

Preventing Maritime Accidents by Effective Management of the Accident Investigative Process

Chengi Kuo, *University of Strathclyde*

ABSTRACT

The paper begins by considering the role of accident investigation and examines the basic difficulties before reviewing the methods adopted. Lessons learnt from major accidents are discussed and the concept of a management-based approach is described. The method of managing accident investigation is then outlined and its application illustrated. Main conclusions are it is useful to perform a risk assessment on the various stages of the accident investigation process and that attention should be given to education and training of those involved in key aspects of accident investigation.

Key words: *accident, investigation, safety, stability.*

1. INTRODUCTION

Maritime accidents, similar to accidents in other transport industries, will occur in spite of steps taken to reduce the number of accidents in relation to passenger-distance travelled. There are many reasons for this state of affairs and key ones include ships are operating in a very hostile environment, heavy marine traffic density at many locations and human factors which involve attitude, behaviour, qualifications and experience. To minimise accidents there is a need to adopt preventive methods.

These methods can range from installing advanced and sensitive instruments for early failure detection to providing education and training to the crew.

However, one key method is to learn from accidents and to devise workable solutions which can be introduced to design and operation of a ship. This factor is well recognised by regular examination in conferences on the subject, see for example the latest conference RINA (2006). The effectiveness in turn depends on the quality and quantity of accident investigation.

In practice, many organisations in various countries have designed accident report form to encourage reporting of accidents, examples include Nautical Institute's MARS (Marine Accident Report Scheme), MARS (2006), US Coast Guard (2004), Maritime New Zealand (2005).

The information sought varied from verbal descriptions of the incidents to selecting influencing factors from lists provided. There is a limited amount of information with respect to success rate and the extent of correlation between the data.

Analyses of published data suggest lessons are drawn from a very small percentage of the report accidents and these were the ones which have been investigated often involving fatalities.

For example, an analysis of accident statistics over the period 1998 to 2004 from UK Marine Accident Investigation Branch yielded the following results: There were 10,459 reported accidents and incidents and 245 were fully investigated, i.e. 2.3% of the total, see MAIB (2005) for a typical report.

Furthermore, of the 245 investigated

accidents, grounding/foundering, collision, capsizing and fire accounted for 21%, 15%, 8% and 7% respectively of the total or 51%. Clearly, in order to gain a better insight into the accident causing factors, for example in capsizing, there is a need to have more analysed information on the accidents.

To have more reported accidents investigated officially is one solution but resources constraints, both effort and time, would ensure that this solution is unlikely to have a major impact. To overcome this problem, there is a need to consider additional methods of acquired accident data and analysing them so that the findings can provide the trends to supplement the findings from investigated accidents.

This paper begins by considering the role of accident investigation before making a brief review of the methods used and lessons learnt from accident investigation. After classifying accidents by their significance, a method of managing accident investigations is outlined and its application illustrated via a ship stability example.

2. ROLE OF ACCIDENT INVESTIGATION

To understand the importance of accident investigation and to enhance its effectiveness in order to save life at sea, it is useful to have a good understanding what is meant by an accident and what is involved in an accident investigation.

Accident is usually associated with an event, incident or situation which involves some undesirable outcome such as personal injury, damage to property, harm to the environment or a combination of all three. Typical examples include crew falling overboard, collision between the ships and oil spillage after the ship is grounded.

The important point to note is that an

accident is not planned and occurs when the individual, or a group of people, is in the process of meeting an objective of an activity. Accident investigation can be defined as follows:

Performing a systematic gathering and analysis of factual information on an accident in order to establish the root causes, consequences and frequency of occurrence and to recommend methods for avoiding future recurrence.

This in turn implies that to avoid future recurrences, the investigation must try to acquire factual information, do analyses, establish relations and present usable tools. Likewise it is unhelpful for the investigation to apportion blame to individuals or to assign failure responsibilities to people. To achieve these points in a balanced way is a very challenging task. Very rarely are the factual data obtainable directly and bearing in mind humans are involved, the tasks become much more difficult. Furthermore, depending on the impact of the accident, the efforts needed can vary considerably.

