Chapter 13

Feedback and the Presentation of Incident Reports

This book has argued that incident reporting systems can play a prominent role in the detection, reduction and mitigation of failure in safety-critical systems. Previous chapters have reviewed a number of elicitation techniques. These are intended to encourage operators to provide information about near-miss incidents and about the failures that affect their everyday tasks. We have also identified the primary and secondary investigation techniques that must be used to recover necessary information about these incidents. This information can be used to reconstruct the events leading to failure. These models, in turn, help to drive causal analysis techniques. Finally, we have described how each cause of a failure must be considered when drafting the recommendations that are intended to avoid, or mitigate the consequences of, future failures. None of this investment in the analysis of adverse occurrenses and near-miss incidents would provide any benefits at all if the findings from an investigation cannot be communicated back to the many different groups who have a stake in the continued safety of an application process.

13.1 The Challenges of Reporting Adverse Occurrences

A number of problems complicate the publication of information about near-miss incidents and adverse occurrences. Investigators must ensure that documentation conforms both to national and international regulatory requirements. These constraints are better developed in some industries than they are in others. For example, the Appendix to ICAO Annex 13 contains detailed guidance on the format to be adopted by incident reports within the aviation industry [386]. A title must be followed by a synopsis. The synopsis is followed by the body of the report which must contain information under the following headings: factual information; analysis; conclusions and safety recommendations. Further guidance is provided about the information that should be presented under each of these sub-headings. Annex 13 also provides detailed instructions on the procedures to be adopted when disseminating the final report into an incident. This approach can be contrasted with the guidelines provided by the International Maritime Organisation's (IMO) code for the Investigation of Marine Casualties and Incidents adopted under Assembly Resolution A.849 [389]. This provides detailed guidelines on the investigatory and consultative process that must precede the publication of any report. It says almost nothing about the format and content of any subsequent documentation.

The lack of national or international guidelines provides investigators with considerable flexibility when they must document their findings about particular failures. It also creates considerable uncertainty amongst those safety managers who must ensure 'best practice' in the operation and maintenance of reporting systems. This uncertainty is well illustrated by the UK National Health Service; risk managers are responding to calls to introduce incident reporting systems without guidance on the form that those systems should take. In consequence, a vast range of local initiatives have been started to develop appropriate formats that might be used to disseminate information about adverse occurrences. The result is that hospitals have developed diverse approaches that both reflect local needs and which also make it very difficult to identify potential similarities between related incidents in different trusts. Further problems are created by the development of different national standards that can cut across these local initiatives. For example, the Royal College of Anaesthetists has taken a leading role within the UK National Health Service by issuing detailed guidance on how to gather data about critical incidents [716]. Unfortunately, the lack of national guidance in other areas of the healthcare system has resulted in standardised formats being used within certain areas of healthcare but not within others.

National and international standards are intended to support the exchange of information about previous failures. The recipients of these documents can have confidence that they will contain the information that is necessary to inform any subsequent intervention. Later paragraphs will return to the problems of encouraging this dissemination of incident reports between organisations that are often seen as 'natural' competitors. For now, however, it is important to recognise the pragmatic problems that arise when attempting to draft minimum requirements for the formatting of incident reports. The problems that arise when attempting to apply causal taxonomies and recommendation matrices illustrate how hard it can be to anticipate the nature of future failures. Similarly, it can be very difficult to predict what form an incident report should take beyond the generic and extremely abstract categories that are proposed by the ICAO.

There is a tension between the need to encourage consistency between reporting formats and the importance of allowing some flexibility in the reporting of individual incidents. The diverse nature of near-miss incidents and adverse occurrences has many further consequences of the drafting and dissemination of incident reports. As we have seen, natural language is most often used to describe the sequence of events leading up to a potential failure. The same medium is used to represent the detailed causal analysis that will, eventually, support particular recommendations. Natural language has the benefits of accessibility and flexibility. No specialist training is required to understand it. It can also be used to capture diverse aspects of an incident and its causes. Unfortunately, it can also be ambiguous and vague about key aspects of an incident. It can also be difficult to follow the large number of concurrent events that often characterise technological failure. Detailed timing issues are not well represented and it can be difficult to form coherent natural language accounts from the individual analysis of multi-disciplinary experts. The flexibility of natural language can be used to capture many different aspects of an incident. This flexibility is also a weakness because it supports the variety of interpretations that can lead to potential ambiguities. Subsequent sections will explore each of these issues in more detail.

13.1.1 Different Reports for Different Incidents

Previous chapters have emphasised the diverse nature of incidents within many industries. At one extreme, they include low-consequence near-misses that border on process improvements rather than safety issues. At the other extreme, reports provide information about high consequence failures that cannot easily be distinguished from accidents rather than incidents. This diversity has an important effect upon the nature of the documents that are used to disseminate the findings of an investigation. For example, high-consequence failures are typically reported using a highly structured format in which reconstruction is followed by analysis, analysis is followed by recommendations and so on. This formal style of presentation can be illustrated by the US Coast Guard's table of contents for a report into the loss of a fishing vessel [834]. What we have termed the reconstruction of the incident is contained within the 'finding of fact' section. The causal analysis is partly contained within these pages but is focussed on the 'Conclusions' section:

Chronology	8
Description of the Vessel	28
Details of Vessel Surveys and Repairs	40
Stability Information	50
Vessel Management	66
External Environment	74
Conclusions	77
Recommendations	96

A similar format can be seen in the Australian Transportation Safety Board's (ATSB) Marine Safety Investigation reports [52]. As with the previous US Coast Guard example, the table of contents reflects the detailed investigation that was conducted in the aftermath of the incident. The reconstruction of the incident is contained within the 'Narrative' sections. Causal analysis is presented under 'Comment and analysis'. There are some differences between this report and the one described in the previous paragraph. Rather than presenting specific recommendations, the ATSB investigators identified contributing factors in the 'Conclusions' section. The lack of proposed interventions in part reflects the nature of the incident. The report's conclusions identified specific procedural problems that contributed to the incorrect loading of this particular vessel. It can, therefore, be argued that the wider publication of such specific recommendations would have had marginal benefits for a more general audience. It also reflects recent initiatives by the ATSB to move away from a 'perfective' approach towards a more 'contextual' form of analysis:

Summary	1
Sources of information	2
Narrative	5
Sun Breeze	5
The incident	5
Loading at Bunbury	6
Sailing from Bunbury, the list and subsequent events	9
Comment and analysis	15
Evidence	15
The charter party	15
Stability of the vessel	15
Stability at first departure	16
Righting lever and heeling arm curves	17
Sun Breeze: Lightship KG	19
The Class Society	20
Cargo stowage	21
Notice of intention to load timber deck cargo	22
Stowage factors, cargo weights and the masters responsibility	23
Deck cargo lashings	23
Two scenarios for the incident	25
Conclusions	27
Submissions	31
Details of Sun Breeze	33
Attachment 1	31
Stability terminology and principles	35

The task of providing feedback from incident reporting systems is complicated by the different formats that are used to disseminate information about different types of incident. For example, the previous tables describe the formal structure that is typically associated with incidents that either did, or might have, resulted in high-consequence failures. The level of detail included in the analysis is indicative of the resources that have been invested in the investigation. In contrast, many less 'critical' incidents are summarised by less formal reports. There are other reasons for exploiting a range of formats. For instance, in many industries it can be difficult to persuade operators and managers to read what are perceived to be long and complex documents about previous incidents that may, or may not, have particular relevance for their daily activities. In consequence, investigators often publish abbreviated accounts in a more 'accessible' format. They summarise the events leading to the failure and provide a brief causal analysis in two or three paragraphs. For example, the UK Marine Accident Investigation Branch (MAIB) uses its Safety Digest articles to provide a brief overview of previous incidents. Is possible to identify sentences that relate to the reconstruction of an incident, to the findings of a causal analysis and to particular recommendations. The formal distinctions that are reflected in the section heading of the more exhaustive documents, illustrated by the US and Australian reports, are not used in these summaries:

> "The ro-ro cargo/passenger ferry SATURN was completing berthing operations alongside a pier at Gourock. Prior to rigging the gangway, it was normal practice for a seaman to throw the safety net ashore from the gangway gateway, which was normally secured in the open position by hooks but, on this occasion, was not. As the net was thrown ashore, part of it became entangled in one of the gates which caused it to close and knock the seaman off balance. He was caught in the net and fell overboard, landing heavily on a pier timber before falling in the water. The seaman surfaced and, with the assistance of another crew member, managed to hold onto a pier timber. Both were recovered from the water by a fast rescue craft." [515]

This account provides a 'vignette' or 'failure scenario'. It describes an incident in an extremely compact manner. Minimal information is provided about the more detailed contributory factors that are considered in more formal reports. The previous summary does not explain the reasons why the door was not secured. In contrast, it provides readers with a direct account of the catalytic events that led to the incident and, most importantly, it illustrates the potential consequences of such incidents. Such accounts have strong similarities with the 'war stories' or anecdotes that are an important means of exchanging safety-related information within teams of operators. This is an important strength of such immediate accounts. It can be argued, however, that the lack of more sustained analysis may limit any long-term effect on system safety.

The previous paragraph provides a relatively simple example of the use of incident vignettes. Several regulatory agencies have developed variations on this approach. Investigators can use these techniques to inform readers about specific safety issues. For example, there is a danger that short vignettes will focus on the specific events that lead to a particular incident. It can then be difficult for readers to identify the more general safety issues that affect the operation or activity that was affected. There is even a danger that the readers of such incident scenarios will forget other safety issues by focusing on the specific failure described in the report. In consequence, some incident reporting systems use vignettes as a form of hook that is used to motivate readers to consider more general safety issues. This can be illustrated by a US Coast Guard report into a particular incident involving a group of sea kayakers:

> "(they) unexpectedly encountered strong currents that resulted in three kayakers being separated from the group and set out to sea. While their friends were set offshore, the main group was able to land their kayaks on a small island. Because a member of the group now ashore carried a signal mirror, the group was able to attract the attention of persons on the mainland, who in turn notified the Coast Guard. Based upon information from persons ashore, an intensive 5 hour effort was launched that eventually located and recovered the missing kayakers. This incident underscores the need for proper planning and signaling equipment, and revealed some of the inherent difficulties in mounting open water searches for objects as small as sea kayaks." [830]

The final sentence in this quotation presents the particular conclusion or finding that can be drawn from this specific incident. It also illustrates the way in which such recommendations can reveal a great deal about the intended readership of the report. The vignette is clearly not intended for the members of the rescue service. If this were the case then some additional detail should be provided about the "inherent difficulties in mounting open water searches...". In contrast, the recommendation is clearly intended for kayaking enthusiasts and to recreational sailors. After drawing this specific conclusion, the Coast Guard report goes on to reminder the reader of a number of more general safety precautions that should be followed when kayaking. The investigators place the specific recommendations about how to prevent this particular incident within the wider context of voyage planning and preparation. This is an extremely powerful technique. The particular circumstances of the incident act as a direct and clear example of the potential consequence of failing to follow safety information. It is doubtful whether the list of safety recommendations would have had the same effect if they had been presented without the incident as a preface:

> "*Voyage planning:* When planning a voyage, no matter how short or simple you intend it to be, take a few minutes to leave a float plan, including departure/arrival times, number of people and color of kayaks with a responsible friend. If it's a spur of the moment trip, write a plan just before you go and leave it in an envelope marked "FLOAT PLAN" on the dashboard of your vehicle. Make sure to always monitor the weather before and during your trip.
>
> *Know your limitations:* You alone are the best judge of your own physical limitations, the capabilities of your kayak, and most importantly, your ability to operate your craft and gear. Respect the indiscriminate power of the sea along the exposed Maine coast, and carefully avoid operating in restricted visibility, including fog, rain, and darkness..." [830]

We are currently working on a number of studies that intend to determine whether or not such presentation techniques have an impact upon decision making and risk-taking behaviour. A host of methodological problems affect such investigations. It is difficult to identify a procedure to demonstrate that individuals would be more likely to follow the safety guidance if they had been informed about previous incidents. These issues will be addressed more directly in the closing sections of this chapter when we look at the problems of validating the 'effectiveness' of incident reports.

13.1.2 Different Reports for Different Audiences

It is important to emphasise the diverse nature of those groups that have an interest in the findings of an incident investigation. Other investigators must read the reports of their colleagues to encourage consistent analysis and common recommendations to similar incidents. This also helps to sensitise individuals to emerging trends within an industry. Designers and developers may also be concerns to read incident reports in order to ensure that previous mistakes are not replicated in future systems. The operators of the application processes that are described in an incident report must also be able to access the recommendations that emerge from previous failures. This not only helps them to understand any proposed revisions to their working practices, it also helps to disseminate information about the consequences of previous failures and the potential for future incidents. These reports must also be disseminated to the managerial staff who supervise end-user activities. In particular, safety managers must be informed of any recommendations. They are often required to ensure the implementation of proposed changes. Regulators have an interest to track individual incidents. This is important if they are to monitor the safety record of individual firms. Such information helps to guide the dissemination of best practice across between companies in the same marketplace. It is also important from regulators to monitor the changing nature of incidents across an industry if they are to identify potential patterns of failure. These comments apply to national regulators. There have also been a number of international attempts to compare incident data from different countries, such as the IMO's work to collate incident reports.

National regulators and international bodies are not the only groups that are interested to learn about the insights provided by incident reports. The general public are often concerned to read the findings in these documents. This interest is often motivated by concerns over personal safety issues, including consumer protection and healthcare provision. As we shall see, many investigation agencies have responded to this concern by placing information about past failures on publically accessible web-sites. This wider interest is also being driven by an increasing willingness to engage in litigation In consequence, legal practices are often concerned to follow the incident reports in several industries. It is difficult to determine whether this public concern has been created by media interest or whether media interest has been fuelled by the engagement of this wider audience. In either case, it is important to acknowledge that all forms of the broadcast media and publishing have an active interest in reports of previous incidents and accidents.

The diverse nature of the potential readership of an incident report creates problems for those who must draft incident reports. Different reporting formats offer different levels of support for particular tasks. For example, operators are likely to require precise summaries and detailed guidance on how to meet particular recommendations. Safety managers are likely to require more information about what a recommendation is intended to achieve and how to demonstrate conformance with its particular requirement. Investigators and lawyers are concerned to understand the reasons why certain causes were identified. They may also be concerned to ensure that recommendations provide appropriate defences against any recurrence of specific causal factors. Designers and regulators will, typically, require a higher degree of technical detail than system operators. Those responsible for the implementation of future systems must also be able to generalise from specific failures to anticipate whether similar problems might affect proposed designs.

Table 13.1 illustrates the range and diversity of reports that can be generated by a single institution. This summarises the reporting activities conducted by the Hong Kong Marine Department [368]. Many of these publication requirements relate to more serious incidents and accidents. It is important, however, to see the presentation and dissemination of less critical incident reports within this wider context of regulatory and judicial requirements. The range of documents that must be produced in the aftermath of an adverse occurrence or near-miss also imposes considerable logistical demands upon such organisations. For instance, primary and secondary investigations may generate interim reports that are intended to warn operators and supervisors of any short-term actions that might help to avoid or mitigate any recurrence of an incident. These documents are, typically, superseded by the final incident report that presents the outcome of the reconstruction, causal analysis and recommendation techniques that have been described in previous chapters. As we have seen, these reports trigger implementation advisories of various forms. These guide operators and managers on the actions that must be taken to fulfill particular recommendations. Finally, statistical summaries can be derived from databases of individual incident reports. These summaries may motivate issue-based reports that investigate a number of similar incidents.

It is difficult to underestimate the logistical challenge that is posed by the production and dissemination of these different documents to the diverse groups that have an interest in a adverse occurrence or near-miss incident. For example, the recipients of an initial notification about short-term corrective actions must be informed of any longer-term measures. If this is not the case then groups and individuals may continue to exploit stop-gap measures to prevent the recurrence of previous failures. Safety managers must have access to updated statistical information if they are to determine whether or not a newly reported incident indeed forms part of a wider pattern. If this seems to be the case then they may have to obtain access to information about on-going enquiries into these related failures. Similarly, it is important that the people who contribute incident reports should receive updated information about the various levels of intervention that have been triggered by their observations.

These distribution problems must, typically, be solved within short time-limits. It is important for information to be disseminated in the aftermath of an incident. There is an obvious need to provide guidance on any short-term corrective actions. There is also a need to prevent any rumours that might be generated in the aftermath of an incident. Even in anonymous systems, it can be necessary to warn operators about the potential for future failure and to publicise the results of any secondary investigation. Conversely, it is important that any preliminary publications should not be premature. Unsubstantiated speculation can create confusion when subsequent incident reports are forced to contradict previous statements about the potential causes of an incident. These complexities not only affect the safety managers and incident investigators who must combat the causes of future incidents. They also affect the tasks of press officers and media relations officers. It is important that initial releases about an incident should not affect the results of any subsequent investigation.

Investigation Type	Summary of Process	Reporting Requirement
Informal Inquiry	Carried out by investigation board into less serious accidents. Director of Marine accepts or rejects the report and institutes follow up action.	No formal report is prepared but findings may be included in a 'Summaries' page on a web-site.
Preliminary Inquiry (Hong Kong Registered)	Director of Marine appoints professional officer(s) to conduct investigation. Report by the appointed officer is submitted to the Secretary for Economic Services with Director of Marine's observations and action. Secretary for Economic Services accepts or rejects the report.	If Marine Court is not ordered, usually the Preliminary Inquiry report will be published. If Marine Court is appointed then it reports to Chief Executive who can approve its publication and may accepts or rejects findings/recommendations of the court.
Preliminary Inquiry (Pilotage)	For minor incidents, Pilotage Authority appoints a Board of Discipline. Board of Discipline may then recommend a caution, written warning, a downgrade on pilot's licence or that Board of Investigation be held. For serious incidents, Pilotage Authority commissions a Preliminary Inquiry. This can result in Board of Investigation.	Board of Investigation submits report to Pilotage Authority. The Pilotage Authority decides on the report's recommendations and decides whether the report should be published.
Local Marine Inquiry (In Hong Kong waters)	The Director of Marine orders a Local Marine Inquiry for incidents occurring in Hong Kong waters, to be conducted by professional officer(s). The appointed officers submit a report to the Director of Marine. The Director accepts or rejects the findings/recommendations.	Findings are published as a report or as a summary on the Department web-site
Industrial Accident	The Marine Industrial Safety Section investigates incident involving repairs to any vessel, break up of a vessel, cargo handling etc.	The Investigating Officer submits report to Director of Marine for serious or fatal accidents only. Director of Marine accepts or rejects findings/recommendations. No formal report is prepared in most cases.
Conduct of Fitness Inquiry	Director of Marine can initiate inquiry into conduct of Hong Kong certified officer for "unfitness, misconduct, incompetence or negligence whether or not an accident has occurred" [368]. Inquiry is conducted by a judicial officer. Person conducting the inquiry may cancel or suspend certificate of competency/licence or censure the holder.	A report is made to the Director of Marine.

Table 13.1: Accident and Incident Reports by the Hong Kong Marine Department

It is also important not to provoke immediate calls for action without careful consideration about the justification and potential risks associated with precipitate intervention.

As we have seen, a number of different reports can be made about the same incident. Preliminary reports must be revised in the light of a secondary investigation. Final reports are informed by any subsequent causal analysis but their recommendations must be revised as regulators reassess the utility of any interventions. Figure 13.1 presents an annotated flow-chart of the procedures that support the New Zealand Transport Accident Investigation Commissions analysis of maritime incidents [633]. The rectangles that are drawn with a double line are used to denote the various publication activities that form part of a single incident investigation. These include the formal delivery of the final report. They also include the distribution of preliminary drafts to the various individuals and groups that have an interest in the outcome of any investigation.

Figure 13.1 extend the New Zealand process model with timing information. The investigation should begin within twenty-four hours of an incident being reported. The safety commission that oversees all investigations should receive a preliminary report within three days and so on. The details of such estimates depend on the nature of the incident being investigated. As we have seen, high risk incidents may justify the allocation of additional investigatory resources. In general, however, such diagrams are useful because they provide a working schedule for investigators and regulators. They also provide an important overview for operators and even for the general public who may be keen to receive feedback about the course of an investigation. In order to validate such timescales, it is important for investigators to assess the amount of time that must be spent at each stage of the analysis. Few organisations take this as far as the US Federal Railroad Administration who have estimated that is should take two hours to write an employee confidential letter, five and a half hours to review each employee statement, five hours to devise a monthly list of injuries and illness and so on [235]. The key point is, however, that if timescales are published then there must be some means of determining whether or not they are met. If they are routinely missed then either additional resources must be committed to an investigation or more realistic timescales must be published for the various participants in an investigation.

13.1.3 Confidentiality, Trust and the Media

A host of social and contextual concerns also affect the dissemination of information about incidents. Confidentiality is arguably the most important of these issues. Many organisations are concerned to ensure that reports are only disseminated to those groups that are perceived to have a 'legitimate' interest in their contents. Operators and managers are encouraged to read incident reports while strenuous efforts are made to prevent the press, lawyers and even regulators from accessing the same documents. The sensitive nature of many incidents has also created situations in which organisations are willing to sacrifice some of the potential benefits from a reporting system in order to ensure that information about previous failures is not disclosed to these 'unauthorised' sources. The ultimate examples of this sort of behaviour involve companies destroying incident databases to ensure that lawyers cannot detect examples of previous failures that might indicate negligence in failing to prevent subsequent incidents. Less extreme measures include the use of computer-based access control mechanisms that restrict those documents that a user of the system can view without specific permissions.

Some industries have also suffered from a variant of the confidentiality and security concerns, mentioned in the previous paragraph. They have become the victim of 'spoof' incident reports that are intended to undermine public confidence in their products [98, 104, 107]. These are often created by disaffected employees, by competitors or by individuals with moral and political objections to particular industries. Within an organisation it is possible to exploit a range of technologies to ensure that an incident report has been produced by an authorised individual or group. For instance, electronic watermarking embeds a code within a file. This code is difficult to alter without corrupting the contents of the report but can easily be read by authenticating software to ensure the provenance of the ocument. If the watermark code is derived from the date at which the file was last edited then this approach can also be used to detect cases in which a report had subsequently been edited or 'tampered with'. It is less easy to deal with spoof reports that originate from outside

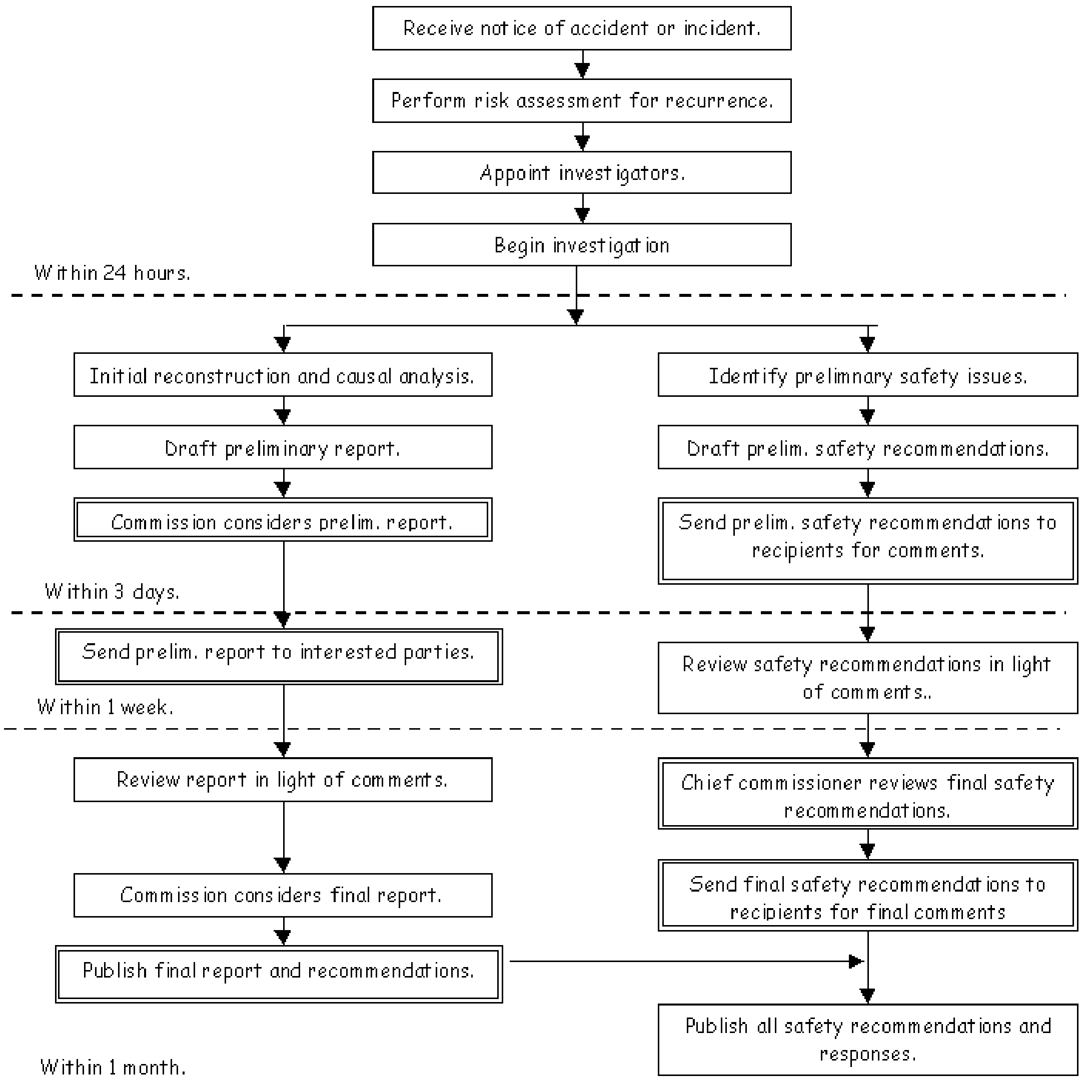

Figure 13.1: Simplified Flowchart of Report Generation Based on [633]

an organisation. In particular, it can be difficult for safety managers and public relations staff to respond to requests for information about incident reports that they know nothing about. This creates particular problems given the concerns to preserve confidentiality, mentioned above. Denials that an incident report has been produced can be interpreted as an attempt to cover up potentially damaging information.

Many incidents involve more than one organisation. Air Traffic Management incidents often stem from the interaction between different national systems. Similarly, maritime incidents can involve ships that are registered by different Sates. Each can independently produce reports into the same incident. In consequence, national and international regulators typically require some form of coordination that is intended to encourage agreement before a final report is disseminated to its intended recipients. This is illustrated by items 4 and 5 in the following section from the Marine Accident Investigators' International Forum's Code for the Investigation of Marine Casualties and Incidents. This code was adopted by IMO Assembly Resolution A.849 (2.0). The State conducting an investigation should invite other "substantially interested" States to:

1. "question witnesses;
2. view and examine evidence and take copies of documentation;
3. produce witnesses or other evidence;
4. make submissions in respect of the evidence, comment on and have their views properly reflected in the final report;
5. and be provided with transcripts, statements and the final report relating to the investigation." [389]

Unfortunately, such high-level guidelines provide little direct help if States are forced to resole any differences over the analysis of an incident.

The difficulties of drafting and disseminating incident reports are further complicated when these documents can contain commercially sensitive information. Previous sections have argued that previous failures provide important learning opportunities. There may be clear commercial benefits to be gained from not sharing these lessons with rivals in the same market place. Similar concerns can be seen within military 'lessons learned' systems where new insights about previous failures can provide direct operational benefits. In consequence, national and international initiatives often rely upon regulatory intervention to ensure that safety-related information is disseminated as widely as possible. This laudable aim raises further questions about the format and presentation of the information that is to be shared. Participation is such schemes often implies that local systems have to conform to the minimum data standards that ensure the consistency and integrity of the common dataset. At best, these national and international presentation requirements can be integrated into existing local formats. There are, however, instances when these wider requirements are perceived to impose unnecessary additional burdens [423]. It can also be argued that these requirements reduce the effectiveness of local systems if they prevent investigators from tailoring the presentation of particular information to their immediate audience. In consequence, many systems maintain multiple versions of an incident report. An internal version can be developed to provide readers with detailed information about the particular local circumstances that contributed to a failure. There may also be a more generic account that is provided to national and international regulators. These accounts supplement the aggregated statistical data about incident frequencies that are described in Chapter 14.5.

Several problems can arise from attempts to maintain 'separate' accounts of the same incident. Firstly, it can be costly to support the production, distribution and maintenance of these different versions of a report. This can involve the duplication of validation activities to ensure that each account conforms to different local and national requirements. There are also additional costs associated with the archiving and retrieval of each report. As we shall see, this can involve the development of two separate but linked information management systems. Secondly, it can be difficult to ensure that these separate accounts are consistent. Even if different accounts are maintained for the best of reasons, there may still be a suspicion that internal reports are 'clean-up' or 'sanitised' before being distributed more widely. This can be illustrated by incident reporting across European Air Traffic Management systems. In one example, the manager of a national reporting system knew that a colleague in a neighbouring country had been involved in the analysis of a high-criticality air proximity violation. He was then surprised to see that they did not report any high-criticality incidents in their annual returns to EUROCONTROL. Their colleague later demonstrated that the incident did not fulfill the requirements that EUROCONTROL publish for such high-criticality mishaps. National safety managers had increased the level of criticality associated with the event because it was perceived to offer a number of key insights for the systems operating in that country. Such examples illustrate how inconsistencies between local and national or international reporting systems can arise from the best of intentions. There are other instances in which they reflect the deliberate 'manipulation' of safety-related information.

This section has briefly introduced some of the problems that complicate the presentation of information about previous failures. Chapter 14.5, in contrast, looks at the complexities that arise when investigators must conduct statistical analyses of aggregate incident data. In contrast, the remainder of this chapter looks at some of the existing and proposed solutions to these problems that affect individual incident reports. The analysis is structured around three generic issues that affect all reporting systems:

- *how to structure the presentation of an incident report?*
  As we have seen, there are national and international guidelines on the information that should be included within an incident report. These guidelines are not, however, available for many industries. When they are available, for example within the field of aviation incident reporting [386], they typically only provide high-level guidance about what sections should be included. They do not provide the detailed advice that is necessary when investigators begin to draft detailed accounts of previous incident. This lack of guidance has resulted in a number of poorly formatted reports in which readers have to refer to information that is distributed across dozens of pages of analysis in order to gain a coherent overview of a particular mishap;

- it how to ensure the effective dissemination of incident reports?
  Previous sections have described how the tension between a need to distribute incident reports to the many different groups and individuals who can make use of them and the need not to jeopardise confidentiality. There is also a concern to restrict 'unauthorised' media intrusion. Other systems avoid these tensions by deliberately adopting an open distribution policy. This can create problems if contributors are reluctant to submit reports that can be seen by a broad audience. Irrespective of the overall dissemination policy that is adopted, investigators face considerable logistical problems in issuing and updating information about previous incidents. Increasingly, electronic information systems are being used to reduce the costs associated with paper-based distribution. These systems are often Internet based and come with a host of implementation issues that must be considered before such applications can effectively replace more traditional techniques. They dom, however, offer considerable benefits in terms of monitoring the rate at which incident reports are accessed by their intended recipients;

- *how to validate the presentation and dissemination of incident reports?*
  Many incident reporting systems have been criticised because too much attention goes into the elicitation of data and too little goes into the effective application of that data to avoid future incidents [702]. It is, therefore, critical that some means be found of validating the particular presentation and distribution techniques are used to disseminate the lessons of previous failures. This creates a host of problems. For example, Chapter 4.3 has described the Hawthorne effect that can bias the results that are obtained when users know that their actions are being observed [687]. In a similar manner, direct questions about the utility of incident publications can elicit responses that may not provide accurate information about their true value.

The importance of ensuring the effective dissemination of incident reports should not be underestimated. Unless employees are provided with authoritative information about previous failures then informal networks can grow up to exchange 'war stories'. These 'war stories' provide important learning opportunities because they often encapsulate users' experiences during adverse occurrences. Unfortunately, they often over-dramatise particular incidents [750]. They can also recommend potentially unsafe interventions that contravene accepted working practices. These informal accounts are also dangerous because they exist as a form of 'distributed knowledge' that exists outside the standard safety management procedures. There is no guarantee that all staff will be told the relevant anecdotes [344]. Nor is there any certainty that appropriate actions will be taken to resolve the underlying failures that lead to the adverse incidents that are described in these accounts.

It is important to identify the intended readers of a report before investigators decide upon an appropriate structure or format for the information that is to be presented. As mentioned in the previous paragraphs, the different recipients of an incident report will have different information requirements. Tables 13.2, 13.3, 13.4 and 13.5 illustrate how information-needs grids can be drawn up to support this analysis. A separate tabular form is produced for each participant in the investigatory process. As can be seen, we have initially focussed on regulators, executive officers of board members, safety managers and operators. In local systems, some of these tables might be omitted. Some of the duties associated with safety managers might instead be allocated to system operators and hence the information needs would have to be revised appropriately. In larger, more formal systems, it would be necessary to introduce additional tables. For example, we have already described important distinctions between the information that is required by national and international regulators. Similarly, distinctions between different types of operator might result in additional tables being introduced to reflect their differing information requirements.

Regulators	Reconstruction	Causal Analysis	Recommendations
Initial Report	An initial report of the events leading to the incident and an indication of the additional information sources to the analysed	A summary of the likely causes based on the initial report together with a preliminary account of any similar incidents. Several causal hypotheses are likely at this stage.	Any immediate measures to be taken in the aftermath of the incident.
Final Report	A detailed description of what happened during the incident together with explicit justification of that account citing the evidence to support each hypothesised event in the reconstruction.	A documented causal analysis using one of the recommended techniques introduced in previous chapters of this book. This analysis may be presented in natural language but should be supported by an appendix documenting semi-formal or formal reasoning.	A detailed analysis of the proposed recommendations describing what, when, who and how they are to be implemented (see Chapter 11.5).
Annual Summary	Reconstruction information may be omitted in a statistical summary or annual report. It should, however, be possible for regulators to work back from the items in the summary to the more detailed final report.	If a causal taxonomy is used, see Chapter 10.4, then the codes or identifiers for each causal factor should be included in the statistical returns.	If a recommendation taxonomy is used, see Chapter 11.5, the statistical analysis should include information about the correlation of those codes to causal factors.

Table 13.2: Generic Information-Needs Table for Regulators

Each information-needs table identifies the different documents that are used to disseminate information about an incident to a particular participant group. For instance, Table 13.2 denotes that regulators should receive an initial notification in the aftermath of an incident. They should also receive a copy of the final report and an annual summary of data about all incidents that have occurred. Of course, this is not an exhaustive list. Additional interim reports may be required in some industries. Similarly, Chapter 11.5 has argued that closer regulatory intervention can be required to monitor and validate the implementation of particular recommendations. These caveats illustrate the generic nature of the information contained in Tables 13.2, 13.3, 13.4 and 13.5. The rows in the table must be tailored to reflect the information needs of the particular participants that are being considered.

