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SOL – Safety through organizational learning: A method for event analysis

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ABSTRACT

Under the guidance of Bernhard Wilpert† a research group at the Berlin University of Technology developed an event analysis methodology called safety through organizational learning (SOL). The method has been adopted by the Swiss and German nuclear industries as standard procedure for their in-depth event analyses. SOL aims at facilitating organizational learning from events by supporting the process of analyzing events, ensuring its standardized conduct and mobilizing expert knowledge and creativity in the analysis. In this paper we provide a short description of SOL and its theoretical background. We summarize the empirical evidence and practical experience regarding SOL, which proves it to be a valid methodology that gives sufficient support to analysts. Finally, practical experiences and challenges for future research are discussed.

1. Introduction

Nearly 20 years ago the influence of human factors on incidents in German nuclear power plants became a topic of increasing interest and significance. At this time practitioners from the nuclear power industry understood human factors mainly as human errors at the man–machine interface, whereas safety researchers had a quite different understanding that subsumed organizational and environmental aspects under the term human factors (e.g. Reason, 1990). In 1992 a research group at Berlin University of Technology started under the guidance of Bernhard Wilpert with the development of a new event analysis methodology called safety through organizational learning (SOL). The authors of the present article worked in this research group. Bernhard Wilpert's central idea was to propagate a holistic socio-technical system approach for analysing events which implies that human factors do not only relate to the immediate man–machine interface, but comprise human actions on all system levels in as much as they contribute to the critical outcome of safety.

According to the organizational learning literature (e.g. Argyris and Schoen, 1978), one important goal of event analysis is to draw lessons from an event to prevent future events. Therefore, adequate recommendations and safety measures must be implemented for all contributing factors identified. When the research group started the development of SOL, event reports in nuclear industries discussed technical failures and human errors as the main contributors to events. Organizational or inter-organizational factors were only considered on an informal basis and did not get due weight in the lessons learned. The group speculated about potential reasons and came to the conclusion that event analysts might not have adequate knowledge about organizational factors, and therefore their methods did not explicitly cover these factors. Moreover, the strong focus on apparent factors might result from shortcomings in causal reasoning. Consequently, the development of SOL should fulfill the following requirements:

- it should cover a broad range of human, organizational, and inter-organizational factors derived from theory and empirical data;
- it should be easy to use without expert knowledge in human factors psychology, because it should be applied by operators and supervisors in nuclear power plants;
- it should help to overcome well known shortcomings in human causal reasoning which could lead to truncated search in event analysis;
- it should support organizational learning from events;
- it should have empirical validation.

In the following sections we will describe the development of the method, show how SOL was evaluated and close with open questions and challenges for the future.

2. The development of SOL – safety through organizational learning

SOL was initially developed for the nuclear power industry (Becker et al., 1995; Wilpert et al., 1997). However, a version for

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the chemical industry exists (Wilpert et al., 1998) and a computer supported version was developed as well (Maimer et al., 1999).

At the time SOL was developed, event analyses were still dominated by approaches characterized by attributions of fault to individual or/and technical actors (Benner, 1981a,b; Hendrick and Benner, 1987; Manuele, 1982; Shealy, 1979). Nevertheless, in high hazard industries a trend of systematic analyses supported by different methodologies could be observed (Fahlbruch and Wilpert, 1999). Unfortunately some of those methodologies were not completely published (e.g. the German human-factor concept of Vereinigung der Großkraftwerksbetreiber – VGB and the Human Performance Enhancement System of INPO – Institute of Nuclear Power Operations). For the development of SOL we reviewed the following methodologies:

- ASSET – Assessment of Safety Significant Events Teams (IAEA, 1991, 1994);
- Change Analysis (Bullock, 1981);
- HPES – Human Performance Enhancement System (INPO Bishop and LaRhette, 1988);
- MORT – Management Oversight and Risk Tree (Johnson, 1973, 1980);
- STEP – Sequentially Timed Event Plotting (Hendrick and Benner, 1987);
- TOR – Technique of Operations and Review (Weaver, 1973).

