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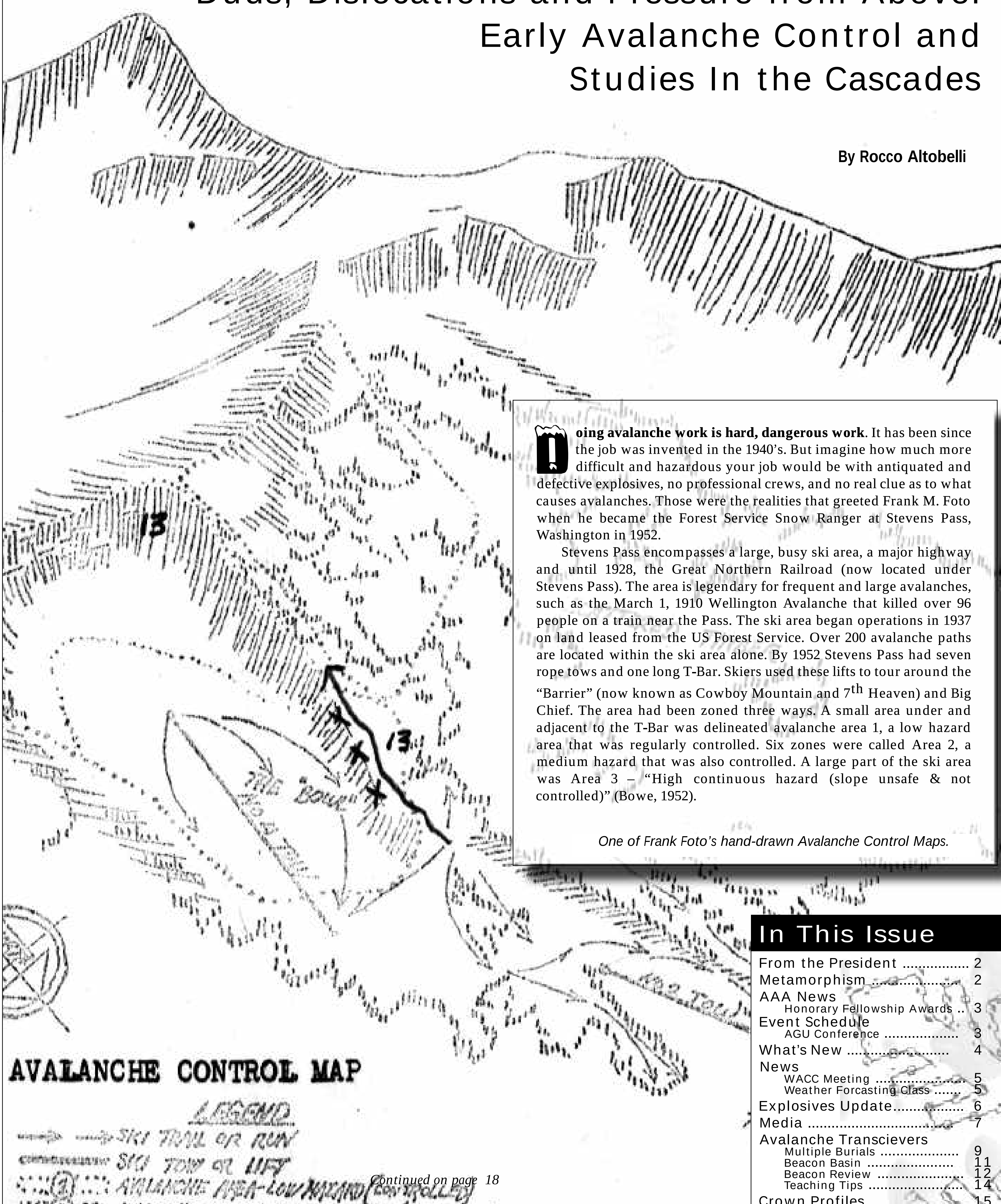
Duds, Dislocations and Pressure from Above: Early Avalanche Control and Studies In the Cascades

By Rocco Altobelli

Doing avalanche work is hard, dangerous work. It has been since the job was invented in the 1940's. But imagine how much more difficult and hazardous your job would be with antiquated and defective explosives, no professional crews, and no real clue as to what causes avalanches. Those were the realities that greeted Frank M. Foto when he became the Forest Service Snow Ranger at Stevens Pass, Washington in 1952.

Stevens Pass encompasses a large, busy ski area, a major highway and until 1928, the Great Northern Railroad (now located under Stevens Pass). The area is legendary for frequent and large avalanches, such as the March 1, 1910 Wellington Avalanche that killed over 96 people on a train near the Pass. The ski area began operations in 1937 on land leased from the US Forest Service. Over 200 avalanche paths are located within the ski area alone. By 1952 Stevens Pass had seven rope tows and one long T-Bar. Skiers used these lifts to tour around the "Barrier" (now known as Cowboy Mountain and 7th Heaven) and Big Chief. The area had been zoned three ways. A small area under and adjacent to the T-Bar was delineated avalanche area 1, a low hazard area that was regularly controlled. Six zones were called Area 2, a medium hazard that was also controlled. A large part of the ski area was Area 3 – "High continuous hazard (slope unsafe & not controlled)" (Bowe, 1952).



One of Frank Foto's hand-drawn Avalanche Control Maps.

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The American Avalanche Association

The mission of the AAA is:

A. To provide information about snow and avalanches;
B. To represent the professional interests of the United States avalanche community
C. To contribute toward high standards of professional competence and ethics for persons engaged in avalanche activities;
D. To exchange technical information and maintain communications among persons engaged in avalanche activities;
E. To promote and act as a resource base for public awareness programs about avalanche hazards and safety measures;
F. To promote research and development in avalanche safety.

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FROM THE PRESIDENT: RUSS JOHNSON

12/19/02, Squaw Valley, California.

After a one-day break and epic skiing, a second wave of storms has begun pounding the northwest and California today. Early season helter-skelter.

Northern California has had two storms or storm cycles this season, which have left us with eleven feet of snow. The first — on November 8-9 — left four feet, and the latest — Dec. 13–17 — left about seven feet. Early season is the most difficult time for forecasting in my area. Large slides in small paths, large slides in large paths. Terrain features, which disappear mid-season, figure prominently in predicting avalanche activity. Ice lenses and depth hoar combine with these micro terrain features to make for nuances in the snow which are hard to keep up with.

On day two of the latest storm, natural activity is the dominant feature. Nearly every major path in the ski area goes out at two feet or more. On day four, control work releases a six inch slab which typically runs a couple of hundred feet. By the time this one hits the Mountain run 900 vertical feet below, it has entrained enough snow to partially bury a grooming machine which is waiting for clearance to cross under the path.

Later that day, as crews are setting up a new area, they see a large natural. It has been snowing since morning but only moderately. Upon investigation, the crown is seven feet deep. The avalanche is on a knoll which is not considered a slide path, is not on any route, and as far as I know has never been controlled, yet is crossed daily by control teams. A seven foot natural — get the heck outta here.

And wasn't it January 4th, 1982 that Jim Mott and Sam Davis were caught and buried and nearly died in another non-slide path? Again, a place never controlled before or since. Helter skelter.

Compounding the problems is the set up of the snow study plots. Inevitably not all sensors work, and this is especially true of the depth sensors. I think it's something about 22 gauge wire and 70 mph winds with rime. Add to the mix the usual bugs in the lifts, inexperienced dispatch and new patrollers, market pressure and competition to have things open, and early season seems to be chaotic on all levels.

So does this helter skelter trickle down to patrollers and customers. You bet. The 12/31 route sheet comment section for Tower 6 simply states "washing machine." That signifies an out of control tumble in the slide, not just a sitting ride. What it doesn't indicate is that this patroller's partner was caught minutes later as he came to his help. That same day we open KT knowing that we haven't gotten to every little pocket. The dogs are in place, and we roll the dice. Sure enough, within an hour we have reports of customers caught in two separate incidents. No burials but good little rides.

The message for me is that the early season is just inherently less predictable. We can take all the precautions and do everything "right," but stuff is going to happen. We're all in big mountains, we're in wild weather, we're dealing with thousands of customers/backcountry riders and it all cannot be predicted much less perfectly controlled.

Early season surprise.

Photos by Will Paden

Knoll where 7 foot deep natural slide occurred.

Crown of seven foot deep natural slide.

METAMORPHISM

Kai Allen has moved on from his position as Snow Ranger at the Mt. Washington Avalanche Center in New Hampshire. He is now Snow Ranger at Crested Butte and District Wilderness Specialist in Gunnison, CO for the Grand Mesa-Uncompagrhe-Gunnison National Forests. His new email address is kallen01@fs.fed.us and his phone number is (970) 641-4417.

Andre Roch passed away this past November. Roch was born at the foot of the Alps in Geneva Switzerland in 1906 and educated in Corvallis Oregon. He is remembered as a pioneer in avalanche science, mountaineering, and the development of the Aspen ski area. Amoung his contributions were the development of the shear frame, the North American avalanche climate classification, the classic route to Everest's South Col, and surveying and organizing the clearing of Aspen's first run in 1937. A full memorium will appear in the next issue of *The Avalanche Review*.

AAA thanks the following members for contributing an additional donation to further our efforts:

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The following avalanche educators are recognized as AAA Certified Avalanche Instructors:
Tom Carter, Carnelian Bay, CA
Denny Hogan, Silt, CO
Sandy Kobrock, Pagosa Springs, CO
Dick Penniman, Truckee, CA
Chuck Rose, Taos Ski Valley, NM
Don Sharaf, Victor, ID

AAA NEWS

AAA Bestows Awards

At the general meeting held in Penticton, BC, the AAA announced four awards. They were: **Doug Fesler**, Honorary Membership; **Tom Kimbrough**, the Bernie Kingery Award for Distinguished Professional Practice; **Dr. Horst Schaffhauser**, Honorary Fellowship, and **Mr. Kazuo Fukuyama**, Honorary Fellowship. The citation for Doug Fesler appeared in Volume 21, Issue 2 of *The Avalanche Review.* The citations for the Honorary Fellowship awardees are printed below. The citation for Tom Kimbrough will appear in the next issue of *The Avalanche Review*.

Honorary Fellowship Award: This award is made to individuals who have contributed significantly to the quality and success of avalanche related programs in countries other than the United States. It recognizes avalanche workers or researchers who have made significant contributions and communicated their work to peers in the U.S. Membership in the AAA is not a requisite for the award. Members should submit a petition and 200-word citation to the Awards Committee Chair. Recent Awardees include: *Karstein Leid* (1998), *Pavel Chernouss* (1996), *David McClung* and *Tsutomu "Tom" Nakamura* (1994).

Mr. Kazuo Fukuyama

Nominated by: Rand Decker, Liam Fitzgerald, Gabe Garcia, Daniel Howlett, Rod Newcomb and Onno Wieringa

Kazuo was born in 1934 in Kumamoto, where it seldom snows. It was about twenty years later that he skied for the first time. After that, he has been fascinated by the snow and has dedicated his life to the snow and skiing for nearly 50 years.

He received the bachelor degree in Laws from Tokyo University in 1963 and then went to Europe to study German at the Goethe Institute, and to join the Austrian National Ski School of St. Christoph in Arlberg. The Austrian Ski School is known, to this day, for its commitment to mountain craft and guiding skills, as well as ski instruction. He spent two years finishing the ski-instructor's course in Austria. During these years, he also spent some time in Paris and Grenoble to learn French. He then joined French National Ski School in Chamonix and finished its courses in 1967.

After returning to Japan, Kazuo remains active in the Ski School of the Zao resort and as the Snow Safety advisor to the new Arai ski area in Japan. He has been a pioneer in bringing North American style avalanche forecast and control techniques to Japanese ski area operations. In that role, he has brought numerous young colleagues to the USAto see Class A avalanche ski area operations first hand. He has attended ISSW's and encouraged Japanese ski area operational colleagues to join the AAA. He is the primary individual responsible for having several North American avalanche professionals visit, present and /or exchange to Japan.

Kazuo is also instrumental in the Morita Sports Foundation; an organization founded by Mr. Akio Morita, the ex-CEO of Sony, to foster and support Asian winter Olympic athletes.

Dr. Horst Schaffhauser

Nominated by: Rand Decker, Peter Hoeller, Art Mears, Rod Newcomb, Knox Williams

Horst is a graduate of Graz University, including a Ph.D. in Geographical Sciences.

After a period of academic service at the University of Graz, and professional practice in the Forest Ministry Headquarters in Vienna, Horst was selected to serve as the Director of the Austrian Institute for Avalanche and Torrent Research in Innsbruck. He has served in this latter role for 29 years. He will retire this role in the spring of 2002.

During his time as the Institute Director, Austria has almost completed building-out the constructed avalanche defense of the Tyrol and other Federal States. Horst was instrumental in the development of Austria's computer models for avalanche run-out, now used operationally in zoning and land use planning considerations. He has also been instrumental in the development and operational deployment of avalanche radars. Even at the close of his time at the Institute, he continues to pursue new initiatives in full-scale avalanche dynamics experiments, snowpack extent and depth radar mapping, and avalanche explosives delivery systems.

Horst has been very active in developing international cooperation. The European representative to the AAA is a member of his staff and regularly attends the ISSW's with Institute leave and support. Over the years, Horst's Institute has hosted a variety of international meeting for the community. He has expanded cooperative arrangements with the Swiss Institute in Davos, and has always been willing to host visiting scientist and operational individuals from around the world, including many from North America.

In his younger days, Horst and a group of skilled colleagues did a number of first winter ascents and descents in the French, Swiss, Italian, and Austrian Alps. To this day, he remains an avid backcountry skier, and spokesman for thoughtful public education on the same.

He is a justifiably proud expert on the wine culture of his native eastern Austria. His *exactingly* detailed model rail collection includes both the Santa Fe and Great Northern lines, amongst numerous European roads.

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Call for Papers for EGS-AGU-EUG Joint Assembly

The organizers of the joint assembly of the European Geophysical Society, American Geophysical Union, and European Geosciences Union have announced the deadlines for registering and submitting papers. The event, to be held April 6-11, 2003 in Nice, France, will offer over 500 sessions covering all areas of geology, geochemistry, geophysics, and bio-geosciences. Deadline for early bird registration is Dec. 31, 2002; deadline for abstracts is Jan. 15, 2003, and deadline for pre-registration is March 7, 2003. For more information, contact the program committee at manager@cosis.net or see http://www.copernicus.org/egsagueug/index.htm.

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WHAT'S NEW?

BCA Awards Avalanche Education Support Grants

The makers of the Tracker DTS avalanche transceiver have announced the recipients of their 2002-03 Avalanche Education Support Grants.

The announcement was made by Backcountry Access (BCA) and Rescue Technology, the distributor and designer, respectively, of the Tracker DTS. The two companies joined forces to donate $20,000 worth of funding and equipment to organizations dedicated to increasing avalanche education in North America.

The top recipients of cash and/or equipment grants were the Alpine Safety Awareness Program of Bellingham, Washington; Gallatin National Forest Avalanche Center in Bozeman, Montana; the Sawtooth National Forest Avalanche Center in Ketchum, Idaho; Teton County, Idaho Search and Rescue; and the American Institute for Avalanche Research and Education, based in Crested Butte, Colorado.

The grants came with "no strings attached," according to BCA President Bruce McGowan. "Our goal was simply to provide resources to those educators that were reaching out to those most at risk." Several of the top recipients were specifically targeting snowmobilers and youth. Both of these groups have experienced a sharp increase in fatalities over the past five years.

"Transceivers are an essential tool for all recreationists travelling in avalanche terrain," said John Hereford, designer of the Tracker DTS. "But there's no substitute for education — and staying out of harm's way. As the industry leader in snow safety technology, we're equally as obligated to promote education as we are to promote the use of beacons."

As part of its Avalanche Education Support Program, BCA's technical reps are also providing avalanche awareness and companion rescue workshops across North America, mainly to user groups that aren't already receiving such education. And on Sept. 6, the company threw a major fundraiser, "Avalanche Jam," which raised $10,000 for the Colorado Avalanche Information Center.

For more information on BCA's Avalanche Education Support Program, see http://www.bcaccess.com.

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New ISSW Video Library: Don't forget what you learned!

By Kellie Erwin

For those of us that attended the 2002 ISSW — "Best one yet, eh?" — the simulcast room was definitely the highlight: big screens, televisions, mats to relax and stretch and good audible sound. What a concept! What you may not have known is that behind the scenes, every presenter was being taped. Yes, that's right; what you saw on the big screen is now available on video.

The video format allows you to refresh your memory and share with your staff some of those favorite talks you don't want to forget. Remember Dan Moroz' case history presentation on an unusual rain event and wet slide cycle at Cooper Mountain? How about Dave McClung's high-powered mechanics presentation? Was there perhaps a presentation you missed because you got carried away with some old buddy? If you did not understand a concept, here is a chance to do some playback and see if the data matches your memory. Ski patrols, heli-ski operations, avalanche educators; this can expand your snow resource library. The bottom line: use it to refresh yourself, educate your staff, or as a teaching tool.