The columns of each table identify the information that should be included within each of the documents that are issued to a particular participant. The generic information-needs tables in this chapter reflect the distinctions that have been used to structure previous chapters. Information about the reconstruction of events is followed by a causal analysis. This, in turn, supports the presentation of recommendations. Again, however, additional columns can be introduced to reflect the more detailed information requirements that are specified in some industries. For example, Tables 13.2 to 13.5 might be extended to explicitly denote whether each document should contain information about mitigating factors or about the failure of particular barriers. Other document-specific information can also be included within these tabular forms. For example, Chapter 11.5 has argues that it is essential to devise a timescale for the production and delivery of information in the aftermath of an incident or accident. If this is not done then there is a danger that important safety measures will be delayed. There is also a danger that potential contributors will be disillusioned by the lack of progress in addressing safety concerns. Such timetable information can be introduced into as an additional column within an information-needs table. We have not done this because such refinements can jeopardise the tractability of the tabular format. This problem might be addressed by drawing up a different information-needs table for each document that will be provided to participants in the investigatory process.

Information-needs tables are intended to help investigators identify what information must be provided to each of the participants in an investigation. Each row of the table can be used to summarise the information that they must receive. It can also be used to explain the reasons why it is necessary to provide this information to regulators, executive officers, safety managers, operators and so on. The information that is contained in each of these tables can be used in a number of ways. For example, the simplest approach is to view each row as a specification of the information needs for a single document that is to be provided to a particular group of recipients. This technique would result in a final report being produced for regulators that was quite different from the version of the final report that is presented to executive officers. The former would focus more on the generic insights derived from the incident while the latter form might provide board members with more detailed information about particular local factors. Of course, any proposed differences between these versions of a final report would have to be approved by the intended recipients. Previous sections have mentioned the suspicions that can be aroused when the internal versions of an incident report is different from that delivered to a regulatory organisation.

An alternative application of information-needs tables is to use them to derive requirements for single documents that are intended to support different participant groups. This is done by identifying similar information needs that might be addressed within a single publication. For example, there are strong similarities between the information that 'final reports' are intended to provide to regulators, board members and safety managers. By collating the respective requirements into a single table, it is possible to construct a checklist that can be used to determine whether any proposed report satisfies the individual requirements of each group. If a draft report does not, for example, provide safety managers with enough information about the potential need for additional data logging techniques, then it can be redrafted to support these potential recipients. Alternatively, investigators might choose to split-off this participant and draft a separate report to satisfy their particular information needs.

No matter which approach is taken, the underlying motivation for these tables is that they focus the investigators attention on the recipient's information needs. If these are not considered early in the drafting of a report then there is a danger that individuals and groups may be denied important feedback about the course of an incident investigation. Conversely, there is a danger that some participants may be deluged by a large volume of apparently irrelevant information. Each table is

Board	Reconstruction	Causal Analysis	Recommendations
Initial Report	Executive officers within the organisation must be informed as quickly as possible about the course of events leading to an incident or accident. They must provide any necessary recourses to support a primary investigation and must coordinate any response to the media.	The causal analysis must summarise the preliminary findings but should stress any areas of uncertainty to ensure that precipitate action is avoided.	Initial recommendations should be presented in the form of a risk assessment or cost-benefit trade-off. The most plausible worst case costs and consequences of potential future failures should be summarised. The potential interventions should be identified together with any potential adverse 'side-effects' and their likelihood of preventing recurrence in the short to medium term.
Final Report	This should provide an executive summary of the events leading to an incident together with all of the information that will be provided to the regulator so that high-levels of management can respond to questions from the regulator if necessary.	The products of a causal analysis should be summarised together with references to the methods used and documentation that was produced. This is important if strategic decisions are to be justified by a detailed understanding of the mechanisms that led to previous failures.	The final report to executive officers must include a detailed list of recommendations. They must justify the allocation of resources that are required to investigate how to achieve the objectives that are specified in the recommendations section of any report.
Implementation Updates	Refer back to final report unless new evidence has been obtained.	Refer back to final report unless new evidence has been obtained.	Detailed information must be provided about attempts to validate the successful implementation of particular recommendations. This should include information from the statistical analysis of incidents and accidents that will be provided to the regulators, see Table 13.2, but will be provided to management on a more frequent basis.

Table 13.3: Generic Information-Needs Table for Executive Officers

Safety Manager	Reconstruction	Causal Analysis	Recommendations
Initial Report	The safety manager is responsible for overseeing the secondary investigation of an incident. They must be able to determine what is initially thought to have happened so that they can direct further investigation.	Initial reports from a primary investigation provide partial insights into the causes of an incident. They are, however, critical if safety managers are to allocate appropriate analytical resources. For instance, an initial causal analysis may indicate a need to provide human factors expertise or to consult with equipment suppliers.	Safety managers must safeguard systems in the aftermath of an incident. They must, therefore, consider ways of implementing those recommendations that they consider to be warranted.
Final Report	Safety managers will not only need to know the evidence that supports elements of a reconstruction, they also need to determine whether any additional logging or tracking equipment might be required to gather additional evidence about future incidents.	Safety managers must be able to determine whether or not similar causal factors have contributed to previous incidents. They may also need to assess the effectiveness of the analysis performed by their investigators, this may imply greater access to the supporting analytical documentation that is required by other parties to an investigation.	Safety manager coordinates the implementation of recommendations and so must be able to unambiguously determine the intentions behind particular proposed interventions. They must then initiate the process of determining how to achieve the recommended objectives. The safety manager will be responsible for producing the implementation reports that are passed to executive officers, see Table 13.3.

Table 13.4: Generic Information-Needs Table for Safety Managers

intended to tailor the provision of information to the particular needs of each recipient rather than allowing the provision of information to be determined by ad hoc requests.

After investigators have identified the information needs that are to be satisfied by particular reports, it is then necessary to consider the most appropriate more or form of presentation. The ‘mode’ of presentation refers to the medium of transmission. Most incident reports are printed, although an increasing number are being published using electronic media. Some reports continue to be delivered orally, especially in the immediate aftermath of an incident when participant must focus their attention on mitigating actions. For example, Section 67 of the Honk Kong Shipping and Port Control Ordinance requires that the owner, agent or master of a vessel to file an oral or written report within twenty-four hours of an incident occurring [367]. The format of a report refers to the content, structure and layout of information that is delivered by a particular mode. For instance, a written report may have to be submitted using an approved form. Alternatively, national regulations may simply specify the information that is to be provided without imposing any particular requirements on the particular form of presentation. For instance, section 80 and 81 od the Hong Kong Merchant Shipping (Safety) Ordinance states that the Director of Marine must be informed of any notifiable incident. This report does not have to be in a ‘prescribed format’, however, the form M.O. 822 “Report of Shipping Casualty” is ‘recommended’ [367].

Previous chapters have reviewed a range of different formats that can be used to support the

Operator	Reconstruction	Causal Analysis	Recommendations
Initial Report	Even in confidential systems, other operators may be aware that an incident has occurred. It is, therefore, often important to briefly summarise the events that led to the incident so that short-term action can be taken to prevent future recurrence.	An initial causal analysis may also be issued with the intended beneficial effect of reducing unnecessary speculation. This may, however, be premature in most cases.	The recommendations that are made in the initial aftermath of an incident must be limited by the information that is available to investigators and supervisors. It is important that no changes should be made that increase the likelihood of other forms of failure.
Implementation Report	It is important that operators receive feedback about the eventual outcomes of any investigation. This feedback is the single most critical factor in eliciting future contributions to most reporting systems. The feedback must provide a detailed account of what happened, this inevitably involves some compromise with the need to preserve confidentiality. Detailed accounts of what happened can be used to provide operators with the 'bigger picture' of events that they may not have witnessed during an incident.	Operators often form their own view of the causal factors behind an incident. These views may be modified or contradicted by the outcome of an official report. It is, therefore, important to justify particular findings. This must, typically, be done without the use of the semi-formal or formal techniques that supported an analysis given that most operators will have no experience of those techniques.	It is essential that operators understand the implications that particular recommendations have upon their working practices. They must not only be informed of what they must do and why, they must also be informed of the consequences of non-compliance and of proposed validation activities.

Table 13.5: Generic Information-Needs Table for Operators

presentation of information about particular aspects of an incident. For example, Chapter 7.3 has described how plans and maps can be used to supplement event based reconstructions of the events that contribute to particular failures and near-miss incidents. The same chapter also examined a range of photorealistic and model-based virtual reality techniques that have been specifically developed to support the electronic dissemination of information about particular events. In contrast, Chapters 9.3 and 10.4 have presented a number of formal and semi-formal approaches to causal analysis. These can play an important role in justifying the findings that are made in many final reports. Current documents have often been criticised because they lack any detailed justification of their causal findings [469, 426]. Why-Because graphs, ECF charts and MORT tables might all be used to format the presentation of information with particular reports. Similarly, Chapter 11.5 has introduced recommendation matrices, barrier summaries and risk analysis matrices that can all be used to document proposed interventions.

There is a tendency to satisfy the information requirements that are identified in Tables 13.2 to 13.5 using the products of those techniques that were used during the course of an investigation. For example, Table 13.2 argues that regulators must be provided with a detailed causal analysis as part of a final report. If investigators had themselves used ECF analysis to identify any causal factors then it would be relatively straightforward to use ECF charts within the body of their submission to national or international regulators. This would ignore the prime injunction to consider the recipient before drafting and disseminating any incident report. Within some industries, it may be entirely appropriate to exploit this semi-formal technique both to direct and document a causal analysis. In most industries, however, it would not be appropriate to expect that regulators would be familiar with this approach. In consequence, investigators must first ask whether or not the recipient of a document might be able to use any proposed form. If the answer is no, or might be no, then that form must typically be supplemented by the use of natural language descriptions. In many situations, it can be difficult for investigators to determine whether or not participants might exploit the semi-formal and formal techniques that have been explicitly developed to support incident analysis. Similarly, it can be difficult to determine whether electronic presentation techniques provide an adequate alternative to more conventional modes. The closing sections of this chapter, therefore, describe validation techniques which might demonstrate that MORT, ECF etc can satisfy recipients' information needs.

13.2 Guidelines for the Presentation of Incident Reports

The previous paragraphs have argued that both the mode and the format of incident reports must be tailored to the information needs of the intended recipients. If those recipients have limited access to computers then there are few benefits to be gained from attempts to exploit electronic presentation techniques. Conversely, if the intended recipients' usual mode of working requires on-line support then it can be particularly frustrating for them to search through, and maintain, archives of paper-based incident reports.

13.2.1 Reconstruction

Chapter 7.3 has considered the use of computer-based simulation techniques to support incident reconstruction. Chapters 8.3 has also described how investigators can exploit a range of graphical and textual notations to model the events leading to an adverse occurrence. This section looks at how investigators can communicate the products of this analysis to the wider audiences that were identified in the previous paragraphs of this chapter. In particular, we focus on the use of prose descriptions to describe the events that lead to near-miss incidents and adverse occurrences. This decision is motivated by the fact that Chapters 7.3 and 8.3 provide a detailed overview of graphical techniques. Subsequent sections in this chapter will also focus on recent advances in the use of computer-based techniques to support these prose reconstructions.

A number of constraints limit the extent to which investigators can tailor the presentation of incident information to support the particular needs of the intended recipients. In particular, they must ensure that each report satisfies any applicable national or international requirements. This can be non-trivial. For example, the AUSREP and REEFREP Australian maritime reporting systems both exploit a message format for submitting initial reports that complies with IMO Resolution A648(16) of 19 October 1989. The initial reports feed into systems that comply with the International Convention for the Safety of Life at Sea (SOLAS) Chapter V regulation 8-1, adopted by the IMO in 1996. The format of the reports derived from these systems must comply with the more recent IMO investigatory code [389].

National and international requirements often provide detailed guidance on the information that must be included in any reconstruction of an adverse occurrence or near-miss incident. For example, the reporting of maritime in incident in the UK is covered by the Merchant Shipping (Accident Reporting and Investigation) Regulations 1999. These require that the master of a vessel must send a report to the Chief Inspector of the MAIB using the quickest means at their disposal [349]. In any event, the report must arrive within twenty-four hours of the incident taking place. These initial reports must contain: the name of the ship and the vessel number or IMO identification; the name and address of owners; the name of the master, skipper or person in charge; the date and time of the accident. The report must also state where the vessel was from and where it was bound; the position at which the accident occurred; the part of ship where the incident occurred if on board; the prevailing weather conditions; the name and port of any other ship involved; the names, addresses and gender of people killed or injured. Finally, the initial report must also provide brief details of the incident, the extent of damage and whether it caused any pollution or hazard to navigation.

There can often be several different sets of applicable national and international regulations covering the dissemination of incident reports. It is possible to identify two different types of information requirement that are specified in these documents: declarative data and incident chronologies. Declarative data provides the contextual information about a system and its working environment. These details often 'set the scene' for incident chronologies. Textual and graphical time-lines focus less on the state of the system or environment prior to an incident. Instead, they focus more directly on the events leading to particular failures. The previous paragraph illustrated how the MAIB maintains relatively high-level requirements for this declarative and 'procedural' information. Other organisations have far more detailed requirements for the information that must be provided when reconstructing an incident. For example, the following list summarises the Marine Accident Investigators' International Forum [520] requirements that have been adopted by the IMO [389].

1. Particulars of voyage:
   Port at which voyage commenced and port at which it was to have ended, with dates; details of cargo and draughts (forward, aft and midships) and any list; last port and date of departure and Port bound for at time of occurrence; any incident during the voyage that may have a material bearing on the incident, or unusual occurrence, whether or not it appears to be relevant to the incident; plan view of ship's layout including cargo spaces, slop tanks, details of cargo, bunkers, fresh water and ballast and consumption.

2. Particulars of personnel involved in incident:
   full name, age, capacity on board and details of injury; description of accident; person supervising activity; first aid or other action on board; certificate of Competency/Licence: grade; date of issue; issuing country/authority and any other Certificates of Competency held; time spent on vessel concerned and experience on similar vessels and experience on other types of vessels experience in current capacity and experience in other ranks; number of hours spent on duty on that day and the previous days; number of hours sleep in the 96 hours prior to the incident; any other factors, on board or personal, that may have affected sleep whether smoker, and if so, quantity and normal alcohol habit together with information about any alcohol consumption immediately prior to incident or in the previous 24 hours; whether under prescribed medication and any ingested non-prescribed drugs and records of drug and alcohol tests.

3. Particulars of sea state, weather and tide:
   direction and force of wind; direction and state of sea and swell; atmospheric conditions and visibility; state and height of tide, in particular, the direction and strength of tidal and other currents, bearing in mind local conditions.

4. Particulars of the incident:
   type of incident together with date, time and place information; details of incident and of the events leading up to it and following it; details of the performance of relevant equipment with special regard to any malfunction; persons on bridge, in engine room and location of master and chief engineer; mode of steering (auto or manual); extracts from all relevant ship and, if applicable, shore documents including details of entries in official, bridge, scrap/rough and engine-room log books, data log printout, computer printouts, course and engine speed recorder, radar log, etc; details of communications made between vessel and radio stations, SAR centres and control centres, etc., with transcript of tape recordings where available; details of any injuries/fatalities; voyage data recorder information (if fitted) for analysis.

5. Assistance after the incident:
   if assistance was summoned, what form and by what means; if assistance was offered or given, by whom and of what nature, and whether it was effective and competent; if assistance was offered and refused, the reason for refusal.

It is important to emphasise that this is a partial list that is intended to be applicable to all types of incidents. Additional guidelines describe the more detailed information that must also be included when reports are submitted after groundings, collisions, fires etc. Such guidelines help to identify the information that should be included when documenting the events leading to an incident. They do not, however, provide detailed guidance on the format or mode of submission. As we have seen, the UK regulations simply require that masters make their initial report by the fastest means possible. The IMO's guidelines recognise that both initial and final reports can be submitted in a range of formats to be determined by the legal requirements of each State.

The IMO's requirements not only affect the initial information that must be reported in the aftermath of an incident. They are often used to guide the presentation of subsequence documents, including the final report. This can be illustrated by the Transportation Safety Board of Canada's report into the striking of a dock with an unloading boom from a bulk carrier [787]. The reconstruction of the incident begins with a section that presents background 'factual' information in a tabular format. This is illustrated in Table 13.6. This format illustrates how information requirements, such as those proposed by the IMO, can be proceduralised. The rows of the table act as a prompt to ensure that investigators provide necessary information.

ALGOBAY	
Port of Registry	Sault Ste. Marie, Ontario
Flag	Canada
Official Number	372053
Type	Self-unloading Bulk Carrier
Gross Tons	21,891
Length	222.51 m
Draught Forward: Aft:	8.05 m 8.11 m
Built	1978, Collingwood, Ontario
Propulsion	Two 10-cylinder Crossley Pielstick (10PC2-3V-400) diesel engines; 7870 kW total. Single controllable-pitch propeller and bow thruster.
Number of Crew	24
Registered Owner	Algoma Central Marine Sault Ste. Marie, Ontario

Table 13.6: Canadian TSB Tabular Preface to A Maritime Incident Report [787]

Such tabular summaries provide the contextual details that are required by national regulations, such as the Merchant Shipping (Accident Reporting and Investigation) Regulations 1999, and international guidelines, such as the IMO investigation code. They provide an overview of the technical details that are necessary in order for the reader to understand the nature of the vessel or vessels that were involved in an adverse occurrence. They also act as useful points of reference or aide-memoires that the reader can refer to as they consider a report. Rather than having to look through dense paragraphs of prose, it is possible to go back to this initial table as a reference point for information about the vessel and her crew. The example illustrated in Table 13.6 is relatively brief. Extended versions of these summary tables have been used in incident reports for other modes of transport. For example, the UK Air Accident Investigation Branch exploits a similar approach to record the registered owner of the aircraft involved in an incident, the operator, the aircraft type, the nationality of the operators, their registration, the place, date and time of the incident [15]. They use a similar tabular format to summarise information about the operators who are involved in an incident. These tables include the sex and age of the individual, the status of any operating licence, their rating, medical certification, the start of any relevant duty period, the time of their previous rest period and so on.

Such tabular forms help to structure the presentation of information that must be present if an incident reports is to conform to particular industry guidelines. They are declarative representations.

The facts that they describe, typically, hold throughout an incident. They cannot easily be used to describe more dynamic aspects of an incident. Table 13.6, therefore, illustrates a common means of prefacing more detailed reconstructions of a near-miss incident or adverse occurrence. Natural language descriptions are used in most reports to describe the way in which particular events contributed to an incident. This can be illustrated by the paragraphs that follow Table 13.6. A section entitled 'History of the Voyage' follows this summary. It describes how the vessel departed Superior, Wisconsin, at 17:10 eastern daylight time on the 7th June 1999 carrying a cargo of 26,137 tons of coal. The opening sentences of the narrative, therefore, satisfy more of the information requirements specified in the IMO's code. Unlike the contextual information that is summarised in the tabular format, illustrated in Table 13.6, this information is integrated into the description of the incident. As mentioned, it can often be difficult to locate such necessary information in large sections of prose. It is, therefore, important that check-lists be developed so that investigators can ensure that a report satisfies national and international requirements prior to publication.

After having presented the contextual information summarised above, the report goes on to describe the events immediately preceding the incident. As with most incident reports, a discussion of more latent causes is postponed until the analysis sections. The narrative is often presented in as simple a form as possible. There is an attempt to minimise any additional commentary on the significance of particular events. This too is postponed until the subsequent sections of analysis. This is an important strength of many incident reports because the readers' interpretation of particular events is not biased by a premature commentary. Equally, however, it can be difficult for readers to determine which events in a narrative will turn out to have a critical significance for the causal analysis and which are introduced to provide additional background. For instance, the following quotation presents the subsequent sections of the 'History of the voyage' section in the Transportation Safety Board of Canada's report. It is difficult to determine whether the unscheduled maintenance will or will not play a significant role in the course of the incident until readers complete the remaining paragraphs:

> "On the morning following departure, as the vessel crossed Lake Superior, the chief engineer, with the authorisation of the master and shore management, shut down the port main engine for unscheduled repairs. At 17:45, the vessel advised Vessel Traffic Services that the passage through the locks at Sault Ste. Marie and the St. Marys River would have to be conducted with one engine. Permission was granted by the United States Coast Guard and Sault Ste. Marie harbour master. Before arriving at the Sault locks, the vessel had developed a one and one-half degree list to port. Concerned with low water levels in the St. Marys River and the 10 cm of extra draught the list would have created, the master ordered the second officer to lift the unloading boom and slew it to starboard as the vessel departed Poe Lock at 0225 on June 9. In doing this, it was hoped that ballast water remaining on board in the No. 3 port ballast tank would be displaced to starboard and the list corrected. As the boom was being lifted from its saddle, it began swinging to port. Despite attempts by the second officer to check its movement with the slewing controls, the boom accelerated outwards until it contacted the front of the accommodation at an angle of 90 degrees to the vessel." [787]

At first sight, it would appear that the unscheduled maintenance is no more than a contextual detail. Investigators mention it in the report because it represents an unusual event that took place before the problems with the boom. In subsequent paragraphs, however, the reader learns that as soon as the boom began to hit objects on the shoreline the master put the engine to 'full astern'. Unfortunately, this overloaded the single remaining engine. The watchkeeping engineer, therefore, informed the master that he would have to reduce power. The master eventually arrested the vessel's forward motion by ordering the lowering of the stern and both bow anchors. This illustrates the manner in which the unscheduled maintenance removed a potential barrier, the main engine, that might have prevented further damage once the incident had begun. This argument is not explicitly presented in the incident report until the analysis section. In consequence, it is very easy for readers to overlook the significance of the maintenance event even as they read about the problems of putting the remaining engine 'full astern'. As mentioned, this technique avoids prejudicing the reader. By separating the reconstruction and the analysis, individuals are encouraged to form their own hypotheses before reading the investigators' interpretation. On the other hand, this approach can be deeply frustrating. During recent interviews, a safety managers referred to the 'Perry Mason' or 'Agatha Christie' style of incident reporting. The reader never understands the true significance of a particular event until they read the final pages of a report. As a result, they must re-read the report several times in order to identify the way in which the elements of a reconstruction contribute to a causal hypothesis.

A Structural Analysis of Incident Reconstructions

There are a number of different ways in which investigators can structure their presentation of the events leading to an incident. For example, they can use prose accounts to summarise the elements of graphical time-lines such as those introduced in Chapter 8.3. This approach describes events in the order in which they occurred during an incident. Alternatively, investigators can exploit a more thematic approach in which the time-line leading to a failure is described from one particular perspective. Subsequent paragraphs then go back to the beginning of an incident to present the flow of events from another perspective. These different approaches have a number of strengths and weaknesses. For example, readers can easily trace the ordering of events if they are described in the order in which they occurred. This can, however, create a false impression. The reader is presented with a global view of all the events that occurred across a diverse system for each point of time. The participants in an incident, typically, would not be in such a fortunate position. Further problems affect the use of more thematic approaches. If investigators describe the course of events from particular perspectives then it can be difficult for readers to piece together an overview of the concurrent failures that often characterise many incidents. The following list, therefore, summarises these different techniques for structuring the presentation of a prose reconstructions:

- *a single chronology*;
  As mentioned, this approach simply reconstructs the time-line leading to an incident. Each significant event is described in chronological order. This provides a relatively simple overview of an incident. An important benefit of this approach is that readers can quickly scan the text to identify what events occurred at any particular point in time. This scanning is facilitated by using time-stamps as marginal notes that can act as indices into particular paragraphs:

08:00	repairs were begun; however, while removing the cylinder head from the engine, it was discovered that a cylinder head stud was broken and would have to be replaced.
08.30 (est.)	The chief engineer, who had previous experience with this type of repair, informed the master of the situation and revised his estimated completion time upwards to 24 hours.
...	...
20:00	the head tunnelman reported to the chief engineer that he had finished raining and cleaning the hydraulic system. The chief engineer indicated that, be cause the head tunnelman was unfamiliar with the procedure to bleed the air from the hydraulic system, he decided to wait until daylight the following morning.

  The limitation with this approach is that events from many diverse areas of an application process can be listed next to each timestamp. This can create problems because these entries will not be uniformly distributed over time. This implies that for any particular system, there may be relevant information scattered across many dozens of paragraphs. This imposes considerable burdens upon readers who want to piece together what happened to a particular subsystem or operator.

- *a single chronology with backtracking*;
  A number of further problems affect the use of single chronologies to structure the presentation of any incident. As we have seen, catalytic and latent events are not uniformally distributed across the time-line of an incident. Typically, initial failures may lie dormant until a number

of triggering conditions defeat any remaining barriers. This creates problems because it can be difficult for readers to gain an overview of an incident. An initial description of the latent failures can quickly become swamped by the mass of details that typically accompany any presentation of catalytic failures. Many investigators have responded to this problem by starting the reconstruction of an incident with a brief overview or summary of the events leading to a failure or near miss. Subsequent paragraphs then go back to the start of the catalytic failures to examine those events in greater detail. The Transportation Safety Board of Canada's report exploits this approach. The initial summary, presented in previous paragraphs, is followed by a more detailed reconstruction of the engineering and maintenance activities during the incident:

> "At 0800 on June 8 the repairs were begun; however, while removing the cylinder head from the engine, it was discovered that a cylinder head stud was broken and would have to be replaced. The chief engineer, who had previous experience with this type of repair, informed the master of the situation and revised his estimated completion time upwards to 24 hours. As the work would be conducted near the running starboard main engine, the chief engineer suggested that the vessel be stopped in Lake Superior for the duration of the repair. In consultation with the master and chief engineer, the company engineering superintendent decided that the vessel should proceed towards Sault Ste. Marie in case further shore support was needed for the repairs. During the previous sailing season, the vessel had operated for several months on one engine, including during passages through the American locks at Sault Ste. Marie..." [787]

This is intended to provide readers with the contextual framework, including latent failures and mitigating factors, that is necessary to understand the significance of particular catalytic events. Unfortunately, this approach also suffers from a number of limitations. In particular, the use of a more detailed chronology for catalytic failures can reduce the amount of attention that is paid to latent failures. This potential bias is often countered by reports that devote most of the subsequent analysis sections to the longer-term causes of an adverse occurrence or near-miss incident.

- *multiple thematic chronologies*;
  Previous chapters have attempted to distinguish between incident reconstruction, which explains what happened, and causal analysis, which explains why an incident occurred in the manner that it did. These distinctions have been maintained because they are, typically, reflected in the structure of most incident reports. An initial discussion of the events leading to a failure are then followed by a discussion of the causes of those events. These distinctions can, however, become blurred in some reports. For example, some accounts are structured around several different chronologies. These time-lines each reflect a particular analytical approach to the incident. For example, an account of the human factors failure may precede a description of the events that contribute to any system failures. The subsequent analytical sections in the incident report are then used to 'weave' together the individual events that are included in these different chronologies. An explanation of systems failure may be given in terms of human factors issues, or vice versa. This approach has much to recommend it. The individual chronologies can be used to demonstrate that analysts have considered a suitable range of potential causal factors before performing their analysis. The causal analysis, in turn, provides an explicit means of unifying these disparate accounts. There are, however, a number of problems with this approach. It often makes little sense to provide a chronology of operator actions without also considering the system behaviours that they were responding to and were helping to direct. Their are logistical problems in ensuring consistency between these multiple chronologies. It can also be expensive to recruit and retain the necessary technical expertise to construct these different perspectives, especially in small-scale local systems.

- *multiple location-based chronologies*;
  A variation on the previous approach is to present different chronologies that record the events taking place within particular locations or subsystems during an incident. For instance, the

report can describe the events on the bridge before describing what happened in the engine room. This approach provides readers with some impression of what happened to individuals and systems within that particular location. It avoids the false 'global' view that can often makes readers wonder why operators did not intervene to rectify what to them is an 'obvious' problem. There is, however, no guarantee that readers will avoid this potential pitfall even if location-based chronologies are used to structure a report. Each successive account contributes to their understanding of an incident. The cumulative insights that can be obtained from reading each of these accounts would clearly not have been available to operators or line managers. There are also more pragmatic problems. It can be difficult to ensure that these different accounts are consistent with each other, especially when materials and other forms of communication pass between different locations. A common flaw in this form of incident report is to find that a message has been sent from one location but that its receipt is never mentioned in subsequent descriptions. In such circumstances, the reader cannot easily determine whether the message was never received or that it did arrive and the investigator simply omitted to mention its receipt in their reconstruction.

This is a partial list, investigators have used a number of hybrid techniques that draw from several elements of this list. Many reports also combine textual chronologies with some of the graphical and diagrammatic reconstruction techniques that were introduced in Chapters 7.3 and 8.3. Subsequent sections of this chapter will describe how these combined approaches have recently been combined to support the on-line publication of incident reports. For now, however, the key point is that investigators must consider the consequences that prose chronologies have upon the intended recipients of the report. If an extended single chronology is used then investigators can help readers to navigate a reconstruction by providing timestamps as marginal indices and by using different paragraphs to describe concurrent events in different areas of the system. If investigators do not consider the potential weaknesses of these formats then there is a danger that the resulting document will fail to support the various user groups that have been identified in previous paragraphs.

The task of reconstructing an incident does not simply depend upon the chronology that is developed. Investigators must also determine what to include and what to omit from any reconstruction. The following list summarises potential guidelines that might be used for determining what information should be included in a reconstruction:

1. *is the information required by regulators?*
   Bodies such as the IMO enumerate the information that must be provided in many incident reports. These requirements typically focus on declarative data about the type of system that was involved in an incident. It can be difficult to identify a suitable format with which to present this information. The statistical nature of much of this data lends itself to tabular formats rather than the prose descriptions that are used in other sections. They also focus on gathering information about the catalytic events leading to a failure.

2. *is the information necessary to understand catalytic events?*
   Chapter 9.3 has shown how ECF analysis can proceed by reconstructing the flow of events back from the point at which energy was 'transferred'. Conversely, investigators might use P-Theory to work forward from the first event that deviated from the normal pattern of operation. In either case, there is a focus on the catalytic events that contributed to an incident. It may seem to be relatively straightforward to present this material. The previous paragraph has, however, summarised the problems that arise when concurrent interactions can contribute to the course of an incident.

3. *is the information necessary to understand latent events?*
   We have also argued that it is important to understand the longer-term factors that contribute to an incident. For example, Chapter 2.3 described how systems may not be in a 'normative' state for many years. For example, working practices can evolve to remove important barriers. This creates considerable problems for the investigators who must determine how best to present this material. If a linear chronology is used then it may not be easy for readers to understand how an apparently insignificant event contributed to an eventual incident. The

significant of that description may only emerge many dozens of pages later. Alternatively, if backtracking is used then the latent events can be described together with more immediate 'triggering' conditions. As we have seen, however, such techniques can provide a perspective that was not available to operators at the time of any failure.

4. *is the information necessary to support the narrative of other events?*
   Some events are included not because they are essential to the readers' understanding of an incident but because they link other more important events. These events can create considerable confusion. For instance, many investigators maintain the distinction between analysis and reconstruction by separating them into different chapters of a report. In consequence, it can be difficult for readers to distinguish between these 'filler' observations and latent or catalytic events. They can, therefore, help to spark alternative causal hypotheses that must be explicitly rejected in any subsequent analysis if readers are to be satisfied by the investigators' interpretation of events.

5. *is the information necessary to eliminate certain hypotheses?*
   One means of restricting the number of putative hypotheses that might be evoked by any reconstruction is to explicitly provide information about events or conditions that were not apparent during an incident. For example, investigators often begin a reconstruction by providing information about the prevailing weather conditions. If they were bad then readers are informed of a potential cause of any failure. This information is, however, also included for incidents that occur under favourable conditions so that readers can better interpret the subsequent chronology. Such techniques must be used with care. It can be argued that in seeking to inform the readers' interpretation of key events, investigators may be introducing an unwarranted bias into their accounts of an incident.

6. *does the information describe a failed barrier?*
   Investigators often decide to provide information about the protection mechanisms that were intended to protect a system and its operators. These events often stand-out from reconstructions because they describe how cross-checks were not made. They may also describe decisions that were contradicted or countermanded to achieve particular operational goals. As with the previous items in this list, the presentation of such information can create certain problems for those who must draft incident reports. Many chronologies describe these checks without explicitly stating that this was an opportunity to protect the system from a potential failure. This is an appropriate approach because the reconstruction of what happened is separated from the causal analysis of why it happened in that way. Equally, however, it can lead to disjointed accounts where catalytic events are interrupted by accounts of apparently insignificant conversations between key personnel. It may then take many pages before readers learn that these conversations might have prevented or mitigated the consequences of the incident.

This is a partial list. Chapters 7.3 and 8.3 present further requirements for the information that must be considered by any reconstructions. These requirements can also inform the presentation and dissemination of information to the readers of incident reports. For instance, investigators must extend the scope of any reconstruction to include remedial or mitigating actions. We have not extended the list to explicitly include these items because they have already been addressed in the previous chapters. In contrast, the items in this list describe the issues that must be considered when presenting particular elements of a reconstruction. For instance, it can be difficult for readers to understand the role that a latent failure can play in an incident if it included in a reconstruction without any supporting explanation. The elements in this list also help to highlight a number of more general issues. For example, investigators may decide to separate analysis from reconstruction in the manner recommended by the previous chapters of this book. This does not, however, imply that readers will simply switch off their analytical skills as they read a reconstruction and then switch them back on again as they start the section labelled 'analysis' or 'findings'. For example, it is tempting to interpret any situation in which an individual questions the safety of an operation as a failed barrier. A reader who forms this belief while reading the reconstruction of an incident may retain this impression even if subsequent sections do not consider the event any further and if the operation has little influence on the outcome of an incident.

A Case Study in the Literary Criticism of Incident Reports

The following paragraphs use a report that was drafted by the ATSB to illustrate some of the issues raised in the previous paragraphs. This case study was chosen because the investigators exploit a simple single chronology with limited backtracking. It, therefore, exploits a relatively simple narrative structure. s will be seen, the form of analysis that is applied to this incident report resembles the techniques that are used in literary criticism. This is entirely intentional. It is important to recognise the prose techniques that investigators often implicitly exploit when drafting their reconstructions of adverse occurrences. As we shall see, these techniques often have an important impact upon the readers of an accident report. The report concerns a stability problem that affected a merchant vessel, the Sun Breeze. The reconstruction begins with a textual summary of the declarative information that was provided Table 13.6 in previous incident reports:

> "The Panama flag Sun Breeze is a 11,478 tonne deadweight general cargo vessel, owned by NT Shipping SA. It was built in 1998 by Miura Shipbuilding Co Ltd of Japan and is classed with ClassNK (Nippon Kaiji Kyokai). The vessel was delivered to the owner on 9 February 1999, six months prior to the incident. Sun Breeze is 109.30 m in length overall, has a beam of 19.8 m and a summer draught of 9.264 m. Propulsive power is delivered by a seven-cylinder Akasaka diesel engine developing 5,390 kW driving a single fixed-pitch propeller and providing a service speed of 13.5 knots..." [52]

This declarative summary continues by describing the dimensions of the vessel's holds and its ballast capacity. It also described the previous expertise of the crew. For example, the master 'had sailed as mate for five years on general cargo ships, log carriers and bulk carriers and had 22 years experience in command of various vessels, mainly bulk carriers' [52]. The reconstruction then goes on to describe how 'no untoward incidents' were reported on previous voyages between Japan and Indonesia, Singapore, Malaysia and Thailand. The report then focuses on the chronology of events leading to the incident. The master received a fax from the charterers of his vessel on the 2nd August. His voyage instructions were to load a minimum of 10,000 m^3, 'up to the vessels full capacity' of jarrah and karri... The instructions also described how there were approximately 650 packs of 4.2 metre lengths of timber, 650 packs of 3 metre lengths, 20 packs of 4.5 metre lengths and 820 packs of 6 metre lengths. The master calculated that this would require some $14,354m^3$ without any allowance for broken stowage [52].

