THE Avalanche REVIEW

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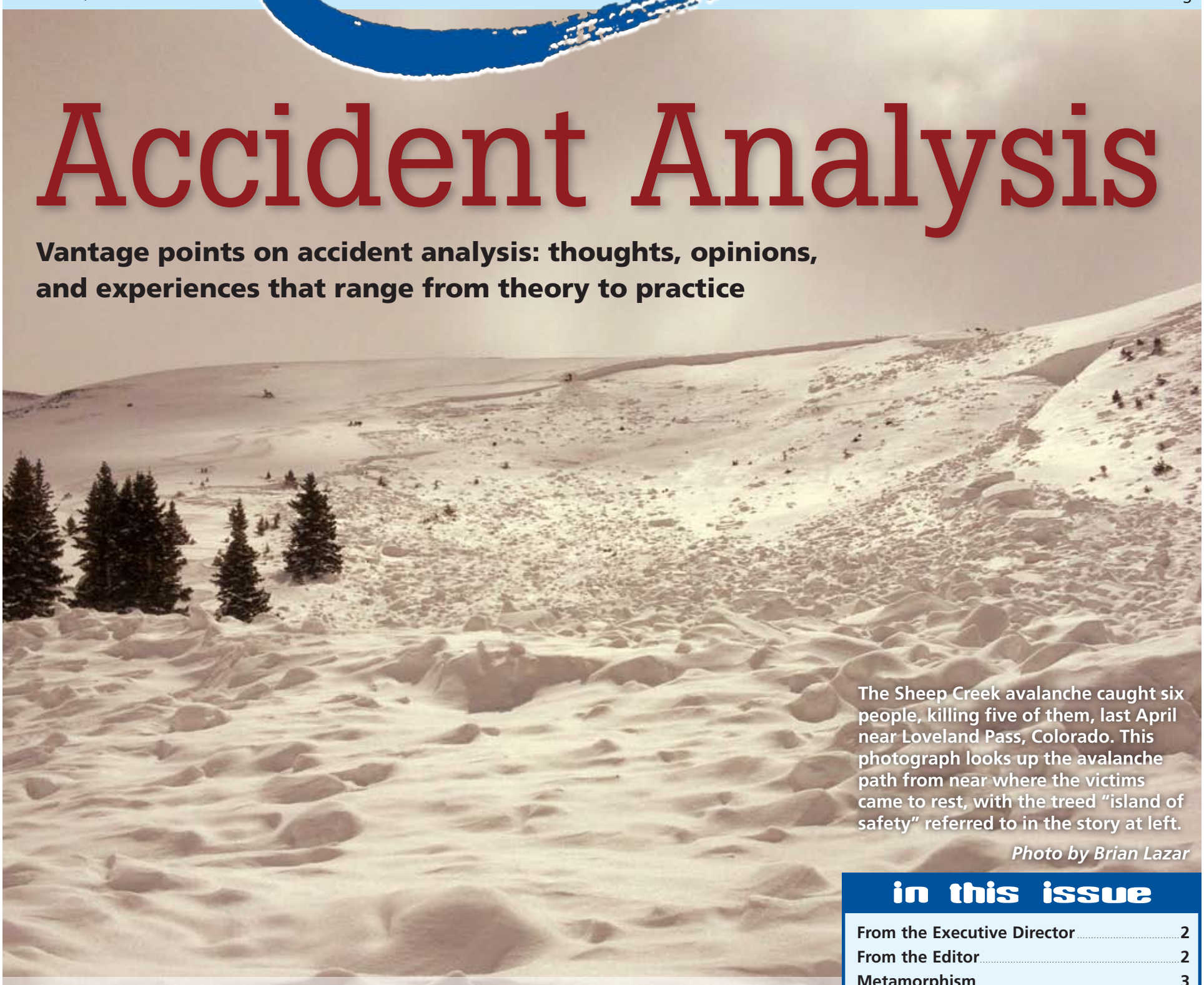
Accident Analysis

Vantage points on accident analysis: thoughts, opinions, and experiences that range from theory to practice



The Sheep Creek avalanche caught six people, killing five of them, last April near Loveland Pass, Colorado. This photograph looks up the avalanche path from near where the victims came to rest, with the treed "island of safety" referred to in the story at left.

Photo by Brian Lazar

REFLECTIONS: Sheep Creek Avalanche

Story by Brian Lazar & Ethan Greene

The national spotlight quickly focused on the worst avalanche accident in Colorado in over 50 years: six people caught and five killed in one large avalanche. The victims were all involved in the ski/snowboard industry. They left behind children, wives, and many loved ones. The accident was tragic and painful. It was also avoidable.

After reflecting on the Sheep Creek accident over the summer – talking with the survivor, friends, and family of the victims, and with many colleagues – it's time to share our thoughts with the professional avalanche community. There are no easy answers, and our intent is not to cast judgment on those involved. Most of us have gotten away with similar decisions at some point in our careers. We hope an honest and frank reflection will challenge us all to consider what we can do better to prevent these types of accidents in the future.

Story continued on page 15 ➡

The Avalanche Review
P.O. Box 248
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in this issue

Does blame lie in something more nebulous, like the emotional pull of the backcountry, the dynamics of peer pressure, or the diabolical whims of Mother Nature herself?

—John Branch, *The Story of Snow Fall*, pg 29

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The mission of the AAA is:

A. To provide information about snow and avalanches;

B. To represent the professional interests of the United States avalanche community;

C. To contribute toward high standards of professional competence and ethics for persons engaged in avalanche activities;

D. To exchange technical information and maintain communications among persons engaged in avalanche activities;

E. To provide direction for, promote, and support avalanche education in the US;

F. To promote research and development in avalanche safety.

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from the executive director

Learning 20/20 Foresight

Jaime stays warm during an arctic cold spell in early December. *Photo by Dan Verbeten*

Similar to many regions around the US this winter, we've had a mixed start to our season here in the Tetons. Some snow, some dry spells, some moderate temps, some deep freeze. As I write, we are back in a period of sunny skies. On a recent ski south of Teton Pass, I was astounded by how quickly (two cold, clear nights) the surface hoar had grown to 10mm. So far, the snowpack has been a little demoralizing in terms of supporting my desires to venture into steeper terrain this season. However, the positive is that this varied and sometimes suspect snowpack provides great teaching opportunities for us avalanche educators and hopefully keeps us on our toes as recreationists.

This season has, so far, provided copious opportunity for discussion and contemplation of making choices and decisions with a grey-zone snowpack. Living and learning about snow around the Tetons over the past decade, I am lucky to have many talented teachers and mentors. With our TAR editor just down the road, I have both a friend and mentor who is in the middle of the melee when it comes to ideas and musings on the juxtaposition of snow and humans. So far this season, we've talked a decent amount about uncertainty: over tea, in the classroom, and along the skin track. How do we handle ourselves in the face of this uncertainty? My personal experience and observations show it frequently comes back to that human factor. It seems there are infinite ways to explore and perceive that place where you and I come face-to-face with the uncertainty. I am excited in this issue of TAR to get a glimpse into some others' minds as they share perspective and experience on analyzing mistakes we have made in snow. As I was recently told in relation to personal experience in this realm, the challenge is to shift the 20/20 hindsight into 20/20 foresight. How do we take learnings from accidents (ours and others') forward to help us reduce the likelihood of making similar mistakes again?

Speaking of learning…it's one of my favorite things to do. This is convenient, as this new role as ED of the AAA has been providing plenty of opportunity over the past several months! A few updates for you on the administrative front… Be on the lookout for the debut of a AAA e-newsletter this winter, in non-TAR months, to help keep you abreast of breaking news and information related to the avalanche world. The newly revised avalanche.org homepage is nearing completion, bringing you an interactive Google map someday very soon. We're also excited to be working to foster new and existing partnerships with a number of companies who care about avalanche professionals. Stay tuned for how these partnerships will benefit you, our members. As always, please be in touch with questions or ideas as they arise. Happy reading!

—Your executive director, Jaime Musnicki

from the editor

The Illusion of Control

On a personal ski day with friends in the Teton Pass backyard, before a long chain of avalanche classes. *Photo by Susan Ward*

I've been working with the material in the Feb issue of TAR for a couple of months now. I began to develop the theme of accident analysis in early November, during a couple of late-night, wine-fueled conversations around Dave Richards' kitchen table in Alta. The experience has been powerful and humbling, even synchronous, as survivors from a recent high-profile Teton accident reached out to me and to the professional avalanche community for insight and a way forward.

A sentence from one of those conversations has stuck with me as I sent out queries to potential writers, explored new angles, and followed my curiosity:

> "The illusion of control makes us think we can outfox uncertainty."

I have begun to feel the weight of uncertainty heavier than ever, and continue to give it room and respect in my decision-making. As I learn more, I realize how much more there is to learn. Curiosity isn't enough; it has to be tempered by grace and humility – and a sense of humor helps. Over time I gain insight on my own accidents or missteps, and own them completely but perhaps awkwardly, and hope to offer empathetic yet honest counsel to others.

I hope that you are able to spend some in-depth time with this issue of TAR, and that you too gain insights from every aspect of the fine writing in this issue. Unfortunately, this wealth of insight into accident analysis has forced me to bump several valuable articles to the April TAR. Those articles include Ron Simenhois' thoughts on avalanche release and the role of friction, an essay on rescue specifics from Chris Joosen, and a book review for Bruce Tremper's new level 1 book, *Avalanche Essentials*. Apologies, friends.

Our starting point is an analysis of last spring's Sheep Creek avalanche, near Loveland, Colorado. A sincere thank you to Ethan Greene and Brian Lazar, who spent time with me on the phone and the email, hashing out the bones of their story and their analysis, then provided an in-depth story for TAR. Halsted Morris shares his impressions and opinions from hours in Sheep Creek spent excavating some of those victims.

We have several essays that bring us a theoretical perspective: Jeff Jackson agreed to write up his work on systems analysis, while Dale Atkins continues his ongoing project of teaching us to manage risk by acknowledging and respecting uncertainty. We also reprise Russ Johnson's fine essay from TAR 21-4 entitled "Breaking the Chain;" it is just as vital today in this context.

I have also included more material on Avalanche Types from around the globe; Canadian and European views of pattern recognition and interpretation can help us in refining our local understanding and interpretation of the problem.

Several forecasters and front-line rescuers weigh in with their opinions and experience: Brett Kobernik tells us about the three categories of survivors, while Rich Baerwald and Van Roberts bring us their National Park Service nuts-and-bolts advice on investigating accidents, avalanche and otherwise.

The personal perspective on accident analysis is incredibly powerful: after two years, Rob Castillo turns a brave 20/20 hindsight look on Tunnel Creek from the inside. TAR sends Rob a heartfelt thank you for his honesty and clarity. John Branch of *The New York Times* gives us his behind-the-scenes perspective on assembling his seminal, multi-media piece on Tunnel Creek. Nancy Elrod then tells us how her avalanche accident empowered her to become an educator.

Finally, we have an essay from Zahan Billimoria on minding our manners publicly. Specifically, to remember graciousness when someone else is in an accident. His insight and empathy brought me a new perspective on this journey years ago when, in presenting a case study of an accident that involved a friend, he didn't just ask how many clues they missed. Rather, he told us

mailbag

Use of Smartphone Apps for Avalanche Search and Rescue

Story by Felix Meier

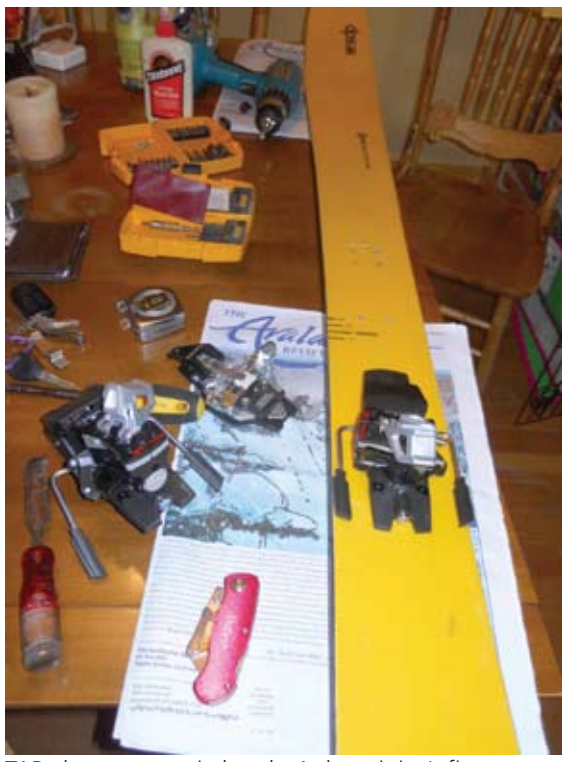
The last issue of TAR contained two contributions on the subject. Both of them did not mention the main reason for not using a smartphone for the following purpose: There is not a single popular smartphone product that is guaranteed by its manufacturer to operate at temperatures below 0ºC. While a smartphone buried in the snow may maintain a temperature above 0ºC, in particular if it is carried on the body of a person, a smartphone that is used in the open for searching may pretty fast cool down to below 0ºC. So you wouldn't necessarily want to rely on any smartphone-based system for purposes of avalanche search and rescue. This is also the main reason why the ARS457 system by Girsberger Elektronik AG of Switzerland has been put on hold. ❄

how he could see himself making that same chain of decisions.

Graciousness is key. It sets the stage for forgiving yourself for mistakes in judgment, for acknowledging that command of a situation is often an illusion, and, finally, for understanding that embracing vulnerability gives us real respect for consequences.

I'd like to end this editorial by challenging the avalanche education community to set an example of graciousness in accident analysis. I hope we may impart to our students how easy it can be to slip into a chain of small decisions that leads to mishap. Our task is to make situational awareness real and personal. In doing so I hope we can break those chains of small bad decisions and live to ski another day.

—Lynne Wolfe ❄



TAR always comes in handy. At least it isn't firestarter.
Photo by Dan Veenhuizen

metamorphism

Sawtooth Natl Forest Avalanche Center Hires Two New Forecasters

Scott Savage has a new job at the Sawtooth Avalanche Center. After entering the public avalanche forecasting arena last season, he successfully competed for the lead forecasting position and is now a full-fledged and permanent employee of the US government. Prior to coming to the Sawtooths in 2012, Scott spent the better part of two decades as an avalanche forecaster and snow safety director at Big Sky Resort. He has frequently contributed articles to *The Avalanche Review*, written columns for regional Montana newspapers, presented at international conferences and regional professional development seminars, and is currently the secretary of the American Avalanche Association. He is also one heck of an outdoor plumber and owns and operates PASO Irrigation in his off time from the avalanche center.

We are proud to welcome **Dr. Eric Lutz** to the Sawtooth Avalanche Center. Eric made the HUGE jump from Dartmouth College to the blue collar snow world of south central Idaho. He has already bought a couple new pair of skis and in his off time fixed all of our "unfixable" technology problems. Eric has studied snow in the Alps, Cascades, Rockies and the Southern Alps. He was an intern at the Swiss Federal Institute for Snow and Avalanche Research (Davos) and earned a European Diploma in mountain geography (University of Innsbruck) and a PhD in snow science (Montana State University). His PhD centered on improving our understanding of the spatial and temporal evolution of avalanche hazards. Eric has also researched the impacts of climate change on Western mountain hydrology (University of Washington) and the Greenland Ice Sheet (Dartmouth College). ❄

what's new

Booth exhibitors at NSAW are rapt by one of the presentations. Note AAA PNW rep Patty Morrison and AVPro director Dallas Glass in the center of the photo. *Photo by Truc Allen*

NSAW 2013 Summary

Story by David Waag

What do PBR tallboys, a rodeo aficionado, a Navy fighter pilot, a PhD in Atmospheric Sciences, and a 12-pack of Kokanee all have in common? It's more than their desirability as ski partners; they all shared the podium at the Sixth Annual Northwest Snow and Avalanche Workshop (NSAW) in Seattle on November 3.

Pacific Northwest backcountry skiers and riders packed the 450-seat auditorium at the University of Washington's Husky Union Building for five excellent presentations and two annual awards: the NSAW Special Recognition Award, given to Oyvind Henningsen for his volunteer efforts on behalf of avalanche education and mountain rescue, and the newly created NSAW Core Award (PBR tallboys), awarded to veteran backcountry skiers Ed Rundle and Silas Wild, who proceeded to showcase their worthiness by cracking open said beer on the spot.

Scott Schell, program director for the Northwest Avalanche Center (NWAC), took the pole position to kick off the show. Though he claimed to be in town for the rodeo, Schell did a great job highlighting changes to NWAC's forecast presentation and website design, including the addition of three paid observer positions to better represent the diverse forecast region under NWAC's banner. The new website features clean, easy-to-navigate graphics and the hazard forecast is now a three-tiered product with a tier aimed at different experience levels of users.

Next at the podium was Navy fighter pilot Captain Jeff Montgomery. In addition to backcountry skiing, Montgomery flies fighter jets for the US Navy. His presentation introduced the recurring theme of risk management and mitigation that appeared in several of the day's lectures. After wowing the crowd with a POV video clip of landing his jet on an aircraft carrier at night, Montgomery shared the simple framework he and fellow pilots rely on for risk management during missions; he then applied the process to making good decisions in the backcountry. The common foundation is clear and concise communication among those involved while considering the key elements of mission, crew, weather, and terrain.

Building on the risk-management theme, Ben Pritchett, AIARE program director, stepped up to share practical strategies for managing risk in the field using his own secret Rocky Mountain stash to demonstrate AIARE's checklist manifesto. His practical approach highlighted the need to monitor and review goals and concerns throughout the day with an emphasis on two concepts: using terrain visuals in tour planning and the importance of good communication at all stages.

Following lunch, Cliff Mass, University of Washington professor of atmospheric sciences and resident PhD, took to the stage to share his perspective on global warming and its impact on the Pacific Northwest. He also graciously opened the floor to all weather-related questions and fielded a wide variety of inquiries regarding Northwest snowpack, short-term forecasting, and the ever-popular ENSO and PDO indices. Bottom line: the Pacific Ocean is likely slowing the impacts of global warming in the Northwest, but you can rest assured the Northwest climate is going to see noticeable change by the late twenty-first century. Mass went as far as to say that skiing on Washington's Snoqualmie Pass could be history by the end of the century.

Throughout the day, BCA Sales Director Steve Christie's MC skills kept the event moving forward while maintaining his trademark good humor. And it was when Christie challenged the audience to name all 10 Canadian provinces as he introduced the anchor speaker of the day, Canadian mountain guide and career snow professional, Colin Zacharias, that the 12-pack of Kokanee made its appearance on the podium. Proving that at least 1-in-450 Americans can name all 10 Canadian provinces, a lucky attendee was awarded the half-rack of Canada's finest.

Zacharias wrapped up the risk-management discussion with a focus on operational risk and communicating the objective hazard. He spoke to the origins of the "run list" and emphasized the importance of the daily meeting for red-lining or green-lining runs. Again, clear and concise communication of goals, hazards, and observations was an underlying theme.

A big thanks goes out to Michael Jackson (MJ), the fearless organizer, as well as his many volunteers: Gib and his Summit Patrol Crew, Mike and Joanne Stanford, Adam Jata, Philip Cantruck, Jesse Reynolds, Sarah Stewart, and a host of others who helped the event go off without a hitch.

A flight pilot is well-tuned into the subtleties of risk management. Jeff Montgomery underlines the importance of good communication in mission, crew, weather, and terrain, regardless of the setting. *Photo by Don Svela*

Of course, without the financial assistance of the sponsors, NSAW would not exist. Thanks to FOAC, AAA, AIARE, K2, Ortovox, BCA, Mammut, The Pettigrew Foundation, BARK, The Summit, Nature's Bakery, The Snohomish Helicopter Rescue Team, Outdoor Research, North Coast Mountain Guides, Pieps, and Second Ascent – and a big thanks to New Belgium Brewing for making the social hours even more social.

Finally, thanks to all who attended.

Dave Waag is the publisher and editor of Off-Piste Magazine. *He's spent the last 20+ years skiing, writing and working in the ski and snow industry all the while wondering what he'll do when he grows up.* ❄

From the photographer: Bacon was my idea. We used to have a fundraiser the night before BBR at Chair 9, Glacier, WA, in which I would fry bacon and have chocolate fondue to dip it in. I've always wanted to have bacon at the event for the past four years but couldn't pull it off being the creator and co-organizer of the event with Jeff Hambelton; we needed more labor. Baker stepped up and put a lot of energy and labor into it this year which allowed for me to organize the bacon and beverage booth. I'm pretty sure BBR is the best-smelling Beacon Rally in the world; even if you didn't hear about you may have smelled it.

Baker Beacon Rally

Story by Steve Christie • Photos by Pat Kennedy

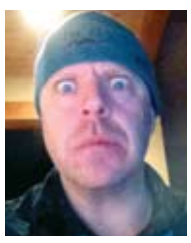
Say this five times quickly: Baker Beacon Bacon Rally.

The fifth annual Baker Beacon Rally on December 15 at the Mt Baker ski area went off without a hitch this year despite the RAIN. Ok, let's be honest: there was slightly less than half the turnout of previous years, but as organizer Jeff Hambelton put it, "Where else in the world can you find 130 people practicing with avalanche beacons and smiling in the rain?" The answer to that is nowhere in the world, in any conditions, will you ever find that many people practicing with avalanche beacons. Not to mention that at least half the locals showed up in their rubber fishing outfits prepared to charge through every search scenario; it was like "Deadliest Catch" and a TGR movie had joined forces!

And then there was bacon. Carne Custom Butcher of Bellingham, WA, donated 50 pounds which was graciously grilled by the folks from the local REI store, resulting in a beacon-searching and bacon buffet for all participants.

Rain or shine, REI and the Mountain Education Center at Mt Baker ski area continue to put on one of the best avalanche-safety-related events known to mankind. We hope to see you there next year.

Oh, one last thing: it was said that Pat Kennedy of REI consumed 24 pieces of bacon and performed 16 beacon search scenarios in three hours. Way to go Pat! We'll call this the first record and track it annually from now on.



Steve Christie, director of sales for Backcountry Access, has spent the first part of this winter working relentlessly on spreadsheets due to the current snow drought in Washington. He will be Nordic skiing tomorrow in tights followed by riding his snowmobile and then skeet shooting. Please do a snow dance for the PNW. ❄

NWAC Early Season Updates

Story by Dennis Damico

December 18, 2013: Last week was a perfect storm of events: we launched our new website on Tuesday, started regular early morning forecast operations that same day, and began our new professional snow observer program. We invited the observers, from all over the PNW, over to the office on Wednesday to learn about our operations and how their observations will be incorporated into our forecasts. Then we went into the field together for a day of training to align and standardize our field observations and improve our communication. The training was led by Colin Zacharias.

Scott Schell presented at NSAW this November *(see story, previous page)*. Held on the University of Washington campus, about 500 people attended this year – great attendance! Scott described the new look and feel of the website, specifically our move away from the danger rose and the focus on avalanche concerns/problems. Thanks to the CAIC, who provided us with their website template and an incredible amount of information and invaluable help.

Outreach has ranged from free avalanche seminars to manning a tent and speaking at the Mt Baker Beacon Rally held at the Mt Baker ski resort to teach and practice transceiver skills, discuss general avalanche knowledge, and learn about policy for backcountry accessed from the ski area *(see story at left)*.

A very large chunk of time has been spent collaborating between the nonprofit board, the forecasters, and the web team before and during the website launch. Our website developers (contractors) spent countless hours addressing the myriad of issues that popped up since the launch. Overall, we are very pleased with the site.

Finally, the weather and snowpack have been quiet for this time of year in the Pacific Northwest. The snow depths at our stations are well below average, and the ski areas are not operating at 100% yet. A disappointment to snow-lovers, but this has allowed us some breathing room to begin the season.

From Dennis Damico: While weather is my passion, it was my love of snow and mountains that first led me into the northeast mountains and eastern Canada. I started my avalanche education in Colorado and Utah while learning to telemark. Eight years ago, when I got tired of only visiting the West, I moved to Seattle to take a job with the National Weather Service. 2012/13 was my first season with the NWAC where I have enjoyed interacting with the knowledgeable and interesting partners and co-operators that make our program possible. ❄

Andy Dietrick used a number of Heather Thamm's impressive photos of last year's deep slab cycle at Alyeska during his SAAW presentation. Here's one shot post-avalanche, looking down the north face. *Photo by Heather Thamm*

First SAAW Held in November

Story by Wendy Wagner and Eeva Latosuo

Chugach National Forest Avalanche Center organized a one-day workshop for 120 avalanche professionals and interested public from the Girdwood/Anchorage area in Alaska. Hosted at Alaska Pacific University, the event was sponsored by a generous grant from the American Avalanche Association. Talks ranged from the technical to practical and included a panel discussion on "Multiple Groups Recreating in the Same Avalanche Terrain." Presenters included snow professionals from Alyeska Resort, Alaska Avalanche School, Chugach Powder Guides, National Weather Service, Alaska Department of Transportation, and more.

Highlights

Ron Simenhois (Coeur Alaska): We lucked out by convincing Ron to speak twice. First was a technical talk on the mechanics of dry slab avalanche release, which made brains bend as he explained the only equations of the workshop. Ron also awed the audience with time-lapse videos of glide avalanches that gave clear visuals on the difficulty in predicting these beasts.

Jim Woodmencey (MountainWeather.com): The famous mountain weather guru gave a nostalgic look at the Alaska avalanche scene from his stint with the Alaska Avalanche Center in the mid-1980s. Contracting helicopters with Doug Fesler and Jill Fredston to investigate avalanches with 30' crowns was part of their program – ah, those were the days.

