Reliability Engineering and System Safety 115 (2013) 136–145

Contents lists available at SciVerse ScienceDirect

Reliability Engineering and System Safety

journal homepage: www.elsevier.com/locate/ress

Practical implications of the new risk perspectives

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ARTICLE INFO

Article history:
Received 6 February 2013
Received in revised form
20 February 2013
Accepted 26 February 2013
Available online 14 March 2013

Keywords:
Risk assessment
Practical issues
Uncertainties
Knowledge
Black swans
Risk perspectives

ABSTRACT

In recent years several authors have argued for the adoption of certain new types of risk perspectives which highlight uncertainties rather than probabilities in the way risk is understood and measured. The theoretical rationale for these new perspectives is well established, but the practical implications have not been so clearly demonstrated. There is a need to show how the new perspectives change the way risk is described and communicated in real-life situations and in its turn the effects on risk management and decision making. The present paper aims at contributing to this end by considering two cases, related to a national risk level, and a specific analysis concerning an LNG plant. The paper concludes that the new risk perspectives influence the current regime in many ways, in particular the manner in which the knowledge dimension is described and dealt with. Two methods for characterising the strength of knowledge are presented, one of them based on a new concept, the "assumption deviation risk", reflecting risks related to the deviations from the conditions/states defined by the assumption made.

1. Introduction

For technological applications, risk has commonly been considered as expected loss and as the pair of losses and probabilities [6]. For example in the nuclear industry, the Kaplan and Garrick [27] definition has prevailed: risk is equal to the triplet (s_i, p_i, c_i), where s_i is the ith scenario, p_i is the probability of that scenario, and c_i is the consequence of the ith scenario, $i=1,2, \ldots N$; i.e., risk captures: What can happen? How likely is that to happen? If it does happen, what are the consequences? Two other examples of definitions of risk capturing more or less the same ideas are as follows: risk is a measure of the probability and severity of adverse effects [30] and risk is the combination of the probability and extent of consequences [1].

These perspectives on risk are all probability-based, and several authors (e.g. [39,23,4]) have argued that these perspectives need to be replaced by broader risk perspectives which are not linked to one specific measure of uncertainty, namely probability. The concept of risk should allow for different ways of describing the uncertainties. This critique has resulted in several new risk perspectives being introduced; see the Appendix which summarises some fundamentals about risk, probability and uncertainty, and also relates the work to some relevant literature. For the purpose of the present study, which is related to the practical implications of these perspectives, the main message is that these new risk perspectives, in addition to risk descriptions based on probability, require additional characterisations that can provide further insights about knowledge and lack of knowledge, as well as potential surprises/black swans [19,44,7]. Fig. 1 illustrates the essence of the risk descriptions of the new perspectives. The (lack of) knowledge dimension captures for example that probability, used as a measure of uncertainty or degree of belief, is not able to reflect the strength of the knowledge that the probabilities are based on, and not that assumptions that the probabilistic analysis is built on could conceal important aspects of uncertainties. The surprise part relates to the fact that surprises may occur relative to the knowledge of the analysts or experts conducting the assessment. The theoretical basis for these risk perspectives is fairly well developed, but there is still a need for work to clarify and describe what the practical implications of them are. This is the topic of the present paper. More specifically, the aim is to show, using some concrete examples, how these new perspectives change the way risk is described, communicated and managed. We use two examples on different levels (national and firm) to illustrate the differences. Firstly, we introduce the cases (Section 2). Then we discuss the effects on risk assessment, risk description and communication (Section 3), followed by a discussion of the risk management and decision-making part (Section 4). To avoid too many repetitions, the second example is less detailed than the first. Finally, Section 5 provides some conclusions.

It is a huge research topic to establish suitable ways of representing and treating the knowledge and surprise dimensions in risk assessment. The final answer on the issue will of course not be provided here. The paper must be seen as just one contribution in the work of meeting the challenge here raised.

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http://dx.doi.org/10.1016/j.ress.2013.02.020

Fig. 1. Basic features of the new risk perspectives compared to the traditional probability-based perspectives.

2. Presentation of the two cases

2.1. National risk level

In Norway national risk assessments (NRAs) have recently been conducted [17,18], the purpose being to provide a common and unified foundation for social safety planning across sectors and professions. The motivation of the NRAs is summarised in a recently published report on innovation in country risk management by the Organisation for European Cooperation and Development [36]:

> "Central governments in particular have had to adopt a broader view on risk; one that is organised to address multiple hazards and vulnerabilities, and seeks to understand their interconnections rather than addressing each hazard and consequence separately. Implementing a broader view on risk requires the mobilisation and coordination of expertise from various government bodies and the private sector to increase breadth and depth of risk analysis for the purpose of better prioritising resource allocation."

