



GUIDANCE NOTES ON

THE INVESTIGATION OF MARINE INCIDENTS

JUNE 2005 (Updated 1 February 2014 – see next page)

**American Bureau of Shipping
Incorporated by Act of Legislature of
the State of New York 1862**

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ABS Plaza
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Houston, TX 77060 USA**

Updates

February 2014 consolidation includes:

- June 2005 version plus Corrigenda/Editorials

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Foreword

The marine industry experiences incidents that range from major accidents to near misses. These incidents should be investigated since many flag administration regulations require it; international agreements mandate it (such as the IMO “International Safety Management Code”); and industry initiatives encourage it. Incident investigation is a process that is designed to help organizations learn from past performance and develop strategies to improve safety.

The ABS Marine Root Cause Analysis Technique (MaRCAT) provides an effective and efficient approach for investigating marine incidents of any magnitude. ABS developed the MaRCAT methodology by customizing and combining the best techniques available and by proving and improving the overall approach through MaRCAT’s application during numerous investigations. The ABS MaRCAT approach to incident investigation caters to the unique needs of the marine industry, including human element; machinery and engineering; structural and security concerns. The objectives of the ABS MaRCAT approach are as follows:

- Provide ABS clients with a technique that will guide incident investigators in the conduct of root cause analyses and in identifying, documenting and trending the causes of accidents and near misses.
- Assist clients with the investigation of a variety of types (e.g., groundings, collisions, fires, etc.) and sizes of incidents (minor to major, including near misses) related to their vessels and facilities (ashore and at sea).
- Allow analysis of losses whether they are related to safety, the environment, human element concerns, security, reliability, quality or business losses.
- Support Class-related activities such as ABS Safety, Quality and Environment (SQE) notation, as well as the International Safety Management Code (ISM Code) and the International Ship and Port Facility Security (ISPS) Code.
- Provide a technique that is sufficiently flexible to allow customization to a client’s own management system, Health, Safety and Environment (HSE) programs or related initiatives.

These Guidance Notes provide instructions for the performance of incident investigation activities, including:

- Incident Investigation Initiation
- Data Gathering
- Data Analysis
- Root Cause Determination
- Generating Recommendations
- Reporting and Trending of Incident Investigation Results

The ABS *Guidance Notes on the Investigation of Marine Incidents* provide a structured approach to the investigation of incidents and near-miss events. The information contained can also assist with identifying and documenting root causes as required by the ISM Code. These Guidance Notes describe an incident investigation methodology that was expressly developed for the maritime industry, and so it reflects those elements of maritime operations and incident causation particular to the industry.

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GUIDANCE NOTES ON THE INVESTIGATION OF MARINE INCIDENTS

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SECTION 1 Introduction

1 Background

The marine industry experiences incidents that range from major accidents to near misses. These incidents should be investigated since many flag administration regulations require it; international agreements mandate it (such as the IMO “International Safety Management Code”) and industry initiatives encourage it. Incident investigation is a process that is designed to help organizations learn from past performance and develop strategies to improve safety.

The American Bureau of Shipping’s (ABS’s) MaRCAT™ (Marine Root Cause Analysis Technique) marine incident investigation methodology presented in these Guidance Notes is designed for use in investigating and categorizing the underlying causes of incidents, including accidents and near misses, with safety, health, environmental, quality, reliability, production and financial impacts. Although the examples used within these Guidance Notes are predominantly those having safety and health impacts, the term “incident” is used to generically identify situations that have any one or more of these types of consequences.

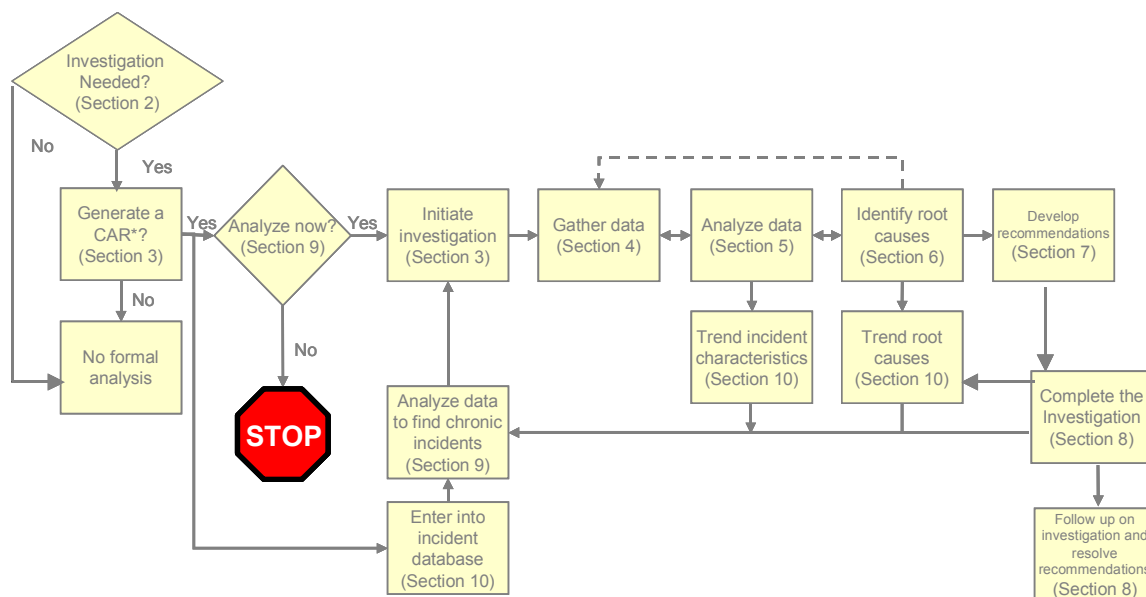
MaRCAT provides an effective and efficient approach for investigating marine incidents of any magnitude. ABS developed the MaRCAT methodology by customizing and combining the best techniques available and by proving and improving the overall approach through MaRCAT’s application during numerous investigations. ABS’s MaRCAT approach to incident investigation caters to the unique needs of the marine industry, including human element, machinery and engineering, structural and security concerns. The objectives of the ABS MaRCAT approach are as follows:

- Provide ABS Clients with a technique that will guide incident investigators in the conduct of root cause analyses and in identifying, documenting and trending the causes of accidents and near misses.
- Assist clients with the investigation of a variety of types (e.g., groundings, collisions, fires, etc.) and sizes of incidents (minor to major, including near misses) related to their vessels and facilities (ashore and at sea).
- Allow analysis of losses whether they are related to safety, the environment, human element concerns, security, reliability, quality or business losses.
- Support Class-related activities such as ABS Safety, Quality and Environment (SQE) notation, as well as the International Safety Management Code (ISM Code) and the International Ship and Port Facility Security (ISPS) Code.
- Provide a technique that is sufficiently flexible to allow customization to a client’s own management system, Health, Safety and Environment (HSE) programs or related initiatives.

2 The ABS Incident Investigation Model: MaRCAT

The ABS Incident Investigation Model (See Section 1, Figure 1, “ABS Incident Investigation Model”) encapsulates a process for conducting investigations following losses whether they are related to people, structures, machinery, equipment, outfitting or other factors.

FIGURE 1
ABS Incident Investigation Model



Note: CAR is an acronym for Corrective Action Request

3 Scope of the Guidance Notes

The focus of these Guidance Notes is on the application of structured analysis techniques, including the use of ABS's *Marine Root Cause Analysis Map*, to the incident investigation process. There are two levels of analyses that can be used as part of the incident investigation process: apparent cause analyses (ACAs) and root cause analyses (RCAs). Root cause analyses involve a deeper level of analysis than apparent cause analyses. The sections in these Guidance Notes generally apply to both levels of analyses. For example, data gathering is performed for both apparent cause analyses and root cause analyses. However, more effort is usually required to gather data for a root cause analysis than for an apparent cause analysis. This is usually true for most analysis activities.

These Guidance Notes provide instructions for the performance of incident investigation activities, including:

- *Incident Investigation Initiation.* How to determine if an incident has occurred, then how to classify and categorize the incident, and how to decide whether to conduct an in-depth investigation.
- *Data Gathering.* How to collect data related to people, processes, procedures, documents, position of the vessel and physical evidence associated with an incident.

- *Data Analysis.* How to analyze incidents to determine causal factors using tools such as causal factor charts, fault trees and the 5-Whys technique. Guidance is also provided regarding the identification of root causes, using the *ABS Marine Root Cause Analysis Map*.
- *Generating Recommendations.* How to document causal factors and root causes identified during an analysis, including how to identify what changes may be needed to enhance management systems and reduce risks.
- *Reporting and Trending.* How to archive findings and recommendations to allow review and trending of incident patterns after some period of MaRCAT use.

4 Contents of the Guidance Notes

These Guidance Notes focus on ten aspects of incident investigation. These Guidance Notes also discuss the process for setting up an incident investigation program. The Guidance Notes Sections are:

- *Section 2, Basics of Incident Investigation* presents a basic overview of the MaRCAT (e.g., Marine Root Causes Analysis Technique) investigation process. It describes the reasons why an organization should perform investigations.
- *Section 3, Initiating Investigations* describes the steps the organization must perform before the actual investigation is begun, such as setting up processes for incident classification and team selection.
- *Section 4, Gathering and Preserving Data* provides guidance for gathering and preserving the different types of data that are usually collected as part of an investigation.
- *Section 5, Analyzing Data* discusses three different methods (fault tree analysis, 5-Whys analysis and causal factor charting) for analyzing the data that have been collected.
- *Section 6, Identifying Root Causes* describes the use of ABS's *Marine Root Cause Analysis Map* to assist in the identification of the underlying causes of incidents.
- *Section 7, Developing Recommendations* explains the different types of recommendations that should be developed to ensure that the highest return is obtained from the analysis.
- *Section 8, Completing the Investigation* describes the activities that should be performed to complete an investigation.
- *Section 9, Selecting Incidents for Analysis* provides guidance on selecting appropriate incidents for analysis
- *Section 10, Results Trending*, explains the factors that should be considered when setting up an incident investigation trending program. Trending will allow an organization to look across all the investigations that have been performed and see if common factors are related to different incidents.
- *Section 11, Developing Incident Investigation Programs* describes the process of setting up the overall investigation program.

