report (see **Figure: Analysis effort over time**, page 119, below).

Analysis involves asking 'Why?' until we get a satisfactory answer. In a marine safety investigation, the satisfactory answer is when the underlying factor(s) that ultimately resulted in the accident are under-covered. However, the process of asking 'Why?' needs to be appropriately structured and guided.

Safety investigations require analysis of complex sets of data and situations where the available evidence can be vague, incomplete and misleading. There are no detailed, prescriptive rules that can be applied in all situations and provide guaranteed success. Although this manual provides guidance on how to conduct analysis activities in a structured and consistent manner, ultimately analysis relies on informed judgement and is, to some extent, subjective.

An investigation team can develop a series of useful, realistic and widely accepted findings by using:

- Well-defined concepts;
- A structured set of processes and stages;
- A team-based approach;
- Knowledge about the domain being investigated;

And by:

- Developing and continuously iterating an exhaustive list of hypotheses that may account for the accident outcomes; and

- Collecting sufficient data to:

    - Evaluate each hypothesis; and

    - Develop compelling arguments for the remaining hypotheses

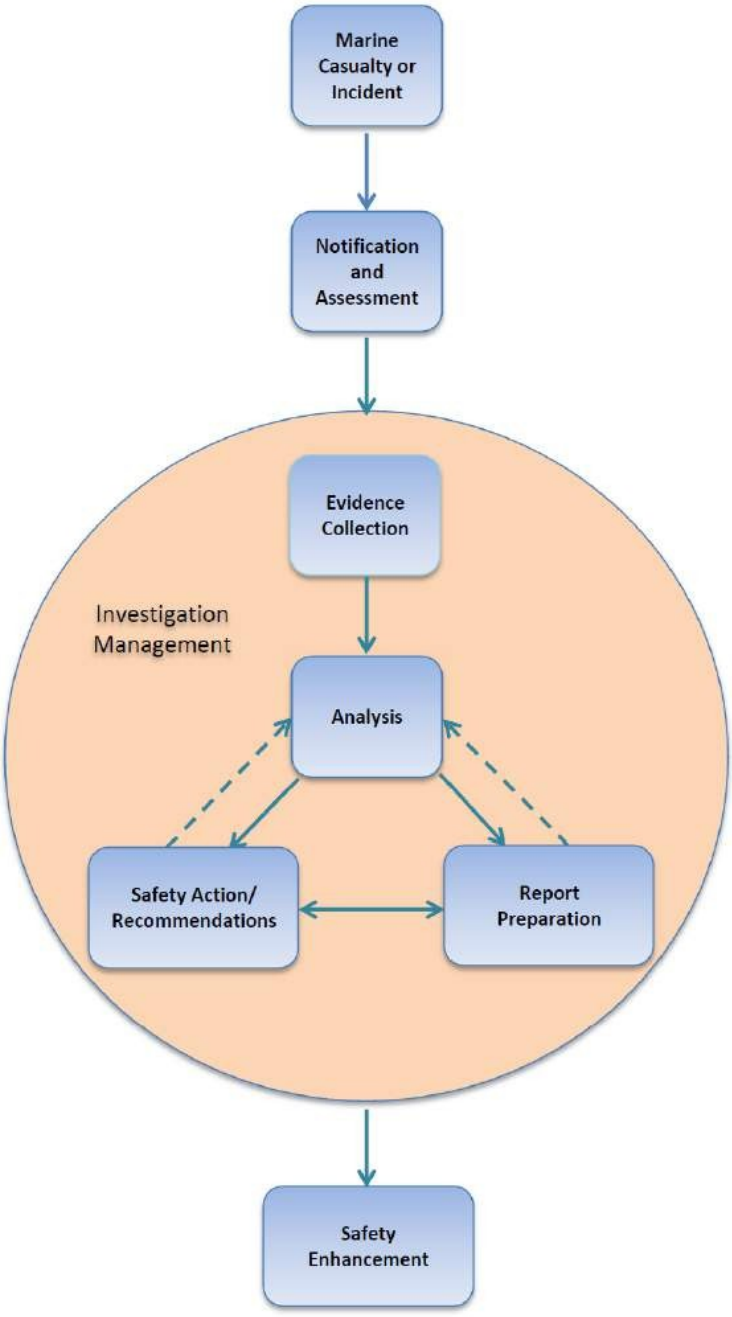


Figure: The relationship between Analysis and other investigation tasks

The figure below indicates the level of investigation effort that might be applied over time on analysis tasks relative to other investigation tasks. The figure is an indicative example rather that an accurate picture for all investigations.

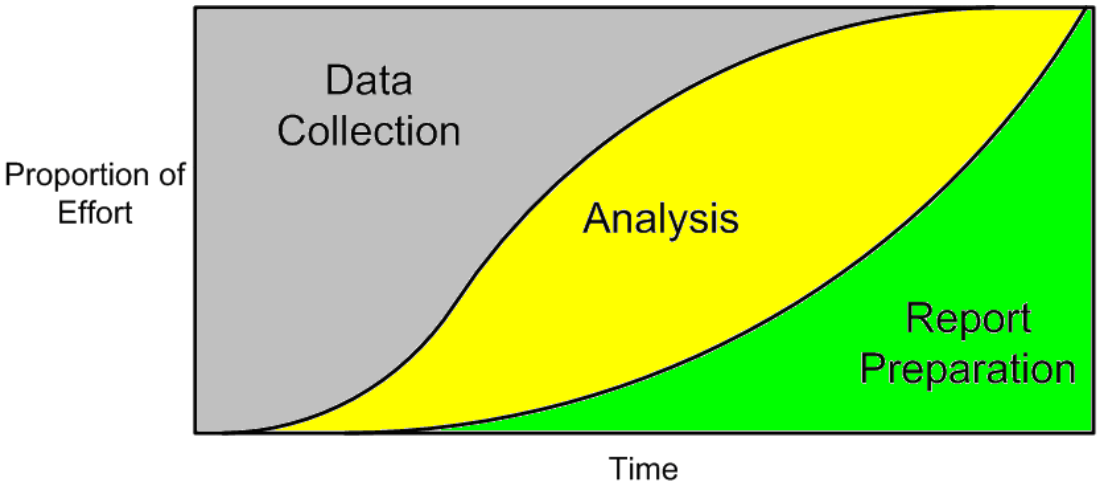


Figure: Analysis effort over time

4.2 ACCIDENT MODELS

In order to gather comprehensive evidence to support a safety investigation and to analyse that evidence effectively, an understanding of the nature of accidents including the organisational structure within which the accidents occur is essential. To this end, academics have, for some time, researched accident processes and developed accident causation models.

4.2.1 GENERAL PROPERTIES

A large number of different theories and models have been proposed about how accidents develop. These models vary greatly in terms of their approach and types of issues considered. A review of accident 'causation' models is beyond the scope of this manual. However, it is useful to provide a summary of some general properties of transport accidents:

- The development of an accident is a process that involves a number of different contributing factors. These factors can vary greatly in terms of their type or nature.

- The manner in which the different factors combine and relate to each other during the events leading up to an accident is usually complex and dynamic.

- A common type of factor involved in most accidents is an action or some actions taken by operational personnel (human error). However, most of these actions are the result of other factors that need to be determined to fully describe the accident.

- Most accidents also involve factors associated with how one or more organisations manage safety, through the use of risk controls and higher-level safety management processes. In other words, in complex technological systems, such as marine transport, accidents do not happen to people, but to entire organisations.

- With each accident, there is a point in time at which control is lost or damage becomes inevitable. Events after this point can modify the level of damage associated with the accident, but cannot prevent the accident from occurring.

- Probability or chance plays an important role in determining whether an accident occurs, as well as the severity of the consequences of an accident. For example, a similar pattern of events in slightly different situations may result in a serious accident, a minor accident, or no accident.

- All accidents can be prevented in an absolute sense, but in a practical sense there are a small proportion of accidents that involve events or conditions that could not reasonably have been foreseen and managed.

- The contributing factors involved in major accidents often involve the same types of factors that contribute to less serious occurrences.

4.2.2 MODELS TO HELP GUIDE INVESTIGATION ANALYSIS

There is no model that explicitly and comprehensively encapsulates all of the important issues that can be involved in the development of an accident. However, some models can help illustrate some of the important features.

In recent years a number of transport safety investigation agencies have utilised the Reason Model of organisational accidents as an underlying framework to guide investigation analysis. Although the Reason Model provides a widely accepted and useful approach for safety investigation, it was not designed for this purpose and there are some features of the model that limit its usability. As a result, academic researchers have developed the Reason Model further and, in some cases, have identified novel approaches to modelling accident causation. Many of these more recent models offer significant improvements and investigators have begun to utilise them and develop them further for the purposes of marine safety investigation.

Examples include:

- HFACS Human Factors Analysis and Classification System

- STEP Sequential Timed Events Plotting

- MTO HuMan – Technology - Organisation

- CREAM Cognitive Reliability and Error Analysis Method

- CASMET Casualty Analysis Methodology for Maritime Operations

This is a dynamic area of research and development and this manual will not attempt to explain these analysis tools in detail. But investigators who are interested in learning more on the subject will find plenty of material on the internet.

For the purpose of this manual, MAIIF suggests a simple approach based on the methodology used by the Australian Transport Safety Bureau (ATSB) modified to account for the IMO

Guidelines to Assist Investigators in the Implementation of the Casualty Investigation Code (Resolution A.1075 (28)). To this end the following definitions, taken from the IMO Guidelines, will form the basis for the strategy suggested:

Event	An action, omission or other happening.
Casualty event	The marine casualty or marine incident, or one of a number of connected marine casualties and/or marine incidents forming the overall occurrence - e.g. a fire leading to a loss of propulsion leading to a grounding.
Accident event	An event that is assessed to be inappropriate and significant in the sequence of events that led to the marine casualty or marine incident - e.g. human erroneous action, equipment failure etc.
Contributing factor	A condition that may have contributed to an accident event or worsened its consequence - e.g. man/machine interaction, inadequate illumination etc.
Safety issue	An issue that encompasses one or more contributing factors and/or other unsafe conditions.
Safety deficiency	A safety issue with risks for which existing defences aimed at preventing an accident event, and/or those aimed at eliminating or reducing its consequences, are assessed to be either inadequate or missing.

Diagram taken from the IMO *Guidelines to assist investigators in the implementation of the Casualty Investigation Code* (Resolution A.1075 (28))

The following diagram illustrates how a sequence of events leading to a casualty occurrence should be classified, using the above terms:

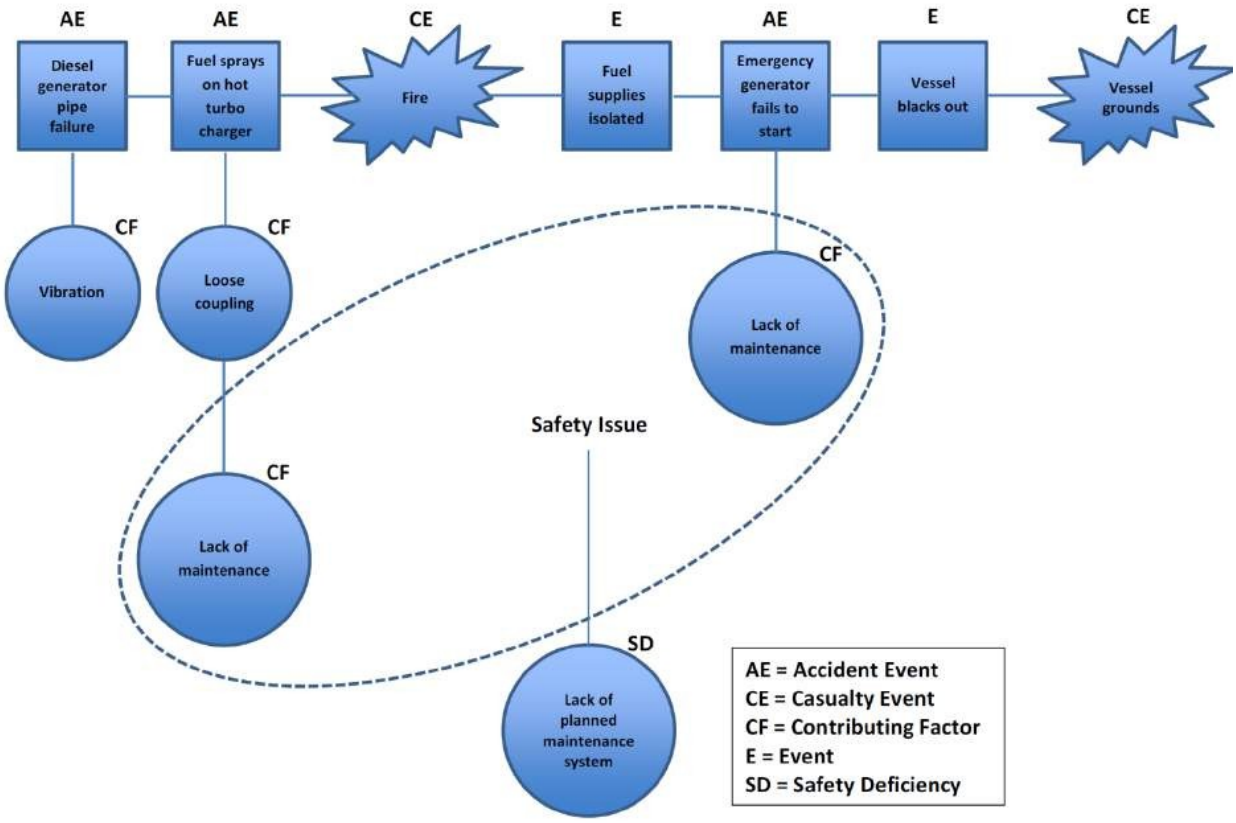


Figure: Example sequence of events leading to a casualty occurrence

Like many other models the ATSB's approach is based on Reason's Model of accident causation.

4.2.3 REASON MODEL

According to the Reason Model, accidents rarely result solely from the actions of operational personnel. Rather, most accidents are due to a combination of problems originating at all levels of the organisation.

