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Written work procedures: Identifying and understanding their risks and a proposed framework for modeling procedure risk

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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

Organizations often direct considerable attention toward the identification and assessment of the various risks associated with hazardous process operations, and as part of their risk control system they typically rely on written procedures for guiding workers in carrying out the necessary task activities. However, these procedures can, in and of themselves, serve as sources of risk, which strongly suggests the need for methods that could enable organizations to efficiently assess the risks potentially intrinsic to their written procedures. This paper focuses on the identification, understanding, and modeling of the risks potentially associated with written work procedures. The idea of controls within procedures and a taxonomy of procedures based on the nature of a procedure's controls are first presented. This is followed by a systematic reappraisal of the risks resident in written procedures that are incurred through the processes of development and management of procedures by organizations. The focus then shifts to the implications for an organization's risk control system of behavioral variability associated with carrying out procedures. This leads to the presentation of a proposed modeling framework intended for translation or adaptation by organizations as a practical means for assessing what is referred to as "procedure risk"—the risk resident in procedures. Key concepts that are emphasized in this framework are the value of a procedural control and the likelihood of failure of a procedural control. Guidance is provided concerning a possible way for instantiating the modeling framework through a case study involving space shuttle ground processing operations.

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1. Introduction

Most organizations rely on procedures or rules, usually conveyed in some type of written format, as the means by which relevant knowledge and actions governing the performance of potentially hazardous work activities are communicated to workers (Hale and Swuste, 1998). These procedures, which are often considered to be "cornerstones of the risk control system," encompass "controls" suggested from an organization's risk analysis studies that are intended for meeting the organization's commitments to its safety and mission goals (Hale and Borys, 2013a). However, despite these intentions, it has been well documented that procedures can, in and of themselves, contribute to the causation of incidents or accidents (e.g., Reason, 1997; Sharit, 1998; Dekker, 2005; Alper and Karsh, 2009; Hollnagel, 2009). Generally, procedures that are ambiguous, poorly understood, or not rationalized; are cumbersome in their content (due in part to incremental aggregation of content without reevaluation of the rule); are effortful to carry out; provide little guidance concerning appropriate actions to take when conditions that are novel or unanticipated are encountered; offer little room for improvisation (especially by skilled personnel) that could potentially improve system performance; are perceived by workers as imposing on them unacceptably high risks; or are resistant to changes due to the inability for workers to communicate to management or designers insights obtained from performance of the procedures, will lead to personnel either failing to perform the procedure, performing it incorrectly, or violating the procedure, and more generally to less resilient organizations (Woods, 2006).

Two relatively distinct models of procedures can be contrasted (Dekker, 2005; Hale and Borys, 2013a, 2013b): model 1, which views procedures or rules as a set of relatively rigid prescriptive norms imposed by management on its workers; and model 2, whose rules are more accurately described as "routines" that emerge from adaptive responses to highly variable and often complex situations, and which often require deviation from any prescribed rules in order to meet performance goals. In this conceptualization of procedures, model 1 rules can be viewed as top-down and more static in nature, devised by experts who are

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knowledgeable with regard to the process activities, the tasks governed by these activities, and the risks inherent to the process and associated tasks. These individuals may feel compelled to clearly specify behaviors that need to be performed, through documentation, communication, and training, in order to counteract potential fallible human tendencies that might arise from the limited competence or experience levels of the workforce. In contrast, model 2 rules are bottom-up and more dynamic, intentionally underspecified in their written content in order to allow presumably higher skilled personnel to determine how quantitative or qualitative performance goals should be achieved.

Both model 1 and model 2 rules have strengths and weaknesses that are largely determined by the correspondence between the nature of the task activities underlying system processes, the skill level of the workers responsible for these task activities, and the degree of standardization or flexibility implicit to the procedures governing these activities (Schulman, 2013). On one extreme, when the knowledge base concerning the process is relatively complete (implying low input variance) and the task activities supporting the process are performed repetitively and with few surprises (implying low system performance and safety variance), highly specified procedures can be prescribed for workers who lack deeper process knowledge in order to ensure standardization and uniformity of the process.

