Impressions from Applying ISO 31000 to an Avalanche Mitigation Project

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ABSTRACT: ISO 31000 is an international standard for risk management. It offers standard risk concepts, terminology and processes for diverse organizations and their component departments. ISO 31000 defines risk as the effect of uncertainty on (organizational) objectives. These effects can be positive or negative. For organizations ultimately responsible for managing avalanche risk (the risk owner), their objectives often include profit, positive relations with the workforce and environmental stewardship. These objectives are subject to diverse influences including uncertain negative events such as loss of life, employee injuries, property damage or transportation delays, all of which can be caused by snow avalanches. Since few applications to avalanche mitigation projects are publicly available, we illustrate ISO 31000 concepts and terminology using a simple hypothetical example of a proposed mining road threatened by snow avalanches. Avalanches can threaten worker safety and cause delays of ore transport as well as of crew changes. The mining company (MC) contracts an avalanche consultant to assess the avalanche risk and recommend mitigation options. The consultant recommends a mitigation strategy which reduces avalanche risk and satisfies contract terms but increases the environmental risk, which was not stated in the contract. Following completion of a second contract, MC selects risk treatments including a forecasting and control program without static defences, a worker safety program specific to the avalanche prone road, increased insurance for the cost of potential delays in shipping ore, and expanded liability coverage. This example illustrates how ISO 31000 can be applied to an organization responsible for managing avalanche risk, and the benefit of it being applied at all levels of the organization.

KEYWORDS: ISO 31000, risk management, avalanche risk, avalanche mitigation

1 INTRODUCTION

ISO 31000 is an international standard for risk management. It offers standard risk concepts, terminology and processes for diverse organizations and their component departments. Few applications of ISO 31000 to avalanche mitigation projects are publicly available.

ISO 31000 defines risk as the effect of uncertainty on (organizational) objectives; these effects can be positive or negative. For organizations ultimately responsible for managing avalanche risk (the risk owner), their objectives often include profit, positive relations with the workforce and environmental stewardship. These objectives are subject to diverse influences including uncertain negative events such as loss of life, employee injuries, property damage or transportation delays, all of which can be caused by snow avalanches. To illustrate ISO 31000 concepts and terminology in Section 2, we use a simple example of a proposed mining road threatened by snow avalanches following the steps outlined in Figure 1.

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Section 3 compares ISO 31000 terminology and concepts to an existing risk management strategy for a road.

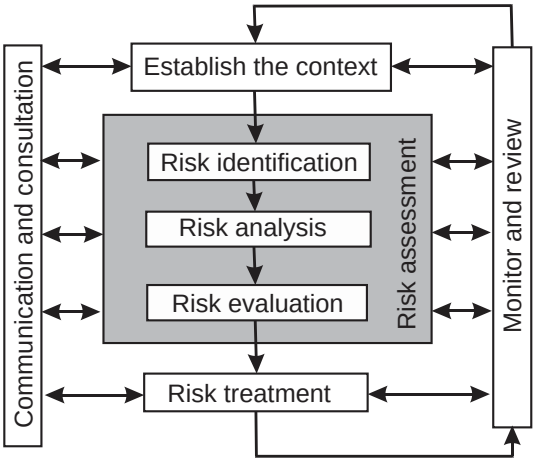

Figure 1: ISO 31000 risk management process (after ISO, 2009).

2 EXAMPLE OF APPLYING ISO 31000 TO A MINING ROAD

2.1 Establish the context

A mining company (MC) plans to develop an underground mine where the haul road is exposed to several avalanche paths. The pro-

posed mine adits and other mine facilities will not be exposed to avalanches. The mine will be in development for the first two years with many expenditures and a net loss expected, followed by 10 to 12 years of profitably hauling ore to the mill and processing facility, followed by 1-2 years of decommissioning the mine. The number of haul trucks and smaller trucks that will use the road each day and for each stage of the mine is estimated.

Internal and external risk criteria are established. For the avalanche risk, MC adopts the relevant national guidelines (e.g. Canadian Avalanche Association, 2002).

The mining company's financial objective is to maximize profit and thereby drive share prices up by at least 10% each year. Other corporate objectives include strong positive relations with the workforce and local communities, as well as environmental stewardship. While the profit objective can be quantified, the other corporate objectives, at least as stated, are difficult to quantify. These objectives are subject to uncertain effects, including uncertain negative effects from avalanches.

