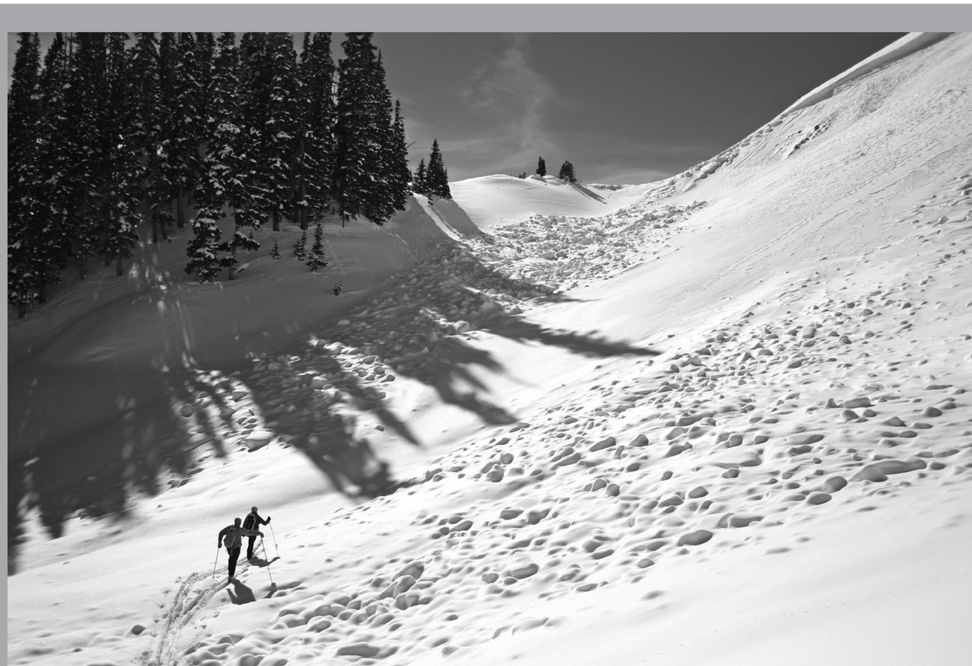
The American Institute for
AIARE
Avalanche Research and Education

Student Manual
2016 - 2017



AIARE 1 Avalanche Course

Decision Making in Avalanche Terrain


Reuben Krabbe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SEND
DSP
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Cover Photo: Don Svela - Red Mountain Pass Colorado

American Institute for Avalanche Research and Education
www.avtraining.org
AIARE 1 Student Manual
November 2016 Edition

Special thanks to the AIARE staff, instructors and others who assisted with this document:
Colin Zacharias, Ben Pritchett, Tom Murphy, Karl Klassen, Howie Schwartz, Brian Lazar, Ethan Greene, Margaret Wheeler, Simon Trautman, Dale Atkins, John Stimberis, Grant Statham, Chris Landry, Don Svela, Vince Anderson, Tom Carter, Gary Bard, Rick Grubin, Scott Schell, Jonathan Shefftz, Marc Beverly.

Important Message for AIARE Course Participants:

After completion of your course you will receive an email from the AIARE office directing you to the AIARE web site where you can log in and print your certificate of completion for this course.

The American Institute for Avalanche Research and Education (AIARE) is a nonprofit educational organization that develops and provides avalanche safety curriculum to organizations and individuals endeavoring to promote avalanche awareness and education.

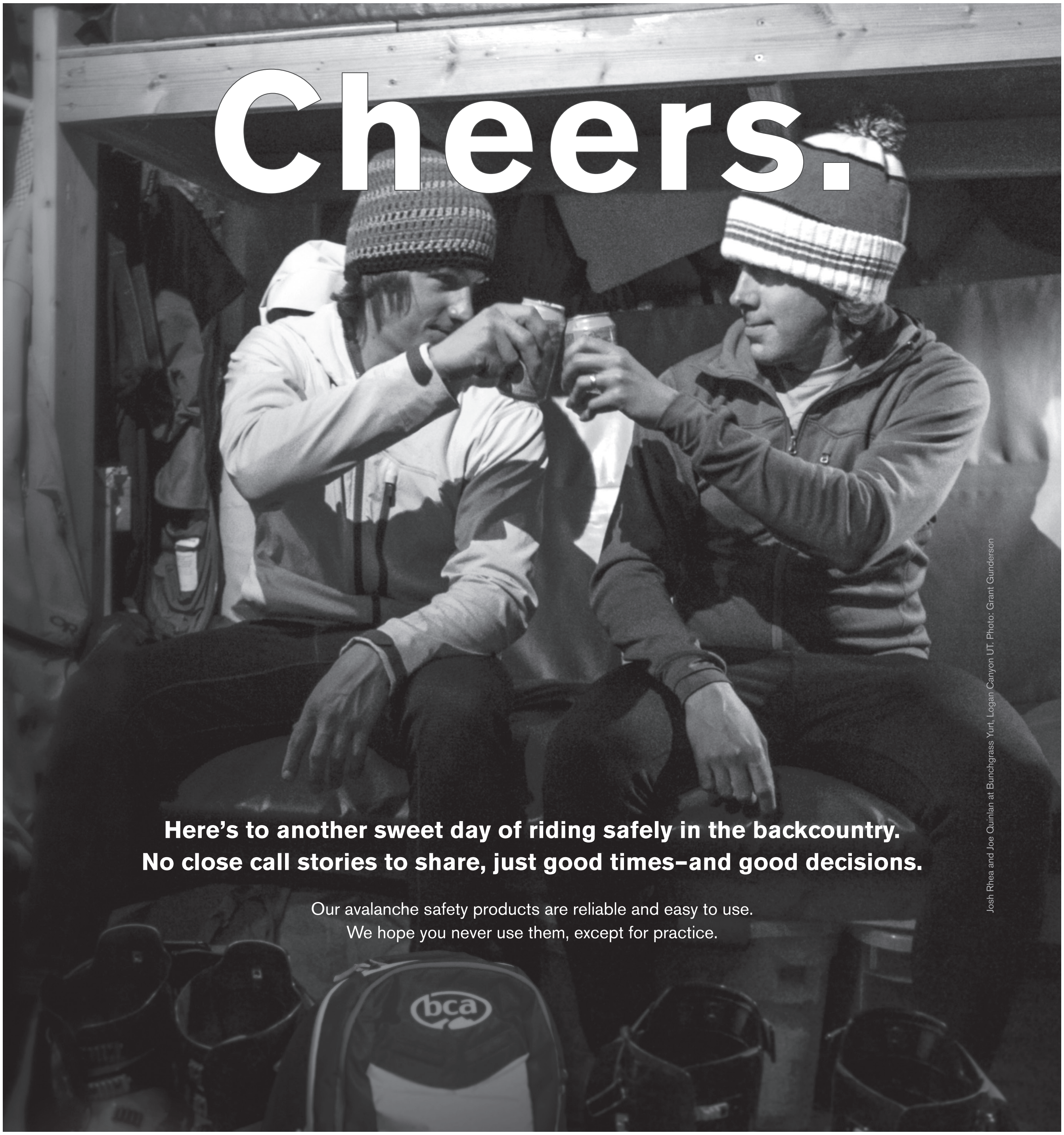
AIARE (and its officers, directors and subcontractors) does not teach, oversee or conduct AIARE 1 or AIARE 2 avalanche courses. It does provide course curriculum and materials to avalanche course providers and qualified instructors to teach AIARE 1 and AIARE 2 courses. All organizations and individuals conducting AIARE courses act independently of AIARE and are solely responsible for conducting the courses.

Importantly, in choosing to voluntarily engage in avalanche courses or programs that operate in the backcountry and/or wilderness settings, individuals must understand that they accept and assume the inherent risks of these activities.

JOIN A BACKCOUNTRY RESEARCH PROJECT

The Montana State University Ski Tracks project combines GPS technology with detailed logbook surveys completed by participants to help us understand how and why decisions are made in the winter backcountry. Throughout the winter ski season participants will use their smartphones to record and send us their ski routes, then they will complete a simple online survey telling us some of the features of their tour. We are looking for skiers and riders of all ages, skills, and abilities in any location. We will not share any detailed information about location or identity. If you want to learn more about our project aims, research questions and how to participate, please visit our web pages:

www.montana.edu/snowscience/tracks



Josh Rhea and Joe Quinlan at Bunchgrass Yurt, Logan Canyon UT. Photo: Grant Gunderson

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The American Institute for
AIARE
Avalanche Research and Education

MISSION

"Save lives through avalanche education"

GOALS

AIARE strives to:

- Increase public awareness of avalanches and avalanche safety.
- Provide high-quality avalanche education and thereby enhance public safety.
- Provide avalanche instructors with the curriculum, training and tools with which to educate students about the knowledge, methods, and decision making skills necessary to travel in avalanche terrain.
- Develop an international network of professional avalanche educators, and provide continued professional development in the form of instructor training and education.
- Fund projects that develop avalanche course support materials for educators and students.

ABOUT AIARE

AIARE is a registered 501(c)(3) nonprofit educational organization, which serves as a focal point for the gathering, development, and dissemination of materials, ideas, and curriculum for avalanche educators in the U.S. There are currently over 90 course providers and 250 instructors nationwide representing AIARE. This student manual was created by input from this community. AIARE is comprised of an Executive Committee charged with assimilating ideas, materials and concepts from AIARE members to develop teaching tools and materials such as this workbook. AIARE's Advisory Board of industry professionals provides guidance and comments in their respective fields of expertise.

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"Saving Lives Through Avalanche Education"

Overview: AIARE 1 – *Decision Making in Avalanche Terrain*

AIARE 1 - LEARNING OUTCOMES

- Develop a plan for travel in avalanche terrain.
- Demonstrate the ability to identify avalanche terrain.
- Effectively use the decision making framework to make terrain choices in a group setting.
- Demonstrate effective companion rescue.

Specifically the AIARE curriculum addresses:

- Decision making.
- Avalanche types and their characteristics.
- An introduction to how avalanches form and release.
- Trip planning and preparation.
- Gathering relevant avalanche, snowpack, and weather observations.
- Avalanche terrain recognition, route assessment, and selection.
- Travel techniques, group management and risk reduction.
- Teamwork and communication as effective measures to mitigate human factors during each stage of planning and decision making.
- Companion rescue.

A Special Note to Students:

Most of the understanding and techniques addressed during this course require extensive practice before you can expect to be proficient. No course, this one included, can provide all that experience.

To establish and maintain proficiency in the knowledge and techniques covered in this course, you will have to practice extensively and regularly on your own after leaving the program. Additionally, avalanche education continues to evolve as new research becomes available. To remain current, you will need to seek out opportunities for continued education.

No course can fully guarantee your safety, either during the course or after you leave. During the course, the instructors will manage risk and involve you in discussions about what is appropriate and what is not. They will inform you of any unusual or exceptional hazards or risks involved in carrying out lessons and exercises. Whether you will be "safer" after the course or not depends entirely on how you apply your new skills and knowledge when in the mountains.

Part 1: Introduction to Decision Making

1.1 - Anatomy of a Decision

ABOUT AIARE

Learning Outcomes

- Identify that backcountry decision making involves five key components: Plan, Observe, Teamwork, Choose Terrain & Travel Wisely.
- Reference the DMF as a mental map for the decision making process that will be used on this course.

