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Recursive modeling of loss of control in human and organizational processes: A systemic model for accident analysis

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A B S T R A C T

A recursive model of accident investigation is proposed by exploiting earlier work in systems thinking. Safety analysts can understand better the underlying causes of decision or action flaws by probing into the patterns of breakdown in the organization of safety. For this deeper analysis, a cybernetic model of organizational factors and a control model of human processes have been integrated in this article (i.e., the viable system model and the extended control model). The joint VSM–ECOM framework has been applied to a case study to help safety practitioners with the analysis of patterns of breakdown with regard to how operators and organizations manage goal conflicts, monitor work progress, recognize weak signals, align goals across teams, and adapt plans on the fly. The recursive accident representation brings together several organizational issues (e.g., the dilemma of autonomy versus compliance, or the interaction between structure and strategy) and addresses how operators adapt to challenges in their environment by adjusting their modes of functioning and recovery. Finally, it facilitates the transfer of knowledge from diverse incidents and near misses within similar domains of practice.

1. Introduction

The occasional but highly consequential failures that occurred in safety-critical organizations have led to a substantial line of research on how catastrophic failures take place in socio-technical systems. Safety analysts and researchers have developed several theoretical models and methodologies for accident investigation which appeared to be adequate for the typical problems of their time. As socio-technical systems became more complex and tightly coupled, models and methods eventually became outdated. Models have over time gone from simple linear models, such as the domino model (Heinrich, 1931), to complex linear or epidemiological models, such as the 'Swiss cheese' model (Reason, 1997) and man-made disaster theory (Turner and Pidgeon, 1997). A range of accident analysis tools have been developed – e.g., Tripod (Wagenaar et al., 1994) and HFACS (Wiegmann and Shappell, 2001) – that focused on the analysis of unsafe human acts and organizational precursors. A prevalent view has been that organizational factors (e.g., strategic decisions and organizational processes) influence local workplace conditions (e.g., time pressure, insufficient training, ambiguous procedures) which combine with natural human tendencies to produce unsafe acts (Reason, 1997). Benefits resulted from this approach span from improvements in the design of workplace and decision support to interventions in communication, decision making and safety culture.

With the growing complexity of systems, however, it became apparent that human actions cannot be completely prescribed in procedures or training because working conditions have become more difficult to understand and predict how they interact together. This calls for operator adjustments to match any variations in working conditions and to get the work done. On an individual level, adjustments have been described as 'sacrificing decisions' or 'efficiency–thoroughness trade-offs' (Hollnagel, 2009). On an organizational level, adjustments have been described using terms as drift to safety boundaries (Cook and Rasmussen, 2005) or adaptive delegation of authority (Roberts, 1993). System variability usually goes unnoticed because operators manage to adapt their plans and control the working conditions. It is only when variability gives rise to unexpected outcomes that it is noticed and deemed to be a cause of failure (Weick and Sutcliffe, 2001). This systemic approach to safety views success and failure as a result of adaptations that organizations and individuals perform to cope with complexity.

Modern applications of systems thinking have recognized the need to move into accident models that are sensitive to how operators and organizations adapt to the challenges they encounter. In particular, Rasmussen (1997) presented a series of models, including the AcciMap technique, that guide safety analysts to look into the workplace and organizational conditions that influence how operators adapt procedures and tools to meet multiple goals, control workload, and maintain a margin for change. Similarly, Leveson

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