THE Avalanche REVIEW

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THE Urban AVALANCHE PROBLEM

in this issue

Mt. Jumbo, Missoula: On Friday, February 28, 2014, an arctic air mass spilled over the Continental Divide, slid down the Blackfoot and Clark Fork river valleys and delivered subzero temperatures, heavy snowfall, and high winds to the Missoula area. The storm arrived a few days after near record-breaking snowfall was recorded for February in Missoula. The heavy snowfall caused many transportation issues and school closures and lured skiers, tubers and snowboarders (the Missoula Police Department described them as snow enthusiasts) to the surrounding and rarely skiable foothills terrain on Mount Jumbo and Mount Sentinel.

Many of the residents living at the base of Mt. Jumbo did not realize the steep grassy hillsides above their homes have the potential to be avalanche paths; in fact there is no written or recorded history of an avalanche ever hitting the valley floor. With the unusual weather and blizzard conditions, fetch areas on Mt. Jumbo loaded from the snow and wind. With forces aligned, the stage was set for what followed.

The only missing ingredient was a trigger.

(Continued on page 18)

Story and Cover Photo by Steve Karkanen

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from the president

Purpose: it's what we seek in life. Purpose is how we find meaning in our work, relationships, and creativity. Purpose is what gives us direction, intent, and meaning. For many of us in the avalanche profession it truly is purpose that drives and motivates us to return to the mountains each winter. We find our greatest joy when we make a difference, when that purpose is met.

The American Avalanche Association recently refined its purpose. Having a clear purpose keeps us on track to deliver our mission and support our goals. Professionalism and excellence in avalanche safety, education, and research are key components of our mission. In the coming months we will further explore these components. Changes to our education guidelines are in the works. Research grants continue to foster new ideas. Avalanche.org has recently seen some great improvements.

TAR editor Lynne Wolfe and AAA president John Stimberis discuss some of the benefits of being a AAA member at the annual meeting at ISSW. *Photo by Doug Richmond*

We are also looking into new ways to not only better define our purpose but also to deliver more for our membership. Doing more takes more, and we are actively considering new ways to raise funds to support these projects. One potential avenue is to pursue grants with the help of a consultant. There are a number of issues on the horizon and we feel it is important to stay on top of these issues and offer guidance and leadership.

Establishing a professional track to the education guidelines will eventually promote better professionalism in our field. We expect improvements to professional training will lead to improved safety in the workplace. Workplace safety is a growing concern for many of us, especially as OSHA and L&I begin to look more closely at our workplaces. Each state may approach the issue with different ideas. As a professional association we need to have a clear vision about what safety guidelines will best serve our interests while keeping us as safe as possible. Look for more information about these issues in upcoming editions of *The Avalanche Review*.

I hope you all have a safe and enjoyable winter. Feel free to contact me at: aaa.stimberis@outlook.com

—John Stimberis, AAA President

THE AMERICAN AVALANCHE ASSOCIATION PROMOTES AND SUPPORTS PROFESSIONALISM AND EXCELLENCE IN AVALANCHE SAFETY, EDUCATION, AND RESEARCH IN THE UNITED STATES.

from the editor

Coming home from ISSW, my brain is always full. I've encountered too much information to process and absorb, and it's hard to know which pieces lead to action. I need a good teacher or interpreter to take the *What* (what was said or done), move it into the *So What* realm (what does this mean?) and from there, make the practitioner's leap to *Now What* (how do I incorporate this into my patterns and rituals?). I see the *The Avalanche Review* as an interpreter, giving you some tangible *Now Whats* to take to your practice. We savor that role, and wholeheartedly thank everyone who has written for TAR over the years; in this issue I especially thank the ISSW report authors, who agreed (sometimes with a little arm-twisting) to write up highlights and observations. They're our interpreters; for example, I read Zach Guy's piece on news in the fracture mechanics world, and find that he has stitched together individual presentations into better ways to look at the relationship between the slab and the weak layer so that we forecasters, guides, patrollers can understand.

I want to underline an observation that Doug Richmond first noted in his ISSW report on page 29 of this TAR: uncertainty has recently gained a prominent place at the table in our current conversations about snow and avalanche risk and decision-making. It's an observation that's helped me see one of the common threads amongst ISSW talks and many other aspects of the avalanche dialog. We're using the term uncertainty in our level 1s, our science-geek conversations and our advisories; we're telling all levels of students to minimize uncertainty by gathering more focused observations. In a recent article for the Montana Snowmobile Association (http://www.mtavalanche.com/articles/media/14/minimizing-uncertainty-backcountry), Eric Knoff introduces his theme:

> A great way to increase the margin of safety in the backcountry is to reduce uncertainty about snowpack stability by gathering meaningful information that is relevant to the day's riding plan.

You'll find mention of uncertainty in almost every ISSW report in this TAR. Honoring uncertainty helps us remove hubris from the equasion and maintain our humility. With every ISSW paper and poster, we find better and smarter ways of describing the avalanche dragon, but uncertainty lingers and consequences loom.

Looking at stark consequences from a spring 2014 avalanche cycle, we'll begin our examination of the urban avalanche problem with a frontline view of Mt Jumbo, Missoula, from Steve Karkanen. For more on the theme, we have a look at zoning and avalanche issues in Ketchum from Janet Kellam; observations on Juneau's neighborhoods and FEMA from Tom Mattice; thoughts from planners Art Mears and Chris Wilbur; a glance at how the Swiss have organized their problem and solutions from Stefan Margreth of the SLF, and finally, some succinct thoughts on the urban wildland interface from Mr Em. We hope that this collection of articles can be useful not only to the avalanche community, but also to planning and zoning professionals as they recognize their avalanche problems and then craft consistent zoning regulations and code.

In addition, we have a couple of wry perspectives on decision-making as Doug Krause presents part two of his Situational Awareness series and Leighann Falley cautions us to continue thinking and questioning even as we see the usefulness of the Checklist. Don Sharaf graciously agreed to share his methods of forecasting for a heli-ski operation when plagued by an unruly layer of Chugach facets.

These days I'm diving deep into avalanche topics: planning schedules, classes, themes, issues, and AAA projects. For example, Jaime and I plan to revitalize the AAA Mentorship project this winter: stay tuned and contact either of us for details or to offer ideas. In addition, I want to ask readers a question for the April TAR:

How do you train intuition?
Send me your tricks, tips, tools, and insight.

Happy winter!

—Lynne Wolfe, Editor

aaa news

Congratulations to the following new AAA Members:

Professional Members:
Aaron Richards – Bishop, CA
Benjamin Hatchett – Reno, NV
Jeff Eckland – Kirkwood, CA
Davy Gunn – Tahoe City, CA
Tucker Cunningham – Tahoe City, CA
Zach Tolby – Carnelian Bay, CA
Andrew Ogden – Boulder, CO
Jake Gaventa – Nederland, CO
Karl Welter – Telluride, CO
Matt Brugge – Fraser, CO
Scott Clements – Durango, CO
Dan Starr – Jackson, WY
Dave Kikkert – Cottonwood Heights, UT
Eric Trenbeath – Moab, UT
Jenna Malone – Salt Lake City, UT
Jesse Quillian – Lander, WY
Josh Beckner – Salt Lake City, UT
Lindsey Fell – Bozeman, MT
Sean Wetterberg –Salt Lake City, UT
Ben Zavora – Cooke City, MT
Pat Hinz – Bozeman, MT
Shawn Orloff – Bozeman, MT
Tony Willits – Kalispell, MT
Bruce Goodlad – France
Davy Gunn – United Kingdom
Alan Jones – Revelstoke, BC
Gonzalo Valdes – Argentina
Gabe Finkelstein – Boise, ID
John Minier – Bellingham, WA

Member Affiliates:
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Kerry Hanes – Albuquerque, NM
Drew Pogge – Bozeman, MT
Bryan Taylor – Colorado Springs, CO
Owen Richard – Fort Collins, CO
Ian Bolliger – Berkeley, CA
Katreen Wikstrom Jones – Anchorage, AK
Matt Jost – Steamboat Springs, CO
Ryan Lewthwaite – Girdwood, AK
Matthew Hartman – Leavenworth, WA
Mathew Brunton – Anchorage, AK
Aaron Diamond – Honesdale, PA
Kyle Dungan – Bellingham, WA

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Donors, July 2013—September 2014:
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Owen Richard – Fort Collins, CO
Keith Roush – Durango, CO
Scott Savage – Stanley, ID
Craig L. Sterbenz – Telluride, CO
Scott M. Toepfer – Breckenridge, CO

Got an Idea? Get an AAA Grant.

Story by Kevin Hammonds

Only about a year ago now, I was sitting in our weekly research group meeting at Dartmouth College, listening to one of my fellow students present her latest laboratory results pertaining to snow metamorphism, when I had the sudden epiphany, as any good snow and avalanche geek would, of how with only minor modifications her experiments could also potentially be applied to better understanding weak layer development in a snowpack. Fast forward to just a few weeks ago, and I was presenting the results from this subtle twist on her research to a full house in Banff, AB at the 2014 International Snow Science Workshop (ISSW). "How did this happen in such a short time-frame?" you may ask. Well, in addition to a lot of extra hours spent in the Dartmouth Ice Research Laboratory over the course of this last summer, it was primarily made possible by a research grant awarded on behalf of the American Avalanche Association (AAA). To read more about the research experiment itself, please see the link at the end of this piece, but to read more about how one small grant can have lasting impacts, just continue to read-on below.

Because my formal Ph.D. research in Materials Science and Engineering is actually more related to studying the effects of chemical impurities on the mechanical properties of solid polycrystalline ice (like sulfuric acid deposited on glaciers and ice sheets), it was not necessarily an easy sell to also be able to get deeply involved in a somewhat unrelated study on the occurrence of kinetic snow metamorphism near ice crusts in a snowpack. What really made this all possible was, quite literally, the award of the Theo Meiner's Research Grant from the AAA. Once armed with this grant, which in reality is also a formal endorsement from a very well-respected group of avalanche scientists and practitioners, I found that I had the backing needed to not only make a sound case to my academic advisor for why this research was important and should be performed, but was also able to use it as a tool to begin a dialogue with the other local folks interested in studying snow and ice at the nearby Cold Regions Research and Engineering Laboratory (CRREL). Once this conversation had begun, I was able to quickly pick up additional collaborators and funds to help purchase the additional materials needed for the experiments I wanted to carry out. But the snowball of research on the horizon didn't stop here, I was also able to find additional collaborators within my own department, who with a different set of expertise from my own were able to very nicely compliment the research and make it more efficient overall. So, with collaborators and funds for the experiment figured out, the only other component necessary was simply fulfilling the agreements in accepting the grant, which primarily involved travelling to the 2014 ISSW to present the results from our research. For this, I was also able to use the broad banner of the AAA to apply for travel funds that were ultimately granted from the Dartmouth Office of Graduate Studies. All told, of the approximate $5000 I needed to do the experiments and travel to ISSW, the AAA had provided a modest monetary sum of $1250, but with the leverage afforded to me via the AAA, I was then able to quite easily cover the difference from additional resources, not to mention pick up additional collaborators and build new relationships along the way.

However, doing good research is not just about acquiring the funds it is also about carrying out the work itself. This can be the most daunting aspect, as the act of physically turning an idea into reality, in my own experience, does not usually go as smoothly as you may have anticipated at first. But it is imperative at this wobbly stage that you persevere and stick to your original plan, as outlined in your proposal, while reminding yourself that you would not have gotten funded in the first place had your idea not been thought to be realizable to some degree. Furthermore, you are hopefully somewhat already well-versed in the most relevant research to your own research topic and you can look to these already proven and published works for additional guidance if you are not sure about your next steps or are not able to immediately make sense of your results. This is exactly why peer review and publication is so critical to scientific advancement in so many different fields, as it important that we collectively build on each other's accomplishments rather than inadvertently recreate them. For our project, I was able to consult the previous work of Ethan Greene, now Director at the Colorado Avalanche Information Center, whenever it was unclear if what we were seeing in our results was physical or if we could reasonably neglect certain terms in our calculations.

In the end, I couldn't have been more proud and pleased with how are research turned out and having the opportunity to give an oral presentation on our results at the 2014 ISSW, was an absolute honor. With that said, there remains much to be done related to our particular topic of research, but it is my hope that for now at least we were able to make a small contribution to this process…all thanks to a grant from the AAA.

Some Suggestions for Potential Researchers:

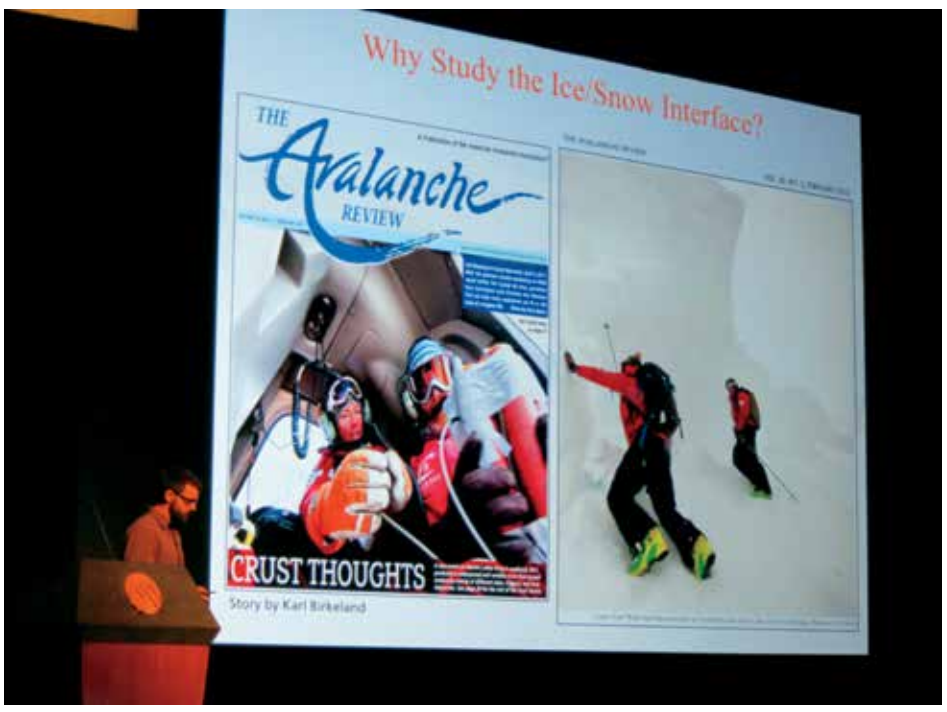
1. If you have a research idea that you think could make even a small contribution to the field of interest and it is worthy of your own blood, sweat, and tears… then submit a grant proposal to the AAA.

2. Even though these AAA research grants can be highly competitive for modest amounts of funding, the leverage that they can afford you to go out and get all the other aspects of your research covered can be significant.

3. If not awarded a research grant your first time around, don't give up, rather think about collaborating with other researchers that may have additional ideas or infrastructure that will make your proposal more competitive in the future.

4. If you do not have access to academic journals, reach out to those who do, or work primarily from prior ISSW proceedings, which are freely available online.

http://sites.dartmouth.edu/khammonds/ —*Kevin Hammonds*



Author Kevin Hammonds uses material from TAR 30.3 *(photo Chris Morin)* in his Ph.D work that led to this ISSW 2014 presentation. *Photo by Doug Richmond*

aaa news

ISSW 2014 Awards Report

Story by Halsted "Hacksaw" Morris; Awards and Memorial List Chair

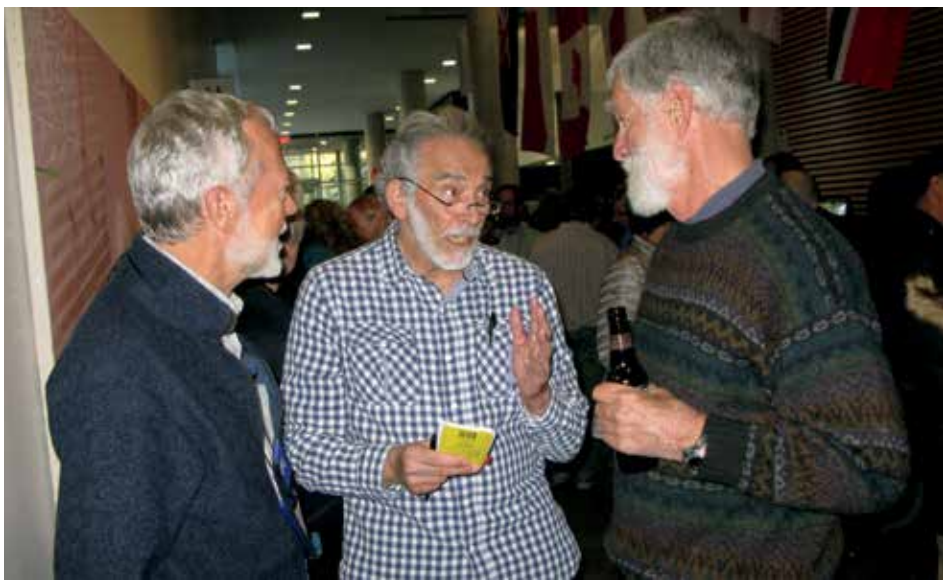
This year the American Avalanche Association gave two awards at the ISSW Banff banquet dinner. The first award was an Honorary Membership to Ron Perla. The second was an Honorary Fellowship award to Bruce Jamieson.

Don Bachman read the citation and presented the **Honorary Membership award** to **Ron Perla**. The co-nominators for this award were Rod Newcomb, Art Judson, Bruce Jamieson and Karl Birkeland. The Honorary Membership award is the highest award given by the AAA, and recognizes a long record of accomplishment in North America avalanche-related activity. Ron had previously received the Honorary Fellowship award in 1991.

"Ronald Ivan Perla is an avalanche pioneer; an elder of that 1st generation of avalanche hunters who established the principles, protocols and practices that define avalanche science to this day. "

Perla was a graduate student at the University of Utah in the early 60s when he joined US Forest Service Alta Snow Ranger team of Binx Sandahl, Will Basset and Ray Lindquist. In 1966 he moved over to Ed LaChapelle's Lab at the USFS Alta Avalanche Study Center, and assumed a duel role of field specialist and researcher. His famous rope-snapping descent of the Baldy Chutes, April 1967 in a large avalanche nearly deprived us of the AASC Snow Safety Guide No. 1, Modern Avalanche Rescue - 1968. The AASC mission was soon consolidated with the Alpine Snow and Avalanche Project at the USFS Research Station in Fort Collins, Colorado, which he joined in 1971. He received his PhD from the U. of U. Department of Atmospheric Science that same year. His thesis, *The Slab Avalanche*, is a seminal work and is still referenced as authority for many subsequent research projects and theses.

While at Fort Collins he was lead author of a completely new edition of the Avalanche Handbook, AH-489, and developed the first National Avalanche School curriculum which debuted at the Reno, NV venue in December, 1971. In 1973, Perla initiated and helped organize a tribute symposium for colleague Monte Atwater at Yosemite National Park. The following year in 1974, Perla realized that operational avalanche research opportunities were perhaps more enduring in Canada, and he left the Forest Service avalanche program and joined Environment Canada – Glaciology Division. The first International Snow Science Workshop was convened here in Banff by Perla and Schaerer in 1976.



Ron Perla shares a story with Art Mears, right, and Krister Kristensen, left.
Photo by Don Bachman

Perla's numerous research papers and publications included such subjects as snow and grain properties, snow liquid water, temperature gradient measurement, snow crystal photography, slab shear strength, avalanche release, hazard evaluation and safety, wet snow, explosives and notably, the PCM and PLK Avalanche Dynamics Models.

Dave McClung, an early Canadian colleague feels Perla exhibited true brilliance in the work we honor him for; "…which places him a few standard deviations above the mean!"

Karl Birkeland presented the **Honorary Fellowship award** to **Bruce Jamieson**, who was completely surprised by the honor. The co-nominators were Rod Newcomb, Ethan Greene, Ian McCammon and Doug Chabot. The Honorary Fellowship award recognizes the contribution of an individual who has contributed significantly to avalanche-related programs in countries other than the US.

"Bruce has been one of the leading figures in avalanche research applicable to practitioners over the past several decades. I recently looked through the digital archives of ISSW proceedings and found that he has authored or co-authored 85 ISSW papers, not including those from this conference. He has shared his work both nationally and internationally, not only through his numerous papers, but also his presentations and – more recently – his videos. He typifies what the Honorary Fellowship Award recognizes: an individual who not only has contributed significantly to the quality and success of snow avalanche related programs in Canada, but who has also effectively communicated that work to practitioners in the U.S. for the common benefit of us all. I cannot think of anyone more deserving of this award.

Bruce's enduring legacy will be at least threefold. First, his volumes of research on numerous important topics will serve as a baseline for future research as well as providing avalanche educators with important material for many years. Second, the datasets amassed during Bruce's tenure will continue to be mined to help untangle the mysteries of avalanches. Finally, Bruce has mentored a large number of graduate students and post-doctoral researchers who continue Bruce's work and who are spread throughout our industry in many different countries.

And, perhaps more importantly, Bruce is a genuinely nice person and a good friend. Heck, he even got me back on a snowboard after many years on skis! It gives me great pleasure to be able to present this award to him in Banff, 18 years after he chaired the highly successful 1996 ISSW at this same venue. Thank you, Bruce!"

Both Ron and Bruce were presented small trophies that were hand-crafted by Lisa Issenberg of Kiitella awards. Lisa is connected to the avalanche community as she is married to Jerry Roberts, former CAIC Red Mountain Pass forecaster.

Karl Birkeland told me that it was great to present these awards in front of their "home crowd." As much as ISSW is about, a merging of theory and practice; it's also about people. Getting to recognize these leaders in our community is another aspect of ISSW.

Bruce Jamieson shows off his Honorary Fellowship award at the ISSW banquet.
Photo by Halsted Morris

Halsted Morris is not only the awards chair for the AAA; he is the new Vice-president and engaged to be married. Congrats Hacksaw on both points! ❄

UAC Safety Award

The Utah Avalanche Center received the Forest Service Intermountain Region Culture of Safety Award. The Intermountain region includes several National Forests in Idaho, Wyoming, Utah and Nevada. Regional Forester Nora Rasure presented the award to Utah Avalanche Center Director Bruce Tremper at a regional meeting in Ogden, Utah, on October 22, 2014. The wording on the award:

"The Utah Avalanche Center embodies the safety culture we are all striving for with their continued dedication and innovation in providing tools, training and information to winter recreationists around the world to prevent avalanche injuries and fatalities."

metamorphism

New Hires in the Avalanche Industry

The **Colorado Avalanche Information Center (CAIC)** has added a couple new faces to its roster for this season, with several other changes occurring as well. Many of these changes were precipitated by the upcoming retirement of Rob Hunker, who has worked as the forecaster for highway passes on Colorado's Western slope since 1994. Rob's snow safety career started in 1970 at Crested Butte Ski Area. He moved to the CAIC when it was established and developed the forecasting programs at McClure Pass and several other Colorado highways. Among the most memorable parts of his career were a three-week work trip to SLF in Davos and several challenging droughts. He is an accomplished pilot, photographer and boater and is excited to travel with his partner Lisa Wagner from their base in Redstone.

Becs Hodgetts, who was the Vail/Summit and Sawatch backcountry forecaster last season, will fill a new position as a highway forecaster based out of Leadville. Her primary responsibilities include Battle Mountain, Twin Lakes and Fremont and Monarch Passes. After nearly 15 years living in Summit County, she'll be moving to Buena Vista, where the mountain biking trails are open more of the year. Anyone who's raced bikes against Becs knows this means watch out.

Ian Hoyer steps in behind Becs as the new Vail/Summit and Sawatch backcountry forecaster. His varied background includes stints as a researcher, ski patroller, and avalanche educator. Over the last two winters, he dug a lifetime's worth of pits while researching the spatial variability of the ECT as part of completing his MS in Snow Science from Montana State University. He patrolled at the Yellowstone Club in Big Sky, MT. He has also worked as an avalanche educator for the Gallatin National Forest Avalanche Center (GNAFC) and learned the joy of snowmobile powder turns while interning with the GNFAC forecaster's around SW Montana. When not out in the snow, Ian enjoys baking bread, tandem bicycling and trying to keep up with his dog.