Additional information that can help the reader to use the MaRCAT approach is provided in the following Appendices. The Appendices include:

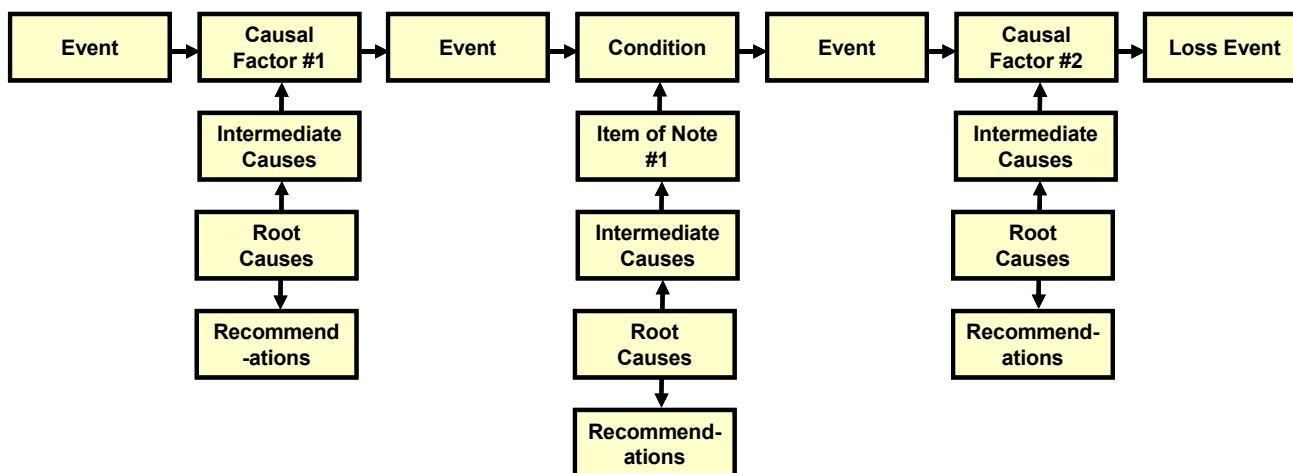
- *Appendix 1, Marine Root Cause Analysis Map Guidance* describes each segment of the Marine Root Cause Analysis Map and presents detailed descriptions of the individual items or nodes on the map. The ABS Marine Root Cause Analysis Map itself is included as an insert at the back of these Guidance Notes.

- *Appendix 2, Fault Tree Details* provides in-depth information about the use, development and construction of fault trees. Some example fault trees are also included. This Appendix supplements information provided in Section 5, “Analyzing Data”.
- *Appendix 3, Causal Factor Charting Details* provides in-depth information about the use, development and construction of causal factor charts. Some example causal factor charts are also included. This Appendix supplements information provided in Section 5, “Analyzing Data”.
- *Appendix 4, Marine Organizations of Interest* provides listings of marine organizations (and website addresses) that may provide additional information to those interested in learning more about incident investigation.
- *Appendix 5, Acronyms and Abbreviations* defines those used in these Guidance Notes.
- *Appendix 6, Glossary* provides definitions and notes on terms used within these Guidance Notes.
- *Appendix 7, MaRCAT Toolkit* provides summary guidance and resources such as checklists and forms that can be used to document incident investigation activities. This same material can be obtained electronically from the ABS website at “<http://www.eagle.org/rules/downloads.html>” under the publication entitled “*ABS Guidance Notes on the Investigation of Marine Incidents*”.
- *Appendix 8, Cross References between ABS Root Cause Analysis Map and Industry Standards* provides a cross-reference between the *ABS Root Cause Analysis Map* and industry standards such as ISM, ISO documents API RPTS and OCIMF TMSA.

5 Terminology

The same terms, relating to incident investigations, are often used differently by different investigators, different organizations or sometimes within the same organization. For the purpose of clarity, a listing of terminology complete with definitions and notes is provided so that the user of these Guidance Notes can better understand the information within the context in which it was created. Section 1, Figure 2, “Relationship of Incident Investigation Terms,” is provided to show the interrelationship of the various terms defined here.

FIGURE 2
Relationship of Incident Investigation Terms



5.1 Incident

An unplanned sequence of events and/or conditions that results in, or could have reasonably resulted in, a loss event.

Notes:

- This definition includes both accidents and near misses (defined below).
- Incidents are a series of events or conditions that contain a number of structural/machinery/equipment/outfitting problems, human errors, external factors as well as positive actions and conditions.
- An incident can be depicted using a timeline that includes the events and conditions that occurred during the incident. However, it also includes information about the context in which the events and conditions were performed.

5.2 Consequences

Undesirable or unexpected outcomes may result in negative effects for an organization. These consequences can range from minor injuries to major events involving loss of life, extensive property loss, environmental damage, and breaches related to security.

Notes:

- Negative effects can include property damage or loss, personnel injury or illness, spills, loss of marine commerce, loss of reputation, etc. Consequences can be of different magnitudes. For example, grounding can result in no damage to the vessel and just a short delay in completing the voyage. Another grounding can result in hull damage and a large release of cargo. The same level of effort may be put into investigating these two incidents, the first based on the potential consequences (a near miss) and the second based on the actual consequences (an accident).
- The consequences and potential consequences of the incident should determine the level of effort to invest in the analysis.

5.3 Loss Event

Undesirable consequences resulting from events or conditions or a combination of these.

Notes:

- Loss events will appear as statements within fault trees, 5-Why trees or causal factor charts. They are developed by the investigator/investigation team to define the scope of the investigation or analysis.
- The way the loss event is stated and understood will define the scope of the incident analysis. For example, selecting engine failure as the loss event will result in focusing on the engine failure. Selecting vessel grounding after engine failure as the loss event will result in focusing on the engine failure as well as the grounding incident. Selecting oil release after grounding following engine failure as the loss event will result in the investigation of all three aspects of the incident. Because of this, the loss event should be stated carefully and be precisely defined. A loss event definition that only includes the immediate consequences results in recommendations that are fairly narrow in scope. A loss event definition that also includes the subsequent consequences of the incident results in recommendations that are broader in scope.
- Multiple loss events may be identified as part of a single investigation. Multiple loss events are usually needed when there are different types of consequences and/or the consequences affect different stakeholders.
- Consequences of loss events can be realized immediately, or they can be delayed (for example, future expenses incurred during repairs and costs of lost time of a vessel in service).

5.4 Accident

An incident with unexpected or undesirable consequences. The consequences may be related to personnel injury or fatality, property loss, environmental impact, business loss, etc. or a combination of these.

5.5 Near Miss

i) An incident with no consequences, but that could have reasonably resulted in consequences under different conditions.

OR

ii) An incident that had some consequences that could have reasonably resulted in much more severe consequences under different conditions.

Notes:

- An incident can be both an accident and a near miss, an accident because it has immediate consequences, but also a near miss because the incident could have resulted in more severe consequences.
- Everyone in the organization needs to have an understanding of how near misses are defined by the organization so that they can report appropriate incidents that meet the definition. An incident can not be investigated if it is not reported. Examples of what is and what is not a near miss are usually required. To define a event that “almost was” is difficult, but near misses can be operationally defined, for example, a near miss can be operationally defined as:
 - Passing a ship or fixed structure by 50 meters
 - Touching soft bottom without grounding or stranding
 - Restarting a lube oil system before vital system damage or failure occurs.
- It should be evident that there are very many possible operational definitions for a near miss. More global definitions are more easily achievable, such as:
 - An unexpected deviation from a passage plan
 - A period of operations where emergency or unusual rapid action is required
 - An event that, under more usual circumstances would have resulted in a loss

5.6 Event

A happening caused by humans, automatically operating equipment/components, external events or the result of a natural phenomenon.

Note: Event descriptions typically include action verbs such as walked, turned, opened, said, radioed, discovered, decided, saw, etc. If negative (an error, failure or external factor), then the event may also be a causal factor, intermediate cause or root cause.

5.7 Condition

A state of being.

Notes:

- Includes process states, such as pressure, temperature, composition and level. Also includes the state of training of an employee, the condition of supplies and cargo and the state of equipment/structure/outfitting. If negative, then it can be a causal factor, intermediate cause or root cause.
- These typically include passive verbs such as “was” and “were”. No time is typically associated with a condition.

5.8 Causal Factor

Structural/Machinery/Equipment/Outfitting problems, human errors and external factors that caused an incident, allowed an incident to occur or allowed the consequences of the incident to be worse than they might have been.

Notes:

- For a typical incident, there are multiple causal factors.
- Causal factors are identified during the first stage of the analysis.
- Each causal factor is an event or condition for which steps should be taken to reduce or mitigate its occurrence.
- For each causal factor, underlying causes will be identified and recommendations will be developed.

5.9 Structural/Machinery/Equipment/Outfitting Problems

Structural/Machinery/Equipment/Outfitting performance that deviates from the desired performance of the item.

Note: The definition is not failure to perform as designed, but failure to perform as desired. This means that items can perform as designed and still fail or be degraded, because it fails to perform as desired (i.e., there is a gap between actual and desired performance). By defining failures in this way, structural/machinery/equipment/outfitting design issues can cause failures/degradations.

5.10 Human Errors

Performance of humans that deviates from the desired performance.

Notes:

- This definition is not a failure to perform as directed, but failure to perform as desired. An individual can follow the procedure precisely and still perform a human error, because the individual does not perform as desired (i.e., there is a gap between actual and desired performance). In this situation, the procedure specifies the incorrect method for performing the task.
- Human errors that are causal factors are might be performed by frontline personnel on the vessel. Human errors performed by support organizations and management are commonly classified as root causes.

5.11 External Factors

Issues outside the control of the organization. Examples include uncharted/unknown hazards to navigation, some sea or weather conditions, suicides or homicides and external events.

5.12 Intermediate Cause

An underlying reason why a causal factor occurred, but it is not deep enough to be a root cause.

Note: Intermediate causes are underlying causes that link causal factors and items-of-note to root causes.

5.13 Item-of-Note (ION)

A deficiency, error or failure that is not directly related to the incident sequence that is discovered during the course of the investigation.

Note: IONs are usually at the causal factor or intermediate cause level. IONs are similar to audit findings. If left uncorrected, these IONs may become causes of future incidents. Underlying causes and recommendations can be developed for IONs as part of the investigation. Some organizations assign responsibility for causal analysis of IONs to the individual departments.

5.14 Root Cause

Deficiency of a management system that allows the causal factors to occur or exist.

