

RISK-BASED AVALANCHE PROGRAM DESIGN

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ABSTRACT: Avalanche safety programs around the world are diverse and varied, challenged to forecast avalanche hazard and manage avalanche risk in a variety of environments, scales and contexts. While each different program comes with its own unique set of objectives and elements-at-risk, the common thread among them all is the underlying, universal components of risk. All risk scenarios are premised upon the concepts of probability and consequence, while avalanche risk specifically combines hazard, exposure and vulnerability. While these factors are often assessed, combined and expressed in different ways for different scenarios, the basic premise of risk is fundamental to the system of avalanche risk management. In this paper we describe how individual decision making can be improved by deconstructing scenarios into risk components, and how the universal nature of risk-based systems makes them a compelling choice upon which to base avalanche education, practice and communication.

KEYWORDS: risk, hazard, probability, consequence, exposure, vulnerability, education

1. INTRODUCTION

Avalanche safety related programs are delivered by professionals in a variety of different applications ranging from education, to planning, to operational forecasting and risk management. Because each of these applications has different context and objectives, the systems and methods used to deliver on these objectives have often developed naturally to meet the specific needs of each application. Following is a breakdown of the different kinds of avalanche safety programs and activities found in Canada.

- 1) Public avalanche warnings
- 2) Public and professional avalanche education
- 3) Guided commercial backcountry recreation
- 4) Avalanche forecasting for ski resorts, transportation corridors and industrial sites
- 5) Avalanche forecasting for fixed infrastructure, including occupied structures
- 6) Search and rescue operations

- 7) Planning, analysis, and studies of avalanche mitigation for fixed infrastructure

Despite each type of program having different objectives, their common denominator is risk. Each one of these programs deals with the residual uncertainty that defines risk (ISO 2009), and finds value in using methods that are based upon the core, underlying components of avalanche risk: hazard, exposure and vulnerability (Figure 1). These components are assembled and combined in various ways, depending on the specific objectives and methods chosen; usually qualitatively and sometimes quantitatively.

Systems and methods that are based upon these concepts are referred to as risk-based systems. The objective of this paper is to describe the universal application of risk-based systems to avalanche programs, and to advocate for individuals and organizations to adopt risk-based systems, standards and language to structure their work.

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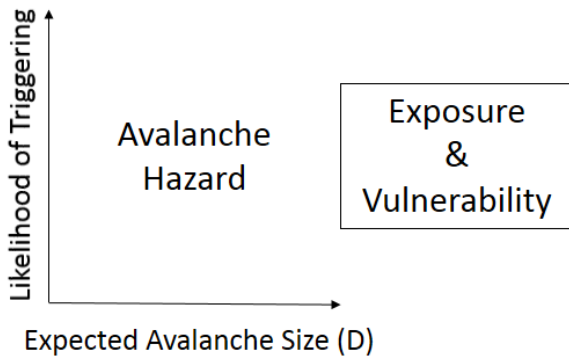


Figure 1: Short-term avalanche risk combines avalanche hazard with the exposure and vulnerability of the element(s)-at-risk (Statham 2008).

2. RISK AS AN OVERRIDING FRAMEWORK

The International Standards Organization (ISO) publishes a risk management standard known as *ISO 31000: Risk Management - Principles and guidelines*. This standard provides high level definitions, principles and generic guidelines on risk management that are purposely not specific to any industry or sector. The ISO standard is intended for use by different industries to develop their own, more specific risk-based standards and processes. Figure 2 shows the generic, ISO 31000 risk management process.