This was the first year the ISSW Workshop has been taped. These tapes will be the first in a new "ISSW Video Library." From 2002 onward, the ISSW will be recorded, with the tapes archived and made available to avalanche practitioners, theorists, scientists, and teachers.

With a minimum order of 100 we can go into final production. The copying warehouse has been generous, and all the time and money spent on this project has been donated by people like you. Special thanks to the speakers who gave us permission to videotape their presentations. Please make an order so we can launch the ISSW Video Library. Once costs are covered, proceeds will go towards avalanche research and education.

The ISSW Video Library is sold for **$89.99**, (US) which includes a box set of 8 tapes in VHS format.

For more information and the order form: please go to **www.isswvideos.com**; E-mail: info@isswvideos.com; Phone: Kellie Erwin 250-344-5707; Ryan Gallagher 250-344-4666.

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NEWS

WACC'S Fall Avalanche Blasters' Workshop

By Patty Morrison

On November 16th, 2002, The Washington Avalanche Control Council (WACC) presented their first Avalanche Blasters' Workshop. The goals of the workshop included education, safety, and bringing together different groups involved in the explosives industry. The WACC was formed in the fall of 2001 to be a collective voice concerning potential changes in State and Federal regulations for avalanche explosives use. It provides services such as information exchange and educational workshops to its 230 members who are licensed blasters. The WACC is looking to become a non-profit organization and has become a member of the International Society of Explosive Engineers (ISEE). Joining the ISEE is an avenue towards exchanging helpful information and improving relations with other communities within the explosives industry.

Shane West, patroller at Stevens Pass, did a great job of organizing the workshop, which included a variety of speakers and topics:

Jerry Wallace, representing the ISEE, gave a brief synopsis of the ISEE. Jerry also pointed out how most of the explosives industry views avalanche control, in regards to how small of a faction we really are (possibly 1%). We are also considered a huge liability due to our use of cap & fuse ignition. Refreshingly, however; the goals of the ISEE are also safety, education, and information exchange.

Shane West, who gave an excellent presentation on the history of avalanche control in the United States.

Gerry Woods, representing the Washington State Labor & Industry Board. Gerry laid out some of the state regulation changes, including a new blaster license test that will be four hours long, open book, and passing with no less than 100% correct answers. She also put major emphasis on documentation and up-to-date accurate inventory. Her slide show was quite humorous.

Paul Baugher, Crystal Mountain's Ski Patrol Director and Head of the Northwest Avalanche Institute. Paul talked about route safety, emphasizing "situational awareness" as well as some of the inherent pressures of avalanche control.

Lee Redden, Snoqualmie Dept. of Transportation, gave an informative talk on the proper use of DET Cord and his preferred knots. He also gave a fun outdoors demonstration of DET cord and the use of non-EL ignition systems, and their advantages and disadvantages.

Dave Sly, representing CIL and Orion Blasting products. He gave an overview and demonstration of some of their products which are used in avalanche control. He voiced a willingness to work with the avalanche community. His company could be a valuable supplier of caps and fuses, providing the prices are right.

Jon Andrews, Avalanche Forecaster for Stevens Pass, AAA northwest Representative, and driving force behind the WACC. Jon compared different common explosives used in avalanche control, giving in-depth detail of velocity rates, density, and sensitivity of each type. All arrows point to the emulsion compounds being the most practical to use.

Patty Morrison, Avalanche Forecaster for Stevens Pass, gave a talk on some accident case histories and how they have shaped the avalanche programs that are presently in place. It is interesting to note that, out of approximately four million ignitions using the cap and fuse, the avalanche control industry has had only three major accidents. However, due to our small portion of the explosives industry, these accidents caused huge repercussions.

Overall, the WACC considered the workshop a success. Most of the forty-five participants, including two major explosive suppliers, members of ISEE, State L & I Regulatory Commission, DOT Avalanche Control, and major players from ski areas in Oregon, Washington, Idaho, and Canada, felt the workshop was valuable. It is a big step in bringing people together for the specific purposes of learning more about explosives and about the industry as a whole.

Patty Morrison is Assistant Avalanche Forecaster (snow safety) for Stevens Pass Ski Area. She is an avid backcountry skier (Cascades, Canada, & Alaska), and a ski -patroller for twelve

Winter Weather Forecasting Course

By Rocco Altobelli

Have you ever wanted to make a weather forecast, but the thought of college and years of differential equations and statistics makes you want to puke? At the end of November 2002, some powder monkeys and weather geeks got together in Jackson, WY to see if it is possible to learn winter weather forecasting in three short days.

Three instructors were on hand to help students like me comprehend the arcane world of contour maps, models and meteogram hieroglyphics. The course was put together by Don Sharaf, instructor for the National Outdoor Leadership School and American Avalanche Institute, and weather and avalanche forecaster for Valdez Heli Ski Guides. Tyler Cruickshank brought a wealth of knowledge to the instructor pool; his research experience includes hydrology, glacial geology and climate change. He has studied snow in Antarctica and been an on-air meteorologist in Rapid City, SD. Currently, he is with the Utah State Division of Air Quality in Salt Lake City. Rounding out the instructor group was Jim Woodmencey. Jim is currently a radio meteorologist in Jackson and forecaster for a helicopter guide service in the Snake River Range near Jackson. He has a BS in meteorology from Montana State University, has been a forecaster for the Alaska Avalanche Forecast Center and climbing ranger in Grand Teton National Park. He has written two books: *Reading Weather* and *Weather in the Southwest*.

The fifteen students represented a great mix of talents and experience. Almost all were interested in weather forecasting as part of a snow stability assessment. Some students had interests in aviation forecasting for heli ski companies or their own general recreation. Most of the students came from southwest Montana, but many came from Alaska, Idaho, Washington State, Wyoming and Colorado. It was a very knowledgeable student base with extensive knowledge of their local regional weather.

Class began with our only mathematical equation, the Ideal Gas Law. Fortunately, we did not have to memorize or use any formulas, but the relationship of pressure, temperature, mass, volume and density was explained. We moved on to discuss fronts, ridges and troughs. Slowly, we started to ferret out areas of instability that would produce the type of weather we were looking for: snow! On the second day we started to look at the weather three dimensionally. This shift is very difficult to make, but I started to see how the different layers of the troposphere interact to produce precipitation, wind and temperatures. We started to add topographic effects — how will weather change in the mountains? This addition added a level of difficulty not faced by most weather forecasters, but the question is critical for us folks living and working in the mountains. At the end of the three-day course, we had looked at every type of map and model a person needs to forecast the weather. By day three I was drowning in information, but I hope to go back through my 40 pages of notes and pull out this information over time. Analysis Paralysis can be a factor with so much information, but Jim used his wit to move us forward.

The World Wide Web has become an amazing resource for forecasting. Models and maps that used to be only available at the National Weather Service can now be found for free on the Internet. This new power-to-the-people technology has now made it possible for amateur forecasters to put together detailed and accurate local weather predictions.

So, are you tired of the crappy forecast you get from your local TV, or the Weather Channel? Are they too worried about the valleys, but give no information about the mountains? Do you need to know if the avalanche hazard will decrease or increase over the next 48 hours? Will you be able to fly? Maybe you should write your own forecast, but before you do, take this course. Three days is not enough time to learn everything you need to know to forecast, but this course is a great start. It will bring order to the chaos.

Now, if I could just figure out when the hell the National Weather Services will get their act together and start using just the metric system.

Rocco Altobelli was born in the most avalanche prone part of North Dakota. His brother's name is El Nino. No kidding. The lack of early season snow in southwest Montana has turned him into a prolific writer.

EXPLOSIVES

Department of the Treasury

Bureau of Alcohol, Tobacco and Firearms
Washington, DC 20226

SAFE EXPLOSIVES ACT FACT SHEET

12/12/02

The Safe Explosives Act (the Act) was signed into law by the President on November 25, 2002. The legislation takes effect in two parts. The first two provisions outlined below are effective 60 days after enactment. The last three provisions outlined below are effective 180 days after enactment.

Effective January 24, 2003:

1. **New Prohibited Persons Categories:** The Act adds three new categories of persons prohibited from receiving or possessing explosives: (1) aliens (with limited exceptions); (2) persons who have been dishonorably discharged from the military; and (3) citizens of the United States who have renounced their citizenship. These categories have been added to the pre-existing list of prohibited persons, which includes felons; fugitives; users of, and persons addicted to, controlled substances; and persons who have been adjudicated mental defectives or committed to mental institutions. All prohibited persons are permitted to apply to the Bureau of Alcohol, Tobacco and Firearms (ATF) for relief from Federal explosives disabilities.

2. **Samples:** When requested by ATF, manufacturers and importers of explosive materials, including Ammonium Nitrate, must submit samples of these materials to ATF, as well as information on their chemical composition or other information. This will assist ATF in the identification of explosives found at crime scenes.-2-

Effective May 24, 2003:

1. **Intrastate Permit:** Intrastate users of explosives must first obtain an ATF "limited permit" prior to receiving explosive materials. Intrastate users may include, for example, farmers or construction companies that acquire and use explosives infrequently and within their own State of residence. The limited permit will allow the purchaser to receive explosive materials from an in-State explosives licensee or permittee on no more than six (6) occasions during the period of the permit. The limited permit will be valid for one year. Currently, intrastate users are exempt from most provisions of Federal explosives law. By contrast, *interstate* users of explosives must obtain ATF user permits; importers, manufacturers, and dealers in explosive materials must obtain ATF licenses. The limited permit will not authorize the permittee to transport or use explosives interstate. This provision is significant, as ultimately all persons possessing explosive materials in either interstate or intrastate commerce must first obtain a Federal license or permit issued by ATF.

2. **New Required Industry Information for More Thorough ATF Background Checks:** ATF must approve an explosives license or permit application if, among other things, the applicant is not prohibited from possessing explosives. Responsible persons (e.g., facility site managers, corporate officers) will now be required to submit to ATF identifying information, fingerprints, and photographs. Employees of licensees and permittees who will be possessing explosive materials must submit only identifying information. ATF must issue "letters of clearance" for those responsible persons and possessor employees who are not prohibited from possessing explosives. If ATF determines that a responsible person or employee is subject to an explosives prohibition, ATF must provide specific information to the employer and to the prohibited person (e.g., advise of appeal procedures). This new provision is significant, as all persons possessing explosive materials in either interstate or intrastate commerce will have to undergo a background check conducted by ATF.

3. **Inspections:** Generally, ATF will have to physically inspect all ATF licensees and permittees at least once every three calendar years for compliance with Federal explosives storage regulations.
   In the case of user permits and licenses, ATF must verify by visual inspection that new applicants and renewal applicants have places of storage for explosive materials that meet the standards of safety and security set forth in the regulations.-3-
   In the case of new applicants for limited permits, ATF is not required to conduct a visual inspection of places of storage. Instead, ATF may verify by inspection or by "such other means as the Secretary determines appropriate" that there is acceptable storage. For the first and second renewal of limited permits, ATF may continue to verify storage by "such other means." However, if a field inspection has not been conducted during the previous three years, ATF must, for the third renewal and at least once every three years after that renewal, verify by a field inspection that the limited permittee has acceptable places of storage.

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Avalanche Explosive Users Update

By Bill Williamson, AAA Explosives Committee Chair

Over the last few months, there have been a couple of significant developments in avalanche explosives use and explosives use in general. The first are the revisions made to the *Explosive Use in Avalanche Control NSAA Guidelines.* The changes are primarily to the "Procedures for No-Lights" portion (Section VII) of the Guidelines. The changes are essentially a compromise made with the explosives industry through the efforts of the International Society of Explosives Engineers (ISEE) Task Force. The task force was comprised of several ski industry personnel, ISEE board members, IME members, a couple of State regulators and some insurance representatives. The meetings proved to be productive and successful, with all leaving with buy-in and supporting the revised guidelines. To view the entire Guidelines, go to www.nsaa.org/nsaa2002/hr employee safety.asp or contact the NSAAat (303)987-1111.

Section VII of the Guidelines now reads:

VII. PROCEDURES FOR NO-LIGHTS
A. Never recut and attempt to relight a fuse which fails to light.
B. Options for no-lights.
1. Deploy the handcharge into an appropriate location and retrieve after the required waiting period; or
2. Disarm the handcharge by removing the failed cap and fuse assembly and immediately cache the cap and fuse assembly in an appropriate location. This must be accomplished within 20 seconds. The unarmed handcharge may be transported for future use or rearmed with a fresh cap and fuse assembly and deployed per Sections V and VI of these guidelines.
3. Retrieve the failed cap and fuse assembly, or destroy it in place, after the required waiting period (minimum 30 minutes).

The second and probably much larger development is the newly signed Safe Explosives Act, which is a result of the country's "War on Terrorism." I'm not sure how it will be interpreted, but I am certain it will affect all of our programs. A Bureau of Alcohol, Tobacco, and Firearms Fact Sheet describes portions of the new act. It is printed in the sidebar to this article. For more info go to www.atf.treas.gov/explarson/safexpact.htm.

Have a great season, and keep your powder dry, if you can get any.

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MEDIA

Glacier Country Avalanche Center Volunteer Observers Webpage

By Ted Steiner

Glacier Country Avalanche Center (GCAC), located in northwest Montana, has had a volunteer observers program in place since its inception in 1995. The original intent of the observer program was to train and incorporate volunteers across GCAC's 10,000 square mile region to gather field observations for GCAC's avalanche advisory. In the process, GCAC volunteers gained avalanche safety knowledge and assisted the government entities of GCAC in collecting field data for GCAC's avalanche advisory. Prior to 2001, volunteers communicated most observations to avalanche specialists by telephone or voicemail.

In the fall of 2001, GCAC Incorporated, the non-profit entity of GCAC, teamed up with Lone Pine Internet Technologies of Whitefish, MT. and revamped the GCAC website (www.glacieravalanche.org) to include a web page titled "Regional Observations."

Creating the Regional Observations page allowed GCAC volunteer observers to record and post field observations directly to a Regional Observations input page on GCAC's website. In turn, visitors to the Regional Observations output page of GCAC's website could view submitted field observations immediately.

In order to submit data to the Regional Observations input page, observers were required to take a GCAC Volunteer Observers Course (8 hours) and have at least a Level I avalanche education background. Once participants completed the Observer Course, they were given a username and password to enter observation data.

Design of the Regional Observations input/output pages boiled down to four ultimate goals:

Keep data entry simple and efficient on the input page.
Have submitted data objective and suitable for database archiving.
Allow subjective information be submitted via a text box entry form.
Have output data provide valuable information to web page viewers.

To achieve this, Rob Marchetti of Lone Pine IT and I designed the input page so that entries submitted to Regional Observations were divided into three geographic areas within the GCAC region: Flathead National Forest, Kootenai National Forest, and Glacier National Park. Once an observer logged into the site and chose a geographic area for submitting observations, they entered data relating to general field observations, weather/snowpack observations, and avalanche observations via parameter designated fields and dropdown boxes. We designed the input page so it was not necessary to enter data into all fields.

The page requires data in text or metric units. At the end of the input page, a text box allowed observers to submit subjective data related to specific observations- i.e.: snow stability tests and general comments. Observers could also submit photos and graphs as images at the end of the form. When an observation was submitted to the Regional Observations page, an automated email was sent to GCAC avalanche specialists and me.

