# Effective risk assessment – beyond the matrix

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## Summary

Many risk assessments are based on a simple analysis using a 5x5 matrix or similar. Such analyses may lack understanding of the organisational context and relevant risk criteria, and naming of risks may fail to describe them in adequate detail.

Often, analyses do not use techniques that provide more detailed information about risk events, consequences and their associated likelihoods; uncertainty may not be adequately considered and impacts on objectives not fully understood.

This paper uses some case studies to explore risk assessment techniques set out in ISO 31010: 2009 *Risk Management – Risk Assessment Techniques* to aid understanding of the nature and level of risks. Key definitions are drawn from ISO 31000:2009 *Risk management – Principles and guidelines* and ISO Guide73 *Risk management – Vocabulary*.

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## Introduction

For the past 12 months I have been running an informal survey of attendees at risk-related conferences to identify which risk assessment techniques are in common use. The results are set out in the table below.

**Table 1. Results from an informal survey of attendees at risk-related conferences**

| Risk assessment technique identified as used | Accountants N=27 | | Risk managers N=12 | | Next group N=23 | | Total N=39 | |
|---|---|---|---|---|---|---|---|---|
| | Number | % | Number | % | Number | % | Number | % |
| **Brainstorming** | 19 | 70% | 8 | 27 | 14 | 64% | 27 | 69% |
| **Risk register** | 23 | 85% | 10 | 33 | 14 | 64% | 33 | 85% |
| **Environment scanning** | 0 | 0% | 7 | 7 | 10 | 45% | 7 | 58% |
| **Professional judgement** | 9 | 33% | 11 | 20 | 14 | 64% | 20 | 51% |
| **5x5 matrix** | 7 | 26% | 8 | 15 | 14 | 64% | 15 | 38% |

Results to date suggest a mix of forward-looking and backward-looking risk identification with brainstorming, environment scanning and risk registers leading to professional judgement and use of risk matrices.

Professional judgement has been described as "the ability of a single person or a team to draw conclusions, give opinions and make interpretations based on experiments, measurements, observations, knowledge, experience, literature and/or other sources of information. In this definition, professional judgement is based on facts and objective evidence as well as experience, which includes some subjectivity. However, professional judgement should not be based on political or societal opinions. Professionalism refers to skill and competence of a degree definitely above average" (Anon, 1998). As noted it relies in part on "knowledge, experience, literature and/or other sources of information" yet in New Zealand we have no formal training in risk management generally or risk assessment specifically and access to academic literature (a key source for some information) is limited.

Experience shows that risk assessments in many organisations are largely based on the use of a simple risk analysis tool, the consequence/likelihood matrix. However, risk matrices may be poorly designed with little relationship to the risk profile of the organisation (case study cited in Cox, 2008, p. 20). Further, information provided by risk analyses may be limited to "snapshot" views of consequences and their likelihoods derived from the experiences of a few people. Decisions about acceptance and treatment of risks may then be made using inadequate information. It comes as no surprise that some, perhaps many, decisions may subsequently be found to have been ill-informed.

In this paper it is argued that complete application of the risk management process set out in ISO 31000:2009 *Risk management – Principles and guidelines*, supported by additional definitions in ISO/IEC Guide 73 *Risk management – vocabulary – Guidelines for use in standards* will significantly aid development of risk assessments and subsequent decision-making. The paper therefore is structured around that process and supporting definitions.

However, to understand risk assessments carried out using other codes, it is essential to pay attention to those codes and their definitions. This is especially so in New Zealand, a trading country.

**Risk – definitions and usages**

In the six months prior to writing this paper, several catastrophic events have killed or injured many thousands of people and caused considerable economic damage. In the same period, major investment decisions have been made – investments that may take decades to demonstrate any return on investment. At the other end of the scale, small-scale events routinely result in minor harm to people and assets and minor investments have been made. All are linked by "risk", a term that is simultaneously well-understood and misunderstood. For many people, risk has negative connotations while for some it represents opportunity.

