AVALANCHE CLOSE-CALLS DURING COURSES – WHAT CAN WE LEARN?

Steven M. Conger[1]*

[1]Snow Knowledge, Golden, BC Canada

ABSTRACT: This paper and its associated poster present a study of avalanche close-calls or incidents that have occurred during field sessions in a formalized avalanche course setting. The research was undertaken through a survey to collect, collate, and analyze commonalities of actual avalanche risk scenarios during both recreational and professional avalanche courses. The information was reviewed and is presented in categories relevant to modern avalanche hazard and risk assessment. The data provides good material for discussion among avalanche curriculum developers, course providers, and instructors. Responses describing 29 events suggest that there are common threads and themes to learn from and that there is room to improve both course delivery and information sharing.

KEYWORDS: Avalanche accidents, close calls, hazard evaluation conceptual model, recognition primed decision-making.

1. INTRODUCTION

In the Canadian Avalanche Association's shift towards a self-regulated profession, emphasis has been placed on ensuring members work in a way that improves the safety of people and resources in avalanche terrain. This has included the establishment of workplace competencies for entry-to-practice. Recognized within these competencies are specific abilities related to avalanche course delivery and instruction. One expected ability is competency in the selection of instructional terrain that balances student learning with abilities and risk.

Historically published accident provided known examples of events in the U.S., Canada, and New Zealand that occurred in 1964, 1967, 1976, 1987, 1991, 1999, and 2005 (Gallagher, 1967) (Irwin, MacQueen, & Owens, 2002) (Jamieson & Geldsetzer, 1996) (Williams, 1975) (Williams & Armstrong, 1984) (Jamieson, Haegeli, & Gauthier, 2010) (avalanche.org, 2016). These provided limited guidance and no other background could be found on the topic for use by course leaders and instructors. This scarcity was tackled with the belief that close calls might reveal clues for future guidance. Research was initiated to collect and analyze commonalities of actual avalanche risk scenarios during avalanche courses. The identification of relevant course structure and exploring content for close-call reporting were investigation goals as well.

An online survey was crafted and a request for participation was sent out in May of 2016 to the following organizations for distribution: American Avalanche Association, Canadian Avalanche Association-Industry Training Program, Avalanche Canada's Avalanche Skill Training, American Institute for Avalanche Research and Education, National Ski Patrol, National Avalanche Foundation, and New Zealand Mountain Safety Council.

I am gratefully indebted to the individuals who took the time to answer the survey. I am especially grateful to those who chose to share their experience and insights in an effort to improve our craft and the safety of delivering it.

2. SURVEY STRUCTURE

The phrasing applied in the research used current avalanche risk management processes and terminology with regards to terrain selection, hazard assessment, and risk mitigation. The 26 questions used in the survey can be found at the end of this article. Questions were organized in sets that asked: for some generic and contextual information; about the geography and exposure; about the instructional organization; about hazard and risk assessment; and, for any shareable insights.

The questions purposefully did not ask about hazard/danger ratings, event descriptions, involvements, outcomes, or other topics that would be unique to the event. Instead they focused on concepts and information that one might consider universal or available in any circumstance where

* *Corresponding author address:*
Steve Conger, Snow Knowledge Inc.,
Golden, BC V0A 1H3;
tel: 250-344-0762;
email: steve@snowknowledge.com

patterns or insights would be useful and applicable across the board.

All contributions to the survey were anonymous in an effort to elicit the best response possible. The value of unhampered response was felt to be worth the potential uncertainty in vetting events for duplication and in-ability to follow-up with any questions.

3. SUMMARY STATISTICS

Unfortunately there is not a way to normalize the data as it is unknown how many courses have been taught each season that is represented here.

3.1 Responses

There were 152 survey responses, 101 (66%) stated they were not aware of an event. The balance was divided three ways (aware & willing, aware & not willing, aware & incomplete). Thirty-three responses were willing to share information about the event. In the end there appeared to only be four events that received duplicate responses (though these were suspected to from separate individuals present to the close-call and provided valuable contribution to the survey).

Five responses stated they were aware of an event but did not wish to share any information; three of these are likely duplicates to follow-up entries (i.e. the same year / month). The percentage of responses that were aware of an event but for which the survey was incomplete (9%) represents uncertainty associated with this survey. When asked about using field notes to complete the survey, 65% stated no, 15% yes, and the answer is unknown for 24%.