2.2 Identification

In consultation with MC executives and managers, the Chief Risk Officer (CRO) of MC identifies the following uncertainties of the mining operation that can affect the corporate objectives. These sources of risk, many of which involve uncertain costs, include:

- International sale price of ore over the life of the mine
- MC's financial resources including financial returns from MC's other mines
- Development of the mine infrastructure
- Construction of the haul road ()Extracting ore
- Hauling ore[2], excluding the avalanche protection program
- Insurance[2]
- Labour[2]
- Environmental mitigation including mitigation due to changes in environmental regulations[2]
- Reputation[1]
- Legal liability[1]
- Occupational health and safety of the workers [1] (OH&S)
- Natural hazards and mitigation[1]

This last risk source includes snow avalanches. The mining company contracts ABC avalanche consulting company (first contract) to identify the avalanche hazard to the haul road. The contract specifies the anticipated number of haul trucks and number of smaller trucks that will use the road per day. ABC reports that five avalanche paths affect the road, including one (Path 2) that is expected to impact the road with at least one Size D3 or larger avalanche each winter. The other paths affect the road with a lower frequency. Forecasting, explosive control and static defences are proposed as options for mitigation.

The mining company then expands the list of risk sources to include:

- Avalanche forecasting and control program for the haul road (AFC)[1]
- Static avalanche defences for the haul road[1]

For some of these sources, it is not the expected level or cost of these processes or elements that constitute risk; rather it is the potential deviations (positive or negative) from the expected that constitute risk. Examples include: development of the mine infrastructure could cost more or less than expected; static avalanche defences for the haul road could cost more or less than expected; long closures for avalanche protection could increase labour costs and impair MC's reputation; avalanches that impact the haul road could injure or kill employees and thereby increase OH&S and legal costs and damage MC's reputation.

Avalanches that threaten the haul road (and thereby affect MC's objectives) are thus a risk. The risk to MC's objectives increases with avalanche size and frequency but can be reduced by avalanche mitigation.

2.3 Analysis

Superscripts in the list of risks identified in Section 2.2 indicate risks related to avalanches and/or avalanche mitigation. Risks superscripted 2 have only secondary effects from avalanches and are not analyzed further in this example. That leaves risks superscripted 1, which have primary impacts from avalanches or avalanche mitigation. The estimated outset risks, all of which are negative, for these primary risks are analyzed in Table 1. For the outset risk, without treatment by static defences and/or AFC, avalanches are likely to injure or kill workers (OH&S), trigger penalties from regulatory agencies (OH&S), result in lawsuits (Liability) and increase hauling costs due to delays (delivery penalty in the contract with the mill), and increase overtime costs due to delayed crew changes (OVT delays).

Table 1: Matrix of *outset* avalanche related risks over life of mine (without risk treatment)

		Consequence[1]				
		Negligible	Minor	Moderate	Major	Catastrophic
Likelihood	Almost certain			Delays (delivery penalty)		
	Likely		Delays (labour)		OH&S Reputation	Liability
	Possible					
	Unlikely					
	Rare					

[1] a range of costs could be attached to some of these risks.

2.4 Evaluation

The OH&S, liability and reputation risk are unacceptable to MC's executives, who contract ABC (second contract) to provide a cost-benefit analyses of mitigation options.

2.5 Treatment

ABC is contracted to provide the cost-benefit analysis of avalanche mitigation options during construction of the haul road, construction of the mine and subsequent mining and hauling, as well as decommissioning. The benefit is analyzed in terms of risk reduction.

ABC recommends Option 1, which includes a deflection dike for Path 2 and an avalanche forecasting and control program for all paths. These are expected to reduce closures to 50 hours per winter with at most one closure longer than 24 hours each winter. The likelihood of destructive avalanches (Size D3 or larger that could damage a vehicle and injure or kill the driver) on the open haul road is sharply reduced but not eliminated.

Option 2 is for an avalanche and forecasting program without the deflection dike on Path 2. The resulting size and frequency of avalanches to the road is similar to Option 1, but the cost of the AFC program is higher due to increased staffing and explosive control measures.

2.6 Review

Risk management processes including ISO 31000 allows for multiple iterations of evaluation and review.