AIARE DECISION MAKING FRAMEWORK

Backcountry decision making encompasses much more than whether or not to ski or ride a slope. The process is a continuous cascade of questions and thoughts that start before the trip begins and constantly affect one's actions until the trip ends. Most backcountry decisions fall into two basic categories: Choosing Terrain and Traveling Wisely.

Choose Terrain: This fundamental choice defines our risk management in avalanche terrain. A group's choice of "where to go" implicitly broadcasts its goals, how stable or unstable they believe the snow to be, their group's skill and fitness levels, level of emergency preparedness, the depth of planning and confidence in each other as backcountry partners. Choosing Terrain occurs at a variety of scales: within the mountain range, within the drainage and across the slope. An example of mountain range scale is choosing to ski east of the divide instead of west of the divide or further north or south hoping to find better conditions. An example of drainage scale is the choice to ski the north aspect of White Mountain instead of the south aspect of White Mountain. Slope scale is the decision to stay on a small ridge feature, or to avoid steep convex rollovers or stick to the sheltered treed glades below the open alpine terrain. Terrain choices reveal how deeply one understands the current avalanche hazard.

The bottom line is that terrain selection in the mountains is a life or death matter. The choice of where to go should be a consensus decision, made by all group members. Teamwork begins when making a plan, resumes as a group gathers gear and information preparing for travel, and continues repeatedly each time that team communicates and decides together at critical junctures in the field.

Travel Wisely: How a group decides to manage itself and move through avalanche terrain is integral to risk management. Travel techniques like exposing only one person on a slope while others watch, or spreading out across a series of small avalanche paths can further reduce risk when applied appropriately. Bear in mind, a travel ***technique should never be applied to justify moving through a hazardous piece of terrain.*** For example, moving one person at a time across an avalanche slope may not reduce the likelihood of triggering the avalanche, only the consequence to the entire team! Travel techniques should be discussed and anticipated as part of the terrain choice.

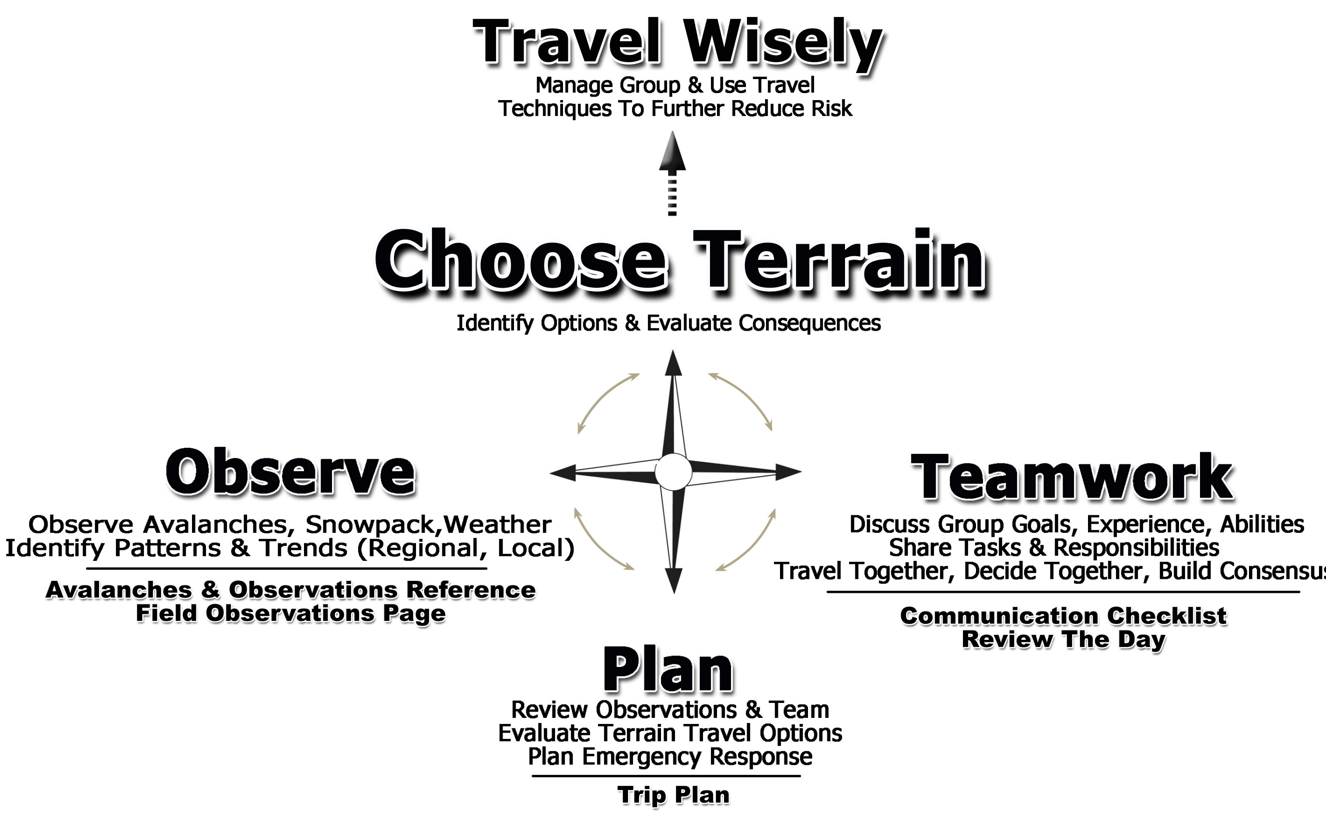
Decision making is the product of the three interwoven components of choosing terrain appropriate for the conditions. These factors are graphically illustrated in the AIARE Decision Making Framework: 1) Plan, 2) Observe, and 3) Teamwork. *Note the interplay of factors in the discussions below:*

- **Plan:** Trip planning is where most terrain choices begin. Prior to travel in avalanche terrain, a group's effort to establish communication (Teamwork), understand current conditions (Observe), anticipate hazards, and plan realistic options and contingencies lays the foundation for good decisions in the field. Depending on the circumstances, trip plans often detail specific time plans, route options down to the slope scale, where to gather field observations and choose between terrain options, even navigation plans for poor visibility. This process helps prevent accidents from occurring by planning for the day's decisions. Experienced decision makers commonly find it easier to be objective at the planning stage, rather than when facing the emotional lure of an enticing powder slope. Planning options also make error correction easier to implement. Another component, emergency response planning, ensures that the group is prepared to manage unwanted situations like an injury, broken equipment or an avalanche accident.

- **Observe:** Before Choosing Terrain, while building a Plan and in the field, a Team evaluates current conditions through first-hand observation and by gathering information from other sources such as an avalanche advisoryor local experts. These observations are made in the three information categories of avalanche activity, snowpack, and weather. It takes practice and experience to assess when observations may indicate avalanche danger. Public avalanche bulletins present and interpret observations at the range and sometimes drainage scale, a complex task for a single backcountry group to do alone. In the field, the group must actively and continuously observe and gather relevant local (drainage - slope scale) information and compare it to the bulletin and other information gathered prior to the trip. Observation quality and quantity directly affect the reliability of a groups terrain decisions.

- **Teamwork:** Appropriate Terrain Choices depend upon the group make-up. Decision makers must learn to recognize how group dynamics and communication impact the terrain selection process, and what group qualities facilitate good decision making. Human factors are dynamic and require constant monitoring. They also contribute to nearly all avalanche accidents. Human factors within the group have the potential to affect trip preparation (Plan), our ability to recognize clues in the field (Observe), and to make safe Terrain Choices. Recognizing and even more importantly pre-empting human factors through communication is a critical component of good backcountry decision making.

AIARE Decision Making Framework



QUESTIONS TO TEST UNDERSTANDING:

1. Why is trip planning an important element of managing risk when travelling in avalanche terrain?

2. How does the AIARE Decision Making Framework assist with decision making?

3. In most avalanche accidents human factor traps have been identified as playing a role. The following chapter includes a case history that illustrates the complexity of making decisions. Describe a situation where human factors played a key role affecting your trip decisions? How could improved communication or a more consistent decision making process have changed your choices?

PRESENTATION NOTES:

PRESENTATION NOTES:

1.2 - Case Study

Case studies are accident accounts that can provide valuable insight into how people make decisions that lead to accidents. Read the following case study (or one supplied by the instructor) and consider how the components of the AIARE DMF apply to the decisions that were made. They are regular backcountry recreationists whose decisions led to unwanted consequences. Note that while this incident affected recreational backcountry users, professionals have made similar mistakes. This story underscores the fact that all humans are capable of making poor decisions. Following the case study is an exercise to complete. While reading, make a note of any factors outlined in the DMF that in retrospect could have alerted the group about the risk to which they were exposing themselves. How could the team have created and chosen better options for the day? How could they have increased their margin of safety and still accomplished their goals?

ACCIDENT REPORT: OHIO PASS, COLORADO

Date: *February 25, 2001*
Location: *East Bowl in the Anthracite Range, 7 miles west of Crested Butte, CO.*
The account below is condensed from a report written by Dale Atkins, who investigated the accident for the CAIC:

The day dawned clear and cold after a 10” snowfall the day before. A group of 5 friends - two men and three women - met at the Kebler Pass trailhead and snowmobiled into the Anthracite Range, approximately 7 miles from Crested Butte, for a day of powder skiing in the backcountry. All of the group were experienced backcountry travelers familiar with the terrain, most having lived and skied in the area for 15 plus years. One member of the party was former ski patroller. Everyone had formal avalanche training and carried a transceiver, shovel and probe.

The public avalanche advisorythat day reported a danger level of “moderate with pockets of considerable at or near treeline.” The bulletin also noted that backcountry skiers in the Crested Butte area had reported triggering avalanches recently but had no information about where or when the avalanches had occurred. That day, the group left early and did not access the bulletin. The day was going well as the group skied laps on 30+ degree slopes in treed and open runs generally on northern facing aspects. The snow was perfect and they experienced no cracking and saw no avalanches. Two other groups were skiing in the same area.


Photo: T. Murphy

On their last run they decided to ski “East Bowl” one of the available routes down to the snowmobiles. East Bowl, as the name implies, faces east and is a mix of treed and open slopes with a variety of terrain features such as convexities, wind rolls, small cliffs and many small trees. In general it is steeper than the terrain the group had been skiing that day with slope angles between 25-45 degrees. At the top, the group saw two ski tracks leading into the bowl. All was progressing fine when part way down the group split up into one group of 2 and one group of 3 with the plan to meet on a shelf in the trees above the last pitch. The group of 2 (Mitch and Sue) split up with Mitch skiing to the bottom beyond the meeting point and the other, Sue, meeting the group of 3, above the last pitch, in sight of the snowmobiles at the bottom. The group had voice contact with Mitch at the bottom of the run a short distance away and Sue decided to traverse over to where he had skied down. On the traverse to the slope that Mitch had descended she intersected with a steep rollover, triggered and was caught in an avalanche. Sue remained on the surface but sustained a fatal head injury and died at the scene. Crested Butte lost a cherished member of the community that day.

ACTIVITY:

Discuss the case study and the accident summary with your group. Assume the role of an accident investigator. Using both the case study story and the accident summary, seek clues to causes of the accident. List the clues in the appropriate categories below.