3. THE BASIC DIFFICULTIES

To be effective in learning from marine accidents there is the need to perform the following tasks:

- To collect accident data from practice
- To investigate the causes
- To analyse the available information
- To correlate the findings in a meaningful manner
- To present the knowledge gained in usable form

Task (a) is being done by many organisations using report forms of various completeness, see for example the MARS (Marine Accident Report Scheme) of the Nautical Institute, MARS (2006), US Coast Guard (2004), and Maritime New Zealand

(2005).

Some shipping companies and ship management organisations have also linked accident data with their general reporting procedures as part of the quality management systems.

Task (b) requires expertise and resources and as a result only a small percentage of the reported accidents is investigated.

Task (c) presents a serious problem because the accident data are collected in different reporting forms with specific emphases and this in turn makes analysing difficult.

On the one extreme, the MARS approach attracts many responses from conscientious seafarers and by giving them freedom of expression many valuable insights can be obtained, but it is very difficult to correlate the information in a consistent manner.

On the other extreme, some organisations ask the crew or safety officer to return a 15 page reporting form, the casualties or witnesses are asked many questions by selecting answers from a very comprehensive list of accident causes. The analyses become effort intensive and rely on more specialised skills.

Following from Task (c), the job of correlating accident data from various sources becomes very difficult while presentation of the results faces the same challenge.

4. METHODS OF ACCIDENT INVESTIGATION

There are many methods of performing accident investigation and the key ones will now be considered briefly under the following headings:

4.1 Informal Investigation

This method is usually applied to investigating minor accidents where no one is seriously injured, property damage is small and is within the regulatory requirements. Such investigation usually involves recording the incident.

This type of investigation requires limited effort over a short period and can be carried out internally by the crew or staff of a shipping organisation and data collected would be useful. The main drawbacks of this method are that acquired information is not used as fully as it might be and the quality of the acquired data will depend on the persons doing the investigation.

4.2 Formal Investigation

In this case, accident has led to injuries to person, e.g. broken limbs, hospital treatments are required. The incident would be reported to the appropriate authority of the flag state. Since the injuries are not life threatening, so the investigation may involve external personnel but the actual investigation would take place locally to allow factual information to be examined.

The merits of this method are that the accident receives attention and findings are recorded formally. Since a significant number of accidents fall into this category, there is generally insufficient resources to investigate all the reported accidents and certainly not in too great a depth.

4.3 Public Inquiry

When an accident involving death of people, there would be public inquiries conducted formally by a committee with legal representations. When there are multiple deaths, the inquiries are thoroughly investigated.

Examples of major inquiries include the loss of Ro-Ro ferries, "The Herald of Free Enterprise", Dept of Transport (1987) and

"Estonia" (1997) and offshore semi submersible "Ocean Ranger" (1984) and "Alexander Kielland" (1981).

The findings of these inquiries generally led to significant changes in prescriptive regulations.

The merits of these inquiries are that the accident is examined in great detail and the findings can assist in preventing future recurrence via the recommendations.

The drawbacks are that there is the danger of "over focusing" on a specific failure which could lead to other accidents because different parameters are interacting adversely deriving from the changes.

Furthermore, these inquiries are time consuming and costly.

From these considerations, it is clear that fresh approaches are needed to supplement and ensure valuable accident data can be obtained from the first two types of accident investigations.

5. LESSONS FROM ACCIDENT INVESTIGATION

An examination of the reports of accidents involving fatalities it is possible to derive a number of valuable lessons and the key ones will now be considered under the following headings:

5.1 Acquiring Factual Information

To achieve an understanding of what actually happened in an accident will be difficult when information and witnesses are not available. Sometimes, even the persons involved in the accident may not be able to provide a true picture due to shock, personal belief and misinterpretation of the event. In many cases, the insight to the accident was

assembled forensically.

5.2 The Organisational Culture Adopted

In general, crew tend to follow the behaviour culture of the organisation which employ them. Depending on the choice selected it will influence the interpretation of the situation.