3.2 Events

Twenty nine events provide the information that was analyzed (note that 4 of these 29 had two submissions of information). 76% (22) of the events were from the US, 10% (3) each from Canada and New Zealand, and 4% (1) from Scandinavia.

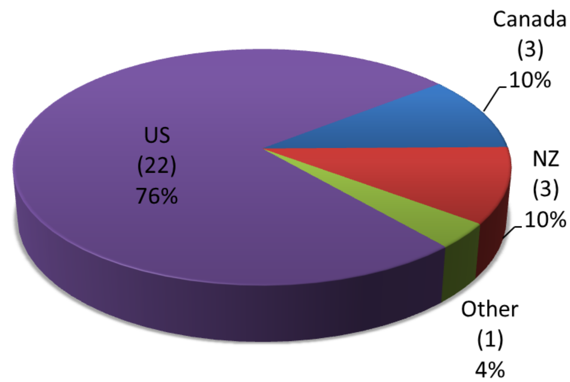


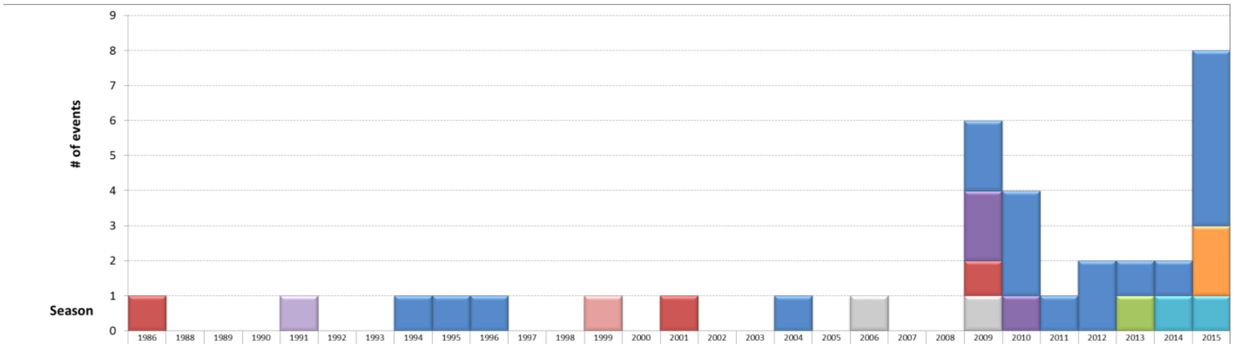
Figure 1. Distribution of respondent described events by country.

The majority of the events were divided between two group types; professional (54%) and recreational (38%). Two responses (5%) stated the group was mixed and one (3%) was a university course. Courses were included in the professional-focus courses that were described as: professional snowmobilers but not avalanche professionals, ski patrol, and a ski guide exam.

The median student to instructor ratio follows a decreasing trend over time from 6:1 in 1986/87 to 4½:1 in 2015/16. In most cases (19), the previous day was at least a partial field day (3 took place on the first field day and in 8 it this information was unknown).

3.3 When & Where

There are 33 events illustrated in Figure 2. Two are from published records for which there were no survey responses. Two are from the survey for which no information was submitted. Locations where these events occurred include Alaska, the western US, northeastern US, Canada, New Zealand, and Scandinavia. Other alpine regions such as Europe or Japan were not targeted in the survey distribution and logically are not represented in the data.



Season	1986	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Western US - from survey								1	1	1								1					2	3	1	2	1	1	5
New Zealand - from records					1																								
New Zealand - from survey																							2	1					
Eastern US - from survey																													2
Canada - from records													1																
Canada - from survey	1														1								1						
Alaska - from survey																												1	1
Scandinavia - from survey																											1		
Unk - from survey																				1			1						

Figure 2. Events since the 1986/87 season by geographic location and year.

The 29 events described in the responses spanned winters from 1986/87 through 2015/16. There are 8 for the most recent season. The pattern visible in Figure 2 suggests a dramatic recent rise in the annual number of events, possibly the presence of the availability heuristic, possibly more educational opportunities, or some combination. More recent or notable events may have prompted responses to the survey. It may also indicate a recent shift in people's willingness for close-call sharing.

