Snow Science and Safety for the Mountain Guide

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ABSTRACT

The safety of people in a winter, backcountry mountain environment is presented in terms of margins of security and margins of survival. The elements of a security determination are expanded on assessments of snow stability, hazard, and risk. Processes of reasoning by mountain guides in light of many uncertainties are outlined. Risk management is treated in terms of human psychology. Finally, tools affecting margins of survival are put into context with recent results of risk homeostasis theory.

INTRODUCTION

A mountain guide is “one who the way…by reason of…greater experience with the course to be pursued.” The profession of guiding is both an art and a science. The question, vigorously debated at time, is how much is art, and how much is science. The challenge, for practicing guides, is to merge elements of art and of science in their work.

In exercising one’s duties as a guide, the overarching consideration is the safety and enjoyment of the client(s). This paper presents a conceptual framework for safety determinations by guides on behalf of clients. Contributions from snow science are indicated, and scope for further research is presented, in the spirit of merging theory and practice.

SITUATIONAL SAFETY, SECURITY AND SURVIVAL

Safety is freedom from danger, risk or injury. Mountain guides consider safety in a situational context. The act of guiding consists of linking a sequence of dangerous situations which deliver enjoyment to the client(s). Consideration of safety for each situation necessitates a sequence of cognitive processes: the perception of danger attendant to the situation, the assessment of hazard in light of uncertainties, and the management of risk by free choice. Let us call this cognitive sequence the security determination. Guides navigate through dangerous situations with the security determination as a compass. Perception of danger is not exact, nor are cognitive processes precise. The security determination for any situation is fraught with uncertainties. It does not necessarily correspond to the anticipated safety of the situation, which is why an 'accident' could occur. In the event of a mishap, further survival measures come into play. These may influence overall safety, depending on outcomes. The anticipated safety margin is dependent on the margin of security that is determined and the anticipated margin of survival that would arise with a mishap:

Anticipated Margin of Safety = Margin of Security x
Anticipated Margin of Survival.

MARGIN OF SECURITY

Danger, Hazard, Risk

Snow avalanches constitute the greatest danger to people in a winter, backcountry mountain environment. Other dangers, such as treewells, crevasses, or effects of the harsh environment are not considered here. The danger due to avalanches in a given situation begins with the stability of the snowpack. Snow cover distribution, and thus snow stability, varies widely with terrain. Snow instability is defined as the probability of avalanches starting. A snow stability rating scale defines generalized categories for stability assessments, which are applied over relevant domains.

Avalanche hazard refers to exposure of people or property to the probability of avalanches starting. Exposure also varies widely with terrain. Uncertainties in the probability of avalanches starting compound with uncertainties in the extent of people's exposure to it. Hazard is an order of magnitude more complex to estimate than stability. A rating scale for generalized hazard assessments applies over larger domains or to fixed points in a domain, such as permanent structures, whenever exposure is kept fairly constant.

Avalanche risk refers to the consequences to people or property of exposure to the probability of avalanches starting:

Risk = Consequences x Exposure x Probability of Avalanches Starting

= Consequences x Hazard.

Uncertainties in the anticipation of consequences compound with previous uncertainties, so that risk assessments are third order in complexity. To be meaningful, a rating scale for risk must keep two of the three variables fairly constant.

Anticipating Danger, Hazard, Risk

Ski guides conduct numerous experiments, within the guidelines provided by snow science, and generally with a minimum of resources, to determine a stability rating relevant to the program. Snow science develops and refines tools for observation and methods of analysis. While this ongoing effort contributes to a reduction of uncertainty in the assessment of the probability of avalanches starting, a residual element of uncertainty will always remain. Guides conduct a sufficiently comprehensive and reasonable first order analysis of stability, using processes of reduction and deduction in their reasoning, and then they must proceed in the face of uncertainty. Where snow science conducts experiments and performs analysis from an external perspective, guides take their clients and step into the experiment!

Second order hazard assessment for a given situation involves terrain as it affects stability intertwined with terrain as it affects exposure of the guided group in the situation. At this level of complexity, the terrain-dependent variables that interrelate to influence both stability and exposure of people, with their associated uncertainties, begin to blur in human perception. Further investigations to deduce or reduce uncertainties are often bounded by resource constraints or are simply not possible. Processes of induction apply to a learning curve. Guides look for common themes and begin to think in terms of patterns, relating these patterns more and more subconsciously as the complexity increases. Experience enters by providing a greater number of patterns to draw on. Intuition enters by virtue of subconscious processes.