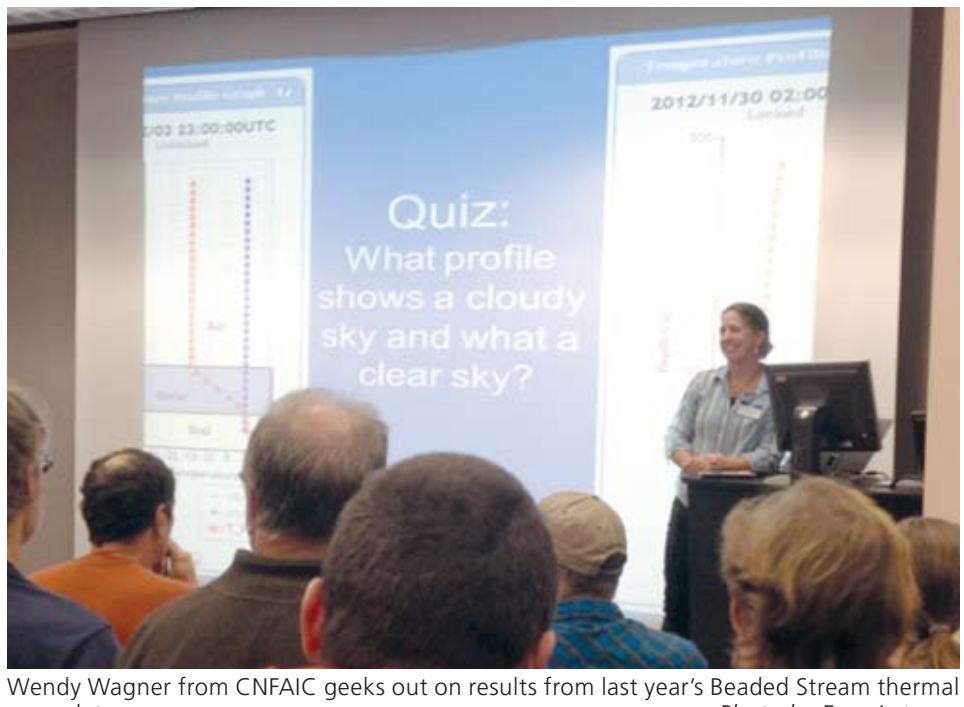
Henry Munter (Chugach Powder Guides): Henry discussed the challenges of "data overload" in the heli-guiding business. Listeners had aha moments during Henry's discussion of the traps professionals can fall into when they becomes so focused on a specific snowpack problem that a subtle, yet possibly more important one, gets missed.

Jim Kennedy and Andy Dietrick (Alyeska Resort): These two chiefs of Alyeska Snow Safety showed off some amazing video and photographic avy eye candy of last season's impressive deep-slab avalanche cycle *(see above)*. This was a total crowd pleaser.

This was the first stab at a regional avalanche workshop geared toward professional development for the Southcentral Alaska snow and avalanche community. We had an extremely positive response from both the presenters and the audience. The day ended with a beer social (of course) and live music. Plans are already underway to make this a yearly event.

Visit akavalancheworkshop.org for more info as well as 2013 proceedings.

Wendy Wagner is a forecaster at the Chugach National Forest, based out of Girdwood, AK. TAR hears that she may need some coaching for her snowmobile skills to match her avalanche and weather skills.



Wendy Wagner from CNFAIC geeks out on results from last year's Beaded Stream thermal array data. *Photo by Eeva Latosuo*

Presenter Tim Brown discusses subtleties in interpreting the avalanche problems.

Third Annual ESAW

Story by Jonathan S. Shefftz • Photos by Brian Irwin Media

The third-annual Eastern Snow & Avalanche Workshop was held in North Conway, NH, near the base of Mount Washington in the Presidential Range. This year's ESAW was once again a collaborative effort between members of the USFS Mount Washington Avalanche Center – led by Chris Joosen – and members of the American Avalanche Association, led by AAA Eastern Representative Kyle Tyler. A record attendance of 145 filled the entire gym of our host, the John H. Fuller Elementary School. This year's registration fee was supplemented with a $500 grant from the AAA, and registration fee proceeds over and above the hosting costs went to the youth-oriented White Mountain Avalanche Education Fund.

As with similar workshops in other regions, the presentations appealed to the attendee mix of snow professionals and enthusiastic recreationists. This year's program started with Rebecca Scholand, a Mount Washington Observatory meteorologist. In her 2011 presentation on up-slope snow development, Rebecca remarked that she didn't care about snow after it falls on the ground. But since then, backcountry skiing has drawn her into our avalanche community, and her presentation covered a number of resources and protocols for improving our avalanche-related weather observations.

Ben Woodward, chief ranger of Maine's Baxter State Park and its Mount Katahdin, provided attendees with an alpine tour of that area, exploring the ramifications of the limited winter road access and the challenges of self rescue (a sharp contrast to NH's Presidentials). Bob Baribeau, from Mahoosuc Search and Rescue, summarized how Katahdin's "Tableland" snow farm loads up on the technical ice climbing routes and summer hiking trails, so avalanche risk is not exclusive to skiers seeking powder. With a limited number of on-site park rangers, long approaches, and only a weekend and holiday presence of formal rescue groups, self rescue is often the only option (a rarity in the Northeast). Bob noted that the average visitor now has more technical gear than common sense. Although he sees more avalanche rescue gear among climbers, Bob also sees parties cutting down on time devoted to information gathering. Both of these presentations tied in nicely with the prior presentation on the importance of weather observations.

Doug Richmond, sporting a "Big Green" cap from his nearby alma mater Dartmouth College, assessed human behavior at the ski area boundary. Informed by his many years as the Bridger Bowl ski patrol director, Doug provided a historical overview of some of the changes affecting the management of backcountry ski areas. According to Doug, a 1970s federal ordinance legally sealed off the ski area boundary. The legal status has since changed, as has interest in out-of-bounds skiing and the prevalence of ski-touring gear. Doug's "favorite" incident included a helmet-cam video of a skier whose partner is avalanched, then takes out his beacon in order to review the back of the housing for the instructions on how to conduct a search.

A series of short sessions started with Julie LeBlanc, who updated us on her presentation from last year on the avalanche forecast center in Quebec's Haute-Gaspesie (aka Chic Chocs), the only avalanche forecast center east of the Rockies other than our own Mount Washington. (Once again, her Québécois accent contrasted nicely with a bunch of American male presenters!)

Roger Damon, who has been teaching National Ski Patrol avalanche-safety courses at Mount Washington since the mid-1960s, presented an update of his earlier ISSW paper on Eastern ski resort avalanches. Our ski resorts' natural snowfall and typically scouring winds, further combined with high skier density, almost never allow for natural snow avalanches. Yet our snowmaking prowess can also make…avalanches. A December 2002 avalanche at 750' Holiday Valley (near Buffalo, NY) left a 2.1m crown, representing a crown face almost exactly 1% of the entire resort vertical drop – perhaps some sort of record? And preparations for the 1980 Lake Placid Winter Olympics were evocative of a Monty Python scene:

Everyone said I was daft to build a castle on a swamp, but I built it all the same, just to show 'em. It sank into the swamp. So I built a second one. That sank into the swamp.

Chris Joosen, director of the Mt Washington Avalanche Center and safety officer on his Forest, was selected to receive the Chief's Honor Award for Creating a Safety Culture. The award goes to Chris and his Forest Safety Committee for "revolutionizing safety and safety culture." This is a huge award and a great honor for Chris which reflects well not only on Chris and his team, but also on the avalanche program.

For the downhill race course, Whiteface Mountain blew a massive amount of snow onto bare ground. Subsequently, the slope avalanched into the woods, leaving bare ground. In response, the ski area below another massive amount of snow with the same result: another avalanche into the woods, leaving behind bare ground. Fortunately the third try was not another strike!

Last year, Dr Eric Lutz, a snow scientist with the Dartmouth College Glaciology Group, explained the art and science of snow penetrometry, taking us from the ramsonde in the 1930s to the SnowMicroPen in the 1990s. This year, Brint Markle, with his fellow MIT whizzes at their AvaTech Safety start-up, took workshop participants into the next era. Brint asked us to imagine sticking a sectional probe into the snow and immediately transmitting a complete hardness profile to your phone, which would then be uploaded to a crowd-sourced geospatial map. Brint and his team will continue to conduct extensive field testing this avalanche season by many snow-science professionals. Stayed tuned for further updates.

Another highlight was a presentation by Dale Atkins, former AAA president. Dale focused on the concept of risk and introduced us to VUCA: volatility, uncertainty, complexity, and ambiguity. Dale's message included that the goal should be not to minimize risk but rather to minimize uncertainty. He closed on the thought that when faced with uncertainty, don't rely on decisions that require predictions.

The next series of short sessions started with a second talk by Dale, this time on avalanche rescue. Dale is RECCO's training and education manager, but his presentation encompassed all the types, phases, and equipment involved in rescue. His closing thought was that rescue gear puts you in a place to be lucky – but you don't ever want to rely on luck!

Next was Jeff Lane, one of Mt Washington's snow rangers, who introduced us to meteorological variability on Mount Washington (and also announced a new free continuing education series scheduled for the second Saturday of every month). Cyrena Briedé, director of summit operations for the Mount Washington Observatory, assessed how well the summit above-treeline 24/7 observations correlate with conditions for the avalanche forecast areas down in the at-treeline glacial cirques.

Tim Brown, an instructor trainer for the American Institute for Avalanche Research and Education (AIARE), explained the evolution and current usage of "avalanche problem" descriptors to communicate risk. With our local "arctic maritime" avalanche climate, wind slab is almost always our primary or even exclusive concern. But Eastern skiers see more varied avalanche conditions since we're always flying out to various Western regions in search of better snow and bigger mountains. Tim's presentation was especially important for anyone suddenly exposed to the avalanche bulletin format of different forecast centers.

Finally, Doug Richmond explained Bridger Bowl's avalanche program and operations. Despite those previously discussed snowmaking avalanches, and also Whiteface Mountain's lift-served access to avalanche-prone landslide paths, Eastern ski resorts are pretty much immune from avalanche danger. Therefore, Doug provided a glimpse into a world that is not experienced locally.

Interspersed throughout the event were raffles of prizes donated by our sponsors, including American Alpine Club, AIARE, ARVA, Backcountry Access, Black Diamond/Pieps, DPS Skis, Dynafit, Leki, La Sportiva, Mammut, Mountain Hardwear, Off-Piste Mag, Petzl, Ortovox, Skimo.co, Sterling Rope, Toko, and Voile.

ESAW finally adjourned down to our second host, International Mountain Equipment for socializing amidst vendor displays from AIARE, AvaTech Safety, BCA, BD/Pieps, La Sportiva, Mammut, Ortovox, Petzl, RECCO, Friends of the Mt Washington Avalanche Center, and Sterling.

The following morning, an AIARE instructor refresher training was held at the 2011 ESAW venue. The group marveled at how the first ESAW attendees were ever able to squeeze into that place only two years ago! And indeed we are now outgrowing our current venue, so plan to join us for ESAW at the even larger "Theater in the Woods" in neighboring Intervale, NH, on November 8, 2014.

Jonathan Shefftz lives with his wife and mondopoint-size 16 daughter (still too small for "Tech"-compatible ski touring boots) in western Massachusetts, where he patrols at Northfield Mountain and Mount Greylock. He is an AIARE-qualified instructor, NSP avalanche instructor, and AAA governing board member. When he is not searching out elusive freshies in southern New England, he works as a financial economics consultant and has been qualified as an expert witness in state and federal courts. He can be reached at jshefftz@post.harvard.edu or just look for the lycra-clad skinner training for his NE Rando Race Series.

aaa news

AAA Certified Instructor Program: *Recertification Details & Continued Professional Development Matrix*

Story by Brad Sawtell

Note: These docs will be available for download at www.americanavalancheassociation.org under the education tab.

Introduction

To re-certify, each Certified Instructor must accumulate 90 continuing professional development hours every three years. In addition, all AAA Certified Instructors will do the following:

A. Be active practitioners of avalanche education.
B. Acquire additional education pertinent to avalanche education.
C. Participate in activities which advance or broaden the body of knowledge for avalanche education.
D. Maintain and make available upon request a written log of applicable professional development hours (see below for criteria).

Requirements

1. Maintain AAA Professional Membership.
2. On a three-year cycle, complete a minimum of 90 hours of CPD for academic (see section 1) and experiential practice (see section 2). New CIs will have three years from their acceptance date to complete the 90-hour requirement. Existing CIs will begin the three-year cycle 02/2014. New applicants will start their three-year cycle beginning on their acceptance date. Feel free to use the CI CPD Matrix for examples, ideas, or as a checklist.

Emeritus Status

Certified Instructors may adopt Emeritus or inactive status if they so choose. This will be reflected in a column in the online CI list. Emeritus or inactive status may be reactivated at any time with documentation of CPD. Contact the CI administrator for details.

Continuing Professional Development

The following are examples of permissible topics and activities, but this is NOT a complete list. CIs must exercise judgment on what activities count toward continuing professional development requirements. Questions about specific activities or courses should be addressed to the AAA CI administrator.

1. Academic *(30 hours minimum)*

a. Attend or instruct Winter Weather Forecasting, Teach the Teacher, Blaster's training, etc.
b. Avalanche bulletin writing workshop
c. University/college-level courses in computer science, math, physics, earth science, meteorology, etc.
d. University/College-level courses in education, teaching instruction
e. CPD seminars: can be snow and avalanche-related (ISSW, CAA, regional workshops such as the SAW workshops, etc) or teaching and education-related
f. Present at a professional conference or workshop.
g. AMGA/ACMG ski guide course
h. Complete an AIARE ITC course
i. Complete a Level 3 (AAI, AIARE, CAA) or AVPro avalanche course.

2. Experiential *(15 hours minimum)*

a. Instruct AVPro or L3 courses.
b. Teach a course with a different program (break out of your own circle)
c. Work in a different snow climate
d. Volunteer/exchange at a Forecast Center
e. Ski Patrol exchange
f. Mentor other AAA Professionals or AAA Member Affiliates.
g. Focused ski tour with AMGA/ACMG Ski Guide or Avalanche Center Forecaster
h. Work with your local SAR team
i. Teach a basic class to middle or high school kids.
j. Publish article(s) for TAR or other media publication/outlet.

3. Mentorship *(See Matrix, below)*

In affixing my signature to this application I warrant that all statements made herein best of my knowledge, information, and belief and further, I affirm that I have read the Bylaws and Code of Ethics of the American Avalanche Association and that I subscribe to and will abide by them and all of the provisions in them as now in effect or hereafter amended, and that any untrue or incorrect statement knowingly made by me in this application, or my failure to abide by the Bylaws and Code of Ethics, shall be grounds for my suspension or expulsion from the Association as may be determined and directed by the Governing Board.

I affirm adherence to applicable professional and ethical standards, have not had a certification, license, or similar qualification suspended or terminated for ethical or disciplinary reasons during my career, nor have I resigned from such designation in participation of or in settlement of proposed grievance or disciplinary proceedings.

I agree to fully cooperate in the processing by American Avalanche Association of my application. I will furnish any additional information requested by the Association. I hereby grant AAA permission to contact listed employers, sponsors, and others who may provide information concerning my qualifications for Certified Instructor, and to divulge information contained in the application, or obtained in AAA's investigation of my qualifications, which is necessary for AAA to independently verify my qualifications. ❄

AAA Certified Instructor Continuing Professional Development (CPD) Matrix

Track and complete 90 hours in three years.

Teaching *(any mix of 3 below)*:
- Level 1 courses
- Level 2 courses
- Level 3 or AvPro course
- SAR, explosive, guide, etc. trainings
- Avalanche awareness courses (eg. adults, school kids, general public, etc.)
- Present a paper or a poster at an ISSW
- Present at a local snow/avalanche workshop (eg. CSAW, NSAW, USAW, CAA, etc.)
- AIARE ITCs
- Open *(explain)*

Continuing Education *(any mix of 4 below):*
- Be a student (eg. Winter Wx Fxing, Teach the Teacher, Blasters training, avalanche bulletin writing workshop, etc.)
- Attend a snow/avalanche workshop (eg. CSAW, NSAW, UAWS, CAA, etc.)
- Audit AVPro or L3 (AIARE or AAI)
- Participate in a SAR dog seminar
- Volunteer at your local avalanche center (field work or help writing forecasts)
- Ski patrol exchange
- Guide exchange
- DOT exchange
- Take an AMGA or ACMG Ski Guide Course.
- Take an AIARE or AAI L3 or CAA L2
- Take an AIARE ITC
- Work a season in a different snow climate (other than your home climate)
- Open *(explain)*

Mentorship: Be a mentor to at least two aspiring snow workers compiled over THREE seasons *(below)*:
- Another AAA Pro or Affiliate Member
- Another ski patroller
- Another guide
- Another highway worker
- Graduate student
- Open *(explain)*

AAA Pro Membership (current)

Total CPD hours (plus mentorship credits)

Mentorship over TWO seasons *(to at least 2 below)*:
- AAA Pro or Affiliate Member
- Ski patroller, forecaster, or guide
- Highway worker
- Researcher or graduate student
- Avalanche educator
- Other *(explain)*

CI Program: Thoughts, Changes, Opportunity

Story by Brad Sawtell

Recently, I was teaching an avalanche course and one of the students was a fellow avalanche instructor from Canada. He was on a splitboard and refused to say that he was a rider. As far as he could tell, he was a skier. He "skied" up, and he "skied" down. He insisted that when he went into the backcountry, he was either snowmobiling or skiing. He continued to explain that it did not matter how one got down; what mattered was how one made observations on the way up and related them to the avalanche problem. I must admit that he had a point. It seems that the emphasis on the avalanche problem should be more important than the vehicle we choose, and how we, as users of the backcountry, decide to travel as a team. I can appreciate the emphasis on making observations, making a plan within your group, and using teamwork to fulfill the dream for a good outcome.

Another thing I have observed lately is there seems to be a change in the format in many avalanche bulletins published by the various avalanche centers throughout the US. As an educator, I like the changes. Moving away from the the danger rose, and focusing more on the avalanche problem and where to find/avoid it. I feel as an educator, the structure of the bulletin makes my job easier. It seems to make more sense to our students when educators can coach them about what the problem is, where to find it, how to avoid it, decide on where and how to make observations and decision points, and use terrain to either choose to continue or back off. When teaching, please consider looking closely at the bulletin published by your local avalanche forecast center, and use it as a tool to relate the avalanche problem, linking the danger to acceptable terrain and the location of avalanche problem.

Note that changes have been made to the CI program, including the application requirements and, most notably, continuing professional development (CPD) requirements. We all are professionals. Continuing our own education is important in educating others. A high standard has been set, so take a look at the matrix *(at left)*, and please keep track of your CPD hours.

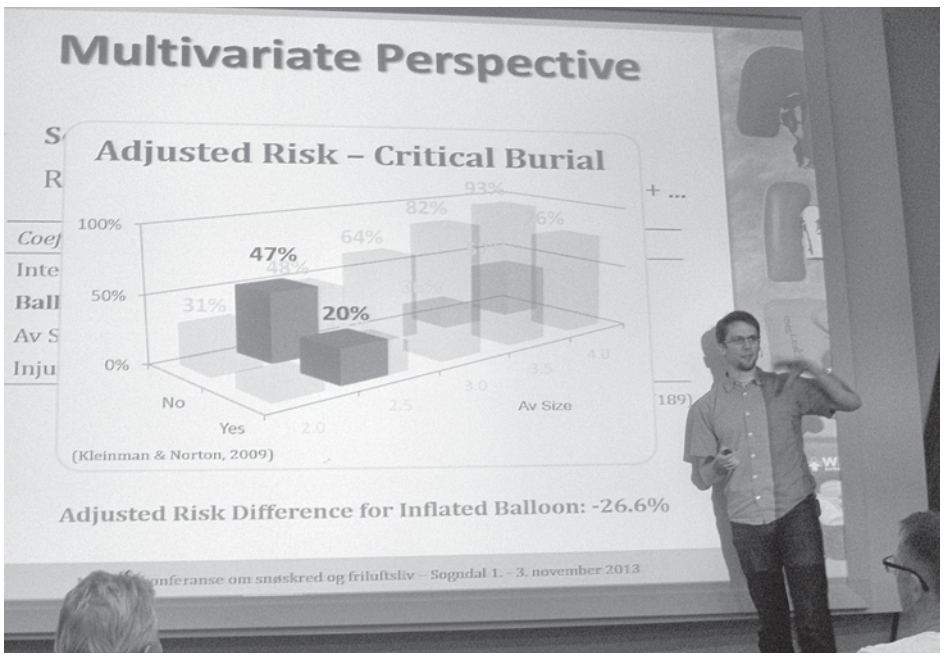
As a last note, I have decided to step down as the CI Representative for the AAA. My other time commitments and goals have caught up with me. I feel that it is best for me to step down so that new energy can lead the program to a new and higher level.

I am grateful and honored to have served on the Education Committee and as the Certified Instructor Representative. I wish the best for the future of the program and hope the path for the future is not too much snow to shovel.

Certified Instructor Representative

Duties include but are not limited to:
- Represent the AAA, the AAA Board and AAA CIs professionally.
- Attend spring and fall AAA Board meetings whenever possible, in person or via Skype
- Oversee the CI Program and help it grow.
- Serve on the AAA Education Committee. This includes being present at quarterly meetings via Skype.
- Manage the review process of all CI applicants. Reviewing applicants is a paid position.

Those interested in applying for the AAA Certified Instructor Representative position should send resumé and cover letter to John Stimberis, aaa.stimberis@outlook.com, by March 20, 2014. Candidate selection will be made at AAA Governing Board meeting on April 26. ❄



Pascal Haegeli was a guest speaker at this year's Nordic Avalanche Conference in western Norway, presenting about his continued research into the efficacy of avalanche balloon packs.
Photo by Krister Kristensen

Nordic Avalanche Conference

The Nordic Avalanche Conference was held the first weekend of November in Sogndal in western Norway. This year a record number of participants included more than 350 from Norway, Sweden, and Iceland, in addition to guest speakers from USA, Canada, and Germany. For almost 20 years now, this conference has been a premier venue for the exchange of expertise and ideas about avalanches. All interested parties are invited: industry professionals, volunteers, rescue, military, government, skiers of all persuasions, and anyone who is curious about the subject.

The main topics this year were avalanche education, personal protection technology, and hazard assessment. An inspiring keynote speech was given by Ian McCammon on the avalanche education topic. Most of the presentations can be found here (some are in English): www.skredkonferansen.no/

AAA Practitioner Research Grant Proposals Due March 1

The AAA Research Committee would like to remind members of the upcoming call for Practitioner Research Grants. The deadline is **March 1, 2014**.

The American Avalanche Association awards research grants to avalanche field practitioners conducting research on snow avalanches. Preference will be given to proposals whose results will benefit avalanche field practitioners or will extend our understanding of snow and avalanche phenomena. Proposals should embody the theme of the International Snow Science Workshop (ISSW), an international meeting of snow scientists and avalanche practitioners, "a merging of theory and practice."

In an effort to assist more practitioner applications we have compiled a list of potential mentors/scientific partners for applicants. The list provides details about members who have expressed a strong willingness to assist practitioners with research ideas and develop them into research applications. For more information and application forms, please go to the AAA research homepage: www.americanavalancheassociation.org/grants_research.php.

ISSW 2014 Ready to Rock Banff

Story by Mary Clayton

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ISSW 2014 is squarely focused on truly merging theory and practice. This concept has been the framework for these international conferences since 1982. But fully realizing this ideal has proven challenging. There are many reasons for this, not the least being that ISSW is modeled on a scientific conference, where papers, presentations and posters must all adhere to a scientific form.

The Banff ISSW organizers are working hard to make room for practitioners' expertise within this framework. A series of one-hour workshops aimed at front-line workers will encourage participants to exchange ideas on topics such as: avalanche safety for ice and alpine climbing; training, certification and scope of practice for avalanche workers; compaction; and the role of research in avalanche risk management.

There will be an emphasis on presentations that have a practical impact on avalanche work, and all presenters will be asked to explain or describe how their work can be used in practice. The team at the University of Calgary's Applied Snow and Avalanche Research program has generously offered to mentor anyone wishing to submit an abstract, with guidance on how to develop it, formatting their paper or poster, and delivering the presentation.

And it wouldn't be Canadian if we didn't talk about snowmobiling. Plans are in the works for an oral presentation session under the theme of snowmobiling and avalanches. Anyone with topics related to mountain sledding is encouraged to submit an abstract.

Following in the spirit of the Anchorage ISSW there will also be an art auction, showcasing local talent. This is organized by well-known photographer and mountain guide Brad White, who will call for submissions in the spring. Be sure to keep checking the website (www.issw2014.com) or the Facebook page (International Snow Science Workshop 2014) as both are growing almost every day.

A lot of work has been accomplished already by the planning committee and we're grateful for the support of our sponsors. There's still room for more sponsors; anyone who wants to be involved can visit the website or email sponsorship@issw2014.com. Anyone interested in having a booth at the tradeshow should also see the website for more information.

Of course a lot of fun is planned as well. There will be a "daily mission" guided by a local, where you have the opportunity to go for a group bike ride or hike every day at 1 pm. Diva Night is Tuesday, September 30; movie night on Monday, September 29, will feature films from the Banff Mountain Film Festival – "Whiskey and Words at the Whyte Museum" is definitely a don't-miss, and there will also be a rockin' after party for volunteers at the Bear Street Tavern. Volunteer spots are filling up fast – check that website!

Mary Clayton is the communications director for the CAA.

SLF Creates White Risk App for Swiss Backcountry Users

Over the past 10 years more than 2,000 people have been affected by avalanches in Switzerland; one third of them were injured or even killed. The WSL Institute for Snow and Avalanche Research SLF and Suva have created the interactive avalanche prevention platform "White Risk" as a new tool for snowsports fans, enabling them to acquire knowledge about avalanches and to plan their routes. The goal is to promote risk awareness and to prevent avalanche accidents.

White Risk is the app for all those who engage in winter activities in the mountains outside marked and open pistes. By way of the avalanche bulletin and snow and weather data, the smartphone app gives up-to-date information about the snow and avalanche situation in Switzerland. White Risk also provides useful background knowledge to assist in assessing the avalanche danger. Various tools, such as the Danger Analyser, help the user to evaluate the avalanche situation in the field. White Risk does not, however, make any decisions on your behalf. You alone must decide which slopes are safe to use, and which ones are to be avoided.

The app's Tour function allows tour plans produced on the Web to be depicted on maps offline. The smartphone's GPS function shows the user's current location on the tour plan.

The multilingual app is available as a free download from the iTunes store and the Google Play store. For an annual subscription of 13 francs you can also access the snow and temperature data collected by the automatic measuring stations operated by the cantons and the SLF (iPhone version only). These data are valuable for backcountry trip planning purposes.