4. SNOW CLIMATE

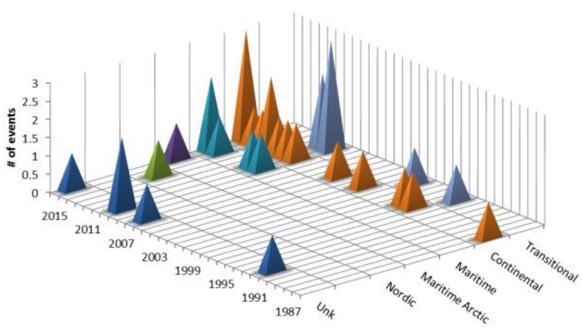


Figure 3. Illustration of events by season and snow climate.

The snow climate and terrain where events occurred was also considered for evidence of patterns (Figure 3). Suppositions might be made, but no definitive factors are apparent. Continental (50%) represented the most common, transitional (20%), maritime (17%), maritime arctic (New England) and Nordic (Scandinavia) (3%). Events in the continental snow climate seem to stand out as regularly occurring and most prevalent in the western US. The clustering seen in transitional climate events may reflect seasonal variations associated with the prevalence of persistent weak layers.

5. TERRAIN

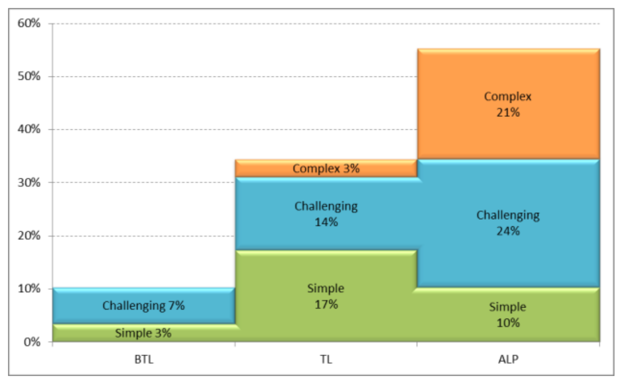


Figure 4. Percentage of total events divided by ATES and elevation band.

Respondents were asked to rate the terrain in terms of the Avalanche Terrain Exposure Scale (ATES). Challenging as well as situations where the transition was being made from simple to challenging account for 45% of the events. Complex (including challenging to complex) rated terrain made up 24% of the events. The balance occurred in terrain rated simple (31%).

When broken down by elevation band (Figure 4), the responses seem to highlight a lower likelihood of events if simple terrain is chosen in the alpine. However, any pattern here may simply be an artifact of the distribution of terrain types by elevation band.

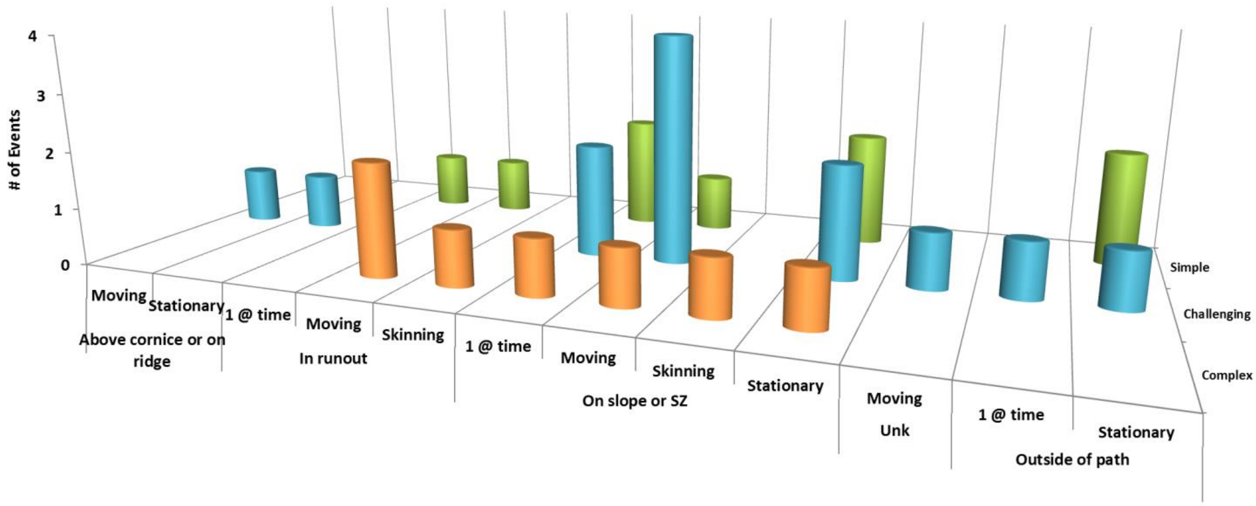


Figure 5. An illustration of group position and movement by ATES.