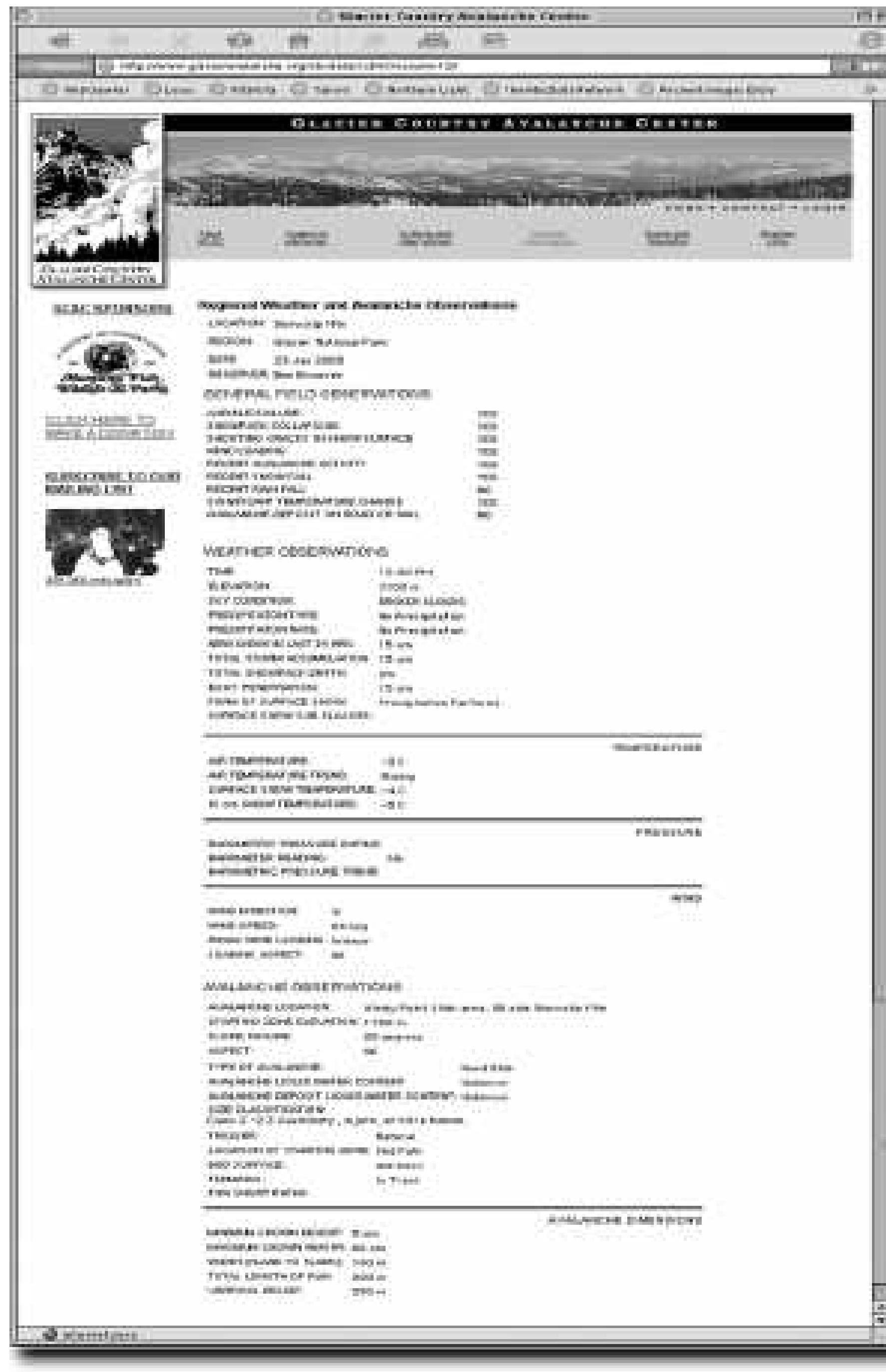
Due to the newness of the Regional Observations web page, text box entries were limited to the Regional Observations input page for the first year, and could only be viewed by accessing the GCAC Observations Administrative Site. This restriction was enacted to filter out any non-pertinent or misleading subjective information that may have been submitted to Regional Observations.

With advice and direction from GCAC Board Members and volunteer observers, GCAC's Regional Observations web page was up and running by mid-December 2001. At the end of the season, April 2002, the Regional Observations web page had recorded 49 individual observations from all geographic areas within the GCAC region. Feedback from GCAC observers indicated the webpage was a success, and public comments suggested the GCAC Regional Observations web page was providing a powerful new avalanche safety product for winter backcountry travelers in the GCAC region.

For the 2002-2003 season, the GCAC Volunteer Observers Program is again in full swing and the Regional Observations web page is functioning well. Changes to the Regional Observations web page for 2003 will be minimal and program focus will be on expanding the volunteer observation network.

Ted Steiner is Executive Director of GCAC, Inc., a non-profit avalanche education and fundraising organization in northwest Montana. He has worked as a ski patroller at Solitude Ski Area in Utah and Big Mountain Ski Area in Montana. You can contact him with questions regarding GCAC, Inc.'s webpage and programs at ted.steiner@glacieravalanche.org.

❈



Sample Regional Observations page at www.glacieravalanche.org

www.jhsnowobs.org: A Community Website

By Evan Howe

Jackson Hole Snow Observations is a one-year-old, public snow observation website. It enables backcountry travelers to share their snow and avalanche observations with the backcountry community. Anyone can submit snow stability and avalanche observations, or peruse the database. The greater goal of the website is to promote safe winter travel by encouraging hazard evaluation and awareness.

The impetus for a snow observation website came on several fronts in the winter of 2000-2001. Since 1996, Don Sharaf and Allen O'Bannon had been writing and emailing "Teton Snow Obs" to interested NOLS winter staff, friends, and, eventually, to the Bridger-Teton National Forest (BTNF) Avalanche Forecast Center. Their observations (snow pit data, stability tests, and avalanches) gained popularity and the user list grew to 170. A few other experienced backcountry travelers began to submit useful observations to Sharaf, who then distributed them as "Teton Snow Obs." It was apparent the backcountry community wanted to share more information than could be exchanged in the Brewpub. That winter also developed a particularly unstable snowpack resulting in six avalanche fatalities in six separate events. For a backcountry community that rarely suffered fatalities, it was alarming and tragic. Why the mistakes? Given the experience and aptitude of backcountry travelers in the region, could we not be safer? The vision of a public snow observation website was born.

Further direction came from McClung and Schaerer's clear concepts of backcountry hazard evaluation in The Avalanche Handbook: *"The first step in hazard evaluation consists of forming an opinion about the current snow stability (with)…all relevant data. These data may include direct observations of local conditions (new snowfall, avalanche occurrences, etc.), general backcountry forecasts, past knowledge of stability in the mountain range, and questioning of other travelers."* We knew the data set was much larger than what people had access to and it occurred to us we all could benefit from more information.

In the fall of 2001, Dan Starr, Tom Wuthrich and I designed Jhsnowobs. Wuthrich programmed the site, and sponsored it on his server. Other site "administrators" include Eric Henderson, Lynne Wolfe, and Doug Workman. There are no sponsors or advertisers but they may be solicited for future projects and site promotion.

Features of Jhsnowobs include: (1) a bulletin board for recent observations of snow stability; (2) a bulletin board for avalanche activity; (3) a search engine to access specific observations and avalanches based upon date, location, aspect, and/or observer; (4) charted weather data; (5) a discussion board, and (6) links to the BTNF Avalanche Hazard Forecast and avalanche education courses.

To gain initial access to Jhsnowobs, users must "log in" and accept the disclaimer. Otherwise, there is unlimited access to data. Anyone is welcome to submit snow observations and jpegs, and the site is unedited. Users are given guidelines on what relevant data to include in their submissions and how to perform and score stability tests. Snow observations are written freeform and, predictably, some can be difficult to interpret. Avalanche data is entered into specific data fields with space for elaboration. We debated the value of restricting submissions to qualified observers, but decided to promote submissions as much as possible, even if it meant wading through inaccurate or needless data. Consequently, users must be selective and make their own judgments, but have a larger set of data from which to benefit. Users are able to choose a login name, which is then used to tag submissions. Knowing the territorial and secretive nature of some powder hounds, we think some people will be more apt to use the site if they have the option to remain anonymous.

In December 2002, there were 292 registered users of Jhsnowobs and an average of 247 successful requests for pages per day. In actuality, there are about 100 users who typically log on during snow and avalanche cycles. Those who take the time to submit observations are typically mountain guides, avalanche educators, ski patrol, local engineers, and super-avid riders and skiers. A recent avalanche incident, reported by the Grand Targhee Ski Patrol, is a good example of what is being shared on the site:

Grand Targhee Backcountry-
Steve Baugh Bowl
Type: N/A
Class: N/A
Aspect: 360 degrees
Slope: 34 degrees
Crown Width: 70m
Crown Depth: N/Am
Path Length: 300m
Slide Trigger: N/A

A group of six skiers dropped into the center of Steve Baugh Bowl, one at a time, approx. 3:00 p.m. The first four skiers skied to the bottom of the slope. The fifth skier dropped in and triggered the slide on a hard, melt-freeze crust bed surface. He was able to stay on top of the debris until he hit a small group of trees near the toe of the slope, where he was spun sideways, and buried approx. 2-3 feet. He was unable to move his arms, but was able to create a small air pocket by moving his head back and forth. Two of the other skiers were able to start a beacon search almost immediately, while the other skiers hiked up to the site. When they pinpointed the location, they scuffed a loose ski first, then his foot. They were able to dig to his face. About this point, the other skiers arrived on scene, and finished digging him out. After a brief rest, the group hiked back inside the boundary, where the Ski Patrol escorted the patient to the base, where he was warmed up and debriefed. After about forty-five minutes, he left the first aid room under his own power, a very happy, lucky man.

Here is an example of an early season observation: (submitter's name omitted)

12/10/2002
GTNP- Avalanche Canyon Region
Peak 10696; Chute the Moon Couloir, & South Fork of Avalanche Canyon
Surface hoar snow crystals up to 2 1/2 mm in size paired with "airy" snow to three inches below surface found on East and North aspects. Beware of this layer the rest of the season. Interestingly, snowpack on Southeast face of 10,696 and North aspect in Chute the Moon Couloir felt bomber, while faces below South Fork Ramp were hollow through to the ground. So, we can theorize that TG metamorphism has weakened the snowpack on this aspect in this locale below an elevation of about 9,500 to 10,000 feet. I tried to get a weak face to slide to ground level, but no results. The largest surface hoar crystals I saw all day were in Avalanche Canyon. Also noticed that Jenny Lake was melted while Taggart was frozen enough to skate ski the perimeter. Cheers!

The future of Jhsnowobs rests in the hands of its users. An information exchange simply cannot function without active participation. From what we can tell, there is an excited group of backcountry travelers eager to share and learn. Potential improvements of the site include adding weather data from Grand Targhee Resort and the Wyoming Department of Transportation as well as inputting several years' worth of "Teton Snow Obs" into the database. This work takes time, money, and dedication. Thanks to all the Teton backcountry travelers willing to share their experience and observations. Go have a look!

Evan Howe has been guiding for Jackson Hole Mountain Guides since 1995 and has been teaching avalanche education for three years. Diurnal recrystallization is his favorite metamorphic process. He is equally fond of granitic batholiths, Teton powder, spatial dendrites, and Thai limestone.

TRANSCEIVERS

Statistical Analyses on Multiple Burial Situations and Search Strategies for Multiple Burials

By Manuel Genswein * Stephan Harvey, Swiss Federal Institute for Snow and Avalanche Research (SLF), Davos

Editor's Note: Manuel and Stephan originally presented the following article as a poster at the 2002 ISSW in Penticton, B.C.

Abstract: Recent statistical analysis based on 466 skier triggered avalanches in Switzerland from almost 30 years (winter 1970/71 to 1998/99) causing 698 completely buried people show that a surprisingly high percentage of victims get caught and completely buried in avalanches producing multiple burial situations. The analysis where focused on victims which could not be found by visible parts, so all of them clearly match the criteria for transceiver search. This surprisingly high percentage is an important sign for the importance of the multiple burial criteria in transceiver training, in testing, as well as in the further development of transceivers and specialized training solutions.

The transceiver search for multiple burials always presents lay and professional rescuers with a difficult task. Manufacturers suggest various, transceiver technology specific search approaches, which makes training demanding and time consuming.

The proposed search approach requires, on the one hand, a thorough analysis of the burial situation, and on the other, a systematic search procedure that can be applied in any situation and independently of the transceiver technology. This systematic way makes the system teachable and therefore learnable. The experience in the field of transceiver based pinpointing systems for deep burials has already shown that many experienced and professional rescuers have developed their own, for themselves highly efficient search strategies. However, it is often very difficult to formalize such highly individualistic approaches in order to make them available to a wider public.

The thorough and continuous analysis of the burial situation tells the rescuer at any time how many victims there are in which radius around him. This information allows to define an appropriate search strategy.

The systematic search procedure is based on the idea that a clear signal isolation makes locating an avalanche victim easier for human ears with an analogue transceiver - but as well for a digital transceiver. Taking differences in signal strength as criteria to separate the different transmitters from each other, all zones where one individual signal is significantly stronger relative to the other signals have to be discovered. This situation can be found where the rescuer is close to a certain victim relative to the others.

Applying the micro search strip search strategy the searcher systematically scans the potential area for those zones close to transmitters where one signal is significantly stronger than the other ones.

The more victims there are and the closer they are together, the narrower is the micro search strip width:

The strip width is reverse proportional to the spatial density of the burials.

1. Recent statistical analysis of avalanches causing multiple, completely buried victims.

Recent statistical analysis based on 466 skier triggered avalanches from almost 30 years (winter 1970/71 to 1998/99) causing 698 completely buried people show that a surprisingly high percentage of victims get caught and completely buried in avalanches producing multiple burial situations. The analysis where focused on victims which could not be found by visible parts, so all of them match the criteria of transceiver search. 280 avalanches out of the 466 where trigged in backcountry skiing terrain (ski touring) , while the remaining 186 occurred during out of bound (off piste) skiing. 61% of all backcountry skiers who could not be found by visible parts were involved in a multiple burial situation. 26% of all backcountry skiers, *more than every forth*, who could not be found by visible parts were part of a 4 or more burial situation! 13,6% were in a 5 or more burial situation, 8,3% in a 6 or more, 3,2% in a 7 or more and finally 1,7% in a 8 burial situation.

The distance between the burial locations is not known. However, it is known in almost all the cases if the group was ascending or skiing downhill when they triggered the avalanche. As expected, in those cases which produced a high amount of burials (5 or more), the groups where almost always ascending and got caught as a group. It is therefore very likely that the group was not too much spaced out between each other and was carried downhill and buried in a very similar constellation they were ascending. Therefore, the likelihood that they created a situation with multiple burials in close proximity is fairly high.

Even tough the percentage of accidents causing a high amount of completely buried victims is fairly low looking at all avalanche accidents, one clearly has to state that IF a transceiver search is necessary - because the victims can not be found by visible parts - the chance that many victims have to be searched for is much higher than previously expected.

If a backcountry skier claims to be able to find 90% of all victims, still leaving out every tenth - then he must be able to solve a 6 burial scenario.

If he is not able to solve a 4 burial scenario, he would not have found 25% of all victims - every forth!

Looking at all accidents in the backcountry with completely buried victims that can not be found by visibly parts, 35% cause multiple burial situations.

Compared to out of bound skiers, the group of back country skiers is much more likely to be involved in a situation with a high amount of victims. This is manly due to the bad habit of back country skiers to travel in large groups.

Looking at out of bound skiing accidents, the amount of avalanches causing multiple burial situations drops to 16%.

If an out of bound skier claims to be able to find 90% of all victims, still leaving out every tenth - then he must be able to solve a 3 burial scenario.

If he is not able to solve a 2 burial scenario, he would not have found 31% of all victims - almost every third!

	off-piste	ski touring
x burials	y % not found	y % not found
1	100.0	100.0
2	31.3	61.2
3	11.0	40.3
4	4.4	26.3
5	4.4	13.6
6	no cases	8.3
7	no cases	3.2
8	no cases	1.7
9+	no cases	no cases

Table 1: If you are not able to solve a x-amount burial scenario, you would not have found y % of all victims! Backcountry / ski touring: 100% = 471 victims Out of bound / off-piste skiing: 100% = 227 victims
All those surprisingly high percentages are an important sign for the importance of the multiple burial criteria in transceiver training, in testing, as well as in the further development of transceivers and specialized training solutions such as radio controlled transmitters.

	ski touring				off-piste				total			
amount of burials	amount of accidents	%	amount of affected persons	%	amount of accidents	%	amount of affected persons	%	amount of accidents	%	amount of affected persons	%
1	183	65.4	183	38.9	156	83.9	156	68.7	339	72.8	339	48.6
2	49	17.5	98	20.8	21	12.4	46	20.3	72	15.6	144	20.6
3	22	7.9	66	14.0	5	2.7	15	6.6	27	5.8	81	11.6
4	15	5.4	60	12.7	0	0.0	0	0.0	15	3.2	60	8.6
5	5	1.8	25	5.3	2	1.1	10	4.4	7	1.5	35	5.0
6	4	1.4	24	5.1	0	0.0	0	0.0	4	0.9	24	3.4
7	1	0.4	7	1.5	0	0.0	0	0.0	1	0.2	7	1.0
8	1	0.4	8	1.7	0	0.0	0	0.0	1	0.2	8	1.2
total	280	100	471	100	186	100	227	100	466	100	698	100

Table 2: Number of accidents and affected people for multiple burials (completely buried people found without visible parts from 1970 to 1999).

2. Introduction to search strategies for multiple burials

The transceiver search for multiple burials always presents lay and professional rescuers with a difficult task. Manufacturers suggest various, transceiver technology specific search approaches, which makes training demanding and time consuming.

The proposed approach requires, on the one hand, a thorough analysis of the burial situation, and on the other, a systematic search procedure that can be applied in any situation and independently of the transceiver technology. This systematic way makes the system teachable and therefore learnable. The experience in the field of transceiver based pinpointing systems for deep burials has already shown that many experienced and professional rescuers have developed their own, for themselves highly efficient search strategies. However, it is often very difficult to formalize such highly individualistic approaches in order to make them available to a wider public.