Althaus (2005) reviewed 12 academic approaches to the definition of risk and suggested they each helped "confront the unknown so as to order its randomness and convert it into a risk proposition. This epistemological approach suggests the concept of risk can act as a mirror, reflecting the preoccupations, strengths, and weaknesses of each discipline as they grapple with uncertainty".

The joint Australia/New Zealand standard AS/NZS 4360 *Risk Management*, first published in 1995, required consideration of the context of an organisation before undertaking a risk assessment. In New Zealand, the context includes the status of the country as a major exporter of food. As such, account must be taken of international agreements on food and animal health. For food-related risks, the Food and Agriculture Organisation (FAO) defines risk as a "function of the probability of an adverse health effect and the severity of that effect, consequential to hazard(s) in food" (FAO, 2006) whereas the World Organisation for Animal Health (WOAH) defines animal and human health-related risk as "the likelihood of the occurrence and the likely magnitude of the biological and economic consequences of an adverse event or effect to animal or human health" (WOAH, 2009).

These definitions are aligned with the meaning of risk commonly used by many people – something with negative or feared consequences – but, as noted, others see risk as introducing opportunity.

The definition of risk in international standard ISO 31000, "the effect of uncertainty on objectives", can be argued to encompass all interpretations and meanings. However, this definition begs some questions, some being answered by five notes to the definition.

- *What sort of effects might need to be considered?* The first note tells us that "an effect is a deviation from the expected – positive or negative". Thus, the popular meanings of risk are covered.
- *What is meant by uncertainty?* "Uncertainty is the state, even partial, of deficiency of information related to, understanding or knowledge of, an event, its consequence, or likelihood". Explicitly addressing uncertainty helps a risk analyst to research any deficiency of knowledge. This appears to answer many concerns of risk academics, practitioners and lay people.
- *What is meant by objectives?* While "objectives can have different aspects such as financial, health and safety, and environmental goals and can apply at different levels such as strategic, organisation-wide, project, product, and process", the note does not address the question "whose objectives?". Objectives may be set consciously or

unconsciously by stakeholders outside an organisation. These issues are addressed separately through the communication and consultation stage of the risk management process.

- *How might a risk be characterised?* Note 3 to the definition suggests risk "is often characterised by reference to potential events, consequences, or a combination of these and how they can affect the achievement of objectives". Inclusion of "potential" in this note is both essential and redundant; all risk is in the future but users of the standard need to be reminded there is no certainty with any risk.
- *How might a risk be expressed?* "Risk is often expressed in terms of a combination of the consequences of an event or a change in circumstances, and the associated likelihood of occurrence".

The above definition of risk and associated notes was developed by a diverse writing group and subsequently subjected to international comment. For risk practitioners at least, it provides some common ground for work on and review of risk assessments.

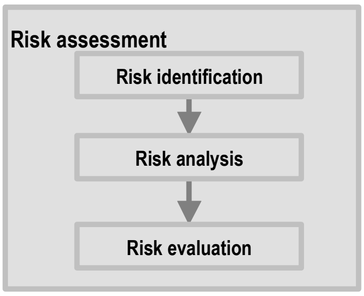
**Risk assessment – definitions and usages**

In ISO 31000, risk assessment is part of an overall process that includes establishing the context, communication and consultation and monitoring and review; risk treatment follows assessment if risks are not acceptable at the current level of control and need to be modified.

The standard defines risk assessment as "the overall process of risk identification, risk analysis and risk evaluation". Each of these three terms is separately defined in the standard; see the graphic to the right illustrating these relationships.

However, and as might be expected, the term "risk assessment" also has varying meanings in academic and practitioner literature.

