

# THE AVALANCHE REVIEW

#nothingbadhappened

**TRACKS AND CRACKS:** SW aspect of Tincan, AK, January 15, 2016 — the same day as the first Seattle Ridge glide release. (See page 16 for more on the Seattle Ridge glide.) To date these cracks have not released. *Photo Heather Thamm*

See page 18 where Iain Stewart-Patterson kicks off our decision-making issue with his article about the illusion of validity, #nothingbadhappened.

# THE AVALANCHE REVIEW

The *Avalanche Review* is published each fall through spring by the American Avalanche Association, Inc., a nonprofit corporation. *The Avalanche Review* welcomes the submission of articles, photographs and illustrations.

**Please send submissions to:**

Lynne Wolfe — Editor  
PO Box 1135  
Driggs, Idaho 83422  
tel: (208) 709-4073  
lwolfe.avalanchereview@gmail.com

**Business and Subscription Office:**

Jaime Musnicki — AAA Executive Director  
PO Box 248  
Victor, ID 83455  
tel: (307) 699-2049  
aaa.jaimem@gmail.com, aaa@avalanche.org

**Advertising:**

Jaime Musnicki  
PO Box 248  
Victor, ID 83455  
tel: (307) 699-2049  
aaa.jaimem@gmail.com

**Production:**

McKenzie Long  
PO Box 1776  
Mammoth Lakes, CA 93546  
tel: (513) 515-0723  
mckenzie@cardinalinnovative.com



AMERICAN  
AVALANCHE  
ASSOCIATION

## AAA STATEMENT OF PURPOSE

The American Avalanche Association promotes and supports professionalism and excellence in avalanche safety, education, and research in the United States.

**Executive Director** . Jaime Musnicki

**AAA Officers**

- \*President.....John Stimberis
- \*Vice President.....Halsted Morris
- \*Secretary.....Scott Savage
- \*Treasurer.....Mike Ferrari

**Committee Chairs**

- Awards.....Halsted Morris
- Data & IT/Web.....Ned Bair
- Education.....Kirk Bachman
- Ethics.....Aleph Johnston-Bloom, Dave Hendrickson
- Membership.....Stuart Thompson
- Research.....Jordy Hendrikx
- Search & Rescue... Maura Longden, Nick Armitage
- Ski Area.....Bill Williamson
- \*Publications.....Blase Reardon

**Publications Committee**

- Editor.....Lynne Wolfe
- Editor Emeritus.....Steve Conger
- Editor Emeritus.....Sue Ferguson
- Editor Emeritus.....Blase Reardon
- Editor Emeritus.....Bruce Tremper

**Section Representatives**

- Alaska.....Andy Dietrick
- Eastern Section.....Chris Joosen
- European Section.....Krister Kristensen
- Intermountain North....Erich Peitzsch
- Intermountain South...Damian Jackson
- Northwest.....Patty Morrison
- Rockies.....Beccs Hodgetts
- Sierra.....Gene Urie
- Member Rep.....Jonathan Shefftz
- Certified Instructor Rep..Jake Hutchinson

*Executive Committee denoted by \**

**Subscription:** \$30 per year (4 issues). Subscription is included with membership dues to AAA. For subscription and membership information, see [www.AmericanAvalancheAssociation.org](http://www.AmericanAvalancheAssociation.org).

**Contributions:** Please submit material eight weeks prior to publication date. Include address and telephone number. Please submit typed manuscripts by e-mail or disk (CD or DVD), using any popular word processing program. Submit any figures as an EPS (preferred), PDF, TIFF or JPG file (300 dpi resolution at 100%). We will return materials if you include a stamped, self-addressed envelope.

**Articles**, including editorials, appearing in *The Avalanche Review* reflect the individual views of the authors and not the official points of view adopted by AAA or the organizations with which the authors are affiliated unless otherwise stated.

**Layout & Design:** McKenzie Long, Cardinal Innovative, (513) 515-0723, [mckenzie@cardinalinnovative.com](mailto:mckenzie@cardinalinnovative.com).

©2016 by the American Avalanche Association.

Materials may be reproduced for research or classroom use. Permission is also granted for use of short quotations, figures, and tables in scientific books and journals. For permission for other uses, contact *The Avalanche Review*.

# CONTRIBUTORS



**Iain Stewart-Patterson**, PhD, IFMGA, is a Senior Lecturer and one of the founding members of the Adventure Studies Department at Thompson Rivers University. Blending theory and practice, he is a certified IFMGA Mountain Guide and recently completed a PhD, in which he investigated the decision process used by expert heli and snowcat guides. He has been guiding ski, rock and alpine adventures for over 25 years. He is an active avalanche educator with the Canadian Avalanche Association Industry Training Programme. He is also an enthusiastic climber with many first ascents on both ice and rock.



**Clair Israelson** was hired by Parks Canada in 1971 to implement avalanche safety programs for railways, highways, and ski areas. In 2001 he was hired as Executive Director for the CAA where he created the CAC (now Avalanche Canada). Now he manages guiding operations for Northern Escape Heli-Skiing, works on research projects with Dr. Pascal Haegeli, and mentors some of the next generation.



**John Fitzgerald** has moved on from CNFAIC and now splits his season between Tetons and Valdez. Between teaching avalanche courses, guiding in the Tetons, and forecasting and guiding for VHSG, he's looking forward to catching up on sleep in a couple months.



**Michael Jackson** is a never-been snow professional on a tenure track hoping to become a has-been at the University of Irrelevance. He has been known to teach an avalanche class now and again through his ASAP kids avalanche education organization out of Bellingham, Washington.



**Joe Stock** is an IFMGA-licensed Mountain Guide based in Anchorage, Alaska. His favorite thing ever is skiing in the Southcentral Alaska mountains with friends, clients and his wife Cathy. He also likes teaching people how to avoid avalanches. [www.stockalpine.com](http://www.stockalpine.com).



**Cheyenne Brown** is a 6th generation Palouse farmer, originally from North Idaho who now spends most of the year living, playing and working in the Teton Valley. She dropped out of graduate school to work for Shepp Ranch Outfitters on the Salmon River and for the Teton Valley Branch of the National Outdoor Leadership School. She is an aspiring outdoor and avalanche educator and has spent most of this winter falling down a lot in an attempt to learn to telemark ski.



**Dave Zinn** grew up skiing in the backcountry of Northern Colorado with friends and family. Dave began working with the Yellowstone Club Ski Patrol seven years ago when he moved to Southwest Montana after several years chasing summer. He is excited to have four seasons again.



**Steve Conger** is an avalanche consultant, instructor, and former Avalanche Review Editor. Still in his home watershed, he lives in and skis near Golden, BC.

## CONTENTS / CROWN PROFILES

## 18 Decision-making #nothingbadhappened

Iain Stewart-Patterson  
Clair Israelson  
John Fitzgerald  
Michael Jackson  
Jerry Isaak and Matt Schonwald  
Owen Brown  
Joe Stock  
Cheyenne Brown  
Dave Zinn  
Steve Conger

## 36 How Can We Foster a Culture of Questioning Decisions Within Recreational Touring Teams?

Sarah Carpenter  
Jamie Weeks  
Ron Perla  
Doug Krause  
Blase Reardon  
Jason Stieglmeyer  
Nancy Bockino

## 46 Avalanche Satire by Ryan Williams

## CONTENTS / DEPARTMENTS

- 2 Letters  
8 News  
11 Education  
12 Snow Science: Atmospheric River by Matthew Primomo  
16 Snow Science: Glide Cracks by Aleph Johnston-Bloom  
42 Snow Science: AAA Grant Recipient Report by Robyn Wooldridge

## FROM THE EDITOR

BY LYNNE WOLFE

**Here's another installment** of our annual April decision-making issue. Inside you'll find a variety of excellent articles that hopefully provoke you to think and to continue having decision-making conversations with your friends and peers.

First up on the slate: a thoughtful article from Stewart-Patterson giving a deeper and more focused explanation of the winter backcountry as a wicked learning environment. I chose his piece #nothingbadhappened as our lead story for this issue; upon reading it I was struck by how clearly he articulated many concepts I had been pondering all winter.

Also in our line-up with sharp insights on other aspects of decision-making: John Fitzgerald presents a tool used at the Chugach NFAIC; Joe Stock discusses systems; Michael Jackson brings his backcountry communication protocol to the table; Steve Conger gives us more tools for taking uncertainty from theory to practice; Dave Zinn suggests that we add the crucial question of "Why?" into decision-making. Further along the list, Cheyenne Brown takes a look at vulnerability in avalanche terrain—how to understand and minimize it; while Matt Schonwald and Jerry Isaak tell us how uncertainty led to doubt which then led to appropriate decision margins on a trip they did to Kyrgyzstan with a college group. Along those lines, I plucked an essay from the business world about mindful doubt by consultant Owen Brown—I think you'll find it to be most relevant. In an article reprinted from Avalanche Canada, Clair Israelson shows us how Northern Escape Heli Skiing combines the tools of mindset and terrain classification to manage risk and save money.

The final installment in the decision-making theme revolves around responses to a question that I posed to a variety of professionals and recreationists who travel in avalanche terrain:

**"How can we foster a culture of questioning decisions within recreational touring teams?"**

It's a question that continually stymies me as I read case studies and encounter recreational groups in the backcountry. Certainly we as professionals make our own mistakes, but I see a clear competence gap from when we cut loose our level 1 graduates to when people enter the professional track with expertise and more refined habits. What are the most important take-away tools to highlight in our classes and our practice? Thanks to Jamie Weeks, Sarah Carpenter, Ron Perla, Jason Stieglmeyer, Nancy Bockino, Doug Krause, and Blase Reardon for sharing their insights.

Not all the material for April deals with decision-making, however. On the science side, Matt Primomo looks at atmospheric rivers and how they affect avalanche conditions in Slide Canyon, Utah; Robyn Wooldridge gives us insight into non-avalanche effects of explosives on snowpack; and Aleph Johnston-Bloom and the crew up at Turnagain Pass tackle the perplexing glide crack phenomenon, accompanied by dramatic photos from Heather Thamm (one of which we grabbed for the cover).

Other features include a rant from Dan Moroz's Colorado weather/ avalanche page on Facebook, where he articulates our collective frustration at a record number of avalanche involvements and fatalities for the winter. A letter to the editor from George Varygas and subsequent response from Martin Radwin regarding helmet recommendations show us that personal protection equipment (PPE), rescue, and first aid are still rapidly-evolving fields.

Finally, we were able to sprinkle a selection of great images into the text. Thanks to all our contributing photographers; please continue to think of TAR when you capture an avalanche photo. Please remember that, with our redesign, detailed on page 4 by graphic designer McKenzie Long, all photos, figures, and graphics need to be at least 1 MB in size.

Deadline for the September issue, 35.1, will be August 1, in time for ISSW. ▲



Photo Aaron Diamond

## FROM THE PRESIDENT

BY JOHN STIMBERIS

**Decisions, decisions, decisions...**

Decision-making and human factors are the themes of the issue and I had the perfect intro to write and then I find myself faced with the decision of whether to use it or not; irony at its finest. Decision-making and human factors have been topics of much discussion in our world for many years. As a practitioner first and foremost I often don't have the time to wax poetically about which human factor is at work or the confidence level of my decision. I need to grab the best information I have and come up with a plan and there's rarely time to look back. It's like that line from the Tame Impala song Elephant:

// **He pulled the mirrors off his Cadillac (yeah)**

**'Cause he doesn't like it looking like he looks back"**

And yet I like to look back. Confidence and reflection are independent, and yet codependent. One needs to be confident to make decisions (mostly) free of indecision and at the same time we need to reflect on those decisions to ensure we chose the best possible path. Reflection provides us with more assurance and confidence that we'll do the right thing when the next choice comes around.

Another irony is that being questioned about our decision-making process often feels offensive and leads to uncertainty and less confidence. Asking questions about the decision-making process shouldn't be viewed as an insult against our judgment but rather as an opportunity to demonstrate how we used the best available information to make the best possible decision at the time. Be confident when you or your team members ask you to explain how and why you chose a certain path. Chances are you will all learn something and improve your chances of a better decision in the future. ▲

Nets above I-90 in the "Side Curve" area.



sn<sup>❄</sup>wmetrics.com



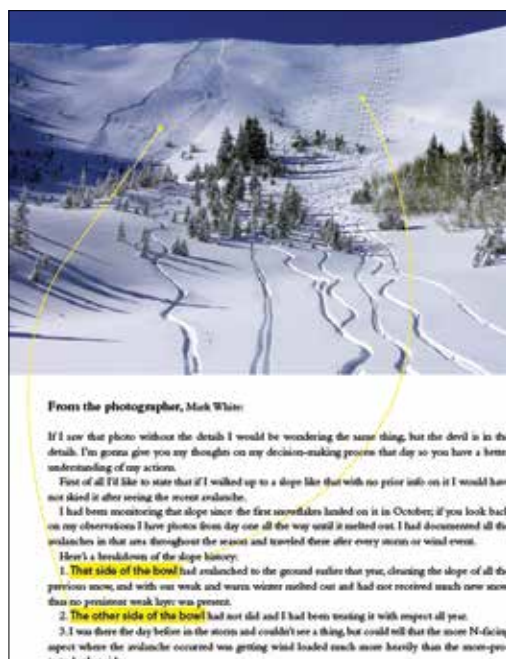
970-482-4279

# THE AVALANCHE REVIEW TRANSFORMATION

BY MCKENZIE LONG



Can *The Avalanche Review* hang with other modern publications now? Earth Treks climbing gym in Golden, CO. Photo Halsted Morris



The element of surprise: adding small details such as arrows connect the text with the images and are an avenue to bring the readers into the content. Used sparingly, they are an interesting detail throughout each issue.

**Strong editorial design** doesn't just decorate text or make something look pretty, but it takes into account its content and its readers. Over the summer of 2015 I was tasked with redesigning *The Avalanche Review*. I carefully considered what type of content is included and who reads this publication. I wanted to be able to communicate better with the new layout and make this publication even more useful to *you*, the people who receive and read it.

The first step of the redesign was to change the format. It went from 11x17 half color, half black and white newsprint to a large format, full-color, saddle-stitched magazine. This was a much needed change. It transformed *TAR* from a dated looking newspaper to a professional publication that truly expresses the importance and level of engagement that the people working in this field exhibit.

The goals of the redesign were to make each issue easily scannable and digestible as well as fun and professional. Readers tend to pick up a publication and read it in a few stages with varying degrees of involvement. First they glance at it, flip through the pages and see if anything catches their eye. This is when people notice photographs, headlines, and pull quotes. If this reader finds something interesting, they will look at the page a little longer, reading sub-heads and captions. Finally, if they decide this is an article that really interests them, they will read the whole piece.

I wanted to build these different levels of engagement into *The Avalanche Review*. Since the tone of the content can range from dense and scientific to light and humorous, I wanted to allow the content room to speak for itself, and let readers choose how deep they want to go with each article. I wanted the design to make the already excellent content more engaging and more accessible to the readers.

To design the template, I started by setting up some ground rules. In reality, a template design is really just a collection of rules. The first rule I decided on was flexibility. (I know, that doesn't really sound like a rule.) I wanted to have a clean and solid framework for the whole magazine, but let each issue have some individuality. The feature articles in each issue have their own color palette, own unique typeface, and can even have a varied grid treatment. This prevents the magazine from becoming boring issue to issue and allows for excitement and something unexpected in each one.

After deciding upon this flexible concept, I built the framework of the rest of the magazine using the basic elements of layout design: identity, fonts, colors, and grid.

## Identity

The older issues of *TAR* had a hand drawn banner that was used since its inception in the 80s. Though this banner had a very tactile quality to it, it looked dated. I wanted to give *TAR* a completely new identity that is clean, recognizable, yet modern. I chose one of my favorite clean typefaces, *Avenir*, to use as the primary typeface. The cover image and text will change with every issue, but the magazine's title and identity will remain the same every time.

## Typefaces and Standard Headlines

After choosing the identity for the cover, I had to decide how to implement standard type treatments on the inside of the magazine. I chose a standard headline and byline treatment in *Avenir* for department articles, leaving feature articles the flexibility of having their own headline treatment. I also chose a serif font, *Bembo*, as the primary text typeface. This serif font is easier to read in blocks of text than a sans-serif font, and the classic typeface makes for an elegant contrast to the clean sans-serif headlines and bylines.

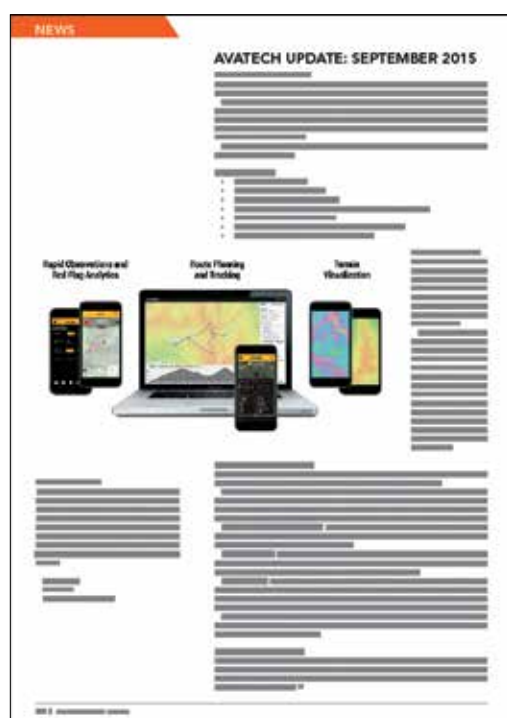
## Color Palette

This palette includes three warm colors that contrast with the predominantly white and blue photos of snow and sky, and three cool colors that complement wintry photos. When used on the kicker, these swatches add a splash of color to the pages that are very text heavy and will be mostly black and white. The kicker is a tag that helps to orient the reader and labels different subjects frequently covered in each issue. These categories also help to organize the content appearing in each issue, which before had some organization but felt a little scattered.

## Grid

Finally, I considered the grid, which is the underlying framework of every issue. I wanted something a little more interesting than standard two or three column treatments, so, sticking with the theme, I developed a flexible three column grid that can be used as an uneven two column grid with a larger column, a thinner column, and a blank column in between for call-outs and pull-quotes. This allows for a perfect space to add secondary information such as references, definitions, and links to source presentations or articles. This also has the benefit of adding a lot of white space and breathing room to the pages, which in a scientific journal is a welcome rest to the eye. ▲

McKenzie Long is a climber, skier, and mountain biker who runs a freelance graphic design business in her spare time. To see more of her work or consult about a project, check out her website, [cardinalinnovative.com](http://cardinalinnovative.com).



A page showing the kicker on the top left and the use of the flexible 3-column grid.

# A Rant

By Dan Moroz

About 5 years ago I started writing a weather and avalanche blog on Facebook after I suffered a season-ending ski accident. Since I could not ski I thought it would be helpful to write an information exchange blog each day on current and future weather and how it is affecting the avalanche hazard. Within this synopsis I merge the two together to help trace how weather events led up to current snowpack conditions and what avalanche problem might ensue depending on the future forecasted weather.

I also try to make it educational and explain in laymen terms many of the concepts of avalanche science as in how and why faceting occurs to explanations of what an avalanche is and how they might be triggered. By consolidating weather forecast from the National Weather Service and hazard forecasts from the Colorado Avalanche Information Center my goal is to educate the reader about the current avalanche hazard, how it formed, how it will react to future load, and help guide them in their decision process for choosing the terrain to ski or ride the next day. I open it up to reader's comments and observations to get other backcountry users opinions and to share pertinent information on current conditions.



Dan Moroz added 2 new photos.  
January 25 at 6:53 am · Edited ·

Snow flurries to light snow will continue to fall today and will wrap up tonight. A good warmup will be coming as the weather calms down and reloads. Looks like a good storm for next weekend will be moving in. Could be substantial so stay tuned.

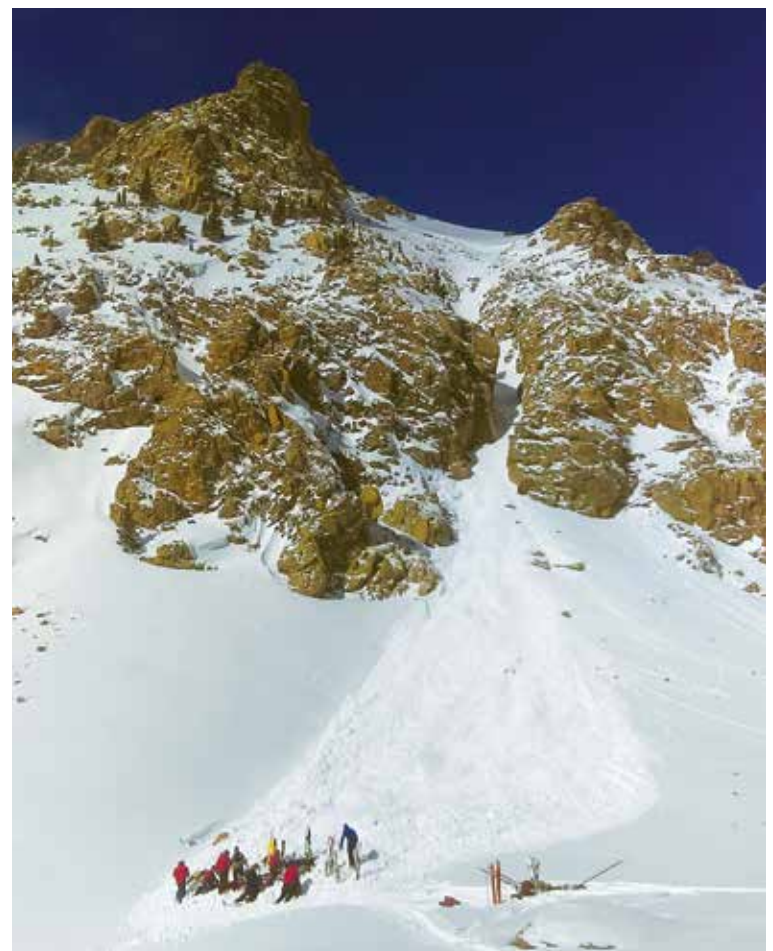
Avi wise: WHOA, SLOW DOWN, THROTTLE BACK, REASSESS!!!! It is hard to believe but also troubling that 10 people have lost their lives in the last eight days in western US due to avalanches. *[Editor's note: as of press time there have been 21 fatalities in winter 2015-16, and 17 in 2016 alone.]* These accidents were all preventable and the person in all cases was the cause of the incident. There is a common theme in the overall cause for most of these slides which was a lull in snowfall in December, which, coupled with cold temperatures, produced a strong temperature gradient forming faceted snow grains within the snowpack. This weak layer then was buried by subsequent snowfalls and wind. It has formed a persistent weak layer that is widespread throughout the west.

Depending on how much snow has fallen or has been transferred by wind covering this weakness, triggered slides are likely. Due to spatial variation of snowpack structure over short distances this snowpack configuration can be extremely unstable or relatively strong. Very difficult to predict how it will react. Compression tests have to be paired with other observations to help get a handle on stability. However, the one thing we do have control over is our terrain choice. The "human factor" becomes what might save us. If we make wise choices in where we go due to the fact that we are skiing or riding over a ticking time bomb or a mine field of triggers for slides perhaps we can stem some of these accidents.

The photos are of fracture lines from Berthoud Pass, Fremont Pass area, but the last two are from Loveland Pass. During a field day of a Level 1 avi class we were digging an information snowpit at a safe location to view the layering within the snowpack. Suddenly on a radical 40-degree plus, wind loaded, wind scoured, nasty looking slope, a solo rider comes whizzing down without a care in the world. No partner, no gear, and seemingly no brain. So as I caught my breath, two more riders tackled even steeper terrain and without any caution jumped in and caution literally thrown to the wind (slab) they took different lines (one with a Go Pro selfie stick in hand but no rescue gear). Non stop, no caution, jumping rock bands to the bottom. They did meet up at the bottom, several "high fives" and they were gone.

I was absolutely mortified by what I had witnessed but boy was it a great conversation with the class. So what we witnessed was a

total lack of awareness or respect for what can happen. Young and dumb can be the recipe for disaster. Remember we have choices. We decide where we go. We decide our fate. Time to reflect and respect the unprecedented widespread conditions that are out there. As the atmosphere reloads and a potential major storm will be moving in late in the week, stability will only get worse. Think before you leap as it is getting "real" out there. Heed the warning!!!!



# FURTHER DISCUSSION ON HELMET USE

BY DR. GEORGE VARYGAS

**It was with** great interest that I examined the article presented by Dr. Martin Radwin, in *TAR* 34.3, February 2016. Trauma and avalanche mortality is a hot topic in recent years, and warrants further discussion and investigation.

The topic of graded evidence presented on the issue merits additional clarification. The field of Evidence Based Medicine (EBM) is the application of scientific methods to healthcare decisions. Grading of evidence/research/studies provides a method to assess the quality and reliability of information available.

The high grade (1B) evidence given to support the recommendation of wearing a helmet in avalanche terrain requires further examination. The data cited in support of the recommendation are from studies examining the cause of death in avalanche victims. As discussed in the article, there is great variability in reported incidence of trauma as the primary cause of death (25% {Canada}-5% {Europe}). Trauma to the head is found to some extent in as many as 61% of victims<sup>1</sup>, or as little as 0%<sup>2</sup>.

There is an unusually wide range of incidence of trauma as a whole, as well as head trauma, which is pointed out in the article. This large variability erodes confidence and degrades the evidence from which to draw conclusions. In addition, small sample sizes (number of victims) contribute to making interpretation difficult. These study limitations greatly impact ones ability to make a broad or strong recommendation with any confidence.

A greater concern is the fact that making a strong recommendation to wear a helmet in avalanche terrain is based on no prospective data. There are no studies examining this topic, and none are forthcoming any time soon. When there is no data available, the 'evidence' falls into a category of opinion or hypothesis. Recognizing a highly variable incidence of head trauma and proposing a current technology helmet as a solution – seems intuitive, but it is not evidence. It is critically important to distinguish opinion from robust evidence, and mistaking one for the other can cause confusion. To be clear, there is no evidence that wearing a helmet in avalanche terrain will improve survival. It is the opinion and experience of Dr. Radwin (and others) which claim potential benefit. While recognizing this opinion, I do not believe the answer is so simple. Associated challenges and limitations of helmet use in avalanche terrain require further evaluation.

Lastly, the grade of 2C for the use of airbags to reduce trauma mortality also raises questions. It is appropriately made clear that there is a lack of research supporting airbag use for trauma protection. Similarly, helmet effectiveness in avalanches is also lacking. It is therefore inconsistent to elevate the recommendation of helmet effectiveness while not recognizing the same limitations of objective study of the topic. For all of the reasons mentioned, a grade not exceeding 2C should be applied to helmet use in avalanche terrain.

The medical field has a long history of making misguided recommendations, only to find out many years later that what we have been doing is not beneficial, and possibly even harmful. Epinephrine and other prehospital drugs have been standard care for cardiac arrest for decades. But, we are slowly learning that its use probably does not result in improved survival to hospital discharge<sup>3,4</sup> and there are some studies that show their use can even cause more harm than good<sup>5</sup>. Reversing practice takes much longer than initiating new practice. Our focus on epinephrine for cardiac arrest has delayed the recognition of what appears to actually save lives: early defibrillation and early high quality CPR. Epinephrine gets the heart going, supports blood pressure and makes everyone feel good – but the patient usually dies hours or days later just the same. Physiologic reasoning without objective data can often steer us in the wrong direction, and sometimes delay our recognition of what may, and may not, affect outcomes.