Previous paragraphs have considered how the Sun Breeze case study satisfies the declarative requirements imposed by the IMO. The opening pages of the narrative describe the vessel, its crew, the cargo and the nature of the proposed voyage. The report then goes on to trace latent communication problems between the master and the company that was chartering his vessel. He tried to find out if they wanted to load the minimum agreed figure of 10,000 m^3? If so then the entire cargo could be loaded underdeck. If not then did they want to load the 14,354 m^3 of cargo in the instructions? The shippers acting on this presumption had prepared to load about 15,000 m^3 of cargo. This would exceed the vessel's bale capacity. The charterers replied by noting that the cargo had been fixed with them on the basis of lump sum freight and that the vessel had been accepted. This illustrates the way in which the ATSB investigators use the preliminary paragraphs to reconstruct the situation that was faced by the master of the Sun Breeze before he commenced the loading of his vessel. This is important because it enables the reader to follow the way in which the context for an incident developed from its initial stages. Readers are informed of the relationship between the charterer and the master. He voiced his concerns but was ultimately reminded of the contract that he was expected to honour. His concerns were also partly addressed by the development of a loading plan that met the charterer's requirements. It is also important to note that, although the opening sections of the chronology provide important information about the context in which the incident occurred, they only hint at the events that eventually threatened the safety of the vessel. It would surprise the reader to find that the incident did not involve the way in which the cargo was stowed on-board the Sun Breeze. Equally, however, the opening paragraphs provide few cues about the eventual nature of the incident. This narrative technique avoids the problems associated with reconstructions that provide information that could not have been available to the participants in an incident.

The report follows a simple, single path chronology. The background events, mentioned above, are followed by an account of the more immediate events that led to the incident. The Sun Breeze arrived at Bunbury at 23:24 on 15 August 1999. Subsequent paragraphs describe how loading commenced at 09:00 on the 16th August. It is important to emphasise, however, that many incident reports exploit a number of different chronologies. For example, the ATSB's reconstruction goes on to develop a multiple, location-based chronology. The report surveys the operations to load the cargo. While this was going on, the report also describes how the third mate took various steps to improve on these operations. Previous paragraphs have mentioned the burdens that this can impose upon readers. It can be difficult to reconstruct the time-line of events that led to an incident if individuals must piece together the partial orderings of multiple chronologies. This problem is often apparent in the marginal notes that are made by the readers. For example, printed incident reports often contain informal sketches and time-lines that individuals have made to help them keep track of the parallel events that are described in the sequential accounts of prose reconstructions.

Previous paragraphs have argued that readers cannot simply disengage their critical and analytical faculties as they read the reconstruction section of an incident report. In consequence, there is a continual temptation to filter and analyse the information that is presented in any account. This can be illustrated by the following paragraph from the ATSB's report. At one level, it describes how the ship's master managed to convince the harbour master that he knew how to address any stability concerns. At another level, the same prose can be interpreted as describing the failure of a barrier that might have prevented the incident. Previous paragraphs in this chapter have described a number of reasons why investigators might include particular information in an incident report. It is important to recognise that a careful reading of such documents will yield not only the basic event structure in any reconstruction but also the investigators intentions behind the presentation of particular information:

> "Between 06:00 and 09:00 that morning, after loading had been completed, the harbour master noted that the ship initially had a list to starboard of about 4 degrees. It then had port list of about 4 degrees before becoming upright. He became concerned about the vessels stability... The harbour master went on board Sun Breeze at about 15:00 to discuss the vessels stability with the master. The ship was upright then and the harbour master recalled the master saying that he was going to transfer fuel oil from high tanks to low tanks to provide additional stability. The master gave the harbour master a copy of the stability calculation for the vessels departure condition, indicating that the GM, after correction for free surfaces effects in tanks, was 47cm. The harbour master asked the master how he knew what the weight of the cargo was and whether the packs of timber were marked with weights. The master said that the packs were not marked with weights and that he had estimated cargo weights by draught survey. The masters reply gave the harbour master the impression that the master knew what he was doing." [52]

Investigators have clear intentions when they introduce such narratives into incident reconstructions. They describe how a potential barrier, provided by the harbour master's stability checks, were circumvented. The question that this paragraph raises is whether or not the intended audience for a particular report would be able to identify this intention as they read the narrative reconstruction. The previous sections of this book have introduced accident and incident models that provide semantics for terms such as 'barrier', 'target', 'event', 'condition' and 'catalytic failure'. These concepts form part of a vocabulary that many readers of an incident report will not have acquired. This has important consequences. Some readers will be able to interpret the intention behind particular elements in a reconstruction. Other readers of the same document may view them as random observations that seem to contribute little to the overall report. These individuals may require considerable help in the subsequent analysis if they are to filter the mass of contextual information and 'filler' events to identify key aspects of an incident. The closing sections of this chapter will describe a range of validation techniques that can be used to determine whether or not such differences can jeopardise the effective communication of safety information within an incident report. As we shall see, however, these techniques have not been widely applied and there is little empirical evidence about individual differences in the interpretation and analysis of incident reports.

One of the key problems in reading an incident reconstruction is that it can be difficult to distinguish key events from the mass of background detail that investigators often include in their accounts. As mentioned, these background details include contextual information that is necessary to establish the circumstance in which an incident occurred. They also include the less important 'filler' events that link together other more significant aspects of an incident. This can be illustrates by the ATSB's description of the events that occurred immediately after the Sun Breeze left Bunbury. The first sentence can be described as a filler; 'When the harbour master disembarked at 18:15, he returned ashore and drove back to the wharf where Sun Breeze had been berthed, watching the ship'. The second sentence provides important information that must be supported by interviews that were conducted after the incident had occurred; 'he had some lingering concerns about the vessels stability but, when there seemed to be no problems as the vessel proceeded outbound, he returned home'. Readers face a number of further problems in anticipating what will and what will not turn out to be key elements of any reconstruction. For example, the same paragraph in the report continues; 'the vessel was being set to the east by the tide and he adjusted the course to 335 degrees, using about 5 or 10 degrees of port rudder to do so'. It is difficult to determine how important the bearings will be for the subsequent analysis of the incident. An initial reading cannot determine the significance to attach to the change of course. One consequence of this is that the reader of an incident report often have to read reconstruction sections several times after having read a subsequent analysis in order to understand how particular events contributed to an eventual incident [750].

The previous paragraphs in this section have presented a *structural analysis* of the ATSB report. For instance, we have shown how this document exploits several different chronological structures. A single linear thread can branch into consecutive accounts that each depict parallel events in different locations. It has been argued that this can impose significant burdens on the reader of an incident report who must piece together these accounts in order to derive an overview of the events leading to a near miss or adverse occurrence. Similarly, we have identified some of the problems that can arise from the usual practice of presenting a reconstruction before any causal analysis. Some readers may be forced to re-read narrative accounts several times before they can place key events within the time-line of an incident. We have also argued that it can be difficult to entirely separate analysis from reconstruction. A careful reading of an incident reconstruction will not only provide information about the 'flow' of events, it can also reveal the investigators' intentions behind the presentation of particular events. This structural analysis should not obscure the importance of the prose that is used in any reconstruction. Investigators must tailor their use of language so that readers can clearly follow the flow of events. It is important that the prose should not over-dramatise the incident by adding literary effects that do not contribute to the exposition. The ATSB avoid this potential pitfall and provide a valuable example of the precise and concise use of language to describe what must have been an 'extreme' situation:

> "The 3rd mate changed back to manual steering and ordered 10 degrees of port helm to bring the vessel back on course. At this time, the vessel started listing to port. The mate, who was on the bridge at the time, told the 3rd mate to telephone the master. The masters phone was busy so the 2nd mate went below to call him. When the mate was on his way to the bridge to take over the watch, he noticed that the vessel was taking a port list. He thought that the vessel might have taken a 15 degrees list but, by the time he got to the bridge, the vessel was coming upright again. He telephoned the master asking him to come to the bridge, after which the vessel took a starboard list. When the master returned to the bridge the list was about 15 degrees or 20 degrees to starboard. He stopped the engine. The rudder was amidships but the vessel was still turning to starboard. The list continued to increase as the vessel turned slowly. The ship attained a maximum list of about 30 degrees to starboard before it reduced to about 25 degrees.

> At about this time, lashings on the cargo on no. 1 hatch top released when securing clips opened and nine packs of timber were lost over the side." [52]

The prose that describes subsequent events also exhibits this sparse but effective style. It also provides further examples of the way in which a single chronology will branch at key moments during an incident. In particular, the report uses consecutive parallel chronologies to describe the remedial actions on shore and on-board the vessel. The basic structure is further complicated by the use of consecutive time segments. In other words, an initial paragraph describes how a distress broadcast was received by a volunteer group who, in turn, triggered the response on-shore. A subsequent paragraph then describes the crews' actions while the police and harbour master were coordinating their efforts. A further paragraph then resumes the account of the shore-side activities. This technique is similar to the way in which movie directors frequently cut between parallel streams of 'action'. It is, however, a difficult technique to sustain throughout the many pages of prose narrative that can are presented in many incident reports. As in many films, the different strand of activity that we have termed 'chronologies' are brought together by joint efforts to resolve the incident: The harbour master drove to the pilot boat and eventually helped to coordinate the use of the tug Capel to disembark some of the Sun Breeze's crew. A single chronology is then resumed as the report describes how the master reduced the list to about 5 degrees by altering the ballast in the vessels tanks. A surveyor joined the Sun Breeze and performed more detailed stability calculations. These identified problems both in the previous assumptions that had been used by the crew and in the factors that had been included in their calculation. The vessel eventually berthed again at Bunbury, where the cargo was secured and some of the packs were removed; 'the vessel sailed at 2005 on 25 August for the discharge port in China, arriving there at 0600 on 10 September 1999 without further incident' [52].

Less Detailed Reconstructions...

The directness of the prose style that is used in the ATSB report is even more important for incident reports that summarise less critical failures. These documents may be limited to a few brief paragraphs that must not only reconstruct the events that led to the incident but must also document any analysis and summarise the subsequent recommendations. Space limitations are not the only constraint that complicates the task of drafting these less formal accounts. The national and international requirements, listed in previous pages, do not apply to the less 'critical' failures that may only be reported to internal company schemes. Greater diversity is permitted for incidents which are perceived to offer a relatively low risk from any potential recurrence. A report into a minor workplace injury need not record the position of the captain and the chief engineer, as required under the IMO guidelines that were cited in previous paragraphs. Similarly, the information that is required in any reconstruction is also tailored according to the audience. The exhaustive lists of information requirements compiled for the UK MAIB and the IMO are intended to ensure that national and international regulators can access necessary details. This amount of contextual information is often irrelevant to the masters, operators and employees who must endeavour to avoid future incidents. Investigatory agencies, therefore, do not include all of the informations that is provided in a final report to them when they disseminate accounts of an incident or accident to the industry that they protect. This point can be illustrated by the summary reports that various agencies have published to disseminate information about previous incidents These documents strip out much of the contextual information and what we have described as 'filler' details to focus in on particular hazards. As can be seen, four sentences are used to reconstruct the near-miss incidents. The investigators also summarise the recommendation to ensure that fuel containers are separated from potential ignition sources and secured to prevent shifting:

> "Portable space heaters are frequently utilised on-board vessels in this fishery to warm divers and to keep sea urchins from freezing. Coast Guard personnel have observed, at sea, a number of fishing vessels using these portable heaters while also carrying portable fuel containers, including those used to carry gasoline for outboard engines. If gasoline or other flammable liquids are carried on-board a vessel it is critically important to ensure

> that these items are well separated from any potential ignition sources and secured or lashed in place to prevent shifting. Accidental spillage of any flammable liquid, especially gasoline, in the vicinity of an open flame source can result in a catastrophic fire that will quickly engulf a vessel." [828]

Such brevity and directness is achieved at the cost of much of the detail that is provided in the previous example of the Sun Breeze report. Relatively little is said about the range of heaters and storage devices that were observed on the vessel. Nor do the Coast Guard state whether or not they saw any particularly hazardous uses of space heaters and fuel storage containers. It can be argued, however, that such details are irrelevant to the intended readers of this account. The Coast Guard have identified a generic problem based on their observation of previous incidents. The recommendation is also suitably generic so that individuals can apply the advice to guide their daily operations.

It might appear from the preceding discussion that the level of detail that is provided in any reconstruction should simply reflect the nature of the incidents that are being reported on. The Sun Breeze was an inherently more complex incident, involving potentially greater risks from any recurrence than the 'simpler' problems observed by the US Coast Guard. The ATSB could have summarised the previous incident in a few lines; 'various communications failure contributed to a failure to correctly load the cargo, this ultimately compromised the stability of the vessel'. Such a summary would strip out necessary information so that readers would have little opportunity to gain the many insights that the investigators derived from their more detailed reconstruction of this incident. Conversely, 20-30 pages of reconstruction could have been devoted to the reconstruction of previous incidents involving the storage of flammable substances on-board oyster boats. It is far from certain that such a detail analysis would contribute much beyond the existing summary [828].

It is, however, too superficial to argue that the nature of an incident determines the depth of any reconstruction. A number of additional factors must be considered when investigators decide how much detail should be introduced into a reconstruction. In particular, Chapter 1.3 identified the tension that exists between the need to provide sufficient contextual information for operators to understand the ways in which an incident occurred and the potential problems that can arise if a report threatens the anonymity or confidentiality of a submission. If too many details are provided about the context in which an incident occurred then the readers of a report may be able to infer the identify of the person who originally instigated a subsequent investigation. Conversely, if too few details are provided then operators may feel that any recommendations are not properly grounded in the detailed operational circumstances of their working practices [423]. The elements of the following list present some of the issues that help to determine the amount of detail that must be introduced into any reconstruction:

1. *what are the boundaries of trust and confidentiality?*
   There may be significant constraints upon the amount of detail that an investigator can include within any reconstruction. Participation rates in any incident reporting system can be threatened if previous assurances of anonymity are compromised by an investigators publication of particular items of information. This can lead to a difficult ethical decision in which investigators might choose not to release important information about a potential hazard in order to safeguard the longer term future of the reporting system [444].

2. *how serious is the incident?*
   If investigators are not constrained by bounds of confidentiality then the level of detail in a report can be determined by an assessment of the potential seriousness of an incident. Chapters 10.4 and 11.5 have described how risk assessment techniques can be used to assess the potential threat the might be posed by the recurrence of an incident. This can be estimated in terms of the probability and consequence associated with each of the hazards that contributed to the incident. Investigators must also account for the risk associated with those hazards that were identified during an investigation but which did not actually occur during a near miss. In general, these techniques are only likely to provide subjective estimates that cannot easily be validated until some time after a report has been published and disseminated.

3. *how complex is the incident?*
   Chapter reviewed Perrow's argument that the increasing coupling of complex application processes is producing new generations of technological hazards. These hazards are being generated faster than techniques are being developed to reduce or mitigate those hazards [677]. If this is correct then it will be increasingly difficult to summarise an adverse occurrence or near miss incident in only a few sentences or paragraphs. The complexity and coupling of application processes defy attempts to summarise their failure. It is certainly true that incidents involving the use of high-technology systems, in general, require greater explanation than those that involve less advanced systems. It is difficult, however, to be certain that this is a result of the inherent complexity of high-technology systems or the lack of familiarity that many potential readers have with their design and operation.

4. *how much of the context can be assumed?*
   Investigators can often omit contextual information if they assume that such information is already widely known amongst their intended readership. This provides a partial explanation for the hypothesised differences between reports into the failure of high and low technology systems. Investigators need not provide additional information about the nature and use of fuel containers because they can assume that most readers will be familiar with these components. On the other hand, greater details must be provided for similar reports into the failure of navigational radar systems. Such assumptions can, however, be ill-founded. As we have seen, it can be difficult to anticipate the many diverse groups and individuals who have an interest in any particular incident report. In consequence, investigators can make unwarranted assumptions about their knowledge of particular working practices.

5. *how significant are the recommended changes?*
   Investigators may be forced to provide a detailed reconstruction of an incident or incidents in order to demonstrate that particular recommendations are justified by previous failures. If they propose radical changes to particular working practices or considerable investment in additional plant then safety managers must be confident that those recommendations are warranted by a detailed analysis of a near miss or adverse occurrence. In particular, it can be important to identify those plants, systems or production processes that have been affected by previous failures. If this is not done then operators can claim exemptions from particular recommendations on the grounds that any subsequent analysis is not based on evidence from their production processes.

6. *can details be introduced to achieve particular effects?*
   The introductory sections of this chapter argued that investigators must consider the information requirements of the various readers of an incident report. Any proposed document must support the different needs of regulators, safety managers, operators and so on. These requirements clearly have an effect on the level of detail that is required in any reconstruction. As we have seen, safety managers will require a considerable attention to detail if they are to accept radical reforms. Conversely, system operators may require less detailed information in order to motivate them to implement specific changes to their daily routines [865]. Not only can investigators vary the level of detail in incident reconstructions to support the different end users of a report, they can also adjust these details to achieve specific effects upon those readers. For example, the US Coast Guard place their warnings about the dangers of fuel cannisters in the context of the oyster fleet even though the same warning might be applied to everyone at sea. It can be argued that a generic or abstract warning 'never put fuel cannisters next to an ignition source' would have lacked the immediacy and directness of the report that places the analysis and recommendation within the context of a brief reconstruction of previous near misses involving particular vessels that *were observed* by particular Coast Guard officers.

The previous list identifies a number of factors that can influence the level of detail that investigators provide in the reconstruction of a near miss or adverse occurrence. Several of these concerns can be illustrated by a case study from the UK MAIB's Safety Digest. This provides a relatively brief account of a particular set of failures . The location of the incident and the types of vessel involved are all clearly identified in the reconstruction. Anonymity is less important than disseminating this contextual information which, as we have seen, can contribute to the authenticity and 'directness' of a report. As we shall see, however, this detailed example is then used to make some very generic points about the nature of system failure:

> "The Veesea Eagle, a 622gt standby vessel, was on station in the North Sea. Early one morning, the superintendent received a call saying that No 1 generator had failed due to an exhaust pipe failure. Shortly afterwards, he received a further report saying that because of a damaged piston, No 2 generator had also failed. Back on board, the harbour generator was started to enable repairs to No 2 generator to be undertaken. While the company arranged for a replacement standby vessel, the chief engineer started to replace the damaged piston. Meanwhile, the harbour generator also failed. Although the main engine was still functioning, and steering was available by using the independently driven Azimuth Thruster, the company decided to tow the vessel back to port for repairs." [518]

This example illustrates how relatively short reports can be well situated within particular locations and operating environments. The vessel is clearly identified as the Veesea Eagle and its purpose and methods of operation can be assumed from its role as a standby vessel in the North Sea oil fields. The previous list, however, makes the point that such assumptions can be dangerous. Some potential readers may lack the prior knowledge that is necessary to infer the style of operation from the first sentence in the report.

This MAIB report is instructive for a number of further reasons. At one level, the previous quotation describes a 'freak' collection of failures that successively denies operators of their reserve power sources. The author of this report, however, takes considerable care to use this particular incident to make several more generic points about the nature of incidents and accidents. They achieve this using a relatively simple technique that avoids much of the jargon that often weakens more academic work on accident models. These points are illustrated by the findings that follow the reconstruction cited above:

1. No 1 generator
   Had been running successfully following a complete overhaul, including a new crankshaft, earlier in the year. After the vessel re-entered service, the chief engineer adjusted the fuel timing to improve performance. When he left, the relieving chief engineer also adjusted the fuel timing, but had not been told about the last adjustment. The result of the latter was massive after burning damage to a piston head, cylinder head, and exhaust trunking.

2. No 2 generator
   Had also been running successfully, when a piston failed for no apparent reason.

3. Harbour generator
   Failed because of a lack of lubricating oil and it wasn't monitored. [518]

There is no mention of a Swiss cheese model or of dominoes or of latent and catalytic causes. The analysis does, however, provide clear examples of the ways in which different types of failure combine to breech redundant defences. It is tempting to argue that the format and layout of the report reflect the investigator's intention to explain how each defence was breeched. This implicit approach might, in time, encourage readers to recognise the value of this style of analysis. Such an analysis is not as unrealistic as it might sound, given that readers are often expected to infer the more general lessons that can be derived from such specific reconstructions. Unfortunately, there is no way of knowing whether this was a deliberate intention on the part of the investigator or whether they simply described the reasons why each power source failed on demand.

13.2.2 Analysis

The previous paragraph illustrated the way in which the MAIB presented the particular findings that were derived from the Veesea Eagle. The following paragraphs build on this analysis to identify a number of more general issues that must inform the presentation of any causal analysis in incident reports. This chapter draws upon case study reports that have been published by maritime investigation authorities in countries ranging from Australia to Japan, from Hong Kong to Sweden. Before reviewing the presentation of causal findings in these reports, it is important to emphasise that the case studies reflect existing reporting practices within the maritime domain. A number of important characteristics differentiate these practices from those that hold in other areas of incident reporting, for example within commercial aviation or the medical industries. Maritime incident reporting systems have some advantages over these other systems. In particular, as we have seen, the IMO provides a structure for ensuring some degree of consistency between the incident reporting systems that are operated in member states. Equally, there are a number of features of the maritime industry that create problems which are less apparent in the aviation domain. For example, many maritime occupations are characterised by a plethora of relatively small companies. The structure of the in-shore fishing industries provides a strong contrast with that of the global market in commercial passenger aviation. In consequence, although we focus on particular case studies that are drawn from the maritime industries the following analysis will also occasionally digress to look at wider issues that affect the presentation of causal analyses in wider domains.

Very few maritime incident investigations exploit any of the semi-formal or formal causal analysis techniques that have been introduced in Chapters 9.3 and 10.4. This is not to say that causal techniques have not been proposed or developed for these industries. For example, Pate-Cornell has demonstrated how a range of existing techniques might have been applied to the Piper Alpha accident [667]. Wagenaar and Groeneweg's paper entitled 'Accidents At Sea : Multiple Causes And Impossible Consequences' exploits a variant of the Fault tree notation introduced in Chapter 8.3 [853]. Unfortunately, this pioneering work has had little or no impact on the reports that are disseminated by investigation agencies. The situation is best summarised by recent proposals for a research program to 'tailor' causal analysis techniques so that they can match the requirements of the maritime industries. The US Subcommittee on Coordinated Research and Development Strategies for Human Performance to Improve Marine Operations and Safety under the auspices of the National research Council helped to draft a report advancing a 'prevention through people program' [836]. This report proposed that in order for the Coast Guard to interpret information about previous successes and failures 'a methodology using root cause (or factor) analysis tailored for the marine industry and taking legal issues into account, could be developed'. Such 'a system of analysis' would 'trace the chain of events and identify root causes or factors of accidents in maritime transportation system'. The general lack of established causal analysis techniques within the maritime industry is also illustrated by very similar European research initiatives. For instance, the European Commission recently funded the Casualty Analysis Methodology for Maritime Operations (CASMET) project [154]. This was to facilitate 'the development of a common methodology for the investigation of maritime accidents and the reporting of hazardous incidents, to improve the understanding of human elements as related to accidents and account for these aspects in the common methodology'. Although the project developed a high-level architecture for such a method it did not have the impact on regulatory organisations that was anticipated. As we shall see, the CASMET criticisms of previous practices could equally be applied today as they were when the project was launched in 1998. They argued that 'present schemes are rooted in a compliance culture, in which the competence and focus are by tradition oriented towards guilt-finding' [154]. Even those countries that have established independent investigation units will still initiate legal proceedings if an investigation reveals a violation. They further argue that this inhibits individuals from contributing to an incident reporting system. This quotation reflects the results of a survey that the CASMET project conducted into existing incident and accident investigation techniques within the European maritime industries. The emphasis was on identifying situations in which individuals and organisations failed to comply with regulations. Few attempts were made to perform any form of deeper causal analysis to understand why such failures occurred. Their analysis raises important issues but it is slightly superficial. Chapter 4.3 has analysed the limitations of 'no blame' systems in comparison to the 'proportionate blame' approaches that have been adopted within areas of the aviation and healthcare communities. There are a number of further reasons why maritime incident reports are not guided by the causal analysis techniques that have been applied in other domains. One important consideration is that statutory requirements often focus on the findings that are derived from a causal analysis rather than the process that is used to produce them. The use of particular techniques is, typically, less important than that any incident should be investigated and reported on within particular time limits. For instance, the UK Merchant Shipping (Accident Reporting and Investigation) Regulations 1999 simply state that the master will 'provide the Chief Inspector with a report giving the findings of such examination and stating any measures taken or proposed to prevent a recurrence' within fourteen days of a serious injury [349].

Such requirements do not simply reflect a concern with identifying violations, they also reflect the need to address important safety concerns within a specified timelimit. They also reflect a pragmatic desire to maximise limited investigatory resources. These are particularly stretched by the transient and dynamic nature of the maritime industry. It is an obvious point but the location in which an incident occurs does not remain in the same position as it might do in many other industries. Indeed, it may move outside of the territorial waters of the nation in which the incident occurred. This gives rise to the National Research Council's concern that any causal analysis technique must recognise the particular legal concerns that characterise the maritime industry [836]. The complexity of addressing these legal issues often results in a high-level of ambiguity in the international recommendations that are intended to guide both the conduct and the publication of any causal analysis. For instance, the IMO's Code for the Investigation of Marine Casualties and Incidents simply defines a cause to mean 'actions, omissions, events, existing or pre-existing conditions or a combination thereof, which led to the casualty or incident' [389]. While this indicates a relatively broad view of causation, it provides little concrete guidance to investigators who must first identify appropriate causal analysis techniques and then determine how best to publish the findings of such techniques. In contrast, the IMO code continues by identifying the high-level, organisational processes that might support any analysis. It avoids imposing any constraints on the techniques that might be used; 'marine casualty or incident safety investigation means a process held either in public or in camera conducted for the purpose of casualty prevention which includes the gathering and analysis of information, the drawing of conclusions, including the identification of the circumstances and the determination of causes and contributing factors and, when appropriate, the making of safety recommendations' [389].

The lack of specific guidance on appropriate causal analysis techniques and or presentation formats for the findings of such approaches does not imply that international regulatory organisations are insensitive to the problems of analysing incident and accident reports. The 20th session of the IMO assembly adopted resolution A.850(20) on the 'human element vision, principles and goals' for the Organisation. This stressed that the ships' crews, shore based management, regulatory bodies, recognised organisations, shipyards and even legislators contribute to the causes of near miss incidents and adverse occurrences. It was argued that "effective remedial action following maritime casualties requires a sound understanding of human element involvement in accident causation... gained by a thorough investigation and systematic analysis of casualties for contributory factors and the causal chain of events". It was argued that the "dissemination of information through effective communication is essential to sound management and operational decisions". Unfortunately, the resolution did not identify appropriate means for reconstructing such causal chains nor did it describe effective means of dissemination. In contrast, the resolution identified a number of high-level goals that mirror the more general objectives of the IMO's investigation code. Item (e) describes the high-level objective of disseminating the lessons learned from maritime incident investigations within the wider context of safety management within these industries:

- "(a) to have in place a structured approach for the proper consideration of human element issues for use in the development of regulations and guidelines by all committees and sub-committees;
- (b) to conduct a comprehensive review of selected existing IMO instruments from the human element perspective;
- (c) to promote and communicate, through human element principles, a maritime safety culture and heightened marine environment awareness;
- (d) to provide a framework to encourage the development of non-regulatory solutions and their assessment based upon human element principles;

- (e) to have in place a system to discover and to disseminate to maritime interests studies, research and other relevant information on the human element, including findings from marine and non-marine incident investigations; and
- (f) to provide material to educate seafarers so as to increase their knowledge and awareness of the impact of human element issues on safe ship operations, to help them do the right thing." [390]

The lack of specific guidance provided by national and international organisations is understandable. Their main concern is often to ensure that incident and accident reporting systems are established in the first place. Unless incident and accident reporting systems are perceived to meet particular local needs then there is a danger that they will be under-resourced or abandoned. The imposition of detailed requirements for causal techniques or presentation formats might jeopardise the ability of individual agencies to tailor their system to meet those local needs [423]. In consequence, different nations have adopted a radically different approaches to incident analysis even though they are signatories to the same IMO resolutions. These differences have a significant impact on the manner in which the findings of a causal analysis are both presented and disseminated. For instance, the Japanese maritime incident reporting system is based upon a judicial model.

> "The inquiry takes an adversarial form pitting the parties concerned, against each other. 'Open court', 'Oral pleadings','Inquiry by evidence' and 'Free impression' are employed in the inquiry. Moreover the independence of the Judge's authority in exercising inquiry is laid down by the Marine Accidents Inquiry Law. The examinee, counselor and commissioner may file an appeal with the High Marine Accidents Inquiry Agency within seven days after the pronouncement when he is dissatisfied with a judgement pronounced at a Local Marine Accidents Inquiry Agency. A collegiate body of five judges conducts the inquiry in the second instance through the same procedure of the first instance. When a judgement delivered by the High Marine Accidents Inquiry Agency is not satisfactory, it is possible to file litigation with the Tokyo High Court within 30 days after the delivery to revoke the judgement."[395]

The Swedish reporting system is far less adversarial. The purpose of maritime investigations is to provide 'a complete picture of the event'. The intention is to understand why an accident or incident occurred so that effective preventive measures can be taken to avoid future failures. The Swedish investigation board argue that 'it is to be underlined that it is not the purpose of the investigation to establish or apportion blame or liability' [769]. Such contrasting approaches have important implications for the nature of the findings that are likely to emerge from any investigation. They can also have a profound impact upon the techniques that might be used to disseminate those findings. For instance, in the Japanese system the individuals who contribute to an incident will have direct disciplinary action taken by the investigatory board if they are found to be negligent. In contrast, the Swedish system arguably adopts a more contextual approach that seeks to understand the circumstances that contribute to a failure rather than simply punish any particular violation or error. Such distinctions are an over-simplification. They ignore many of the cultural influences that have a profound effect on the manner in which these systems are actually operated. They also ignore the detailed motivations that justify particular approaches. These caveats are important because other researchers and analysts have often been too quick to identify a 'blame culture' or a 'perfective approach' in systems that they are not involved in. Although it is clear that the Japanese system exploits a judicial process, this does not mean that it ignores the contextual factors that lead to errors and violations. Although the Japanese system may ultimately prosecute individuals and groups, this is the very reason why a judicial process is exploited:

> "Marine accidents occur frequently not merely from human act or error but from a complexity of factors like working conditions, ship and engine structure, natural circumstances such as harbor and sea-lane, and weather and sea condition. On the other hand, material and circumstantial evidence is often scant. So it is sometime difficult to grasp what actually happened and to investigate its cause. Since disciplinary punishment against the holder of a seaman and pilot's competency certificate may restrict

their activities and right, a lawsuit-like procedure is used in marine accidents inquiry to ensure careful consideration and fairness." [395]

One cannot assess the way in which an incident reporing system is operated simply by the aims and mission statements that they espouse. Abstract comments about the multi-facted nature of incidents and accidents need not result in practices that reflect a broad view of causation. It is, therefore, important to look beyond such statements to examine the findings that are produced by these different systems. For instance, the Japanese Marine Accident Inquiry Agency have published a number of the incident reports that they have submitted to the IMO. These include an analysis of a collision between a dry bulk carrier, Kenryu-Maru, and a cargo vessel, Hokkai-Maru [393]. The reconstruction exploits two location-based chronologies. The events leading to the collision are described first from the perspective of the Kenryu-Maru's crew and then from that of the Hokkai-Maru. The Kenryu-Maru reconstruction describes how the third mate found the echo of Hokkai-Maru on the radar but did not report it to the master . The Summary of Events section continues that 'the master went down to his room without a concrete order that the third mate should report him when the visibility become worth'. Some time later, the third mate again established radar contact with the Hokkai-Maru 'but he did not set eyes on HOKKAI-MARU carefully'. He changed course 'degrees but he did not watch out for HOKKAI-MARU carefully on her radar to determine if a close-quarters situation is developing and/or risk of collision exits' nor did he use 'sound signals in restricted visibility'. The report describes how the third mate oredered the vessel hard to starboard when he eventually recognised that the echo of the Hokkai-Maru was crossing their course. He made an attempt to telephone the master 'but he could not dial as it was so dark'. The collision occurred shortly afterwards.

The style of reconstruction used by the Japanese Marine Accident Inquiry Agency in the Hokkai-Maru report is very different from that described in previous incident reports. There is a strong element of interpretation and analysis in the Summary of Events section. For instance, the reconstruction includes the statement that 'the third mate did not know (about) this dangerous situation, as he did not watch carefully by her radar... he believed each ships could pass on the port each other'. Such sentences are, typically, to be found in the analysis sections of the reports produced by organisations such as the US National Transportation Safety Board (NTSB) or the UK MAIB. In contrast, the findings from the analysis of the Hokkai-Maru incident were presented to the IMO as follows:

1. Principle findings:
   Both KENRYU-MARU and HOKKAI-MARU did not sound signals in the restricted visibility, proceed at a safe speed adapted to the prevailing circumstances, reduce her speed to the minimum at which she can be kept on her course and take all her way off if necessary, because they did not keep watch on each other by radars. Both masters did not ordered to report to them in case of restricted visibility. Also both duty officers did not report to their masters on restricted visibility.

2. Action taken:
   The masters of KENRYU-MARU and HOKKAI-MARU were inflicted reprimand as a disciplinary punishment. The duty officers of the both ships were inflicted suspensions of their certificates for one month as a disciplinary punishment.

3. Findings affecting international regulations: No reported" [393]

It can, therefore, be argued that the judicial nature of the Japanese maritime reporting system has a profound impact on the presentation of a reconstruction, on the interpretation of an adverse occurrence and on the findings that are drawn from an analysis. Similar collisions have led other organisations to look in detail at the precise communications that occurred between members of the crew immediately before the incident [827]. These findings have prompted further research into what has become known as Bridge Resource Management. Conversely, other incident reports have looked at the particular demands that are imposed on crewmembers who use radar for two potentially conflicting tasks. Such systems are typically used both for target correlation, for example to identify the position of the Hokkai-Maru, and for navigation support [408]. It should be stressed that it is impossible to tell whether these broader issues were considered during the investigation and analysis of the incident. It is clear, however, that the findings that are published in the report focus on the responsibility of the individuals who were involved in the incident.