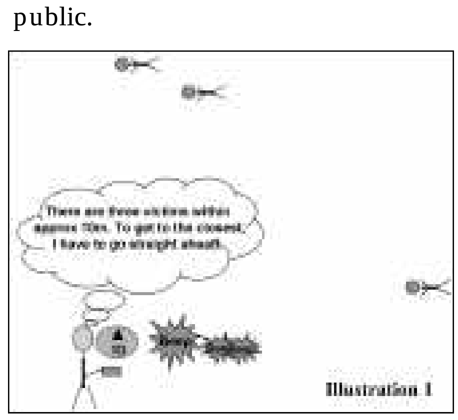


Illustration 1

3. A systematic analysis of the burial situation

3.1 How many victims are there within which radius?

In searching for multiple victims, it is fundamental to be aware of the entire situation. The first question is: *"how many victims are there within which radius?"* As

this set of information is only valid relative to a specific geographic location, evaluation is a continual process.

In the following diagram (ill. 1) the rescuer is approaching three buried victims. The triple beep indicates the number of victims, the distance indicator or the setting of the sound level (sensitivity), gives a rough indication of the radius in which those victims are situated. By getting closer and closer to the first

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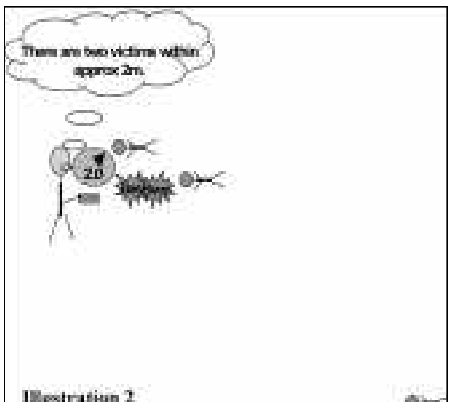

Illustration 2

Illustration 2 Beep Beep There are two victims within approx 2m. 2.0BeepThere is only one victim within approx 2m. 1.8

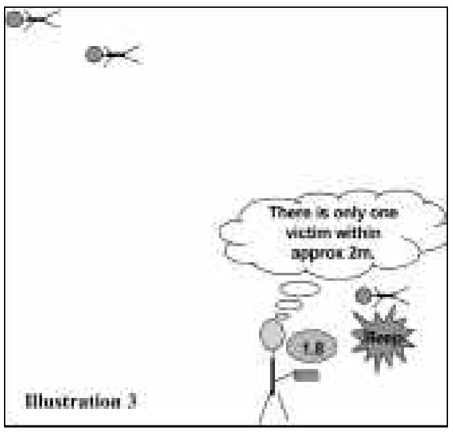

Illustration 3

victim (ill. 2), the rescuer will in the end, only hear a single beep sound. This indicates there aren't any another victims in the immediate vicinity. For the victims two and three (ill. 3) the situation is different. Even though the distance indicator reaches only two (or the sensitivity (volume) setting is very low), there are still two beep sounds. The rescuer then knows that there are two victims in close proximity. There are three victims within approx 10m. To get to the closest,I have to go straight ahead. 10

3.2 Analogue or digital ?

To answer the question: *"how many victims are there within which radius?"* the number of victims and their distance to the rescuer must be available simultaneously and at all times. This set of information is only valid relative to a specific location on the avalanche. Digital only transceivers, can with today's display units only show information about one single victim at the time. This is a serial way to present an information. The rescuer who is continually moving on the avalanche cannot readily asses the entire situation as not all the necessary information is simultaneously available. On the other hand, transceivers with analogue search mode provide the rescuer on average every second the complete set of information simultaneously – and therefore it is fully valid for the current location of the rescuer.

Traditional analogue transceivers require a considerable amount of training as all the necessary search information (distance, direction, amount of burials) needs to be interpreted based on the analogue sound. Digital transceiver technology allows to calculate and display distance (single antenna devices) or distance and direction information (dual antenna devices) - this makes interpretation much easier for the user. However, regarding the processing of multiple signals, the human hearing abilities are still much stronger that what today's digital transceiver technology is able to do. Why? The sound patterns which all of us have to analyse every day have clear similarities with what we face in a multiple burial situation:

- a group of people is talking and you are still able to concentrate on a single voice.
- you are in a bar with loud music - everybody is talking - but you are still able to concentrate on a single voice.

They show how powerful the human hearing abilities are in analysing sound patterns and filtering out the relevant information. Manufacturers are trying hard to improve their digital transceivers for multiple burial problems. The success of their efforts is as well heavily depending on what becomes available on the integrated circuit and microprocessor market and meets their specific needs concerning power consumption, performance and finally as well the price. In the mean time, it is a very good alternative to combine already reliably realised features of digital technology and still taking advantage of some specifically strong points of our human hearing abilities. Such digital/analogue devices provide visual information as well as traditional analogue sound. There are several digital/analogue devices available on the market. The only thing the rescuer has to be able to do with the analogue sound is to count the amount of signals. All the other information (like distance indication) is given on the screen and does not have to be derived of the analogue sound.

In the future, the percentage of digital technology in a transceiver will increase - and some day it might be possible to fully replace the analogue part without any disadvantages. However, for a successful, fully digital approach the way how digital transceivers exchange information (i.e. the length and frequency of the transmitted pulses) would have to be optimized for digital transceiving systems. If such a change will be backward compatible to already existing transceivers, can not be conclusively answered at this time.

4. The main problem is multiple burials in close proximity

When victims are buried in different search strips (primary search), they will not be detected by the transceiver at the same time. In such a situation there is in fact a multiple burial situation on the avalanche, however concerning the transceiver search, it is a step by step single burial search. If there are two victims within the range of the transceiver, but far apart of each other, the situation can as well be solved rather easily. The main difficulty clearly is, to locate several victims in close proximity to each other.

Diagram 1 illustrates the typical situation in such cases: several transmitters are received more or less at the same amplitude. Human hearing as well as a microprocessor do not have the ability to clearly distinguish the signal of one transmitter from that of another in this situation. But precisely this is necessary to be able to locate an avalanche victim.

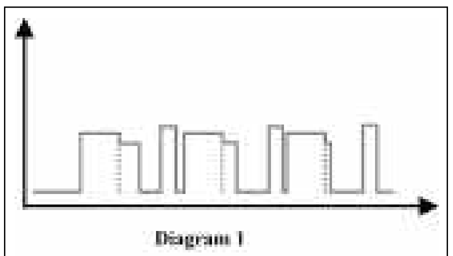

Diagram 1

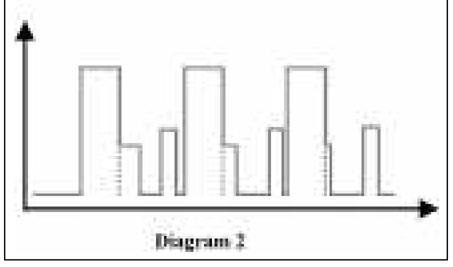

Diagram 2

By contrast, in diagram 2, one signal is considerably louder than the others. In this situation it is easier for our hearing and for a microprocessor to isolate this specific signal, permitting the rescuer to locate the victim fairly easy.

4.1 Micro search strips as systematic search method for several closely buried victims

In developing a systematic search method for several closely buried victims, I have where possible, refereed back to already established concepts that are part of every standard transceiver training. I took the search strip principle as elementary concept. Only the width of the search strip needs to adjusted to the given situation.

As described in the previous section, it is almost impossible to systematically solve a scenario like described in diagram 1 by a deliberate search. The micro search strips make it possible to the rescuer, through a systematic approach, to achieve a easy to solve situation like shown in diagram 2.

As always, the rescuer analyses how many victims there are in which radius around him. The more victims there are and the closer they are together, the narrower is the micro search strip width. Technically speaking, the width of the search strip decreases proportional to the increase of density of victims in their spatial distribution.

The diagram 3 illustrates a fictive search pattern as applied to a potential search area. The blue markings indicate areas which provide unfavourable signal patterns, as described in diagram 1. On the other hand, the areas of the white circles denote a situation as described in diagram 2. The victims can fairly easy be located independently of the transceiver technology within this circles. Adapting the micro search strip width to the actual situation ensures that all those areas will be discovered.

4.2 Practical approach

After evaluating the number of victims in a certain area, the rescuer determines the micro search strip width. Usually the width is between 2 – 5 m. During the search process, hold the transceiver always in the same orientation close to the snow surface and concentrate on the increase and decrease of the distance indication, respectively to the volume of the analogue sound. The final localisation is carried out by applying a classical orthogonal search. Here also, the orientation of the device must be kept always in the same orientation.

Direction indications, where available, should be completely ignored in this phase. Multiple burials in close proximity produce field line patterns which become so weird that it is not anymore possible to reliably follow a specific field line.

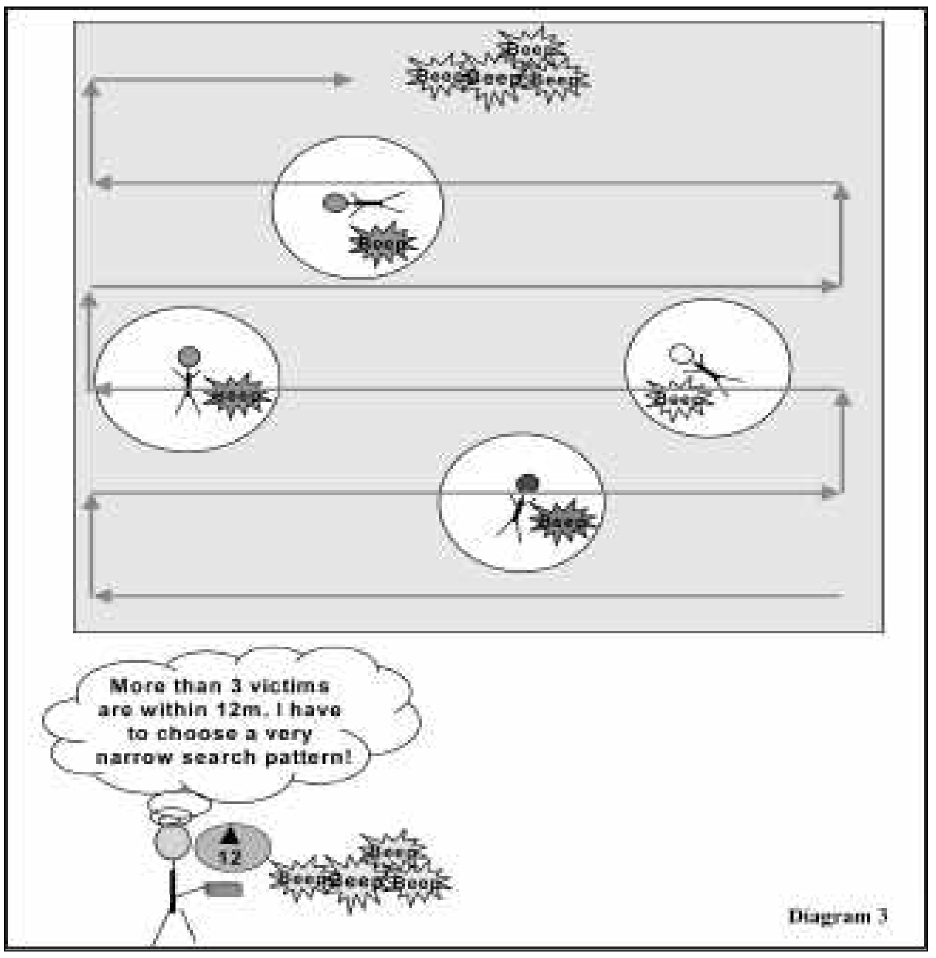

Diagram 3

BeepBeepBeepMore than 3 victims are within 12m. I have to choose a very narrow search pattern!

It is important not to stray away from the systematic search path towards seemingly obvious targets or impressions of them. In the case of several closely buried victims the situation becomes so complex and misleading that any inconsistencies to the systematic approach lead to confusion and a waste of time.

When publicly demonstrating this search system, I was sometimes tending to leave the systematic search pattern and take an *expert's short-cut* in order to be even faster - however too often without success – that's why I don't even try anymore...

The dimensions of the area to be searched with the micro strip pattern is determined in the following way: should the distance indicator only increase or the volume of the analogue sounds only get fainter, the rescuer has reached the borders of the area.

4.3 What does the micro search strip strategy have in common with conventional methods?

Until recently rescuers have, after locating a victim and independent of the transceiver technology, consciously moved away from this first victim before they where able to search for further victims. This "moving away" (from the strongest signal) was in an accidentally chosen direction as the location of the he next victim is obviously still unknown at this time. With the micro strip search pattern "moving away" in an accidentally chosen direction is replaced by a systematic search of the area. This reduces the possibility of missing a victim or returning to victims which have already been located: It increases the over all reliability of the search.

4.4 How to search with transceivers without analogue sound

The micro search strip system can as well be used with transceivers which do not anymore provide an analogue sound. Some specific limitations are discussed in paragraph 2.2 "Analogue or digital" and concern mainly how the rescuer can get a reliable image of the burial situation. The answers to the main question: "How many victims are there within which radius?" is presented to the rescuer in average every second by listening to the analogue sound. On the other hand side, a rescuer using a digital only device has to stand still and slowly rotate the device 180°. By counting the different distance / direction indications given on the screen he can try to find out how many victims there are in which radius. The process of locating the victims within the micro search strips is exactly the same as with other transceivers, however, the importance of having a good general impression of the search scenario at all times when searching for multiple burials is unquestionable.

4.5 How to proceed when there are multiple deep burials?

This situation is probably the most complex one, especially if the different burial depths are widely varying. It is important that you always solve the multiple burial problem before you solve the deep burial problem - and at a certain point probing always starts to be an legitimate mean. However, one should always keep in mind that probing can take an enormous amount of time - especially when only a few probes are available. If enough rescuers are available - which is probably only the case in organized rescue - you can always use the two means (probes and transceivers) at the same time. In companion rescue, however, one often has to decide on a single search mean - and when you decide to stop the transceiver search an proceed with probing, you often loose track of what happened in transceiver search. An eventual step back to the transceiver might become very time consuming. One always has to take into account that only a very few people where found alive by probing. Furthermore, the probes do not penetrate the snow pack in a straight line which means in case of deep burials, that search precision and reliability of this mean of rescue is again reduced. 5. Technical remark on the use of the term "distance indicator" In this article the term distance indicator is used. In fact it actually is an indication of a tendency. Specially single antenna devices give values, which, depending on the relative orientation between the transmitter's and the receiver's antenna, may widely vary from the real distances. Basically the precision improves with decreasing distance to the transmitter. In the case of several buried victims in close proximity we are generally in an area where the transceivers produce fairly reliable results.

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Beacon Basin Opens

By Bruce Edgerly

Backcountry Access (BCA) opened a state-of-the-art avalanche beacon training facility this winter at Loveland Basin ski area. Designed for training avalanche educators and advanced beacon users, the facility is the first of its kind worldwide. Nicknamed "Beacon Basin," the site features 14 permanently buried transmitters, each separately hard-wired to a central control panel. The panel consists of 14 switches for turning the transmitters on and off, plus a remote power supply consisting of 6 alkaline D cells. All transmitters are Tracker DTS beacons buried to the ground in various orientations. Above each transmitter is a 12-by-18 inch plywood probe target approximately one foot beneath the snow surface. The long axis of each target is aligned with the transmitter's flux line, to encourage pinpointing on a line (see *The Avalanche Review*, June 2002). By permanently burying the transmitters at Beacon Basin and controlling them remotely, trainers can eliminate the time-consuming process of excavating and re-burying transmitters between searches. It is especially effective for practicing multiple and deep burials, which are the most time-consuming scenarios of all — and which require the most practice. The system was designed by Dwayne Paynton, BCA's technical representative for the snowmobiling industry. It was installed by BCA staff from Boulder, with support from Loveland patrol director Ron Kidder.

BCA held its first training day at Beacon Basin on Nov. 20. Participants included Knox Williams, Halsted Morris and Brad Sawtell of the Colorado Avalanche Information Center (CAIC); Mark Kelly of Colorado Mountain School; Leslie Ross of Babes in the Backcountry; Marcus Beck of Alpine World Ascents; and members of the Loveland Basin pro patrol. On Dec.7, the site was opened to the public, in a joint event with the Colorado-based Backcountry Skiers Alliance. Access to the site is mainly restricted to avalanche professionals who have been trained by professionals from BCA, CAIC, or the Loveland Basin patrol. "Even with today's easy-to-use transceiver technology, there is still no substitute for practice," said BCA Colorado Front Range Technical Representative Steve Christie. "By providing a super-efficient training opportunity like this, we hope to raise the bar on transceiver education in our region." He said BCA hopes to expand the program next year to include sites in Europe and other regions of North America.

For more information, see www.bcaccess.com or call (303)417-1345.

Bruce Edgerly is the Vice President and co-founder of BCA and a self-proclaimed "beacon nerd." His first transceiver was a Ramer Echo, which is now safely out of commission in BCA's rapidly expanding beacon museum.