If you are not completely bored already, and wish to read more on the topic of avalanche mortality and helmet use, consider either reading my blog entry at the Utah Avalanche Center ([utahavalanchecenter.org/blog/26737](http://utahavalanchecenter.org/blog/26737)), or my commentary in *Wilderness and Environmental Medicine*, March, 2016 ([dx.doi.org/10.1016/j.wem.2015.09.020](https://doi.org/10.1016/j.wem.2015.09.020)). ▲

## References

1. Johnson SM, Johnson AC, Barton RG. Avalanche trauma and closed head injury. *Wilderness and Environ. Med.* 2001;12:244-247.
2. Hohlrieder M, et al. Pattern and severity of injury in avalanche victims. *High Alt Med. Biol.* 2007;8:56-61.
3. Atiksawedparit, P., et al, *Crit Care*, 18(4):463, July 31, 2014
4. Jacobs, I.G., et al, *Resuscitation*, 82:1138, 2011
5. Hagihara, A., et al, *JAMA*, 307(11):1161, March 21, 2012

George Varygas, MD, FACEP, works in the emergency department of the Intermountain Medical Center in Murray, Utah, and is an Adjunct Assistant Professor in the Division of Emergency Medicine at the University of Utah. He is Medical Advisor for Wasatch Backcountry Rescue and the Snowbird Ski Patrol, and is a board member of the Wasatch Backcountry Alliance. He's been a backcountry skier and climber for 30+ years and called SLC home for 18 years.



# REPLY TO THE EDITOR

BY MARTIN I. RADWIN, M.D.

**In the present** issue of *The Avalanche Review* (see facing page), Dr. George Vargyas questions the evidence-based graded recommendation assigned to the preventative use of helmets in avalanche head trauma as noted in my article (issue 34.3, Feb 2016), *Avalanche Victim Trauma; Evidence-Based Recommendations*. The use of helmets in the backcountry setting as they relate to avalanche Traumatic Brain Injury (TBI) has been a matter of controversy. Dr. Vargyas correctly notes that there is no definitive evidence that wearing a helmet in avalanche terrain will improve survival, as no prospective, randomized, controlled trials exist, or ever will due to the inability to perform such studies. However, unlike the hospital-based, urban EMS analogy he uses to exemplify a history of misguided medical recommendations that are later found to be ineffective or even harmful, data regarding wilderness medicine disputes in the austere environment are often lacking robust evidence or impossible to resolve experimentally. I greatly respect and appreciate debate on such issues and thank Dr. Vargyas for several interesting comments in his present commentary and an upcoming Letter to the Editor on this topic in *Wilderness and Environmental Medicine* (March 2016).

The article in question grades helmet use as 1B (Strong recommendation, moderate quality evidence)<sup>1</sup> which does allow for inconsistent results, methodological flaws and indirect evidence, understanding that further research is likely to have an impact on the confidence of risk-benefit estimates. The recommendation was initially made by consensus from an international expert panel convened by The Wilderness Medical Society to develop evidence-based Practice Guidelines for three primary aspects of avalanche accidents: prevention, rescue and resuscitation. Although these Guidelines are still a work in progress and soon to be published, my trauma-focused article was submitted to *TAR* before further review and vigorous debate amongst the group subsequently led to a downgrading of the helmet recommendation grade to 1C (Strong recommendation, low quality evidence). An erratum was to be presented to the readers of *TAR* with the updated grade. However, to rate helmets as 2C (Weak recommendation, low quality evidence) such as Dr. Vargyas suggests, thereby equating the existing indirect evidence regarding helmets and TBI to the complete lack of knowledge we have on the prevention of trauma from airbag systems, where no direct or indirect evidence exists, would be irresponsible.

Although the literature on helmet use and severe TBI in the resort setting is mixed, some researchers do feel that helmets are having a positive impact in decreasing the potential of serious TBI.<sup>2,3</sup> In this light and with the findings in Canada that two-thirds of the traumatic deaths involved collision with trees while in Utah 61% of the avalanche victims studied specifically for TBI by autopsy revealed such evidence<sup>4</sup>, it is clear that the head (and neck) must be protected by some practical method. I strongly agree with Dr. Vargyas that our present helmet technology may be insufficient to prevent head injury from severe impact and also urge manufacturers to focus future research and development on this issue. However, since there is no risk to wearing a helmet, a strong recommendation should prevail as any mitigation of head injury may save lives, even from asphyxiation. The argument about emboldening users to greater risk-taking by wearing a helmet is weak and has been previously visited upon transceivers, artificial air pocket devices and airbags, all considered to have saved lives. As always, protective equipment should never take precedence over continued education, sound decision-making, and other preventive behavior approaches. ▲

## References

1. Guyatt G, Gutterman D, Baumann MH, et al. Grading strength of recommendations and quality of evidence in clinical guidelines: report from an American college of chest physicians task force. *Chest*. 2006;129(1):174-181.
2. Shealy J, Johnson R, Ettlinger C, Scher I. Role of helmets in mitigation of head injuries: epidemiologic study of head injuries to skiers. In: Johnson R, Shealy J, Greenwald R, eds. *Skiing Trauma and Safety: 20th Volume*. STP1582 West Conshohocken, PA: ASTM International; 2015:22-38.
3. Haider AHS, Bilaniuk JW et al. An evidence-based review: efficacy of safety helmets in the reduction of head injuries in recreational skiers and snowboarders. *J Trauma Acute Care Surg*. 2012;73(5).
4. Johnson SM, Johnson AC, Barton RG. Avalanche trauma and closed head injury: adding insult to injury. *Wilderness Environ Med*. 2001;12:244-247.

Martin I. Radwin, M.D., a professional member of the AAA for almost 20 years, has combined much of his professional medical research and a passion for snow and avalanche science, to better understanding avalanche victim pathophysiology and translating that knowledge into improved survival devices. Well-published in this area, he was an early member of the team investigating the efficacy of the AvaLung that further studied respiratory physiology and hypothermia in buried victims. An international lecturer, long time WMS member and lecturer and former member and lecturer for the Weber County Sheriff's SAR mountain rescue team, he lives, skis, and practices medicine in the Salt Lake City area.



## Field Obs

More eye candy from a mid-December avalanche cycle in the Wasatch: wind slab on basal facets, Radar Love Bowl.

Photos Mark White

## NEW PUBLICATION: TECHNICAL ASPECTS OF AVALANCHE RISK MANAGEMENT

BY STEVE CONGER

**The Canadian Avalanche Association** is publishing a new document that represents the culmination of a project to revise and update the guidance that avalanche professionals in Canada use for avalanche risk management planning and operations. This document has relevance to the



American avalanche community as it provides a common lexicon and assessment structure that can work on both sides of the border. It describes the foundations of risk management as they apply to avalanches as well as drawing upon international risk management process standards. It presents, under one cover, a uniform treatment of both avalanche risk management planning and operations.

Distinction is made between the two: planning involves the study of avalanche hazard, risk, and/or mitigation for specific objectives. It is separate from avalanche operations in that the focus of the specific objectives are long-term, and result in maps, plans, and reports. Avalanche operations are seasonal activities that include avalanche forecasting tasks and the direction and implementation of short-term mitigation measures in order to achieve specific organizational objectives.

It offers a description of best practices at the time of publication including an overview of technical guidelines and typical applications for avalanche risk assessment and mitigation that includes:

- Managing uncertainty.
- Avalanche terrain identification, classification and mapping.
- Avalanche hazard and risk assessment concepts and systems.
- Assessment/decision aids.
- Mitigation options.
- Guidelines for use of avalanche terrain in Canada.
- Other considerations.
- Records and reports.

The focus of this publication is on what to do, not how to do it. Specific methods are referred to whenever possible, or included as an appendix.

For more information and to obtain copies of the documents as they become available, visit [www.avalancheassociation.ca](http://www.avalancheassociation.ca). ▲

Steve Conger has been a Professional Member of the American Avalanche Association since 1992 and a Professional Member of the Canadian Avalanche Association since 2007. He is one of five subject matter experts, who, with principal investigator Cam Campbell, are the editors of this document.

## BOOK REVIEW OF AUTONOMY, MASTERY AND PURPOSE IN THE AVALANCHE PATCH

BY ALLEN O'BANNON

**Bruce Kay**, a former ski patroller and avalanche industry professional, has written a book that is right up my alley. I love reading about how we make decisions and what we can do to improve the process. *Autonomy, Mastery and Purpose in the Avalanche Patch* captures in one place a lot of the theory that is out there. It relies heavily on Daniel Kahneman's definitive *Thinking, Fast and Slow* and does a nice job of summarizing some of his important points, theory and strategies. If you ever wondered how our brains function to process information, make a decision and what system 1 and system 2 are, but don't have the time for Kahneman's tome then this is a book for you.

Kay has done more than simply summarize Kahneman's work though. He has captured a lot of the other research on pitfalls we can fall prey to, such as the Dunning-Kruger effect where we as humans often overestimate our knowledge, skills, and abilities.

*Autonomy, Mastery and Purpose in the Avalanche Patch* is really a book about why we as humans have a hard time making good decisions in very complex, low feedback, high consequence environments – such as avalanche terrain or say for instance global warming since he touches on this a bit as well. We learn how our subconscious works to sidetrack us into making decisions that if we were to look at them objectively – assuming it is possible to objectively analyze them – we probably wouldn't make.

Kay also gives us some examples in the form of true stories and mistakes he and others have made to illustrate many of the book's points. Nothing like learning from the mistakes of others.

I particularly liked the section on judgment, and while none of the information was new to me, I liked how Kay brought together a lot of the current thinking, and shows us why we are so

fallible and how our intuitions can lead us astray – or not. We learn that our subconscious has a lot more to do with our actions than we would ever want to know.

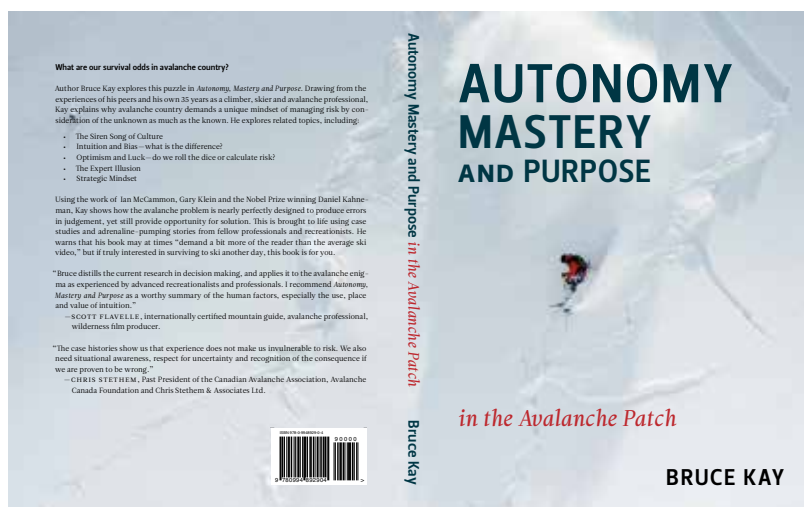
In the last two sections Kay also leaves us with some tools and ideas that can help us better frame the risks and possibly even get us to realize them. One that I have been using for a long time is the pre-mortem

where you purposely ask yourself and/or your partners what is going to go wrong with the decision you just made to ski a slope or whatever else you are planning on doing, the idea being to skeptically look at your decision to find the flaws in your assumptions.

At times I had a hard time following Kay's line of thought, especially in his first section "Landscape" where he is painting a picture for the reader of who we are and how we behave. There were also times when I felt I had come into the middle of a conversation that had been going on for a long time. And while the conversants knew all the background context, I was left to guess or figure out what I could about the conversation. For example, the Avaluator, which is one of the tools we should find useful, is not really explained and it is up to the reader to find an example of it at the back of the book. Luckily I have heard of the Avaluator and so had an idea of what it is all about and how it was developed, but for a number of readers outside Canada more detail would probably be appreciated.

Overall though I think most readers will enjoy the book as I did. Decision-making and judgment are huge fields of thought and research and Kay does a good job of presenting some of the most useful information for us. Lastly, if you are an avalanche educator looking to develop a class on human factors then you will find plenty of material here. ▲

Allen O'Bannon has been working in the cold for over 20 years and has been teaching about avalanches almost as long. A NOLS winter instructor since 1988, Allen has honed his educational skills and has taught at levels from avalanche awareness courses through level 3. He has worked as a guide and avalanche educator for Exum, American Avalanche Institute and Yostmark Backcountry Ski Tours. Allen has also spent five seasons in Antarctica doing safety trainings and guiding National Science Foundation research groups. He is the author of four books (the Allen and Mike Really Cool series) on camping and skiing.







# CO

## ISSW16


### INTERNATIONAL SNOW SCIENCE WORKSHOP

*A merging of theory and practice*

**October 3-7, 2016  
Breckenridge, Colorado**

**SUBMIT YOUR ABSTRACT  
AND REGISTER NOW**

[www.issw.org](http://www.issw.org)



**Training for backcountry enthusiasts  
and mountain professionals.**

- Instructor Training Courses
- Level 1 & 2 Program Materials
- Professional Level Certification Courses

[www.avtraining.org](http://www.avtraining.org)  
**(303) 817-7378**

### AVALANCHE DIVAS FEMALE PROFESSIONALS

## AVALANCHE DIVAS AT ISSW 2016

BY ALEPH JOHNSTON-BLOOM

Come join the Avalanche Divas for dinner, drinks, and dancing Tuesday night, October 4th at ISSW 2016 in Breckenridge, CO. We will be honoring some amazing women and provide an opportunity to network with women in your specific field of avalanche science. Dancing and fun will be open to all genders later in the evening!!!

We are soliciting your nominations for the 2016 Avalanche Divas honorees. If you would like to nominate an exceptional female colleague, friend or mentor please email: [snowaleph@gmail.com](mailto:snowaleph@gmail.com).

The Avalanche Divas will also be offering travel grants to women presenting at ISSW 2016. A PDF application link will be available soon on the ISSW 2016 website. Look for the Divas link in the Social drop down menu! Questions? email: [snowaleph@gmail.com](mailto:snowaleph@gmail.com). ▲



## Field Obs

**We had been** staying at the Ski Cabin (in the Gros Ventre Range, near Goodwin Lake and Jackson Peak, up above Jackson, WY), and although it hadn't snowed in a little while (I forget how long), we had broken the skin track in, miraculously finding the cabin in the dark. The particular conditions here included heavily faceted snow on the surface from a long high pressure system and relatively thin snowpack. This was all on a super thin sun crust about 10" down. When we had skinned up through the trees and done a little digging, the sun crust wasn't apparent. Poking around when we got to the top of this short line, we were able to feel the sun crust in the areas that were less shaded. As a group of two experienced backcountry skiers and two novice backcountry skiers, myself and the other experienced guy decided that a more prudent choice would be to stay in the trees and/or close to the treeline in order to minimize our exposure to an unreliable layer. Our second and third skiers disregarded the advice to stick to the shaded tree areas, venturing out onto the area where increased sun exposure had created that layer before the last storm cycle. That was a good lesson for the two backcountry novices on how slight variances in terrain, aspect, and exposure can create significantly different avalanche conditions. All said and done, the slide only ran a couple hundred feet, depositing debris in an open flat area at the bottom of the slope. The pictured skier's chosen line continued towards where I took the photo, and he was not caught or carried in the slide.

—Ben Johnson

# IN MEMORIAM: DARREN JOHNSON

BY DOUG MCCABE AND THE YELLOWSTONE CLUB SKI PATROL

**Darren Johnson, 34**, was killed in an avalanche on January 19, 2016. At the time of the incident he was working as an on-duty professional ski patroller with the Yellowstone Club (YC) in southwest Montana, where he had been patrolling for the past six seasons.

On that day, he had volunteered to assist a Montana State University (MSU) graduate student collect snowpack data outside of the ski area boundary on Cedar Mountain. While returning in-bounds to the YC ski area, the group navigated through uncontrolled backcountry avalanche terrain. Darren was the second skier to descend, and chose a line that was steeper, and identified by the group beforehand as a particular slope of concern. Although his line was only 50 feet to the east of the first skier to descend, this subtlety had immensely devastating consequences. He jumped off a cornice and two turns into his run the slope broke above him, failing on a layer of depth hoar at the ground (2-4 feet deep), propagating out 300 feet, and carrying him downhill 300 feet through a thick patch of large trees. He came to rest only partially buried, but the trauma was too severe to survive.



The rescue efforts that ensued were initiated by the two MSU students, both of whom had several years of professional patrolling experience, and a first year patroller at YC who had also been assisting with their research. Patrol Dispatch was informed, life flight was contacted, and a mountain operations-wide effort was made to save Darren. Despite our best efforts in trying to revive Darren for over an hour, we tragically lost our brother that day to the mountains.

Noticeable from Darren's service, there wasn't a single person who wouldn't have been able to tell a story about him. From short quip to elaborate tale of adventure, each person was holding a piece of Darren in their heart. The memory of their stories was intense enough in that moment that tears fell upon corners of a smile.

Darren was passionate about snow, avalanches, and patrolling; in many ways this was simply a reflection of his approach to life. Never one to waste a day or turn down a challenge, he grabbed life by the horns and energized those around him to do the same. Those that knew him best, and of his thousands of adventures, clearly thought he was invincible. Darren was a merry prankster, jolly and jovial, witty and mischievous. He was not the type to wait around for a good time. He made it happen, and we got to tag along. There is a palpable hole in our patrol that Darren's spunk, enthusiasm, and endless humor used to fill. Compassionately looking out for the underdog, he was quick to open his heart and lend a helping hand. He could and would dispute to the end if it was something he believed in. Then he would carry on self-assured, never once backing down from who he was. Self-possessed charm was his effortless companion.

It also seems that part of his calling was to find the edge. He lived in that place where the sense of aliveness was so rich. It's probably safe to say Darren helped many of us find our own edge at one point or another; the edge where we felt most alive, most ourselves. Is there any greater gift? For everyone else experiencing the weight of this unbearable loss, there is a gift somewhere at this edge as well.

The circumstances of his death painfully remind us that despite several years of avalanche and ski patrol training, none of us are immune to the perils of weather, snowpack, terrain, and heuristics. The conditions that formed the avalanche that took Darren's life were a depth hoar basal layer later followed by 13 inches of snow with 0.8 inches of SWE in two days of wind loading onto an east facing 40° slope that was overhung by a cornice. Regardless of the many snowpits dug that day by Darren and fellow researchers showing signs of deep instability and recent avalanche activity on similar slopes, he chose a line that we can't understand. There is no fault or blame, only tragedy and an enormously difficult lesson. We can all choose to remember our training, be conservative in questionable conditions, and continue in our commitment to loving these beautiful, often cruel mountains we call home. We will miss you Darren.

In Darren's memory we have established an education scholarship fund to assist pro ski patrollers in attending the National Avalanche School. This scholarship money will go to qualified applicants who are passionate about attending the program and furthering their avalanche education to the benefit of their patrol and their community. Donations can be made at: [www.djmemorialfund.org](http://www.djmemorialfund.org). ▲



**Darren Johnson**  
Avalanche Education Memorial Fund  
Associated with the National Avalanche Foundation  
[www.djmemorialfund.org](http://www.djmemorialfund.org)

# PRO / REC SPLIT: PROGRESS REPORT

INTERVIEW OF DALLAS GLASS CONDUCTED BY SEAN ZIMMERMAN-WALL

**The snow continues** to fall across the US and we as professionals are remembering what it is like to have a normal winter. Each day bleeds into the next as we get up before the sun to make our livings in the mountains. Trenching deep turns through the high country to find our moments of Zen rewards our tireless efforts.

In addition to the daily rigors of simply getting the job done, we work to become better in every aspect of our chosen field and to pass that knowledge onto others. Raising the bar for training of avalanche workers has remained the focal point of the pro/rec project since its initial proposal two years ago. Led by the AAA, a multitude of entities from across the industry have channeled their energies into developing a track for avalanche training that will serve as the backbone for current and aspiring snow professionals. The project has evolved to meet changing conditions as it continues to incorporate feedback from the parties involved. At the helm of collecting information and managing this side of the split is Dallas Glass, the Professional Training Coordinator (PTC). His organizational skills are a welcomed addition to the project and his track record has proven him to be a valued member of the AAA's educational efforts. The following interview allows us to look into the current roles of the PTC and how the project is moving towards completion.

## Describe your involvement with the project and how your role has changed since its inception?

My roles within this project have evolved over the past year. I began as the AVPRO Coordinator for the AAA. Due to my role in professional avalanche education, I was a member of many of the early meetings discussing the pro/rec split. At our summer meeting this past July in Victor, ID, we identified a need for a more job-specific role. During that meeting, I was asked to step into an interim position as the Pro Training Coordinator (PTC). We also discussed the need for the AAA to competitively hire this position. During the fall of 2015 the AAA accepted applications, interviewed, and hired the PTC. I was hired mid-Dec and moved from the interim PTC to the PTC on Jan 1, 2016.

## What are your core responsibilities as the project moves ahead?

I facilitate the development of guidelines and oversight for the Pro Program. This includes working with course providers and members of the industry to develop, solicit feedback, and edit all needed guidance. Additionally, I coordinate AAA-run instructor trainings for pro level courses and provide information to the professional community through a variety of mediums about the Pro Training Program.

## Have you been working with any other consultants to keep the project moving along smoothly?

During the hiring process for the PTC job, the hiring committee spoke with and subsequently engaged some wonderful individuals, eager to participate and who provide skills and perspective that will increase the quality of the end product.

## Overall, how has it been trying to get the variety of parties on board with the project from the professional side?

I have consistently been impressed with the level of camaraderie that has been displayed amongst members of the industry. A common goal based around the expressed need for the continuing development of US professional avalanche training has provided the focus for consensus. The individuals and groups have been wonderful about providing a variety of opinions throughout the process, but at the end of the day, they have come together to develop a set of standards that can grow and move with the industry.

## What methods is the AAA using to keep an open forum of collaboration in place?

We've tried to employ a variety of methods to allow for industry input including:

- One email forum to the AAA for feedback on the initial proposal and the white paper.
- Several *TAR* articles that allow for responses.
- The AAA Executive Director, Jaime Musnicki, and I traveled to numerous Snow and Avalanche Workshops this fall to give presentations and listen to members' feedback.

- We've developed an Industry Advisory Group composed of individuals from different segments of the avalanche industry. These people were chosen for their knowledge, but also for their networks within the industry.
- Lastly, we've always had an open door policy and welcomed comments and feedback to Jaime and myself.

## Has the Industry Advisory Group been a good tool for gathering various insights from a broader constituency?

Absolutely. These individuals have provided not simply their own opinion during the development process, but also reached out to those across the industry as a point of contact. They have sent formal emails, made phone calls, and shared cups of coffee with other members of the avalanche community regarding this new program. As a result, they have brought us an industry-wide view that I couldn't hope to produce on my own.

## Moving onto specifics, how are these courses going to be different than the current program structure that exists and who is the intended demographic for each course?

The current programs in the US are doing a great job of training professionals, but they've generally grown-up individually based around need. As a result, the programs have a variety of audiences.

The new programs have been developed from the ground up, for the industry, by the industry. I say that to emphasize that these courses have been developed as a large collaborative project between all segments within the avalanche industry.

Pro 1 is targeted toward entry-level avalanche workers, people who want to move into or are working as a member of an avalanche operational team. Folks who are becoming route members at a ski area, tail guides at a back-country ski operation, professional observers at an avalanche center, and avalanche technicians at highway operations. The Pro 2 is targeted towards individuals who want to develop leadership skills and move into leadership positions within their programs: snow safety staff, lead guides, forecaster positions, etc.

## What can providers of Professional Avalanche Training be doing to prepare for the roll out of the project?

Stay engaged. This is a large shift in professional training. It isn't a quick six-month project. It isn't even a one-year project. We need everyone engaged, giving us feedback, helping keep the project rolling. It's exciting!

## What are the major challenges being faced right now and how does the AAA plan to handle them to meet stated objectives?

Time. I'm not sure I know any avalanche professional who isn't busy right now. Let's be honest, it's winter. We all have jobs that demand our attention. As a result, we need to allow plenty of time for folks engaged in the process to act. The program is moving forward every day, every week. We just need to be patient this time of year. The snow is still falling, avalanches are still happening.

Furthermore, we are committed to the quality of this program. We understand that this is a major shift in the avalanche industry and in professional avalanche training. We want to make sure that things are done well, not simply boxes checked. We have target dates in mind, but we aren't trying to rush to meet a deadline.

As the winter rolls on, Glass and the AAA will continue to make strides towards a smooth launch of the pro/rec project by engaging current providers and gathering additional feedback from the Industry Advisory Group. The Professional Training Program will also be holding more workshops this spring to familiarize the trainers with the new guidelines and hammer out remaining questions. These actions will work to ensure that the standards being put into place are realistic and representative of what the industry expects of its employees. It is inspiring to witness the forward progress the project has made since 2013 and there is no doubt that the end result will greatly benefit the avalanche community here in the United States. Please keep your ears and eyes open to advancing developments and turn to the AAA and *TAR* for updates as the project enters its final stages. ▲

# ATMOSPHERIC RIVERS AND AVALANCHE CYCLES: SLIDE CANYON, UTAH

STORY AND PHOTOS BY MATTHEW PRIMOMO

An atmospheric river (AR) is a narrow and lengthy atmospheric structure that is responsible for the majority of horizontal water vapor transport outside of the tropics (Zhu and Newell 1998). They originate in the tropics and/or via local moisture convergence (Bao et al. 2006), and form narrow bands which stretch poleward (Zhu and Newell 1998). When these features make landfall, heavy and prolonged precipitation events can occur. Once an AR makes landfall, the presence of orography can enhance the ascent of air parcels and result in highly variable precipitation rates during an event. ARs contribute significantly to flooding and snowpack changes in western North America (Neiman et al. 2008).

The strongest events are often accompanied by anomalously warm temperatures, rain-on-snow, flooding, landslides, and debris flows (Neiman et al. 2008). ARs were present in all of the seven floods on the Russian River in California between 1997 and 2006 (Ralph et al. 2006). Heavy rains during an AR caused the Nisqually River to overtake a National Park Service Road in Mount Rainier National Park in November 2006 (Neiman et al. 2008). An example of a likely AR coincidence with a historic avalanche cycle is the winter storm in the Central Chilean Andes during early August 2015 (see TAR 34.2) in which Colin Mitchell reports 66.5" of snow with 8.3" of snow water equivalent in 52 hours (Mitchell 2016) and a historic avalanche cycle (see Figure 1).

NOAA, the Earth System Research Laboratory's Physical Sciences Division, the USGS, and other atmospheric scientists worked together cranking

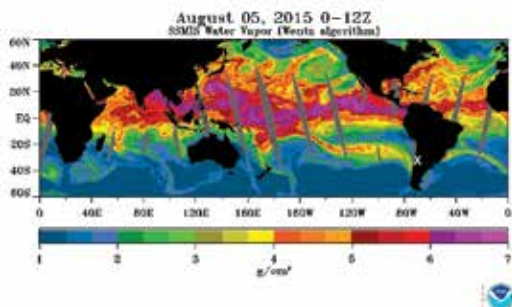


FIGURE 1: Example of an AR from the Special Sensor Microwave Imager (SSM/I/S) showing the high values of integrated water vapor that likely contributed to a historic avalanche cycle at Pimentón, Chile marked with a white X. [www.esrl.noaa.gov/psd/psd2/coastal/satres/archive.html](http://www.esrl.noaa.gov/psd/psd2/coastal/satres/archive.html)

the models to create a "perfect storm" version of a wintertime atmospheric river. Their storm was a composite of two major winter storms that California has experienced in recent history; January 1969 and February 1986. The series of storms are simulated with a Weather Research and Forecasting (WRF) Model, which gives insight to what could happen in the snow and avalanche world. They find precipitation rates reach 1.57"/hr in windward areas of the Sierra, and maximum 24 hour precipitation totals near 11.8". The resultant flood damage to the area and central valley would be a major natural disaster. Sedimentary records reveal that floods of comparable scales have occurred a few times in just the past thousand years (Kirby et al. 2012).