On the other extreme are situations for which the existing organizational knowledge base is incomplete or informal and task conditions are unexpected and changing (implying high input and high output variance). These conditions would benefit from skilled workers who would be undermined by highly detailed and inflexible procedures. Instead, such workers would likely need to resort to pattern-recognition and intuitive skills shaped by the linking of highly contextualized past process situations to system outcomes in order to transform fluctuating inputs, which may be signifying conflicting goals, into low-variability high-quality outputs. Responses or "routines" deemed successful by these skilled workers would then have the opportunity, assuming a resilient, "learning" organization (Wreathall, 2006), to become dynamically embedded into the largely informal knowledge base of the organization's work culture. Between these two extreme cases are various situations which may require compromises incorporating elements of both model 1 and model 2 rules (Grote et al., 2009), with the optimal instantiation of any type of rule model ultimately depending on factors related to the organization's rule-management process (Hale and Borys, 2013b).

As implied above, procedures generally encompass rules that can be thought of as "controls." ISO 31000 (2009) defines controls as any process, policy, device, practice, or other actions which modify risk (risk will be defined more explicitly below), and importantly, which may not always exert the intended or assumed modifying effect. Within procedures, controls typically define concrete actions that need to be taken under particular conditions (e.g., if the radiation levels exceed 20 rad, immediately back out from the vessel and ensure that it is sealed), or that require specific system states be established (e.g., do not initiate operations until inspection of the pump has determined that its insulation is not compromised). Such controls derive from the considerable attention that organizations often direct toward the identification of the various risks associated with hazardous (i.e., potentially harmful) work operations and to the quantitative or qualitative assessment of those risks (Center for Chemical Process Safety, 1992; Kumamoto and Henley, 1996; Sharit, 2012). However, although procedures are invariably in place for carrying out these activities as part of an organization's risk control system, organizations currently lack guidance or methods for enabling them to efficiently assess, ideally early on in the design of their procedures, the risks potentially intrinsic to these written procedures themselves. These risks can arise in part from the fact, as ISO 31000 emphasizes, that the controls in place within these procedures "may not always exert the intended or assumed modifying effect."

The primary purpose of this paper is to elaborate on a modeling framework that an organization's management could use or adapt as a tool for estimating the relative risks implicit to their written work procedures. To put this problem in perspective, issues related to the generation, identification, and understanding of what will be referred to as "procedure risk"—the risks resident within procedures—will first be presented. Also, although the modeling framework is presumed to address mainly model 1 rules, which are often referred to as standardized work procedures, the boundaries which define this class of rules are often not very sharp. Thus, the framework is considered to be applicable as well to "process rules" (Grote et al., 2009). Such rules, though they might specify the process by which task activities should be undertaken, still allow some leeway with regard to how these activities can be accomplished.

To clarify the term "procedure risk" and other references to terminology related to risk used throughout this paper, we follow the conventions offered in ISO 31000 (2009) in which *risk* is defined broadly as an "effect of uncertainty on objectives." The *effect* is some deviation from the expected; *uncertainty* refers to a state of deficiency related to the understanding or knowledge of an event, its consequence, or likelihood; an *event* can be an occurrence of a particular set of circumstances (which could include incidents or accidents); and an *objective* can encompass different aspects (e.g., financial cost, health and safety, and environmental goals) and can apply at different levels (e.g., at the product, process, or organization-wide level). In addition, ISO 31000 defines a *risk source* as an element which has the intrinsic potential to give rise to risk; *risk analysis* as a process for comprehending the nature of risk and for determining the level of risk (which is often expressed in terms of the combination of the consequences and corresponding likelihoods associated with an event); and *risk management* as the coordinated activities needed to direct and control an organization with regard to the risks that it may encounter. Notably, while the consideration of the combinations of consequences and likelihoods associated with an (adverse) event is a common way of expressing risk, the ISO 31000 definitions clearly imply a broader context in which risk can be considered, and one that is consistent with the central concept of "procedure risk." As will be argued, the problem of risk analysis as applied directly to written work procedures, which are regarded here as risk sources, benefits from this broader context as conventional approaches for expressing risk that rely on explicit identification of consequences and corresponding likelihoods of an *event*—which in this case represents the circumstances stemming from instantiation of the procedure—would not be practical from the standpoint of an organization's risk management process.

This paper is structured as follows. First, the central idea of controls within procedures is examined, followed by a proposed taxonomy of procedures and the corresponding role of controls within this taxonomy. Next, we consider the potential risks resident in written procedures that are incurred through the processes of development and maintenance of procedures by organizations and the implications of behavioral variability associated with carrying out these procedures. We conclude with a proposed modeling framework for assessing procedure risk, which we believe can be used to guide risk management strategies directed at the

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