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Decisions and decision support for major accident prevention in the process industries

Trond Kongsvik [a, *], Petter Almklov [a], Torgeir Haavik [a], Stein Haugen [b], Jan Erik Vinnem [b], Per Morten Schiefloe [a]

[a] NTNU Social Research, Dragvoll Allè 38B, 7491 Trondheim, Norway
[b] Norwegian University of Science and Technology, Department of Marine Technology, 7491 Trondheim, Norway

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ABSTRACT

Decision making is a central component in the management of safety-critical operations. Some attempts have been made to employ Quantitative Risk Analysis as input to such decisions. Although adequate for long-term planning where the average risk is the relevant parameter, such systems tend to fall short in operational and instantaneous decisions where 'average risk' is of less relevance. In this paper we investigate how operational and instantaneous risk can be managed and supported.

Our analysis is based on interviews and observation studies at a major plant processing hazardous fluids and gas. We suggest a typology for decisional situations at the plant, and relate these to well-known traditions in the literature of decision-making theory. Strategic decisions in the plant fit well into the characteristics of rational choice theory, operational decisions are well described in terms of bounded rationality, and, finally, instantaneous decisions are typically taken as described by naturalistic decision making theory.

We suggest several principles for improving decision support. While many decisions today are based on a high degree of probabilistic information, we see a need to deploy more factual information to make the risk picture more relevant for both operational and instantaneous decisions. In addition, the available probabilistic information is often inaccurate; improving the probabilistic information base, through more nuanced criticality factors for example, will also be an improvement. Finally, a basic premise for improvements in the decision process, is the need to be conscious regarding what should be considered strategic, operational and instantaneous decisions.

1. Introduction

Investigations of major accidents usually point at flaws in the decision making process at some stage when accidents are explained. Decisions of significance can be made long before an accident, such as those related to design or to long term planning, but also by 'sharp end' personnel immediately before an initiating event. In the National Commission's report after the Deepwater Horizon disaster, for example, it is stated that better management of the decision making processes in BP and other companies was an important factor that could have prevented the incident, and several concrete examples of decisions that increased the risk at Maccondo before the catastrophe were given (National Commission, 2011: 125).

Improving decisional support is thus one measure that can prevent major accidents. Prevention of major accidents may be achieved either by preventing incidents to occur, or by preventing incidents developing into major accidents, the latter is mainly achieved through the emergency response planning and associated equipment. In practice it will often be a combination of the two approaches. The main emphasis in this paper is on prevention of incidents to occur, corresponding to the left hand side of a typical Bow-tie diagram. This implies that emergency response and mitigating systems are not focused on.

* Corresponding author.
E-mail addresses: trond.kongsvik@samfunn.ntnu.no (T. Kongsvik), petter.almklov@samfunn.ntnu.no (P. Almklov), torgeir.haavik@samfunn.ntnu.no (T. Haavik), stein.haugen@ntnu.no (S. Haugen), jan.erik.vinnem@ntnu.no (J.E. Vinnem), per.morten.schiefloe@svt.ntnu.no (P.M. Schiefloe).

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The aim of this paper is twofold: (1) Using an onshore plant processing hazardous fluids/gas as a case study, we will first describe concrete decisional situations of relevance to major accident prevention. (2) Based on this, we will discuss principles for decision support which are of relevance for different decision situations.

Different tools and methods for providing risk information as decision support are used in the process industries (e.g. Reniers et al., 2006; Mazri et al., 2014), including qualitative risk analysis and numerical information based on Quantitative Risk Analysis (QRA). It has become increasingly clear, however, that present methods of quantitative risk analysis do not always provide adequate support for operational decisions in the oil and gas industry. One reason for this is that the analyses mainly cover technical aspects of design, and only reflect operational and organisational issues to a limited degree. The current methods and approaches used for risk analysis have to a large extent also been developed from methods originating in the nuclear industry. These methods provide useful decision support for selecting design solutions, operating practices and other solutions which, as an average over a (long) period of time, will give the lowest risk. This may be called average risk [over a long period]. It should be emphasized that 'average risk' implies averaging some risk value over at least a year, and should not be confused by specific metrics like Fatal Accident Rate (FAR) or Individual Risk per Annum (IRPA). However, these methods do not necessarily give good answers if we want to decide about whether a specific situation or a specific operation is safe or not. In such a situation, we are not interested in average risk, but in what may be called 'the instantaneous risk', associated with this particular situation. Averaging over a long period is not sufficient.