The White Risk app is available as a free download on iTunes or Google Play. Links can be found at www.slf.ch/ueber/organisation/warnung_praevention/projekte/white_risk_mobile/index_EN

A slush flow in Norway: not every avalanche-prone locale has the same problems. *Photo by Krister Kristensen*

The Use of "Avalanche Problems" in Norway

Story by Krister Kristensen

The newly started avalanche warning service in Norway has adopted the "avalanche problem" description in their advisories.

Many avalanche-forecasting services today include a descriptive summary of the avalanche situation in their advisories, often called "avalanche problem," "avalanche character," or "avalanche pattern." The summaries typically indicate some key features that correspond to one of several prototypical scenarios. These scenarios or patterns are classified according to some predefined scheme. An interesting article in TAR 31-2 *(Lazar et al. 2013)* sums up the work currently going on in North America.

The idea of classifying a situation according to avalanche conditions is of course not new, as avalanche frequency relationships to weather and snow features date far back. The present approaches are maybe more focused on recreational activities than before, where the snow stability with regard to human release is now more important than cycles of widespread natural avalanching. The other difference is that the main purposes now are communicative and educational. That is, to give a broader picture of different avalanche-hazard situations and, in time, a deeper insight on behalf of the users of the bulletins. In addition, the approach could assist recognition-primed decision-making in the field. An inherent problem with such approaches is also that unusual circumstances will likely not be recognized.

There is an ongoing discussion in the forecasting community on how to best achieve this. This December, a public avalanche-forecasting service was started in Norway. The service has adopted a Norwegian "avalanche problem" description based on the experiences from other services around the world and from discussions in Norway *(Landrø et al. 2013)*. In the bulletins, both primary and secondary problems can be included. It is expected that the approach will have to be dynamic, as new input from observers and experts become available and since it was presented at the ISSW 2013, the classification has already been somewhat modified.

The table *(below)* shows an overview of the "avalanche problem" descriptions currently in use in some countries. It is evident that they are not directly comparable, since some characteristics include descriptions of snow stratigraphy, some are process-oriented, and some include snow features like spatial distribution and mechanical properties.

In the table, Switzerland is listed with only four main categories, but these are divided further in subcategories *(Harvey, et al 2013)*. Notably, the Swiss also use a set of patterns of four "favorable conditions," as recognizing patterns that do NOT pose a serious avalanche problem might also be useful for many users. In the Norwegian approach, the "problems" are more directly linked to specific types of stratigraphy. Both the Swiss and the Norwegian use a main separation between wet and dry snow conditions. As a reflection of the periodic extreme slush flow occurrences in Norway and special climatic conditions, situations where there is free water present in the snowpack are also included.

The "avalanche problems" will be likely subject to discussions in the future, for instance in the European Avalanche Warning Services (EAWS). There will probably be a need for some regional differentiation because of varying climatic conditions and diverse user groups, and it may be that one classification scheme will not fit all. In North America the approach is envisioned to be coupled with risk-management practices and travel advice. In Europe, this may also require some discussion, since differences regarding risk tolerance, utility, and risk-management practices may vary among users and settings.

Table 1: Avalanche problem definitions used in some countries

Switzerland	CA/NZ/USA	Tyrol	Norway
Fresh Snow	Loose Dry Avalanches	Early winter, ground-level hoar	DRY snow: Buried weak layer of new snow
Old Snow	Loose Wet Avalanches	Gliding snow	DRY snow: Poor bonding in wind-deposited snow
Drifting Snow	Wet Slab Avalanches	Rain	DRY snow: Buried weak layer of surface hoar
Wet Snow	Storm Snow Avalanches	Cold after warm / Warm after cold	DRY snow: Buried weak layer of faceted snow
	Wind Slab Avalanches	Snowfall after long enduring cold	DRY snow: Buried weak layers of faceted snow near the ground
	Persistent Slab Avalanches	Cold, loose, new-fallen snow plus wind	DRY snow: Poor bonding between buried crust and overlying snow
	Persistent Deep Slab Avalanches	Shallow snow areas surrounded by deep snow areas	DRY snow: Loose snow with poor cohesion
	Cornice Falls	Surface hoar covered with snow	WET snow throughout the snowpack with unstable basal layer
	(Glide Avalanche: USA, 2013)	Graupel covered with snow	WET snow throughout the snowpack with unstable top layer
		Springtime situation	WATER accumulation above crust layer
			WATER-saturated snow

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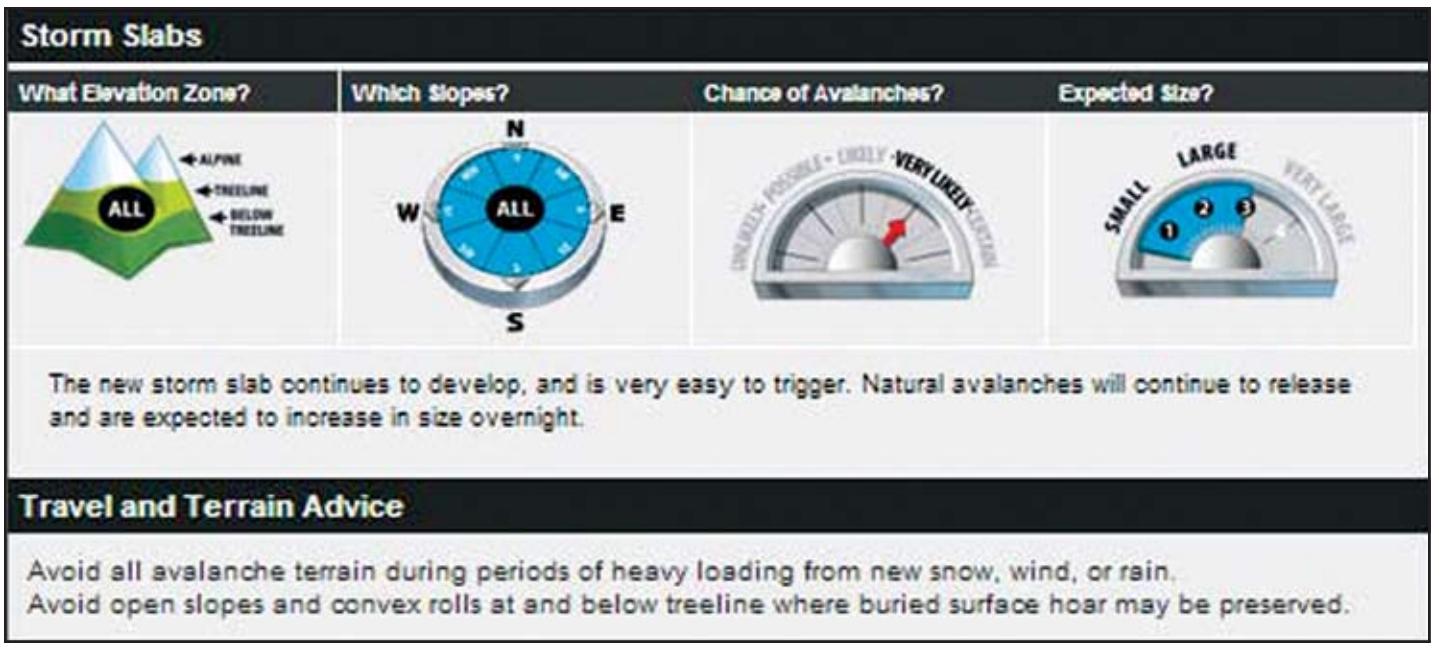
Krister Kristensen is the AAA EU section representative.



CAC avalanche problem information chunk, created using the AvalX forecasting software *(Statham et al., 2012)*

The Role Of Avalanche Character In Public Avalanche Safety Products

Story by Karl Klassen, Pascal Haegeli, Grant Statham

Editor's Note: We didn't have enough room to reprint this entire paper, but chose portions that directly apply this conversation into risk management and forecasting. The paper can be found at http://arc.lib.montana.edu/snow-science/workshops.php

In recent years, the public avalanche forecasts in Canada have become increasingly "chunked," meaning information is broken down into shorter, simpler statements that incorporate graphical elements to provide to-the-point information in a standardized format. Avalanche character fits squarely into the "Avalanche Problem" chunk of information *(see illustration, above)*, which describes:

- What kind of avalanche is expected.
- Where the problem exists.
- The likelihood of triggering.
- How large an avalanche is expected.
- A brief information statement.
- Travel and terrain advice, which describes travel techniques and terrain choices that help mitigate risk.

Chunking the Avalanche Problem and using avalanche character as part of the description of the problem significantly enhances avalanche forecasts by making it simple for the user to understand not only what the regional danger rating is but what kind of terrain choices and techniques might be employed to manage risk.

Much like professionals, who adjust their terrain and risk mitigation techniques according to avalanche character regardless of other factors such as snow stability ratings *(Atkins, 2004)*, recreationists also need to take the character of the existing avalanche problem into account when making terrain choices under a given danger rating.

For example: a Considerable danger rating could be applied when many small Wind Slabs are expected to run only to terrain transitions. At the same time, a Considerable danger rating could also be applied when infrequent but large, Deep Persistent Slabs will likely to run to valley bottom.

In these two scenarios however, even though the danger rating is the same, completely different terrain choices and travel techniques will be required to manage risk. However, despite these efforts, our experience shows that the concept of adjusting terrain choices or travel techniques according to avalanche character is currently not well understood or practiced in the recreational community.

CHALLENGES AND SUGGESTIONS

Based on our experience, we have identified a number of challenges for the application of the concept of avalanche character in public avalanche hazard communication with proposed suggestions for addressing these challenges.

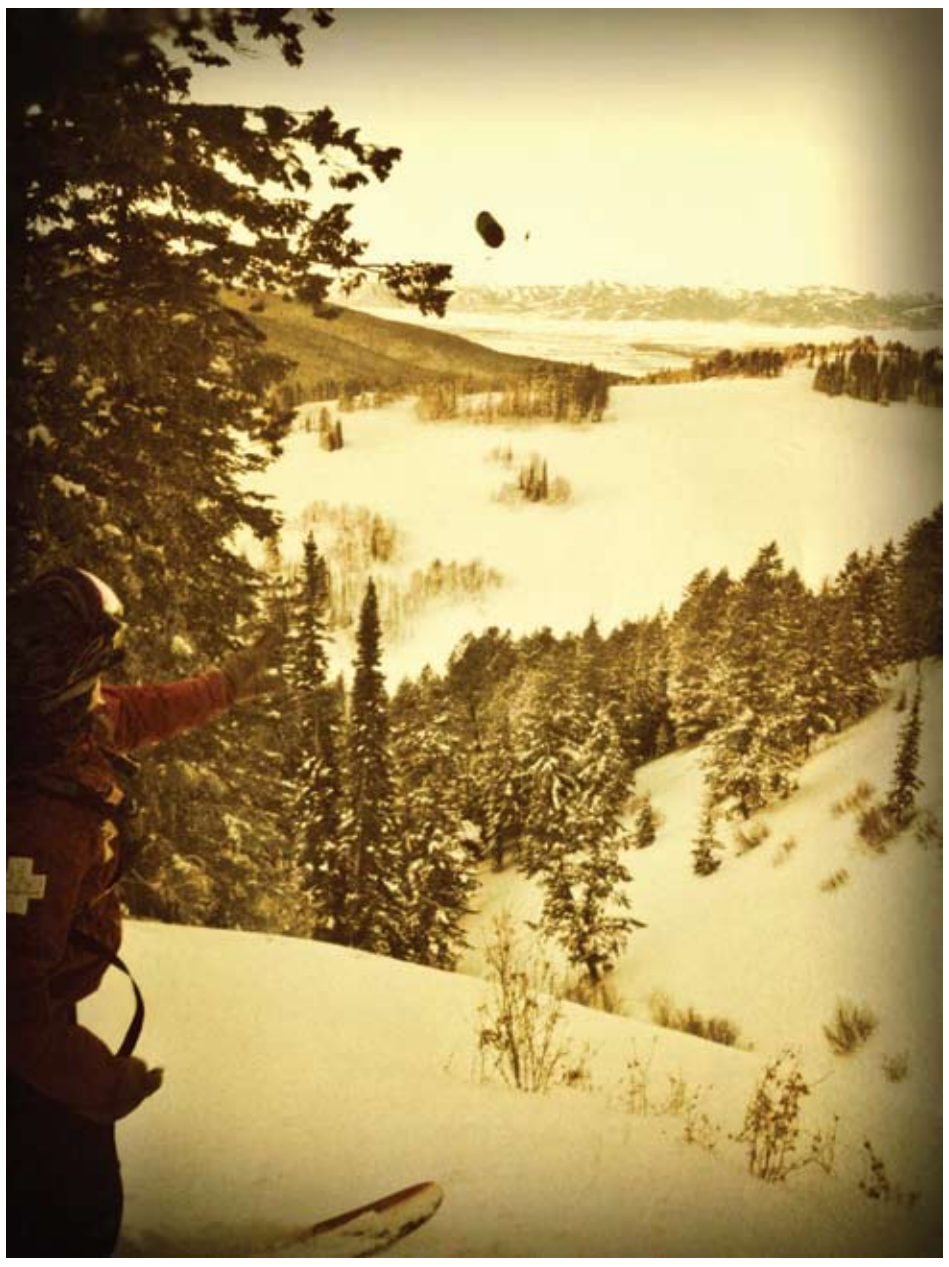
Terminology

In Canada, the terms "primary avalanche concern," "avalanche problem," "avalanche character," and "avalanche type" are common. In other parts of the world "avalanche threat" and "avalanche situation" are common *(Jamieson et al., 2010)*. These terms are often used inter-changeably, which creates confusion.

At the CAC, primary avalanche concern has been abandoned in favour of avalanche problem, which has evolved into the term that encompasses a variety of factors that together form a chunk of information in an avalanche forecast. Avalanche character is the part of the avalanche problem that identifies the kind of avalanche expected.

Avalanche type is actually a better term than avalanche character. However, avalanche type is already used in the Observation Guidelines and Recording Standards (OGRS) of the Canadian Avalanche Association *(CAA, 2007)* to differentiate between slab and loose avalanches. We believe that avalanche character

Continued on page 14 ➡



A Grand Targhee patroller tests out a new storm load on Christmas morning

From: Lindsey Fell
Photo by: James Hlavety

The photo was taken Christmas Day at Targhee in the catskiing area known as Beaver Dicks.

Because that area does not see much skier traffic, conditions mimicked those of the backcountry: 50-80cm of rotten facets and depth hoar, topped by our last storm's somewhat heavy load. James and I threw a couple of cover shots before entering Beaver Dicks, and we saw no results or collapsing from the blasts. Upon entering for a ski cut, however, the whole slope collapsed and moved slightly downward on me, but did not pull out. Further shots one lap later brought nothing. Results proved similar for Phil and me in the other catski areas that day. The cool thing about earlier season work in the catski area is that it really calls for some creativity when there is no skier compaction to help out. Our rotten pack is proving sensitive yet finicky.

Avalanche Types

Story by Don Sharaf

Roger Atkins (lead guide for CMH) was the person who made me start thinking in terms of avalanche character. At the 2004 ISSW he presented his avalanche character checklist and it instantly resonated with me. I recall his account of spending months dancing around deeply buried facets at perpetual "fair stability" where very few runs of their enormous run catalog were skied. The next season came along with far more consistent snowfall, and they skied virtually all the runs in their run catalog, despite having the same number of days at "fair." The difference in duration, predictability, and management between persistent slabs and storm slabs is dramatic, even though they may fall under the same hazard rating.

In 2010 Grant Statham et al came up with their conceptual model of avalanche hazard, and from that we developed an avalanche-forecasting checklist that is based upon the seven common avalanche problems. This checklist has become a part of my forecasting routine at Valdez Heli-Ski Guides, and more importantly it has become part of my communication to guides. For years the guides have been filling out stability roses with their observations, which I would then compile and plug into a modified avalanche-character checklist and years later into our forecasting worksheet. It wasn't until last year when I incorporated avalanche character into a matrix of likelihood vs consequence AND presented it visually, that the light bulbs went off for the entire guide staff. I learned how important it was to not only provide good descriptions of the avalanche problems, their distribution, and their sensitivity to triggering, but to visually present where they sit in a risk-management realm. Our run selection improved with the advent of avalanche character, but our communication really improved when we put those avalanche problems into the perspective of risk.

I try to convey the concept of avalanche character (or problems…or types) in my avalanche courses, but a lot of the utility of the concept comes from experience. Hearing about avalanches that occur six weeks after a layer is buried is one thing. First-hand experience of seeing a long-buried layer produce an avalanche has far more impact. Case studies and forecasting scenarios can all help, but like all concepts, experience is the best teacher. Incorporating avalanche problems into our forecasts and our decision-making process should help put our students' experiences into perspectives that are far more useful than saying, "Those avalanches occurred during considerable hazard."

There is a bit of contention about whether to use the term *character*, *problem*, or *type*, and I find myself often using several of the terms interchangeably. The important part is that we continue to realize that all avalanches are not created equal, and some behave more by the rules than others.

Don Sharaf is an owner of the American Avalanche Institute and avalanche forecaster and heli-ski guide at Valdez Heli-Ski.

Briefing sheet for Valdez Heli-Ski Guides from avalanche forecaster Don Sharaf; April 01, 2013

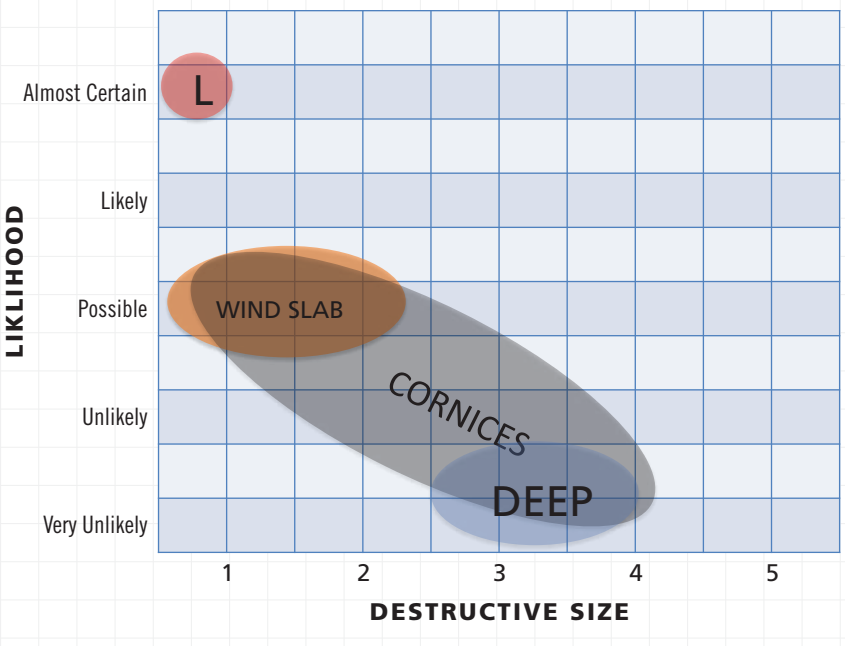
Summary: Yesterday's snowfall amounted to 5-10cm of new low-density snow sitting atop the most recent storm snow. The new snow was running as low volume, low to moderate speed sluffs on slopes greater than 40 degrees. The snowfall from the previous storm (3/29 and 3/30) had some wind associated with it and is producing shallow wind slabs on steeper north-facing terrain from 10-20cm deep. Warm temperatures have helped to bond the previously reactive storm instabilities, but near-surface facets from the 3/23 storm interface remain on the radar in protected areas. (Greatest concern for this persistent layer is generally in the Cry Babies, Billy Bitchin' area – possibly extending into the Cauliflowers and Clueland). The downside of the warmer temperatures and increasing daylight length is that the cornices may soon start losing strength. Not warm enough for an early shed cycle, but the warning flags for cornices were there before this warm-up. A big enough cornice drop onto high-elevation north-facing terrain could be enough to awaken the basal facets, though there has been no deep activity for 2.5 weeks since Prosciutto was cornice-triggered.

Concern # 1
EVIDENCE: Shallow FRESH slabs on Cracked Ice (skier's-right pitch) and in Funny Farm. SS-ASc-R1-D1+ 10-20cm deep.
DISTRIBUTION: Wind-loaded areas from southerly winds. All elevations above 4000'.
SENSITIVITY: Touchy.
LIKELIHOOD: Possible to Likely on steep rolls that are freshly loaded. Unlikely to Possible for deeper and older wind slabs.
CONSEQUENCES: D1-D2 – deeper to the south.

Concern # 2
EVIDENCE: Continued to build during recent storms. Warmer temperatures of past five days and the increasing daylight length are making these even more suspect.
DISTRIBUTION: Normal locations at ridge crest.
SENSITIVITY: Sensitive fresh cornice buildup. Unreactive to Touchy for older cornices – highly variable.
LIKELIHOOD: Likely for fresh cornices. Possible for older bigger cornices .
CONSEQUENCES: D0 to D4 (see deep slab).

Concern #3
EVIDENCE: 5-10cm of new lower-density snow sitting on top of wind slab and warmer storm snow. Low volume and low/moderate speed sluffs.
DISTRIBUTION: Non-wind-affected areas. Above 3000'. Slope angles > 40 degrees.
SENSITIVITY: Reactive to skiers, naturals likely in very steep terrain and off rock bands and on solar aspects.
LIKELIHOOD: Likely in non-wind-affected areas.
CONSEQUENCES: D1.

Concern # 4
EVIDENCE: Several days of warmer temps and relatively light loading should have helped this interface. Last avalanche: Proud Mary (NE 6400' Wortmans Glacier Zone) on 3/28. SS-AFr-R2-D2-I.
DISTRIBUTION: Old/new snow interface from 3/23. Near-surface facets. Cry Babies/Billy Zone – also basal facets. NW through ENE above 3500'. Wind-protected areas.
SENSITIVITY: Stubborn.
LIKELIHOOD: Unlikely to Possible (Billy Zone).
CONSEQUENCES: D1-D2 – deeper to the south 35-90cm D2-D3 on basal facets in shallow snowpacks.



Above are both written and graphic representations of translating the common avalanche problems from theory into practice. The lower graph gives us visual insight into likelihood and potential consequence.

Bridge to the sky: top of the Aiguille du Midi cable car

ISSW 2013 Report

Story by Bob Comey • Photos by John Stimberis

The International Snow Science Workshop (ISSW 2013) was held for the first time in France and for the second time in Europe (Davos 2009) during the second week of October. It was sponsored by the National Association for the Study of Snow and Avalanches (ANENA), the National Research Institute of Science and Technology for Environment and Agriculture (IRSTEA) and the French weather service (Meteo France). It was well attended with over 740 participants of which 43% were scientist and 57% were practitioners. Forty-six percent of those attending were from France, 10% were from North America, 8.5% were from Switzerland, and 7% were from Italy.

It was jam packed with a field trip to Chamonix and four days of presentations. The papers committee received 350 abstracts and 270 papers. At the conference there were 160 oral presentations and 150 posters. Oral presentations were shortened to 12 minutes with three minutes of questions in an attempt to not overwhelm the participants. A brief summary of a few of the studies presented follows.

Limitations of using an infrared camera to measure snow pit-wall temperatures

SCHIRMER, Michael; JAMIESON, Bruce

This study by the Department of Civil Engineering at the University of Calgary was a follow up on work conducted by Cora Shea and presented by Karl Birkeland at ISSW 2012. Schirmer and Jamieson tested the hypothesis that a thermal image of the wall of a freshly exposed snowpit was representative of the internal temperature of the snowpack. Their efforts found that exposing the snowpit wall to the effects of the atmosphere complicates the interpretation of the snowpit wall temperature data derived from an infrared camera image.

Avalanche Danger Patterns - A new approach to snow and avalanche analysis

MAIR, Rudi; NAIRZ, Patrick

A paper presented by members of the Avalanche Warning Service in Tyrol, Austria, introduced the concept of "Avalanche Danger Patterns" as a tool to communicate snow and avalanche analysis to the public. Ten patterns that represent a certain combination of natural factors perceived to be the direct cause of natural risk have been used for three seasons by the Tyrol service in their daily avalanche hazard bulletins with overwhelming success. Each pattern represents a clearly defined weather situation that creates a certain snowpack structure that determines the avalanche hazard. Independent presentations by members of the Norwegian Avalanche Forecasting Center revealed that avalanche patterns are also a component of their daily avalanche hazard forecasting program. Avalanche patterns are also used by the Swiss avalanche forecasting program, however those patterns are based to some extent on avalanche type and thus are somewhat similar to the avalanche problems that are used by some avalanche centers in North America.

Plume Formation in Powder Snow Avalanches

BARTELT, Perry; BÜHLER, Yves; BUSER, Othmar; GINZLER, Christian

This study conducted by scientists from the Institute for Snow and Avalanche Research (SLF) in Davos, Switzerland, used photo-grammetric measurements of powder-snow avalanche clouds from the Vallée de la Sionne test site to construct three-dimensional powder cloud surface models. Their research indicates that up to 10 million cubic meters of air are entrained and expelled into the avalanche powder cloud as it travels down slope in a process that creates the plume-cleft structure of the cloud. This study appears to provide valuable new information regarding the flow dynamics of fast-moving dry-snow avalanches.

Survival Chance Optimized Procedures in Rescue and How to Minimize Injuries During Excavation

GENSWEIN, Manuel

This paper by Manual Genswein of Switzerland provides guidance for rescue procedures in circumstances when a shortage of rescue resources exists in an incident with multiple buried subjects and injuries. This scenario is possible in a companion rescue or in the early phases of an organized rescue. Manuel introduces the concept of reverse triage, which puts the focus of the limited rescue resources on patients who have good survival chances and require only a moderate rescue effort.

"In reverse triage, the focus is on patients who have good survival chances and require only a moderate rescue effort. Normal triage allows to treat everyone in need simultaneously and to allocate all necessary resources – even to patients who require a lot of rescue effort and/or have only little survival chances."

This paper also discusses how to minimize injuries during the excavation of a buried person, spiral probing and modified shoveling techniques for deep burials and in very hard avalanche debris.

