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Outlines of a sensitising model for industrial safety assessment

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A R T I C L E I N F O

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A B S T R A C T

This paper introduces what is defined as a sensitising model. This model has been developed to support empirical and methodological research and studies in different high-risk industries. Its purpose is to assist current and future practices of industrial safety assessments by taking into account input from the social sciences, reflecting in particular their insights on major accidents. For this purpose, the first objective of this paper is to take an overall view. There is not, in principle, only one way of introducing social sciences into safety assessment practices. In a historical approach four research traditions (safety management system, safety culture, high-reliability organisations, accident investigations and models) are introduced. A classification scheme is produced to make sense of the diversity of traditions according to three dimensions. It is argued that an integration of all the different research traditions would not be realistic. However, it is explained that some models offer complementary features worth exploring. The second objective of this paper is thus to present the design rationale of such an exploration in order to produce a sensitising model for safety assessments. This model is obtained by combining two generic models from the managerial and sociological (safety) literature. Safety is approached in this model as the dynamic interaction between several dimensions, including technological design and tasks, structural and functional features of organisations, but also cognitive, cultural and power issues, at several layers of analysis. Theoretical aspects with regard to the position and status of this model are discussed.

1. Introduction

Certainly one of the most challenging tasks in safety science today is to develop ways of assessing systems in order to capture the patterns identified by social sciences following major accidents, to prevent them from causing disasters. In other words, the challenge is to develop ways to better grasp in foresight what is being interpreted in hindsight, or, as shown in Fig. 1, to move from a study of past failures (1) to an anticipation of future ones (2).

This challenge is empirical, methodological, theoretical and epistemological (Le Coze, 2011a). This paper deals more specifically with the theoretical aspect of this challenge, setting aside the empirical, methodological and epistemological ones. A recent event such as the Macondo well disaster (Chief Counsel's Report, 2011) demonstrates again the necessity of moving beyond traditional methods and tools designed for assessing safety. So far, these have been strongly dominated by technologically and quantitatively oriented rationales (e.g. probabilistic safety assessment), with attempts to complement them from other backgrounds such as human factors (e.g. human reliability assessment). This technological and quantitative rationale can now be considered too simplistic (although certainly prerequisite for any safety approach). It does not incorporate what makes these systems so highly complex, i.e. their dynamic and systemic properties (Le Coze, 2005; Vaughan, 2005). Yet, the current and next generation of technological developments require enhanced abilities, both from states, public and private companies, to better anticipate technological, human, organisational and socio-cultural types of failures (Evan and Manion, 2002). This calls for a better interface between technology and social sciences and their translation into safety assessment practices.

If one wants to tackle this challenge, one has to deal with a theoretical problem: data collection and interpretation are always, whether implicitly or explicitly, and to a large extent, knowledge-driven. A safety assessment must rely on some form of indications about where to look and what to derive from observations. As a consequence, one has to specify key dimensions indicating relevant areas to be considered and investigated for safety assessment during empirical phases (Le Coze, 2011b). This issue has been clearly formulated by Bourrier and Laroche (2001, p. 49) '*One needs to determine where to look (...) it is difficult to study the entire functioning of an organisation or a system of organisations. One has to make choices and decide to approach the organisational reality through a series of slices, perspectives and angles of observations*'.

Although some authors have now started to move in this direction and provide some guidance (e.g. Berman and Ackroyd, 2006; Dalzell and Hopkins, 2006; Reimann and Pia, 2007, 2009; Boin and Schulman, 2010), this research area still remains without a

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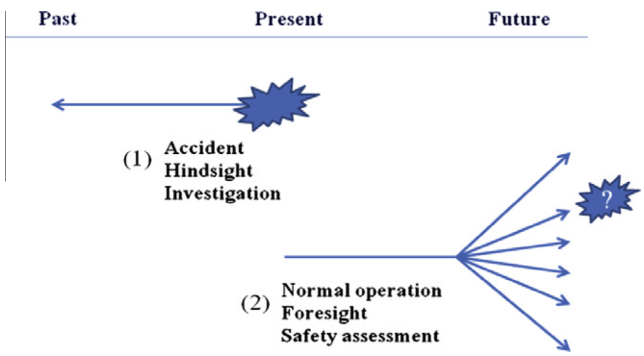

Fig. 1. Moving from hindsight (investigation) to foresight (safety assessment).

strong base. For instance, no systematic and analytical overview of models is available so far for this particular subject. Yet, this is a necessary step in clarifying different design rationales for safety assessment. The first purpose of the paper is thus to offer such an overview. It identifies and classifies a variety of models available from a social science background (Sections 3–6). A historical and 'genealogical' approach has been followed and has helped to delineate different 'research traditions'. The second objective (Sections 7 and 8) is to present the design rationale of a sensitising model established for industrial safety assessment. The theoretical aspects of this model are then discussed (Section 9).