Note: The brief overview of the Reason model in this section uses some terms that are not used elsewhere in this manual.

In simple terms, the accident sequence begins with the negative consequences of organisational processes - for example, management decisions associated with planning, scheduling, designing, specifying, communicating, and regulating.

These 'organisational conditions' are transmitted to the workplace in which the relevant operational tasks are performed. They result in 'local conditions' that have a negative impact on operator performance - for example, fatigue, high workload, lack of skills - and set the conditions for 'unsafe acts' (human errors).

These unsafe acts have consequences that are not identified or controlled by the 'defences' or safety net built into the system - for example, warnings and emergency procedures. Therefore,

local conditions and inadequate defences facilitate or do not adequately control unsafe acts, and these local conditions and inadequate defences are symptoms of wider systemic issues or organisational conditions, such as poor communication.

The figure below shows the general nature of the Reason Model.

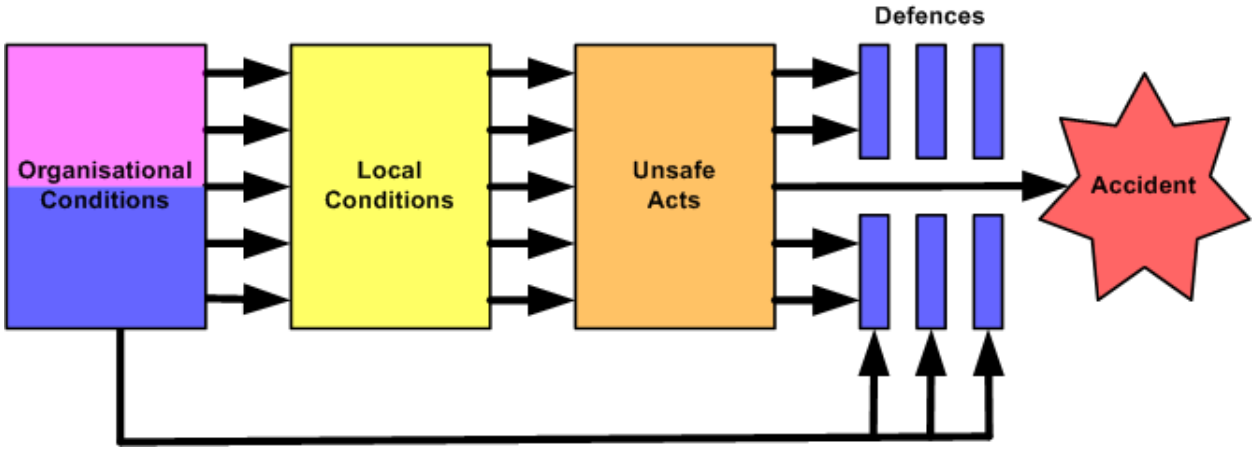


Figure: The general nature of the Reason Model

4.2.3.1 Active and latent failures

Reason distinguishes between active failures and latent failures:

- **Active failures** are the unsafe acts (human errors) committed by operational personnel, such as pilots, masters, watchkeepers, winchmen or engineers. They generally occur close in proximity to the accident.

- **Latent failures** are the conditions that influence the way operational personnel perform their assigned tasks, or which influence the ability of the system to cope with unexpected behaviour or circumstances - that is, inadequate defences or organisational conditions. Latent failures can be present in the system long before the breakdown or accident occurs.

In summary, the Reason Model emphasises that unsafe acts have a key role to play in the development of accidents. However, the origins of unsafe acts are (usually) in management systems, not within the individuals who made the unsafe acts - that is, the model emphasises a 'system' approach to improving safety rather than an approach focussing on the individuals who make unsafe acts.

When considering the Reason Model, it is also worth noting the following:

- Many other models of accident development have also emphasised the importance of management systems and organisational conditions.

- Since 1990 there has been much work done in using the model as a basis for designing safety management systems and also investigating organisations as part of an accident/incident investigation.

- There are now many different versions or interpretations of the Reason Model. There are no necessarily 'right' or 'wrong' versions, as long as the definitions being used are clear. However, the definition of terms in various versions has not always been clear, and this has resulted in a significant degree of confusion at times.

- The model is relatively simple and does not attempt to represent the full complex, dynamic nature of accident development. Such a representation is beyond the scope of any one model.

- The model focuses on human factors issues, which are obviously of great importance. As a result, issues associated with technical problems or failures are under-emphasised.

- The model can sometimes be frustrating to use when trying to rigidly apply it to classify specific events or conditions into one of the boxes - for example, poor training could be considered an organisational factor, an inadequate defence or a local factor. There can sometimes be significant disagreement between different investigators. In such situations it is usually better to consider the general concepts behind the model, rather than worry about specific classifications.

- The concept of defences is now often considered to be much broader than the 'last-line' defences described in early versions of the model. This can also create a degree of confusion as to whether some issues are best classified as defences, organisational conditions or local conditions. The ATSB preference is to use the term 'risk control' rather than 'defence'.

- The Reason Model provides a useful framework for identifying and organising safety factors during investigation analysis. However, by itself it is not an analysis method. A full analysis method needs clear definitions of key terms, guidelines for critical reasoning, and a structured process for identifying, defining and testing contributing factors.

4.2.4 THE ATSB INVESTIGATION ANALYSIS MODEL (MODIFIED)

4.2.4.1 Introduction

The ATSB Model does not attempt to describe all of the complexities involved in the development of an accident, but attempts to provide a general framework that investigators can use to guide data collection and analysis activities during an investigation.

ATSB investigators are encouraged to use this model as the underlying framework for their investigation activities. Other models will have relevance for describing specific events and conditions in some situations, and these models should also be used where investigators think they are useful. However, where terminology in these other models is referring to the same concept, the terminology presented in these guidelines should be used.

4.2.4.2 The Modified ATSB Model

The figure below outlines the basic features of the ATSB Model.

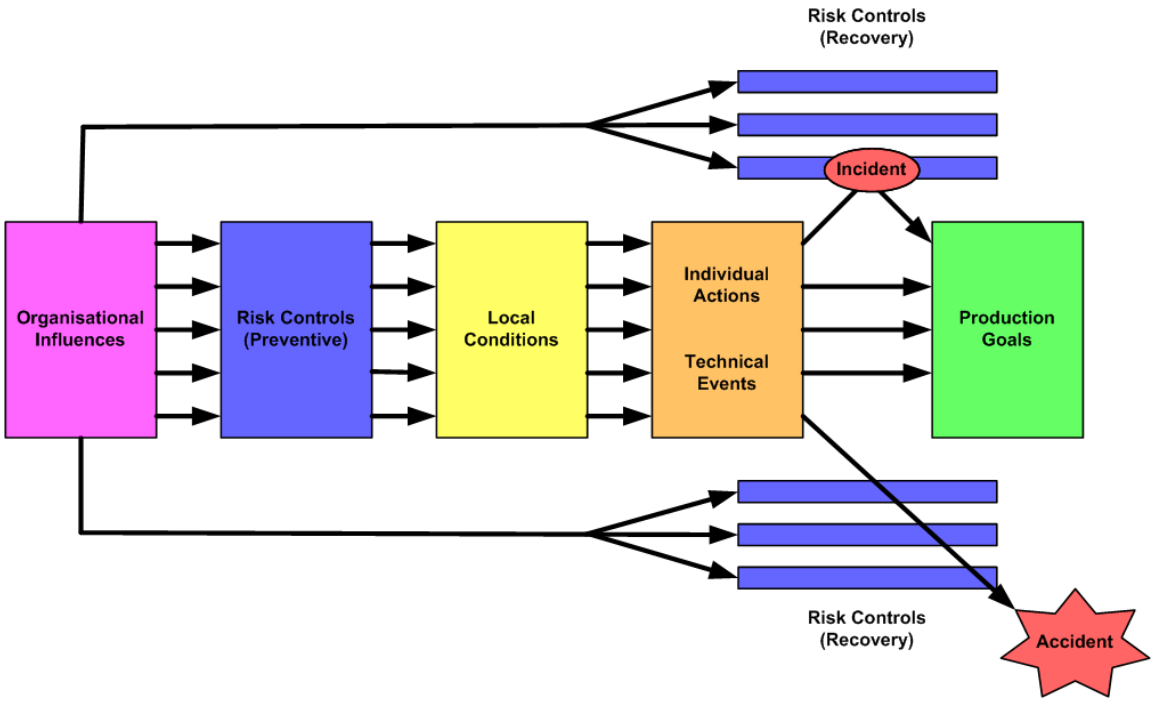


Figure: The basic features of the ATSB Model

Note: The angled arrows can be considered as representing 'accident events' – the first indications that an otherwise smooth operation is going wrong

4.2.4.3 The Modified ATSB Model

The figure above shows in simple terms how an organisation achieves its production goals through the combination of various events and conditions. Different types of organisations have different production goals - for example, the production goal of a:

- *Transport operator* is to transport people or cargo from one location to another location in an efficient manner.

- *Maintenance organisation* is to conduct maintenance activities to a certain standard in an efficient manner.

In most situations, the production goals will be achieved. However, in some situations, the various events and conditions will combine to produce 'accident events' (depicted by the angled arrows in the model) - where the system 'goes off track' - and risk controls are required to ensure that an accident or 'casualty event' does not occur or to minimise the severity of the casualty's consequences.

In other situations, the risk controls will not be effective in preventing a 'casualty event' or minimising its consequences.

4.2.4.4 Types of events and conditions

The main types of events and conditions outlined by the model as potentially being contributing factors to an occurrence are:

- Accident events (including technical problems);
- Individual actions including human errors and technical failure mechanisms;
- Local conditions (including operational factors);
- Risk controls (including preventive and recovery controls);
- Organisational influences (including internal organisational conditions and external influences).

4.2.5 THE MAIIF/IMO MODEL

4.2.5.1 General

The figure showing the ATSB Model (modified) is a simplistic diagram and it does not attempt to describe the full complexity of accident development. It also does not provide clear guidance on an appropriate strategy for ordering an investigation analysis.

The strategy for ordering an investigation analysis recommended in this manual necessarily must be in accord with both the IMO *Guidelines to Assist Investigators in the Implementation of the Casualty Investigation Code* (Resolution A.1075 (28)) and the *Revised Harmonized reporting Requirements* (MSC-MEPC.3/Circ.4). In order to achieve this, the components outlined in the ATSB model can be modified and simplified further into a five step approach as shown in the figure below:

4.2.5.2 Levels of Analysis

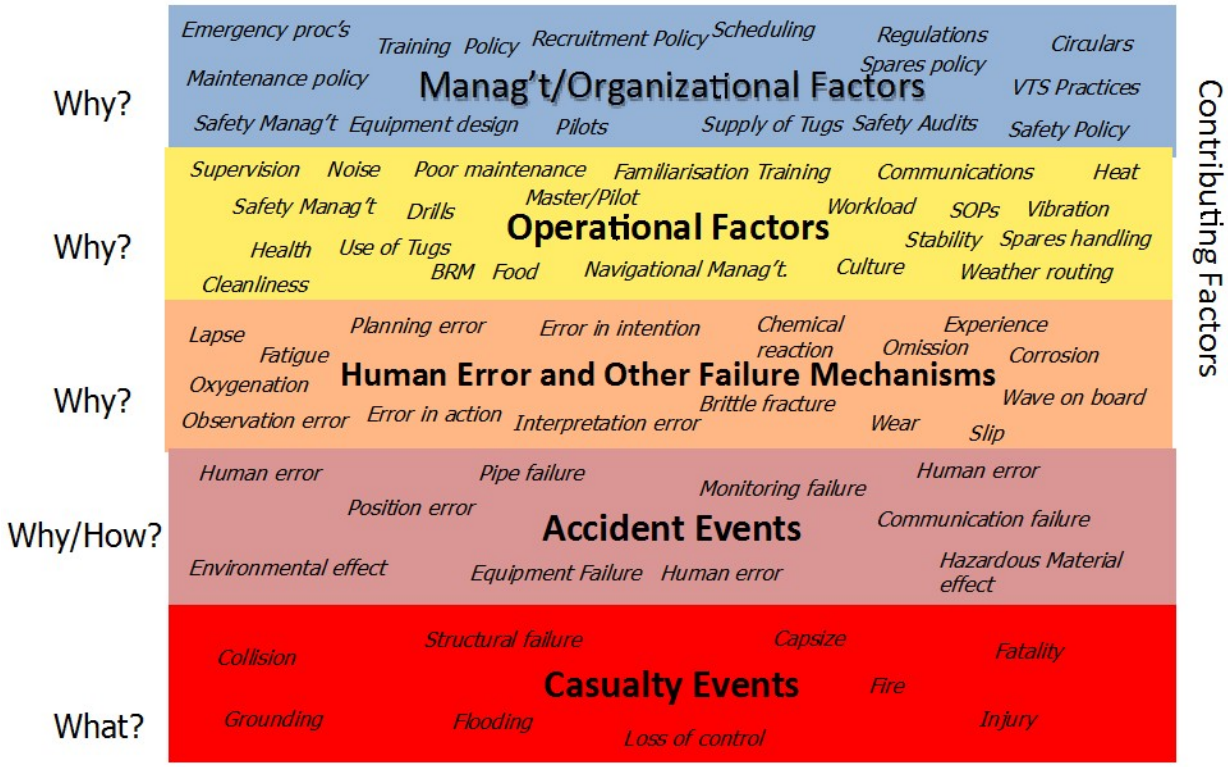


Figure: Levels of Analysis

4.2.5.3 Bottom up approach

From an investigation viewpoint, the most useful way of identifying contributing factors at each of these five levels is to start at the bottom and work up, asking a series of strategic questions.

Level of Analysis	Strategic Question
Casualty Events	What major events best describe this accident/
Accident Events	What events in the sequence of events that led to the casualty were BOTH significant and inappropriate in the context of what was happening at the time?
Human Error and other Failure Mechanisms	What best describes the human error or other failure mechanism?
Operational Factors	What shortfalls in the shipboard operation allowed the errors and failures to occur?
Management and Organizational Factors	What shore management or organizational factors influenced the relevant shipboard operations?

