PERCEPTION OF RISK IN AVALANCHE TERRAIN

Krister Kristensen[1], Manuel Genswein and Werner Munter

[1]Norwegian Geotechnical Institute, Oslo, Norway

ABSTRACT: Although avalanche training and the risk minimization strategies have greatly evolved and are being widely taught to recreational and professional users, too many serious accidents continue to happen within the educated user groups. Whereas misinterpretation of the hazards as well as the complexity and uncertainty of hazard assessment are potential causes for such accidents, a faulty perception of the probabilities of accidents and their implications might be a more important factor, in particular with trained user groups.

Although absolute numbers of terrain users and accidents can only be estimated, it is reasonable to assume that the case fatality rate of recreational activities in avalanche terrain has decreased considerably over the last 30 years. Despite all these efforts and the higher level of awareness, the pattern in the remaining accidents in many countries remains the same. The key to the reduction of future accidents might not be in increased investments within the traditional fields which are already part of avalanche awareness and training in most countries, but a higher level of awareness on how to interpret the probabilities and potential consequences. This calls for a higher level of understanding on how low-probability / high consequence events can to be transformed to real life decision-making. Comparisons with activities including similar case fatality rates are not easy as there are only few activities with so few regulations left as in mountain sport activities. Furthermore, different utility functions within user groups influence the risk behavior. Finally we suggest ways of dealing with risk perception in curricula for avalanche courses.

KEYWORDS: Avalanche, risk perception, education

1. INTRODUCTION

Avalanche accident prevention work has improved markedly the last few decades; many of the methods we have available today are quite sophisticated. These include both regional avalanche forecasts, as well as decision support systems for the local level like the “reduction method” (Munter, 2003), its many derivates and similar approaches. In addition, methods for consequence reduction like efficient rescue systems and personal protection equipment such as floatation devices have also developed significantly the last decades and they are in common use. Regarding preventive measures, it seems as if most of the low hanging fruit have been picked by now. Further significant developments in forecasting, snow stability test methods, consequence reduction measures, a.s.o. will probably neither be easy nor come cheap.

Still, quite a few winter trips with experienced winter mountain users end in fatal avalanche accidents (e.g. Atkins, 2000). One can ask why this is the case, especially when most of the accidents occur under conditions where the avalanche hazard is rather obvious according to the methods used and taught today (McCammon, 2004).

Today most mountain users can assess the probability of avalanche release reasonably well and the potential consequences are often possible to guess by considering the terrain features, a.s.o. The chances of being “fooled by randomness” regarding snow pack stability is always present of course (see Munter, 2001) and this is important to point out. But the inherent randomness does not explain the high number of accidents in obviously hazardous situations. If we regard the exposure to the potential hazard of avalanches as a conscious choice, then today’s fatality rates among experienced winter mountain users are maybe something that actually reflect the risk levels that is considered acceptable by these peo-

**Corresponding author address:* Krister Kristensen, Norwegian Geotechnical Institute- Stryn. P.O. Box 236, N-6781 Stryn Norway. email: kkr@ngi.no

ple. Thus they may be just the result of a utility maximization among the winter mountain users - the personal benefit of being in the mountains is worth the cost in terms of a certain probability of dying in an avalanche.

The underlying assumption is of course that people behave in a rational manner and that they weigh relevant information before making a decision. However, numerous psychological studies have shown that this is often not the case (not even in economics where the methods are well established).

In this paper we would like to focus on the winter mountain skiers that may take high risks without being aware of how real the potential of a negative outcome is. That is, people who would, given the right kind of information and framing, choose to be compliant to the recommendations of the available risk calculation methods.

2. DISCUSSION

Benefit

In life, nothing is achieved without taking risk. A rational agent takes risks when the expected utility value is sufficient. All things being equal, the greater the benefit, the greater the tolerance for a risk. Although individual risk tolerance varies, society will sometimes determine what is acceptable in the form of legislation and regulations, but these commonly lack any quantification and are open to interpretation. It is sometimes argued that the present accident statistics reflect society's risk acceptance, but often this cannot be said to be the case since considerable effort is done to reduce the number of accidents.