How big is big: Results of the avalanche size classification survey

MONER, Ivan; ORGUÉ, Sara; GAVALDÀ, Jordi; BACARDIT, Montse

These Spanish researchers conducted a survey of European and Canadian avalanche forecasters in an attempt to determine uniformity among these

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Reflections ISSW 2013 Grenoble

Story by Roland Emetaz, aka Mr Em • Photos by John Stimberis

The second European International Snow Science Workshop (ISSW) was hosted by France. An excellent venue and a spectacular field day in Chamonix. Over 600 attendees from 36 nations.

The theme: "A merging of theory and practice." The first two days were pretty much devoted to theory with much of it a bit heavy for my rather less-than-analytical mind. The last two days were more on the practical, applied side. Subjects on climate change, risk management, and education more in my area of interest. A very brief overview of these:

Climate Change

Presenters agreed, yes there is climate change: gradual warming is happening, that will result in earlier snow-free conditions, too little snow, too much snow, snow at the wrong time… And it is not the largest resorts that will survive, but the ones that can adapt.

At Rogers Pass, Canada, a study: *Does Climate Change Affect Avalanche Activity* (Bellaire, Thumlert, Jamieson). They noted more early rain events may have favored the formation of early season crusts and later more avalanches in January and March which may be related to these early season crusts.

Risk Management/Human Factors

Numerous presentations and posters on the subject. Bottom line: ***communicate, communicate, communicate.*** Everyone in a group has a voice, experienced need to listen to the least experienced. Complex situations require checklists. Plan, monitor, review, decide, act. And there is always a tomorrow!

Avalanche Awareness Education

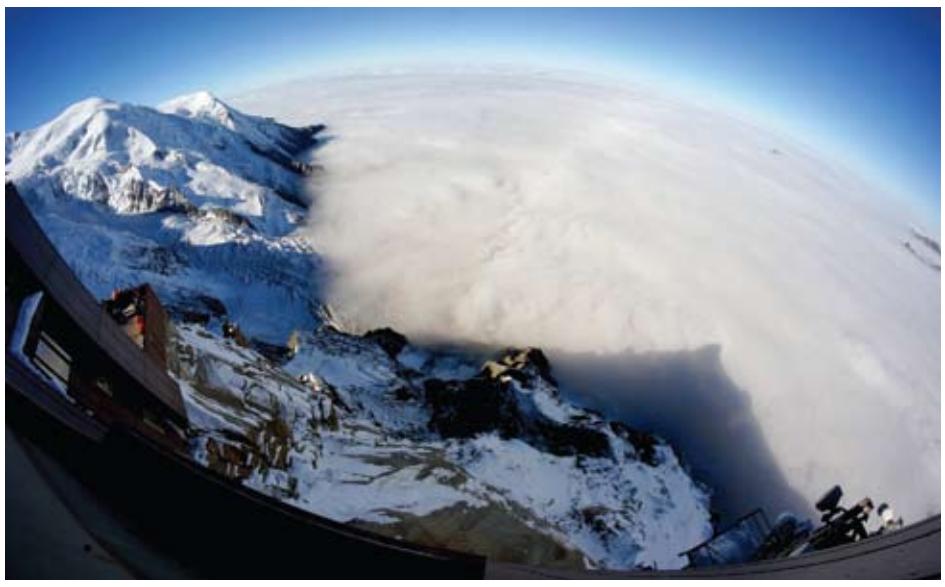
Again, numerous presentations on the subject. The one that stood out came from a non-mountainous nation (Netherlands): *Modern Avalanche Education*.

Westerhof (rolf@snowsafety.nl): Two extremes describe the range of teaching techniques. *Active Learning*, where the students do much of the work themselves by formulating and solving problems. *Passive Learning*, where students are merely passive and absorb the information coming from the teacher. Together with Werner Munter (inventor of the reduction method) they developed a card game that provided an active learning situation. Also they used rubber gloves to help novices to understand contour lines. While wearing the gloves, the contour lines are drawn – once gloves are removed, one has a flat contour map!

Field Day

We chose the open tour of Chamonix, riding the Aiguille du Midi cable car up to 3,749m/12,300' and had a 360-degree view of Mont Blanc and Swiss & Italian summits: SPECTACULAR!

Roland Emetaz, aka Mr Em, is a now-retired long-time Forest Service worker from the Pacific Northwest. His mentorship was crucial in getting NWAC on its feet "back in the day." You can find him at every ISSW in his trademark green jacket.



Another photo from John Stimberis of the view from the top of the world, field trip to Chamonix and up the trams.

ISSW 2013 REPORT

continued from previous page

professionals with respect to the use of the Canadian Destructive Avalanche Size Scale. This avalanche size classification scale was developed in the United States by Atwater in 1961, introduced to Canada by Perla in 1977, and adopted by the European Avalanche Warning Services in 2009. This survey asked the participants to rate the size of 18 separate avalanche events depicted by pictures and maps. The survey results show a lack of uniformity in the classification of avalanche sizes by those surveyed. Only about half of those surveyed agreed on the size of a particular example, and the range of size classifications for each of the 18 examples usually spanned 3 or 4 sizes. The results of this survey will be used to improve the uniformity of avalanche size classification among European avalanche forecasters.

Measuring acoustic emissions in an avalanche starting zone to monitor snow stability

REIWEGER, Ingrid; SCHWEIZER, Jürg

Natural heterogeneous materials such as wood, limestone, and ice emit acoustic signals that can be monitored to predict failure. This field study, conducted by researchers at the SLF in Switzerland, tested a method for monitoring acoustic emissions associated with snow stability with the goal of potentially predicting avalanche release. During the evening of December 11-12, 2012, an avalanche spontaneously released from a slide path located close to the monitoring equipment. On this evening the equipment detected a significant change in the acoustic emissions of the snowpack. This was the only spontaneous avalanche release near the equipment during the 2012/13 season. Continued fieldwork is planned for the upcoming season with the goal of confirming this result.

Thermal energy in snow avalanches

STEINKOGLER, Walter; SOVILLA, Betty; JONAS, Tobias; LEHNING, Michael

This study conducted by Swiss researchers used infrared radiation thermography to video the changes in snow temperature as an artificially triggered avalanche ran down a slide path, entrained snow, and caused a secondary avalanche release. Snow temperature measurements determined by this methodology require further verification; however this research could provide future insight regarding the relationship between snow temperatures and the flow regime of powder-snow avalanches.

One of the options for the field trip in Chamonix was a visit to the Taconnaz avalanche defense structures. This tour was hosted by engineers from IRSTEA who designed them. The starting zone for the Taconnaz avalanche is an icefall in a hanging glacier on Mt Blanc located 3000m above an inhabited area. The massive structures constructed in the runout zone of this avalanche path are some of the most important avalanche defense structures in Europe.

Bob Comey is director of the Bridger-Teton Avalanche Forecast Center, which is based in Teton Village, Wyoming. ❄

Bill Glude shares an intimate moment with the peripatetic Weiner, who made an appearance at yet another ISSW, although he does need to be tied into his chair these days in order to remain upright.

AVALANCHE CHARACTER

continued from page 11

is simply an extension of the existing avalanche type definition and that the two concepts should be combined in the next revision of OGRS, at which point the term avalanche type should replace avalanche character as the term of choice.

We propose using the term "Avalanche Type" as the label for avalanche character, and that avalanche type definitions in the OGRS (CAA, 2007) be expanded to include the eight definitions currently in the avalanche character matrix.

Deep Persistent Slabs

Deep persistent slab is intended to mean the weak layer of concern is deep in relation to the snowpack as a whole. The avalanche character matrix describes the weak layer location as "deep or basal" which includes scenarios like basal depth hoar layers in a shallow continental snowpack or persistent weak layers several metres deep but still well above ground level in maritime or transitional snowpacks. This has led to confusion when forecasters (and users) from continental snowpack areas compare their problem to that in a deep intermountain or maritime snowpack.

We believe that a better distinction between persistent and deep persistent slab categories would considerably improve the application of the avalanche character concept.

Deciding on the most appropriate classification: persistent slab or not; storm slab or wind slab?

There has been much discussion about how to decide which category applies when storm snow or windblown snow overlies grain types that are commonly attributed to persistent avalanches. For example, if a wind slab is deposited on surface facets, is it a wind slab or a persistent slab? Similarly, a classification question arises when a storm slab lies on surface hoar grains. Furthermore, if a wind slab or a storm slab classification is applied in the above situations, can the classification be changed to a persistent slab later and if so, at what time?

At the CAC, in the scenarios described above, we tend to use wind slab or storm slab designations at the outset of a new problem, even when potentially persistent grains are likely to play a role in avalanche release. Generally, we hold off on using persistent slab until after initial loading has produced a notable avalanche cycle and it is clear further avalanches can be expected after the normal duration of a wind or storm slab cycle has expired.

A similar situation exists for the distinction between wind slabs and storm slabs. Clearly, most storms have wind associated with them and this plays a role in the development of slab avalanches during storms. However, at the CAC we tend to use storm slab during most major storms when avalanches can be expected on most aspects. After a storm ends, the forecaster must determine if any lingering avalanche activity is more likely on most aspects (in which case a storm slab designation is appropriate) or if activity will be more isolated to lee or cross-loaded aspects and features, in which case wind slab is more accurate.

In some wind/storm slab vs. persistent slab scenarios, it may be obvious that a problem will almost certainly become a persistent slab sooner rather than later. In a storm vs. wind slab situation, when avalanche problems develop in the absence of significant new snow loading and redistribution by wind is the primary factor creating slabs, wind slab is clearly the right choice. Certainly there are times where it's appropriate to apply persistent slab rather than wind/storm slab from the outset of a new problem or using wind slab during a storm.

If forecasters are debating which term best applies, it's important to remember that Atkins's primary motivation for introducing the avalanche character concept *(2004)* was its direct link to risk mitigation practices. Therefore, the desirable travel advice and the character of the likely triggering mechanism can help forecasters classify an avalanche problem when other criteria are ambiguous.

Probably more important than having hard and fast rules about when to use which designation is to ensure forecasters be consistent. Familiarity with the matrix and the detailed descriptions such as the CAC's Avalanche Essentials series is essential. Tools such as the CAIC's flow chart *(see TAR 31-1)* are helpful. Perhaps the most important means of achieving consistency is peer discussion, both within the forecasting team and between partner agencies who are dealing with the same problem(s).

In situations when it is difficult to decide between different avalanche character types, we propose the final classification should be based on the risk mitigation strategy that is more appropriate for the current situation. Consistency in these assessment situations among avalanche forecasters and agencies is paramount for providing a clear message to the users of avalanche bulletins.

Public Understanding

Professional guides intuitively understand the effect of different avalanche characteristics on decision-making and risk management. However, using

Continued page 32 ➡

Accident Analysis: CASE STUDY

The Sheep Creek terrain trap as seen from the stand of trees where three of the victims were located when the avalanche struck.
Photo by Bruce Edgerly

REFLECTIONS: Sheep Creek Avalanche

Story by Brian Lazar and Ethan Greene *(continued from cover)*

Deep Persistent Slab Cycle

The Sheep Creek avalanche was the culminating event of an unusual deep persistent slab cycle in Colorado. Our snowpack developed as it often does: a pronounced layer of depth hoar formed during the fall when the snowpack was shallow and the weather was cold and dry. This happened statewide, but in the Northern Mountains, where Sheep Creek is located, two warm days in early December formed a thin melt-freeze crust on easterly aspects that capped the depth hoar. Facets formed both above and below the crust. When steady snowfall finally arrived in January, it buried this crust/facet combination.

As the snowpack over this weak layer got deeper, the avalanches became larger. Through January and February, avalanches running on this layer were easy to trigger and generally small (D1 to D2). The overlying slab was soft and not continuous across terrain features. In most cases the avalanches were not stepping down into the depth hoar. However, it was evident that the layer was quite reactive. Many of the avalanches during this period ran naturally or were triggered remotely from distances of up to 1500 feet away. By early March we had transitioned from a persistent slab problem to a deep persistent slab problem. It got harder to trigger avalanches on this layer, but they were very large and destructive (D3).

On March 4, a skier near Cameron Pass triggered a large hard slab 1200' wide and 6' deep (R3 D3). One person was killed, and his partner miraculously survived a 3+ hour burial. Throughout the rest of March, we continued to see large deep-slab avalanches of a similar size triggered remotely and even running naturally. The slabs were still running on the crust/facet combination, but now were commonly stepping down and taking the depth hoar with it.

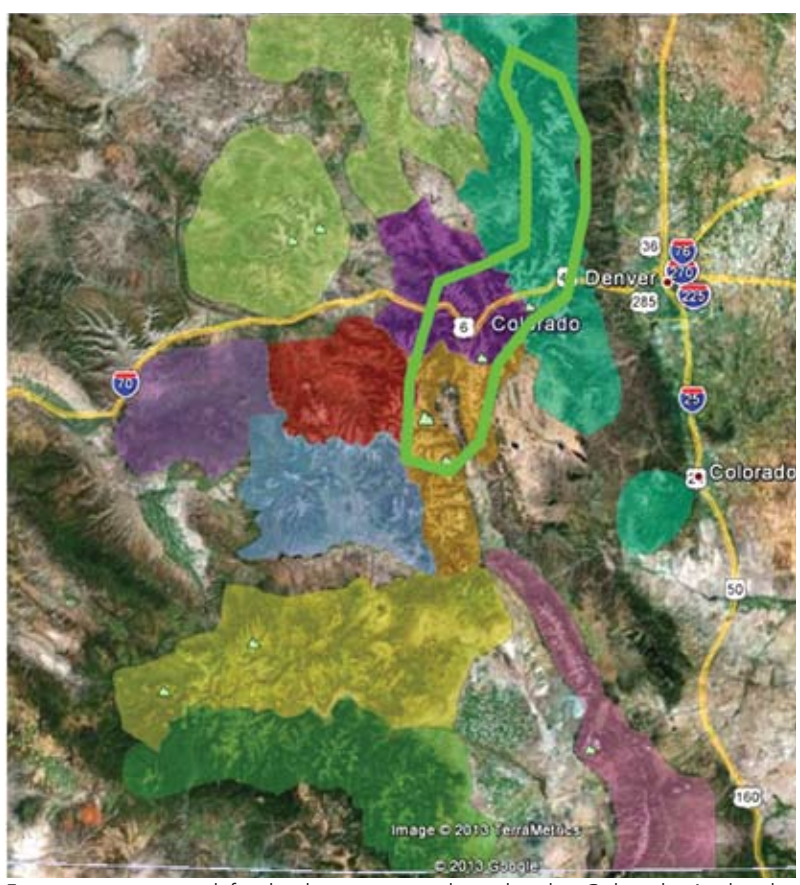
Then came April; as most avalanche centers were wrapping up for the season, we received three to four feet of snow and over three inches of water in just the week leading up to the Sheep Creek accident. Another round of deep persistent slab avalanches ensued.

On April 14 a large slab avalanche (6-8' deep, 1200' wide) released naturally in the Berthoud Pass area, not far from Sheep Creek. On April 18, a very large human-triggered slide (R4 D3.5) killed a snowboarder near Vail Pass. This was after the slope had been skied at least 40 times (including more than a dozen times by the affected group) the day prior to and the day of the accident. On the same day, multiple deep-slab avalanches released naturally in Straight Creek, less than two miles from Sheep Creek. There was a clear pattern; all these slides occurred on steep (35 to 40 degrees) northeast-facing slopes near treeline. The Sheep Creek accident happened two days later on the same aspect, elevation, and terrain configuration.

So what made this deep persistent slab cycle unique? 1) Lots of evidence. It's rare to have such clear evidence of a deep-slab problem with such a clear spatial pattern. Often with deep slabs, we see a release here or there accompanied by little or no pattern in timing or spatial distribution. This cycle was the clearest pattern for a deep-slab cycle we've seen. 2) The thin crust capping the depth hoar seemed to be the key ingredient. In Colorado, we are used to depth hoar. Although the chains that formed during the fall of 2012 were impressive, we see varying degrees of depth hoar every year. And yet we do not see deep-slab cycles like this every year. In fact, we rarely see them. The avalanches were confined to the portions of the state that had the thin crust capping the depth hoar, even though slabs over depth hoar existed statewide. Could two warm days in December really be the cause of this devastating cycle? It seems like they at least played a role.

Continued next page ➡

Google Earth image of the area between Vail and Berthoud Pass with the three avalanche events are shown by red triangles. The distance between the Ptarmigan Hill accident on April 18 and the Sheep Creek accident on April 20 is approximately 25 miles.



Forecast zones used for backcountry products by the Colorado Avalanche Information Center. The green line outlines the area in the Northern Mountains where the deep persistent slab cycle took place. This area roughly coincides with where the depth hoar was capped by a thin crust.

SHEEP CREEK

continued from previous page

The Accident

The group remotely triggered a hard slab (HS-AR-R3/D3-O/G) from the bottom of the slope. The crown ranged from less than a foot to over 12' deep, with an average crown height of 5'. The slide was 800' wide, ran 600 vertical feet, and broke trees up to two inches in diameter.

Everyone involved was taking part in the Rocky Mountain High Backcountry Gathering, an event focused on safe backcountry travel for splitboarders. Of the six caught, avalanche training ranged from a basic awareness to a level 2 course. This was the first backcountry tour for at least one member of the group.

The night before the event, they held a fundraiser for the Colorado Avalanche Information Center (CAIC). Scott Toepfer, an avalanche forecaster at the CAIC, came to the event to speak about avalanche safety and current conditions, including the recent deep persistent slab avalanche cycle. The next morning the participants of the event met at Loveland Ski Area. Many of them drove right by the deep slabs that had released naturally in Straight Creek two days earlier – these avalanches were clearly visible from the highway.

Event participants split into several small groups with the intent of doing some short backcountry tours and meeting up back at the ski area in the early afternoon. Before departing for their tour, the group of six involved in the accident read the avalanche forecast. They identified deep persistent slabs on steep northeast-facing slopes as the primary avalanche problem, and selected low-angle, west- to north-facing slopes as an appropriate objective.

They left the ski area parking lot around 10:00am and drove a short distance to the hairpin turn on Loveland Pass (US Highway 6) called Scotty's Corner. To reach their objective they needed to cross below a loaded northeast-facing slope and above a gully they all recognized as a terrain trap. Thinking they were well clear of the area where they could trigger a slide, they decided to keep about 50 feet between each group member to mitigate the hazard from the overhead slope. They were aiming to regroup at a small stand of trees on the far side of the slope before continuing on to their objective for the day.

They only travelled a couple hundred yards from the highway before triggering the avalanche. The first three members of the group made it to the "island of safety" only to be caught and buried. The whole group was buried within only 20 minutes or so after leaving the ski area parking lot, and only minutes after leaving their cars at Scotty's Corner.

The group triggered the avalanche remotely from low-angle terrain at the bottom of the slope. They heard a large whumph. As they looked up they saw the avalanche roaring toward them. They sprinted for safety, but none of the victims travelled very far before the flow overtook them. Some were wearing airbags, and some had AvaLungs. No one deployed their airbag (the triggers were still stowed away), and nobody was found with their AvaLung mouthpiece near their mouth. Presumably, they were so close to the car, in very low-angle terrain, and did not see the need to have safety devices ready. Five of the six were completely buried. The survivor was fourth in line. He made a dash for the tree island and ended up partially buried in close proximity (touching) the first two members of the group. His face was very near the surface, and one arm was free enough for him to brush snow away from his mouth and nose. He could do nothing else, and he stayed in this position for four hours before rescuers finally arrived on the scene.

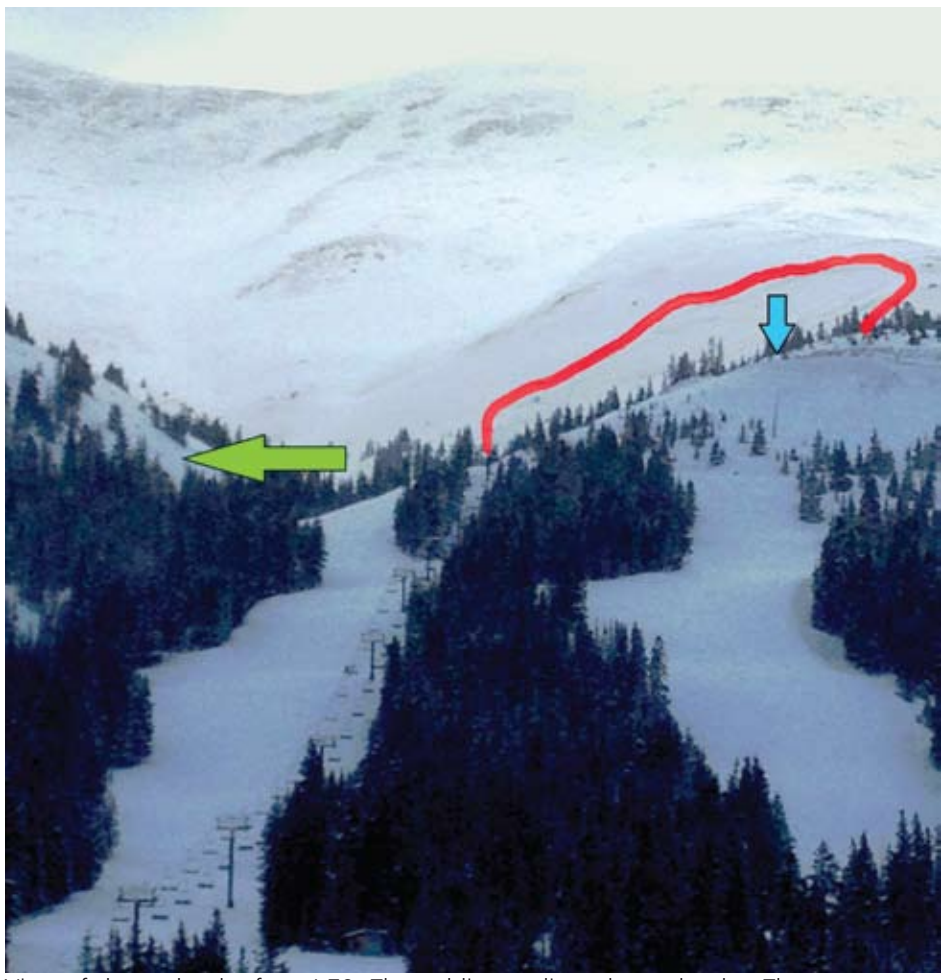
The Rescue

What took so long? Why did nobody respond for four hours even though the avalanche was so close to the highway and clearly visible from I-70? The first people to notice the slide were two CAIC highway forecasters. They were driving from Berthoud Pass toward Loveland Pass and noticed the slide from I-70 around 12:15pm (two hours after the avalanche released). By 12:45pm they parked at Scotty's Corner and followed the skin track of the group to check out the avalanche, not knowing if anyone was caught. They were on foot (no skis), so they walked to the edge of the debris and turned on their beacons to see if they could get a signal, but didn't pick up any. The victims were just out of range on the far side of the debris. They scanned the debris with binoculars for any signs of tracks going into our coming out of the slide. Again, there was no sign anyone was caught. They got back in the truck and drove down to Loveland Ski Area to see if anyone at the Rocky Mountain High Gathering knew anything about the avalanche. They arrived at 1:30pm.

Once the CAIC staff asked if anyone knew anything about the avalanche in Sheep Creek, people began to scramble, knowing that a group had headed that way earlier in the day and had not yet returned. The initial rescue response involved friends and Loveland ski patrol members. They found Jerome (the survivor) after 20 to 30 minutes of searching, as they picked up several beacon signals along the way. The rest of the rescue involved locating the deeply buried victims and excavating lots of snow. Given the elapsed time since the avalanche, hopes for a live recovery were slim. Rescuers eventually located and extricated the five deceased victims just before dark.

Lessons Learned: *As a Backcountry Traveler*

It's hard to gain much experience with deep persistent slabs without getting killed by one. People generally underestimate the size and destructive potential of this type of avalanche, precisely because most people haven't seen many of them. A dangerous perception is that these avalanches can be "managed" with the same route-finding and travel techniques for other types of avalanches. But deep-slab avalanches are always large and destructive, and since they break along persistent weak layers, it is hard to anticipate what it will take to release the avalanche or what the dimensions will be.



View of the avalanche from I-70. The red line outlines the avalanche. The green arrow points toward the area the group intended to ski. The blue arrow indicates Scotty's Corner, where the group parked their cars. *Photo by Brian Lazar*

The yellow diamond shows where group emerged from the trees, less than 100 yards from where they parked. The blue line shows the approximate route the group travelled toward the tree island, indicated by the red arrow. I-70 is visible in the upper left. *Photo by Brian Lazar*

The yellow line shows the group's approximate route; red arrow indicates the tree island. The low-angle terrain the group was aiming to access is in the background. *Photo by John Snook*

The only effective strategy for managing this avalanche problem is to avoid suspect slopes. Once deep persistent slabs develop, it means you have to rein in your terrain choices, perhaps for the rest of the season. The hard part is that so many people get away with skiing on deep slabs. After all, the odds are in your favor. They are stubborn to trigger by definition. It really is a game of Russian roulette. You may have more than six chambers (maybe 50 or 100), but there is still a deadly bullet in there. There is very little room for error. If you hit the spot, you're unlikely to walk away from these avalanches and learn your lesson through a close call.

In this case, the group recognized the problem and spread out to mitigate the hazard. Obviously, this strategy was ineffective. Spreading out is intended to only expose one or two people to the avalanche hazard at a time. With deep slabs, you need to spread out so far between people that it often becomes an impractical travel technique. This travel technique also assumes that if there is an avalanche, there is a chance of rescuing the person caught. But with a deep persistent slab, you probably won't survive the ride. The group had spaced out about 50 feet between people. With six members in the group, that meant there was only 250 feet separating the first person from the last person – not nearly enough distance to mitigate the hazard from such a large avalanche.

This slope could easily have been avoided by travelling above it. This is how we travelled while doing the accident investigation. Hindsight is of course 20/20, but there was an obvious and much safer route clearly visible from where the cars were parked.

At the CAIC, we avoid talking about avalanches as *manageable* or *unmanageable* in public forecasts because it's easy to unintentionally send the wrong message. But with deep persistent slabs it's simple – they are not a manageable problem. You might get lucky, but that is not managing the hazard. Deep persistent slabs mean "stay away" for the backcountry traveler.