Colin Mitchell takes over the highway programs west of the Sawatch Divide from Rob. He has been skiing and climbing in the Rockies for the past 20 years. After many seasons working as a ski patroller in Colorado, he has spent the last few years chasing snow and avalanches in faraway places, working as an avalanche forecaster and educator in South America, and as the snow safety officer for Gulmarg Gondola in Kashmir.

Welcome to **WYDOT:**

Photo by Karl Kelley

Brian Gorsage joins the staff of the Wyoming Department of Transportation as an avalanche technician. He comes to Wyoming with over 10 years as a avalanche professional. Brian grew up in Denver, Colorado and started his snow career chasing powder in Alta, UT. There he spent 7 years working as a professional ski patroller at Snowbird Ski and Summer Resort. In Utah, Brian taught the Know Before You Go avalanche awareness program and Outdoor Emergency Care courses. He was also involved in the Wasatch back country rescue program. During the summer months he consumed his time with mountain biking, golfing and working as a finish carpenter. Brian spent the last three years working in Lowman, ID for the Idaho Transportation Department as an avalanche forecaster. Lowman is where Brian acquired a solid foundation for highway forecasting and is looking forward to contributing to WYDOT's strong staff.

Congratulations to **Sawtooth National Forest Avalanche Center** new hires Brad Carpenter and Lisa Portune.

Brad Carpenter hails from the great state of Montana where he spent most of the last several seasons working as a ski patroller and then Snow Safety Director at Moonlight Basin in Big Sky. In recent years he has divided his time between Montana and the tropical South Pacific archipelago of New Zealand where he works as the Snow Safety Officer at Porters Ski Area and as a public avalanche forecaster for the New Zealand Mountain Safety Council. In between winter seasons, Brad enjoys as much sunshine as humanly possible, preferably on random polynesian beaches or on long trail runs in the beech forests of New Zealand. He is very excited to be a part of the Sawtooth Avalanche Center forecast team.

Lisa Portune worked as a forecaster from 2005-2011 for the CNFAIC in Girdwood, AK and most recently as a wilderness ranger in the North Cascades. Ten years in Alaska taught her the more snow sliding tools in the quiver, the better...skis, splitboards, skate skis, ice skates, snow kites, etc. She is looking forward to working in a totally different snow climate, especially one without breakable rain crusts.

divas

This year's Avalanche Divas event was coordinated by Canadians Lisa Paulson, Emily Grady, and Anna Brown. The event was at the Dancing Sasquatch in downtown Banff on Wednesday evening, and had a hundred attendees who applauded the new and past Divas, ate and drank, then visited and danced the rest of the evening. Thanks to Diny Harrison for her services as MC. Special recognition is given to David McClung who danced every song with a variety of Divas.

Congratulations to this year's Divas; Sarah Carpenter, American Avalanche Institute, Victor, Idaho; Kirstie Simpson, Avalanche North in the Yukon; and Mylène Bonnefoy-Demongeot of IRSTEA, Grenoble, France.

This year's Divas were ready to party! *Photo courtesy Lisa Paulson*

Sarah Loves Snow

Photo by Mark Fisher

Sarah Carpenter is a vibrant new addition to the ranks of the Avalanche Divas. She's been in the snow for most of her life, starting at 3 or 4 years old in New Mexico, where she grew up.

Young and determined, she would hitchhike to the ski area in junior high and high school- her folks would write down the car license plate numbers, and the road dead-ended at the ski area. She went on to get a French degree from Montana State University in Bozeman, Montana, as it was the quickest way to graduate, she was able to live in France for a semester as well.

She took her first avalanche class winter of 97/98 from Karl Birkeland and Ron Johnson through MSU, took a WFR that same year and an EMT course the next year. She started ski patrolling for Fay Johnson at Bridger Bowl in Feb. 1999, patrolled 1 ½ years at Bridger Bowl, where Fay Johnson was an amazing mentor, as were Doug Richmond, Peter Carse, Dean Brandt. Then she patrolled 1 year at Yellowstone Club, whereTom Leonard was a huge, influential mentor. Sarah then started working for NOLS summer of 1999, where she worked hiking, mountaineering, canyon and winter courses.

She married Don Carpenter in 2004, started teaching avalanche courses winter of 2003 or 2004 with Don Sharaf (who took her under his wing) and with Lynne Wolfe (another one who took her under her wing), started ski guiding for Yostmark a year or two later, started teaching for AAI in 2006 or so. Then in April 2009, she and Don Carpenter and Don Sharaf bought AAI from Rod Newcomb, where they both carried on Rod's traditions and brought the school up to date.

Since that time, she has built a straw bale home by hand with her husband Don in 2005, started ski guiding at JHMR in 2007, and was awarded her AMGA ski certification in April 2011. Inbetween those dates, she chaired the Education Committee at the American Avalanche Association, where she started and managed the new AvPro course, among other achievements.

Along the way she has endured seven knee surgeries and one ankle surgery, while maintaining a consistently positive attitude and high level of fitness (thanks to the rowing machine- one leg on a skateboard off to the side).

Sarah is badass and hardcore, but also has a soft side: she helped a friend give birth; she loves crafts with kids and cherishes the AAI kids avalanche classes above all other educational endeavors (see her poster at ISSW 2014). She's a great mentor for those entering or even continuing their career in the avalanche and snow guiding world, and a worthy Diva.

—Lynne Wolfe

Kirstie Simpson

Kirstie Simpson has been a ski patroller in Yukon Zone since 1994; she has dedicated herself to avalanche education in the Yukon and beyond. This effort has earned her several ski patrol division awards as well as a National Appreciation Award in 2001 and a Canadian Ski Patroller Award in 2007, plus a special contribution award from the Canadian Avalanche Association for her contribution to education and awareness in the area of avalanche safety; the National Search and Rescue Secretariat's Certificate of Achievement in Recognition of Service to Search and Rescue in Canada; and the government of Canada's Award of Excellence for Exceptional Contribution to the Public Service. In addition, and of note to Kirstie personally, is her recognition in 1998 of a "Woman Educator" by the Yukon Women's Directorate.

Kirstie is an active member of the Canadian Avalanche Association and Yukon Avalanche Association, where she has been the lead in securing an $800,000 federal grant to improve avalanche safety in Yukon. She has brought Yukon Zone on as a full partner in avalanche programming and has also mentored other ski patrollers as avalanche educators.

Kirstie has been the Yukon's most prominent avalanche training course provider since 1991. As a member of the Canadian Ski Patrol, Kirstie was involved with the curriculum development of the Canadian Avalanche Centre's Recreational Avalanche Course (RAC), now the Avalanche Skills Training (AST) course and is committed to providing a national standard curriculum for courses that ensures skiers get the most up to date information combined with an intimate local knowledge of the Yukon snowpack and terrain. Most recently, Kirstie was on the avalanche education team that developed the new avalanche module in the Canadian Ski Patrol manual. In this capacity, she was the key contributor with her extensive background and experience in avalanche education and awareness.

Kirstie has been a leader in the provision of public avalanche safety messaging and programs in Yukon and Northwest British Columbia for more than 20 years and the Avalanche Divas are proud to have her join their ranks.

Mylène Bonnefoy-Demongeot

Mylène Bonnefoy-Demongeot is from Grenoble, France, where she works as a ski patroller and avalanche control specialist at the ski resort Les 7 Laux (Alps). In addition, she is avalanche mapping technical coordinator and manager at Irstea, Grenoble (Alps) She has a master's degree in mountain land-use planning, in addition to a good knowledge of GIS and database software (Arcgis, Grass, Access, SQL Developer) She also has aerial photograph and field expertise, investigation and eye-witness accounts collection experience.

She also is a participating member of the proofreading committee for the ANENA journal (ANENA: French National Association for the Study of Snow and Avalanches) and has participated in informal science and avalanche education for high school students and specialized technical students. She was co-organizer of the Avalanche Divas night at the Grenoble ISSW.

She is a mountaineer, rock climber, ski mountaineer, ski patroller, and Mom. Welcome to the ranks of the Avalanche Divas! ❄

what's new

At ISSW we had 102 AAA members attend our annual membership meeting.
Photo by Craig Sterbenz

Changes In The Locations Of Future Issws

Story by Rich Marriott

The ISSW Steering Committee met twice during ISSW 2014 and covered many important topics. Most of these will be covered in a future article in TAR. However, one of the decisions is a major change affecting the locations of future of ISSWs and it's important to report it as soon as possible.

The Steering Committee wrapped up a four-year debate on the geographical rotation of ISSW. At ISSW 1984 in Aspen, the Steering Committee decided on a geographical rotation of US-US-Canada in even years which has been followed through this year. However, in 2009 and 2013, ISSWs were held on a trial basis in Europe with great success. It was proposed at ISSW 2010 to make Europe part of the regular rotation. (You can find the full history of this question in last April's TAR in the article "The Future of European ISSWs"). After much debate, both online prior to ISSW and in Banff, the Steering Committee voted to rotate the "right of first refusal" between the US, Europe, and Canada. The right to host ISSW will be offered to locations within a geographical region. If there is no group willing to host ISSW, it will then be offered to the other regions. Beginning in 2016, the rotation will be US – Europe – Canada. It was noted by the Steering Committee that this was approved on a trial basis.

The next ISSW was previously approved and will be held in Breckenridge, Colorado, October 3-7, 2016. A group from Innsbruck, Austria presented a proposal to the Steering Committee in Banff to hold ISSW 2018 in Innsbruck. This proposal was approved. The dates for ISSW 2018 have not been firmly decided yet but will probably be either September 15-21 or September 30- October 5, 2018. The right to host ISSW 2020 is open to sites within Canada. The right to host ISSW 2022 is open to sites within the US. ISSWs are usually awarded four years in advance; however, proposals can be considered earlier. Groups interested in hosting ISSW in the future can contact the Secretary, Rich Marriott at isswsteering@gmail.com

In other news, the ingestion of ISSW 2014 papers into the Montana State Digital archive is hoped to be completed by the end of the year. If you need a copy of a paper immediately, contact Rich Marriott at isswsteering@gmail.com . In the meantime, remember to visit www.issw.net for the latest updates on ISSW, access to all of the ISSW Papers from 1976 through 2013, plus the archived ISSW Websites and the history of ISSW.

Have a safe winter!! ❄

2015 AVPRO Dates

The American Avalanche Association is pleased to announce this year's AVPRO course location and dates

This season AVPRO will be returning to **Summit County, Colorado, February 25 - March 4, 2015**. Summit County holds a rich history within the avalanche industry. Students will learn from several of the top avalanche professionals in the region in one of the most interesting snow climates in the nation. Details can be found at **www.americanavalancheassociation.org/edu_courses.php.**

Who should attend AVPRO? AVPRO is intended for all disciplines of avalanche professionals with a solid background in avalanche fundamentals, companion rescue, and basic snow assessment. The course will continue to build on this foundation of snow science with an emphasis on high level of companion and organized avalanche rescue, accurate and advanced snow stability assessment, and avalanche control programs and procedures. Other common questions and answers can be found at **http://americanavalancheassociation.org/pdf/AVPro_FAQs.pdf** or by contacting the AVPRO coordinator, Dallas Glass.

Join us this season for what will be an exciting time of learning and networking as avalanche professionals.

Dallas Glass
AVPRO Coordinator - Education Committee
American Avalanche Association
dallasglass@yahoo.com

SLF: International Advanced Training Course on Snow and Avalanches

Since 2000, every winter, avalanche professionals in Switzerland can participate in training courses offered by the SLF, an institute with a long and rich history of snow and avalanche research. Starting in 2015, the SLF will also offer an international training course allowing for a unique opportunity to gain new insight into the research performed at the institute. The motto of the course is "Practice meets science." A mixture of lectures and hands-on activities will allow you to acquire new knowledge and expertise. You will improve your observational skills in the field and your analytical capabilities in data interpretation and will be able to integrate novel techniques and methods into your daily work. The course is meant for people with at least some basic knowledge and experience in the field of snow and avalanches. The international setting will allow for a unique exchange among practitioners with various backgrounds.

When: 23 – 27 February 2015
Where: Davos, Switzerland
Who: avalanche forecasters, avalanche specialists and consultants, avalanche instructors, avalanche hazard managers for infrastructures, avalanche control services, representatives of institutions, private services and associations
Language: English
Organizer: WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland
Course topics:

- Physical and mechanical properties of snow
- Avalanche formation and avalanche dynamics
- Snow stability evaluation
- Avalanche forecasting
- Risk management and mitigation

The course is structured in two parts. The first part is a review of the basics on snow and avalanches. The second part of the course consists of two separate modules on **a)** snow stability and avalanche forecasting and **b)** avalanche safety and control. Elements of the course: Lectures, exercises, field days and discussions.

Further information and registration: **www.slf.ch/more/training**

Sign up until 31 December 2014 (limited number of participants).

Photos courtesy of SLF.

what's new

Snowmobile Avalanche Education: Thoughts from the International Snowmobile Congress & ISSW

Story by Drew Gibson

Mid-summer I had the pleasure of attending the 46th annual International Snowmobile Congress. Much like ISSW, the ISC is the industry's meeting of the minds; attendees include snowmobile club leadership, manufacturers and land use managers. These groups talk on a variety of topics and on the schedule for this year's congress was avalanche safety and education.

Though snowmobile-specific avalanche education exists both in the US and Canada, it is far from mainstream, and more exposure seems to be needed to reach this demographic of backcountry users. On day two, current educators, avalanche industry professionals, and snowmobile advocates took part in a panel to discuss the future of snowmobile avalanche education and to ask for ideas on how to continue to try to make an educational impact.

Industry insiders Matt Entz of Mountain Skillz, Mike Duffy of Avalanche1, and Brian Lundstedt of Tyler's Backcountry Awareness gave insight as to how they currently run courses and how we as educators and forecasters can cater curriculum and product. Their inside industry support is valuable due to their credibility as active snowmobilers and their contacts within the business. If one thing at all should be clear is snowmobilers want to learn from other snowmobilers.

A few other key things I noticed during the panel:

- Among some groups the "never go" fear culture is alive and well.
- More than a few representatives in the crowd raised their hands to preach this philosophy. This attitude will not allow the culture to become informed, only scared. As we know, we can get around this by teaching good planning, communication, observation, and terrain selection, especially since snowmobiles excel in flat terrain.
- As a snowmobile-specific curriculum is developed, outreach to current snowmobile instructors should be encouraged in order to share ideas and ensure we are spreading the correct message. One consistent curriculum is much more effective than many independent ones.
- The final question of the panel was "If you had to give people one piece of advice what would it be?" Audience members came up with some very different points than the panel and they were very specific: Turn on your beacon, carry a shovel, carry an EPLB. Though all valid points, the big picture was missed by the majority of the experienced riders. How do we put it in focus?

During the ISC, the overall attitude toward avalanche education was a positive one. Many riders expressed that they thought it was time to make a change in their user group and how industry partners are moving down the right path to spread the message. So I pose the question, "How do we as professional avalanche educators support this industry as they seek to make a change?"

ISSW Findings

AIARE held an Instructor Refresher Course the day before the ISSW began and during the afternoon session another panel discussion featured myself briefing the group on the ISC, Carole Savage-Milne on "What can we do to improve snowmobile avalanche education?" and Jeremy Hanke on "What are the opportunities for snowmobile education?"

Both Carole and Jeremy have a long history as snowmobile avalanche educators in Canada and the perspectives they bring to the table will greatly help in creating an effective snowmobile avalanche education program, though their thoughts may have raised more questions than answers.

Understanding and Teaching to the Culture

To get to the nitty-gritty of it, most educators do not understand the snowmobile culture and it is imperative that we do. To be an effective teacher we must inspire our students, we must show them that we have put in the time on the sled and we understand what it means to be a rider. The only way to do this is to ride. This is not for everyone, some educators may not agree with the usage of snowmobiles, so I would like to kindly ask those folks to pass along students to an educator who does ride and is willing to teach that student. Keep in mind, as educators we are hoping to save a life by sharing our experience and skills, we cannot ignore a user group.

Many believe that the money aspect of obtaining education and safety equipment is far less of an obstacle for riders than the time commitment. Many riders do not want to spend three whole riding days taking a traditional Level 1 course. How can we cater a course to maximize their learning and to get them riding? Can a course be taught in only two days? Are there any distance learning opportunities to front load information before their arrival for field work?

With a snowmobile-specific course comes snowmobile-specific photos, videos, and diagrams. This helps with a frame of reference for the student and shows them that these techniques, observations and skills are applicable and they can then model themselves after what they have been shown.

Focus on Terrain Management and Communication

Being that the travel speed of a snowmobiler is much faster than a skier, more emphasis needs to be put on how riders position themselves in terrain and less on in depth snowpit observations. As outline by Sean Wisner, Mike Buck, and Sarah Carter in TAR Vol. 28 #4 there's a variety of slope tests that can be completed while riding, giving more insight to layer interaction. By focusing on recognition of hazards through better, more focused observations we can then teach avoidance and in turn hopefully achieve prevention.

Communication while riding is impacted by engine noise and bulky helmets. Though radio systems are improving, riders may not be able to interpret what their partners are saying due to the aforementioned ambient noise. One proposal to help fix this would be a standardization of hand signals within the snowmobile community, rather than mixing hand signals from water sports, OHV use, rafting and tactical applications.

As the many snowmobile educators continue to collaborate and with the help of AIARE, we work towards an effective curriculum and a methodology to deliver it. This is an exciting venture and I would like to hear people's thoughts on the previously mentioned topics as well as any other snowmobile-specific topics. This is the outreach portion, how can we make snowmobile education more effective and more accessible?

Drew works as an avalanche forecaster, ski patroller, educator and guide. He currently sets skin tracks and burns gas in Summit County, CO. ❄

Avalanche Education Videos

The **Gallatin NF Avalanche Center** has videos posted from the last five years of their annual Professional Development Workshop (held each spring up in Bozeman). Topics include:

Avalanche Science (2014)
Lessons Learned (2013)
Decision-making and Psychology (2012)
Surprise Avalanches and Post Control Releases (2011)
Wet Snow (2010)

What a great resource for the avalanche community. Watch any / all of these here: **http://bit.ly/1wzHJJw**

Or search for the **Avalanche Guys** on **YouTube**.

decision-making

The Checklist Controversy

Story by Leighan Falley

As an avalanche educator and a newly minted flight instructor, I have had a lot of exposure to checklists lately. Of course, they have been implemented with success in aviation for as long as complex aircraft have been flying, but they are relatively newish to the decision-making process for outdoor recreationalists. Though I have taught avalanche classes under many different curriculums for many different organizations, one trend keeps making itself obvious: the increasing use of checklist-based decision-making. In fact, with the increasing pressure for regulation, certification, and accountability, it seems a trend throughout the outdoor industry in general.

Not too long ago, the unthinkable happened in an aircraft I was flying: the engine quit. The faithful thrum of the powerplant was replaced by the sound of wind on the airframe as my powered-flight airplane became a glider. I was at a pretty low altitude, and remained calm enough to estimate that I had about 30 seconds from that moment until a forced landing had to happen. So I implemented my emergency procedure checklist for engine failure, just as I had been teaching my students all summer. "The average person takes about twenty seconds to respond to an emergency in flight," an experienced CFI (certified flight instructor) told me some time ago. "Most of the time is eaten up by denial of the situation, and a lack of knowing what to do about it." I didn't want that to be me, especially as I couldn't really afford 20 seconds at the moment. I happened to be over a river with some large sandbars, and was able to successfully land the plane on one of them without injury to her or to me (I later took off from this spot). There was luck in the choice of sandbar, but the real reason that things turned out all right was the use of that checklist…in the order it was written, followed exactly. No, I did not pull out a piece of paper while I was trying to maneuver an aircraft in a dangerous situation: I had memorized it. Memorized and internalized and visualized to the point that it really did work when I needed it to.

The odd thing about this incident is that I had not been a fan of matrix-based approaches to problems, and still may not be. It has concerned me that we as guides and outdoor educators are being pushed to implement or follow increasingly complex proceedures. The National Park Service has been adding numerous requirements for concessions, fallout from accidents that have dubious relation to the accountability being implemented. Many guide companies are requiring AMGA certfication. A field book is a legal document, and can be used as evidence in court. More and more checklists are being added to the framework of avalanche classes. In an avalanche class in Utah, I realized that we were asking our level one students to complete no less than four different checklists during the course of a daylong tour. In almost every class came the dreaded question: "Do… you… use these?" On my own time, with my own partners, I love nothing more than to meet at a trailhead and wordlessly, seamlessly disappear into the backcountry. One of my favorite days in the mountains consisted of saying the only following two things: "What? Ok!"

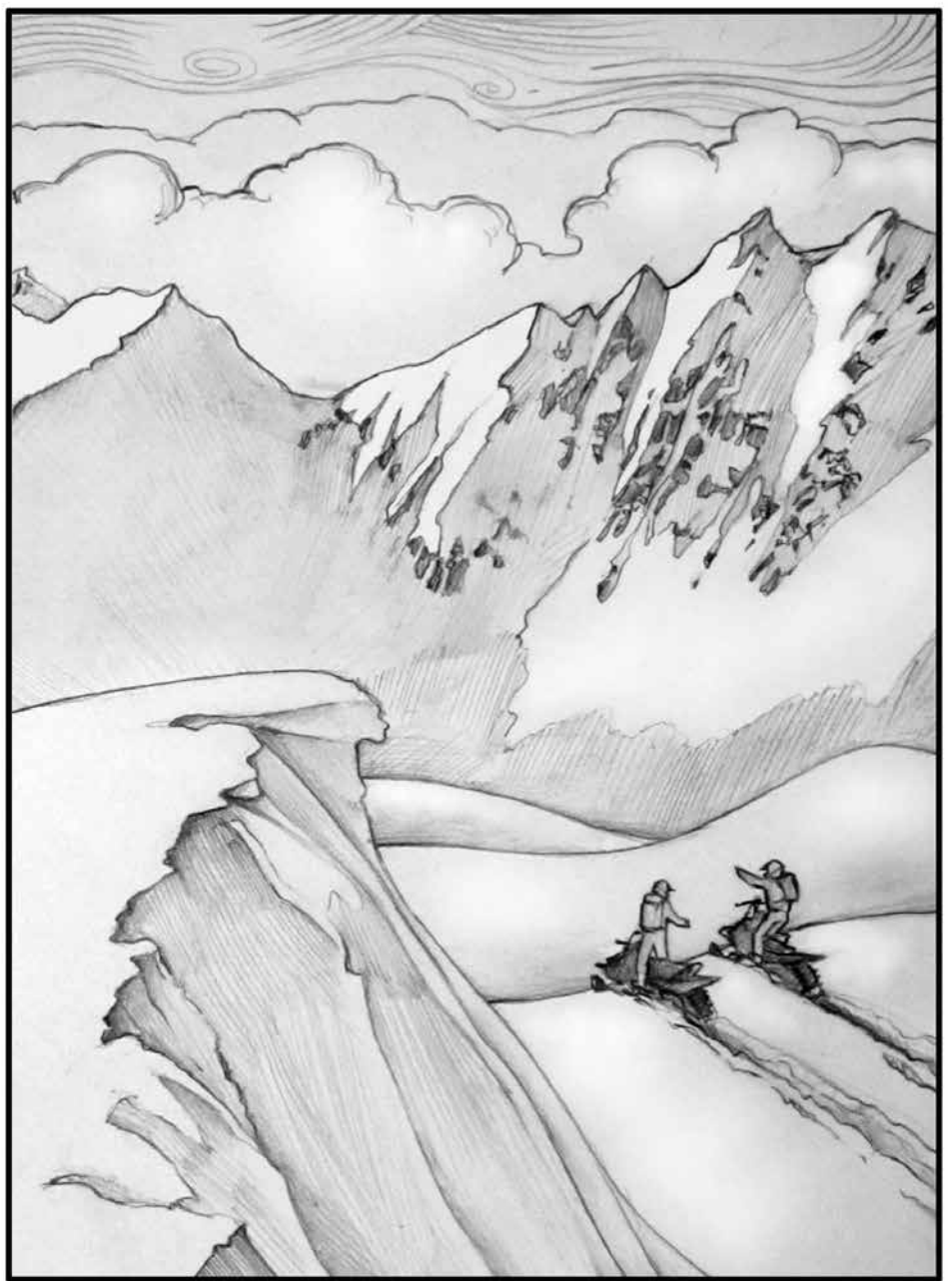
You might argue that my friends and I, being experienced backcountry travelers, had already internalized some version of the checklists I was pushing on my students. That we probably started from some rigid version of them until we gained enough experience to develop the intuition to move beyond them. And you would be mostly right. So here I stand, a pilot and backcountry user who has directly benefited from checklists. But something still bothered me about them, bothers me about the trend of increasing use by the outdoor industry. It bothered me to the point that I decided to investigate this checklist controversy within myself.