Understanding the mechanisms which describe the human error, mechanical failure or environmental effect is an essential stage in this analysis process but, the most important contributing factors to identify are those that occur at the Operational and Management and Organizational levels. These are the levels where changes can be made which can have a meaningful influence on safety. Some of the identified contributing factors which occur at

these levels are safety issues and safety deficiencies which should form the basis of safety action and recommendation to improve safety.

Many investigations stop short of identifying problems at Shore Management and Organizational factors level, or perhaps even the operational factors level. This is due to a number of reasons, including:

- The fact that the presence of a problems at lower levels does not always mean there is a significant problem in the way an organisation manages its safety activities.

- Collecting and interpreting information about organisational influences is time consuming and difficult, the problems (if there are any) are often hard to clarify, and investigations have limited time and resources.

4.2.5.4 The Stop Rule

How far back into the system does an investigation need to go - that is, what is the 'stop' rule? This depends on many factors, such as the severity of the occurrence and the resources available.

If the investigation is:

- Still identifying safety issues that are significant and could practicably be addressed, then the investigation should continue.

- Focusing on factors that no organisation could reasonably be expected to address then the investigation should be finalised.

However, even when the investigation has reached this 'stop' point, it can be useful to try to explain why the highest level safety issue(s) occurred - not for the purpose of identifying additional safety issues, but to provide information on the context in which the issues occurred. Such an approach can provide balance, and also help avoid the natural tendency of some parties, such as the media, to allocate blame.

4.3 THE ANALYSIS PROCESS

For the purpose of this manual MAIIF suggests a simple approach to analysis based on the MAIIF/IMO strategy outlined in Section **4.2.5**, above and consisting of the following steps:

1. Develop a sequence of events diagram.

2. Identify which events in the sequence should be considered as **Casualty** and **Accident Events**.

3. Analyse each Accident Event to determine why the event occurred (discovering the background to individual actions and the **Human Error** and **Technical Failure Mechanisms**).

4. For each Individual action and technical failure analyse the **Operational Factors** which may have had an influence including any **Risk Controls** that failed or were not in place.

5. Analyse further to discover why the relevant **Operational Factors** existed to discover the **Shore Management and Organisational Factors** that underlay the events.

At each stage in the analysis process the investigator should identify gaps in his evidence and understanding of the case and seek clarification through additional evidence and analysis. The analysis process should start at the very beginning of the investigation and continue throughout.

Additionally, in this manual, MAIIF advocates the use of an Event and Contributing Factors Chart to diagrammatically portray the analysis results

4.3.1 ANALYSIS PROCESS, STAGE 1 - DEVELOP A SEQUENCE OF EVENTS DIAGRAM

Using the evidence collected in witness interviews, from recordings, VDR records and other sources, develop a complete timeline of the events that were associated with the accident.

From the beginning of a marine safety investigation, investigators will collect data that will allow them to piece together the sequence of events that led to the casualty. In addition to identifying the sequence of events, investigators should display these events as part of an Event and Contributing Factors Chart (see Section **4.3.5.2**). The diagram is the basis of a tool for summarizing, documenting, and communicating the results of an investigation.

1. Identify the sequence of events that led to the casualty event(s):

    - The events are determined from the evidence collected and placed in the diagram.

2. Determine all happenings or action steps:

    - Each event describes a single, discrete happening or an action step in a sequence of happenings/actions that led to the casualty.

    - An event is not a condition, state, circumstance, issue, conclusion or result.

    - Events should be based on solid facts or be clearly indicated as being presumptive.

    - Each event should be described by a short sentence with one subject and one active verb.

    - Each event should be described precisely.

    - Each event should be quantified when possible and given a date and time.

    - Additional events will be determined as information is gathered.

3. Portray events in a logical flow indicating 'what' happened:

    - All pertinent events should track in logical progression from the beginning to the end of the occurrence (initiation, pre-casualty, 1st casualty event, post casualty response, 2nd Casualty event, post 2nd casualty response etc.) and should include all pertinent happenings.

    - Define clearly the beginning of the accident sequence – go back in time sufficiently far to include all relevant events.

    - Analysts frequently use the first **Casualty Event** as the key event and proceed from it in both directions to reconstruct pre-casualty and post-casualty sequences.

4. Where necessary or deemed preferable, as in the case of a collision for instance, draw two or more sequence of events lines one for each of the main players (or actors):

    - All events should be shown against a single time base.

4.3.1.1 Illustrate the events

Illustrate events according to the following guidelines:

- Arrange the events chronologically left to right (or top to bottom) in rectangles.

- Each event block should contain the time and date of the event when available.

- Connect events with solid arrows.

- Depict presumptive events with dashed rectangles and dashed arrows.

- Depict events in a continuous horizontal (or vertical) line.

- Where more than one event line is used depict them in parallel horizontal (or vertical) lines.

4.3.2 ANALYSIS PROCESS, STAGE 2 - IDENTIFY THE CASUALTY AND ACCIDENT EVENTS

Firstly identify and clearly depict the **Casualty Events**, bearing in mind that there may be more than one. For instance **Mechanical Failure**, leads to **Grounding**, leads to **Pollution.**

Then identify all the **Accident Events** in the sequence. To determine which events can be deemed **Accident Events** an investigator should consider every event in turn asking the questions:

1. Is this event significant in the sequence of events that led to the casualty?

2. Does this event concur with what would have been expected on a well-run ship given the particular circumstances at the time?

If the answer to question 1 is 'Yes' and the answer to question 2 is 'No' then the event should be designated as an **Accident Event** and marked in a distinctive fashion. If the answer to either question is not as indicated above the event should be passed over and the next event in the sequence considered.

When this process has been completed the investigator will have almost certainly identified several human errors, and possibly mechanical failures and environmental events, which can be considered as **Accident Events** and which should form the basis for the ongoing analysis

4.3.3 ANALYSIS PROCESS, STAGES 3, 4 AND 5 - ANALYSE THE ACCIDENT EVENTS – THE 5 'WHYS'

The next stage in the analysis process is to analyse each **Accident Event** in turn considering in detail the questions 'How?' and especially 'Why?' the event occurred.

This process will firstly uncover the mechanisms and error types which best describe the **Human Errors** (see Chapter 3 Section **3.2**) and **Technical Failures** (**Stage 3**) and then, by continuing to ask 'Why?' these features existed on board the ship conditions which are **Contributory Factors** concerning the Operation of the vessel will be uncovered (**Stage 4**). More than one contributory factor might be uncovered for each **Accident Event** or **Accident Event Mechanism** at this level and some **Contributing Factors** may be presumptive at this stage - indicating the need for more evidence to support or counter the result. The analysis process is iterative.

Investigators might find that keeping the SHEL Model in the back of the mind when considering these questions might help to ensure that all the main areas of human factors are considered (Software, Hardware, Environment and Liveware) and accounted for (See Chapter 3, Section **3.1.4.1**). For instance if considering why an operator was fatigued, the investigator would consider the physical and mental condition of the person and any effects that interactions with other people may have had (**Liveware**); the procedures and scheduling that might have affected his performance (**Software**); the conditions at the workstation, warm/cold, noise, vibration and, maybe, the weather conditions (**Environment**); The design and operability of the workstation (**Hardware**) as well as many other factors under these headings.

The process should be continued further by asking again 'Why?' each of the **Operational Contributory Factors** existed at that time. The results of this questioning might uncover more **Operational Factors** and **Shore Management and Organizational Contributory Factors** that were influential in the incident or which failed to operate effectively (**Stage 5**). Once again, the process may highlight gaps in the evidence or understanding of the case and/or the factors uncovered might be presumptive. In either case more investigation is likely to be needed.

This process can be likened to the questioning of a young child who is apparently never satisfied by the answer that it is given. Likewise the investigator must continue asking 'Why?' until he is satisfied that investigating that particular **Accident Event** further would serve no practical purpose (see section ***4.2.5.4 The Stop*** Rule, above). Taking this process to five levels (**5 'Whys'**) will certainly fulfil the objective of the operation - that is, to discover **Management and Organizational Factors.** (See section ***4.2.5.2 Levels of Analysis***, above).

The results of this process should be depicted graphically, and experienced investigators should consider which charting method is most suitable for this purpose, bearing in mind the accident type, the evidence and other factors. The principal charting methods are outlined in the next section but, for the purpose of this manual, MAIIF suggests that investigators construct an Event and Contributory Factor Chart the process for which is covered in detail in Section **4.3.4**, below.

4.3.4 CHARTS TO REPRESENT THE ANALYSIS PROCESS

When identifying potential contributing factors and safety issues, it is useful to use some form of chart which shows all of the events and potential factors and the potential relationships between them.

The process of completing such a chart can often help investigators think about the occurrence in new ways. In addition, the use of such charts can help identify gaps in a set of factors (that is, where a given factor has not been adequately explained). Charts are also a very useful way of summarising and communicating an occurrence to others.

Some charting techniques can result in large, complex diagrams which can confuse rather than enhance explanations for those not familiar with the techniques. In addition, with some of these techniques, the focus of safety factors analysis can become the development of the chart rather than the process of identifying potential safety factors and testing (or verifying) that they were influential.

Many of the safety factor charting techniques do not indicate the importance of the factors with reference to levels of an underlying analysis model. This can make it difficult to appreciate the relative significance of the factors for safety enhancement purposes.

Many charting techniques also do not cater for important safety factors which were identified in the investigation, but were not considered to have contributed to the occurrence being examined.

A range of different types of charts have been used in occurrence investigation. The common types of techniques used are presented in the following paragraphs and include:

- AcciMaps;
- Event and contributory factors charts;
- Fault trees;
- Mind maps.
-

Some types of charts are quite simple, and some are quite complex. Different charts also tend to focus on different types of factors, or may be more suitable for certain types of occurrences.

For simplicity, sample charts are not included in this manual for all the charting methods mentioned but a simple search of the internet can provide many good examples.

4.3.4.1 AcciMaps

The AcciMap format shows the events involved in the occurrence from left to right, and then adds the contributing factors to these events in a series of hierarchical layers. The types of layers used vary from one user to the next, with many applications extending to government policy or national culture levels. The AcciMap format is a relatively simple way of summarising an analysis of the contributing factors associated with an occurrence on one page. The technique is not associated with any specific guidance for identifying or testing factors. The format was developed by Jens Rasmussen, and has been modified by a variety of safety researchers and practitioners, including Andrew Hopkins at the Australian National University.

Source for further information:

- Hopkins, A., (2003) "Fault Trees, ICAM & Accimaps: A Methodological Analysis", *Safety in Australia*, Vol 25, Issue 2, pp 13-23.

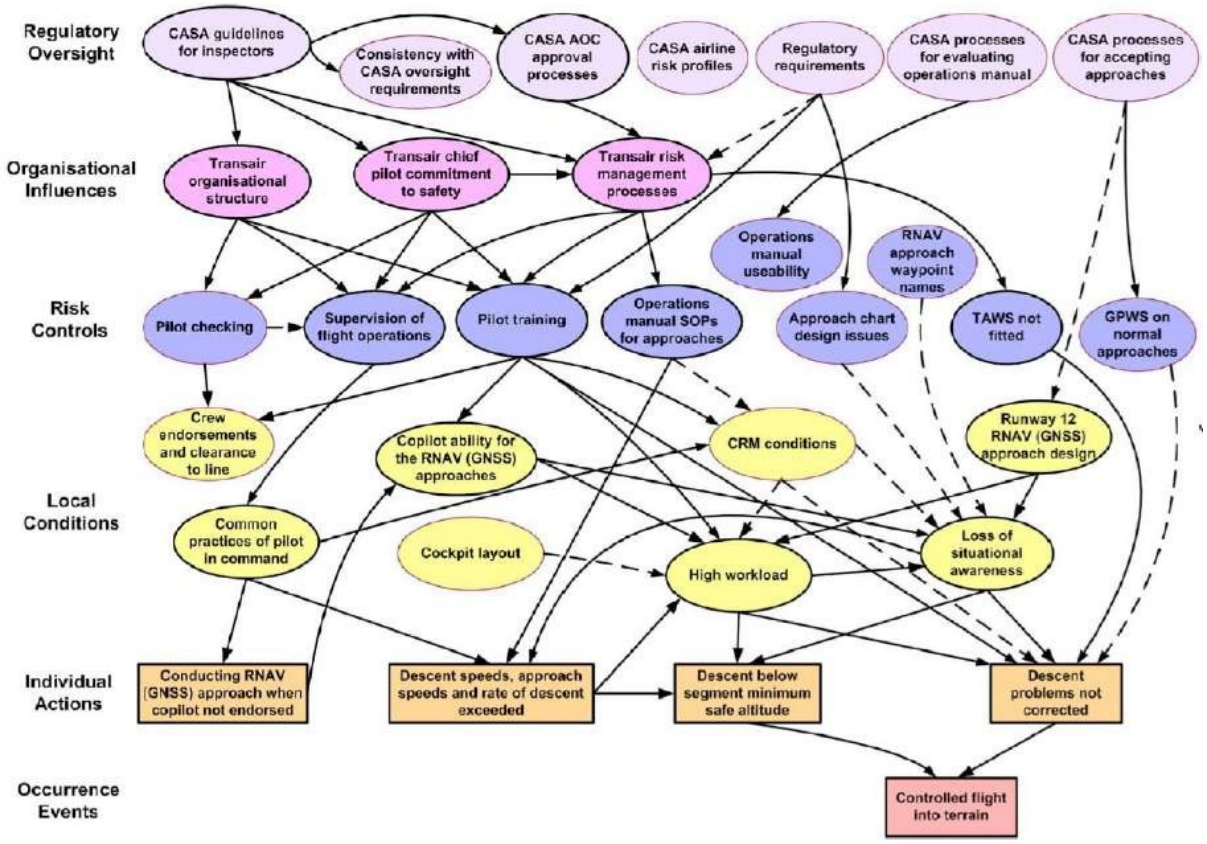


Figure: An example of an AcciMap
(From the ATSB publication *Analysis, Causality and Proof in Safety Investigations*)

4.3.4.2 Event and Contributory Factors Charts

This subject is covered in more detail in Section **4.3.5**, below but briefly, an Event and Contributory Factors Chart lists the key events involved in the occurrence in a series of boxes in chronological order from left to right - that is, a sequence of events (see **Sequence of Events Diagram**, page 122, above). It then adds contributory factors which led to the key events in the

sequence. There are usually no distinctions made in terms of the types of contributory factors or their hierarchy based on an analysis model.