Lessons Learned: *As a Forecaster*

As a public forecasting operation we learned a couple important lessons from this tragic accident. First, it's not enough to have an accurate forecast. Second, it really helps to manage your media contacts.

Here is an excerpt from the CAIC forecast, issued by Spencer Logan, for the Front Range zone on the morning of the accident:

> The most recent deep persistent slab avalanches occurred on Thursday in the Vail-Summit Zone, with natural avalanches in Straight Creek (west of the Eisenhower Tunnel) and the fatal avalanche near Vail Pass. In many of the avalanches throughout the winter, the culprit weak layers were small facets above a thin crust, on top of depth hoar. Slopes where these layers remain weakest are north through east aspects near and above treeline. The slab above the weak layer may be very hard (P or K) and strong. The strong slab and stubborn, unlikely triggering, give the slopes a false sense of strength. Likely trigger points are where the slab is thin, like shallow rocky areas or along the margins or bottom of the slab. If you find the wrong spot, the resulting avalanche will be very large, destructive, and dangerous. Conservative and cautious route finding and terrain selection are the best ways to avoid the problem.

At the scale of the CAIC's backcountry zones, it's hard to imagine a better description of the avalanche problem and where to find it. The forecast included the avalanche type, aspect, elevation, trigger mechanism, pictures of the large deep slabs triggered in the days prior to the accident, and the text cited a fatality as a stark reminder. This forecast could have been written after the accident, and it would look almost identical. The group read this description, and then 20 minutes later triggered the avalanche on a northeast-facing slope near treeline. They triggered it from a thin area at the bottom of the slab.

Something was lost in the group's interpretation of the forecast and how to avoid the problem. They thought they were employing "conservative and cautious route finding and terrain selection." So what was missing? What more can we do to deliver the message more effectively?

I'm not sure we know the answers to these questions. It certainly seems that given the accuracy of this forecast, we'd be well-advised to put more of our efforts into communicating it better. Many avalanche centers, including the CAIC, have been using the avalanche-problem construct to communicate the hazard. We use these categories of avalanches because they have different risk-management strategies in the field. But the avalanche problem alone only *implies* the risk-management suggestions. We think it might help the users of our products if we *imply* less and *explicitly describe* more.

Should we tell people to simply avoid these slopes and travel under them to manage a deep-slab problem? If we suggest "conservative and cautious route finding and terrain selection" we need to define this as precisely as possible. If we warn of unlikely deep persistent slabs, and suggest people stay away from suspect slopes for weeks on end with no avalanche activity, how do we combat message fatigue? We are implementing some of these ideas in our forecasts this year, including stock risk treatment statements that will accompany each avalanche problem. It is basically a list of appropriate actions for each problem.

Educators clearly have a role to play here. They are teaching students how to use the avalanche forecasts to help make better decisions. From as early as a level 1 course, instructors need to be teaching a repeatable decision-making process that instills safe backcountry rituals. Using detailed trip plans and checklists helps short-circuit some of the pitfalls of emotional decision-making. Fortunately, many avalanche courses have embraced this concept and have developed teaching tools to help facilitate transfer to the students.

We are encouraged that forecast centers and avalanche educators are more consistent in describing the avalanche problems and how to treat them in the field. We believe that the more consistent avalanche centers across the country are in describing and communicating the avalanche problems and risk treatments, the better we will serve the public. We have made good progress in the last several years but still have some work to do.

The Media

We rely on the media to get our message out. Most times they are our allies in the public safety mission. When high-profile accidents like Sheep Creek happen, they can inadvertently become our adversaries. It's not out of malice, but out of the burning desire to tell the story. In this pursuit, many journalists come to the scene with a story line already in mind: "This avalanche struck a group of experts from out of nowhere," "This accident was unavoidable/it can happen to anyone," "Something is broken in avalanche education," etc.

It is very difficult to manage the message in such a frenzied environment, and to make sure that the reporting is accurate. As soon as the Sheep Creek accident happened, we decided to have one point of contact for the media. All media inquiries went through Ethan, while Brian directed the investigation. We directed all CAIC staff members to not talk to the media about the accident, and to refer them to Ethan. This approach served us very well. One small incident confirmed our belief that this was a good approach. The day of the accident, one of our forecasters made an inconsequential comment to a reporter on the scene as he exited the field. The comment was misquoted, taken out of context, and made it into one of the initial media reports. Our single media contact approach stopped this from

Continued on next page ➡

Documenting Human Avalanche Involvements: We need your help!

Story by Ethan Greene and Spencer Logan

Have you ever wondered whether more people are killed in hard-slab or soft-slab avalanches? Or put a slide in your avalanche-awareness talk showing the staggering increase in avalanche deaths since 1950? Or talked to the media about whether more people die in avalanches from being buried or from traumatic injury?

Access to avalanche accident records helps us communicate why avalanche safety is important and helps us show examples in avalanche classes of what went wrong. The record of avalanche accidents in the US is an incredible tool, but the quality is declining, and we are in danger of losing some of the key pieces of information we all rely on, such as the method used to recover a victim and cause of death in fatal accidents. As a community we need to make sure we maintain this important resource.

After the powder cloud has settled, the rescue workers have returned to sort gear, and the media has moved on to the next human tragedy, avalanche professionals complete avalanche accident investigations. These reports add to a vital long-term record that helps us to communicate how avalanches affect people and work toward preventing future accidents. It allows us to make the case that avalanches are an important safety issue for governments concerned with public safety and businesses concerned with safeguarding their clients and capital assets. The numbers help researchers identify trends and evaluate their significance, so educators, engineers, and field workers can put the lessons into practice. The statistics allow us to put avalanches into context with other natural hazards. This summer part of Colorado's Front Range experienced a devastating flood. Thousands of people were evacuated, tens of thousands of homes were damaged, and the cost of repairing roads and bridges rose over $500 million. Although this was a tragic event that affected thousands of people, the loss of life was less than Colorado's 2012/13 avalanche season. We need an accurate record of avalanche events to be able to compare them with other natural hazards.

The Colorado Avalanche Information Center is the current home of the avalanche accident record for the United States. This database grew out of the work done by USDA Forest Service staff in the mid-1900s. It was passed on to the USDA Rocky Mountain Research Station and then the Colorado Avalanche Warning Center. The record starts in the late 1800s, and the quality of the data is the due to the hard work of many people, including Dale Gallagher, Betsy Armstrong, Knox Williams, Nick Logan, and Dale Atkins.

As the avalanche and search and rescue communities in the US have grown, maintaining this record has become more difficult. We are losing confidence in the validity of key statistics like burial depth and avalanche size. We are unable to show the level of avalanche training in fatal avalanche accidents. Even basic demographic information like the distribution in the age and sex of avalanche victims is now incomplete. The decline of the data record is the result of the growing number of accidents, the limited resources we have to track down the information, and number and nature of the reports people send to us. We need your help in maintaining this important record.

What you can do to help? Send us information about avalanche accidents in your area. Many of the regional avalanche centers, local groups, and individuals create great narratives about human avalanche involvements. Although these narratives are very helpful, they typically do not contain the basic information we need to compare events. In order to maintain the long-term record we need people to complete and send us accident report forms. You can find these forms in Snow, Weather, and Avalanches (SWAG) or on the websites of the Forest Service National Avalanche Center, American Avalanche Association, and Colorado Avalanche Information Center. The short form contains the base information we need to document any avalanche accident.

Please send us the information you have, both as soon as you know about an accident, and when you finish collecting more detailed information. You can send questions or content to caic@state.co.us or call 303-499-9650. Include links to online narrative, images, video, and anything else you think could help.

Today avalanche accident reports serve a dual purpose, conveying current events and documenting a long-term record. Society has developed an insatiable appetite for information, and with smart phones and other portable devices we all want to know what happened as soon as possible. Posting information that can help people right away is extremely important, but so is collecting information that will help all of us in the future. We use the data collected by avalanche workers nearly every day when we teach classes, talk to the media, or look for new ways to approach avalanche safety. As a community, we need to preserve this record. In 50 years, the number of Likes a Facebook post got won't be very important, but the number of people killed in avalanches wearing releasable bindings might.

Memorial cross placed at the entry point to Sheep Creek by family and friends of the victims. Crown, right flank, and stauchwall are visible in the background. *Photo by Bruce Edgerly*

Accident Analysis: CASE STUDY

WHY? *Thoughts About Sheep Creek*

Story & Photo by Halsted Morris

There is a lot that goes through my mind when I think back about the Sheep Creek accident. I was heavily involved in the recovery of one of the five victims and was responsible for pinpointing on the deepest burial victim and for his recovery.

When I had worked at the CAIC, I had used Sheep Creek as a snowpit study site for the Loveland Pass area; so I knew the area well, and that's why Loveland ski patrol asked me to help on April 20. When I dug snowpits there (mainly alone) I always came in from above and to the side on a self-belay rope; Sheep Creek has always had all of my respect and attention, because I once triggered the same slope that killed the five victims, but not as big as it went in April 2013.

Overall, the recovery of the five victims was fairly textbook. If there are lessons learned from this accident, for rescuers I would suggest LOTS of practice with multiple burial transceiver searches and learn the conveyor-style strategic digging technique for deep burials (i.e., 14 feet).

Why did this accident happen to "experienced" folks, in such an obvious terrain trap, when they had repeatedly read the avalanche center's forecast? This is the unanswered million-dollar question.

There seems to be no clear, easy answers to what happened, but I have been thinking about what "experienced" means. The mainstream media likes to use word "experienced" and "expert." In the days that followed the accident there was a lot of coverage where these words were used. Maybe one day the mainstream media will come to understand that there is a real difference between taking avalanche courses, and actually taking the courses and applying the knowledge correctly to gain real world experience. But, I wouldn't hold my breath on that one.

In the months since the accident, I have come to believe that the Sheep Creek group hugely underestimated the terrain they were entering. To me, Sheep Creek is a classic terrain trap. There really isn't anywhere to hide from big avalanches. I think the group thought they could "manage" the hazard by using safe travel protocols. Obviously, being 50-60 feet apart wasn't enough. If anything would have worked that day, it would have been better route-finding skills to avoid the avalanche hazard entirely.

From theory to practice: deep burials take a long time to excavate, even with a lot of shovel-power.

"Consequences" is the one concept I continue to think about with the Sheep Creek accident. Obviously, everyone underestimated the consequences if the bowl avalanched. I don't think anyone in the group was out to "push the envelope" that day. They were just out to have a short fun tour. If any single lesson can be learned here, it's a lesson that even what you think may be a simple, fun, short tour can still have fatal consequences.

Hacksaw is formerly of the CAIC and has been on over 20 avalanche rescue missions. He skis a lot in the Loveland Pass area and in British Columbia. ⁂

SHEEP CREEK

continued from previous page

happening again and allowed us to disseminate a timely and accurate message:

- Members of the group worked in the ski/snowboard industry, and many were expert snowboarders or skiers. This is different from having experience with avalanches, and this was not a group of avalanche experts.
- Although this is a tragic accident, the avalanche did not come out of nowhere. It was predictable, and in fact *was* predicted. The accident was avoidable.
- The group used route and travel techniques that were not appropriate for this type of avalanche.
- Avalanche centers need to improve how we deliver our message. It's not enough to be accurate.

These points may sound harsh, but they are important truths if we are to learn from this accident. We are not casting judgment. Again, if we are honest with ourselves, how many of us have gotten away with testing a deep slab at some point?

We spoke with the survivor about this article several times, and we sent him a draft for review. We asked if he would like to add anything or write a sidebar. After reviewing the article and speaking with us, he declined. He believes he cannot add much to what we wrote. To quote him, "I feel like your article is complete. It is hard for me to admit that the accident could have been avoided but also difficult to deny it."

Acknowledgements

This story could not have been told without the cooperation from Jerome Boulay. Jerome was gracious with his time in discussing the accident with us. In return we provided a shelter from the endless media requests he was receiving. We cannot thank Jerome enough for his honesty, thoughtful self-reflection, and desire to learn from this painful accident. Thank you!

Special thanks to Spencer Logan who helped pull together the information and data to tell the story of the deep-slab cycle. Thank you to Scott Toepfer and John Snook who helped with the accident investigation. Dale Atkins provided good details from the search and rescue response perspective. Thank you to all the initial responders and friends of the victims who granted us interviews.

We would like to extend our deepest condolences to the families and friends of the people killed in this accident. These young men were active in our local communities and taken from us too soon. They left behind friends, parents, siblings, wives, girlfriends, and children. There are several growing efforts to honor their memories. One is the International Avalanche Nest Egg (ianfund.org) for the children of avalanche victims.

Ethan has worked as a ski patroller and avalanche forecaster in Montana, Utah, and Colorado. He has studied weather and snow in Utah, Colorado, and Switzerland. He lives in Leadville, Colorado, working as the director of the CAIC and heads the snow and avalanche division of the International Association of Cryospheric Sciences.

Brian Lazar is the deputy director for the CAIC and executive director of American Institute for Avalanche Research and Education. Lynne has learned to lie to him about submission deadlines to get his articles in on time (barely). He borrowed his current forecasting motto from physicist Niels Bohr: "Prediction is very difficult, especially about the future." ⁂

Accident Analysis: THEORY

A Different Way To Think About Accidents

Story by Dale Atkins

Have you ever watched the news or read an accident report and thought, "Wow! What were they thinking?" Maybe you followed up with a statement like, "They're crazy," or, "I would never do that." If you have muttered such words – and I have – you missed an opportunity to learn from the accident because your ego may have gotten in the way of learning. We may even predispose others and organizations to suffering a similar fate because we have distanced ourselves from the unlucky victim.

The purposes of investigating an accident (generally referring to an unexpected event that caused harm) or incident (did not cause harm but had the potential) are many and range from regulatory compliance to fiscal impacts to legal requirements; however, the most important is to learn the cause so to prevent similar accidents in the future. No matter whether an industrial or recreational accident the conventional approach of assessing accidents focuses on what happened and how it happened. We tend to view avalanche accidents as a sequential or linear path that is observed through the clear, sharp lens of hindsight. Thus accidents are reviewed and presented as relatively simple problems with simple solutions.

Many investigators, whether professionals or Monday-morning quarterbacks, seek the "root cause" (usually there seem to be several root causes, which should clue the investigator that accidents are not simple) where an implemented intervention would have prevented the catastrophe. Most often an accident's cause is labeled as human error[1] because the skier, rider, or worker chose to go there or do something. The prevention strategy that follows is the advice to be smarter and to be more careful.

I have espoused this approach for decades, but it's not the better way to study, report, and educate people about accidents. At best it helps some, but it also harms others. Avalanche accidents are a failure of a very complex system – the interaction of people and avalanches. Therefore we should not investigate and report accidents as simple, sequential, linear events, but as complex systems. Avalanche accidents involving enthusiasts and professionals are breakdowns in adaptation necessary to cope with complexity.

To understand this we first must explore why accidents are not always preventable, why hindsight is hazardous, and speculation can be good. By knowing how these three topics limit assessments and learning, we can approach accidents as a breakdown in coping with complexity and then learn what to do about it.

> Enthusiasts start early on to rely on making judgment-based decisions when they lack necessary knowledge and experience – a potentially dangerous precedent, because good luck breeds bad habits.

Nearly all accidents are not preventable.

You read it right. My statement is contrary to the omnipresent avalanche maxim that states: "Nearly all accidents are preventable." This advice occurs in books, articles, blogs, videos, and news reports worldwide. But the maxim is wrong. If it is wrong, why is it always used when talking about accidents?

The reason for its use is because on the surface it seems like fact, but this fact is multifaceted. The argument goes that in the United States about 30 people die annually in avalanches; 95% of those deaths were triggered by the victim or other people (usually companions but sometimes by other parties in the area). Basically since the victims chose the fateful spot, and since avalanche accidents are human caused, it follows that avalanche accidents should be preventable. But can they?

Accidents are not necessarily preventable for three reasons. First, ***many enthusiasts take avalanche education not to improve their safety but to improve utility or benefit – to seek steeper slopes and deeper snow***. They get educated and purchase safety gear with the perception that they are reducing their risk, but then continue to expose themselves to more hazard, which actually increases their risk. As long as people seek to knowingly venture into high consequence terrain during periods of significant instability, accidents will be inevitable and not avoidable.

Second is ***the illusion of control***, a term coined by Harvard psychologist Ellen Langer, the first woman professor to receive tenure at Harvard. She says people overestimate their ability to control or at least influence events that they have no control over. If we overestimate our ability to control events, we become an accident looking for a place to happen.

Langer points out that we like to believe that we can control our own destiny. Since we think we control our own destiny and can chose between right and wrong; we feel that other people can do the same. This also is why it's easy to lay blame or fault on another person, or deflect the problem on to others. For example, backcountry skiers believe that accidents are two times more likely to happen to someone else *(Kobe and Jenkins, 1988)*. Research has demonstrated that the illusion is more common in stressful and competitive situations, and when people become more familiar with the activity through practice. There is also a theory amongst some organizational behaviorists that when one lacks control, one will falsely attribute to oneself control of the situation.

The third reason is ***judgment***. Simply stated: accidents happen because people don't think they will have an accident, and that decision is based on their judgment. The problem with judgment, as American philosopher Michael Davis says, is that it's personal; it's subjective. Two equally skilled practitioners can reach different judgments without either making a mistake, or one can be right and the other wrong. So how can we define judgment? This is an especially important question as we use "judgment" all the time in avalanche education and decision-making, but do we know what does it mean?

[1] Dr James Reason give a simple description of an error as circumstances in which planned actions fail to achieve the desired outcome.

Continued on page 21 ➡

Accident Analysis: THEORY

Breaking the Chain

Story by Russ Johnson *(reprinted from TAR 21-4)*

Ever since the deaths of Brendan Allan and Bryan Richmond on the backside of KT-22 between Squaw Valley and Alpine Meadows, California, I have been struck by what I call the "chain" of bad decisions that it takes to get caught in an avalanche. I think avalanches are rare enough and there are so many thousands of uneducated backcountry users that simply making one bad decision isn't enough in most cases to get nailed. We usually don't say, "Man, if he had just done this one thing right…" Of course, there is the fatal "last straw" but what about the decisions which led up to it? It usually takes an unbroken chain of bad decisions to arouse the wrath of the dragon.

I use the Allan-Richmond case of February 21, 2001, due to my familiarity with it. An ongoing storm deposited 20" of new snow over the previous two days. Temperatures have warmed over the last 24 hours. The Forecast Center rates the hazard as "considerable." The boys, expert racers each 17-years old, decide to go through the closed ski-area boundary to ski to Brendan's house on the Alpine Meadows Road, which they have done many times previously. They ski together into the West Gully, a terrain trap with a history of slides onto the Alpine Meadows Road. They trigger a slab in the gully and are buried 3 feet apart and 3 to 4 feet deep. Although they confided to another racer their plan, no one knows they are missing until Bryan doesn't show up at work. The search doesn't begin until the evening.

In this scenario there are several decisions, any one of which, if decided the other way, would have broken the chain. (Now, some of these "decisions" it can be argued are not decisions at all. They didn't "decide" not to call the Forest Service to get the backcountry hazard forecast. I'm sure it didn't occur to them. But this is 2001 and the information is out there so not checking this information, I argue, amounts to a decision). So, (1) they decide not to check the backcountry forecast or get any information on hazard. They (2) decide to go into the backcountry during a warming storm. Then, (3) they decide to go through a closed area boundary. But these decisions on their own don't get them killed. They (4) decide not to take any backcountry rescue equipment with them. They (5) decide to ski together, and finally, (6) they ski in a gully, which is a terrain trap.

It is also true that having rescue equipment with them but doing everything else the same way would not have affected the outcome. But suppose they take all the same decisions except two. They decide to take rescue equipment, and they decide not to ski together. The outcome may have been that no one dies. Or forget the rescue equipment, and they just don't ski together. Maybe only one of them dies. Perhaps the only good decision they make is to ski 30' to the left out of the gully. In that case they are fine even after having made five bad decisions previously. The point is they only needed to make one good decision out of six to change the outcome.

Besides decisions, there are "contributing factors" in this case as well. The victims are young men – the demographic most likely to be caught in avalanches. They are expert skiers; therefore the terrain is anything but intimidating and may seem barely steep enough to slide, although the top of the gully is 40 degrees and the main slide path goes 38 to 35 degrees. They are very familiar with the terrain having skied this route many times in the past, so again they have no hesitation to ski it. And they are buddies, so their camaraderie and perhaps competitive spirit drives them to ski right together.

These classic contributing factors along with an unbroken chain of bad decisions led the boys to a tragic end. I'm not arguing that accidents haven't happened even though a group or individual did everything right or perhaps just made one mistake. But, in general, as I look through *The Snowy Torrents* and at the recent accidents on the web, I am struck that very few appear to be in the "only one mistake" category. In the avalanche classes I have taught this year, I have tried to emphasize that among the things people should take away are enough good decision-making skills to avoid a chain of bad decisions. They need to break the chain; they need to make the one good choice that diverts their fate away from tragedy.

Russ Johnson is a former president of the American Avalanche Association and Squaw Valley's avalanche forecaster since 1993.

Accident Analysis: THEORY

Getting Beyond Operator Error

Using systems to analyze events

Story by Jeff Jackson

The emerging systems-based approach to risk management planning has altered the way we conceive, organize, and implement risk systems. Many high-risk industries have incorporated systems-based risk management to analyze and understand critical events beyond the default causes of inherent risk and operator error. This paper introduces a systems approach to looking beyond operator error and understanding the latent and organizational causes of events and accidents. While my own perspective and this model's assumptions are based on a guide/operator within an organizational setting, "organization" can be interpreted at the widest level: recreational groups, ski areas, or events are a form of "organization" beyond the typical guide-for-hire or backcountry program.

> "Human error is a consequence, not a cause."
>
> —*Reason, 1997*

Operator Error

Mountain guiding belongs to a small group of industries in which both "production" and "protection" lie in the hands of a sole operator. The guide is responsible to create and deliver a backcountry experience, while at the same time to oversee and balance the safety and protection of clients. There is continual tension between these two poles, and in some cases outright conflict. Given the purposeful exposure to risk as the defining feature of an adventure activity, production involves seeking risk while protection requires insulation from it. For any specific event, the balance between positive exposure (production) and negative exposure (too little protection) is open to interpretation. In hindsight, it is easy to second guess the operator's on-the-spot balance between the two. It takes the right combination of small errors, at a particular time, to cascade into a large-scale crisis. In hindsight, these factors become errors *(Weick, 1990)*.

Writes industrial psychologist James Reason, "Human fallibility, like gravity, weather or terrain, is just another foreseeable hazard…" *(Reason, 1997)*. He continues, "…The issue is not why an error occurred but how it failed to be corrected."

Why We Blame the Guide:

When something goes wrong, the spotlight historically shines almost exclusively on the hazard at hand and the individual's actions and decisions in the moments or events leading up to encountering it. This has, as an underlying assumption, the idea of the "fallible guide" – somewhere, someone made a mistake. By dissecting the event an error or cause will be found.

On top of this, there are predictable psychological factors at play. Consider Attribution Error, where people tend to blame the person over the circumstance *(Ross & Nisbett, 1991)*; Confirmation Bias, which is the tendency to match a situation with what is already suspected or known *(Reason, 2001)*; or Hindsight Bias, where retrospective connections seem obvious that might not have been visible at the time *(Hoffrage, Hertwig & Gigerenzer, 2000)*.

Regardless of human tendency and a history predisposed to blame the operator, program managers attempt to devise systems, policies, and procedures that will prevent error, or at the least minimize it. Systems-based risk planning represents the most sophisticated form of this to date. But consider:

"While the probability of operator error can often be reduced, there is no evidence whatever that it can be eliminated altogether... Human errors are fundamentally 'caused' by human variability, which cannot be designed away." *(Ayres and Rohatgi, 1987)*

Table 1: Active and Latent Errors

Active Errors	Latent Errors
• Guide Slips, Lapses, Mistakes	• Dormant, Long-Term Conditions
• "Sharp End"	• "Blunt End"
• Focus of Trigger/Event-Based RM	• Focus of Systems-Based Risk Management

Understanding Errors

The field of error management recognizes two types of errors: active and latent *(Table 1)*. Active errors are the immediate, guide-based slips, lapses, and mistakes – the "sharp end" *(Reason, 1990)* of a risk event. But Perrow *(1999)* cautions: "Be suspicious of operator error…" as it is often the easy target in an unclear scenario. He claims 60-80% of system errors are blamed on the operator.

System errors are considered latent errors; dormant, long term conditions that set the stage for any number of unconnected active errors. Latent errors are the "blunt end" of a risk event, and could include anything from poor equipment design, bad management decisions, poor planning, communication difficulties, or legislative or regulatory failure. Latent errors are created by the system that hosts them and are difficult to detect, since the "active" and visible portion of the risk event usually takes the focus. Plus, the current "objective hazard + subjective hazard + unsafe act" does not look for these latent, background contributors.

Writes James Reason in *Human Error (1990)*, "There is a growing awareness… [that to] discover latent failures is the best means of limiting [active] error." Mountain guides inherit the system defects and latent errors that set them up for active errors: staffing decisions, logistics restrictions, client screening, continuing down a possibly long list. While it is the guide who pulls the trigger, so to speak, it is the organization that put the gun in their hand.

Using Systems to Understand and Analyze Critical Events:

A systems-based approach to understanding critical events is based on the premise that "Human error is a consequence, not a cause" *(Reason, 1997)*. It incorporates the operator's contributing actions (active error) within a greater context of social, organizational, and latent factors *(Figure 1)*.

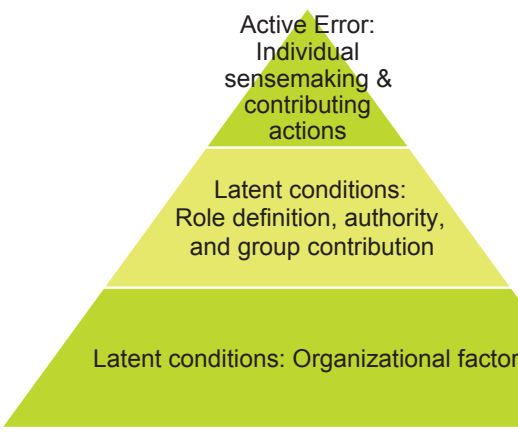


Figure 1: Systems-based approach to understanding critical events

Step 1: Understanding What Happened

Understanding what happened precedes any deeper analysis, and includes actions, decisions, conversations, and events both leading up to and after the critical event. This may prove deceptively difficult, given the subjective nature of human memory, especially when challenged with confusing, complex, and stressful situations *(Hoffrag, Hertwig & Gigerenzer, 2000)*.