Travel Wisely

Choose Terrain

Observe

Avalanche Activity

Snowpack

Weather

Plan

Teamwork

PRESENTATION NOTES:

Part 2: Avalanche Fundamentals

2.1 - Avalanche Types and Characteristics

Learning Outcomes

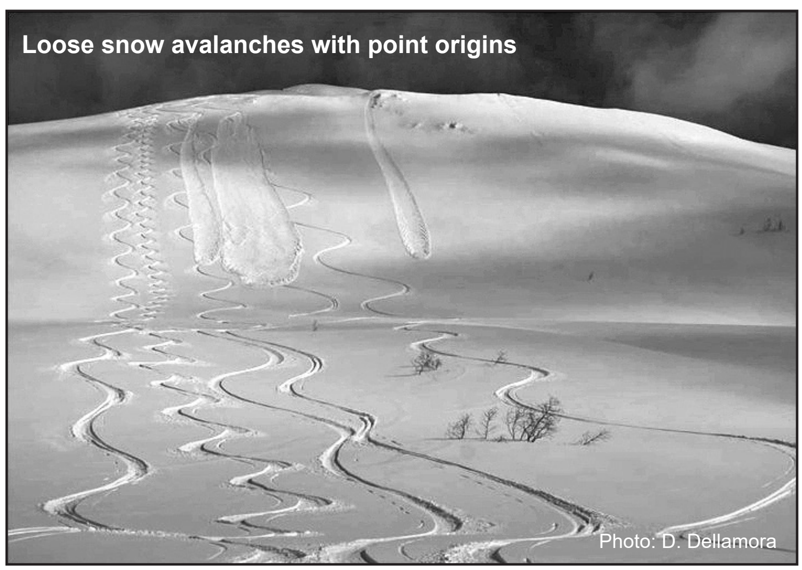
- Identify the avalanche problem by its characteristics as described in a public bulletin.
- Associate the relationship of the avalanche problem to potential consequences for backcountry travelers.
- Relate knowledge of avalanche motion to risk and safer travel techniques.
- Outline the classification system for size and destructive potential.

Avalanche type refers specifically to the physical characteristics of an avalanche. The types of avalanches include loose snow, slab, and cornice avalanches. The word “avalanche” is often used interchangeably with the word “slide.”

Backcountry travelers note patterns in avalanche distribution and characteristics - their destructive potential, width, slab thickness, trigger etc... These patterns in the types, characteristics, location and extent throughout the terrain are described as “avalanche problems,” “concerns” or “issues” in avalanche advisories or bulletins issued by avalanche forecast centers. Avalanche problems are categorized by how we treat different kinds of avalanches in the field.

Loose Snow Avalanches

Loose snow avalanches begin as loose, unconsolidated surface snow. They usually start from a point, gathering mass and speed as they flow down the slope. They result in a “fan shaped” trail of disturbed surface snow. Because they have a characteristic start point, loose-snow avalanches are commonly referred to as point releases or sluffs. The disturbed snow left behind after an avalanche is the bed surface. The pile of debris where the avalanche comes to rest is the deposit. Loose snow avalanches are easier to predict than slab avalanches. The conditions, timing, and snowpack characteristics at the point of slope failure are, relatively speaking, easier to observe and assess. This is not to say that loose snow avalanches should be taken lightly - an error in prediction or underestimating the destructive potential, size or trajectory can lead to serious consequences.



Loose snow avalanches with point origins

Photo: D. Dellamora

Loose Dry Snow Avalanches

Experienced backcountry travelers expect loose dry snow avalanches (sluffs) in freshly fallen new snow during or shortly after a storm on steep slopes. They are observed before the storm snow has time to settle and strengthen. Loose dry snow avalanches can be triggered naturally from new snow loading, from snow chunks falling from rocks, trees or cornices; or as a result of a rider's track in steep terrain. Also, riders in steep terrain notice that loose dry snow avalanches occur days or weeks after a storm in loose faceted (sugary) old snow that has been exposed to cold temperatures.

Loose dry snow avalanches involve the surface or near surface layers and are therefore smaller and less destructive as compared to slab avalanches. While small loose snow avalanches are relatively insignificant in terms of volume or impact force, they often occur on steep hazardous terrain. NOTE: Even a small sluff can have significant consequences if a person is in a precarious position or a terrain trap exists below (e.g., a climber on steep, technical ground above cliffs, water, or confined terrain where snow could pile up deeply). Backcountry travelers can attempt to manage the loose dry-snow avalanche hazards in the several ways:

- **Avoid steep terrain with traps below** (gullies, creeks, tree wells, road cuts), especially when loose dry snow avalanches are observed. The debris pile may bury a rider even on a small slope. Timing is a critical factor when the hazard is initiated by sun affect or warming.

- **Initiate the sluffs intentionally**, wait until the moving snow stops, and descend within the area of the disturbed snow.

- **Sluff management is applied by expert riders** who descend the "steeps" when they perceive low consequences and their concern is primarily the loose surface layers. This involves taking a diagonal line where any sluff triggered will pass down and behind the line of descent. If a trailing sluff is gaining mass and momentum, pull out onto high ground, changing fall-lines, or wait until the sluff passes prior to continuing down the original descent line. NOTE: this technique requires expert judgment and descent skill and errors could obviously have fatal consequences.

Loose Dry Snow Avalanche

Photo: B Pritchett

Loose Wet Snow Avalanches

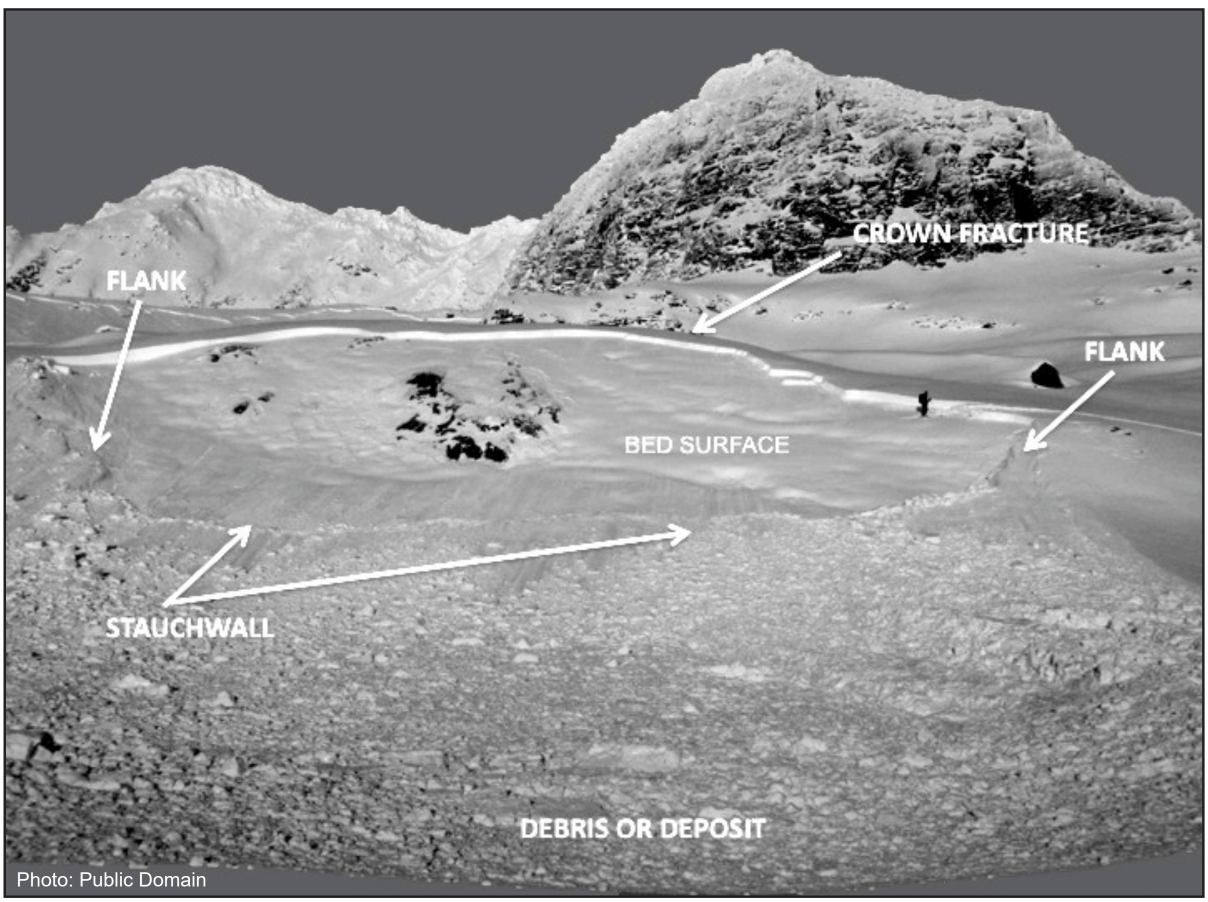
Warming, solar radiation, rain or a combination of these factors can result in the surface layers warming to 32°F / 0°C. The surface wet layer results in a localized loss of cohesion and a point release similar to a loose dry snow avalanche. A slower moving loose wet snow avalanche may be small and localized. It may entrain a greater mass of snow, leaving grooves or striations in the bed surface, even scouring the entire depth of the snowpack (usually in shallow continental snowpacks) resulting in large destructive avalanches. Despite their slow motion, loose wet snow avalanches are difficult to escape, similar to a cement flow. They may involve large wide sections of the slope and result in a dense debris pile that could quickly trap or bury the rider with few options for survival. Loose wet snow avalanches may result in a channeled or ribbed deposit that may run for some distance across the flats. In slush flows water may be visible on the deposit.

This wet loose slide injured the rider who triggered it

Photo: A. Parmet

Loose wet snow avalanches are often preceded or triggered by “pinwheels” or snowballs gathering momentum on solar aspects. Loose wet snow avalanches may trigger wet slabs during rapid warming, rain events or spring conditions. This lends an unpredictable element to conditions that result in loose wet snow avalanches. Wet slabs (see below) can be very destructive and involve the entire snowpack.

Slab Avalanches



Slab avalanches start as a unit of cohesive snow. The unit of snow becomes fractured and separated from the surrounding snow. The unit (slab) often quickly (sometimes almost instantaneously) breaks into smaller, angular chunks as it moves down the slope. If the avalanche moves far enough and fast enough, the chunks eventually break up into smaller and smaller pieces.

The *slab* is the unit of snow that initially fails and displaces. The wall of snow left behind at the upper limit of the slab is the *fracture line or crown.*

The sides of the slab are the *flanks*. The surface left behind is the *bed surface*. The layer where bond failure between the slab and bed surface occurs is called the failure layer or weak layer. The failure layer is often thin (<0.5" / 1cm) and sometimes indistinguishable to the untrained eye. The lower limit of the original slab is the *stauchwall*. In most cases, the stauchwall is overrun and obliterated by the passage of the slab and is generally unrecognizable. The pile of debris an avalanche leaves behind is referred to as the deposit. For a slab avalanche to occur there needs to be a slab that overlies a weak layer, a bed surface and a trigger.

A slab avalanche generally has an angular shape, with the fracture line usually running close to horizontal across the slope and with the flanks parallel to the slope. The fracture line and flanks may be straight or irregular. The bed surface is usually smooth, but occasionally contains steps or irregularities across some portion of the slope.

