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'Accident investigation in the wild' – A small-scale, field-based evaluation of the STAMP method for accident analysis

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ABSTRACT

Little information is currently available about the application of systemic accident analysis methods by practitioners and whether their analysis needs are met. This study provides an insight into this issue by obtaining a practitioner evaluation of STAMP and understanding how the method's usage characteristics affect its use in a live investigation scenario. Six participants took part in a workshop to analyse data collected during a (high-fidelity, partly field-based) simulated investigation exercise using STAMP. The analysis outputs were assessed, along with the participants' questionnaire and focus group responses pertaining to their experiences of using the method. When combining the mixed methods data generated during the study, a number of observations regarding the participants' experiences of using STAMP were made. However, improving the method's usability and graphical output were highlighted as key developments that may improve its acceptance by practitioners.

1. Introduction

Use of the systems approach to understand accident causation and improve system safety is commonplace within the research community (e.g. Asadzadeh and Azadeh, 2014; Kazaras et al., 2014; Leveson and Stephanopoulos, 2014). Utilising concepts of systems theory, it views accidents as the result of unexpected, uncontrolled relationships between a system's constituent parts. Systems must, therefore, be analysed holistically as whole entities, rather than considering their parts in isolation. Traditional theories of accident causation suggest that complex systems accidents are caused by sequences of causal events which are initiated by a single 'root cause' event, such as catastrophic equipment failure or an unsafe human action. However, as system complexity has increased over time, many accidents (e.g. space shuttle Columbia; Comair flight 5191) have not simply resulted from such trigger events. Instead these accidents emerge as complex phenomena within the normal operational variability of a system (de Carvalho, 2011).

Describing accidents in a sequential (cause–effect) fashion is, therefore, arguably inadequate. 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 how to prevent accident recurrence. The use of the systems approach, via systemic accident analysis, tries to avoid these limitations. It has been used as the conceptual foundation for various accident analysis techniques, of which STAMP (Leveson, 2004, 2012), FRAM (Hollnagel, 2004, 2012) and AcciMap (Rasmussen, 1997) are the most popular within the research community (Underwood and Waterson, 2012).

1.1. The systemic accident analysis research-practice gap

Despite the proposed advantages of the systems approach, there is evidence within the scientific literature which suggests that methods and tools employing a systemic perspective are not being adopted in practice. In other words, a research-practice gap exists. Some researchers (e.g. Carhart and Yearworth, 2010; Dien et al., 2012; Leveson, 2012) comment that the most commonly used tools for accident analysis are based on linear, reductionist models of systems and causality. Furthermore, other researchers note that systemic accident analysis and its related techniques, e.g. STAMP, are yet to gain acceptance outside of the research community (e.g. Hollnagel et al., 2008; Okstad et al., 2012; Read et al., 2013; Salmon et al., 2012a,b). 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 and Standards Board, 2011) and the focus on 'sharp end' factors within investigation reports (e.g. Cedergren and Petersen, 2011; Schröder-Hinrichs et al., 2011).

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Along with a number of researchers, the authors of this study have previously suggested that the research-practice gap should be bridged, where possible, as the systems approach can provide a better understanding of accidents (e.g. Underwood, 2013; Underwood and Waterson, 2013).

1.2. Bridging the research-practice gap

A key method for bridging the gap is ensuring that systemic accident analysis techniques are suitable for use by practitioners (Underwood and Waterson, 2013). The use of systemic methods to analyse accidents has predominantly existed within research and very little is known about their application by practitioners. Therefore, in order to understand if the systemic techniques meet the needs of practitioners, it must be established how these methods cope with the demands of live investigations. Recruiting practitioners to apply and evaluate the systemic analysis methods would be a useful start towards achieving this goal.