A variety of other formats has also been used for these types of charts. Some formats have a sequence of events for each of the main players (or actors) in the build up to the casualty.

This type of chart is widely used in some industries, and is advocated by organisations such as the Canadian Transportation Safety Board, The UK Marine Accident Investigation Branch and the US Department of Energy.

Sources for further information:

1. Department of Energy (DOE), *Conducting Accident Investigations: DOE Workbook*, Revision 2, 1999. Section 7: Analyzing Data.

2. C.W. Johnson, *Failure in Safety-Critical Systems: A Handbook of Accident and Incident Reporting*, University of Glasgow Press, Glasgow, Scotland, October 2003. Chapter 10 (Causal Analysis).

4.3.4.3 Fault trees

Fault trees are a tool for depicting the reasons or causes for a specific event or problem. The tool uses 'and' gates and 'or' gates to combine the various events and conditions that led to (or could lead to) previous events and conditions, working back in time. There are usually no distinctions made in terms of the types of conditions or their hierarchy in any analysis model. The technique is not usually associated with any specific guidance for identifying or testing factors. The US NTSB is currently developing an analysis methodology using sequence of event charts, with each key event then subject to a fault tree analysis. Although widely used in some industries, fault trees are more common when dealing with technical problems. Fault trees and similar techniques are best used when identifying potential explanations for a specific problem, and where multiple (and mutually exclusive) explanations may be relevant.

Sources for further information:

1. FAA, *System Safety Handbook*, 2000. Chapter 9: Analysis Techniques.

2. C.W. Johnson, *Failure in Safety-Critical Systems: A Handbook of Accident and Incident Reporting*, University of Glasgow Press, Glasgow, Scotland, October 2003. Chapter 9 (Modelling Notations).

3. D. Livingston et al., *Root cause analysis: Literature review*, UK Health and Safety Executive Contract Research Report 325, 2001.

R. H. Wood & R. W. Sweginnis, Aircraft *Accident Investigation*, Endeavor Books: Casper WY, 1995. Chapter 37: Analysis Techniques.

4.3.4.4 Mind maps

In general terms, a mind map is a diagram used to display words, ideas, tasks or other items linked to and arranged radially around a central key word or idea. In terms of an accident analysis, it can be used to show all of the potential contributing factors that may have influenced other factors and events.

As with fault trees, mind maps are most suitable when identifying potential explanations for a specific factor. In addition to just displaying potential explanations, additional information about each of the explanations can also be included, such as the degree of supporting evidence.

4.3.5 ANALYSIS PROCESS - EVENT AND CONTRIBUTING FACTOR CHARTING

Event and contributory factor charting is a graphical display of the accident's chronology and is used primarily for compiling and organizing evidence to portray the sequence of the accident's events and the casualty's contributing factors. It is a continuous process performed throughout the investigation. During the process of developing the chart, the analysis is performed to identify contributory factors at all levels. Subsequently the chart can be used to help identify the underlying **Safety Issues** and **Safety Deficiencies**.

Event and contributing factors charting is possibly the most widely used analytic technique because the events and contributing factors chart is easy to develop and provides a clear depiction of the data. By carefully tracing the events and contributory factors that allowed the accident to occur, team members can pinpoint specific contributory factors in the Operational or Management and Organizational levels (**Safety Issues**) which, if addressed through corrective actions, would prevent a recurrence.

4.3.5.1 Benefits of events and condition charting

- Illustrating and validating the sequence of events leading to the accident and the contributory factors affecting these events.
- Assisting in the identification of casualty and accident events.
- Directing the progression of additional data collection and analysis by identifying information gaps.
- Linking facts, events and contributing factors to organizational issues and management systems - conveying the possibility of multiple safety issues.
- Validating the results of other analytic techniques.
- Providing a structured method for collecting, organizing, and integrating collected evidence.
- Providing an on-going method of organizing and presenting data to facilitate communication among the investigators.

- Clearly presenting information regarding the accident that can be used to guide report writing.

4.3.5.2 Constructing the chart

Constructing the Event and Contributing Factors Chart should begin immediately at the start of the investigation. However, the initial chart will be only a skeleton of the final product. Many facts and conditions will be discovered in a short amount of time, and therefore, the chart should be updated frequently throughout the investigative data collection phase. Keeping the chart up to date helps ensure that the investigation proceeds smoothly, that gaps in information are identified, and that the investigators have a clear representation of accident chronology for use in evidence collection and witness interviewing.

Investigators and analysts can construct an event and contributing factors chart using either a manual or computerized method. Marine safety investigation teams often use both techniques during the course of the investigation, developing the initial chart manually and then transferring the resulting data into computer programs.

The manual method employs removable adhesive notes to chronologically depict events and the conditions affecting these events. The chart is generally constructed on a large conference room wall or many sheets of poster paper. Events and conditions are recorded on removable adhesive notes and affixed sequentially to the wall in a team's conference room or office. As the exact chronology of the information is not yet known, using removable adhesive notes allows investigators to easily change the sequence of this information and to add information as it becomes available. Different coloured notes or inks can be used to distinguish between events and conditions in this initial manual construction of the events and condition chart.

If the information becomes too unwieldy to manipulate manually, the data can be entered into a computerized analysis programme. Using specialized analytical software, investigators can produce an event and causal factors graphic, as well as other analytical trees or accident models.

Whether using a manual or a computerized approach, the process begins by chronologically constructing, from left to right, the primary chain of events that led to an accident. In more complex cases secondary and miscellaneous events can then be added to the events and contributing factors chart, inserted where appropriate in a line above or below these events. The figure below illustrates the basic format of the events and contributing factors chart, with just the single primary event line and the analysis of only one accident event shown.

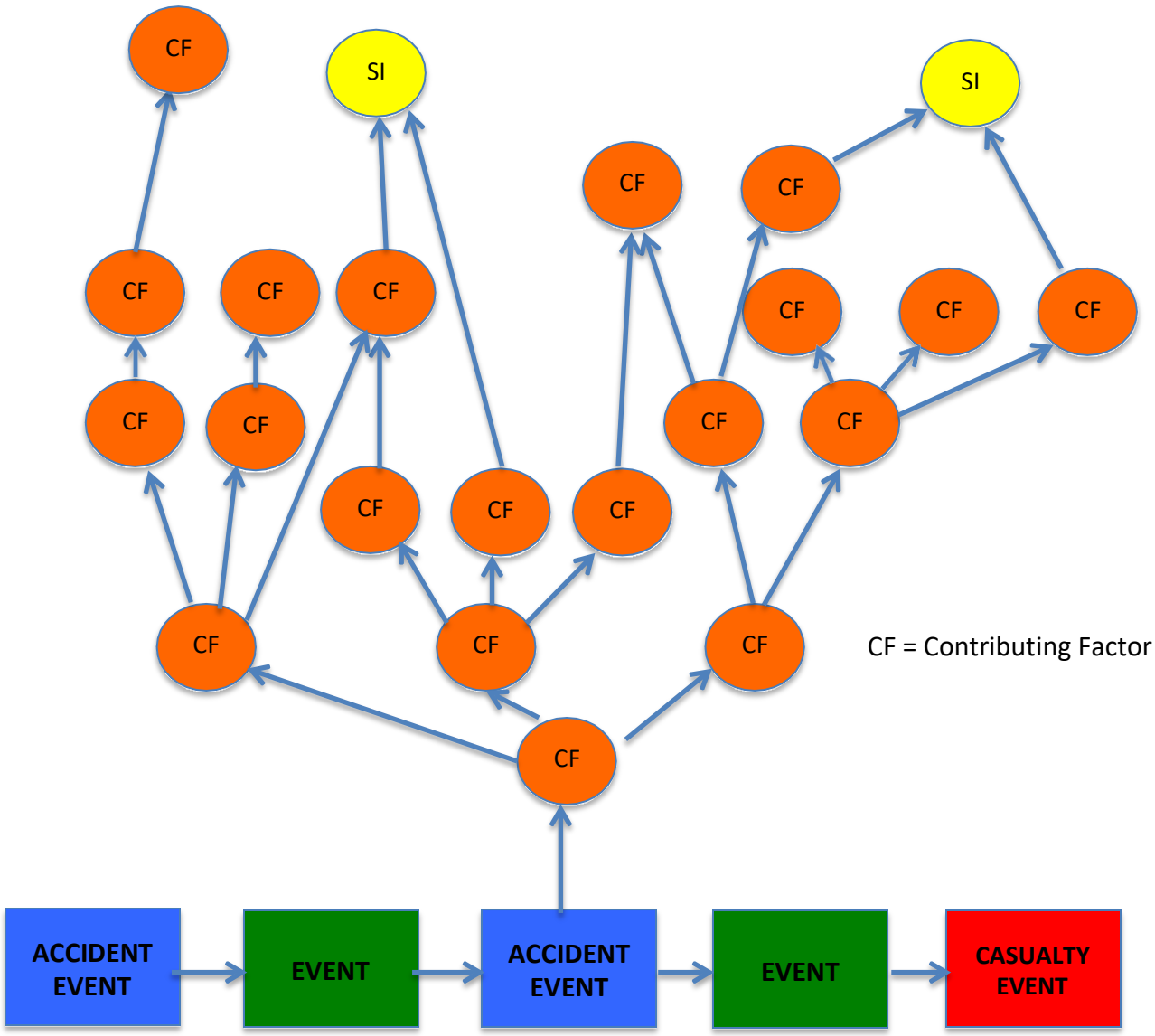
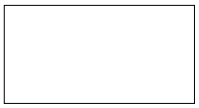


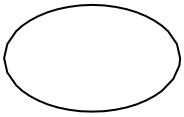
Figure: Event and Contributing Factors Diagram

Depending on the complexity of the EVENT accident, the charts may result in a very large complex sequence of events. If deemed suitable for the purpose of inclusion in the investigation report and closeout briefings, the chart is generally summarized. Note that 'presumed conditions' may appear in the final chart. These are conditions the team presumed affected the accident sequence, but the effect could not be substantiated with evidence. Such presumptive conditions, however, should be clearly identified as assumptions and given appropriate weight in the final analysis.

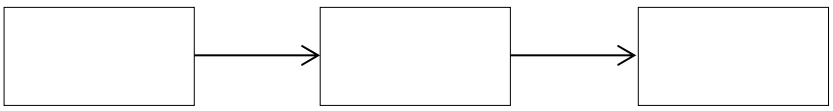
4.3.5.3 Explanation of symbols and conventions

	Guidelines
Events	Are actions, omissions or other happenings, e.g. 'crane strikes building'. Should be stated simply using one noun and one active verb. Should be quantified as much as possible and where applicable, e.g. 'the worker fell 6.3 metres' rather than 'the worker fell off the platform'. Should indicate the date and time of the event, when they are known.
Contributing factors	Describe conditions or circumstances that existed and possibly influenced or affected the event. These factors include risk controls that failed or were missing some of which could be safety issues, e.g. watchkeeper fatigued; insufficient manning; safe manning policy. Must be associated with the corresponding event.
Primary event sequence	Encompasses the main events of the accident and those that form the main line of the chart.
Secondary event sequence	In collisions or other complex cases a secondary event line helps depict clearly the events and how they related in time to each other.

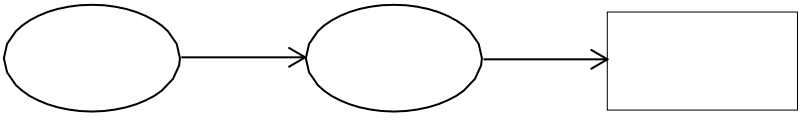
1. All events are enclosed in rectangles 

2. All contributing factors are enclosed in ovals 

3. All events are connected to the preceding and subsequent events by arrows.

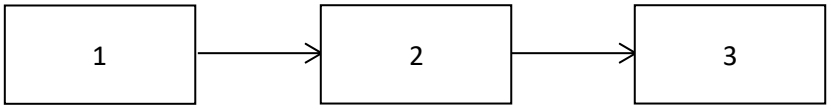


4. All contributing factors are connected to other contributing factors and/or events by arrows

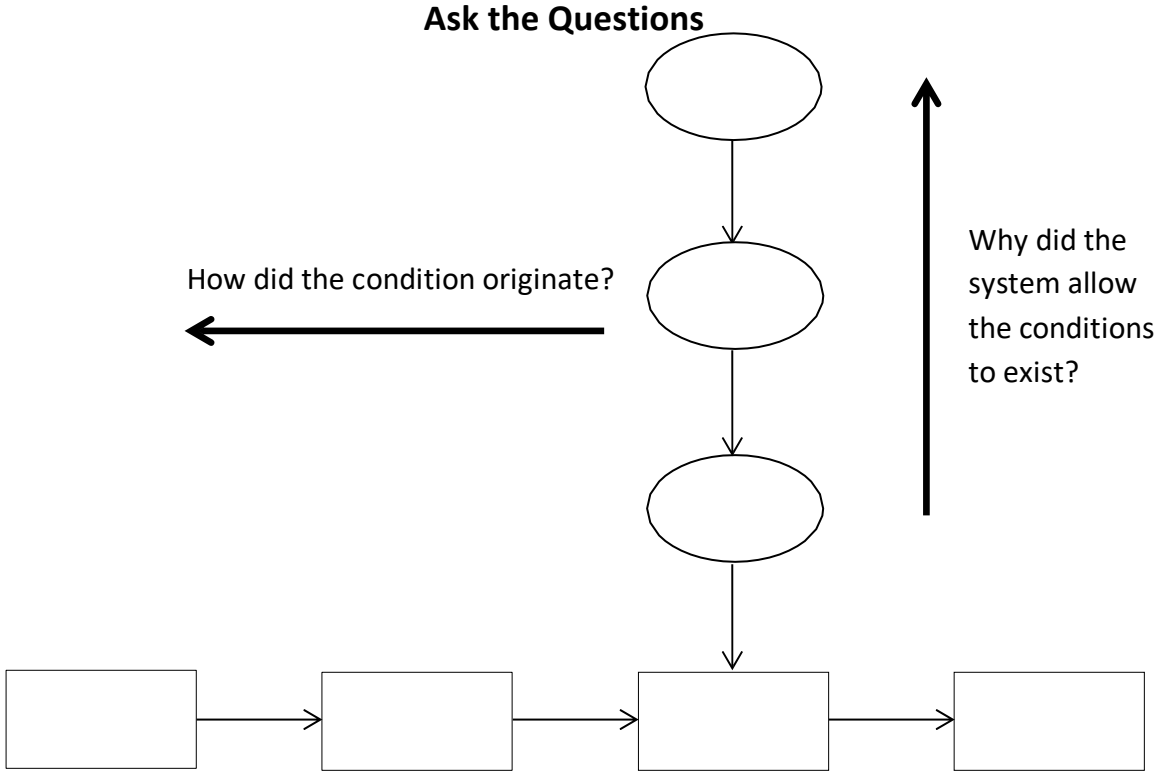


5. Presumptive events or contributing factors are shown by dashed rectangles or ovals.

6. 'Primary' sequences of events are depicted in a straight horizontal line with the relative time sequence from left to right.