Observations of patterns of natural avalanche activity going into any situation give the best baseline. Relating patterns of snowpack evolution and distribution to patterns of natural activity over time is probably the most valuable database a guide can have. Powers of observation and a memory that captures images are crucial attributes of good guides. This begins to explain why those with a rudimentary education, minimal snow-technical skills and limited analytic capabilities can function very effectively in the mountains. Where snow science can make a significant contribution is in providing better tools for the capturing of images and the recording of patterns of natural activity, snowcover distribution and snow stability. With the advent of GIS, methods of analysis on a relational database offer the potential to augment pattern recognition processes that bump up against the limitations of the human brain.

Having stepped into the experiment, guides and their clients then roam about and become the experiment!! Third order risk assessment again involves terrain as it affects consequences interrelated with hazard assessment in the static case, but there is now the additional element of free choice in how terrain is managed and in how much risk is accepted. The majority of avalanches involving people are initiated by the people themselves. The exercise of choice becomes the crucial component.

The task of interpreting or explaining a specific pattern of observations is known as abduction. Guides begin to think in terms of scenarios. They take the patterns from hazard assessment, link them as still frames of a moving picture on the terrain, and then run that movie forward in time to anticipate consequences. Cognitive processes become ever more intuitive. The influence of snow science diminishes; methods of probabilistic reasoning and the science of psychology increasingly apply.

The trick throughout is to simplify: each situation is reduced to its most basic component situations and dealt with in causal sequence. Input factors are screened so that only the most relevant need to be considered. These are filtered, weighed by relevance to the situation, prioritized and dealt with accordingly. Uncertainties are translated into levels of non-confidence; those for which there is lowest confidence become prime subjects for more extensive discussion. The process is iterative to identify and reject redundancies and inconsistencies.

Guides tend to ignore most of the good, and focus on what is bad, to reduce the volume of things requiring consideration. That could explain why veteran guides are often crusty, skeptical codgers who speak up only in the negative! They contribute to stability, hazard or risk assessments by telling stories of their (bad) experiences, relating a series of images, patterns or scenarios to the less experienced. Left-brain guides who are linear, analytic thinkers are quickly mired in uncertainty, and frozen into inaction, unless they make increasingly radical assumptions. Right-brain, kaleidoscopic thinking lends itself more

readily to the challenge. It is beautiful to behold in others – like fireworks in the night sky – but difficult to follow or to understand in one's own brain. Rather than being clearly communicated, these processes are increasingly shared as joint experiences; they leave the domain of science and enter the realm of social interaction and of art.

Managing Risk

The essence of risk management is to weigh uncertainty against possible gain, to make decisions, and then to take action. The assessment of risk is rife with uncertainty. The possible gain is a subset of human expectation.

At the outset, expectations need to be defined. A guide aims to deliver safety and enjoyment to the clients; they in turn expect both. Safety and enjoyment often pull in opposite directions: in a heli-ski situation they can (and generally do) vary inversely.

The conventional approach in business situations has been to try to minimize uncertainty and to maximize gain. Call it a risk/reward ratio or a cost/benefit analysis, the standard effort is to drive risks (costs) down and bring rewards (benefits) up. More recently, management theorists have begun to acknowledge that this approach is not ideal for the health of the business in the long term.

Guides, managing risks on behalf of clients, are conducting a business. They must first align their own expectations of safety and enjoyment with those of their clients. Then, rather than applying a maximum/minimum analysis to risk, they need to seek an optimum solution.

Insofar as risks can be perceived, control can be exercised over them. The degree of control corresponds with the extent of perception. Control takes the form of avoidance, mitigation, or conscious acceptance in the choices that are made.

Where the risks are not perceived, the de facto choice is tacit acceptance; one cannot avoid or mitigate that which is not perceived. The choice is purely to anticipate unperceived risk as intrinsic to the situation, without recourse to further assessment. Tacit acceptance of unperceived risk simply acknowledges its existence – and implicitly accepts the potential consequences – without further knowledge. This so-called residual risk is pervasive in the background of any mountain guiding situation.

Where the risks are perceived, there is a degree of freedom of choice in the form of control corresponding to the acuity of perception. If the ramifications of hazards appear inconsequential, then these are consciously accepted as a threshold value: the so-called acceptable risk. If the anticipated consequences appear unacceptable, the risks are nullified by avoidance. Hazards for which the consequences seem negotiable, in the sense that uncertainty can be weighed against possible gain, are optimized by mitigation.