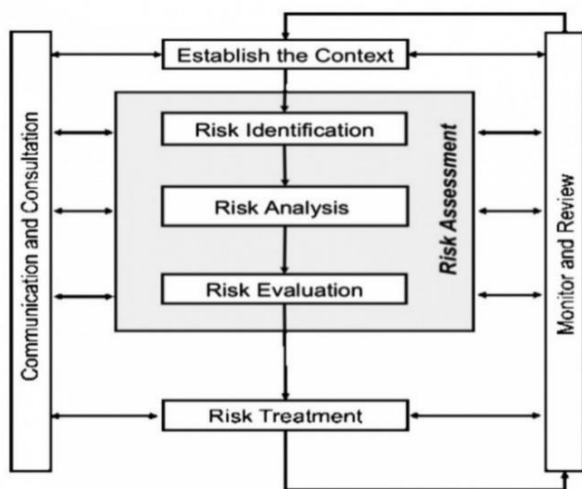


Figure 2: ISO 31000 risk management process (ISO 2009)

Based upon ISO 31000, the CAA (2016) developed an avalanche risk management process (Figure 3) that separates avalanche risk

management into two distinct categories: *Planning* and *Operations*. This division recognizes that different assessment methods are used for the planning stages (long-term outlook) versus the operations stages (short-term outlook).

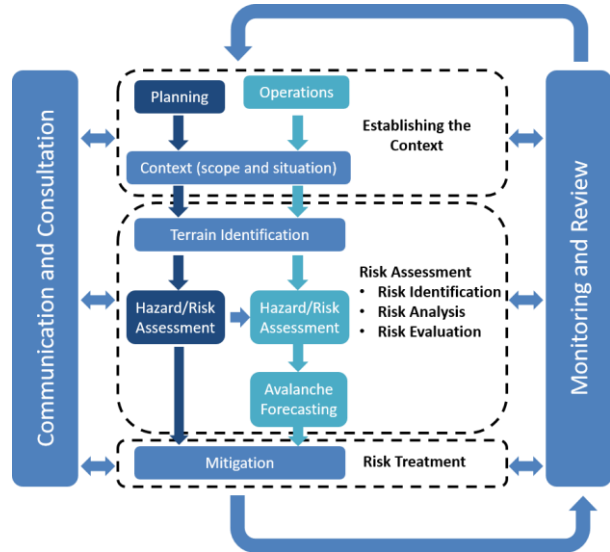


Figure 3: The avalanche risk management process (CAA 2016). The bulleted text on the right shows the connection with the ISO 31000 process.

The choice of which method to use for a particular risk scenario is based upon the scope and situation of each scenario (CAA 2016). For applications with abundant data and enough time to analyze it, typically at the planning stage, quantitative risk assessment methods can be applied. In real-time, however, qualitative techniques prevail in avalanche forecasting programs such as ski areas, transportation corridors and backcountry guiding. Although there are important and fundamental differences between the individual methods, their common theme is that they are risk-based and captured under a broad risk management framework.

While different methods are better suited for different activities (e.g.: protecting infrastructure versus guiding a ski run), the need to combine hazard, exposure and vulnerability is universal. In Canada, avalanche risk is defined as *the probability of harm or cost resulting from interaction between avalanche hazard and a specific element(s) at risk* (CAA 2016; after Statham 2008). This definition can be expanded

mathematically to facilitate quantitative risk assessment (Kaplan and Garrick 1981), or simplified further to teach a basic avalanche course. This ability to scale up or down the technical difficulty of the concepts to meet the target audience is a key feature of risk-based systems.

3. DECONSTRUCTING SCENARIOS INTO RISK COMPONENTS

The planning and engineering side of the avalanche industry has long been breaking down avalanche risk scenarios into constituent parts. This practice facilitates a focused study of the interaction between avalanche hazard and the element(s)-at-risk, and promotes an objective, logical analysis of all the factors that contribute to the risk. The resulting decisions and actions are then well supported and explained using a consistent, widely accepted risk framework (e.g.: ISO 2009; CAA 2016).

Avalanche forecasting and backcountry travel, on the other hand, does not have a long history of explicit, risk-based analysis and communication. Contributing factors such as snowpack, avalanches, weather and terrain have always been combined using various methods (e.g.: McClung and Schaerer 2006), but usually in the absence of an overriding risk framework to tie all the factors together in combination with the element-at-risk.