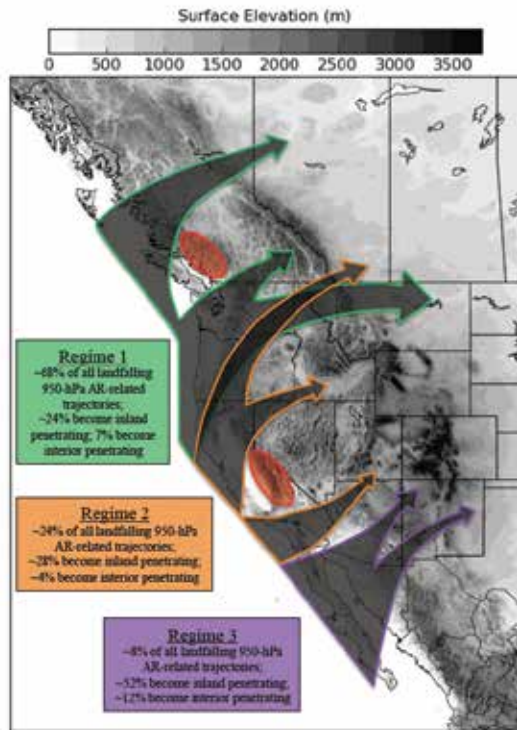


FIGURE 2: Atmospheric river transport regimes into the interior Western US. Courtesy of Rutz and Steenburgh 2014

Mountain ranges enhance lift, dry an air mass out, and inhibit the downstream spread of more moisture (Hughes and Mahoney 2014, Rutz et al. 2015). Pacific originating ARs most frequently influence precipitation along the Sierra Nevada and Cascade Ranges, but occasionally penetrate further inland. Distinctly different patterns are responsible for AR penetration into the Northwest, and Southwest interior and can be achieved when an AR passes through lowland corridors from the west (Figure 2; Rutz and Steenburgh 2014). Birkeland and Mock (2001) found that avalanche extremes at four different sites in the West occur when moisture is allowed to flow through low elevation pathways to the site. Each of the four sites studied has its own unique pathway for a storm track in order to achieve optimal precipitation influence.

One optimal pathway that has become recognizable because it favors Provo Canyon is via the Southern Cascades in Oregon and Northern California. Provo Canyon is a major weakness in a chain of the Southern Wasatch Mountains that rise 7,000 vertical feet off the valley floor (see locator map). The spine of these mountains has a North-North-



FIGURE 3: Slide Canyon as seen on a dry season, 3/2013. Highway US-189 is in view below.

west to South-Southeast orientation, and strong orographic enhancement of precipitation is often observed during events with West to Southwest winds. Slide Canyon is a large path with long planar slopes (See Figure 3). The avalanche starting zones face Northeast to Southeast with an upper ridgetop elevation of 10,645ft. The track is a long channel with a consistent pitch, and the runout is an alluvial fan where US-189 passes through Pro-

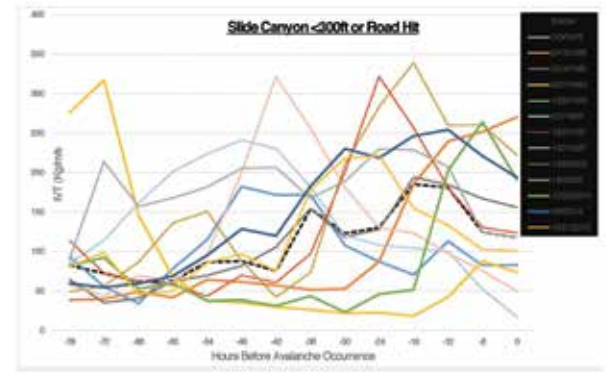


FIGURE 4: Seven out of 13 occurrences met the >250 IVT requirement in the three days preceding a D4 avalanche that came within 300ft, or covered US-189 with debris. In 11 out of the 13 occurrences on record within the Reanalysis data, IVT exceeded 220 Kg/m/s within three days preceding an avalanche. The lowest maximum value was 182 Kg/m/s.

Storm Hour	Event 1, 20101229					Event 2, 20140205					Event 3, 20151220				
	IVT (Kg/m <sup>2</sup> )	Max Precip Rate (in/ Hr)	HSTW (in)	HS (in)	Avg T Air (F)	IVT (Kg/m <sup>2</sup> )	Max Precip Rate (in/ Hr)	HSTW (in)	HS (in)	Avg T Air (F)	IVT (Kg/m <sup>2</sup> )	Max Precip Rate (in/ Hr)	HSTW (in)	HS (in)	Avg T Air (F)
T-24-18	23.3	0	0	63.1	15.7	59.6	0	0	40.5	9.4	46.03	0	0	24.0	29.1
T-18-12	46.2	0	0	62.7	14.9	68.9	0	0	40.0	15.8	49.93	0	0	23.7	32.4
T-12-6	51.8	0	0	62.3	23.7	95.3	0	0	39.8	15.9	86.71	0	0	22.8	38.2
T-6-0	202.9	0	0	62.4	24.3	128.8	0	0	39.7	18.1	97.01	0	0	20.6	35.4
T 0-6	264.4	0.20	0.66	62.2	25.0	120.2	0.01	0.02	39.2	18.6	75.64	0.13	0.35	24.6	32.0
T 6-12	<b>191.201</b>	<b>0.21</b>	<b>1.39</b>	<b>68.2</b>	<b>26.0</b>	<b>182.9</b>	<b>0.02</b>	<b>0.10</b>	<b>38.7</b>	<b>21.9</b>	<b>177.94</b>	<b>0.08</b>	<b>0.48</b>	<b>25.6</b>	<b>26.5</b>
T 12-18	67.1	0.41	3.47	73.9	26.5	230.2	0.05	0.24	38.3	22.3	218.27	0.16	0.92	30.0	26.0
T 18-24	39.3	0.40	4.71	84.8	21.2	218.9	0.23	0.88	36.6	23.1	221.58	0.20	1.48	32.4	25.2
T 24-30	20.4	0.04	4.86	88.2	14.5	246.6	0.02	0.92	45.1	23.1	155.26	0.01	1.49	31.6	24.0
T 30-36	32.1	0.03	4.96	87.8	10.4	254.5	0.01	0.96	44.5	23.4	133.15	0.23	2.3	36.3	24.1
T 36-40	19.0	0.01	4.97	87.4	15.3	221.3	0.32	1.84	44.2	25.0	<b>102.75</b>	<b>0.39</b>	<b>3.63</b>	<b>42.2</b>	<b>27.1</b>
T 40-48	19.3	0.13	5.14	86.2	8.0	194.1	0.22	2.75	49.8	26.1	101.25	0.39	5.47	52.3	27.6
T 48-54	14.8	0.03	5.25	86	4.1	<b>118.57</b>	<b>0.28</b>	<b>3.68</b>	<b>33.7</b>	<b>27.2</b>	64.79	0.29	6.09	55.9	26.3
T 54-60	17.7	0.03	5.35	85	2.8	141.1	0.27	4.89	58.9	29.1	80.01	0.12	6.4	56.5	26.7
T 60-66	20.3	0.05	5.4	83.8	7.2	80.7	0.37	6.01	63.7	30.6	38.8	0.08	6.53	NA	27.1
T 66-72	23.1	0.05	5.61	84.1	-1.9	77.8	0.04	6.08	65.2	32.0	34.39	0.02	6.59	59.5	23.4

FIGURE 5: Three storm events with the first column being time before and after storm start. The six-hour period in which an avalanche occurred out of Slide Canyon that came to within 300ft. of US-189 is highlighted in yellow. In bold are the Peak IVT values and peak hourly precipitation rates observed during the storm.

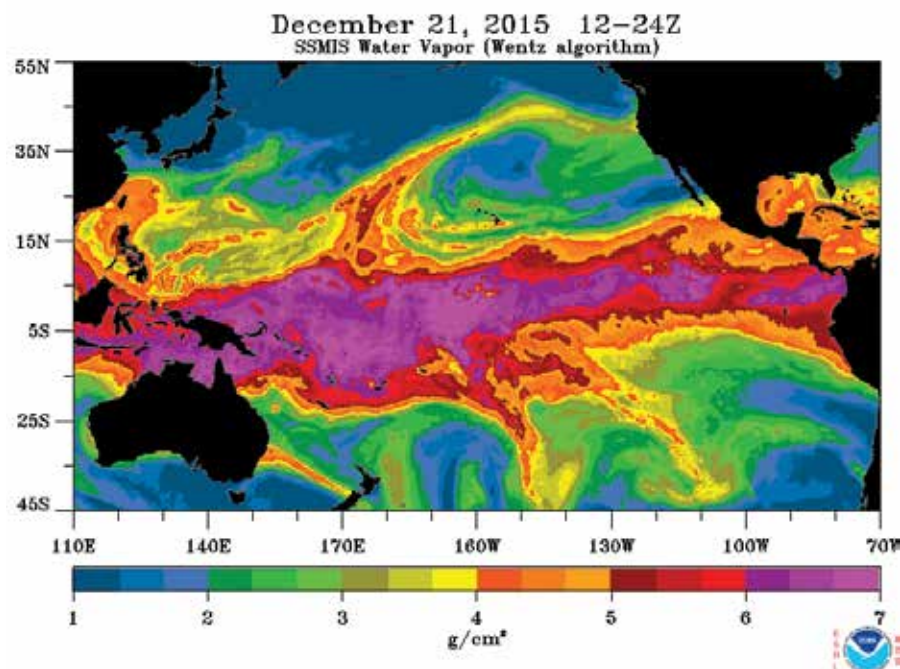
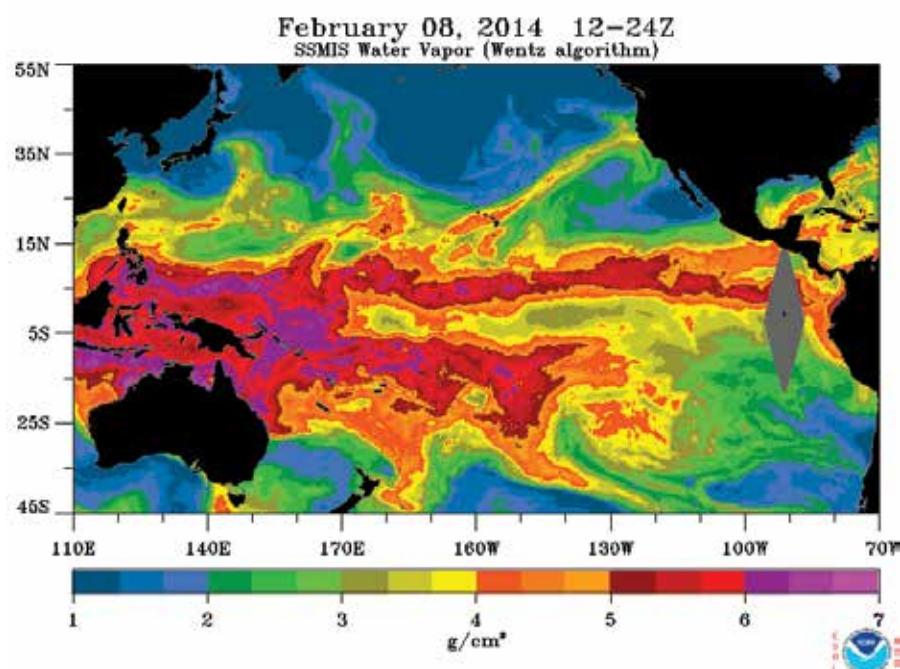
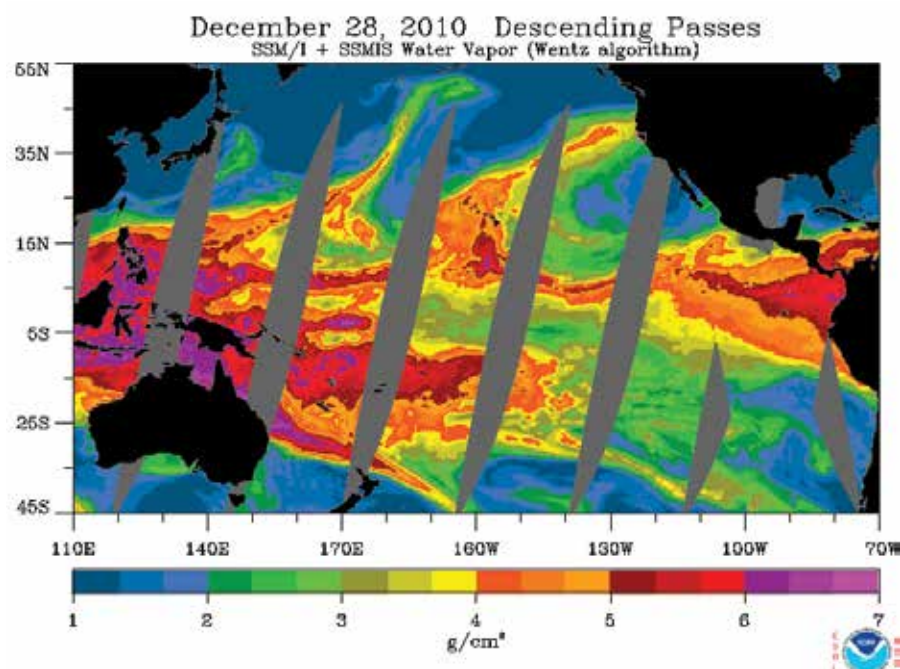
vo Canyon at 5,228ft. The Mid Mountain Weather Station located at Sundance Mountain Resort is the closest, most representative site for snowfall and precipitation data. It sits at 7,450ft, roughly one mile to the Northeast from the center of the main starting zone and one drainage over.

My first experience with one of these ugly beasts while working with the Utah Department of Transportation was in early February of 2014. The storm was characterized by strong West-Northwest upper level jet stream winds, strong Southwest lower level winds, anomalously high amounts of precipitable water, and strong warm air advection. During warm air advection the winds increased, and so did the precipitation rates. We saw a one-hour period of 0.37"/hr at the Sundance Mid Mountain plot (7,450ft). During the lulls between these waves, temperatures would slowly increase so each passing wave would be warmer than the previous one. Widespread instabilities rapidly developed and were overloaded in short order. Many large paths on the Timpanogos and Cascade massifs ran full track, producing roughly 10 D4's and a D5. The initial failure was suspected to have been low density stellars that fell at the beginning of the storm, but 4-Finger hardness, 2mm basal facets also played a role. In any case, the strong warm air advection and intense precipitation rates observed were incredible. We ended up with more than double the storm totals as nearby sites, and far overachieved all weather forecasts.

A way of assessing ARs and strong moisture transport events in general is through the presence of high values of integrated water vapor transport (IVT), which provides a quantitative measure of how much water is being transported in the atmosphere by taking the product of wind speed and water vapor throughout a column of air. With the help of Jonathan Rutz (NWS) I obtained a catalog of IVT and the presence of ARs by identifying whether a moisture plume is >2000km long and has  $IVT > 250 \text{ Kg/m/s}$  throughout (Rutz et al. 2014). The data is in a 2.5 degree resolution (roughly  $277 \text{ km}^2$ ), so the area where Provo Canyon lies is quite large, and IVT values are likely smoothed over a bit due to the complex topography. Because the presence of an AR at this location under these requirements are infrequent and the Reanalysis resolution not very high, I did not take into account whether the occurrence classifies as an AR but instead focused on the values of IVT. IVT forecasts have been recently made available at the Center for Western Weather and Water Extremes (CW3E: [woodland.ucsd.edu/?cat=12](http://woodland.ucsd.edu/?cat=12)).

For avalanche data, 13 occurrences were found that came within 300ft. of or covered US-189. 300ft. is used because that seems to be a threshold of avalanche occurrences in the data set. The next closest running avalanche was recorded to have come 1,400ft. from the road, this one was triggered by a heli-bombing mission with special mention of an ice crust being involved in the snowpack at the time. The 13 occurrences ran either naturally, with heli-bombing, or with artillery. They were both hard and soft slabs, but the debris almost always showed signs of wet flowing motion. These all classify as at least D4 in size, two were D4.5. The largest was in 1978 when debris was reported to be 30 to 75ft. deep along a 900ft. length of road. It took nearly three days for crews working around the clock to clear the road (Daily Herald 1978).

Figure 4 shows IVT for the three days prior to avalanche occurrences from Slide Canyon, where



FIGURES 6, 7, AND 8: Three archives from the Special Sensor Microwave Imager (SSM/I/S) showing high values of integrated water vapor transport for the three events from Figure 5. [www.esrl.noaa.gov/psd/psd2/coastal/satres/archive.html](http://www.esrl.noaa.gov/psd/psd2/coastal/satres/archive.html)

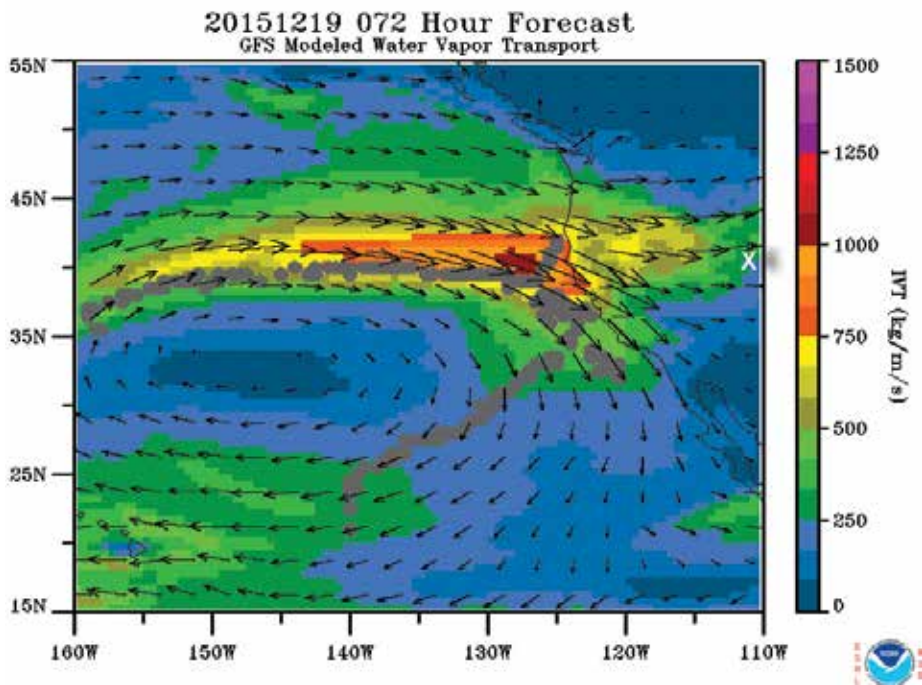


FIGURE 9: Armed with a newfound awareness of the situation, we have been able to prepare for pronounced AR events. One of the tools we can use are water vapor transport models from the GFS. Here, an archived 72 hour forecast from 12/19/2015. Roughly 72 hours later in the middle of the night, we were triggering a D4 avalanche in Slide Canyon with artillery that came 70ft. from the highway. A white X marks the approximate location. [www.esrl.noaa.gov/psd/psd2/coastal/satres/data/html/ar\\_detect\\_gfs.php](http://www.esrl.noaa.gov/psd/psd2/coastal/satres/data/html/ar_detect_gfs.php)



Close up of a lateral side of a churning debris flow from 12/21/2015 avalanche in Slide Canyon.



Debris on alluvial fan from 12/21/2015 avalanche out of Slide Canyon. US-189 visible on left side.

debris made it less than 300ft. from US-189. Seven out of 13 occurrences met the >250 IVT requirement in the three days preceding an avalanche. In 11 out of the 13 occurrences on record within the Reanalysis data, IVT exceeded 220 Kg/m/s within three days preceding an avalanche. The lowest maximum IVT value was 182 Kg/m/s.

A closer look: Archived SSMI/S images help complete the picture. Figures 6, 7, and 8 show the three events in this next case study. The three studied here are the three most recent events. Figure 5 is a table depicting relationship of IVT values to precipitation and snowfall, along with temperature. Winds will be evaluated in a subsequent analysis. Events 1 and 2 ran naturally, Event 3 was triggered by artillery.

Although preliminary, these results demonstrate that high IVT values may provide important information in the forecasting of large avalanche events. High IVT were observed during the 3-day period preceding all of the recent large avalanches out of Slide Canyon. The three most recent occurrences coincided with warm air advection, and the heaviest precipitation rates were observed before temperatures fell with the passage of cooler air. Peak IVT occurred prior to peak hourly precipitation rates.

It is likely that if a mountain area has a low elevation pathway from the coast then ARs play a role in heavy wintertime precipitation episodes, which closely relate to large magnitude avalanche occurrences (Perla 1970). It isn't clear yet if ARs invited everyone else to the party, but it surely looks like they attended and had a grand old time. Continued investigations are needed to find out "Are they the life of the party?" and if so, what can we identify about them that will help us determine if they will produce enhanced precipitation rates? A more detailed analysis will be submitted to the International Snow Science Workshop 2016.

Special thanks to Jonathan J. Rutz PhD, Benjamin J. Hatchett MSc, and Chris Covington for guidance and suggestions. ▲

References:

J-W. Bao, S. A. Michelson, P. J. Neiman, F. M. Ralph, and J. M. Wilczak, 2006: Interpretation of Enhanced Integrated Water Vapor Bands Associated with Extratropical Cyclones: Their Formation and Connection to Tropical Moisture. *Monthly Weather Review*, 134, 1063–1080.

Karl W. Birkeland, Mock, C., and Shinker, J.J., 2001. *Avalanche Extremes and Atmospheric Circulation Patterns*. *Annals of Glaciology*, 32, 135-140.

Data, NCAR/NCEP reanalysis courtesy Jonathan Rutz: [www.inssc.utah.edu/~rutz/ar\\_catalogs/ncep\\_2.5/](http://www.inssc.utah.edu/~rutz/ar_catalogs/ncep_2.5/)

Data, UDOT Avalanche Office, Provo Canyon: [mprimomo@utah.gov](mailto:mprimomo@utah.gov)

Mimi Hughes, Kelly M. Mahoney, Paul J. Neiman, Benjamin J. Moore, Michael Alexander, and F. Martin Ralph, 2014: The Landfall and Inland Penetration of a Flood-Producing Atmospheric River in Arizona. Part II: Sensitivity of Modeled Precipitation to Terrain Height and Atmospheric River Orientation. *J. Hydrometeorol*, 15, 1954–1974.

Kirby, Zimmerman, Patterson, and Rivera, 2012. A 9170-year record of decadal-to-multi-centennial scale pluvial episodes from the coastal Southwest United States: a role for atmospheric rivers? *Quaternary Science Reviews* 46, 57-65.

Leung, L. R., and Y. Qian, 2009. Atmospheric Rivers Induced Heavy Precipitation and Flooding in the Western U.S. Simulated by the WRF Regional Climate Model, *Geophysical Research Letters*, 36, L03820.

# Snow Safety is in our DNA.



**FLOAT 42**

Affordable, proven, and easy to use.

Snow safety is our specialty. We support all of our products with education and customer service.



**The most trusted name in backcountry safety.™**

[www.backcountryaccess.com](http://www.backcountryaccess.com)

Pro and fleet pricing available.  
(800) 670-8735



Upper starting zone of Slide Canyon 1/21/2016.



View down the tube of Slide Canyon a month after the 12/21/2015 D4 avalanche.

David McClung and Peter Schaerer, 2006. *The Avalanche Handbook, Edition 3: The Mountaineers Books.*

Mitchell, Colin. Personal Communication 2/25/2016.

Paul J. Neiman, et al, 2008: *Diagnosis of an Intense Atmospheric River Impacting the Pacific Northwest: Storm Summary and Offshore Vertical Structure Observed with COSMIC Satellite Retrievals.* *Monthly Weather Review*, 136, 4398–4420.

Reginald E. Newell et al, 1992. *Tropospheric Rivers?—A Pilot Study.* *Geophysical Research Letters*, 12, 24, 2401–2404.

Ron I. Perla, 1970. *On Contributory Factors in Avalanche Hazard Evaluation.* *Canadian Geotechnical Journal*, 7, 414–419.

Martin F. Ralph, Paul J. Neiman, Gary A. Wick, Seth I. Gutman, Michael D. Dettinger, Daniel R. Cayan, and Allen B. White, 2006. *Flooding on California's Russian River: Role of Atmospheric Rivers.* *Geophysical Research Letters*, 33, L13801.

Martin Ralph, et al., 2004. *Satellite and CALJET Aircraft Observations of Atmospheric Rivers over the Eastern North Pacific Ocean during the Winter of 1997/98.* *Monthly Weather Review*, 132, 1721–1745.

Jonathan J. Rutz, W. James Steenburgh, and F. Martin Ralph, 2015. *The Inland Penetration of Atmospheric Rivers over Western North America: A Lagrangian Analysis.* *Monthly Weather Review*, 143, 1924–1944.

Rutz J. and Steenburgh J., 2014. *Climatological Characteristics of Atmospheric Rivers and Their Inland Penetration over the Western US.* *American Meteorological Society*, 142, 905–921.

Gao, Y., J. Lu, L. R. Leung, Q. Yang, S. Hagos, and Y. Qian, 2015. *Dynamical and Thermodynamical Modulations on Future Changes of Landfalling Atmospheric Rivers Over Western North America.* *Geophysical Research Letters*, 42, 7179–7186.

Yong Zhu and Newell, R., 1998. *A Proposed Algorithm for Moisture Fluxes from Atmospheric Rivers.* *American Meteorological Society*, 126, 725–735.

Matt is an avalanche forecaster, mountain guide, and world adventurer. He recently had his first summer in five years after 10 back-to-back winters in the Northern and Southern Hemispheres. He enjoyed it immensely.



# DON'T MESS WITH THE

# BROWN FROWN

Glide crack with tracks on Lipps Ridge, 1/6. This crack released five days later.  
Photo Heather Thamm

BY ALEPH JOHNSTON-BLOOM

*“Good Morning this is Graham Predeger with the Chugach National Forest Avalanche Information Center with your snow and avalanche conditions for Tuesday January 12th at 7 am. The Primary Concern today is Glide Avalanches: It’s not every-day that our avalanche problems are so obvious and visible to the naked eye but that seems to be the case today. Found on all aspects, glide cracks are mostly relegated to the 1,000’ – 2,500’ elevation band. Glide cracks are strange beasts that really are impossible to predict. Weather and other triggers such as humans, or even explosives, that we associate with other dangerous avalanche problems don’t seem to affect glides. There is no discernible pattern to predict a failure, as they tend to fail naturally and on their own schedule. Sometimes a glide crack won’t release at all, and benignly just fill back in with snow. Knowing when or even whether a glide crack will avalanche is like asking is there “Life on Mars?” Maybe, though the jury is still out so in the meantime, take your protein pill and put your helmet on!*

*Glide cracks are best to be given a wide berth. Limit your exposure time underneath and if skiing or riding in terrain with glide cracks, try and map them out first as not to end up directly on top of or inside one. Remember, when these do fail, they tend to be destructive, failing to the ground bringing the entirety of the snowpack with them.”*

Glide avalanches as the Primary Concern? In January? The day after David Bowie died...

Several years ago when the avalanche problems and icons were being discussed in the avalanche community, there was talk of not needing a glide avalanche icon. Here in Southcentral AK, we are glad that it made the cut. It has been used in our forecast product for the past five weeks, and the primary concern on many days.

Following a warm storm pattern over the holidays that deposited over 14 ft. of snow, glide cracks started appearing throughout the mid-elevations from Girdwood Valley to Turnagain Pass and beyond. The term ‘littered’ has been used more than once to describe the widespread cracking of the snowpack. The forecast area has seen glide cracks in previous Januarys but this year’s cycles have been unusually active. There have been two major spikes in activity so far with a third beginning as I type this.