In exercising their free choice, guides are continuously determining margins of security through a sequence of situations. Allowance must be made for human error, and given the threshold value of acceptable risk over a background of residual risk, provision must be made for an accident.

MARGIN OF SURVIVAL

Shovels, probes, transceivers, avalanche balloons, etc. are tools to enhance margins of survival in the event of an accident. Similarly, rescue plans, procedures, and training enhance chances of survival through the improved capabilities of people to respond to the accident. Snow science develops and refines rescue tools and methods which continuously improve the chances for people caught in avalanches. Guides are equipped with a compliment of tools relevant to the situation, and they are highly trained in appropriate procedures.

While these tools and procedures have a direct influence on margins of survival, they also have an indirect influence on margins of security. Here is where psychological factors really come into play. In anticipating consequences, there is a feedback effect from the margins of survival that are put in place to the margins of security that are being determined. Armed with all the high-tech gadgets and backup, the brain's defenses tend to come down. Unarmed and alone, one's guard definitely goes up. As Werner Munter says: "High-tech, low brain; low-tech, high brain"!

RISK HOMEOSTASIS THEORY

"*Risk homeostasis theory* maintains that, in any activity, people accept a certain level of subjectively estimated risk to their health, safety, and other things they value, in exchange for the benefits they hope to receive from that activity (transportation, work, eating, drinking, drug use, recreation, romance, sports or whatever).

"In any ongoing activity, people continuously check the amount of risk they feel they are exposed to. They compare this with the amount of risk they are willing to accept, and try to reduce any difference between the two to zero. Thus, if the level of subjectively experienced risk is lower than is acceptable, people tend to engage in actions that increase their exposure to risk. If, however, if the level of subjectively experienced risk is higher than is acceptable, they make an attempt to exercise greater caution.

"Consequently, they will choose their next action so that its subjectively expected amount of risk matches the level of risk accepted. During that next action, perceived and accepted risk are again compared and the subsequent adjustment action is chosen in order to minimize the difference, and so on."

"The term 'homeostasis' does not refer to a fixed and invariable end result, or to an immutably fixed state of affairs, but to a particular kind of dynamic process that matches actual output to a target."

With these words, and the supporting analysis in his book *Target Risk*, Gerald Wilde has captured the essence of what guides do when they seek, by mitigation, an optimum solution in the negotiable realm of hazards and anticipated consequences. His findings challenge the conventional "Triple E" wisdom that better engineering (tools for stability assessments and for survival), better education (methods of stability and hazard analysis and of rescue), and more enforcement (pre-programmed assessments or decisions) necessarily result in better safety. The concept of an individual's motivation in setting a target for risk is the most relevant to safety of all.

ACTUAL MARGIN OF SAFETY

A guide will never know the actual margin of safety going into any situation, only the anticipated one. And at the end of the day, a guide will never know how safe the program actually was. If there was no mishap, then actual safety was as uncertain as the uncertainty in targeting a level of risk:

Actual Margin of Safety = Anticipated Margin of Safety x Margin of Luck.

If there was an accident, then actual safety was as uncertain as the margin of survival:

Actual Margin of Safety = Anticipated Margin of Survival x Margin of Luck.

CONCLUSIONS

Snow science provides and refines tools for observation and experiment, methods of stability analysis, and tools and procedures for survival. Current research opportunities for snow scientists abound in hazard analysis on the terrain and database structures for the collective experiences and accumulated learning of guides. But such efforts will not necessarily result in better margins of safety. Truly exciting opportunities arise with the application of risk homeostasis theory and risk analysis using principles of probabilistic reasoning. Beyond that, guides need a healthy dose of psychology and sociology, an appreciation for art and beauty, and – oh yeah, almost forgot – a modicum of luck!

REFERENCES

The American Heritage Dictionary of the English Language. 1970. American Heritage Publishing Co., Inc., New York, 1550 pp.

McClung, D.M. and Schaerer, P.A. 1993. *The Avalanche Handbook.* The Mountaineers, Seattle, 271 pp.

Wilde, G.J.S. 1994, *Target Risk.* PDE Publications, Toronto, 234 pp.

Pearl, Judea. 1988. *Probabilistic Reasoning in Intelligent Systems: Networks of Plausible Inference.* Morgan Kaufmann Publishers, Inc., San Fransisco, 552 pp.

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