Photos by Bruce Edgerly

Above: A closeup of the Beacon Basin control panel. The laminated card on the right is a site map showing the approximate location of each transmitter.

Right: Karen Edgerly working the control panel at the Beacon Basin public training session on Dec. 7.

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On the Practical Use of Avalanche Beacons – the Austrian Transceiver Test 2001

By Peter Höller and F. Gibler

Editor's Note: Peter Höller presented this research at the 2002 ISSW in Penticton, B.C. This paper is reprinted from the 2002 ISSW Proceedings.

Abstract: The development of new avalanche beacons in the last years was the motive to initiate a test of electronic transceivers by the Austrian Institute for Avalanche Research. The project was carried out in 2001 in cooperation with the Austrian Consumer's Association (VKI) and the Austrian Institute for Home and Leisuretime Safety. Seven different types of beacons were tested under comparable conditions in the laboratory as well as in the field. Goal of the project was to provide relevant information for backcountry skiers, off-piste skiers and snowboarders; moreover a folder was printed to help people when buying a new transceiver.

The investigations in the lab were concentrated not only on technical measurements (including measurements on the energy consumption of the different transceivers) but also on practical tests (e.g. how is the battery capacity indicated, how can the beacons be used with gloves…).

For the field work a standardized test was developed, which had to be comprehensible and objective on the one hand, and as efficient as possible on the other hand. The search tests were carried out with three different groups of individuals (1. skiers without knowledge on avalanche beacons, 2. backcountry skiers with a basic knowledge and 3. professionals). In total about 130 persons took part in the search tests. The participants were also asked to fill out a questionnaire. So it was possible to get additional information on operation instructions and handling of the transceivers.

The results were described with marks ranging from 1 (very good) to 5 (not sufficient). All beacons passed the tests. However, only one beacon got a "1" in the technical as well as in the practical test, two beacons got a "1" in the technical test and a "2" in the practical test; the marks of the other transceivers were between "2" und "3".

1. Introduction

1992 Brugger and Falk presented their first results on survival probability of avalanche victims. From this investigation we know that the survival probability is relatively high within the first 15 minutes of burial (93%), but decreases to about 25% if the burial time is more than 45 minutes.

That implies that the survival probability can be improved only when the burial time by fast transceiver search can be reduced.

Brugger (1997) analysed data from 1981 to 1994 and found that the burial time of people rescued by companion transceiver search was only 35 minutes in average whereas the burial time was 120 minutes without use of a beacon. However, from the statistical point of view their effects on the mortality rate were only marginal significant (Brugger, 1997).

Recent investigations by Tschirky et al. (2000) show that in the last 5 years transceiver search was more successful. The probability of being recovered alive by companions using transceiver devices has increased from 30% to 75%, the burial time of people located alive by companions using beacons was 15 minutes (Tschirky et al., 2000). From this it can be assumed that the state of the training of transceiver-users has probably been improved.

But also new types of transceivers could contribute to reduce the burial time in the near future. These new devices with digital technology have shown enormous benefits in several key areas of avalanche rescue like search speed, ease of use and ease of learning (Edgerly and Hereford, 1998). And these transceivers have some advantages (determination of the direction, distance calculation…) which may lead to shorten the search time.

2. The transceiver test 2001

The development of new transceivers and the fact that the last important test on avalanche beacons was done in 1998 (Krüsi et al. 1998) was the motive to initiate a new test on electronic transceivers by the Austrian Institute for Avalanche Research. The investigations were carried out in 2001 in cooperation with the Austrian Consumer's Association (VKI) and the Austrian Institute for Home and Leisuretime Safety. Seven different types of beacons (Pieps 457, Tracker DTS, Ortovox F1 classic, Ortovox F1 focus, Mammut Barryvox, Ortovox m2, Arva 9000) were tested under comparable conditions in the laboratory as well as in the field. (see fig. 1).

The goal of the project was to provide relevant information for backcountry skiers, off-piste skiers and snowboarders; moreover a folder was printed to help people when buying a new transceiver.

3. Methods of tests

3.1. Practical and field tests

The search tests were carried out with three different groups of individuals (1. skiers without knowledge on avalanche beacons, 2. backcountry skiers with a basic knowledge and 3. professionals). In total about 130 persons took part in the search tests.

The investigations were done in January and March 2001 in Maria Alm (Federal province of Salzburg) as well as in July and August 2001 in the glacier areas of Hintertux and Neustift/Stubai (Federal province of Tyrol).

For the search tests (fine search) a standardized method was developed, which was comprehensible and objective on the one hand, and as efficient as possible on the other hand:

1. To avoid effects due to different conditions of the test persons a relatively flat slope (15 - 18% which corresponds to 8.5° - 10°) was selected.
2. Two transceivers (turned into the transmitting mode) were buried in a distance of 20 m from the starting point (the first in a vertical position, the second in a horizontal position). The starting point was marked with a pole; as transmitting beacons two Ortovox F1 were used.
3. The position of the beacons was aligned (from the pole at the starting point to a well known point in a certain distance). So it was easy to find out (without entering the test area) whether the test person has located the buried transceiver or not (the person was successful when he/she was within of $1m^2$ of the buried beacon).
4. The test area was prepared in a way that possible tracks could not be seen by the test persons.
5. Start with the search tests: only one person was allowed to be at the test area at each time. The following instructions and information were given to the test persons:
   - to move with normal walking-speed.
   - to be prepared that two beacons are buried.
   - to define the position ($1m^2$) of the transceiver; therefore the test persons had to mark the closest area ($1m^2$) with four pennants.
   - to let the beacon in the snow.
6. The following parameters were recorded respectively noticed:
   1. The time which was needed by the test persons from the starting point to the closest area of the transceiver ($1m^2$).
   2. The distance (measured with a laser rangefinder) and the direction from the starting point to the pennants (this was necessary to check if the test persons have located the beacons on the right place). Additionally we assessed the statements of the test persons concerning clearness of the acoustical and optical signals as well as clearness of the signals in case of multiple burials.

Moreover the test persons were asked to fill out a questionnaire. Thus it was possible to get additional information on operation instructions and handling of the transceivers.

The questions were grouped into the following topics:

- operating instructions .
- short instructions on the transceivers.
- handling (operating, how to put the beacon on).
- optical and acoustical indicators.

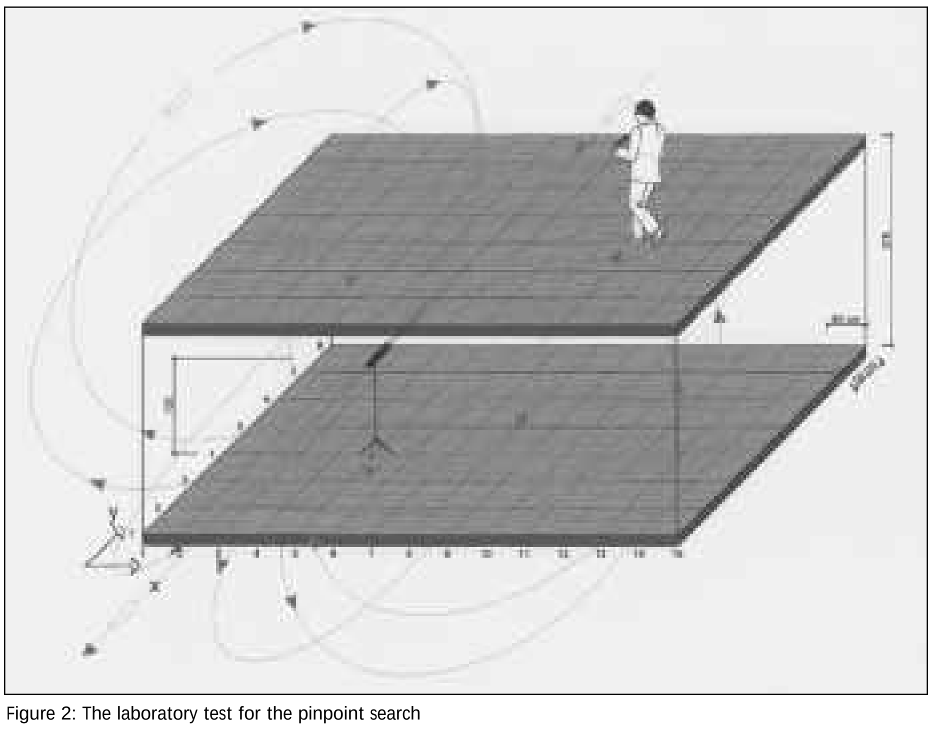

Figure 2: The laboratory test for the pinpoint search

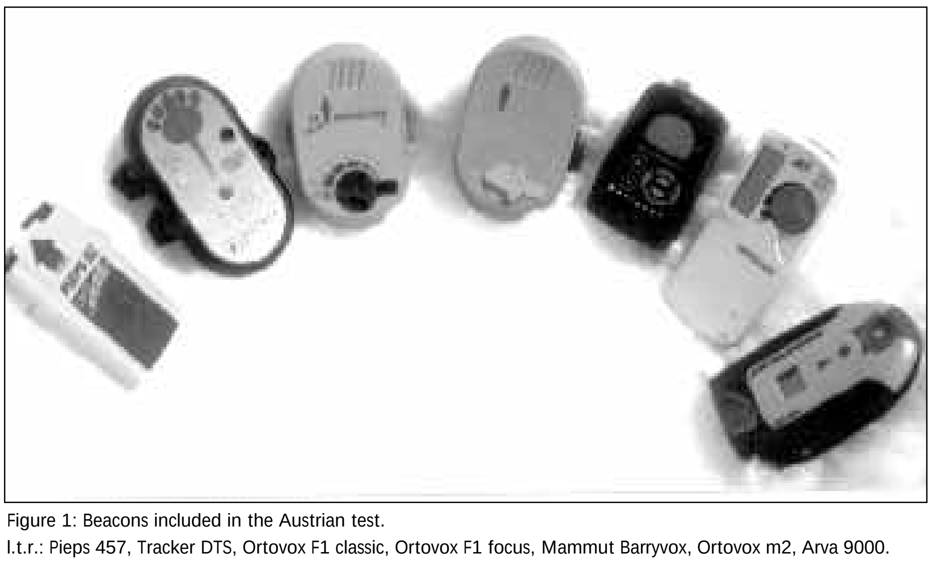

Figure 1: Beacons included in the Austrian test.
l.t.r.: Pieps 457, Tracker DTS, Ortovox F1 classic, Ortovox F1 focus, Mammut Barryvox, Ortovox m2, Arva 9000.

3.2. Laboratory tests

The laboratory tests were divided into a technical test and into the pinpoint search. The technical test included the following checks:

- operating elements (clarity and comprehensibility of operating elements, use of switches with gloves)
- battery capacity control (clearness of the capacity control).
- polarity test (effects on the transceivers if batteries are inserted in the wrong way).
- humidity test (the beacons were tested one week under 99% rel. humidity).
- energy consumption (the power consumption was measured both in the transmitting mode and in the search mode).

	Barryvox	Tracker	Arva 9000	Ortovox m2	Ortovox F1	Pieps 457	Ortovox F1 focus
search	good	good	good	good	good	good	good
locating	good	very good	very good	good	sufficient	sufficient	good
instructions	very good	good	very good	good	good	good	good
short instr.	very good	sufficient	good	sufficient	good	less suff.	good
operating	good	good	good	sufficient	less suff.	sufficient	less suff.
straps	very good	sufficient	less suff.	good	sufficient	good	sufficient
indicators	very good	very good	very good	sufficient	less suff.	less suff.	sufficient

Table 1: Results of the practical test

	Barryvox	Tracker	Arva 9000	Ortovox m2	Ortovox F1	Pieps 457	Ortovox F1 focus
switches etc.	good	good	very good	good	sufficient	sufficient	sufficient
capacity control	very good	very good	very good	good	less suff.	not suff.	less suff.
polarity test	very good	very good	sufficient	less suff.	very good	very good	less suff.
humidity test	passed	passed	passed	passed	passed	passed	passed
transmit (mA)	3.2	8	8.1	5	5.4	8	6
search (mA)	90	144	54	50	58	110	63
SUMMARY	very good	very good	very good	sufficient	sufficient	sufficient	less suff.

Table 2: Results of the technical tests

To be as effective as possible it was decided to have the pinpoint search test in the lab. Fig. 2. gives an overview on the test site.

The idea was to investigate the pinpoint search independently from snow conditions.

Under avoidance of electric installations two floors were set in the laboratory of the VKI; the distance was 2.75 m. On the ground of each floor a grid was marked, so that the x-axis as well as the y-axis lay one on top of the other. The size of the grid was 50 to 50 cm, in total 98 grids (7*14) were marked on each floor. So it was possible to place the transmitting beacons not only in different depths (with a maximum burial depth of 2.75 m) but also in different positions (vertical, horizontal).

The tests were done similar to the field tests. Only one person was allowed to be on the upper floor at each time. The following instructions and information were given to the test persons:

- to move with normal walking-speed.
- to mark the exact position of the transmitting transceiver on the floor.

We recorded the time which was needed by the test persons to locate the beacon as well as the accuracy of the locating (the accuracy was determined by using the grids on the ground). The following scheme was used to assess the results: 1. locating within 50 cm (very good), 2. locating within 75 cm (good) and 3. locating within 100 cm (sufficient).

4. Results

Table 1 gives an overview on the results of the practical and field tests; in table 2 further information on the laboratory tests can be found. In general all transceivers passed the test.

It can be seen that all beacons got a good in the category "search" (tab.1). Taking into account only those persons who were able to define the position of the beacon (area of 1m^{2}), it can be shown that 75% of these persons needed less than 3 min. (average 2 min) to reach this area; the fastest person was within 1 min (with a Tracker TDS). However, there was no significant difference between new (with digital technology) and old beacons (with analogous technology).

In the category "locating" (pin point search in the lab) the results varied between very good and sufficient. Better results were obtained by those beacons with good optical indicators (LEDs etc.). It can be assumed that this is connected with the fact that most people are visual types.

The "operating instructions" were judged with very good to good. However, the "short instructions" on the transceivers regularly did not reach the good marks of the general instructions (see tab. 1).

The category "handling" was divided into "operating" and "how to put the beacon on and out". While in the category "operating" none of the transceivers got a very good (the operating with gloves, especially during low temperatures was difficult), the assessment in the category "how to put the beacon on and out" (straps) varied between very good and less sufficient. Those beacons which require a complete opening of the straps when starting with the search procedure got the lower marks. Especially in the case of an accident it is very important that the search procedure can be started as fast as possible. In the category "indicators" the new beacons (with digital technology) had better rankings than the analogous transceivers. This can be explained with the fact that the optical indicators of the new transceivers are relatively easy to understand, especially for non-professionals.

To summarize the field test we can say that the better the level of the training the better the search results. However, when people from the third group (professionals) had to operate a transceiver which they are not used, their search time increased significantly.

In table 2 the results of the technical tests are presented. The "battery capacity control" was judged from very good to not sufficient. The better marks were given to the beacons with a direct symbol of the battery capacity on the display. On the other hand there are some beacons which are equipped with only one LED; to check the capacity of the batteries it is necessary to count the number of lightning. Since this system is less comfortable (and also inaccurate), it got a lower ranking (less sufficient to not sufficient) in our test.

In the category "polarity test" we had two less sufficient.

The "humidity test" was passed by all beacons.

5. Conclusion

Electronic transceivers can help to reduce the search time in the case of an avalanche accident and will contribute to increase the survival probability of buried people. Moreover beacons are an imperative tool for companion rescue.

It seems that optical indicators can be better understood by the users than acoustic signals (because most of the people are visual types).

However, it is absolutely necessary to train the handling with avalanche transceivers regularly. The best beacon does not help when the user is not able to operate the device.

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Beacon Teaching Tips

Compiled by Lynne Wolfe with material from Janet Kellam, Blase Reardon, Don Sharaf, Bruce Edgerly, and Rocco Altobelli

This article is not intended to be a complete transceiver class or presentation. It is a list of "work-hardened" tips and tricks that have been collected from avalanche educators across the Rockies.

The Big Picture:
This emphasis helps prevent rescuers from becoming too beacon-focused; therefore not putting the pieces together quickly enough to search for a buried victum and dig them out in time.

- Emphasize that people are learning how to perform a rescue with a beacon, not learning how to find a beacon in a snowbank. This emphasis helps prevent them from becoming too beacon-focused and from putting the pieces together quickly enough to search for a buried victim and dig them out in time.
- It is important to "do" and not just talk. Theory is background for action. Plan in enough time to practice each skill. Use scenarios to put it all together at the end.
- Start with small pieces. Allow students to master little parts of The Big Picture before moving into more complex phases of rescue. Build on success to minimize frustration.
- Always teach and demonstrate wearing a pack that contains a shovel and a probe.
- Any rescue begins with the following questions. Incorporate them into your habits, even while teaching the components of a rescue.

  Questions:
  1-How many missing?
  2-Last point seen?
  3- Were they wearing beacons?
  4- Is it safe for rescuers?
  5- Cell phones off?