It may be argued that the quantitative risk analysis was never intended to support operational decision-making, although a number of attempts have been made in recent years to use QRAs also for this purpose. On the other hand, when considering what oil companies use in relation to major hazard decision-making in the operations phase, there are no other quantitative tools available, although qualitative methods like Safe Job Analysis, HAZOP and others are extensively used.

The quantitative risk analysis also provides input to the preparation of the emergency response plan, which is a fundamental tool in the decision making process. This is certainly a relevant aspect; however it is applicable for decision-making after the occurrence of an incident. The main focus in this work is on prevention of incidents, such as hydrocarbon leaks.

This paper builds on work performed in an initial phase of the project 'Modelling instantaneous risk for major accident prevention' (MIRMAP). In particular, MIRMAP seeks to develop a concept for *living risk analysis*,[1] as a supplement to traditional risk analysis. The scope of the project includes decision situations on both on- and offshore facilities that involve major accident risk, directly or indirectly. According to the Petroleum Safety Authority in Norway, a major accident can be defined as "an acute incident, such as a major discharge/emission or a fire/explosion, which immediately or subsequently causes several serious injuries and/or loss of human life, serious harm to the environment and/or loss of substantial material assets" (PSA, 2013).

The term 'instantaneous risk' is in this paper used without a precise definition, except that it refers to risk during a short period. Average risk in a QRA study is typically averaged over a 12 month period. 'Instantaneous risk' applies to a substantially shorter period, without specifying exactly how long period, but may cover one day, one shift, one hour, etc., see further discussion in Yang (2014). QRA studies usually express FAR values averaged over a year.

It should be noted that 'instantaneous risk' implies some kind of systematic and documented assessment. The implication of this is that the subjective, unsystematic and undocumented assessment of the situation made indirectly by an operator when deciding how to perform an activity or in what sequence several activities shall be carried out, is not classified as assessment of 'instantaneous risk'. This should not be taken to imply that such indirect evaluations necessarily are of substandard. It may on the other hand be a good assessment of how work can be performed safely, if the individual is very experienced and has a good overview of the situation and all applicable operational restrictions. But it lacks a systematic approach to ensure that all relevant factors have been considered, and it is completely undocumented. Sometimes the situation may also be so complex that an unsystematic assessment may be insufficient.

The main context of the paper is as previously mentioned the prevention of occurrence of incidents. This implies that the assessments referred to here are related to decision-making which will influence the likelihood of occurrence of incidents, such as which activities to allow in parallel, what restrictions to put on execution of activities, what extent of independent verification to be performed, etc. We do not refer to decision-making relating to emergency response, which is quite different, e. g. involving stronger time constraints and other priorities in an evolving situation.

Decision making has been subject to extensive attention by different theorists. In the next section we will present some main contributions to the field, representing different views on the subject. In Section 3, the methodological approach of the study is presented, followed by results from the case study in Section 4. In Section 5, and based on the findings from the case study, we will discuss principles for decision support that may improve the quality of decisions in the process industry.

2. Decisions and decision making in the literature

Major accidents are often associated with human interventions, and investigations will typically identify choices and decisions made before the accidents, and how these contributed to losses of barriers or the actual triggering of the event.[2] These can be purely operational decisions, such as which tool or method an operator uses, or more long term choices such as which maintenance strategy a plant should apply. Understanding decision making is, consequently, important for preventing major accidents in processing plants. It is not just a matter of having the right information and the right tools, but also of actually making the right decisions.

The Oxford English Dictionary offers two definitions of decision. The first points at the outcome of a process: "The final and definite result of examining a question; a conclusion, judgement". The other focuses on the process itself: "The making up of one's mind on any point or on a course of action; a resolution, determination". This process is usually labelled decision making.

It is reasonable to talk about a decision when there is a time lag between consideration, conclusion and the action or outcome of the decision. This time lag varies. In decisions concerning strategic and operational matters the reasons for a specific choice between alternatives can usually be given before an action takes place or

[1] The term 'living risk analysis' is used as an expression of a risk analysis which addresses 'instantaneous risk', not in the same manner as the term is used in the nuclear power industry (NEA, 2005).

[2] This was also the case in the Deepwater Horizon investigations; see Skogdalen and Vinnem (2012), and National Commission (2011).