2. Four research traditions

The last two or three decades of research by the social sciences in both safety and accident investigation offer many empirical and theoretical insights. Four historical traditions of empirical and theoretical research are distinguished in this paper: safety management system (SMS), safety culture (SC), high-reliability organisations (HROs) and accident investigations and models (AIM).[1] Each of these research traditions has its own history and a degree of autonomy, but also a diversity of studies and evolutions within its own boundaries. It is however important to warn that this presentation does not pretend to give an 'objective' retrospective. There are without a doubt other possibilities for presenting the contribution of the social sciences to safety, making use of different associations between authors, works, approaches and themes. The one introduced here, identifying 'research traditions', is one among probably many, but one that is useful for the purpose of this paper. Thus, the next sections (3–6), present each research tradition, keeping the descriptive and normative distinction as a central 'red line' across sections. This is a classic division in the socials sciences in general and in the field of safety, as asserted by Pidgeon '*While consultants and engineers seek answers which provide the 'best' solution to a risk management problem, social science is often ambivalent or even hostile to making either rapid or strong normative claims. This reflects a genuine epistemological concern with the conditional nature of our interpretation of events (...), as well as the very real difficulty of defining what should count as 'dysfunctional' in ill-structured risky environments*'. (Pidgeon, 1998, p. 204). The pattern retained for each presentation is first, to provide a short introduction to the research traditions; second, to describe some of their key outcomes, and third, to identify recent developments and/or debates in each of the research traditions.

[1] The resilience engineering approach (Hollnagel et al., 2006) is not included in this study. Although a promising field, it seems a little too early to identify stabilised concepts and/or trends given the body of theoretical and empirical works available in this area so far, when it comes to organisational aspects.

3. Safety management system (SMS)

3.1. Introduction to the research tradition

The historical background of the 'safety management system' research tradition has been reviewed, for instance, by Hale (1985) and Hale et al. (1991), and more extensively in Hale et al. (1997). It includes empirical and conceptualised knowledge from industrial and consulting practices (e.g. Petersen, 1978), guidance promoted by control authorities (e.g. the Health and Safety Executive – HSE in the UK), standards from international bodies across industries (e.g. the International Standards Organisation – ISO, with strong quality management influences) or entities in a specific industrial domain (the International Atomic Energy Agency – IAEA for the nuclear industry). All these sources are based to a sizeable degree around this tradition, reflecting the existence of a great body of knowledge. Its roots can be located in the quality movement. However, although soundly based on (more or less) shared experiences between different high-risk industries, consulting companies and control authorities, the field has remained for quite some time without established 'foundations', according to Hale. The conclusion of his reviews was therefore that "*There have been few attempts to produce coherent and comprehensive models of an SMS (...) There is a need for a framework to represent the complexity and dynamics in this area*" (Hale et al., 1997, p. 124). The work of Hale, who has been one of the main promoters of this research tradition in subsequent years from an academic point of view, helps to identify the key outcomes as well as current developments and debates in this research tradition.

3.2. Key outcomes

One way to find an answer to this lack of sound foundation consists of identifying and relating a number of safety-related activities (or functions) that companies should implement for managing safety, based on a functional type of decomposition. One approach is to represent them in a graphical way. This is translated into a management and normative perspective intended to make the model more explicit for engineering purposes, such as safety auditing and organisational design: '*Its objective is to provide a systematic and complete description of what elements should be present in an SMS and how they should be related to each other (...) The framework therefore aims to provide the basis for assessing or improving an existing SMS and for designing a new one from scratch*' (Hale et al., 1997, p. 125). The program of this research tradition can be defined as the conceptualisation of an ideal model against which organisations can be compared and assessed. Gaps between the ideal model and actual observed practices reveal room for improvement, but also a certain level of safety.

As indicated, an influential approach in this research tradition relies on graphical representations, linking activities together through boxes and arrows, indicating inputs and outputs, in the spirit of process descriptions of organisations but also in the spirit of a branch of cognitive sciences that some have described as "boxology" (e.g. Andler, 2002). Hale's contribution (e.g. Hale, 1999, 2003a) in different industrial domains (e.g. the chemical industry, aviation or railways) integrates a number of activities such as risk analysis, management of change (added to the author's model), auditing, maintenance and inspection, training, and learning from experience (Fig. 2), relying on principles of "delivery systems" including issues like communication and coordination, conflict resolution, involvement, etc. (these are not represented in Fig. 2 but are included in others available in Hale, 2003a). Each function can then be broken down further into sub-functions to be carried out.