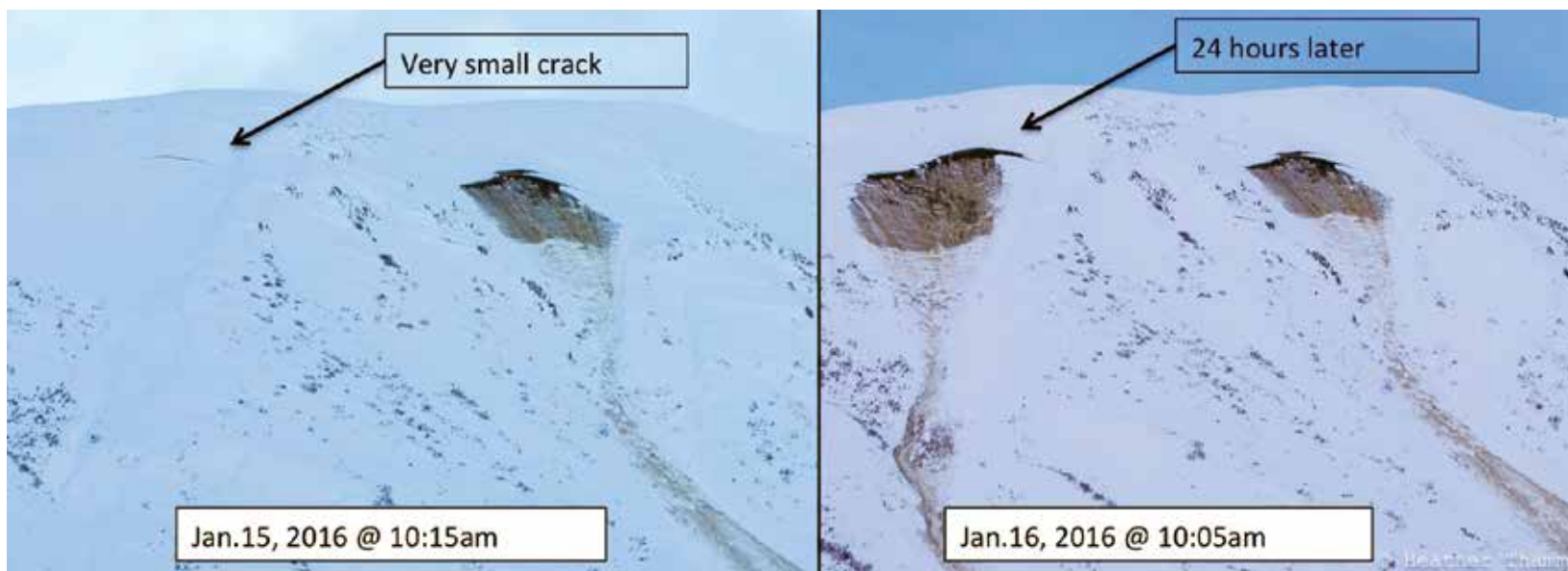
One thing is for certain; it has added an interesting twist to evaluating and communicating the avalanche hazard to the public. One LOW danger January day we had a large glide crack release in the heart of our most popular snowmachine zone, the next day we bumped the danger to MODERATE for glide avalanches and indeed another one released (photo above on next page). The meat of the problem is cracks continue to appear and occasionally release in terrain that people recreate in. Watching how recreationalists treat glide cracks has been almost as interesting as watching them pop.

**Public observation on 1/8:** Toured up usual skin track on Lipps and observed two sizable glide cracks on the south face, above 3000’. One guy from a group above us decided to jump into it and measured it 5-6 ft. deep to the ground. Also observed a large glide crack on the south face of the peak directly north of Lipps.

**Public observation on 1/14:** The staff has been warning about the dangers of ‘Glide Cracks’. I am very familiar with the Lipps area, and the glide cracks on it. I have no memory of the glide crack releases on Lipps having so much destructive force. They ran much farther than usual, the size of debris is much larger than usual, and the amount of energy is way above usual. Just crossing the debris field was an exercise in humility. I have been watching many glide cracks over the last couple weeks, most in usual spots, but I felt the need to warn others about these results.

**Public observation on 1/15:** Touring up to Tincan Proper our group of four observed a glide crack release across the valley on the Eddies wall. The Eddies wall is currently littered with glide cracks all at a similar elevation. My estimate is 2000ish feet. The release was very audible. The crack that pulled out is pretty far down the wall. Dirty snow ran toward the valley floor.





Glide avalanches on the southeast face of Seattle Ridge, Turnagain Pass, AK. This area receives the most motorized use in our forecast zone. Photos Heather Thamm

In talking to long time locals and professionals we have heard some additional anecdotal ideas about this current glide situation.

**Dave Hamre** (Alaska Railroad Corp., Avalanche Program Director): Ah, good luck with that.

**Scott Hilliard** (Alyeska Snow Safety Director): Glide-induced avalanches are every forecaster's nightmare. I think we have a solid understanding of the ground-interface mechanisms at work. The problem is that, like cornicefalls and seracfalls, the delayed and indirect action nature of these hazards makes it impossible to predict with any certainty when or if they will release. The only good news is that a cycle of glide activity will eventually be followed by cycle of inactivity, but that may come fairly quickly, or not until the final spring meltdown.

Here at the Resort, our current glide cycle is significant in that among the numerous glide cracks that have appeared, we have had two actual glide avalanche releases to date, which is relatively rare during midwinter. While this activity is not unexpected we are well above average in the water content and temperature of our snowpack it is nonetheless difficult to guess when the cycle may end.

**Jim Kennedy** (Alaska DOT Avalanche Program Director): They are a pain in the ass and give them room.

**Andy Morrison** (Owner/operator, Alaska Backcountry Access, snowmachine guide service): After 15 years of taking clients out at Turnagain Pass – “I have never seen a glide avalanche problem like this, at this time of year. I really think it has to do with warm temperatures and the ground not freezing as hard as it usually does. There is a lot of mud in the glide releases. Watching them release with cold temps and warm temps has emphasized the unpredictability.

**Heather Thamm** (Avalanche Specialist for the Chugach NFAIC): It is hard to avoid being under/around glides. They're everywhere. When slopes get tracked out, people have a tendency to go where the snow is soft despite the unpredictable nature of glides.



Lipps Ridge, debris from glide release on 1/11. Photo Ray Koleser

So, are there any themes to this season's glide activity? Although we are not jumping to any conclusions, and have some data analysis ahead of us, cracks tend to appear during warm stormy weather but it is not until afterward, with minor cooling and clearing, that boom... the brown frown fails. Not even a 7.1 magnitude earthquake January 24th was able to rattle any of these loose – go figure. It is a fascinating phenomenon that really may all tie in with David Bowie... ▲

Aleph Johnston-Bloom is currently an avalanche specialist for the Chugach National Forest Avalanche Information Center in Girdwood Alaska and an instructor for the Alaska Avalanche School. She has had a varied career as an avalanche professional. She is a member of the American Avalanche Association's Governing Board and a Certified Instructor. Enjoying her third winter in Alaska, she is happily riding snowmachines, eating moose burgers and developing a new relationship to SWE.



# #nothingbadhappened

## AVOIDING THE ILLUSION OF VALIDITY

STORY AND PHOTOS BY IAIN STEWART-PATTERSON

**How do we** measure decision competence in avalanche terrain? Can a decision outcome be used as a measurement of decision competence? Is an avalanche involvement indicative of a poor decision? Is it possible to “do everything right” and still get caught in an avalanche? Can the lack of a negative outcome be equated with a good decision? A good day is often used to describe a day when nothing bad happened.

Travel in avalanche terrain can be plagued by a lack of decision feedback. Sequential decision-making is often based on non-event feedback.

*We rode that line. The snow was great and nothing bad happened. What is next?*

When the avalanche problem is characterized by a near-surface instability such as a wind slab or storm slab, the inability to trigger a slide can be a reasonable indicator of stability. However this is not the case when dealing with a persistent weak layer (PWL), particularly when it is deeper in the snowpack. Situations that have no natural activity, a deep persistent weak layer, a low likelihood of triggering, and a high degree of spatial variability are challenging decision environments. Fortunately, accidental human-triggered avalanches happen with a relatively low frequency in these situations. However, as a learning environment, this scenario sets the decision-maker up for potential failure sometime in the future. Patterns are learned and saved for future use. Unfortunately patterns learned in a “wicked” environment (Hogarth, 1980), conditions of poor feedback and high consequence, may lead to a sense of “it won’t happen to me.”

Every avalanche fatality influences future decisions. A fatality provides raw, in-your-face feedback to those involved. It sends ripples through the collective consciousness of the community. Some events may have a limited sphere of influence and be contained within a subset of the larger community, while bigger or more highly publicized events cross boundaries.

If a norm is established, based on an assumption that good decision-making is reflected in the absence of bad things happening, we become surprised when an event occurs that falls outside of the anticipated range of potential outcomes. An event occurs that is worse than our imagined worst-case scenario. Termed a black swan, it is often rationalized post event (Taleb, 2010). In January 2003, seven people died on a guided ski touring trip in the Selkirk Mountains of BC. Ten days later, seven school children died on a school ski trip to Rogers Pass. These two back-to-back black swan events created a paradigm shift in the way that avalanche hazard was described and communicated. So are we doomed to only learn from black swan events? Additionally, do we retain the learning indefinitely?

For example, avalanche fatalities in the Canadian snowmobile community spiked in 2008-2009 with a total of 19. Eight sledders died in a single event. The BC Coroner’s office commissioned a Death Review Panel to investigate. Numerous recommendations were made. A month after the report was released, a catastrophic avalanche occurred on Boulder Mountain in Revelstoke, BC. Over 200 sledders were involved: 100+ partial burials, 60+ full burials, 43 injured and 2 fatalities.

Learning and behavior change occurred. It had to. But on January 30th 2015, 17 sledders from four different parties were caught in an avalanche on Mount Renshaw, BC. Fifteen were buried and five died.

When you throw a pebble into a pond, the ripples extend outward in all directions, but eventually die out and the water becomes calm again. If you throw many large rocks in, the water becomes a chaotic mess, but eventually becomes calm again. How easily is the chaotic mess forgotten?

**We can do better.**

**It is easy to be critical of a peer’s decision when something bad happens,**



The story behind these shots: I was heli guiding. First run of the day. Suspected windslab problem. The pocket that ripped was a known consistent indicator slope. I tried to trigger the roll and put in a ski cut on the convexity at what I considered a safe distance from where the slide might occur. NOTHING HAPPENED. The first guest came down, crossed his tips on the convex roll and head planted into it. The slope released. Good feedback. No involvement.

When were you most at risk, particularly when nothing bad happened?



Experts typically make rapid, good decisions based on situational awareness and pattern recognition. They use a high quality mental model as a bridge between the current situation and a previously experienced pattern.

*Have I been here before? What did I do and did it work?*

*If I am wrong, how will I know?*

This works well when previous experiences have a high degree of similarity with a new situation and the outcome has been analyzed. It requires

**but not so easy  
when everything  
appears to  
have gone well.**

high quality peer validation and feedback that goes beyond the implicit environmental feedback.

Unfortunately, pattern recognition does not solve all decision problems, as bad patterns can also be formed, particularly when dealing with low frequency scenarios.

#### **So what does feedback do for us?**

Essentially it gives us the opportunity to react and modify our decision strategy. Human triggered avalanches are the most intimate form of feedback as it provides direct evidence. What about accidentally triggered avalanches that result in near misses? What do they do for the decision-maker? In many ways they are the best form of feedback as they create a powerful opportunity for reflection, discussion and peer feedback on the decision process.

#### **Are you willing to be critical of a peer's decision that resulted in a non-event?**

Although nothing bad happened, each group member's situational awareness and evolved expertise may result in differing pattern recognition. It is easy to

be critical of a peer's decision when something bad happens, but not so easy when everything appears to have gone well. Yet open and honest peer feedback is one of the best ways to improve decision accuracy. So when #nothingbadhappened, scrutinize the process. Was it flawed? The analysis hinges on the perception of whether the outcome was representative of existing conditions. Does it create a template for future flawed decisions? Perhaps next time the outcome will not be as favorable.

#### **Analyze the decision environment.**

What is the likelihood of occurrence and severity of consequence?  
What is the source and quality of feedback?  
Is this a wicked environment, with low probability of occurrence, low quality feedback and high consequence?  
What is my frequency of dealing with this particular decision challenge?

Evaluate and reflect on the quality of every decision. The critical element is the decision-maker's level of mastery within the specific environmental context.

Look at the conditions of the environment. Have you been there before? Were you getting good feedback?

Ask the question:

*When were you most at risk, particularly when nothing bad happened?*

A lack of negative feedback and a tendency to be selective in our memories can generate an unshakable confidence that promotes an illusion of validity (Einhorn & Hogarth, 1978). Can you honestly attribute a good outcome to the quality of your decision-making? ▲

#### **REFERENCES**

- Einhorn, H. J., & Hogarth, R. M. (1978). *Confidence in judgment: Persistence in the illusion of validity*. *Psychological Review*, 85(5), 395–416.
- Hogarth, R. M. (1980). *Judgement and choice: The psychology of decision*. Chichester: Wiley.
- Taleb, N. M. (2010). *The Black Swan: The impact of the highly improbable* (2nd ed.). New York, NY: Random House.

## A SUGGESTED **CONCEPTUAL** MODEL FOR DAILY TERRAIN USE DECISIONS AT NORTHERN ESCAPE HELI-SKIING

Background for a pilot project with Dr. Pascal Haegeli

BY CLAIR ISRAELSON

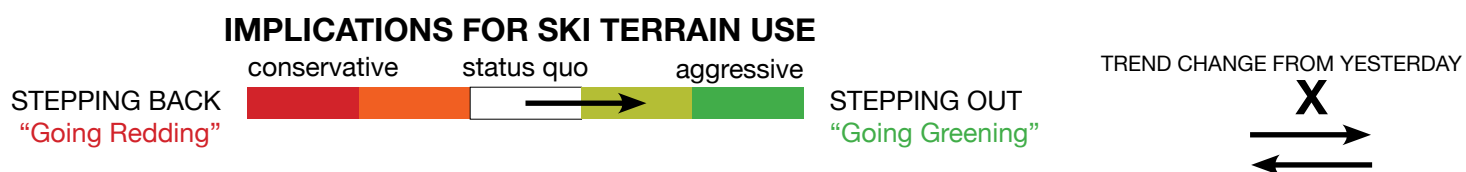
*Editor's Note: This article first appeared in Avalanche Canada's fall 2015 issue of the Avalanche Journal. Thanks to Clair Israelson, Mary Clayton, and Karilyn Kempton for permission to reprint.*

For several years, Pascal Haegeli and I have talked about the potential for research into avalanche safety decision processes in heli skiing. Specifically, we were interested in how the inputs to our morning avalanche hazard evaluation and run list decisions—taken in the safety and isolation of our office—correspond to the terrain we actually use when we get out into the mountains that day.

By the beginning of the 2015 winter season the pieces for the pilot project were in place. Pascal had the time and interest to take the project on. Northern Escape Heli Skiing (NEH) had some innovative operational procedures and documentation in place to generate daily data for analysis. Importantly, our guiding team had bought into the operational value of these procedures, and had a couple of years of experience using them. Data from GPS units carried by our lead guides closed the circle, generating data to track our movements through the mountains with a high degree of precision. From these data we hope to address the following questions:

- At our morning guides meetings, what are the key factors that drive the avalanche hazard evaluation and risk management decisions to produce our run list?
- Can analysis of our daily operational records and GPS tracking data offer insights to improve the avalanche safety decision processes used by heli ski guides in the field?

### NEH GUIDE TEAM DAILY STRATEGIC MINDSET STATEMENT




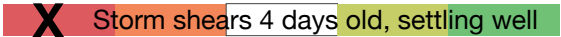




MINDSET CONDITION	COMMENTS	DESCRIPTORS
INITIAL ASSESSMENT		Collecting data to establish baseline
ROUTINE OPERATIONS	 Storm shears 4 days old, settling well	Situation normal (snowpack, weather, confidence)
HIGH ALERT		Unusual, unpredictable dangerous conditions
ENTRENCHMENT		Known persistent, dangerous slabs
OPEN SEASON		Most terrain is safe, we're going for it
SPRING DIURNAL		Adjust terrain use to daily MF cycle

FIGURE 1: NEH Daily Mindset Sample.

#### HOW WE GOT HERE

When I started trying to forecast and control avalanches for Parks Canada in the early 1970s, avalanche science and professional practice were in their infancy. Ed LaChapelle, a leading US researcher at the time, said avalanche forecasting was an iterative, experience-primed intuitive process that defied description. We threw a lot of bombs and hoped we were getting it right. Since then, collaboration between researchers and practitioners meeting around the table of the Canadian Avalanche Association and elsewhere has significantly advanced professional practice.

Technical communications with colleagues and the arrival of computing required a Canadian data standard, and the Observations Guidelines and Recording Standards (OGRS) was born. Computers brought us the internet, propelling InfoEx from a labour intensive faxed paper product to a comprehensive real-time database which invites analysis. Over the years Dr. Dave McClung, Dr. Bruce Jamieson and their research colleagues have contributed immeasurably to our understanding of avalanche science. Thierry Cardon at CMH pioneered the run list concept for heli skiing. With ATES, Parks Canada staff showed it is possible to classify mountainous terrain into categories of potential avalanche severity. Roger Atkins introduced

TERRAIN ATTRIBUTES	Severity Class 1 (Green)	Severity Class 2 (Blue)	Severity Class 3 (Black)
Ski terrain slope angles (fall line ski pitches, not flats or traverses)	Low 30's or less. May contain very short (max avalanche size 1.5) slopes to 35'	Generally between 30' and 35'. May contain very short (max avalanche size 1.5) slopes >35'	Large slopes >35' with some areas exceeding 40'
Max avalanche size possible (initiating from ski line)	2 or less	3	>3
Exposure to overhead hazards	Low. Size 2 avalanche reaches ski line <1:3 yr	Considerable. Size 2 avalanche reaches ski line 1/yr	High. Size 3 avalanche reaches ski line 1/yr
Forest density	Slopes >30', forest density prevents avalanches from starting	Sparse trees, open glades that do not prevent avalanches from starting	Alpine or TL / BTL features with little or no forest cover.
Terrain Traps (avalanche consequence)	Gentle transitions, few trees, obstacles to cause trauma	Some abrupt transitions or trees, obstacles to cause trauma	Many terrain traps or obstacles. Deep burials or trauma likely
Slope shape	Often uniform, planar	Convexities or unsupported slopes may be present	N/A
Escape options	Options exist to escape to safer lines	Limited options to escape to safer lines	Few or no options for escape to safer lines

FIGURE 3: Potential Avalanche Severity Classification Scheme for NEH Ski Terrain. Suggest guide team classifies ski lines on a run as either Green, Blue, or Black depending on which class of attributes, considering all attributes in combination, most closely describes the terrain on the ski line being considered.

the concepts of avalanche character and strategic mindset. The conceptual model for avalanche forecasting, now fully integrated with InfoEx, was developed by a group of American and Canadian avalanche experts led by Grant Statham. These foundations set the stage for our pilot project.

Northern Escape Heli-Skiing Run List										END SKIING TIME		1800	
CAT ZONE ROADS					ZONE 3: Promised Land					NORMAL OPERATIONS			
The Y	BTL	N	1		Molybdenum Creek					Facelot West			
Switchback	BTL	N	1		Shrek	TL, BTL	W	2	3	Miss Robinson	1	2	
The Notch	A	N	1		Donkey	A, TL, BTL	NW	1	2	Mrs Robinson			
Natha's Hill	A	E	2		Poison Apple	A	S		3	Schnackelhuber	1	2	Crevasse?
Machete	BTL	N	1		Poison Beauty	A	SE	2	3	Pillow Talk		2	
					Sleeping Beauty Bl	A	E	2	3	Steep and Easy			
ZONE 1: First Nations					Sleeping B Ridge	A	NE		3	Lava Life			Crevasse, LL
Exstew River					Sleeping B Gully	A	SE		3	Back Door		2	
How	A	NE		3						Nelson River			
										Alder Patch			3 ski quality

FIGURE 2: NEH Run List Sample.

## THE CONTEXT ISSUE

From the outset, we realized avalanche hazard was only one of many factors that influence terrain use decisions in heli skiing. When interpreting our GPS tracking data, analysis of avalanche safety decisions would have to consider the operational context, a conceptual framework for terrain use decisions in heli-skiing. Unable to find any satisfactory description of such a framework in the literature, what follows is my attempt to articulate a plausible decision hierarchy. If this description is reasonable, then experienced heli ski guides should find what follows is common sense and self-evident. If not, I've got it wrong and we need to get it right. I invite your comments and suggestions for improvements.

## THE DECISION FILTER CONCEPT

I suggest heli ski guides use a series of decision filters to consecutively eliminate terrain from our menu of possible choices each day. The end product of this filtering and elimination process is the terrain we actually use, as captured by the GPS tracking data.

**Filter 1: Terrain Inventory and Assessment.** At NEH we sell heli skiing. If we're going to sell this product we need to know what we have to offer and where it is within our operating tenure. Early in the life of the company, we explored our tenure to identify and map skiing zones with relatively similar geography, climate, glaciation, forest cover, spatial relationships to lodges, fuel caches, highway accessible staging areas, and the density and character of potential ski runs.

NEH has twelve skiing zones encompassing 7,000km<sup>2</sup>. Economics and skier satisfaction dictate that zones closest to lodges and fuel caches with a good mix of alpine and tree skiing and lots of ski runs in close proximity to each other get used first and most often (e.g., Promised Land), while more remote zones with fewer ski terrain options (e.g., South Shore) are used when conditions in the more accessible ski zones are unsuitable due to avalanche hazard, ski quality or other reasons.

All possible ski runs are explored, named, mapped, and the various ski lines on each run are classified for potential avalanche severity using a

green/blue/black rating system overlaid onto photos in our run photo catalogue. The potential avalanche severity rating is determined by consensus within the guide team based on our personal experience in that terrain. This is an ongoing process as new ski runs continue to be developed. NEH maps, run photo catalogues and run list formats are updated annually as part of our pre-season planning. At NEH this terrain inventory is the foundation for the avalanche risk assessment required under the recently revised WorkSafeBC regulations.

## Filter 2: Hazard Evaluation and Risk Management Processes

AM Guides Meeting. Our AM guides meeting of guides and pilots generates three key products which build on each other to produce a tentative operating plan for the day.

- **AM avalanche hazard forecast.** Using the InfoEx workflows, this is an iterative process reflecting the change from yesterday's AM forecast. Key inputs are yesterday afternoon's InfoEx now-cast, 24-hour snow and weather actuals and forecasts, and InfoEx subscriber reports. This assessment is a combination of data analysis and intuitive, experience-based gut feel. A goldmine of input data and assessment conclusions are captured in the InfoEx database for future analysis.
- **Strategic Mindset and Run List.** For years I have been advocating for some sort of tool to help our guide team reach a shared mental model for the rationale and extent of the stepping out (greening) or stepping back (redding) we do on our run list each day. The eureka moment occurred when Roger Atkins gave his strategic mindset talk at ISSW in Banff last fall. We combined some of his ideas with some of our own, and the resulting product works well for us (see Fig. 1 above). This strategic mindset exercise only takes one or two minutes and saves us time in the long run by streamlining our run list discussions that follow. Our guiding team is sold on the concept; you may want to try it out in your workplace.

Next we create the run list for the zones that we plan to use that day. The sequence of photos in our run photo catalogue mirrors the order of the run list for each ski zone. As we scroll through the run photos, the green, blue or black lines on each run are considered. Decisions to open or close a line for the day are by team consensus; if consensus is not reached the line is closed by default. On the run list, lines determined to be safe for skiing that day are color coded green (see Fig. 2). Lines closed for avalanche hazard are color coded red. Lines closed for other mountain hazards (crevasses, open creeks, ski quality, etc.) are color coded black. Ski runs in zones not being considered that day are undiscussed and color coded white. Company policy decrees that only the green lines on the run list are options for our guides to ski today. Everything else is off limits.

A copy of the day's run list is printed for each helicopter. Run photo catalogues are downloaded to phones or tablets so guides and pilots can cross reference and confirm they are operating within the criteria established during the AM guides meeting. New runs are not on the run list; the NEH operations manual specifies criteria for exploring and skiing new runs.

- **Daily Operations Planning.** Lead guides and pilots discuss who will go where in which helicopter. Considerations include the number of helicopters operating, weather, anticipated snow conditions, previous terrain use, etc.

The Filter 2 decisions are consensus-based guiding team decisions made at the morning guides meeting, before going out into the field. They are best guesses based on all available evidence, factoring in uncertainty driven in large part by the time elapsed since we were last in the field.

**Filter 3: Weather and Flying Conditions.** Guides are responsible for terrain choice decisions, and pilots are responsible for flight safety. Using real-time observations and forecasts, pilots and guides collaborate to decide where/if we can heli ski on a given day. Bluebird days are easy, since visibility is unlimited. However, bluebird days aren't the norm. Commonly, at least some of the terrain we would like to get to is unreachable due to cloud, snowfall, fog layers or wind, eliminating that terrain from our list of options. Last winter we kept a daily flying weather log to document how much of our terrain was unusable each day due to inclement weather.



Far-running wet avalanche debris 20 meters deep fills the bottom of Kautz Creek on Mount Rainier, February 2015. How does this score on the terrain classification chart? Photo Scott Larson

**Filter 4: Flight Economics.** Most guests purchase a ski package with a specified amount of vertical feet of skiing. Guests get refunds if they fail to reach this specified number, and pay extra for skiing in excess of their package's vertical promise.

Production is the ratio between flight hours used and the number of vertical feet each guest group skis in a day. A guide's job is to optimize production while giving our guests the best possible skiing experience. The helicopters we use cost \$30 and \$40 per flight minute. If a helicopter costing \$40/minute is servicing three groups of skiers and burns just one minute of unnecessary flight time per lift, over the course of a twelve run day our helicopter cost increases by almost \$1,500. Multiply that by a one-hundred-day operating season with three helicopters and it becomes apparent that if I'm a lead guide who burns helicopter time frivolously, I won't have a job for long.

NEH provides standing written guidance to our guiding team stating that our operational priorities are safety first, guest satisfaction second and economics (i.e., helicopter costs) third. We need to be safe and keep our guests happy without bankrupting the company.

The closest good skiing gets used first, and as those runs become skied out we move further afield to terrain that requires more cost (flight time) to access. Most days, this precludes routine use of areas on the far fringes of our tenure. Fortunately, there is little correlation between ski quality and distance from the lodge, so there is seldom pressure from the guests to launch off into the remote reaches of the tenure in a faint hope search for blower powder. When those excursions do occur, it is usually by private groups who pay for flight time rather than by vertical feet of skiing. Decisions regarding production and terrain use are made on site in real time by the individual lead guides.

**Filter 5: Safety and Skiing Quality.** Subject to decisions prescribed for the day at the AM guides meeting, each lead guide inherits accountability for the run choices they make. Safety concerns, primarily avalanches, remain our priority. Our morning avalanche forecast and run list are created before we go out into the field. Just because a ski line is green on our run list today does not necessarily mean that we really should go there. Conditions in the mountains may be dramatically different from what we had envisioned back in the office. The decision for the lead guide is "should I land here or not?"

It is common practice for lead guides to start on a safe, "standard" first run to feel out that day's snow and avalanche conditions before embarking on their intended circuit. As we move through the mountains, we observe terrain-dependent variations and patterns in snow quality, structure and stability. We look for runs with acceptable avalanche risk and the best possible skiing conditions. Once onto a run, we feel the snow structure and quality, and take our guests to the micro terrain features where the best skiing is. We're guiding—using our knowledge, experience and judgment to provide the best possible experience for our guests. Decisions about where we will ski next are driven by everything that we have observed prior. This is the classic Bayesian updating process described by McClung.

Extensive local experience and pattern recognition skills are required to put together a good heli skiing day. Decisions are made on site, in real time. A lead guide's skiing plan for the day often has a very short shelf life.

**Filter 6: Guest Preferences.** Not all guests want the same heli skiing experience. Snowboarders and skiers often prefer different types of terrain. Some groups want to charge the steep and deep, racking up vertical as fast as they can. Others want to ski less challenging terrain at more leisurely pace. We're in the customer service business, so we try to take our guests to the type of terrain that's best for them. On any given day, we may consciously avoid going to a ski line or run that has safe, good skiing because it's just not the right fit for the that particular group of guests.

## CONCLUSIONS

I suggest the pilot project data collected at Northern Escape Heli-Skiing during the winter of 2014-15 might be interpreted in the context of the decision filtering processes described above and shown in Fig. 3. Each of the filters described above consecutively eliminates more and more of the terrain from our menu of choices for that day. We ski what remains after all filters have been applied.