Notes:

- Root causes must be within the control of management to address. For a typical causal factor, there are one to four root causes.
- Root causes are usually as deep as a typical root cause analysis will go in attempting to identify the underlying causes of an incident. Organizational culture issue, which are deeper than root causes, could also be identified and addressed, but most root cause analyses do not go to this level because developing effective recommendations at the organizational culture level may be difficult.

5.15 Management System (MS)

A system put in place by management to encourage desirable behaviors and discourage undesirable behaviors.

Note: Examples of management system elements include policies, procedures, training, communications protocols, acceptance testing requirements, incident investigation processes, design methods and codes and standards. Management systems strongly influence the behavior of personnel in an organization.

5.16 Safeguard

A physical, procedural or administrative control that prevents or mitigates consequences associated with an incident.

Note: These are physical, procedural and administrative systems controlled by the organization's management systems. For example, a design process (the management system) will result in installation of dual electric generators (the safeguard). The procedure development process (the management system element) will result in a procedure on how to perform vessel loading of fuel (the safeguard).

5.17 Recommendation

A suggestion to develop, modify or enhance management systems or safeguards.

Note: Recommendations can be made to address the causal factor, intermediate cause and/or root cause levels of the incident. Recommendations are the most important product of the analysis. They are what will be implemented to change the organization's behavior and prevent recurrence of the incident or to minimize the consequences of the incident.

5.18 Resolution

The disposition of a recommendation.

Note: Often, recommendation resolution results in implementation of the recommendation. However, resolution could also result in implementing an alternate recommendation or no action at all.

5.19 Root Cause Analysis (RCA)

An analysis that identifies the causal factors, intermediate causes and root causes of an incident and develops recommendations to address each level of the analysis.

5.20 Apparent Cause Analysis (ACA)

An analysis that identifies the causal factors for the event and develops recommendations to address them, but does not necessarily identify the root causes of the incident.

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SECTION 2 Basics of Incidents and Investigations

1 The Need for Incident Investigation

Question: If an organization has never had a means for formally investigating incidents and yet still learns something from past mistakes, why is a structured approach needed? Why should time be invested in performing an incident investigation?

Answer: While something may be learned from every incident by performing even a cursory investigation, much more can be learned by using a more structured approach. If the structured approach is efficient, the user can obtain an increased level of learning without much additional effort.

1.1 Rationale for Taking a Structured Approach to Incident Investigation

Unstructured approaches can allow an organization to prevent the same incident from recurring, but often unstructured approaches simply delay the recurrence (or change the specifics of) the incident.

Example 1. A bearing on a pump fails. During an unstructured analysis, when it is discovered that a pump failed because of a bad bearing, the bearing would be replaced and the pump started again. But with this approach was anything learned from this failure? No. How might something be learned? One means would be to ask questions in a structured fashion, such as:

- Why did the bearing fail?
- Was the correct bearing for the pump used?
- Was it installed correctly?
- Was the bearing made of the correct material?
- If it is made of the wrong material, how did our organization allow that to occur?
- Why did a bearing of the wrong material get installed?
- How is it determined which bearings to use when a repair is needed?

The answers to all of these questions allow a more thorough analysis of the incident.

Example 2. A deckhand slips and falls on the deck. Once medical treatment is administered, is there anything else that should be done? How can something be learned from this incident? Applicable questions that could be used to further examine the situation could include:

- Where did the person fall?
- What were the deck conditions?
- What was the weather like?
- What shoes did the person have on?

- Did any of these factors contribute to the incident?
- Are there conditions like this on other vessels in our fleet that could prove problematic?
- What can be done by the organization to prevent or minimize the consequences of this type of incident?

Yet many within an organization might question, “Why should we take the time to answer these questions? The equipment has been repaired and the deckhand is working again. In addition, the deckhand has been told not to fall down anymore (to be more careful). Aren’t we done?”

1.2 Depths of Analyses

A structured or systematic approach to incident investigation allows a deeper look into management and work processes to determine the underlying causes of incidents. This allows more fundamental changes to be made in processes. Section 2, Figure 1, “Task Triangle Showing Possible Depths of Analyses,” shows potential levels of analyses. At the top, human errors, problems (including those related to structure, machinery, equipment or outfitting items) and/or external factors are analyzed. Farther down in the triangle are more fundamental causes and aspects of organizations. These include controls for the task and for the process. Eventually management systems and the organization’s culture can be analyzed. Analyzing deeper into the triangle allows organizations to increase the level of learning about how the organization functions and, therefore, develop corrective and preventative actions that are more fundamental in nature and broader in scope. These fundamental changes allow problems to be solved once instead of several times.

Vessel operations actually consist of many hundreds or thousands of these triangles, one triangle for each task. Section 2, Figure 2, “Overlap of Multiple Task Triangles,” shows three task triangles. The triangles have some areas in common and some that are not. At the bottom levels of the triangles, the three task triangles have more in common with each other. All share the same organizational culture. The different tasks have many management systems in common. As one moves to higher levels, there is less and less in common between the tasks.

To demonstrate how the commonality of management systems could affect different tasks, suppose that there is a problem with one aspect of a management system. For example, a limitation in a maintenance scheduling system could make it difficult to assign personnel to tasks. As a result, some maintenance tasks may not get completed on schedule. This could affect not only the proper performance of the maintenance tasks, but it could impact operational tasks too. If an equipment failure occurs because of lack of proper maintenance, operational workarounds might be used that could also lead to losses. If this management system issue is situated at Location 1 on Section 2, Figure 2, then it is in the task triangles for all three tasks. This management system problem will make performing all three tasks difficult, resulting in an increased potential for human errors and failures for all three tasks.

Traditional problem solving would try to correct the situation at the human error, failure/degradation or external factor level. To do so requires solving the problem multiple times (whenever an error is committed during performance of any of these tasks).

What if an incident investigation went deeper into the task triangles and solved the problem at the management system level? This only requires solving the problem once. Solving the problem once is much more efficient than solving it three times.

FIGURE 1
Task Triangle Showing Possible Depths of Analyses

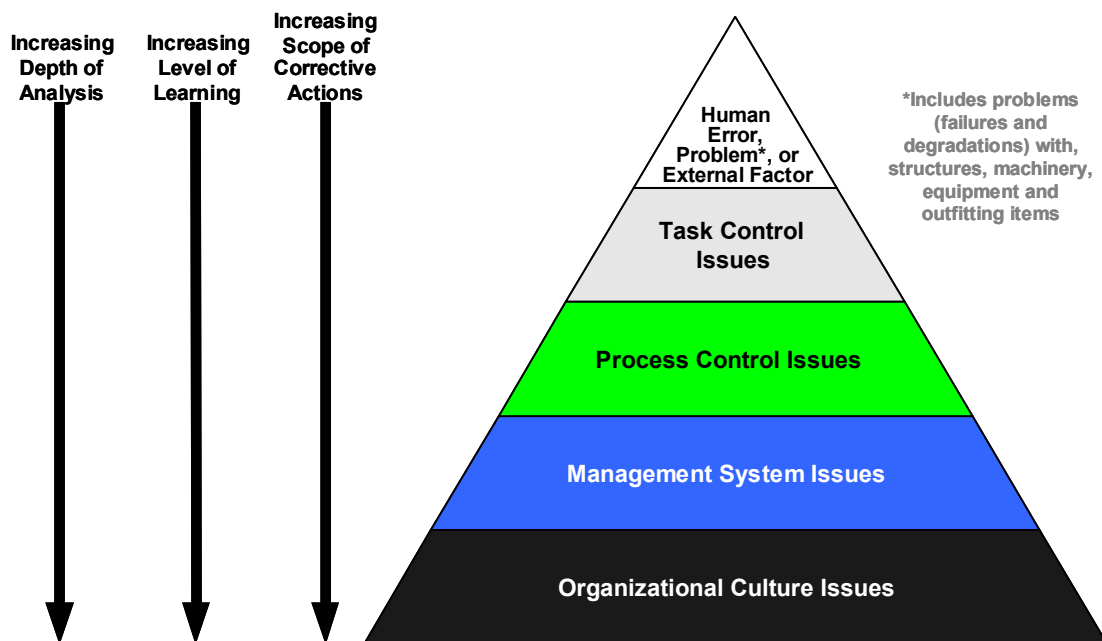
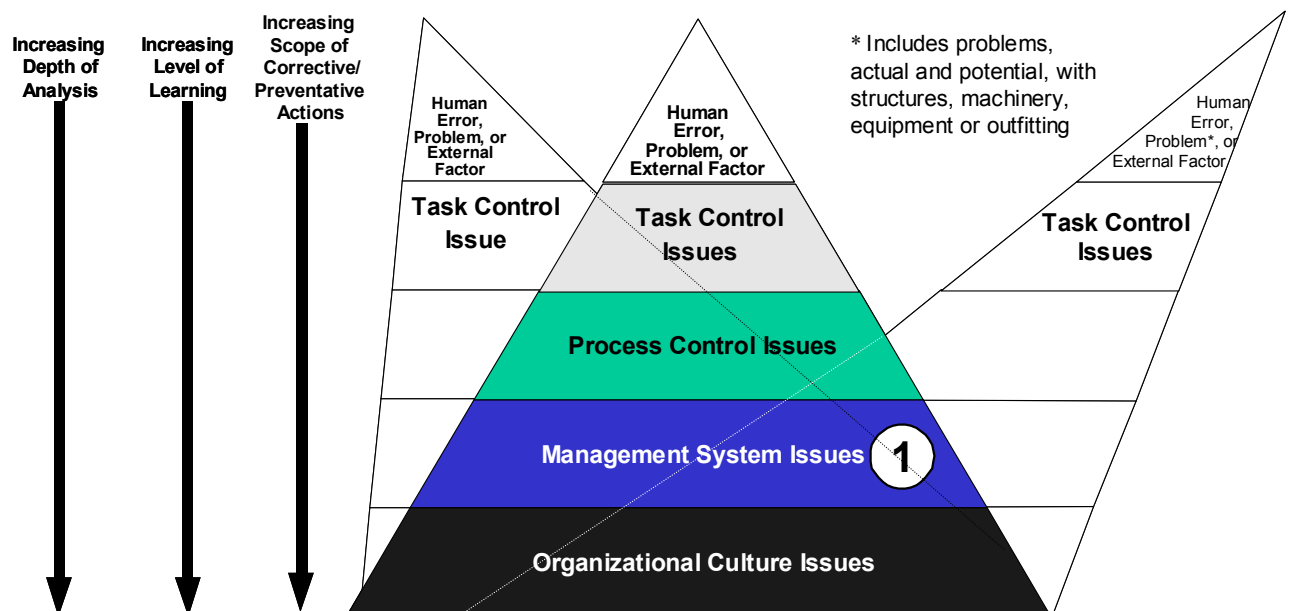


FIGURE 2
Overlap of Multiple Task Triangles



① Indicates position of Location 1

1.3 Structured Analysis Process

First, the problems at the top of the task triangle almost always make themselves known without having to do in-depth analysis. For example, a human error results in a failure of the pump or the failure of the pump itself causes a loss of propulsion. In both cases, not much investigation has to be done to figure out what to correct. In the case of trying to solve the problem at the management system level, some investigative work will need to be done. The symptom (the failed pump or loss of propulsion) can be seen at the top of the task triangles, but the causes are buried within deeper levels of the triangle. Some work (an investigation) will need to be done to identify what is happening at these deeper levels. The question, “What is it about the way we operate our business or vessel that caused or allowed this to occur?” must be answered. If an answer to this question can be found, the investigation will have dug deep into the task triangle. This will allow the issue to be addressed once, not three times. In addition, the problem will be solved the first time so that the other two failures can be avoided.