**Figure 1. Risk assessment**



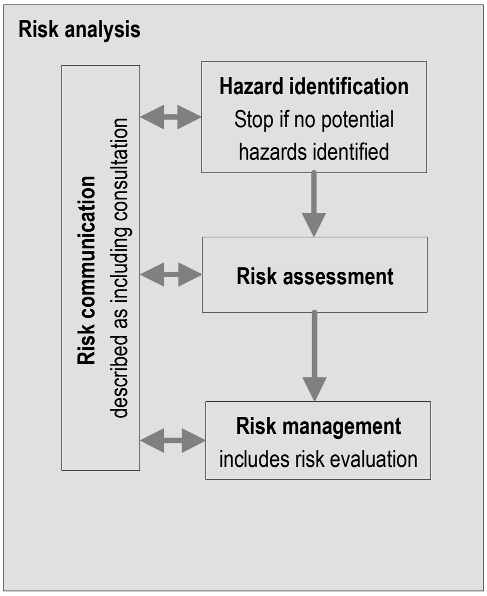

For some, the term risk assessment is used interchangeably with the term "risk analysis". To add to the potential for confusion, FAO (2006) and WOAH (2009) define risk assessment as part of risk analysis.

For WOAH, risk analysis means "the process composed of hazard identification, risk assessment, risk management and risk communication" while for the FAO, risk analysis consists of "three components: risk assessment, risk management and risk communication" (see the graphic to the right).

In the FAO guidance, risk assessment is a "scientifically based process consisting of the following steps: i) hazard identification; ii) hazard characterization; iii) exposure assessment; and iv) risk characterization" while WOAH defines risk assessment as "the evaluation of the likelihood and the biological and economic consequences of entry, establishment and spread of a hazard within the territory of an importing country".

For many risk practitioners, there is no agreed definition of risk assessment with, for example, the terms quantitative risk *analysis* and quantitative risk *assessment* being used to mean the same thing. If we apply the ISO 31000 definitions, the latter usage would give rise to the need to carry out quantitative risk identification and evaluation, neither likely to be achievable.

**Figure 2. Risk analysis (FAO and WOAH models)**



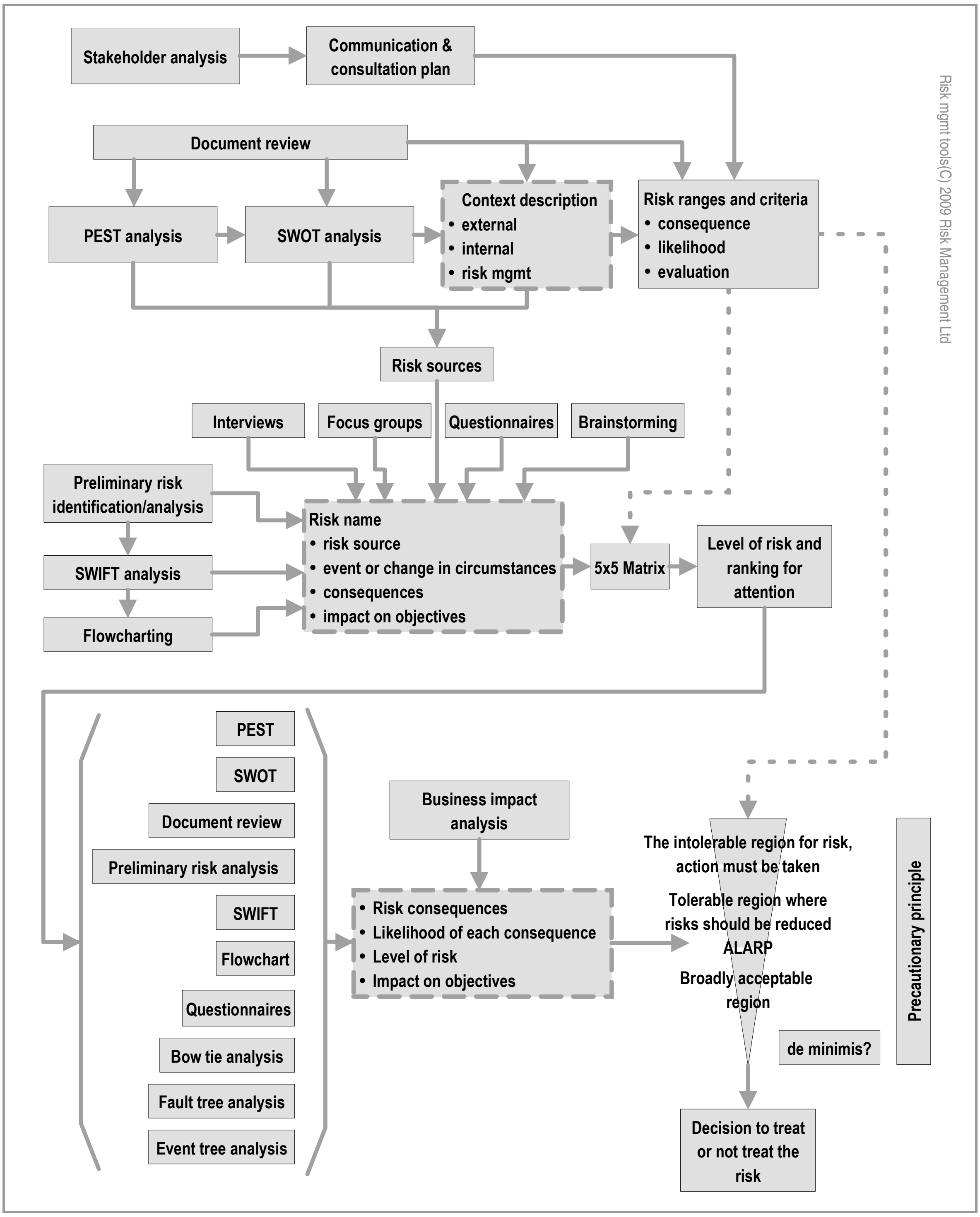
To avoid confusion, this paper follows the ISO 31000 definitions and usages.

