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## Organization: A new focus on mine safety improvement in a complex operational and business environment



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### ABSTRACT

The daily operations in the mining industry are still a significant source of risk with regard to occupational safety and health (OS & H). Various research studies and statistical data world-wide show that the number of serious injuries and fatalities still remains high despite substantial efforts the industry has put in recent years in decreasing those numbers. This paper argues that the next level of safety performance will have to consider a transition from coping solely with workplace dangers, to a more systemic model taking organizational risks in consideration. In this aspect, lessons learned from the nuclear industry may be useful, as organizational learning processes are believed to be more universal than the technologies in which they are used. With the notable exception of major accidents, organizational performance has not received all the attention it deserves. A key element for reaching the next level of performance is to include organizational factors in low level events analyses, and approach the management as a risk control system. These factors will then appear not only in the event analysis, but in supervision activities, audits, change management and the like. Many recent event analyses across various industries have shown that organizational factors play a key role in creating conditions for triggering major accidents (aviation, railway transportation, nuclear industry, oil exploitation, mining, etc.). In this paper, a perspective that may be used in supervisory activities, self-assessments and minor events investigations, is presented. When ingrained in an organizational culture, such perspective has the highest potential for continuous safety improvement.

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#### 1. Introduction

The problem regarding the occurrence of major technological accidents in modern society has captured a lot of attention in last decades at all the levels (citizens and civil society, organizations, universities, research institutions, regulatory and legislative bodies, etc.). Numerous studies, books and high quality refereed papers have been published on this topic. Many innovative technical measures and pieces of legislation or regulation have been introduced in order to prevent and reduce those risks.

Despite an accumulated knowledge from both the past experience and research works, major and catastrophic accidents across various high-reliability-at-risk industries (nuclear, aviation, petrochemical, transportation, mining, etc.) continue to occur. They can cause human fatalities, injuries and suffering, significant destruction, substantial environmental pollution and huge financial losses. The number of such accidents still remains unacceptably high, and the consequences are enormous. Subsequent official analyses have shown that the majority of accidents were preventable. Some recent catastrophic events sustain well this statement [1–5,53].

Were these "out-of-the-blue" events, or did one miss some information that was available in low level events, but lost in an organizational "blind spot"?

The business and operational environment considerably changed for the majority of organizations. One of the peculiarities of this change comes from the integration of various industrial, technical, political, economic, environmental and financial pressures with regulatory adjustments which ensue from it [1,6–24]. The operation of these sectors, which were relatively autonomous and independent, became more complex as the number of stakeholders increases, including the advent of new technologies and interrelations between entities that are not anymore isolated and independent. A direct consequence of these changes is the nature of the events which continue to occur. While the accidents which arose previously found generally their cause in known and

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assumed factors, modern events find their origin in unforeseen interactions between elements without visible links. The linear story-telling of events is thus less suited for improvement in conventional and public safety [1,9,10,14–17,21,24]. This diagnosis is not limited to major accidents but also applies to other types of events (such as process disruptions or bankruptcies) [18,19,23,25].

In this paper, a discussion is presented upon the evolution of the nature of the causal factors, and approaches and tools developed and used in the nuclear industry to take into account the complexity of its operational environment. It builds up further on previous studies, but focuses in detail on the role of the organization, and safety culture in ensuring a safe workplace in the mining industry [17]. This paper aims at providing some new insights which may contribute to the body of knowledge in this area particularly in the field of mine safety. This experience can be transposed to other industries as well.

#### 2. Classic view of event: failure of a weak link

One is accustomed to simple story-telling of significant events and accidents. It is natural to identify a barrier which, if it had worked adequately, would have prevented the undesired event. The barrier analysis allows to identify the less than adequate performance of defenses and to propose specific corrective actions. Even more elaborating methodologies, such as management oversight and risk tree (MORT) or systems-theoretic accident model and processes (STAMP), stands on the identification of independent administrative barriers in complicated organizational systems, but not necessarily complex interactions [12,15].