As the entire slab displaces from the slope, those caught have a difficult time getting off the moving snow towards the flanks of the avalanche. The rider's action in the first one or two seconds offers the best hope of exiting to either slower moving snow or a safe zone to one side of the avalanche. To escape off the slab itself, one must act when the slab is moving in gliding motion and before it gains speed and the blocks disintegrate into flowing motion (see avalanche motion below). Most avalanche fatalities involve slab avalanches.

Wind slabs

Whenever there is sufficient wind (>12mph / 20kph), loose dry surface snow, and suitable terrain, wind slabs will develop. The wind picks up and transports freshly fallen or loose surface snow from the windward slope, breaking up the snow into smaller particles, and deposits the fragments onto the lee slope. Wind slabs commonly occur below ridges, below cornices, below convexities and to one side of mid slope moraines. The recently deposited snow rapidly settles and strengthens into a cohesive layer. When this slab sits over a weak layer of recent snow or does not bond well to the old snow surface avalanche conditions can develop.

Wind slabs are often triggered naturally by additional overloading of new snow or wind deposit during or shortly after a storm. Recent wind slabs may be softer in stiffness (one finger easily penetrates) or hard enough that skis or even boots won't penetrate the surface. Soft slabs forming within hours or days of the storm tend to be more reactive to skier triggering. Slabs may sit undisturbed by a natural trigger until a skier or rider provides the trigger.

Fresh snowfalls may hide visual clues that wind slabs formed during the storm. Local history and expert advice is the best indicator of where wind slabs have formed and whether they are likely to be triggered. Wind slabs may be thin, rapidly tapering slabs or large resulting in destructive avalanches. Watch for snow "plumes" or snow blowing off the ridgetop for evidence that wind slabs may be forming. Watch for recent avalanche activity, especially crown fractures below the ridge crest, for evidence of wind slab avalanches. Watch for mid-slope cross wind effect near ribs parallel to the fall line and tree islands after periods of strong winds. Wind slabs sitting over storm snow may strengthen after a day or two. However, wind slabs sitting over persistent large irregular grain types may develop into Persistent Slabs (see Persistent Slabs).

Storm Slabs

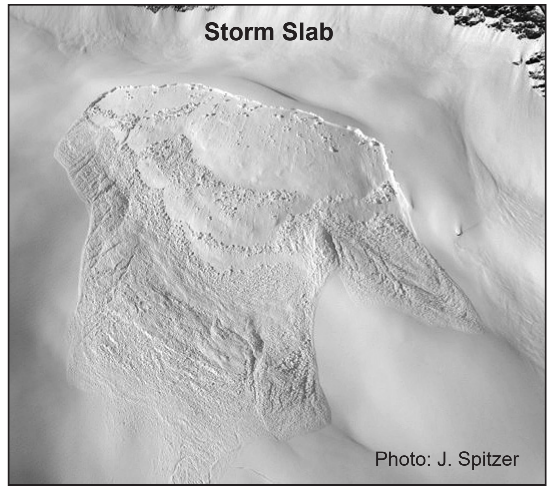

Storm Slab

Photo: J. Spitzer

Throughout the year storms depositing significant loads (>12” snow / 30cm) can form widespread soft slabs. Storm slabs occur as the overburden of the new snow forms a denser, stronger layer over a less stiff, weaker layer bonds poorly with the old snow surface. One scenario where this can occur is when a storm deposits a new load over weaker surface snow. An alternate scenario can develop within the new snow when the top of the storm snow settles more rapidly than the bottom, creating a relatively stronger more cohesive layer above a less dense layer of new snow. The problem is exaggerated if temperatures warm as a storm ends, creating “upside down” layers.

Larger storms can result in storm slabs over a great range of terrain and elevation. As the storm progresses smaller releases on steeper slopes may be followed by larger avalanches on lower angled slopes.


Paths that may run naturally during storms

Photo: B. Pritchett

As the storm continues and the overburden grows, paths that do not avalanche frequently may become active, often referred to as a widespread avalanche cycle. Without persistent weak layers below, a storm slab avalanche cycle tends to end in two or three days. Storm slabs are usually “soft slabs” and prone to triggering during or shortly after the storm. Storms where the air temperature warms during the event may also be accompanied by high winds aloft. “Upside down” riding conditions may result in triggering storm slabs below treeline and triggering wind slabs in open exposed alpine terrain.

Recently formed “snow cones” or settlement cones around small trees give clues that the storm snow is rapidly changing. Skiers may notice their ski penetration has lessened or snowboarders may notice their boot penetration had decreased. This could illustrate the storm snow is settling and gaining strength; or if there is a buried weak layer it may indicate the formation of a storm slab. If that weak layer is composed of large sugary grains (facets), the avalanche problem may linger as a Persistent Slab (see below). Powder fever and storm slabs lie at the heart of many backcountry accidents.

Wet Slabs

During periods with above freezing temperatures, especially with intense sun or rain the snowpack may become warmed to a moist snow condition (32^{0}F / 0^{0}C) and the underlying weak layer is affected by liquid water. Wet slabs may be triggered by a loose wet-snow avalanche or fracture and release independently.

Wet slabs occur during prolonged warming events common to spring conditions or during rain events. Depending on the depth and nature of the weak layer, wet slabs may be small and confined to steep, rocky, solar-radiated terrain or involve the full width of start zones during rain on snow events. Large wet slabs tend to initiate slowly, break into smaller sections and run full path if the terrain permits.


Photo: C. Mitchell

Timing is critical to avoid sunny aspects as they heat during the day. During warming events night time cloud cover or haze may prevent diurnal cooling and stabilization; the following day’s warm up may result in avalanches earlier in the day than would otherwise occur.

Rain events will affect all aspects simultaneously and may affect large portions of a mountain range. Rain does not have to penetrate to the weak layer to trigger slab avalanches! Avalanches may begin within minutes of rain falling on cold snow! Continued rain events may result in the same path avalanching more than once in the same cycle with full depth slope failure.

Persistent Slabs and Deep Slabs

Photo: avalanche.ca

Soft or hard slabs overlying a reactive weak layer made up of surface hoar, facets, a facet/crust interface, or depth hoar are referred to as a persistent slab (see Formation of Layers in the Mountain Snowpack). This condition may be the most dangerous avalanche condition to manage: may be difficult to forecast, may be easy or stubborn to trigger, and likely will persist through the initial storm avalanche cycle evolving into larger more destructive avalanche conditions.

Unlike storm snow avalanches where observed avalanches point to increased danger, fatalities have occurred involving persistent slab avalanches when NO or few natural avalanches are occurring! This is a condition where close attention to the bulletin and digging and observing the snowpack layers and completing a few basic snowpack tests (such as a Rutschblock test) may be the best method of observing the buried instability.

Photo: L. Castillo

A thick, hard slab sitting over a deep or basal weak layer is referred to as a 'deep slab'. While it is less common to ski trigger slabs deeper than 3', they may be triggered from spots with weaker shallower snow. If the weak layer is a persistent grain type, they can be triggered from a location distant from the actual fracture, known as a remote trigger. Deep slabs are destructive, with fractures that may propagate for long distances across the slope, may run full path with significant impact force, and involve thousands of tons of snow in the deposit. A noteworthy portion of avalanche research involves attempting to understand the nature of large slab avalanches that have historically affected transportation corridors, mountain villages, and backcountry recreation.

Mature Cornice

Cornices

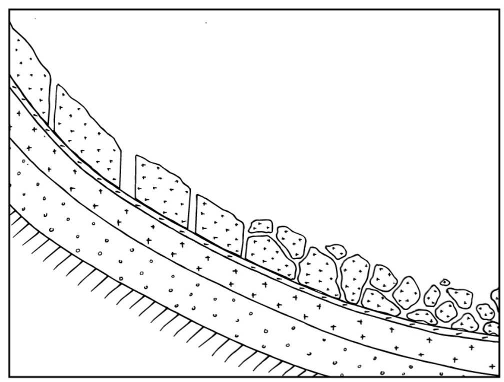
Cornices are overhanging snow structures that form from wind drifting of snow across the top of a ridge. The wind tumbles and fragments snow particles into small even-sized grains that pack together and bond quickly. Cornices are layered and can range from small wind lips to mature 30' (10m) overhangs of snow. Cornices can collapse suddenly fracturing back right onto the top of the ridge. The subsequent cornice fall can be hazardous pulling the inattentive climber or skier off the ridge onto the slope or over the cliff below. Even small cornice chunks are dense and heavy and can be destructive and deadly. The cornice fall can entrain loose surface snow or trigger slab avalanches resulting in significant and destructive avalanches. Backcountry travelers are wise to avoid slopes with large cornices above especially on days with warming, light rain or intense solar radiation.

Mature Cornice Pull Away

AVALANCHE MOTION

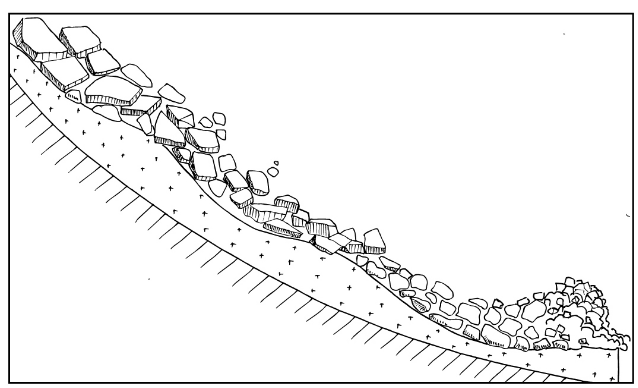
Gliding Motion

- *Speed:* 0-15 mph (0-25 kph).
- *Movement Characteristics:* Some break-up of the initial mass may occur. Blocks of various sizes tend to stay intact while the avalanche moves. No or very little mixing or turbulence.
- *Powder Cloud:* No significant airborne snow component (no powder cloud).
- *Deposit Characteristics:* Deposits from avalanches of hard snow usually contain angular chunks of a similar size as those that formed during movement. Deposits from avalanches of soft snow may contain smaller chunks and perhaps some fine-grained snow.
- *Constraint by Terrain:* Gliding motion avalanches are relatively easily constrained or stopped. They tend to follow or flow around terrain features such as gullies, mounds, banks, hills, etc.
- *Comments:* Gliding motion is experienced early in an avalanche, before enough speed or mass creates turbulence.
- *Hazards:* In general, less destructive than other types of motion. Can be serious if terrain traps exist. Slow, twisting mechanism injuries. Impact with solid, stationary objects.