So the tradeoff is this: do more work now to understand the underlying causes and solve them. In return, solve one problem instead of many and avoid future failures. Avoiding failures allows (vessel) operations to run more smoothly, allows personnel to plan with more confidence and reduces the stress associated with always having to “fight the latest fire.”

2 Selecting Incidents to Investigate

Although root cause analysis (RCA) is a good process, sometimes the investment in the up-front analysis will not provide enough return in the end to justify the investment in an investigation. For example, suppose that a light in a passageway burns out. Should a root cause analysis be done? Will digging deeper into the levels of the task triangle help solve the problem once and avoid future losses? Will it help with understanding how to change our operations to prevent or minimize the consequences of this failure? Probably not. When bulbs fail after an expected lifetime, they are replaced. Even if one or two burn out prematurely, there is probably not much to be learned from an investigation into why this occurred. For lights in passageways, the consequences of the failure of the bulb are small enough that the failure can be tolerated for a short period. For this particular failure, one could choose to wait for the failure to occur and then respond to it by replacing the bulb. Could some proactive strategy be identified for preventing bulb failures? Maybe, but it probably would not be worth the effort because the consequences of the failure are so small.

So, rather than investigate every incident, when should investigations be undertaken? There are three types of incidents that should be analyzed in depth.

- The *first* type is the large consequence incident. For these incidents, the actual consequences are large enough that a single incident is intolerable to the organization. Examples of this type of incident would be groundings, allisions, collisions, fatalities, lost-time accidents and environmental spills.
- The *second* type of incident is a near miss to one of these large consequence incidents. Often these are referred to as near-miss (or near-hit) incidents. The actual consequences of the actual experienced incident are small, but there is a reasonable potential for a large consequence. Examples of these types of incidents might include near-miss allisions, near-miss groundings, medical treatment incidents and small spills with the potential for a much larger spill. Individuals involved in such incidents may say, “It was lucky that ...” or “I’m glad this happened out at sea. If this had happened during close maneuvering, we would have rammed something for sure” or “We’re lucky this happened when we were empty. If we had been full, we would have been leaking stuff all over.” For these types of incidents, it is prudent to investigate proactively before a large loss occurs.

- The *third* type of incident is actually a set of incidents. In this case, there are a number of small incidents that collectively add up to something big. As with the example above, if a passageway light burns out, there probably wouldn't be too much thought about it and a root cause analysis would not be performed. On the other hand, if 150 lights all burned out in the last week, there would probably be enough concern to warrant an analysis. Something new is going on in the lower levels of the task triangle, and it would be important to figure out what it is before replacing another 150 bulbs.

3 The Investigation Thought Process

Incident investigations require a different thought process than is often used in solving the small daily problems that are encountered. This section describes the differences between incident investigations and traditional problem-solving approaches, as well as the approach needed to perform a good analysis.

3.1 Differences Between Traditional Problem Solving and Structured Incident Investigation

Not only are the outcomes of an incident investigation fundamentally different from traditional problem solving, the overall approach is different, too. Section 2, Figure 3, "Differences Between Traditional Problem Solving and Structured Root Cause Analysis," shows some of the differences between the two approaches.

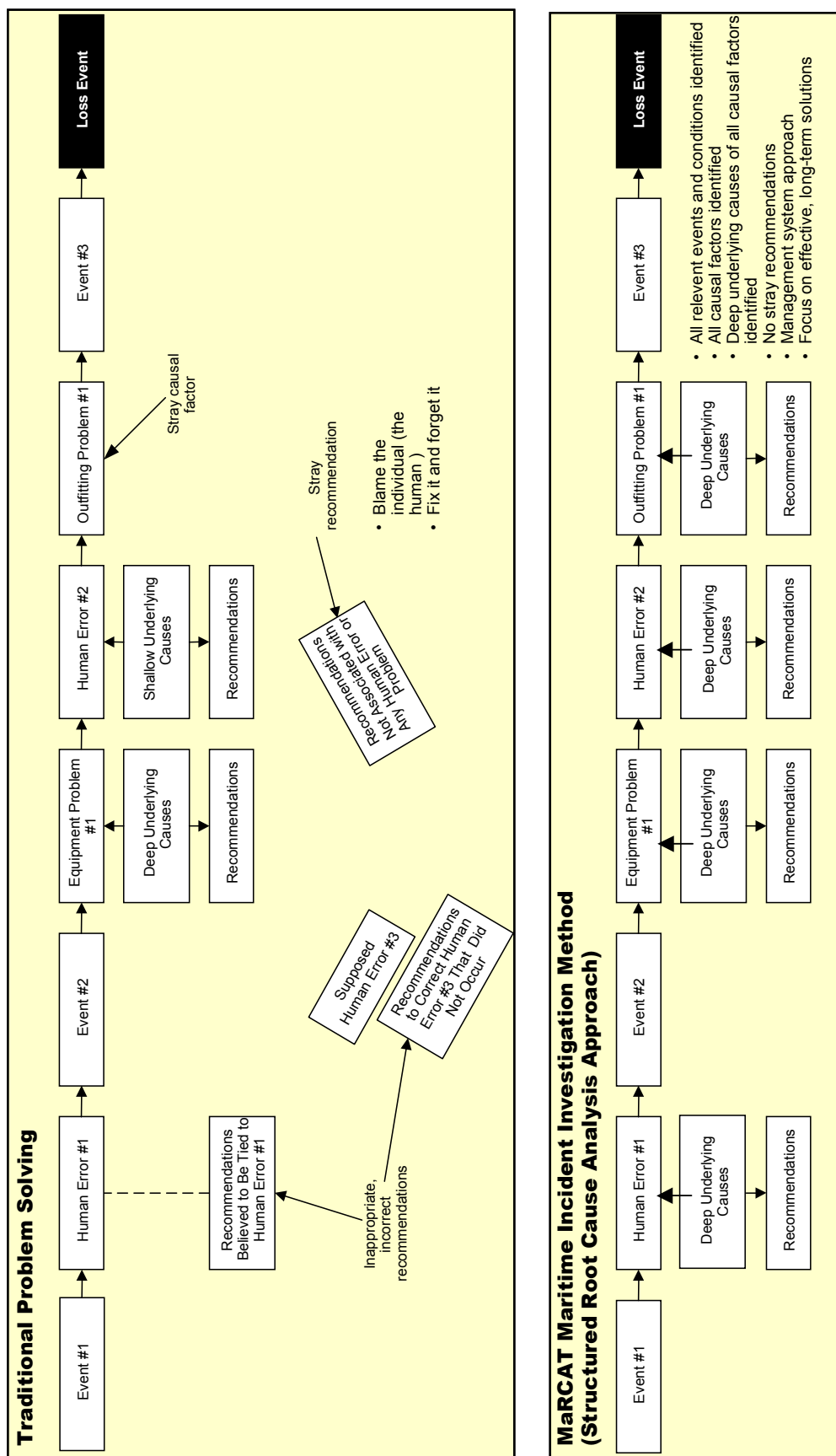
In traditional problem solving, the approach to gathering, organizing and analyzing data is usually unstructured. As a result, the conclusions and recommendations that are generated are often ineffective in preventing or mitigating the incident. In addition, the recommendations usually focus on correcting the individual and ignore the environment in which the individual performs the task.

An incident investigation approach looks at all of the factors that affect the performance of the task: the individual, the work environment and processes, the structure, the machinery, the equipment, the outfitting and external factors. Effective solutions often involve changes to the way the organization functions or how it deals with external factors. Traditional problem-solving approaches lack the structure and rigor to ensure the identification of effective solutions that are logically connected to the causes of an incident.

3.2 An Incident Investigation Approach to the Analysis

When performing an incident investigation, the investigator must question many of the "givens" of a situation. In a proactive analysis, such as a process hazard analysis or reliability analysis, many assumptions are made to expedite the analysis. However, assumptions should be questioned when performing incident investigations.

FIGURE 3
Differences Between Traditional Problem Solving and Structured Root Cause Analysis



The following are examples of common questions that must be asked when performing an incident investigation to prevent making assumptions about the organization:

- *Have changes to vessel design been adequately addressed?* Often changes are made to a vessel after initial design work is completed or delivery has been taken. Such changes can affect how the vessel operates or responds or how the machinery systems work. Changes in procedures may also affect operations. Have such changes been made?
- *Have changes in operation been adequately addressed?* Changes to structure, machinery, equipment or outfitting may have been made to address changes in organizational needs and economic pressures to haul different cargo or operate under different environmental conditions than originally anticipated.
- *Are personnel well trained?* It is assumed that personnel are well trained to perform the majority of the tasks they encounter. However, changes from the normal situations and practices are often not addressed in the training or procedures provided to personnel.
- *Are written procedures accurate and clear?* Procedures are always clear to those who wrote the procedures. However, they are often vague and unclear to those who use them. As a result, users are forced to interpret the procedures for situations not explicitly covered by the procedures.
- *Are policies enforced?* Many policies are written but not enforced by the organization. As a result, there are often many deviations from these written and unwritten policies.

In addition, there may be other items that are not properly understood by personnel. Two examples of such circumstances are provided below.