Chapter 11.5 has argued that a perfective approach that focuses exclusively on individual responsibility and blame is unlikely to address the underlying causes of many incidents. This does not imply, however, that the Japanese approach will be counter-productive. We have already cited the objectives of the investigation agency. These clearly recognise the complex, multi-faceted nature of many incidents and accidents. It is, therefore, possible to distinguish the broader aims of the reporting system from the findings of judicial enquiries. It is entirely conceivable that other actions may be instigated within the transport ministry to address the broader problems that are illustrateed by the Hokkai-Maru incident even though the investigation agency publishes a narrower view that reflects a focus on individual responsibility. Such a hybrid approach avoids situations in which operators view a reporting scheme as a means of avoiding disciplinary action for their actions. It is, however, important not to base such wide-ranging observations upon the analysis of a single report. The Hokkai-Maru case study might not be typical of the other reports that are produced by this system. It can be argued that the investigator who drafted the findings in this report was unusual in their focus on individual blame. Alternatively, the crews' actions in this incident might genuinely be interpreted as negligent in some respect. A careful reading of the other submissions to the IMO does, however, confirm that this style of analysis is part of a wider pattern. The judicial nature of the investigatory and analytical processes results in findings that focus on individual responsibility for the causes of adverse occurrences and near miss incidents. For instance, another report describes the grounding that ultimately led to the loss of the Bik Don, a cargo vessel. The findings of this report again focus on the role of the master rather than the circumstances that helped to influence his actions; 'the grounding was caused from that the master did not check the circumstances of course, which he selected newly for short-cut, on charts or sailing directions' [394]. However, no disciplinary action was taken even though the vessel was lost and the crew had to be rescued by a patrol boat of the Japanese Maritime Safety Agency. There are number of puzzling aspects to this incident report. It is unclear why the analysis identifies human error as the primary cause and yet the judicial system does not take any retributive action. This might reflect a recognition that the Master had suffered enough from the loss of a vessel under their command. Alternatively, this might be an indication that the investigatory authorities had recognised some of the contextual issues that influence human error. There is some evidence for this in the report's 'Summary of Events' which again contains detailed causal analysis:

> "He thought she could pass through south of the island safely because he sometimes saw the same type ships as her navigated that area. He had no experience to pass through south of Shirashima islands. But he did not confirm about Meshima island shallow waters extended from Meshima island, and especially independent shallow water named Nakase that was apart 1,000 meters from the Meshima island shallow waters by checking charts or sailing directions before his deciding." [394]

This case study illustrates two key points about the presentation of any causal analysis. Firstly, readers can experience considerable practical problems if the interpretation of an incident is distributed throughout a report. It can be necessary to read and re-read many different chapters in order to piece together the reasons why particular causes were identified. Unless this can be done then it is difficult to justify or explain the recommendations that are proposed in the aftermath of an incident. In the previous example, the decision not to act against the Master could only be explained by piecing together elements of the analysis that were presented in the Summary of Events and in the Principle Findings sections of the IMO report. Secondly, it is important that investigators explain the reasons why particular conclusions were reached and why other potential causes were excluded during an analysis. In this case, the incident report focuses exclusively on the actions of the Master. It does not consider factors such as external pressures to meet contract obligations that motivated the navigational error. In contrast, the reader is simply informed of the finding without any of the intermediate analysis or documentation that might accompany the application of the techniques described in Chapter arefpart:analysis and 10.4, such as MORT or ECF analysis. It is important to note that the IMO reports, cited above, provide only brief summaries of each adverse occurrences. The documents are only between five and six pages in length. The tractability of these documents might be significantly compromised if these additional details were included. This, in turn, can act as a powerful disincentive for many readers who are daunted by the task of carefully reading incident reports that often run to dozens of pages in length. There are, however, a number of techniques that might be used to address this problem. For instance, summary reports might explicitly refer to the more detailed documents that are required to justify a causal analysis. In the Japanese maritime system this might include summary transcripts of the judicial process that is used to examine causal hypotheses. ECF charts or other more formal documentation might be provided. Alternatively, the findings of a causal analysis might be justified in a natural language summary. Clearly the choice of approach must depend on the investigatory process, the resources that are available to support any analysis and on the nature of each incident. Without this information, however, readers can be left with considerable doubts about the findings of many incident investigations [750].

The Japanese approach to the presentation of causal findings within IMO summary reports can be contrasted with the approach adopted by the Swedish Board of Accident Investigation. The high-level guidelines that describe their approach to causal analysis are very similar to those presented by the Japanese Marine Accident Inquiry Agency. They both stress the way in which incidents stem from multiple causes. As we have seen, the Japanese argue that "...marine accidents occur frequently not merely from human act or error but from a complexity of factors" [395]. The Swedish approach is summarised as follows:

> "An accident can normally not be attributed to one cause. Behind the event are often enough a series of causes. An investigation is therefore aimed at the consideration of different possible causes to the accident. Many of these will in the course of the investigation be eliminated as improbable. This elimination however means that the remaining possible causes gain strength and will develop into probable causes. Needless to say, both direct and indirect causes must be considered." [769]

There are also some interesting differences between the Japanese Marine Accident Inquiry Agency's guidelines and those published by the Swedish Board of Accident Investigation. As might be expected, the Japanese stress the need to protect those involved in an incident when the findings of any report 'may restrict their activities and rights'. A judicial process is required because it can be 'difficult to grasp what actually happened and to investigate its cause' [395]. The value of these defences cannot be underestimated in proportionate blame systems. The judicial proceedings provide for the representation of the individuals concerned in an incident. This contrasts strongly with many Western systems in which the causal findings of an investigation can be reported, often without any detailed supporting analysis, and with only a minimal participation of those involved in an incident. The Swedish system focuses less on issues of individual representation and protection. In contrast, it focuses on the more detailed problems that must be addressed by any causal analysis. They make the important distinction between direct and indirect causes. This resembles the distinction that we have made between latent and catalytic failures. Their high-level guidelines also stress the need to eliminate certain hypotheses in order to identity potential causes. Previous sections have argued that it is important that readers can understand why particular hypotheses have been eliminated if they are to have confidence in the findings of any causal analysis [200, 199].

The following paragraphs analyse a case study report that follows the Swedish Board of Accident Investigation's guidelines. This can be contrasted with the case studies from the Japanese reports to the IMO, although it should be remembered that these are summary descriptions whereas the Swedish report provides a more detailed analysis. This incident resulted in a collision between the Swedish vessel, MT Tärnsjö and the Russian vessel, MV Amur-2524 [768]. The Swedish report follows the formatting conventions that have been described in previous section. A summary section is presented which includes an initial set of recommendations. This is then followed by factual information. The 'Analysis' chapter is then presented before the conclusions and a re-statement of the recommendations. Our focus here is on the presentation of the analysis section. This begins with an analysis of the place and the time of the accident. There were "concurring statements from the pilots and the crews, the accident took place approximately 100m west or west north west of Strömskärs northern point" [768]. There was, however, some disagreement about whether the collision occurred at 18:28 or 18:30. This reinforces the point that reports do not simply focus on the causal analysis of an incident. They often also include an assessment or interpretation of the evidence upon which such an analysis is grounded. The Tärnsjö report continues with an analysis of the speed at which each vessel approached the point of collision. This again illustrates the way in which the investigators analyse the various accounts of the incident to make inferences that will eventually support their causal findings:

> "The accounts of the course of events show that the Tärnsjö passed Toppvik about the same time that Amur-2524 passed Nybyholm. The distance between Toppvik and the collision site is approximately 2.8 M. Hence the Tärnsjö sailed about twice as far as Amur-2524. The Tärnsjö's average speed on the stretch becomes 10.5 or 9.4 knots... Toward the end of the stretch, her speed was reduced by the reversing and was approximately 2 knots at the collision. This means that her speed during the first part of the stretch must have been above the average. Taking the lower average speed of 7.6 knots and assuming the full astern manoeuvre was somewhat hampered by the ice and therefore began 0.3 M before the collision site, then the Tärnsjös speed before reversing becomes 10 knots. If one assumes instead that the reversing was fully effective as in the emergency stopping trial, then the same calculation gives a speed just before the reversing of close to 10 knots. Against this background the Board considers that Tärnsjös speed when entering the yaw off Tedarö light must have been considerably greater than the 6-7 knots stated by the pilot." [768]

As mentioned, the analysis of the evidence is used to support particular findings about the course of the incident. These, in turn, support any subsequent causal analysis. In this case, the Swedish board found nothing to show that the reversing procedure was less effective than what the stopping trial had revealed. From this they concluded that the reversing procedure was probably initiated too late and that this, combined with the high speed of the Tärnsjö, prevent the crew from stopping the vessel before the collision.

Many investigators might have concluded their analysis with the finding that one of the crews had failed to apply the full astern manoeuvre in time to avoid the collision. In contrast, the Swedish report follows the distinction between direct and indirect causes made in the guidelines, cited above. The investigators go on to analyse the communications that took place between the vessel prior to the incident. The analysis section goes on to explain that the pilots of the two vessels had met on at least two occasions prior to the incident during which they discussed the passing manoeuvre. The report observed that "from then on they did not communicate nor give any information regarding positions or speeds; neither did they agree upon how they would handle the meeting, in other words, at what speed they would meet or if one vessel should heave to" [768]. The analysis then focuses on the role played by the officers of the watch in the interval immediately before the incident. As before, the investigators use the evidence that was identified during the reconstruction of the incident to support particular findings about the crews' behaviour. In this instance, it is argued that the Tärnsjös chief officer and second officer "did not participate in the navigation nor did they follow what was happening other than temporarily during the passage through the Hjulsta bends" [768]. In consequence, they were both unsure about the vessel's speed before the collision. Neither could recall when and where the reversing procedure was started. The report describes a similar situation on the Amur-2524. The helmsmen and the master did not participate in the navigation once responsibility for this had been handed to the pilot. After having analysed the evidence that was obtained for the events immediately before the incident, the analysis section then goes on to consider more proximal factors. It prefaces this by summarising the outcome of the investigation which draws upon the analysis of the evidence that was presented in previous paragraphs:

> "The immediate cause of the collision was that the meeting was poorly planned. This in turn was mainly due to faulty communication between the pilots regarding how and where the meeting would take place. The Board however is obliged to note a circumstance that it has had reason to mention in several previous investigations; that is, the

> tendency that vessels with a pilot on board are conned by the pilot alone without use of the other resources available on the bridge. The accident could have had far worse consequences had the Tärnsjö's stem collided with the Amur-2524 a little further aft and also penetrated the athwartships bulkhead to hold nr 3. If this had happened Amur-2524 would probably have capsized and sunk." [768].

This quotation not only illustrates the way in which the Swedish report gradually build up a causal analysis from the investigators' interpretation of the available evidence. It also makes explicit the investigators' assessment of the worst plausible consequences of an incident. Chapters 4.3, 6.4and 9.3 have all emphasised that such estimates must inform the allocation of resources to an investigation as well as the implementation of any recommendations. The Tärnsjö report also illustrates good practice by the way in which the investigators justify their assessment of this 'worst plausible outcome' . Auch justifications are particularly important if readers are to be convinced by this subjunctive form of reasoning. The report describes how the investigators' finding was reached without access to the Amur-2524's stability data under the relevant load conditions. In spite of this they argue that 'if the timber had not entirely filled the hold but the logs, instead, had been able to move around or shift while floating, the vessels metacentre height could have been decreased by half a metre through the effect of the free water surface alone... (this) could have constituted a serious risk to the vessels stability" [768].

A further strength of the Swedish report is that the analysis extends beyond the immediate and the distal causes of the incident to examine the response to the collision. This analysis extends the initial reconstruction because it does not simply discuss what was done, it also considers what was not done in the aftermath of the incident. The Södertälje Traffic Information Centre was informed immediately but the Marine Rescue Control Centre was not informed until approximately ninety minutes after the collision. Similarly, the analysis goes on to argue that the crew of the Tärnsjö should have remained on-site to assist the Amur-2524 after thad determined that they only sustained minor damage. Instead of illuminating the area and helping the Amur-2524 to break the surrounding ice, the "Tärnsjö's master chose to leave the site right after the accident and before the Amur-2524 began her attempt to reach shallow water" [768]. They had to abandon this plan as it became clear that the vessel was more seriously damaged than had first been appreciated. The investigators acknowledge the inherent difficulty of performing an accurate damage assessment in the aftermath of a collision. The investigators use a form of counterfactual reasoning to argue that the Tärnsjö's haste contributed to Amur-2524's predicament:

> "The Tärnsjö or the tug could have escorted the Amur-2524 back to Hjulsta bridge where they could have obtained help to pump out the bilge and investigate the damage. Even if the vessel had been assisted by the tug during the journey, the Board estimates it would have been more difficult and risky to transfer the crew to the tug if the vessel had started to list or even capsized. The Board considers it remarkable that the Tärnsjö's master chose to proceed immediately following the accident without ensuring that the Amur-2524 was out of danger. Evidently the vessel left the site without having fully ascertained the extent of the damage. He was aware that the Amur-2524 was going to try to reach shallow water, but did not wait to see that she accomplished this." [768].

This counterfactual argument illustrates the importance of looking beyond an initial adverse event to look at the response to an incident. In this case, the consequences to the Amur-2524 could have been far more serious than they actually were. It is interesting to note, however, that this line of analysis is not represented in the conclusions that are drawn by the report. The investigators argue simply that the immediate cause of the collision was that the meeting of the two vessels was "poorly planned" [768]. Contributory factors included insufficient communication between the pilots and ineffective use of the resources available on the bridge. It is also interesting to note the recommendations that were made on the basis of the extensive analysis that was performed by the investigators. The proposed interventions were summarised by a single word: None. This raises a number of questions. In particular, the lack of any recommendations suggests that similar incidents might recur in the future.

Presentation Issues for Causal Analysis

The previous paragraphs in this section have used case studies drawn from the Japanese Marine Accident Inquiry Agency and the Swedish Board of Accident Investigation to illustrate a number of key points about the presentation of any analysis in an incident report. It has been argued that this analysis should consider not only the proximal and distal causes of an incident. The report must also present the findings of any analysis of mitigating actions in the aftermath of an incident. Similarly, it has been argued that incident reports should document the evidence and the analytical processes that support particular findings so that readers can understand why particular conclusions were reached. The following enumeration builds on these observations and presents a number of recommendations for the presentation of analytical material in incident reports. It is important to emphasise that these guidelines are not appropriate for all systems. For example, the informal nature and limited resources of local systems can impose tight constraints both on the analysis that is performed and on the documentation of that analysis. Similarly, it can be difficult to summarise all of the procedures that might be used in order to support the findings of larger-scale investigations. Equally, however, it remains the case that many incident reports present findings that cannot easily be justified from the evidence that is presented in a report [750]. This can lead to skepticism about the benefits of participation and can encourage the creation of 'war stories' that provide alternative accounts of the events that were not revealed in the official report:

1. *describe the process used to derive the findings.*
   It is important that incident reports describe the steps that were taken to identify particular causes. For example, the IMO request information about the 'form' of any investigation that is conducted for more serious classes of incident. The Japanese Marine Accident Inquiry Agency describe how "the Judges make the announcement of the judgement in the court after argument" [395]. Similarly, it is important that the readers of an incident report should be able to identify the validation activities that support particular causal findings. For instance, the Board of Accident Investigation ensures that 'interested parties' have the right to follow an investigation. They can also request "further investigative measures that they deem necessary" [769]. This does not go as far as the right of reply that is granted under sub-regulations 16(3) and 16(4) of the Australian Navigation (Maritime casualty) regulations. These provide 'interested parties' with the opportunity to have their responses published together with the findings of the investigators' analysis. The key point here is that the investigatory process should be apparent to the readers of an incident report. Unless people are provided with this information then they cannot be assured that potential biases will not unduly influence the results of an investigation. The suspicion that findings may be based upon an isolated subjective opinion can be sustained even when investigators have gone to great lengths to ensure the veracity of their findings [200].

2. *document the process used to produce the findings.*
   For many incidents, it may be sufficient simply to outline the processes that were used to identify and validate particular findings. In other situations, however, it is also important that the readers of a report can assess the analytical procedures that were employed. This is important if, for instance, the possible consequences of a future recurrence are judged to be particular severe. Similarly, it is important that readers can critically examine the conduct of any analysis if the proposed remedies impose considerable burdens upon the recipients of a report. Very few organisations that recommend techniques, such as the use of Fault Tree diagrams or ECF analysis, ever publish the documents that are intended to support their findings. This is worrying because it can be difficult to avoid making mistakes with these and similar techniques [530, 424]. In consequence, the readers of a report simply have to trust that investigators and the other members of investigation boards have correctly applied those methods that have been adopted. The role of the outside expert is a particular concern in this respect. Too often, investigation agencies have relied upon the advice of individuals whose reputation and expertise is sufficient validation of their insights. This can be particularly frustrating for other readers with their area of expertise who must struggle to interpret their

findings during subsequent design and redevelopment. Several years ago I wrote a paper entitled 'Why Human Error Analysis Fails to Support Systems Development' [410]. This summarised the problems that I felt when the analysis of human factors analysis in an incident report used technical terms, such as 'crew resource management' or 'high workload', without showing any evidence or reasoning to support these particular findings. This created enormous problems for the safety managers and operational staff who then had to take concrete measures to prevent such failures from recurring in the future. It is insufficient simply to state that these problems occurred without documenting the detailed reasons why such a diagnosis is appropriate.

3. *link evidence to arguments.*
A particular strength of the Swedish Board of Accident Investigation's approach is that the analysis of an incident is directly linked to an assessment of the evidence that is presented within any reconstruction. The Tärnsjö case study illustrates the way in which the investigation board is content to leave potential inconsistencies, for instance over the time of the collision, where they do not affect their findings. In other situations, the Board actively reject eye-witness statements that are contradicted by other forms of evidence. For instance, observations about the progress of the Tärnsjö are used to infer the speed of the vessel. This is then used to support the main findings of the report that contradict the Pilot's statements. In other situations, the Board clearly state where they could not obtain the evidence that might be necessary to directly support their findings. For instance, the investigators argue that the consequences for the MV Amur-2524 could easily have been far worse even though they could not obtain a detailed stability analysis for the vessel. Such transparency is rare found. Most incident reports simply describe the results of any causal analysis. This leaves the reader to piece together the evidence that supports those findings from the previous reconstruction sections of the report. This creates many problems. Firstly, it increases the burdens on the reader who must also assimilate a complex mass of contextual information that increasingly characterises incident reporting involving high-technology applications. Secondly, there is a danger that readers will fail to identify the evidence that support the investigators' findings. In pathological cases, this evidence may not even have been included within the report [426]. Finally, there is a danger that readers may infer causal relationships that were not intended by incident investigators. In such circumstances it is likely that particular items of evidence, such as witness testimonies, will be given undue significance. This becomes important if that evidence is subsequently challenged or is stronger that the evidence that the investigator used in deriving a particular finding.

4. *justify proportion of blame.*
As we have seen, most reporting systems employ a proportionate approach in which deliberate violations and illegal acts are handled differently than human error. It can, however, be difficult to distinguish between violations, slips, lapses or mistakes from observations of an incident. Such evidence rarely yields insights into operator intention. Investigators must, therefore, explain why they interpreted observations in a particular manner if readers are to understand the basis for their findings. In other systems, such as the Japanese maritime case study, incident reports result in punitive actions. The importance of justifying those findings is correspondingly greater. This explains the use of a judicial investigation process. Even in 'no blame' systems there is still an obligation to explain why the analysis of an incident focuses on certain causes. For instance, it is important to describe why systems failure might have been considered more significant than operator involvement. 'No-blame' systems also assume additional burdens. By shifting attention away from system operators, they hope to identify the contextual and environmental factors that contribute to incidents and accidents. They must, therefore, look to the higher-level organisational and managerial influences that expose systems and their operators to such 'adverse' conditions. Too often there is a tendency to describe environment and contextual factors as part of a more general 'safety culture' without ever address the detailed resons why such a culture is permitted to exist within a particular organisation. Such approaches not only avoid blaming specific individuals, they also ignore

the importance of managerial responsibility for the consequences of particular incidents.

5. *justify any exclusions.*
Not only must investigators justify their decision to focus on certain causal factors, it is also important that they document the reasons why other forms of analysis were excluded or eliminated. For instance, the NTSB routinely includes a section entitled 'exclusions' within their analysis of incidents and accidents. In their maritime reports, this typically considers whether adverse weather conditions contributed to any failure. They may also document the investigators' findings that "the vessel's navigation, propulsion, and steering systems had no bearing on the cause of the fire" [608]. Subsequent paragraphs, typically, exclude inadequate training or qualification. They may also consider the potential influence of drugs or alcohol. In some cases this can lead to qualified exclusions. This can be illustrated by a recent investigation into an on-board fire. Tests indicated that the first officer had used marijuana in the weeks before the fire occurred, however, "based on witnesses descriptions of the first officers actions on the bridge during the emergency, no behavioral evidence indicated that he was impaired by drugs at the time of the fire" [608]. Such explicit exclusions help to address the alternative causal hypotheses that readers often form when analysing incident and accident reports. This is particular important because empirical studies have shown that trained accident investigators will often sustain such theories in the face of contradictory evidence. For instance, Woodcock and Smiley describe a study involving incident investigators from the American Society of Safety Engineers. One of the fifteen participants continued to believe the drugs were a factor in an incident even though witness statements contradicted this belief [871].

6. *clearly assess the 'causal asymmetry' of the incident.*
Chapter 10.4 introduced the term 'causal asymmetry'. This is used to describe the imbalance that exists between attempts to identify the effects of causes and attempts to identify the causes of given effects. It can be difficult or impossible to determine the precise causes of a given effect. Lack of evidence and the existence of multiple causal paths can prevent investigators from ever finding a single causal hypothesis. This is particularly true of incidents involving human intervention. As we have seen, it can be particularly difficult to identify those factors that influence particular operator behaviours. Previous chapters have described the problems that arise when attempting to identify the ignition source of maritime fires [623]. Two particular effects are at work here. Small-scale, local reporting systems often lack the necessary investigatory resources to conduct the detailed analysis that may be required to unambiguously determine causal sequences. Large-scale national systems are, typically, only able to devote necessary analytical resources to a small percentage of the most serious incidents that are reported. The opposite aspect of causal asymmetry is that investigators must trace a path between the cause that is identified in their findings and the observed effects that are recorded in the aftermath of an incident. These forms of analysis are, typically, constructed using the counterfactual arguments that have been described in Chapters 9.3 and 10.4. There are particular problems associated with these forms of argument. In particular, readers often draw 'incorrect' inferences about the potential consequences of any counterfactuals [124]. In practical terms, the problems of causal asymmetry in incident reports are best addressed by validation activities. These can be used to determine whether the potential readers of a report can reconstruct the causal arguments that are presented. These studies can also be used to determine whether readers are convinced by the exclusions that are intended to prune alternative causal hypotheses. These validation activities are described in later sections of this chapter.

7. *present the analysis of catalytic, latent and mitigating factors.*
Chapters 9.3 and 10.4 have described the importance of analysing a range of causal factors. These include both the triggering events that led directly to an incident. They also include the longer term factors that contribute to a failure. We have also emphasised the importance of analysing the mitigating or exacerbating factors that can arise after an initial failure. Many investigators routinely consider these factors but then fail to document them within the resulting report. These omissions can be justified in the summary reports that support the

statistical analyses described in Chapter 14.5. Even there, however, it can be important for safety managers and regulators to gain a clear understanding of the broader context in which an incident occurs. Too often incident databases simply record the frequency of particular catalytic failures [444]. It, therefore, comes as little surprise when the overall failure rate fails to decline over time. New catalysts replace those that have been addressed by previous recommendations and the latent causes of accidents and incidents remain unresolved. Such potential pitfalls can be avoided if information about latent and mitigating factors is propagated into the reports that document particular investigations.

8. *examine the adequacy of interim recommendations.*
The analysis in an incident report may also consider whether or not any interim recommendations are sufficient to address those causes that are identified by a more detailed investigation. It might be argued that this form of analysis should be considered together with the recommendations in an incident report. The NTSB follows the practice adopted by a number of similar organisations when it includes this form of assessment in the analytical sections of their incident reports. Investigators categorise each interim recommendation proposed by the Safety Board as either acceptable or unacceptable and as open or closed. For instance, recommendation M-98-126 was drafted following a fire on-board a passenger vessel. This required operators to 'institute a program to verify on a continuing basis that the laundry ventilation systems, including ducts and plenums, remain clean and clear of any combustible material that poses a fire hazard on your vessels' [608]. 21 of the 22 recipients of the recommendation replied to indicate that they had taken measures to comply with the proposed actions. As a result, the Board classified Safety Recommendations M-98-126 as a Closed Acceptable Action.

The previous paragraph described how organisations such as the NTSB often include an assessment of interim recommendations within the analysis section of their incident reports. We have not, however, considered how to include particular recommendations within these documents. The following section, therefore, extend the previous analysis to consider the problems that must be considered when presenting readers with proposal that are intended to avoid future incidents.

13.2.3 Recommendations

Previous sections have described how the executive summaries are usually followed by incident reconstructions. These precede paragraphs of analysis that then support any recommendations that might be made in the aftermath of an incident. Previous sections have also stressed the diverse nature of the publications that are produced in order to publicise information about adverse occurrences and near-miss failures. This has important consequences. In particular, Chapter 11.5 assumed an investigatory process in which investigators presented their recommendations in a final report to a regulatory organisation. They, in turn, were then assumed to provide feedback on whether or not each recommendation might be accepted for implementation throughout an industry. As we have seen, however, incident reports fulfill a more diverse set of roles. For example, interim reports can be directly targeted at the operators and managers who must implement particular recommendations. Conversely, statistical reports may not be published in any conventional sense. Instead, they often summarise the recommended actions so that investigators can survey previous responses to similar incidents in the future. Investigators must, therefore, tailor the presentation of particular recommendations to both the audience and the intended use of the document in which they appear. This point can be illustrated by the list of proposed outputs that are to be derived from the US Coast Guard's International Maritime Information Safety System (IMISS) [835]:

- Alert Bulletins. These distribute interim recommendations as soon as possible after an incident has occurred. These recommendations may simply focus on the need to increase vigilance in order to detect potential failures that, as yet, cannot be prevented by more direct measures.

- For Your Information Notices. Less critical incidents can result in notices that inform personnel of potential problems. The criticality of the information contained should be clearly distinguished from the more immediate alarm bulletins mentioned above. Any recommendations associated with these notices should be periodically reviewed to ensure that they do not provide stop-gap solutions to the latent conditions for more serious incidents in the future.

- Monthly Safety Bulletins. These documents can present collections of 'lessons learned, safety messages, areas for improvement, precautions and data trends' [835]. They play an important role in informing the wider maritime community of significant safety issues. The Notices and Alerts, mentioned above, can be distributed directly to the safety managers and representatives who must oversee the implementation of particular recommendations. In contrast, Monthly Bulletins often present more general recommendations directly to individual operators in the field.

- Periodic Journal and Magazine Articles and Workshops. Individual incident reports can be analysed by a 'data centre'. They may then write articles that examine the effectiveness of recommendations in terms of safety analyses and trends. These should not only be published through in-house media. They should also be submitted to relevant safety journals or conferences. This provides an important means of obtained external peer review for many of the activities that are conducted within a reporting system.

- Publicly Available Database. Databases can be established to provide the public with access to summary information about previous adverse occurrences and near-miss incidents. Increasingly these are provided over the Internet, this approach will be discussed in the following sections and in Chapter 14.5. An important benefit of these systems is that they can enable 'interested parties' to follow the actions that have been recommended in the aftermath of previous incidents. If they have been unsuccessful in prevent recurrences then this also can be inferred from these collections.

- Client Work and Research Services. Some incident reporting systems recoup some of the inherent expenditure that is involved in their maintenance by offering a range of additional commercial services. These can include advances search and retrieval tasks over their datasets. It can also include services that support other investigatory bodies. For instance, they may be anxious to identify any previous recommendations that have been made in response to similar incidents in other 'jurisdictions'.

- International initiatives. Incident reports can trigger actions to change international agreements. This can involve the publication of requests to amend the recommendations that have been agreed to by members from many different states. Clearly, the scope and tone of such requests are liable to be quite different from recommendations that are directed at the operators and managers within a particular industry.

- Measures of Success. The data derived about the causes of incidents and the proposed recommendations can be used to derive a number og high-level measures of the success of a reporting system. The problems that can arise from this approach are described in Chapter 14.5. For now it is sufficient to realise that such activities can identify the need to revise previous recommendations. The publication of this data can, therefore, trigger the publication of additional Alerts and Notices.

Brevity prevents a full discussion of the particular techniques that are used to present incident recommendations in each of these different forms of report. In contrast, the following pages draw upon examples of the most widespread formats, for example Information Notices and Alert Bulletins. These are used to identify general features that also characterise aspects of these more diverse formats. For example, the UK MAIB's Safety Digest is typically only produced twice or three times per year. They are, however, intended to fulfill the same role as the 'monthly bulletin' described in the previous list. These documents present case study incidents and then draw a range of general recommendations that are intended to inform the future actions of many different operators and managers within the maritime industries. This can be illustrated by two recent incidents involving fishing vessels [517]. The first incident began when a wooden fishing vessel touched bottom. This caused damage to the vessel's planking. Shortly after this a bilge alarm in the fish hold went off. The crew discovered that the hold was flooding. They contacted the coastguard and headed for the nearest port. Watertight bulkheads either side of the hold restricted the flooding. The vessel made port safely and was eventually pumped dry by a fire brigade tender. In the second incident, a bilge alarm went off during a severe gale. The crew of the trawler found that their engine room was flooding from a fractured casing of the main engine driven cooling pump. A bilge pump was started from an auxiliary power source. This incident was particularly serious because the damaged casing meant that the main engine had to be slowed in order to reduce the rate of flooding. This compromised the vessel's ability to remain close to a lee shore. The engine had to be shut down when water reached the main engine flywheel. The valve to the sea water inlet was closed to stop any more flooding and the engineers then investigated why the bilge pumping had so little effect. Debris had accumulated inside the bilge line valve body and this prevented it from closing. Once it had been cleaned, the bilge pumping system functioned as intended. A salvage pump from a lifeboat was also used to lower the water level in the engine room so that the main engine could be restarted. These incidents inspired a number of recommendations. It is interesting to note, however, that the MAIB refers to these as lessons. This is an important distinction because the term 'lesson' can to imply the sharing of insight into a particular problem. The term 'recommendation' is reserved for the proposed actions that are identified as part of a formal enquiry into particular accidents. The Safety Digest, in contrast, identifies the following findings from the two case studies described above:

1. "Both cases illustrate the benefits of bilge alarms, functioning bilge pump systems, and watertight bulkheads to limit the severity of a flooding incident.

2. The second incident shows the importance of maintaining a vessel's bilges free of rubbish so it cannot be drawn into the bilge system.

3. Valves on a bilge system must be regularly checked for correct operation." [517]

This case study illustrates the way in which the readers of periodical bulletins can be presented with insights from recent incidents. As can be seen, they typically take the form of reminders. They emphasise the importance of particular safety-related activities, such as the maintenance of bilge lines and valves. They also illustrate the potential consequences of neglecting those activities. The previous example also illustrates the way in which incident reports can be used to emphasise the importance of particular items of safety equipment. This is particularly significant for highly-competitive industries in which their might be an economic temptation to avoid the installation and maintenance of such devices that are not strictly necessary in order to achieve particular production quotas.

It is difficult to capture the diversity of recommendations that appear in incident reports. It can also be difficult to anticipate the particular focus that investigators will take when making particular proposals. Both of these points can be illustrated by the conclusions of a report by the Australian Maritime Safety Authority into livestock mortalities on board the MV Temburong [42]. This incident occurred when the deck generator supplying power to a livestock ventilation system failed. The crew identified that the generator's diesel fuel supply had been contaminated with a heavier grade of intermediate fuel oil. The power for the ventilation system was then transferred to the engine room generators. These subsequently failed. The consequences were a complete loss of electrical power including the shut down of the ventilation system to the livestock spaces. This second failure was traced to water contamination of the engine room generator's diesel fuel supply. The report focuses on the adverse outcome of the incident; over 800 cattle died. Less attention is paid to the potential dangers posed to the crew and other mariners by the loss of power to the vessel. This focus is entirely justifiable given that the investigators associated with a relatively low risk with the second and total power loss. This assessment is never made explicit within the report. The Australian Maritime Safety Authority do not present particular recommendations in this report. In contrast, they enumerate a number of conclusions. This approach is instructive because it typifies incident reporting systems that separate the determination of what happened from the recommendation of potential interventions:

> "14.1 The failure of both the primary and secondary sources of power was due to contamination of the ships fuel supplies: contamination of the fuel for the primary power source was water and the contamination in the case of the secondary power source was heavy fuel oil.
>
> 14.2 The situation was compounded by the failure of the ships communications systems during the incident as a result of an unexplained battery failure.
>
> 14.3 The serious nature of the incident was exacerbated by inadequacies on the part of the ships personnel in their immediate response to the incident and the absence of contemporary ship management practices.
>
> ...
>
> 14.6 On departure the operation and configuration of the ships generating equipment was in accord with the prescribed regulatory requirements. However the manner of operation has raised the issue of whether the Marine Order requires redrafting so as to ensure that the meaning of a secondary power source is more clearly defined.
>
> 14.7 Whilst the fuel contamination situation was avoidable the incident has nevertheless raised the general issue of the ability of livestock vessels to recover from a dead-ship situation. Whilst the Temburong satisfied class and flag rules in this regard the system was shown to be particularly vulnerable when the well being of the livestock is considered.
>
> 14.8 Following the restoration of power the crew performed well in a most difficult situation to remove the dead cattle from the vessel." [42]

As can be seen the findings from this investigation address a broad range of system failures. They consider problems in the crews' management, they address the failure of specific subsystems, they also consider regulatory failure and potential problems in the interpretation of Marine orders. The previous quotation does not, however, present particular recommendations. These are left implicit within the findings that are derived from the causal analysis. Sentences such as 'whilst the the Temburong satisfied class and flag rules in this regard, the system was shown to be particularly vulnerable' imply that the rules or their interpretation may be inadequate to prevent future incidents. Similarly, the report questions 'whether the Marine Order requires redrafting so as to ensure that the meaning of a secondary power source is more clearly defined'. This arguably implies that a recommendation be made to examine the sufficiency of the relevant Marine Order. Previous paragraphs have argued that this approach typifies incident reporting systems in which the identification of what happened is separated from the recommendation of remedial actions. This represents an extreme example of the heuristic introduced in Chapter 11.5 that investigators should leave domain experts to determine *how* to avoid future failures. It can, however, lead to a number of potential pitfalls. In particular, it is essential to ensure that the organisations and individuals who subsequently identify potential recommendations are independent from those who are implicated in a report. Fortunately, the investigators in our case study avoid this potential pitfall by passing their report directly to the Australian Maritime Safety Authority who, in turn, are responsible for identifying means of avoiding similar incidents in the future [43].

The use of language in an incident report can reflect the effect that particular recommendations are intended to have upon their audience. The previous recommendations illustrate the focused use of particular recommendations to reinforce existing safety information. They do not require significant additional expenditure nor do they imply a major safety initiative on behalf of the industry involved. In contrast, very different language is used by the US Coast Guard when a Quality Action Team presents its recommendations into towing vessel incidents on American Waterways [829]. They argued that the incidence of fatalities and injuries can be reduced by a program including prevention measures, the collection and dissemination of lessons learned, improved investigation and data collection techniques and the regular assessment of towing industry performance over time using a fatality rate model. in order to interpret the language used in these recommendations it is necessary to understand the nature of the relationship between the Quality Action Team and the intended recipients of their proposals. The team were anxious to preserve a cordial working relationship between the Coast Guard and the American Waterways Operators Safety Partnership. In consequence, they were anxious to stress 'non-regulatory solutions'. Under prevention, they argued that companies should implement a fall overboard prevention program. In particular, they should:

1. "Formulate and implement fall prevention work procedures consistent with vessel mission. crew complement, and geographic area of operation. Procedures should emphasise teamwork, communication, and safe work practices.