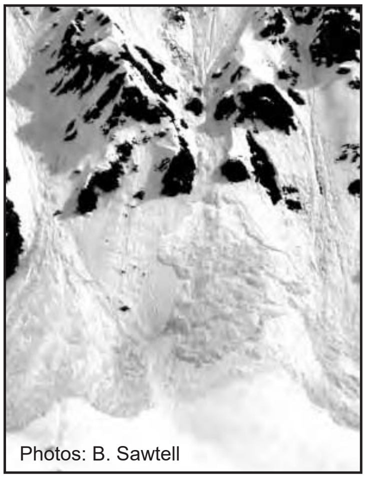


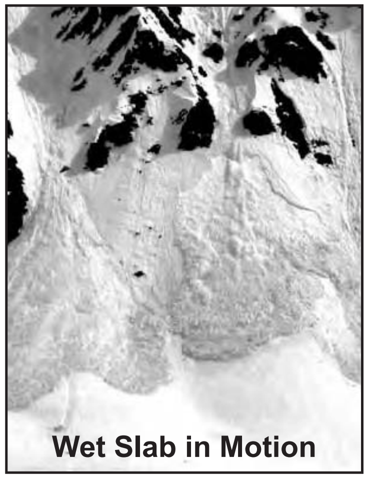
Wet Flowing Motion (in wet snow avalanches)

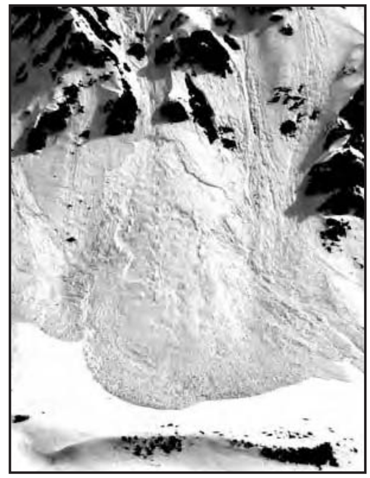
- Speed: About 15-40 mph (25-60 kph).
- Movement Characteristics: Break-up of the initial mass occurs. Rounded particles of up to 4" (10cm) in diameter and/or rounded lumps up to several meters/ yards in diameter often form while the avalanche moves. Very wet snow may have no particles or lumps, and a slush mixture may form while the avalanche moves. Mixing and turbulence occurs.
- Powder Cloud: No significant airborne snow component (no powder cloud).
- Deposit Characteristics: Deposit usually contains rounded particles and lumps. Often these are of a similar size as those that formed during movement. In very wet conditions, the deposit may consist of small, fine grained particles. Channels, runnels, ribs and ridges are common.



- *Constraint by Terrain:* Like wet cement, wet flowing motion avalanches tend to flow around or be constrained by terrain features such as gullies, mounds, banks, hills, etc.
- *Comments:* Any time moisture content is high wet flowing motion can occur in loose-snow or slab avalanches.
- *Hazards:* Slow, twisting mechanism injuries. Impact with solid, stationary objects. Wet snow is very dense and has little trapped air leading to suffocation hazard.

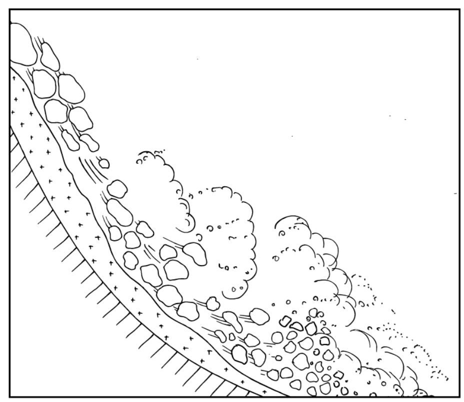

Photos: B. Sawtell


Wet Slab in Motion



Dry Flowing Motion

- *Speed:* 15-75 mph (25-120 kph).
- *Movement Characteristics:* Break-up of the initial mass occurs. Rounded particles of 4”-12” (10-30cm) create the core mass of the moving avalanche. A high degree of mixing and turbulence occurs. A series of waves is often observed in the core.
- *Powder Cloud:* An airborne snow component (powder cloud) forms above, around, and in front of the core mass. This powder cloud often gives the impression that the avalanche is much larger and travels much farther than actually occurs. The powder cloud has less destructive potential than moving debris.
- *Deposit Characteristics:* Deposit usually contains small, fine-grained particles with few lumps or chunks.
- *Constraint by Terrain:* Dry flowing motion avalanches often do not follow terrain features and are not easily constrained or stopped. Once they attain top speeds and turbulence, they can easily jump terrain features such as gullies, mounds, banks, hills, etc. Walls or banks are often jumped where a gully or similar feature makes a curve or bend. Large flat areas and even small hills are often overrun. In some cases, large, dry flowing motion avalanches have been known to run uphill significant distances before stopping.
- *Comments:* This type of motion is generally associated with large, dry slab avalanches. It produces the greatest destructive potentials.
- *Hazards:* High speed impact injuries. Impact with solid, stationary objects. Impact with solid objects in debris flow.



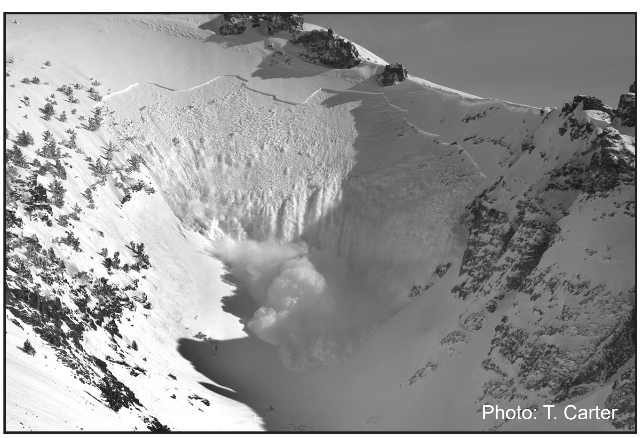


Photo: T. Carter


Photo: J. Royer

SIZE CLASSIFICATIONS

Relative to Path

Avalanches are often classified by estimating the size of the event relative to the terrain feature or path where it occurred. This system uses five classifications, based on the approximate percentage of the path that avalanched, relative to the path's full potential width, length and volume of snow:

- R1 Very Small 0 - 20%
- R2 Small 20 - 40%
- R3 Medium 40 - 60%
- R4 Large 60 - 80%
- R5 Major or Maximum 80 - 100%

This type of system is useful for recording or comparing events over time in the same, known location. Since past avalanche activity plays a large part in determining future snow stability and avalanche hazard, knowing which parts of a slope have previously avalanched is pertinent information when trying to determine conditions on a slope after evidence of avalanche activity has been hidden by subsequent weather events (e.g., drifting or snowfalls).

A relative-to-path-based classification system is less useful when comparing or discussing events in different areas, especially when the locations are not similar or known to all parties. For example, an R5 avalanche on a small slope cannot be compared to an R5 on a large slope. If a rider in the Rockies were talking to a climber in the Sierra, it would be difficult to convey the magnitude of an event by simply using this size classification without an understanding of the actual path dimensions.

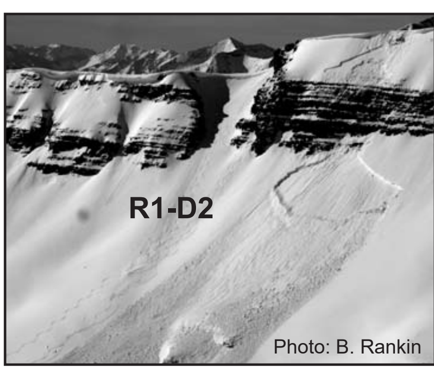
Destructive Potential

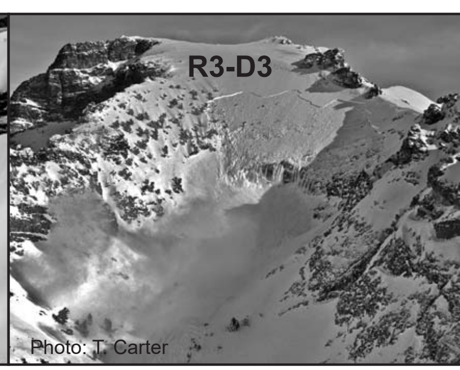
Avalanches are often classified using destructive potential as the ranking criteria. Size is defined by estimating the maximum destructive potential of the avalanche, taking into account factors such as speed, mass, terrain, etc. This destructive-potential-based system uses five classifications:

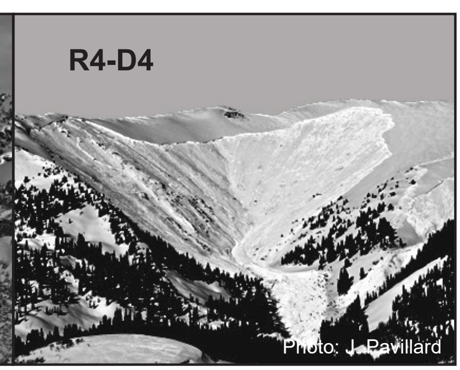
- D1: Too small to injure or bury a person.
- D2: Could bury, injure, or kill a person.
- D3: Could bury or destroy a car, damage a truck, destroy a small building, or break a few trees.
- D4: Could destroy a truck, railway car, several buildings, or forest up to 10 acres.
- D5: Could destroy a village or forest of 100 acres or more.

A destructive-potential-based classification system is useful when comparing or discussing events in different areas, especially when the locations are not similar or known to all parties. A D3 avalanche will have similar characteristics no matter where it occurred. For example, a rider in the Wasatch Mountains can discuss a D3 avalanche with a climber in the North Cascades and, to some extent, convey the magnitude of the event by simply stating the classification.

This type of system is less useful for recording or comparing events over time in the same, known location. It is difficult to assess the effect a D3 avalanche might have on future snow stability after evidence of avalanche activity has been hidden by subsequent weather events (e.g., drifting or snowfalls).







QUESTIONS TO TEST UNDERSTANDING:

1. How does a slab avalanche differ from a loose snow avalanche?

2. How does the expected avalanche character affect one's terrain choices?

3. Using the Destructive Potential scale, what size avalanche could injure or kill a backcountry traveler?

4. If caught in an avalanche, your action taken during the first second or two may be crucial to survival. Why is this and how does it relate to a slab avalanche in motion?

PRESENTATION NOTES:

2.2 Avalanche Terrain

Learning Outcomes:

- Recognize defined and poorly defined avalanche paths and start zones, tracks and run outs zones.
- Explain how terrain modifies the snowpack character by varying exposure to wind and sun.
- Recognize terrain features where avalanches are more likely to be triggered.
- Visualize terrain consequence and avoid terrain traps.
- Improve terrain knowledge, safer route selection and terrain management.

Appropriate terrain selection is the ultimate goal of backcountry decision-making. To understand terrain and avalanche risk, backcountry travelers first need to learn where in the terrain avalanches have historically occurred or under similar conditions in the past. Developing the knowledge and skill to understand bulletin advisories and to identify avalanche terrain requires experience and practice. Once developed, this skill becomes one of your most valuable tools. If you are uncertain about everything else you can minimize risk by traveling in terrain where avalanches cannot start and will not run. While weather, snowpack, and other factors are in a constant state of change, terrain is a relatively stable part of the avalanche puzzle.

RECOGNIZING & AVOIDING AVALANCHE TERRAIN

Essentially, any snow-covered mountainous terrain greater than 25 degrees in steepness can be considered potential avalanche terrain. Additionally, terrain that lies in the “fall line” or along a down hill line of trajectory should also be considered capable of being hit by an avalanche. This coarse description of avalanche terrain falls short of being precise, but from a worst-case scenario is fairly accurate. The reality is avalanches actually run in a smaller proportion of mountainous terrain than one would estimate based on the above criteria.

Avoiding avalanche terrain can be simple. In most cases safe areas include:

- Ridges, with no snow covered slopes above.
- Dense forest.
- Well out in the valley floor, beyond the furthest extent of historic vegetation damage. If vegetation is no help, the Avalanche Handbook (2006) describes methods for estimating runout potential.
- Slopes no greater than 25 degrees in steepness, with slopes no steeper overhead. Avalanche professionals measure the critical incline of the avalanche start zone as the steepest part of a slope with a down slope length of 60ft (20m) or more, (not the average incline) not including cliffs. (OGRS 2008 addendum)

Skiing near avalanche terrain

Photo: D. Svela

Following these guidelines avoids encounters with avalanches but can restrict travel options. Many backcountry recreationists hope to access terrain that these simple guidelines would not allow.

