Integration of a Causal Analysis process into an Accident Investigation Organisation

Rebecca Charles & John Stewart

Rail Accident Investigation Branch

SUMMARY

Accident investigation requires a structure and framework within which to determine why an accident happened. The Rail Accident Investigation Branch (RAIB) promotes that causal analysis (CA) will be the backbone of its investigation activities. It will capture the logical structure of how events came together to result in the accident. It will also drive the evidence collection and interview strategies by defining what is necessary and relevant to understand the causality.

RAIB recognises that there are many CA tools and techniques and encourages use of the most appropriate tools for each investigation. However, it is important to RAIB to define a discipline framework within which the relevant tools are applied and to strive for consistency in this across all investigations. Historically, there has been some variability in this. To achieve this consistency, it is necessary to understand the variability in understanding of CA processes and techniques by inspectors, how they have applied them and the challenges they have faced. To that end, 21 inspectors of varying experience were taken through a structured interview and the key issues elicited. These have been used as the basis for a revision to the RAIB's approach to CA and its implementation.

KEYWORDS

Accident investigation, Causal analysis, Rail

Introduction

The Rail Accident Investigation Branch (RAIB) is a UK based independent no-blame safety organisation, who investigate rail accidents to improve safety, and inform the industry and public, to ultimately improve the safety of the railways. It does this by following a structured approach to investigating accidents which includes multiple opportunities for peer and manager review, as well as collaboration between multiple inspectors. RAIB refers to this process as Causal Analysis (CA) and adopts it in its investigations to determine why an accident happened. It provides the structure for the investigation activities, directing what evidence needs to be collected and analysed to determine the events that came together to result in the accident. RAIB's approach to causal analysis is based around a simple failure model taking into account active and latent failures throughout the sociotechnical system (Reason et al., 2006). This model assumes that systems generally exist within a normal operating envelope. However, deviations sometimes occur causing a system to operate outside of this envelope, but still within an emergency envelope, where things are not normal, but nothing catastrophic has happened. From this state, a system can either be returned to the normal operating envelope or the deviation can be allowed to continue so that an accident becomes inevitable. The return to the normal operating envelope is generally achieved by defences provided by the system designer, having recognised the possibility of the deviation.

Therefore, accidents happen due to the initial failure/s causing the deviation, and failures of the barrier/s (or their non-provision) allowing the deviation to continue uncontrolled. Each of these

failures, which are referred to as causal factors, will be the result of other failures within the railway system, or sometimes external to the railway system, such as flood defences. The purpose of causal analysis is to determine each of the failures that resulted in the causal factors, and the underlying factors that made the bottom events more likely. These underlying factors are likely to exist within the associated environmental, supervisory, and organisational arrangements.

The current CA process involves developing a sequence of events (timeline) in order to identify the key fault events. The process then uses fault tree analysis (Watson, 1961) and why-because analysis to identify the precursor events which led to the fault, including any influencing factors, such as environmental, or cultural factors. The final causal diagram is then used to structure the investigation report, to enable the reader to follow the causes of the accident in a logical manner. Although all inspectors are trained in CA tools and techniques, there are different structures within which they can be applied. The main driver for this exercise was to clearly define a standard structure within which CA will be applied on all investigations, such that it continues to be the backbone of the investigation. The structure would then ensure discipline and consistency in CA implementation and investigative activities. RAIB wanted to define certain activities that would be undertaken on all investigations, but not necessarily how they would be executed. In a similar manner, it also wanted to define a consistent review framework based on the emerging causal analysis.

Aim

The aim of the study was to understand the range of different approaches to implementing CA currently being adopted in RAIB and how these influenced other investigation activities, in particular evidence gathering and assessment. The objectives were to gain an understanding the inspectors' attitudes to having a defined CA technique, what they were doing at the moment in terms of CA, the barriers to use, and what they felt they needed in terms of support and training moving forwards. All inspectors who are fully qualified and have completed at least one full investigation (14 inspectors, six principal inspectors, and the Deputy Chief Inspector) were invited to attend an informal interview, either in person or on Teams. Conversations lasted between 30, and 120 minutes and were semi-structured, with a list of questions prepared to act as prompts, but the interviewer was led largely by the inspector and topics were explored which were of interest to them or they felt were important. Detailed notes were taken during the interviews.

Results

The interviews were analysed using thematic analysis, and six key themes were identified. These will be discussed in turn:

1. *Techniques:* A fault tree (Watson, 1961) combined with a why / because analysis is the most commonly used technique, as it is the one that has been trained. It was seen that one size does not fit all, and there may be different needs for different investigations, especially when considering static vs dynamic problems. However, all inspectors followed the guidelines set out in the training which are to build a sequence of events and then to identify where the system failed.

   The fault tree output is seen as useful and is used by many as the structure for the final report, and the framework to guide interviews, evidence collection, and lines of inquiry. Some did state that this sequential technique was too simplistic and may result in things being missed, which could potentially be identified using more complex, systems-based models (Underwood & Waterson 2013). This was consciously noted by two inspectors who found that developing

possible scenarios and then working through them systematically was useful and identified different lines of enquiry. A few inspectors have tried certain aspects of other techniques such as Accimap (Rasmussen, 1997) or STAMP (Leveson, 2004, 2011), but felt that while some aspects of the technique are extremely valuable, the overall result did not translate well to the report due to the output being complex. Specifically, Accimap was seen as being a good tool for brainstorming ideas by one inspector, but they stated that they could not see how it would translate to the final report or be used to develop standalone causal factors.

