ABSTRACT:

Ski cutting is a snow stability test that avalanche risk management professionals may apply for the purpose of either observing snow pack structural failure sensitivity or initiating snow avalanches for the purpose of hazard reduction and risk control. In its practice ski cutting is the merger of prediction of events and their character to the actions of practitioners moving within avalanche terrain. Hazard encounter probability is at the core of decision making within this practice. Key risk indicators from observations and evidence available from avalanche character, terrain character and human behaviour may be utilized to control risk in the practice of this activity. This paper is about supporting decision making and appropriately aligning the actions of avalanche professionals that are engaged in skier controlled avalanche release work as a means to controlling risk.

KEY WORDS: ski cutting, hazard reduction, risk control, encounter probability, key risk indicators

1. INTRODUCTION

Skier controlled avalanche release (ski cutting) work is unique in that it involves deliberate positioning in terrain by technicians to test for and initiate snow avalanches. In order to conduct this work safely decisions must consider avalanche hazard, terrain and vulnerability as related to actions by technicians. Decision making in this practice is supported through environmental observation, direct evidence and deliberate behaviour which can all act as indicators to higher risk for practitioners. Awareness of key risk indicators may not only assist technicians in managing risk within the act of ski cutting but they may also indicate conditions where exposure from this practice is not appropriate.

2. AVALANCHE HAZARD

“Avalanche hazard is the potential for an avalanche (s) to cause damage to something of value. It is a function of the likelihood of triggering and the destructive size of the avalanche (s)” (Statham, 2008). An important concept in ski cutting is understanding that avalanche hazard is not a static value that applies uniformly through terrain or across an avalanche path. While hazard may be defined according to the likelihood of triggering and the destructive size of an avalanche the characteristics of the avalanche’s initiation, propagation and flow through the terrain will result in variations of potential to cause damage. This perspective is essential to conceptualize how technicians can safely enter avalanche terrain that may have avalanche hazard within it.

This idea is supported by the variables that contribute to destructive potential. “The destructive potential of avalanches is a function of their mass, speed and density as well as the length and cross-section of the avalanche path” (McClung and Schaerer, 1981). Avalanches as they occur will obtain momentum, may entrain mass, have their flow adjusted by shape within the terrain and will eventually decelerate and stop. All of these stages across the flow boundaries of an avalanche path will have variations in destructive potential. It can be argued that terrain that observes the greatest amounts of mass with the highest degrees of
momentum will typically experience the greatest destructive potential from an event. These areas are typically within the track or run out zone of a path.

In the case of ski cutting, hazard is applied to the context of a worker entering terrain that is within or in close proximity to an avalanche starting zone. It is purposeful that the act of ski cutting positions the technician within the probable initiation zone of the avalanche as it gives them the best opportunity to avoid the consequences associated with an events related hazard. In ski cutting practice hazard estimation is not confined to just likelihood of triggering and destructive size but must also consider terrain modification to avalanche initiation and flow. This point is very important in considering vulnerability estimation as well as exposure relative to planned behaviour. These points ultimately allow an analyst to estimate encounter probability and destructive potential relative to a person.

3. ENCOUNTER PROBABILITY

In ski cutting prediction of avalanche character within terrain is considered according to a person’s planned behaviour. Where a technician plans to position themselves and how they will approach their movement through the terrain is the primary strategy for managing their probability of exposure to the avalanche hazard. The key is aligning behaviour strategy to avalanche initiation character in a way that supports hazard avoidance. Precision in this process obviously presents challenges that are compounded by terrain as the snow pack may become modified over space and time, a condition that practitioners have come to know as spatial variability.

Ultimately decision makers in this practice are tasked with making a probability decision that a certain action will result in a certain outcome. John Haigh defines probability as “the study of the notion of uncertainty” (Haigh, 2012). Reducing and recognizing uncertainty in decisions that carry consequences (such as ski cutting) may improve the predictability of outcomes when certain actions are being considered. The main strategy that technicians employ on these grounds is deliberate positioning through prone avalanche initiation features and less exposed positions within the terrain. If the avalanche character is estimated correctly this strategy gives the technician the greatest chance to initiate the event and maintain their positioning there by avoiding hazard and controlling their risk.

4. UNCERTAINTY AND ASSESSMENT

Accurate prediction of how snow failure will occur according to actions within terrain obviously involves much uncertainty. Terrain and its ability to modify a snow packs structure over space and time may present wide variations in avalanche characteristics that may draw unaware practitioners into positions where hazards encountered may result in severe consequences. As a result, analysts who are making decisions about the suitability of ski cutting as a practice on behalf of others must ensure that their decisions are well supported and are appropriately conservative in order to acknowledge the potential uncertainties linked to both their assessment and consequences associated with their directives.