Often, climbers, snowshoers, cross-country skiers, ski tourers and snowmobilers choose not to travel in areas where avalanches start. This approach does not guarantee safety. The avalanche may not start directly underfoot; the exposure may be to an avalanche initiating above. In some circumstances, when the snowpack is highly unstable, failure occurs in terrain that does not appear as a start zone and is at considerable distance from the start zone.

Defined Avalanche Path

A specific location where avalanches repetitively occur may be referred to as an avalanche path. In some cases, avalanche paths are well defined and contain the three recognizable features: the start zone, the track, and the runout zone.

- The start zone is where avalanches typically start.
- The track is where the avalanche typically gains mass and speed as it picks up snow and other debris on its descent.
- The runout zone is where the avalanche begins to slow down and lose mass as snow and debris are deposited.

Poorly Defined Avalanche Path

Be wary of assuming too much about the somewhat arbitrary definitions of start zone, track, and runout zone or the idea that slides start only at the top of the mountain in the steepest part of the start zone. Many avalanche paths are quite poorly defined by comparison to the “classic” path. In many cases, the start zone, track, and runout zone are indistinguishable from one another, and the avalanche path is almost indistinguishable from the surrounding terrain. Given unstable snow, if a slope is steep enough to have an enjoyable descent it is steep enough to slide. If tree openings (glades) are wide enough to travel through at speed they are open enough to permit avalanches to release and run.

Vegetation

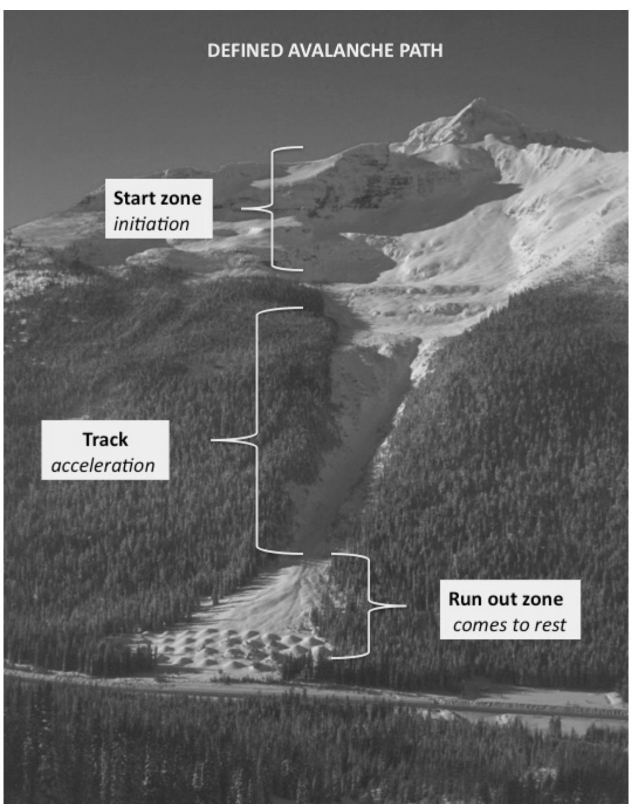
Avalanches that have previously run through an area leave obvious clues. Look for:

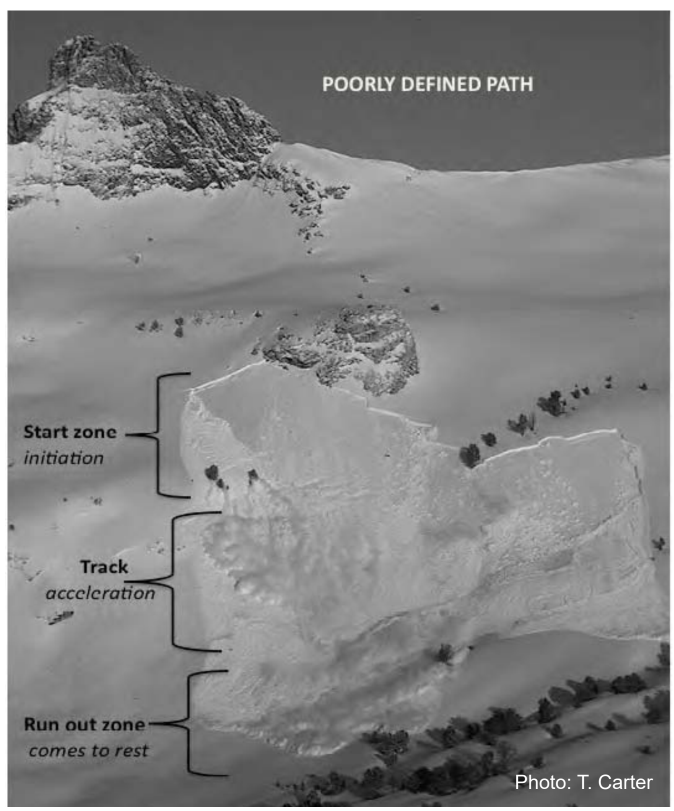
- Unexplained clearings
- All trees above a certain height broken or missing
- Trees broken above ground level
- Branches missing on uphill side of trees
- Lack of smaller trees
- Areas where trees are less dense

Avalanche Debris

Of course, the most obvious clue that avalanches have run in the past is evidence of debris. Fresh debris is relatively easy to spot but older debris can be hard to see. Look for:

- Lumps or chunks
- Piles of snow
- Uneven surface
- Ribs or runnels
- Snow sticking to uphill side of obstructions (trees, rocks, buildings, etc.)





EVALUATING AVALANCHE TERRAIN

The challenge is understanding terrain's influence on the snowpack. The concepts introduced in this lesson and on this course explain how snow cover and terrain interact. The reality is that a 24 hour avalanche course simply cannot ensure a student gains reliable avalanche terrain evaluation skills. The basic tenets of how to avoid avalanche terrain are simple enough to understand and implement. The real-world complexities of how terrain modifies the snowpack, as well as where and why a specific avalanche runs, take years of applied terrain experience to grasp. Field mentoring, observing and analyzing many avalanches and a cautious margin of error are the tenets of successfully learning to evaluate avalanche terrain.

A 'terrain expert' can effectively visualize the snowpack lying over the terrain in 3 dimensions. The most effective manner to acquire these skills is to travel through many miles of snow-covered terrain, frequently using an avalanche probe to measure snowpack depth and layering along the way. Make a prediction about the snow cover over nearby terrain, verify with a probe. Repeat in a variety of terrain features across many a different snowpack.

This lesson cannot provide these hands-on evaluation skills, but rather it introduces the observations we use to evaluate whether terrain is capable of avalanching include. The list begins with more broad scale factors, scaling down to individual terrain feature details:

IMPORTANT TERRAIN FACTORS

Location of the slope within the mountain range

Elevation of the slope

Aspect to Wind

Aspect to Sun

Slope angle (Incline)

Physical characteristics in the start zone (and path)

Location Within The Mountain Range

Weather influences vary from one mountain range to the next (see Snow Climates). Significantly weather influences vary within the mountain range, even from slope to slope.

- Note which areas of the mountain range are true 'snow belts' receiving additional yearly precipitation. Terrain that face into the prevailing storm track, tend to receive the most snowfall. The "favored" areas tend to have avalanche cycles more frequently, with each passing storm. In the long run, these areas develop a deeper, and stronger snowpack (see Formation of Layers in the Mountain Snowpack).
- Observe and remember which are the drier regions. These may be "rain shadows" in the lee of the range receiving less precipitation. Or, they may be distant from the prevailing storm track and receive fewer annual precipitation events. As a result the drier regions may not see as many avalanche cycles, simply because they receive critical snowfall loads less frequently. However, these areas are usually characterized by shallower snowpacks, which promote formation of persistence weak layers. Here the avalanche problems may be long lasting, once critical loads develop.
- Importantly, observe the prevailing winds and regions that are subject to terrain accelerated winds. The windy drier regions are often less predictable.

Elevation Of The Slope

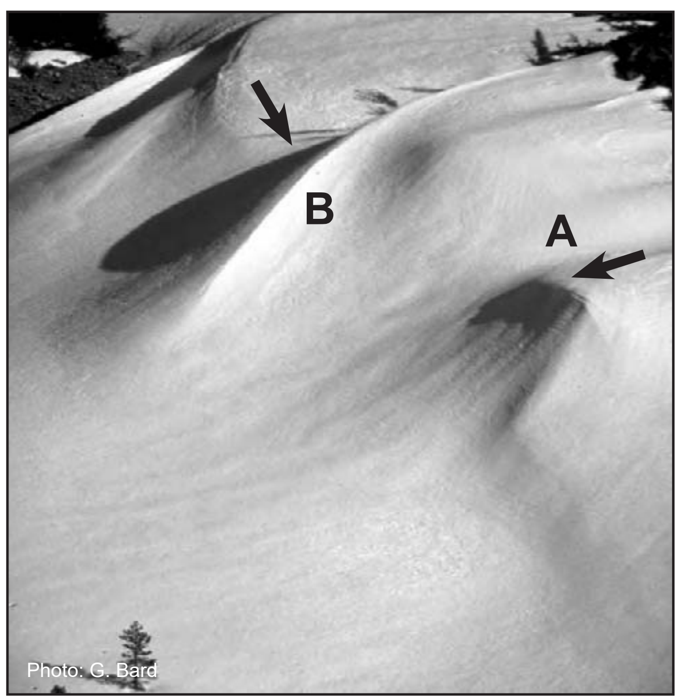
As warm moist air rises it cools and precipitates (rain or snow). When air masses rise over a mountain range it is referred to as orographic lifting. This accounts for a large proportion of snowfall in the mountain ranges. As a result higher elevations receive more total precipitation and more snow than lower elevations. Weather forecasts will mention the expected rain/snow elevation referred to as the "freezing level." Across this critical elevation threshold, expect different avalanche concerns.

Aspect to Wind

Wind has a regular and significant influence on the development of the mountain snowpack. Its greatest effect is *rapid loading of* wind deposited snow in the start zones. Wind accelerates across windward slopes scouring or picking up and moving loose surface snow with speeds as little as 12 mph (20+ kph). Snow grains fragment, bounce along, getting picked up by the wind. The actual wind speed necessary to transport snow varies based on the snow's properties (moisture, texture, stiffness etc.). On lee slopes the wind speed slows, depositing the broken snow grains. This process is sometimes referred to as *redistribution* of snow and *wind loading*. During a storm, wind often loads start zones 3 to 5 times faster than snow is accumulating in sheltered areas. As wind speeds change, wind deposits snow at varying rates resulting in wind slabs and layers (with stiff layers over less stiff layers) in the start zone. Visual clues that recent wind loading has occurred include snow plumes off ridges, recent cornice growth, and snow pillows on or just below ridges. These snow pillows appear smooth and deep or "fat."