One practical example is a typical scenario of crossing an avalanche prone slope with a group of skiers. Using a risk-based analysis, the slope is first analyzed for its likelihood of triggering an avalanche of a given size (this is the hazard). Based upon this, decisions can then be made on how to best manage the scenario. The vulnerability of individuals within the group determines how (or if) they should be exposed to the hazard. In this scenario, the exposure component of risk is the single most important consideration for managing the risk. Even minor adjustments in how one is exposed to the hazard can change their risk – a few meters in either direction can be the difference between a low and high-risk situation (Statham 2008).

While this example describes a real-time, qualitative risk analysis based on descriptive, field observations, Jamieson and Jones (2012) show how to calculate and compare risks by quantifying these same components. Despite differences in data and methods, the risk-based concepts are the same.

When avalanche professionals and recreationists alike learn to deconstruct and analyze different scenarios using the components of risk, their understanding of the risk and how to manage it is greatly enhanced, and their practice becomes aligned with widely accepted risk frameworks.

4. APPLICATION TO EDUCATION, PRACTICE AND COMMUNICATION

When people understand what contributes to risk, their role in each scenario, and how they can influence outcomes, their decision making improves. Their fluency in learning, doing and talking with others about avalanche risk becomes a natural part of their everyday practice. When someone can easily explain their decisions and actions using conventional risk language, they demonstrate the depth of their understanding. In order to reach this level of insight, individuals and organizations who work with avalanche risk need to explicitly bring risk-based thinking to the centre of their systems.

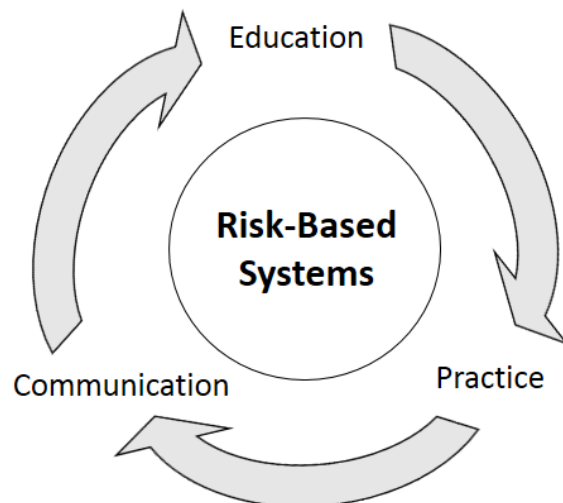


Figure 4: Risk-based systems are at the core of avalanche safety education, practice and communication.

Education is where this starts. Framed around risk, avalanche education teaches the fundamentals of how to deconstruct scenarios and tie them into a risk framework. Once this foundation is established, people's day-to-day practice becomes guided by risk-based thinking, and when combined with workplace or recreational systems that are similarly risk-based, a natural fluency emerges. From this fluency comes an ease of communication, grounded in consistent risk terminology and scaled to meet the target audience. Figure 4 illustrates this continuous loop of education, practice and communication centred around risk-based systems.

5. SUMMARY

Avalanche safety systems have for years been developed to meet specific industry needs, using logical and effective methods, but often without explicit links to a broader industry framework. This has resulted in systems that sometimes appear disjointed, when in fact most of them can be easily linked to the universal concepts of risk. Historically, risk has been presented as a complex phenomenon, which is true in some cases, but the perceived complexity of avalanche risk can be reduced down to two basic questions:

1. What is the chance that an avalanche will occur?
2. If it does, what will happen?

This is probability and consequence in its rawest form and is the premise of any avalanche risk assessment. The concept of vulnerability forces a detailed understanding of the element-at-risk,

while exposure anchors everything to its position on the ground. Taken together, these concepts offer fertile ground for common language, and a better understanding of avalanche risk for everyone.

6. ACKNOWLEDGEMENTS

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