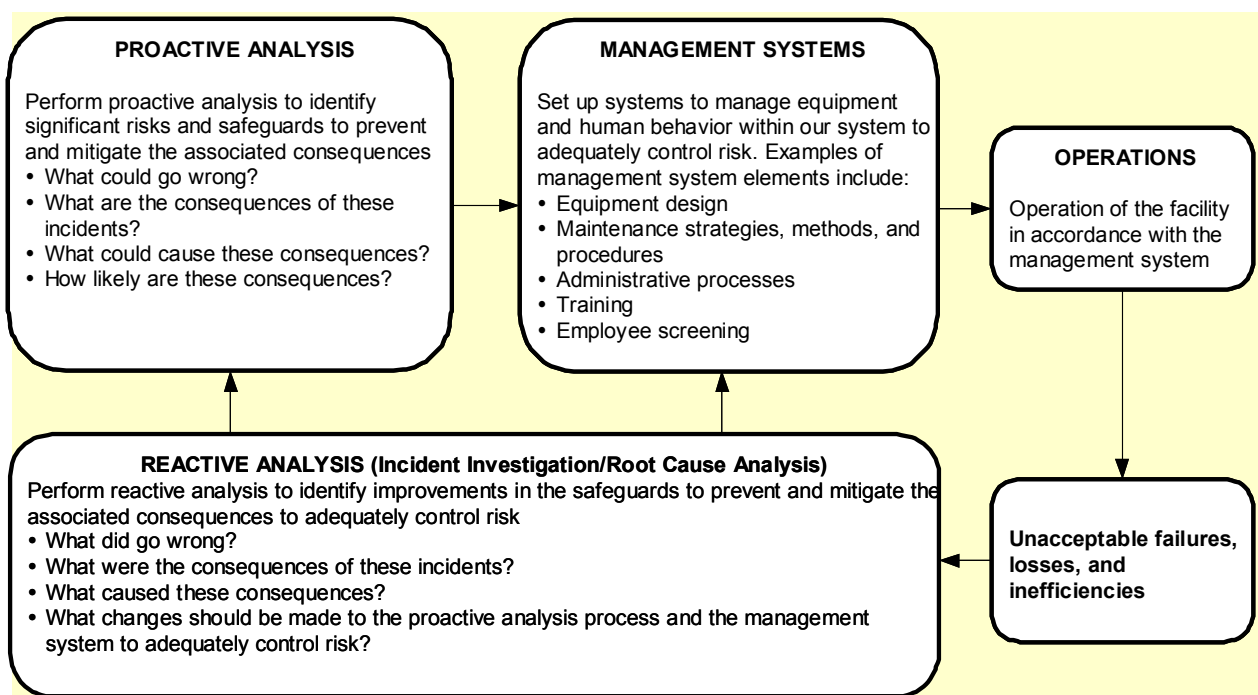
- *Example 1.* A tank has two level sensors, one for normal operations and one for a safety cutoff. The normal indication has a span that is the same as that of the tank. However, the safety system has a much narrower range; it can only detect level in the top 25% of the tank. This is fine because the only function of the safety system is to provide an independent cutoff of flow into the tank to prevent an overflow. Maintenance personnel are directed to set the safety system to 80%. The person who wrote the procedure meant this as 80% of the tank level (20% of the output of the level sensor). However, the maintenance personnel assumed this to be 80% of the span of the detector (80% of the output of the sensor), so they set the system to actuate at 95%. As a result, a small spill occurred.
- *Example 2.* Personnel have two temperature detectors to monitor the temperature of the cooling oil. When the temperature gets too high, they are supposed to operate an auxiliary oil cooler. However, too much cooling of the oil is also a problem, so the auxiliary cooler should not be used when it is not required. The procedure only tells the personnel to operate the auxiliary cooler “when the local temperature indicators read more than 130°F (55°C)” It is clear that when both indications are above 130°F (55°C), the auxiliary cooler should be turned on. However, what about the situation where one indication is above 130°F (55°C) and one is below 130°F (55°C)? What should the personnel do under these conditions? What will the personnel do? Will different personnel respond to this situation differently?

No possibilities within the scope of the investigation should be prematurely excluded. Often the root causes of incidents are deficiencies in the management systems that are designed to ensure that these assumptions will be valid. The investigation process is designed to ensure that assumptions are questioned and confirmed by the investigator.

4 Incident Investigation within a Business Context

Root cause analysis (RCA) is just one of many activities that an organization should undertake. Section 2, Figure 4, “Relationship Among Proactive Analysis, Reactive Analysis and Management Systems,” shows three general activities that an organization needs to operate: proactive analysis, reactive analysis and management systems.

FIGURE 4
Relationship Among Proactive Analysis, Reactive Analysis and Management Systems



Proactive analysis is designed to determine what might go wrong and how can strategies be developed to avoid these losses or reduce the losses to acceptable levels. Proactive analysis methods include failure modes and effects analyses, reliability-centered maintenance analyses, what-if analyses and human reliability analyses. The results of these assessments are usually implemented through management systems, such as design control processes, maintenance strategies, procedure development processes and human resources policies.

The management systems are designed to minimize the probability and/or the consequences of a loss. In addition, they are designed to maximize efficiency, profitability and employee satisfaction. The results of using these management systems are the procedures, training, equipment, communications protocols, procurement processes and maintenance strategies that are used in daily vessel or dock operations.

If the proactive analysis has been done well and the resulting management systems have been implemented perfectly, there would be no need to do reactive analyses. Because it is impossible to perform a perfect proactive analysis or implement management systems perfectly, losses do occur. When they occur, these can be investigated using reactive analysis methodology, Root Cause Analysis. The results of root cause analyses are fed back into the first two types of activities described above. Root cause analyses result in improvements in how proactive analysis is performed or lead to

changes in management systems used to control work processes. All of these tools are closely related to each other. Having a great incident investigation program is not enough. Unless the results of the investigation are fed back to improve the proactive analyses and management systems, the effort put into the investigation will be wasted.

Incident investigation methods are typically used to discover underlying reasons for poor or undesirable performance. However, these same methods can be used to discover the underlying factors that contribute to positive aspects of the operations. For example, if it is found that the methods used to track crew qualifications on one vessel are working very well, the incident investigation technique could be used to discover what factors contribute to this positive performance. Then, improvements can be made with proactive analysis and management systems to take advantage of this knowledge on other vessels and in other parts of the organization.

5 The Elements of an Incident

Every process has a number of key stakeholders. A key stakeholder is anyone who is interested in the performance of the system. Key stakeholders can be interested in safety, environmental, quality, reliability and financial performance. An incident is an unplanned sequence of actions and conditions that results in, or could have reasonably resulted (a near miss) in, consequences for a system stakeholder.

Incidents result in unintended consequences. They occur as the result of a combination of human errors, structural/machinery/equipment/outfitting problems and/or external factors that occur within the context of the work environment. These incidents have significant impacts on equipment/property, business continuity, safety/health and the environment. Generally, they have underlying causes that create error-likely situations for people and vulnerabilities for equipment.

Organizations have many methods for protecting themselves against these loss events, including hardware, procedural and administrative controls. The types and complexity of the controls depend on the perceptions of the risks. The proactive analyses influence the organization's perceptions of the types and magnitudes of the risks. Incidents occur when the safeguards for unacceptable risks are deficient, missing or fail. Sometimes safeguards are not incorporated because the proactive analysis did not result in the proper identification or understanding of the risks.

Another common cause is the result of changes that introduce unidentified risks or defeat safeguards (failure in management of change). Management of change programs can often control the risks associated with single changes. However, proactive analysis of the synergy of the changes is very difficult to perform. Therefore, reactive analyses are often required to understand these adverse cumulative effects.

6 The Goal of the Incident Investigation Process

The overall goal of the incident investigation process is to ensure that the proper safeguards are in place and functioning to prevent and mitigate incidents. If adequate safeguards are provided, any losses that do occur will be acceptable losses. This is the same goal as proactive analysis.

Individuals in the organization may have specific investigation objectives, such as the following:

- Protect the safety and health of workers and the public
- Preserve the organization's human and capital resources
- Improve quality, reliability and productivity
- Ensure continued service to clients and customers
- Comply with regulatory and insurance requirements

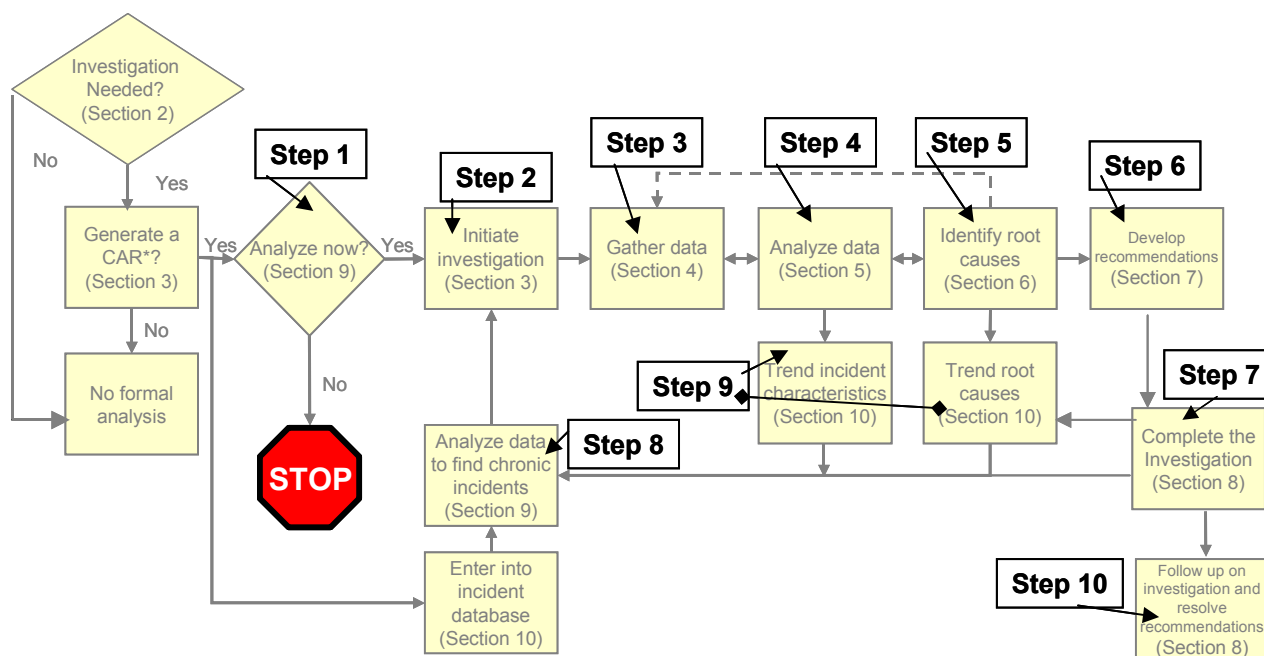
- Comply with organizational and industry policies
- Respond to legal, regulatory, organization, community and/or employee concerns
- Educate management, staff and employees
- Demonstrate management concern and promote employee involvement
- Advise others of unrecognized risks and/or more effective risk management strategies

All of these specific objectives are enveloped by the overall goal of ensuring that adequate safeguards are developed and are functioning within the organization.