The largest clustering of events in Figure 5 seems to have occurred in challenging terrain while moving either as a group or one at a time. A key thing to remember when looking at this information is there is no delineation of whether there was an involvement or a surprising avalanche very nearby.

Answers to questions about magnitude and frequency suggest an incomplete understanding of frequency by the typical respondent. A best guess coding of the responses indicates that most felt the location where the event occurred was a high frequency path for D2 or smaller avalanches. Many stated they did not believe the path was capable of producing larger than D3 avalanches.

Three of the responses described the close call happening near a profile location due to travel or slope testing by a group member. One described the location as under a cornice that it was unknown whether the cornice was stable or not.

6. HAZARD AND RISK FACTORS

Question 24 asked respondents to rank the role hazard assessment or risk components played in the event. The box-plot in Figure 6 illustrates the relative importance that was associated with each of the components. Sensitivity to triggering (hazard element) and exposure location (risk element) are the two highest ranked components. Individual analysis in the following sections provides a better perspective.

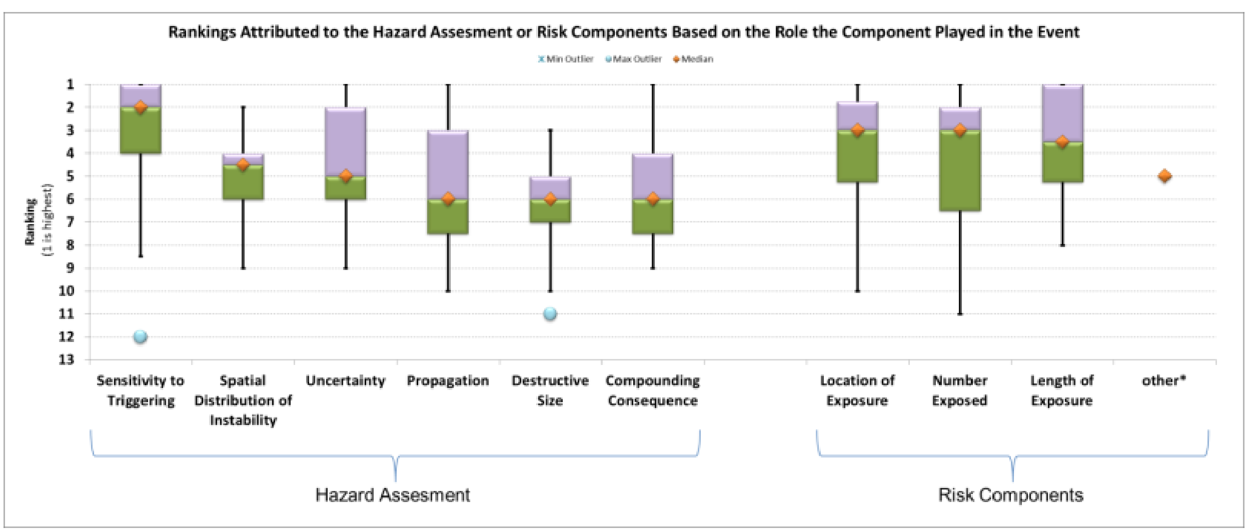


Figure 6. Box-plot of the ratings attributed to components of hazard and risk.

7. AVALANCHE HAZARD

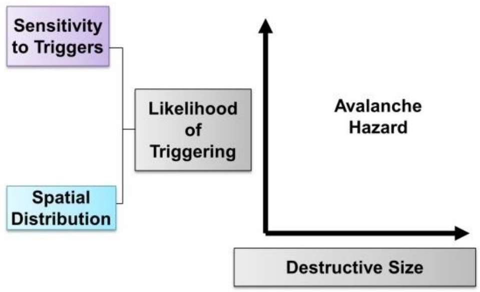


Figure 7. Graphic of the conceptual model of avalanche hazard evaluation.