Intro to Beacons:

- Demo how to wear each beacon properly, turn it on, get it out fast and switch to receive.
- Teach these skills in a circle, so that folks can see how to operate different brands of beacon.
- An initial understanding of the flux lines is essential. The BCA flux line chart on weather proof vinyl works great. Show how a searching beacon will come onto the line and follow it in.
- Split large groups into smaller ones by beacon type. Learning to use a beacon can be confusing and complicated enough without students having to learn the details of a beacon they don't use.

Pinpoint Search:

- Put a beacon (transmitting) under a sturdy table, get on said table, and grid with a receiving beacon. You can demonstrate most concepts of beacon searches, like change in volume with distance and orientation, grid movement between beacons, moving between the beeps, and best and worst coupling orientations at 90 degrees. Students seem to really get beacon concepts after these demonstrations – possibly because they can visualize the burial, so starting with this demonstration often makes ensuing discussions and practice much easier. Use any type beacon as the transmitter; an analog beacon works well as the "receiver" since the volume changes dramatically as you change orientation. This technique is particularly useful in classrooms or when you have no snow in which to bury beacons. You can also use a porch or deck for the demonstration.
- During practice, remind folks to "slow down to go fast." It takes time for some digital beacons to interpret a signal; you can run beyond your target if you are within a few meters and moving too fast. This problem occurs for both analog and digital beacons when the transmitting beacon has a slow pulse rate, such as the Ortovox F-1.
- Note how all beacons will experience a "fade" or "spike" signal close to the transmitter. The search should extend through this area in search of a stronger signal.
- During a rescue scenario, as the primary searcher homes in on a signal, have other beacons on receive turn to OFF since the plethora of signals can be confusing.
- Other searchers should be getting their probes and shovel out to use the moment the beacon searcher has a general area in which to begin probing.

Range Check:

- *Phase One:* Have all the students turn to transmit and place their beacons in the same plane. With your beacon on receive and in worst coupling mode (perpendicular to the plane of the receiving beacons), walk away till you hear and see no signal. Then instruct each student to walk slowly towards you until you pick up their signal; at that point, tell them stop and turn off their beacon. Then signal the next to move forward. At the end of this exercise, people will be at different distances from you. Pace off the shortest distance to give a visual example of the "worst coupling" with your transceiver.
- *Phase Two:* Have the students line up with all their beacons on receive. With yours on transmit, with the transmitting antenna oriented vertically, walk slowly towards the group, maintaining worst coupling orientation. As each person picks up your signal, have them sing out; stop for a moment to let them get a visual on that distance. Conservatively use the smallest distance as half your search strip width.

The "Walk-through":

- Primary Search: Early on in the lesson go outdoors and move as a group, alongside the instructor whose beacon is on receive. Approach a distant beacon that is sitting clearly visible on the BCA flux line chart on the ground. Run and traverse the "slide path" looking and listening to get to the "debris" area, using your predetermined search strip widths. Have visual clues lying on the ground. Holler, scuff, and mark "I have a hat / pole!" Holler and mark "I have a signal over here!"
- *Secondary search, Tangent Pattern:* For those with analog beacons, stop when the light goes red (F1, SOS F1ND and the Ortovox X1 when greater then 10m from transmitting beacon), turn the volume down, then sweep the beacon from side to side – roughly from 10-2 on a clock face – slowly and steadily sweep with the elbows in and feet planted. Take the point of the strongest signal in this pie-shaped sweep and step forward 5-8 steps, and repeat. Take fewer steps each time as you get closer, in order to follow the steepening curve of the flux line. With digital beacons (Tracker, Barryvox, Ortovox X1 within 10m) do not sweep, but follow the directional arrows, making sure the distance numbers are getting smaller.
- At one point have them all turn around 180 degrees to get the idea that the flux line is going through them and away from them; have them take a few steps and see how it gets fainter or the distance numbers get larger. This exercise helps them recognize if they get turned around by mistake.

Probing:

- Demo how to put together probes and probe poles. Show how to probe consistently perpendicular to the surface, not at varying angles.
- Have folks gently probe your torso as they stand in front of you. This demonstration helps them feel the difference between a body, the ground, a stump, and the snowpack.
- Remind them to leave the probe in place when they get a strike, and to dig around the probe.
- Explain the importance of spot probing below slope clues and in deceleration zones.
- Remind them that on inclines the beacon will likely be uphill of the strongest signal. Probe on the uphill side to find the target.
- Digging is the most time consuming part of the recovery phase. If the person is buried 1m deep, then start your hole as a $1m^2$ area. If 2m down, then start with a $2m^2$ area, and so on. This method avoids an inefficient worm hole.

Scenarios:

- After discussing leadership and decision-making during the Human Factors classroom lectures, scenarios are a chance for folks to practice different roles and communication styles. Break up students into 2 teams; each sets up scenarios for the other team in escalating complexity. Each site has an instructor who monitors as the teams rotate back and forth.
- Seed your initial team with a few questions to promote communication as you are burying duffels and scuffing debris zones. "Who will be the leader if there is an emergency? Who has a probe and knows how to use it? Who has good transceiver skills? Do you know everyone else's name?"
- Have folks consider and practice all roles within both large and small groups of rescuers.
- The larger the target, the more likely the students will find it in a timely fashion. Probing for a mitten shell is considerably more difficult than probing for a body size duffel, auto floor mat, or lid of a large Rubbermaid® bin.
- Use terrain traps (especially gullies) to facilitate practice for deep burials. Even when snow depths are shallow (less than 1 meter), you can achieve deep burials easily if there is a small gully on the site.
- Try to do some beacon work on each day of your seminar / course. An overload on the front end doesn't allow for much reflection on mistakes. Too much time initially can also lead to frustration as the students become overwhelmed with mistakes.
- At the end of a field session as you are headed back to the cars, spring a scenario on the students in a roughed up area at the base of a slope. 2 "victims" are beacons in duffels. One victim has no beacon, but there are one or two visual clues and the "victim" is a jacket stuffed with snow with a glove attached, fingers barely out of the snow. Bury the dummy in a "likely" location — in front of or behind trees, behind rocks and covered with debris. It tends to hit home when people tug on a glove and an arm follows it. The surprise factor makes this scenario their final exam.

Multiple Burials:

- As an educator, learn the vagaries of each beacon. Digitals block a second signal at approximately 10 to 15 meters. The Tracker has the "SP" button, whereas the Barryvox shows an icon of 2 heads when receiving multiple signals.
- With the Tracker, a second signal can be evident in the "null or spike" segment of a first signal.
- Landmine method: In order to find a second signal, run a disciplined circular pattern, using the initial beacon as your center and moving outwards. Decrease volume to lowest setting with an analog beacon and maintain the same orientation to the path throughout the circle.
- Divergent method: Good communication is essential in these scenarios. Teach folks to holler and mark "I have 2 signals!" and the leader can delegate another team member in that direction. In a small group, the transceiver searcher can return to that marked point to home in on the second signal as the rest of the team digs out the first victim. The Tracker has the "SP" button, which enables you to get the second signal back.
- Both the Landmine and Divergent methods are helpful depending on the scenario. The Landmine method works well with closely buried beacons, and the Divergent method works with beacons buried far apart. A well-practiced quiver of these two methods and SP mode are important when handling most any multi-signal search.

Debriefing:

- Run a stopwatch on each scenario, and jot notes and times in the back of a Field Notebook. At the end of each session, go through the timeline, paying attention to actions such as delegating tasks, turning off other beacons, and communicating discoveries. Students often comment how real their anxiety seems in these scenarios, and they begin to imagine the pressure and chaos of an actual rescue.

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CROWN PROFILES

An Early Morning Surprise

By Tom Leonard

If you work as an avalanche forecaster long enough, it is inevitable that you will occasionally be surprised. If you are lucky, those events will have little in the way of consequences, and you will be able to just learn from them. This article is about one such avalanche for me.

The surprise occurred on Sunday morning, April 7, 2002, at about 8:45 at The Yellowstone Club. A 1/2 inch of new snow melted off the near vertical rocks at the top of an unskied 37° chute, sluffed several feet and caused the slope to climax. The avalanche, with a 3-4' crown, ran into an open and well-skied area and fell 500 vertical feet, broke several 4 to 8" diameter trees and piled up 4 to 7 feet of debris about 200' wide. The debris contained not only the timber but a couple hundred feet of avalanche sign line.

The days preceding this event had been spring-like with mostly clear skies and temps of mid to upper 20s at night and mid 30s to near 50 degrees during the day. With the clear skies, the snow surface was freezing hard into the top several inches at night, although the rest of the typically faceted snowpack was staying damp. As you'd expect, the skiing would go from treacherous on frozen ice balls to pretty good corn before getting too soft by midday. By early afternoon, it was not unusual to see some sun ball or point release activity in the top few inches of wet snow. We typically kept slopes open until the snow surface became unsupportable, and then closed them for the rest of the day.

The weather the day before the avalanche was a little different, with a trace of wet snow in the afternoon and mostly cloudy skies into the evening. Clearly, the cloud cover delayed the refreezing of the snow surface, but the skies became partly cloudy overnight and the temperature dropped to 20 degrees at midnight. Sunday morning, when the avalanche occurred, dawned clear. On my normal ski run where I check out the snow conditions along the ridge, I found the snow to be frozen rock solid as I chattered and flailed across the slopes. It was certainly surprising to ski up to the edge of a 4 foot drop-off into the rocks and brush of the bed surface of a fresh avalanche. Some of the smaller trees were still snapping and crackling as they were straightening up and shedding snow after being plowed over by the slide. Interestingly, if the timing had been different, I would have been a couple of hundred feet down the avalanche track.

I would have not been surprised if this had happened mid-afternoon with maximum solar gain, flooded poor spaces, active water channels, free water cutting at the bed surface, etc., and some force from sun balls or sluffing. Most of us have seen wet snow avalanches like that. However, this slide was a different story. The air temperature was 23 degrees on Sunday morning after the coldest night in 5 days. The snow surface was knife hard except right at the top of this east facing, concave chute that had been exposed to the sun for about half an hour. My best guess is that a little bit of new snow sluffed off the warming rocks and gouged out only a couple of inches of snow for a few feet before breaking down into the damp faceted snow on a smooth rock bed surface. Perhaps there was also a minor amount of free water starting to run on the rock bed surface. The avalanche remained full depth for its entire length; it did not run up on either the hard cold snow of the upper path or the frozen and skier compacted bottom _ of the path.

I want to mention this event not because the avalanche itself was noteworthy but because the early morning time of the slide has certainly changed how I will look at a spring snowpack. Perhaps I put too much emphasis on cold and/or clear overnight conditions freezing the snow surface and thinking there is a fair amount of stability until the surface crust melts. Maybe I need to pay attention to and understand better the effects of a persistently damp or wet lower snow pack even with a frozen surface. One thing that is clear is that I need to make sure I am thinking about 100% of the slide path and the varying impacts of solar gain with elevation, aspect, and slope angle. The top of this path was a very small bowl, with some steep, unskied, east-facing terrain, and a rock wall to radiate more heat into the snowpack. Still, it surprised me that a relatively small point sluff that initiated from this area was able to trigger this large of an avalanche when the snow surface in general was so hard. It's just one more reason to always keep your eyes open for changing conditions and hope that we can learn from these unusual avalanches instead of being caught in them.

Tom Leonard is Snow Safety Director for The Yellowstone Club, in southwestern Montana. He was Snow Safety Director at Snow Basin in Utah for 16 years. He is a Professional Member of the AAA and was a member of the Governing Board of the AAA in the mid 90's.

Looking up the slide path to the crown. Photos by Doug Chabot.

Looking down the slide path to the debris. Photo by Doug Chabot

I Saw the Perfect Avalanche

By Ron Johnson

On December 18, 2002, I saw the "perfect avalanche" on Lionhead, near West Yellowstone, Montana. I was with Karl Birkeland of the U.S. Forest Service National Avalanche Center and Spencer Logan, who is a graduate student in the Department of Earth Sciences at Montana State University. Their objective was to gather field data for a research project while I checked snowpack and avalanche conditions for the Gallatin National Forest Avalanche Center.

Two weeks prior to this trip I was on Lionhead with my colleague, Doug Chabot. We found an ice crust that had formed from rain, which fell the day before Thanksgiving. The ice crust was covered by a few centimeters of near-surface faceted snow, and large surface hoar crystals produced a fuzzy snow surface. A few minor storm events buried these layers with the most significant one depositing 25 centimeters of snow on December 15-17th.

The morning of December 18th was cold and clear. When we arrived at the slope, we found that a dry slab avalanche had naturally released sometime that morning. I measured the crown face, checked the slope angle, and identified the slab, weak layer and bed surface. As I wrote the numbers into my notebook, I realized I was looking at the perfect avalanche.

It was the perfect avalanche based on the results of various field studies on the characteristics of dry slab avalanches, which are summarized in several publications, including *The Avalanche Handbook.* Jürg Schweizer lists typical values for several parameters of slabs and weak layers in a 1999 paper. Some of these values are:

Parameter	Typical Value	Range
Slab Density	200 kg m-3	100-300 kg m-3
Slope Angle	38°	30-45°
Slab Depth (perpendicular)	0.5 m	0.3-1 m
Weak Layer Thickness	10 mm	1-15 mm

Values for the avalanche we saw were:

Parameter	Value
Slab Density	153 kg m-3
	200 kg m-3 for layer above the weak layer
Slope Angle	38°
Slab Depth (perpendicular)	0.5 m
Weak Layer Thickness	10 mm

There you have it: the perfect avalanche.

As I struggled to keep my footing on the icy bed surface at the crown fracture, I poked at the slab and tickled the surface hoar that formed the weak layer. I understood how these layers formed. The set-up for this avalanche was obvious. There were also several things about this avalanche that were not obvious. What upset the balance between stress and strength within the different layers of the snowpack? Why did fractures propagate across the slope? Could I have predicted the time this avalanche released? These questions baffle me, but pursuing the answers inspires me. That is why this was *my* perfect avalanche.

Ron Johnson is an Avalanche Specialist at the Gallatin National Forest Avalanche Center and a Climbing Ranger at Grand Teton National Park. He developed his passion for snow in the cold, flatlands of Minnesota while riding underpowered snow machines.

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Faceted Snow and Large Avalanche Cycles in a Maritime Climate

Story and Photos By Jon Andrews

It has always been a myth that most avalanches in a maritime snowpack are direct action avalanches. After many investigations and observations into some of the larger avalanches in the north central part of the Cascade Range, I have concluded that most large avalanche cycles there happen on faceted snow.

A weather pattern stands out in most of these large avalanche cycles. It goes: rain on snow, followed by a colder weather trend and a slow build up of snow load on the rain crust over time.

On the cooling end of the rain event, we usually end up with four to six inches of snow. Then it continues to cool down and generally clears off for a period from one day to several weeks. During this clear spell, the four to six inches of snow on the rain crust becomes faceted, a process that can occur in a matter of one to two hours because of the east and west flows over the Cascades.

The pattern tends to give us a false sense of stability. The common idea is that the rain tends to help stabilize the snowpack, and as it snows, the skiing gets better and better. This idea is partly true. What many people do not realize is that while it snowing and the skiing is getting better, the slow build up of snow on the faceted layer is also building snow load and stress to a critical point. This slow build up of the avalanche dragon can last several weeks to over several months before we start to see skier-triggered avalanches.

A natural avalanche that ran on faceted snow near the start of the avalanche cycle in late February, 2002.

An example of this pattern occurred in January, 2002. It was a blue-sky day. No avalanche activity had been observed for some time. Skiers were everywhere, and conditions were excellent. Prior to this day, it had snowed off and on for several weeks with no real avalanche activity. Yet at approximately the same time on this blue sky day, two ski groups triggered fairly large avalanches about three feet deep. These two groups were about one and one half miles apart on south-southwest facing slopes. People were hurt in these two avalanches but no one was killed.