Having discussed some of the issues associated with three international approaches to risk and risk assessment this paper now focuses on the main theme, carrying out risk assessments beyond risk analysis with a risk matrix.

**Risk assessment or risk management techniques?**

Figure 3 below shows how different risk assessment techniques described in ISO 31010 can be combined to aid identification, analysis and evaluation of risks. By expanding the model from risk assessment techniques to risk management techniques, it becomes possible to see how other stages in the risk management process can be assessed, so improving our understanding of risks.

**Figure 3. Risk management techniques combined in a major risk assessment**



It is not necessary to use all of the techniques in Figure 3 or described in ISO 31010: 2009 for every assessment but, it is argued, practitioners should know of and be able to apply several techniques to enable more effective risk assessments.

**Context**

The context of an organisation is not covered in most widely-used risk management standards whereas ISO 31000 requires consideration of the external and internal context. It is argued that establishing the context is crucial to an effective risk assessment. It often will aid identification of hazards, risk sources and risks. Understanding the context helps determine which risk identification and analysis methods to use and (taking account of the needs of stakeholders) how to present the results of the evaluation. This stage in a risk assessment includes development of risk criteria that are subsequently used for risk evaluation.

For example, use of a political, economic, social and technology (PEST) analysis will help identify factors in the external context (eg, risk sources such as legislation) whereas a strengths, weaknesses, opportunities and threats (SWOT) analysis might aid identification of factors in the internal context. Understanding the context of the risk management process will help establish terms of reference for a project, a stage in the development of risk management or a specific risk assessment.

**Risk identification**

Risk identification is the “process of finding, recognising and describing risks”. ISO 31000 suggests “the organisation should identify sources of risk, areas of impacts, events (including changes in circumstances) and their causes and potential consequences”. The identification stage might be limited only by the imagination of the risk assessor but should certainly consider “all significant causes and consequences”.

The standard gives no explicit guidance on how this might be done but recommends using “risk identification tools and techniques that are suited to its objectives … and to the risks faced”. ISO 31010: 2009, sets out 31 risk assessment techniques, 14 of which are “strongly applicable” to risk identification. These include brainstorming, structured or semi-structured interviews and the structured what if technique (SWIFT).

The need to use two or more different techniques (triangulation [1]) is emphasised by a risk that emerged during this author’s work with a transport-related organisation several years ago. During semi-structured interviews, concerns were raised by several people about the effects of changing fuel prices and possible consequences related to altered vehicle use. This led to application of SWIFT and the identification of a wide range risks associated with both increased and reduced costs of oil-based fuels.