2. Ensure that all crewmembers receive initial and recurrent training in such procedures.

3. Assign responsibility for ensuring compliance with procedures to on-board supervision.

4. Enforce fall overboard prevention policies and consider the use of counseling, recurrent training, and discipline in the enforcement process.

5. Investigate all fall overboard incidents to determine what happened and how such incidents could be prevented in the future.

6. Inform all employees of fall overboard incidents and use lessons learned as part of a recurrent training program.

7. Modify fall prevention procedures as necessary based on investigation of fall overboard incidents." [829]

The detailed nature of these requirements arguably illustrates the way in which the Quality Action Team sought to ensure that the recipients of their report clearly understood the proposed remedies. This contrasts with the previous recommendations from the UK MAIB report that were far less detailed in encouraging companies to follow what can be regarded as existing practices. The previous requirements can be contrasted with further recommendation that were made by the Coast Guard. These acknowledged the diverse circumstances that characterise towing operations. They, therefore, encouraged companies to select 'best practices' from a list that was developed during the drafting of the report. This illustrates the cooperative, 'non-regulatory' tone of the report.

These is an interesting recursive element to the Coast Guard report. Their recommendations include the establishment of an incident reporting systems that would be used to 'publicise the findings and recommendations of the Towing Vessel Crew Fatalities Quality Action Team through the American Waterways Operators Letter, sector committee meetings, regional meetings, and the Interregion Safety Committee' [829]. The recommendations were also applied reflexively to members of the Quality Action Teams own parent organisation. They argued that the Coast Guard should publicise their recommendations through the Marine Safety Newsletter and 'Industry Days'. Brevity prevents a more sustained analysis of a detailed and exhaustive set of recommendations to a complex problem. It is worth noting in passing, however, that this document like many other products of incident report systems breaks many of the guidelines that were presented in Chapter 11.5. For example, we have described the US Air Force's injunction not to recommend further studies [795]. Instead, investigatory and regulatory bodies should propose actions even if they are are contingent upon on-going studies. In contrast, the Coast Guard's report identifies numerous areas for further analysis. American Waterways Operators and the Coast Guard are urged to find out more about the factors influencing survivability following a fall overboard Incident. They also recommend that the Quality Action Team's report be used to guide a more detailed analysis of fatalities in other segments of the barge and towing industry. Finally, they describe how further studies must be conducted to determine a means of measuring the impact that fall prevention programs, policies, and procedures have upon incident rates. The differences between this Coast Guard report and the heuristics that guide investigatory practice in the US Air Force can, in part, be explained by the differences in the nature of the recommendations that they propose. These differences, in turn, stem from the diverse nature of the reports that are being produced. The Air Force procedures refer to the recommendations that are produced after specific incidents and accidents. Further studies imply a delay that may jeopardise the safety of existing operations. Hence, the focus is on providing a rapid and effective response to particular failures. In contrast, the Coast Guard report presents recommendations that are themselves the product of a study into a collection of incident reports. Given the complex nature of these occurrences and previous problems in reducing the rate of towing incidents it is hardly surprising that some of the recommendations should focus on the need for further analysis.

As mentioned, the form and tone in which recommendations are presented can vary depending on the intended audience and the publication in which it appears. This can be illustrated by the recommendations from a more detailed investigation by the Transportation Safety Board of Canada into a 'bottom contact' incident involving a bulk carrier [786]. This report cannot easily be categorised in terms of the previous enumeration of document types because it does not directly introduce any new recommendations. It does, however, validate the interim measures that were proposed in collaboration with the Canadian Coast Guard . It is important to emphasise, however, that the lack of any new recommendations does not imply that the report does not play a role in the presentation of proposed interventions. In contrast, it provides an important means of disseminating information about those actions that have already been initiated by other organisations. The main cause of the incident was identified as the bridge crew's lack of information about a 'shallow spot' in the navigable channel of the Fraser River. This was attributed to inadequacies in the current system of monitoring navigable channels and producing depth information for vessels in that area. As mentioned, rather than making specific recommendations the investigators described the 'safety actions' that had been taken. The report concludes the Transportation Safety Board's investigation and, therefore, the reader can assume that these actions are considered to be sufficient to ensure that similar incidents will not occur in the future:

> "The Canadian Coast Guard advised that a formal Working Committee, with representatives from the Fraser River Pilots Association, Fraser River Port Authority and Coast Guard has been established and will be meeting quarterly to review channel conditions and status of the channel monitoring and maintenance dredging program. A possibility of modelling the sedimentation process to determine various rates of in-fill associated with forcasted river flow/discharge will be explored." [786]

It is clear from this quotation that the previous recommendations have a relatively limited geographical scope. They focus on the activities of the Fraser River Pilots Association and the Fraser River Port Authority. The local nature of such proposed interventions enables investigators to defer much of the detail about any recommendation. In contrast, previous paragraphs have described how incident investigations can motivate far more general proposals. These recommendations go beyond working practices in particular geographical area to address industry-wide operating procedures throughout the globe. The presentation and form of such recommendations can be very different from those in the interim and final reports that are generated after many incidents. This can be illustrated by the NTSB's recommendations following a series of fire on board passenger ships. The Board issued detailed proposals to the International Council of Cruise Lines and Cruise Line Companies Regarding Fires on Board Passenger Ships. As might be expected, such an action was not taken without considerable resources being allocated to analysing the causes of many previous incidents. Although the letter was drafted in July 2000, the initial incidents that prompted their intervention occurred on board the Universe Explorer in 1996 and the Vistafjord in 1997 [615]. The NTSB issued safety recommendations to the U.S. Coast Guard in April 1997 that automatic smoke alarms should be installed to protect both crew berthing and passenger accommodation areas. These recommendations were, in turn, forwarded by the Coast Guard to the International Council of Cruise Lines and the International Chamber of Shipping. The NTSB's proposals were opposed on the grounds that such systems might generate false alarms and could create crowd control problems. Three further incidents in 1998, 1999 and 2000 prompted the Board to reiterate their recommendations. They requested that Cruise Line Companies 'without delay install automatic local-sounding smoke alarms in crew accommodation areas on company passenger ships so that crews will receive immediate warning of the presence of smoke and will have the maximum available escape time during a fire' [615]. The same recommendation was also made for the installation 'without delay' of the same devices in accommodation areas on company passenger ship. The International Council of Cruise Lines were requested to withdraw their 'opposition to the amendment of the Safety of Life at Sea Convention chapter II-2 to require automatic local-sounding smoke alarms in crew accommodation spaces on board passenger ships and support a full discussion of the technical issues and any further U.S. Coast Guard actions on this matter before the IMO'. The same request was reiterated for their opposition to smoke alarms in passenger accommodation spaces. The recommendations concluded with an appeal that the council should support a 'full discussion of the technical issues involved and any further U.S. Coast Guard actions on this matter before the IMO' [615]. It is important not to overlook the colour or tone of the language used in this document. The note of exasperation or frustration reflects the Board's concern over this issue. Only time will tell whether this choice of language was an appropriate means of ensuring international agreement over these particular recommendations.

The analytical procedures that have been described in the previous section have a strong influence both on the recommendations that are derived from an investigation and also on the manner in which any proposed interventions are described in a subsequent report. For instance, the Swedish Board of Accident Investigation's 'no blame' approach is deliberately intended to help them issue recommendations as soon as possible after an incident has occurred; "...with the ongoing technical development it is also necessary to quickly get knowledge of shortcomings in an operation that can cause an accident or contribute to one" [769]. In more judicial systems, the focus is on identifying recommendations in a more deliberate fashion given that their findings can have a profound implication upon the livelihoods of the individuals who are affected [395]. The majority of incident reporting systems can be interpreted to lie between these two extremes. Proportionate blame approaches, such as that adopted by the US NTSB, will often issue interim recommendations that are then supplemented by any subsequent findings from a secondary investigation. The previous section has also described how reports assess these initial recommendations in terms of whether or not they were acceptable and, if so, can their implementation be declared closed. This two stage process creates considerable problems for those who must publish and disseminate information about potential recommendations. They must firstly ensure that all of the intended recipients receive copies of initial advisories. It is important that these individuals and organisations both understand the intended response to such recommendations and that they have the adequate resources to satisfy particular requirements. Regulators must then, typically, ensure that the same recipients of the initial advisories are then provided with the updated recommendations that may be made in any particular incident report. Of course, these may also 'countermand' or replace recommendations that were made as a result of incident reports that were issued many months or years before the present investigation.

Such dissemination activities require considerable logistical support. Investigatory organisations have, therefore, developed a range of databases to monitor and support the dissemination of incident recommendations. For example, Chapter 11.5 describe some of the applications that support US Army reporting systems. Other organisations have developed billboards that help the intended recipients of a recommendation to monitor amendments and revisions. Such resources are important when logistical barriers prevent regulators and investigators from guaranteeing the delivery of proposed interventions. For example, it can be difficult for the crews of many different merchant vessels to continually monitor the findings of incident reports that cover all of their possible ports of call. Later sections will focus on these dissemination problems in more detail. For now it is sufficient to stress that many of these systems fulfill a dual purpose. Not only do they help monitor the distribution and receipt of particular recommendations, they can also be used to monitor their implementation. These databases, typically, restrict access to such information. In contrast, the New Zealand Transport Accident Investigation Commission maintains a World Wide Web list of information about marine safety recommendations [632]. They recognise that "not all safety recommendations and responses are published in the Commission's Occurrence Reports because at the time of printing some recommendations may have been incomplete or some responses may not have been available". The bulletin-board is accessed via a list of previous incidents. For example, the user would select a link labelled 'Report 00-211, harbour tug Waka Kume, loss of control, Auckland Harbour, 19 November 2000' in order to view any revisions to the recommendations that were made in that particular report. An alternative approach is to publish revised recommendations in terms of particular safety-related themes, such as transfers between ships and helicopters. This approach is similar to that adopted by the Australian Maritime Safety Authority [43]. Assuming that the reader had selected the New Zealand link, cited above, they would be presented with information about the recommendations that were made in the initial report. The Commission recommended to the manager of marine services for the Ports of Auckland Limited that he revise their tug operator training manual to include detailed information about engine and control system failures. They also requested that he introduce regular, documented peer reviews to ensure that all tug operators complied with the relevant safety regulations. These reviews should also assess the training that the Ports of Auckland Limited provides for its skippers. They should be performed by independent experts in the operation of similar tugs. The New Zealand Transport Accident Investigation Commission's recommendation summary goes on to describe the Manager's response to these proposals. This response illustrate the way in which bulletin boards can be used to inform 'interested parties' that particular recommendations have been accepted and are being implemented. The Manager confirmed that:

1. "Updates to the tug operator training manuals shall be carried out as follows: engine control system failures, this section shall be expanded; response to engine control system failures, this section shall be expanded; handling the tug with one azimuthing unit, this task shall be given greater emphasis; introduce a system of peer review, this is being done.

2. The requirement to review Ports of Auckland Ltd training skippers by independent experts is not practical. The trainer we originally used was from Canada no other trainer exists in NZ. Many of our staff have gained good skill levels with these vessels and will be adequate for use in peer reviews." [631]

Unfortunately, further problems complicate the presentation of those recommendations that are made in aftermath of an adverse occurrence or near-miss incident. In particular, incident reporting systems must not simply present the findings that are derived from isolated near-miss incidents or adverse occurrences. They must also consider interventions that address common features amongst a number of previous failures. The problems of presenting these findings from multiple incidents are assessed in later sections. In contrast, the following paragraphs focus more narrowly on guidelines for the presentation of recommendations that relate to single incidents.

Presentation Issues for Recommendations

As we have seen, previous incident reports have been weakened by factual omissions. This can prevent readers from gaining a good impression of the events leading to an adverse occurrence or near-miss incident. Similarly, if parts of an analysis are omitted then it can be difficult to follow the conclusions that are derived from an incident investigation. The level of quality control that can be observed by reading large numbers of incident reports is, arguably, higher in the preliminary sections of these documents than it is in the concluding paragraphs that, typically, list any potential recommendations. One means of validating this claim is by looking at the litigation that follows from many incidents and accidents. These proceedings, typically, focus on the proposed interventions in the aftermath of an adverse occurrence. Far fewer proceedings are initiated to question the evidence that is put forward in an incident report. Such differences can also be explained in terms of the consequences that recommendations have upon the future operation of safety-critical systems. Incident reconstructions are likely to be less contentious than any proposed interventions because they need not carry with them the costs that are associated with implementing any subsequent changes. It makes little practical difference whether one explains the focus on recommendations as being due to flaws in their presentation or to natural concerns over the cost implications their implementation. In either case, it is clearly important that analysts devote considerable time and attention to ensuring that their findings are presented in a clear and coherent manner. As we shall see, this can involve the publication of preliminary or interim reports to solicit comments of proposed interventions. It can also involve more restricted forms of pre-publication or consultation during which analysts validate their recommendations before disseminating them more widely. Such techniques can be used to ensure that the presentation of recommendations satisfies a number of detailed requirements:

1. *Identify the recipients and draft recommendations accordingly.*
   Chapter 11.5 has already described how recommendations should consider what must be achieved but not necessarily how those goals will be implemented. It has also been argued that the recipients of a recommendation must have the necessary resources to achieve particular objectives by the dates that are specified in an incident report. Unfortunately, many incident reports fail to follow these guidelines. For example, the following excerpt is taken from a report issued by the Hong Kong Marine Accident Investigation Section:

   > "Non compliance of the safety guidelines for the transport of motor vehicles/cycles is considered the principle cause of this accident. Had the guidelines been followed, there would have been no uncleaned fuel tanks of motorcycles containing residue of volatile hydrocarbon based substance and residual fuel in the engine assemblies, and as a result no accumulation of hydrocarbon vapour in the container." [366] http://www.info.gov.hk/mardep/dept/mai/elmi399.htm

   This illustrates how recommendations may often be implicit within the findings of an incident report: operating companies must follow the safety guidelines for the transport of motor vehicles. There are a number of problems with this implicit approach. Firstly, reminders to operators that they must 'try harder' offer few guarantees about the future safety of an application process [411]. Secondly, the implicit nature of such recommendations can lead to a range of different interpretations of the proposed remedies. Readers might infer that the harbour authorities ought to initiate more frequent checks to ensure compliance with these regulations. Alternatively, improved training might be offered to the particular working groups that were involved in loading this vessel. In an ideal world, such alternative interpretations might encourage readers to initiate a range of interventions. In practice, however, there is a danger that any ambiguity can encourage individuals and organisations to pass-on responsibility for implementing particular recommendations.

2. *consider the problems of non-compliance or opposition.*
   The most observant readers of this work will have noticed a particular trend that is apparent in the response to many of the recommendations that have been proposed by the NTSB. In Chapter 8.3 we looked at the recommendations that were issued in response to a succession of gas explosions. The Office of Pipeline Safety in the Department of Transportation questioned NTSB initiatives to install Excess Flow Valves [589]. Similarly, previous sections in this chapter have described the reluctance of the International Council of Cruise Lines and the International Chamber of Shipping to introduce automatic smoke alarms into crew berthing and passenger accommodation areas [615]. One explanation for the opposition that is often provoked by NTSB recommendations is that their investigators focus primarily on the safety issues rather than the cost implications of implementing particular proposals. As we have seen, other incident reporting systems take a more cautious approach when they 'target the doable'. The reluctance to implement particular recommendations, arguably, provides a further illustration of the relationship that exists between corporations and federal agencies in the United States. In either case, such opposition illustrates the importance of explicitly considering what to do when the recipients of a report object to particular recommendations. As we have seen, some reporting agencies simply document the findings of an investigation without providing the reader with any idea of whether or not they were actually implemented. Any objections that block the implementation of a recommendation are then, typically, only revealed in subsequent reports that document the recurrence of similar incidents. Of course, this approach cannot be used to identify situations in which objections to a recommendation have not contributed to

subsequent incidents. This approach creates considerable problems both for incident investigators and safety managers. It can be difficult for them to recreate the different arguments that support and oppose particular recommendations. As a reader of incident reports, it can often be frustrating to see investigatory agencies repeatedly advocate the same interventions without any explanation of why their recommendations are consistently not being implemented. Other reporting organisations have avoided these problems by publicising any dialogues that take place with 'interested parties'. This can be illustrated by the way in which the IMO have collated the arguments for and against particular recommendations in the aftermath of Erica oil pollution incident off the French coast. The IMO collated and published responses from the IMO Maritime Safety Committee and their Maritime Environment Protection Agency. These addressed recommendations and proposals made by the International Association of Classification Societies and a resolution by the European parliament. Their views on changes to condition assessment schemes provoked further response from the International Association of Ports and Harbours. Amendments were proposed by maritime organisations in Belgium, Brazil, the Bahamas, Germany Greece, Japan etc. The IMO Maritime Environment Protection Agency then commented on these national submissions. Further statements were made by the International Chamber of Shipping and the International Association of Independent Tanker Owners. Such multi-national responses represent an extreme example. In most incident reports, it is possible to represent different attitudes to particular findings within a final report. This enables investigators to document the reasons why particular groups might oppose the implementation of any potential recommendations. This explicit statement of objections is very important. There have been many instances in which operating companies have denied objecting to recommendations that might have prevented incidents and accidents.

3. *define conformance and validation criteria.*
Like most guidelines, it is possible to identify a number of problems that must be addressed when attempting to use the items in this list as a means of informing the presentation of recommendations that are derived from incident reports. For instance, we have argued that investigators should, if possible, avoid trying to specify the precise mechanisms and procedures that might be used to satisfy a particular finding. This create problems because regulatory authorities, safety managers and operators must determine appropriate means of meeting particular recommendations. There is an obvious danger that incident investigators might conclude that any failure to prevent subsequent incidents indicates a failure to satisfactorily implement their recommendations rather than concluding that their previous recommendations were inadequate. It is, therefore, important that if a report documents what must be done rather than how then the report must also specify conformance criteria that can be used by operators and regulators to determine whether particular mechanisms have satisfied particular high-level objectives. Or put another way, without such criteria investigators may continue to blame inadequate implementation of previous recommendations rather than investigating whether those recommendations were adequate in the first place. Establish conformance is non-trivial. We might like to specify that any proposed changes will make it extremely unlikelihood that an incident will recur. As we have seen, however, many safety-critical incidents have an extremely low probability. If we consider an incident that occurs once in every 100,000 hours of operation, we may have to wait a considerable period of time before we can have any assurance that proposed changes have reduced this frequency. Basic probability theory suggests that even if we observe a system for 99,999 hours there is no guarantee that an incident will not occur twice in the remaining hour. These issues will be discussed in greater detail in Chapter 14.5. For now, the UK Coastguard Agency's Marine Pollution Control Unit's report into the Sea Empress Incident illustrates some of the points mentioned in this paragraph [794]. The report does not focus on the causes that contributed to the grounding of the vessel and subsequent release of 72,000 tonnes of crude oil into Milford Haven. Instead, it analyses the environmental response and makes a number of recommendations that are intended to improve the 'clean-up' operation after future incidents. The Sea Empress was grounded in 1996, since that time there have been no comparable incidents that might be used to judge whether or not the

recommendations have had their intended effect. All that can be done is for the relevant agencies to test their preparedness in simulated exercises that are intended to demonstrate that they meet the recommendations outlines in the Coast Guard report. The nature of these exercises can vary significantly from one local authority to another. This guideline, therefore, argues that incident reports should document acceptance criteria that can be used to determine whether or not particular mechanisms have actually satisfied a recommendation.

4. *Link the recommendations to the analysis.*
The previous section has argued that incident reports must develop explicit links between the evidence that supports a reconstruction and the analysis that leads to certain causal findings. This is intended to reassure readers that those findings are grounded in the evidence that is obtained in the aftermath of an incident. Similarly, it is important that an incident report documents the relationship between particular recommendations and the products of a causal analysis. Such links create a clear path between the events that contributed to previous failures and the proposed interventions that are intended to prevent future recurrences. The importance of these connections can be illustrated by two recommendations from a report that was issued by the UK MAIB [516]. The incident began when the watchkeeping motorman on a roll-on, roll-off cargo vessel started to clean the top of an electrical cabinet. To gain access, he stood on top of a pipe and lent over a fuel oil booster pump. As he did this, he inadvertently activated the emergency stop button on the pump. The pump stopped and this caused a fall in the fuel pressure for the main engine. This, in turn, caused the main engine to stop resulting in a 'black out' when the generator breaker on the main switchboard tripped. The particular details of this incident are less significant in the context of this section than the recommendations that were identified. The first of these stressed that all emergency stop buttons should be fitted with bright protective covers that should alert operators to their presence and function. The relationship between this recommendation and the details of the incident is relatively clear given the details that were provided in the reconstruction. In contrast, a further recommendation focussed on the "need for an active Safety Committee" even though the report tells us nothing at all about the activities of the safety committee of the vessel involved in the incident. A recommendation that "safety committees should examine all new regulations, operating requirements and the implications of new equipment to see whether any affect the risk profile" seems almost incidental to the occurrence being reported. Such proposals require further justification if readers are to be convinced that they might play a significant role in prevent future incidents [124]. Conversely, it is also important to justify a decision not to derive any recommendations from an incident. This can be illustrated by the conclusion to the Swedish Board of Accident Investigation's report into the collision between the MT Tärnsjö and the MV Amur-2524 mentioned in previous paragraphs [768]. This tersely summarises the proposed interventions as follows: "4. Recommendations. None". When investigators propose particular interventions, they must provide safety managers with a justification that will motivate them to implement any recommendations. Conversely, if investigators decide not to propose any potential interventions then they must provide the authorities that commission the report or which regulate the reporting system with a justification for their decision that no recommendations need be drawn.

5. *explain why recommendations have been rejected or modified.*
The previous example provides an extreme case in which no recommendations were identified in the aftermath of what might have been a very serious incident. More generally, it is necessary to explain why particular recommendations were rejected rather than justifying a decision to entirely reject making any recommendation at all. This is important because readers often form particular hypotheses about potential interventions that might have avoided an incident. If investigators propose alternative remedies then there is a danger that operators and safety managers will choose to follow their own intuitions rather than the proposed alternative. As we have seen, this can have the knock-on effect of complicating any attempts to validate recommendations unless significant resources are used to assess the degree of non-compliance within an industry. The US Coast Guard avoid this problem by a relatively sophisticated process that

also helps to validate particular recommendations. The initial investigation restricts itself to an examination of the facts that are known about an incident. A subsequent section of 'Findings' are then used to present the results of the analysis. A preliminary report is then presented together with a letter containing proposed recommendations is then sent to the Coast Guard Commandant. They review each recommendation, typically, with the Commander of the district in which the incident occurred. They then draft a letter that is printed at the start of each report. Their response lists each recommendation and states whether or not they concur with the proposal. If they do not concur with the specific recommendation, they may agree with the intent and modify the proposal. It is difficult to find any examples of investigator's recommendations that have been rejected. However, this style of report does present detailed arguments to explain why some recommendation are considered inappropriate. This, in turn, can help to justify the alternative recommendations that are proposed by the Commandant and his staff [832]. The Transportation Safety Board of Canada report into the Fraser river incident, mentioned in previous paragraphs [786], provides an example of an alternative approach. In this instance, rather than having an external auditor validate the recommendations made by the investigators, the investigators validate the interim actions that have been taken by local and regional officers in the aftermath of the incident. As mentioned previously, the report into this incident describes the investigation as closed without proposing any new recommendations. The investigators do not modify or revise the interim recommendations presumably because they are considered to be sufficient to prevent any recurrence of a similar incident.

6. *Distinguish between recommendations and lessons learned.*
   This section began by listing the publications that are used to report on information submitted to the US Coast Guard's International Maritime Safety System. These range from formal alert bulletins that describe interim recommendations through to the informal information notices that summarise more general problems and which provide background information about potential hazards. This distinction between different forms of publication provides readers with important cues about the relative importance of particular recommendations. Alert bulletins, typically, describe particular actions that should be allocated an extremely high priority within daily working practices. In contrast, information notices may provide general advice that often simply describes 'best practice' without requiring the rapid implementation of particular procedures. Such differences are apparent both in the medium of publication and in the style of prose that is used to convey these different types of information. For instance, the difference between formal alerts and information notices is intended to reflect a distinction between incident recommendations and more general 'lessons learned'. The Coast Guard describe the style and format of lessons in the following terms: "Lessons learned: the information presented through the links below is mostly anecdotal and primarily intended for those who work on the many vessels that navigate our oceans and waterways" [833]. In contrast, incident recommendations follow the more structured format suggested by the previous guidelines in this section.

This section has presented a number of high-level guidelines that are intended to help investigators draft reports into adverse incidents and near-miss occurrences. The focus has been on the more formal style of report that are typically produced in the aftermath of failures that carry relatively severe potential consequences. This is justified by the observation that many of these reports have been flawed by omissions and inconsistencies [426]. It is also possible to selectively use subsets of these guidelines to inform the presentation of less formal reports. In both cases, it is important that investigators consider means of validating the documents that they produce. The guidelines presented in this section are no more than heuristics or rules of thumb. They are the product of experience in generating incident reports. They may not, therefore, provide appropriate guidance for the ast range of incident reporting systems that are currently being implemented. It is, therefore, often necessary to conduct further studies to increase confidence that incident reports provide their readers with all necessary information in a format that supports the operation and maintenance of safety-critical applications.

13.3 Quality Assurance

This section presents a range of techniques that can be used to support both the validation and the verification of incident reports. Verification establishes that a document meets a certain number of technical requirements. These include the need to ensure that a report does not contain inconsistent information about the course of events leading to an incident. They also include the requirement to ensure that any recommendations do not rely upon contradictory lines of analysis. In contrast, validation techniques can be used to establish that a document actually satisfies a range of user requirements. For instance, it is important to determine whether or not the potential readers of an incident report gain a clear understanding of any proposed recommendations. Similarly, it should be possible to demonstrate that the recipients of a report will have confidence both in the reconstruction of events and in the analysis that is derived from any reconstruction. It can be argued that properties such as consistent and a lack of contradiction are basic user requirements and hence that verification techniques form a subset of the more general validation methods. We retain a clear distinction between these different approaches by assuming that verification techniques often yield insights into a document without the direct involvement of the intended recipients. In contrast, validation techniques involve user testing and the observation of readers using incident reports to support particular activities.

13.3.1 Verification

It is possible to identify a range of properties that investigators might require of an incident report. A small subset of these can be summarised as follows:

- *consistency*. It is important that an incident report should 'get the facts correct'. This implies that the timing of events should be reported consistently throughout a document. If there is genuine uncertainty over the timing of a particular action then this should be made explicit. This form of temporal coherence should be supported by location coherence. The position of key individuals and systems should be consistently reported for any particular moment during an incident. In other words, people should not appear to be in two places at once. Similarly, technical details such as the serial number, type and operating characteristics of particular devices should not change throughout a report unless such changes are explained in the supporting prose. It might seem unnecessary to state these requirements. However, a number of previous studies have document numerous violations of these apparently simple requirements. One of the best known instances involves an incident report in which inconsistent timings were given throughout the document because the emergency services disagreed over who reached the scene first. This disagreement was not made explicit in the document and the reader was offered no explanation as to why key events were given different times in different sections of the report [502].

- *lack of contradiction*. Contradictions can be seen as a particular form of inconsistency. For instance, mathematical proofs of consistency can be used to identify potential contradictions. In incident reports, they occur when the same document assets that some fact A is both true and not true. It is relatively rare to find factual contradictions within an incident report. It is more common to find that an event A is reported to occur at a range of different times rather than an assertion that A did *not* occur at a particular time. Contradictions are, however, more often found in the arguments that support particular findings in an incident report. They occur when the same evidence is used both to support and to weaken particular lines of analysis. As we shall see, the same events can be interpreted within the same report as evidence that operators were following standard operating procedures and yet were disregarding particular safety requirements. It is important that investigators identify such situations not because they are in some sense 'incorrect' but because they often require further explanation in order to convince readers that they do not reflect a deeper weakness within the interpretation and analysis of an incident.

- *limited use of rhetorical devices.* Chapter 10.4 has described a range of biases that affect the interpretation of information about safety-critical incidents: author bias; confidence bias; hindsight bias; judgement bias; political bias; sponsor bias; professional bias; recognition bias; confirmation bias; frequency bias; recency bias; weapon bias etc. These often stem from the external pressures that social and political groups can place upon investigators. There is a danger that these pressures can encourage individuals to support lines of reasoning that may not be directly supported by the available evidence. There is also a danger that this will result in reports that use rhetorical devices, which help to persuade readers that alternative hypotheses should be discounted. As we shall see, it is impossible within any prose document to entirely avoid the use of rhetorical devices. It is, however, important that investigators are aware of the potential impact of these techniques. It is also possible to employ structured reading techniques to ensure that these devices are not used in a way that might mislead the intended audience about the course or causes of adverse occurrences and near-miss incidents.

- *structural simplicity.* There are a number of structural problems that complicate the task of drafting an incident report. The standard formats mentioned in previous sections require that reconstructions and summaries of the events leading to an incident are presented before any sections that analyse the causes of an incident. Dozens of pages can, therefore, separate the presentation of evidence from the arguments that use particular facts about the course of events. Similarly, recommendations may be presented many pages after the lines of analysis that support them. Many investigators have addressed this problem by reiterating factual information within the analysis section. Analytical arguments may also be repeated before the presentation of any recommendations. This creates further problems because subsequent editing of either section can introduce the inconsistencies and contradictions mentioned above. In other reports, key facts can be omited from a reconstruction and may only be presented before particular recommendations. Previous sections have referred to such practices as the 'Perry Mason' or 'Agatha Christie' approach to incident reporting. Readers cannot form a coherent picture of an incident until they have read the closing pages of the report.

This is a partial list. Investigators can identify a range of other requirements that should be satisfied by incident reports. For instance, they might wish to guarantee that sufficient warrants are provided to support the evidence that is presented in these documents. Warrants describe the backing or source that supports particular items of information. Brevity prevents a complete analysis of these diverse properties. In contrast, the following pages briefly introduce a number of techniques that can be used to verify particular properties in incident reports. As mentioned, they can be distinguished from validation techniques because they can typically be performed by an analysis of the document prior to publication and they do not require direct access to the intended recipients of a particular report.

Analysis of Rhetorical Devices

Rhetorical devices, or tropes, represent common and traditional techniques of style and arrangement that can be used in prose to achieve a number of particular effects. These effects include emphasis, association, clarification and focus. They also involve the physical organisation of text through transition, disposition and arrangement. A further class of tropes deals with variety and decoration. It is difficult to write effective prose without making use of these different devices. It is also important to understand the particular effects that these devices can have upon the readers of an incident report. In particular, investigators must recognise when their use of particular rhetorical devices might have an unwanted or unwarranted impact upon their audience.

There are many good textbooks that provide an overview of rhetorical techniques. Some, such as the primer by Corbett and Connors, also include progymnasta or classical composition exercises that are intended to help writers use particular devices [184]. It is ironic that many of these techniques, that are traditionally intended to persuade others of your own opinion, might be abused in the context of incident reporting. They provide case studies in the use of language to create an effect that does not stem solely from the information that is contained in the sentence. Brevity prevents a complete introduction to all of these techniques. In contrast, the following list briefly summarises a selection of the most common tropes and provides examples of their use within a single incident report. These illustrations come from a report that was published by the Transportation Safety Board of Canada [785]. In this incident, the Navimar V, a pilot boat, came alongside a bulk carrier, the Navios Minerva. As she did so, she overtook a wave generated by the carrier and pitched onto its crest. The Navimar V then surged into the trough of the next wave and plunged into the sea. The submerged bow slowed the pilot boat but her momentum continued to pitch the vessel until she turned over. The incident resulted in serious injuries to one crew member and minor injuries to three more people, including two pilots who were using the accommodation ladder to board the Navimar V. The subsequent report into this incident can be used to illustrate the role that particular tropes or rhetorical devices can have upon the reader of an incident report:

- *Amplification*
  This technique involves the restatement of an idea or argument. It often also involves the introduction of additional details. For example, the report into the capsize of the Navimar V includes the following findings:

  > "2. Under international regulations, the vessel was required to use a pilot ladder to transfer pilots.
  > 3. Instructing Marine Communications and Traffic Services traffic regulating officers to tell foreign crews to use the accommodation ladder is a request made by the pilots but is contrary to international regulations." [785]

  The first finding notes that international requirements require the use of a pilot ladder. The second finding amplifies this observation by noting that the request to use an accommodation ladder is also forbidden. This technique can have the effect of drawing the reader's attention to a particular concept or idea. The amplification not only introduces new facts but it also supports and reiterates the arguments that are introduced in previous sentences. This technique can create problems when the amplification of particular aspects of a previous assertion can detract from other arguments or items of information. The combined effect of these confirmatory statements can have a significant impact upon the reader of an incident report. It is, therefore, also important to provide sufficient evidence to establish the credibility of both an initial assertion and the subsequent amplification. For instance, the reader of the Navimar V report is referred to Chapter 5, Rule 17 of the 1974 International Convention for the Safety of Life at Sea (SOLAS). This stipulates that pilot ladders must be used for pilotage service.

- *Anaphora*
  This technique uses repetition at the beginning of successive phrases, clauses or sentences. It can create an impression of climax in which the repetition leads to a particularly important insight or conclusion. The Navimar V report uses this technique in the paragraphs of analysis that immediately precede the investigator's conclusions:

  > "Because the bulk carrier was moving at a speed through the water of about 10 knots, the waves she generated were probably unusually large. During the transfer, the pilot boat was manuevred onto the crest of one of those waves which was just forward of the accommodation ladder platform. Because the speed of the wave was less than the speed of the pilot boat, the 'NAVIMAR V' accelerated into the trough towards the next wave. Because the accommodation ladder was on the vessel's quarter, the bottom platform was not resting onto the vessel's side and the pilot boat's bow had to be rested on the vessel's side to line up the after deck under the accommodation ladder".[785]

  This example illustrates the successive use of the phrase 'Because the...' to build up a causal explanation of one aspect of the incident. It is reminiscent of the phrases that can be derived using the Why-Because Analysis (WBA) described in Chapter 9.3, although this technique was not used in this instance. The rhetorical device creates the impression of 'building up a case'.

The investigator uses each successive sentence to 'stack up' the evidence in a manner that supports the analysis. It is important to emphasise that such techniques are not of themselves either 'good' or 'bad'. Rhetorical devices can be used to convince us of well-justified conclusions or to support half-baked theories. It is important, however, to be sensitive to the effects that such techniques might have on the readers of an incident report. For instance, the previous citation can be interpreted to provide readers with a clear summary of the arguments that support the investigators' conclusions. It can also be interpreted in a more negative light. The repetition of such phrases may create an impression of certainty about the causes of an incident that might not be justified by the evidence. This particular rhetorical device leaves little room for suggesting alternate hypotheses as this particular argument is being presented.

- *Antithesis*
This uses juxtaposition to contrasts two ideas or concepts. This can be illustrated by the use of the term 'rather than' in the following sentence: "The custom on the St. Lawrence River for a number of decades has been for pilots to use the accommodation ladder rather than the pilot ladder, unless exceptional conditions require a departure from that practice" [785]. Here the practice of using the pilot ladder is being juxtaposed with the use of the accommodation ladder. This technique is important because readers may make a number of additional inferences based upon such constructions. In this context, it is tempting to infer that the prevailing custom on the St Lawrence is some form of violation. We know that an incident has occurred and the juxtaposition of existing practice with another procedure, such as the use of the pilot ladder, suggests ways in which those alternative practices might have avoided the failure. It can be argued that this analysis makes too many assumptions about the inferences that readers might draw from such an antithetical device. It is important to remember, however, that these additional inferences are very similar to those that been identified by Byrne and Tasso's experimental studies of counterfactual reasoning [124].

