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Systemic accident analysis: Examining the gap between research and practice

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ABSTRACT

The systems approach is arguably the dominant concept within accident analysis research. Viewing accidents as a result of uncontrolled system interactions, it forms the theoretical basis of various systemic accident analysis (SAA) models and methods. Despite the proposed benefits of SAA, such as an improved description of accident causation, evidence within the scientific literature suggests that these techniques are not being used in practice and that a research–practice gap exists. The aim of this study was to explore the issues stemming from research and practice which could hinder the awareness, adoption and usage of SAA. To achieve this, semi-structured interviews were conducted with 42 safety experts from ten countries and a variety of industries, including rail, aviation and maritime. This study suggests that the research–practice gap should be closed and efforts to bridge the gap should focus on ensuring that systemic methods meet the needs of practitioners and improving the communication of SAA research.

1. Introduction

The systems approach is arguably the dominant paradigm in accident analysis and human factors research (e.g. Salmon et al., 2012a; Stanton et al., 2012). It views socio-technical system accidents as the result of unexpected, uncontrolled relationships between a system's constituent parts. This requires the study of systems as whole entities, rather than considering their parts in isolation. Many complex system accidents, e.g. space shuttle Columbia and Comair flight 5191, have not simply resulted from catastrophic equipment failure or an unsafe human action, as required according to traditional cause-effect accident models; instead accidents emerge as complex phenomena within the normal operational variability of a system (de Carvalho, 2011). Therefore, describing accidents in a sequential (cause-effect) fashion is arguably inadequate, as it is unable to sufficiently explain the non-linear complexity of modern-day socio-technical system accidents (Hollnagel, 2004; Lindberg et al., 2010). It can also lead to equipment or humans at the 'sharp end' of a system being incorrectly blamed for an accident. This represents a missed opportunity to learn important lessons about system safety and, therefore, develop more effective safety recommendations. Use of the systems approach, via systemic accident analysis (SAA), supposedly avoids these limitations and it has been used as the conceptual foundation for various SAA methods and models, e.g. Systems Theoretic Accident Modelling and Processes model (STAMP) (Leveson, 2004), the Functional Resonance Analysis Method (FRAM) (Hollnagel, 2004) and Accimap (Rasmussen, 1997).

1.1. Systemic accident analysis in research

A number of studies have compared SAA methods with established non-systemic analysis techniques, such as Fault Tree Analysis (e.g. Belmonte et al., 2011) and the Sequentially Timed Events Plotting method (e.g. Herrera and Woltjer, 2010). These studies and others like them (e.g. Ferjencik, 2011) suggest that, whilst the non-systemic methods are suitable for describing what happened in an accident, the SAA techniques provide a deeper understanding of how dynamic, complex system behaviour contributed to the event.

Furthermore, Leveson (2011, p. 349) comments that most accident reports are written from the perspective of cause-effect models and that the analysis frequently stops prematurely. Some studies exemplify this by stating that additional insights were achieved using SAA methods, when compared with the findings of official investigation reports (e.g. Jenkins et al., 2010; Johnson and de Almeida, 2008). The improved understanding of accident causation provided by SAA should, therefore, allow the development of more effective safety recommendations.

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1.2. Systemic accident analysis in practice

Despite the proposed advantages of SAA, there is evidence within the scientific literature to suggest that methods and tools employing a systemic perspective are not being adopted in practice. For example, some researchers (e.g. Carhart and Yearworth, 2010; Leveson, 2011) comment that the most widely used accident analysis tools are based on sequential, reductionist models of systems and causality. Other researchers also suggest that SAA techniques are yet to gain acceptance outside of the research community (e.g. Okstad et al., 2012; Salmon et al., 2012a). These observations are supported by the sequential understanding of accident causation presented within various elements of the practitioner-focused safety literature (e.g. Energy Institute, 2008; Health and Safety Executive, 2004; Rail Safety Standards Board, 2011).

