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Review

Risk influence frameworks for activity-related risk analysis during operation: A literature review

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ABSTRACT

Experience gained in the petroleum activities have showed that major accident risk is inherent in daily activities. Risk influence methodology is perceived as a good candidate to model the activity-related risk, as a key input to operational planning decisions. The paper reviews and summarizes 11 risk influence frameworks that integrate organizational and human factors in a structured way. The intention was to evaluate how these frameworks and identified risk influencing factors (RIFs) can be used for activity-related risk analysis. The main conclusion is that it is not necessary to model explicitly RIFs for activity consequence risk - the effect that performing an activity will have on the risk level after the activity has been completed. Operational management RIFs, direct organizational RIFs, personal risk influencing factors, task characteristics RIFs, technical system RIFs, and environmental RIFs are relevant for activity performance risk – the risk associated with performing the action. Operational management RIFs influence planning, which is important to identification of interactions while estimating period risk – the risk for a plant or facility over a period.

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1. Introduction

Risk analysis to support operational decision-making has become increasingly important for the Norwegian oil and gas industry as the industry has matured and more and more installations are in operation. Several aspects of operational decision-making creates a need for different risk analyses compared to the traditional QRAs[1] which are developed more for design purposes.

An important aspect is that in operation, the technical systems represents a "baseline" risk level, while experience gained in the petroleum activities have shown that the risk inherent in the activities changes more or less continuously (PSAN, 2015). The changes in risk from day-to-day are primarily activity driven, implying that an activity-based risk analysis rather than a system-based analysis is required (Haugen and Vinnem, 2015). When we are considering the risk associated with an operation on a daily basis, we need to consider different aspects of risk that consider human intervention with machines and the environment, which are activity consequence risk (ACR), activity performance risk (APR) and period risk (PR) (Yang and Haugen, 2015). This implies that human and organizational factors (HOFs) become more important to model properly. Modelling of HOFs have received great attention over the last decades. Bley et al. (1992) stated that "*any model that fails to examine the organizational factors is guaranteed to underestimate the overall risk by an undetermined amount*".

Risk influence analysis methodology focuses on identification and modelling of risk influencing factors (RIFs), as a means to efficiently identify risk reduction measures, so that a set of actions can be taken to change the state of RIFs in turn to reduce risk level (Rosness, 1998). This has gained popularity due to the inability of traditional QRA to incorporate organizational factors very well into the risk models. The methodology enables reflecting effects of "soft" factors on the performance of technical systems and human actions. Risk influence methodology is perceived as a good candidate to model activity-related risks as described above, to support operational planning decisions (OPDs) which have been identified as one of the key contributors to major accident or incidents that have major accident potential (Sarshar et al., 2015). Operational planning decisions are decisions made during the planning and preparation for execution of activities, as opposed to decisions made during the execution. For OPDs, the time lag from the need to make a decision arises until the decision is made is relatively short (Yang and Haugen, 2016). Risk influence methodology aids decision-making by:

(a) Providing decision-maker (e.g., operational manager) with an overview of factors that influence the activity-related risk.
(b) Providing support to identify and assess proactive risk reduction measures before activities are executed.

[1] QRA is short for Quantitative Risk Analysis with principles and guidelines described in ISO (2009). *ISO 31000:2009: Risk Management - Principles and Guidelines*. International Standardization Organization, Geneva, Switzerland. Different notions are used in the literature, such as Probability Safety Analysis (PSA) and Probability Risk Analysis (PRA). QRA is the unified term used in this paper.

The overarching objective of this paper is to undertake a review of major risk influencing models that integrate organizational and human factors, to evaluate how they can be of potential use to model HOF aspects of ACR, APR and PR.

The objective is broken into the following sub-objectives:

1. Identify what risk factors can be used/relevant for activity modelling
2. Identify how risk factors can be linked to derive corresponding risk level

Eight models have been identified with keyword "risk influence" and "major accident" from published articles. The models are MACHINE (Model of Accident Causation using Hierarchical Influence Network) (Embrey, 1992), SAM (System Action Management) (Paté-Cornell and Murphy, 1996), ω-factor model (Mosleh et al., 1997; Mosleh and Goldfeiz, 1999), I-RISK (Integrated Risk) (Papazoglou et al., 2002), ORIM (Organizational Risk Influence Model) (Øien, 2001a, 2001b), BORA (Barrier and Organizational Risk Analysis) (Aven et al., 2006), HCL (Hybrid Causal Logic), which has been applied to oil and gas industry by Røed et al. (2009), RISK_OMT (Vinnem et al., 2012), SoTeRiA (Socio-Technical Risk Analysis) (Mohaghegh et al., 2009; Mohaghegh and Mosleh, 2009) and Phoenix (Ekanem et al., 2016). In addition, WPAM (Work Process Analysis Model) (Davoudian et al., 1994) has also been included due to its activity-oriented nature. A time series of these models has been drawn in Fig. 1.

All these frameworks have the same motivation to model indirect effects of organizational factors into the risk picture. Some of the models have common parts (Skogdalen and Vinnem, 2011), such as

- A set of organizational factors
- A link to the system risk model
- A set of modelling techniques
- A set of measurement methods.

The review focuses on the different aspects of these models, from both a qualitative and quantitative point of view. The paper is organized as follows: in Section 2, terminology used in risk influence modelling covering risk, risk influencing factor, risk indicator, and Bayesian network are briefly presented. The reviewed models are compared and discussed in detail in Section 3. Implications for activity-related risk analysis are discussed in Section 4, and conclusion and further work are given in Section 5.

2. Terminology in risk influence modelling

Risk influence methodology was developed to help stakeholders concentrate on identification and analysis of "soft" factors that