I hope the Canadian avalanche community will let me know if this conceptual approach works for them (or not) and how it might be improved. Please contact me at [clair@neheliski.com](mailto:clair@neheliski.com) with your feedback. If your organization is interested in becoming part of this research project please contact Dr. Pascal Haegeli at [pascal@avisualanche.ca](mailto:pascal@avisualanche.ca). ▲

# WEEKLY MEETING FORMAT Chugach National Forest Avalanche Center

BY JOHN FITZGERALD

At the CNFAIC in 2014/2015 we developed a system for improving our accuracy and ability to convey our message consistently. The main vehicle for this is a weekly snowpack meeting. In the past we relied on piecemeal communication via email, phone and text, in addition to reading each others' advisories. Those components are still in place and of great value. The weekly meeting has created several benefits to the program.

## MEETING FORMAT:

- Tour locations day by day
- Breakdown of avalanche problems by elevation band and zones (Turnagain Pass, Summit Lake, Girdwood Valley)
- Layer(s) of concern
- Layer(s) to track
- Info gaps (areas, aspects)
- Focused questions
- Blown Forecasts/Lessons Learned
- Confidence Rating by zone (blind ballot)

We rotate the meeting facilitator every week, giving everyone the opportunity to be in charge of running the meeting. Typical meeting time is ~60 minutes. **Notes are taken** and filed electronically.

## BENEFITS:

The meeting format allows for open conversation among the team. The facilitator is responsible for moving the conversation forward while at the same time slowing down when necessary to work through disagreements or conflicting opinions.

By taking stock of the week we are able to think through our observations (and others, including the public). All team members have their notes in front

of them. We invite and often have present other professionals/forecasters from DOT, Alyeska Resort, CPG, and Alaska Railroad, adding depth to the conversations.

By identifying gaps in our knowledge we have a basis for picking tour locations for the coming week. The CNFAIC is unique in that it identifies a "core advisory area." With this in mind the focus for field observations is typically on Turnagain Pass. Knowing the gaps helps to ensure that the team covers both the core and peripheral areas appropriately.

Having newer forecasters and interns attending these meetings have the added benefit of providing an excellent forum for focused mentoring. There are always opportunities for all team members to voice their opinion. This is the result of good tone-setting by the facilitator. By having a comfortable and trusting atmosphere to work in, team members of varying experience levels have the ability to coach, be coached, learn and improve their understanding of all aspects of snow science and avalanche forecasting.

These meetings also allow the team to work through or at least address common problems associated with broadcasting avalanche products to the public. Message fatigue, effectiveness of social media, and webpage format are just some of the topics that come up.

The most interesting and thought provoking aspect of these meetings is the confidence voting at the end. The scale is 1-5 and the rating is based on your confidence in each person's understanding of the snowpack. ▲



# BACKCOUNTRY COMMUNICATION PROTOCOL

BY MICHAEL JACKSON

The genesis of the Backcountry Communication Protocol (BCP) came from belaying my six-year-old son at the local rock gym. Within 10 minutes he was dialed in on the Climbers' Verbal Protocol:

"On belay?" "Belay on."

"Climbing." "Climb On"

and the foundation of his climbing career became rooted in critical communication being transmitted quickly and efficiently to increase safety and to avoid accidents.

So why doesn't backcountry travel have the same sort of protocol to prompt us to address critical information quickly and with 100% participation by all group members?

The BCP mandates all group members communicate and provide input before any member can proceed. The goal of the BCP is to make a habit out of good communication as well as to mandate group participation. It should be practiced constantly throughout a tour or avalanche course.

This tool assumes that the group has planned and prepared for their tour properly. Studying the avalanche report, making a tour plan with options, having tour members with the similar skill levels and risk acceptance levels, as well as making certain all members have proper equipment, is the baseline before the Protocol can be effective.

The overall goal of the BCP is to continually reinforce critical communication between all group members efficiently and effectively.

## The BCP addresses three vital questions:

### HAZARD

What is the current avalanche hazard and what are the avalanche problem of concern?

ALL group members MUST respond verbally and state the avalanche hazard and specific avalanche problem(s) to the rest of the group.

### TERRAIN

Is the terrain appropriate for the avalanche hazard?

ALL group members MUST verbally agree that the terrain is appropriate for the avalanche hazard and problem(s) found in the terrain, that other concerns are identified (cliffs, terrain traps, blind spots, etc.), and that a mitigation strategy is agreed upon by ALL members prior to entering into the terrain.

If ANY member expresses ANY concern, ALL members MUST reach a unanimous decision prior to entering the terrain. If no Unanimous decision can be reached, the group MUST default to a more conservative terrain option where the BCP must be used again to evaluate the hazard, terrain, and consequences.

### CONSEQUENCES

What are the consequences to our party if we are involved in an avalanche in this terrain?

ALL group members MUST verbally respond and discuss the consequences of a worst-case scenario in the chosen terrain. There MUST be UNANIMOUS agreement that the ALL members are aware of the consequences, recognize the risk, and agree to proceed. If there is not UNANIMOUS consent, the group MUST default to more conservative terrain option.

This BCP is intended for private parties and not guided groups, but the components of the protocol are still worth mentioning to clients for their own educational benefit. I have used this with my own touring partners, as well as to course participants.

It is not cumbersome, takes very little time, and addresses critical concerns to all group members. Since lack of effective communication is a recurring theme in avalanche accidents, the BCP could make a difference in behavior, which could have a direct correlation in the reduction of avalanche accidents due to communication issues.

Don't let the **MANDATORY RESPONSES** scare you away from trying this: it is simple and effective. It is nowhere near being an elegant solution, but I do believe from using it that it creates a very good habit, much like looking both ways at stoplights, putting on your seat belt, and making certain your climbing partner is tied in and ready to go. ▲

## ORGANIZING DOUBT

BY JERRY ISAAK AND MATT SCHONWALD

**It seemed like** a good idea at the time. In January of 2016 the two of us would travel more than 6,500 miles to ski tour in an area neither of us had ever seen, based out of backcountry yurts, with no avalanche forecast or snowpack history and virtually no weather forecasting. We would bring six undergraduate students and one graduate student with us to guide and teach for college credit. Also, we had never met in person.

To paraphrase the now famous words of Donald Rumsfeld, there were many unknowns, both known and unknown. Matt and I certainly had more questions than answers as we headed into the Tien Shan Mountains of north-eastern Kyrgyzstan.

During the trip we had many conversations about the role of questioning and doubt in dynamically complex environments. Despite the seemingly abstract nature of the discussion, our context allowed us to apply these ideas immediately. Daily backcountry tours during a period we forecasted as Considerable Hazard forced us to act in a situation with high levels of ambiguity without the ability to analyze every detail in advance. Doubt was our ever-present companion, but rather than paralyzing our decision-making, doubt empowered us to develop meaningful ideas while staying critical of these ideas.

After the trip (which we confirmed was a great idea) Matt returned to Seattle and his work as a ski guide, avalanche educator, and professional observer for NWAC, and I traveled to upstate New York where I work as an Associate Professor at the State University of New York. We decided to continue our conversation via email and Google Docs. This conversation/interview is reproduced here, hopefully to introduce some new ways of thinking about doubt and to spark reflection and discussion among our community of snow professionals.

**Jerry:** *When we were in Kyrgyzstan you were reading a (huge) book which seemed to introduce new ways of thinking about the role of doubt and dealing with dynamically complex environments. What was the title of that book, and why did you relate its content to decision-making in avalanche terrain?*

**Matt:** Seven years ago I was teaching an avalanche course in Bellingham for a friend and we both were trying to articulate the role of confidence and doubt in decision-making. We went back and forth trying to compare how each affected our choice, looking at how meteorologists discussed how much confidence they had in their forecasts by expressing a percentage versus how doubt sat as a pit in our stomach. The pit in our stomach seemed harder to discount, so despite the lack of empirical evidence at the time we decided to give it more weight and treat it as our evolutionary warning system. I used doubt to teach students to trust themselves to follow up when feeling uneasy about their situation in the backcountry. I told them it usually is an unarticulated concern that once brought up allowed the group to open up, reassess the plan, and address new observations that were not stated earlier.

During NSAW this fall, I asked one of the presenters (Susan Joslyn, PhD, Associate Professor of Psychology at the University of Washington) about the difference between uncertainty and doubt and she confirmed that doubt arises from uncertainty, not the other way around. I started researching the psychology of doubt and found a book by Eric-Hans Kramer that addressed my question. *Organizing Doubt: Grounded Theory, Army Units and Dealing with Dynamic Complexity* addresses the idea that doubt throughout history assisted our evolution by driving our species to question our assumptions of reality and evaluate them to improve our understanding.

The author examined how to build an organizational structure that can harness doubt as a tool for operating successfully in an environment with high levels of uncertainty. This parallels the challenges we face while traveling in Considerable Hazard.

How do we operate as a group when our levels of uncertainty exceed our ability to forecast hazard across multiple elevation zones and aspects? Kramer says Doubt helps form action from argumentation about current understanding or lack of understanding about the local environment and develop a meaningful plan to find out. The AIARE Communication Checklist resembles



Kramer's utility of doubt by remaining critical of the current information and creating space for the group to actively re-evaluate what they know and address the uncertainty before committing to new terrain.

**Uncertainty requires everyone to actively observe and express their observations.**

**Jerry:** *Kramer presents doubt in a positive way, as a powerful tool for action. Why do you think "doubt" often has negative connotations in popular culture?*

**Matt:** Just Google "doubt" and you see it in direct conflict with "faith." Our culture wants us decisive and faithful. Anytime we deviate from 'our faith' it is not looked upon favorably. The Huffington Post has many articles about how faith can overcome doubt. Many scholars have written and spoken about the 'Anti-Intellectualism' in the U.S. Religious and corporate interests encourage an attitude that treats doubt or skepticism as something in direct conflict with the desire to keep things simple whether it involves religion, climate change, taxes, or any other major issue today.

Eric-Hans Kramer's *Doubt* represents the ability of people to develop meaningful ideas while staying critical of them. Doubt prevents the decision-making system from closing off from new input.

**'Doubt is symmetrical: It is not simply that an organization should doubt what it knows for certain, It should also treat as certain the very things it doubts.'**

Kramer states that this contradiction is necessary in order to act decisively yet with curiosity, openness, and complex sensing to avoid extreme confidence and caution blinding them to other possibilities and new information. This definition of doubt requires intellectual curiosity and discipline to maintain a critical view of your world and challenges people of faith and dogma. In other words, no silver bullet can give you 100% confidence that you are making the right choice, just consistent inquiry.

**Jerry:** *This seems to be the obvious link between Kramer's research and our practice in the backcountry. Both extreme confidence and caution can limit our ability to process new information.*

*I read a passage this morning discussing scientific process generally, but seems to me to be highly applicable in the context of backcountry travel.*

*Questions are just as important as answers. Science is a way of asking more and more meaningful questions. So try to learn some answers, because they are useful and interesting, but don't forget that it isn't the answers that make a scientist, it's the questions. (Ames & Wyler, 1961).*

*This resonates with me as an educator and guide. One of the primary emphases of my avalanche-related classes is to have us collectively learn to develop better questions. This doesn't mean being unprepared. Quite the opposite, we can and should do our research on snowpack history, weather patterns, and terrain, so that we can be more aware of our ignorance. The point is: you have to know what you do expect before you can be surprised by what you didn't expect. The unknown reveals itself, as Louis Pasteur once said, only to the prepared mind! You have to be prepared to recognize your ignorance*





SUNY Plattsburgh Expeditionary Studies students hard at work in a big classroom, on the summit ridge of Green Hill in the Babash-Ata Mountains above Arslanbob, Kyrgyzstan.  
Photo Zander Connor

if you are to benefit from it. This seems to describe the ability to develop meaningful ideas while staying critical of them.

I have found that this perspective can be difficult to engage with. We are so programmed to seek solutions that we coexist very uneasily with ambiguity.

How does Considerable Hazard relate to the description of dynamic complexity in Organizing Doubt?

**Matt:** Dynamic Complexity is defined as: a situation requiring the need to act without the ability to analyze every detail in advance. Groups are confronted by problems for which no clear cut rules or procedures are available. Kramer uses case studies of Dutch Military Peacetime operations in Bosnia where situations on the ground changed on a daily basis, not allowing rule of thumb-based decision-making to function. Kramer also discusses the need to use a Holographic model of organization, where everyone is involved and can perform any role (aka: each part is interchangeable). Leadership flattens

## Error correction is preferable to stubborn pride holding onto old ideas in the face of new information.

out as 'the leader' asks more questions to arrive at a consensus before moving on to the next objective.

In Considerable Hazard, the level of uncertainty requires everyone to actively observe and express their observations. This conversation takes effort and the understanding that error correction is preferable to stubborn pride holding on to old ideas in the face of new information.

**Jerry:** The combination of limited terrain knowledge, wind slab, and a persistent weak layer confronted us with a situation of dynamic complexity this January in Kyrgyzstan. In addition we were tasked with instructing and guiding seven students between the ages of 19-25, all millennials.

The millennial generation has incredible access to information, primarily via the internet and their online social networks. There is a general sense that "it can be known" if only we have enough, or the right, information. Basically, doubt is stupid, just ask Siri! They want well-defined solutions based on the abundant excess of information. The abundance of information has influenced a trend away from apprenticeship and towards a belief that we don't need experts, we can just Google it (WebMD for example). This is seductive because it contains elements of truth. However, backcountry environments can't be Googled, at least not in a way that provides real-time solutions for the problems of people/snowpack/terrain.

How does Kramer's research on Organizing Doubt speak to our students, or readers of TAR, who have access to an abundant excess of information?

**Matt:** I think Kramer sees doubt as skill to develop when the information from digital or social sources fails to help the group with understanding the environment. Doubt becomes a trigger to focus your questions on the areas of greatest uncertainty and, for a generation that prefers texting to phone calls, that presents a challenge. When I teach avalanche courses the conversation itself always seems the most challenging part to get the students to learn and participate in.

Kramer frames his model based on managing groups in a high level of uncertainty which requires acceptance of the concept that all previous information may be wrong. This process requires action to collect information, rather than a rule-based if-then decision. In Kyrgyzstan this January our students found themselves in an analog reality forced to engage with the environment and themselves to figure out where their uncertainty is and actively act to gain more information then re-evaluate before moving on. This involved multiple Avalanche, Snowpack & Weather observations per day along with everyone speaking up to decide what terrain was closed to maintain a margin of safety while developing a meaningful understanding of the hazards.

Each day we channeled the Canadian Heli-guide model, reviewed the observations of the day, assessed the hazard then in the AM meeting opened and closed terrain. Each day included each student evaluating what went well, where they were at greatest risk and what they could improve upon the next day. After four days the students recognized what terrain we observed avalanche activity, the possibility of propagation from our tests, and made the connection to the travel advice in the Avalanche Hazard Scale. This allowed us to forecast Moderate by the end of trip by reducing our concern to specific terrain based on Ethan Greene's version of 'Moderate.' Doubt channeled our questions to our greatest uncertainty, which existed on the leeward aspects above 2900 meters.

The rigor required to gather your own information stands in stark contrast to Google or Siri because it takes effort and time. When forced to build your own forecast, the daily tasks take up a larger portion of your day compared to simply looking up forecasts from the local Avalanche Center. Students learn how much goes into avalanche and weather forecasts, altering their perspective as they slow down to verify the validity of incoming information.

**Jerry:** I'm still processing this new research on doubt, particularly on how to apply it in avalanche terrain. One of the major strengths I see is that, as you wrote, "uncertainty requires everyone to actively observe and express their observations. This conversation takes effort and the understanding that error correction is preferable to stubborn pride holding on to old ideas in the face of new information."

I know that I will think differently about doubt and uncertainty and I look forward to applying these ideas on our next ski expedition! ▲

### REFERENCES

- Ames, G., & Wylar, R. (1961). *The giant golden book of biology: An introduction to the science of life*. Racine, WI: Golden Press
- Kramer, E.H. (2007). *Organizing doubt: Grounded theory, army units and dealing with dynamic complexity*. Liber: Copenhagen Business School Press.

Jerry Isaak is an Associate Professor and Chair of the Department of Expeditionary Studies at the State University of New York in Plattsburgh. His research interests are in the areas of outdoor education, social influences on risk tolerance levels and decision-making, and educational expeditions. His favorite place to conduct research is on mountains while skiing. He can be contacted at [jerry.isaak@plattsburgh.edu](mailto:jerry.isaak@plattsburgh.edu)



Matt Schonwald is founder of BC Adventure Guides and a certified AMGA Ski-Mountaineering Guide, a certified Avalanche Instructor with the American Avalanche Association and Professional Observer with the Northwest Avalanche Center. Dedicated to perfecting his craft, Matt completed his MBA in sustainable business from BGI to help preserve wild places. Matt now shares his passion for snow with his daughter and enjoys the greatest touring on Earth at Snoqualmie Pass. He can be contacted at [matt@bcadventureguides.com](mailto:matt@bcadventureguides.com)



# CERTAINTY, the Enemy of Wisdom

## Why Mindful Doubt is Good for You and Your Business

BY OWEN BROWN

*Editor's Note: I ran across this article while reading up on uncertainty and doubt. Anywhere the author mentions "business," we can substitute the phrase "decision-making in avalanche settings."*

*I've learned to question success a lot more than failure. I'll ask more questions when sales are up than I do when they're down. I ask more questions when things seem to be moving smoothly, because I'm thinking: "There's got to be something I don't know. There's always something." This approach means that people don't feel beat up for failing, but they should feel very concerned if they don't understand why they're successful. I made mistakes over the years that taught me to ask those questions.*

**Mindfulness also supports humility. Because despite all our hopes, we don't know much.**

This is Kat Cole, president of Cinnabon, speaking. Our immediate reaction is good for you. "There's got to be something I don't know. There's always something." Ms. Cole, there are plenty of things we don't know, from the number of fish in the sea, to the fissibility of Thorium, to whether the SF Giants can repeat this season. You don't know them either.

But the statement invites further thought. Surely Ms. Cole is not implying that we can know everything. Or that we can ascribe with absolute certainty a particular event to an antecedent. Because we cannot.

### THE WORLD IS PROBABILISTIC

There is more to the world than we can ever know. We who had math beaten into our heads may take comfort in the particular results from curve fitting, overdetermined systems, and other abstruse statistical constructs. And we wouldn't deny that in many cases, we can predict with some degree of confidence. We expect our lights to turn on at the flip of a switch – there's a reason why we call the laws of physics... laws. Without that trust the world would be a more confusing place.

But those laws were made to be broken. Einstein bloodied Newton's nose, and you can bet that someone, somewhere, is gunning for the last century's most famous genius.

### CERTAINTY IS PLEASURABLE

Let's face it, certainty is pleasurable. So can be the process of understanding: I question how this

www.tas.fr

**tas**  
Natural Hazards Control Solutions  
By MND Group

**Project Consultation, Design, Installation, & Maintenance Support**

gazex®  
gazflex®  
O'bell'x  
daisybell®

jay.bristow@mnd-group.com | brandon.dodge@mnd-group.com | 970-328-5330



© 2016 Patagonia, Inc.

# Packed with Possibility

There's no more steadfast fun hog than a Black Hole™ bag. It swallows gear, endures aggressive stuffing, tolerates awful weather and toughs out rough treatment without the slightest grudge. It's witness to your best excursions, keeper of outrageous stories and a common denominator of fun around the globe. Check out our "GO Guide" to find the right Black Hole bag for your next trip: [patagonia.com/blackhole](http://patagonia.com/blackhole)



## patagonia®

came about, you gave me an answer that I can understand, we can all relax. We have done our job for the business, and our shareholders. End of story.

Except it's not. Because it's likely that the cognitive shortcuts you took lead you into a too easy answer.

### PARTICULAR BIASES CAUSE US TO SHORT CIRCUIT UNCERTAINTY

Such as? It's likely that your reasoning was affected by:

- **Framing**, which causes assumptions to be colored through the way information is presented, or
- **Confirmation**, where one seeks out information to only confirm a previously-held conviction, or
- **Projection**, that is, the tendency to assume that others share the same, or similar thoughts, or beliefs, or
- **Primacy**, in which one weights initial events more than subsequent ones, or even
- **Recency**, where more recent events are weighted more heavily than earlier ones!

There are plenty more biases than these. Cognitive scientists fill learned journals with them, and their various permutations. Maybe we shouldn't be so comfortable with easy conclusions, but what's a businesswoman to do?

### MINDFULNESS PERMITS US GREATER COMFORT IN THE FACE OF AMBIGUITY

One can and should adopt any number of approaches to try to balance out the skews in our systems of inquiry and judgment. Interesting to us, our consultancy splits into what we think are mutually supportive camps (doubtless due to our own biases!). On the one hand, we educate our clients on the existence of the most common biases in decision-making and belief, attribution and errors, and we work with them to try to mitigate their effects. For example, a few tips we give everyone:

- Have members with diverse backgrounds on teams on every project, (because we are all different, but have the commendable tendency to not think that we are)
- Memorialize not only decisions, but the process that led to them, (as memory is a thief and a liar)

- Provide for anonymous input, (thus avoiding prejudices, latent or obvious about their origin)
- Make best efforts to provide data in multiple formats (as presentation can effect judgment!)

These are useful whether you are developing a new muffin, launching its marketing campaign, negotiating with the supplier of its raw materials, or modifying its manufacturing and packaging runs in your factories.

Our other approach is to promote mindfulness in general. That could be the subject of an entire volume of blogs. Here we could call it a general promotion of awareness, in yourself and others. We believe that this can lead to a deeper understanding of the world, and a help facilitate a deeper investigation into the causes of things. It can be encouraged, in individuals and groups. There are techniques to promote it. We employ these, as well.

### HUMILITY IN SUCCESS AND FAILURE

Mindfulness also supports humility. Because despite all our hopes, we don't know much. Why were sales up? The best answer is we have some idea, but we don't really know. Why is employee satisfaction sideways? Maybe it's less about your business, and more about two weeks of constant snowfall. You'll never really know. But if you can learn to manage resiliently and kindly with this uncertainty, you'll make a great CEO. Which Kat probably is. ▲

### RESOURCES

[www.nytimes.com/2014/07/20/business/corner-office-kat-cole-of-cinnamon-questioning-success-more-than-failure.html](http://www.nytimes.com/2014/07/20/business/corner-office-kat-cole-of-cinnamon-questioning-success-more-than-failure.html)

Owen Brown is a Managing Partner of 4128 Associates, and has over 25 years experience as a senior manager in both for-profits and non-profits. Owen's expertise lies in the areas of finance, operational and organizational redesign, process efficiencies and product development, strategic, and tactical planning, and sales and marketing management. His consulting company's website is [4128associates.com](http://4128associates.com). A talented fine arts painter and pianist, Owen holds degrees from Yale College and the University of Chicago. His paintings are available for viewing at [www.eyesvoice.com](http://www.eyesvoice.com).



# YOUR SYSTEM

## An Individual Approach to Avoiding Avalanches

STORY AND PHOTOS BY JOE STOCK

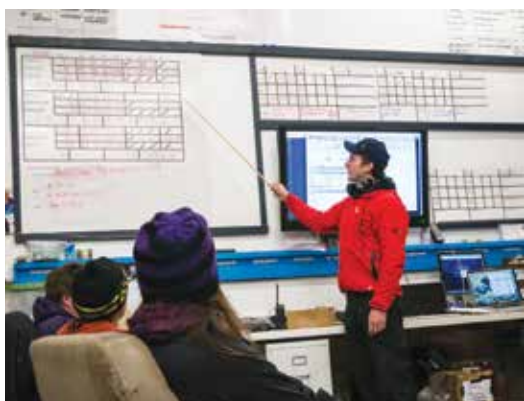
I've never been caught in avalanche. Maybe it's because I'm good at mountain travel. Maybe it's because I maintain a healthy margin for error. Maybe it's luck. In any case, I work hard to avoid avalanches. I'm in the snowy mountains most of the winter. The odds are against me. One of the things I work at is my system for avoiding avalanches.

My system is a method for avoiding avalanches that focuses on my human factors—the seemingly silly mistakes I make in avalanche terrain despite how much I know about avalanches. My system is rigid. I follow it every time I ski, but it changes every year.

Target your own human factors with your system.

A system is a set of principles or procedures used to achieve a goal—in this case, avalanche avoidance. Avalanche professionals who work in large operations like ski patrol or Canadian heli ski services use a time-tested system that keeps them relatively safe day after day in a high-risk environment. These systems work well in operational settings, but they do not target individual human factors.

**Ski guide and avalanche instructor Sarah Carpenter says, on [Wildsnow.com](http://Wildsnow.com), that recreational skiers should model their daily routine after snow professionals, who often follow these nine steps:**



- 1 Check the avalanche forecast every day.**

---

- 2 Follow the weather.**

---

- 3 Track avalanche activity.**

---

- 4 Plan before you leave the house.**

---

- 5 Be prepared.**

---

- 6 Have an opinion.**

---

- 7 Adjust your plan if conditions are different than you anticipated.**

---

- 8 Report your observations.**

---

- 9 Review your tour at the end of the day.**

---

**In *Avalanche Essentials*, Bruce Tremper says that the system for avalanche safety includes:**



- 1 Have trip plans.**

---

- 2 Gather information.**

---

- 3 Know what kind of avalanches you are dealing with.**

---

- 4 Know what the avalanche pattern is.**

---

- 5 Choose safe terrain based on those patterns.**

---

- 6 Know how to travel on the terrain.**

---

- 7 Know what to do if things go wrong.**

---

These lists can be thought of as baseline systems. Avalanche professionals and mindful recreationists follow a baseline system day after day, year after year in the backcountry. Through years of practice, most elements of Carpenter and Tremper's baseline systems have become second nature to me. But even if I adhere to a baseline system, an avalanche could get me through one of my own human factors, factors not shared by all avalanche professionals.

To address your human factors, add a personalized system—your system—that incorporates what avalanche researcher Ian McCammon calls your disaster factors—human factors that are most likely to kill you in avalanche terrain. If you know your disaster factors, you can target those issues with your system.

Your system is a list of items you want to practice to improve your safety. If you practice each step in your system consistently, you will mitigate your human factors, and stay alive longer. Your system is a secondary list that complements baseline systems. It builds onto, rather than replaces, baseline systems like Carpenter and Tremper's.

As you gain experience, knowledge and maturity, your system will change. Tweak it at the beginning of each season. A few years ago, for example, I added, “Look for reasons to turn around” to my system as a way to mitigate my goal-obsession on personal trips. After working on that, I felt I’d mostly overcome it and I removed it from my system. Last year I went after my tendency to become too engrossed in pleasing ski clients. I wanted every client to say, “That was the best day of skiing in my life.” To address this, I remind myself of the guiding priorities “#1 Safety, #2 Achieving the Objective, and #3 Having Fun.”

My current system for avalanche avoidance focuses on guiding. It ensures that I’ve done as much as possible to keep my clients and myself safe in avalanche terrain. I work on these seven points every time I guide. As these become second nature, I will change them out for other points that I want to focus on.”

## JOE’S SYSTEM FOR AVALANCHE AVOIDANCE, FEBRUARY 2016

### Communicate with Clients

1 Lack of communication is a core problem in most avalanche accidents. There are many aspects to good pre-trip communication with clients. Below are the aspects I am working on now, until they become habit like the rest of my pre-trip communication with clients.

- Send pre-trip letter to client.
- Discuss objective and options with client.
- Discuss risks with client.
- View and discuss weather with client.
- View and discuss avalanche advisory with client.

### Attend Guide Meetings

2 The morning guide meeting is an important step to processing information before going into the field. Since I primarily work by myself, the guide meeting is often just me, at 5:30 am at home or in the sleeping bag. I review the weather, snow and avalanche conditions, the group and the plan. When possible, I join Chugach Powder Guides in Girdwood for their morning meeting.

### Practice Avalanche Companion Rescue with Clients

3 Before going near avalanche terrain, I practice companion rescue with every client. I do the same for glaciers. Before skiing on glaciers, I practice building snow anchors for crevasse rescue with each client.

### Apply Terrain Progression

4 Alaska ski guide Brad Cosgrove first explained terrain progression to me. Brad said to start every day, and every trip, mellow. This is akin to skiing at a resort where you warm up with some groomers, hit your challenging run toward the end of the day, and then warm down for the last run. While backcountry skiing, I apply terrain progression by starting on easier terrain and ramping it up if conditions and the group allow. Before every trip, I explain terrain progression to clients so they understand how it works.