Utility functions are of course also subjective and individual. Some really do want lives that are "intense and short". But most probably do not. Research in psychometrics (Slovic, 2000) has shown that risk perception is more dependent on experience and emotions, than a realistic assessment of probabilities. When asked directly, people generally had lower risk tolerance than what was reflected in societal risk.

If there are flaws in the general perception of risks, then this should be addressed if we want to reduce the number of fatalities further. A main problem with the perception of risks seems to be the ability to translate the abstract probabilities into personal life consequences. In particular regarding trained user groups, it seems that a flawed perception of the probabilities of accidents and their implications might be the most important factor.

Probabilistic reasoning

Probabilistic reasoning has been called "The Achilles' heel of Human Cognition" (Stanovich, 1992). Experiments of gambling have shown that people are notoriously bad at evaluating probabilities, especially when the feedback is slow or infrequent. A now well known finding was that people use more often heuristics to evaluate information. Being useful shortcuts when quick decisions are called for, they often lead to faulty judgments of the probability of something happening and they can become dangerous cognitive biases (Kahnemann, Tversky, 1979).

Another problem is that the chance of releasing an avalanche in a specific slope is a *single event probability*. But the human mind may have evolved to think of probabilities as relative frequencies in the long run, not as numbers expressing confidence in a single event (Pinker, 1997). It can be claimed that single event probabilities in principle cannot even be handled by probability theory, since the single event will have it's very own specific features. Gigerenzer (2000) suggests that people often retort to non-quantified definitions of probabilities like "degree of belief" and terms like "weight of evidence" and "reasonable doubt". A reason for this may of course be that reliable frequency data are often hard to come by or apply to a specific situation.

Formal probabilistic reasoning is a fairly recent invention. Even more recent is the possibility to input high quality data gathered and checked by teams and institutions to the formulas for probability. This is a big step from the hearsay and rumors that our ancestors had to rely on - and using only one's own experience from accidental avalanche releases a as base for frequency assessments, obviously have large disadvantages.

Using numbers to describe the probability of a single event, are commonplace nowadays: weather forecasters use them every day in messages to the public about what percent chance of rain there will be tomorrow. The probability of rain at a specific location, or for a single avalanche release, can never be exactly determined as many of the individual input variables cannot be precisely determined. Therefore, in this paper, probability refers to relative frequencies in the long run (mean values).

Risk tolerance

Many attempts have been made to regulate societal risk tolerance. A Tolerable Risk (TR) framework has for example been suggested by the British Health and Safety Executive (HSE) during its work on the safety of nuclear power plants (Scarlett et al., 2011).

The HSE has based risk thresholds on risks commonly accepted by the public, such as the risk of death from rock climbing, high risk professions, and traffic accidents (HSE, 1992). The HSE determined that the highest level of risk the general public would bear in order to receive some benefit was roughly 1 in 10,000 (deaths per year), corresponding to the highest mortality rate in the average population (for 15-25 year old males). Risks with a chance of less than 1 in 1,000,000 (deaths per year) were generally considered by the public to be inconsequential (HSE, 2001). The region in between is then considered tolerable, although not immediately acceptable.

Lifetime risk

In the book "3x3 Lawinen" (Munter, 2003) and in other forums, the author discusses the case fatality rates of winter mountain skiing. An estimate of the ski tour case fatality rate (avalanche accidents) in Switzerland in the 1980-ies corresponds to about one death in 36000 ski touring days. A high number of tours per winter (i.e. exposure) with this case fatality rate could easily enter into the unacceptable region if one would use the HSE Tolerable Risk (TR) framework for annual fatality rates. A use of 1/100000 as a base rate for winter mountaineering seems nevertheless reasonable (Munter, 2008). Compared to other risks this can still be seen as rather high, but it can be seen as *the price that we must pay for the freedom of the mountains.* (Munter, 2008).

Legal cases concerning risk and negligence are often complicated, and outcomes can be unpredictable. If we want to prevent arbitrary judgments in court, it is important to define reasonable risk thresholds in winter mountaineering.