The conceptual model of avalanche hazard evaluation (Figure 7) was developed in a effort to provide a common framework for all North American avalanche bulletin writers (Statham, et al., 2010). It has been embedded in operational avalanche risk management through its inclusion at the heart of chapter 6 in Technical Aspects of Snow Avalanche Risk Mangement (TASARM) (Canadian Avalanche Association, 2015). Several of the elements that were ranked in question 24 were selected to directly match the conceptual model components. Elements in question 24 also included exposure and uncertainty.

The conceptual model (Figure 7) may be used as a framework to add structure to backcountry decision making (Conger, 2016).

Figure 8 shows histograms of the rankings for each of the components related to likelihood of triggering and destructive size. Distribution of rankings shows sensitivity to triggers as the one considered most important. The distribution seen for propagation shows two distinct peaks (bimodal) and worthy of note. It has a group of events where propagation is ranked high; the balance is spread out as less important.

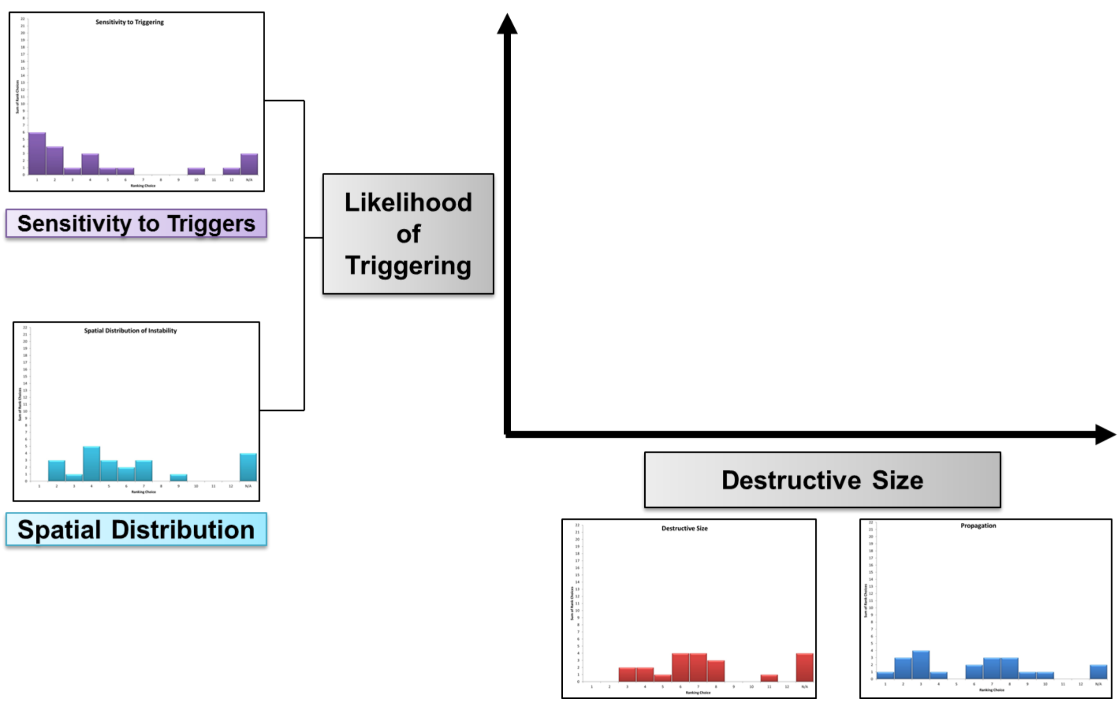


Figure 8. Graphic illustration showing histograms of rankings attributed to conceptual model components.

8. AVALANCHE RISK

Avalanche risk is a function of the likelihood and magnitude of the avalanche, the exposure in space and time, and vulnerability of the element at risk (Canadian Avalanche Association, 2015). Figure 9 provides a view combining the histograms as they relate to avalanche risk. Sensitivity to triggers and spatial distribution histograms are combined into likelihood of triggering. Propagation and destructive size are combined into magnitude.