The CRO and executives for MC review the mitigation options and select Option 2. Option 1 involving the deflection dike is rejected because of potential environmental impacts to a creek (fish habitat) during construction and associated environmental mitigation costs and construction delays. Environmental impacts were not part of the cost-benefit analysis requested from ABC.

Costs for the AFC (Option 2, $2M over the life of the mine) are approved and included with the cost of building the mine and road. The cost of the forecasting and control program is greater than it would have been for Option 1.

2.7 Analysis of residual risk with mitigation

The expected costs of constructing the mine and road and insurance are not risks. Although these activities and associated costs must be carefully managed, only the uncertain effects on MC's objectives constitute risk. The risks include construction costs higher or lower than expected and environmental impacts and avalanche mitigation costs. The effects of avalanches on OH&S, liability and mitigation costs, which are uncertain in terms of likelihood and/or consequence, are included in Table 2.

Table 2 shows the matrix of avalanche related *residual* risks, which assume mitigation of the avalanche risk by Option 2. In this simple example, both the consequences (columns) and likelihood (rows) are qualitative. The likelihood and cost of OH&S as well as liability are categorically reduced compared to Table 1. The cost of labour, e.g. OVT related to delays, is less likely but still of minor consequence.

2.8 Re-evaluation

Compared to the risks in Table 1, the risks in Table 2 are of lower consequence and lower likelihood.

MC performs a cost-benefit analysis including the expected cost – or perhaps some percentile, say the 75th percentile of probable costs - associated with the risks, and accepts the risks with the proposed mitigation by Option 2. *2.9 Treatment*

The expected cost for AFC is approved and the risk (effect of uncertainty on cost) is accepted. The mine is built with the approved avalanche mitigation.

In addition to workers compensation that is required by regulation, MC increases its commercial general liability insurance and expands the contract with its legal services firm to include responding to avalanche accidents. The law firm compiles a short list of avalanche experts

Table 2: Matrix of avalanche related *residual* risks over life of mine assuming risk treatment by Option 2

		Consequence				
		Negligible	Minor	Moderate	Major	Catastrophic
Likelihood	Almost certain					
	Likely		Delays (delivery penalty)			
	Possible	OH&S AFC	Delays (labour)			
	Unlikely		Liability, Reputation			
	Rare					

that can perform accident investigations and provide advice to the law firm should there be an avalanche accident. The uncertain costs due to a potential avalanche incident are included in Table 2 under Liability.

MC seeks insurance for the costs of delayed deliveries of ore to the mill, but based on a cost-benefit analysis finds the insurance cost not to be worthwhile.

2.10 Periodic review

Reviews of the effectiveness of the AFC and associated costs are conducted annually or after any large avalanche impacts the haul road while it is open for hauling ore. The cost of mitigation is compared with the reduction in risk (benefit).

2.11 Summary of mining road example

After the first analysis of outset risks associated with the unmitigated avalanche hazard, the MC mining company evaluated the risks and found them unacceptable. Following analysis of mitigation strategies, ABC Avalanche Consulting recommended a combination of a static deflection dike and temporary measures, specifically a forecasting and control program. The mining company did not select this option. MC's decision was based on a risk (environmental), which was not included in the terms of reference for ABC's contract.

It is common for the project owner not to include all its objectives in the contract terms or even inform the consultant of their overall objectives. This focuses the work for bidders (potential contractors) with the required expertise. However, it means the contractor's preferred recommendation – or indeed any of its recommendations - may not be accepted by the project owner because of factors including risk sources that were not included the contract terms. Schaerer (1970) call such factors "intangibles." In avalanche mitigation contracts, the risk analysis often involves analyzing the effects of avalanche events (in terms of their frequency and magnitude) *on the objectives specified in the contract* and recommending and/or providing cost-effective treatment for the avalanche risk. Since all corporate objectives are often not included in the terms of the avalanche contract, in many cases the overall risk assessment to ISO 31000 standards can only be done by the corporation that owns the project and the risk.

This example illustrates some components of the ISO 31000 risk management process shown in Figure 1. We found no problems applying ISO 31000 to this hypothetical avalanche mitigation project. The ISO 31000 process prompted a sound consideration of the risks that affected the mining company in developing a new mine with an avalanche prone road.