For example, if blame philosophy is in operation investigations are likely to obtain answers which would be different to those obtainable when a collaborative or "no blame" philosophy is in practice.

5.3 Extensive Effort Needed

All accident investigations require resources and major disasters involving multiple fatalities need lots of time and considerable effort.

For example, the capsizing of the semi submersible "Ocean Ranger" in Canada was investigated by a Royal Commission, Ocean Ranger (1984) and the loss of the "Herald of Free Enterprise" involved a Public Inquiry, Dept of Transport (1987).

Thus only a few accidents are investigated in such great depth. Because of the extensive nature of these inquiries, the recommendations often have very significant influence on the follow up prescriptive regulations.

5.4 Common Accident Causes

Although there are many marine accidents, the type is limited with grounding/foundering, collision, capsizing and fire dominating. The causes can also be restricted to the following: Technical, e.g. design fault; Operational, e.g. door maintenance or machinery; Management, e.g. incorrect decision; and Human Factors, e.g. making an error.

It will be noted that prevention would also be based on these methods.

For these reasons it would be useful to classify the accidents into different types and focus on gaining more accident data for those not involving fatalities.

6. CLASSIFICATION OF ACCIDENTS

The first question to ask is why the need to classify accidents. There are two reasons.

(a) By classifying accidents, it helps to prioritise effort and in the present case the accident investigation effort of the experts and specialists can be devoted to major accidents where deaths are involved.

(b) Once classification is done, it enables minor accidents to be investigated in a structured manner by ship's crew or others such as safety officers after appropriate training. In this way, more valuable accident data would be available to assist in accident prevention.

There are various possible methods of classifying accidents and the selected one has the following three categories:

(a) Minor accidents: These accidents have low consequences, e.g. cut hand, but high frequency of occurrence, e.g. once per week. Generally, the injuries are not serious and property damage insignificant and little impact on the environment. The risk level is therefore regarded as "tolerable". The responsibility can be given to the crew after training and using carefully designed accident report forms. These forms should be simple and unambiguous.

(b) Medium accidents: These accidents have higher consequences than minor ones e.g. broken limbs, serious damage to property, but the frequency of occurrence is lower, e.g. once per year. The risk level can again be regarded as "tolerable". The responsibility can again be given to the ship's crew or personnel such as

safety officer or manager to do the investigation. The accident reporting form would be similar to the one used for minor accidents.

(c) Major accidents: These accidents have catastrophic consequence, e.g. multiple deaths and/or ship lost, but the frequency of occurrence is very low or rare, e.g. once per 20 years. The risk level can be determined as "tolerable" provided the critical aspects are well controlled to ensure the risks are reduced.

The responsibility for accident investigation is by the appropriate organisation of the flag state, e.g. in the UK it is the Marine Accident Investigation Branch.

It will be noted that regardless of the type of accident, when accidents occur, immediate action may be necessary to make the situation safe and prevent further deterioration and injury. It may also be necessary to rescue injured person.

7. MANAGING ACCIDENT INVESTIGATIONS

For investigations concerning minor and medium accidents to be effective it needs to be managed and as mentioned earlier since it is something that is not absolute, a management system is needed. The approach adopted is the Generic Management System (GMS) for accident investigation. The application would be most appropriate for minor and medium accidents.

The basis of the approach is the GMS unit which is made up of two parts as follows:

- A Management System (MS)
- A Process Scheme (PS)

(a) Management system of the GMS unit

The basic steps can be stated as follows:

- Step 1: DEFINE Goal, performance criteria, etc.

- Step 2: ORGANISE Activities, resources, methods, planning
- Step 3: IMPLEMENT An accident investigation scheme
- Step 4: MEASURE Results, response against criteria
- Step 5: REVIEW Results, lessons learnt, recommendations

Usually the Steps 1 to 5 are located in a straight line but more effective if these steps, known as elements, are placed on a circuit so that improvement is continuous and iteration can also be introduced.