An important consideration when evaluating the effect of recent wind is to differentiate between prevailing wind directions and local terrain influence on the wind. Many weather stations are positioned to record the prevailing "free air" wind directions. Keep the prevailing wind directions in mind, but on a slope scale, personally watching snow, and observing wind textures and the location of fresh deposits offers a much more accurate picture than simply generalizing about aspect in relation to the prevailing wind. The ability to relate prevailing winds to local wind loading patterns is a specific skill that takes experience and coaching to develop. Wind slabs are the most common type of avalanches triggered by backcountry travelers during or just after snow storms.

Cross loading occurs when wind moves snow across a slope and the wind-blown snow settles into hollows or gullies. The photo on the right shows patterns of snow loading from two different wind directions. A southerly wind originally loaded this slope from the right to left **(A)**. After the storm the northeast wind cross-loaded the slope from top left to bottom right **(B)**.



Aspect to Sun

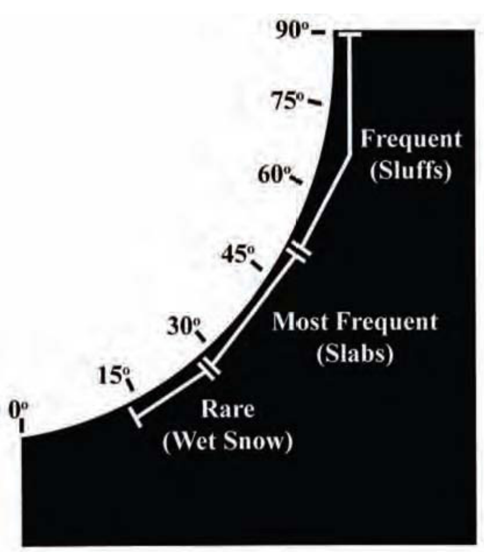
Solar radiation (sun) dramatically impacts the snow cover by changing the temperature of the snow surface and warming the air above the snow's surface. Effects range from melting the snow surface and snow cover, to forming crusts, to softening the snow surface (see Formation of Layers in the Mountain Snowpack). Depending upon the time of year and latitude, small changes in aspect or slope incline can dramatically change the influence of the sun's radiation.
Early in the season, the presence or absence of snow varies with aspect. In continental snow climates, often these early season snows form persistent weak layers. Later in the season, anticipating crusted vs. non-crusted snow surfaces depends upon aspect and incline. Terrain experts anticipate and observe radiation influence constantly.

Slope Angle (or incline)

Inclines of 30 - 45 degrees are ideal angles for skiing, snowboarding, high marking and *avalanche start zones*. Not surprisingly, this is where a large proportion of human triggered slab avalanches start. Slopes at this inclination allow unstable snow to slide readily yet are low angle enough to promote significant accumulations of snow before an avalanche starts.

Slope Angle	**Avalanche Characteristics**	**Slope Equivalent in a Resort Setting**
0º – 25º	Infrequent wet snow avalanches and slush flows.	Beginner to intermediate slopes – green and blue slopes
25º – 30º	Infrequent slabs in unstable conditions. Those that do occur tend to be large.	Intermediate slopes –blue slopes
30º – 35º	Slabs in unstable conditions.	Advanced slopes – black diamond
35º – 45º	Frequent slab avalanches of all sizes.	Advanced to Expert terrain – double black diamond
45º – 55º	Many loose avalanches start, often dry; some slabs, usually small	Out of Bounds: cliffs and couloirs
55º +	Few avalanches start, sometimes loose dry.	Out of Bounds: alpine climbing terrain

Consider the influence of poor visibility on one's ability to estimate slope angle. Perceptions of slope angle also vary with perspective. For these reasons, decisions related to slope angle should be measured, not estimated (see Part 5).



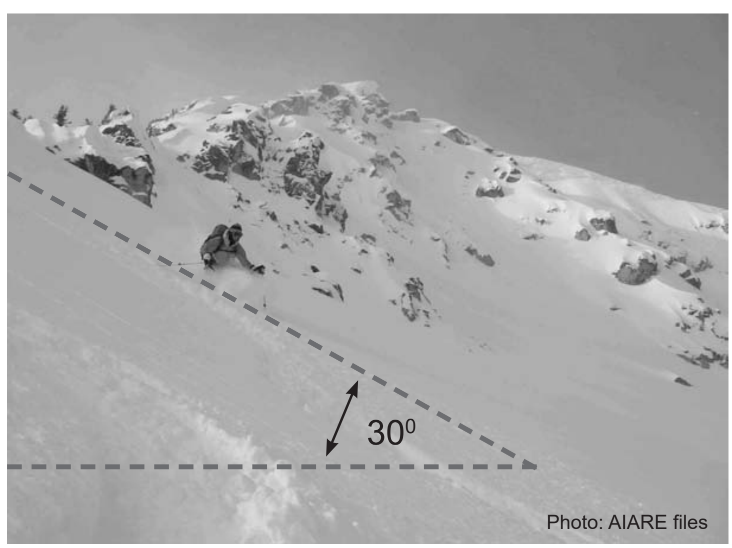


Photo: AIARE files

Physical Characteristics in the Start Zone (and Path)

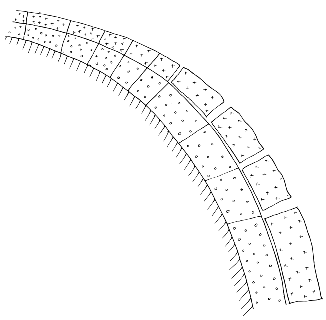
The size and shape of an avalanche path is key to determining areas of strong snow, weak snow, and destructive potential. Avalanche terrain can range from slopes as small as ten's of feet (several meters), to entire mountain faces. Considering the effect of slope size can dramatically alter the consequences of an avalanche. Slope length, incline throughout, and forest and rock cover relates to how far, and through how many obstacles a victim will be dragged. Slope width and connectivity to adjacent slopes often relates to how much snow will be entrained in the slide. Slope shape (along with the type of avalanche motion) will determine the flow of an avalanche and whether the debris will spread out or converge. Terrain experts combine these factors to envision the size of an expected avalanche and potential consequences if caught.

The character of the start zone determines the snowpack character and the development of strong or weak areas in this part of the slope where avalanches are likely to initiate. The presence of convexities (roll overs and bulges), concavities (scoops), rock ribs, trees and other vegetation affects snowpack layering. It changes how the snowfall accumulates and settles, how wind deposits the snow, and how the snow deforms and strains during the down slope creep of the snowpack under the unending influence of gravity. The weak snow that forms around localized terrain features are called trigger points.

Trigger Points

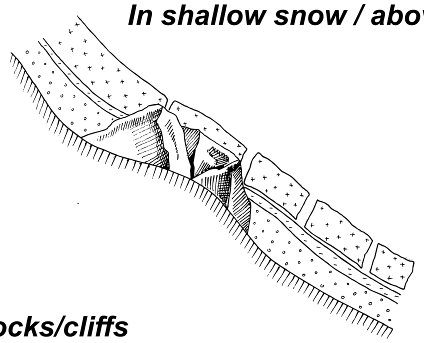
Understanding the notion of trigger points is crucial for backcountry travelers in avalanche terrain. A trigger point is a specific location where localized fracturing of the snow begins and leads to the propagation of an avalanche. These trigger points often occur at places where strain on the snowpack is concentrated or weak areas in the snowpack. Think of trigger points as land mines where avalanches tend to initiate. Knowing where avalanches initiate easiest helps one to avoid triggering avalanches while travelling in avalanche terrain.

Convex rolls

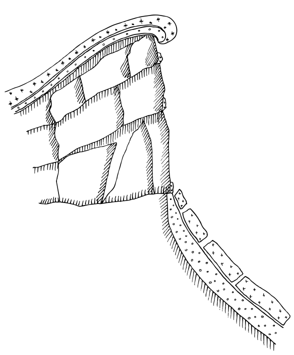


Around protruding objects

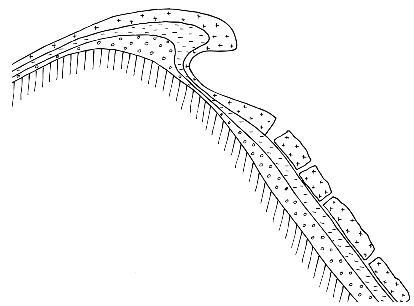
In shallow snow / above buried objects



Below rocks/cliffs



Below cornices



Terrain Traps

Any feature in the terrain that raises the consequence of being caught is a **terrain trap**. Examples include:

- Cliffs
- Gullies which cause moving avalanches to converge and speed up, as well as debris to pile up
- Bodies of water (creeks, lakes)
- Trees or exposed rock
- Benches or roads where debris will pile up
- Crevasses / Bergschrund / Ice fall