Several years ago, my husband was researching heuristics and decision-making processes for a talk he was to give in for the National Park Service. He started, as I suspect all avalanche educators do, with the papers written by Ian McCammon. McCammon's ideas have always been very helpful, but his bibliographies ended up being the real resource. We began to acquire books from this bibliography. They began to stack up against the desk, the walls, on top of the dresser. One rainy day, instead of doing my taxes, I idly picked up a copy of *Streetlights and Shadows: Searching for the Keys to Adaptive Decision Making* by author Gary Klein. Klein's book is essentially a 304-page rant against procedure. I was captivated.

The reason that my engine failure checklist worked so well was because the problem I faced was very obvious, with clearly identifiable hazards and limited courses of action. And because I had internalized it to the point where it was no longer a procedure: it was just something I did naturally. Its kin in the avalanche world would be the checklist for companion rescue. A checklist-hater could argue that such things are not even checklists anymore, but rather, the right reflexes applied at the right time.

But what about more complex problems that we face in the backcountry…such as "…what is the stability on this slope?" Or, "…is my group being influenced by human factors?" Are checklists appropriate for these kinds of issues? We hand them out to our students dutifully, implying that if you mind the things listed here you will come to a solution. But we all know that a good intuition beats a checklist any day.

Analysis and logic-based decision-making are a good place to start, but I wonder it can actually hurt the eventual path towards cultivating intuition. And what is intuition? The word gets thrown around as if it were some mystical property. However, Klein defines it as "…ways we use our experience without consciously thinking things out. Intuition includes tacit knowledge that we can't describe. It includes our ability to recognize patterns stored in memory."



Cover of the Alaska Avalanche School's new snowmobile handbook.
Drawing by Leighan Falley

Unfortunately, he implies that one must have experience, thus creating memory, in order to have intuition. And then there is the old saying that good judgment comes from experience, and experience comes from bad judgment. And we can only develop reliable intuition under the following circumstances: developing a holistic understanding of the problem (moving beyond rote) by being able to see results that corroborate our theories about the problem. Unfortunately, the latter is not always available in the backcountry. Have you ever asked yourself this question: *Did I just ski that rad line because I am awesome at judging stability… or I was I just lucky?* Tricky, tricky.

So where are we going to start? We are going to start with checklists. But I have seen well-meaning groups become so mired in following procedure that they fail to make it up the mountain. Failing to experience… well, experience. And for the less analysis-friendly, lets just say that more than once have I seen one of my handouts fluttering across the parking lot.

I believe in the following: getting out a lot, maybe having little epics, without killing yourself; giving avalanche students a checklist for black and white problems, and stressing the importance of seeking mentors; doing your planning, but making sure you still get some skiing in; and respecting the wise old uncertified guide.

Don't you hate when people highlight a problem without suggesting a solution? I am afraid that I am doing just that: this article is merely my ruminations and not suggesting anything definitive for our backcountry users. However, I will conclude by paraphrasing Klein: Analysis-based thinking works great for well-ordered problems, problems such as companion rescue and engine failure. However, it can be ponderous and even lead to poor results through overthinking in the shadowy circumstances so often found in the question of say, stability. I feel that the outdoor industry may be in a cultural shift: one that over-encourages institutions to set up procedures and analytical practices that may make it harder to develop good intuition. I am not suggesting that we do away with planning and checklists, I am merely warning against marginalizing automatic, intuitive thinking.. Anything that promotes safety, accountability, and professionalism is indeed a great thing. However, as a respected outdoor professional pointed out recently, rules are so often added and generally never subtracted. So lets maybe be careful not to fence ourselves in.

Leighan Falley has worked as a ski patroller, ski guide, climbing guide, artist, avalanche educator, and commercial pilot. She lives in Talkeetna, Alaska with her climbing ranger husband, a feisty two year old, and an airplane manufactured in 1957.

snow science

THE EFFECT OF CHANGING SLOPE ANGLE ON COMPRESSION TEST RESULTS

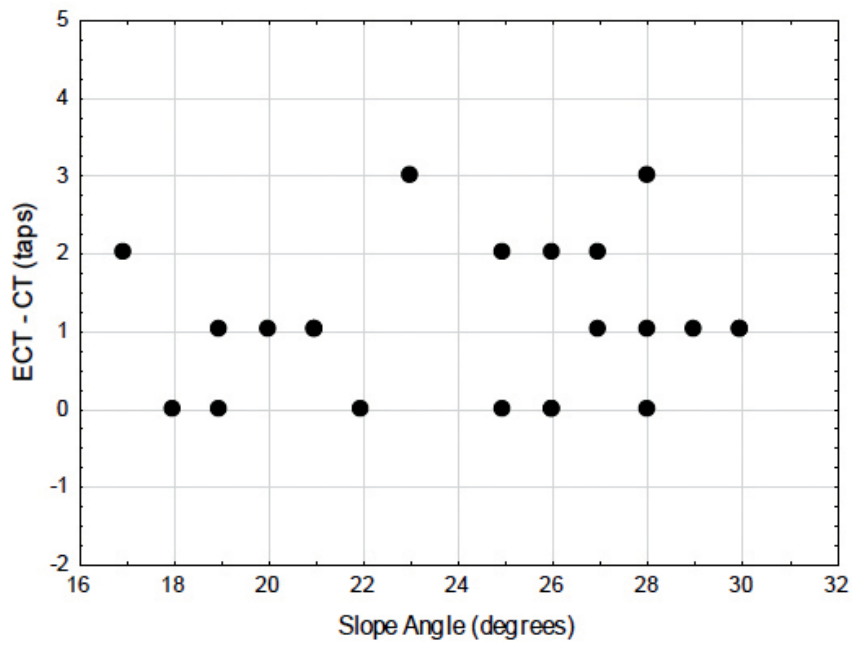
Story by Karl W. Birkeland, Ned Bair and Doug Chabot

In March, 2014 a group of backcountry skiers in Montana travelled onto a steep slope to assess the avalanche conditions. Their initial observations indicated unstable conditions, but they moved further down the slope to see if similar conditions existed as it steepened. Tragically, they triggered a slide that killed one person. This accident graphically demonstrates the danger of conducting stability tests in avalanche terrain when conditions are unstable. The consequences of a mistake in these situations can clearly be severe.

Though conducting tests on slopes safe from avalanches will minimize risk to observers, conventional wisdom has been that it is necessary to get into steep terrain to get good data. Recent research on some tests runs contrary that conventional wisdom. For example, Gauthier and Jamieson and McClung both show that propagation saw test (PST) cut lengths are similar, or shorter, in lower angled terrain in comparison to steeper slopes. Further, Birkeland et al. and Simenhois et al. found that the number of taps required to initiate fracture for extended column tests (ECTs) that propagate completely across the column (ECTPs) is similar or perhaps actually decreases slightly in lower angled terrain as long as the snow structure remains consistent across a slope. This was true for both persistent and non-persistent weak layers.

The compression test (CT) has been used for more than 35 years. Its popularity continues to the present; it was the second most utilized test among SnowPilot users behind the ECT during the 2011/12 winter . Jamieson (1999) found a significant trend in CT test results with changing slope angle in 7 of 11 datasets (64%), and suggested a decrease of approximately one tap in CT score for every 10 degree increase in slope angle. Data collection for this work differed from that with the ECT. The 11 slopes used for the CTs were sampled in two to four locations with varying slope angles, with multiple tests at each sampling location, while the ECT work sampled at multiple (more than 20), closely spaced locations with varying slope angles. Though the CT work runs counter to that with the ECT, the methods differed and the reported change of one tap for every 10 degrees is small given the potential variability of CT results.

The purpose of this paper is to utilize the techniques and methods of to test the effect of slope angle on CT results. Additionally, we analyze a large amount of data from SnowPilot to compare the difference between ECTs and CTs with changing slope angle. Since ECT results are largely independent of slope angle, the relationship between the difference between ECTs and CTs and slope angle can provide additional information about the slope angle dependence of CT results.



The difference between side-by-side CTs and ECTs from Dataset 1 do not show any statistically significant relationship with slope angle (p-value = 0.64). Throughout the range of slope angles it took between zero and three additional taps to fracture ECTs in comparison to CTs at this site.

METHODS

Field sites

We used three different slopes for our fieldwork. Our first slope was the same Lionhead study site in southwest Montana that Birkeland et al. (2010) utilized for their ECT study. On this slope we collected 22 side-by-side CTs and ECTs fracturing on surface hoar on slope angles ranging from 17 to 30 degrees. When we tried to access terrain in the low 30 degree range we collapsed the slope and triggered a small avalanche below our study site, attesting to the unstable condition on that sampling day.

Our two other slopes are located in California's Eastern Sierra Range. On these slopes our CTs fractured on depth hoar. We conducted 8 CTs on the first slope with slope angles ranging from 7 to 24 degrees, and 14 CTs on the second slope with slope angles from 0 to 38 degrees.

For this work we specifically sought out uniform slopes. This limited the amount of data we could collect, but we felt this provided optimal datasets for testing the effect of slope angle on CT tests.

Snowpack structure for field data

The snowpack structure differed between our datasets. The tests in our first dataset fractured on surface hoar buried beneath a recently deposited slab, while the CTs in our other two datasets fractured on depth hoar. The depth hoar for Dataset 2 was dry, while the depth hoar for Dataset 3 was slightly moist. We dug one manual pit for each field day following the techniques outlined in Greene et al. (2010).

Test procedure for field data

A single observer conducted every test in each of our three datasets for consistency. We followed standard procedure for the CT. Also, at our first slope we conducted our tests side-by-side with ECTs . Prior to each test, we sighted up the snow surface with a Suunto clinometer, measuring the slope angle to an estimated accuracy of ±1°. In most cases tests were immediately upslope, or within a meter, of one another. We did this for ease of testing, as well as to minimize any spatial changes in the snow structure.

SnowPilot data analysis

Because our field data are somewhat limited, we utilized data from SnowPilot to further address our research question. In particular, since previous research suggests that the number of ECT taps is approximately independent of slope angle (Birkeland et al., 2010; Simenhois et al., 2012), testing if the relationship between CTs and ECTs varies by slope angle will give us additional information about the relationship between CTs and slope angle.

In SnowPilot we looked for cases where CTs and ECTs fractured on the same layer and where ECTs fully propagated (ECTP). We had 534 total test pairs on slope angles from zero to 45 degrees. We graphed the data and tested for the existence of statistically significant ($p<0.05$) linear trends.

RESULTS AND DISCUSSION

Field data

In all three of our field datasets the number of CT taps remained relatively constant or increased slightly with increasing slope angle (Figure 2), paralleling previous work with the ECT (Birkeland et al. 2010). A side-by-side comparison of ECTs and CTs in Dataset 1 shows no trend between the difference between ECTs and CTs and slope angle (Figure 3).

Our results differ from those of Jamieson . We believe the primary reason for this discrepancy lies in our differing methods of data collection. While Jamieson (1999) conducted multiple tests at two to four locations per slope, each of our tests is considered individually and we conducted all our tests in close proximity on relatively uniform slopes with a changing slope angle. A particular strength of our data is the nature of our slopes, which yielded consistent results. The average standard deviation in CT taps for our datasets was just 1.34 (Dataset 1 = 0.83, Dataset 2 = 1.19, Dataset 3 = 1.99). In comparison, Jamieson's average standard deviation was double that at 2.26 (range 0.5-4.0). We believe that our data collection techniques are better able to capture relatively subtle variations in CT scores with slope angle.

Our work confirms that low angle slopes work well for data collection. Likewise, Jamieson's (1999) conclusion that there may be a 1 tap decrease for every 10 degree increase in steepness means that practitioners can conduct CTs on safer 25 degree slopes rather than more dangerous 35 degree slopes and still expect quite similar results.

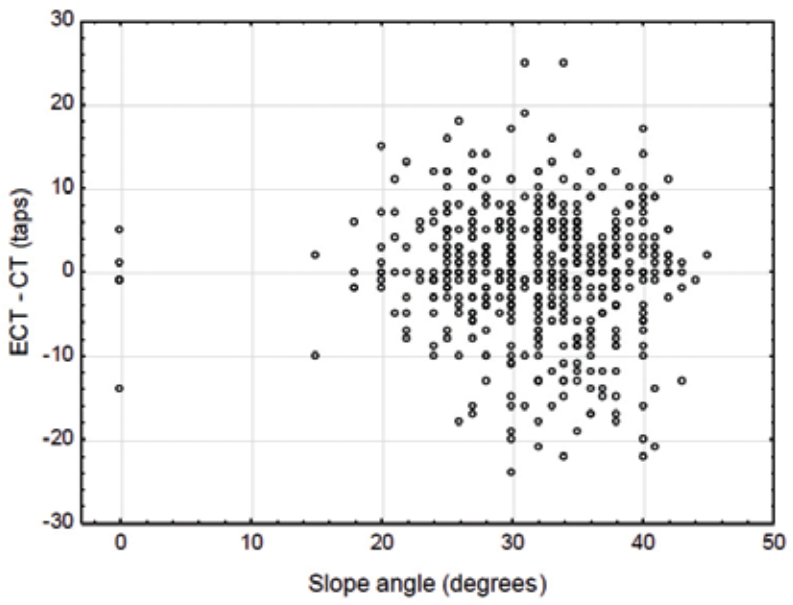
SnowPilot data

A plot of the difference between ECT and CT results versus slope angle shows a great deal of scatter and no statistically significant trend (Figure 4). A least squares linear fit to the data has a slightly downward trend, but it is not plotted since the fit is not significant at the 5% level ($p=0.19$).

The scatter in these data contrasts sharply with the low scatter in our Montana field data (Figure 3). However, the Montana data were collected on one fairly uniform slope with a well-defined weak layer, while the SnowPilot data represent data from a broad range of observers, snow climates, slopes, slabs, and weak layers. Still, if a relationship exists between the difference between ECTs and CTs and slope angle, we expect that it would be reflected in this large (n=534) dataset.

CONCLUSIONS

This research utilized two independent methods to test the slope dependence of CT results. Our first method was field-based and followed Birkeland et al. (2010), and



A scatterplot of 534 pairs of CTs and ECTs from the SnowPilot dataset does not show a statistically significant relationship between the difference between ECT and CT results and slope angle (p=0.19). This provides further evidence that CT results are largely independent of slope angle.

our second method utilized SnowPilot data. Our field data show that the number of CT taps are constant, or increase slightly as slopes steepen. The SnowPilot data reinforce these results by showing that the difference between ECT and CT tests is not statistically dependent on slope angle (p=0.19).

Our results differ from those presented by Jamieson (1999), who found that CT scores decreased slightly as slope angle increased. While Jamieson collected multiple tests from two to four locations, we sampled up to 22 per slope and did one test at each location. The slopes we tested had considerably less variation than those tested by.

Our results also contradict laboratory tests which showed a decrease in sample strength with increasing slope angle for small (≤ 20 cm in length) samples with weak layers of surface hoar, depth hoar, and facets . One explanation for the discrepancy might be a geometrical effect of the CT with changing slope angle. Alternatively, it could have something to do with the difference between methods utilized (lab vs field work and the way the loading method for the snow). Currently, the exact reason for the difference in our results is unclear.

Given that CTs, ECTs, and PSTs all show slope angle independence in their scores , we suggest that crack initiation (measured by the CT), and crack propagation (measured by the ECT and PST) have little dependence on slope angle over the range of angles investigated.

The primary practical consideration of our results is that tests on safer, lower-angled terrain are useful since CTs have similar or perhaps lower scores in lower angled terrain. This result is similar to results previously reported for the ECT (Birkeland et al. 2010) and the PST (Gauthier and Jamieson 2008).

ACKNOWLEDGEMENTS

The Gallatin National Forest Avalanche Center provided logistical support and assistance for the Montana field work. Mark Kahrl developed SnowPilot and queried the database for this paper. Sue Burak helped with field work in the Sierra.

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decision-making

Situational Awareness Part Two: Integrating Belief and Perception

Story by Doug Krause

Situational awareness (SA) is a cycle we use to process problems in a dynamic environment. Effective SA enhances task execution. When the poop is flying, SA helps you keep it in a proper pile, yet SA is equally valuable in low intensity environments with shifting variables and complex relationships. As avalanche workers and deep powder skiers we use the SA cycle to assess real-time hazard and risk. The cycle involves three phases: perception, integration and projection. Each phase can be examined by defining its role, describing common failure patterns, and suggesting techniques for improving practice.

Phase 1 is perception; most SA failures trace to the perceptual phase. During perception the savvy avalanchista gathers information and assigns each bit an initial value reflecting the datum's priority and a level of confidence. If you lack perceptual rigor, I direct you to part 1 of this series, Enhancing Perception, in TAR 32.4. Here's a summary: develop tactics for purposefully acquiring and assessing information.

Phase 2, the subject of this essay, is cognitive: the integration phase. During integration your big gray cranial decider gets to work on the information it's receiving. Integration includes the continuum between reflectively digesting a problem and making an intuitive expert assessment. A happy medium between purely intuitive and purely analytical integration is a balanced deep-breath-moment where we check our instincts and supplement them with analysis.

Phase 3, projection, is the subject of the next essay. Projection supports decision-making, action, and a plan for the next perceptual phase. Projection is a forecast built with detailed information about the here-and-now. How might things go relative to various courses of action?

In an action-oriented context, situational awareness plugs in like this: drop a problem in your SA mill (perception, integration, projection), decide, act, rinse, repeat as necessary. The wheel goes round. Om Mani Padme Hum. Cultivating situational awareness optimizes decision-making and action.

WHAT IS INTEGRATION?

"The best and safest thing is to keep a balance in your life " —*Euripides*

So, here we are on top of a mountain in the howling wind and snow. The radio is droning on. Things could be exploding. We're tired and cold, maybe afraid, certainly apprehensive. We are in a hurry, yet we are prioritizing a moment to ruminate upon our instincts: to integrate. Or, maybe it's calm and bluebird, the unicorns are chirping, we have all the time in the world, yet we are eager to pounce on the powdery glory that covers the slope below. We will still take a moment to integrate, si? Ok. What does that mean?

Integration synthesizes observations with knowledge. Mental models represent knowledge by describing various beliefs and their relationships. Avalanchistas have mental models that describe avalanches. Bakers have mental models that describe cookies. Rookies will have a storm slab model based on academic knowledge, maybe some backcountry experience, and various bits of anecdotal information. Experts have models that are informed by years of experience.

Experts incorporate pattern recognition to intuit an entire SA cycle at once. A pattern represents the convergence of multiple models and observations in a given context. Patterns are associated with a set of circumstances, a course of action, and an expected result. A local storm slab pattern may draw on multiple weather, terrain, and avalanche models to describe problem behavior in the context of slope-specific weather and topography: cut that start zone, right there, right now, and a low density storm slab will fail at the apex of the convexity.

During integration we compare our knowledge of current conditions to our model representations of similar scenarios, our beliefs. How does what we see relate to what we believe? Experts lean towards recognizing familiar patterns and novices rely more on "thinking it through." Each can benefit from the other's approach. Indeed, effective decision-making requires a balanced approach.

WHAT COULD POSSIBLY GO WRONG?

"There are no secrets to success. It is the result of preparation, hard work, and learning from failure" —*Colin Powell*

Recognizing the mistakes we make in the integration phase of situational awareness prepares us for improvement. These mistakes fall into several broad categories: misunderstanding, not thinking at all, and not reassessing. Misunderstanding the problem leads to using inappropriate or weak models. Skipping the integration phase all together, not thinking, results in Darwin Awards. Failing to reassess may compromise integration via unchecked errors from phase 1.

Using the wrong model is a deceptively common source of integration failure. A storm slab model applied to a persistent slab problem results in judgment that is not on point. Confirmation bias and complacency are two potential sources of this problem. The wrong model can be used to explain away information that would otherwise appear anomalous or discount information that would otherwise be pertinent. Don't force a preferred explanation at the expense of others and don't default to a given model because it's so soft and cozy. All the clues were there. Becoming unreasonably attached to a given model may lead to failure during the integration phase.

Krause and Mead-O pause for integration.
Photo by Jose Beccar

Using an incomplete or weak model can also lead to integration failure. Novices, who lack sufficient knowledge, routinely suffer from this problem. Experts fall victim by not recognizing the interplay of multiple problems. Hazard mitigation may involve deciding whether to use explosive or ski testing on a storm slab problem, with an underlying deep persistent instability, mid-storm cycle, in terrain that we would like to keep open, but don't have to. Eek. Multiple problems straddling the path require us to integrate multiple models or patterns. If it were easy, we'd call it ski school.

The integration phase is particularly vulnerable to the garbage-in/garbage-out trap: perceptual phase failures can propagate through the integration phase and eventually compromise decision-making and action. If you miss a clue that is highly relevant to a serious problem, then fail to reassess your observations, good luck getting un-fucked. Critical cues are just that. The Shaolin masters of the avalanche world not only recognize critical cues but purposefully stalk and track them.

Integration is degraded or eclipsed by environmental, operational, physical, and mental distractors: oppressive weather, time constraints, task-overload, fatigue, stress, etc. Anything that impedes information processing is a threat to your situational awareness. Distractors are legion. Rookies are at a tremendous disadvantage in complex environments but experts rolling on adrenaline and instinct make mistakes too. What do we do? Take a deep breath, wipe that snot off your lip, and pause for integration.

HOW CAN WE IMPROVE?

"Everyone has a plan 'till they get punched in the mouth." —*Mike Tyson*

It's important to practice. That's how good habits become automatic. When your SA plan becomes an SA reflex you will achieve total consciousness, which is nice. Tackle the simple stuff first. Good health, fitness, and organization go a long way. Health and fitness mitigate environmental and physical challenges. Effective time management requires planning; spend time to save time. Even brief moments of planning and communication reduce the effects of time-constraint and task-overload. Organization can create the extra moments you need to integrate.

Focus requires practice. Practice distraction recovery. Identify common distractors like radio traffic or pow in the face, then practice tagging them. Follow each tag with a simple distraction recovery moment like asking yourself what the heck you were just doing. What's my 20? Purposefully identifying distractors helps us preserve and recover situational awareness.

Reassess observations for value, confidence, and completeness. This is vital. Crushing it in the perceptual phase will get us most of the way to effective SA but remember, garbage-in/garbage-out. Consider the relevance and priority of your observations and the observations you lack. Anomalous information is a red flag that a model may be inappropriate, incomplete, or weak; anomalies should taste like salt in your coffee. If the seal looks like a duck; and you're thinking WTF; pause for integration.

Is our model appropriate and complete? In a dynamic environment problem definitions should be constantly evolving. John Boyd, the godfather of aerial combat theory, asserts that any logical model of reality is incomplete and must be constantly refined relative to new observations; so question beliefs. We can check cognitive biases (heuristics) by aggressively questioning our beliefs and assumptions. Don't get carried away, this is not a book club, but take it seriously. That's how you balance instinct with analysis.

Review the big picture. Reviewing goals will help. Goals can wander like a wolverine on crack. Is desire driving goal? Is the goal still appropriate given the big picture? "Belief decay" is a fancy way of saying we forgot to pay attention to something because it wasn't up in our face; it wasn't in the little picture. What about that buried surface hoar layer we were tracking last month? Questioning beliefs and pausing to consider the big picture help us develop appropriate and complete models.