7. Secondary event sequences, contributing factors and safety issues are depicted above or below the primary sequencing line. In evaluating events and contributing factors, ask simple questions:



The further removed from the event line that a contributory factor exists, the higher the level of management involved.

4.3.6 SAMPLE ANALYSIS CASE STUDY

The following series of figures represents the stages of an analysis based on the ATSB investigation into an occupational accident to a seaman on board MSC SONIA, which occurred in Melbourne Australia in 2007. The information used is taken from the relevant ATSB investigation report.

Note: These figures and the conclusions reached are for illustrative/educational purposes only. Some assumptions concerning the evidence have been made to facilitate this exercise, and the

analysis has been simplified. These results should not be taken to represent a true description of the events and contributing factors of the casualty. The ATSB report must be consulted for an accurate description of what happened and of the underlying reasons for the accident.

4.3.6.1 Case Study: MSC SONIA - ATSB report

(http://www.atsb.gov.au/publications/investigation_reports/2007/mair/mair239.aspx)

4.3.6.2 Summary of the casualty

NB: For the purpose of this case study some assumptions about the events that led up to the accident have been made.

At about 0945 (LT) on 10th April 2007, MSC SONIA's Boatswain(Bosun) and Ordinary Seaman (OS) were on the top platform of the funnel casing painting the starboard main engine exhaust pipe when steam unexpectedly exhausted from the nearby boiler safety valve vent pipe. The ordinary seaman was seriously burned by the steam. At the time of the accident a survey of the boiler installation was underway in the engine room with the Chief Engineer (C/E), Second Engineer (2/E), the Electrician and a classification society surveyor present. The Chief Officer (C/O), who gave the instructions for the painting work, the Bosun and OS were not aware that the boiler survey was taking place that morning. The engineer officers and the surveyor were not aware that work was being conducted on the funnel top.

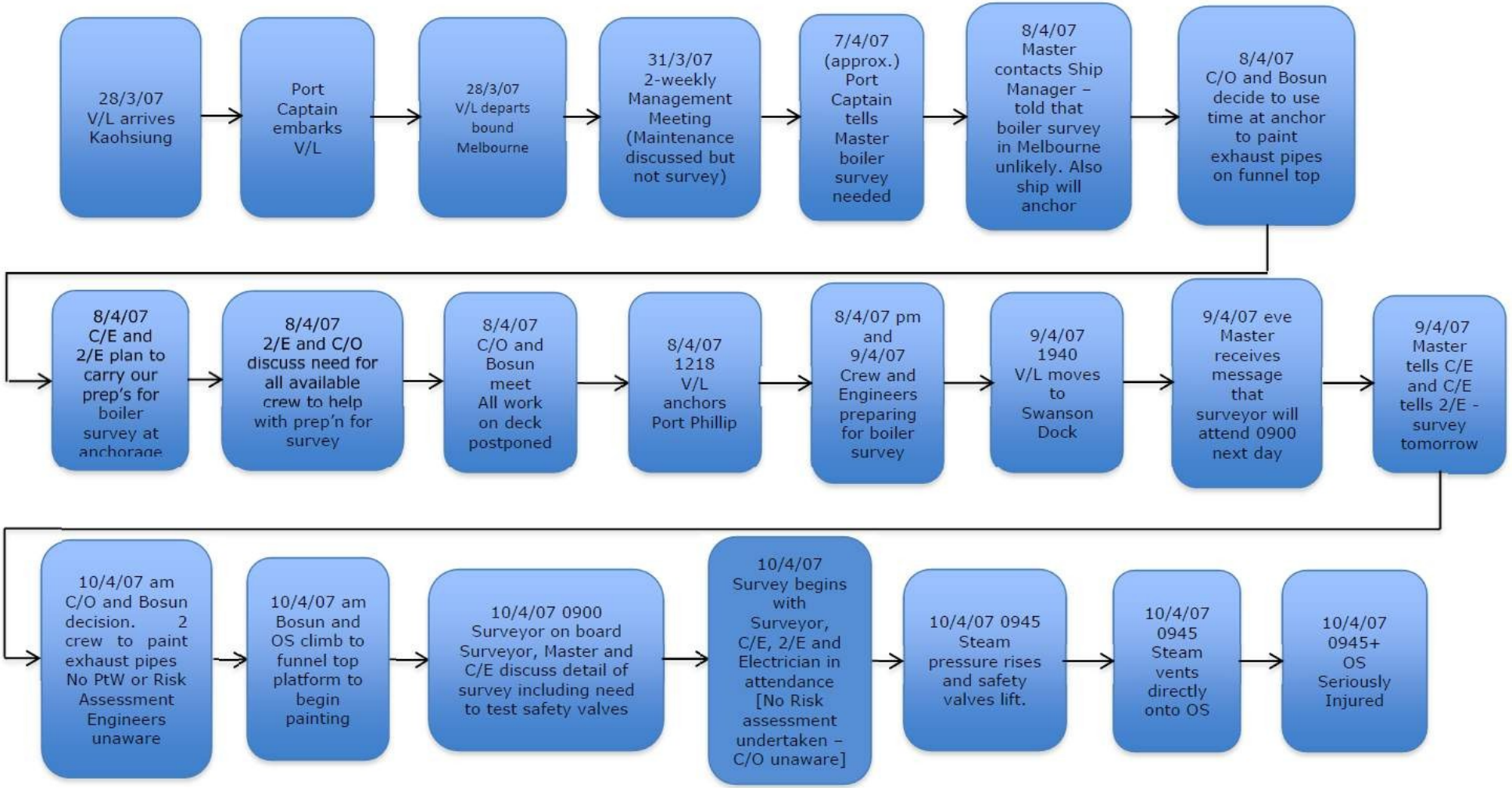
Information about upcoming work programmes was exchanged between the deck and engine departments during 2-weekly management meetings chaired by the Master, the last of which had taken place 10 days before the accident. At that meeting neither the boiler survey nor the painting work was raised and discussed (the need for the survey was communicated by the ship manager's 'port captain', who was traveling with the ship, about two days before arrival at Melbourne and the decision to paint the exhaust was taken opportunistically when it was discovered that the ship would be anchoring prior to berthing at Melbourne). In between management meetings interdepartmental discussion between the 2/E and the C/O concerning work programmes occurred only if extra personnel were required from the other department. Engine room work was discussed on a daily basis between the 2/E and the C/E and deck work was discussed between the C/O and the Master, also on a daily basis. The master and Chief Engineer also sometime discussed upcoming planned work in between management meetings on an ad hoc basis. The master was aware of the requirement to test the boiler safety valves and he was aware that the deck crew would be painting the starboard exhaust pipe at some time. He was not aware that they were intending to paint it on the morning of the survey.

Note: Although the above case contains interesting information about the post-accident response, for the purpose of this exercise, the events that followed the incident have not been considered.

4.3.6.3 Sequence of Events and Analysis Diagrams

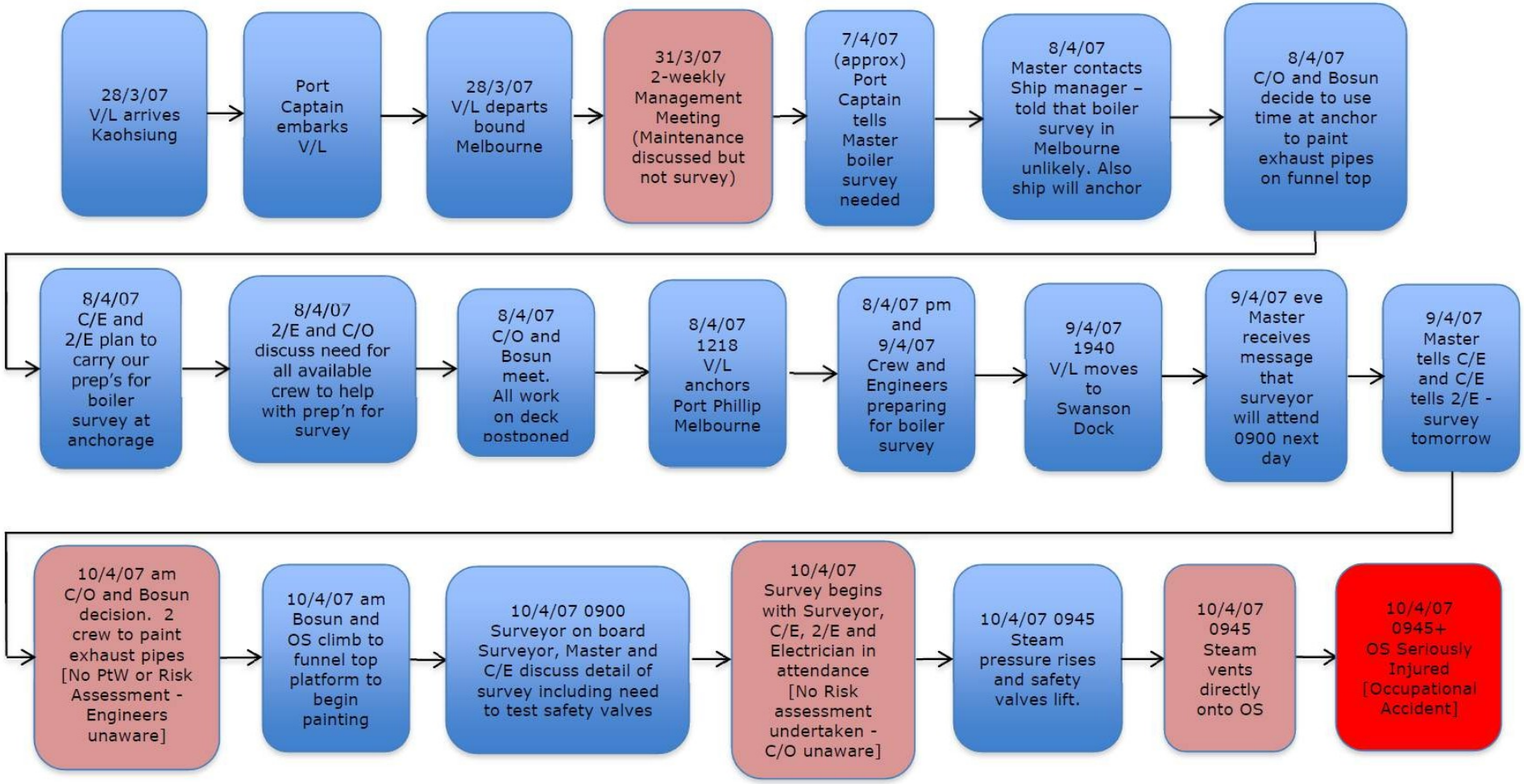
Pages 141 to 146 illustrate the various *Sequence of Events* and *Analysis* Diagrams used in this Case Study.

MSC Sonia - Case Study
Sequence of Events Diagram

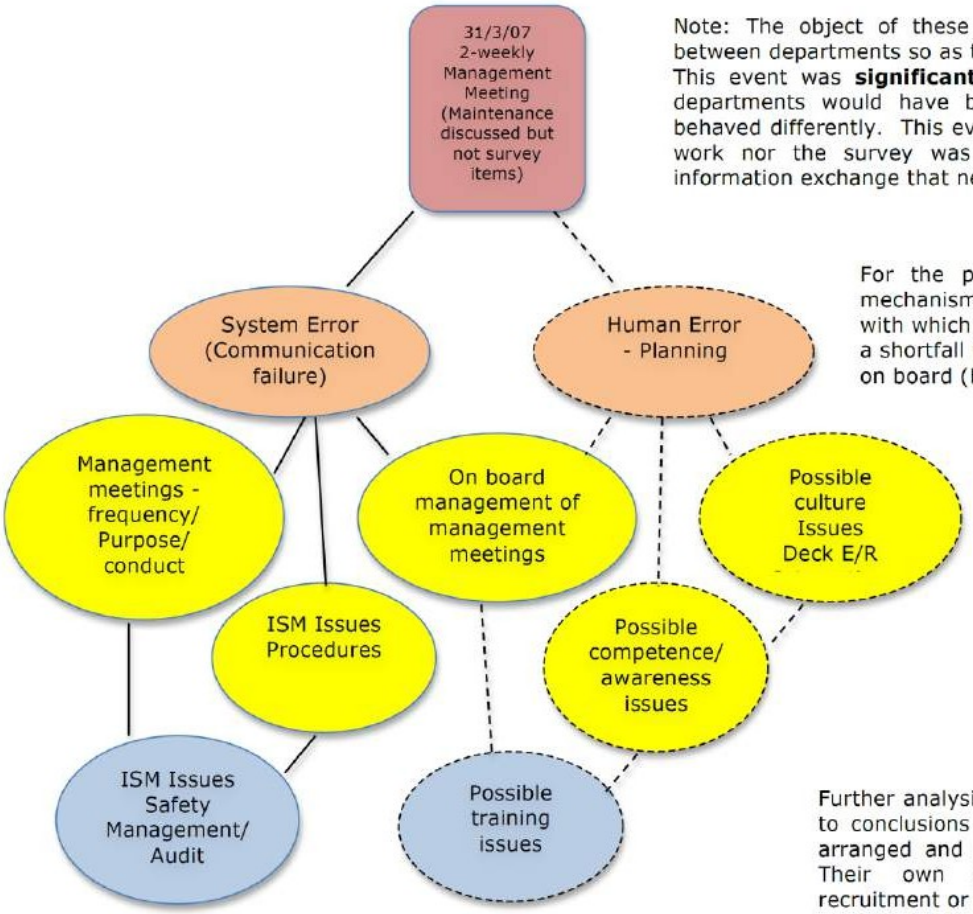


Establish Casualty and Accident Events

Note: To be classified as an Accident Event - event must be BOTH **significant** in the lead up to the casualty and **inappropriate** in the context of the circumstances at the time.



