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A study of the precursors leading to 'organisational' accidents in complex industrial settings

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A B S T R A C T

This study aggregates the narrative findings from the investigation of 12 accidents or 'near hits' across a wide range of industrial settings to build a catalogue of organisational and cultural precursors to accidents. It was found that many were important factors in multiple events. It is argued that by addressing these potential vulnerabilities using the findings and proposed tools based upon them, organisations undertaking safety related activities will not only develop greater awareness of these deeper-lying issues but should be able to better control the risks associated with them.

The precursors have been classified under eight headings and examples of key findings from three of these are presented. Statements providing potential defences against the identified vulnerabilities have been developed which should enable organisations to scrutinise the adequacy of existing expectations or requirements within their business. Probing questions have been developed based on the statements which should allow an assessment to be made as to whether these have been 'embedded' in the organisation.

It is argued that organisational vulnerability tools should be developed to enable a systematic approach to 'diagnosing' incubating precursors. It is also argued that there is the potential for further resilience to be achieved through the use of models of the complex dynamics of socio-technical processes within organisations.

Keywords: Organisational vulnerabilities; Organisational resilience; Accident precursors; Systems thinking; Hierarchical process modelling; Socio-technical dynamics models

1. Introduction

Significant 'man-made' industrial accidents or serious 'near-hits' still occur quite regularly despite continuing efforts in all areas of technology to reduce both their scale and frequency. These events usually have both engineering and human performance failures as direct causes, and much work has gone into trying to minimise these. However, research and formal accident reports have confirmed that a systematic and deeper analysis of the complex interaction between engineered defences, organisational processes and the cultural and psychological factors which 'shape' organisational learning must be addressed if organisations are to achieve greater resilience against 'organisational accidents'.

This paper provides an analysis of findings from twelve significant events, from a range of settings, based on a qualitative ethnographic study of the original event investigation reports. This analysis reveals the common learning relating to the underlying organisational and cultural 'precursors'.

A pilot study by Taylor and Rycraft (2004) and an earlier account of the present study (Van Wijk et al., 2008) found that the organisational and cultural precursors to several events in different industrial sectors appeared to be very similar. This was noted by Haddon-Cave QC (2009) in his report on the Nimrod aircraft crash. The research reported in this paper confirms this by looking in greater detail at a wider range of events, and collating and synthesising the findings into a comprehensive and focussed catalogue of common potential

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precursors. In general, operational organisations and regulatory bodies attempt to respond to the recommendations arising from each successive event in relative isolation. It is argued that using synthesised findings can provide an improved basis for assessing organisational vulnerability and the development of tools with wider applicability to protect against it. It also has the potential to minimise the additional requirements arising from successive event analyses and the potential overlap and interaction between successive organisational changes. Furthermore, these are not always considered in more conventional auditing processes which tend to concentrate on adherence to existing processes and procedures rather than deeper-lying issues, something recognised in several post event analyses (Baker et al., 2007; Office of Rail Regulation, 2006).

In addition to extracting the generic organisational and cultural issues present in the twelve events, two specific outputs have been developed using this approach:

1. *Statements of expectation* – These interpret the recommendations from the original investigations to extract the qualities of a 'good' organisation. They have been developed to encourage pro-active action.
2. *Diagnostic questions* – These are aimed at assessing whether the organisational and cultural issues identified in the statements of expectation are actually 'embedded' in the organisation. They aim to allow a deeper assessment of the incubating 'causes' of organisational failure and (importantly) are laid out explicitly for organisations to use directly.

The body of this paper focuses on three common areas important to all of the studied events. These have been chosen to illustrate the approach used. They are:

- Leadership.
- Oversight and scrutiny.
- Organisational learning.

The following section outlines the theory and method of analysis while Section 3 provides the full list of events studied and the basis for their selection. Section 4 summarises the common issues identified and Section 5 looks at the statements of expectation and diagnostic questions.

This paper concludes with a discussion outlining the direction the modelling might take in order to develop tools which might be used in organisations to utilise more fully the issues revealed in this analysis. The first approach considered, hierarchical process modelling (HPM), shows how the diagnostic questions might be placed within a framework rather like the use of PRA in considering vulnerability to engineering failures thus providing a systematic and disciplined approach to their use. However, it is suggested that the complex process dynamics can also be important, and therefore HPM can be enhanced by approaches based on systems theory. The second approach considered is based on a systems methodology, recognising the importance of the interaction between elements in the system and potential emergent properties (Leveson et al., 2003b). It is suggested that the use of such models will allow organisations to obtain a clearer picture of their complex vulnerabilities and hence the ways in which they might develop greater organisational resilience.

An overview of the approach used is shown in Fig. 1 which also serves as an outline to this paper. The method and qualitative analysis used to extract the learning from the event reports is described in the following section.

2. Background and method

Complementary theories which have arisen in the development of accident models and the nature of the underlying causes and their relation to warning signs have influenced the method of analysis implemented here and discussed throughout this paper. This section provides a brief overview of this.

2.1. Development of accident models

The analysis reported here draws on important early work in developing the conceptual framework of complex accidents, aimed at obtaining an understanding of the underlying causes of accidents carried out by such authors as Turner, Pidgeon and Blockley (Pidgeon et al., 1991; Turner and Pidgeon, 1997), Reason (1997), and Toft and Reynolds (1994). Over the last sixty years accident models and the associated tools for event investigation can be shown to have developed from simple linear models of cause-and-effect (such as fault trees) to complex models of the whole system (see Saleh et al., 2010; Hollnagel, 2004; Qureshi, 2007).

Other accident models, following studies into complex socio-technical systems, have been developed to model failure processes at a richer level of detail. Perrow's normal accident theory (Perrow, 1984) with its concept of coupling and complexity, presented an argument for the need for a greater understanding of the inherent interdependence within the systems being modelled and attempts to exercise control. These 'Systems' models and tools have been developed by Rasmussen (1997), Hollnagel and Goteman (2004), Leveson (2004), Léger et al. (2009) and others.

The analysis of the twelve events, as described in this paper, set out to identify and catalogue the inherent weaknesses and shortfalls which can exist within an organisation's operations and associated defences. In doing this, it draws primarily on the theoretical framework of Reason's Swiss-Cheese Model (SCM). Thus the collected precursor weaknesses and shortfalls could be regarded as 'holes' in the defences or the wider cultural issues which facilitate or allow these holes to develop. The SCM of how accidents occur has been influential within industry, forming the basis (implicitly or explicitly) of many of the accident investigation methods used by organisations and event investigators, despite not being designed specifically for this purpose.

The analysis and development of statements of expectation and diagnostic questions were developed with review by industry and regulatory practitioners, and were based on externally conducted investigations which effectively used an SCM approach, although this was not generally acknowledged by them. Thus, this theoretical framework influences the extraction of the required information. However, the SCM and its theoretical assumptions have limitations (as recognised by Reason) and it is also important to understand these and how they can be addressed.

The selection of an appropriate accident model can influence the conclusions of an investigation (Lundberg et al., 2009), so it is accepted that there may be value in attempting to adopt complementary methods. The SCM is seen, largely by those who advocate systems based approaches (e.g. Hollnagel and Goteman, 2004; Leveson, 2012) as reductionist, linear and focused on specific failures rather than emergent system level behaviours. This focus and sequential modelling can be at the expense of understanding more complex accident aetiology, particular in situations where an accident can be shown to emerge at the system level without any specific 'failures' at lower levels. This behaviour can occur due to the structure of the system itself (Marais et al., 2006; Senge, 1990). While Reason has argued that the actual theory underlying SCM better reflects the complexity of reality than the often