If a problem seems overwhelming, break it down into smaller parts. Zoom in to determine how you are going to manage the challenges of the next fifty feet, then zoom back out to see if you can reconcile that with the rest of your program. If we make a point of developing micro-models that represent very specific problems, we can use them to build support for larger problem solutions: a big picture composed of several little pictures. That sounds kind of like pattern recognition, what the experts use. It is.

Finally, (can you hear my drum?) speak up. Verbalizing a mental model enables critical scrutiny and knowledge transfer. Rookies will develop pattern recognition skills more quickly if they can "see" the cues a veteran is using. That's why, as a training tool, old dudes telling stories has actually worked for so many years. But veterans may overlook the biases of a familiar pattern. From the fresh perspective of a novice, they will leap like cats on fire. Our mindset will influence analytical

and intuitive reasoning. Communication helps establish an appropriate mindset for the situation, and it helps adjust that mindset as the situation changes.

Communication is the most valuable tool we have for refining our mental models: more valuable than experience. Hazardous avalanche environments provide notoriously poor and irregular feedback, therefore, experience does not translate directly into expertise. "It's like you're dreamin' about Gorgonzola cheese when it's clearly Brie time, baby." We can assess the validity of our experience via communication. We can invite feedback through communication. We can broaden our knowledge base through communication. Communication is the best tool we have for diversifying the perspective on a model's appropriateness, completeness, and strength.

Call it phase 2 situational awareness, mindfulness, metacognition, orientation, synergy, having your finger on the pulse, balancing yak-yak with whack-whack, whatever; doesn't matter, same ingredient. This is a lightweight overview, but it's still a lot to digest. You never stop learning, you question your beliefs, and you talk to your partner. That's the meat. I love meat. What's my 20?

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Doug Krause can be found wandering and wondering in Silverton, Valdez, and Lima.

snow science

High Resolution Snow Stratigraphy

Part 1: A Change of Perspective

Story by Steve Conger

Avalanche practitioners are conditioned to see the snow pack structure graphically represented in the blocky, low resolution, higher-scale representation of hand-hardness. The advent of high-resolution snow profile probes introduces a significant challenge to practitioners since these probes measure at a scale far finer than classical manual techniques.

During the winter of 2004/2005, I began a project to determine through field investigation and experimentation how instability present at a slope feature is related spatially to the slope around it. I proposed to use an electronic snow sonde, however, fieldwork immediately illustrated that the probe required substantiation for use in any experimental exploration. The project became one of instrument validation during which I measured, observed, and compared a very large number of electronic and manual snow profiles. In this article (Part I of Interpreting High Resolution Snow Stratigraphy), I describe the manual, reproducible layer identification technique developed during this investigation to expose or highlight stratigraphy variation suggested by the probe output. The use of this technique coupled with an understanding of what it illustrates is anticipated to provide the practitioner a sound basis to bridge from graphical hand-hardness snow profiles to interpreting representations of the snow structure generated by an electronic probe.

I believe that most of us who work in snow can agree that metamorphism of the snow results in a change of texture and structure (Bader, 1954) and that grains within a layer become more similar as they age or the layer becomes more dense. Though various theories exist on the true nature of densification, it is generally observed that grain shape and mass along with size and number of bonds per grain relate directly to the density of a sample and the multiple processes occurring result in increasing density depending on the location within the snowpack. Andersen (1960) introduced the use of a brush to highlight layers. It was included in the earliest avalanche handbook; "careful horizontal strokes will model out layers" (USDA Forest Service, 1961).

Using the brush technique described here along with the appropriate brush will provide you an observation wall in your snowpit exhibiting layers more representative of a structure you might see from an electronic probe. The assumption on which the method is based is that the brush applies a uniform force of disaggregation to the grain structure on the face of the snowpit wall based on the stiffness of the brush. Disaggregation force is related to the density and strength of the layer (Mellor, 1964).

1) Prepare pit wall or column as customary with a shovel blade (a shaded column side wall if the method is to be used for an inclined snowpit).

2) Determine the upper layer representing fist or lowest hand hardness resistance.

3) Hold the brush perpendicular to the pit or column wall, brush lightly, smoothly, and parallel to the layering; with a full sweep across before beginning the return stroke. Across the pit wall for flat terrain and along the side of the column or pit wall for inclined terrain.

4) Exercise caution to maintain the brush handle perpendicular to the wall to ensure accurate results.

5) Count the number of strokes (each direction is counted individually) until the fist or lowest resistance snow is displaced by the brush to a depth equal to half the bristle length.

6) Move to an undisturbed area or re-prepare the pit wall or column side.

7) Brush the width of the wall or the length of the column side the number of strokes determined in the prior step.

8) Move the brush position down the wall or column one brush-width and repeat.

9) Continue to the bottom of the pit.

After completing your pit wall you will be faced with "enough layers to dull your pencil while filling up multiple pages in your field book." There will likely be variations in the hardness relief of the lowest density layers (HN and HST). These generally correspond to subtle grain differences that represent variations in near-surface conditions during deposition (wind and new snow type) and variations in metamorphism occurring near the surface.

Use of this technique generates generally consistent characteristics of the brushed pit walls. The regions of F and 4F contain far more variation relief than 1F and harder. 1F and harder layers are generally smooth with only strongly bonded (e.g. former crusts or ice layers) or persistent weak bonded (e.g. buried SH) layers presenting any relief. In regions where primary densification was taking place, nominally in storm snow, are typically alternating rounded ridges and valleys with a relief of 0.5 to 1 cm. This is observed with no distinct layering or multiple layer behaviour. General stiffening of the layers with increasing depth in the storm snow is observable. Where the brush leaves a pronounced or nearly right angle at interfaces between layers, such softer layers were often the location of compression test results. If you'd like to keep notes:

10) A) Record if hardness relief is ≥1 cm or if edges (layer boundaries) are square to adjacent faces, **B)** Annotate square edges with] or [and smooth valleys or raises with) or (depending on the shape of the top of the relief face.

11) Determine boundaries between classic hand hardness changes, e.g. F to 1F.

A drafting brush is the tool of choice (e.g. Staedtler #98900, Alvin #2342). This brush style distinguishes thin F or 4F layers from adjacent layers that are harder or softer by one hand hardness level. Thicker and stiffer brushes do not perform well; they damage the surface making variations in hardness and layering difficult to see. Snow adhesion is a problem on synthetic brush fibers when snow and air temperature are warmer.

Part 1 has described a calibrated brush technique for identification of layers and their hardness. if you are interested in a real world example of the snow structure that an electronic probe senses, give the calibrated brush method a try. It's also a functional method to more accurately attribute hand hardness values to thin layers. Part 2 will present examples of electronic probe based snow profiles with possible interpretations.

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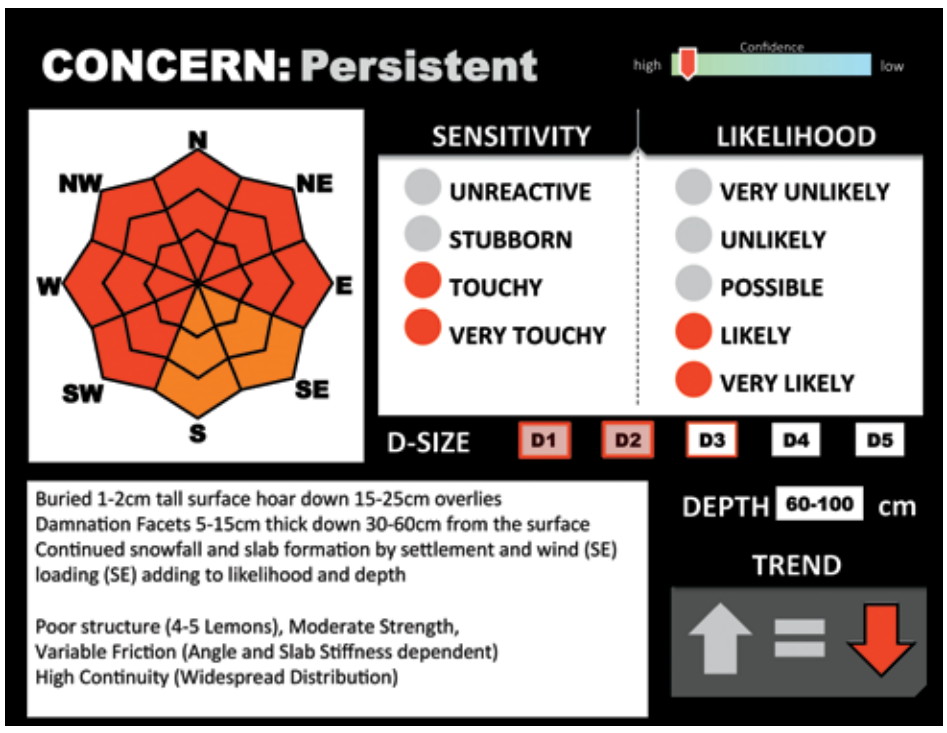
Steve Conger is a TAR Editor Emeritus, AAA and CAA Professional Member who continues to enjoy working with uncertainty. Steve's initial avalanche encounter was the first day of summer 1974 and has accumulated 29 seasons thus far in a broad spectrum of roles including researcher,consultant, instructor, forecaster, control technician, author, rescuer, and dog handler. He resides in Golden BC.

Crown Profiles

DAM FACETS

By Don Sharaf

In the vein of no good deed goes unpunished, Lynne Wolfe (*The Avalanche Review* Editor) asked me to write about the 'dam facets' after my talk at ISSW. After writing an eight-page paper and preparing two presentations on the wretched layer I pondered what was truly useful, unique, and transferable from the time I spent with the dam facets last season. What follows is a distilled rundown of what I learned from forecasting and guiding last season.



Set-up

The "Hawaiian Sucker Punch" (TAR vol.32 no.4) that walloped Southern Alaska last January made national news, particularly the size D4.5 avalanche that came down, dammed the Lowe River, and cut off road travel to Valdez for 12 days. The wet slides quickly achieved legendary status, but the layer that followed the "Damalanche" and other similar-scale events is the one that challenged Thompson Pass heli-ski operations in the months to follow.

The storm that put down more than 11" (279mm) of rain in the Town of Valdez on January 24th and 25th ended with ~4" (10cm) of snow at Thompson Pass. The resulting snowpack consisted of water-saturated snow from sea level to ~5000' with varying amounts of "dry snow" on the surface above 2000'. The following three weeks brought seasonably cold temperatures to the Thompson Pass area (as well as most of southern Alaska) and created a layer of near-surface facets formed by melt-layer recrystallization. Conditions for facet growth on and near the surface were ideal and in the areas north and east of Thompson Pass the facets ranged from 1-3mm striated facets to 3-5mm fully developed depth hoar. Many areas also had long chains of facets above the now-frozen Damalanche Crust. Given the challenges we saw ahead for avalanche forecasting this facet layer was named the Damnation Facets or Dam Facets for short.

From Whumphs to Sonic Booms

Most of the heli-ski operations that operate in the Eastern Chugach start up in late February or early March. I arrived at my home away from home, Mile 35 on the Richardson Highway on February 22nd and heard reports from backcountry tourers of rumblings in the backyard. My first tour, the next day, was fascinating from an avalanche forecaster's perspective and horrifying from a skier's perspective. Virtually every step produced collapses or whumpfs up to 20 meters away (visible from the jets of snow and air that came out the alder trunks). The slab that now laid atop the Dam Facets was 12" (30cm) thick but it had also faceted (in this case by diurnal recrystallization). An interesting paradox was set up, where propagation was ubiquitious – covering all aspects from 2000'-5000', but you couldn't buy an avalanche regardless of the slope angle. In early March, the situation changed overnight as a moderate outflow event produced strong northeasterly winds that created localized hard slabs on west aspects – particularly lee sides of gully walls along the Thompson Pass corridor. Avalanches were now sporadic, but the whumps were propagating further away – up to 60 meters in some cases. The layer was so weak that we could collapse the same area two to three times within seconds of the first collapse. Two whumpfs under the thickest hard slabs were truly sonic booms.

February 23,2014: 30cm of three week old snow sits atop a 10cm thick layer of dam facets that are 2-3mm striated grains. This "slab" was made up of fist hardness near surface facets which supported propagation everywhere we traveled between 2000"-5000', but until the slab stiffened with later wind transport, would not avalanche regardless of slope angle.
Photo by Don Sharaf

March 11th promised to change the scenario, as up to 6" of SWE was forecasted in a two-part storm. The first part produced ~2.8" (70mm) of SWE, but the second part fizzled, destroying our hopes of the Crush and Flush avalanche cycle. What remained was a mosaic of many size D1.5 to D2 avalanches varying between 19"-39" (50-100cm) deep. Remote triggering was rampant, even more so than the days before the storm, but natural avalanches seemed to end on March 14th. The following three weeks were virtually snow-free and human-triggered avalanches became fewer and smaller. The Dam Facets appeared to enter their period of dormancy after April 11th, when our last skier triggered avalanche was logged. Extended column tests continued to propagate in most cases well into the dormant period, but friction evolved from Sudden Planar and Sudden Collapse to Resistant Planar results. Strength remained in the moderate range for these facets from their height of activity to far into their dormant period.

So What?

We recognized that the Dam Facet Layer of 2014 was going to be a problem from the outset of the heli skiing season. You couldn't have such high continuity of a weak layer with such large grains without seeing fear in the eyes of ever-optomistic guides. As such, we did all we could to identify the terrain where this layer was most prevalent; the strength, structure, friction, and propagation on different aspects and elevations; and tracked those characters for the rest of the season. We treated this layer with respect, our terrain selection was drastically altered by this layer. For the most part we stayed out of trouble by carefully choosing our slope angles and looking for clean run-outs at the middle elevations. We had more leeway with terrain above 5000', but coming down out of the couloirs took careful group management.

Reining in the guides necessitated their buy-in to the problem. Avalanches in your face are obviously helpful, but it is not always that obvious. Photos and videos of pit results and observed avalanches all add to the forecast – ask any public forecast center. A detailed summary of the avalanche problems of the day, broken down by sensitivity to triggering, distribution, size along with 24-hour weather observations and the day's forecast is a lot to assimilate in a short morning meeting. Every patroller and guide has heard an over-caffeinated forecaster give a verbal vomit of numbers and cardinal directions with little to show for it at the end. What helped our operation was getting the forecast out an hour before the guide meeting. We

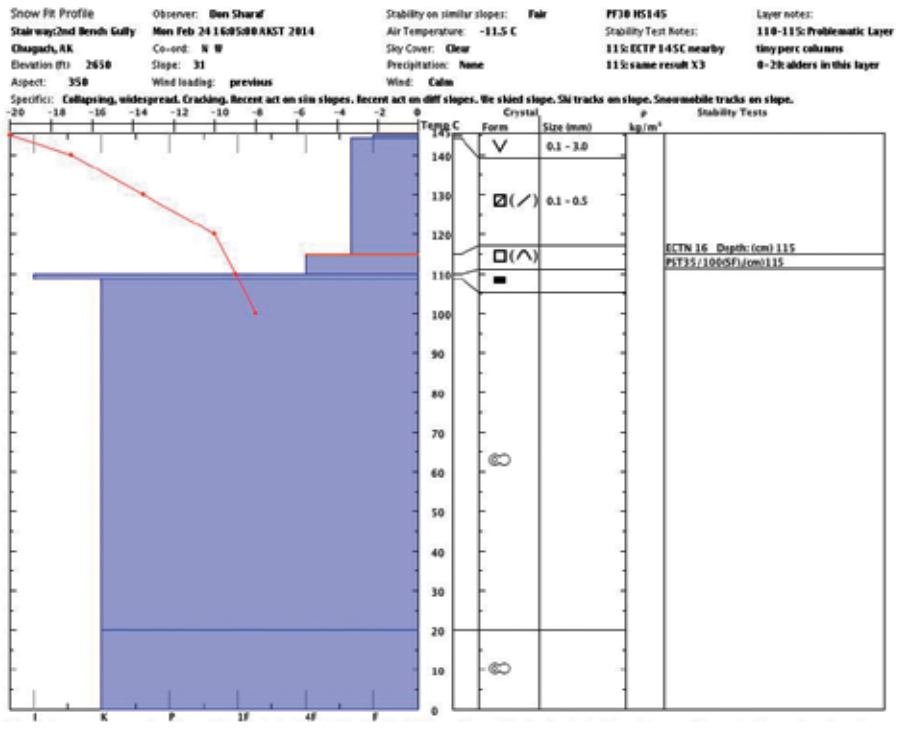
would put up the forecast along with pictures and videos on to a file-sharing site (Drop Box in our case, but any site will work). That allowed the guides to process the information over breakfast and come in with some opinions and questions. The change in comprehension and actions was discernible this year and I think the added time to process the information contributed to that.

Tracking a persistent weak layer, or really any avalanche problem, is most easily done in hindsight. It is easy to say "Aha, this is when the layer became dormant."

In real-time it is not near as easy and we continually asked ourselves "is this layer done producing avalanches, will it reactivate, when will it be out of sight and out of mind?" Being the eternal pessimist (forecaster-hat not guide-hat) I felt that this layer may not be done until it was under someone's raft. During the shed cycle and on into the summer we only know of only one confirmed avalanche that ran on the Dam Facet layer. More remarkable was that same avalanche stepped down to the ground through what had previously been a knife-hard meter-thick Damalanche Crust. I believe more avalanches may have run to this layer, but lack of observations in May leaves that as conjecture. What we did throughout the season was tried to pin down the weak layer in its evolution.

Formation → Activity ↔ Dormancy → Inactivity → Removal

In this case formation was from the period over three weeks of cold and clear weather. Activity is classified as periods of actual avalanches, which may or may not end quickly as it enters a period of dormancy. Periods of dormancy may have low test scores, full propagation, and varying degrees of friction, but by definition no avalanches. In the case of the Dam facets they alternated between activity and dormancy three times before becoming inactive (where significant test results are few and far between, but the layer is still structurally recognizable). Removal is when the layer is no longer recognizable in the pit – it may have metamorphosed into an entirely different grain type, it may have been crushed out of existence, it may have been flushed away by avalanches, or it may have melted away.



A more reactive profile further into the heart of the Dam Facet habitat. This was in the first dormant period following the short avalanche cycle that occurred around February 18 when the Dam Facets were first buried.

April 7, 2014 After a week of no human triggered avalanches, we were starting to believe that the Dam Facets had become dormant. This avalanche surprised us. Warmer temperatures at lower elevations (+2 to +4 degrees C) likely had a role in this avalanche that showed wider propagation than typical avalanches on this layer. The second skier on the slope triggered this slide and was caught. He successfully deployed his airbag and stayed on the surface for the 200 meter ride. He lost a ski, but was skiing again two days later. A hasty ECT done just below the three skiers visible at the top of the photo yielded an ECTX on the Dam Facet layer. SS-ASu-R3-D2.5-O.
Photo by Don Sharaf

Viewing the big picture of avalanche release

This layer was a tough one to predict from pit results. Its structure remained virtually the same through periods of activity, dormancy, and inactivity. Large faceted and striated grains only very slowly started to round. Propagation continued far into dormant periods. Continuity of the weak layer was profound, but the slab was less continuous – that may have limited the avalanche size to D2.5 at the most (along with the general lack of snow in March and April). As mentioned before, the strength of the weak layer was almost always in the moderate range of CTs and ECTs regardless of whether it was in the height of activity or depths of dormancy. Friction seemingly had the best correlation to avalanche activity, as we mostly saw sudden planar results during active cycles and the rest of the time Sudden Collapses and Resistant Planar results were the norm. I wouldn't tell anyone to discount fully propagating test results with Sudden Collapse fracture character, but in this case sudden collapses fell more into the gray area that Q2 shears reside in. I believe that only sudden planar results translate well to Q1 shears, but I think we can develop better observations of friction for the future.

While there is no panacea, or magic bullet, for forecasting persistent weak layers I believe that current research is giving us more tools to suss out what's happening. Using both the PST and ECT to understand propagation helped to understand why we were getting thundering whumphs, yet no avalanches. Watching Karl Birkeland's videos from last season at the ISSW also helped to understand the interplay of the weak layer with the overlying slab. I encourage people to use science to help understand the situation and forecast from it. I also encourage them to embrace their humility, as we only see a fraction of the whole spectrum of slab/weak layer combos. This Dam Facets provided a great opportunity to learn and to stay humble.

Don Sharaf will return for his 15th season as a forecaster for Valdez Heli-Ski Guides. One of his favorite quotes is from Jim Kanzler: "I'm learning… God it hurts, but I'm learning" ⁂

NEW ZE

(Upper Left) **PATH: Adrians Bowl**
In mid-September two explosives-triggered wind slab avalanches were released early in a secondary control run following a strong northwest storm event. We nearly walked right past these slabs as our bomb holes from the previous day's control work were still visible at the surface, but decided another test wasn't such a bad idea. We had noted on the previous day how much it felt like the slab was still forming under our skis, and it turned out we were correct.
Photo: Brad Carpenter

(Lower Left) **PATH: Margots/Broken River**
A northwest warming event eventually broke down the persistent weak layer of facets we were concerned about during the mid season. Across the Craigieburn Range loose wet slides were recorded from steep terrain. No wet slabs were recorded during this time.
Photo: Doug McCabe

(Right) **PATH: Weatherbook**
A natural cornice failure in the proposed expansion area of Crystal Valley near Porters Ski Area. Porters has been permitted to utilize explosives in this area to determine maximum runouts of specific start zones although this area is not part of the operational ski area...yet. We had extensively bombed this zone two days prior in an attempt to understand a storm slab instability we were seeing inbounds but had only small cornice failures. Another storm snow and intense loading event from the northwest finally triggered the cornice which caused the slope below to fail as well.
Upper Photo: Tony Phillips
Lower Photo: Luke Armstrong

Stitched panoramic photo of the Craigieburn Range by Luke Armstrong

E A L A N D

Mt. Jumbo: Missoula's Urban Avalanche Problem

By Steve Karkanen

1 the event

HISTORY

(Continued from Cover) Mount Jumbo is located within the Missoula City limits and is administered by the Missoula Parks and Recreation Open Space Program. The majority of the mountain was acquired by the city in the 1990s to protect visual and recreational amenities. It also provides critical winter range and shelter for 75-100 elk that move out of their higher summer range to over-winter on Mount Jumbo.

Public access to the mountain in the winter months was closed in the late 1990s to protect the elk from displacement and stress caused by hikers and their pets.

The lower Rattlesnake Valley is anchored by Mount Jumbo and is one of the more desirable residential areas in Missoula. It is an attractive area within walking distance to schools, the University of Montana and Missoula's downtown. Many of the homes at the base of the mountain were built in the thirties and forties with no historical reference to snow avalanches, mud slides or flash floods during the relatively short history of white settlement in the area.

In most winters the mountain retains little, if any, snowpack. The low elevation (3280' to 4773' at the summit), its exposure to the sun, prevailing winds and low precipitation amounts are not conducive to development of a snowpack that can produce avalanche activity.

The terrain however is another matter.

There has been previous recorded avalanche activity on the mountain. In 1993, a 12-year-old was killed after triggering a small avalanche in a terrain trap on the east side of the mountain. This event occurred after an east wind stripped available snow and formed sensitive hard slabs on the leeward terrain features that caught the windblown snow.

During our investigation this past spring, I talked with residents who spoke of avalanches that reached homes in the same neighborhood in the early 1970s. I communicated with a person who triggered an avalanche that buried Van Buren Street near the Missoula Avenue intersection; also in the 1970s. Fred Allendorf (who survived the 2014 avalanche) informed me that a small avalanche hit their home shortly after they bought the property in the early 1970s. No official record exists of these events.

Since the glaciers receded and glacial Lake Missoula drained some 30,000 years ago, historic documentation is limited to events that occurred after the first permanent settlement in the 1860s. There is no denying that Mount Jumbo is avalanche terrain when the snow is deep enough and weather factors create instability. There's just no record of a similar event happening in the past 150 years.

EVENTS LEADING UP TO THE AVALANCHE

Late that Friday afternoon, a group of four friends, ranging from 13 to 27 years old, wanted to take advantage of a rare snow day that forced local schools to close. They decided to snowboard and ride sleds on the untracked west face of Mount Jumbo. The group, with three plastic sleds and one snowboard, made their way to the summit of Mount Jumbo with the intention of sledding and riding the untracked snow.