The interviewees also raised the importance of recognising that normal conditions can be contributory to an accident and that these need to be captured. Also, they emphasised the importance of adequately capturing and recording all discounted factors and the associated justification. Any tool or guidance specifically needs to allow for both.

2. *Timing, Personnel and responsibilities:* Each investigation team consists of a Lead Inspector (LI), who is responsible for running the investigation and guiding its direction, and an Investigation Manager (IM) who maintains a strategic overview of several investigations at any one time. Also included in the investigation are Subject Matter Experts (SMEs) and the Chief (CI) and Deputy Chief Inspector (DCI) who maintain an overview and review the CA towards the end of the process

   All inspectors felt that early development of the CA is essential, and that the setting of the remit (the document which guides the investigation) and the first CA should be complimentary activities, initiated by the IM. Some inspectors encountered problems when SMEs were not involved in the early stages of an investigation and felt that their early involvement in the CA process "was essential" to setting a clear direction for the investigation and helped in eliminating potential factors early on in the process. This has been partly addressed by introducing two bespoke meetings early in the investigation process involving all relevant parties. An Initial Strategy Meeting (ISM) to set the investigation remit and evidence collection strategies, and an initial facilitated causal analysis workshop (see point 3) to ensure that the accident has been defined appropriately, and that the immediate cause of the accident and the likely lines of enquiry have been identified.

   One key theme which was mentioned frequently in the interviews was around ownership of the CA process. It is imperative that the LI maintains ownership of the CA and can prove that the arguments are backed up by evidence. The IM's role is to provide 'challenge and support' to the LI, and is primarily an assurance role, as well as a project management element. Ensuring correct attendance at the ISM and facilitated causal analysis workshop is considered the responsibility of the IM, with input from the LI.

3. *Facilitated causal analysis workshops:* A facilitated causal analysis workshop is a session where an experienced inspector not actively involved in the investigation works with the LI, IM, and the various other stakeholders to build a fault tree using questioning techniques and strategies. These sessions were seen as a valuable addition to the process. Interviewees noted that a strong facilitator is essential, but they should also be engaging, a good listener, and able to think on their feet, while remaining impartial and avoiding taking ownership of the analysis – the latter being a real risk that needs careful management. The general view was that SMEs should be involved in the facilitated workshops. It was recognised that a causal analysis

workshop needs to be held early in the investigation and that there can be merit in a second session towards the end of the investigation as a sterile review of the analysis. The facilitated workshops were found to help mitigate against challenges later in the investigation process, thereby increasing the efficiency of the investigation process.

4. *Review of the CA throughout the investigation:* The overall opinion is that the CA is a live document, and should be updated, and re-checked throughout the investigation. Historically, many of the investigation review meetings were centred around progress against the investigation remit, and the findings from the related activities. The focus has been revised to ensure consideration of the emerging CA, ensuring the logic is regularly checked and revised, and the interview, evidence collection, and media strategies remain relevant. This focus on the CA logic helps ensure that it is followed through into the report structure.

   It is recognised that the CA needs to be demonstrably supported by evidence. Most inspectors maintain a separate log of evidence, with a link to the relevant part of the CA that it supports. It is important that inspectors can evidence both that an event happened and that it had the effect being modelled in the CA.

5. *Presentation of findings:* The CA is usually presented as a fault tree. RAIB does not use dedicated fault tree drawing package, inspectors adopt different approaches, some hand draw their diagrams, and some use standard programmes such as PowerPoint or Visio. The causal fault tree diagrams are not presented in the final published reports. Most inspectors stated that including a causal diagram in the report would mean the causal analysis lost all the nuance and would miss the subtleties that text allows. It would also make presenting discounted factors difficult.

6. *Training:* Training was mentioned as being good in its current state, which consists of a training session when inspectors first join the branch, plus refresher training. However, more case studies, worked examples and ‘having a go’ practical sessions were considered as being beneficial. There is recognition that just being part of the CA process (on other investigations as well as your own) will help with familiarity, and with embedding the process into the wider investigation process going forwards. Also, having oversight of different methods and approaches was seen to be a positive thing and would enable people to adapt the approach to suit to varying demands of different investigations.

Conclusions

Key findings from interviews

The CA process was seen by all inspectors to be the cornerstone of the investigation process, and one which most engaged with fully. Although different approaches are taken, generally, fault trees are used to determine causality, and in turn as the basis for the structure of the report. All inspectors saw the initial strategy meeting and the facilitated workshops, both involving the SMEs, as beneficial additions to the process.

The key barriers to successful implementation of CA were seen to be lack of ownership of the CA by the lead inspectors and a lack of exposure to and familiarity the CA process.

RAIB response to findings

Following on from this piece of work, RAIB has developed its causal analysis process into a framework that is to be adopted by all inspectors. The framework consists of a series of steps that must be adhered to, but the process allows for flexibility in how each is undertaken. The overall investigation process is being revised to integrate these steps.

The main steps in the process are: to precisely define the accident, understand the elements of the system that should have ensured safety in the accident scenario, define the immediate cause, develop a sequence of events to identify the fault conditions that led to the accident and develop fault trees to determine the causality. The steps are supported by guidance that ensures a degree of consistency, but also drives the investigation to all relevant areas of the overall sociotechnical environment. The widest consideration of issues is ensured by implementation of the facilitated causal analysis workshops attended by all relevant technical experts within the branch. Guidance documents include:

- Conducting facilitated sessions.
- Roles and responsibilities within the CA process, including attendance at key stage meetings.
- Guidance on evidence attribution.
- Review process and actions.
- Revised training material
- Related Competence Management arrangements for inspectors

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