Analyse Accident Events 1



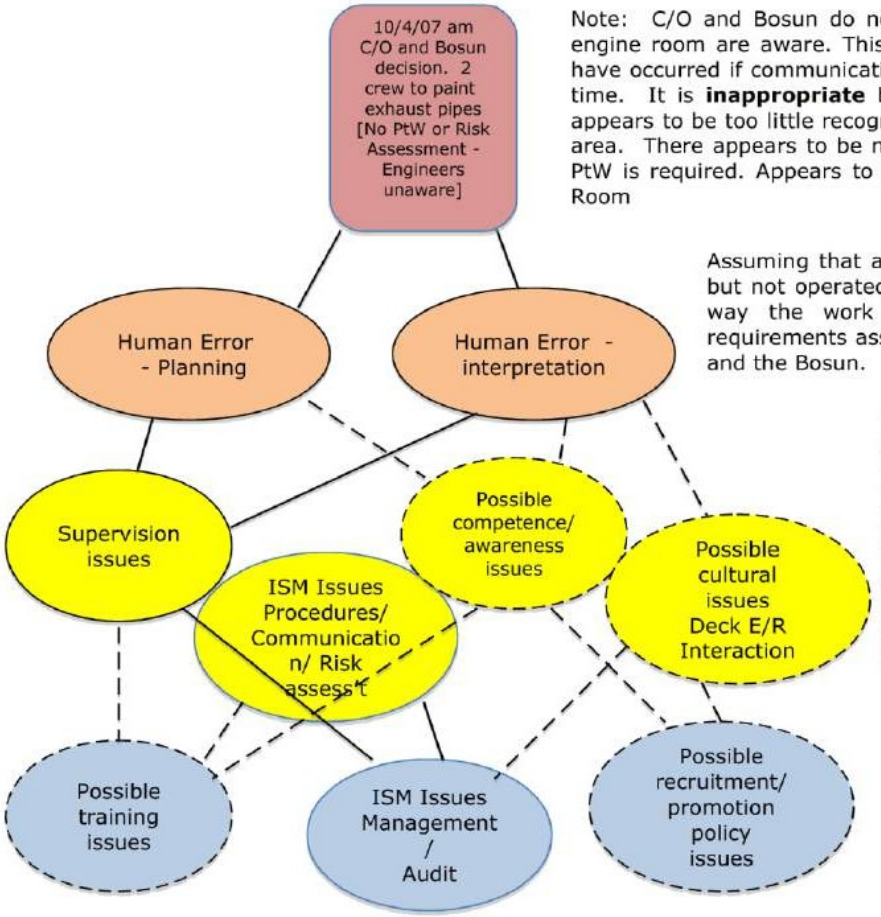
Note: The object of these Management Meetings was to aid communication between departments so as to avoid the circumstances of this accident.
This event was **significant** because, had the meeting achieved its aim both departments would have been aware of the others actions nd might have behaved differently. This event was **inappropriate** because neither the painting work nor the survey was discussed (indicating a relevant shortfall in the information exchange that needs analysing)

For the purpose of this exercise it is assumed that the mechanism for the shortfall was connected with the frequency with which the meetings were scheduled (System Error) and/or a shortfall in the way the requirement was interpreted by those on board (HE – Planning Error)

There are a number of possible operational reasons why management meetings (or shorter inter-departmental work programming meetings) were not held more frequently. This could be to do with interpretation of the ISM requirements, the way the meetings were run, the safety culture on board and/or possible competence issues. There also possible operational factors connected with the reasons why the boiler survey was not planned well in advance and why the painting job was not planned before the meeting

Further analysis of the operational factors will lead to conclusions about the way shore management arranged and audited the ISM system on board. Their own safety culture and/or possible recruitment or training issues

Analyse Accident Events 2

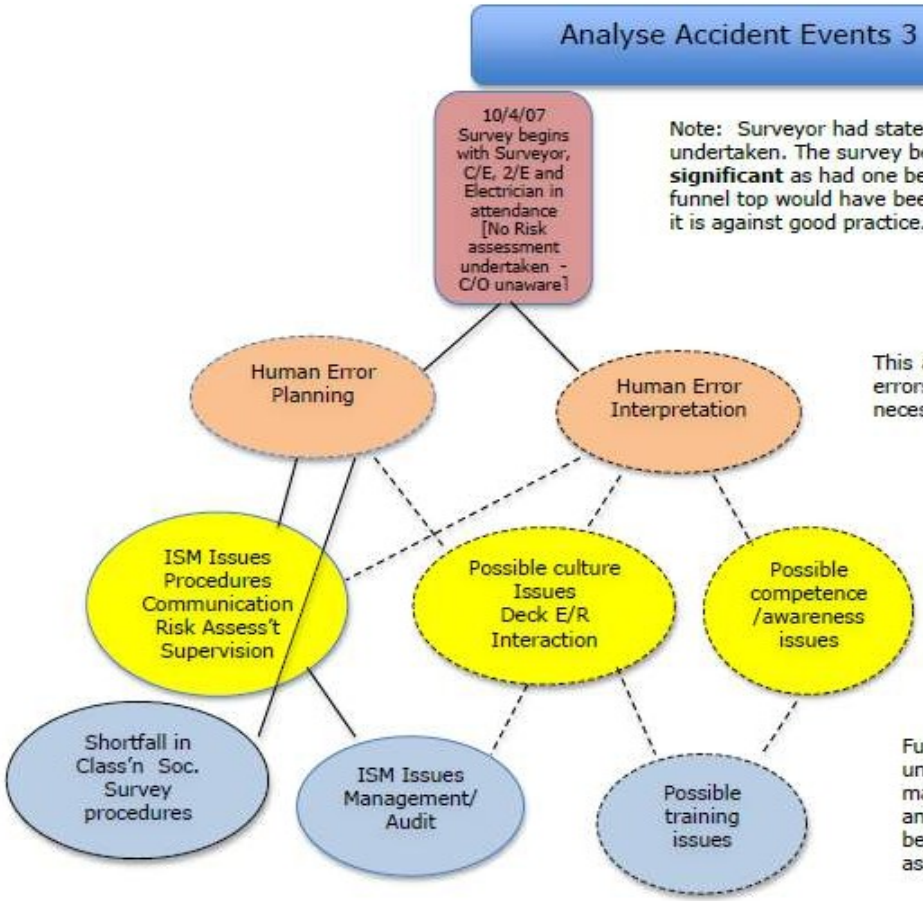


Note: C/O and Bosun do not discuss need for PtW or the need to ensure engine room are aware. This is **significant** because the casualty might not have occurred if communications and risk aware ness had been better at this time. It is **inappropriate** because it is contrary to good practice. There appears to be too little recognition that the Funnel Top might be a dangerous area. There appears to be no recognition that risk assessment is needed or PtW is required. Appears to be no recognition of need to liaise with Engine Room

Assuming that a PtW and Risk assessment system was in place but not operated this accident event was a human error in the way the work was planned and/or in the way that the requirements associated with safety were interpreted by the C/O and the Bosun.

A planning error might have occurred because of poor supervision on board or because the requirements were open to misinterpretation or, possibly, because of competence issues. An interpretation error for many of the same reasons or because of cultural problems between the personnel involved. NB These errors could also involve omissions due to fatigue or distraction (not covered in this exercise)– actual conclusions would need to be drawn from the evidence

The risk controls, which should have contained the shortfalls in operational practice, possibly include management of the ISM system, training, recruitment and promotion policies.



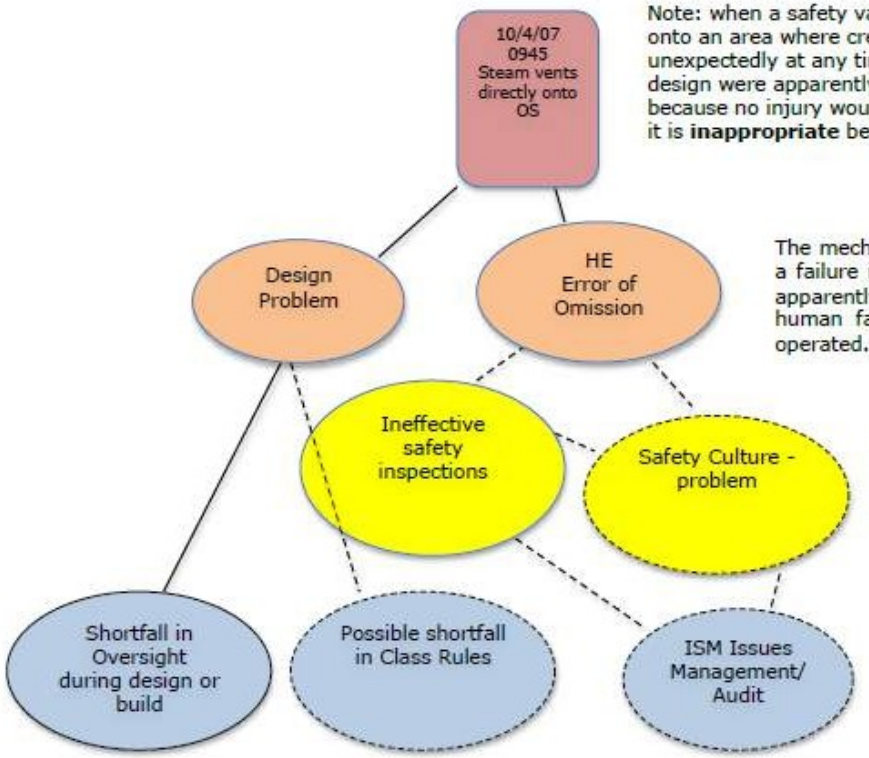
Note: Surveyor had stated need for Safety Valve test but no risk assessment undertaken. The survey beginning without any risk assessment was **significant** as had one been done it is likely that a check of the area on the funnel top would have been undertaken. It was also **inappropriate** because it is against good practice.

This accident event involves human error, possibly an errors of either planning or interpretation of the necessary/ required processes.

Analysis of the reasons why the human error occurred will uncover shortfalls on operational practice on board to do with communication, safety culture and possibly competence and training

Further analysis of the operational factors will uncover shortfalls in the way the safety of ship was managed possibly including problems with audit and/or training. The surveyor's role should also not be ignored – there were possible problems associated with procedures/instruction/training

Analyse Accident Events 4



Note: when a safety valve lifted dangerous gasses were vented directly onto an area where crew might be working. This could have occurred unexpectedly at any time in operation. The risks associated with this design were apparently not realised on board. This is **significant** because no injury would have occurred if this had not been the case and it is **inappropriate** because it is contrary to good design practice

The mechanism that allowed this accident event to occur was a failure in design. Additionally the fact that the crew were apparently unaware of the associated dangers indicates a human failure in the way the Safety Management System operated.

Routine area safety inspections are designed to pick up this type of problem. The fact that they had not indicates a possible shortfall in the way they were conducted which in turn might indicate a problem with the safety culture on board. i

Further analysis would indicates shortfalls with the risk controls designed to avoid an accident event like this. *e.g.* Plan approval and design during build, Class Rules and possibly issues with the ISM system and audit.

4.3.7 ANALYSIS PROCESS - DETERMINE THE SAFETY ISSUES AND SAFETY DEFICIENCIES

Before considering what safety issues (see definition in Section **4.2.2**, above) arise from the investigation, the investigator should ensure that his analysis is complete and that the process has been rigorous fair and unbiased. It is good to share the investigation findings at this and at earlier stages with other investigators (if this has not already been done).

By the time the team is ready to conduct a safety issue analysis they will have spent a great deal of time adding, removing, and rearranging events and contributory factors. In all likelihood, the chart will be lengthy and complex. Given the magnitude of data it is best to employ a strategy to identify the safety issues.

Start at the first accident event and its associated contributing factors/conditions. Consider the conditions in turn, asking:

- Is this factor associated with/linked to another factors in this analysis chain that may indicate a more general or larger deficiency?

- Is this contributory factor associated with/linked to another factors in another analysis chain that may indicate a more general or larger deficiency?

Other questions may arise to help identify the significance of the contributory factor. The team uses these questions to deductively determine linked factors and/or those of particular significance. The safety issues that are thus identified will be found towards the end of the analysis chain connected with failed or missing risk controls or organisational influences.

The steps in this process are repeated through the entire chart. As the most significant contributing factors are identified, they should be marked as safety issues.

For example, in two analysis chains deriving from two accident events, the contributing factors "poor communications on the bridge" and "Master overloaded" maybe associated to indicate a shortfall in Bridge Resource Management (BRM). In such a case, the investigator can write one safety issue concerning 'BRM', place it on the chart, and connect it with an arrow to the two analysis chains from which it was derived. Alternatively, the investigator can record the same safety issue twice, placing it above each of the analysis chains from which it was derived.

When the investigator has applied this methodology to each analysis chain on the chart it is likely that a number safety issues will have been discovered. Consideration of the significance of these will enable safety deficiencies (see definition in 2.1 above) to be identified from which will then form the basis for safety action and recommendations to improve safety and avoid similar accidents. For example, where a shortfall in Bridge Resource Management is identified as a safety issue and the lack of any training (a risk control) in the subject is identified the associated safety deficiency could be Bridge Resource Management Training.