Earlier storms had deposited enough snow on the low elevation terrain in the mountains surrounding Missoula to allow for unique skiing and riding opportunities within walking distance of many residents. Mount Sentinel, above the University of Montana and south of Mount Jumbo, had been skied and ridden earlier in the week and was heavily tracked.

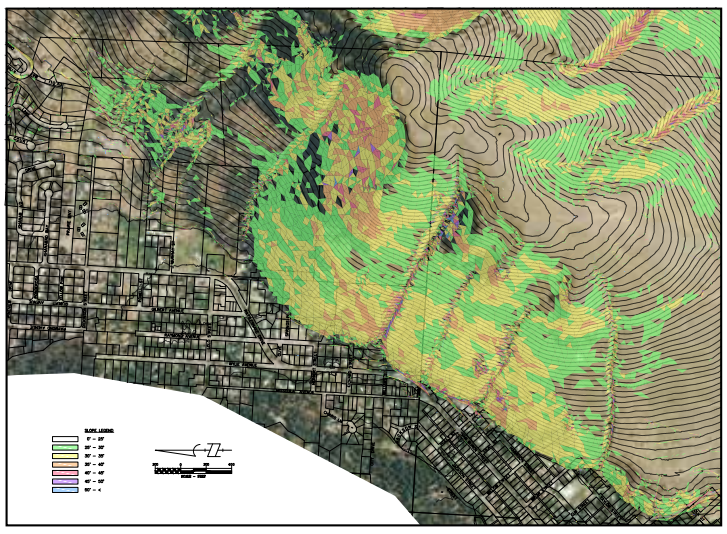
The friends met at a home in the lower Rattlesnake and opted to hike Jumbo since Sentinel had already been tracked up. Their intention was to hike to the summit, ride down the untracked west face, walk back to the same home where they planned to get a shuttle vehicle and retrieve their first vehicle at the trailhead.

No one in the group had previous avalanche training or rescue equipment. The group had no winter backcountry travel experience. They carried a small shovel with them in case one of their vehicles got stuck.

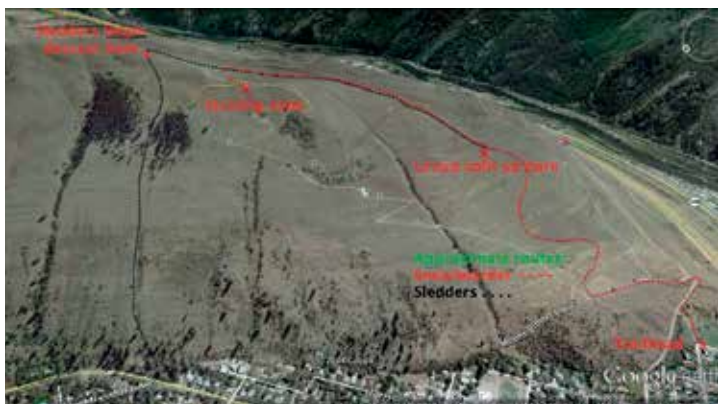
They parked at the Poplar Street trailhead and initially followed the trail system part way up the mountain until they lost the trail in the new snow. The snowboarder described having to break trail through several drifts where gullies and depressions created small lee zones. There was no sign of obvious instability such as collapse noise or fracture propagations to get their attention. They made their way up the southwest face avoiding the deeper pockets of snow and eventually found easy hiking on bare ground near the ridge.

Near the halfway point, the snowboarder became separated from the three sledders as his board was acting like a sail in the strong winds, impeding his travel.

As the sledders approached the summit, wind and snow conditions hindered their visibility so they decided to begin their descent in an area between two shelter belts of timber.



Courtesy of WGM Group



Courtesy of Google Earth and Steve Karkanen

They were not aware of the location of the snowboarder.

The snowboarder reached a point above the slide path and opted not to push toward the summit. He strapped on his board, entered the slide path at the highest point, and immediately fell. He got back up and noticed movement in his peripheral vision and realized he was being carried downslope by an avalanche. He was at the top of the slab and able to self arrest by digging in with the edge of his board and using his arms and fingers to grab the bed surface as the snow passed by. A terrain convexity prevented him from seeing where the avalanche ran.

The sledders, having already descended, were near the base of the mountain to the north of the slide path. At least one of them saw a powder cloud and heard the avalanche slam into the home. They immediately went to the site and began digging for an eight-year-old boy who was buried. Shortly after this the snowboarder walked down the slide path and assisted with the initial rescue effort. All four left the scene after talking with responding police officers and were later interviewed by Missoula City Police detectives at the Police Department.

The avalanche entrained most of the available snow in the fetch zone and accelerated as it advanced over a terrain convexity halfway down the track.

At the base of the ravine, the avalanche caught two children,

Erin Scoles-Coburn, the mother of Phoenix and Coral, is led away from the location where neighbors and first responders are searching for her son. *Missoulian Photo by Tom Bauer*

Phoenix and Coral Scoles-Coburn, ages eight and ten, who were playing in their backyard. The avalanche also slammed into and destroyed a two-story wood frame home. The two residents of the home, Fred Allendorf, 66, and his wife Michel Colville, 68, were inside the house when it was hit.

The two children saw and heard the avalanche coming down the ravine and ran downslope toward their home. Both were caught and carried several feet before coming to rest next to their home. Coral was partially buried, up to her armpits, and was able to dig herself out quickly. Phoenix was completely buried next to the house about three feet deep.

Allenedorf and Colville were together in their home and were also completely buried under several feet of snow and debris from their destroyed home.

SAR AND INVESTIGATION

At 1618, Missoula City Fire, Police, Missoula County Sheriff, MT Highway Patrol units and local EMS teams were dispatched. A large contingent of neighbors equipped with avalanche rescue gear soon began arriving on scene.

The Avalanche Center was contacted by Missoula County SAR at 1620 asking for our assistance at the avalanche site. They needed help with the initial assessment of the slide path for rescue worker safety.

Rescue coordination for the arriving units was complicated by live power lines, broken natural gas lines, blizzard conditions and the very real possibility of another avalanche. The crown was not visible from the valley floor due to the mid-slope convexity and extreme weather that blocked visibility.

The number of possible victims was unknown and there was a report of missing backcountry skiers reported to 911 at the same time. A quick transceiver search was performed based on this information. The missing skier were later determined to be in the backcountry near Montana Snowbowl Ski Area.

A rough probe line formed near the home just below Phoenix's last seen point. Phoenix described being in the dark and unable to move his arms after being buried. He stated that he tried eating and chewing away at the snow until he became so tired that he fell asleep.

He was located three to four feet deep by a probe strike after approximately 55 minutes at 1709 hrs. When extricated from the snow, he was unresponsive. Rescue breaths were given and he was immediately transported by ground ambulance to Saint Patrick Hospital's Emergency Department.

After a Northwestern Energy gas line technician assessed the area for explosion hazard, rescue efforts then concentrated on spot probing and digging in areas directly below the last known location of Allendorf and Colville. A neighbor showed rescue teams the probable location on the destroyed homes foundation where the couple may have been on a Friday afternoon.

There was a noticeable presence of natural gas in the air but the high wind dissipated the gas enough to allow the rescue operations to continue safely.

Probe teams were directed to concentrate on possible catchment features (debris from the home, vehicles, outbuildings and fences) on the fall line below this area of the house. A probe strike was confirmed and Allendorf was located at 1758 hrs in a cavity under a brick chimney and a wall or roof partition approximately four feet deep. He was responsive and able to inform rescuers that his wife was three feet from him when the house was hit.

He was extricated and transported by ground ambulance to Saint Patrick Hospital's Emergency Department.

At 1907 hrs, Colville was located by a responding neighbor with a probe. An earlier probe detected a soft spot that turned out to be a sofa. This location was re-probed after the sofa was removed and a probe strike located Colville. She was buried two to three feet deep, approximately 25 feet downslope of her husbands location.

Colville was breathing but unresponsive. Extricated at 1914 hrs, she was transported to Saint Patrick Hospital's Emergency Department in critical condition. She died on March 3 from traumatic injuries.

Three other homes, several vehicles and an apartment building were also damaged by the avalanche.

2 Avalanche center involvement

Shortly after Allendorf was found, avalanche center employee Travis Craft and I met with the Fire Department Incident Commander, the commanding Police Department (PD) officer on site and the Missoula County Sheriff regarding the possible need to advise residents to evacuate.

The commanding PD officer, Sandy Kosena, asked us to show her the areas we believed to be most at risk from further avalanche activity. Keep in mind that an avalanche just occurred and the accident site and adjacent residents are directly beneath 35+ degree open unanchored terrain during a blizzard.

Travis and I talked with the Incident Commander regarding his concern about the weather and the unknown hazard above. His plan was to abandon the site at 10pm for scene safety. It had been determined there were only three buried victims; once they were evacuated all further rescue operations ceased.

We were then informed by Kosena that detectives were planning to interview the snowboarder and sledders at the Police Department so Travis and I headed there hoping to capture whatever info we could from the interviews.

On arrival, we were asked to attend an emergency meeting with the Mayor, Missoula County Sheriff, City Police Chief, City Fire Chief, DES Coordinator, PD detectives, City Public Information Officer and several other city and county staff officials.

My experience with in-briefing IMTs (what does this stand for?) and dealing with emerging wildfire incidents prepared me well for this event. We were expecting to sit in on an interview of the witnesses and ended up on the hot-seat, with all present wanting to hear our opinion. It was intimidating to say the least but everyone there was looking after the interests of the community and needed the best available information.

Given the situation and our best assessment of the snowpack and weather conditions, the Mayor asked that City Fire and Police Departments go door to door to advise affected residents of the situation and that residents within a defined zone at the base of Jumbo be under an evacuation advisory.

The Mayor issued a closure order for all of Mount Jumbo and Mount Sentinel above the University of Montana.

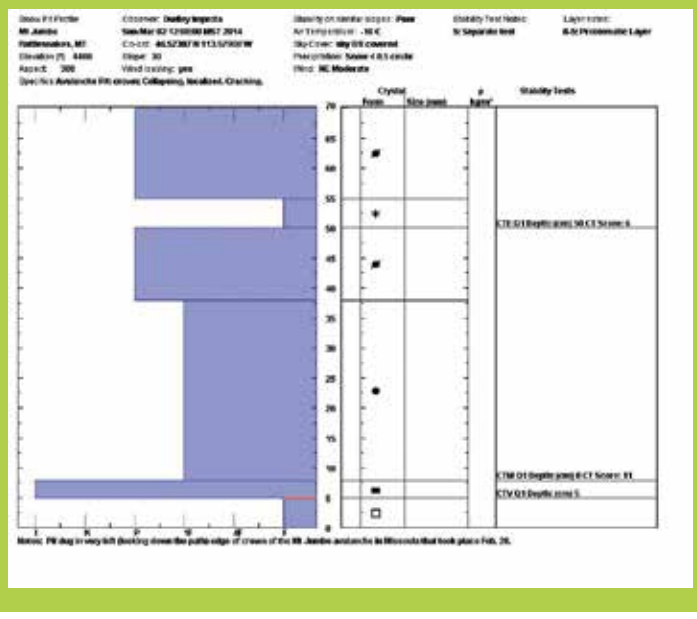
From this point on the avalanche center became tied to the event as the authoritative body.

On Saturday March 1, we began our investigation, including assessment of avalanche hazard to UM and residents at the base of Sentinel.

Phone calls from local and national media began flooding in. We were also fielding calls from residents living at the base of any steep slope in the valley wanting to know if they should stay or go.

Montana and Idaho Departments of Transportation were also having avalanche issues near the mountain passes and were asking for assistance. Northwest Energy was concerned about a natural gas transfer station located at the base of Sentinel. The UM President was concerned about student housing near base of Sentinel.

On Sunday Avalanche Specialist Dudley Improta and David Williams, one of our Forest Service field observers, skinned to the avalanche crown to capture snow data. During their ascent, they experienced collapsing and fracture propagations and found an extremely weak snowpack structure. On arrival at the crown they discovered that the start zone had partially reloaded from the high winds.



The Missoula Office of the National Weather Service forecast a rapid warmup starting Monday w/potential for 1.5" of rain in the Missoula area. This was the worst possible forecast.

Early Monday I attended a meeting with city staff regarding cleanup and recovery of the site. This is where we learned that Michel Colville died from her injuries.

Considering what I was seeing at the site, (with nearly 50 volunteers searching debris for personal belongings) the assessment of avalanche specialists at the crown and the grim weather forecast, I recommended to the Mayor that no one be allowed on the site and that the evacuation advisory be extended until the threat of rain had passed.

There was a rapid warm up but fortunately very little rain from Monday to Thursday. On Wednesday, Improta and Travis Craft returned to the crown and did multiple snow stability tests and profiles at the top of Jumbo. Their assessment was that the danger has passed and that the advisory be lifted.

Avalanche Classification: HS-ARu-D3.5-R4-S,O

Description:
HS: A hard slab avalanche.
ARu: Triggered unintentionally by a snowboarder.
D3.5: The destructive force (D) destroyed a house, several cars and damaged several other structures.
R4: The avalanche was large but did not involve the maximum area.
S,O: A surface wind slab initially released at the recent storm snow interface and stepped down to the ice crust at ground level.

Avalanche Dimensions:
Coordinates: N 46.8739 X W -113.9639 (mid-crown)
Aspect: 294 degrees
Crown elevation: 4480 feet
Terminus: 3280 feet
Vertical drop: 1200 feet
Crown width: 658 feet
Depth: 2.5 feet, Max: 4 feet
Average depth: 3 feet
Slope steepness at crown: 38+ degrees
Average: 35
Distance from crown to terminus: 2200 feet
Average slope steepness: 35 degrees
Maximum steepness at convexity: Estimated at 40 degrees
Alpha Angle at terminus: 30 degree

Dudley working up the crown profile on SE corner of crown. *Photo by David Williams*

A lifelong western Montana resident, Steve Karkanen's outdoor career began in 1979 as a professional ski patroller and wildland firefighter. He has been director of the West Central Montana Avalanche Center since 2006. He retired from the Forest Service in 2011 but continues to serve as avalanche center director under a personal services contract with the agency.

Photo by Steve Karkanen

3 Lessons Learned

My experience managing wildfires and working with local agencies was a tremendous benefit in dealing with the Mount Jumbo avalanche. Many of the responders were familiar with the Avalanche Center through our education programs or know us personally. Not being familiar with or knowing how to navigate the Incident Command System would be a big disadvantage.

This was a front page story for several days. I took calls from reporters representing all the national media outlets for a two week period after the event. It's important to return their calls if they leave a message, especially the local reporters. Many reporters have little working knowledge about avalanches; it can be trying at times to give Avalanche 101 lessons over the phone. If you want the story to be accurate, take the time to educate them. Generally they are on our side.

Having a trained Public Information Officer (PIO) available to assist with taking calls and providing concerned residents with solid information would have been a huge help. Even with little working snow safety knowledge, these individuals are very good at dealing with the media. PIOs can be easily ordered through any local Forest, State or BLM dispatch office. Figuring out a way to pay them is the hard part.

We tried deflecting calls from affected residents by asking them to contact the Fire or Police Department but there was no clear contact, and many received conflicting information from the two departments. So they called us back. It really put us in a tough position. The worst thing we could have done would have been to ignore their questions or give them the runaround. We decided the best strategy was to just tell them what the conditions were and that it was entirely their decision whether to stay put or evacuate. This ultimately paid off for us.

Interviewing those involved was a challenge. I wasn't able to meet with the snowboarder, who triggered the avalanche, until after the City Attorney decided there was no basis to press charges. I was finally able to interview this person, accompanied by his attorney, in May. This was an important interview as he was able to clarify important information about the events leading up to and subsequently triggering of the avalanche.

Our limited resources were stretched to the max during and after the event. We also issued avalanche warnings for the backcountry and investigated an avalanche fatality in the Flint Creek Range on March 10.

We made the decision not to ask the city to pay for our time and our Friends group stepped up and covered the additional expense. This also paid off for us as the community was able to see how responsive we were to the need for assistance. We gained many new supporters in the community who have since made financial contributions to our Friends group.

We are an avalanche center that issues backcountry advisories for those who choose to put themselves in avalanche terrain for recreation. Relating the avalanche risk to someone in their home is an entirely different paradigm. The danger scale is hard to understand for backcountry users, let alone those in their homes who do not venture into the mountains. The terms "moderate" or "considerable" were confusing to many homeowners. Perhaps better adjectives are "imminent danger" or "totally safe."

FOLLOW UP

Since this event occurred several miles outside our advisory area, we started communicating with the responsible city officials and proposed a cost share agreement or memorandum of understanding to formalizes a relationship with City/County land managers. This will give us the authority needed to provide avalanche hazard assessments and advisories for the City of Missoula if a similar situation were to present itself again.

In early October, we received communication that the City leadership team wants to enter into a cost share agreement with the avalanche center. This is significant and the initial direction is that the City Fire Department will be the primary point of contact during future events.

The foothills around Missoula are skiable every 10 years or so. It is possible there have been conditions that would have produced an avalanche in years past, had there been a trigger. The rocketing popularity of backcountry skiing and riding has put many more people into these foothills when the snow conditions are good. It has become imperative for backcountry users in popular areas to think about putting not just themselves, but other people, at risk, when riding a steep slope. The potential for a skier or rider to put a community at risk has been demonstrated by the Mount Jumbo avalanche; certainly something to ponder in our shrinking world.

Many thanks to Tom Mattice, Janet Kellam, Art Judson, Karl Birkeland and others who offered assistance and solid advice during this event. ❄

THE urban AVALANCHE PUZZLE

By Janet Kellam

IN THE EARLY WESTERN MINING DAYS avalanches destroyed buildings and homes, killed men, women, and children and were seen as an unfortunate part of life. Moving forward into more modern times in Idaho's Wood River Valley, slides have blocked highways and roads, destroyed one city home, killed two people in a cabin in neighboring Camas County, flooded neighborhoods and damaged several other homes and buildings. These are just some of the notable events that have taken place in my community; many similar instances have occurred throughout the western US. The Missoula 2014 avalanche brings the issue of urban avalanches front & center. I like to think that now in the 21st century, the consequences are greater than we want to accept.

After experiencing two dramatic urban avalanche cycles during the winter of 2008 and having followed avalanche problems in the Wood River Valley for decades, I decided to write a 2012 ISSW paper. (Kellam, J. 2012, The Urban Avalanche Interface and Community Impacts. ISSW proceedings, Anchorage 2012, 9-15). The paper illustrates that even with a zoning program, avalanche-engineered structures and a level of awareness, a surprising number of individuals and groups are placed at risk during an urban avalanche event. The City of Ketchum has begun to manage the urban problem during avalanche conditions and their program may prove helpful to other communities facing similar issues. My 2012 paper also indicates that more needs to be done. The problem is complex and the best solution is often not to build in avalanche areas at all.

I like to examine the urban avalanche problem as two main categories: how to deal with existing problems and how to minimize or prevent future problems.

In the case of existing problems (i.e. all communities that have structures and roads built beneath slopes that receive enough snow and are steep enough to slide), widespread education is key. Community programs need to identify management steps leading up to, during and after an avalanche event. Every single person needs to know how to recognize serious avalanche hazard during storms and extreme weather events, with or without a local forecasting program. They need to grasp the low probability but high consequence nature of their avalanche problems. Individuals need to understand the basic actions they need to take to avoid the hazard. In the case of responding EMS services, local emergency crews need to know how to protect themselves and minimize their risk.

Sage Road and Huffman Drive slide paths viewed from Warm Springs Road, Ketchum, Idaho.
Photo by Janet Kellam

The intermittent nature and long return period of avalanches in many of these communities poses a challenging perception for most people. Often, full time forecasting programs may not be warranted and mitigation or snow retention structures are not possible. Even if urban avalanches do not occur every year, the nature of these problems means avalanche education needs to annually reach community leaders and planners, EMS services, residents, utility services and every individual that works in or visits within avalanche areas.

What about after an avalanche has brought havoc and destruction to a community? Tom Mattice continues to work with the City of Juneau, AK (Mattice, T. 2012, Re-Evaluation of Avalanche Mitigation Measures for Juneau. ISSW proceedings Anchorage 2012, 150-156). Tom offers insight and an understanding of possible resources in dealing with the aftermath of properties impacted by avalanches, including some experience with government buy-out programs. (see Tom Mattice's article, this issue of TAR, page 21.)

Progress in identifying and managing for future problems tends to be made directly after accidents or close calls. Legal rulings for the 1971 Yodelin, Washington accident established a responsibility and "duty to warn." This case found the responsibility lay with Washington State government and developers for allowing residences beneath avalanche slopes.

Based on the Yodelin ruling, the City of Ketchum pursued a zoning program in the 1970s and places some of this "duty to warn" on the avalanche-zoned property owners. Legal documents are attached to the deeds, property owners acknowledge they are buying land or building in an avalanche zone and they accept responsibility for all activities and individuals on their property during avalanche hazard. This "responsibility" has yet to be tested in the courts and many property owners simply forget they signed the document and what it means. Blaine County and adjacent cities have different avalanche zoning or treatments.

The Idaho Local Land Use Planning Act has established a duty to plan for and adopt zoning for avalanche prone areas, but what "avalanche prone" means and how communities implement any zoning can differ. There are no national standards for avalanche mapping or engineering, but the Swiss red-blue-yellow definitions of the 1950s have been adopted in the US thanks to the work of Art Mears, Norm Wilson and others. Interpretation and implementation seem to vary from state to state or community to community based upon local needs, economics or political concerns.

To see solutions to the urban avalanche interface, we as avalanche professionals want community planners and leaders to understand our world. In turn I'd like to suggest we make an effort to better understand their world. Community planners tell me they could benefit from better recognition of and information regarding avalanches as a natural hazard. They need some key points in federal and state planning handbooks such as how they are able to identify avalanche areas and how to address avalanche problems. Without a consistent core of information, the result has been inconsistent zoning and an inability for planners to defend the need for management of a variety of avalanche concerns.

One place to begin could be to provide mountain town planners with a basic understanding of avalanches and avalanche terrain and illustrate existing problems. The Avalanche Hazard Conceptual Model (Statham et. al 2008, 2010, see figure 1.) could be helpful. The American Planning Association has state chapters and focus groups annually hosting state and national meetings. Urban avalanches could be presented as a contemporary topic since natural hazards such as flooding and wildland fire are gaining a greater presence in planning & zoning concerns as well as in community management.

With a better understanding of avalanches and avalanche terrain, the planners can begin to develop the tools they need to create or modify avalanche zoning programs. One such tool would be a "Model" Zoning Code for avalanche prone areas. Model Zoning Codes exist for a number of planning topics. They outline the critical components of a good code and are not only useful for community planners when updating their own land use codes, but they can lead to more consistency nationwide. Planners may even be able to gain funding or grants from a variety of sources for something like this.

Community officials and leaders are a critical part of this equation; without their participation and support the planners are helpless. Educating the planners and community leaders with accurate and consistent information about avalanches and their impacts could help them collaborate on accepted zoning programs and reduce future problems.

With ISSW 2016 coming to Breckenridge and Colorado's long history of people living in avalanche country, the Colorado APA chapter may be a good place to begin an exchange of urban avalanche information between planners and avalanche professionals. The 2015 Colorado APA conference is Sept 30-Oct 3 in Steamboat. It would be pretty wonderful if this coming together of concerned avalanche professionals at Banff 2014 could lead to some improvements in the urban avalanche puzzle for our next ISSW.