It is possible to apply these thresholds to the framework of the Reduction Method (RM). The method is based on the assessment of five key variables; general danger level, slope inclination, slope aspect, previous skiing and load, which are weighted and integrated (Munter, 2003). In short the weighted general danger rating is divided by the product of at least three weighted observations from different levels: regional, local and slope (on site level).

The risk level is expressed as an RM-value, which in principle can be any number from 0 to 32. Analyses of the Swiss accident data from the 1980-ies imply that an RM of 2.2 corresponds to the accident rate of this particular period, while an RM of 1 corresponds to the suggested acceptable case fatality rate of 1/100000.

The term "Limits" was introduced by Munter (2003) to define a maximum reasonable risk level, akin to "The Stupid Line" used by Tremper (2007). This corresponds to an RM level of 2,

Table 1. The probability of a fatal accident as a function of exposure. Typical exposures are assumed for the categories of users.

User Group	Exposure	Sum of activity days in a lifetime	Case fatality rate at RM 1	Case fatality rate at RM 2	Case fatality rate at RM 4
			Risk Profile		
			Rewarding, with minor limitations, and a reasonably long life	Close to the limit (*"Limits"*)	Intense, but short life
Active freeriding	50 day per season / 15 years	750	1 in 130	1 in 65	1 in 30
Active ski touring	20 days per season for 50 years	1000	1 in 100	1 in 50	~1 in 25
Very active ski touring	50 days per season for 20 years, followed by 30 days per season for 30 years	1900	~1 in 50	~1 in 25	~1 in 12
Professional Mountain Guide	100 days per season for 20 years, then 30 days per season for 20 years	2600	~1 in 40	~1 in 20	~1 in 10

or a fatality rate of 1 in 50000 ski tours, i.e. close to the historical fatality rate from the 1980-ies. RM=4 stands for the average residual risk which had been taken in multiple fatality accidents in Switzerland in the 1980ies with 5 and more fatalities. This is equal to a case fatality rate of 1:25000. Munter suggests to keep the activities whenever possible to RM smaller or equal to one and to use the extended range of motion given by RM=2 (Limits) only in special situations under special circumstances. For novice users, the elementary reduction method targets for RM=0,5 to allow for extended error tolerance. However it has to be understood that these residual risk values always represent a mean value due to uncertainty in determining the input variables of the reduction method. For RM=1, the case fatality rate in a single event may have a stray effect between 1:50'000 and 1:200'000 which is equal to a factor two error. Higher error factors are unlikely.

With this approach it is possible to conveniently visualize the accident probabilities for different categories of mountain activities. Table 1 shows the probability of a fatal accident during the period in life in which they are pursuing their activity, when estimates of typical exposures are assumed.

It is natural to strive to get the most out of one's chosen activities, without being subject to unacceptable risks and a likely early death.

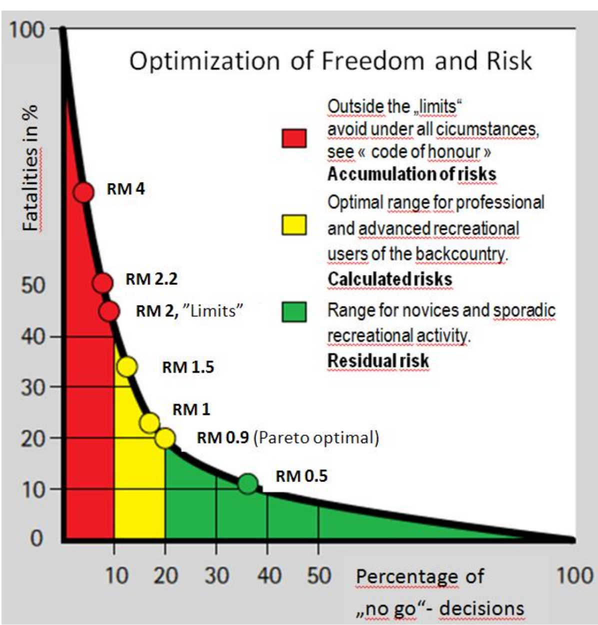

Figure 1. The relationship between fatality rate and the percentage of "no go" situations

A long term study over 5000 guided touring days of the DAV Summit Club (source: Peter Geyer) shows retrospectively that the mean risk of all activities when respecting RM <=1 corresponds to RM=0.8. A reduction to the risk profile to RM 1 for most users therefore seems feasible and an acceptable restriction of freedom, versus the benefit of a longer life as a ski tourer.