4.3.7.2 Safety Deficiencies – Case Study MSC SONIA

Using this process it is possible to determine safety issues and deficiencies arising from the analysis into the serious injury that occurred to the Ordinary Seaman on board MSC SONIA. It is clear from the analysis that there are consistent question marks over the performance of the

safety management system on board and in particular the effectiveness of the system of 2-weekly management meetings.

A safety deficiency in this case might concern how the present ISM system deals with these meetings; a possible recommendation arising from this safety deficiency might be aimed at the ship managers to increase the frequency and effectiveness of the meetings. Other safety issues, to do with the interdepartmental communications for instance, can also be identified with the possibility of other safety deficiencies being identified leading to more safety actions/recommendations.

4.4 SAFETY RECOMMENDATIONS

A safety recommendation is a proposal from an investigation body, based on the information derived from an investigation, made with the intention of preventing future accidents or incidents. Safety recommendations should be addressed to the individual(s) or organisation(s) best placed to take remedial action. Their formulation may be achieved in cooperation and consultation with the relevant stakeholders since they are often well-placed to identify and implement appropriate safety actions. However, the final decision on the content and addressee of safety recommendations should rest with the lead investigation body.

Safety actions and safety recommendations should flow directly from the analysis. They should address safety issues and safety deficiencies identified in the investigation report and should be directed at those organisations or individuals best placed to take remedial action.

Where an identified safety issue is considered so serious that it should be addressed urgently, an interim safety recommendation should be issued, even though the investigation is still ongoing and the report has not yet been drafted.

4.4.1 DEVELOPMENT OF SAFETY RECOMMENDATIONS

To develop effective recommendations it is vital that the 'What?', 'How?' and 'Why?' of an accident or incident is understood so that the investigator can consider what can be done to stop it happening again.

Safety recommendations should be developed from the safety issues and safety deficiencies that have been identified during the analysis of the evidence. The safety deficiencies will, in turn, have been derived from shortcomings discovered in the risk controls (both preventative and recovery) and from discovering how organisations including regulators, the shipping company, equipment manufacturers and others, influenced the events leading up to the accident (shore management and organisational factors).

Usually, failings in a number of risk controls (those controls that, had they been in place and effective, would have prevented the accident or lessened the consequences) are identified and consequently safety deficiencies are derived from several areas of the analysis. However, because of this structured approach to the derivation of recommendations, the link between the recommendation and the events that were significant in the chain of events that led to the casualty (accident events) will be obvious; and can easily be portrayed on a diagram such as an Event and Contributing Factors Chart.

Recommendations must:

- Be stated clearly and concisely;
- Be based on facts/evidence and the derived safety deficiencies;
- Be a basis for safety action that will help to avoid, or limit the consequences of, future accidents;
- Be addressed to the individual or organisation that is best placed to implement the corrective action;
- Represent a balanced response to identified deficiency.

Recommendations must not only be well written, concise and clearly result from the investigation analysis in the investigation report, but also be supported by a convincing argument for taking action. The facts and the analysis in the report must lead logically to the recommendations presented. The recommendations should be specific enough to avoid any misunderstanding or opportunity for misinterpretation. They should not simply state: 'company X to improve their safety'.

Recommendations should concisely identify the specific risk to be addressed. However, investigators should be cautious about recommending specific solutions and the precise nature of the safety action that should be taken. It should be sufficient that the operator or authority, having been alerted to a specific risk, be permitted to determine the most cost-effective solution. In fact, they may find the risks preferable to the control measures. Often the recipients of recommendations have specific expertise that would enable them to arrive at alternative solutions. Investigation bodies must remember that recommendations are just that; they are not mandatory and therefore, the recipients must take full responsibility for the corrective measures and actions they take.

Investigators must not be deterred from addressing recommendations to government administrations recommending amendments or improvements to legislative provisions.

For any recommendation stemming from a maritime safety investigation to be accepted and implemented by its recipient, it needs also to be:

- Necessary;
- Likely to be effective;
- Practicable;
- Relevant;
- Targeted.

The recipient of any recommendation needs to be persuaded that the recommendation satisfies all the above. This persuasion is most effectively done by making the investigation and analysis thorough, rigorous and being able to demonstrate that this is so.

It is very important to involve and interact with likely recipients of recommendations to ensure:

- The recommendation does not come as a surprise;
- To assist in ensuring the recommendation is practical;
- Is targeted at the right recipient;
- That recipients gain 'ownership' and 'buy-in' to the recommendation; and
- Allows potential action to be initiated sooner rather than later.

In some circumstances, recommendations need not be confined specifically to the contributing factors to the accident, but they should be related to matters covered in the investigation; they must be practicable; and they must be reasonable. Recommended safety actions in whatever form should clearly identify what needs to be done, who or what organisation is to implement the change and, where possible, the urgency for completion. They must be balanced. The effort and cost of a safety measure must be weighed against the severity of the risk posed.

4.4.2 RECOMMENDATION CATEGORIES

Safety recommendations can be broadly considered to fall into three categories:

1. Those that have the broadest importance, sometimes global importance, possibly leading to new or changes in legislation.
2. Those addressed to industry bodies or organisations requiring the reinforcement of best practice.
3. Those that can be targeted at an individual organisation, company or owner that is specific to their ships or company.

Unsurprisingly, the first is the hardest and most difficult one to address while the last is the easiest and simplest problem to tackle. However, it is important that not all recommendations fall into the last category, as often there can be a deeper underlying issue that must be tackled with a more global recommendation.

In some cases, a safety investigation may result in no recommendations being made, as effective action is planned or has been taken. However, any safety actions taken or planned for the near future should be included in the investigation report, to ensure the reader understands why no safety recommendations are necessary.

4.4.3 EARLY COMMUNICATION OF SAFETY ISSUES

Where the investigation body considers that an identified safety issue is so serious and could readily happen again unless urgent action is taken then a recommended safety action should be issued to those that can best address the issue. This may include the marine safety administration of the Flag State who in turn may notify IMO of the issues so that early and urgent international action can be considered.

4.4.4 SAFETY STUDIES

Safety recommendations may also result from the analysis of a series or several accidents. The data analysis can either be presented to supported one particular safety investigation's recommendations or arise from a 'Safety Study' where a particular issue or accident trend is examined.

4.5 FOLLOW UP

The investigation bodies should endeavour to ascertain details of action taken in response to safety recommendations.

4.5.1 ACTION TAKEN

One of the key purposes of accident investigation is the creation of recommendations to prevent similar accidents from reoccurring. However, recommended 'safety actions' are only recommendations, they are not legally binding instructions.

Administrations should consider passing legislation to support a recommendations follow-up system and require recipients of recommendations to respond to the investigating body. This does not mean that any operator or organization must adopt the safety recommendation, but must provide cogent reasons why they have not adopted a recommended safety action or have addressed the problem in some other way. Legislation should provide a realistic time frame for a response from those to whom the recommended safety actions are addressed. Having a recommendations 'closed loop' system will ensure an investigation body has its recommendations listen to and not simply ignored.

Administrations should consider publishing a report each year on the outcome of their recommendations. This can be included as part of an investigation body's annual accident report, or separately. It allows transparency in the recommendations made and enables those recipients who have rejected recommendations to be highlighted with their reasons for rejection published. In this manner it still allows recipients of recommendations to reject a recommendation but they also will be aware that the consequence will be that their response will be published.

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5.1 INVESTIGATION REPORTS

The investigation body of the marine safety investigating state should produce a draft report in liaison with other Substantially Interested States. It should clearly present, in a consistent and concise style, the facts and analysis which are used to support the conclusions and recommendations.

5.1.1 REPORT WRITING

Many investigating teams have found the writing of the final report to be the most difficult part of the investigation, often requiring several iterations. Report quality is crucial, because the final report is the official record of the investigation and no matter how high the quality of the investigation the whole effort is lost if the final report fails to adequately communicate a clear set of facts, supporting evidence and firm conclusions supported by the facts and evidence. The lead investigator should:

- Develop a report outline as soon as possible and, if several authors are involved, should strive to ensure that there are no overlaps in assignments so that content is not duplicated.

- Begin drafting (in outline form) the accident chronology, background information andfacts as soon as possible.

- Continuously review the progress to identify where sections should be added or amalgamated.

- If supervising a team effort, pair strong and weak writers together to avoid delays and maintain quality.

- If necessary use a technical report writer to evaluate grammar, format, consistency, technical content and links between sections and facts so that the report ends up technically correct, clear, concise, logical and consistent in style and approach.

The intended readership of the report should be carefully considered. Writing a highly technical report assuming expert knowledge by the reader will be appropriate for only a few investigation reports. Equally, assuming that everything must be explained as if the reader knows nothing about maritime matters will not be sensible, especially given the length of report required to do so. A balance must therefore be struck. In an accident involving a passenger ship where many of the passengers will have been involved, greater description may be required in some areas. For an investigation into a machinery failure, then greater reader knowledge should be assumed for particularly technical areas. Highly technical details can be included in Appendices. The skill for the investigator concerned is summarising such technical descriptions into the salient points needed to appreciate the safety issues.

5.1.2 REPORT CONTENTS

A Marine Safety Investigation Report should contain information in accordance with section 2.12 of the CI Code.

5.1.3 REPORT TEMPLATE

The main sections to be included in any report should be:

- **Title page** – clearly identifying the nature, time, place of the casualty or incident and also identifying the investigating administration.

- **Preamble page**(s) - a list of contents, an abstract/summary, the legislative basis for the investigation, a foreword, acknowledgements, technical terms, (tabular details of the ship, e.g. name, flag State , IMO number, owners, class etc. can be included here or at the end of the report).

- **Factual Information** - outlining the particulars of the ship and its voyage, its crew, the circumstances of the casualty and the sequence or Narrative of Events which led to the casualty or incident. Ensure that all factual evidence which is needed to understand the analysis is included

- **Analysis** - identify the key (accident) events in the build up to the casualty and its aftermath. Clearly articulate the analysis process including how each of these accident events has been analysed to discover contributing factors and ultimately safety issues. Identify, where appropriate, the evidence that underpins the analysis. Clearly indicate how identified safety issues and deficiencies have been derived from a logical process. Details of laboratory tests or more involved analysis should be attached as an appendix to the report. Do not mention factual evidence in this section for the first time.

- **Conclusions** – identify the findings of the investigation - the contributing factors and safety issues

- **Recommended Safety Actions**

- **Appendices**

5.1.4 FOREWORD

The report should include a foreword explaining:

- The aim of the investigation report;

- That the report has not be written, in terms of content and style, with the intention of it being used in legal proceedings and should be inadmissible as evidence for such use where blame or liability is to be attributed;

- That the safety recommendations shall in no case create a presumption of liability or blame;

The investigation body's legal basis under which it functions can also be included for information.

The foreword is essential to prevent the report directly being used as evidence in judicial proceedings. Clearly, once the report is published, anybody can read the report, but the important aspect is that they must find their own supporting evidence and not rely on the safety investigation report. Careful consideration of the phrasing of the foreword is required to ensure national legislation respects and recognises the role of safety investigation.

5.1.5 FACTUAL INFORMATION

The narrative gives the reader an idea of the general circumstances of the accident by providing a factual description of what happened. In general it should only go as far back in time as is necessary to include all events directly related to the accident and should continue in chronological order.

Separate sub-sections covering each of the relevant actors should be considered. However, it is important that all information that is pertinent to the understanding of the circumstances surrounding the accident, including all significant events that had some bearing on the causes or on identified safety deficiencies are included.

The factual information section should also include all significant facts relevant to aspects of voyage planning, crew competence and experience, findings from autopsies and engineering reports, observations by witnesses and information from data loggers, voyage data recorders, radio recordings and transcripts. The names of people should not appear in the report. They should be identified by the positions they held on board or in the company, e.g. the master, the deckhand, the second engineer, the AB, the managing director. A person's age should only be included if it has any bearing on the accident.

Safety related activities which took place before the accident, as well as attempts, successful or unsuccessful, to deal with an identified safety deficiency, should also be included in this section of the report.

Safety deficiencies discovered during the investigation should be clearly substantiated. Information that is safety related, either in a negative or positive manner, should be included, and could lead to a finding, even if it is not pertinent to the causes and contributing factors of the accident.

Human factors information is an integral part of the investigation. In the same sense, consideration should be given to integrating human factors information in to the appropriate areas of the narrative, rather than being placed under separate human factors headings. When presenting human factors information, the investigator should adopt a style of language which is consistent with the rest of the report. Sensitive or confidential human factors information poses a particular challenge because public revelation of it could justifiably upset readers. If sensitive human factors information must be included it should be reported diplomatically.

The factual information section should not contain any analysis of "Why" the accident or incident occurred.

Long lists of regulations or extracts from codes of practice should be avoided; they are better placed in an annex, although pertinent short extracts can be more appropriate and effective.

5.1.6 ANALYSIS

The analysis section is the bridge between the factual information and the conclusions. The analysis should not introduce any new factual information nor only be a restatement of the facts. Arguments should follow the rules of logic, and conclusions should be supported by the facts.

A summary of the evidence sources is a useful way for the reader to understand the basis of analysis. Reference to testing, simulation or scientific/forensic analysis provides a clear basis for the analysis that follows.

The investigator must judge the relevance of the gathered information, and select the arrangement of the material in such a way as to present a clear explanation of why the accident happened.

A logical identification of the key events in the chain of events that led to the accident and a description of the arguments considered in analysing why and how those events occurred is the basis for this section of the report. The reader should be left in no doubt about the thoroughness of the investigation and that a logical process has been followed leading to relevant findings. All relevant evidence should be considered.

Evidence is relevant to the analysis if it will indicate a contributing factor or, if left out, will raise questions in the reader's mind about the completeness of the investigation. Gaps in factual information should be filled in by extrapolation from the available information, by making assumptions, by the use of logic (based on knowledge of operational factors, for instance) or by applying common sense. This does not mean that information can be invented; assumptions must be clearly identified as such.