From a research perspective, it would be favourable to collect method usage data within a live investigation. However, there may be reluctance to trial new analysis techniques in an investigation. Furthermore, this goal may be practicably difficult to achieve for a number of reasons, such as: the unpredictable schedule of accident investigations, the expense of extended field-based research and gaining access to sensitive information. There is also the ethical issue that if a method is trialled in this way and fails, the investigation and the agency conducting it may be damaged and affected parties (e.g. those involved or perhaps family members of injured/deceased) may not receive timely feedback. Anecdotally, this is often suggested as a reason why investigation agencies are reluctant to try new methods in a live investigation.

The use of simulated accident scenarios offers a solution to these problems and balances the realism of an investigation with the theoretical and practical needs of researchers. For example, previous work by Woodcock et al. (2005) demonstrated that the investigation of simulated accidents is suitable for analysis method evaluation. However, participants (accident investigators) of their laboratory-based study commented that a lack of site visits limited the realism of the exercise. Therefore, the preferred format for an accident simulation should involve field-based elements.

1.3. Study aims

The principle aim of this small scale, exploratory study was to provide an initial insight into the use of a systemic accident analysis method within the context of accident investigation. In order to achieve this aim, the study had two main objectives:

- Obtain a practitioner evaluation of a systemic accident analysis method, based on their experience of using it in a (high-fidelity, partly field-based) simulated investigation.
- Understand how the usage characteristics of the method affect its use in a live investigation scenario.

By conducting this study, it was hoped that a greater understanding of the extent of the systemic accident analysis research-practice gap could be achieved.

2. Methods

2.1. Accident analysis method selection

The Systems Theoretic Accident Modelling and Processes (STAMP) method was chosen for evaluation for a number of reasons. As identified by Underwood and Waterson (2012), it is the most frequently cited systemic analysis technique. It was previously used by the authors (see Underwood and Waterson, 2014) and would, therefore, allow a comparison between its use in the research and practice contexts. Finally, detailed guidance about the application of the technique is available (see Leveson, 2012), thereby facilitating the training of participants in the use of STAMP.

STAMP focuses on safety as a control problem, i.e. emergent system properties (e.g. safety) are controlled by imposing constraints on the behaviour and interaction of system components (Leveson, 2012). Hierarchical safety control structures are used by STAMP to describe the composition of systems. Control (two-way communication) processes operate between system levels to enforce the safety constraints. Accidents are consequently seen as a result of a lack of control over the safety constraints.

The process of using STAMP to analyse an accident consists of nine stages and is defined by Leveson (2012 p. 349) as the Causal Analysis based on STAMP (CAST) approach. The stages of CAST are summarised below:

1. Identify the system(s) and hazard(s) involved in the loss.
2. Identify the system safety constraints and system requirements associated with the hazard.
3. Document the control structure in place to control the hazard and enforce the safety constraints.
4. Determine the proximal events leading to the loss.
5. Analyse the loss at the physical system level.
6. Analyse the higher levels of the control structure.
7. Examine the overall coordination and communication contributors to the loss.
8. Determine the dynamics and changes to the system and its control structure over time.
9. Generate recommendations.

2.2. Sampling strategy

A combination of the stratified purposive and convenience sampling strategies, as defined by Miles and Huberman (1994), was employed in this study. The objectives of the study necessitated the recruitment of a particular group of individuals, i.e. practitioners employed (on a full- or part-time basis) as accident/incident investigators. However, due to their unpredictable working patterns, the recruitment of experienced investigators was considered unfeasible. Therefore, participants were recruited from a group of individuals that were training to be full-time aviation accident investigators or aviation safety professionals (e.g. safety managers) with a part-time responsibility for accident investigation. However, as only aviation practitioners were available for recruitment, a degree of convenience sampling was utilised.

2.3. Participants

Six participants (mean age: 43.8 years) were recruited for the study. A summary of the participants' backgrounds and analysis experience is provided in Table 1.

None of the participants were aware of STAMP before attending the training course, which offered a degree of control over the experimental bias associated with the previous experiences of the participants.

2.4. Training provided

The participants were enrolled on a six-week training course (run by the Cranfield Safety and Accident Investigation Centre at Cranfield University) which covered fundamental aspects of the investigation process, such as pre-deployment planning, on-site