### Use Strategic Mindset Terms with Clients

5 In *Yin, Yang and You*, Roger Atkins describes seven mindsets for integrating human factors into decision-making. For example, when a big storm clears and while collecting information, you’ll be in assessment mindset. After a few days of stepping out mindset with no signs of snow instability, you may enter open season mindset and go for it. I use this terminology with clients so they better understand our status relative to avalanche danger.

### Pause Before Skiing

6 I pause and think before diving into each run. Standing there on the ridge, I create what McCammon calls a pre-mortem. I ask myself, “If this slope avalanches, what clues would I have missed?” I pick out the dumb mistakes from my imagined obituary and try to correct those mistakes before they happen. Southcentral Alaskans can ask themselves: “What would Medred say?”

### Ski Test Every Run

7 I ski test every run, to keep it a habit. Ski testing is similar to ski cutting done by ski patrollers, but different. You’re not trying to start an avalanche. Rather you’re starting the run defensively with a couple zig-zags, aiming toward your escape route just in case the slope does release. As Larry Goldie explains in *Off Piste*, a ski test is “one last test before we fully commit to the slope.... a tool ... used to further minimize the risk while skiing.”

What are your human factors? What is your system to address those human factors? Write it down on your coffee cup. Tape it to your skis. Stick to it. And change it each year. ▲



### MORE READING

*Morning Meeting, The Importance of a Clear Plan and Conditions Dialogue*, by Larry Goldie, *Off Piste*, October 2015.

[offpistemag.com/avalanche-safety-morning-meeting](http://offpistemag.com/avalanche-safety-morning-meeting)

*Avalanche Essentials*, by Bruce Tremper, Mountaineers Books.

*The Daily Rituals of Avalanche Professionals*, by Sarah Carpenter.

[www.wildsnow.com/18266/daily-rituals-avalanche-professionals](http://www.wildsnow.com/18266/daily-rituals-avalanche-professionals)

*Yin, Yang and You*, by Roger Atkins. *Proceedings of the 2014 ISSW*, pages 210-217.

[arc.lib.montana.edu/snow-science/objects/ISSW14\\_paper\\_09.02.pdf](http://arc.lib.montana.edu/snow-science/objects/ISSW14_paper_09.02.pdf)

*A Question of Risk*, by Drew Hardesty, [blackdiamondequipment.com](http://blackdiamondequipment.com).

[blackdiamondequipment.com/en/experience-story?q=drew%20hardesty&format=landing&cid=drew-hardesty-risk](http://blackdiamondequipment.com/en/experience-story?q=drew%20hardesty&format=landing&cid=drew-hardesty-risk)

*Decision-making in the Wild*, NOLS, by Ian McCammon, May 18, 2015.

[www.youtube.com/watch?v=uhKavZZVMBo](http://www.youtube.com/watch?v=uhKavZZVMBo)

*The Biggest Secret Your Avalanche Instructor Never Mentioned: The Ski Cut*, by Larry Goldie, *Off Piste*, December 2013, pages 20-21.

Document your field days.

- waterproof paper
- zero failure rate



To order: [www.hacksawpublishing.com](http://www.hacksawpublishing.com)  
[www.facebook.com/HacksawPublishing](https://www.facebook.com/HacksawPublishing)

BY CHEYENNE BROWN

**“Ours is a vulnerability which may be reduced or deferred, but is never overcome: a susceptibility that is not simply a failing, a structural fault, or a surmountable hurdle, but is a part of our all-too-humanness.”**

—Nigel Clark

As travelers in snowy environs our challenge is not to eliminate or even overcome our vulnerability but to find ways to reduce and manage it.

While attending graduate school in geography the topic of vulnerability (specifically the vulnerability of particular groups and communities to the impacts of climate change) was very en vogue in geography and associated disciplines. Like our department, and the discipline in general, the lively discussions around vulnerability were incredibly interdisciplinary. Recently I got to wondering why, if vulnerability is so important to a community of researchers so closely related and sharing so many similar topics as our avalanche community (both interested in questions regarding a changing and dynamic biophysical world and its intersection with human interests), it wasn't something that had been discussed much within our community. If it added so much to the research being done in hazards, geography, sustainability science, and climate studies, then surely there was something that could add to our “human factors” discussions and thinking.

Doing this first requires knowing what exactly we mean by vulnerability when it comes to working and playing in places where avalanche hazards exist. The interdisciplinary ground and the diversity of folks involved in the discussion make communication difficult. We are often, quite literally, speaking entirely different languages and carrying around entirely different ideas about what it means to be vulnerable.

**“There are some days when no matter what I say it feels like I'm far away in another country and whoever is doing the translating has had far too much to drink...”**

—Brian Andreas

### WHICH VULNERABILITY?

We don't often question the meaning of vulnerability in our everyday conversations; we don't require a precise definition of it. Brenè Brown's popular daring greatly vulnerability is well suited to interpersonal relationships and personal growth. This vague, ambiguous vulnerability doesn't serve us very well in terms of reducing our vulnerability in the backcountry. Engineers can calculate and measure vulnerability with equations. This calculated, quantitative vulnerability is important in analyzing and assessing infrastructure projects but is not a great tool for evaluating our everyday interactions with the biophysical world. With such a broad range of possible meanings it can be hard to know precisely what we mean when we (the avalanche community) talk about vulnerability. What discussion there has been in the avalanche realm has focused almost exclusively on the power of technological and gear-based solutions to limit our vulnerability. We deserve better than that, and can have better. We can develop a more useful vulnerability; one that is specific to our needs, grounded in the realities of traveling in and around avalanche terrain, and can help us frame our habits and decisions in the backcountry.

### DEFINING VULNERABILITY

**“Vulnerability is the characteristics of a person or group and their situation that influence their capacity to cope with, resist, and recover from the impact (or potential impact) of a hazard.”**

—Wisner et al 2003

These characteristics tend to be highly dynamic, whether they are human or biophysical. Our level of vulnerability is driven in large part by our dynamism and that of the environments in which we put ourselves. We are combining the highly dynamic nature of human beings (as individuals and then compounded with group dynamics), with the highly dynamic and variable nature of the biophysical world.

Our vulnerability is in a constant state of flux. We cannot calculate all of the probabilities and contingencies of this relationship between the mountains and us. The variables are too many, the unknowns high, and our cognitive abilities inadequate in the face of this. So we simplify. We attempt to find the most representative variables and components, we attempt to bound the problem within useful parameters and heuristics.

### MAKING VULNERABILITY USEFUL

Vulnerability is made up of three key components:

- **Exposure:** the stress to which a system is exposed. This includes magnitude, frequency, duration, and areal extent (how widespread, spatially, the stress is).
- **Sensitivity:** the degree to which a system is modified or affected by that stress.
- **Adaptive capacity:** the ability of a system to evolve in order to accommodate hazards or changes and to expand the range of variability with which it can cope.

In our case “the system” is the human/environment interaction and “the stress” is, perhaps obviously, avalanches. We can further define three components of vulnerability in the context of avalanche hazards:

**Exposure:** This is a concept that has been widely discussed in the avalanche community. In our world exposure commonly distills down to one thing: managing terrain.

**Sensitivity:** Our sensitivity is relatively static. Humans are highly sensitive, especially to natural hazards. We are small and squishy relative to the elements we face in the natural world. We are highly susceptible to harm from avalanches, whether trauma (including not just physical trauma but also mental and emotional) or death. Relative to exposure and adaptive capacity we really can't do a ton about our sensitivity. And what we can do about sensitivity is predominantly in response to already being caught in an avalanche. We can wear helmets to make our vitally important heads less squishy should they encounter rocks or trees or consolidated snow chunks. We can wear beacons and airbags, which, in essence, make us slightly “bigger” and more findable should we be caught.

**Adaptive capacity:** This concept is a little less straightforward and certainly underutilized within the avalanche community. Rather than a set of specific actions, this concept offers an important framework for analyzing our behaviors and actions as they relate to avalanches. A given group or community's adaptive capacity is generally considered to be made up of a few key elements: availability of technologies, availability of resources and capital (social, cultural, symbolic and financial\*), the structure of critical institutions, education, decision-maker's ability to manage information, and public perceptions of risks, hazards and vulnerability.

### FROM VULNERABILITY TO RESILIENCE

It is our susceptibility to harm and an absence of the capacity to adapt that make us the most vulnerable.

Resilience is the answer to vulnerability. By decreasing our sensitivity and increasing our adaptive capacity we increase our resilience. We build resilience predominantly by identifying and strengthening the key elements (mentioned above) of adaptive capacity.

Like vulnerability, adaptive capacity is highly dynamic. There are very few universal certainties when it comes to adaptive capacity and building it. It is context-specific (specific to the hazard, time and place), it is time, place and scale dependent. It should be noted that the aforementioned determinants of adaptive capacity, and adaptive capacity itself, can happen at a variety of scales (individual, family, community, state, national, global and everything in between) and that those scales are in no way independent of one another. It should also be noted (and perhaps obvious) that many of these determinants are interwoven; availability of technology and education are closely linked with the availability of particular types of resources and capital, the structure of critical institutions impacts decision-maker's ability to manage information, both of which feed into the public perceptions of risks, hazards, and vulnerability. There hasn't been any research into what actually builds adaptive capacity when it comes to dealing with avalanche hazards but I feel confident making some educated guesses.

Availability of technologies such as beacons, shovels, probes are vitally important to our adaptive capacity once caught in an avalanche, but availability of technologies such as computers, internet, and smartphones (which allow access to navigation programs, programs like Avamet, as well as access to case studies, incident reports, and stories) are likely also crucial in building adaptive capacity.

The availability of resources and capital represents an incredibly broad category but would include things like personal experience, access to mentors or more experienced backcountry partners, an avalanche culture in the community, money available for pursuing guided trips or to further education or technologies. Do you have access not just to folks to romp around in the snow with but also people to debrief with, to share thoughts and ideas and concerns with?

Decision-maker's ability to manage information in its most obvious form would be the ability of our local avalanche forecasters to get useful information to the public. The success of this is also closely linked with the structure of certain critical institutions at the state and national level (Forest Service and National Weather Service for example). Education is perhaps one of the largest potential spaces for building adaptive capacity. This would include everything from organizations setting up at trailheads to talk with folks, to formal avalanche courses, to articles in local newspapers, to mentoring/being mentored.

This piece is highly intertwined with many of the other determinants, particularly in the availability of education to folks, which could be a combination of availability of resources (do they live in a community where there are avalanche organizations, course opportunities available, do they have the money, do they have friends to join them, etc), availability of technology (do they have access to internet?), and the structure of critical institutions in their area. This education component is certainly on us as individuals to seek out opportunities for furthering our education, but is also on organizations to, in some ways, make the opportunities for education more widely available, or perhaps to force it on folks in some cases.

Public perception of risks and hazards seems like an especially crucial component to me right now. Many of the accidents in my community (the Tetons) this year have been folks who have slipped out the gates or under the rope at Grand Targhee or Jackson Hole Mountain Resort. Although many things were at play in these accidents, a big one is no doubt the public perception of the risks of exiting the ski area. Many of these folks were not locals, were not from places with strong avalanche cultures or access to education. Public perception of the risks and of vulnerability represent a really important place for growth in adaptive capacity, and an opportunity for snow and actions sports media and local media to play an important role, as well as more specialized organizations such as the AAA.

Research into finding useful ways of measuring and successfully building adaptive capacity are still in their infancy, and there's no research to date that focuses on measuring vulnerability or adaptive capacity as it relates to recreation and avalanche hazards. There is the potential for widespread investigations into our perceptions of vulnerability, why we make ourselves vulnerable, what determinants of adaptive capacity are most important in the avalanche community, and what our greatest weakness might be in building that adaptive capacity.

Despite the dynamism of our vulnerability and an inherent, inescapable aspect to it, our level of vulnerability is almost always driven "by inadvertent or deliberate actions that reinforce self-interest." Vulnerability results from choices we make, "processes in which we actively engage and which can almost always be mitigated." (Adger, 2006, p 170).

As backcountry enthusiasts we struggle with this sort of decision-making on a regular basis and often we get away with making decisions which make us highly vulnerable; our quest for untouched powder some days gets the best of us. How many accident reports do we read in which numerous no-go clues were present? There is a very high level of voluntariness to our vulnerability. We do not have to go out into the backcountry, we do not have to ski or climb at all (we might sometimes feel we need to, and we may get melodramatic and insistent about our need to but we will not actually die if we don't). In an ideal world this voluntariness is accompanied by an equally high or higher level of awareness about the decisions that we are making, about the level of vulnerability we are manifesting for ourselves.

By working towards an explicit vulnerability we gain a new framework for situating our thinking and acting that can help ground the decisions we make in the context of resilience and vulnerability and provide a new way of talking about what we are doing and why. We can work towards understanding our rituals, our behaviors, and our choices in terms of whether or not they our increasing our adaptive capacity and our resilience to avalanches. ▲

## REFERENCES

- Adger, WN (2006) *Vulnerability*. *Global Environmental Change* 16, 268-281.
- Clark, Nigel (2007) *Living through tsunami: vulnerability and generosity on a volatile earth*. *Geoforum* 38(6), 1127-1139.
- Fuchs, S. (2009) *Susceptibility versus resilience to mountain hazards in Austria – paradigms of vulnerability revisited*. *Nat. Hazards and Earth System Sciences* 9, 337-352.
- O'Brien, K. et al (2004) *What's in a word? Conflicting interpretations of vulnerability in climate change research*. *CICERO Working Paper* 2004:04, 1-16.
- Statham, Grant (2008) *Avalanche hazard, danger and risk – a practical explanation*. ISSW, 224-227.
- Wisner B, Blaikie PM, Canon T, Davis I. (2003) *At Risk: Natural Hazards, People's Vulnerability and Disasters*. London, UK: Taylor and Francis.

## SO WHAT?

*(Editor's Note: While editing her article, I asked Chyenne about the personal applications of vulnerability. Our conversation is below.)*

**TAR:** What would you counsel for a recreational touring team to do in order to reduce and manage their vulnerability? Is this a conversation during pre-trip planning? What questions should be asked? What does it look like?

**CB:** At the individual level, action refers to a lot of the human factor things we discuss. I don't know that on an individual level we really need to do anything differently. It's more about how we think about and approach what we're doing: when we debrief, when we talk with more experienced folks, when we take an avy class, when we read articles, check the incident map, that's all stuff that is building our adaptive capacity, our resilience, so that we can adapt to conditions. It isn't just these stand alone, disparate things we're doing, they're part of this system of capacity building.

I think looking at vulnerability in the framework I've presented, it is a lot less about that moment-of or that day-of-trip stuff and more about bigger picture stuff. But there are day-of things like making sure everyone is there to look over the map, maybe if you have an app on your phone you're all dropping way points, discussing zones on the map that you want to avoid, checking the avy forecast together, making sure everyone has their beacon, shovel, and probe.

The vulnerability management stuff is more about looking at building that adaptive capacity in your non-touring time. Obviously just getting experience in the backcountry, but also messing around in beacon basin or practicing rescue scenarios with friends, reading, taking courses, going to talks, picking brains, etc.

When I look at my own adaptive capacity I recognize that I certainly am active on an individual level in pursuing more information, more education, reaching out to folks, that sort of thing. But really a large part of my adaptive capacity comes at the community level. I lack in the financial capital/resources area but live in a community that can mitigate that...we've got great avy forecasting for the Tetons, we've got a backcountry community with a really strong avalanche culture, I have access to avy courses from any number of different organizations, I have amazing access to mentors and experienced backcountry and avalanche and outdoor professionals. Not everyone has that and so I just really started thinking about what happens in the absence of that easy access to education and mentors and experience and avy culture.

I'm becoming more interested in what we can do as educators and educational organizations and avalanche organizations to create space for adaptive capacity. The individual level is so much about psychology and so much about "why did they do this?" or "why didn't they do this?" and we may never be able to track down solid answers...so I guess I'm interested in what we can do to help folks/ the community out and build adaptive capacity at a larger scale. Part of that is obviously going to be research-based, trying to figure out what is effective and what isn't, and why people do the stuff that to us might seem kind of stupid...essentially why aren't they adapting to conditions? Maybe they're just being idiots and there's plenty of adaptive capacity available to them and nothing we do will change that, but maybe there wasn't that adaptive capacity present. Maybe they didn't have access to avy forecasts for their region, maybe there are no avy education resources available in their community, no avalanche culture in their community, maybe they don't have internet access, maybe they don't have the money for beacon, shovel, probe etc?

For me I've come to see this framework as a way for us to be able to analyze what we can do better as educators and as organizations. Looking at those adaptive capacity determinants- which ones matter most in our context? Which ones are we not as effective at addressing? We can't force individuals to adapt but we can make absolutely sure that we are creating the space for communities and individuals to be able to build as much adaptive capacity as possible. ▲

# #theimportanceofwhy

## ACTIVE DECISION-MAKING FOR BACKCOUNTRY SKIERS

BY DAVE ZINN

**Conversations about backcountry** decision-making so often revolve around reflection on a tragic event. As a community we ask how could a group make, what seem in hindsight, such foolish decisions? This critique often occurs while neglecting numerous times we made similar calls without paying the price. Reflection on successful days tends to consider the nature of the approach, the depth of the new snow, the comradery and how good the beers tasted back at the trailhead. We need to include in our reflection a conversation about the decisions that brought us to a successful outcome. Asking the simple question “*Why?*” can lead this discussion and using it, not only in post trip analysis, but as an action item through our day, forces our more rational, less powder-driven selves to engage in the discussion about risk.

Last spring a series of days without freezing temperatures ended with a cold spring storm blanketing the range with 10 inches of fresh snow. Our primary avalanche concern was whether or not the one night of cold temperatures sufficiently froze the melting snowpack, thus protecting us from wet slides with a secondary concern being new slabs created by overnight snowfall. We set out early for a long southeast facing couloir to wrap-up our season.

Looking at our group through the lens of Ian McCammon’s Heuristic Traps, the decision-making short cuts and human factor mistakes causing a group to expose themselves to greater objective hazard, we were a bit of a nightmare. Our group of three consisted of one male and two females: one with six years of professional avalanche experience as a ski patroller and many more as a recreational backcountry user, and two who knew how to use avalanche beacons and gear, but had little to no backcountry experience, both of whom are incredible skiers and athletes. It was the end of the season and barring another surprise spring storm this would be the last powder skiing for us until the following winter. Furthermore, we had invested a significant amount of time to arrive at our destination.

PHOTO: Hansi Heckmair

BEING PREPARED  
EDUCATION AND PRODUCTS FOR MAXIMUM PROTECTION

We show you how to stay safe –  
in the **SAFETY ACADEMY LAB**  
on [ortovox.com](http://ortovox.com)

**ORTOVOX**





Introducing the Halo 28 JetForce

 **Black Diamond®**

BlackDiamondEquipment.com



Photographer: Adam Clark

## Asking “Why?” forces our more rational, less power-driven selves to engage in the discussion about risk.

Simply put, to impress the girls, men may engage in risky behavior. And, because the male in this case was the perceived expert we were in extra trouble. Perceptions of scarcity also play into our decision. If we fail to ski we could certainly enjoy some more spring corn, but it would be six months before the opportunity arose to ski powder again. Extrapolating further, groups like ours often substitute one question for another... “Should we ski this line?” fluidly transitions to, “Are we able to ski this line?” And, yes, all of us were technically able to ski the couloir in question.

While we were a theoretical nightmare of group decision-making, we complete our due diligence prior to making our final ascent and decisions about skiing. We pre-discuss triggers that would prompt a turn around, we probe the snow assessing for a solid freeze, we stay in a group throughout the climb crossing suspect slopes one at a time and together we dig into the snow to assess stability. Together we agree to go forward and make a plan to do so as safely as possible defining several safer spots through the decent where we will stop watching the other skiers descend.

After a fantastic run we reflected on the processes used through the day. It seems we made good decisions based on information gathered while ascending

(if not, then we got away with our bad decisions). But, one friend asked, “How can we be better?” and, “How can individuals without training or a long backcountry resumé contribute meaningfully to the discussion about whether or not to proceed with a day’s objectives?” This is really a fundamental question defining how we learn and develop as backcountry skiers, snowboarders, climbers, and snowmobilers and how we strive to return home safely.

The answer is, “Why?” This simple question allows us to process information used to make decisions. It is the equivalent of showing work in a math class. Our evidence should be diversely sourced from the regional-scale of weather and avalanche forecast to the local-scale of our observations, snow pits, and tests. Asking our ski partners and ourselves “why” engages the slower rational thinking part of our brains so we might fully consider the nature of the problems facing us. The simple process limits the inertia driving us toward our objectives, our powder and our aesthetic lines and makes us think. Insisting our group leader or de facto expert articulates information they are using to make a determination about slope stability provides a group tools to give feedback and to contribute to the conversation. If our group’s “expert” is unable to provide convincing evidence, it gives us a check prior to blindly following through avalanche terrain. We can also use this system as a self-check. Forcing ourselves to explicitly define evidence decreases the likelihood that we will allow gut feels or desire to ski powder to drive our actions. So, “Why is the slope is safe to ski?” It is the simplest action item for people with or without experience to promote development of more complex thought.

We live an age of checklists, “lemons” and red-flags designed to minimize our risk exposure when operating in avalanche terrain. We evaluate human factors and heuristics to frame decisions leading to positive and negative outcomes. Sometimes one simple question is the most powerful checklist tool available to people recreating in the backcountry. Through questioning we have an avenue to more fully appreciate the experience of working as a team to accomplish, or turn back from, our objectives. In the short-term it helps us to make safe decisions and to ensure our partners are fully considering the problem by making them defend decisions. In the long-term it facilitates learning in both the experienced backcountry user and the apprentice. So, this winter if you find yourself charging uphill toward the endless bounties of the snow-covered mountains ask yourself and your partners, “Why?” ▲

## THE AVALANCHE INDUSTRY DISCUSSES RISK AT THE MSU SAW PANEL

BY DAVE ZINN

“There has certainly never been anything in my life that has changed the way I look at risk and the attractiveness of risk like having a child,” Doug Workman responded to an audience member who asked about his risk assessment as a new parent. As a long-time ski and mountain guide Doug is no stranger to pushing close to the line while trying to stay on the right side of it. An exercise he acknowledged is impossible to get right every time.

On November 11th 2015, Montana State University hosted Bozeman’s first Snow and Avalanche Workshop. With nearly 450 participants pre-registering for the event, Southwest Montana enthusiastically welcomed the MSU SAW. The central theme of the workshop was human factors in backcountry travel. During the day attendees participated in a number of excellent presentations and worked through drills in a beacon park. I had the opportunity to host an industry panel discussion looking at the roles of technology and industry in backcountry decision-making. The panel featured Doug Workman from Mammut, Brint Markle from Avatech, and Minot Maser from Backcountry Access.

We divided the conversation into three parts. First, panelists looked into areas of research, product development and the integration of these advances in practice and technology into backcountry travel. Second, they discussed risk tolerance and its relation to technology. And, finally there was a question and answer session with the audience. Throughout the discussion educational outreach and the enhancement of communication within individual groups and at a larger communal scale resonated as areas where the backcountry community has improved and needs continued improvement.

During the initial phase of the talk, panelists discussed communication during a time which information is available to its consumers at incredible rates. Avatech and Backcountry Access position themselves to develop instantaneous communication for the backcountry in different ways. Markle stressed large scale crowd-sourced data he hopes will supplement daily reports from avalanche advisory centers. He suggested that instantaneous updates on mountain snowpack and behavior could have prevented a near miss he was involved in while skiing in the Swiss Alps prior to founding Avatech. Backcountry Access seeks to transform communication within groups of backcountry travelers with the development of updated and powerful radios for recreational users. Maser explained informal surveys of their customers regarding close calls in the backcountry highlighted communication deficits that radios and increased communication could affect in positive ways.

In addition to sharing observations and facilitating communication within backcountry groups, panelists largely agreed that their companies need to

be go-to points for the initial dissemination of information regarding new research and best practices. Mechanisms for transmitting this information included everything from hangtags to online content to academic research. Ultimately, they suggested, end users must own the prerogative to engage with this information as no development in technology or education would eliminate the uncertainty of human behavior. Workman went on to suggest that, “If we completely eliminate the human factor, this will be a pretty boring sport.” The other two panelists agreed and audience members nodded their heads. This is one of the paradoxes the panel uncovered. They want to make backcountry travel safe, but do so without losing the appeal to the adventurous.

Responding to questions about how their companies can facilitate making avalanche knowledge and best practices mainstream, panelists suggested that the industry needs to make avalanche safety cool. Maser explained one method to accomplish this is to ensure that all BCA athletes are educated. For those who haven’t taken avalanche courses yet: “We’ll pay for it.” Markle was explicit in Avatech’s quest to popularize safety. He described their work with Teton Gravity Research and Matchstick Productions. He hopes that, “In future videos you might see guides on the radio or snowpits before someone rips a big line. We want to make this stuff cool and sexy. That you will be the most badass backcountry skier if you know your stuff.” The flip side to the manner in which the community perceives safe behavior, is how the community perceives risk.

The panelists’ discussion of acceptable risk was a highlight of the session. So we come back to Workman seeking to comment on acceptable risk exposure for a parent. He cannot define communal norms. He can only work to address the question at a personal level and he is painfully aware of the repercussions of missing a call. During an interchange with Karl Birkeland, who was in the audience, the two discussed how taking one step back from the line was really insufficient. To ensure a lifetime in the mountains it is a matter of taking three or four steps back. One difficulty they highlighted is everyone has different definitions of “right” decisions. If someone skis a line and has a great run, was that a “right” decision? If another person chose to walk away from the same line was that a “wrong” decision?

Panelists considered another facet of the same issue, communal risk tolerance. Workman proposed, “Everyone’s individual choices are affected by the community’s choices.” An example he returned to several times was that of Glory Bowl on Teton Pass, questioning what it means for the community to have a de facto agreement that we are okay skiing a large avalanche path threatening a public road. Additionally, Workman contemplated systems we need to develop as a community to ski safely in an increasingly crowded backcountry. He said, “Crowds are going to give us a problem that we don’t right now have a solution for. I, for one, don’t know how to ski safely in a situation where I don’t know if there are people above and below me.” The conversation did not offer definitive answers. Panelists valued, “the freedom of the hills,” but they suggested, as others have recently put forth, we as a community need to have these conversations before events necessitate other groups having them for us.

Those in attendance agreed that the first MSU SAW at Montana State University was a great success and it is exciting to think about its development in the future. Having Doug Workman, Minot Maser, and Brint Markle on the stage considering the industry and technology’s role in human factors provided a great basis to continue the conversation about the industry’s role in the dissemination of information, development of equipment and perceptions of risk. With continued education and work we may just succeed in making avalanche safety both, “cool and sexy.” ▲

Mt. Shuksan in magical light. Photo Eric Ming



# ACCEPTABLE UNCERTAINTY

BY STEVE CONGER

**Stupid risks are what make life worth living. Now your mother, she's the steady type and that's fine in small doses, but me, I'm a risk taker. That's why I have so many adventures!**

— Homer Simpson (episode 24: season 9), *The Simpsons* (1998)

A person can get in murky water when it comes to conveying to a novice the type of decision-making necessary to avalanche risk management. This is especially accurate in a culture where risk is frequently linked to reward and opportunity. This article describes a strategy to impart an appropriate feeling of risk to a vulnerable individual when faced with exposure to avalanche hazard.

There have been a phenomenal number of advancements in the field of avalanches over the past couple of decades. Many have translated directly into how we teach and train both recreationalists and professionals. We've been honing in on ways to identify and describe likelihood and triggering, propagation, human factors, and avalanche risk management. Can all of these be combined to provide an effective answer to the silver bullet question heard so often, e.g. "How do I or where do I dig a profile to decide whether or not to ski that [fill-in the blank]?" My thoughts are Yes.