> The risk “oil reaches US$500 bbl in five years …” is now routinely used in my consultancy, training and teaching work to help people think about significant shifts in the cost of oil, what risk indicators and initiating events might exist for such a change and what consequences might flow from such an event. Common indicators and initiating include factors leading to armed conflict in a key oil-producing country and factors indicating rapidly increasing demand for oil in emerging economies.
>
> “Event” is defined in ISO 31000 as an “occurrence or change of a particular set of circumstances” that can be one or more occurrences, and can have several causes. The changes in circumstances might be slow (eg, spread over 2 or 3 years) and almost imperceptible day-to-day.
>
> Common consequences include reduction in commuting by car and increased demand for public transport. Demand for more videoconferencing would likely increase and house values would change, perhaps significantly as more value was placed on houses closer to workplaces.

[1] Triangulation is the use of two or more independent sources of data or data collection methods within one study in order to help ensure that the data are telling you what you think they are telling you (Saunders, Lewis, & Thornhill, 2007).

For this oil cost risk, it is necessary to consider many causes as well as many consequences, suggesting the possible application of bow-tie risk analysis, a technique often used in the petrochemical and aviation sectors.

Note the likelihood of any of the consequences is not considered at this stage as it forms part of risk analysis.

**Risk naming**

Naming of risks is crucial to effective risk analysis and risk evaluation. Thus, “contracts” might be named as a risk but the name is meaningless; it conveys little information beyond some concern or interest in contracts. Unbalanced contracts or onerous contract conditions or unenforceable contracts are more meaningful names but still need to be expanded to give a clear understanding of the identified risk. This will aid selection of appropriate risk analysis techniques and effective risk analyses.

Meaningful names of risks identify causes or initiating events, how they might trigger an event and the consequences that might flow from that event. For “slow” risks, the event may be a change in circumstances.

**Trans-boundary risks and risks beyond the worst case scenario**

Trans-boundary risks and the crises they may give rise to provide complex risk assessment problems (Ansell, Boin, & Keller, 2010). Such risks may occur across organisational, political or geographical boundaries and require risk management actions by each risk stakeholder. Hermann & Dayton (2009) reviewed 81 trans-boundary crises and found the likelihood of proactive management action depended on how managers viewed likely causative events. Speed and adequacy of response to risk events also can depend on how well preconceptions match the reality of an event.

In other words, identification of a black swan event (Taleb, 2010) may be greeted by some with frank disbelief and demands for evidence (Fischbacher-Smith, 2010) while white swan events may be regarded as within the competence of managers to control through “standard operating procedures”.

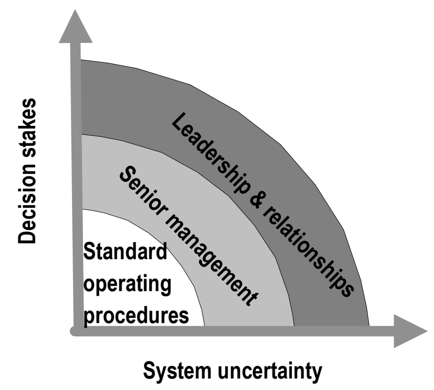
Funtowicz & Ravetz (1992) suggested risks might be analysed in three broad groups typified here as the level of system uncertainty in risks:

- capable of control through standard operating procedures
- requiring senior management oversight or intervention
- requiring leadership and relationship management.

They also suggested the level of decision stakes might override system uncertainty. Thus, a low level of system uncertainty might require management or leadership intervention due to high decision stakes. Intuitively, this matches real world experiences.

Thus, introduction of grey swans may help decision-makers to grapple with black swans that otherwise would be rejected as incredible.