Avalanche risk assessment typically follows an updating pattern, where observations and evidence may continually adjust an initial hypothesis regarding the hazard condition. As a risk management approach analysts who frame their initial assessment as a hypothesis and offer probable modifiers to their theory may better prepare workers to adjust both decisions and actions once they are actively managing their own risk in the terrain. A question from this approach: Are there observations that may be key risk indicators within the decision making process that correlate to greater risk for technicians practicing ski cutting?

5. RESEARCH & OBSERVATION SUMMARY

In order to examine this question I reviewed a series of incidents within a lift access ski area operation. The data series involved 10 events where workers involved in the act of skier controlled avalanche release became directly involved in the event that they or a nearby co-worker initiated. The events were examined and compared in terms of avalanche character,
terrain shape and technician behaviour and outcomes.

An examination of the data showed the following.

100% of the sample had a release type as slab. Seven events classified the slab character as hard meaning that considerable effort was required to bring the technicians ski penetration to the same level as the failure plane. Of the 3 events that observed a soft slab, all cases noted over 25mm of water equivalency and showed a reduction in density in depth relative to the failure plane. Four events from the sample involved wind slab which did not correlate to study plot surface densities that all ranged near 100 kg/m³ (in the range of 4 finger resistance).

The stability test referenced is the tilt block shear and in all cases but one showed the key shear observed in the moderate range. Only 2 events linked an old problem at the failure plane interface citing faceted and surface hoar forms at the failure level. All other events cited a preserved or decomposing precipitation type particle, most notable stellar type forms sized 3mm or greater.

In examining terrain character 6 of the events showed starting zones as unsupported in shape meaning initial convex areas led into gullies or short planar slope features that then had additional convex areas within their slope runs. In relation to wind 6 of the events occurred in typically cross loaded terrain features and 4 of events could be linked to accumulation features such as cliff bases (spill zones). Three of the events involved horizontal concave shape where the technician’s momentum was arrested and subsequent avalanche initiation resulted in capture.

In terms of technician actions; in all cases chosen trajectories into terrain features were below the crown fracture axis and as a result involved snow slab mass over-running the technician’s position or carrying the technician downslope. 6 of the events involved the loss or removal of equipment by the technician in the avalanche and 1 event involved complications due to inability to void ski poles. Communication emerged as a factor in all events observed and demonstrated incident contribution through acts including congestion of hazard areas, unclear directives, under-estimation of vulnerability and underestimated degree of hazard. 100% of the events involved the technician making attempts to decelerate, accelerate or otherwise escape capture. Minor injuries were the most severe reported.

6. ANALYSIS AND RECOMMENDATIONS

It is noted that the sample reviewed offers a very small and singular operational view to the question of identifying key risk indicators related to ski cutting work. Based on this point observations offered are more intended to base points for discussion amongst avalanche safety team members rather than offering specific exact variables.

In considering avalanche characteristics slab type conditions where hardness and failure plane nature support propagation are key risk indicators. Included within slab type attention should be given to slab hardness, density variation and water equivalencies that link greater than 25mm into the slab being managed. Affects from wind should also be a key risk indicator especially if initial assessment values for new snowfall suggest lower density values.

Observations from terrain examined suggest cross loaded areas and snow mass accumulation areas offer greater risk. Terrain shapes that promote technician capture may include concave horizontal axes and repeated convex patterns within a slope run. All of these points are made in relation to the previously noted avalanche characteristics.

In terms of technician behaviour ski cutting trajectories should align to the expected crown fracture propagation axis in both direction and elevation within a starting zone. Entrapping equipment should be managed in a way that it is removable but also in support of escape strategies. Effective communication and functional working relationships between all team members are of vital importance. Monitoring of objectives, ensuring clear directives, avoiding congestion in high exposure areas and recognizing safe working limitations are all
considerations for effective risk management in this practice.

7. CONCLUSION

Ski cutting is a dynamic and complex job requiring focus and attention on the mountain environment. While the objective may be to test snow stability or initiate avalanches the priority within the activity must always be personal safety.

Managing risk in ski cutting requires decision makers to make probabilistic conclusions about snow mechanical behaviour in accordance to deliberate actions which involve exposure. Vulnerability estimation is a critical component to decision making and requires a spectral view of hazard that combines avalanche character in all of its stages in relation to terrain.

Encounter probability is attempted to be managed but involves extensive uncertainty which must be addressed through operational approaches that promote identification of heightened risk indicators over that of directives focused to task completion.

Recognition of key risk indicators and management that promotes active discussion and conscious behaviour relative to assessed avalanche hazard, terrain, exposure and vulnerability is ultimately what can support encounter probability decision making in the practice of ski cutting.

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9. REFERENCES