1.3. The gap between research and practice

The different analysis approaches taken by the researcher and practitioner communities suggest that a research–practice gap exists in the domain of SAA. Various aspects of the research–practice gap in accident analysis have been previously studied, both from a general perspective and within the context of SAA. Generic factors which can influence a practitioner's approach to accident analysis have been identified, such as investigator bias and resource constraints (e.g. Johnson, 2003; Lundberg et al., 2010). These influences can arguably lead practitioners away from the theoretical ideal of accident investigation and therefore contribute to a research–practice gap (Lundberg et al., 2010). Other studies (e.g. Salmon et al., 2012a; Underwood and Waterson, 2012) have examined how the characteristics of several systemic analysis models impact on the ability of an individual to successfully perform SAA, such as the lack of method reliability caused by their qualitative nature.

Despite the presence of such a research–practice gap there is evidence to suggest that a desire to adopt SAA exists within sections of the practitioner community. For example, accident investigators within aviation have begun to recognise the need to look beyond sequential analysis methods (e.g. Martinez, 2011, p. 8). Furthermore, Steele and Pariès (2006) suggest that many practitioners acknowledge the limitations of traditional models and are keen to apply new techniques. Given that a demand to apply SAA seems to exist in both the researcher and practitioner communities, the research–practice gap needs to be examined in more depth.

1.4. Study aims

Whilst some of the research-based factors contributing to the SAA research–practice gap have been identified in previous studies (e.g. Underwood and Waterson, 2012), it is believed that practitioner-related influences, such as those described by Lundberg et al. (2010), require further examination within the context of SAA. Therefore, the following aims for the study were established:

- Understand how the awareness of, and need for, SAA within the practitioner community could inhibit the adoption and use of SAA.
- Understand how the factors influencing current analysis approaches may hinder the adoption and use of SAA.
- Follow up and probe deeper into the issues stemming from research which may impede the diffusion of SAA into practice.

2. Methods

The use of semi-structured interviews was selected as the most appropriate method to achieve the aims of the study for a number of reasons. Firstly, the lack of information regarding SAA within the practitioner literature prevented the use of document analysis alone. Secondly, previous studies focused on the SAA research–practice gap have used methods such as thematic analysis of the scientific literature (e.g. Underwood and Waterson, 2012) and user evaluations of SAA methods (e.g. Salmon et al., 2012a). Consequentially, interview data was viewed as the most suitable form of information to supplement the existing findings. Finally, semi-structured interviews provide the ability to examine topics of interest in varying degrees of depth; an approach which suited the exploratory nature of this study (Robson, 2002).

2.1. Sampling strategy

Due to the study resource constraints, it was not possible to create a statistically representative sample. Therefore a convenience sample, considered to be indicative of the accident investigation community, was created. The sample included participants employed as full-time accident investigators, health and safety professionals (e.g. company safety managers), human factors specialists and accident analysis researchers. However, these participant categories were not mutually exclusive, e.g. some practitioners had research experience. Therefore, participants were allocated to the category associated with their current role as it was felt that their role would have the most influence on their analysis approach, e.g. due to resource constraints. Also, gaining a detailed understanding of how a participant's background influenced their analysis approach was beyond the study scope.

Human factors experts were recruited as they are often employed on a consultancy basis to provide input into accident investigations or safety-critical system design. The views of researchers were also sought to enable a comparison with the practitioners' perspectives and further explore the research-based factors that may influence the SAA research–practice gap.

Participants were required to have experience of investigating accidents and/or performing risk assessments within at least one safety-critical industry. No specific inclusion criteria were set regarding the level of their experience. Participant recruitment was halted when an appropriate level of thematic data saturation was judged to have been achieved.

2.2. Participants

Interviews were conducted with 42 participants (age range: 28–79 years; mean age: 46.4 years) based in ten countries. The nine full time accident investigators (AI), 17 health and safety professionals (HS), ten human factors specialists (HFE) and six researchers (R) had experience of working in at least one of 25 industries. Of these industries, those that had been worked in by at least five participants included: rail, aviation, maritime, oil and gas, defence, healthcare, nuclear power and manufacturing. The interviews lasted between 28 and 128 min (mean interview length: 70 min).

2.3. Interview question design

The interview questions were designed to understand the following topics: (1) the participants' knowledge of SAA and accident causation, (2) the analysis methods and processes they currently use and (3) the barriers they feel prevent information flowing between the research and practice communities. In order to provide a comprehensive deductive analysis framework, the interview questions were based on these topics, the questions employed by Lundberg et al. (2010) and the findings of previous studies (e.g. Underwood and Waterson, 2012) (see Appendix A for interview questions).