This corresponds to green area of the curve graph (Figure 1) suggested by Munter (2008) on the relationship between fatality rate and the percentage of "no go" situations. Further reduction of the case fatality rate is possible, but only at the cost of an increasing number of missed tour opportunities. The percentage of the backcountry users who are willing to comply to the proposed rules of behavior would probably also decrease markedly.

3. CONCLUSION AND SUGGESTIONS

With today's state of the art, a knowledgeable mountain skier, guide or group leader will be aware of the well known cognitive biases that influence decision making. The problem may be an understanding of what the probabilities of fatal accidents actually means for the individual.

A way of countering the tendencies of unreflected high risk behavior could be to introduce a "Code of Honor", that states that professionalism should be valued more than perceived heroism (that most likely is just a consequence of luck) and includes these invariable rules:

Elementary precautions:

- Always carry a probe, shovel and transceiver
- Heed alarm signs*
- Keep distances in case of doubt

** Whumph noise, recent avalanching, remote triggering. Each of these should be considered a stop criterion and a search for gentler terrain.*

Respect the Limit RM < 2*:

- Avoid terrain of <30° at danger level *High*
- Avoid terrain of < 40° at danger level *Considerable*
- Avoid untracked terrain of < 40° within sector North at danger level *Moderate*

** for more details, see Munter, 2003.*

Other measures that we feel should be discussed are the following:

- Risk Classification of tour routes*. Tour route descriptions should preferably include a risk category (and not just the technical difficulty). This will require some sort of universal risk classification scheme

  ** Promising work has already been done regarding this item by the Canadian Avalanche Association in their avalanche terrain classification scheme (Campbell, 2010). This could be expanded to include a general description of a typical risk exposure.*

- Develop simulation training set up with fast feedback. (The lack of fast feedback prevents internalizing of objective risk perception).

- Reframing the activity in a way that is prevents loss aversion and other bias (e.g. the tour is the goal, not necessarily the summit).

4. REFERENCES

Atkins, D. (2000). Human factors in avalanche accidents. Colorado Avalanche Center. Boulder, Colorado.

Campbell, C., Marshall, P. 2010. Mapping Exposure to Avalanche Terrain, 2010 International Snow Science Workshop

Canadian Avalanche Centre, Revelstoke, British Columbia

Fritzsche, A.F. 1992. Wie gefährlich leben wir? Verlag TÜV Rheinland, Köln 1992

Gigerenzer, G., Todd, P. M., ABC Research Group (2000) Simple Heuristics That Make Us Smart

HSE United Kingdom Health & Safety Executive. (2001). Reducing risks, Protecting people. Norwich: Her Majesty's Stationary Office.

Kahnemann, D., Tversky, A. 1979. Prospect Theory: An Analysis of Decision under Risk. Econometrica, 47(2), 263–292

McCammon, I. (2004). Heuristic Traps in Recreational Avalanche Accsidents: Evidence and Implications. Avalanche News, No. 68.

Munter, W. 2003. 3x3 Lawinen. Risikomanagement im Wintersport. Dritte Auflage. Pohl& Shellhammer

Munter, W. 2008. Auf der Suche nach dem Gleichgewicht. 4/08, bergundsteigen 4/08

Munter, W. 2011. Und Gott würfelt doch (But God *does* throw dice), bergundsteigen 4/11.

Pinker, S. 1997. How the Mind Works (Norton, 1997)

Scarlett, L., Linkov, I., Kousky, C. 2011 Risk Management Practices. Cross-Agency Comparisons with Minerals Management Service. Discussion Paper. Rescources for the Future, Washington

Slovic, P., ed. 2000. The Perception of Risk. Earthscan, Virginia. 2000.

Stanovich, K., 2004 How to Think Straight About Psychology

Tremper, B. 2007. Staying Alive in Avalanche Terrain. The Mountaineers Books: Seattle.