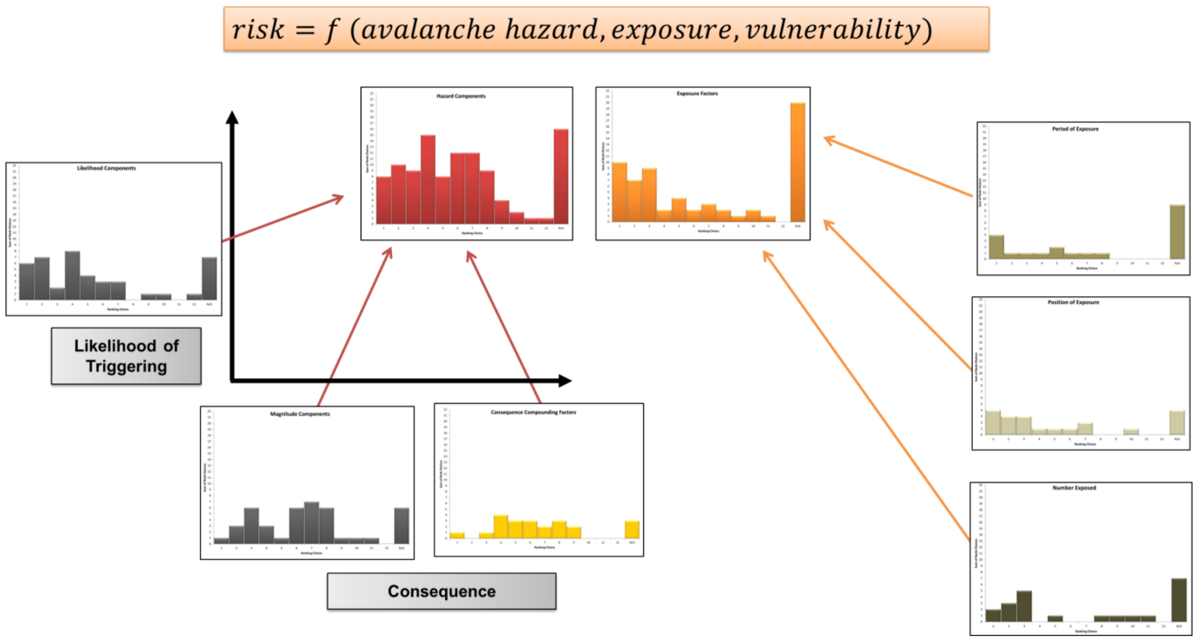


Figure 9. Graphic illustration showing histograms of rankings attributed to avalanche risk components.

The three exposure histograms (period, position, and number) are combined into one.

When one looks at the overall pattern in comparison with the individual histograms, the components that standout are sensitivity to triggering, propagation, number and position of exposure. These are the most important and attention to them may have the largest impact to the risk level.

There are two ways to think of risk (Canadian Avalanche Association, 2015). The second is at a conceptual level where risk is described as the effect of uncertainty on objectives. The median ranking of uncertainty was 6 overall and only ranked once each as 1 or 2. Most respondents ranked uncertainty as not applicable.

9. DISCUSSION

" I'm in an avy course to learn how to avoid being buried and the outcome is being buried? How fucked up is that!?" (quote attributed to a succinct course participant)

Klein (1998) suggests that the sources of power needed for decision-making in natural settings are intuition, mental simulation, metaphor, and storytelling. The power of metaphor helps to draw on experience by drawing parallels between current circumstances and other things that one has come across. Storytelling makes both our and other's experiences available in the future.

The sharing of close call experience is precisely what Klein is suggesting improves our decision-making abilities. Several questions asked respondents to reflect on the close call: how was the potential risk scenario communicated; and any narative or insight that might be useful. It is here that the information collected in the survey shines in helping us in the selection of instructional terrain that balances student learning with abilities and risk. There are a few threads that seemed to become exposed when the responses were reviewed as a whole.

Humility is essential (e.g. *assessed and understood the conditions well, but still got very lucky; recognizing the potential for luck to have played a role in previous success when uncertain; admitting that successfully 'threading the needle' had more to do with luck that knowledge or skill*).

Margin of safety when instructing is key. Key in many ways. This is evident in response examples which: *acknowledged being ten meters from being right; that the safety margin was very small; we can make all observations necessary to predict nature, margin needs to be there to allow for error; and, that the large margins of safety built into the day ensured the outcome would be managable*.