The Norwegian NRA methodology is to a large extent inspired by methodologies developed in other European countries, primarily in the United Kingdom and the Netherlands [46]. The Norwegian NRA process consists of four steps: (1) establish societal values, (2) identify hazards and threats, (3) conduct risk analysis, and (4) establish a common risk matrix.

The societal values are used for characterising the consequences of the identified hazards/threats. The following main categories of values are used (with associated consequence types to be used in the risk assessment in parentheses): Life and health (loss of life, damage and disease, and physical strain), Nature and environment (long-term damage to nature and the environment), Economy (financial and material loss), Social stability (social unrest and disturbance in daily life) and National governance and territorial control (reduced national governance and reduced control over territory).

Next the identified hazards and threats are assessed with respect to risk. The assessment is based on the identification of a set of scenarios, referred to as plausible worst-case scenarios. From these scenarios, risk is described by predicting the consequences and assigning the associated probabilities of these scenarios. Each consequence type is given a score between *A* (very low) and *E* (very high); this is transformed to a numerical score and the assigned scores for the nine consequence types of a given scenario are aggregated into one overall consequence score. The extreme case is a maximum score on each type, giving $1/9+\ldots\ 1/9=1.0$, which is the maximum consequence score possible. If only two of the consequence types are relevant, the maximum consequence would be 2/9 and depending on the score for these two types we can get a total score between 0 and 2/9. The result is thus one overall score representing the entire spectrum of assessed consequences for one specific scenario.

The probabilities are assessed on the basis of historical data and expert judgements. The probability of risk events from intentional acts is assessed by considering the threat level posed by the capacity of malicious actor groups and the vulnerability of the targets defined in the scenario.

From these assessments, a standard risk matrix is established as a tool for presenting the overall results, reflecting the assigned probabilities of the hazards/threats/scenarios, and the expected total consequences given the occurrences of these events.

The Norwegian Directorate for Civil Protection and Emergency Planning (DCPEP), which runs these NRAs, is in the process of adjusting the analysis approach by providing a more nuanced risk picture also reflecting uncertainties. So far, the analysis has to a large extent been based on a traditional risk perspective as described at the beginning of the previous section. Now a broader risk perspective is to be adopted, but the present paper will here leave the DCPEP and address the issue from a more general point of view. Given the general challenges raised in this type of risk assessment, how should we describe risk if we are to implement the new and broader risk perspectives mentioned in Section 1 and summarised in the Appendix? How should we reflect the knowledge (lack of knowledge) and the surprise dimensions concretely when adopting the ideas of Fig. 1 and not only the probability-based thinking and the use of standard risk matrices? This is the issue we will address in Section 3.

2.2. A risk assessment of an LNG plant

An LNG (Liquefied Natural Gas) plant is planned and the operator would like to locate it not more than some few hundred metres from a residential area [47]. Several quantitative risk assessments (QRAs) are performed in order to demonstrate that the risk is acceptable according to some pre-defined risk acceptance criteria. In the QRAs risk is expressed using computed probabilities and expected values. The risk metrics used cover both individual risk and *f*–*n* curves (these will be explained in Section 3). It turns out that the assessments and the associated risk management meet strong criticism. The neighbours and many independent experts find the risk characterisation insufficient—they argue that risk has been reported according to a too narrow risk perspective.

The risk assessments carried out in this case were all based on a traditional risk perspective as outlined at the beginning of Section 1. Now, how should we describe risk if we have instead adopted a broader risk perspective in line with Fig. 1?

3. Risk assessment, description and communication

3.1. National risk level

Let us first consider the national risk assessment challenge, how to describe risk in this case. The identification of risk events is the natural starting point, as for most types of risk assessments. To illustrate, let us focus on two such events (we refer to these as events *A*): storm and terrorist attack. The probabilities of these events are assigned, and expected consequences determined for each consequence type used and aggregated as explained in Section 2.1. We may find it adequate to report the results for specific consequence types and for all together. We obviously need to be careful in defining the events. For instance, a storm may be defined in relation to the Beaufort scale, and it could for example be reasonable to distinguish between a storm (Beaufort number 10: 24.5–28.4 m/s) and a violent or worse storm (Beaufort number 11 or higher: 28.5 m/s-). Let us focus on the latter case. A probability can be assigned for this event to occur in Norway in