This step also deals with the active error, but steers away from blame and towards what is known as "sensemaking." Rather than looking for bad people making poor decisions (operator error), sensemaking tries to understand how good people attempt to make sense of a situation, and enacted what they likely thought was the best idea given their understanding of the situation *(Weick, 1998)*. This particular step is not the focus of this paper.

Step 2: Substitution Test

The substitution test is an important lens through which to assess an event. It defines an event as either a true operator error situation, or one involving latent factors *(Johnston, 1995)*. The substitution test asks this question:

"Given how events unfolded and were perceived in real time, is it likely that a new individual, with the same training and experience, would have behaved any differently?"

If the answer is an honest "yes" (accounting for hindsight bias and attribution error mentioned previously), as in a similar person would not have behaved the same way, then the event could be considered primarily an operator error situation: a slip, lapse, or mistake. In such case, driving to "why" yields little information to improve safety or prevent a similar event. The investigation can end here.

If the answer is "no" - a similar person would likely have acted and behaved in a similar way - then latent conditions played some role in causing the event. The substitution test implies that if the scenario were to present itself again, another individual would respond in the same way. These latent conditions are explored next.

Step 3: Group Contribution

This first layer of latent conditions is the social interactions which directly or indirectly steer action, decisions, and sensemaking in the moment. This layer is rich in explanatory power although is difficult to access given the complex nature of social groups. Primarily these interactions revolve around authority and role definition and the assumptions and expectations they create. A guiding situation is influenced by the organization and management/supervisory structure, while recreational groups are victim of much looser assumptions regarding expertise and leadership. This analysis can also extend to team functionality, peer pressure, and group interaction. The human factors topic has been introduced into the avalanche world as a means of addressing these, but is only the tip of the iceberg. These particular interactions are not the focus of this paper, but readers are directed to the work of Snook *(2000)* and his analysis of group interaction as latent cause in one particular case.

Step 4: Organizational Factors

Key organizational processes and factors form the base layer of potential latent errors and causes of events. Any of these may be perfectly functional in normal conditions, but can prove to be poorly conceived, implemented, or supervised when faced with an abnormal situation or when combined in unforeseen ways *(Perrow, 1999)*. Organizational factors with the most potential for latent errors are briefly introduced below.

4.1 Risk Tolerance

Risk tolerance is the articulated limits on the nature and magnitude of hazards and uncertainty to which an organization will expose its clients, staff, and self. Best when explicitly stated, it can also be viewed within program parameters and the exposure limits inherent in the organization's chosen activities or operating environments.

As an analysis tool, the guide's sensemaking and contributing actions reflect their understanding of the organization's risk tolerance. Any discrepancies here need to be examined. It is important to note that a written risk tolerance statement serves little use if it conflicts with the actual risk culture in the organization (its true risk tolerance). The prevalence of a culture of safety (vs. production), where management chooses to direct their attention and where money gets spent are all signals that the guide interprets their own understanding of risk tolerance.

Social groups in a recreational setting, too, have a risk tolerance, though heavily skewed with individual target level risk and social dynamics. This social risk tolerance is best examined as a group contribution in Step 3, above.

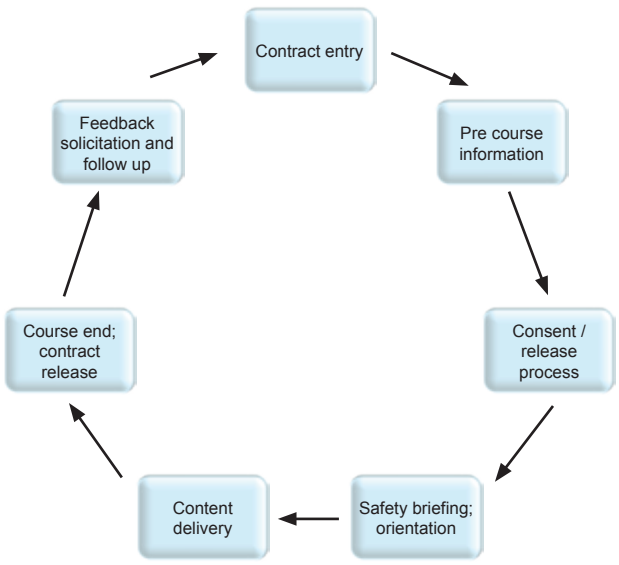


Figure 2: Core process map (in basic detail)

4.2 Core Process Map

Systems-based risk-management planning is organized around a core process; the central interactions that produce the programs, trips, or services the organization offers *(Figure 2)*. As it is the focal point of systems-based planning, analyzing the core process map in detail looks for gaps, failures, or inadequate system performance standards that may have created latent conditions. In effect, this asks the question "Did everything perform as it is supposed to?" Answering no shows a clear breakdown, but even with the answer yes, there is a follow up question: Is the current vision of how it supposed to work good enough? "Good enough" needs to be related to the organization's risk tolerance, performance standards / expectations, sense of values, and industry standards. This continues by assessing the seven systems *(below)*.

Ski areas or events that inadvertently host backcountry skiing raise interesting questions at this point. What kind of expectations were set up in advance? What messages were being communicated to potential participants? While the core process as envisioned here revolves around a commercial contract, a similar process can be imagined which generates social expectations or inadvertent duty of care.

Figure 3: Seven systems of risk-management planning

4.3 Seven Systems Analysis

Risk management planning is about systems planning. These systems are turned into processes and routines. These routines ensure that system and organizational targets are met.

Any critical event calls for a review of every single system and routine within the operation, to understand its relation to and perhaps factor in creating the event. By mapping the seven systems (in advance), each system can be methodically examined in detail *(Figure 3)*. Each system, its control structures, performance standards and routines can be assessed as contributing and/or adequate.

What's more, these systems and routines are examined in light of the event and guide's sensemaking, contributing actions, an assessment of risk tolerance, and the basic interaction of the core process. This examination looks for more subtle or sophisticated interactions, and detailed system maps make these points apparent.

Latent errors need not be just one thing, but can be a combination of well-intentioned, normally adequate system or operational structures.

4.4 Operational Features

If systems provide the structure, organizations adapt them to their own needs. As operations grow and evolve, certain operational features may lend themselves to latent errors *(Perrow, 1999; Reason, 1997)*.

Coupling is the amount of slack or free space in an operation or activity. A tightly scheduled, high volume or tight and efficient operation is more at risk of error, for the simple fact there is less time to correct them. Small errors cascade quickly in an environment where things happen quickly – the typical BC setting. Inserting slack into an operation is always a good idea when it comes to preventing errors, but is directly at odds with efficiency (an example of conflict between production and protection).

Operational consistency, Supervisory and management models and complexity creep all play a role. Critical incident experience is an indicator of future individual and system resiliency. A system that has been tested is more predictable than one that hasn't been (even if it failed the first time). Individuals within and the system itself will have experience recognizing what failure looks like, and either predict/prevent or effectively manage it prior to escalation *(Jackson, 2009)*.

Within this, individual experience at failure level is good for error prevention. Training above and beyond normal operating levels (to the point of failure) builds an understanding of where the edge lies, and how events unfold there. The point is to be able to recognize when failure is near, and have the ability to make sense of a critical situation as it unfolds.

Conclusion

This article provides a systems approach to looking beyond operator error and understanding the latent and organizational causes of events and accidents. This analysis framework examines the operator's contributing actions, but also looks at group and system contributions. From a systems perspective, risk tolerance, the core process and system maps provide concrete points of examination, as do operational factors such as coupling and supervisory models. This systems based analysis model can be applied to critical and non-critical events, and to different program and organizational structures.

Reason – writes, "We cannot change the human condition; people will always make errors." He continues, however, to assert "We can change the conditions under which they work and make unsafe acts less likely." By understanding the system and operational factors that contribute to latent errors is to make progress in minimizing them.

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It takes the right combination of small errors, at a particular time, to cascade into a large-scale crisis.

DIFFERENT WAY TO THINK

continued from page 19

The witty and often heard answer is: "Good judgment comes experience; experience comes from bad judgment." It's a clever definition, but we can't teach to that definition. A better definition comes from Harold Brown *(1988)* who defines judgment as "the ability to evaluate a situation, assess evidence, and come to a reasonable decision without following rules."

Brown's inclusion of "following rules" is the key distinction from how judgment is generally applied to avalanche accidents. The problem is that enthusiasts start early on to rely on making judgment-based decisions when they lack necessary knowledge and experience. This line of reasoning sets a potentially dangerous precedent, because good luck breeds bad habits.

Hindsight is hazardous

Our conventional way of assessing accidents (caused by human error) with hindsight can be harmful and will not reduce accidents and may lead to future accidents. Not necessarily *more* accidents, but accidents to other people who will make the same mistakes but thought they never would. Hindsight is the "knew-it-all-along" bias that results in blame and deflection. The magic of hindsight is that all lines of causality zero in on the accident. After the event the correct path or course of action becomes crystal clear. The solutions become simple.

Unfortunately, in the pre-event the hindsight-identified path is seldom ever clearly marked. Simple solutions get applied to complex situations. Sometimes they work, but when the solutions don't, the failures can be catastrophic because some problems are complex.

Both people and avalanches are complex (unpredictable) phenomena rather than simple or complicated (predictable)[2]. Avalanche accidents – involving enthusiasts and professionals[3] – are the result of the interaction of people and avalanches. Therefore, avalanche accidents are complex events – and people are not good at complexity. According to psychologists like Dietrich Doerner and James Reason, when it comes to complex systems (think of networks or web), people think in linear or sequential fashion. In complex systems, problems tend to start slowly with a gradual drift toward failure, then suddenly things happen exponentially or in non-linear ways. According to Reason, people think in causal series rather than causal networks. When people think in terms of causal series they tend to seek only facts. However, when thinking in terms of networks and non-linear ways, people need to be more creative.

[2] Complexity means one can control inputs but not outputs, therefore outcomes are uncertain and not predictable. Complicated means one can control both inputs and outputs. Outcomes are predictable. Both human decision-making and avalanche release are uncertain but not unknowable.

[3] When referring to the interaction of people and avalanches I am only focusing on enthusiasts and professionals. Enthusiasts are avid recreationists who have at least some avalanche awareness training. Professionals are those who work in and around snow and avalanches. If an accident occurs to either group, both the casual and educated observer will say the subjects should have known better.

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DIFFERENT WAY TO THINK

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Speculation is Okay
(to the right audience and at the right time)

Conventional thinking by safety and accident experts follows the dictum of the old TV-show detective character Joe Friday who intoned, "All we want are the facts, ma'am." Speculation is avoided, but once those facts are collected the final story is told with one set of causes and effects that are often guided by hindsight. In the end, often, only one lesson is learned.

There is a right audience and a right time to share speculation. The news media is generally *not* that audience. Statements made to the media can never be recalled. However, when it comes to education and training, speculation can be very effective in teaching many lessons from one situation by providing a means to explore multiple scenarios. In reviewing accidents, one should not stop at what happened but should explore: "What else could have caused this?" Or: "Why was it allowed to happen?" Or, perhaps more importantly: "Why did it make sense to do what they did? The exploration often reveals multiple answers because it forces us to look for evidence that is not always obvious. These answers can provide reasons how or why the same accident might occur again with similar conditions. When using speculation it's important to be patient and to acknowledge why and how it's being used. Otherwise, especially when information gathering is rushed and incomplete, its use can be devastating to careers and reputations.

Coping with Complexity

Have you ever heard someone say that they didn't need to know more about avalanches? That they had avalanches all figured out? When it comes to avalanches, both newbies and seasoned professionals will always say they wished they knew more about avalanches. This is a sure sign that we're dealing with a complex phenomenon. The challenge for those who work and play in avalanche terrain is how we adapt to this complexity. Thus, avalanche accidents involving enthusiasts and professionals are a breakdown in adaptation necessary to cope with complexity.

No one – from novice to enthusiast to professional – goes out planning to have an accident, much less get killed. Pilots don't mean to fly into the ground. Doctors don't mean to kill patients, and snow enthusiasts and professionals don't mean to die in avalanches. No matter our level of knowledge and skill, we all employ some strategy that we trust to prevent an accident or serious harm. Called *local rationality*, we make decisions based on some balance of our knowledge, ability, mindset, and goals. In hindsight these strategies sometimes seem almost absurd, but to those individuals, their rationale and actions seemed reasonable.

Accidents happen all the time and in all activities. In 2001 the *Journal of the American Medical Association* reported that an estimated 119,000 preventable deaths occur each year in the US from bad medical care. Things haven't gotten better. A paper just published this fall by John James in the *Journal of Patient Safety* estimates that more than 400,000 preventable medical deaths occur each year. Back in the mid-1970s a very senior KLM captain (who was also KLM's chief flying instructor and safety officer) had logical reasons for his actions that tragically and unintentionally resulted in his passenger-packed 747 plowing into another packed 747 on the Spanish island of Tenerife. A total of 585 people died.

Snow enthusiasts and professionals are not immune from misapplying local rationality. Think of the skier or snowboarder who forgets their transceiver, so they are positioned in the middle of the group. That way if caught, there will be friends above and below who can come to their aid. Every winter this scenario is played out. Usually, no avalanche occurs so the group compliments themselves for being smart and for exercising good judgment, and in reality it was *luck* that likely prevailed. But sometimes things go terribly wrong. On average each winter a person who forgot their transceiver dies buried under the snow.

Preventing accidents or catastrophic outcomes requires investigators, educators, pundits, professionals, and enthusiasts to take a deeper look into an event. Ten years ago human-factor experts David Woods and Richard Cook wrote of pursing second stories. First stories of accidents tend to be biased by knowledge outcome and over-simplified accounts. The accident cause tends to end with the result and label of "human error." To prevent future accidents, people and organizations are advised to try harder and be more careful. Today Woods and Cook, as well as other leading human-factor experts, argue that human error is a symptom requiring more investigation – seeking the second story.

Seeking second stories is about looking deeper for understanding of interactions in dynamic, complex situations. For example, why it made sense for people to do what they did.

Second stories are also about identifying vulnerabilities that lead to failures and accidents. Recognizing and treating vulnerabilities goes a long way in preventing incidents and accidents, especially in situations where catastrophic failures are rare.

Peril of Positive Outcomes

Our challenge is that avalanche accidents occur in situations that almost always produce successful, accident-free outcomes: the peril of positive outcomes. When it comes to avalanches we can seemingly do things right 999 times but get killed on the 1000th time. (Or you can do things wrong 1000 times and not get killed.) Nature can be pretty cruel. But, were we really doing things right? Aviation human-factors expert Tony Kern has written about why continued success can be fatal. He argues that good luck can breed bad habits. Besides bad habits there are at least a couple of other important causes where good luck can lead to danger – complacency and overconfidence; these causes apply in the air or on snow. Enthusiasts are especially prone to falling prey to the peril of positive outcomes.

Basically, enthusiasts go out and play knowingly, or unknowingly, near the "edge" and no failure occurs. The only consequence is good fun – a positive outcome. They perceive (perhaps clouded by the illusion of control) they had acted smart and careful. The activity becomes a form of positive feedback[4], which leads them to do it again and again.

In the avalanche community we interpret and teach that past successes should be seen as a reason for confidence. This is a dangerous path when doers don't know what they don't know. Instead we should be teaching people to anticipate the changing potential for failure. This is really hard to do but vital to do. Those who deal with uncertainty get this, or think they do. Wall Street cautions about past performance all the time: "Past performance is no guarantee of future returns." However, they still screwed up when they thought they could manage risk and eliminate uncertainty with a relatively simple financial model. Basically, the model was descriptive, but the world's financial houses used it to be predictive. They got caught up in their own illusion of control. In the mountains people suffer the same illusion.

We think we can manage avalanche risk and eliminate uncertainty by applying some simple techniques. Nature occasionally reminds us in an unforgiving fashion that we can't.

A New Look To Assessing Accidents

While your role as to why you're assessing an accident (whether formally investigating or casually commenting to friends) may change, your framework (methods and ethics) should not change. The conventional approach to reviewing accidents is to focus on hindsight and track facts. With avalanches that means terrain, weather, and snowpack. The human data is the hardest to collect, and generally we loosely follow James Reason's class (unintentional or intentional) and type of error (slip, lapse, mistake, or violation)[5]. While this describes the type of error and failure, it does not address the more important issue of why or how the failure happened. When we can learn why it made sense for someone to do what they did, *and* we can personalize that action or rationale, then we have personal condition or action we can watch out for.

Here are some ways for doing this, courtesy of David Woods and his colleagues, and by Tony Kern:

1. Assume you were in the accident, then ask, "Why did I let this accident happen to me?" This personalizes the accident and connects rather than disconnects you with the event.
2. Escape from hindsight. We tend to evaluate and judge an action based on the outcome rather than the process. When evaluating an accident, momentarily assume the accident did not occur. If you judged the actions, sans accident, differently, your evaluation of the accident is biased. Research for the past 40 years is strong and robust that hindsight can narrow and distort an investigation or analysis. Try to escape its clutches by focusing on the process and not the outcome.
3. Look for and identify local rationalities, or why did it make sense for the people to do what they did.
4. Speculate about possible motives and circumstances to explore complexities and to find multiple answers that may help you and others in similar but different circumstances. Use speculation deliberately; otherwise you may find trouble.
5. Try to understand what people actually did. People tend to exaggerate their description of what they did. GoPro-type cameras have a way of revealing these discrepancies when it comes to rescues and snowpits. If there is no filmed evidence, challenge people (kindly) to explain how they might handle a situation such as performing a transceiver search or digging and interpreting a snowpit.

[4] Positive feedback amplifies like the ear-splitting noise when a microphone is too close to a loudspeaker and picks up noise from the loudspeaker, amplifies it and sends it back to the loudspeaker. Negative feedback regulates. A thermostat on a furnace or a governor on an engine gives negative feedback and tends to make their system self-regulating. Likewise, clues to instability like whumphing, shooting cracks, avalanches, etc. are forms of negative feedback and should make one stop and change plans.

[5] An "attentional failure" such as blindness or ignoring changing weather or snow conditions is a type of "slip" is classed as an "unintended action." A "rules-based failure" such as the misapplication of a good rule or the application of bad rule are "mistakes" that are classed as an "intentional action."

Accident Analysis: THEORY

A Look at Sportgevity

Story by Robb Gaffney

Sportgevity believes in athletic progression as well as the beauty of having a lifelong experience doing the sports and activities we love. We believe that experiencing our sports from different perspectives across many decades creates a rich sense of fulfillment. To help skiers and snowboarders achieve this goal, we put them in touch with true experts in fields such as avalanche science. In doing so, we hope to help redefine the very meaning of "expert."

Robb discusses why he began the Sportgevity project: "I started Sportgevity to help us regain perspective of our sports and to counterbalance the growing high risk culture. I recognize the underlying drives that attract us to pushing boundaries. But we have an opportunity to look deeper into the true meaning and purpose of our sports. Sportgevity's goal is to redefine the expert as someone who makes decisions that enable them to experience a full life doing the sports and activities they love."

6. Search for systematic vulnerabilities; these are the conditions when one can be harmed. However, "systematic" means these vulnerabilities can be planned for and managed. Awareness and correction of systematic vulnerabilities prevents accidents.
7. Look for underlying patterns of how people share and coordinate information and activities to handle evolving situations and complexities. Generally, we look only so far as to see what data (weather, terrain, snow, or avalanche) was collected, but we don't look further to learn how and why the data was collected and used.

Accidents are a failure of coping with complexity that often starts with a gradual drift toward failure – letting one's guard down is a common observation. Woods and colleagues argue that the best way to tame complexity is through feedback. But feedback is not simply gathering more weather, terrain, or snow data. Feedback is about the interactions of the people and how they coordinate information and activities. Our challenge is that we are looking for foresight, which means our feedback loops must be tuned to the future so we can recognize our drift toward failure in ever-changing situations and take corrective actions. This is called *resilience*.

We'll never eliminate all accidents or deaths, but these different approaches will prevent some future accidents.

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Dale Atkins is a long-time avalanche rescue expert and past president of the American Avalanche Association. During this year's ESAW, Dale furthered our education about risk with the concept of minimizing uncertainty via risk's components of VUCA: volatility, uncertainty, complexity, and ambiguity. Photo by Brian Irwin Media.

Accident Analysis: INDUSTRY PROFESSIONALS

Strategies From the Front Line

Story by Van Roberts

As climbers and skiers, death and injury have always been more present in our community than in typical American culture. When I started in these sports, my enthusiasm far exceeded my skill level, and I feel lucky to have survived the learning curve. Early in my career as a climber and skier, I read accident reports with the thought that it would never happen to me; it was my first exposure to the sometimes morbid reality of this lifestyle. Unfortunately, I discovered firsthand that it could happen to me, and luckily I survived my own serious mishap while climbing in the Tetons. Reflecting on the accident in the weeks that followed, I realized the multitude of errors I had made that led up to my mistake and wondered how I could have missed so many obvious signs of danger.

I began to search out and read accident reports to try and understand how intelligent people could make such poor decisions in such high-stakes activities. At the same time, my career led me down a path where dealing with mortality firsthand was a regular occurrence, and managing risk was a necessity – working as a paramedic, ski patroller, guide, and park ranger impressed upon me the fragility of human life on a near daily basis. Now, as a ski patroller and as a ranger, a major component of my job is to investigate accidents and try to understand why they occurred.

I have found many people shy away from accident investigations; some think they serve no purpose and only end up pointing fingers at those injured, broken, or beyond the grave. I think some people may see too much of themselves in another's misfortune, so they choose to ignore the obvious. Personally, I believe we are all exceedingly human, and the only way to understand and maybe avoid accidents is to think critically about those that have already occurred. If you read a few volumes of *Accidents in North American Mountaineering*, it becomes all too apparent that history does repeat itself. The same goes for the world of avalanche accidents. I think it is important to cast aside our collective egos, and take a good, hard look at why our fellow skiers and climbers are dying.

I begin an investigation with the persons closest to the accident; that may be the victim of the accident or witnesses to the event. If the accident was minor, or a near miss, you can sometimes stop the investigation there. Often, the victim can recount most of the details, and other people on scene can fill in any missed facts. When a person is unable to speak with you, unable to remember the accident, or the accident involved a fatality or serious injury, it becomes more complex. You may need to travel to the scene of the accident, talk more to witnesses, and speak with family or friends.

For me, visiting the scene of an accident helps me to visualize what occurred. Those of you who have been to the scene of an avalanche fatality know the feeling I am referring to; it gives you an up close and personal view of a life-altering event. If the accident involves a serious injury or fatality, I am usually on scene with the initial response, either as a rescuer or with the assigned role of investigator. On scene I take photographs from a variety of angles and of anything I think may be helpful in the investigation. Impact marks and objects scattered above the victim sometimes help indicate the fall line.

If I can look at photos on a digital camera from the victim or witnesses, I try to piece together what happened. In certain cases measurements can help reconstruct the accident scene later; this is usually more helpful in long falls or climbing accidents than in avalanche accidents. I usually GPS locations I want to remember: the victim's final point of rest, a backpack torn off in the ride or fall, a ski lost in the same. In avalanche accidents, I dig a crown or flank profile, identify the weak layer that failed, and do the appropriate stability tests. In climbing accidents, I may climb the route and look at protection or anchors placed by the victim. Once I get all the information I think I need from the scene, I move on to speaking to witnesses.

I like to have a typed-out template of questions I plan to ask witnesses or persons involved in the accident; I may speak with someone for up to one hour or more to get a good idea of their account of the accident, depending on the complexity. I write down everything the witness says, and repeat it back to them to make sure I don't misunderstand them. I want to understand every detail of the events leading up to an accident; I try to reconstruct at least the entire day's events, if not the 24 hours prior to the accident. If it doesn't make sense in my head, I verbalize my understanding of the accident to the person I am speaking with; if I have it wrong, they will usually correct me or fill in a pertinent detail that helps me better understand what happened. I want to know when the plan was made to go climbing or skiing, how the plan was made, how the destination was chosen, who drove, what the victim and witnesses ate for breakfast, the conversation they had on the way to the trailhead, and every other minute detail you can think of. I try to look for human factors behind the accident: were they tired, was there something in their personal life distracting them, were they being complacent? Some of the people whose lives I know best are those whose deaths or accidents I have investigated.

The most difficult part for me is speaking with family. Calling up someone's wife, mother, or child to ask them personal questions about their deceased loved one is a part of the investigative process I'm not sure I will ever be comfortable with. While talking with the family, I usually try to get a picture of the person's experience level, risk tolerance, and any recent conversations the family member has had with them that they think are pertinent. At the end, I leave it open for the family member to add any details they feel are appropriate, and they usually do. People react in different ways to the death of a loved one. Some are angry and want someone or something to blame, some are quiet and reserved, some are unwilling to accept what has happened. I always hope to remain respectful and empathetic while speaking to family members, and like I said above, I'm not sure I will ever get used to it.

After this process, I try to write up my narrative portion in chronological order. I know that I am naturally very curious about accidents, so if I can take an accident from the days leading up to it and detail it out to the actual event with no questions on my end, I feel pretty confident that I haven't overlooked anything. I like to include pictures from the accident site and a diagram with the accident site mapped out and locations labeled and routes of travel superimposed; this can help those who are unfamiliar with the location get a picture of what happened in their heads. In avalanche accidents, weather history for the season and the days/weeks leading up to the accident, the avalanche advisory for the day, and if possible, a crown profile, are included. A written timeline of the day's events can provide a simple, easy-to-read summary of the accident.

Finally, I will write my analysis of the accident cause. I try to be respectful of all those involved and objectively critique the actions taken that may have led to the accident. I make it a point to state facts as much as possible; if I have to conjecture about a person's thought process or decision-making, I try to make it clear that I am only entertaining possibilities and that what really happened can't be known for sure. Hindsight is 20/20.