One respondent's words rang strong: *"Despite very good stability, the clues that morning were obvious and clear. There was a significant weak layer, a new slab, steep slope, and a bunch of triggers. The situation was clearly dangerous, and I thought we could "threat the needle" or "walk the thin line" so speak. The uncertainty that was kind of acknowledged, but really was more unforeseen was the fracture line. It broke basically at our feet. That was way too close."*

Group position as a margin of safety stands out many times as the difference between the close call being a "free lesson" versus a potentially tragic one (e.g. *the identification of safe zones saved most of the group from being buried; students and other instructor were on the safe lower angle adjacent terrain; propagation cracks extended from the 35 degree slab area to the 20 degree adjacent slope where the group was; my group was in a safe location, but I took a ride for 150 vertical feet before grabbing a tree and escaping; the group underestimated the probability of remote triggering, it was assumed that fairly flat terrain well below an avalanche start zone would be reasonably safe; we remotely triggered the slope by digging our snowpits so close to the starting zone*). Operating in a "seeing the future" mode is essential so that a student does not have the option to go into undesired locations or a no-go area whether due to travel skill or their choice.

The loss of situational awareness of the field classroom objective was well described in one event: *"We had been avoiding avalanche terrain all day, lots of walking and very little skiing. Upon arriving at the last skiable slope before returning to the lodge the group all expressed their desire to ski it - a small slope with sparse trees, barely steep enough to slide. To avoid a revolt I agreed, we would practice "safety measures" and ski one at a time. After reviewing what we all should do the first skier launched onto the slope and it released 20 to 40 cms deep on his second turn. The mass was too small for burial, but he was knocked off his feet and hit a small tree as he tumbled downhill, breaking his hip."*

10. CONCLUSSION

This paper summarized a survey of avalanche close-calls that have occurred during field sessions in a formalized avalanche course setting. The information from 29 events was described in terms of ATES, snow climate, course characteristics, the conceptual model of avalanche hazard evaluation and modern avalanche risk assessment.

It brings to the forefront topics that are important, worth consideration and addressing.

A type of scenario seems present that I believe is high risk and described in enough responses to warrant attention. In 24% of the events, motion was described as "1 at a time" which I interpret where not specifically stated as using "standard traveling safety proceedures". The part that disquieted me the most and offers a good guideline is: when one feels that relying on exposing 1 at a time is the difference between go and no go (e.g. *pushing it for the sake of demonstrating safe travel techniques*), one is well outside the margin of safety that addresses the objectives of learning. This is mitigation that relies soley on a probability of changing vulnerability. The risk equation for an individual in avalanche terrain is already strongly affected by a vulnerability value that is closer to 0 than it is to 1. It's about learning about snow, not learning how to guide as some related to their close call (e.g. *defer to simpler terrain; courses should not target complex terrain; it is a class environment not leading near the edge of the abyss*).

Sharing information about close calls in a non-punitive model will improve the collective decision-making abilities of those responsible for selecting terrain while at the same time, balancing learning, abilities, and risk. The model should capture key details in a manner that protects identity of a specific event. An anonymous and freely open reporting system that uses narative along with specific choices (e.g. ATES rating, position, modern assessment factors). Clues to new patterns or connections often lie in the narrative. In a field such as avalanche forecasting where uncertainty plays such a critical role, there will be unforeseen events that should not be treated as mistakes; i.e., there can be error without negligence. Reflection is very much a part of the professional identity of an avalanche worker, possibly because they will likely be first to an event or that an event may threaten their lives too.

There remains a reluctance to share information about close calls or "inconsequential" involvements, evidenced by responses to this survey. This is a part of the professional culture that presents an on-going challenge and is requisite to be transformed.

11. REFERENCES

Abdelhalim, A., Helali, K., Ayed, A., & Hass, R. (2012). Performance Measures for Inter-Agency Comparison of Road Networks Safety. Fredericton: Transportation Association of Canada.

avalanche.org. (2016). U.S. Avalanche Accidents Reports. Retrieved 08 01, 2016, from http://www.avalanche.org/accidents.php

Canadian Avalanche Association. (2015). Technical Aspects of Snow Avalanche Risk Management - Resources and Guidelines for Avalanche Pratictioners in Canada. (C. Campbell, S. Conger, B. Gould, P. Haegeli, B. Jamieson, & G. Statham, Eds.) Revelstoke: Canadian Avalanche Association.

Conger, S. M. (2016, April). Acceptable Uncertainty. the Avalanche Review, 34(4).

Gallagher, D. (1967). The Snowy Torrents: Avalanche Accidents in the United States, 1910-1966. Alta: Alta Avalanche Study Center.