(b) Process Scheme of the GMS Unit

"Process Scheme" is the name given to the tasks to be implemented in order to ensure the objective can be met while using the outputs from the MS element ORGANISE. The contents of the scheme will depend on the situation under consideration. For the accident investigation scheme, the tasks would involve the following segments:

- Segment 1: Risk assessment
- Segment 2: Perform investigation

The arrangement in which the Management System is linked through the IMPLEMENT element to the Process Scheme of the GMS for accident investigation is illustrated in Figure 1.

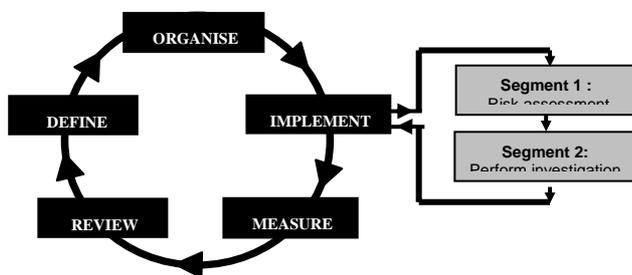


Figure 1 GMS for accident investigation

Further details of the approach can be found in Kuo (2004) and Kuo (2005) which considered the use of the approach to various

applications. The main components of the two segments are given below:

Segment 1: Risk assessment

The three components in this segment are:

- Component 1.1 Identify hurdles
- Component 1.2 Assess the risk levels of the hurdles.
- Component 1.3 Risk reduction.

Segment 2: Performing the investigation

The four components of this segment are as follows:

- Component 2.1 Gather factual data
- Component 2.2 Analyse the information.
- Component 2.3 Correlate findings.
- Component 2.4 Document the experience in usable form.

8. ILLUSTRATIVE EXAMPLE OF APPLICATION

(a) Background

The accident selected for illustrating the approach makes use of a published report of the capsizing and loss of a tanker, when no fatalities or serious injuries were involved, see MAIB (2006).

The trawler Bounty with two men on board was trawling when the fishing net became snagged against a fastener and while trying to extract the net from the snag, a large wave came over the deck.

As the freeboard was low and the freeing port openings were small, it led to the vessel becoming unstable and capsized before sinking.

Luckily both skipper and crewman jumped into the water and although not wearing lifejackets, the life raft emerged from the ship and they were able to climb on board until they were rescued.

(b) The aim of the illustration

The main aim of the illustration is to show that in similar accidents or ones with lesser outcome, it is possible to obtain valuable accident data that would be helpful to the analysis and contribute to minimising accidents.

(c) Presentation of the information

Using Figures 2, 3 and 4 it is possible to obtain a significant amount of the accident information from the witnesses, i.e. the skipper and the crewman. This method of acquiring data is valuable because only a small number of reported accidents are investigated in such detail.

9. DISCUSSION

This paper has examined several aspects of accident investigation and it is useful to discuss briefly a number of issues.

(a) Methods of minimise accidents

Accidents have a special characteristic in that they are caused directly and indirectly by humans and it is humans who can prevent accidents as well. In a marine context, it is the naval architects who design ships and the mariners who operate them. It is important to make the findings of accident investigation available from mariners to the naval architects. In addition to the reports published after major disasters, it is very valuable to provide accident information from minor accidents or where there is no fatalities to the designers and other stakeholders as a method improving awareness continually improve operational procedures and design out human error prone situations.

(b) The contribution of education and training

The crew can play a role in investigating accidents and for them to be efficient and

effective at acquiring accident data, education and training can make a valuable contribution. Education can help to explain the importance of accident investigation for enhancing ship safety and assist in developing a positive safety culture.

The latter can ensure greater awareness of having factual information from accidents. Training will help crew to acquire skills in performing accident investigation for minor accidents when no fatalities are involved. Training can take many forms ranging from an instructor lecturing how the investigation should be done to practical demonstrations.

A useful method which can supplement the existing form is to prepare CDs for accident investigation that combine texts, photos, procedures and animation so that the crew can learn the skills at their own pace.

(c) Usefulness of non-fatal accident data

Less attention is paid to accidents involving no injuries but accident ratio studies from many sources have shown that a major accident involving multiple fatalities is at the top of a pyramid of accidents.