- *Asyndeton*
This device omits conjunctions between words, phrases and clauses. This technique creates an impression of 'unpremeditated multiplicity' [309]. The document creator can think of so many elements in the list that they hardly have time to introduce explicit conjunctions. This is illustrated by an enumeration describing the commitment of Transport Canada: "to the review and approval of construction plans, stability data, and the subsequent inspection of proposed or existing vessels, to ensure compliance with applicable regulatory requirements." [785] The omission of the final conjunction implies that the list is incomplete. There is also a sense in which this technique also builds to a particular conclusion. The final term 'to ensure compliance with applicable regulatory requirements' may be the most important. Asyndeton creates precise and concise summaries. It, therefore, offers considerable stylistic benefits to more formal incident reports that can otherwise appear to be verbose examinations of complex failures. There are, however, dangers. The implied omission of closing conjuncts, as in the previous example, can lead to uncertainty if the reader is unsure of what other information might have been omitted from a list.

- *Conduplicato*
This technique relies upon the repetition of key words or phrases at, or very near the beginning, of subsequent sentences. This can be illustrated by the following quotation in which the investigators stress the effects of "modifications" on the trimming characteristics of the Navimar V.

> "The series of modifications carried out in 1993, 1996, and in the spring of 1997, prior to this occurrence, were collectively unsuccessful in eliminating the perceived shortcomings in the vessel's dynamic trimming characteristics. Further modifications, after refloating the vessel in 1998, were made to reduce once again the detrimental after trimming characteristics." [785]

Conduplicato provides a focusing device because writers can use it to emphasise key features in preceding sentences. This helps to ensure that readers notice key concepts or ideas that may have overlooked when they read the initial sentence. The previous example also illustrates the way in which particular passages can simultaneously exploit several different rhetorical techniques. Not only is conduplicato used to emphasise the importance of "modifications" to the vessel. The term "trimming characteristics" is also emphasised by its use at the end of both sentences in the previous example. This technique focuses the readers' attention on the consequences of those modifications. Most investigators draft incident reports without ever being aware that they are exploiting such rhetorical devices. However, some of the material in this section is widely taught within courses on technical writing and composition. The intention behind these courses is to make writers more aware of the techniques that they can exploit in their documents. Previous paragraphs have stressed the dangers that can stem from the (ab)use of particular rhetorical techniques. They have also described how the inadvertent use of some devices can encourage readers to form hypotheses that were not intended by those who drafted an incident report. It is also important to acknowledge that some familiarity with the application of tropes might improve the prose that it often used to present these documents.

- *Diazeugma*
This rhetorical device involves sentences that are constructed using a single subject and multiple verbs. It is frequently used in the reconstruction sections of incident reports and can help to describe a number of consecutive actions. Diazeugmas can provide an impression of rapid change over time. For instance, the Navimar V report describes the master's actions in extricating himself from the capsized vessel: "he saw light which he thought was coming from the surface and swam in that direction, but found himself in the engine compartment" [785]. As can be seen, this rhetorical device captures a sense of urgency in addition to the temporal information that may be implicit within such structures. There is, however, a danger that diazeugma can provide misleading information if the actions occur over a prolonged period of time. There is also a concern that the implied sequences may divert attention from intervening events. This problem can arise from the use of a single subject throughout the sentence. The actions of other subjects may be postponed to subsequent sentences even though they may have been interleaved with those of the initial subject. For instance, the passage cited above continues as follows:

> "In the meantime the deck-hand, who was wearing a flotation device, surfaced near the hull. One of the two relief pilots hurried to the bulk carrier's bridge to inform the bridge team of the situation. At 0012, he reported the accident to the Quebec MCTS centre" [785].

Chapter 8.3 describes the problems that can arise when readers must reconstruct partial timelines from such prose descriptions.

- *Expletive*
This technique can be used to emphasise particular concepts by interrupting normal syntax. Examples include the use of 'in fact' or 'indeed'. The following excerpt drawn from the Navimar V report uses the expletive 'moreover' as a preamble to form of amplification. This again illustrates the way in which tropes can be combined to particular effect:

> "More recent pilot boats generally have a larger embarkation area forward of the wheel-house than aft of it, which makes it easier for the master to observe the transfer manuevre. Moreover, today's pilot boats operate at higher speeds during pilot transfers. Consequently, specific attention must be paid to their dynamic longitudinal trimming characteristics in the design stage, to ensure a safe operation throughout the vessel's displacement, transition, and full-planing modes." [785]

Such techniques can be used in a variety of different ways. In this example, the expletive is simply used to focus attention on an additional factors that increases the importance of considering the trim characteristics of pilot vessels. There are other instances in which reports have used expletives to cat doubt upon particular aspects of a testimony. For instance, the NTSB report into the loss of a clamming vessel contains the following sentence: “Mr Rubin also testified that he ‘absolutely’ registered his emergency position indication radio beacon with the National Oceanic and Atmospheric Administration” [832]. In this case the witnesses own rhetorical use of the expletive ‘absolutely’ is deliberately cited as a precursor to subsequent arguments questioning the truth of their statement. The witnesses own emphasis, therefore, imperils the credibility of the rest of their evidence if readers believe the investigators counter-arguments about the registration of the beacon.

- *Procatalepsis*
  This technique enables an argument to develop by raising and then answering a possible objection. This is intended to avoid a situation in which the reader’s attention is distracted from any subsequent argument by the doubts that might have arisen during their reading of the preceding prose. The case study report provides a relatively complex example of this technique: “it is difficult to see how a pilot boat could be completely immune to capsizing or plunging, but pilot boat design criteria must meet the needs of the industry and pilotage authorities” [785]. This illustrates the use of procatalepsis because it addresses the implicit objection that it is impossible to design a pilot boat that is completely immune to capsizing or plunging. The answer to this possible objection is that ‘design criteria must meet the needs of the industry and pilotage authorities’. As with previous techniques, this is not without its dangers. The purpose behind the use of procatalepsis is to enable investigators to continue with the main thrust of their argument. There is a danger that such brief comments may do little to address the underlying doubts of the reader. For instance, the Navimar V does not consider the form that such criteria might take not does it address the problems of establishing consensus about the needs of industry and pilotage authorities.

This list presents a preliminary analysis of the rhetorical devices used in incident reports. It builds on initial work by Snowdon [750]. He has argued that it is possible to apply this style of analysis as a means of hecking whether or not particular linguistic constructs are (ab)used to support bias in incident and accident reports. The objective of his work is to teach investigators to perform a detailed and critical reading-through of their reports prior to publication. The intention is not that they should be forced to learn the complex names and ideas associated with each trope. It is, however, intended that greater attention be paid to the effect that particular devices can have upon the readers of an incident report.

Logic

As mentioned, the previous list only provides a partial account of the many rhetorical devices that can be identified in incident and accident reports. Over sixty of these are identified by Harris’ Handbook of Rhetorical Devices [309]. Brevity prevents a more sustained analysis. It is, however, worth pausing to consider one additional trope known as *enthymeme*. This is an informally-stated syllogism in which either a premise or the conclusion is omitted. This can be illustrated by the following quotation for the Navimar V case study: “since visibility was good, conduct of both the vessel and the pilot boat was carried out by visual observation during the approach of the two vessels and the transfer of the pilots” [785]. This is an enthymeme because it omits the premise that if visibility is good then such manuevres should be performed using visual observation.

It is also possible to omit the conclusion in an enthymeme if it can be ‘generally’ understood from the premises. For instance, a meeting was convened between Transport Canada, the Corporation des pilotes du Saint-Laurent central, the Corporation des pilotes du Bas Saint-Laurent and the Laurentian Pilotage Authority to decide upon an initial response to the capsize of the pilot vessel. It was agreed that “Transport Canada would issue a Ship Safety Bulletin if the parties came to a consensus, but such consensus was not reached” [785]. This omits the conclusion that no Ship Safety Bulletin was issued. This illustrates a potential danger that stems from the use on enthymemes. The previous quotation provides no guarantees that such a Bulletin was not issued for other reasons.

In logical terms the 'if' in the preceding extract represents implication not bi-implication. Many readers of this extract may, however, make the inference that the publication was not issued and that this can be entirely explained in terms of the lack of agreement between the parties involved in the investigation.

There are further forms of enthymeme. An initial premise can create a specific context that affects the readers' interpretation of subsequent, more general, premises. Readers may then apply the initial premise to the generalisations in order to infer a number of more particular conclusions. For instance, the following excerpt refers to a range of human factors issues that may have affected the Navimar V incident:

> "The level of care and skill required of a crew manoeuvring a pilot boat are significant factors in this occurrence. Even the most experienced master may suffer a moment's inattention. An emergency manoeuvre to correct the vessel's behaviour may be as harmful as poor vessel design. The human factor is also part of the operating system." [785]

The initial sentence states that operator behaviour contributed to this particular incident. The following sentences provide generalised premises that do not refer directly to the circumstances surrounding the capsize of the Navimar V. The implicit conclusions that readers might identify from this enthymeme is that, in this particular incident, key personnel suffered from a moment's inattention, an emergency maneuver may have taken place and that human factors issues may have impaired the operation of the Navimar V.

There are considerable dangers in the use of enthymemes within incident reports. As we have seen, they often rely upon readers inferring conclusions that are implicit within the premises that appear in the published account. Unfortunately, there are few guarantees that every reader will correctly form the implied syllogism. In particular, the distinction between implication and bi-implication can lead to numerous problems with a negated premise. Statements of the form *not A* and *if A then B* does not enable us to conclude *notB*. However, we can conclude *not B* if we have a premise of the form *A if and only if B*. These problems may appear to be of esoteric significance. They have, however, resulted in numerous objections to the accounts that are presented in incident reports [427]. One solution is to use formal logic as a means of verifying that incident reports present all of the information that readers require in order to form the syllogisms that are used by investigators [415]. It is important to emphasise that there are some important differences between this use of logic and that proposed by Ladkin and Loer [470], reviewed in Chapter 10.4. WBA uses causal logics to support the causal analysis that must be conducted before a report is drafted. In contrast, the techniques that I have developed are aimed more at improving the presentation and argument in incident reports. Philosophically these differences are important because WBA embodies an objective view of causation from Lewis' approach to counterfactual reasoning [491]. This creates some technical problems when there may be rival explanations for the same observed events; Chapter 10.4 describes proposals to resolve this by introducing weightings into Lewis' modal structures. In contrast, the use of logic to verify the content of incident reports can avoid making any strong assumptions about what actually was the cause of an incident. This can be left up to the skill and expertise of the investigators. The use of logic in this context is simply intended to ensure that the account of an incident avoids the problems associated with the inappropriate use of enthymemes.

The practical application of logic to support the verification of incident reports is very close to that described in Chapter 8.3. In this previous chapter, mathematically-based notations were used to reconstruct the events leading to an incident. Rather than constructing clauses from the primary evidence that is obtained in the aftermath of an incident, verification proceeds by building a formal model from the phrases in a report document. This can be illustrated by the previous excerpt from the Navimar V case study. It was agreed that "Transport Canada would issue a Ship Safety Bulletin if the parties came to a consensus, but such consensus was not reached" [785]. This an be formalised using the following clauses, note that some of the parties to the agreement have been omited to simplify the exposition:

$$consensus(transport\_canada, laurentian\_pilotage\_authority) \Rightarrow$$

$$issue(transport\_canada, ship\_safety\_bulletin). \tag{13.1}$$

$$not\ consensus(transport\_canada, laurentian\_pilotage\_authority). \tag{13.2}$$

The first clause states that if consensus is reached between Transport Canada and the Laurentian Pilotage Authority then Transport Canada issues a Ship Safety Bulletin. The second clause states that consensus was not reached. Unfortunately, the laws of first order logic do not enable us to make any inferences from these premises about whether or not a bulletin was issued. This can be illustrated by the following inference rule that represents arguably represents the informal inferences that many readers would apply to the previous quotation. If we know that A is true and that if A is true then B is true, we can conclude that B is indeed true:

$$A, A \Rightarrow B \vdash B \tag{13.3}$$

Unfortunately, this rule cannot be applied to clauses (13.1) and (13.2) because these take the form $A \Rightarrow B, notA$. In order to address any potential confusion, we would be forced to explicitly state that no bulletin was issued by Transport Canada:

$$not\ issue(transport\_canada, ship\_safety\_bulletin). \tag{13.4}$$

Alternatively, we could re-write the prose used in the incident report: Transport Canada would *only* issue a Ship Safety Bulletin if the parties came to a consensus, but such consensus was not reached. The introduction of the modifier 'only' rules out other circumstances that might have led to the publication of the bulletin and which are not mentioned in that particular passage. This would result in the following formalisation which includes the $\Leftrightarrow$ operator (read as 'if and only if'):

$$\begin{aligned} &consensus(transport\_canada, laurentian\_pilotage\_authority) \Leftrightarrow \\ &\quad issue(transport\_canada, ship\_safety\_bulletin). \end{aligned} \tag{13.5}$$

$$not\ consensus(transport\_canada, laurentian\_pilotage\_authority). \tag{13.6}$$

The use of the $\Leftrightarrow$ operator provides a number of additional inference rules that can be used to verify the informal reasoning process that has been described in previous paragraphs. One of these rules can be formalised as follows:

$$not\ A, A \Leftrightarrow B \vdash not\ B \tag{13.7}$$

The proof proceeds by applying (13.7) to clauses (13.5) and (13.6) to derive:

$$not\ issue(transport\_canada, ship\_safety\_bulletin). \tag{13.8}$$

The use of formal logics offers a number of additional benefits to the verification of incident reports. In particular, it can be used to strip out repetition when it is used as a rhetorical device. For example, the Navimar V case study includes the following phrases:

> "In the compulsory pilotage areas on the St. Lawrence River, most pilots use the accommodation ladder for access to vessels." (Section 1.12.2, [785])
>
> "The custom on the St. Lawrence River for a number of decades has been for pilots to use the accommodation ladder rather than the pilot ladder, unless exceptional conditions require a departure from that practice." (Section 2.2, [785])
>
> "Most St. Lawrence River pilots use the accommodation ladder to board vessels." (Section 3.1, [785])

Such repetition can have an adverse effect on the reader of an incident report. The recurrence of similar sentences reiterates particular observations. This indirectly lends additional weight to arguments even though each restatement of the information is based on the same evidence. There may be insidious effects when, as in the previous examples, no evidence is cited to support particular assertions about existing practices on the St. Lawrence. The previous citations might be represented by the following clauses.

$$\begin{aligned}&\mathit{size\_of}(\mathit{pilot}(P1), \mathit{perform}(P1, \mathit{access\_accommodation\_ladder}), N1) \wedge \\ &\mathit{size\_of}(\mathit{pilot}(P2), \mathit{perform}(P2, \mathit{access\_pilot\_ladder}), N2) \wedge \mathit{most}(N1, N2).\end{aligned} \tag{13.9}$$

As mentioned, such formalisations help to strip out the rhetorical effects of repetition. Logical conjunction is idempotent. In other words, $A \wedge A \wedge A \wedge A$ is logically equivalent to A even though the rhetorical effect may be quite different. It is important to note, however, that we have had to rely upon a second order notation in order to formalise the notion of 'most' in (13.9). This illustrates a limitation of our application of logic. A range of relatively complex mathematical concepts may be required in order to formalise the prose within an incident report. There are further limitations. For example, we have not provided the semantics for *most*. We might have resorted to the use of $>$ but this would not have captured the true meaning of the investigators' remarks. Such a formalisation would evaluate to true if just one more pilot used the accommodation ladder rather than the pilot ladder. We might, therefore, specify that $\mathit{most}(N1, N2)$ is true if $N1$ is twice as big as $N2$, three times as big as $N2$, four times as big as $N2$... The key point here is that the process of formalisation forces us to be precise about the meaning of the prose that is used within an incident report. This offers important safeguards during the verification of a particular document. For example, if we consider precise numerical values to support the definition of *most* we might then require that investigators providing statistical evidence to demonstrate that three, four or five times as many Pilots use the accommodation ladders as use the Pilot ladders.

The previous example has illustrated not only how logic can be used to combat the rhetorical effects of repetition, it has also illustrated the level of precision that this approach promotes during the verification of an incident report. There are further benefits, especially when investigators consider variants of the enthymeme tropes mentioned above. An enthymeme involves the omission of a premise or conclusion from an argument. It is relatively rare to find incident reports that deliberately omit major facts from their account [426]. More frequently, evidence can be cited many pages away from the arguments that it supports This creates problems because readers can easily overlook this confirmatory evidence and hence may not draw the conclusions that might otherwise have been derived about the course and causes of an incident. Similar problems can arise from the use of the structuring mechanisms that have been described in previous sections of this chapter. In particular, by stating the conclusions at the end of an incident report it is relatively easy for readers to forget or overlook the caveats and provisos that may have been used to circumscribe those findings in the previous sections of a report. For example, the Navimar report includes the following conclusion: "9. the pilot aboard the bulk carrier and the master of the pilot boat did not come to an agreement by radio communication on the time and position for the transfer" [785]. An initial reading of this finding might suggest that radio communication ought to have been made and that this might have helped to avoid the incident. Such an interpretation ignores some of the contextual factors that convinced both of these experienced mariners that such a course of action was unnecessary. For instance, the report make the following observations ten or more pages before the conclusions cited above:

> "Since neither the master of the pilot boat nor the pilot on board the bulk carrier was expecting any problems with the transfer manoeuvre, they did not see any point in making contact by radiotelephone to determine when the pilot boat should come alongside and transfer the pilots, nor were they required to do so by regulations." (Section 1.9.2, [785])

In order to correctly interpret finding 9, cited above, readers must remember that the pilot and master were not required to make radio contact and that both considered such contact to be unnecessary given the prevailing conditions at the time of the transfer. This is a non-trivial task. As we have seen, most incident reports contain a mass of contextual detail. For example, the Navimar V report provides details of previous pilot transfers that did not play any direct role in this particular incident.

It can be difficult for readers to identify those details that will be significant to their understanding of the conclusions in an incident report and those that simply add circumstantial information. Logic can be used to strip out this contextual information. we have pioneered a style of analysis that is similar to the WBA, described in Chapter 8.3. Rather than starting with a temporal sequence of events leading to an incident, we start with the conclusions in an incident report. For example, the conclusion about the lack of communication can be represented by the following clause:

$$notmessage(pilot\_bulk\_carrier, master\_pilot\_boat, transfer\_details). \tag{13.10}$$

The verification process then proceeds by a careful reading of the incident report to identify any previous information that relates to this conclusion. The previous citation might be formalised as part of this analysis in the following manner:

$$\begin{aligned} & weather(visibility\_good) \wedge \\ & notrequired\_message(pilot\_bulk\_carrier, master\_pilot\_boat, transfer\_details) \Rightarrow \\ & notmessage(pilot\_bulk\_carrier, master\_pilot\_boat, transfer\_details). \end{aligned} \tag{13.11}$$

Ideally, we would like to apply a formal proof rule, such as (13.3), to show that the conclusion was supported by available evidence. In order to do this we must first demonstrate that the visibility was good and that there was no requirement for the master and the pilot to communicate the details of the transfer. The report contains detailed meteorological information: "since visibility was good, conduct of both the vessel and the pilot boat was carried out by visual observation during the approach of the two vessels and the transfer of the pilots" (Section 1.8.2, [785]). Much less information is presented about the regulatory requirements, which might otherwise have required that the communication take place. This example illustrates the way in which logic can be used to focus on particular aspects of an incident report. The evidence that supports particular conclusions can be described in a precise and concise manner. This directs further analysis of an incident report. Investigators must identify those passages that provide the evidence to support these conclusions. Such extracts can, in turn, be translated into a logic notation to complete the formal proof in a manner similar to that illustrated in previous paragraphs.

A number of caveats can be raised about our use of logic to verify particular properties of an incident report. In particular, our formalisations have relied upon relatively simple variants of first order logic. These lack the sophistication of the more complex, causal techniques that have been derived from Lewis' work on counterfactual arguments [491]. This issue is discussed at greater length in Chapter 8.3. As we shall see, however, there are more fundamental objections against the use of any logic formalism to analyse the arguments that are put forward within an incident or accident report [776]. For now, however, it is sufficient to briefly summarise a number of additional benefits that can be derived from this technique. In particular, it is possible to demonstrate inconsistencies between two or more accounts of the same incident [427]. For instance, if one report omits a particular piece of evidence then we must consider not only the impact of that omission itself but we must also account for the loss of any inferences that may depend upon that evidence. In the previous example, if a rival report failed to provide any information about the prevailing weather conditions then readers might doubt clause (13.11) as an 'explanation' for the lack of communication. It is also possible to extend the formal model of an incident report to analyse any proposed recommendations. For instance, in previous work we have used formal proof techniques to show that proposed interventions following a rail collision need not prevent the recurrence of a similar incident in the future [427].

Toulmin

Toulmin's 'The Uses of Argument' [776] can be seen as a measured attack against the use of formal logic as a primary means of understanding rational argument. This work, therefore, has considerable importance for any attempt to use logic as a means of verifying the correctness and consistency of arguments within incident reports. One aspect of Toulmin's attack was that many arguments do not follow the formal rules and conventions that are, typically, used to construct logics. An example of this is the use of warrant, or an appeal to the soundness criteria that are applied within a particular field of argumentation. These criteria differ between fields or domain. The style of warrant that might be acceptable within a court of law might, therefore not be acceptable in a clinical environment. Similarly, the clinical arguments that support a particular diagnosis are unlikely to exploit the same soundness criteria that might establish validity within the domain of literary criticism. The abstractions of a formal logic are unlikely to capture the argumentation conventions that characterise particular domains. Toulmin urges us to question the notions of objective or 'universal' truth. The truth of a statement relies upon the acceptance of a set of rules or procedures that are accepted within a domain of discourse.

This initial analysis of Toulmin's work can be applied to the verification of incident reports. For instance, it is possible to identify certain norms and conventions within particular reporting systems. These norms and conventions help to define what is and what is not an acceptable argument about causes of an incident. For example, eye-witness testimony typically provides insufficient grounds for a causal analysis unless it is supported by physical evidence. Conversely, the data from a logging system is unlikely to provide a sufficient basis for any argument about the systemic causes of an adverse occurrence or near-miss incident. One approach to the verification of incident reports would be to enumerate a list of these conventions that are often implicit assumptions within an investigation team. Any report could then be checked against this list to confirm that it met the appropriate argumentation conventions. One of the strong features of this field-dependent aspect of Toulmin's work is that it reflects the differing practices that are apparent between different reporting systems. What might be acceptable as a valid argument about causation for a local investigation into a low-risk incident might not be acceptable within a full-scale investigation of a high-risk incident. Similarly, the standards that might be applied to the argument in an incident report within the nuclear industry might be quite different from those that would be acceptable within a catering business. This domain-dependent approach contrasts strongly with logic-based techniques that rely upon formal notions of correctness. The underlying proof procedures remain the same irrespective of the domain under investigation. This has important practical consequences. The high costs that can be associated with the application of formal modelling techniques can prevent it from being used to verify the correctness of low-risk incidents. The complexity of higher-risk failures can also force investigators to construct abstract models of the information that is contained in accident reports. These models often fail to capture important details of an incident or accident. In either case, problems are apparent because of the inflexibility of logic-based techniques. They cannot simply be tailored to reflect the different forms of argumentation that are exploited within different contexts. Some people would argue that this is a strong benefit of a formal approach; it avoids the imprecision and inconsistencies that can arise from domain dependent argumentation procedures.

The conflict between logic-based models and Toulmin's ideas of domain-dependent discourse has had a profound impact upon the theory of argumentation. Fortunately, many of the consequences of Toulmin's ideas do not apply within the domain of incident reporting. In particular, large-scale reporting systems often encourage their investigators to adopt a model of argument in their reports that closely mirrors aspects of formal proof. Evidence is presented in a reconstruction section, arguments are then developed within an analysis section, conclusions are then presented on the basis of the arguments. It can, therefore, be argued that the domain dependent procedures of incident and accident investigation are similar to our previous application of proof procedures such as Modus Ponens. This, in turn, explains why so many people have proposed logic based techniques as appropriate means of verifying the products of incident investigations [469, 415].

Toulmin acknowledges that people rely upon both domain-dependent and domain-independent procedures to establish the validity of an argument. In contrast to the field-dependent issues mentioned in the previous paragraphs, , most of Toulmin's work focuses on domain-independent procedures. The simplest of these procedures consists of a claim that is supported by some data. A claim is an assertion, for example about a cause of an incident. There are three types of claim:

1. Claims of fact. A claim of fact is supported by citing data, such as the results of simulator studies or of data recorders. This data must be sufficient, accurate, recent, appropriate.

2. Claims of value. These claims represent moral or aesthetic judgements which are not factual and cannot be directly supported by data alone. They can be supported by citing unbiased

and qualified authorities. A claim of value can also be supported by arguing that it produces good results or that negative results may be obtained if it is ignored.

3. Claims of policy. A policy claim is supported by showing that a procedure of regulation is both feasible and positive. Such arguments tend tpo rely upon a combination of fact and of value.

Most incident reports rely upon claims of fact. Arguments about the causes of an incident must be grounded in the evidence that can be obtained by primary and secondary investigations. We are also often concerned with claims of policy. For instance, there may be little a priori evidence that a particular recommendation will avoid or mitigating future incidents. The best that can be done is to follow the advice of relevant experts based on data from similar systems. It is more rare for an incident report to be concerned with value claims, except in circumstances where moral decisions must be made, for instance, over the amount of money that might be invested to avoid future fatalities. as mentioned, incident reports are primarily concerned with claims of fact. The rest of this section, therefore, focuses on the arguments that can be used to support this form of argument.

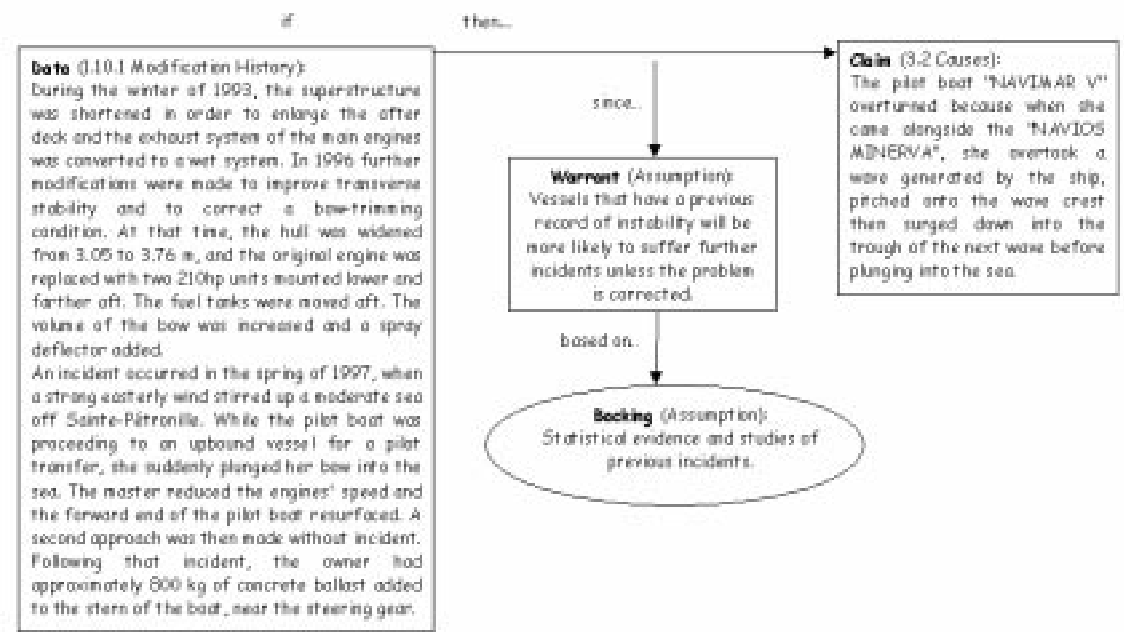

Figure 13.2: Data and Claims in the Navimar Case Study.

As mentioned, data can be used to support particular claims of fact. Data represents a body of evidence that can be used to determine whether or not a claim is valid. This concept is not straightforward because there can be further arguments about the validity of an item of evidence. It is for this reason that data, or grounds, refers to the part of an argument that is not in dispute. Toulmin avoids some of the practical issues that can arise when the different parties to an incident investigation cannot agree about what is and what is not acceptable evidence:

> "Of course we may not get the challenger to even to agree about the correctness of these facts, and in that case we have to clear his objection out of the way by a preliminary argument: only when this prior issue or 'lemma', as geometers would call it, has been dealt with, are we in a position to return to the original argument. But this complication we need only mention: supposing the lemma to have been disposed of, our question is how to set the original argument out most fully and explicitly". [776]

Chapters 5.4 and 6.4 describe techniques that are intended to encourage agreement over the reliability and accuracy of particular items of evidence. In contrast, Figure 13.2 illustrates how Toulmin approach can be applied to the Navimar case study. As can be seen, the Transportation Safety Board of Canada report argues that the incident was caused when the pilot boat pitched onto a wave crest and surged into the trough of the next wave. This claim of fact is supported in the incident report by evidence of a similar, previous incident in 1997. Figure 13.2 also introduces two further components of the Toulmin model of argumentation. A *warrant* describes the assumptions that help to connect a claim with the grounds or data that supports it. This illustrates a superficial relationship between Toulmin and the syllogisms that have been introduced in previous sections [307]. The grounds and warrant can be though of as premises, the claim represent the conclusion to be drawn. Figure 13.2 also illustrates the notion of *backing*. This helps to establish a warrant; backing can also be a claim of fact or value. In this example, the relationship between the previous incident and the conclusion of the report is never made explicit in the incident report. In consequence, readers have to infer the reason why this data might support the overall conclusions. Vessels that have suffered previous incidents are more likely to suffer future recurrences of similar incidents. This warrant might be supported by statistical studies to indicate that vessels which are involved in one incident and then more likely to ve involved in another similar incident in the future.

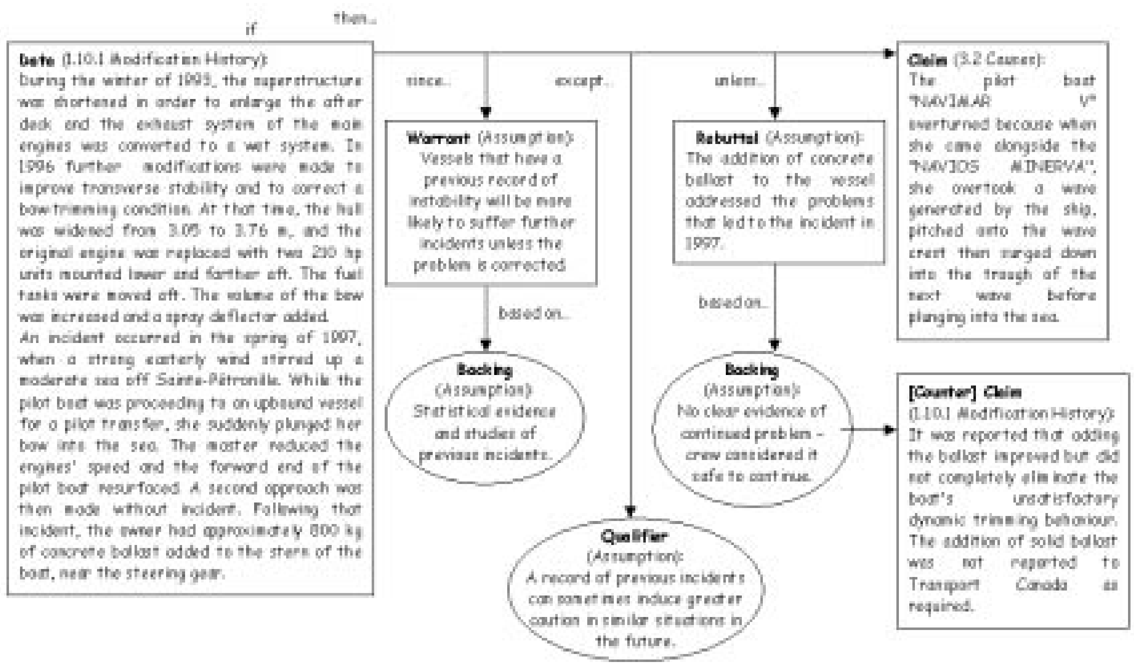

Figure 13.3: Qualification and Rebuttal in the Navimar Case Study.

An argument is valid if the warrant and any associated data provides adequate support for the claim. It is possible, however, that can investigators' colleagues might raise objections to a particular argument. Alternatively, the writer of an incident report may themselves have doubts about the scope and applicability of their analysis. Finally, the readers of an incident report might question the argument that is embodied within such a document. Toulmin's domain independent model can be used to capture these alternate positions that challenge or modify an initial position. Figure 13.3 uses the Navimar case study to illustrate such an extension. As can be seen, a qualification node had been introduced to record the observation that a previous incident can induce greater caution amongst the crew of some vessels. This qualifier effects the previous warrant the represents the implicit argument that vessels involved in previous incidents will be more likely to be involved in future incidents. The claim can also be qualified in a similar fashion, if it has been challenged and its truth is in doubt. This use of a qualifier does not deny that there may be a relationship between the vessels involved in an incident and previous involvement in similar occurrences. Instead, it argues that this effect may not apply to all vessels.

Figure 13.3 also illustrates the use of a rebuttal to challenge the argument that was first sketched in Figure 13.2. The suggestion that vessels are more likely to be involved in an adverse occurrence if they have been involved in previous incidents is contradicted in this case by arguing that previous modifications were effective in addressing the causes of the problem. This rebuttal is supported by the lack of evidence to indicate that there was a continuing problem. The crew also continued to risk their lives by operating the vessel in what can be a difficult and hazardous environment. Such counter-arguments can be challenged. For instance by arguing that economic pressures often force individuals to operate equipment that they know to have safety problems. Similarly, the lack of evidence about further incidents between spring 1997 and the incident need not provide direct assurance that the problem would not recur. The vessel might not have faced similar operating conditions. Such arguments against a rebuttal could be incorporated into the structures of Figures 13.2 and 13.3. The resulting graphs can quickly become intractable. A number of researchers have, therefore, developed tools that can be used to support the use of Toulmin's techniques to map out argument structures [503, 749]. Much of this work has been inspired not by Toulmin's initial interest in studying the structure of argument but by a more prosaic interest in improving the support that is provided for particular decisions. This practical application of Toulmin's model can be illustrated by Locker's recent work on improving 'Business and administrative communication' [498]. Locker suggests that business writers decide how much of Toulmin's model they should use by analysing the reader and the situation. Writers should make both their claim and the data explicit unless they are sure that the reader will act without questioning a decision. The warrant should be included in most cases and the backing should be made explicit explicit. It is also important for effective communication that any rebuttals should be addressed by counter-claims, as suggested above. Authors should also be careful to explicitly address any limiting or qualifying claims.