International Organization for Standardization. (2010). CAN/CSA-ISO 31000 Risk management - Principles and guidelines. Mississauga: Canadian Standards Association.

Irwin, D., MacQueen, W., & Owens, I. (2002). Avalanche Accidents in Aotearoa - New Zealand. Wellington: New Zealand Mountain Safety Council.

Jamieson, B., & Geldsetzer, T. (1996). Avalanche Accidents in Canada Volume 4: 1984 - 1996. Revelstoke: Canadian Avalanche Association.

Jamieson, B., Haegeli, P., & Gauthier, D. (2010). Avalanche Accidents in Canada 1997-2007 Volume 4. Revelstoke: Canadian Avalanche Association.

Klein, G. (1998). Sources of Power: How People Make Decisions. Cambridge: MIT Press.

Logan, N., & Atkins, D. (1996). The Snowy Torrents: Avalanche Accidents in the United States, 1980-1987. Denver: Colorado Geological Survey.

Statham, G., Haegeli, P., Birkeland, K. W., Greene, E., Israelson, C., Tremper, B., et al. (2010). A Conceptual Model of Avalanche Hazard. Proceedings 2010 International Snow Science Workshop (p. 685). Squaw Valley: ISSW 2010.

Williams, K. (1975). The Snowy Torrents: Avalanche Accidents in the United States, 1966-1971. Fort Collins: Rocky Mountain Forest and Range Experiment Station.

Williams, K., & Armstrong, B. (1984). The Snowy Torrents: Avalanche Accidents in the United States, 1972-1979. Jackson: Teton Bookshop Publishing Company.

12. APPENDIX

1. Are you aware or knowledgeable of a close-call or avalanche involvement during an organized course? In other words, have you experienced one or have first-hand knowledge as an instructor or course provider?
2. What month/year did this occur?
3. What type of group was the focus of this course? (e.g. recreation, professional)
4. Do you wish to share additional information as part of a survey to understand any commonalities present in terrain use and hazard conditions?
5. What global location did this occur in? [U.S. lwr 48, Alaska, Canada, South America, New Zealand, European Alps, Pyrenes, Japan, other]
6. Was this in simple, challenging, or complex terrain?
7. What snow climate did this occur in? [maritime, transitional, continental, other]
8. What elevation band? [alpine, treeline, below treeline, arctic]
9. What position in avalanche terrain was the group or individual? [e.g. top sz, mid sz, top track, mid track, top runout, mid runout, toe of runout, not in distinct avalanche path, steep trees, etc].
10. Was the group moving or stationary (i.e. skis off)?
11. What form of instruction occurred on the previous day? [e.g it was first day of the course, classroom, previous day was a field day]
12. Were there and if so please describe the travel objectives for the field session?
13. Were there and if so please describe the learning objectives for the field session?
14. Were there and if so please describe the experience / skill practice objectives for the field session?
15. What was the situation (i.e. the group size, structure & control)? [e.g. 2 instructors leading 6 students each]
16. How was the avalanche hazard evaluated? [e.g. Procedural as in using Alaska Mountain Safety Center Hazard Evaluation Field Checklist, CAA Hazard & Risk Evaluation Worksheet, regional danger bulletin.] If other method, please provide a brief description.
17. Are you reconstructing the event from field book notes you kept?
18. What existing hazard or risk mitigations were in place prior to the field session (other than avalanche survival gear: transceiver, shovel, and probe)?
19. Did the mitigation methods in place have an influence in your choice of terrain?
20. Would you expand on how these were considered in making decisions?
21. Please describe how the potential scenario resulting in risk or exposure to the hazard was identified and communicated within the group?

22. In retrospect, what were the uncertainties present? Which were identified / acknowledged at the time? Which were unforeseen?
23. Estimate the annual frequency and magnitude of avalanches at the location of the group.
24. Please rank the role the following hazard assessment or risk components played in the event:
    - Exposure time
    - Exposure location
    - Exposure # of people
    - Sensitivity to triggering
    - Spatial distribution of instability
    - Avalanche magnitude
    - Propagation
    - Compounding consequence [e.g. terrain trap]
    - Uncertainty [e.g. weather, location familiarity]
    - other
25. Please describe the uncertainty or other in previous question.
26. Please add any narrative or insight you feel is useful or important.