For example, the UK Health and Safety Executive shows that for every major accident, there are 7 minor accidents with injuries and 189 non injury accidents. Better understanding of non injury accidents and overcoming the hurdles in accident investigation process are important.

Risk assessment of the process showed that of the 30 hurdles identified 2 had intolerable, 19 had tolerable and 9 had negligible risk. The two hurdles with intolerable risks were absence of witnesses to accident and a lack of awareness on the relative importance of accident data. The latter risk can be reduced with training.

1 Ship Data

- 1.1 Ship's Name: Bounty
1.2 Ship's Owner: David Wilson Flag State: UK
1.3 Ship Type: Stern Trawler Displacement (Tonnes) 20
1.4 Ship Dimension (m): Length 9.8 Beam Draft

Figure (2)

2 Data relating to Accident

2.1 Date and time of accident:

Date: 23-5-2005 Time: 9.30

2.2 Location :

About 4 miles south of Berry Head, Devon, England

2.3 Activity or Voyage:

Fishing

2.4 Environmental condition in sea states

1-2 2-3 3-4 4-5 Above 5

2.5 Ship's speed

Stationary 0-1 1-5 5-10 Above 10 knots

2.6 Type of accident:

Collision Fire Foundering
 Grounding Stability Weather
 Other (Please specify _____)

2.7 Give THREE important features leading to the accident

Feature 1: Nets snagged against a fastner and while trying to extract the net, the deck was overwhelmed by a large wave

Feature 2: Trawler capsizing to port, skipper and crewman jumped overboard.

The vessel slowly sank

Feature 3: The life raft emerged from the sinking ship. The skipper and crewman were able to climb onto it until they were rescued

2.8 Which factors made most significant contribution to the accident

Poor Judgement Extreme Weather Communication Failure
 Crew Fatigue Wrong Decision Inappropriate Procedure
 Equipment Failure Human Error Inadequate training
 Other (Please specify _____)

2.9 Summarised Accident Damage :

Loss of the ship

2.10 Additional observation and comments:

Carrying of life raft (not a mandatory requirement) saved the livs of the crew

Figure (3)

3 Highlight of Lessons Learnt and Suggestions

3.1 One operational related suggestion to improve the following aspect:

Working Procedure Training Knowledge
 Other (Please specify) _____

Brief suggestion: It is useful to understand the effects of snagging and train the crew to extract nets from the situation in likely difficult environmental conditions. Devise an appropriate procedure for use as this is a regular occurrence.

3.2 One key equipment related suggestion to improve the following aspect

Maintenance Design Usage
 Other (Please specify) _____

Brief suggestion: It is very valuable to understand the roles of freeboard and freeing ports so as to ensure the correct dimensions are met

3.3 One key human factors related suggestion to improve the following aspect

Error Attitude Reaction
 Other (Please specify) _____

Brief suggestion: It is very valuable to carry life raft even though this is not a mandatory requirement. This is particularly relevant to small ships.

3.4 One key management related suggestion to improve the following aspect

Preparation Culture Safety awareness
 Other (Please specify) _____

Brief suggestion: Be aware of safety implications for those working on small craft. Location of centre of gravity is very important. Inadequate stability or freeboard is a main cause of small vessel losses. From a personal point of view, self-inflating lifejacket should be worn at all times.

Figure (4)

10. CONCLUSIONS

Based on the work outlined, the following conclusions can be drawn.

(a) To be effective in accident investigation, the process has to be managed using a methodology such as GMS for accident investigation and it is useful to perform a risk assessment on the various stages of the process so as to ensure proper attention is focused on the most significant hurdles.

(b) There is a need to make more effective use of information obtained from all forms of maritime accident investigations in addition to those derived formally involving fatalities and the non-injury accident data should also be gathered systematically, analysed by a range of methods and presented in user friendly relations.

(c) More ship's crew or safety officers can contribute in accident investigations which do not involve serious injuries or fatalities and education and training can play important roles.

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