Accident investigation is a difficult and often time-consuming process for a number of reasons. In spite of this, I find it interesting and challenging, and I believe it is important to this community. With every investigation I do, I hope to find lessons that we can all use to better our decision-making in the mountains, that will allow us to come home safely afterward to our loved ones. More importantly, I want to provide closure to family and friends who may have lost one of their own in an accident. I hope as a group we can continue to analyze climbing and skiing accidents so we may be able to avoid the same mistakes in the future.

Van Roberts currently splits his time between Estes Park, CO, and Teton Valley, ID. In the summers he works as a ranger in Rocky Mountain National Park and spends winters ski patrolling at Grand Targhee Resort.

Accident Analysis: INDUSTRY PROFESSIONALS

Just the Facts

Story by Rich Baerwald

As a year-round Grand Teton National Park climbing ranger, getting into my investigative mind-set is very helpful when digging deeper into the questions of how did this accident happen and why. This can sometimes be difficult, especially during the initial phases of the investigation when a rescue or recovery may still be in progress, when friends and partners may still be on scene, and when threats of more avalanches, rockfall, or lightning persist. Once these variables have been controlled to the best of our ability, the detailed investigation may begin. During avalanche events in Grand Teton National Park, this detailed investigation is important. It may provide partners and loved ones with much needed information and it may impart the lessons learned to other adventurers to help guide their decisions in similar terrain or conditions.

It's human nature to want to know how it happened. One reason accident investigations are initiated is to answer the question, "Why did I lose a friend or family member to the mountains we enjoy?" Accident investigations are also initiated by policy, and they vary by jurisdiction. In Grand Teton, as in most parks, a death investigation is conducted immediately to determine if a crime has been committed or if the incident was accidental. Not all accident scenes are formally investigated, but details of the accident are then generally captured during the rescue or during medical treatment.

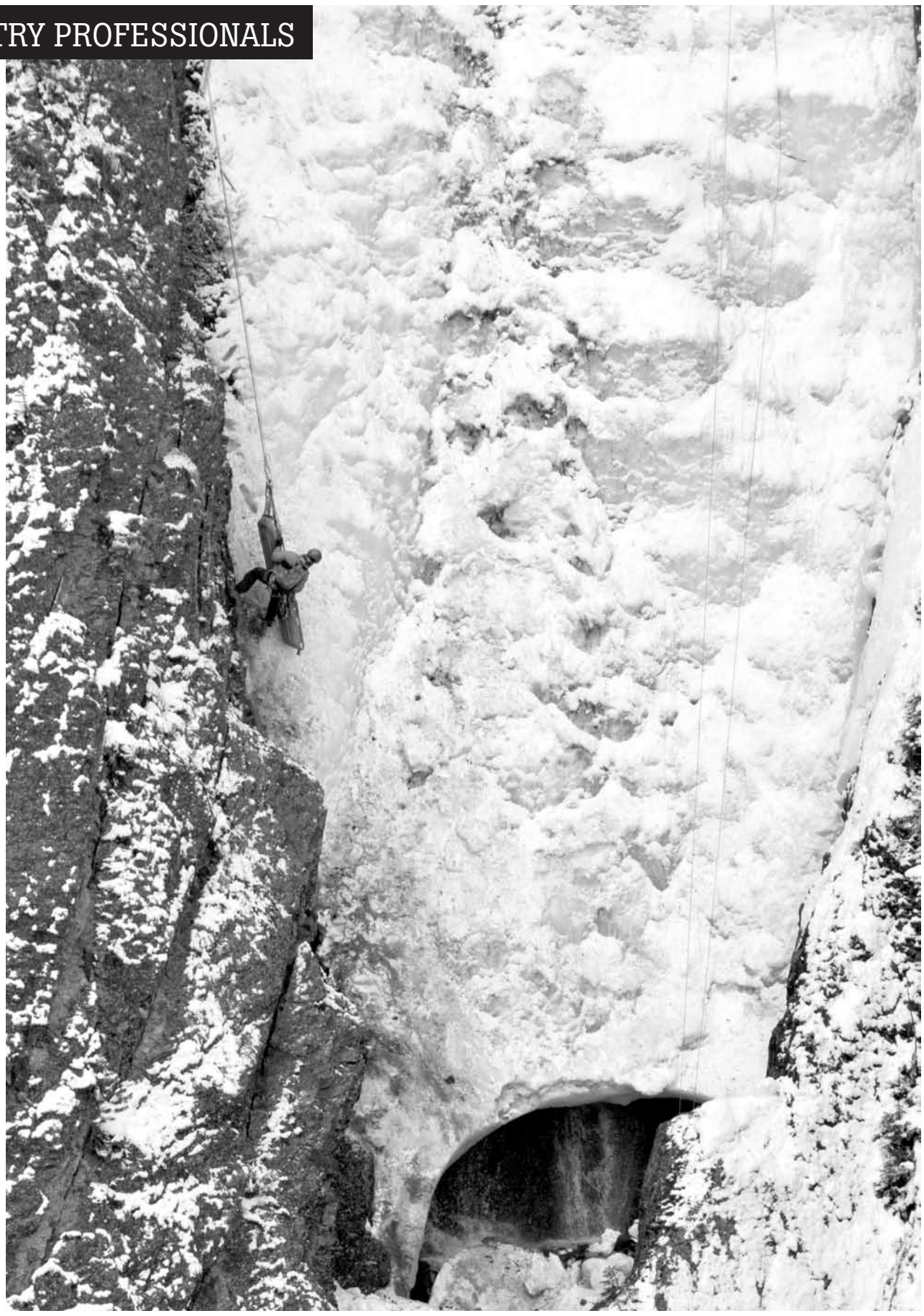
Investigative reporting was not something I took great interest in when I first began ski patrolling at Big Sky, Montana. It was not something I sought out but rather an interest that grew out of necessity. The first time I asked why was when I was nearly killed by a series of close calls with large avalanches. Soon after that came my first experience with digging out a friend's lifeless body from avalanche debris. Since then I've responded to fatal avalanche events while skiing in the Teton backcountry and at work as a ranger. Each of those traumatic events left a lasting impression that often reminds me of those who we have lost in the mountains.

Accident report writing is not glamorous; it's not something I look forward to doing, but the investigative report is important, and it is imperative that it be completed in a thorough and thoughtful manner. A well-written accident investigation can be a big help to family and friends after a loss. It tells the story of the accident and the events leading up to the event, and it may shed light on the factors contributing to the accident. It may also help put to rest misunderstanding and bring some closure to a very emotional event.

Partners and/or witnesses to an accident often provide critical investigative information. During the initial phases of any accident, emotions often run high and vary from person to person. In many cases surviving accident victims are distraught and have a very difficult time recalling the incident, while in other cases that firsthand account is extremely detailed. In the absence of a survivor or witnesses it becomes much more difficult to determine what happened. Still we are compelled to do our best to answer the questions.

An accident analysis is often an important part of the investigative report. A good analysis examines all available information gathered during the fact-finding phase, such as firsthand accounts, witness statements, photos, videos, past weather information, available snowpack data, and the physical findings at the scene. Physical findings may include ski tracks, skin tracks, a stopping or turnaround point, cut rope, placed ice screws and rock protection, and the overall equipment in use.

I have found that the *Snow, Weather, and Avalanches: Observational Guidelines* (SWAG) avalanche incident short and long forms provide a good outline for the important questions. Input from locals, educators, and avalanche experts also helps the investigator provide a sound, credible, and well-received analysis.



Rich Baerwald is point rescuer on a complicated rescue in May 2010 from the Silver Cord Cascade in Yellowstone National Park. *Photo courtesy Rich Baerwald*

Though a small component of a larger education effort, an accident analysis can also be an important part of accident prevention within the recreational environment as well as in the work place, and it may promote safer practices. Many federal agencies and private companies use these findings to help identify hazardous working conditions and accident trends before a series of small accidents or close calls leads to a serious injury or fatality.

It takes a team of dedicated people to respond to and investigate a serious accident, or worse a fatality. At Grand Teton National Park, trained rescuers and investigators must provide care and secure the scene. Family Liaisons and National Park Service Critical Incident Stress Management (CISM) trained staff provide necessary emotional support for victims and family. Helicopter evacuation during the winter is a joint effort with Teton County Search and Rescue. Emergency medical providers aid and transport the injured to St Johns Medical Center in Jackson. These and many others support the response, rescue effort, and investigation of an accident.

Many high-profile and/or tragic incidents receive extra public attention. The media may take an interest in the story and do good investigative reporting. Good investigative media reporting may be well received when the author has incorporated expert opinions, eye-witness statements, accounts of the rescue efforts, aerial photos of the scene, and snowpack information from the starting zone.

Over the years I have investigated many accidents involving snow and ice, ranging from deep avalanche burials to glissading out of control into rocks to climbers crushed by falling ice. These are not unusual accidents, but we naturally wonder, would I have made the same decisions? Could this happen to me? We wonder if these accidents could have been avoided. In some cases, yes. In other cases, likely not, unless we just stay away from the mountains and hole up at home. Ultimately, challenge and adventure in the mountains will always carry some amount of risk. Unfortunately, accidents will continue to happen and tragically, we may lose neighbors, friends, and even family. We must do our best to learn from the experiences of others, and good accident investigations are one place to gain this education. Holing up at home is not an option. The mountains call, and we respond to challenge ourselves on the steep slopes and frozen waterfalls.

Rich Baerwald has over 30 years of experience as a ski patroller, climbing and mountain rescue ranger, and as an avalanche forecaster in the National Park Service. As a National Park Ranger he has also worked in search and rescue and climbing programs in Rocky Mountain, Glacier, Yosemite and Yellowstone National Parks. Currently he lives in Grand Teton National Park, where Rich works as a Jenny Lake climbing and mountain rescue ranger.

Accident Analysis: INDUSTRY PROFESSIONALS

Notes from a Forecaster

Story & Photos by Brett Kobernik

Spooky photo of the high mark above the crown of an avalanche that killed the rider. He evidently had another very close call a few weeks prior. I would've categorized him as naive, but after learning about the other close call, I think there was something else going on with his decision-making.

I just finished writing about an avalanche accident that happened in Grizzly Gulch here in the Wasatch. A "professional" skier was caught and fully buried while wearing an airbag. She was rescued by other people who were in the area, and she was able to walk away from the accident uninjured. They had read the daily avalanche advisory which described the exact terrain that they went into as being the most dangerous.

It's too easy to look at the situation and say, "Boy, they were dumb. I would never get caught like that." But there's a whole different outlook if you've been involved in an accident as either someone in the party or as someone investigating the accident. I've played both roles. These days, it's easy for me to empathise with people who have accidents that look totally avoidable. Humans are fallible. Therefore, it is assumed we will make errors in judgment. We will never be able to make the correct decision in every situation, 100% of the time. I've seen many accidents that involved people who are (were) VERY snow savvy and who understood the conditions at the time. Yet, they made a wrong choice.

After an accident, those involved can be very emotionally delicate. Not everyone is willing to talk with a forecaster doing an investigation. Overall, it seems the majority are willing. Over the years I've changed my technique of how to initially approach people. I no longer take my list of SWAG short-form questions and rattle them off like a robot: WHAT - EQUIPMENT - WAS - CARRIED? WHAT - IS - YOUR - AVALANCHE - TRAINING? WHAT - SIGNS - OF - INSTABILITY - WERE - NOTED?

When I used to take that approach, I felt that I was inadvertently pointing fingers at the people involved. It was almost like an interrogation.

I try to take a more human approach these days. If someone is willing to talk with me, I first try to establish a comfortable setting and build trust. I tell them that I've seen quite a few accidents, and they aren't the only one this has happened to. I tell them that all of the forecasters at the Utah Avalanche Center have been involved in accidents, so we are not strangers to how it feels. I let them know that we are not going to pass judgment on them, because we've been there too. We've seen and been involved in accidents just like theirs. I tell them their personal information is kept confidential unless release is okayed by them. I basically try to make them feel that we are on their side. It's easy because it's the truth.

The next part of the interaction is very interesting to me. It's the part where they reveal their understanding of the accident and the events leading up to it. I lump these into three categories:

Naive

The first category includes people who are unaware that there is any danger to begin with. All you can do is console them and help educate them. I let them know that it is easy to be naive about avalanche danger.

Understanding

The second category includes people who fully understand what went wrong. Either they already knew better, or they learned by being involved in the accident. This was the case in the recent Grizzly Gulch accident. They had read the advisory. They knew where the dangers were. And afterward, they understood that they had gotten caught up in one of the familiar human factors – powder fever, familiarity, scarcity, expert halo, etc. The bliss of the day got in the way of logic.

It is rewarding to hear someone discuss their accident when you know they really get it. It becomes a valuable learning experience for them as well as for the whole backcountry community. They understand the conditions and why they made their choices. I've been told by more than one person that after talking with a forecaster, they've felt relief and closure. It's almost like a release for them.

Missing the Point

The third category is a tough one. These are the folks who think they understand what went wrong, but they really don't get it for one reason or another. Some people in this category just don't have the knowledge or experience that they think they have. They insist they know exactly what went wrong and exactly what they should have done differently. For instance, they think that if they had skied 20 feet farther to the left, they would've been safe when, in reality, the entire slope had a known persistent weak layer. The weak layer had been producing avalanches on many slopes over the past week.

Perhaps their egos struggle to admit fault? I think denial plays a role in this category also. I've seen people who believe if they'd done a better job with their beacon search, their friend would be alive – but there were many signs that should have told them not to be on that slope to begin with. Mastering beacon skills won't necessarily save you or your buddy if you can't make proper judgments on terrain, route finding, stability testing, changes in weather, etc. What makes this category difficult is trying to correct someone who is very sure they know what went wrong.

With accident investigating and reporting, the physical characteristics of the avalanche are the easy part. The human involvement is much more intense and is really what we learn from when we read these accident reports. The goal of these reports is to allow the victim's experience to (hopefully) be self educating as well as to benefit the greater community. I try to follow suit of the old *Snowy Torrents* publications. I feel that it is important to state the facts as well as to introduce some thoughts through comments about the human side of things.

Not all victims have the opportunity to learn from their mistakes. Death and all the grief I see are the worst part of my job as an avalanche forecaster. However, I try to remind myself that there is a positive aspect that comes from investigating these accidents because we, as a backcountry community, have an opportunity to learn from others' mistakes.

Brett Kobernik is an avalanche forecaster with the Utah Avalanche Center. He has a PhD in "garage science." He is comfortable on skis, snowboards, and snowmobiles, and he mixes well with all those user groups. ❄

Deep crown from an accident where the group purposely avoided climbing the slope because they knew of the avalanche danger. Near the end of the day, they were pinched for time so took a very familiar summer road to get home. The summer road passed underneath the slope that avalanched.

Accident Analysis: DIGGING DEEP

Looking up and down the Tunnel Creek terrain, the day after the avalanche. *Photos by Ian Mallinson, Stevens Pass ski patrol*

Tunnel Vision at Tunnel Creek

Story by Rob Castillo

Although the avalanche at Tunnel Creek on February 19, 2012, has been one of the most storied avalanches of all time, very little has been written as an analysis of what went wrong. As a member of that group, I am writing this not only to better understand what I have taken away from this tragic day, but to help people understand what went wrong in order to avoid these mistakes and have a long life of skiing powder. I first want it to be known how very sorry I am that this happened, and how my heart bleeds for all the community that was affected by the terrible loss of those three amazing gentleman. Most of all, I am sorry for the families that were left behind wondering how and why this could have happened. It is obvious that mistakes were made; whenever an accident like this happens, we cannot simply blame bad luck, but rather, as a member of that day's ski party, I feel a duty to dissect the mistakes that were made.

While many avalanche fatalities have occurred when glaringly obvious mistakes were made by people ignorant of and/or unprepared for the risks they were taking, at Tunnel Creek this was not the case. In fact, our group was very prepared for the dangers that lurked. We were all carrying probes, shovels, beacons, and one member of the party was able to stay alive by the use of a flotation device. We all knew how to use our equipment, and we were familiar with backcountry travel. The avalanche stemmed from, as Russ Johnson put it, "a chain of bad decisions." I will attempt to detail that chain as I see it now.

1. The Beginning

A large group of both friends and industry professionals began to spontaneously develop around the coffee shop where locals often go to hook up with other skiers. This in itself was not bad, because the group was comprised of mostly accomplished backcountry travelers. The problem was that there was no clear leader and no clear plan. Establishing a leader in that kind of situation can be difficult because, when not everybody knows one another, it can feel awkward or arrogant to step up and declare a plan. People who feel uncomfortable or have questions don't see a central "go-to" person to discuss their concerns. Also with a large group, people get lost in the shuffle – we never even took a head count, so it became hard to keep track of who was missing. Whether in the backcountry or frontcountry, herding a group takes longer, and people used to moving swiftly can become impatient. We were waiting for Chris, and by the time he came running out declaring, "Let's go quickly so I don't get dragged into another meeting," the group was more than eager to get going.

As far as the avalanche forecast *(see right)*, some members of the party had read it, others had not, and only some folks discussed it amongst themselves. I had been relying on reports from local skiers and had heard good reports from a group that had skied the run late on Saturday. After reading the avalanche forecast, I now see how if I had just scanned the report, I could have seen what I wanted to believe – basically, that conditions seemed manageable.

However, further down in the detailed forecast it explained the scenario that was set to happen. The old layer of buried surface hoar was called out. I'll be honest and say that since I moved to the Northwest, I stopped paying as much attention to the old layers as I did when I lived in the Intermountain West. From what I was seeing on Saturday and Sunday morning, the new snow was relatively stable. Also because it was cold when we started out, we didn't really pay much attention to the warming – but at noon, the sun broke for just a bit, and as seen on a graph, the temperature spiked, and avalanches were reported all around the region, one even killing a snowboarder in the Alpental area.

The information was there, but we didn't dig for it. I think if I had been alerted to the details of that lingering layer, I would definitely have changed some of my decisions to ski that part of Tunnel Creek.

From the NWAC forecast for February 19, 2012

Snowpack Analysis

Prior to the recent moderate to heavy snowfall arriving mid- to late Friday and continuing Saturday morning, the old snow surface consisted mainly of one of the following:

- generally shallow amounts of recent snow overlying strong near surface melt-freeze or sun-crust layers
- shallow wind deposits over an old crust on north through east exposures
- a thin freezing fog or drizzle crust from Thursday night and early Friday (Alpental, Snoqualmie Pass).
- thin wind slab deposits on higher elevation north through east exposures
- shallow settled powder or recycled powder over a firm underlying crust
- some buried surface hoar layers near Stevens Pass (recently unreactive due to burial by several thin crusts)

Increasing moderate to heavy amounts of snowfall at lowering freezing levels and increasing winds were deposited over this variety of pre-existing snow surfaces mid-late Friday into Saturday morning, with up to 12-14 inches of new snowfall being reported as of mid-late Saturday morning. As temperatures cooled during precipitation, a relatively good bond of the moderate to heavy snow accumulations formed with the most of the old snow surfaces below about 5000 feet, and this temporarily helped limit the danger increase associated with the heavy snowfall. However, a gradually weakening bond with increasing elevation above 5000 feet has combined with stronger winds to create increasingly dangerous avalanche conditions on most lee slopes above 5 to 6000 feet and dangerous conditions in most avalanche terrain elsewhere.

Saturday and Saturday night

Relatively strong ridgetop and increasing pass winds, low freezing levels and moderate to heavy snow or snow showers are expected for most of Saturday, with locally heavy snow accumulations likely. This weather should combine to produce a further increase in the avalanche danger as thickening, more cohesive and somewhat brittle wind slabs develop over either the old snow surface or weaker snow layers produced in breaks between showers later Friday night or early Saturday. Some of these slabs may reach 2-3 feet or more by later Saturday and run quickly on an old smooth crust surface. As a result, increasingly dangerous avalanche conditions are expected on lee slopes near higher ridges…especially northeast through southeast exposures where human-triggered avalanches should become very likely and where backcountry travel is not recommended. As indicated earlier, on lee slopes receiving heavy loading, some slides may involve or activate some recently buried weak layers, such as the surface hoar reported about a week ago near Stevens Pass.

A large-scale view of Tunnel Creek (outlined in red) as part of larger terrain. *Photo by Ian Mallinson, Stevens Pass ski patrol*

2. The Peak

Again, here the group size was a big problem. Though everybody made it to the top swiftly, the nature of the peak had the group spread out on the ridge so that those on one end of the group had difficulty speaking to, or even knowing, the others who were in our group.

The peak is the hub for many routes, and skiers from other groups were filing through. Then a mild frenzy began as some people were eager to move, and others may have been hurrying to get ready; again no clear leader was established, so people were pushing off without a plan. I noticed this and called to the group that everybody should "buddy up," and they did. Part of the bigger group noticed what was happening and decided to split off and go another route – a really good decision for them, but again, communication was minimal. Had we had a leader, that group could have explained their decision, and we could all have agreed, then known where they were going.

3. The Descent

With the other group gone, our group of 12 now started to seem a bit more manageable; however, the logistics still made it hard to communicate with everyone. Chris skied first, as this was *his* mountain and a run he had skied countless times in a variety of conditions. We were lined up ready to go one at a time using proper "eyes-on" protocol, but we were skiing just out of sight of each other.

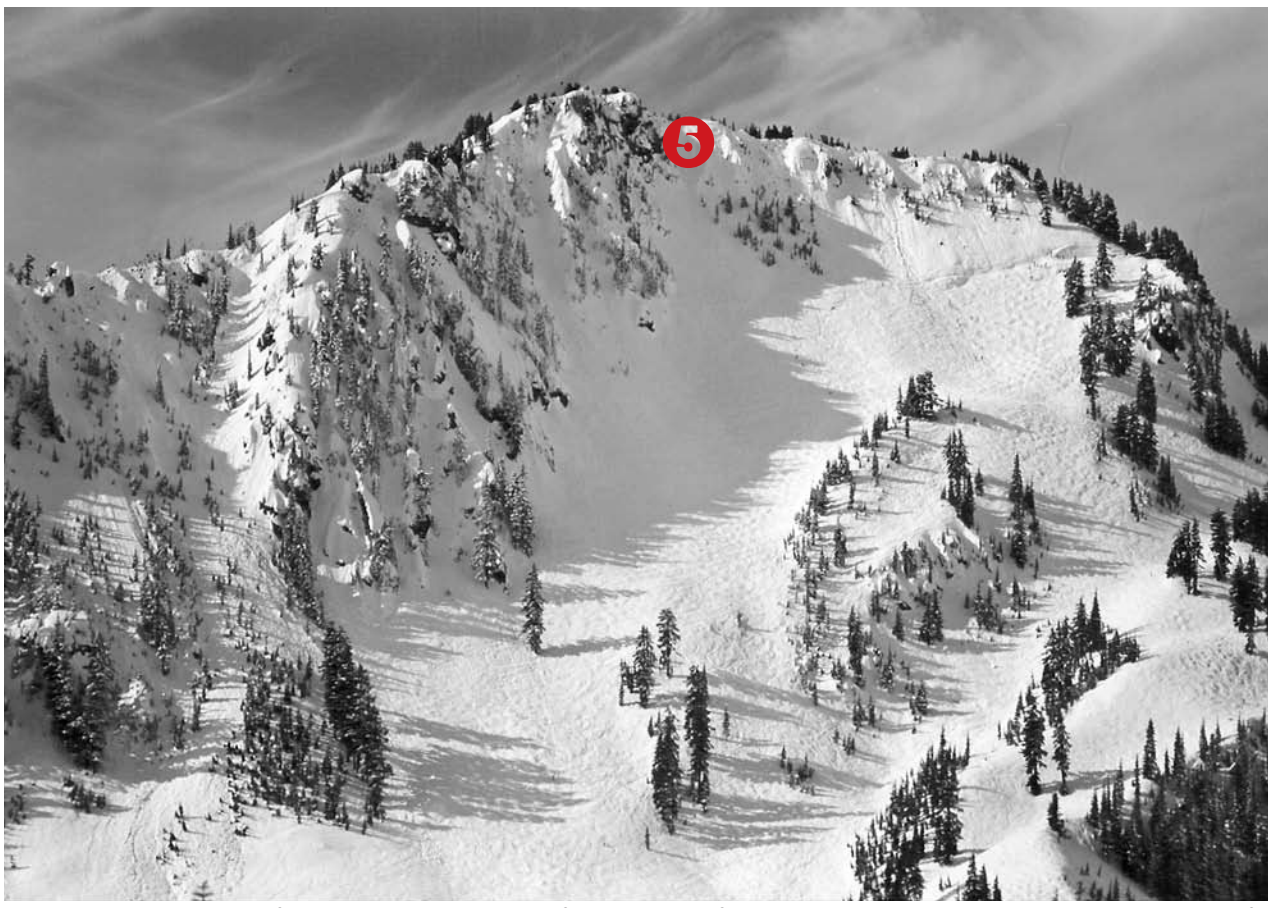
Here is where I see another small mistake: Since Chris was guiding Elyse, he told her to ski to him, and he would show her where to go next. Had this been a small group of locals, we would have discussed our route briefly and skied directly to the correct island of safety. Instead, because we were guiding newcomers, Chris stopped in a false island of safety, a tightly spaced stand of really big old-growth trees. I came down next, saw the others waiting in the trees, and pulled in just below them, but tight and uphill to a stand of trees. There was never any plan to ski all the way down that slope, just to be clear; we all knew we were going to traverse to the next ridge because further below us, the terrain becomes a huge terrain trap.

I want to note that during my run, I saw no signs of instability. But I felt a pang of vulnerability, and when I came to a stop I quizzed myself as to what were my reasons for having an AvaLung backpack yet not having my breather in my mouth and, worse yet, not even having it out. Why had I been taking this nonchalantly?

Next came Johnny, my partner, and he stopped with the others. He was followed by two other locals who did not stop with our group but instead, correctly skied to the proper island of safety. I noticed this and realized I didn't like where we were waiting, so I called to the group to move – to which everybody agreed – and then the wave of avalanche came down.

I was incredibly lucky that I had done my usual, and stood tight to the trees. I was able to hold on. Above us, Jim had skied; I obviously couldn't see him, so based on my experience skiing many days with Jim, and on others' accounts, I can surmise what happened. Having seen six skiers in front of him ski the slope safely with little or no real slough or signs of instability, Jim ventured further out into the open bowl than the rest of the group. Jim was a very graceful skier, but he also skied with a lot of power. I believe he saw a pocket, and it looked like such a beautiful place to slash a turn that he laid into it, and the whole slope just popped three-feet deep and swallowed him.