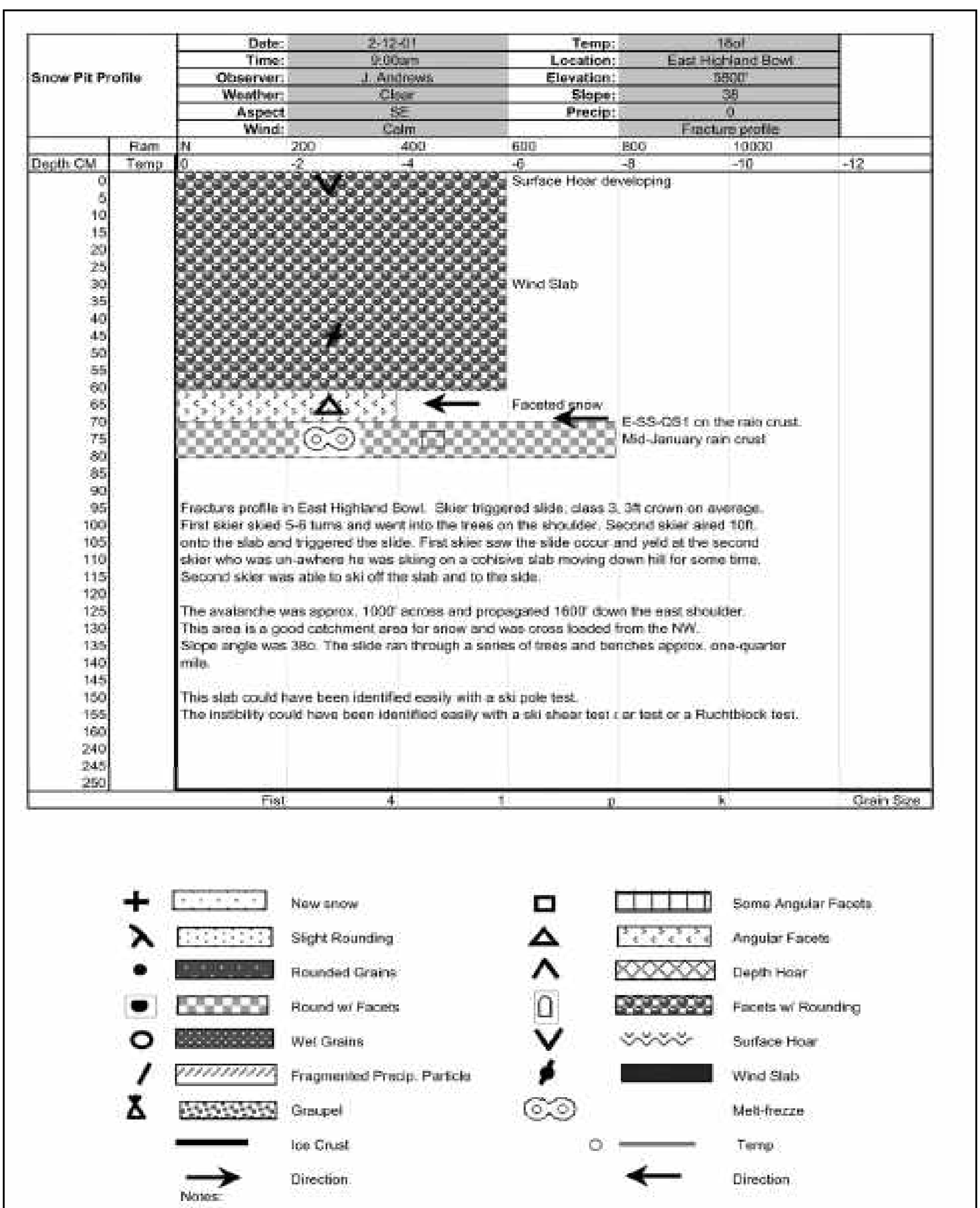
The two slides illustrate several elements common to slides that involve faceted snow in the Cascades. Observations also show that skier triggered avalanches on faceted weak layers in the Cascades range from one to three feet in crown depth. And we tend to see faceting on southwest facing slopes occur more rapidly because of the temperature fluctuations. Avalanche profiles and interviews from the January 2002 accidents revealed that in each instance, skiers triggered the avalanches from the shallower part of these slabs, which is a common trigger point in human-triggered avalanches on faceted snow in the Cascades.

The East Highland Bowl avalanche, January 2000, was a class 4 avalanche. The first skier made turns down a 38^{o} slope to a shoulder with no problems. The second skier jumped into the slope at the shallower end of the slab, where it was one foot in depth. This additional load triggered the entire path that the first skier had been down. Fortunately, no one was hurt but the slab could have been easily detected with a simple ski pole test or a quick pit. In these situations, where no obvious signs of instability are apparent, there has been no signs of natural activity for weeks, skier for the most part just don't take the few minuets to assess the avalanche potential. I would say maybe one percent of backcountry skiers would actively do something to assess avalanche potential in these situations.

Avalanche that ran on a faceted crust in the Stevens Pass ski area in 1990.

The larger avalanches in these typical weather patterns are the ones that scare me the most. They involve eight and ten foot slabs sitting on a dense layer of faceted snow with a crust bed surface, and it is extremely hard to determine what kind of additional load or force it will take to make them go. Sometimes I think it might take an earthquake to shake the deep slabs loose, yet other times these eight foot slabs develop into large avalanches with only two inches of rain.

I have measured temperature gradients across faceted layers with depths of eight and ten feet of dense snow on top to be high enough to continue to promote faceted growth. This faceted layer usually becomes



Typical fracture profile of avalanches that occur on faceted snow in the Cascades.

A profile of the layering prior to the natural cycle starting late February, 2002 very dense. Sometimes the densities at the faceted layer are comparable with the densities above. The faceted layers are dense, but do not bond. When the faceted layers begin to get buried one to three feet deep, the shears are easy but not clean, indicating to me that there is some bond and that the slab is not under enough tension to release with average force. The critical indicators are moderate to hard shears with clean, smooth sliding surfaces, shear quality 1, which indicates the slab is under more tension and the bond is broken.

In 2002, late one of the largest natural avalanche cycles on faceted snow we have seen in a long time began in late February and lasted into May. Most of the snow for the season stayed along the crest of the Cascades. Several large avalanches just outside the Stevens Pass ski area were observed with crowns five to eight feet in depth. One class 4 avalanche, with a crown of eight feet, ran the night of April 13th in the ski area after in was closed. This avalanche ran on a faceted layer that formed on a rain crust in January. The avalanche was triggered by a small surface slide that was rain induced.

Later that summer, my family and I spent many days on horseback along the east and west side of the Cascade crest from Snoqualmie Pass to the Glacier Peak Wilderness. We were astounded how large and

The skier triggered East Highland Bowl slide of 2000 on faceted snow.

extensive this cycle of natural avalanches had been. Several of the paths we observed ran up to five miles through and across valley floors. Many paths were redefined, taking out millions of board feet of timber. By the first of October in some runout zones, a fair amount of snow left buried under old growth timber. Some of that snow will remain and become re-buried with this season's snow.

The 2002 slide cycle was an example of another observation regarding slides on faceted snow in the Cascades. The larger avalanche cycles we tend to see are in leaner snow years. In the 2002 winter, Stevens Pass recorded just three hundred inches of snow for the season. During lower snowfall seasons, we see more variety in the weather with prolonged clearing trends that create crusts and weak layers. By contrast, during the winter of 1996, we received above average snowfall — six hundred and sixty inches season total. The temperature was fairly constant, and snowfall was consistent with eight inches on the average every 24 hours from December through February. By March, there were no crusts or weak layers in the snowpack. At Stevens Pass, we observed only surface avalanches in the new snow and no large springtime avalanches.

Spending many hours in the local libraries going through newspaper accounts of daily weather events it was relatively easy to reconstruct the condition of the snow pack at the time of some of these large avalanche events. Talking with some of the old timers about snow conditions in these events, it was evident that most of these large avalanches occurred with the weather scenario of crusts, facets and snow.

The 1910 Wellington disaster was rain induced but ran on a faceted crust just west of Stevens Pass, killing over one hundred people. During this avalanche cycle, many avalanches happened over this two week period from Stevens Pass east into Idaho and Oregon. There is a lot of documentation clearly stating weather and snowpack conditions in most of these situations. The Yodelin avalanche in the mid 1970s, east of the Stevens Pass ran in faceted snow. 12 miles further east, the School House avalanche of 1950 ran on faceted snow. This avalanche wiped out a schoolhouse that was on the west end of my property. Fortunately, school was out that day due to deep snow.

As I finish this article, January 2003, we have just gone through a rain cycle in the Cascades. This rain cycle left us with a rain crust and a few inches of snow on top. A strong easterly flow developed which created a strong temperature gradient around the surface of the snowpack immediately beginning to facet and weaken the crust and the snow above. The ski mood is down right now but will climb into frenzy as it begins to snow, with the avalanche dragon building and lurking under the surface waiting for the right load, the right trigger.

Jon Andrews is Avalanche Forecaster at Stevens Pass Ski Area in Washington. He is a Professional Member of the AAA and Northwest Representative for the AAA.

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Crown of the April 13th, 2002 natural avalanche on faceted snow in the ski area boundary.

The Central Sierra Snow Laboratory: A Brief History

By Randall Osterhuber

During 1946, just after the end of World War II, the Army Corp of Engineers and the (then) U.S. Weather Bureau constructed three research weather stations in the Western United States. The multi-year research goal of these "snow laboratories" was to collect information with which to develop empirical models on snow accumulation and ablation in order to better facilitate water resource management for the west.

Three snow laboratories were built: one at Donner Pass in California's Sierra Nevada, one in central Oregon in the Blue River drainage, and one on the Continental Divide in Montana near Flathead Lake. The three sites were chosen based on accessibility and differing winter climatic regimes. The Oregon site received its winter precipitation primarily as rain with some snowfall. The Donner Pass site received most of its winter precipitation as snowfall with some rain. The Montana site's winter precipitation was primarily snow. The watersheds above and surrounding the three labs were heavily instrumented with both weather measuring devices and stream flow gauges. In addition, much data on snowfall, snow cover, and soil was manually collected during fieldwork for the winters 1946 through 1953.

In June of 1956, the North Pacific Division Corps of Engineers, U.S. Army, released *Snow Hydrology* (by G.A. Hathaway et. al.), summarizing the research findings from the three snow labs. The text is still cited today.

At project's end, the research branch of the U.S. Forest Service took over management of the Donner Pass lab, the Central Sierra Snow Laboratory (CSSL). It is the only lab of the three that survives today.

The CSSL sits at 2100 m elevation on the west slope of the Sierra crest about 3 km below Donner Summit. Donner Pass was named after, and achieved infamy because of, the ill-advised and (subsequently) ill-fated Donner Party. (Unable to surmount the Sierra crest because of heavy early-winter snows, the Donner pioneers wintered over on the east side of the pass. As well as reporting tremendous snow depths, the survivors of that winter came away with tales of their fellow adventurers demonstrating some particularly deficient camp etiquette.) Though snow depths of Donner Party winter 1846 have never been observed since—not even close—the Donner Summit region of the Sierra Nevada remains one of the snowiest inhabited places in the United States, and consequently one of the best places to study snow.

Donner Pass has had full-time residents since the late 1860s when the Southern Pacific Railroad tunneled through the bullet-hard granite of Donner Peak. The railroad and utility companies started precipitation measurements in 1871, and snowfall measurements in 1879. As a result, the Donner Summit region possesses the longest precipitation record from any western United States snow zone. The CSSL continues that record today. Average snowfall is just over 10 m with a maximum of 20.8 m in 1938 and a minimum of 3.9 m during winter 1881. Average annual precipitation is just over 1.3 m with a maximum of 2.85 m during water year 1982 and a minimum of .48 m during 1924.

The CSSLis a fully instrumented site, though the stream flow record of Castle Creek (which flows through the CSSL property at the headwaters of the South Fork Yuba River) was discontinued. This was due to the bisection and channelization of the stream course by the construction of Interstate 80 in the early 1960s.

Hundreds of snow research projects have been conducted at the CSSL, notably research on mountain climatology, snow chemistry, the effects and physics of rain-on-snow, and instrument design (including the isotopic profiling snow gauge). Current research projects include using dilute concentrations of rare earth elements (La series) as melt tracers within the snowpack, the isotopic evolution of the snowpack, and continued refinements on the gamma energy sensing snow gauge. Snow avalanche related research has centered on the effect of rainfall on avalanche frequency, avalanche rescue, and demographics of avalanche victims. Level I and Level II avalanche safety classroom/field courses have been taught by the CSSL personnel, and data from the CSSL is used to generate daily avalanche hazard forecasts for the northern and central Sierra Nevada. Many snow and avalanche talks, workshops, and slide shows are presented to the Lake Tahoe community.

Today, the CSSL is a field station of the University of California, Berkeley. The CSSL has research cooperations with over 40 public, private, state, and federal agencies, as well as numerous colleges and universities.

More information can be obtained from:

University of California Berkeley
Central Sierra Snow Laboratory
10162 Bunny Hill Road
PO Box 810
Soda Springs, California 95728 USA
(530) 426-0318
(530) 426-0319 fax
Email: randall@sierra.net
http://research.chance.berkeley.edu/cssl/index.htm

http://cdec.water.ca.gov/snow/current/snow/pillowplots/YubaAmerican.html

www.wrcc.dri.edu/weather/cssl.html

Randall Osterhuber is a snow researcher and photographer from Donner Summit, California.

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Continued from cover.

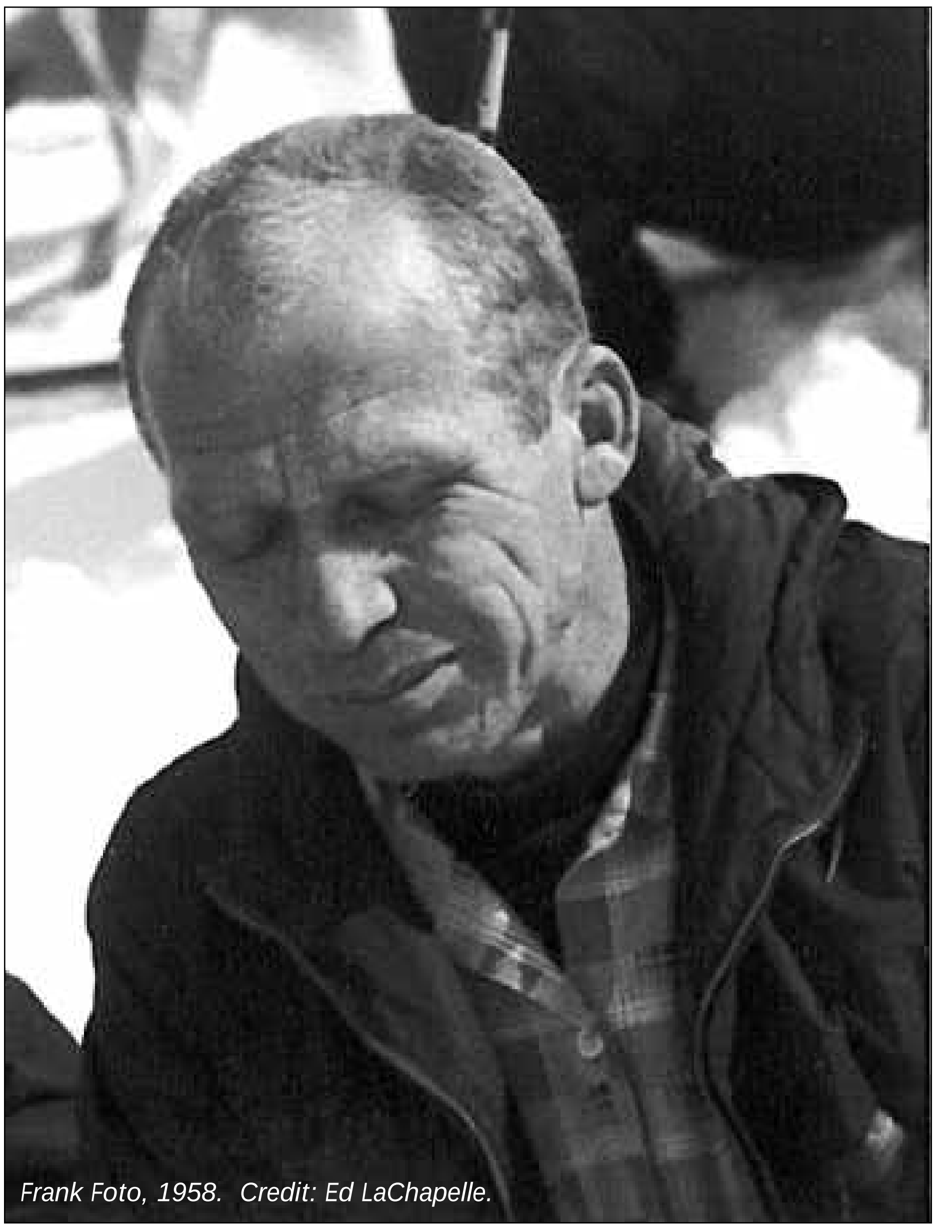
The 1940's and 50's are considered the 'Golden Age' of avalanche study thanks to the promotional efforts of Montgomery M. Atwater, Snow Ranger at Alta, Utah. He headed up what became know as the Administrative Avalanche Study with Supervisor Felix Koziol. At the urging of Andre Roch, a visiting Swiss avalanche scientist {*Ed. note: See Memoriam on page 2 of this issue*], Monty set up three 'study' stations - one in each climatic zone. Alta was chosen to represent the 'middle' climate-zone, Berthoud Pass, Colorado was the 'high alpine' and Stevens Pass as the 'coastal' after Mt. Baker had dropped out (Atwater 1952).