**Figure 4. Problem solving strategies**




Source: adapted from Funtowicz & Ravetz (1992)

**Risk analysis**

The definition of risk in ISO 31000 tells us that risk “is often expressed in terms of a combination of the consequences of an event and the likelihood of occurrence”. Many people use this information to guide their analysis of risks based on one consequence and its likelihood. However, this misses the point considerably – risk events may have many consequences, each with a related likelihood. Further, in ISO 31000, risk analysis is the “process to comprehend the nature of risk and to determine the level of risk” and “provides the basis for risk evaluation and decisions about risk treatment and includes risk estimation”. These apparently simple definitions and associated notes are too often glossed over in risk analyses.

As ISO 31000 reminds us, it is important to consider the context as a prelude to any risk analysis. For example, a current analysis of the risk “oil reaches US$500 bbl in five years …” would show comparison with the oil shocks of the 1970s is no longer relevant (much has changed in the intervening 35 years) and that different factors should be considered, including the availability of specific types of crude oil (Anon, 2011).

The following safety-related case study reinforces this.

> Because of a lack of risk assessment competence in-house and in order to avoid duplicated effort, a company used a risk assessment prepared for a similar site, to show that, compared with risk tolerability criteria, the risks were low. However there were significant differences between the natural features of the two sites. For example, the second one was immediately adjacent to a river, which was not a feature of the site with the risk assessment. As a result, accidental spillage of very toxic substances and subsequent contamination of the river had not been considered. The risk assessment was therefore incomplete and conclusions from the risk assessment were inappropriate. (case study cited in Gadd, Keeley, & Balmforth, 2003, p. 10)

The need to consider the context is further reinforced in the following, adapted from a risk assessment the author carried out some years ago.

Consideration of a just a few questions about the risk “ground shaking or deformation due to an earthquake near a key asset or population centre” showed why a risk may require considerable research and information gathering.

| Questions | Possible responses |
|---|---|
| Is the asset in question unique or one of several on the same site or located on separate sites? | Several on separate sites but all are linked by a specific utility |
| Is the asset likely to withstand the ground shaking or deformation under consideration? | Beyond our competence – need to consult a seismic engineer but no budget for such work |
| Is the population centre a key source of revenue or a small component? | A small population centre that is a small source of revenue but residents work for a major consumer of company services |
| How long would it take to replace the asset if it was severely damaged? | Replacement lead times are months or longer |

Such answers begin to suggest the risk analysis might require a flowchart mapping the asset and its relationship with customers and linked to a spreadsheet to enable a range of numerical inputs and outputs. Output data on loss of service measured in financial impacts could then be mapped against the consequence scales for a matrix. A seismic engineer then gives a range of likelihoods for such losses. These consequences and their likelihoods could then be analysed with a matrix to show the respective levels of risk (the “magnitude of a risk expressed in terms of the combination of consequences and their likelihood”).

In this simplified example, use of a matrix needs to be preceded by much analytical work and careful development of a matrix that gives a fair representation of the risk appetite of the organisation.

**Development and use of matrices**

“Risk matrix” is defined in ISO Guide 73 as a “tool for ranking and displaying risks by defining ranges for consequence and likelihood”. Each defined range needs to be calibrated against the risk appetite (the “amount and type of risk an organisation is prepared to pursue, retain or take”). Generally, the board and senior management team should set the risk appetite and approve the related ranges for consequence and likelihood scales. A handbook published jointly by Standards Australia and Standards New Zealand, HB 436 *Risk Management Guidelines: companion to*

*AS/NZS 4360: 2004* (SA/SNZ, 2004), gives detailed guidance on the development of a matrix including consequence, likelihood and level of risk scales [2].

Even if a matrix has been well designed and takes account of these factors, “there has been very little rigorous empirical or theoretical study of how well risk matrices succeed in actually leading to improved risk” management (Cox, 2008). Franks, Whitehead, Crossthwaite, & Smail (2002, p. 20) provide similar comments about use of matrices in risk analyses for major accident hazards and Hubbard (2009) identifies issues in their use in internal audit work. Matrices therefore must be used with suitable care – indeed suspicion.

Simple risks might require application of a simple risk analysis technique and, for some risks, the risk matrix could be used alone. In many cases, use of a risk matrix showing consequence and likelihood scales may be useful as a way of crudely comparing and ranking risks. Risks might be ranked in different ways. For example, in descending level of risk as if:

- there are no controls or all current controls have failed
- only key controls have failed
- all controls are effective.