Locker's normative application of the Toulmin model suggests how this approach might be used to support the presentation of incident and accident reports. Given the importance of effective communication in this context, we might require that this approach be used to make explicit the association between data and the claims that are made in a report. If data is not presented in the document then the claim is unsupported. This application of the technique is similar to the manner in which logic might be used to identify enthymemes in other forms of syllogism. It can also be argued that investigators should explicitly document the warrant that links data and evidence within an incident report. This is important because, as we have seen, incident reports are often read by many diverse communities including operators, managers, regulators, engineers etc. It is, therefore, difficult to make strong assumptions about the background knowledge that is required in order to infer the relationships that exist between data and particular clausal claims. This is illustrated by the Navimar case study that has been introduced in the previous paragraphs. The Transportation Safety Board report never makes explicit the relationship between evidence of a previous incident and the overall conclusion of the enquiry. We have had to infer an appropriate warrant in Figure 13.2. It is entirely possible that we have made a mistake. Investigators may have had entirely different reasons for introducing the events in 1997. Unfortunately, we have know way of telling whether this argument is correct or not from the report into the subsequent capsize.

This requirement to make explicit data, claims and warrant goes beyond Locker's requirements for effective business communication. These differences should not be surprising, given that Toulmin acknowledges the importance of domain independent and domain dependent requirements for effective argument. The 'standards of proof' are potentially higher in the case of incident investigation than they might be amongst more general business applications. Other aspects of good practice will be common across these different domains. For example, Locker argues that effective communication relies upon writers explicitly addressing any proposed rebuttals of an initial argument. This is equally important within the field of incident reporting. For instance, the Navimar report comments that 'it was reported that adding ballast improved but did not completely eliminate the boat's unsatisfactory trimming behaviour' [785]. This partly addresses the rebuttal in Figure 13.3. It does not, however, explicitly provide backing for such a counter-argument beyond the rather vague reference to previous reports.

Figure 13.4 provides a slightly more complex example of the application of Toulmin's model to the Navimar case study. In this instance, data about the layout of the pilot vessel is used to support a claim that the use of the accommodation adder rather than the pilot ladder contributed to the incident. This argument is supported by the warrant that the use of the accommodation ladder complicated the task of keeping the pilot boat's transfer deck in position because their boat cannot rest parallel to the vessel's side during the transfer. The difficulty of performing such maneuvers is recognised by international regulations requiring that pilot ladders be used for pilotage transfers. The argument is also supported by the warrant that the master had to divide his attention between completing this relatively complex manuevre with the vessel in front of him and the task of looking aft to ensure that the after deck lined up under the accommodation ladder. This warrant is not backed by any particular citations in the incident report. There are no direct observations or accounts of the difficulty of this task. In contrast, the investigators acknowledge that "there is every indication that the crew were well rested and highly experienced" [785]. The omission of any backing provides a further example of an enthymeme trope. If we apply Toulmin's model in the normative manner proposed above then it can be argued that more information ought to be introduced into the report to support this warrant. For instance, an analysis of the ergonomics of the bridge design might provide sufficient detail for operators to determine whether similar problems might affect not simply transfer tasks but other pilot operations as well.

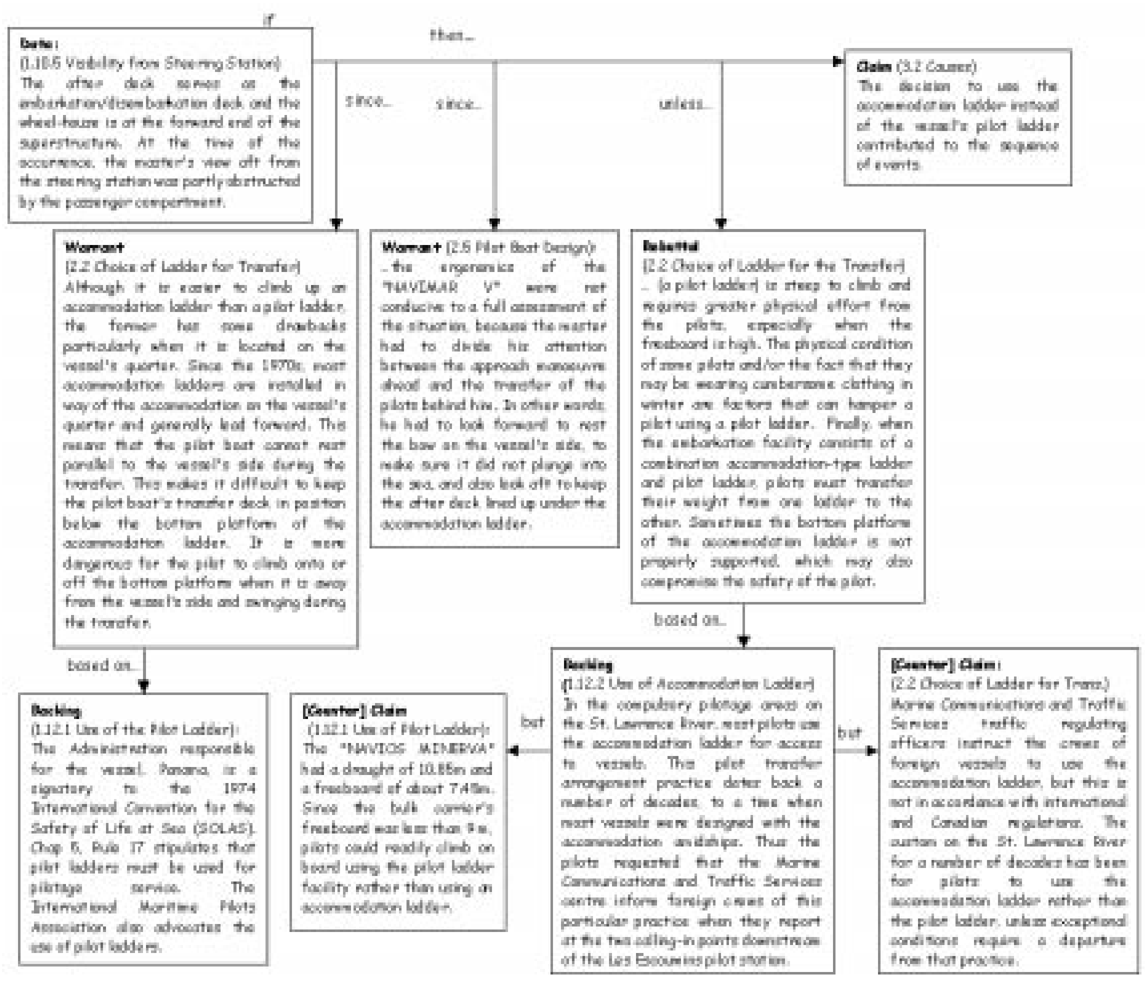

Figure 13.4: More Complex Applications of Toulmin's Model.

Figure 13.4 also provides a further illustration of a rebuttal that readers might form from the information that is presented in the Navimar report. There are a number of drawbacks that affect the use of pilot ladders. Some if these potential problems relate to significant safety concerns, especially if hybrid pilot and accommodation ladders are joined together. This rebuttal is supported by the observation that it was common practice to use accommodation ladders in the pilotage areas of the St. Lawrence River. This had reached such an extent that the Marine Communications and Traffic Service centre explicitly informed foreign crews of this practice. Previous paragraphs have argued that it is important for investigators to address such rebuttals if readers are to have confidence in the findings of an incident report. This caveat is, therefore, addressed by two counter claims. Firstly, the free board of the Navios Minerva was less than nine meters. This obviated the need for a combination ladder of the type mentioned above. The rebuttal is also addressed by the counter claim that the Marine Communications and Traffic Service instruction was neither in accordance with international nor Canadian regulations. The safety concerns mentioned in the initial rebuttal cannot avoid the conclusion that common practice was in violation of the recommended rules and regulations that had been issued to the crews.

A number of further comments can be made about the use of Toulmin's model in Figure 13.4. It is possible to use the resulting graphs to trace the location of information to various sections within the report. Although most of the information that supports the rebuttal appears together in Section 2.2, some of the material can be found in 1.12.2. This is important because this information provides evidence that can be used to contradict the initial rebuttal. Similarly, the backing for part of the warrant, in Section 2.2, supporting the argument in Figure 13.3 is to be found in Section 1.12.1. This forms part of a more general pattern that can be observed through the application of Toulmin's model to incident reports. The warrant that outlines a particular line of support for an argument, typically, appears many pages after the backing that supports it. This separation arises from the policy of separating the arguments and analysis that explain the significance of key events from the reconstructions that first describe the context in which an incident occurs. This approach helps to avoid any confusion between what is known and what is inferred about a near miss incident or adverse occurrence. A further consequence of this is that readers may only learn the significance of particular items of information after they have finished reader the report. In consequence, it is often necessary to read and re-read such documents several times in order to follow the complex argument that may be distributed across hundreds of pages of prose. Snowdon has argued that these problems might be reduced if, instead of using Toulmin to check an argument in an incident report, the readers of a report were provided with diagrams such as those shown in Figures 13.2, 13.3 and 13.4, [749]. These could be printed inside an incident report to provide readers with a 'roadmap' of the various arguments that are being proposed by an investigator. This approach might also increase confidence in any conclusions by explicitly indicating the counter-arguments that might be deployed against particular rebuttals.

Figure 13.4 illustrates the relatively complex diagrams that can emerge from the application of Toulmin's techniques to incident reports. It also illustrates some of the problems that arise in the practical use of this approach. Toulmin's focus was on explaining the domain dependent and domain independent components of argument structures. His purpose was "to raise problems, not to solve them; to draw attention to a field of inquiry, rather than to survey it fully; and to provoke discussion rather than to serve as a systematic treatise" [776]. His model was never intended to be used as a tool to support the development of incident reports. One consequence of this is that is can be difficult to categorise the paragraphs within an incident report. For example, it can be argued that the rebuttal in Figure 13.4 might be reclassified as a form of qualifier. It does not directly contradict the argument that the decision to use the accommodation ladder contributed to the incident. In contrast, it explains why many operators chose not to use pilot ladders. This could be interpreted as a qualifier because it refers to previous instances in which the use of the accommodation ladder had not resulted in an adverse outcome. Further problems complicate this application of the Toulmin model. For instance, we have constructed our analysis at the level of individual paragraphs within the Navimar report. Rather than translate the original prose in a manner that might support the classification of those paragraphs within the Toulmin approach, we have chosen to retain verbatim quotations within our analysis. The drawback to this application of the model is that some of the paragraphs may themselves contain more detailed argument structures. For example, the backing for the rebuttal in Figure 13.4 contains a claim that most pilots use the accommodation ladder in the St Lawrence River pilotage areas. This might, in turn, be supported by additional data. The introduction of this data would then need to be supported by an appropriate warrant and so on.

The previous objections relate to the difficulty of applying Toulmin's model to the complex prose and argument structures that are used in many incident reports. It is possible to reverse these objections by arguing that this very complexity increases the importance of any techniques that might be able to identify potential errors of omission and commission. The principle benefit of this approach is that it provides a graphical representation of various positions within an incident report. These diagrams can then form a focus for subsequent discussion amongst an investigation team prior to publication. The very accessibility of these diagrams helps to ensure that any disagreements about the classification of particular sentences and paragraphs can be checked by an investigator's colleagues. It also forms a strong contrast with the use of more formal logic-based approaches. The accessibility of the Toulmin model, however, comes at the price of far weaker concepts of proof or correctness. The adequacy of an argument can only be assessed in terms of the domain dependent procedures that are accepted within an investigation team. These procedures guide the normative application of Toulmin's model, proposed for business communication by Locker [498] and sketched for incident reporting in previous paragraphs. Problems can arise when those procedures that are acceptable within one domain of argument are questioned or rejected by other groups who employ different standards of 'correctness' .

A number of authors have proposed further extensions to the Toulmin model of argumentation. For instance, the initial proposals provide backing for the propositions that are captures in a warrant. They did not provide similar support for the data that backs a claim. As mentioned above, data is assumed to be accepted. If it is questioned then it must be addressed by a secondary argument. In contrast, Ver Linden has argued that the Toulmin model should be expanded to include 'verifiers' for data [494]. Explicit verifiers involve a further argument, which concludes that the data in the original argument is correct. Thee include citations as well as reference to common knowledge and to personal background. Implicit verifiers stem from the observation that arguers often do not express a clear rationale for accepting data. Instead, people provide a range of cues that are intended to convince the recipient that data is correct. Ver Linden argues that such "sincerity cues probably differ from culture to culture and in the general American culture they include the use of eye contact, tone of voice, and facial expression and other signs of emotion appropriate to the subject, as well as language that emphasises the arguer's sincerity". Implicit verifiers are suggested by the person supporting the claim. In contrast, inferred verifiers are supplied by the receiver without explicit suggestion by the claimant. For instance, the reader of an incident report may believe in an assertion simply because it has been made by a national transportation safety board. It is important to emphasise that this does not imply that the arguers are unaware of the likelihood that recipients will form such inferences. For instance, a national transportation safety board might make an assertion and state it as a fact without citing any source. In such circumstances, they rely on the belief that their reputation will carry a particular weight with the intended audience. This analysis has important implications for the presentation and analysis of incident reports. Data should be supported by explicit verifiers rather than the suggestive expressions of belief provided by implicit verifiers or any reliance on reputation to support the use of inferred verifiers. Ver Linden's analysis not only applies to the backing for data, it can also be applied to the backing that supports warrants and rebuttals. For instance, the backing for the rebuttal in Figure 13.4 clearly relies upon an inferred verifier because no evidence is supplied to support the observation that most pilots use accommodation ladders.

The previous paragraph focused on practical extensions to the Toulmin model. A number of other authors have raised more theoretical objections to this approach. For instance, Freeman introduces the notion of 'gappiness' between a warrant and some data [282]. Warrants can be thought of as inference rules that allow us to move from data to a claim. They are only necessary because the reader senses a gap between the data and the claim that it supports. Freeman's revision has disturbing implications. It can be difficult to predict where readers might sense a 'gap' in an underlying argument. Investigators might, therefore, attempt to exhaustively addresses all of the possible doubts that a skeptical reader might have about an incident report. Such an approach raises further problems. Many supporting arguments would be unnecessary. They exhaustive approach would address gaps that would never occur to many of the readers of an incident report. For instance, it might be necessary to justify the reference to SOLAS in Figure 13.4. The importance and relevance of such agreements would be self-evident to all domain experts. The introduction of additional warrants would support a minority of readers but it would also increases the size and scope of incident reports.

To summarise, Toulmin argues that it is possible to identify domain dependent procedures that help to define convincing arguments within a particular context. Freeman argues that for structural reasons, some of those procedures relate to the individual reader's perception of gaps between claims and data. This implies that normative techniques, such as those proposed by Locker [498], may fail to identify the individual information needs of particular readers. There are currently two practical means that can be used to address Freeman's more theoretical caveats. One technique involved the use of user-testing and experimental analysis to determine whether or not domain dependent procedures are sufficient for a broad cross-section of the intended readership of an incident report. This approach is described in more detail in the next section. It will not address the individual information needs identified by Freeman. It can, however, increase confidence that the argument in an incident report provides sufficient backing to convince a specified proportion of its intended audience.

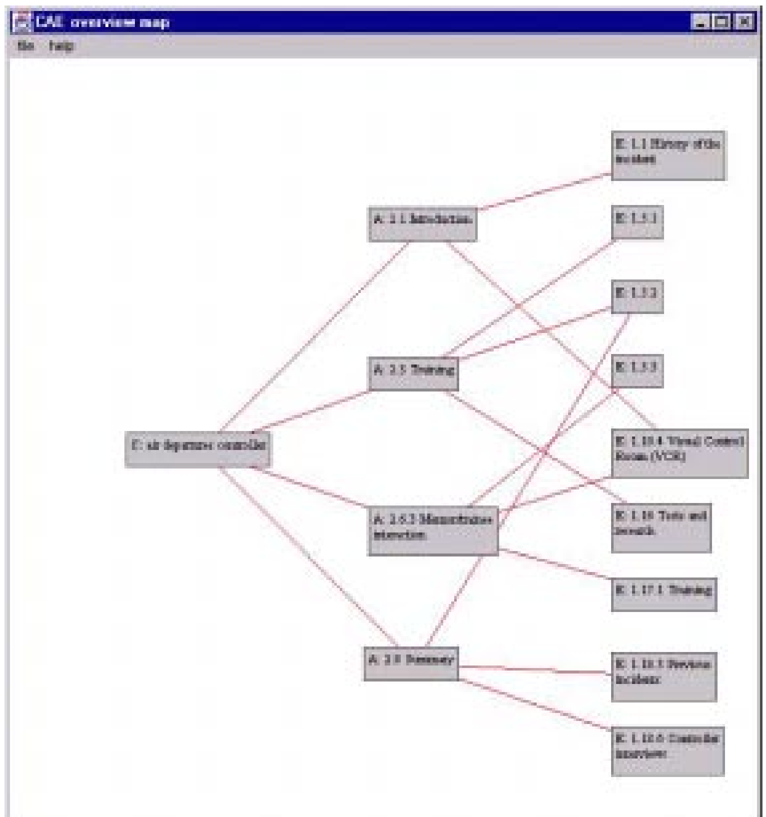

Figure 13.5: Snowdon's Tool for Visualising Argument in Incident Reports (1).

Freeman's caveats about the individual perception of 'gappiness' in argument structures can also be addressed by tool support. These techniques enable readers to view the argument that supports an incident report at a number of different levels of granularity. For example, Snowdon has developed a tool that is based on the Conclusion, Analysis and Evidence structures that were in introduced in Chapter 8.3. This is a simplification of the full Toulmin model that is specifically intended to support the analysis of incident and accident reports [414]. When the reader of an incident report initially uses the tool, they are presented with a simple overview of the highest level argument. This typically consists of a node that lists the conclusions of the report. By clicking on one of those conclusions they can expand their view of the argumentation in the report to look at the evidence or data that supports a conclusion. By clicking on that data, they can expand their view of the warrant, or analysis, that connects the evidence to the conclusion. This interactive process continues until the user reaches the bottom level in the system. These leaf nodes represent the paragraphs of prose that have been written by the investigators. Figure 13.5 illustrates a partial expansion of the argument structure in an aviation incident report. Figure 13.6 represents the end result of continuing to ask for more information about the investigator's argument. The reader is free to continue to ask for more justification until they reach the sections of prose written by the investigators.

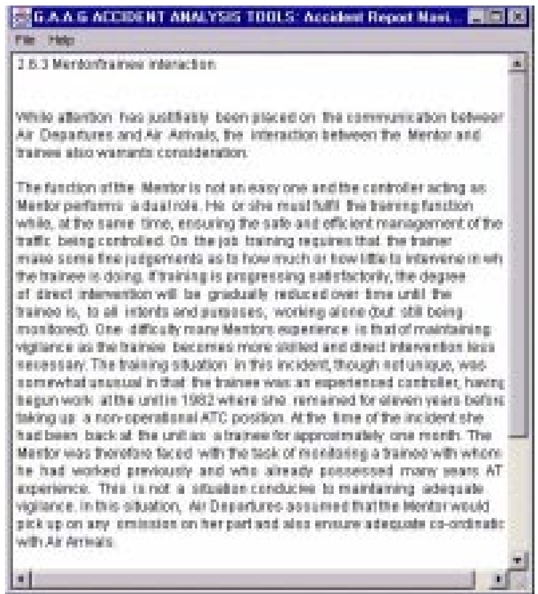

Figure 13.6: Snowdon's Tool for Visualising Argument in Incident Reports (2).

Snowdon's tool provides an alternative means both of verifying the argument that is presented in an incident report and of presenting the contents of the report to end users. Investigators can explore the graphical hierarchy to ensure that sufficient backing has been provided for key arguments. Readers can also use the graphical interface to rapidly fill any gaps between data and claims. The key benefits from their perspective is that they need only request additional information about those areas of an argument that they perceive to require additional support. Extensions to the system can also log those areas of a report where users repeatedly ask for additional warrants. Such information can help to guide the presentation of future incident reports.

13.3.2 Validation

There is no direct evidence that any of the techniques described in the previous section will contribute to a sustained improvement in the quality of incident reports within complex, real-world applications. These approaches are the product of research initiatives that have been commissioned by regulatory and other government organisations because of the perceived weaknesses in existing reporting techniques. A number of groups, including my own, are using several of the more recent verification techniques as part of an initial 'field trial'. These studies are intended to yield the evidence that many will require before introducing such 'leading edge' techniques. Until such evidence is available there remains a strong suspicion that the more elaborate approaches, such as the use of formal logics, may contribute little beyond what can be achieved through a careful reading of the prose in an incident report. Two principle objections can be raised to this argument:

1. why do so many people criticise the quality of incident reports if careful reading is sufficient to identify the enthymemes and other rhetorical effects that reflect systematic biases and inappropriate assumptions about the potential readership of these documents?

2. careful reading is, typically, conducted by other investigators. Those investigators often do not reflect the broad range of skills and expertise that characterise the intended audience of an incident report. This is significant because, as Freeman suggests [282], the background of the reader can help to determine the sufficiency of an argument. In other words, members of an investigatory organisation may fail to identify the 'gaps' that will be identified by the eventual readership of an incident report.

The following sections explore the substance of these objections. Firstly, we assess empirical work to determine the nature of existing criticisms against the presentation of incident reports. Subsequent sections then describe a range of techniques that have been used to identify particular weaknesses in individual reports. These validation techniques different from the approaches that were described in the previous section because they focus on end-user testing to assess the utility of these documents. In contrast, verification techniques look more narrowly at whether particular documents satisfy a range of technical properties that can, typically, be established without direct user testing.

User Testing

It is surprising how little research has actually been conducted into the presentation of incident and accident reports. The format described in the previous sections of this chapter has remained largely unaltered for at least one hundred and thirty years [359]. Most of the previous studies commissioned by investigatory and regulatory organisations have focussed on recurrence rates to demonstrate that a reporting scheme has had the desired effect. Relatively little work has been conducted to determine whether any observed improvements might be increased by changing the presentation and dissemination of incident reports. This omission led Snowdon to survey a number of safety managers in an attempt to identify particular attitudes towards incident reporting practices. This study raised considerable practical challenges. In particular, it proved difficult to obtain responses by contacting individuals in their workplace. The sensitive nature of their job can be argued to create a justifiable nervousness in replying to surveys that address their relationship with investigatory and regulatory organisations. He was, therefore, forced to issue questionnaires to a random sample of safety managers at a trade conference. Steps were taken to ensure that the delegates were registered participants at the meeting but assurances were also provided to protect the respondents' anonymity. The average age of respondents was 43 years old. The average experience in a field relevant to safety management was 13 years. These constraints limit the generalisations that can be made from the results of this work. Snowdon argues that it can only be seen as a pilot study but that his observations are strongly suggestive of the existing limitations with incident and accident reports.

Question	Positive responses (N= 27)
Do you use accident reports to inform you of design problems?	19
Do you only read reports that you feel are related to your areas?	17
Do you read the whole of the report?	24
Do you assess the conclusions by checking the evidence or other forms of analysis?	22

Table 13.7: Summary of Results from Snowdon's Survey of Accident Reporting Practices [750]

Table 13.7 presents an overview of the results from part of Snowdon's survey. As can be seen, he focuses on attitudes towards the larger-scale documents that report on accidents and high-consequence incidents. It is interesting to note the relatively high number of respondents who claim to read the entire report and who check the conclusions against either the evidence or the analysis that is presented in these documents. He also documents a number of responses to more open questions about the nature of such reports [749]. Some of these responses provide additional evidence for the broad results that are summarised in Table 13.7. For example, one safety manager was able to illustrate their detailed knowledge of a report that had a direct impact upon their working life. The level of detail in the following response is highly indicative both of the checking that this individual had been motivated to perform and of a careful reading of the entire report:

> "They are poorly structured and are often not tailored to their audiences mixed ability to get an overall picture. Many scenarios are hidden in different parts of the report, e.g. in the Watford junction tain accident in paragraph 143/4 it says a signal sighting committee should have been set up before the accident. After the accident this committee suggested that the removal of some trees would increase the sighting distance. In paragraph 171 it says that if the train had braked earlier, i.e. given the removal of the trees, there would not have been an accident." (Cited in [749])

Some of these responses reveal the continuing perception that many of these documents reflect a blame culture: "investigators usually assume that the victim is the sole cause even when the equipment has glaring design defects that entrap the user". Other responses are less easy to interpret. For instance, one safety manager identified the "tendency on the part of the reporter to write report to support his or her conclusions rather than openly evaluate all of the information/evidence that collected about the event." At one level, this seems to reflect an awareness of the conformation bias that is described in Chapter 10.4. At another level, it is difficult to know how an investigator could consider every aspect of the evidence that is obtained from a primary and secondary investigation. As we have seen, the drafting of an incident or accident report inevitably involves a filtering or selection process.

Snowdon's survey also provides some confirmation of the analysis that is presented in previous sections of this chapter. Ver Linden's [494] comments on the importance of 'verifiers' are illustrated by the following comment; "they present their account as definitive without acknowledging missing evidence or contradictory opinions". Some of the comments also relate to the concept of 'gappiness' proposed by Freeman [282]. One safety manager wrote that "conclusions draw that do not appear to be 'in line' with facts presented; change in level of strength of assertions - report starts with 'it may have been due to' and ends with 'this was because'." Other feedback relates more strongly to the normative application of Toulmin's ideas proposed by Locker [498]. For example, the following quotation emphasises the importance of explicitly addressing both the qualifiers and rebuttals that can limit the scope of an argument:

> "A good report is one w(h)ere all possibilities are considered and a balanced view is taken. If the report is not able to be conclusive then so be it. All possible causes are listed." (Cited in [749])

As with the previous comment about accounting for every item of evidence, this response illustrates the high expectations that many safety managers have for the presentation of information in accident and incident reports. Chapter 10.4 describes how causal asymmetries prevent investigators from identifying all of the possible causes for any observed set of effects. The results of previous studies into the theoretical and technical foundations of causation have, therefore, had little impact on the practical actitivies of safety managers. This is surprising given that some of the responses to the survey show a considerable level of knowledge about previous studies of accidents and incidents. These studies have clearly provided a vocabulary with which to voice their criticisms:

> "The report just contains direct causes of accident but information of underlying factors of accident is not available. Accident report should encompass not only direct causes but also proximal causes as well as distal causes. It means that failures mechanism should cover not only operative's failure but also management and organisational failure including design failure". (Cited in [749])

The main impression gained from an analysis of these various comments was that many safety managers are unhappy with the structure and format of the information that is presented in incident reports. Several comments related to the problems of using these documents to inform their daily activities: "...the information I am interested in (human error contribution to the accident and cognitive factors in general) is dispersed over different sections of the report, and that related information might be 'hidden' and I will have to spend a lot of time and effort trying to find it". It can be argued, however, that incident and accident reports are not intended to be used in this way. Their primary purpose is to trigger regulatory action by the bodies that commission individual reports. They are not intended to inform local initiatives by local safety managers. Such a response ignores the high level of interest in these documents that is reported by the safety managers that Snowdon surveyed. They seem to perceive these documents as important components of any safety management system that should be, and are, read as part of their normal working activities. The negative reaction to existing reporting techniques can be summarised by the following response:

> "It is becoming less uncommon to find a report that reflects little effort at gathering evidence. Consequently the analysis and conclusions are shallow. Often when the analysis is shallow, the few facts available are over-emphasised, as if the writer knows the facts are insufficient and attempts to cover by reaching firm conclusions." (Cited in [749])

Unfortunately, there are theoretical and practical barrers that prevent investigators from addressing some of the criticisms that were voiced in Snowdon's survey. As we have seen, it is often impossible to accurately summarise all of the evidence that is collected in the aftermath of an adverse occurrence or near miss incident. Similarly, it is infeasible to consider *every possible* cause of a failure. Freeman [282] provides a possible solution when he emphasises the subjective nature of the problems that many readers experience when they read complex documents. He argued that the notion of a 'convincing' argument depends upon the information that a reader requires in order to bridge the devide between a claim and some evidence. It, therefore, follows that any claims to the sufficiency of an argument make little sense without additional validation to assess whether or not the intended audience can make the necessary connections.

User testing provides one means of assessing whether or not particular groups of individuals are convinced by the argument in an incident report. This approach is described in a large number of introductory textbooks. The following pages, therefore, briefly summarise the main features of the available techniques. The interested reader is directed to [687] and [741] for a more sustained analysis. It is possible to distinguish between two different approaches to validation that can be applied to assess the quality of incident reports. Summative techniques can be used at the end of the production phase when a report is ready to be issued. In contrast, formative evaluation techniques can be used to determine whether particular sections of a report provide the necessary feedback the safety managers and regulators need to complete their tasks.

Formative evaluation helps to guide or form the decisions that must be made during the drafting of an incident report. The importance of this form of incremental user testing depends on the scale of the incident report. It also gives rise to an important paradox. Reports into 'higher-risk' incidents are, typically, longer and more complex than lower risk occurrences or near misses. In consequence, there is a greater need to identify potential problems in the presentation of material about the incident. Any potential 'gaps', omissions or inconsistencies should be identified well before the document is published. In contrast, it is precisely these documents that create the greatest concerns about security and media interest prior to publication. These concerns, mentioned in the opening sections of this chapter, create considerable practical problems when recruiting subjects to provide feedback on the information that is contained in a draft report.

In contrast to formative evaluation, summative evaluation takes place immediately prior to the publication of an incident report. This approach can be problematic unless it is supported by other forms of quality control. It can be costly and time-consuming to make major structural changes to the argument that is presented in an incident report at this late stage in the investigation process. User testing can, occasionally, identify rebuttals that are not addressed either by existing arguments or by available evidence. This is particularly the case when investigators may not have the same degree of domain expertise as the individuals reading the report [250]. Summative evaluation can identify these potential doubts at a time when there are insufficient resources available to commission additional studies of the available evidence.

User-testing methods have been widely applied to computer systems and to the documentation that is intended to support them. As we shall see, some of these techniques can be applied to support the validation of incident reports. The following list identifies some of these approaches and indicates whether they offer the greatest benefits for summative or formative evaluations:

- *Scenario-Based Evaluation.* Scenarios or sample traces of interaction can be used to drive both the drafting and evaluation of an incident report systems. This approach forces investigators to identify key requirements of an incident report. These requirements are summarised as brief descriptions of the sorts of prototypical tasks that different readers might want to perform with such a document. The resulting scenarios resemble a more detailed form of the descriptions that are presented in Table 13.1. This identified the reporting requirements that must be satisfied by the various accident and incident reports that are published by the Hong Kong Marine Department. As the drafting of a report progresses, investigators can ask themselves whether the document that they have prepared might be used to complete the tasks that are identified in each of the scenarios. The 'evaluation' continues by showing a colleague what it would be like to use the document to achieve these identified tasks. This technique an be used at the very earliest stages of drafting a report and hence is a useful approach to formative evaluation. The problems with the use of scenarios are that it can focus designers' attention upon a small selection of tasks and users. For instance, a scenario might require that the Director of Marine Operations should be able to rapidly identify any regulations that were violated in the course of an incident. Such a scenario would not provide confidence that an engineer would be able to use the same document to rapidly identify detailed design recommendations. A further limitation is that it is difficult to derive empirical data from the use of scenario based techniques. Investigators may be able to convince their colleagues that a draft report satisfies the proposed requirements. This need not increase confidence that others will reach the same conclusions.

- *Experimental Techniques.* The main difference between the various approaches to evaluation is the degree to which investigators must constrain the reader's working environment. In experimental approaches, there is an attempt to introduce the empirical techniques of scientific disciplines. It is, therefore, important to identify the hypothesis that is to be tested. The next step is to devise an appropriate experimental method. Typically, this will involve focusing in upon a particular aspect of the many tasks that might eventually be supported by an incident report. For example, a safety-manager might be asked to reconstruct the events leading to an incident after having read a report for some specified amount of time. The reconstructions might then be examined to demonstrate that potential readers can more accurately recall these events in one version of the report than in another.

  In order to avoid any outside influences, tests will typically be conducted under laboratory conditions. Individuals are expected to read the draft report without the usual distractions of telephones, faxes, other readers etc. The experimenter must not directly interact with the reader in case they bias the results. The intention is to derive some measurable observations that can be analysed using statistical techniques. There are a number of limitations with the experimental approach to evaluation. For instance, by excluding distractions it is extremely likely that investigators will create a false environment. This means that readers may be able to draw inferences from a report more quickly and with greater accuracy than might otherwise be obtained within a noisy, complex working environment. These techniques are not useful if investigators only require formative evaluation for half-formed hypotheses. It is little use attempting to gain measurable results if you are uncertain what it is that you are looking for.

- *Cooperative evaluation techniques.* Laboratory based evaluation techniques are useful in the final stages of summative evaluation. In contrast, cooperative evaluation techniques (sometimes referred to as 'think-aloud' evaluation) are particularly useful during the formative stages of drafting an incident report. They are less clearly hypothesis driven and are an extremely good means of eliciting feedback on the initial drafts of a document. The approach is extremely simple. The experimenter sits with the reader while they work their way through a series of tasks with a potential report. This can occur in the reader's working context or in a quiet room away from the 'shop-floor'. The experimenter is free to talk to the reader but it is obviously important that they should not be too much of a distraction. If the reader requires help then the investigator should offer it and note down the context in which the problem arose. These requests for help represent the 'gaps' identified by Freeman [282]. Additional evidence or warrants may be necessary to support the claims that are made in an incident report. The main point about this exercise is that the reader should vocalise their thoughts as they work with the draft. This low cost technique is exceptionally good for providing rough and ready feedback. Readers can feel directly involved in the drafting of a final document. The limitations of cooperative evaluation are that it provides qualitative feedback and not the measurable results of empirical science. In other words, the process produces opinions and not numbers. Cooperative evaluation is extremely bad if investigators are unaware of the political and other presures that might bias a reader's responses.

- *Observational techniques.* There has been a sudden increase in interest in the use of observation techniques to help 'evaluate' a range of computer-based systems [752], of management structures [398] and of safety-critical working practices [120]. This has largely been in response to the growing realisation that the laboratory techniques of experimental psychology cannot easily be used to investigate the problems that individuals can experience in real-world settings. Ethnomethodology requires that a neutral observer should enter the users' working lives in an unobtrusive manner. They should not have any prior hypotheses and simply record what they see, although the recording process may itself bias results. This approach provides lots of useful feedback during an initial requirements analysis. In complex situations, it may be difficult to form hypotheses about readers' tasks until investigators have a clear understanding of the working problems that face their users. This is precisely the situation that affects many incident reporting systems; the individuals who run these applications often have very limited information about the ways in which others in their organisation, or in other organisations, are using the information that they gather [749]. There is a natural concern to be seen to meet existing regulatory requirements. Consequently it can be difficult to interpret an organisations' response when asked whether or not a particular report has guided their operating practices. Ethnography focuses not on what an organisation says that it does but on what key individuals and groups actually do in their everyday working lives. Unfortunately, this approach requires considerable skill and time. It is extremely difficult to enter a working context, observe working practices and yet not affect the users behaviour in any way. There have been some notable examples of this work. For example, Harris has shown how these techniques can be used to improve our understanding of midwife's behaviour in a range of safety-critical applications [308]. Her work also illustrates the potential drawbacks of the approach; her observations are grounded in several years of experience observing their working environment.