Working on human performance fundamentals has allowed for improvement without digging in through events. Human performance fundamentals and error prevention tools did a lot to further reduce events and improve performance. Nevertheless, it did not question the sequential view of events. This view of an event supposes some linearity (a time line) which could be representative of reality to a certain extent. Even if some aspects were not reflected in the analysis, the identification of some barriers remained good enough for corrective actions. Today, for most situations, such a linear approach is insufficient to allow a complete and useful understanding of the stakes and challenges regarding safety. It is less the fault of the model than the complexification of many industrial environments. Also, in some fields, e.g. nuclear, aviation, one might have a good understanding of the performance of the elements and enough data to develop good models. In some new fields, one might not have data or even models e.g. nanotechnologies.

As early as 1980s, Perrow introduced the contribution of the complexity and operator errors to industrial accidents [20]. This topic was further expanded through research works carried out by Rasmussen and his team in the second half of 1990s, and he argues that the analysis of modern and complex systems requires a system-oriented approach based on functional abstraction rather than structural decomposition [21]. Instead of focusing on action sequences and occasional deviations in terms of human error, the analysis should be performed by a model behavior shaping mechanism considering an array of influential factors. Perrow proposes the convergence of research paradigms of human sciences guided by cognitive sciences concepts [21]. Reason has also brought significant contributions regarding the understanding of human error [26].

A further contribution to a better understanding of accident creating mechanisms is provided through significant research works carried out by Leveson [15,16]. In her research, she questions assumptions and approaches related to accident causality models, definitions of safety and its relationship with reliability retrospective versus prospective analysis and operator error. She argues and demonstrates that the past assumptions and beliefs related to those areas are not necessarily true in complex systems. The behavior of the latter is quite difficult or almost impossible to predict with a growing number of interactions. She stresses that safety, unlike reliability, is a system property, not a component property. Therefore, safety is an emergent property. The unsafe system behavior is defined in terms of safety constraints on the behavior of the system components. Thus, safety is perceived as a control problem rather than a failure or reliability problem. Several other authors share this vision [1,6,10,19,24]. It is an important statement for further analyses because it also involves an overall organizational performance.

In this period, Reason also carried out important research works aiming at understanding the role of organizational performance in the occurrence of accidents [27,28]. He argues that there are two kinds of accidents: those that happen to individuals and those that happen to organizations. Individual accidents are larger in numbers. Organizational accidents are relatively rare and often catastrophic; and they occur within complex modern technologies. Organizational accidents are challenging events to understand and control.

Retrospective event analysis and accident causation models assumptions are questioned in complex systems. It seems that one of their characteristics is a continuous drift to danger or failure which is almost impossible to capture in traditional of chain-ofevent analyses. In fact, the basic assumption that cause and effect shall be directly related is not always valid. This idea is also supported by other authors [1,6,8,10,11,17,23,24,29,30].

The role of operator error has also been thoroughly examined. The classic narrative that most accidents are caused by operators is questionable. The "reward-punishment" approach for reduc-ing/eliminating accidents does not function in modern, complex systems [1,16,17]. Understanding human error seems to remain the final frontier for safety professionals, and is an ongoing challenge for the technical community. But it is not only those on the front line that are to blame, as will be discussed further below [1].

Mosey also identifies "managerial ignorance" as a recurrent element in accidents, noting the "failure to learn from the experience of the past" [2]. He states that organizations have no memories. Only people do, and they leave. Failing to learn from experience (or failing to properly record those lessons and ensure they remain part of the collective consciousness) is a major factor. Moreover, there are others such as "unofficial" messages from management, and acceptance of abnormalities (or "the insidious acceptance of slowly-degrading standards").

In fact, several authors argue that the individual human behavior is always influenced by the environment in which it takes place. Marais et al. discuss why safety related decisions do not always result in desired behavior, and how independent decisions in different parts of the organization can combine to have a negative, and often unforeseen, impact on safety [31]. The key is in positively changing this environment. Traditional event-based and risk models are quite ineffective in dealing with human error and decisionenvironment making complex systems and in [1,5,6,10,17,21,24,32,33]. A real reduction of accident frequency requires getting to the bottom of human and organizational performance issues. Katina has also suggested that there might be situations in which human performance, in relation to adhering to laws, principles, and theorems of systems theory, is affected through three conditions: (1) knowing systems theory but choosing to ignore it, (2) knowing systems theory but having poor execution and (3) not knowing systems theory [13].

There are also some studies which question the one-sided thesis that contemporary organizations rely on the mobilization of cognitive capacities [34]. The authors suggest that severe restrictions on

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