The Components of Avalanche Hazard and Risk

Avalanche Hazard		Vulnerability		Exposure		
➢ Likelihood of Triggering ➢ Destructive Size	&	➢ Fragility ➢ Number exposed	&	➢ Position in terrain ➢ Time exposed	=	AVALANCHE RISK

Graph from Grant Statham and the ADFAR committee

Janet Kellam began to pay attention to the urban avalanche puzzle in 1982 when her car ran out of gas beneath one of Ketchum's slide paths during a big nighttime storm. Since then, she feels fortunate to have worked with snow and avalanches as a ski guide, director and forecaster at the Sawtooth Avalanche Center and as an instructor. Janet is currently program director for the National Avalanche School. ❄

Juneau's URBAN AVALANCHE PROBLEM

Story and Photo Series of Berhands Avalanche above Juneau by Tom Mattice

ALASKA'S CAPITAL CITY, Juneau, lies in SE Alaska nestled between the Juneau Ice Field and the Gulf of Alaska. When we receive onshore flow it is moisture-packed, producing large amounts of precipitation. When we receive offshore flow it comes with the harsh cold temperatures the icefield produces. When east meets west Juneau gets huge deposits of snow that bring with it the threat of avalanche. The mountains around Juneau are quite rugged with little to no flat land available for development. Most of our community was either built on mine tailings or the alluvial fans of debris left from centuries of rockfall, mudslide, and avalanche.

With 62 homes, a hotel, a boat harbor, and the main east west road connecting our downtown area and Douglas Island to the Hospital and Airport all located in avalanche terrain, Juneau faces the threat of a catastrophic avalanche. With the mean inclination from the topmost crown of the avalanche path to Berhands Avenue next to the water, at 34 degrees it is hard to ignore the potential on initial assessment. Juneau has a history of avalanches reaching tidewater all the way back into the 1980s, when large avalanches deposited hundreds of tons of snow on what is now Glacier Highway below the neighborhoods. But why would residents choose to build or live in an area such as this?

Alaska has a long and proud history of personal accountability and rugged individualism. We want to go where we want, when we want, to do what we want to with only our imagination, mother nature, or the gods limiting our ability. With this mindset comes the increased risk of danger in many forms. Our graveyards are littered with tombstones from fisherman whose boats never returned, from miners who never saw daylight again, from foresters who underestimated the risks, and from adventurers and mountaineers who were never heard from or seen again. Before the age of lawsuits, liability and FEMA, people were aware of and accepted personal responsibility for the risks they chose by living in this rugged terrain.

Before the homes were built in the Berhands neighborhood of Juneau in the late 50s, Tom Laurent (one of the first US Forest Service Snow Rangers) a Juneau resident, addressed the city assembly again and again about not building in these avalanche zones. As buildable land was at a premium, and there were no recent avalanches in memory to remind the residents of the risk, permits to develop the area were granted. After the neighborhoods were built zoning in and around them was questioned again and again with no real results.

In 1962 the Berhands Avenue Avalanche Path slid on a cool crisp morning with glacier outflow winds loading the starting paths at a very rapid rate. Fortunately for the community, it was described by one local as a belly flop of an avalanche with only the powder blast affecting the urban environment. Locals reported the cause to their insurance companies as a "wind event" due to the lack of avalanche insurance; seven homes were severely damaged, nice homes were moderately damaged, and 18 homes received minor damage. Roofs were blown off, houses were pushed off foundations, and one resident woke up in bed with a tree lying across his chest. Thankfully no one was killed. This has since been determined by avalanche specialists to be in the range of a 30-year event.

Since that time, zoning and understanding of the problem have changed. We now have avalanche zones in place designating high hazard and moderate hazard avalanche areas. New construction within these zones has to be built to withstand the estimated impact pressures for avalanche scenarios developed by experts and engineers. Yet most of the homes in these areas remain unchanged even all these years later.

One of the problems in re-zoning areas into newly designated avalanche areas is the outcry by landowners. Many would say by changing the zoning you have taken the value of their land and therefore they should be compensated for their loss or by having their properties purchased outright by the government that is imposing these zoning standards.

This places local government into a difficult position as recent lawsuits have shown that knowingly placing both members of public and workers into a known hazard area creates liability for the government. Therefore it is the government's duty to zone accordingly and tag titles for land in hazard areas so that both current and future landowners in these areas are fully aware of the risks they have chosen to take.

Thankfully for Juneau this zoning change was some time ago. The landowner outcry has mostly disappeared and all current landowners in the hazard area are fully aware of the dangers they choose to live in on a daily basis. Recent studies have also shown that Juneau homes located in avalanche zones are no less expensive than their comparable counterparts out of the hazard areas. This has made the zoning a little more palatable over time.

In recent efforts to readdress the avalanche problem, the city of Juneau, in the process of working though a FEMA Hazard Mitigation Grant Program, was able to contract the Swiss Institute for Snow and Avalanche Research(SLF) to conduct avalanche mitigation studies to determine the best way to eliminate this hazard for the long term. Although the city was hoping to see if active mitigation via GASEX systems in conjunction with breaking mounds and catchment dams would be a viable solution, thereby eliminating the risk to homeowners, SLF came to the conclusion that if conditions ever exceeded the design parameters, no catchment dams (meeting U.S. cost benefit standards) would ever be large enough to protect the area. Therefore SLF advised that the buyout of endangered homes in the avalanche paths by the government is the only way to effectively reduce the avalanche risk long term.

Buyout and removal of homes would create a project in the neighborhood of 30 million dollars, unattainable for a town of 33,000 people. The city once again turned to the Federal Emergency Management Agency (FEMA) for direction. FEMA pays for and conducts mitigation on a regular basis. Whether that be post Katrina or Sandy for a large scale natural disaster or post 911 for manmade events, FEMA has grant programs that fund disaster mitigation both pre and post disaster.

The city is now looking into the purchase and removal of the houses in the high hazard avalanche area. This project will be conducted in six phases due to the limited funding available. For this particular mitigation grant, every time there is a natural disaster in the state, FEMA earmarks 15% of the documented disaster amount towards future pre-disaster mitigation projects. Recognizing that most of our disasters are quite small we hope to break down our project into manageable bites. Currently cost benefit analysis' are being created for the interested homeowners in priority area #1. This is a voluntary buyout, only done in agreement with the owners. Even though a grant will ultimately fund the project, there are thousands of hours of labor put into applying for and managing the grant and related projects.

Valdez and Cordova, Alaska both have been through this process, not only with urban avalanches but also with the use of the FEMA Hazard Mitigation Grant Program (HMGP) funds to remove the structures in the area, thus eliminating the risk for future events.

One of the keys to avalanche mitigation is proper recognition of the threat ahead of time. You only have one EASY chance to mitigate and that is IMMEDIATELY after an event. Once people rebuild, the problem is much more expensive and you have to then sell your point again as people have time and money invested in rebuilding their properties and won't want to leave.

I would recommend that every mountain community re-examine the area around them for snow cover and avalanche-related terrain in conjunction with current zoning practices. By early recognition of these potential threats, zoning can be changed to match the threat and to ensure you do not enter into decades of controversy under the shadow of the threat that members of your community could be buried and killed in an avalanche.

Tom Mattice
City and Borough of Juneau Emergency Programs Manager/ Avalanche Forecaster
Director SE Alaska Avalanche Center
Board Member Alaska Search and Rescue Association ❄

urban AVALANCHE INTERFACE:

Consultants' Perspectives

By Art Mears & Chris Wilbur

URBAN AVALANCHE PROBLEMS DIFFER FROM HIGHWAY AND RESORT AVALANCHE PROBLEMS.

We include rural mountain residential along with urban. Evacuations can be problematic and structures remain exposed. Most avalanche professionals work on paths that tend to be steeper and run more frequently than those that must be considered for land-use planning. Long-return period avalanches may have less steep starting zones (28-32 degrees) that can allow thick slabs to build up prior to release causing long runouts over gentle slopes. Intentional triggering with explosives is seeing increasing use above industrial structures such as power lines and mines that can be evacuated and the owner accepts the risk of damage. This practice is largely avoided in the USA above residential developments due to liability issues.

AVALANCHE MAPPING VARIES WIDELY. Many urban areas with numerous avalanche paths or known histories of avalanches were mapped in the 1970s and 1980s, in response to residential development pressures. Examples include the towns of Ophir, Telluride, Vail, and Silverton, and Pitkin, Gunnison and San Juan Counties in Colorado, Ketchum, Sun Valley, Blaine County in Idaho, Taos Ski Valley New Mexico, Juneau, Cordova (in 2000), and Anchorage, Alaska, Alta/Snowbird and Sundance, Utah. In some cases, these maps are more than 30 years old. They should be interpreted knowing their limitations and that new methods and additional data are available.

New mountain developments in areas without accepted official maps are often addressed by local planning and building departments. Examples of growth adjacent to existing mapped urban areas include Park City, Mammoth Lakes, Placer, Mono and Inyo Counties, California and Chelan County, Washington.

Many urban avalanche areas have not been mapped. Examples include Missoula, Montana; Valdez, Alaska; and Twin Lakes, Colorado. Property owners often understandably object to avalanche zoning because it can place significant limitations on development and affect property values. Communities are often reluctant to revise or update avalanche zoning maps, even when new data and better mapping tools and methods become available. Revised maps may conflict with existing zoning plans used in urban development. Adopted official avalanche maps, therefore, become "set in stone."

AVALANCHE ORDINANCES REFLECT LOCAL SOCIAL, ECONOMIC AND POLITICAL CONDITIONS. Mapping standards, hazard zone definitions and ordinances vary widely. Land use restrictions in avalanche zones range from very restrictive (only open space in high hazard areas) to essentially unrestricted "buyer beware." Local government control is the norm in the USA and local officials rarely have the necessary expertise on their staff. Some land use restrictions such as prohibitions of any development in high hazard zones eliminate some structural mitigation options, including starting zone structures, mounds and deflection dams. Ridgeline and viewshed ordinances can also affect mitigation options. Deflection of avalanche flows is a factor that is addressed in some ordinances, but not always.

PUBLIC RISK PERCEPTION IS OFTEN IRRATIONAL. Public perception of hazard and risk is often irrational due to limited observations and short historic records relative to the long return periods that must be considered in avalanche zoning plans. Risk depends on the hazard probability, intensity, exposure and vulnerability. Vulnerability can be reduced by avalanche-resistant construction, but this is often uneconomical, except where land is scarce and expensive. The exposure component is important in residential settings because people spend significant amounts of time at home, compared to roads and driveways. The difference in risk between houses and driveways is substantial, but it is often treated as though it is equal.

The distinction between private property rights and voluntary risk acceptance for residents versus involuntary risk for service providers such as deliveries and emergency response is not well-defined and largely neglected in ordinances.

People often interpret High and Moderate Avalanche Hazard limits the same as property lines with precision that does not exist.

WILL FEMA SAVE US? Avoidance is the obvious solution, but in many places it is too late. That was the case in Cordova and Valdez, Alaska where FEMA paid for land and building relocations to permanently avoid a known high hazard areas.

IS CLIMATE CHANGE THE POLAR BEAR IN MY KITCHEN? Climate change could either increase or decrease avalanche hazards. Factors that could reduce the hazard include shorter snowfall seasons with more rain, particularly in maritime climates. Opposing factors include loss of forests, especially in starting zones, and warmer wetter air masses causing more intense precipitation events. Like other climate change impacts, the effects could vary with location.

IDEAS FOR IMPROVING URBAN AVALANCHE SAFETY:

- Establish a "model ordinance" that is consistent with other natural hazards such as floods and earthquakes.
- Provide planners with the resources and information needed to identify potential avalanche terrain for new developments. A good resource is: 2002 Land Managers Guide to Snow Avalanche Hazards in Canada. It is available from the Canadian Avalanche Association and was edited by Jamieson, J.B., C.J. Stethem, P.A. Schaerer and D.M. McClung.
- Establish consistent definitions for hazard zones. Improve mapping by including "Hazard Intensity Maps" that show various runouts based on return periods, including probabilities that are not regulated, but allow developers and owners to make better informed decisions.

Art is well known throughout North America and Europe for his work in avalanche mapping, mitigation design and land use in avalanche zones. For the past eight years he has partnered with Chris Wilbur, who has dragged Art, kicking and screaming, into the 21st century.

Chris Wilbur is a geohazard engineer who likes to ski in the Red Zone, but lives well outside of the Blue Zone in Durango, Colorado where he and his wife Sue are raising two teenage boys. Art & Chris can be reached at ***Info@mearsandwilbur.com*** ❄

LIVING IN THE URBANWILDLAND INTERFACE...

More Of Us Do

By Roland Emetaz, aka Mr Em

Whether it be the threat of wildfire, avalanches, landslides, volcanic eruptions, floods, or coastal storms, people, knowingly or not, find themselves at risk living in the urban/ wild land interface.

My experience being a member of an incident management team: in the past, we were rarely confronted with structures threatened by a wildfire, today it is the norm. More people are looking for their home in the woods, a spot adjacent to a scenic mountain slope or an ocean shore.

State or county codes may prevent building in potentially dangerous areas; avalanche run out zones, unstable slopes, or in areas of high wildfire danger. But risk disclosure varies greatly from state to state or county to county. In other cases the risks are not recognized or identified. The bottom line…restricting the right to build is difficult…

Such scenarios can lead to loss of life, homes, values and costly search and rescues, investigations, and litigation. Eliminating all risk is difficult or impossible, but in some cases mitigation may be feasible. For example, making one's property fire resistant. But in other cases, mitigation of the danger may be very costly, like stabilizing unstable slopes, constructing defense structures or diversion barriers for buildings threatened by avalanches . Providing incentives for people to move or buy back might well be the best solutions…allowing sites to return to open space.

So my message to the avalanche professionals…Why is this important to you? And what can you do about it? Simply put, if you see something, say something! You probably won't win a popularity contest but you may save a life!

Roland V. Emetaz, aka "Mr. EM" is a retired Forester with the USDA Forest Service, Pacific Northwest Region. After devoting his long enjoyable career to advocating outdoor safety, quality customer service and teamwork, Mr. EM continues as a volunteer teaching those lessons. He represents the Northwest Weather and Avalanche Center in avalanche awareness programs he presents to various audiences. At other times he is on assignment with the Central Washington All Hazards Incident Management Team (one of 54 in the Nation) managing incidents as diverse as wildfires and hurricanes from the Arctic Circle to the Gulf Coast. Office- Starbucks-I-205/ Mill Plain Blvd-Vancouver, WA USA emetaz@earthlink.net ❄

Photo by John Stimberis

Read more about hazard mapping in Switzerland on page 31. →

ISSW Impressions

All ISSW proceedings, including Banff 2014, can be found online here: ***http://arc.lib.montana.edu/snow-science/workshops.php***

ISSW beer socials are great opportunities to see old and new colleagues face to face.
Photo Doug Richmond

ALEX MARIENTHAL**: A Comprehensive Overview**

The 2014 International Snow Science Workshop was a successful merging of theory and practice. The ensemble of speakers continuously provoked thought through the week, and posters highlighted modern tools and methods to forecast avalanches, and to inform and educate the public. The snowcapped limestone peaks that rise thousands of feet in every direction around Banff inspired the best in all presenters and delegates at the workshop. Of the high quality posters and talks, I have summarized a few that stood out to me.

The first round of speakers started off with a strong group of presentations about forecasting deep-slabs and wet-slabs, which have proven to be more difficult to forecast than many other types of avalanches. Paul Baugher's talk about a historic deep wet-slab cycle at Crystal Mountain had me thinking about the effects of skier compaction on how water flows vertically through the snowpack. Hypothetically, if continuous skier compaction creates one homogenous layer above a weak layer, then water would flow more quickly to the weak layer boundary than if multiple layers of snow existed above to impede water flow. A summary of the other ISSW presentations about deep-slabs and wet-slabs will be included with a summary of my AAA-funded graduate research in the February issue of TAR.

Kevin Hammond's experimental measurements of temperature gradients and facet growth around an ice lens supported many years of theory with amazingly detailed measurements of temperature gradients. He measured temperature gradients up to -600°C/m around the crust. These spanned a distance that is hard to measure a temperature gradient across in a typical snowpit. In many instances large avalanches occur above an ice-crust, which provides a strong planar bed-surface. This means an ice-crust can be a repeat offender because it will grow facets again once it is reburied.

Bruce Tremper discussed the UAC's use of Web based media to collect data from crowds, and provide information to the public. He mentioned that many parts of the crowd go places that we don't go, or are more often unwilling to go, and "they see avalanches!" With the modern speed and connectivity of media platforms this information can be collected and shared within minutes of someone recording an observation. Other presentations mentioned the speed and connectivity of modern communications as useful in rescue scenarios. People can quickly send a message to a group, and people in that group can easily connect and assemble further resources.

I attended Tuesday morning's panel discussion about avalanche research that was subtitled with the question, "What has science done for us?" I think it became obvious that science has done a lot. More importantly it was stated that practitioners are scientists by nature, and that those who can bridge the gap between science and practice are essential. Lynn Martel wrote a nice review of this session in the Rocky Mountain Outlook titled: Science and Practice Essential Partners in Avalanche Work; this can be found at http://www.rmoutlook.com/article/20141009/RMO0801/310099987/0/RMO.

Tuesday afternoon began with nicely visually aided talks about slab fracture. I enjoyed Ned Bair and co-authors' data on ECT tests with longer columns. One of their key findings was that a standard (0.9m) ECTP that is followed by a 2m ECTP is a clear sign of instability. This combination of outcomes was seen more frequently as the a priori stability rating decreased. They still observed 2m ECTN/Xs following standard ECTPs during poor and very poor stability, so using this combination of tests to determine stable conditions remains inconclusive. Using longer tests may help decrease false unstable results, and improve interpretation of propagation tests. Johan Gaume and others also suggested using longer beams in stability tests in their conference paper: Discrete Element Modeling of Crack Propagation in Weak Snowpack Layers.

Modification of stability tests is not only a great way to examine how well different column lengths perform, but it can give different users special insight into unique problems. Eric Knoff's poster on the "Cross-slope PST" provided another way of viewing propagation. His test is a PST performed on a column that is situated across the slope like an ECT. He noted the test's quick reproducibility and ease of setup compared to a traditional PST. As with most tests there are caveats, but Knoff's test is another good way to get a quick look and feel for the snow.

Human factors and worker safety were among the featured topics on Thursday. Joe Royer from Ruby Mtn. Helicopter skiing emphasized the goal to return home at the end of each day, and to recognize protocols and procedures to limit exposure in order to achieve this goal.

Karl Geisler from New Mexico Sate University spoke about a need to convey a better perception of low probability, high consequence events, especially in avalanche education in order to compensate for a lack of experience with these events. This is important from beginner to advanced levels of education because those with some experience tend to take on more risk due to overconfidence (e.g., the 27-year-old after a level 2 or 3 class). Furthermore, unless you are constantly triggering avalanches, experience in avalanche terrain often has more positive than negative feedback regardless of the quality of decision-making. This reinforces bad habits and decisions. Geisler concluded with support for a lately popular suggestion to give more emphasis to the process of decision-making in avalanche courses.

The workshop concluded on Friday with sessions on avalanche education, and accidents and rescue. Spencer Logan reviewed the distribution of avalanche problems involved in 14 years of avalanche fatalities in Colorado. He demonstrated that the majority (87%) of avalanches involved in fatalities were persistent slabs and deep persistent slabs. Avalanche events with multiple fatalities occurred more with deep persistent slabs than with other types of avalanche. He stated that these types of patterns should be included and emphasized in education and travel advice or planning, with emphasis on avoidance of terrain that has the presence of persistent instabilities.

It was a great ISSW, and I want to extend gratitude to the organizers and sponsors that made it all happen, and that have continuously made it happen, as well as the presenters and delegates for showing up and sharing their ideas, experiences, and lessons. Thanks to Bridger Bowl ski patrol and Jordy Hendrikx at Montana State University for providing support for me to show up and present in Banff.

Alex should have a Masters degree in snow science from Montana State University by the time this is published. He looks forward to more practice than theory while ski patrolling at Bridger Bowl and coordinating education for the Friends of GNFAC this winter. His summer activities include biking, fishing, whiskey, and watching videos of water flow through layers of soil in an attempt to better understand wet-slabs.
e-mail: alexm1417@hotmail.com

ERIC HUBER**: A Thoughtful Synopsis**

As promised, here are some comments on some of the ISSW sessions. I preface these notes by saying that I felt that the organization of the presentations was better this year than in past ISSWs. I suspect that I felt this way for two reasons. The first is that I am more familiar with the topics now than I might have been been previously, and, therefore, was better able to organize them in my mind. The second, more importantly, is that it feels to me as if the field is maturing somewhat and, consequently, the paper topics fit more neatly in what have become, somewhat, more distinct, "fixed" categories. As a result of these two things, for the most part I usually synthesized what I heard by session rather than take detailed notes on any given talk.

In any case, this year I focused on the presentations of greatest interested to me. To broaden my perspective, I also attended all of the panel discussions which I found to be an informative change to the program format.

Monday, September 29

Avalanche Forecasting 1 - Wet Slabs and Deep Slabs
Confirms experience. Releases hard to predict. Low probability/high consequence events. Long runouts — low alpha angles of note.

Preconditions — dry(ish) fall/pronounced basal faceting. Lots of moisture in/on slab w/ sustained warming right before event cycles. Role of wind especially right before event cycle??

Wonder if these phenomena aren't signs of conditions to come with "climate change." Bursty weather. Slower moving fronts — more intense storms/longer duration precipitation.

Panel Discussion: Avalanche Safety Equipment for Ice and Alpine Climbing - Not if, but how.
Interesting to hear perspectives of people who don't come to mountains primarily as skiers. e.g. climbers. Similar to different perspectives of sledders as compared to skiers.

Avalanche preparedness and awareness not currently part of climbing culture. Similar to sledding. Changing culture critical. Modeling by leaders and role models probably a meaningful part of changing mindset/culture.

Avalanche Forecasting 2 - Modeling

Don Sharaf's talk about 2014 winter in Valdez, AK.

Activation & reactivation of PWL. Hawaiian sucker punch.

Avalanche Forecasting 3 - Public Forecasting

Beginning use of data mining/big data & social networking in forecasting.

Bruce Tremper — Increasing role of crowdsourcing and social media in forecasting. Feedback loops of user involvement appear likely to have interesting implications. GoPro crowd willing to test slopes and conditions that rational people wouldn't go near. This, clearly, is an important topic. Appears to be a piece of Project Zero.

Case study of March 6, 2012, event cycle at Sunshine Village. Continuing case of lessons learned.

Tuesday, September 30 : Instrumentation and Measurement

Further increased use of sensors, remote data collection and data analysis w/ visualization. Various approaches to remote sensing of snow cover, avalanches, avalanche activity at slope to basin(~10 m to ~4000 m) scales. Each appear to have more promise than earlier approaches. Suspect that these will be increasingly applied in fixed situations (e.g. known slide paths) particularly if/when prices come down.

Seismic and acoustic sensor technologies come straight from oil & gas, infrastructure, etc. industries.

I wonder about use of remote/web cams to monitor slide paths and activity in fixed locations.

Chris Morin — first pass of data mining of 35 years of forecasts from NWAC. Demonstrates tiny part of the power of data mining of large data sets. Also demonstrates how much work goes into the front end of large data set analysis. 80% of more of work goes into cleaning and preparing data.

Panel: Avalanche Research - What has science done for us?

Mostly a description of the increasing application over the last 25 years of the scientific method, scientific rigor and resulting systems to the avalanche problem.

No one talked about it explicitly, but it seems clear that advancements in communication (technology) and information exchange have played a fundamental role in improving avalanche safety systems.

The tight(er) connection of the research w/ practical applications (avalanche researchers w/ practitioners) is probably somewhat unique in research/application world. Tighter/shorter feedback loop than in other fields,… perhaps.

However, several commented during and after session that the real problem is (once again) the human/behavioral element — human factors, decision-making, cognitive biases, group dynamics, groupthink/groupidity, etc. This aligns with my observation that, after a point, it primarily boils down to human factors and that it seems to me that this is where the greatest opportunities for improvement reside. Redux: We have met the enemy and he is us.

Roger Atkins repeated several times that given the uncertainty that is currently an inherent part of the avalanche game, judgment will always be a significant part of the guiding process (avalanche game). (see sidebar)

Stated another way, from the guides' perspective the problem still boils down to the slope scale: Should I ski it? Will it slide if I do?

Avalanche Formation, Failure and Dynamics 2 - Fracture

Three talks on propagation tests. Nearly pure mechanics including finite element analyses. Some general observations can be extrapolated, but little (no?) practical applications at this time.