Investigators should not shy away from findings based on conjecture, and indeed in many cases a report based purely on fact would be of little value; but speculation must be shown to be based on careful reasoning and the investigator must be confident that his argument can reasonably be sustained.

It is equally important to clarify what is not known and could not be determined (ambiguity) and to discuss and, if possible, resolve both controversial and contradictory evidence.

The report should address all relevant evidence which should be tested for 'existence', 'influence' and 'importance'. It is important that all potential issues are identified and where a specific piece of evidence is thought to be not relevant, the reason should be stated. In absence of these arguments there is a danger that the investigation will be considered shallow or worse, accused of sweeping important issues under the carpet.

Sometimes, meaningful conclusions will not be able to be reached from the analysis of the evidence. Some of the more likely hypotheses should be discussed, but there should be no hesitation about stating that the underlying reasons for the accident cannot be determined with certainty, if that is the case.

5.1.7 CONCLUSIONS

It must be remembered that this is often the part of the report which interested parties read first. The safety issues should flow directly from the analysis, and there should be no surprises for a reader who has read and understood it. The results of other technical investigations whether commissioned by the investigation body or not, as well as data/conclusions derived from other studies, can be presented in the narrative section. Conclusions are frequently based on interpretation and assessment of scientific evidence. Therefore, to ensure these are not taken out of context, or misinterpreted, the source for the conclusions should be clearly identified, and the conclusions should be quoted verbatim, if at all possible.

5.1.8 RECOMMENDED SAFETY ACTIONS

Recommendations need not be confined specifically to the contributing factors to the accident, but they should be related to matters covered in the investigation; they must be practicable, and they must be reasonable. They must be clearly derived from the analysis section of the report.

Recommended safety actions in whatever form should clearly identify what needs to be done, who or what organisation is to implement the change, and where possible, the urgency for completion.

Where no recommendations are made, consideration should be given to excluding the Recommendations section from the report. Any safety actions taken, under an appropriate heading, should prove sufficient for the reader to realise that enough action has been taken to warrant the making of recommendations unnecessary.

5.1.9 APPENDICES

An appendix may contain any information relevant to the investigation, for example, detailed stability assessment, regulations or extracts from codes of practice, copies of ship certificates, expert reports etc. Any non-confidential documentation which is considered to be essential to a sensible reading of the report, including photographs, moving images, charts, drawings etc. should be incorporated in to the actual report or as appendices. If any early alert has been published after the accident, it should be included as an appendix.

5.1.10 PHOTOGRAPHS

"A picture paints a thousand words". Photographs (with acknowledgements from external sources), charts and diagrams should be used where possible to aid special understanding of the matters under discussion.

5.2 TYPES OF REPORT

5.2.1 FULL REPORT

All very serious casualties will require the publication of a full investigation report, complying with the outline of the report template previously discussed. This report should be published within 12 months of the accident occurring, unless there is good reason otherwise. Where an

investigation body decides a case other than a very serious casualty warrants a full safety investigation report, it should be produced to the same standard and within the same timeframe as the very serious casualty reports.

5.2.2 INTERIM REPORT

Where it is not possible to publish an investigation report within 12 months of the accident date, investigation bodies may consider publishing an interim report, within 12 months, pending the final report publication that follows later. It is anticipated that this should only occur for particularly complex investigations or where delays outside of an investigation body's control are incurred. There is no standard template for an interim report but it should, as a minimum, provide some factual data about the casualty and the ship(s) involved, along with an estimated timeframe for the final report's publication where possible.

5.2.3 SIMPLIFIED REPORT

In cases other than very serious casualties, if the findings of a safety investigation do not have the potential to lead to the prevention of future accidents, a simplified report may be published. There is no standard template for a simplified report but it should follow the basic lines of the full report, including factual information and basic analysis leading to some conclusions.

5.2.4 PUBLICATION PROCEDURES

A draft of the report should be sent for comment, IN CONFIDENCE, to:

- Any person or organisation who could be affected by the report; or if that person is deceased, the person or persons best-placed to represent his/her interests;

- The investigation bodies of all of the other substantially interested States (CI Code Ch. 13, Ch. 14 and Ch. 25);

- Any other person or organisation likely to be involved in developing appropriate safety recommendations, if deemed necessary.

This consultation process provides an opportunity for the report's scope, factual accuracy and analytical logic to be checked and for comments to be provided. However, the accident investigation body is in no way bound by the comments received, although fair and thorough consideration of the issues raised should take place. Ultimately, it is up to the investigation body to provide their opinion in the report, which after all will not be agreed with by all parties involved.

Based on the comments received in the consultation process, further data may be collected and analysed as necessary, and the report amended accordingly. Following this the report must be published and should be freely available to all. Two to three days prior to the report being made public, it should be sent to the interested parties concerned and especially any next-of-kin. Consideration may also be given to provide a copy for the maritime Administration and/or national government department responsible for shipping.

A completed safety investigation report or simplified safety investigation report should be sent to the IMO in accordance with the requirements set out in MSC-MEPC 3/Circ.4.

5.2.4.1 Substantially Interested States

Provided that the other Substantially Interested States undertake not to make public any part of the draft report a draft of the report should be sent to the Substantially Interested State(s), in confidence, for comment. It may also be appropriate to provide a copy to the national maritime administration of the investigation body.

The marine safety investigating State should allow the Substantially Interested State(s) 30 days or some other mutually agreed time to submit their comments on the safety investigation report. The marine safety investigating State should consider the comments before preparing the final report and where the acceptance or rejection of the comments will have direct impact on the interests of the Substantially Interested State(s) that submitted them, then the lead safety investigating State should notify the Substantially Interested State(s) of the manner in which the comments were addressed.

If the marine safety investigating State receives no comments after the 30 days or the mutually agreed period has expired, then it may proceed to finalize the investigation report.

5.2.4.2 Other interested parties

Within the constraints of any applicable national legislation, a draft of the report, or parts thereof, should be sent to other interested parties, in confidence, for comment as appropriate.

The marine safety investigating State should allow the interested parties 30 days or some other mutually agreed time to submit their comments on the investigation report. The marine safety investigating State should consider the comments before preparing the final investigation report. Ideally, individual response to those who have provided comments should be provided to explain why amendments or indeed no changes have been made in light of their comments. In this manner, the investigation body will not be regarded as having ignored the input of others, but still retains the ability to publish what it believes is a true reflection of the accident and the surrounding circumstances.

Those parties closely involved with an accident, such as ship owners, key crew members, port owners, etc. will often seek advice from their legal advisors when commenting on the draft report. These parties are perfectly entitled to do this, but it must be made clear that the report is still confidential and must not be made public, widely distributed for comment or used for trial proceedings.

When reviewing the comments received accident investigation bodies should be aware of the likely legal reasons behind some of the proposed amendments and judge them accordingly. Safety investigation reports cannot be written to appear completely blameless, so do not feel obligated to amend the reports as suggested by all the legal representation likely to be involved, as otherwise the resulting report may not be able to conclude anything.

5.2.5 ELECTRONIC PUBLICATION

The Internet is a valuable tool for making investigation reports available to the public and the shipping industry. It is also important that users can easily access investigation reports and important lessons they want to find. Publication of investigation reports on a website can be more effective if it has a function to search and view them in a user-friendly manner, e.g. utilizing dropdowns and checkboxes to set search criteria, showing accident locations on a map to assist users find an area of interest etc.

5.3 OTHER PUBLICATIONS

5.3.1 EARLY ALERTS

Early communication of 'safety alerts' or 'safety bulletins' may contain recommendations that are deemed essential to prevent the reoccurrence of a similar accident. The safety alert should contain a brief account of the background of the incident and the safety issue highlighted. It should also include the fact that the safety investigation is ongoing and a published report will be produced within the appropriate time frames.

5.3.2 INVESTIGATION SUMMARIES/SAFETY FLYERS

Investigation reports by their very nature have to be thorough and can be a substantial document to read, for some audiences. Therefore, in some cases consideration should be given to producing an accident summary or 'safety flyer' which provides a brief account of the accident, highlights the safety issues and provides the salient conclusions and recommendations in no more than 2 sides of A4. This type of document can be particularly useful when trying to reach a particular element of the maritime community, for example the fishing industry or recreational craft users. As a published report will have been produced, the account need not be anonymous, as the summary will contain no more than is contained within the published report.

5.3.3 ANONYMITY IN SAFETY PUBLICATIONS

A safety article that omits references to a specific accident can emanate from a safety investigation, simplified investigation report, preliminary assessment, overseas accident reports, and from reports from any reputable authority including ports, shipping companies or ships' officers. The guiding theme is that there must be a useful lesson worth drawing to the attention of others. The style may be very different from a full published report, can be lighter and focussed on a few specific safety issues.

The anonymity extends to the ships' and peoples' names, and the exact date or place of the accident or incident. There is no limit as to how long or short they are but, in general, they should not exceed two pages. Ensuring anonymity also removes the need for consulting with interested parties, although warning them such an article may be drafted is polite and provides an opportunity to comment if deemed appropriate.

Such articles can be a very effective means of conveying safety messages to the seafarer and are often useful as material for seafarer training establishments.

5.4 ACCIDENT REVIEWS/ANNUAL REPORTS

Although not required by the CI Code, the production of an annual accident review or annual report by an investigation body can be a very useful document. It allows the maritime community and public in general to view accident statistics and to compare year or year accident trends and the consequences. A summary of the investigations started and publications issued during the year can also be included. It can allow overarching safety messages to be promulgated and provides a key document to raise the public awareness of a nation's marine accident investigation body.

It also provides a measure of the organisation's performance and can be used to justify resources and plan for the future. It can also provide a vehicle to document the responses to recommendations made by the accident investigation body and perhaps highlight those who may not be taking safety as seriously as they should. The annual report may be a requirement of national law or just a voluntary document but, if deemed necessary, sufficient resource should be allocated to its productions to ensure it is a document worth of the accident investigation authority.

5.5 RE-OPENING A SAFETY INVESTIGATION (CI CODE, CH. 26)

When significant new evidence is presented, following completion of an investigation, it should be fully assessed, or referred to the investigation body of the marine safety investigating State.

Where that evidence materially alters the determination of the circumstances under which the marine casualty or incident occurred, and may materially alter the conclusions and recommended safety actions, the re-opening of the safety investigation should be considered.

The original conclusions and recommendations can then be reviewed and the report amended to ensure the investigation report has provided a factually correct and fair assessment of the accident.

5.6 MARINE CASUALTY DATABASES

5.6.1 NATIONAL DATABASES

A number of national marine safety investigation bodies have developed their own databases for storing contributing factor information from the investigations they have undertaken. The data is then used to identify trends, to support safety studies and multi-accident analysis or to provide historical data to strengthen the justification for safety recommendations. Although access to this data is usually restricted, the investigation bodies are responsive to requests for information from other accident investigators and researchers. The databases also provide casualty statistics for publication in annual reports.

5.6.2 IMO'S GLOBAL INTEGRATED SHIPPING INFORMATION SYSTEM (GISIS)

GISIS is the IMO information database, within which is a number of separate modules. Most importantly, GISIS is the medium through which Administrations must report casualty information directly to the IMO secretariat. Other modules in GISIS of possible use to casualty investigators are *Recognised Organizations* and *Contact Points*. Other fields are *Maritime*

Security, *Condition Assessment Scheme*, *Port Reception Facilities*, *Pollution Prevention Equipment*, *Simulators* and *Greenhouse Gas Emissions*.

GISIS includes a Maritime Casualties and Incidents (MCI) module database, which includes data on Maritime Casualties and Incidents, as defined by circular MSC-MEPC.3/Circ.4. The GISIS module also includes all Casualty Analyses which were approved by the III Sub-Committee (Formerly FSI) for release to the public on the GISIS module, where they can be accessed. Some elements of GISIS can be accessed by members of the public and some data concerning ship casualties can be downloaded.

MSC-MEPC.3/Circ.4 - www.maiif.org/images/stories/PDF/conventions/MSC_MEPC_3_Circ_4 - requires casualty data to be supplied to the IMO Secretariat by electronic means.

Marine safety investigators should be aware of the detail contained in this circular; however, an extract of the most important information follows:

Following a very serious marine casualty, where data from a marine safety investigation is to be supplied to the Organization, the marine safety investigating State should submit a marine safety investigation report in addition to the data required in the appendices to this circular. Where there are important lessons to be learned from marine casualties or incidents other than very serious marine casualties, full investigation reports should also be submitted in addition to completing the database.

Investigating States are invited to populate the GISIS MCI module with basic factual data about the casualty as soon as possible after the occurrence. This will register on GISIS that a casualty event has occurred and that it is being investigated. At this early stage, investigating States should aim, as a minimum, at completing all the asterisked fields in appendices 1 and 2 and as much of the consequence data in appendix 3, as possible.

[Note: a very few fields are marked in the appropriate tables within GISIS on the IMO website]

The GISIS MCI module is divided into five appendices, as follows:

1. **Appendix 1** requires generic information: the marine safety investigating State, the number of ships involved, generic casualty data, external environmental data, actions taken following the marine casualties and/or marine incidents forming the overall occurrence, and safety recommendations made with the aim of preventing future marine casualties;

2. **Appendix 2** requires factual information relating to each ship involved in each marine casualty or marine incident: ship particulars, voyage data, casualty data and consequences;

3. **Appendix 3** requires casualty analysis data relating to each ship involved in each marine casualty or marine incident: accidental events and contributing factors;

4. **Appendix 4** requires supplementary information to be added in particular circumstances relating to each marine casualty or marine incident. These additional data requirements will be automatically prompted; and

5. **Appendix 5** provides field value option tables.

The IMO electronic database for Contact Points within GISIS allows investigators, and others, to search for Flag State contact points for PSC matters, Casualty investigation services and Ships' inspection services (including Secretariats of Memoranda of Understanding on Port State Control).

The Casualties section of the IMO website includes valuable information and documents on casualty, the guide on the process of reporting on marine casualties and incidents and reviewing the analysis of marine safety investigation reports submitted to IMO. There is also a very useful list of the IMO documents most relevant to marine safety investigations. (www.imo.org/OurWork/Safety/Implementation/Casualties/Pages/Default.aspx)