7 The MaRCAT Marine Incident Investigation Process

Section 2, Figure 5, “The MaRCAT Marine Incident Investigation Process,” shows an overall process diagram for the MaRCAT Marine incident investigation process. This process applies to incidents of all types (safety, quality, reliability, environmental) although the implementation of the individual steps may be somewhat different for each type of incident. The steps also apply to incidents of various magnitudes. In other words, the process applies to small investigations that involve one person and last a few minutes and also to those that involve a large team and last for several weeks or months. Again, the steps in the process will be implemented differently, depending upon the depth of the analysis. An overview of each step is provided below:

FIGURE 5
The MaRCAT Marine Incident Investigation Process



*CAR is an acronym for Corrective Action Request

7.1 Step 1: Should the Incident Be Analyzed Now?

The first decision to be made is whether an incident merits an investigation on its own. After documenting some cursory information about an incident (e.g., Who? What? Where? Extent), a decision should be reached as to whether an incident should be investigated. When the actual or potential consequences of the incident are small, it may be sufficient to just enter the incident into a database. If the decision is for “No Investigation Necessary”, relevant facts will be documented and filed.

If the incident is deemed worthy of further investigation, a corrective action request (CAR) should be started. Following the generation of a corrective action request (CAR) that formally reports an incident, a decision needs to be made whether the incident should be analyzed now or if a later time could be more appropriate.

The decision about whether to launch a full formal investigation or merely document facts is needed in order for the organization to use its investigation resources wisely; that is, on those incidents where the potential return on the investment is believed to be sufficiently large so as to justify a formal investigation.

7.2 Step 2: Initiating the Investigation

In this step, preparation for conducting an investigation occurs. Activities in this step include ensuring that there is a precise and agreed-upon definition of the issue, determining how much effort to invest in the investigation, putting together a team and gathering the resources needed to perform the investigation.

7.3 Step 3: Gathering and Preserving Data

In this step, data is gathered. There are five basic types of data: people, paper, electronic, physical and position. Methods are available for efficiently and effectively gathering each type of data. These data are vital for ensuring that an understanding can be reached about what, how, and eventually, why the incident occurred. Some initial data analysis is also performed at this time.

7.4 Step 4: Analyzing Data

The MaRCAT methodology uses three basic tools to perform this step: the causal factor chart, the fault tree and the 5 Whys technique. However, other tools can also be used, such as hazard and operability analysis. Any of these analysis techniques can be used to organize the data that has been collected in Step 3. The data analysis techniques also help identify the data that still needs to be collected and the questions that need to be answered to understand the incident and its causes. By specifically identifying the needed data, the data gathering and preservation step (Step 3) is made more efficient. As a result, the data analysis step often sends us back to Step 3 to gather more data. This loop may occur many times during an investigation. The end goal of this step is to identify the causal factors.

7.5 Step 5: Identifying Root Causes

Once the who, what, where and when of the incident is understood and the human errors, structural/machinery/equipment/outfitting problems and external factors that led to the incident have been identified, the underlying causes of the incident can be understood. Root cause identification methods assist us in probing deeply enough to understand the underlying causes of the incident.

7.6 Step 6: Developing Recommendations

Identifying causes is not enough. Changes need to be made that address each of the underlying causes that have been identified. In this step, short-term, medium-term and long-term recommendations are developed to address the causes identified in Steps 4 and 5. Measures to assess the effectiveness of the recommendations are also developed.

7.7 Step 7: Completing the Investigation

To complete the investigation process, everything needs to be pulled together in a report. In this step, the results of the analysis are communicated to those who were not on the team. Then it needs to be ensured that the recommendations developed in Step 6 are implemented. Finally, the investigation process itself is critiqued and improved.

7.8 Step 8: Selecting Problems for Analysis

In this step, a method to select incidents for analysis is determined. Guidance is provided for determining if an immediate analysis is performed or if the incident data are only documented or trended. Investigation of near misses and chronic event analyses are also addressed.

7.9 Step 9: Trending

Steps 2 through 8 were performed on those incidents that had sufficiently large actual or potential consequences to warrant an investigation on their own. This step looks at all the data from incidents that have been analyzed, as well as all of those that it was decided not to analyze, to see if a group of incidents should be analyzed together. Are the same types of problems occurring repeatedly? If so, it may be decided that an investigation of this group of incidents is warranted.

7.10 Step 10: Following up an Investigation

Finally, once an investigation is completed and recommendations accepted, follow-up is needed to determine the effectiveness of the implemented preventative and correction actions. No matter how thorough the analysis, it is possible that the recommended actions are not completed or that they were not effective in solving the original problem.

7.11 Developing an Overall Incident Investigation Program Management Issues

This step really surrounds the remaining steps. It asks, “Are the management systems put in place to ensure that the other steps are properly performed?”

8 Levels of the Analysis: Root Cause Analysis and Apparent Cause Analysis

Section 2, Figure 6, “Levels of Analysis,” shows the various levels of the analysis in a flow diagram format. The analysis begins with an understanding of the sequence of events that led up to the incident. The underlying causes (or the causal factors) of the losses are structural/machinery/equipment/outfitting problems; human errors and external factors. Underlying these are the root causes. However, it is not possible to move directly from causal factors to the root causes since there will be a number of intermediate causes between the causal factors and root causes.

The analysis requires the identification of intermediate causes to connect the causal factors to the root causes. Section 2, Figure 7, “Connection Between Causal Factors and Root Causes,” shows the typical progression of the analysis down to the root cause level. This is consistent with the view of the organization through the task triangles examined earlier.

Root cause analyses investigate the causes of the incident down to the root cause level. Apparent cause analyses only investigate the causes of the incident down to the causal factor level. Apparent cause analyses are typically performed on events with smaller consequences. Apparent cause analyses may be time driven. In other words, a certain level of effort is allocated to the analysis. Root cause analysis efforts are typically goal driven. The level of effort is determined by what it takes to achieve the goal of the analysis.

FIGURE 6
Levels of Analysis

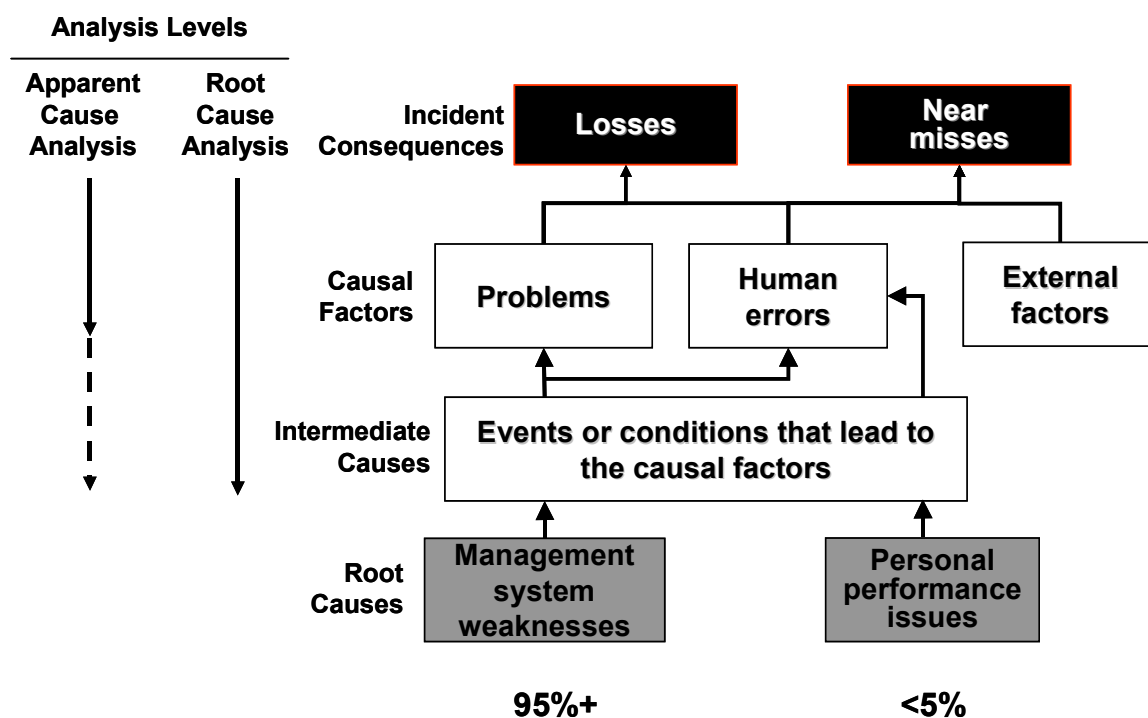
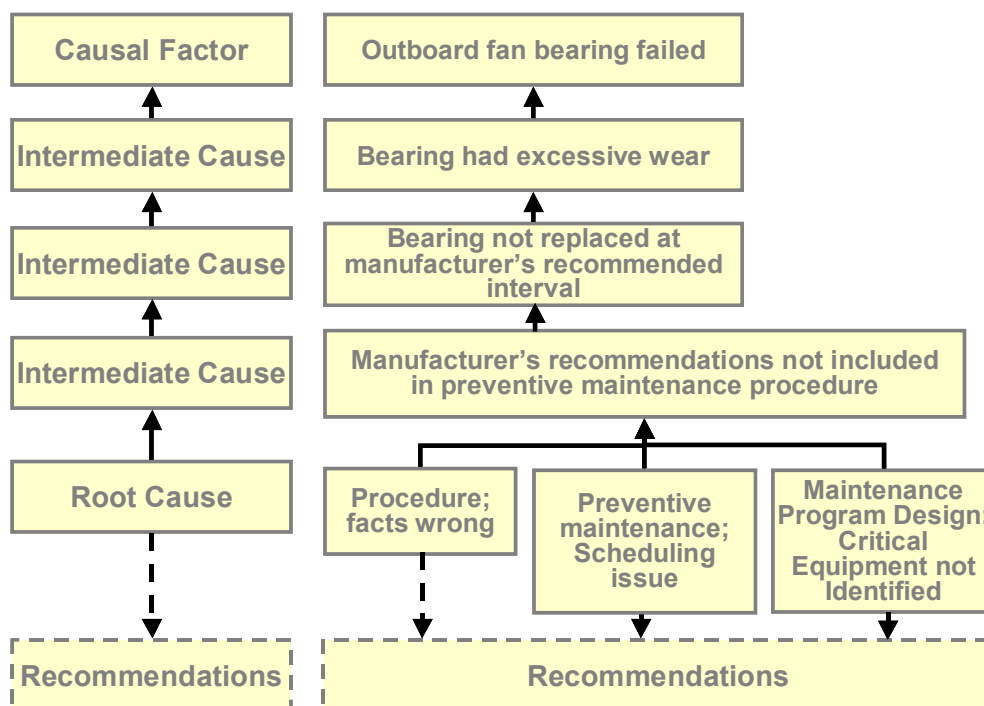