Again I draw back to group size. If there were only three of us, would he have ventured out there? Or by that time would we all have been at a true island of safety? Also how much confidence was gained by seeing a large group ski it in front of him?



Tunnel Creek is accessed from Stevens Pass ski area from the top of Cowboy Mountain, using the 7th Heaven chairlift. The number 5 indicates the group's approximate start point on the other side. *Photo courtesy Stevens Pass ski patrol*

4. The Rescue

I will not go into details here, as this was an obviously traumatic experience, but I would like to say I think the group did an amazing job of mobilizing, working together, and using their equipment properly. We had a very difficult terrain trap to navigate without knowing who was missing, how much hangfire was left, and who was coming down above us.

Continued next page ➡

A view of the runout from Tunnel Creek, with burial locations marked 1 through 4. *Photo by Ian Mallinson, Stevens Pass ski patrol*

TUNNEL CREEK HINDSIGHT

continued from previous page

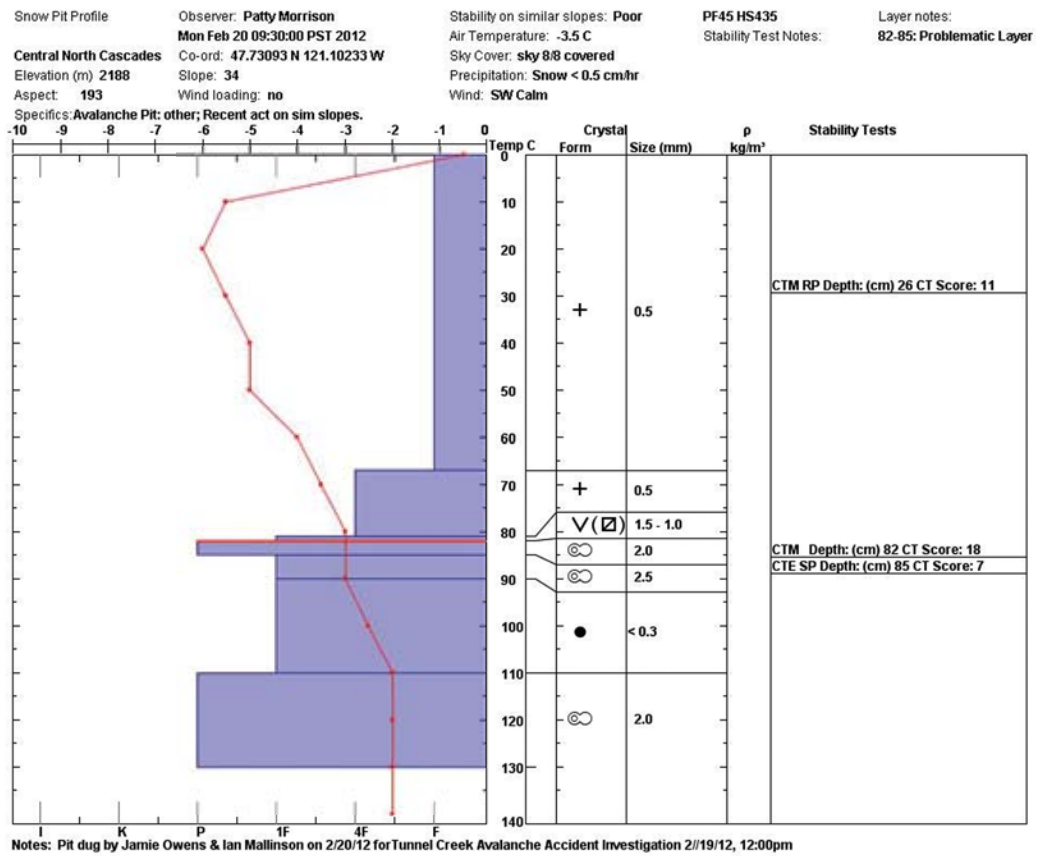
Summary

Although our errors were fatal, I do believe if we were able to tighten it up just a bit, we could have skied our objective (good deep powder, not necessarily the run we skied) safely that day and all been back with our loved ones as we had planned. I think the main take-away points that I have learned are the following:

1. ***Read the avalanche report!*** When you read it don't extricate only what you want to hear, but scour the information for how it may affect you. In Utah, the report is very detailed and user-friendly, but the size of our mountains here makes for so many micro-climates that the forecasts are more general. If it is the first few storms after an extended high pressure or cold spell, think back to the old layers.
2. ***Group size:*** I would prefer to keep the group size small – three to four max. If you must have a large group, make sure to establish a clear leader and have a discussion of the route, spots to avoid, and islands of safety.
3. ***Move swiftly, but don't hurry.*** Hurrying can make you overlook simple things that you normally would do routinely, for example, exposing my AvaLung breather.
4. ***Stay scared.*** Just because you have seen several people ski something, don't believe it's safe. Plan your route for the worst-case scenario, and always have an exit strategy.
5. ***Real islands of safety versus false ones:*** Make sure you are stopping in good places. We exposed ourselves too much, and what could have been one fatality turned into three, and almost five.
6. ***Communication:*** This one is huge. Let others know what you are thinking, where you plan to go, etc. Don't be shy, but don't block out other people's concerns.
7. And the most important rule, ***come home safe*** because there are far too many people who care about you.

I hope this helps people break their own chain of bad decisions so that they can safely enjoy the miracle of powder skiing.

Rob Castillo is a husband and father of two. A former competitive skier, he has spent over 20 years in the pursuit of powder. He has skied big mountains and first descents from Alaska to Europe. He now lives in Seattle and is raising his family to become outdoor enthusiasts.



Mark Moore of NWAC and Patty Morrison and Jamie Owens of Stevens Pass pro patrol did an accident report after the incident. Below is a photo of their snowpit, with several weak interfaces evident just below the pit kit. Due to significant remaining slab and associated continuing danger, profile was done about 60 ft above actual avalanche release point.

Rob Castillo. *Photo by Lee Cohen*

Accident Analysis: DIGGING DEEP

TUNNEL CREEK: Assembling the Story of "Snow Fall"

Story by John Branch

From the top of Cowboy Mountain, the steep trees and deep powder of Tunnel Creek beckon. *Photo by Ian Mallinson, Stevens Pass ski patrol*

I thought I knew plenty about avalanches when I first set out to start reporting the story that eventually became "Snow Fall" for *The New York Times*. I grew up in Golden, Colorado, after all, and winters were sprinkled with day trips to ski areas – Loveland, Winter Park, and Breckenridge, mostly. As recently as a decade ago, before moving to New York, I had a season pass at Copper Mountain.

I rarely ventured out of bounds. The threats of ticket revocation were enough to keep my friends and me inside the ropes. But I knew the danger that lurked out there. I had seen movies. I had read or heard the occasional news report about missing hikers or skiers. Like many people, I imagine, I probably shook my head, wondering how people could put themselves in such a position. Weren't victims of avalanches mostly clueless people who wandered beyond the safe zones and their own limits with little regard for the possibilities that lurked?

I recently gave a speech to a graduating class of journalism majors at the University of Colorado. I told them that "Snow Fall" was not a story about an avalanche. It was the story about people in an avalanche. As journalists, every compelling story is rooted in humanity.

It is probably why you don't see or read many avalanche accounts in the media from the perspective of nature. Even books or movies about natural disasters – "The Perfect Storm," for example, or "Into Thin Air" – are rooted in characters. The story is about what they faced: the mysterious and dark forces of nature, the seemingly mundane series of events that lead to an extraordinary, if tragic, outcome.

That is why I began my reporting with the people who were at Tunnel Creek, on the back side of Stevens Pass ski area, that day in February 2012. I wanted to know more than just what they went through. I wanted to know what events led them to Stevens Pass that weekend and to Tunnel Creek that morning. I wanted to know who they talked to, what they ate, and what they did in the hours before. I wanted to know what they thought, what they felt, what they said to others and to themselves as the group gathered and made its way up two lifts and hiked the short distance to the top of Cowboy Mountain.

I was in a position that might have been both an advantage and a disadvantage. I did not start my reporting until nearly three months after the avalanche occurred. *The New York Times* had written a news story that ran on the front page two days after the avalanche, by a freelancer based in Colorado. It was a typical approach for us – wrap the news event inside broader context. In this case, the Stevens Pass avalanche was one of two fatal avalanches in Washington on that day, and was the latest in a series of avalanches in the West that claimed the lives of well-known, experienced backcountry skiers.

It was months later when I received a call from Joe Sexton, *The New York Times* sports editor at the time. It gnawed at him that there was a broader story to be told than the one we did in the wake of the avalanche. If, in fact, more people are dying in avalanches than before, drawn by the lure of everything from equipment advances that make backcountry skiing easier (and, with beacons and air bags, presumably safer), to the widening open-gate policies of ski areas eager to promote their sidecountry terrain, to an era of risk taking that has spread across the entire sports landscape, well, that was a story we should try to tell.

Do people even know what avalanches are, anyway? We see them in disaster movies and cartoons and glib popular-culture references. What causes them? How can fluffy snow be a killer? Are there more of them than there used to be? And (a lot of people asked me this) does climate change have anything to do with this?

We had not seen most of those subjects tackled, in depth, in the mainstream media. It seemed a worthwhile pursuit. But, as with any story rooted in statistics and science and trends, it needed humanity. A decision was quickly made, and it followed a philosophy I've long had: The best way to illuminate a big story is to shine a narrow beam of light on it. Perhaps we should focus on one avalanche.

Tunnel Creek was the obvious candidate. It was not only the deadliest of the season, and one involving experienced skiers, but it had something that most fatal avalanches do not have: lots of witnesses. So that is where I began, trying to track down everyone who was involved in the avalanche at Tunnel Creek that took the lives of Johnny Brenan, Jim Jack, and Chris Rudolph.

Over the next several weeks and months, I conducted interviews with those who were there, trying to reconstruct the events of that weekend – before, during, and after the avalanche. It took time to ascertain who was in the group; no one knew everyone who was there, and no one had counted the size at the top of the mountain. But one person led to another, and another, and each person was, eventually, willing to share a detailed account of what happened. Using time markers such as cell-phone calls and text messages, GPS apps on their phones, GoPro footage, and 911 calls, I was able to create a timeline of the day, almost to the minute.

Along the way, I interviewed several dozen others. Many were involved deeply that day – family members of all the victims, members of ski patrol and Stevens Pass management, avalanche forecasters on duty, friends who were at Stevens Pass and watched and heard it all unfold from arm's length.

I also spoke to experts from around the world who could teach me about the trends in the industry and the science behind avalanches. I attended the week-long International Snow Science Workshop in Anchorage in September 2012. People I tell this to are always amazed that there were 700 attendees at a symposium for snow. I admit, I had no idea such an industry existed. It's just snow, right?

Their expertise is sprinkled, silently, throughout the text and became much of the basis for some of the extraordinary multi-media components that my *New York Times* colleagues created. We needed to understand how avalanches happen and the current methods employed for keeping people safe. We needed to know why some slopes are more dangerous than others, what makes a mountain give way, and how fluffy, virgin snow can instantly turn itself into a mass of ice nearly impossible to escape.

When it came time to write the story, a decision was made: It will be told solely through the eyes of the people who were there, directly involved. And I wanted to tell it in chronological time, so that readers could get a sense of how such a tragedy could unfold.

I did not want to inject outside voices, those of experts somewhere, warmed by the cozy confines of an office and granted the perfect vision of hindsight. The people who were at Tunnel Creek that day were, by all accounts, experts in their field. Many knew the terrain well, and most were trained in avalanche safety. Their mistakes would reveal themselves in the course of the story. I wanted readers to think, "What would I do?" without the interference of someone else's high-minded analysis. Those people were not there. To let them play Monday morning quarterback and interject their thoughts into someone else's tragedy seemed inappropriate.

I knew that the story might spur a discussion about what went wrong and how others could avoid it (I didn't foresee the Harvard Business School's interest in using the story as a case study for group dynamics, however), and that would be a healthy development. But I set out to tell a story, not answer every question. I simply wanted to explain what happened.

It is why the story never takes a stance. Who is to blame? The forecasters, the ski area, the group leaders, the people who never articulated the doubts in the back of their minds? Or does blame lie in something more nebulous, like the emotional pull of the backcountry, the dynamics of peer pressure, or the diabolical whims of Mother Nature herself?

"Snow Fall" never set out to answer those questions, but to raise them.

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Accident Analysis: DIGGING DEEP

I remember taking this picture; it was remarkable because there were so many people converging in one place, at the top of our run. The avalanche in the shaded area was remotely triggered a couple hours before our accident, but no one was talking about that. The accident happened minutes later. *Photo by Nancy Elrod*

From Burial to Education

Story by Nancy Elrod

I was buried more than five feet deep in an avalanche on December 13, 2008, on Turnagain Pass in Alaska.

It was a slab avalanche triggered by one of my ski partners. I was the only skier caught and buried. My approximate burial time was 11 to 13 minutes. This article is not as much about the decisions leading up to the event, but rather how I processed and analyzed the event afterward. Specific details about the accident can be found on the CNFAIC website at www.cnfaic.org/accidents/avy121308.htm.

I applaud my ski and snowboard partners for being brave enough to interview with the CNFAIC forecasters after the event so that the accident could be made public. Those of us who did interview wanted others to learn from our experience. I am appreciative to the CNFAIC forecasters for their professionalism and seemingly neutral approach to the interview. We met where we could drink a beer and talk comfortably while making the report.

My husband ran into the flight nurse at a bar, who apologized for not getting the entire slide path in this photograph.
Photo courtesy LifeMed Alaska and Alaska Mountain Rescue Group

In reflecting on the event, the obvious errors and poor decisions leading up to the accident were relatively easy to see, but factors such as the subtleties in the snowpack, the weather, and certain decisions took longer to process. The positive feedback from the previous day, up to the tracks on the slope before us were all very seductive. Our group leader asked me if I felt OK with the slope we were going to ski. I replied with a confident "yes." It wasn't until a couple years later that the person who triggered the slab told me she had an uneasy gut feeling on the approach to the peak and didn't say anything. She speaks up now, something that wasn't always easy for her to do before in mixed-gender company.

There were many other decisions that I cannot delve into here that could have affected the outcome that day. Though complex and problematic because we are human, it became clear to me that *every* decision needs to be a good decision. In a chaotic world, this is impossible to do all the time. Checklists do seem the best option to counteract misperception for backcountry recreationists, then widen the safety margin in avalanche terrain. However, the practical utilization of checklists for recreationists does seem challenging.

For this article, I was asked how I processed the events of my experience and if I used writing as one of those processes. I did write, and I guess I am still processing five years later because I wasn't inclined to read what I had previously written. While preparing for this article I did read my first couple thoughts, which were: "It's the closest moon in 60 years," and, "Don't watch the news." Anyone who hasn't been buried in an avalanche cannot understand all the emotions that arise including feelings of inadequacy and vulnerability. The accident was reported briefly on the news and in the newspaper, but because no one was killed, or perhaps due to protection by the forecasters, our names were never reported to the public. I was thankful for this because of my heightened sensitivity at the time and for the privacy of all involved. I can empathize with those who are involved in avalanche incidences and don't subsequently share their experience.

In my discussions with my ski party, a common emotion expressed after the accident was guilt. I felt guilt as the victim; guilt that I should not have stopped on the slope, or I should have read the terrain more effectively to not get caught. The female snowboarder who initiated the slab above me felt guilty that she could have snowboarded differently to not cut the slope. Our group leader had guilt that he didn't communicate to her how to properly ski the slope. My husband had guilt that he told her to go before they knew I was off the slope. It's difficult to discuss the details of an avalanche incident knowing that others may criticize, judge, and blame. Because of the emotions that can be associated with an incident, I think it's important to critique incidents without criticizing those involved. There is much to be gained if victims feel safe enough to report non-fatal experiences.

I think it's fair to say that the emotional trauma takes the longest to process. Beyond the feelings of guilt and inadequacy, I also had to cope with the experience of being swallowed by nature, losing all control of my existence, realizing my finiteness, and having a lot of time to think about it.

Coincidentally, on the day of my accident there was an inter-agency avalanche rescue training taking place. The rescue helicopter came to our aid, but by then we were already skiing out to the road in the dark. At the highway I was whisked away by someone in an SUV and taken to the rescue training incident command center. I remember there being a lot of traffic, lights, and activity. My senses seemed heightened. I was taken to the mobile medical unit and assessed. They had a real live victim! My vitals checked out fine, so I went home. I felt like I had been abducted by aliens and let go. It was surreal.

I remember so vividly the 45-minute ride home in silence, with that closest of moons on the horizon. I remember thinking: Why do my pants feel wet? And then it occurred to me that the last thing I remembered, in the blackness of my last breath of consciousness, was my bladder emptying as my body was shutting down. As we turned the last corner home, I looked at my husband. He was quiet and teary eyed. I said, "You realized you still love me didn't you?" trying in vain to lift the mood. "Yes," he said. He didn't talk about it much afterward, not for a long time. A week later a friend asked him how he had felt during the accident. He paused, and quietly said, "That was my WIFE under there." There was fortunately no lasting physical trauma for any of us, but the emotional trauma runs deep.

After the accident I was consoled by an acquaintance who was involved in an incident with fatalities. He told me about post-traumatic stress (PTS) and where to find out more about it. Another friend came by the day after the accident and made me go skiing at the resort which thankfully I was physically able to do. Her husband had to be resuscitated from his avalanche burial years earlier (I did not). She wanted me to remember what I loved about skiing. We had a few moments of tears and appreciation for life. I suffered PTS for about 30 days, took a sedative, and slept with the light on for a while. I can't imagine what it would be like to be involved in an incident with fatalities. Had someone in our party died, the PTS would have lasted much longer. We were fortunate.

Five days after the accident my husband and I went back to the site of the avalanche. I wanted to "get back on the horse." The buried rock trigger point was easily seen in the avalanche crown from our viewpoint below. It was sobering to see the hole I was in. Being an avid backcountry and free skier, and having a fairly extensive avalanche education at that time, I thought I should explore educating. I felt that by teaching I might save a life and give my experience meaning. A friend and now avalanche education provider suggested we start an avalanche class just for women, and we did. I now teach AIARE avalanche courses. Educating is making me a better practitioner but has also been beneficial for my healing process. I have used my own case study which has proven powerful for students. While presenting the avalanche bulletin for that day, it has taken me a very long time to get past this part without choking up: "Normal travel caution is advised today. Manage your terrain and follow mountain travel rituals. One at a time, watch your partners, stay clear of terrain traps, and never ski above your partner." When the accident happened, we were inadvertently following none of these rules.

Today I would say I'm mostly healed. I still regularly ski in the backcountry, albeit with a heightened level of anxiety, except in the most innocuous of conditions. Lately I have been processing my role as an educator. Teaching has helped me heal, and I believe I can now teach with more objectivity. However, though I know that any education is better than none, still I question whether a three-day crash course on such a complex topic provides students the ability to reliably recognize hazards in order to evaluate risk in avalanche terrain. The stakes are high, especially for new backcountry enthusiasts. It seems at times inadequate – as if students are provided with shapeless knives and a book of rules, then sent out into the world of avalanche dragons. Despite these questions, I gain solace by knowing that sharing my backcountry experience and avalanche case study might help save someone else from heartache on a beautiful ski day. It accomplishes my goal: to help, and in that, to heal.

Nancy Elrod is a civil engineer who works in construction management in Alaska. She has worked in the ski resort industry from ski patrol to grooming, and she has skied competitively on the Freeride Tour where she enjoys judging juniors. She also works for Squaw Valley marketing as a ski model and teaches avalanche awareness and AIARE Level 1 courses. ❄

Accident Analysis: DIGGING DEEP

Steve Romeo in the Newk Couloir on the north face of Buck Mountain, in the Tetons.

On Graciousness

Story & Photo by Zahan Billimoria

I have gotten away with mistakes. I have made the wrong call and had "good fortune" save my hide. But I have also seen good fortune run short.

When Steve Romeo was killed on March 7, 2012, the ski world unleashed a barrage of media, announcing the grim news. The story was everywhere for weeks, and it seemed that while everyone mourned the loss of a ski pioneer, the story of Steve's passing made sense: here was an individual who pursued the dangerous passion of riding in the high and lonesome corners of America's steepest mountain range. After two decades of making the right call, one wrong call ended it all.

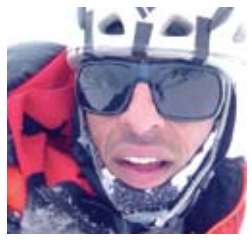
However, in the midst of the mourning, there were some who had harsher words – about the skiers failing to "use their brains" and assuming unacceptable levels of risk. This incident, and the harsh words that followed, hit close to home. Steve was a close friend, and it was hard to accept he was gone, and perhaps because of my proximity to the situation, the criticism was especially angering. It is close to two years since the incident, and many other close calls and fatalities have rocked the ski world since then. After each event, I observe how there are always voices that cycle back into the same barrage of criticism. In the midst of that, I also notice a pattern in myself – the farther away I am from the victims of the incident, the easier it feels to point fingers and lay blame.

I come back to my earlier confession: I know that I have made plenty of mistakes, but I haven't always paid the price – I have gotten lucky. We all have, and knowing that, we have to ask ourselves how we would expect to be treated if our mistakes, even small ones, had big consequences. Ultimately it is a question of what kind of a culture we, as mountain professionals, foster in the larger mountain culture. The more incidents I observe, the more I am trying to come down on the side of being gracious. Being gracious is in the details, it's how we debrief accidents and what we tell our guests and students, but it's also what we tell ourselves. If we allow ourselves to believe that we aren't capable of mistakes that we would regret, our condescension will permeate everything we outwardly say.

There is another reason for being gracious. There is no standard for acceptable risk tolerance. There is a lot of freedom in the mountains – and while that freedom is something we all share, we use it very differently. I have kids, and I am a guide; and though I like skiing big terrain, I tend to be conservative about how and when I do that. Many of my friends come to the mountains as athletes: young, hungry and ready to charge. I have a lot of respect for that too. On March 7, Steve was totally engaged, I'm sure, but ultimately his risk/reward lines intersected a different place on the graph; he tolerated a high level of risk. Personally I don't think I could tolerate that level of risk – I would say at that level, "It's not worth it." However, I make peace with his decision to be there because I think to him "it was worth it." Not just on that day, but in his life: the reward was huge, so the risk was worth it.

I write all this to make a suggestion. As a group of passionate skiers, riders, and mountain people, let's recognize that these varying levels of risk tolerance are an integral part of the freedom of the mountains, and that risk tolerance is a deeply personal balance and choice. As leaders in our various mountain communities let's commit to being gracious, recognizing that our personal level of risk tolerance isn't, and shouldn't be, normative for everyone. We should continue to teach about decision-making and the finer points of snow science, but when tragedy does strike let's not use these lessons to castigate others.

Zahan Billimoria is an Exum Mountain Guide who lives in Jackson, WY. He is a full-time ski guide in the winter leading clients in Grand Teton National Park on human-powered big mountain adventures. Through Exum he also works as a guide for Teton Gravity Research, a Jackson-based film production company. In the summer he guides rock and alpine climbing in the Tetons, Wind Rivers, and surrounding areas. He and his wife Kim have two children: Gemma, age five, and Alyosha, age eight. ❄



AVALANCHE CHARACTER

continued from page 14

avalanche character as a primary component in the formal communication of avalanche hazard in public safety products is a relatively new concept. Based on our anecdotal experience, we believe there is a considerable lack of understanding of the concept of avalanche character among public recreationists. While recreationists appear to understand there are different kinds of avalanches, they do not seem to fully grasp how avalanche character relates to a problem as a whole and the danger rating in particular, and – more importantly – how to use this information to make a better, more informed decision about managing risk.

Avalanche character is also new to recreational avalanche course curriculum. The adoption of products, such as the *Decision-Making in Avalanche Terrain* field book *(Haegeli, Atkins & Klassen, 2010a)* that support teaching avalanche character and its role in decision-making has been slow. This suggests some avalanche course providers in Canada are likely not fully conversant on the subject and less than fully familiar with the link between avalanche character and decision-making.

Public forecasting agencies using avalanche character to describe avalanche problems need to ensure they provide the background information users need to understand what avalanche character means and how it applies to the hazard assessment and risk management process. This can be done by way of hyperlinking on websites, providing access to reference documents, using consistent terminology in forecasts and other communications, writing informative articles and blogs, etc. See the CAC's Avalanche Problem Essentials series *(Haegeli, Atkins & Klassen, 2010b)* at avalanche.ca/cac/ pre-trip-planning/ as an example.

It's also very important that recreational avalanche course providers be familiar with and include in their courses the concepts of avalanche character, its role in the avalanche problem, and its link to decision-making so students can effectively utilize this information in their risk management strategies.

In addition to using the concept of avalanche character in avalanche bulletins, more effort should be put into clearly explaining the background and the benefits of the concept to recreationists and recreational avalanche course instructors.

SUMMARY

Including avalanche character in public avalanche safety products adds value and enhances decision-making support and risk management for users. However, it is a new approach for communicating avalanche hazard that continues to evolve as more agencies adopt it and more thought is put into its role and application. This means all who use it or who plan to implement it should collaborate and cooperate to en-sure common practice and industry standards are developed. Most important, it's essential that recreational avalanche course instructors be-come conversant in the topic so users are well educated and can effectively utilize this information to improve decision-making and better mitigate risk.

Agencies planning to adopt avalanche character should carefully consider how to implement this change. There are a number of factors to take into account, some of the most significant ones being:

- Consider consulting with those agencies that have expended time and energy establishing the concept, standardizing terminology and definitions, and developing various tools to implement and teach avalanche character.
- If you plan to use icons to depict avalanche character, consider contacting the UAC and asking for permission to use theirs. This will help standardize iconography.
- Work with your forecasters to ensure they are trained and knowledgeable before they are expected to incorporate avalanche character into their forecasts.
- Be prepared to provide users with the information they need to effectively use avalanche character when you incorporate it into your products.
- Ensure you familiarize educators with the concept so avalanche character is incorporated into the curriculum of recreational avalanche courses.

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