The above methodologies are based on different accident causation models, e.g. Change Analysis and HPES had no explicit model, whereas MORT and STEP were based on explicitly formulated models. The methodologies vary in degree of standardization from general requirements for the process (Change Analysis) up to a set of attributes evaluated as adequate or less than adequate (MORT). Although ASSET, MORT and TOR explicitly consider organizational factors, inter-organizational factors are not included in any of the reviewed methods. None of the methods had explicit features for overcoming judgmental biases or shortcomings in causal reasoning.

2.1. Theoretical background of SOL

The development of SOL was based on the assumption that an event analysis is a socially accepted reconstruction of a surprise, i.e. the identification of what happened and why. Therefore, it was important to provide not only a method, but also a scientific event causation model which had to be accepted by practitioners in the field. SOL builds upon Reason's Swiss-Cheese-Model (1990) and the socio-technical system approach (e.g. Trist and Bamforth, 1951). It was Bernhard Wilpert's theoretical contribution to combine both models in a socio-technical event causation model. According to this model, contributing factors stem from five sub-systems and their interaction: individual, team, organization, extra-organizational environment and technology. These sub-systems were further divided into categories (or contributing factors) which were derived from organizational theory as well as from an extensive analysis of published event reports in the nuclear power industry (Becker et al., 1995).

In order to promote interdisciplinary work and to develop a method which would be accepted by practitioners and scientists, Bernhard Wilpert put together a team of experts consisting of psychologists and nuclear engineers who evaluated these factors and assigned each to a subsystem or its interaction. Thus an initial set of 19 contributing factors resulted, but practical feedback from the field and expert assessments led to a modified version with 21 potential contributing factors. Furthermore, the factors were differentiated according to their potential direct and indirect (or latent) influence on event causation (see Table 1).

Table 1
SOL categories of contributing factors.

Direct factors	Indirect factors	
Information	Operation scheduling	Responsibility
Communication	Group influence	Control & supervision
Working condition	Rules, procedures & documents	Qualification
Personal performance	Organization & management	Training
Rule violation	Experience feedback	Safety principles
Technical component	Maintenance	Quality management
	Regulatory bodies	Environmental influence
	Technology	

The quality of an event analysis method is not only influenced by its underlying theoretical model, but also depends on the conceptualization of the analysis process and the supporting features (Fahlbruch et al., 1998). Fahlbruch (2000, 2001) modeled the psychological process of analyzing events by drawing on psychological research on attributional processes and causal inferences. She identified various psychological factors which follow from characteristics of human information processing and general attribution processes and which may diminish the quality of an event analysis such as:

- premature hypotheses leading to truncated search for information, i.e. the first plausible "cause" is taken to explain what happened (Einhorn and Hogarth, 1986);
- difficulties to identify contributing factors which are remote in time and space from the actual event (Einhorn and Hogarth, 1986) which result in an over-weighting of so-called active errors;
- mono-causal thinking and satisfaction with only one contributing factor although there may have been multiple factors involved (Shaklee and Fischhoff, 1982);
- identification of contributing factors because of recent past events (mental availability of potentially contributing factors) (Tversky and Kahnemann, 1981);
- ignoring contributing factors which are not written down in the method (e.g. in a given checklist or fault-tree) ("out of sight – out of mind") (Fischhoff et al., 1978);
- concentration on contributions by human actors directly involved in the event (fundamental attribution error) (Ross, 1977).

SOL was intended to be a standardized process of event analysis that would minimize the above factors and cognitive biases.

2.2. Description of SOL

Analyzing events with SOL is conceptualized as a backward oriented problem-solving process (Fahlbruch, 2000; Fahlbruch and Wilpert, 1997). SOL operationalizes the concept of event analysis in a set of two standardized process steps: (1) the description of the actual event situation, and (2) the identification of contributing factors. For both steps guidelines were developed which support the event analyst.

As the first step of the analysis, a situational description is constructed. The information needed for the description of the event is gathered by interviews and document analysis. A set of questions helps the analyst to ask the right questions in order to completely reconstruct the course of an event. Based on the STEP method (Hendrick and Benner, 1987) the collected information is broken down into a sequence of so-called event-building blocks, i.e. the