Such ranking helps decide the urgency of risk treatment action (Moore, 1996) by directing attention to risks needing more detailed analysis.

Simplistic application of a matrix can lead to the false impression of certainty about a consequence or its likelihood or both when there are, in fact a range of consequences or likelihoods or both. In other words, there is uncertainty (“the state, even partial, of deficiency of information related to, understanding or knowledge of, an event, its consequence, or likelihood”) about the impact on objectives of a given risk event. Such uncertainty can be reduced by triangulation and, for residual uncertainty, the frank statement of its nature.

The following example of a consequence range for safety of people suggests a false demarcation between potential injuries.

| **Consequences →** | **Insignificant** | **Minor** | **Moderate** | **Major** | **Catastrophic** |
|---|---|---|---|---|---|
| **Safety of staff or third parties**<br>Human lives and wellbeing (employees, contractors or third parties) | Minor first aid or no medical treatment required | Reversible disability possibly requiring hospitalisation | Moderate irreversible disability (<30%) to one or more people | Single fatality and/or severe irreversible effects (>30%) to one or more people | Multiple fatalities, or significant irreversible effects to >50 people |

Experienced occupational health and safety practitioners know such consequences may be separated by milliseconds or millimetres but lay people will apply their experience to such scales and analyse the worst consequences as “not expected to occur” or “may occur only in exceptional circumstances”.

Trained lay people may correctly analyse the level of risk, perhaps adopting the level of risk known to have been extant some years ago, but that since has changed due to changes in context or control failures.

The following examples illustrate the inadequacies of risk analyses by people lacking experience of the risk or failing to take account of controls and their possible failure.

[2] HB 436 is under review to align the text with ISO 31000. publication of the revised edition is expected in 2012.

**BP Texas City report**

"Workers and supervisors can increasingly rely on how things were done before, rather than rely on sound engineering principles and other controls. People can forget to be afraid. When systems and controls deteriorate, everything can come together in the worst possible way. Equipment malfunctions and controls fail. An explosion and fire occur. People lose their lives or suffer horrible injuries. Families and communities are devastated" (Baker et al., 2007).

Risk analyses that only use a risk matrix may fail to include "what if" questions about controls failure.

"An accident occurred at a factory in which an employee had an arm amputated by a machine he was cleaning. A risk assessment had been carried out by the factory manager, but he had not tested the interlocks (because he didn't have a detailed knowledge of how the machine was operated) or noticed that some of the interlocks and guard switches were missing from the machine. The manager had received no formal training on how to complete the risk assessment form" (case study cited in Gadd et al., 2003, p. 20).

A machine from a case investigated by this author in 1993. The machine could not be easily isolated or stopped but these issues were not identified in a risk assessment. The operator's forearm was cut off when clearing a blockage.

**Figure 5. Double-bladed circular saw for cutting planks**

**Triangulation in risk analyses**

If "risk management is to be part of decision making" (principle c, paragraph 3, ISO 31000) it is essential to provide somewhat more information than the level of risk from the likelihood of one consequence. Indeed, providing a range of consequences and their associated likelihoods will be but part of a risk analysis. Several techniques might be required to adequately "comprehend the nature of risk and to determine the level of risk" from a new technology, major natural disaster, disruption of a supply chain or major loss of containment.

ISO 31010 provides information about 22 risk analysis techniques that are "strongly applicable" to risk analysis regardless of the nature of the risks and Gadd *et al* (2003) suggest use of the following in risk analyses for safety-related risks:

- hazard indices
- hazard and operability (HAZOP) studies
- structured what if technique (SWIFT)
- checklists
- failure modes and effects analysis (FMEA)
- preliminary risk analysis
- fault tree analysis
- event tree analysis
- task analysis.

Wintle, Kenzie, Amphlett, & Smalley (2001) show how a similar range of risk analysis techniques might be applied to risk-based inspection of pressurised plant using a matrix to rank the importance of inspections. Their suggested indicative matrix suffers from the common problem of "one size fits all" and they caution against applying it too literally.