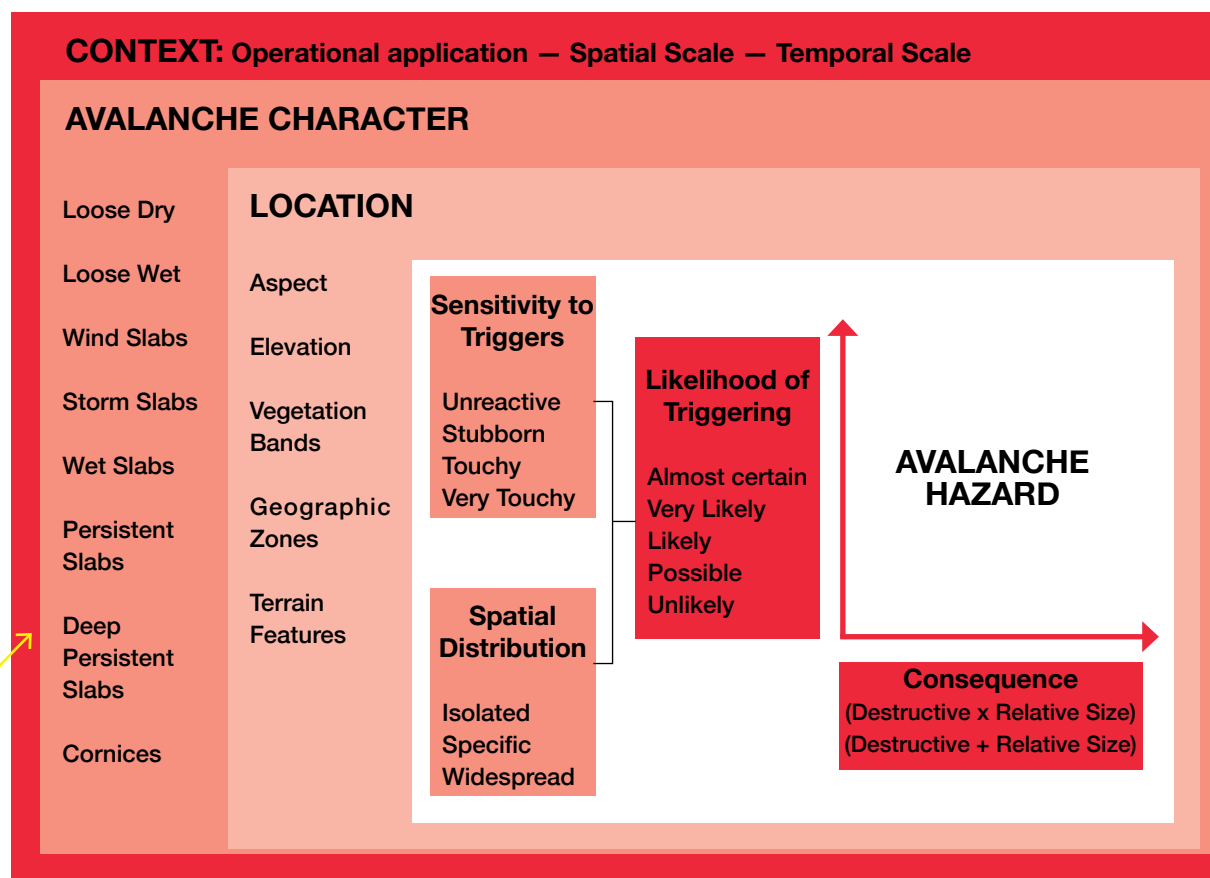
The first step is to remove what bias you can from the discussion. Dave McClung's rule and suggestion number 16 on avalanche forecasting and decisions, "discard your ego ..." points this way (McClung & Schaerer, 2006). We can do this by taking terms that are strongly influenced by ego or emotion out of our answer. Risk is just such a term. The many perspectives and competing definitions of risk make it difficult to begin a fundamental and pragmatic discussion or answer to the question. This will help avoid explanations of rationality like the phrase, "we calculated the risk."

The second step is to give it relevant context. My answer to the silver bullet question usually starts with another question: *Would you like a robust decision-making framework that will work for you at all stages of your learning and practice with avalanches? One that seasoned pros use intuitively and novices can easily follow?*

The third step invokes a commonality currently followed in the avalanche community. Every day we make decisions about avalanche hazard in our work, every day we gauge the exposure that something of value has to that hazard. **The Conceptual Model of Avalanche Hazard** (Statham, et al., 2010) provides a framework that any input to decision can be traced back to. For example: a result from a compression test may provide evidence about the sensitivity of triggering for a particular layer or interface, but what about its spatial distribution and location? What is the avalanche character this result is connected to? An avalanche hazard assessment in an operational setting is made up of defining an avalanche problem using the components of the conceptual model.

The fourth step uses a single filter to identify where to focus the question "What part of the hazard assessment are you most uncertain about?" For example, are you most uncertain about the likelihood of triggering or the propagation (which may relate to its expected relative size)? With this we arrive at the key input for a decision.

Focusing on uncertainty goes a long way towards removing the ego and emotion from the decision process. We know that uncertainty is a defining characteristic of the avalanche hazard discipline (LaChapelle, 1980). It is inherent in avalanche risk management and cannot be eliminated, but it can be



Summary graphic and adaptation of the conceptual model of avalanche hazard. (after Statham, et al., 2010).

accommodated. An excellent strategy has been recommended that includes acknowledging uncertainty's existence, then decreasing it when practical, communicating the irreducible uncertainty and embedding it in decisions (Jamieson, Haegeli, & Statham, 2015).

Answering the silver bullet question is about conveying how and where to draw your safety margin.

You draw it according to what you are most uncertain about in the assessment (e.g. avalanche character, aspect, elevation band, terrain feature, sensitivity to human triggering, sensitivity to natural triggering, spatial distribution of instability, propagation / relative size, destructive size).

Then you do what you can do to change your relationship to the uncertainty (e.g. change the hazard with explosives, change your exposure in space and or time, change the objective to one unaffected by the uncertainties). Altering your efforts to gather more information is an example of changing the objective.

Once your preferred choice of change has been achieved, there is one final filter to the decision before acting:

*Is the uncertainty acceptable?*

Imparting this tool to your avalanche assessment tool box will hopefully help to limit treacherous biases associated with the affect heuristic described by Finucane (Slovic, 2010) and lead to better avalanche risk management decisions. ▲

## REFERENCES:

- Jamieson, B., Haegeli, P., & Statham, G. (2015). *Uncertainty in snow avalanche risk assessments. GeoQuebec 2015. Quebec: Canadian Geotechnical Society.*
- LaChapelle, E. R. (1980). *The Fundamental Processes in Conventional Avalanche Forecasting. Journal of Glaciology, 26, 75-84.*
- McClung, D. M., & Schaerer, P. A. (2006). *The Avalanche Handbook, 3rd Edition. Seattle: The Mountaineers.*
- Slovic, P. (2010). *The Feeling of Risk. New York: Routledge.*
- Statham, G., Haegeli, P., Birkeland, K. W., Greene, E., Israelson, C., Tremper, B., ... Kelly, J. (2010). *A Conceptual Model of Avalanche Hazard. Proceedings 2010 International Snow Science Workshop (p. 685). ISSW 2010.*

# HOW CAN WE FOSTER A CULTURE OF QUESTIONING

All winter this question tugged at my conscience as I taught classes, read case studies, and encountered folks in the backcountry. I posed it to a selection of recreationists and avalanche professionals for their perspectives. What do YOU think?  
— Editor Lynne Wolfe

## 1: FROM SARAH CARPENTER

This is a topic that I've been putting a lot of thought into lately. One part of it is done proactively, during the decision-making process, and a second part is afterwards, for our decisions and those of others.

The American Avalanche Institute (AAI) developed a checklist a few years ago. It's divided into three segments – pre-trip plan, before entering avalanche terrain, and post-trip discussion. It's not a complicated checklist, in fact; most people would argue that it's too simple. Based on the research we have done regarding checklists in other industries, most experienced people do most of what is on a checklist most of the time. Very few, if any, do all of what is on the checklist all of the time. At least, not without the checklist.

One of my solutions to fostering a culture of questioning decisions in recreational touring teams is to take a systematic approach to backcountry travel each and every day. Use a checklist each day you are out in the backcountry. Some days, running through the checklist will be simple and fast. Other days, the checklist will prompt the discussion that everyone has been meaning to have, but didn't want to be the first person to bring it up. A checklist gives everyone in the group a voice. It builds teamwork. It creates a less emotional way to communicate observations.

How do we learn from our mistakes? How do we learn from other people's mistakes? How do we study decisions and accidents, critique them, and not crucify others?

**"If we could all give each other the benefit of the doubt:"** is a quote from a podcast episode by Carl Richard on personal finance. His point is that no one but you knows your personal finance situation and the set up for the choices that you make. If we can start from a place of giving everyone the benefit of the doubt, perhaps communication and learning could come about in an easier manner.

Can we translate this to studying accidents and near misses in the backcountry? Can we weave this in to teamwork and community building within the backcountry community and among our touring partners?

The world of snow and avalanches is a wicked learning environment. We don't often get direct

feedback that we made a bad decision. We often get away with those bad decisions. We can even take the fact that nothing happened and allow it to influence our decisions in the future. As Drew Hardesty phrases it, we can "drift into failure."

Drew gives a great example in a blog post from December 2014 on the Utah Avalanche Center website: [utahavalanche.org/blog-drift-failure-or-mathematics-and-few-thoughts-risk](http://utahavalanche.org/blog-drift-failure-or-mathematics-and-few-thoughts-risk)

Here's what happens -

- 1 The danger is MODERATE OR CONSIDERABLE
- 2 We choose appropriate terrain.
- 3 We see no signs of avalanches.
- 4 We see no shooting cracks. We hear or feel no collapsing or whumphing.
- 5 Test results are inconclusive.
- 6 Cornice drops and slope cuts provide no results.
- 7 We see other tracks on the slope(s).

Now what?

**We "drift" into steeper terrain because we perceive the danger to be lower than it actually is.**

*Result? You guessed it.*

If we don't get consistent feedback from the mountains about our decisions, then we need to build an environment where that feedback comes from within our team, our peers, and our community.

When I tour on my work days and on my days off, I like to ask a few questions at the end of each day.

*"Did we make good decisions?"*

*"Did we manage terrain well? What improvements can we make?"*

*"Did the conditions match the forecast?"*

*"Do we have concerns for future tours?"*

These questions don't take long to discuss and they can foster a tremendous amount of learning. These are the questions listed in the post-trip discussion section of the AAI checklist that lives in my pocket every day of the winter.

It can feel silly or awkward or contrived to ask these questions of the people we ski with day in and day out, but if we take a systematic approach to ski touring each and every day, we can continue our education each and every day.

Another solution to fostering a culture of questioning decisions is, post-incident, to give every-

one the benefit of the doubt. Approach accident review through a lens of "The group involved didn't go out with the goal of getting avalanched." Keep in mind, this benefit of the doubt is a two-way street. If you are on the receiving end of critique, assume that the person critiquing you is doing so with good intentions.

Approach accident review with compassion, aiming to understand and critique decisions, but not to attack the people. This compassion does not mean don't gloss over the mistakes. We have seen a surge in backcountry users over the last few years. We are all human. We can strive for perfection, but we may never get there. So let's at least learn from each others' mistakes and from our own.

Sarah Carpenter is the co-owner of the American Avalanche Institute. Along with teaching avalanche courses throughout the mountain west, and running the AAI office, she works as a ski guide in the Tetons. When she's not working, Sarah can be found adventuring with her husband Don. And if you want to find the powder stashes with her, follow the laughter...



## 2: FROM JAMIE WEEKS

- Push the concept of information sharing, both regarding locales and specific conditions
- Foster quality of information shared, especially regarding avalanche problem/ sensitivity/ location
- One way to do the above is to improve recreationists' ability to give a proper "radio report"
  
- CHALLENGES TO THE ABOVE:
- "protecting your stash"
- amateurs following professionals while guiding can create liability problems

Jamie is a snowboard guide. He divides his time in the winter months between guiding for Exum Mountain Guides and the Jackson Hole Mountain Resort. Jamie also teaches avalanche courses for the American Avalanche Institute. Having been a heli-ski guide in Alaska for 15 years, Jamie now appreciates and prefers the pace of split boarding. He also is a faithful partner to his dog Maynard, who believes Jamie's only purpose in life should be to drive him to the trailhead, throw snowballs, and provide kibble.



# DECISIONS

When in doubt — HESITATE...  
— Jerry Roberts

# WITHIN RECREATIONAL TOURING TEAMS?

## 3: FROM RON PERLA

### Questioning Decisions: an anecdote from the 60s

It was Christmas break, early 1960s. A group of us from Salt Lake City was on the Northeast Ridge of Mount Moran attempting a first winter ascent. We reached the base of the Great Gendarme which in the summer is bypassed by traversing a long sloping ledge on its north side. In the winter, however, the sloping ledge is snow-covered, forming the top of a long, steep avalanche path. Decision time. The vote was to chance the traverse.

One of the youngest dissented *"We are not crossing that slope."*

I replied: *"Then we have to rope up to the top of the Gendarme."*

The young one agreed, *"That's what we have to do."*

I replied, *"Then we have to rappel down to regain the ridge."*

He said, *"Yes, that's what we have to do, but we're not crossing that slope."*

I thought *"who is this kid, anyway?"* Well, he lived on to achieve a physics PhD at the University of Utah. True, most scientists don't get everything right, all the time. But he also became one of our greatest mountaineers, it was George Lowe.

By the way, we did fail on the Gendarme (some of us in bunny boots couldn't hack the climbing.) Next winter, George Lowe led a stronger, better equipped party over the Gendarme and on to the summit. As for me, I became a lucky survivor of two big avalanches, another scientist who didn't get things right all the time.

Ron Perla survived a 1963 avalanche on the Alta Ski Patrol and a bigger one in 1967 as an Alta snow ranger. The USFS decided it would be better if he switched to research.



Ron measuring an Alta slab. Photo Charles Bradley



Ron with his gage for measuring snow deformation on a steep slope. Photo courtesy of USFS



"You think there might be some wind transport up there?" Photo Doug Krause

## 4: FROM DOUG KRAUSE

Off the top of my head, I can think of six things that individuals can DO to help foster a culture of questioning decisions within recreational touring teams. All require practice.

**1** Blindly following the decisions of others is a common trap in group travel. Being just a follower degrades your situational awareness. It impairs your observations and judgment. **Pretend you are alone** (or in charge) and assess the situation from that perspective. If your judgment conflicts with the drift of the group or the leader, maybe it's time to speak up.

**2** **Keep track of decision points over the course of your tour.** Many of the worst decisions aren't really even made consciously...folk just slide into them. Try to get in the habit of mentally acknowledging unplanned decision points. That can be a prompt to assess those decisions and a cue for reassessment.

**3** If you make a decision for the group, add some context. **Support your decision with evidence.** Don't make your partners ask why you love Ben Carson, tell them, and ask for their input regarding your judgment. Inviting questioning fosters a culture where questioning decisions is accepted and encouraged.

**4** **Learn how to speak.** There is a difference between being assertive and being inquisitive. Assertion has many gradations. Learn how to time and deliver your message for best effect. Constructive disagreement is a good thing. Don't spoil it with a poorly composed message.

**5** **Be efficient.** Don't make decision-making a chore and don't make questioning decisions an irritant. Say what you gotta say and move on. If every decision point turns into a long-winded discussion...that is not fun. Skiing should be fun.

**6** **Listen.** Pay attention to what people are saying, and ask questions if you don't understand. Others see things from a personal perspective that you may not share, so questions are important. Don't assume you are all processing the same observations in the same way. An ill-informed critique is often hard to swallow and will compromise a decision-questioning culture.

Doug Krause works as a patroller, guide, educator, and forecaster in Colorado, Alaska, Japan, Argentina, and Chile. Home base is currently Lima, Peru. The commutes are a bitch.



## Field Obs

On February 15, 2016, we left Turnagain Pass and headed over a saddle towards Goldpan and the headwall beyond. Ascending, we observed spatially variable wind effect: three-inch-thick slab, settled powder, zipper crust, etc. Just before the pass, my switchback cleanly broke 15 cm down. I dug a pit on the NW aspect. It did not fail on the above described instability, rather 50 cm down at ECTP29 on buried surface hoar. At the pass we saw three skier tracks on the headwall (visible looker's right in pictures). It appeared they had broken



## 5: FROM BLASE REARDON

**Professionals can model** an interrogative culture in our own recreational and professional tours. Specifically, we can show how natural it can be to integrate dialogue and questions into our everyday practices.

One assumption that determines my approach is the idea that the winter backcountry is a wicked environment. It's a place where we can easily learn the wrong lessons from our experiences because feedback on our decisions is irregular and ambiguous. So my goal is to increase the regularity and quality of feedback in order to have a better sense of what ideas and decisions are keeping me safe. It permeates most aspects of my daily tours.

Developing a culture of questioning decisions requires that people have numerous opportunities for dialogue. I prefer that dialogue to be informal. Below are five suggestions for doing that:

**5 Quit riding solo.** Or more specifically, don't make riding solo a habit. Riding solo only exacerbates the dearth of timely, relevant feedback. If you primarily ride with other people you'll at least recall their voices in the few times you are alone. But riding solo regularly just reinforces bad habits, because no one is there to point out the things to which we're blind. And there are plenty, no matter how safe you feel riding solo. *"When you're alone,"* says Scott Toepfer, *"you've always got a consensus."*

**4 Rely on questions, not statements.** Declarations like *"It doesn't look wind-loaded,"* don't leave much room for dialogue. Your partners have to disagree with you to voice any different ideas. Conversations can easily degenerate into competitions and disagreements. Alternatives that open up dialogue might be *"Does that slope seem wind-loaded to you?"* or *"How wind-loaded does that gully's left side look to you?"*

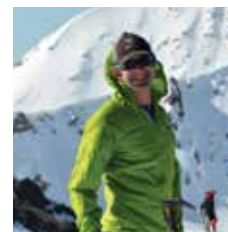
**3 Stop to eat, drink, talk, and survey opinions at major decision points.** It's the group equivalent of taking a deep breath. It helps to avoid rushed decisions that aren't based on a complete picture of conditions. And it offers everyone in the group a chance to raise questions and/or observations that may be troubling them but that they haven't yet articulated. Make it a point that everyone in the group voices an opinion or comfort level before proceeding.

**2 Debrief at the end of the day.** Lynne Wolfe ignites these conversations with a question: *"Did we get it done, or did we get away with it?"* A local guide service where I work includes a similar question on their PM email report: *"When were we most at risk?"* Reflection sometimes affords a clearer view of decisions than is accessible in the moment. And done repeatedly, it can make questioning in the moment easier.

**1 Talk on the up.** Two thirds of our time in the backcountry is spent climbing. It's an ideal opportunity to make observations, communicate impressions, and ask questions. It's a wasted opportunity if we're bent over at the waist, poling to keep from slipping backwards, and breathing too hard to talk. Be aware of your body position. Are you striding mostly erect, able to steadily move forward, while looking around and talking easily with your partners? As you break trail, can you hear people behind you chatting readily? When you become aware that these things aren't happening easily, ask your partner to ease off on the angle of the uptrack, or ease off yourself if you're out front. I don't believe steep skin tracks are faster, particularly if you spend what little time you gain conversing about what some of your party saw and the rest didn't.

We as professionals can manage our days to include natural opportunities for dialogue and questioning. Done regularly, they become expected; they become our culture, and those we mentor carry it forward with them.

Blase Reardon was recently reminded by a student from an avalanche class 15 years ago that he once publicly swore never to ski in Colorado because of the Continental snowpack. He is now in his third winter as the Colorado Avalanche Information Center's backcountry forecaster for the Aspen and Grand Mesa zones. He believes snow science has come a long way in the past decade and a half. And that you never know what students in an avalanche class will remember.



loose small pockets and sloughs. We noticed ongoing small roller balls. Following the ridge to our drop in, two of us skied lower on the headwall, then stopped to watch our final group member descend from the top of the headwall. Riding over the convexity into the steep WSW aspect, the slope shattered around him, and he attempted to egress the slope. Quickly, the majority of the slide was in front of him. He deployed his airbag, though this did not prevent further entrainment as he basically stayed on his feet. Watching the wall of snow approach us was alarming, especially its freight train-esque thundering. Looking up at the bed surface, a set of tracks from before the storm cycle was visible.  
Photos and story by Mike Records



## 6: FROM JASON STIEGELMEYER

**TAR:** So the question is: “How can we foster a culture of questioning decisions within recreational touring teams?”

**Jason Stiegelmeier:** That’s a really complex question, there are lots of variables.

**TAR:** Good. I like hard questions. They make us think. Looking forward to what you come up with.

**JS:** That’s a three-part question. 1. Fostering a culture 2. Questioning decisions 3. Within rec touring teams.

**TAR:** Yes, but don’t feel like you have to take on all permutations/ combinations. How do you do so personally, in your own teams? How did you get there?

**JS:** 1. **Fostering a culture:** social media and what others perceive as cool seems to have a huge impact good and bad. Culture is constantly evolving and often over-analyzed.

2. **Questioning decisions:** This I believe I can be more helpful with...

I think as a whole our society doesn’t spend much time talking or teaching about intuition, It can be your best tool in the backcountry once you are aware of it and have developed a way to tap into it. Seems like something we would start teaching and developing at an early age, but we don’t! Learning to listen to your intuition (gut, inner voice, etc.) can keep you alive. When something doesn’t feel right, even if you don’t know why, it is important to speak up and voice your concern. Having team members that don’t question your hesitation is also important.

**TAR:** Personally I think that intuition is highly refined pattern recognition, perhaps without being able to attribute the source. But what do you do if your touring party is all running on intuition?

**You gotta communicate/ make decisions somehow, don’t you? Or just by grunting? - Ha ha, that’s funny, but I guess if the group is that in-tune with each other, grunting may be a valid form of communication, but we know that won’t work for most groups.**

**JS:** Some of my closest calls have been from ignoring my gut or intuition; doing so almost cost me my life in a cave up Darby. I ignored my intuition for over an hour not knowing why I kept wanting to turn back. 16 hours later I was above ground thanks to two friends that I had trusted with my life from the beginning of the trip.

Another key aspect to this conversation is having partners that you trust and know you can count on. I try to operate with the idea of being fully self sufficient, meaning that I am not relying on anyone in the group unless something goes wrong. That’s a hard to place to get to, but once you have the skills and surround yourself with people that have a similar skill set, it’s a great place to be, everyone is operating as a group but not relying on each other directly.

Finding good mentors can be the biggest challenge as you are gaining skills, how do you really know that the people you are learning from have it together? It takes time to build trust with a partner and during that time you need to make sure you are comfortable and speak up when you are unsure. It’s important to have partners that will listen and not challenge you when your gut says turn back.

**Part 3 (recreational touring teams)** is tied into 1 and 2; team dynamics changes everything.

For me, when skiing committing lines, I prefer just one partner with a similar skill set and skiing style, or a partner that complements my skill set. A group of three can work pretty well too, but the more people you add the more time things take, which means more time spent in a higher risk situation. But I have also been in groups of five that I trusted and worked well with, there are just so many variables to all three of these parts.

I was lucky to have grown up skiing inbounds since I was four-years-old, and had started climbing in middle school. By the time I was 18, I was at Mt Rainier and had climbing rangers as roommates and tried to soak up all I could from them. Looking back, their willingness to show me mountain skills was a huge step. I then hired on as ski patrol and avalanche control at Mt. Baker and logged lots of hours intentionally triggering slides. Learning how to ski cut and do avalanche control work proved to be a valuable tool for reading terrain and determining where avalanches start.

**Take away points:** Pick good partners that have more experience than you, Get as much education as you can, read books, take avy classes, get as much hands on as you can. Learn your limits and know when to call it a day.



Jason has spent 33 years on skis. He and his wife Suzanne live in Victor, Idaho, and spend their free time skiing the Tetons and Jackson Hole.



**Above:** I was at 14K on Denali in June 2012, attempting to launch a kite in the strong winds, when a huge avalanche came down the Messner Couloir towards camp. Only the powder cloud reached camp, but we felt like targets in the cross-hairs for a few minutes.

**Below:** Photographer Chris Olson (friend and ski partner since 1998) took this shot of us out exploring as a team of two. Not much communication was necessary that day.

*Photo above: Jason Stiegelmeier, photo below: Chris Olson*







The Upper Nisqually Glacier sheds ice and snow at 12000 feet on Mount Rainer. April 2015.  
Photo Scott Larson

## 7: FROM NANCY BOCKINO

### Navigating Human Emotion and Team Decision-Making using a Communication Continuum

**Choosing to spend** time in the mountains is an expression of our passion for wild, rugged places, our desire to challenge our physical and emotional limits, to experience the bliss that the inescapable simplicity of the mountains offers, and opportunity to share good times with friends and loved ones that make up our team. Together we decide how to match our passion and desire with safety when we place ourselves in an environment with significant hazard and uncertainty.

Rightly so, in the past several years much attention has been given to the role human emotions, perceptions, and biases play in safety in avalanche terrain. As an avalanche educator I consistently hear my students, whether experienced or just beginning their journey, express that communication is their biggest challenge.

#### What is communication?

From the Merriam-Webster Dictionary: “The exchange of thoughts, messages or information by speech, signals or body language; interpersonal rapport; the art or skill of using words effectively to transmit information or ideas; a message given to someone with a purpose.”

Successful communication is an art to be explored and then practiced. In part, communication in the backcountry is a continuum. The foundation of the continuum is clear, concise messages offered at appropriate times. The range of the continuum is the “strength” of the message from inquiry to advocacy. The chosen strength of each message depends on the level of uncertainty.

In avalanche terrain, uncertainty is the natural condition due to the highly variable and dynamic nature of snow blanketing the mountains combined with our gaps in knowledge and experience and our human biases and emotions. We must acknowledge uncertainty and integrate it into our decision-making system.

The greater the uncertainty, the more strength our message must contain. If we match our choice of strength with the uncertainty, then there is power in our communication. We are practicing risk management, or the assessment of uncertainty, through team-based decision-making based on successful communication.

In order to experience successful communication we must embrace the role of our humanness in our risk management and nurture the following necessities within our team: everyone has a responsibility to contribute an opinion, everyone has a voice, everyone has a veto. Choose to communicate. Use the range of “message strength” available. Know when to inquire and know when to advocate. Make this the foundation of your risk management, decision-making, and team work. Demand this of yourself and of your teammates.

We must also acknowledge that our emotions contribute greatly to how we make decisions. We must make a place for emotions in our systems. Each day we should ask: “What are our human factors today?” Consciously acknowledged they pose a much smaller threat to our safety. In fact, they can even become strengths.

When we are successful we experience moments of happiness and fulfillment, we feel fully functional, responsible for our perceptions and behavior, we are mindful, present, and free of inhibition, fear and doubt. We have achieved flow in a peak experience, as published by Abraham Maslow (1964) and for that moment we are functioning at our optimal level and have reached our true potential.

We can promote this flow and success and strengthen our system and teamwork, through reflection on our communication and decision-making. When we return home at the end of an adventure take a moment to ask ourselves “did we make good decisions, or did we get away with it? And, “did we communicate successfully as a team?” Finally, “what could we do better next time?”