As mentioned, these techniques have been widely applied to evaluate the usability and utility of computer-based systems and of more general forms of documentation [687]. They have not been widely used to have validate the presentation of incident reports. It is for this reason that McGill conducted a series of initial investigations to determine whether some of these approaches might support such evaluations [531]. This work formed part of a wider study that was intended to determine whether the use of electronic presentation techniques support or hinder the presentation of incident reports. These wider findings are discussed in the closing sections of this chapter. For now it is sufficient to observe that the tasks were designed to determine how well readers could use the published report to: identify key events that occurred at the same time during an incident but that occurred in different areas of the system; discover the timing and location of key events; identify whether or not an individual was involved in particular events. His study used laboratory-based, cooperative evaluation techniques but he also derived a number of high-level performance measures during these tasks. Brevity prevents a complete analysis of McGill's results. It is, however, possible to illustrate some of the findings. For instance, readers were relatively proficient at using paper-based reports to find answers to factual information. Questions of the form 'write down the time that the Chief Officer left the mess room to return to the bridge' were answered in an average of 4 minutes and 28 seconds using a relatively small sample of only five readers. In contrast, tasks that involved the resolution of conflict or that related to causal hypotheses took far longer to resolve. For instance, none of the users were able to answer 'Officer A gave conflicting evidence as to the time at which he left G deck to to the mess room - write down the page reference where these conflicting statements are highlighted'. Mc Gill's work, like that of Snowdon [749], is suggestive rather than conclusive. It provides an indication of some of the problems that readers face when attempting to use existing incident reports to perform a particular set of tasks. The study makes a number of recommendations about how those problems might be addressed for an individual incident report and hence indicates how lab-based studies might be used to support both formative and summative evaluation.

These preliminary studies raise more questions than they answer. The subject groups are too small to provide results that can easily be generalised beyond the specific context of the particular evaluations. Previous studies have also been conducted away from the reader's working environment. Snowdon's study looked at safety managers' attitudes during the 'atypical events' of a trade conference. McGill's study took place within a University laboratory. Neither of these environments approaches the ecological validity that is a focus for the ethnographic techniques that are summarised in previous paragraphs.

McGill's work also identified significant problems in accounting for learning effects. In order to demonstrate that any changes to an incident report had addressed the problems identified in previous studies, he was forced to retest subjects. Unfortunately, the readers of the reports were able to use the knowledge gained with earlier versions of the report to perform some of subsequent tasks. He, therefore, used elaborate counter-balancing to ensure that some of the readers were presented first with the revised version of the report and others with the initial version. Unfortunately this leads to further problems where preliminary drafts provide greater support for some tasks that the subsequent versions. The complex nature of prose incident reports make it very difficult to be certain about which particular aspects of a document actually support particular user tasks.

The previous observation leads to further reservations. As mentioned, we know remarkably little about the diverse ways in which readers exploit incident reports. The same documents have been used to inform the drafting of recommendations that are intended to avoid future incidents, they have also been analysed as part of wider statistical summaries, they have been added to international databases that can be searched by interactive queries etc [416]. It is, therefore, difficult to identify appropriate tasks that might help to drive any experimental evaluation. Those studies that have been conducted have all commented on the difficult of 'pinning down' reporting organisations to a precise list of the tasks that these documents are intended to support.

Figure 13.7: MAIB On-Line Feedback Page

Even if we could agree upon an appropriate selection of tasks, it is difficult to envisage ways in which studies might move beyond the test-retest approach taken by McGill. This approach attempts to identify small differences between different formats by testing and retesting users with various versions of a report over a short period of time. It is likely, however, that any changes to the format of incident reports may be introduced as part of more systematic changes and that these changes could have consequences for the long-term application of the information that they contain. I am unaware of any longitudinal studies into the strengths and weaknessed of particular presentation styles for incident reports. This forms a strong contrast with the many studies that have been conducted into the usability and utility of design documents [94, 513]. None of the investigation agencies that I have contacted throughout the preparation of this book have reported the use of direct user-testing to improve the quality of their incident and accident reports. This does not imply that such organisations are not concerned to elicit feedback about the information that they provide. For instance, Figure 13.7 illustrates how the UK MAIB provides a web-based form to elicit feedback about its work. Unfortunately, there is no publically available information about the insights that such systems provide about the presentation of incident reports. It is instructive to observe, however, that this feedback page asks respondents to indicate whether their information related to "ship's officer/crew, shipping company, fishing skipper/crew, fishing company, leisure craft, insurance, training/education, legal, government or other". This diverse list again illustrates the problems of devising appropriate reports that might satisfy the different information requirements for all of these groups. The use of electronic feedback froms to elicit information from the intended readers of an incident report is a relatively new innovation. It reflects a far wider move towards the use of electronic systems in the presentation and dissemination of information about near-miss incidents and adverse occurrences.

13.4 Electronic Presentation Techniques

Many of today's accident reports exploit the same presentation format and structure that was first used at the beginning of the twentieth century. This would not be a concern if the nature of accident investigation had not changed radically over the same time period [250]. Chapter 2.3 has described how the introduction of computer technology has rapidly increased the integration of heterogeneous production processes. This has now reached the point where isolated operator errors or single equipment failures have the potential to create complex and long lasting knock-on effects within many different applications. Accident reports must now not only consider the immediate impact of an accident but also the way in which emergency and other support services responded in the aftermath of an incident. This was illustrated by the Allentown incident, described in Chapter 8.3. Technological change is only one of the factors that have changed the nature of accident reporting. There has, for example, been a move away from blaming the operator. This wider perspective has resulted in many regulatory organisations looking beyond catalytic events to look at the organisational issues that form the latent causes of many failures. These two factors, technological change and new approaches to primary and secondary investigation, have increased the length of many incident reports. The scale and complexity of such documents imposes clear burdens upon the engineers, managers and operators who must understand their implications for the maintenance, development and running of many safety-critical systems. Recently, however, a number of regulatory authorities have begun to use the web as a primary means of disseminating accident reports. The MAIB "are in the process of converting all reports into a format suitable for viewing and downloading from this web site" [519]. Electronic media are perceived to offer considerable support for the communication of these documents.

It is difficult to obtain direct evidence that the changing nature of incident investigation and the complexity of technological failures has increased the length of incident reports. Tables 13.8 and 13.9 show how the number of pages required by marine occurrence reports has risen between 1991 and 1999 for the ATSB. These two years were chosen because 1991 is the earliest year for which it is possible to obtain a relatively complete collection of reports. The fact that it can be difficult to obtain particular documents is itself worth noting. 1999 is the most recent year for which a complete

1991	
Report Number	Number of Pages
27	27
28	28
29	Unavailable
30	44
31	23
33	Unavailable
42	21
32	29
34	18
35	34
36	23
37	38
38	29

Table 13.8: ATSB's 1991 Marine Report Page Counts

1999	
Report Number	Number of Pages
143	40
144	27
145	23
146	35
147	29
148	37
149	40
150	42
151	35
152	42

Table 13.9: ATSB's 1999 Marine Report Page Counts

collection can be obtained, given that some investigations that were started towards the end of 2000 have not published their findings. It was possible to obtain copies of 11 of the 13 reports that were published in 1991. These extended to an average of 28.5 pages, the standard deviation was 7.6 and the total number of pages was 314. In 1999, the average had risen to 35 pages per report over 10 incidents with a standard deviation of 6.63. A certain degree of caution should be exercised over the interpretation of these figures. For instance, the style of presentation has changed radically over this period. In particular, the introduction of photographic evidence has considerably lengthened later reports. It can also be argued that this trend is atypical. The ATSB reports focus on high-risk incidents, they also represent the publications of a single national agency.

Further evidence can be found to support the hypothesis that changes in the scope and complexity of incident investigations has had the knock-on effect of increasing the length of many incident reports. Table 13.10 illustrates how word counts can be used to strip out the formatting differences that distort the page counts shown in Tables 13.8 and 13.9. These word counts were derived from the less critical incidents that are reported by the UK MAIB's Safety Digest publication. Unfortunately, a number of further problems affect such an analysis. The 1996 volume examined approximately 54 incidents while the 2000 edition considered more than 110. It is for this reason that Table 13.10 considers the word counts for the first five incidents in the first number of each volume for each of the years. As can be seen, however, the results of this analysis provide only partial support for

Volume and number	Year	No. of Words First 5 Incidents
Safety Digest 1/00	2000	2845
Safety Digest 2/99 1/99 unavailable	1999	2658
Safety Digest 1/98	1998	4577
Safety Digest 1/97	1997	2720
Safety Digest 1/96	1996	2178

Table 13.10: UK MAIB Safety Digest Incident Word Counts

the general hypothesis of increased page counts. The sudden rise in 1998 cannot be explained by a change in the investigatory process nor any sudden increase in the complexity of maritime incidents. In contrast, this sudden rise can be explained by the introduction of more detailed 'lessons learned' summaries into individual incident reports.

Recent initiatives to exploit electronic presentation and dissemination techniques cannot be explained simply in terms of the changing nature of incidents or new investigatory techniques. There are strong financial incentives that motivate the use of web-based systems to support incident reporting. There are considerable overheads involved in ensuring that investigatory and regulatory organisations have an 'up to date' inventory of previous reports. The growth of the Internet also offers the possibility of dissemination reports to organisations and individuals who might not have taken the trouble to order and pay for paper-based versions of an incident report. Of course, there are obvious security concerns associated with such electronic techniques. There are also a host of additional benefits for the automated indexing and retrieval of large scale incident collections. These retrieval issues will be discussed in the next chapter. In contrast, the following pages identify a range of techniques that are intended to support the electronic presentation of incident reports.

13.4.1 Limitations of Existing Approaches to Web-Based Reports

Two primary techniques have been used to support the electronic dissemination of incident reports: the Hypertext Mark-up Language (HTML) and Adobe's proprietary Portable Display Format (PDF). Figure 13.8 illustrates the use of HTML by the UK MAIB in their Safety Digest, mentioned above. Users can simply select hyperlinks to move between the pages that describe similar incidents.

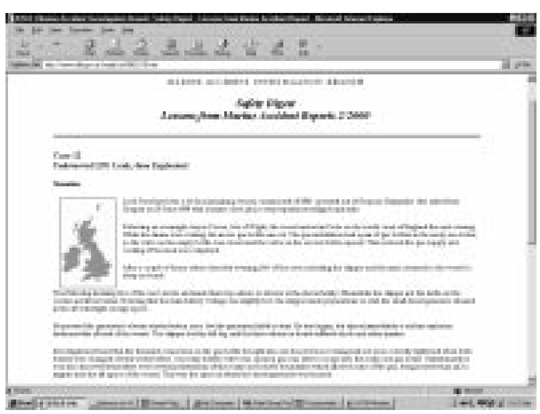

Figure 13.8: MAIB Safety Digest (HTML Version)

This use of the web offers a number of benefits for the presentation of incident reports. It avoids the overheads of maintaining a catalogue of paper-based documents. It is important to note, however, that very few agencies intend to entirely replace paper-based incident reports. For instance, the Transportation Safety Board of Canada include an explicit disclaimer on their web-site that:

> "These documents are the final versions of occurrence investigation reports as approved by the Transportation Safety Board. The TSB assumes no responsibility for any discrepancies that may have been transmitted with the electronic versions. The printed versions of the documents stand as the official record." [789].

HTML offers a number of further benefits. No special software is needed beyond a browser, such as Netscape Navigator or Internet Explorer, that are now installed as a standard feature of most personal computers. The introduction of hyperlinks and on-line keyword search facilities also helps to reduce the navigation problems that frustrate the readers of paper-based documents. There are, however, a number of limitations. Previous research has identified both perceptual and cognitive problems associated with the on-screen reading of technical documents [659]. This explains the subjective difficulties that reader's report when using large HTML documents. The improved comprehension that can be obtained through the appropriate use of hyperlinks as structuring tools can be jeopardised if on-line documents simply replicate the linear structure of paper based reports [672]. It can take almost twice as long to read electronic copy [556]. Readers are more prone to error when reading on-line documents [876]. HTML tags work well when they are interpreted and displayed by current web browsers. They do not work well when the same browsers are used to obtain printed output from HTML documents. Figures and photographs are often embedded as hypertext links in existing HTML reports. These will be missing in the printed version. Readers must manually piece together their hardcopy.

Many of these limitations can be avoided through the use of Adobe's proprietary PDF. It is for this reason that the MAIB publish their Safety Digest in both HTML and PDF formats. This exhaustive approach is, however, rare. Most agencies use either PDF or HTML. Figure 13.9 presents an excerpt from a PDF report into a marine incident published by the ATSB . The freely available PDF viewer integrates images and text to emulate the printed document on the screen. Readers can also obtain well-formatted, printed copies. This reduces the psychological and physiological problems of on-screen reading. However, these important benefits must be balanced against a number of problems. Firstly, it can be difficult for people to obtain and correctly install the most recent version of the PDF reader. This is important because these programmes are, typically, not a standard part of most browsers. Although PDF files are compressed, users can also experience significant delays in accessing these documents compared to HTML reports. Finally, it can be difficult to extract information once it has been encoded within a PDF document. This is a significant barrier if readers want to compile their own index of related incidents within an industry. The ATSB avoid this problem by providing extensive summaries of each incident in HTML format. Readers access the full PDF version of the report by clicking on a hyperlink within the HTML summary. This enables search and retrieval tools to index the HTML summary so that readers can easily find it using many of the existing search engines. They can then read and print the report in the PDF format that is less easy to index because of Adobe's proprietary encoding.

The hybrid use of both HTML and PDF by the ATSB and the MAIB does not address all of the problems that affect the electronic presentation of incident reports. These formats are, typically, used to reproduce the linear document structure that has been exploited since the beginning of the twentieth century. This imposes significant burdens upon the reader and may fail to exploit the full potential of web based technology [158]. It can be argued that investigatory authorities have focussed upon the electronic *dissemination* of accident reports over the web. Few, if any, have considered the opportunities that this medium provides for the effective *presentation* of these documents. The following paragraphs, therefore, describe how visualisation techniques from other areas of human-computer interaction can be used to support the electronic presentation of incident reports.

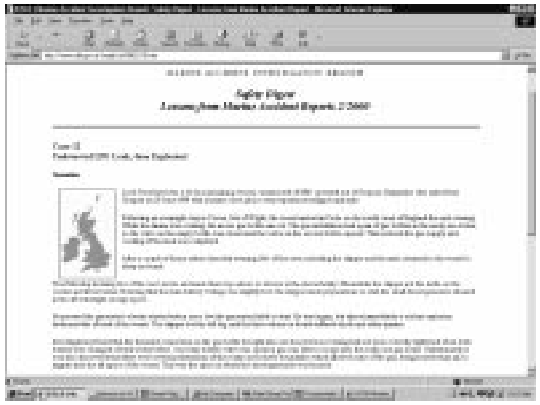

Figure 13.9: ATSB Incident Report (PDF Version)

13.4.2 Using Computer Simulations as an Interface to On-Line Accident Reports

Chapter 7.3 describes a range of simulation techniques that are intended to help investigators gain a better overview of the events leading to an incident. It is surprising that this approach is not more widely integrated into the on-line presentation of accident reports. For instance, Figure 13.10 shows how the NTSB's PDF report into a rail collision uses a still image from a 3-D simulation to provide readers with an overview of the train collision. This simulation was undoubtedly available to accident investigators. It would have been relatively simple to provide access to other readers alongside the PDF report. Instead the reader has to piece together events from more than 40 pages of prose.

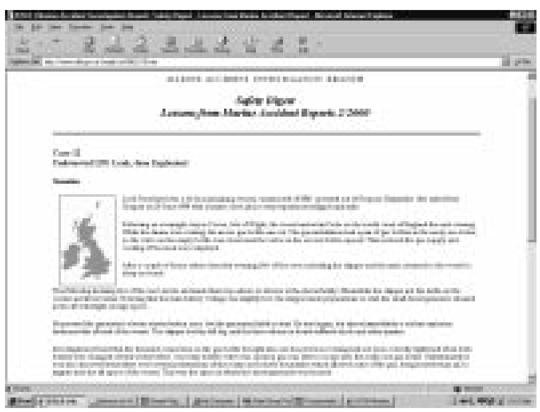

Figure 13.10: NTSB Incident Report (PDF Version)

Such examples, arguably, illustrate a missed opportunity to exploit novel means of presenting information about near-miss incidents and adverse occurrences. Several of my students have, therefore, begun to use simulations as an interface to on-line reports. Users are presented with animations of the events leading to an incident. Their browser also simultaneously present a set of links to those sections of the existing report that deal with the stage of the accident that is currently being simulated. The links are automatically updated as the simulation progresses. Users can stop a simulation at any point during its execution. They can then use their browser to retrieve the relevant sections of the text-based report.

Figures 13.11 and 13.12 illustrate two different applications of this approach. The system in Fig-

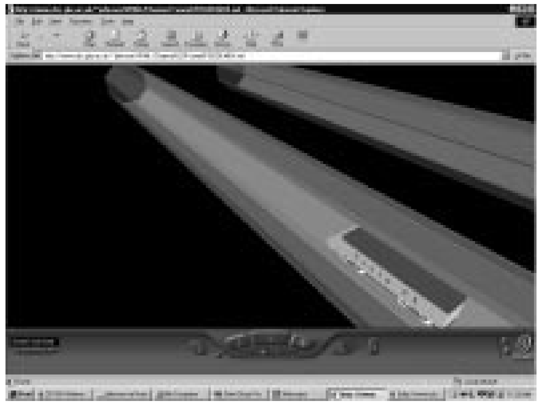

Figure 13.11: Douglas Melvin's Simulation Interface to Rail Incident Report (VRML Version)

ure 13.11 uses the scripting facilities in the Virtual Reality Mark-up Language (VRML) to generate a scale model for part of the Channel Tunnel. The technical details of the VRML approach are briefly introduced in Chapter 7.3. A free helper application is integrated into the browser so that users can view the pseudo-3D images. The user can select areas of the image to replace the simulation with an HTML from the report into the incident. The intention is that the simulation will provide a hgh-level overview of the events leading to the failure. Readers can then use the animation as a means of indexing into the analysis and more detailed reconstructions that are presented in a more conventional format.

Figure 13.12: James Farrel's Simulation Interface to Aviation Incident Report (VRML Version)

The approach in Figure 13.12 exploits similar techniques but focuses on cockpit interaction during an air accident. A series of still images can be updated using the controls in the centre of the screen. On either side of the simulation are sections that present the transcripts both from the cockpit voice recorders and from the Air Traffic Controllers. The prose from the accident report is presented at the bottom of the screen. All sections of the interface are updated as the user moves through the simulation. Unfortunately, simulations cannot be used to support the presentation of all aspects of an incident report. Chapter 7.3 reviews the problems that arise when these techniques are used to model the distal causes of an incident. It is relatively easy to simulate the immediate events surrounding a particular occurrence, it is less easy to recreate the management processes and regulatory actions that create the context for an incident. Similarly, it can be difficult to represent near-misses or errors of omission. readers and 'viewers' often fail to detect that something which ought to have happened has not, in fact, been shown in the simulation.

13.4.3 Using Time-lines as an Interface to Accident Reports

The previous simulations attempted to recreate the events leading to failure. It is also possible to exploit more abstract visualisations to provide readers with a better overview of an incident [502]. For example, we have used the Fault tree syntax that was introduced in Chapter 8.3 as a gateway into an incident report. As shown in Figure 9.9, 9.10 and 9.12 these diagrams can be used to map out both the proximal and distal causes of an incident. They can also be annotated in various ways, for instance events can show the time or interval during which they are assumed to have occurred. Imagemap techniques provide a means of using these diagrams to directly index into an incident report. Imagemaps work by associating the coordinates of particular areas on an image with web-based resources. The net effect is that if the user clicks on a node in a Fault Tree the browser can be automatically updated to show those sections of prose in an incident report that are represented by the graphical component. However, such representations quickly suffer from problems of scale. This is a significant limitation if the scope and complexity of incident reports is increasing in the manner suggested by the opening paragraphs of this section.

Again the desktop virtual reality provided by VRML and similar languages can be exploited to ease some of these problems. We have developed the pseudo-3D time-line shown in Figure 8.7 and the perspective wall, shown in Figures 8.8 and 8.9, to provide novel means of interacting with incident reports. These visualisations enable readers to access reports over the web. Rather than having to scroll over large, two-dimensional imagemaps of graphical structures such as Fault Trees, users can 'walk' into these structures along the Z-plane. The claimed benefits of this approach include a heightened sense of perspective and the ability to focus on particular aspects of the structure by choosing an appropriate viewpoint. As before, readers can use their mouse to select areas of the 3-dimensional models. The system then automatically updates an area of the browser to present the relevant areas of a textual report.

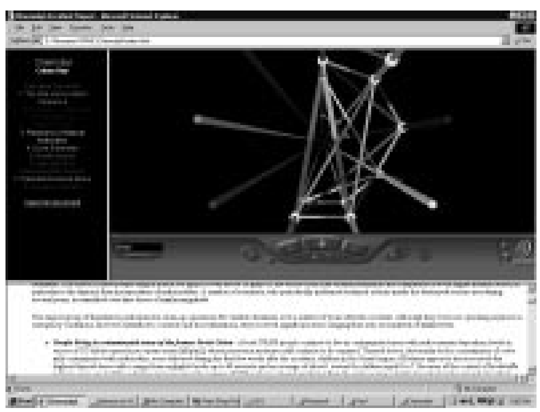

Figure 13.13: Peter Hamilton's Cross-Reference Visualisation (VRML Version)

Unfortunately, the models shown in Figure 8.7, 8.8 and 8.9 were all built manually . This requires considerable skill, expertise and patience. Together with Peter Hamilton, I have developed a similar range of three-dimensional interfaces that can be directly generated from textual incident report. This approach is illustrated in Figure 13.13. A colour-coded index is presented on the left of the image. This refers to each of the bars on the three dimensional representation shown on the right hand side. The image on the right represents time advancing into the Z plane. Each bar, and therefore each colour in the index, relates to a chapter in the incident report. Links are drawn between any two bars that refer to the same instant in time during the accident. It is, therefore, possible to 'walk' into the structure on the right to see whether different chapters treat the same events from slightly different perspectives. The lower area of the browser is used to present the HTML version of the report. Selecting a bar at any point in the Z plane will result in the image being updated to show any text relating to that moment in time in the selected chapter .

Many of these tools satisfy two different sets of requirements. For instance, the perspective wall and the three-dimensional time-line were introduced in Chapter 7.3 as tools to help investigators reconstruct the events leading to an incident. In this chapter, we have also argued that these techniques might also support the presentation of accident and incident reports. Similar comments can be made about the use of location-based simulations. For example, the QuicktimeVR images shown in Figure 8.4 have been integrated into several incident reports. Similarly, the imagemap shown in Figures 8.1 and 8.2 was initially intended as an alternative interface to an incident report rather than as an aid to incident investigators .

These interfaces also support a number of additional tasks. For instance, Schofield has pioneered the use of similar simulations within a range of legal proceedings [731]. This application of forensic animation is still very much in its infancy. The Civil Procedure Rules (CPR) substantially changed the legislative framework that governed the use of these systems in English courts. These rules came into force in April 1999 and gave judges considerable powers to control both the conduct and preparation of trials [294]. However, there is insufficient precedent for the use of these techniques and so much of the focus of Schofield's work has been to build up collections of 'case law' from other legal jurisdictions.

It is clear that the cost associated with the more innovative visualisations proposed in this section can only be justified for high-risk incidents. On the other hand, all of the interfaces shown here were produced using mass-market, software that is available without charge or under shareware license agreements. It is also important to stress that the development costs were minimal. They were developed over a period of approximately 1-2 weeks by final-year undergraduate students participating in my course on safety-critical systems. The intention behind this exercise was to see whether people who knew little about incident reporting but who knew more about the computer-based presentation of information might come up with some innovative presentation ideas.

There are, however, a number of caveats that must be raised about the potential benefits of these innovative presentation techniques. These can be summarised as follows:

1. *The problems of navigating in current desktopVR environments.* Many users experience considerable difficulty in moving along the three dimensional time-lines shown in the previous paragraphs. This problem has been widely reported in previous work on the validation of desktopVR [203]. Several solutions have been proposed. For instance, recent versions of our software have made extensive use both of virtual way-points and of sign posts [639]. This approach takes users on a 'conducted tour' of an incident . Users do not have to concentrate on achieving a particular orientation at a particular point in three-dimensional space in order to view particular events. They can simply click on a menu item that will take them to those events. Their viewpoint and orientation in the virtual world is automatically updated to provide them with the best view of the surrounding events. These navigation problems do not affect all accident simulations. For instance, the interface in Figure 13.12 uses animation techniques that enable the developer to treat the simulation as a 'movie'. They can specify the viewpoint and the sequence of events so that the reader need not navigate within a three dimensional environment.

2. *Unknown rhetorical effects.* Many of the techniques that are presented in this paper introduce new rhetorical techniques, or tropes. The introduction of a simulation can have a profound impact upon many readers. Initial field trials have indicated that people are more willing to believe the version of event shown in a simulation or model than they are in a paper based r eport. On the one hand this illustrates the importance of these new techniques. Investigation agencies can use them as powerful tools to convince readers about a particular view of an incident. On the other hand, these new techniques may persuade people to accept a simulated version of events that cannot be grounded in the complex evidence that characterises modern accidents.

3. *The problems of validating novel interfaces.* DesktopVR interfaces and simulations have a subjective appeal [408]. This should not be under-estimated. Investigatory and regulatory agencies have organisation reasons for being seen to embrace new technology. The Rand study

> [482] and the Institute of Medicine report [453] cited in previous chapter both criticised a range of perceived problems that have limited the effectiveness of more 'traditional' approaches to incident reporting. This pressure to innovate can be reinforced by the strong subjective appeal, mentioned above. However, the attraction can quickly wane. There is a danger that the users of these novel interfaces will reject the additional facilities that they offer if those techniques are not perceived to support their diverse working tasks. Previous sections have described the very limited nature of those studies that have been conducted into the longitudinal use of conventional, paper-based incident reports. We have even less information about the potential long-term use of these more innovative approaches.

There have been some limited evaluations of these novel presentation techniques. For instance, the McGill study mentioned in previous sections was extended to compare the use of a VRML time-line with the use of a location-based imagemap. The imagemap presentation was introduced in Chapter 7.3 and is illustrated in Figures 8.1 and 8.2. As mentioned, the readers of the report use a web browser to view a cross-sectional diagram of the ship that was involved in the incident. By selecting areas of that image, they can access a time-line of the events that happened in particular locations. These events are accompanied by a brief summary of their importance within the wider causes of an incident.

McGill's laboratory evaluation also considered the use of the VRML time-line illustrated in Figure 8.7 as a presentation format for incident reports. Readers used a web-based interface to 'walk' or 'fly' through an abstract map of the events leading to a particular adverse occurrence or near-miss incident. By clicking their mouse on certain areas of the structure, they accessed web pages that presented more detailed textual or graphical information. The participants in the study were asked to perform a number of tasks within a fixed period of time .

In order to minimise the effects of fatigue, each participant was stopped when they had spent a maximum of five minutes on any individual task. The study was counter-balanced so that each task was performed using a different presentation technique and the same number of participants performed each task using a particular approach. McGill also altered the order in which particular tasks were performed to help minimise any effects of fatigue or of learning from answering previous questions using a different presentation technique. The five tasks were as follows:

1. Write down the time that the Chief Officer left the mess room to return to the bridge.
2. Write down the key events which happened on the bridge at approximately 18:23.
3. Officer A gave conflicting evidence as to the time at which he left deck G to go to the mess. Write down the page/paragraph reference where these conflicting statements are highlighted.
4. What events happened at 18:28?
5. Write down the time that crewmember B returned to his cabin.

Table 13.11 summarises the times that were obtained for five users performing these different tasks using cooperative evaluation under laboratory conditions. The small number of participants in the study meant that a very limited number of readers used each interface to perform each task. It can also be argued that his choice of questions may have produced results that are favourable towards particular presentation formats. McGill concludes that the electronic versions offered significant benefits over the paper-based presentation of the incident report. This is revealed principally in the time take to perform the specified tasks but also in a range of attitudinal questions that assessed the readers' subjective response to these systems. These subjective questions indicated a strong preference for the VRML time-line over the image map for most tasks. McGill did not compare subjective responses for the paper-based report because he assumed that the electronic formats would supplement rather than replace more traditional presentation techniques.

The results summarised in Table 13.11 hide a number of factors that influenced the course of the study. For instance, subject 3 in Task 4 missed one of the events. McGill awarded a time penalty for each incorrect answer when presenting his results [531]. His decision to add thirty seconds to the time reported for task completion seems arbitrary. These penalties have not, therefore, been

	Paper report	Image Map	VRML Time-line
User 1	Task 1: Did not complete Task 4: 133 sec.	Task 2: 52 sec. Task 5: 144 sec.	Task 3: 35 sec.
User 2	Task 2: 227 sec. Task 5: 173 sec.	Task 3: 62 sec.	Task 1: 19 sec. Task 4: 45 sec.
User 3	Task 3: Did not complete	Task 1: 189 sec. Task 4: 179 sec.	Task 2: 38 sec. Task 5: 27 sec.
User 4	Task 2: Did not complete	Task 1: 177 sec. Task 5: Did not complete	Task 3: 61 sec. Task 4: 69 sec.
User 5	Task 1: 236 sec. Task 5: 254 sec.	Task 2: 40 sec. Task 4: 273 sec.	Task 3: 42 sec.

Table 13.11: McGill's Timing Results for Tasks with Electronic Incident Reports

included in Table 13.11. The preliminary results provided by this study must be supported by more sustained investigations into the potential errors that might arise from the use of such innovative presentation techniques. A number of further comments can be made about these results. For example, user 4 in task 5 insisted on abandoning the image map and resorted to the paper based report after 3 minutes. Such situations typify experimental studies with users performing complex tasks over even relatively short periods of time. There are inevitable frustrations from being forced to use presentation formats that the reader might not accept if they were given a free choice. This emphasises the need for more sustained longitudinal studies into the 'real world' use of electronic incident reports.

13.5 Summary

Incident reports provide a primary means of ensuring that the weaknesses of previous applications are not propagated into future systems. This chapter has described a number of the problems that complicate the task of drafting these documents. Incident reports may have to be tailored to meet the particular requirements of several diverse audiences. For instance, some reports are produced to be read by the regulators who must decide whether or not to act on their recommendations. Other forms of incident report are intended as case studies or scenarios that are to be read by operators and practitioners. Further factors complicate even these relatively simple distinctions. For instance, the format and presentation of reports that are to be read by operators within the same organisation as the investigator can be quite different from those that may be disseminated to a wider audience. The problems of addressing the needs of intended readers of an incident report are also complicated by the way in which different types od report may be drafted for different types of occurrences. For example, incidents that have a high-risk associated with any future recurrence may warrant greater detail than those that are assumed not to pose any future threat to a system. Different presentation techniques may also be necessary in order to draft reports at different stages of an investigation. The format of an interim report in the immediate aftermath of a near-miss incident or adverse occurrence is unlikely to support the more polished, final report that is required by international organisations, such as the IMO. The task of meeting these various requirements is also exacerbated by the need to preserve confidentiality in the face of growing media and public interest in technological failures.

Subsequent sections of this chapter have presented a number of detailed recommendations that are intended to support the presentation of incident reports. These recommendations are ordered in terms of the different sections that are, typically, used to structure more formal reports into high-risk incidents: reconstruction then analysis then recommendations. However, many of the detailed guidelines can also be applied to documents that analyse less critical failures. For example, any reconstruction should consider both the distal and the proximal events that contributed to an incident. It is also important to describe the evidence that supports a particular version of events. Similarly, the analysis section should not only describe the causes of an incident but also the methods that were used to identify those causes. It is no longer sufficient in many industries to rely simply on the reputation of domain experts without the additional assurance of documented methods to support their conclusions [282]. The guidelines for drafting recommendations include a requirement that investigators should define conformance criteria so that regulators can determine whether or not particular changes have satisfied those recommendations. It is also important to explain the relationship between any proposed changes and the causes that were identified from any analysis of the incident.

It is important that investigators have some means of determining whether or not a particular report supports the tasks that must be performed by its intended audience. This can be done in one of two ways. Firstly, we have described a range of verification techniques that can be used to demonstrate that particular documents satisfy principles or properties that are based on the guidelines, summarised in the previous paragraph. Careful reading of an incident report can also be used to identify a range of rhetorical techniques. These tropes are often effective in more general forms of communication but can lead to ambiguity and inconsistency within engineering documents. Such problems can have profound consequences for safety when they weaken the presentation of incident reports. Mathematical proof techniques provide one means of identifying where enthymemes weaken the use of syllogism in an incident report. This is particularly important because the ommision of evidence not only removes particular information from the reader but it also prevents them from drawing necessary inferences that depend upon the missing information. We have also described how Toulin's [776] model was produced as a response to criticisms of logic as a means of analysing argument. This approach rejects any a priori notions of truth or falsehood. Instead it links evidence and claims through the warrants and backing that support them. It also emphasises the importance of qualifiers and rebuttals in explaining why someone might hold a contrary opinion.

We have identified limitations that affect both the use of logic and of models of argumentation to support the verification of incident reports. Neither approach provides any guarantee that the properties which are established of any particular document will actually be significant to their intended readership. Subsequent sections, therefore, briefly described a range of user-testing techniques that can support the validation of particular formats. Surprisingly few of these techniques have ever been applied to determine whether incident reports actually support the activities of their end-users. The results of some preliminary studies have been described, however, these raise a host of methodological problems that complicate such validation activities. For example, it can be difficult to identify a representative set of tasks that must be supported by a particular incident report.

This lack of evidence about the utility of existing formats is worrying given that a number of factors are creating potential problems for their continued application. Existing paper-based reporting techniques have, however, remained relatively unchanged over the last century. During this time, the introduction of microprocessor technology has significantly increased the integration of heterogeneous processes. There have also been changes to the techniques that drive incident analysis. There is an increasing awareness that contextual and organisational issues must be considered in addition to any narrow findings about operator 'error'. The integration of safety-critical interfaces and the development of organisational approaches to incident analysis have created new challenges for the presentation of these reports. Their scope and complexity is increasing. At the same time, many investigatory organisations have begun to disseminate their incident reports over the World Wide Web. It is, therefore, possible to extend the application of advance visualisation and navigation techniques from other areas of information technology to support the readers of these documents. Unfortunately, most agencies focus on the Web as a means of dissemination rather than communication. Paper based reports are directly translated into HTML or Adobe's PDF. This creates a number of problems. The HTML approach suffers from the well-known problems of reading large on-line documents. The PDF approach prevents many search engines from effectively retrieving information about similar accidents. Finally, the direct translation of paper-based reports into on-line documents ignores the potential flexibility of electronic media. The closing sections of this chapter have described a number of alternative approaches that support the presentation of incident reports. These formats exploit the opportunities created by the electronic dissemination and communication of incident reports. They must, however, be treated as prototypes. Further evidence is required to demonstrate that they support the range of tasks that are currently achieved using paper-based documents and their more orthodox counterparts on the web.

The increasing use of electronic media to document information about adverse occurrences and near-miss incidents not only creates opportunities for new presentation formats. It also, for the first time, creates opportunities to provide automated tools that will help investigators find records of similar incidents in other organisations, in different industries, in other countries. It is far from certain that we will be able to exploit this opportunity. For example, the vast number of records that have been compiled in some industries now makes it practically impossible to accurately search and retrieve information about similar mishaps. The following chapter, therefore, describes a range of computer-based tools and techniques that have been specifically developed to support large-scale collections of incident reports.