## Risk evaluation

Risk evaluation is the "process of comparing the results of risk analysis against risk criteria to determine whether the level of risk is acceptable or tolerable" and "assists in the decision about risk treatment."

The risk evaluation may be set out in a separate paragraph, chapter or part of a risk assessment report. The risk evaluation section must:

- give sufficient information to enable risk acceptance (an "informed decision to take a particular risk")
- if the risk cannot be accepted, assist in the decision about risk treatment and inform options for risk treatment (the "process of developing, selecting and implementing controls")
- consider the risk tolerance of the organisation (the "readiness to bear the risk after risk treatment in order to achieve its objectives").

Each or all of these points might require application of different risk evaluation tools. ISO 31010: 2009 suggests 10 risk assessment techniques that are "strongly applicable" to risk evaluation. A further 12, including bow-tie analysis, are described as "applicable". Bow-tie analysis can be a very useful technique to aid each stage of a risk assessment and provides a graphical presentation of the findings that aids identification of uncertainty.

Three tests to compare risk analysis findings with risk criteria are commonly used in risk evaluation:

- "as low as is reasonably practicable" or ALARP (derived from English common law)
- the precautionary principle (often applied when, despite a competent analysis, high uncertainty about risk consequences, their likelihood, timing or other factors remains)
- *de minimis* (a further legal test meaning the law does not concern itself with trivialities).

## Towards better risk assessments

Fischhoff, Lichtenstein, Slovic, Keeney, & Derby (1980) suggested that a good risk study could be judged against the 10 criteria shown below and Gadd *et al* (2003) identified a range of common deficiencies in safety-related risk assessments.

| 10 criteria for a good risk study | Common deficiencies of safety-related risk assessments |
|---|---|
| Comprehensive<br>Adherent to evidence<br>Logically sound<br>Practical<br>Open to evaluation<br>Based on explicit assumptions and premises<br>Compatible with institutions<br>Conducive to learning<br>Attuned to risk communication<br>Innovative | Carrying out a risk assessment to attempt to justify a decision that has already been made<br>Using a generic assessment when a site-specific assessment is needed<br>Carrying out a detailed quantified risk assessment without first considering whether any relevant good practice was applicable, or when relevant good practice exists<br>Carrying out a risk assessment using inappropriate good practice<br>Making decisions on the basis of individual risk estimates when societal risk is the appropriate measure<br>Only considering the risk from one activity<br>Dividing the time spent on the hazardous activity between several individuals - the 'salami slicing' approach to risk estimation<br>Not involving a team of people in the assessment or not including employees with practical knowledge of the process/activity being assessed<br>Ineffective use of consultants<br>Failure to identify all hazards associated with a particular activity<br>Failure to fully consider all possible outcomes<br>Inappropriate use of data<br>Inappropriate definition of a representative sample of events<br>Inappropriate use of risk criteria<br>No consideration of ALARP or further measures that could be taken<br>Inappropriate use of cost benefit analysis<br>Using 'Reverse ALARP' arguments (ie, using cost benefit analysis to attempt to argue that it is acceptable to reduce existing safety standards)<br>Not doing anything with the results of the assessment<br>Not linking hazards with risk controls. |

These contrasting findings indicate the need to improve risk assessments if they are to be applied to management decisions to aid the creation and protection of value in organisations. Risk assessments need to use the best available information, be systematic, structured and timely and go beyond simplistic application of risk matrices. They have to address uncertainty and take human and cultural factors into account. In addition to being tailored to the specific needs of an organisation, they need to be transparent to enable evaluation and regularly updated in the light of changes in the context.

The results of the informal survey, set out at the beginning of this paper suggest there may be a problem with the quality of risk assessments in New Zealand, perhaps contributing to the findings of recent applied research into the quality of decision-making in the New Zealand manufacturing sector (Green et al., 2010). While a formal research is needed to elaborate on this, there seems to be enough evidence to suggest the need for more training in the conduct of risk assessments and their application to decision-making.

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