This is a life-long journey, demanding our humility, patience, responsibility, and desire to be an endless student. Traveling through the snow-cov-

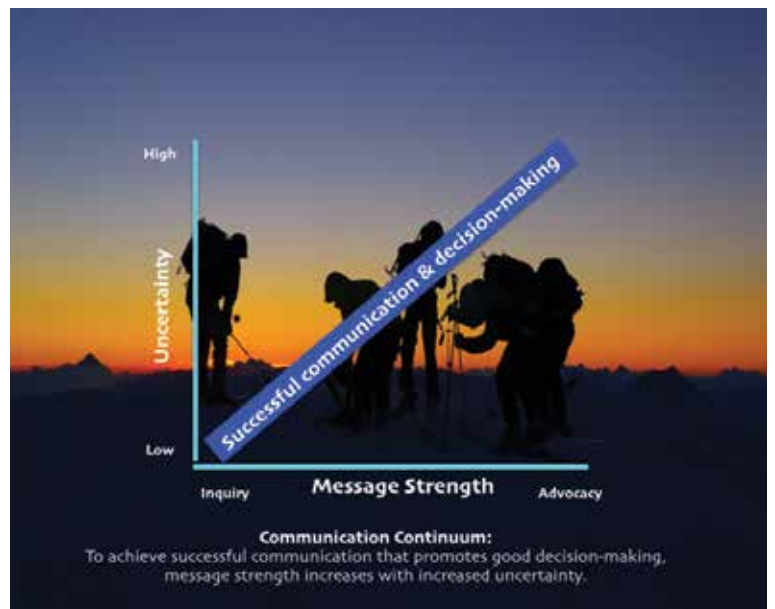


Photo in figure by Nancy Bockino on the Lyell Glacier

ered mountains is our chance to combine passion and responsibility and an opportunity to grow as an individuals and as a team. Navigating the communication continuum is equally important as navigating avalanche terrain and snowpack. When we achieve this within our team and ourselves then true bliss and moments of truth are the reward. ▲

#### REFERENCES

Maslow, A.H. (1964). *Religions, values, and peak experiences*. London: Penguin Books Limited

Nancy grew up in the mountains of Idaho, Montana, and Washington. She began climbing, backcountry skiing, and working as a field ecologist in the early 90s. She moved to Jackson Hole in 2000 and fell in love with the local community. She keeps busy working as a part-time guide for Exum, an ecologist caring for whitebark pine in the Greater Yellowstone Ecosystem, an avalanche course leader, an instructor for Jackson Hole Outdoor Leadership Institute, an EMT and Wilderness First Responder, a member of Teton County Search and Rescue, and as a member of the Ortovox USA ambassador team.





# AAA GRANT RECIPIENT REPORT

## EFFECTS OF EXPLOSIVES ON PHYSICAL SNOW PROPERTIES AND SNOW STABILITY TEST RESULTS

BY ROBYN WOOLDRIDGE

### AN EXPLANATION OF THE CONCEPT OF BOOTSTRAPPING

To understand bootstrap, suppose it were possible to draw repeated samples (of the same size) from the population of interest, a large number of times. Then one would get a fairly good idea about the sampling distribution of a particular statistic from the collection of its values arising from these repeated samples. But that does not make sense as it would be too expensive and defeat the purpose of a sample study, which is to gather information cheaply in a timely fashion.

The idea behind bootstrap is to use the data of a sample study at hand as a "surrogate population", for the purpose of approximating the sampling distribution of a statistic; i.e. to resample (with replacement) from the sample data at hand and create a large number of "phantom samples" known as bootstrap samples.

The sample summary is then computed on each of the bootstrap samples (usually a few thousand). A histogram of the set of these computed values is referred to as the bootstrap distribution of the statistic. ([stat.rutgers.edu/home/mxie/RCPapers/bootstrap.pdf](http://stat.rutgers.edu/home/mxie/RCPapers/bootstrap.pdf))

Also, conceptually useful: [stats.stackexchange.com/questions/26088/explaining-to-laypeople-why-bootstrapping-works](http://stats.stackexchange.com/questions/26088/explaining-to-laypeople-why-bootstrapping-works)

From Singh, K. and Xie, M. "Bootstrap: A Statistical Method", published by Rutgers University. [stat.rutgers.edu/home/mxie/RCPapers/bootstrap.pdf](http://stat.rutgers.edu/home/mxie/RCPapers/bootstrap.pdf)

Explosives are a vitally important part of avalanche hazard mitigation programs and are used by highway departments, ski areas, and other avalanche programs to initiate avalanches and test snowpack stability. Although explosives are an important part of these mitigation efforts, there is little knowledge about their effects on the physical properties of snow. This study contributes to knowledge in this area by presenting field-based observations and analyses of changes in physical snow properties due to explosives use.

Many previous studies focused on shockwave pressures, velocities and accelerations in snow (e.g. Bones, 2012; Gubler, 1977; Livingston, 1968; Lyakhov et al., 1989; Mellor, 1973; Wisotski and Snyer, 1966); and density changes due to explosives have been modeled (Miller et al., 2011), but I could not find studies demonstrating changes in physical snow properties after explosives use. Therefore, I set out to quantify changes in snow density and hardness, to determine whether there was any change in the results of snow stability tests before and after using avalanche explosives. This study was designed to answer two questions: Does snow density or hardness change after a blast and at what distances and depths can these changes be measured in the field; and after using explosives, do Compression Test (CT) or Extended Column Test (ECT) results change and at what distances can these changes be measured in the field.

Data collection spanned three winters from 2010 to 2013 at two field sites in southwestern Montana. My primary site was at Moonlight Basin Resort, and my other study site was at Bridger Bowl Ski Area. The study sites were both located in open meadows which were free of skier traffic and avalanche mitigation, below treeline, and with slope angles ranging from 7° to 20°. For a more detailed description of study sites see Wooldridge et al., 2012 and Wooldridge et al., 2014. I measured snow density and snow hardness at four distances from pre-determined blast centers both before and after detonating 0.9kg cast pentolite boosters suspended 1 meter above the snow surface. Compression Tests and Extended Column Tests were executed before and after blasts at two pre-determined distances. For all tests, four post-blast snowpit locations

**Rugged, Versatile Weather Stations**

PHOTO COURTESY CENTER FOR SNOW AND AVALANCHE STUDIES

Senator Beck Study Site  
Red Mountain Pass, Colorado

**Real-Time Data**

- Live graphs •
- Web-based data display •
- Datalogger with built-in web server •

**Wireless Networks**

- Base stations w/remote substations •
- Easily configured •
- Multiple communication paths •

Call or visit: 435.227.9080  
[campbellsci.com/avalanche](http://campbellsci.com/avalanche)

**CAMPBELL SCIENTIFIC**  
WHEN MEASUREMENTS MATTER

were measured and marked at distances of 0.5, 1, 1.5 and 4 m from a pre-determined blast center. Pre-blast snowpits were located approximately 0.5 m downhill of the marked post-blast snowpit locations in order to leave undisturbed snow in the post-blast pit locations (Figure 1).

Snowpit depth was 1 m where the snow cover was sufficient, and to the ground where snow height was less than 1 m. These depths were determined by using Miller et al.'s (2011) model which predicts compaction zone depths based on charge size and height. I assessed snow density and hardness every 10 cm starting 5 cm below the snow surface using the Strong Stitch density gauge by Winter Engineering and the hand hardness test. Both CTs and ECTs were conducted at distances 1 m and 4 m from the blast center (Table 1, Figure 2).

My initial analysis of the data involved comparing median changes in snow density, hardness, and in CT and ECT results as shown in box and whisker plots. Compaction and minor snow removal due to the blast resulted in a difference in post-blast snow heights in the area of the blast which required matching of pre- and post-blast measurements. I discuss results here from measurements starting at the snow surface down because it was important to correctly match measurements at the top of the snowpack due to greater blast effects near the snow surface and because analysis of pre- and post-blast data was similar for surface down and ground up measurements. Changes in CT score were determined to be any change in the number of taps to failure before and after a blast, even if failure occurred on a different layer post blast. Changes in ECT score were determined to be changes in propagation. Propagation observed on any failure layer after a blast was considered post-blast propagation even when this occurred on a different failure layer than the pre-blast failure layer. Tests that included ECTX results were classified as non-propagating tests.

Changes in density data and Compression Test data were analyzed using the Wilcoxon sign-rank test, a non-parametric comparison test. The distribution of hardness data was not suitable for analysis using the Wilcoxon test. I used bootstrapping with the hardness data to create a population distribution from which parametric statistics could be derived. I also used this technique with the density data to provide a more robust analysis. I used McNemar's Test for paired nominal data to test for significant changes in ECT propagation.

Comparison tests of density measurements show statistically significant increases in snow density in a continuous area reaching a lateral distance of 1.5 m from the blast center and a depth of 50 cm below the snow surface. Statistically significant increases in density were also observed on the snow surface (down to 20 cm). Statistical analysis also identified significant density increases deeper in the snowpack out to 1.5 meters from the blast center, but these were not continuous after a depth of 50 cm. Bootstrapping confirmed these results.

Plots of hardness data showed only very small increases at the bottom of the snowpits, and bootstrapping resulted in statistically significant increases in hardness at the very top (depth of 0-10 cm) and the very bottom (depth of 90-100 cm) of the snowpits. In the top layer, these increases extended out to a distance of 4 m from the blast center, but in the bottom layer increases only extended out to a distance of 1.5 m. Little can be concluded from bottom-layer hardness results since these were derived from small data sets (n = 8, n = 13, n = 13).

Compression Tests showed a statistically significant decrease in taps to failure at sites 1 m and 4 m from the blast center. Extended Column Tests resulted in statistically significant increases in propagation at locations 4 m from the blast center, but no significant change 1 m from center. For more detailed results see Wooldridge et al., 2012 and Wooldridge et al., 2014

These results are the first field-based observations of changes in snow density, snow hardness and snow stability test results due to explosives. The density changes examined in this study indicate that the effects of explosives may reach slightly farther than the depth of 80 cm predicted by Miller et al. (2011). While a continuous increase in density occurred in the area extending out to 1.5 m from the blast center and down to a depth of 50 cm, other increases were observed as deep as 1 m directly below the blast center and to a depth of 90 cm at distances of 1 m and 1.5 m from center. In addition, I used a smaller explosive in lower density snow than did Miller et al. (2011) in their model, so I anticipated the blast having a smaller area of influence which is the opposite of what I observed. When examining the continuous area out to 1.5 m and down to a depth of 80 cm, the greatest percent increases in density did not always occur closest to the blast center. This could be an indication that there is a similar effect on density over this entire area. Furthermore, significant increases in density at distances 4 m from the blast only occurred to a depth of 20 cm suggesting that at this distance, explosives are only affecting density in the upper snowpack. Significant increases in hardness were only found at the very top and the very bottom of the snowpack close to the blast center which could be a product of location. At the top of the snowpack, the snow has direct, unimpeded contact with a shockwave, while at the bottom of the snowpack the snow is constrained by the ground. At both of these locales, snow behavior could be different than within the snowpack. Increases in density are associated with increases in hardness (Kinosita, 1960), but here density increases were observed independently. This could indicate that explosives are affecting snow structure or bonding.

Decreases in CT taps were observed at distances 1 m and 4 m from the blast center, but stronger significance, indicated by smaller p-values, were obtained by analyzing the 4 m data. Increases in propagation 4 m from the blast, but not 1 m away also suggest that there is a greater effect on stability test results farther from the blast center. Considering these results along with the increases in density observed closer to the blast center may give some validation to the idea of changes in slab properties due to explosives. Disruptions in the snowpack closer to the blast

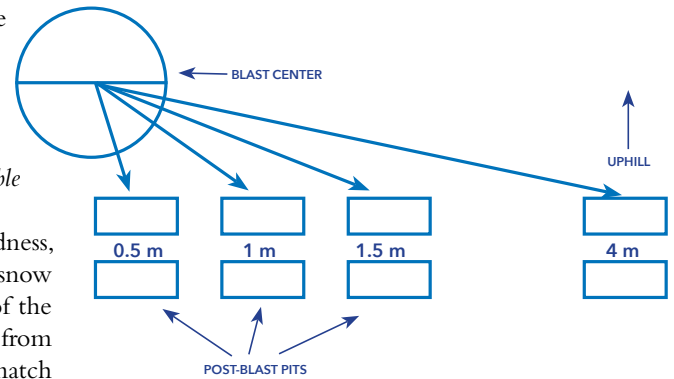


FIGURE 1: Diagram of sampling design, showing the pre- and post-blast pit locations and blast center.



FIGURE 2: Making observations in the field.

	Distance from Blast Center			
Test Type	0.5 m	1 m	1.5 m	4 m
CT	N/A	33	N/A	34
ECT	N/A	29	N/A	27
Density	27	27	27	27
Hardness	27	27	27	27

TABLE 1: Total number of CTs and ECTs performed at each distance from the blast center. Sample sizes of density and hardness data at greater depths are less than sample sizes shown here due to compaction resulting from air blasts.

**Avalanche Hazard Consulting**  
 Avalanche Hazard Mapping for Industry, Residential and Government

Avalanche Forecasting and Safety Training for Mining Facilities  
 Winter Operations Plans for Mines, Avalanche Dynamics Modeling  
 Submittal Assistance for Planning Boards and Local Governments

**TRAUTNER GEOTECH LLC**  
 Contact: J. Andrew Gleason 970-259-5095  
 agleason@trautnergeotech.com  
 www.trautnergeotech.com

# Stay connected.

## Even in the worst conditions.



Effective communication can make the difference between an all-time day in the backcountry or a major junk show. Keep your crew tight with the BC Link.

Winterized controls, remote/accessible Smart Mic, long-lasting battery, and compatibility with all FRS/GMRS radios.

Pro and fleet pricing available (800) 670-8735.

**BC Link™**  
Never alone.



The most trusted name  
in backcountry safety.™

[www.backcountryaccess.com](http://www.backcountryaccess.com)

Photo: Freya Fernwood Photography  
Leif Whitaker and crew on East Kariba peak in Shimamaki, Hokkaido, Japan.



FIGURE 3: Post blast ECTN with top of column removed. These cracks were evident before I isolated the ECT column.

were visible when digging after a blast. These were characterized by cracks, holes and wandering fractures that were present when I dug immediately after a charge was detonated (Figure 3).

These post-blast flaws could be allowing for failure to occur in CTs, while also arresting fractures on a horizontal plane which could account for the decrease in CT taps with no increase in ECT propagation. At locations 4 m from center, CT taps decreased and ECT propagation increased which could indicate that changes in snow structure occurred, but these changes may be slightly different than the changes that occurred where density increased within the snowpack. At all distances from the blast center, the denser post-blast snow may assist transmission of force into a weakened post-blast snowpack. Closer to the blast center, results indicate that there was disruption to the slab which could also cause a disruption in failure planes. Farther away, increased ECT propagation may be a result of failure planes that were still intact after a blast. This region, 4 m from the blast center, could be a transition zone where eas-

ier failures and increased propagation are possible immediately after a blast which could have an influence on some of the decisions we make during avalanche mitigation. Future work in this area would include density measurements between 1.5 m and 4 m from the blast center, more CTs and more ECTs, adding to the data presented here.

### References

- Bones, J. A., 2012. *Experimental investigation of interactions between explosive detonations and the resulting snowpack response*. M.S. Thesis, College of Engineering, Montana State University, Bozeman, MT, USA, 237pp.
- Gubler, H., 1977. *Artificial release of avalanches by explosives*. *Journal of Glaciology* 19 (81), 419-429.
- Kinosita, S., 1960. *The Hardness of Snow*. *Low Temperature Science "A"*, Institute of Low Temperature Science, Hokkaido University, Japan, 19, 119-134.
- Livingston, C.W., 1968. *Explosions in snow*. Technical Report 86, CRREL, Hanover, NH, USA, 124 pp.
- Lyakhov, G., Salitskaya, V., Averchenko, A., Zakharov, S., Bakhushina, L., 1989. *Explosive waves in snow*. *Combustion, Explosion and Shock Waves*, 25(4), 493-499.

Mellor, M., 1968. *Avalanches*. monograph, CRREL, Hanover, NH, USA, 215 pp.

Miller, D., R. Tichota, Adams E., 2011. *An explicit numerical model for the study of snow's response to explosive air blast*. *Cold Regions Science and Technology* 69, 156-164.

Wisotski, J. and Snyder, W.H., 1966. *A study of the effects of snow cover on high explosive blast parameters*. University of Denver, Denver Research Institute CO: Final Report, 2303.

Wooldrige, R., Hendrikx, J., Miller, D., Birkeland, K., 2012. *The Effects of Explosives on the Physical Properties of Snow*. *Proceedings International Snow Science Workshop*, Anchorage, AK, USA. 1033-1039.

Wooldrige, R., Hendrikx, J., Miller, D., 2014. *Field Observations of the Effects of Explosives on Snow Stability Test Results*. *Proceedings International Snow Science Workshop*, Banff, Alberta, Canada. 519-525.

### Acknowledgments:

Special thanks go to: Karl Birkeland, Jordy Hendrikx, Dan Miller, Moonlight Basin Ski Patrol and area, Snowmass Patrol and Snowmass Ski Area, the American Avalanche Association, the American Alpine Club and the Cora Shea Memorial Fund.

Following a decade of work as a ski patroller at Snowmass Ski Area and in Chile at La Parva Ski Area, Robyn returned to school to pursue a degree in Snow Science. She graduated from Montana State University (MSU) with a Master of Science in 2013 and now teaches in the Department of Earth Sciences, MSU, and with the Friends of the Gallatin National Forest Avalanche Center.





**Field Obs**

# WHEN THINGS GO RIGHT

STORY AND PHOTOS BY NICK BRAUN

**April 3rd** of last spring saw a nice coating of very light snow in the Northern Colorado Rockies. It had also fallen on an uncharacteristically stable snowpack in the alpine. We had been out skiing nice lines all week taking advantage of stable winter-like snow before the ensuing transition to the isothermal snowpack. We set out that morning with hopes of skiing a prized line in the Gore Range. The approach up the backside of Red Peak left a beautiful low angle plan B if snow conditions in the couloir weren't to our liking. Luckily what we found was very confidence inspiring and within our risk tolerance. Around fourteen inches of extremely low density snow had fallen/blown into the chute. Having not climbed the line, we elected to have the first skier make a few turns on belay in order to confirm our thoughts on the snowpack. He dug a hasty pit and found similar conditions to what we had seen the last few days on similar aspects in the alpine. With very little probability of deep persistent failure, our primary concern of the day was slough management. Given the volume and density of the snow we knew it would be something to be very aware of while skiing. Luckily the chute has bountiful escape options and safe zones due to a number of subtle yet significant off-sets in the walls of the couloir.

It truly was "one of those days", when everything falls into place. I've learned that those times do not happen often and I think an important aspect of my decision-making is to be patient as to not force them. But patience pays off and we were gifted with 1700' feet of some of the most satisfying and aesthetic turns I've ever made. It was the culmination of hard earned experience, some skill, and a bit of luck. It's days like these that keep me passionate about snow science and allows for memories I'll be forever fond of.

Nick Braun calls Boulder, CO home for the time being, while pursuing an expensive piece of paper. He enjoys setting skin tracks, type 2 fun with good friends, and taking a pair of slalom skis out on the groomers every once and a while.





**DYNAMIC**  
AVALANCHE CONSULTING LTD.

**Professional Snow Avalanche Expertise**



- Hazard mapping & risk assessment
- Engineering design & protection structures
- Avalanche safety plans & worker training
- Avalanche forecasting & risk control

Alan Jones, P.Eng.  
Revelstoke, BC

250.837.4466  
[www.dynamicavalanche.com](http://www.dynamicavalanche.com)

Kevin Fogolin, RPF  
Whistler, BC

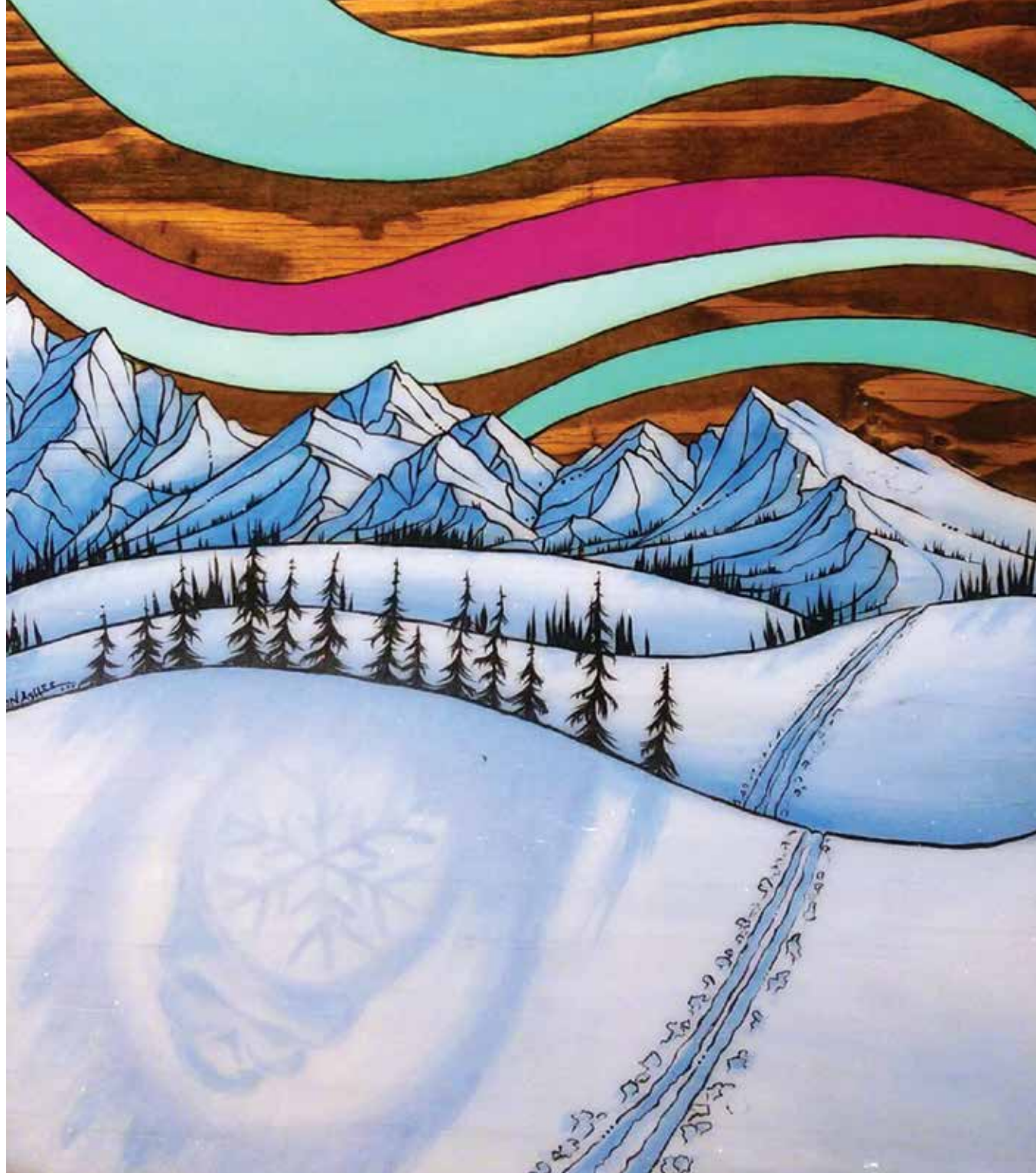
**Snowpro Plus+**

*Create High Quality Snow Profile Graphs*  
Annual Subscription C\$199 for 2 Computers  
Order: [www.snowproplus.com](http://www.snowproplus.com)

- \* New Photo Attachments
- \* New Improved Latitude/Longitude entry with Maps
- \* Conforms to CAA OGRS and AAA SWAG Standards, IACS 2008 Symbols
- \* Snow and Shear Layer Nicknames
- \* 9 Categories of Grain Shape Classifications Symbols with detailed Grain Shape Sub-classes
- \* Implements Flags/Lemons Analysis
- \* Computes Snow Pack Average Density, Cumulative Shear Stress, Ramsonde, Snow Loads and more ...
- \* Automatic updates and telephone support

**Gasman Industries Ltd.**

Telephone: +1-250-999-1490 Email: [info@gasman.com](mailto:info@gasman.com)  
Amount in Canadian Dollars – PAYPAL (MC/VISA/AMEX)  
Delivered by Web Download – Free Trial Download  
Contact us for our Educational Program and Volume Discounts



## WORDS FROM AVALANCHE: A PIECE OF SATIRE

BY RYAN WILLIAMS

### **My Dear Backcountry Travelers,**

I write to you with grave displeasure that not all of you respect me as you should. Do not think you will escape my full wrath; you vile, monosyllabic, obtuse, simpering, pestilent little fools! Indeed, in your better moments, I trust that you hardly wish to do so.

You see, I simply do not care for your lack of respect. Are you not aware that thousands of you adults have been claimed by the force of my power? Every year, some naive person tries to head out and go ‘poking around’ when I am the grumpiest. Then all I hear is grumbling amongst you when I decided to gobble them up.

It is a little disappointing that such tragedy occurs, despite all the fair and ample warnings I give you. Admittedly, sometimes I am simply bored, and enjoy surprising you. It helps to keep your astuteness about you. You think I should act one way, and I will go out of my way to do precisely the exact opposite. On the other hand, your science seems to be improving, helping you to create general rules to remain safe.

It seems to me that a great many of you have taken the time to learn and hone your craft when deciding to engage me. I commend those individuals, as they seem to be the ones who enjoy the majesty of the mountains, while doing so with the utmost admiration. These are the individuals you ought to be following; seek their wisdom. Remember: what you get away with by ignorance will quickly turn into habit.

All I ask is for a little reverence. Don’t go trampling about with no regard for me or other members of your party. When you are not expecting the attack I shall strike with deadly force. Take heed of my warning: I do not play nice with those who simply do not pay attention.

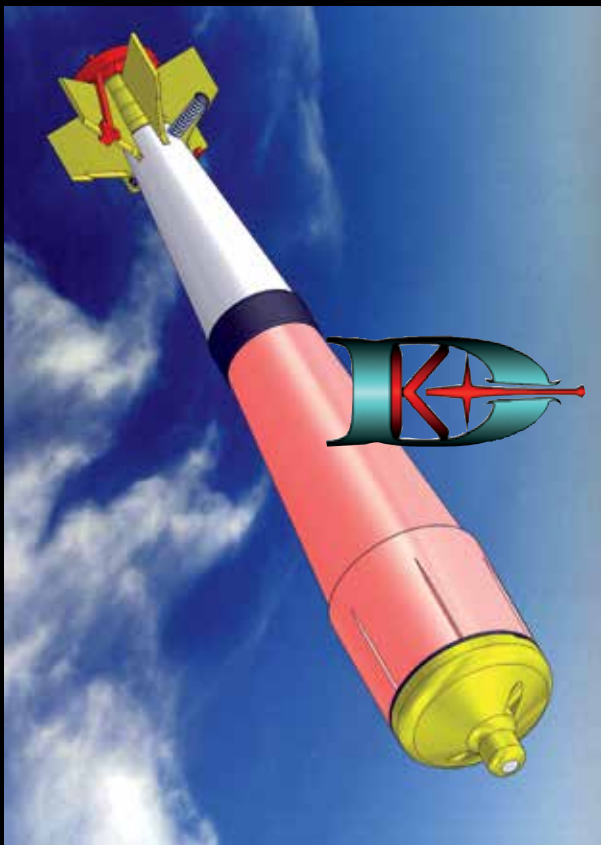
Your demonstrative force of nature,  
*Avalanche*

Ryan Williams is the owner of Sender Guides LLC. He grew up in the mountains of Colorado and loves to travel to ski in new locations. He is working his way through the AMGA guide program to become a fully certified IFMGA guide.





**Safety Thanks to  
Avalanche Guard**



▲ **The DeltaLancer System.**  
Under License from Kevin Powell at  
Delta K Explosive Engineering Systems Ltd.



▲ **The New Redesigned  
CIL Classic Snowlauncher.**



Div: EVANinc

*Explosives*  
**EXPERTS**  
*Explosif*

**Stay a Step Ahead with Custom  
Avalanche-Control Explosives**

**The North American  
Snow Control Industry  
has Spoken.**

**CIL has Listened!**

**CIL In-House Tail Fins** for all ballistic products.

**RECCO Microchips** are installed inside the  
boosters, where they provide the most reliable tracking.

**When you request C-I-L Explosives products,  
you are supporting your industry!**

**3% OF ALL PURCHASES** go to the  
**American Avalanche Association**  
for training purposes.

**David Sly 250.744.8765**  
**davidgsly@mapleleafpowder.com**  
**www.mapleleafpowder.com**



**THE AVALANCHE REVIEW**  
PO Box 248  
Victor, ID 83455

Photographer: Grant Gunderson



Presort Standard  
US Postage Paid  
Permit #592  
Pontiac, IL

A Publication of the  
American Avalanche Association



AMERICAN  
AVALANCHE  
ASSOCIATION



**PIEPS DSP PRO**

 **Black Diamond®**

BlackDiamondEquipment.com