David Hamre — talk about propagation speeds (and perhaps, patterns) as measured from video. While it probably doesn't have much practical application, it might be interesting to look at paper to see range of speeds of propagation and any other conclusions that authors might have drawn about propagation. I wonder what high speed (120 frame/sec)/high resolution cameras would add to analysis.

Thursday, October 2: Human Factors

Note: This session should probably also include Ilya Storm and Grant Helgeson's paper Hot Spots and Hot-Times: Exploring Alternatives to Public Avalanche Forecasts in Canada's Data Sparse Northern Rockies Region.

At this point in the avalanche cycle, once again it appears to me that better understanding of human factors, decision-making and group dynamics is area of great(est) opportunity in avalanche (public) safety.

There is also an increasing overlap between this area and crowdsourcing, data mining and data analytics. e.g Bruce Tremper's crowdsourcing work.

One comment that I found interesting. Not sure if it was intentional or accurate. Not sure exactly what was meant. "Avalanche professionals don't view avalanche hazard scale as linear, but rather exponential." This would imply, I assume, that the hazard scale (stability scale?) is actually logarithmic similar to old Richter scale. Perhaps commenter was conflating this with power-law functions which fits avalanche frequency v. size distribution.

Panel: Compaction - Does it work?

Compaction v. layer disturbance. There is a distinction. One needs to be clear about one's thinking.

Is increased skier traffic creating safer conditions? That is, are more people making it safer for all? One needs to be specific when one thinks about skier traffic volumes. How many tracks — 1, 10, 100,10,000, 1,000,000??

Evidence suggests that compaction/layer disturbance works in dry snow. What about wet snow? Most would seem to say all bets are off when snowpack goes isothermal.

While everyone in the room agreed that knowledge about previous use is important and probably helps increase one's confidence in a particular slope, everyone also saw it as only one factor in determining stability. (Importantly, this is probably not how people skiing in sidecountry see usage/previous tracks.)

This terrain model at the Ortovox table caught our eye as a great education tool to discuss how slope aspect, angle, and wind affect avalanche conditions. *Photo Bill Glude*

In backcountry operations (mechanized backcountry skiing), traffic volumes are relatively low. One thinks in terms of layer disturbance rather than compaction. Is it effective? Depends. In places with surface hoar issues — interior BC — disturbing the surface can't hurt. In places where operations farm areas, disturbance is probably more effective. Keeping track of exact usage is important part of operations process.

Fat skis v. narrower skis make a difference on how deeply one skis and which layers are affected. Fat skis don't penetrate nearly as much.

In all cases, what happens after the disturbance makes a difference. How long does surface sit afterwards? What has the weather been? What comes in afterwards?

Ski areas with large traffic volumes have large areas of compaction. Grooming (and the use of explosives) seen as ultimate in compaction. Early season bootpacking also exists. All are seen as effective, but it is possible that none disturb basal layers. Repeated in-area wet slides noted. Boot packing only effective if it breaks up deep, problematic layers. This doesn't always happen and it isn't always possible to tell if it has taken place during bootpacking process.

Sidecountry seen as problematic by everyone — US, Canadians & Europeans. Sidecountry is perceived by users as safer than backcountry. Despite signage & warnings, sidecountry mostly seen as an extension of in-area skiing. While unstated, it appeared that everyone sees this as a growing problem. Was this issue the elephant in the room?

It seems that increasing sidecountry concerns and in-area wet slides are leading people to question whether a focused research effort shouldn't be directed toward try to better understand compaction.

Risk Management 2 - Backcountry and Public

Don't move to Siglufjorour, Norway. (I wonder why the town was built where it is. Mining? Fishing?) Clear evidence suggests that their zoning and land use regulations relative to hazards (in this case avalanches) is worse and less established than those of Jackson, Wyoming.

Dave McClung continues his efforts to get the avalanche industry to understand and use a common definition of risk.

Case study from Burnie Glacier Chalet of a close call. Introduction of Reason's Swiss Cheese model of accident causation. Read this paper.

Risk Management 3 - Worker Safety

Workplace safety for some avalanche workers appears to be way, way behind most other industries. It appears that everyone could benefit from a critical review of the situation including accident types, uncovering best practices and establishing/formalizing standards based on best practices.

In Canada, it appears that WorkSafeBC has already addressed many of the issues and continues to work on them. Regs appear to have gone into effect five years ago on September 1, 2009. (http:// www2.worksafebc.com/enews/100225/100225.htm)

I would like to see a break-down of worker accident by work type. If I recall, no Canadian guides (working in mechanized industry??) have been killed while guiding. My memory of events suggests that deaths are taking place by ski area workers during control work, but this is only anecdotal and only data could confirm this.

Friday, October 3 : Avalanche Education

More case studies and lessons learned from sledders. Changing Beliefs, Knowledge and Behaviors to Make Snow Safety Stick — This is undoubtedly an important piece of work. Appears to be a part of Project Zero. See AIARE website for details.

The Weiner makes an appearance at yet another ISSW. He needs continual support and occasional supplemental oxygen, but is still having some fun with old friends Mr. Em and Rich Marriott.
Photo John Stimberis

Read paper.

Unified effort to improve snow safety from some of biggest players in the field AIARE, CAC, Dale Atkins, Bruce Tremper, et al.

Group appears to have hired a social scientist/marketing person to understand target audience(s). Cool Tools is worth looking at.

The Development of Ski Guide Decision Expertise — Read paper & references.

Panel: Training, Certification Qualification and Scope of Practice — Who is qualified to do what?

Discussion about moving to self-regulating organization(s) (SRO's) in avalanche work.Formalization of necessary competency profiles seems inevitable as field grows and matures especially since work involves public and working in public interest. For both Canada and the US, SRO's (i.e. self-policing) seem to be the logical alternative to direct government regulation (e.g. OSHA in US). Alternatively, the insurance companies undoubtedly will force the issue at some point if governmentregulators don't.

In guiding industry, IFMGA already exists. Europeans, especially France, are already regulated by their governments far more than North Americans.

Canada is clearly well ahead of US in this area. CAA already appears to be headed to an SRO. ACMG, HeliCat Canada and other trade associations are already SROs or are getting close. (Self-regulation/self-policing has a long history in Canadian guiding/mechanized & backcountry ski industry.)

Dave Cane at Catalysis Consulting in Kamloops ((http://catalysisconsulting.net)) seems to have been brought in by CAA to help them with this work. He spoke about workplace tasks and profiles of competencies. He observed that a competency profile is the foundational document for any SRO. He also discussed the typical evolution of trade organizations which are involved in matters of public interest. e.g. medicine, law and engineering. Cane clearly has been through this process before. His comments about competency and training were brilliant.

US isn't anywhere close to Canada in this area, but it appears that the seeds have been planted and that it will just be a matter of time before they are cultivated. AMGA, AIARE, AAA & Heli-ski US appear to be on a parallel trajectory to similar organizations in Canada with some further along than others.

In the US, engineering, law, medicine and some parts of the financial industry have SROs or professional associations which provide aspects of self-regulation. The National Association of Realtors (NAR) and FINRA (Financial Industry Regulatory Authority) are SROs.

Despite typical resistance from some in the audience (coming from people on both sides of the border),one can safely assume that guiding/avalanche industry is always only one (major) accident away from have governments and/or insurance companies come in and force them to formalize their practices.

One or two people brought up potential downside issues of "creating a guild system" which could be seen as potentially creating a "closed shop" and stifling innovation, new ideas, new practices & competition, but moving the self-policing process forward was seen as a better alternative to direct and/or economic regulation (insurance premiums) by people/goverments/entities who and which don't actually understand practices that they are attempting to regulate/control.

Penny Goddard asked if there shouldn't be an equivalent to the IFMGA for avalanche workers.

Eric's first day of skiing was on January 1, 1965. After 50 years in the snow he feels extremely lucky to have spent as much time in the mountains learning from so many great people as he has. ❄

BRAD WHITE: **Whiskey and Words at the Whyte**

An added hot-ticket evening attraction for participants of the ISSW in Banff this year was an event called Whiskey and Words at the Whyte. Held at the local Whyte Museum, the evening featured a selection of fine single malt scotches for tasting and slide show talks from two local ski historians.

Brad White, descendent of the same family that founded the museum, spoke of his family history in ski development in the Rockies (and explained the different spelling) while intertwining the stories of several early avalanche accidents and the legend of the victims haunting of the Ptarmigan Hut.

The second speaker, author Chic Scott , chronicled the ski exploration of the western Canadian mountains with histories of all of the major multi-day ski traverses from the earliest trips to the present day.

Recovery of Raymond "Kit " Paley, Fossil Mountain avalanche 1933. *Photo courtesy Brad White*

Both speakers had a great collection of early photographs to complement the talks, and the feedback from the audience was that the evening was a great success. ❄

The Eric Harvie Hall at the Banff Convention Centre was full every day. Has the ISSW outgrown the Harvie? Note Peter Schaerer and Chris Stethem up front. *Photo Doug Richmond*

ZACH GUY: **Fracture Mechanics & Avalanche Failure**

At my first ISSW in 2008, Joachim Heierli presented his groundbreaking thesis work on the "mixed-mode anticrack theory." I initially mistook this as a campaign against plumber's butt and park rats in baggy pants, but I've come to realize how instrumental Joachim's research has been for the direction and flavor of new research. Once again, fracture mechanics and avalanche failure was a hot topic at ISSW in Banff. A lot of this year's research was focused on fracture arrest: digging deeper into why some slopes rip wall-to-wall while others pull out just a small pocket or don't fail at all. Presentations covered the full spectrum, from microstructural modeling in a cold lab to in-situ observations on real avalanches. Coming from a practitioner's point of view, I've briefly summarized and thrown in a few thoughts on a handful of the fracture mechanics topics from this year's ISSW.

In 2008, Joachim Heierli presented his groundbreaking thesis work on the "**mixed-mode anticrack theory.**" I initially mistook this as a campaign against plumber's butt and park rats in baggy pants, but I've come to realize how instrumental Joachim's research has been.

Johan Gaume's discrete element model verified some patterns that we see in the field, and did so with some cool videos showing how each particle in the snowpack moves during dynamic crack propagation. Some take-home points from his model were that propagation speed and distance increased for denser or harder slabs, and that longer PSTs may be more appropriate for testing these denser slabs. He also modeled how fractures arrest when tensile strength of the slab (i.e. slab bending) is exceeded to the point where the slab breaks and can no longer communicate crack propagation.

Jurg Schweizer used another modeling approach (cantilever beam and finite element models) in conjunction with field PSTs to explore the effects of slab properties on fracture arrest. Jurg demonstrated how the lower tensile strength of thin, soft, and low density slabs may prevent full propagation due to slab fractures. In contrast, stiffer slabs may require much larger crack lengths to get started, but can have extensive propagation due to their higher tensile strength. It's nice to see models that agree with our field observations and hold potential for future exploration on these topics.

Karl Birkeland spent the winter modifying PSTs and gave us field evidence (and more great videos) showing how the slab is the major driver for fracture propagation or arrest. Undisturbed slabs easily communicated crack propagation across parts of the column where the weak layer had been removed or disturbed, but cuts through the slab caused fracture arrest. Karl used 3-ring notebooks to support parts of the slab from collapsing, and this also halted the advancing crack. I envisioned headlines in the Denver Post this winter reading: "Students rejoice over more recess hours: statewide shortage of school supplies as ski resorts implement new snow safety designs."

Ron Simenhois tackled the conundrum by going to where we actually see fractures arrest: the margins of recent slab avalanches. Ron concluded that at boundaries where gentler terrain wasn't the controlling factor, a majority of the fracture arrests were due to decreases in slab thickness or density. The disappearance of the weak layer also accounted for fracture arrest in some of the cases.

It is great to see how far fracture mechanics have evolved since Joachim's presentation six years ago. But we still have a long way to go. Much of the modeling and fieldwork has been done on isolated columns. There are still questions about the influence of connected slab boundaries (as opposed to isolated slab ends), and how cracks propagate radially outward (rather than linearly across a column). Furthermore, saw cuts or shovel taps have distinct differences from the failure processes leading to spontaneous avalanche release. Connecting these dots can hopefully steer us towards new or improved stability tests and mitigation strategies, especially for those tough-to-forecast problems like deep slabs. David Hamre's presentation about fracture speeds estimated from videos of avalanche failures also raised some insightful questions. Are the models underestimating fracture speeds, and if so, is there another piece of the fracture mechanics puzzle still missing?

Banff was an incredible host this year; the setting was superb, the venue and volunteers were great, and the lunches were so delicious and filling that I slept through all of the afternoon sessions. But I did notice that compared to years past, the single beer ticket frequently led to early social hour arrest. I'm hoping that Breckenridge will serve up denser or thicker beers, or a more continuous weak layer (beer tickets), so that the happy hour will propagate far into the night.

Zach Guy is the lead forecaster at the Crested Butte Avalanche Center and assistant snow safety director for Irwin cat skiing. His favorite ice cream is double fudge brownie. ❄

A stop in the Parks Canada tour, Emerald Lake with the Emerald Lake Lodge set in the center. *Photo John Stimberis*

JOHN FITZGERALD: **Opening Pandora's Box**

If I had to pick out one talk that stood out to me the most it would be Stefan Martensson's presentation of a new smartphone app called "Pandora's App". The development of a new smartphone app that blends, or more precisely, overlays different information on a map application based on avalanche danger (using the North American scale) and terrain classification (using the ATES model), has the potential to go in several different directions.

At the beginning of the talk, Stefan threw up some numbers that showed that upwards of 98% of the people surveyed in this study carried a smartphone with them into the mountains. The percentages for other pieces of gear like a compass, first aid kit, etc. were much lower. There is recognition on the part of the authors that smartphones are ubiquitous and a part of daily life for many people.

The optimist could see this new development as an effective way to communicate avalanche danger in a way that is useable to the public on slope. By having layers of color on a map on a screen, the user would have the ability to see where the danger is greater or lesser. In theory, as I understand it, the skier or snowmachiner could make route decisions based on simple colors that appear on their phone and apply to the actual terrain in front of them.

The pessimist can see a bleak future with this technology. The possibility exists for a person to go to their local gear shop and buy a full kit of gear. They could also buy an app, head out into the mountains and have no training to back up their decisions. While this possibility already exists, and happens with some regularity, now there is a specific electronic device (objective) that has the potential to take the decision-making (subjective) out of the hands of the user.

Rather than lay out some intricate hypothetical future, I think it's best to ask some questions. For this reason I think this was one of the best talks at the conference as it sparked debate and a lot of discussion among my peers.

Can an app such as this be objective? When I use a topo map app on my phone I make the assumption that I am looking at real information based on data. The same goes for sports scores, stock market numbers, or the calendar. As a public forecaster, I know that when I assign a danger rating there is subjectivity involved and the color for a given elevation is painted with a broad brush. In our advisories we strive to provide the critical information that backs up a danger rating. This process and the end result is something that is ultimately done with a degree of subjectivity and considers many factors. Determining terrain ratings using the ATES scale, I think, also relies on some degree of judgment on the part of the technician drawing in the lines on the map.

If an accident occurs, is the forecaster on duty that day directly responsible for the lives and well being of everyone using the forecast area? Forecasting for an operation (e.g. guiding operation, ski areas etc) carries with it this responsibility. But, operational forecasting also involves some degree of control of the people using the area. For example, guides have the ability to steer people away from specific areas. Backcountry forecasters are responsible for communicating danger over vast expanses of public land where the potential exists for hundreds or thousands of people to get into trouble. Will a product like this now create a direct link between the users and the forecaster in terms of liability?

What happens to training and education if backcountry travel becomes dominated by smartphone apps? If I can just look at the screen to tell me where to go why would I need to take an avalanche class or learn how to read a map?

The next time you pull up to a busy traffic light look at all the cars around you. How many of those people are staring at their phone or tapping away on the screen? I like that the authors of this talk recognized that smartphones and their associated technologies are used by many people. I think that it is important to accept and embrace this fact and pay attention to and work towards steering technology like this in a direction that is effective to all users.

John Fitzgerald is returning for his third winter as a public forecaster for the Chugach National Forest Avalanche Center. His most recent piece for TAR, the Hawaiian Sucker Punch, can be found in the April 2014 issue, 32.4. ❄

LYNNE WOLFE: **Two Panel Discussions + Lunch**

The Canadian ISSW organizing committee put on a fabulous conference and instigated a number of new systems this year in Banff. I want to highlight a few of those.

At first glance, the conference tuition seemed much more expensive than previous years, even allowing for higher prices in the tourist town of Banff, AB. On looking deeper into the schedule, however, the discrepancy became clear: lunch for four days was included in the cost. At $25 per lunch, it wasn't a bargain, but a buffet line allowed even the cheapest among us to load up on at least one nutritious meal per day. It also saved time, as popping down to town for lunch would have taken a while, but the biggest bonus was for the community. Having everyone at lunch allowed for greater networking, discussing a presentation or concept, sitting down at an empty slot at a table with people you don't know and finding something in common, or having a quick lunch then heading upstairs to tour the posters, which rotated daily to match the day's theme. It was a format that worked, for me, at least (*got that, ISSW 2016?*).

The second innovation was the inclusion of four panel discussions at the same time as the daily 10:15 to 11:35 presentation session. Topics were (in chronogical order) *Avalanche Safety Equipment for Ice and Alpine Climbing; Avalanche Research- What has science done for us?; Compaction- Does it Work?; and Training, Certification, Qualification and Scope of Practice?* I attended the second and fourth of these panels, and felt that they were very valuable uses of my conference time and attention. Post-panel, a member of the organizing team (panels were sponsored by the ACMG) wrote a short summary, which was then speedily posted on the ISSW web page.

Each panel began with bios and statements from a broad panel of experts on a topic, from a wide geographic and professional cross-section of speakers. After each person spoke, there was ample time set aside for questions from the audience, which led to some memorable quotes and exchanges. You can find panel summaries at http://issw2014.com/workshops/

A few thoughts from panel #2, *Avalanche Research- What has science done for us?* Speakers were Karl Birkeland (KB) and Ethan Greene (EG) of the US, Alex Snickas (AS) of Australia, Jurg Schweizer (JS) of Switzerland, Colin Zacharias (CZ) and Roger Atkins of Canada.

As the panelists spoke, a few notable quotes included:

We are learning to resolve uncertainty via spatial variability through multiple quick pits, more testing options, and more remote weather data. —*KB*

Focusing on properties of snow, we are able to measure changes over space and time. We can make targeted observations by a greater network of weather sites, and then our ability to process information and create accurate models has improved as well. —*EG*

Uncertainty is REAL, and this translates into the question of how to cope with it? There is a strong research/ practitioner loop where we observe, question and hypothesize, test, and then analyze. I suggest that as a community, we continue to improve decision-making by teaching the scientific method from the beginning. —*AS*

Are we sure we are making better decisions than 20 years ago? —*CZ*

See further additions from an email exchange with Roger Atkins in sidebar (right).

Doug Richmond then noted that practitioners have to follow the science in order to make better decisions. Science support practitioner and backs us up. Further discussion brought up the point that the community needs bridges between theipry and practice, people to weight and interpret the research. Mentorship is crucial in this relationship also. The people on the panel were singled out as effective bridges in their roles, as was The Avalanche Review.

The second panel that I attended was Training, Certification, Qualification and Scope of Practice? Who is qualified to do what? I didn't take as detailed notes in this panel, but notable concepts that emerged included: certification is coming down the pike inevitably; it will go better and be more appropriate if we self-regulate rather than have government superimpose regulation upon us as an industry. Recognition of scope of practice, risks of harm, and competency profile is crucial to accurate self-regulation, which includes risk mitigation, clearly articulated job tasks, and a fair system for the public and for the professional.

This sentence jumped out to the AAA: when an agency (private or governmental) moves to an industry regulation role, then its role shifts from primarily member services to serving the public interest. This is very interesting in light of where we choose to go with the Pro-rec split in avalanche education.

A few other small points: the ISSW committee had an ISSW app created for Android and iPhones. Very useful, although internet in the large theater was minimal. They reasoned that having abstracts available electronically would preclude a need for printing them in the programs and save paper. Personally I missed having the abstracts in the hard copy program as I take notes into them, underline and arrow the points, and the text helps me to ID/ remember what I want to see/ what was important.

Sign of the times: sparkle hat and reading glasses. LW presents Divas award to Sarah Carpenter from the DJ perch at the Dancing Sasquatch. Photo Chris Pielmeier

Roger Atkins: **A Few Quotes**

From the Panel Discussion "*What has Science Done for me?*"

> Uncertainty is a personal matter; it is not *the* uncertainty but *your* uncertainty.
>
> –Dennis Lindley
>
> *Understanding Uncertainty (2006)*

Dennis Lindley was a British statistician, decision theorist and leading advocate of Bayesian statistics.

> Science is not yet able to reduce the uncertainty about the stability of a specific slope enough to eliminate the need for human judgment.

This wording leaves the door open to the possibility of eliminating human judgment with objective procedures, although that is not likely to happen any time soon. My opinion is that, at this time, there is more fertile ground for improving decision-making and education through understanding human behavior and cultivating wisdom.

Roger Atkins is originally from the US, and now lives and works in Canada. His passion for powder skiing led him to a certain form of negligence at office work and ultimately into a career as a helicopter ski guide, first in Utah at Wasatch Powderbird Guides and later in British Columbia with Canadian Mountain Holidays.

DON CARPENTER: **A Few Highlights**

Here are the ISSW talks that stood out to me in no particular order...

Roger Atkins: "*Yin, Yang, and You*"
I liked his discussion on "mindsets." It could be a great thing to add to a morning guide meeting and I could see making a great human factor class out of it.

Iain Stewart-Patterson: "*Development of Ski Guide Decision Expertise*"
His discussion of development of expertise is why we have added the debrief as an official part of the checklist. In a wicked learning environment one has to seek out feedback (as it can be rare) to develop intuition.

Karl Birkeland: "*Role of Slabs and Weak Layers in Fracture Arrest*"
Interesting to see how much the slab could communicate the failure even when the weak layer was disturbed.

Panel on "*What has science done for us?*"
Roger Atkins quote to the question "what has science not done for us?"
See sidebar above.

Christoph Dietzflebinger: "*Close Call at the Burnie Glacier Chalet*"
I highly commend him for using a near miss as such a good learning opportunity.

Don Carpenter is an owner and instructor at the American Avalanche Institute. When not working or playing on skis he tries to keep tabs on the early and late season snowpack thru elk hunting and packrafting.

DOUG RICHMOND: **For the Peanut Butter & Jelly Crowd**

Uncertainty and the Operational Field Technician – ISSW 2014

There is plenty of valuable information for the practitioner in the 2014 ISSW proceedings. One recurrent theme throughout the proceedings is Uncertainty. Discussion panels on "Compaction" and on "What has Science Done for Us?" both spent time addressing uncertainty. The scientists are working on identifying variables and on developing tests to characterize and narrow the gray area that exists between go and no-go in the practitioners world. But the grand-scale natural environment we choose to work and play in does not lend itself to total understanding.

Here are a few examples of interest to the operational technician who is charged with mitigation and closure decisions in hazardous avalanche terrain.

"Looking back on this event, it is easy to see that early season tactics such as bootpacking, explosives, ski cutting, and skier compaction are effective avalanche terrain management tools in the continental snowpack."

–Ryan and others, Copper Mountain Ski Resort

Reed Ryan, Jeffrey Davis and William Blair presented a case history from Copper Mountain that looked at the difference their early season trampling made in a season with a stubborn persistent weak layer. They battled the problem all year, operating in that high-consequence gray area that comes with their profession. The battle culminated in large scale February avalanches. Because of their season-long efforts, they had some avalanche terrain that was "unreactive and remained open to the public" during this spectacular cycle. Their story illustrates the daily uncertainty and risk that comes with operating or playing in high-stakes terrain.

"The development of ski guide decision expertise is situated within an environmental context influenced by massive consequence and feedback ambiguity."