FIGURE 7
Connection Between Causal Factors and Root Causes



9 Summary

The goal of incident investigation is not only to understand the “what” and “how” of an incident, but also why it happened. The analysis of an incident begins with the gathering of data. As the data are gathered, they are organized and analyzed using causal factor charting, fault tree analysis or the 5-Whys technique (or other appropriate tools). The goal is first to identify the causal factors for the incident. Causal factors are those contributors (human errors, problems and external factors) that, if eliminated, would have either prevented the occurrence or reduced its severity. Once the incident is understood, root causes are identified for each causal factor. Root causes are deficiencies of management systems that allow the causal factors to occur or exist. Finally, recommendations are developed and implemented to eliminate the root causes and prevent the causal factors from occurring again.

Two levels of analysis can be performed. For an apparent cause analysis, the analysis only goes to the causal factor or intermediate cause level. Root cause analyses identify deeper underlying causes.

Root cause analysis differs from traditional problem solving in that the root cause analysis approach is more structured. The structure of the approach is intended to ensure that a more thorough analysis is performed and assumptions are examined.

SECTION 3 Initiating Investigations

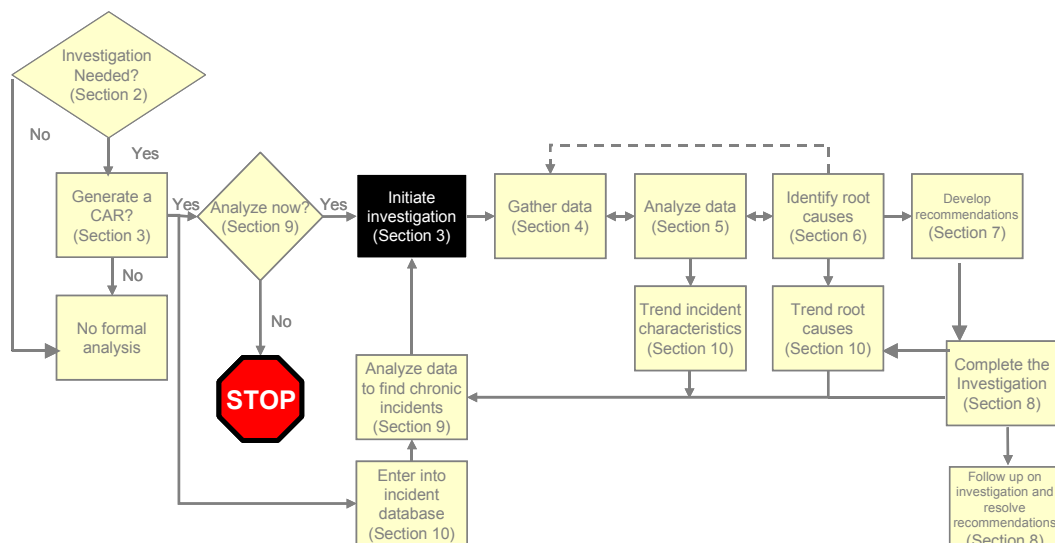
1 Initiating the Investigation

Initiating an investigation or analysis involves many tasks. The following is a list of the typical tasks involved. Each of these issues will be reviewed briefly.

- Notification
- Emergency response activities
- Immediate response
- Beginning the investigation
- Corrective action request (CAR)
- Incident classification
- Investigation management tasks
- Assembling the team
- Restart criteria
- Gathering investigation resources

Section 3, Figure 1 shows where initiating an investigation falls within the context of the overall incident investigation process.

FIGURE 1
Initiating Investigations within the Context
of the Overall Incident Investigation Process



2 Notification

A notification process is needed to ensure that all appropriate personnel are notified of the incident. Designated individuals should report incidents to key individuals within an organization and outside of the organization. Statutory requirements and organizational policies usually specify the personnel who need to be notified, as well as the timing and content of such notifications.

A predefined process (often a contingency plan) should be used to perform internal and external notifications. The organization should develop call lists and procedures to ensure that the correct personnel are promptly notified of incidents. Individuals in the organization should know the internal process used to report incidents and the types of incidents they should report. By completing internal notifications promptly, the appropriate external notifications can be performed within the applicable time requirements. Usually notification of these individuals is outside the scope of the investigation team's responsibility. Appendix 7 provides an Initial Call Checklist to illustrate some of the information that should be documented.

3 Emergency Response Activities

Emergency response personnel cause problems for investigators. During performance of their duties, they alter data. This makes it more difficult to recreate the sequence of events that led to the incident. Despite the alteration of data, the primary goal during the emergency response phase must be preventing further injuries, property damage and environmental impact. The investigation activities should not be allowed to interfere with the proper performance of emergency response activities. However, if the investigation can begin concurrently without interfering, hindering or delaying emergency response activities, then preservation and collection of data can be performed in parallel.

The adequacy of the emergency response may or may not be within the scope of the investigation. The instructions provided to the incident investigation team should specify if the team is supposed to assess the adequacy of the emergency response. The loss events/conditions defined by the team will also determine if emergency response will be within the scope of the investigation.

4 Immediate Response Activities

Some thoughts that should be kept in mind by the incident investigation team immediately following an incident include:

- Ensure that actions of investigators do not lead to another incident.
- Follow all directions and limitations issued by the onsite incident commander.
- Follow all directions and limitations with regard to safe work practices for isolating energy sources and controlling hazards.
- Remember that following an incident, there are often unusual hazards with the potential to create dangerous situations.
- A job risk analysis or job safety analysis may have to be performed to determine how the investigation activities can be performed safely.

Access to the incident site (and any associated records) should be controlled to preserve all relevant incident data. Only personnel specifically authorized by investigation team personnel should be permitted entry to the site.

It is important to determine the data that may be useful in investigating the incident – equipment, personnel, paper, photos, position information, electronic data, etc. – and preserve it for analysis. It is prudent to preserve more than may seem necessary. Unneeded items can always be released later; however, once released, the data from the item can often become useless. A timesaving approach is to develop a generic list of data that are typically useful during investigations. A document entitled Data Needs Checklist in Appendix 7 provides some suggestions for the types of data that might be useful to collect. The checklist should be reviewed at the beginning of an investigation. The Data Needs Form, also in Appendix 7, can be used to document data requirements. Data requirement can be based on the Data Needs checklist, with entries added and deleted, as appropriate. During the investigation, reference back to the checklist and entries on the completed Data Needs form is recommended. Developing a Data Needs list should ensure that the incident investigation team does not forget to obtain key data.

Once access to the incident scene is granted, the Initial Incident Scene Tour checklist and the Post-Tour checklist provided in Appendix 7 can assist with focusing your attention on relevant items to observe and document.

Preliminary photographs should be taken and/or initial sketches made of the incident scene. Having a still camera and a video camera readily available will help in gathering preliminary data. Again, take more photos than may seem necessary. Specific guidance for taking photographs and videos is contained in Section 4, “Gathering and Preserving Data”.

5 Beginning the Investigation

The investigation should begin as soon as possible. Legal and organizational requirements may impose a specific time limit. An investigation can get started even while emergency response activities are still being conducted (as long as it does not interfere with emergency response activities).

The loss events/conditions associated with the incident should be specifically identified. As noted in Section 1, the definition of the loss event/condition determines the scope of the analysis, and the magnitude of the consequences determines the level of effort. Therefore, a precise definition of the loss event is vital to the success of the analysis. What equipment, structures, items, cargo and systems were involved should be identified; as well as who was involved; when it occurred (day, date, time; watch); and how much or how many were involved (how much material was released, how many items were damaged).

Multiple loss events/conditions may need to be identified to address the different types of losses and the different stakeholders affected by the incident. For example, a fire could damage equipment in one area of the vessel. The smoke from the fire could be transported to another vital area of the vessel and affect personnel there. The fire could also damage a portion of the cargo. Separate loss events will be needed to address each of these. By having multiple loss events/conditions, it is ensured that the causes of each are identified as part of the analysis.

Loss events/conditions are the starting point for causal factor charts, 5-Whys and fault trees. Therefore, the issue of specifically defining loss events/conditions will be addressed in Section 5, “Analyzing Data”.

6 Corrective Action Requests

For most organizations, the first step towards performing an investigation is the generation of a Corrective Action Request (CAR). Although CARs can be generated for many reasons, some of the CARs will result in triggering an investigation. (*Note:* Not all companies use the “CAR” acronym, but the meaning is the same.)

6.1 Reasons to Generate a CAR

CARs are often the first form completed when problems arise. CARs can be generated as the result of the following activities:

6.1.1 Audits

Following the completion of an audit, nonconformities that need corrective actions are identified. The CAR is initiated to document the corrective actions and relate the corrective actions to the source (in this case, an audit).

6.1.2 Inspections

During inspections of materials, nonconformities may be identified that require further action to resolve. As an example, a purchase order specifies Model 42XP breakers that are purchased from Company A. During receipt inspection, it is noted that Model 52PX breakers from Company B have been received. A CAR may be generated to determine if the substitute breakers are acceptable for use.

6.1.3 Preventative Actions

CARs may be generated for preventative actions (e.g., near-misses, opportunity for improvement or to alleviate conflicts within the management system).

6.1.4 Meetings

During meetings, corrective actions may be identified. By generating a CAR, the action items can be easily tracked.

6.1.5 Training/Drills

During training and drills, performance problems may be identified that require corrective actions to resolve. Generation of a CAR identifies these corrective actions and allows them to be tracked.