During that 'Golden Age' a prodigious amount of important research came out of all three study centers, but very few resources were invested by the Forest Service. Atwater eventually got artillery and the assistance of Ed LaChapelle, a "graduate physicist, glaciologist with a year's study at the Avalanche Institute [in Davos, Switzerland], skilled craftsman in the shop, [and] an expert ski mountaineer." (Atwater, 1968). At Berthoud was Dick Stillman. *Editors Note: See memorium in The Avalanche Review, Vol. 20, Issue 3.* Frank Foto was the Forest Service Snow Ranger at Stevens Pass. He and Stillman functioned with part-time and volunteer help only. No professional crew of avalanche technicians.

Four people. That was it. As the Forest Service encouraged development and access to more dangerous and difficult avalanche terrain, they only assigned four men to figure out the problem and fix it. Frank Foto was their man in the maritime climate. From 1952 to 1961 he tracked down and controlled many slides - in the ski area and by 1956 on Highway 2. When time allowed he did ground breaking research on precipitation and snow intensity, settlement and new control methods.

By 1949 most of what was known about avalanches came from Europe. Foto had an eight-page 'handbook' by Bennon Rybiska to guide him in predicting hazard, and Atwater would produce *The Avalanche Handbook* in 1953 [*Ed. Note: See* The Avalanche Review *V21/1*]. Rybiska, a guide with the German and Austrian Mountain Club, helped form the basis for much of Foto's research. His article explains the importance of wind, precipitation, and temperature in creating slides. It did not, however, address how much wind, or precipitation was critical. For protective measures he recommended "Do not go into high mountains after a heavy snowfall or following a storm with a good deal of wind. Instead, let the snow settle for at least three days." (Rybiska, 1949) This plan may have worked well for guiding in the Alps, but it would guarantee that a ski area in the Cascades would be closed more then open. It would be up to Foto and his comrades to the east to flesh out this information and add science to their art.

They had to make it up and improvise as they went along. Atwater and LaChapelle created innovative 'data loggers' from used, pieced together weather equipment, but more manual observations were recorded by all these men than were collected by sensors. No Campbell units where available. "The likes of Stillman [in Colorado], Atwater [in Utah] and Foto proved what can be done with a pair of pliers and a roll of tape." (Atwater, 1968) All four of them went for some very scary rides on slides with nothing to locate them except a 30-meter length of avalanche cord. Rudimentary beacons would not become available until the late 60's. If not for the quick reflexes and incredible luck of these men, the lack of knowledge and near misses would have turned tragic.



Frank Foto, 1958. Credit: Ed LaChapelle.

Dislocations and Danger

Being a Snow Ranger was very dangerous - and fun. No matter the dangers, as long as everything came out all right, these guys had a great time. Foto's daily reports, storm plot studies and notes provide an interesting insight into the early days of avalanche forecasting and control.

April 23, 1955 was a good example: "Corky [Erickson] and I went up the [Solitude rope] tow10 feet apart. We were within 10 feet of the cornice when a 2 foot fracture occurred above us and we were in the avalanche. We went about 50 feet when we regained our feet and escaped the avalanche." Scary, but not enough to call it quits for the day. They went on to blast Nancy Chute until, "Corky was caught in the avalanche. He was taken about 30 feet. He grabbed for a tree when in the process he dislocated his left shoulder. It took us about 20 minutes to put his shoulder back in place." Enough already! Two near misses, a shoulder injury and its time to go home, right? No, they kept skiing and blasting until "Avalanching done. This is what you call an exciting session... This is what makes research notes!"

At the start of the next season, Foto and partner Lloyd Burki broke off a 5-foot deep avalanche while ski cutting at Windy Knoll. "Needless to say the knees were quite wobbly after skiing this avalanche. Pulse was high too." (Foto report 11/25/55)

At an area now know as Marry-Go-Round, Foto had another near miss:

"I said 'I don't like the feel of this. We are getting out of here.' I told Ted [Berchard] to give me 15 feet of lead with the [belay] rope... I set off at a steep angel [sic] to get a fast run across the slope. Half way across she gave a rumbel [sic] and that was it. I was all ready to yell to Ted to let go of the rope, but all I got was buried and my mouth full of snow. I was swimming like mad, safety bindings didn't release. Twisting and stretching from the pull, I came up and saw I was traveling like mad at the trees below. I made an effort at a roll and got the skis downhill and went under again. I came up again, saw a tree, made a grab for it but was torn loose. About 20 feet further, I grabbed another tree and made it by hanging on. My skis were torn off. I looked up and there was good old Ted on top the snow still hanging on the rope and ok. The ride down was approximately 250 feet. It seemed like ages. We just sat there and looked at each other shaking. What was going through our minds? Ever hear the song 'Count your Blessings'? We did. We traversed to the top terminal of the chair [#1], put out Avalanche signs, and restricted skiing to lift line only." (Foto Report 1/15/56 p. 2)

Bureaucracy

By the mid-fifties Frank was under fire from his supervisors. The job of Snow Ranger was difficult and dangerous. Resources were very limited, and Foto occasionally found himself alone on control missions. Writing in his report of 12/11/54 Foto "Had skier volunteers. It was so nasty weather and cold they didn't stick around so while there decided to do it alone." Acting Supervisor Jack Handy added in the margins "Was this good judgment? Was the job important enough that it couldn't have been delayed a day?" Obviously, Handy did not think the job was important enough to allocate more professionals to the crew for safety. At this time, the ski area was only open two days a week, and people expected to ski. Nonetheless, what the hell was Frank thinking? Even in the halcyon days of the 50's control work alone must have seemed like a bad idea.

Ski cutting was another technique Supervisor Handy disapproved of: "The use of skis to trigger an avalanche does not seem a reliable method from a safety standpoint" (Handy, 1954). Foto's judgment was questioned and he was accused of wasting explosives and blasting wire. The whole program was coming under scrutiny from the main office.

Acting Supervisor Handy was keeping score. The program made Handy look bad when Foto injured his knee resulting in "the forest's first lost time injury in 42 months." Foto's supervisor went on to tally the score against the program:

2. Bruce Kirkland, filling in for Foto, fell and ran a ski pole into his thigh on January 21.

3. Foto and two others caught in an avalanche on December 31 while triggering an avalanche with skis.

4. Foto and one other caught in another avalanche on April 23 doing the same thing. (Handy 1955).

Handy, in this letter to Monty Atwater, went on to question Foto's judgment and even the need for a study program at all "...it is a serious concern to us... The snow ranger is much harder to supervise, due to his isolated location, than most other personnel. Certainly if he isn't a man of mature judgment and completely safety conscious, we are in trouble."

Clearly, Foto was putting the mission before his own safety. He felt it was important to get the ski area, and highway open. That was his job, and he was "a tough and determined character" (LaChapelle). His regard for his personal safety and 'the Forest's lost time record' came second. There were no standard or guidelines to fall back on with these missions. You found volunteers to act as mules and belay your safety rope, or you went alone. Hopefully, these assistants knew something about first aid and avalanches, but not always. Monty Atwater bragged about finding good-looking gals to help ferry loads in Alta (Atwater, 1968). Some of these beauties can be seen in the 1953 Avalanche Handbook holding up a 'Closed Area / Avalanche Danger' sign (and is that a wine bottle at their feet?). The 'Golden Age' of avalanche study was also the golden age of the avalanche playboy, with the cardinal roles being: "1. Ski in deep powder; 2. Drink rye whiskey; 3. Never use one stick of powder where a dozen will make a louder bang" (Atwater, 1968).

Under increased pressure and suffering from an explosive shortage, Foto replied in his 1/26/56 report "When you have a hazard, then you must control the hazard. In a ski area that does not mean closing the area indefinitely. When you have time, then the effective measures must be taken to eliminate the hazards. Here it is done with explosives. If you don't have the explosives, then you have to do it with skiers, taking a calculated risk... Again if he [the snow ranger] is qualified, but if judgments are made by those who do not go on the avalanche control projects then I feel lives are again in danger because the Snow Ranger's hands are tied in eliminating the hazard."

The culpability of supervisors was never brought into question. Why was only one person allocated to such a dangerous and difficult task? Supervisor Handy alluded to the problem himself, writing: "The factor that is alarming about this is the fact that four accidents occurred in a very short time on a project with a one-man crew." (Handy, 1955) Foto was understaffed and functioning with primitive skis and bindings, and poorly designed electrically detonated explosives - when he had them at all. His job was daunting. By the mid-fifties he was doing avalanche control in the ski area *and* on the highway, in addition to directing rescues and doing research on precipitation intensity, settlement and general factors contributing to avalanches. He had volunteers, on occasion, but the buck stopped at Frank Foto. If control work need to be done to open the area then he went out alone. If no explosives were available, then he skied the avalanches down. What's amazing is not that he was injured, but that he survived.

Dud Policy: Circa 1956

Just getting explosives was a constant challenge. Again, Foto's report of 1/26/56 was an indictment against the difficulties placed on him by his supervisors: "Used all the powder we had, but it was not sufficient for all the cornice work [on Bobby Chute]. I presented the problem to the main office personnel. I got word that arrangements would be made to send powder up to the pass so that it would be on hand for week-end control work. The next day I received word that the explosives would not arrive because their decision was that too much powder was used—mainly wasted."

Making control safer was a constant battle between the men in the field and the bureaucracy. Typical of the difficulty was the insistence by the Washington DC office to use only explosives detonated electrically. *The Avalanche Handbook* is emphatic about this, stating: "Electrical detonation is mandatory at the Forest Service" (Atwater, 1953). Everyone in the field disagreed, even Monty, who literally wrote the book on avalanche control. In the mountains of the West, the people actually doing the work wanted a throw-able form of explosive. Electrically detonated explosives often required the blaster to venture out on to the slide path. A typical problem with electrical detonators was encountered by Foto on November 26, 1955: "Joy of all Joys! Tossed the dynamite on the slope and the lead wires snapped off - so I had to walk about 20 feet below the usual fracture point to recover the dynamite." No dud policy here. He went on to state: "I still maintain avalanche control work isn't any more dangerous than any other ordinary work. It is the methods used to do the control work. Dynamite is fine for cornice work but such explosives as concussion grenades would bring to the minimum the danger of getting caught in an avalanche. The purchase of a gun would solve the problem."

Foto finally got the ammunition he needed to battle the bureaucrats. Magnus Bakke, the explosives expert for the Forest Service, joined Bruce Kirkland and Foto on a mission to the Bobby and Nancy area to see what was going on in this troubled and isolated corner of the Forest. Foto, feeling vindicated, relayed Bike's findings in his 1/17/56 report:

"1. Explosives are not being wasted. 2. Should have different explosives. One needs some form of explosive to throw into the avalanche slope. Fuse dynamite or concussion grenades. The present system requires walking out onto avalanche slope and placing charge. This is just asking for trouble. 3. Blasting wire is being wasted, but under present conditions it cannot be prevented. Blasting wire is wrapped around dynamite before being thrown out, to prevent the dynamite from being torn loose... then we have to go on the slope to get the lost dynamite. I think most people will agree it is better to lose wire than to go on the avalanche slope."

By the spring of 1956, Foto becomes even more desperate, pleading with his supervisors for more dynamite. He faced the twentieth storm of the season - a three-week blizzard, and no explosives where available. "Then there is the point of SAFETY. When you have a limit on explosives to use for only the worse avalanche, then the Snow Ranger has to ski the tricky slopes. The more you ski avalanches, the more danger there is of being caught" (Foto Report 3/14/56).

While Foto was working with explosives experts in the Cascades, Atwater and LaChapelle lobbied the Forest Service Administration. "The winning argument came when [Atwater and LaChapelle] were able to demonstrate that drifting snow sometimes created an electrical charge on exposed wires that could detonate the electric blasting caps" (LaChapelle).

Foto was overjoyed when he finally received cap and fuse explosives. March 14, 1956, Foto made possibly the first official use of cap and fuse explosives for control work, although many stations (such as the bad boys at Alta) had been using the method - covertly - for years. In his report that day, he commented "Safety in obtaining avalanche research data has advanced a step forward. The credit goes for the use of fuse caps. Today was the first time the fuse caps were put to use. They are faster to prepare... Also there is the satisfaction that the explosives can be tossed from a protected area" (Foto Report 3/14/56).

Craziness at Crystal

The fifties were a time of incredible growth in the ski industry. A new ski area was being promoted southeast of Seattle, near Mt. Rainer National Park, to be called Crystal Mountain. In the spring of 1958 Ed LaChapelle, Frank and his wife Edie, and nine other people did an overnight tour to an old miner's cabin in a valley above Silver Springs. The promoters of the area had been touring the area for years and had never seen an avalanche. Foto and LaChapelle "were skeptical, because the terrain told otherwise." They were about to prove the promoters wrong. While traversing an old burn an avalanche caught most of the party. "Some of us got a free ride and a good scare, but others got variously beat up by the snags. The worst was Frank, who seriously injured his back" (LaChapelle). Foto injured his back so badly the party improvised a toboggan from skis and dragged him all the way out to the Chinook Pass Highway.

Storm Plot #2

On December 3, 1953 Frank Foto undertook a study of a storm labeled Plot #2 to assess the effect of precipitation intensity on producing avalanches. This was a new concept originally postulated by Monty Atwater in Alta, Utah. Atwater believed that the rate, not just the amount, of precipitation falling from the sky was a major contributing factor in producing slides. Stevens Pass was an ideal location to test this theory, because of its large, frequent storms that deposit enormous amounts of precipitation.

In 1953, the automatic weather instruments of today were only beginning to be developed. If they had been available to Foto, they would have been unreliable. So Frank got the information the only way possible. He slogged out into a tempest every hour for *one hundred and three hours* to take measurements. That is over *four days* with little sleep! Atwater called it "an exhibition of stamina unequaled in my experience" (Atwater, 1968).

Foto measured 137.75 inches of snow with a maximum snow intensity of five inches per hour and an average of one inch per hour. The storm deposited 6.08 inches of water with a maximum intensity of .3 inches per hour on the night of December 5. "Expected to see the whole mountain side come down," Foto reported, "Very dangerous conditions here. Temperature warmed up and damp snow fell. Snowpack began getting top heavy" (Foto Storm Plot #2 Report).

Then the nature of the storm changed. Snow and water intensity and wind stayed critical, but settlement increased and temperatures dropped and remained low until the end of the storm on the seventh. Only "little sluffs on the highway" were noted.

So, while searching for the Holy Grail of avalanche forecasting tools Foto discovered something more important. It is the interaction of snow and water intensity, combined with wind, temperature trend, settlement and other factors, that is the critical contribution to many avalanches in the coastal range. "Conductive to avalanches [during Storm Plot #2] were the SI (snow intensity), PI, and wind... Only disadvantage to discourage avalanches was settlement which did the trick. Might say I was disappointed again."

The Legacy

In 1961 Frank Foto was transferred to a flatland station, and died from a brain tumor shortly afterwards. Today, the slide path below the Double Diamond (#9) Chair at Stevens Pass is named Foto's Alley in honor of Frank, a path where he broke his leg doing control work. Foto's work was continued at Stevens by subsequent snow rangers, until the baton was passed on to the Steven Pass Professional Ski Patrol in the 1970's. Mitigation along Highway 2 is now the responsibility of Washington DOT. The Pass remains a place of avalanche innovation and study. It now takes over 50 avalanche professionals to monitor and control avalanches in the ski area and on Highway 2.

Atwater and Stillman would go on to Squaw Valley for the 1960 Olympics. LaChapelle became a Professor at the University of Washington, and continued to advance avalanche research in the Cascades, the Wasatch and the San Juans. He currently lives in Alaska.

The work done by the men of the Administrative Avalanche Study was a great foundation for future research in North America. It began the tradition of 'merging theory and practice' that is still alive and well in the avalanche community today.

In many respects Franks problems are very similar to those of the 21st century avalanche worker. Administrators still do not know what we do, and place unrealistic expectations on us. Most avalanche programs could use a larger staff and budget. Equipment breaks or is inadequate for the job. All these aspects are topics of heated discussion whenever beer (or rye whisky) and avalanche pros congregate. But we have come a long way. We are not up against nearly the hurdles that faced Monty, Dick, Ed and Frank. It is awe inspiring that they accomplished so much with so little.

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Ed LaChapelle offered some great insights into Frank and the 'Golden Age' and I am very grateful for his assistance. Ed obviously enjoyed working with Frank and is "happy to see Frank get some long-overdue and well deserved credit."

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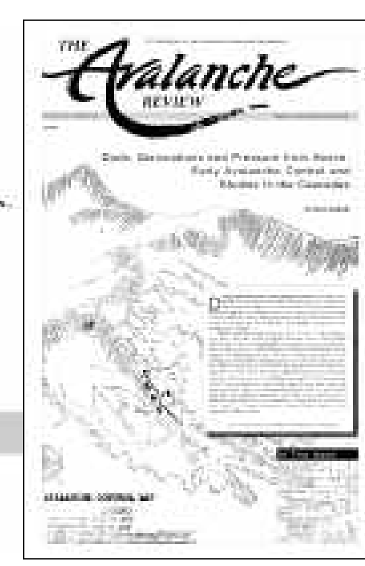

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