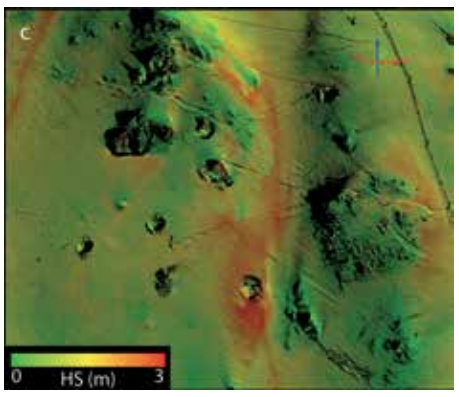
"The central problem is that decision feedback often lacks clarity when nothing goes wrong."

–Iain Stewart-Patterson, Thompson Rivers University, Kamloops, BC

Iain Stewart-Patterson analyzed the problem of making high-consequence decisions in huge natural settings with ambiguous clues. He says we should not discount intuition and that "Deliberate practice aimed at the development of context specific expertise provides the foundation for a high quality decision process." In other words: to know there, go there- and pay attention.

"TLS [Terrestrial Laser Scanning] technology has advanced rapidly in recent years, and the latest generation of sensor systems has enabled the starting zone mapping described here... the future for avalanche research and application using this powerful tool holds much promise."

–Jeff Deems, National Snow and Ice Data Center, Boulder, CO



Jeff Deems helps us with what to see out there. He presented spectacular high-resolution images of snowpack thickness at A-Basin. These are powerful illustrations of how terrain and snowpack interact. Jeff's presentation was the most exciting progress I saw at this ISSW. This Terrestrial Laser Scanning (TLS) technology looks to be on the right track for development of the Stratigraphy Goggles we want from the scientists. Maybe we can put the MIT Avatech folks on this one. Right now, it looks like you could mount the unit on your helmet, but you would have to hold still and try not to blind people.

> Avalanche forecasting is a challenging and humbling profession that can only improve with fastidious record keeping, abundant field observations, an eye to the science behind it, and a passion for sliding on snow.
>
> *–Don Sharaf*
> *Valdez Heli-Ski Guides*

> One regret is that I am not a scientist, and data recording is not my strength, so I can't provide a lot of hard data on this – but we know it's true.
>
> *–Akio Shinya*
> *Niseko Avalanche Institute, Japan*

"Fortunately our policy of continuous testing with explosives revealed the scope of the problem and allowed us to mitigate the risk to both the public and to Crystal Mountain employees."

–Paul Baugher, Crystal Mountain, WA

Paul Baugher presented another case history. This one involves a very large wet slide cycle at Crystal Mountain, Washington, where a chairlift was destroyed. Once again, this was a persistent weak layer problem, in this case caused by atypical early season conditions for Washington. Explosives played a big part in their operational decision making.

"We argue that it is not acceptable to use explosives to determine "stability". The message this term conveys is erroneous and misleading."

–Dick Penniman, Consultant, Truckee, CA

Dick Penniman and Michael Leatherbee presented a poster where they discuss the strict meaning of the words "test" vs "tool" in the controlled laboratory or mathematics sense, and then wrongly conclude that explosives should not be called a test and that "When explosives fall short of producing a definitive conclusion (i.e., an avalanche), even institutional knowledge and experience do not yield data dependable enough to support a conclusion that the slope is safe." They also say that without such data, "… the only safe decision is to isolate the questionable area from public access." This black-or-white perspective does not reflect the uncertainty that practitioners work in. Their conclusions also underestimate the value of negative explosives tests to the experienced field decision maker. They cite two of the historic cases where post control releases occurred on persistent weak layers, but fail to look at the long history of successful programs that count on explosives as the most reliable and powerful test available to the field practitioner.

"The litigation process was instructive and the accident prompted procedural changes at Canyons, including improvements to internal snow safety manuals, improved warnings to skiers, and better overall awareness of the inherent risk of inbounds avalanches."

–Jake Hutchinson, AAI, Park City, Utah

Finally, Jake Hutchinson shared the details of an avalanche fatality that occurred in open terrain at Canyons Ski Resort, Utah in December 2007. His paper presents lessons learned from this event and from the ensuing trial, with a unanimous jury verdict in favor of the resort. He credits diligent efforts (including explosive testing), good record keeping, and adequate signage for convincing the jury that the patrol had done their best in dealing with the inherent uncertainty. His insight and advice are must reading for field technicians and decision-makers.

There are many more interesting papers in these proceedings. They all help the field practitioners broaden their perspectives and improve their chances for positive outcomes in their choice to work in majestic natural places where they sometimes face grand scale perils.

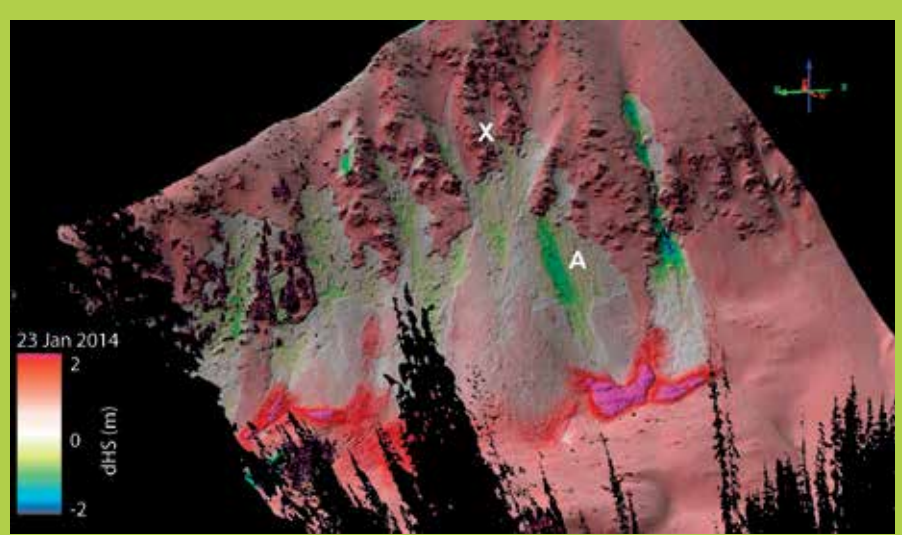
Doug Richmond is a 40-year veteran ski patroller. Some of Doug's notable quotes from ISSW are scattered through the text. ❄

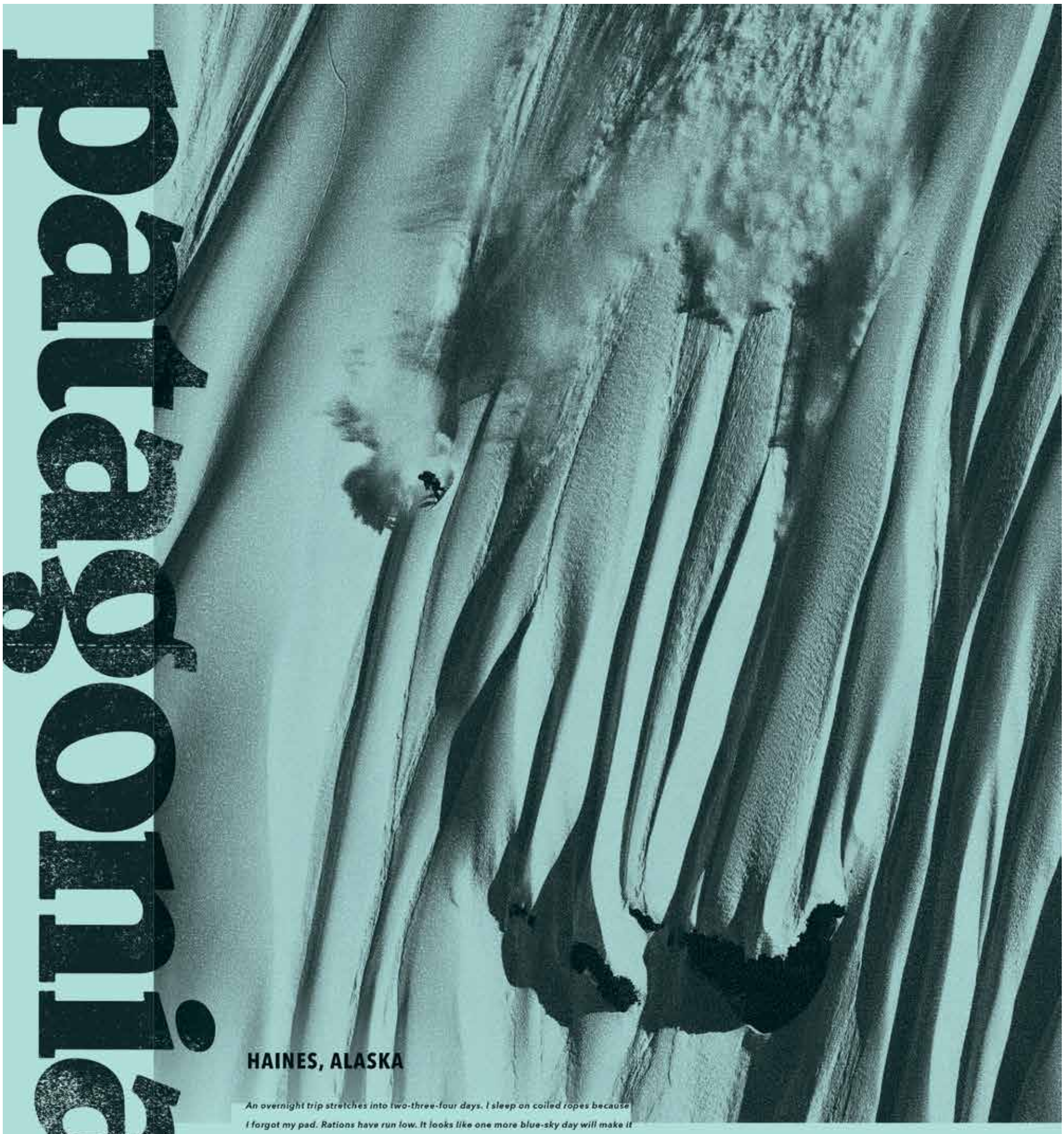
JEFF DEEMS: **Mapping of Starting Zone Snow Depths**

Results from a pilot study (funded by a AAA Theo Meiners Grant) to map starting zone snow depths at Arapahoe Basin, CO with a ground-based laser scanner were presented at ISSW 2014. The scanner uses laser pulses to map terrain or snow surface elevations at high resolutions. Subtraction of two elevation data sets produces snow depth or snow depth change if a prior scan is used as the reference data set. The data reveal the complex loading patterns in this alpine, wind-affected terrain, and show much promise for informing avalanche control efforts.

(a) Snow depth change map of the East Wall on February 1, 2014. Colors indicate change in depth from the prior scan on January 23. Avalanche features are readily observable and measureable. The white color (0 depth change) of the bed surface indicates that the slides ran on the old snow interface.

(b) Snow depth map of a drift feature in Montezuma Bowl, January 17, 2014. Ski cuts and bomb craters are evident. These data could be used to evaluate shot placement or non-result shots, and to document control efforts in conjunction with a digital route/path atlas. ❄





HAINES, ALASKA

An overnight trip stretches into two-three-four days. I sleep on coiled ropes because I forgot my pad. Rations have run low. It looks like one more blue-sky day will make it five. One more legendary line. We have it timed: Pack up camp, move down glacier, drop gear, charge up the line. The cold has sucked out all the moisture from the top layer–crystalline flakes spray triple-overhead. We're back to the boat by dark.

#Find_Away

Ryland Bell was supposed to grab all the food from the fridge–but forgot. "This became an issue when the overnight trip turned into five days." With AK as a backyard, things are bound to happen. See more photos and video online. patagonia.com/findaway
Photos: Jeff Curley |

hazard

Mapping in Switzerland

By Stefan Margreth
WSL Institute for Snow and Avalanche Research SLF, Flüelastrasse 11, CH-7260 Davos Dorf

The mitigation of natural disasters has a long tradition in Switzerland. Approximately 15% of the 8.2 million Swiss inhabitants live in dangerous mountainous areas, about half the total land area of this small European country. Switzerland is divided into 26 largely independent "cantons" or states. However, federal laws require the cantons to consider the danger of natural hazards such as avalanches, rockfall, landslides, debris flows and floodings for land use planning. The fundamental legal base to prevent building in hazardous zones is (1) the Federal Forest Law, (2) the Federal Law for land use planning and (3) the general principle that the state must protect life and property of its citizens. For this purpose hazard maps are prepared and event cadasters are kept. The communal building plans must be in agreement with the hazard maps. The principle idea behind the hazard maps is that building outside of a safe zone is not permitted. The first avalanche hazard map was elaborated in 1954. Today 97% of the required avalanche hazard maps have been drawn up and implemented.

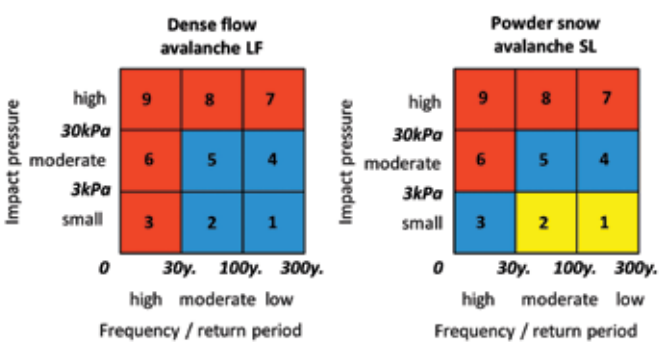
HISTORICAL BACKGROUND

The Second World War caused a change in social and economic life in Switzerland which had considerable influence on the value of land. A rise in land value occurred especially in the alpine areas as farming decreased and tourism increased. The expanding tourist resort areas needed new building sites, leaving the farmland unused. This caused a rapid increase in the real estate prices up to a factor of 50 in some communities compared to the pre-war level (Frutiger 1980). The consequence was a speculation in land price without considering avalanche danger. Conflicts were inevitable. This problem quickly became evident during the two catastrophic avalanche cycles of 1951, the worst avalanche winter in 100 years. A total of 98 people were killed, 73 in buildings. Over 1400 buildings were destroyed. As a consequence, in 1952, the federal Swiss government made the first proposals to adopt avalanche hazard mapping. In Switzerland the first hazard maps were made in Gadmen and Wengen (both located in the Canton of Bern) in 1954 and 1960, respectively. The hazard map of Wengen was divided into red zones (no construction allowed) and blue zones (construction with structural reinforcement) for the first time. These first hazard maps were elaborated in a qualitative way. Expert evaluation and analysis of observed avalanches was used without any avalanche dynamics calculations. The threshold between the red and blue zone corresponded to an impact pressure of 20 kPa of a 100-year avalanche. In 1962 the Federal Institute for Snow and Avalanche Research SLF conducted the first training course on avalanche hazard mapping.

On 27 January 1968 Davos was struck by several extreme avalanches. The Dorfbach avalanche exceeded the blue zone by a distance of 300 m Twenty-nine buildings were destroyed and four people were killed. This event was a wake-up call for authorities, insurance companies and the public. It became clear that a legal basis for hazard mapping was necessary and that better criteria to define the extent of hazard zones were needed.

SWISS GUIDELINES FOR AVALANCHE HAZARD MAPPING

In order to harmonize avalanche hazard maps throughout Switzerland, the Federal Office of Forestry and SLF published in 1984 the "Guidelines to account for avalanche hazard in land use planning" (BFF and SLF, 1984). The hazard level was defined as a function of return period and intensity of an avalanche. A return period of 300 years was defined as extreme scenario beyond which the avalanche danger is considered as residual risk. A return period of 300 years was chosen because many event cadasters date back to the 17th century. Fracture depths of avalanches can be extrapolated with an acceptable uncertainty for 300 years based on the available snow data from observation series, which typically cover 30 to 70 years. If the avalanche pressure of a 300-year avalanche is greater than 30 kPa an area is defined as a red zone. The value of 30 kPa was chosen because up to this pressure a structural reinforcement of a building is economically justifiable. Windows and doors break with a pressure of 1 to 2 kPa and a masonry building will be destroyed with a pressure of 12 to 24 kPa. Frequent avalanches with a return period of 30 years need to be additionally considered in hazard mapping. By definition the whole runout area of a 30-year dense flow avalanche is also a red zone. A return period of 30 years was chosen to achieve a significant difference to the extreme scenario of 300 years. Because other natural hazard processes used a 100-year scenario the avalanche hazard mapping guidelines were extended to include 100-year events in the 1990s.



Hazard matrices for dense flow and powder snow avalanches. The hazard level is defined as a function of return period and intensity.

Residential building in a blue zone with structural reinforcement. The structural reinforcement increases the cost of a building by around 10%.

The core of the Swiss hazard mapping system has three colors: red, blue and yellow. Each color indicates a specific hazard level. This three-color system is used in Switzerland for all natural hazards, i.e. avalanches, flooding, debris flows, landslides and rockfall. The return periods are the same for all hazards. However, the criteria to classify the intensity for the individual hazards are different. For avalanches a specific hazard matrix for dense flow and powder snow avalanches is distinguished. In a red zone the construction of new buildings is prohibited. Existing buildings can be maintained although it is prohibited to substantially increase the monetary value or increase the number of people (e.g. to add an additional floor on a house). In a blue zone the construction of new buildings is possible under certain conditions (e.g. structural reinforcement of the building against avalanche impacts, see photo). The specifications are outlined in the communal building code. In a yellow zone sensitive infrastructure or buildings with a high concentration of people (e.g. school) need to consider the prevailing hazards.

PRACTICAL ASPECTS

The elaboration of hazard maps is based on the following points: inspection of terrain and vegetation, analysis of snow and weather data, study of historical avalanches, definition of scenarios, avalanche dynamics calculations and expert interpretation. The application of two-dimensional avalanche simulation models such as RAMMS (ramms.slf.ch) is considered to be state of the art in hazard mapping. However, the results of avalanche simulations have to be carefully interpreted. In a first step, intensity maps are prepared which show avalanche intensities for the 30-, 100- and 300-year scenarios. Then the three intensity maps are summarized in a hazard map according to hazard matrices (Fig. 3). The hazard maps are elaborated at a scale of 1:5'000 for settlement areas only. The elaboration is done by private engineering companies supervised by cantonal natural hazard experts. The communes are required by law to integrate the hazard map in the local building plan which has to be accepted by vote. Experience shows that an early and open dialogue between the cantonal and communal authorities and the public helps to accept a hazard map. The hazard maps and their implementation into a legally binding land-use plan have direct implications for land owners. Conflicts between landowners and legally based land-use restrictions are not always solved without debate. For example, questions concerning the compensation for land in a high hazard zone can lead to legal conflicts. In difficult cases a second expert evaluation is often requested. If legal objections cause a court case the SLF can be asked to contribute an independent evaluation of the case. The hazard maps of the different processes are summarized in one synoptic hazard map which facilitates the interpretation for communes (PLANAT, 2005). The interpretation of hazard maps for different processes elaborated according to unequal criteria (e.g. different colors, different scenarios) is considered too complex. The intensity maps are an important tool to define reinforcement measures if a building is situated in a blue zone. The structural reinforcement measures of new buildings are in some cantons supervised by insurance companies. Avalanche damages to buildings are covered by insurance companies if the execution of the reinforcement measures corresponds to the requirements. If a building is destroyed in a red zone (e.g.

by a fire) the damage cost is covered by the insurance company (not the cost of the land). However, the building cannot be re-built at the same location. Hazard maps are also an important basis to devise alarm and evacuation plans, which are obligatory for all hazard zones.

A problematic point of hazard maps is that they often arrive too late. Many settlements with avalanche problems have existed for centuries. Hazard maps in such areas, however, are nonetheless useful to direct future development without increasing the damaging potential. Hazard maps are a cost-effective way to manage danger due to avalanches. The elaboration of hazard maps requires about 5 to 10 working days per km2. To establish a map for a commune requires approximately one year. If a hazard map shows that existing buildings are situated in a red zone the use of the buildings is not prohibited. However, future building is prohibited and often structural mitigation measures are planned to improve the hazard situation. In average 40 million USD are spent per year for avalanche mitigation projects in Switzerland. Such measures are subsidized by the federal government and the cantons up to 70 to 90% of the total cost. If existing hazard maps are not considered in building activities no subsidies are paid. Resettlement has been applied only in few cases. A rough estimation shows that in Switzerland about 3000 residential buildings are in red avalanche zones and about 10,000 residential buildings in blue avalanche zones.

EXPERIENCE

Three large snowfall periods during the 1999 winter led to numerous extreme avalanche events, causing the deaths of 17 people, damage to about 1000 buildings and blockage of many important traffic lines. This extreme avalanche cycle was a valuable test for the Swiss avalanche hazard mapping procedure. The 1999 avalanche winter is considered the most extreme avalanche cycle since 1951, the avalanche cycle which initiated avalanche mapping in Switzerland. In almost all cases, the observed avalanches stopped within the avalanche-hazard zones. The avalanche hazard maps clearly contributed to the reduction of the number of deaths in buildings since the maps were often used for the planning and execution of community evacuations (Gruber and Margreth, 2001). Furthermore, 1999 followed a period of 15 years with no major damage caused by avalanches in inhabited regions. The events of 1999 emphasized that it would be wrong, in periods of low avalanche activity, to reduce efforts to integrate avalanche-hazard maps in land-use planning. Approximately 40 of about 1200 large avalanche events passed the limits of the existing hazard zones. The primary deficiencies were underestimation of the hazard of powder-snow avalanches, multiple avalanche events in a single track within a short time period (see figure at right) and fracture depths larger than those used in avalanche-dynamics simulations.

The Swiss hazard mapping procedure is transparent and easy to understand. The approach is based on a number of manuals (guidelines and recommendations), which are supported nationwide. Only small differences exist between individual cantons. An advantage for the elaboration of hazard maps in Switzerland is that event cadasters have a long tradition. Further a legal framework exists to implement hazard maps (landuse plans and building codes at the communal level). Due to the high number of supporting structures and dams implemented in Switzerland, the consideration of structural mitigation measures in hazard mapping is becoming more and more important. In Switzerland only permanent mitigation measures are considered. The effect of temporary measures such as artificial release of avalanches is not considered in hazard mapping because human intervention is necessary.

In summary, avalanche-hazard mapping has proved its usefulness as a long-term instrument to reduce the damage potential in Switzerland and many other mountainous regions.

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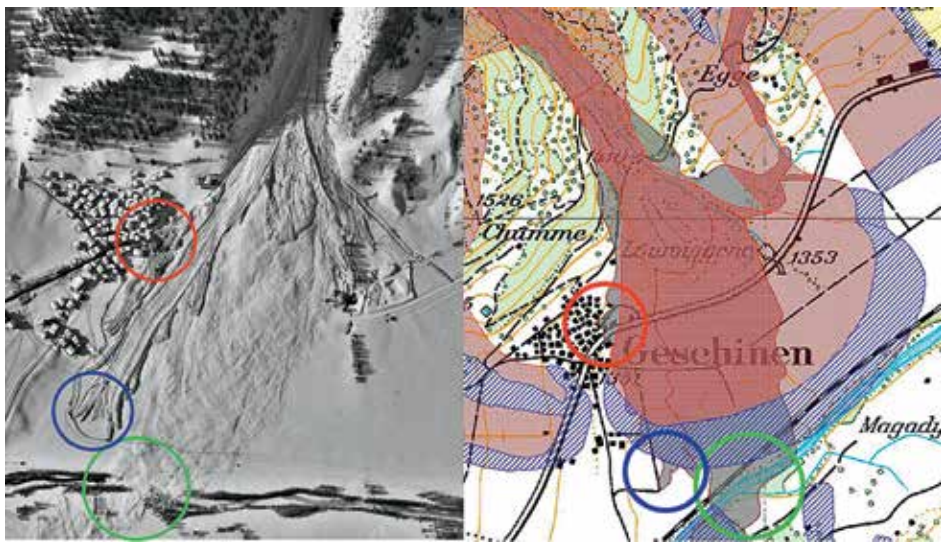

Aerial picture of the deposition area of the avalanche events in Geschinen in February 1999 and corresponding hazard map. Seven large avalanches occurred. The last event of 23 February 1999 reached the evacuated village and destroyed several houses. The deposition height was up to 18 m. At three locations avalanches exceeded the hazard zones (red, blue and green circle).