6.1.6 Incident

When a performance problem is observed in the field, a CAR is generated to identify and track any additional actions that are needed to respond to the incident.

6.2 Typical Information Contained in a CAR

CAR formats vary somewhat from one organization to another. However, the forms typically contain information such as the following:

- Source/type: audit, inspection, meeting, training, drill, incident
- Audit, investigation, inspection, meeting, training or drill: date, reference number and initiator
- Title
- Description
- Immediate corrective actions taken (i.e., to stabilize the situation or fix the broken item)
- Remarks/comments
- Category
- Applicable regulations/standards
- Status (pending review, approved, etc.)

- Corrective actions (recommendations)

Description

Assigned to

Date to be completed

Follow-up actions

Date verified

A CAR can be generated in response to any of these items. As part of generating the CAR, corrective actions can be developed and assigned to individuals. If a more detailed analysis of the issue is desired, an incident investigation can be performed for any of these issues. For example, an incident investigation could be performed to determine what caused the nonconformities that were identified by an audit. An incident investigation could be used to determine why substitutions occurred during the procurement process. An incident investigation can also be used in the traditional sense, following a typical safety or reliability incident.

As shown on the process flow diagram (Section 3, Figure 1, “Initiating Investigations within the Context of the Overall Incident Investigation Process”), the CAR process is not considered part of the investigation process itself. This is because CARs can be generated from many different processes, as described above. For root cause analyses, the CAR is only used to start the process.

6.3 Using the CAR in the Incident Investigation Process

As can be seen from the information normally contained in a CAR, an entire analysis can be performed with the CAR process. The process is much more simplified than an Apparent Cause Analysis or Root Cause Analysis approach. However, it certainly is appropriate for situations where the organization believes there is not much to learn from a more detailed analysis of the situation.

If more details on the sequence of events, the interactions between personnel, the interactions of the management systems and the underlying causes of the incident are needed to generate effective corrective actions (recommendations), then an Apparent Cause Analysis or Root Cause Analysis is probably appropriate.

The incident reported by the CAR is then assessed against the incident classification criteria discussed in the next subsection.

7 Incident Classification

Once the loss event/condition and consequences are defined, the incident should be classified. By classifying the incident, the organization can appropriately allocate resources to the investigation, identify a qualified team leader and determine team composition (e.g., organizational personnel, outsiders, contractors as required). Typically, the classification scheme is based on the actual or potential consequences of the incident. Organizations typically define two or three levels of analysis.

For each level, the organization provides guidance on the amount of effort appropriate for the analysis. For example, for the lowest level of analysis, a single individual may spend less than one hour and complete a standard report form. For the highest level of analysis, a team of six personnel may spend weeks determining the deep underlying causes and developing a detailed report of their findings.. Example investigation plans are provided in Appendix 7 that can aid with either Simple or Detailed Investigations.

Setting up classification schemes can convey clear expectations for investigations. Classification schemes can account for all types of losses. For example, thresholds can be identified for safety, reliability, environmental, security and quality incidents. Section 3, Table 1, “Incident Classification Criteria,” shows some sample classifications.

TABLE 1
Incident Classification Criteria

<i>Operations Complexity</i>	<i>Type of Incident</i>	<i>Severity</i>	<i>Applicable Regulation</i>
<i>High</i> • Inerting • Vessel gas freeing • Maneuvering - traffic - restricted waters - weather • Tanker operations • Bunkering • Stability calculations • Cargo operations - start up - rate down • Hazardous materials use/storage	<i>Accident</i> • Collision • Spill/Release • Grounding • Explosion • Fire • Sinking • Personnel harm	<i>Multiple fatalities/serious injuries</i>	<i>IMO</i> • SOLAS • MARPOL • ISM • STCW • COLREGS • ISPS
		<i>Fatality</i>	
		<i>Injury</i> • Hospitalization • Lost time accident • Recordable • Medical treatment only • First aid	
	<i>Near miss</i> • Near collision • Dragging anchor • Failure of critical safeguard • Challenge last line of defense • Serious process excursion	<i>Evacuation</i>	<i>ILO</i>
		<i>Abandonment</i>	<i>Flag Administration</i>
		<i>Reportable</i>	<i>Port State</i>
		<i>Level of business interruption/product of losses</i>	<i>Port Authority</i>
			<i>Class Society</i>
		<i>Moderate</i> • Navigation at sea • Engine operation • Maintenance activities	<i>Other</i> • Machinery upsets • Quality variations • Downtime
<i>Simple</i> • Taking on stores • Housekeeping			

8 Investigation Management Tasks

From a project management standpoint, incident investigations should be treated like any other project. All of the problems that can be encountered during any other project can also be encountered during an incident investigation. However, because of the short time frame involved, any problem that is encountered during an incident investigation tends to have larger, more immediate effects. Incident investigations should have a project manager and project staff with clearly stated goals from the individual or group commissioning the investigation. This helps keep the investigation on track.

Like any other project, ill-defined goals will often result in the team failing to meet the objectives that were expected of it. Although it may initially appear to be a waste of time, determining a very specific goal generally pays off in the end by eliminating any investigation efforts that are not within the scope of the analysis.

Like any other project, the team leader should establish schedule requirements and commitments and arrange for funding consistent with the objectives, scope and schedule. In addition, the team leader needs to assign roles and responsibilities to the team members and augment the team with outsiders, as required. Communication protocols and logistics arrangements should also be handled by the team leader.

All of these investigation management issues are dealt with on both small and large investigations. However, for the small investigations, only a few moments may be spent on these planning tasks. The Team Leader Responsibilities Checklist, included in the MaRCAT Toolkit in Appendix 7, lists specific tasks the team leader should address. Other forms are provided that can assist with investigation management, such as an Investigator's Log, Open Issues Log, meeting forms and a Contacts form.

9 Assembling the Team

The composition of the team depends primarily upon the characteristics of the incident (recall the classification scheme discussed above). Teams can range from a single investigator to a large, multidisciplinary group of onboard, shore-based, corporate and/or outside personnel. The largest workable team usually has a core group of about eight. However, two to six is the optimum number. Other people may assist the team, but they usually have very specific tasks assigned to them.

A typical team consists of shipboard personnel, operations personnel, naval architects, marine engineers, safety/reliability/quality department representatives and an individual with investigation expertise. Many others can help with the investigation, even if they are not on the team. Examples include vendor representatives, fire investigators, chemists, company attorneys, instrument designers, reliability engineers/specialists and technicians.

In general, individuals who have one or more of the following characteristics should **NOT** be on the investigation team:

- *People too close to the incident.* They often cannot see what occurred during the event because they were too involved in the event.
- *People with insufficient time to participate in the investigation.* The investigators need to be able to devote adequate time to the investigation in order to obtain acceptable results.
- *People who already know the answer.* If someone believes that he or she already “knows” the answer, the investigation becomes just a way to confirm what he or she already believes instead of an investigation that explores all the possibilities. Often by the questioning the assumptions about how the organization and systems operate helps to identify the causes of the incident. Someone who already “knows” the answer never questions these assumptions.
- *People too high up in the management chain.* Individuals too high up in the management chain tend to dominate the investigation and intimidate the individuals involved. This can lead to limited data being uncovered during the analysis. Thorough data are needed in order to understand the underlying causes and develop effective recommendations.

Exceptions may need to be made to these rules as a matter of practicality. There are a limited number of shipboard personnel. As a result, providing the investigator or investigation team with the skills and knowledge needed to perform the investigation may require assigning individuals to the team who have one or more of these undesirable characteristics.

10 Restart Criteria

In some instances, restart criteria may need to be established before the equipment or system or even a voyage can be restarted. For example, if a pump malfunctions and is damaged, criteria should be established for its return to operation to ensure that it does not fail again. In most cases, it is not practical to wait for the root causes of the incident to be identified before the equipment is released for restart. However, at least one of the causal factors needs to be identified and addressed before the pump is restarted. By identifying and correcting at least one of the causal factors, there is some assurance that the pump will operate without failing or that the consequences of its failure will be reduced while the underlying causes of the failure are identified and corrected. As described in Section 7, recommendations may be short-term, medium-term or long-term in nature. Restart criteria usually involve implementation of short-term recommendations to ensure that the incident does not recur before implementation of medium- or long-term recommendations.

Restart criteria may also apply to personnel safety incidents. For example, if someone is injured because of an electrical system malfunction, short-term recommendations will need to be implemented to prevent further injuries to personnel. These short-term recommendations may consist of repair of the equipment (correcting a short-to-ground condition) or involve a lockout of the

equipment until the underlying causes of the problem can be identified. Medium- and long-term recommendations will need to be implemented to ensure that malfunctions of other electrical equipment are prevented or their consequences are minimized.

Restart criteria have another purpose. In addition to ensuring that the consequences of future failures are avoided or minimized, restart criteria are also used to ensure that the appropriate data are collected before the equipment is released. For example, photographs of scratches on the surface of a failed shaft may be needed to understand the failure. Restart criteria may involve obtaining these photos before returning the component to service. Another example would be collecting oil samples from various portions of a diesel engine before flushing it.

In some cases, development of specific restart criteria may not be possible. For example, following a loss of propulsion, equipment may have to be restarted as soon as possible without regard to the investigation objectives. Because of the immediate need for the operation of the equipment, investigation objectives are a lower priority during the short-term emergency response efforts. Once normal operation is restored, personnel can then begin the investigation process.

11 Gathering Investigation Resources

The team will need some basic tools to perform its investigation. Most of these tools are commonly available items. Examples include:

- Measuring devices – ruler, tape measure
- Markers – pens, pencils
- Self-stick removable (Post-it®) notes
- Flipchart paper
- Forms
- Office supplies – paper clips, stapler
- Gloves
- Plastic bags
- Plastic tarp
- Camera (preferably digital or with film, batteries, etc.)
- Flashlight with extra batteries
- Clipboard
- Personal protective equipment (PPE)

Most of these items can be put together in a kit so that they can be quickly obtained by investigation team members when they begin their work. Suggestions for materials to be included in such a kit can be found in the document entitled “Investigation Tools Checklist” in Appendix 7.

12 Summary

Preplanning must be performed to ensure that the investigation is initiated quickly. The faster the investigation is started, the easier it will be to complete the investigation.

Classifying the incident will help organizations allocate their resources properly. For larger investigations, an effective team leader is needed to manage the investigation process and the investigation team.