3 COMPARISON OF ISO 31000 WITH AN EXISTING RISK MANAGEMENT PROCESS FOR AN ROAD THREATENED BY AVALANCHES

In this section, we apply the ISO 31000 terms to Margreth et al.'s (2003) risk management flowchart for transportation routes (Figure 2). The key elements of the ISO 31000 risk management process are included in Margreth et al.'s process. However, two differences are apparent:

- With increasing buy-in to ISO 31000 over time, its terminology will become suited to communication throughout the organization that own the risk including with its directors, insurers, lawyers, marketing department, public relations department, etc., as well as with its contractors.
- ISO 31000 requires that risks be related to organizational objectives throughout the risk management process.

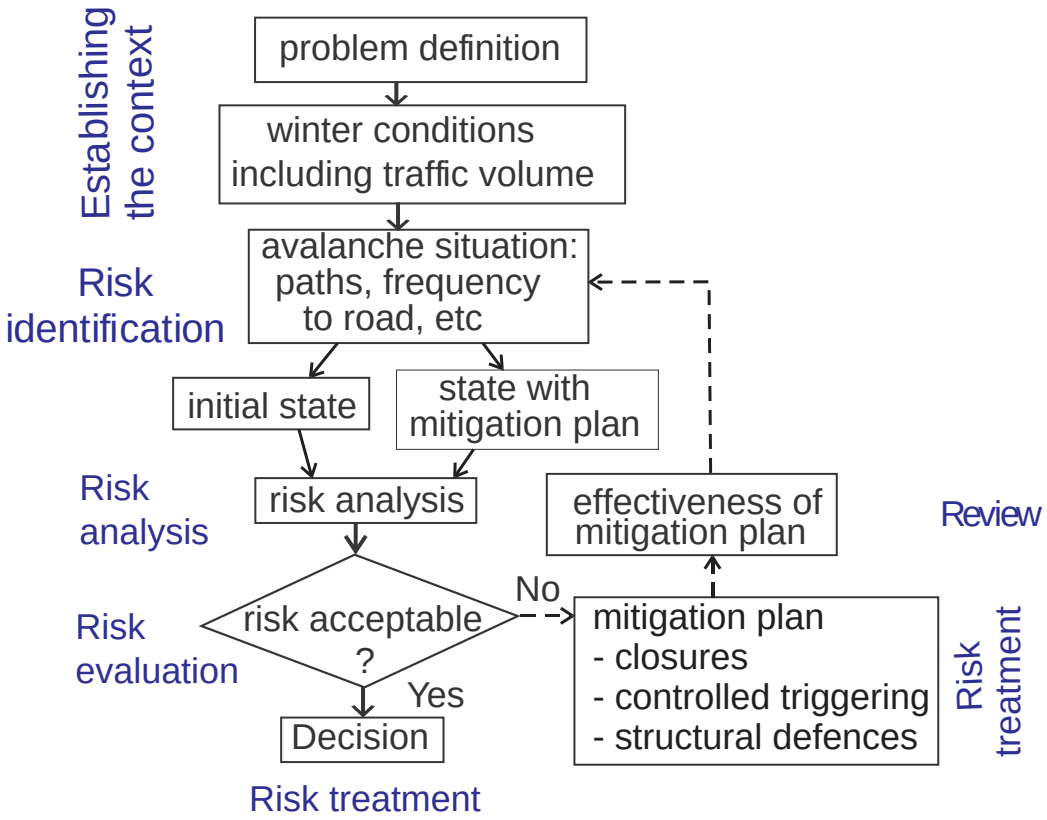

Figure 2: Risk management flowchart from Margreth et al. (2003). Outer blue labels show the corresponding ISO 31000 terminology.

4 SUMMARY

The ISO 31000 risk management process is a top down process that starts with the organizational objectives. In the example of the mining road, the mining company included only avalanche related risks in the terms of reference for the avalanche consultant. The mitigation option preferred by the avalanche consultant did not consider environmental impacts. Consequently, the mining company – the risk owner – selected a different option, one that better reflected its organizational objectives, resulting in a preferred mitigation strategy.

A client's rejection of a consultant's recommendation is common because of organizational objectives, including acceptable cost, are often not communicated to contractors. By identifying risk as the effect of uncertainty on organizational objectives, as well as using ISO 31000 terminology and conveying these throughout the organization and to its contractors, organizationally sound avalanche mitigation strategies may be obtained.

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