Photo: B. Pritchett

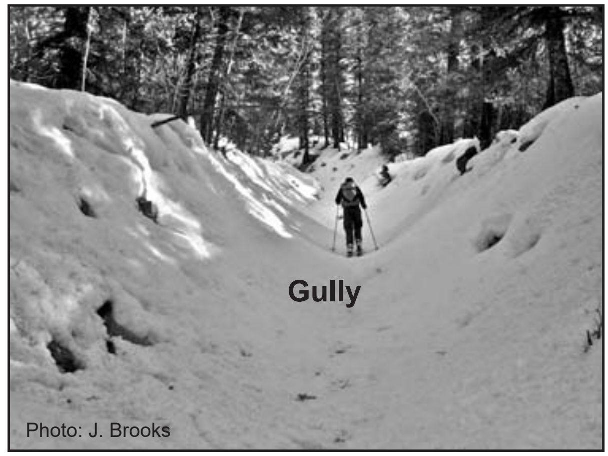


Photo: J. Brooks

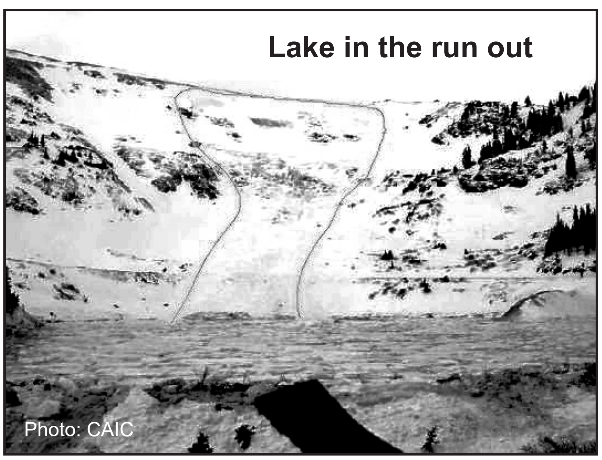


Photo: CAIC

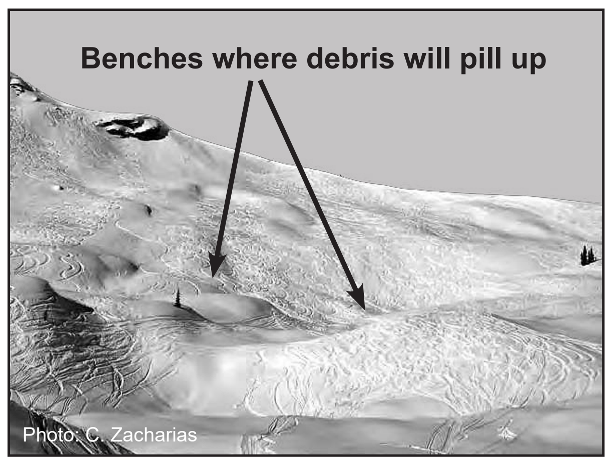


Photo: C. Zacharias

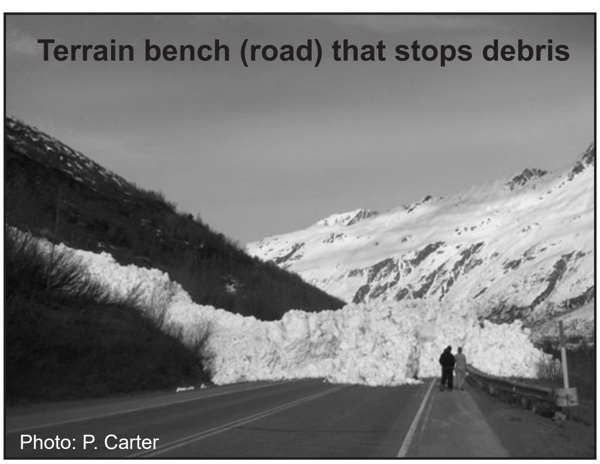


Photo: P. Carter

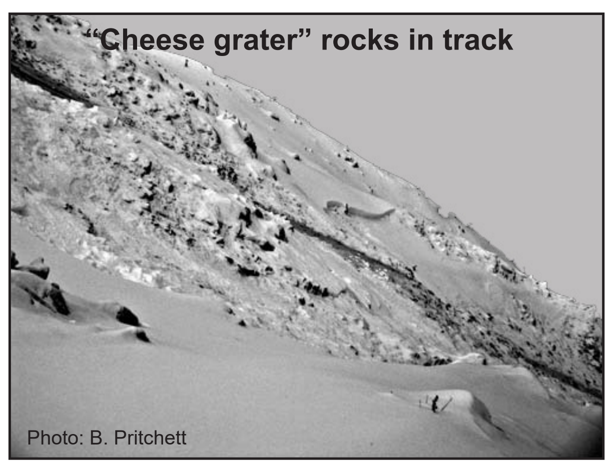


Photo: B. Pritchett

WHEN CHOOSING TERRAIN

Prior to traveling in the backcountry without an expert present, one needs be able to perform the following avalanche terrain evaluation skills reliably:

- Identify avalanche terrain
- Evaluate where in the mountain range and where in specific terrain avalanches may occur given current snowpack and weather conditions
- Anticipate the likelihood of encountering avalanches when traveling in the backcountry
- Anticipate the size and consequence of an avalanche occurrence
- Identify terrain choices that mitigate the hazard and reduce the risk

(See Chapter 5: Choose Terrain and Travel Wisely for a continuation of the topic - decision making in avalanche terrain)

QUESTIONS TO TEST UNDERSTANDING

1. How do you know if you are in avalanche terrain?

2. If you are unsure of the danger on a given day in the backcountry, how can you best manage your risk?

3. Name the six key recognizable terrain factors that create variation in the snowpack in the start zone?

4. How is it possible to trigger an avalanche from outside the start zone?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2.3 – Formation of Layers in the Mountain Snowpack

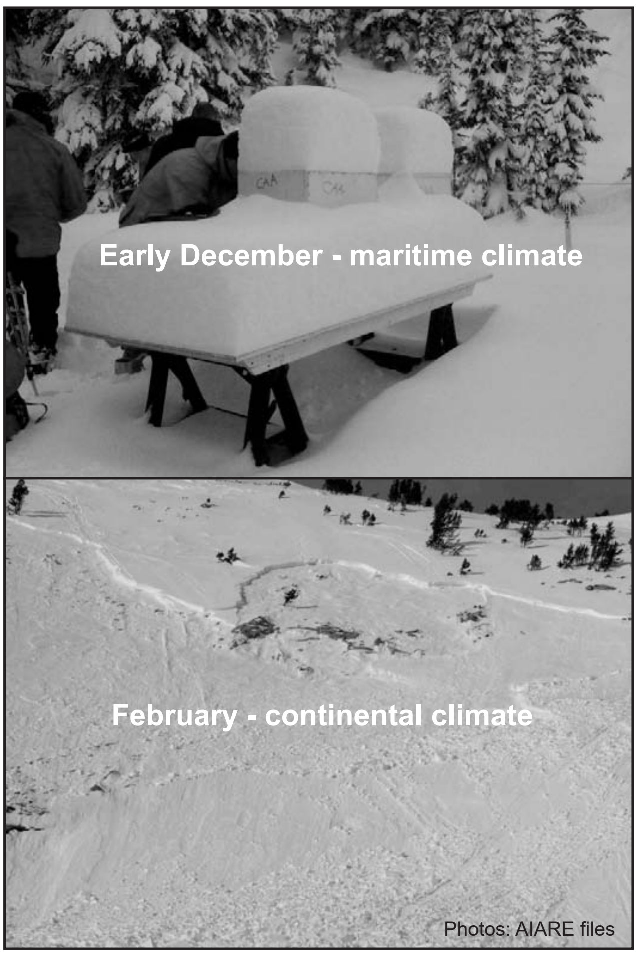
Learning Outcomes:

- Describe how snowpack layers form and metamorphose over time.
- Recognize the influence of wind, rain, temperature & sun and how they may form weak layers in the snowpack.
- Relate weather / snowpack patterns that lead to faceting, rounding, surface hoar, crusts & corn snow.
- Explain the importance of recognizing and tracking weak layers in the snowpack.

SNOW CLIMATES

The mountain snowpack varies in character, depth, density, and strength. Each layer is related to both the shape of the terrain (as previously discussed in this chapter) and the seasonal effect of climate and weather. The mountain snowpack varies from season to season. The snowpack varies from mountain range to mountain range. And, the snowpack varies within the range. The geographic location of the large mountain ranges in the North American continent and the prevailing climate differences from between ranges have given names to three principle snow climate regions within the continent. These are Maritime (coastal), Intermountain (or Interior) and Continental (Rocky Mountain) snow climate zones.

The maritime snowpack, proximal to the moist air masses arriving from the Pacific, is characterized by warmer temperatures, frequent precipitation and a deeper denser snowpack. This climate may see regular (monthly) rain events to ridgetop and infrequent influence of the cold Arctic front.



Photos: AIARE files

The intermountain region also has regular winter snowfall events and a relatively deep snowpack. The weather results from the back and forth influence of both the Arctic front (clear cold northerly air), and the warm Pacific air (warmer temps, snowfall, wind). Rain events to ridgetop are unusual. Persistent weak layers are common in addition to quality powder skiing.

Continental snow climates are frequent influence by cold dry arctic air and occasional visits from the distant milder Pacific air. Fewer seasonal snowfall events occur with comparatively long dry periods.

Many geographic variations exist, notably the American northeast that is considered an “Arctic Maritime” climate, and Alaskan/Canadian Territories that combine the “classic” maritime climate features with arctic factors (e.g., cold temperatures and short days and sometimes high altitudes).

Travelers who grow up in and learn one climate should be careful not to indiscriminately apply the “rules” of their region in areas where a different climate exists. For example: a rider from the Sierra, where the avalanche danger tends to quickly improve after a storm, would not be wise to use this approach in the Colorado Rockies where avalanche danger is often much slower to improve. In addition, many exceptions to the “rules” exist. Rain shadow zones in the coast range and only a few miles east of the snowy divide can develop an unstable shallow snowpack that bears more similarity to a continental snowpack than it’s nearby coastal relative!

THE EFFECT OF WEATHER AT THE SNOW SURFACE

Snow forms and falls to the ground when atmospheric conditions (primarily temperature and humidity) are right. Snow *crystals* are individual grains of snow; the classic "stellar" shape is what we often think of when we talk about snow crystals. In reality, snow crystals come in many different types. A snow crystal's size and shape depend on the environment in the atmosphere at the time it forms. Snowflakes are formed when a number of individual crystals join together as they descend. Once deposited, snow crystals begin to immediately change form.

As well as snow coming in a variety of shapes and sizes snow falls to the ground at different times and under various weather conditions (windy/calm, cold/warm, dry/damp, etc.). Therefore, the snowpack does not develop as a uniform blanket, it forms as a series of layers with or without similar properties.

Snowpack layers undergo continuous change. The snow grains that make up the layers change over time, which in turn changes the characteristics of the layers themselves. The process of change in the snow grains within the snowpack is called metamorphism. Metamorphism takes place over time and is driven primarily by weather factors. At a basic level, effects of weather include short term, near snow surface effects, and longer-term trends driving change within the snowpack.

Metamorphic effects ultimately change the structure of the layers that make up the snowpack: crusts may form or break down, layers may gain or lose hardness, grain size and shape may change, etc. Metamorphism can also change the nature of the bonds at the interface between layers. The bonds may gain or lose strength and failure characteristics may change over time. Weather effects play a role in changing the layers at or near the surface.

Event	Effect on Snow Surface
Wind	Wind etches and erodes soft windward surfaces. Wind battered snow develops thin stiff layers called wind crusts. Thicker wind slabs form where blowing snow accumulates.
Rain	Rapidly changes and weakens the surface layers, also freezes into a hard crust which could become a buried weak layer or sliding surface.
Temperature	Rapid warming or rapid cooling trends have been linked to cornice collapses and avalanche cycles. Warm layers freeze into crusts similar to thin rain crusts.
Sun	Solar radiation can soften and consolidate snow surfaces, enhancing the effect of warm temperatures.

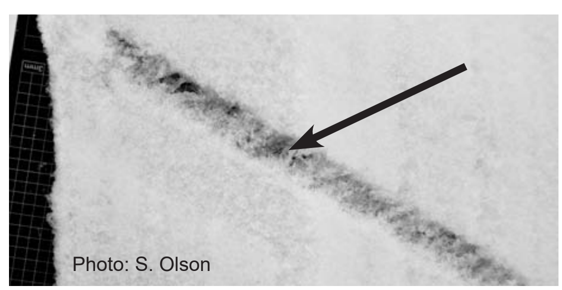
Other weather factors can also play a direct role, but the ones named above are the most common and have the most significant effect. The depth to which these weather effects are felt is not clearly defined, but the strongest effects are at the surface or in the upper layer(s).

SURFACE HOAR

Surface hoar deposits on the snow surface during cold clear nights with calm winds. Some people describe it as "winter's dew." Regularly it is destroyed by sun or wind when exposed on the surface. This often feathery crystal grows large enough to be visible to the naked eye.

BURIED SURFACE HOAR

But, if buried intact, surface hoar becomes a persistent weak layer. It is important to be able to observe this grain type as it becomes the failure layer for many avalanches.

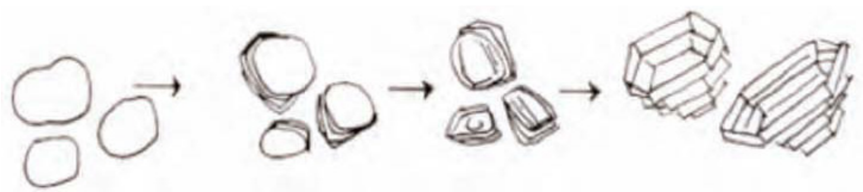


THE MOUNTAIN SNOWPACK CHANGES OVER TIME

Once snow grains are buried in the snowpack, they become protected from direct weather effects. Metamorphism still occurs in deeper layers and the weather still plays a role, but the effects of weather are indirect. The weather influences the environment in which the grains reside, rather than directly altering the grains themselves. As the environment changes, snow grains metamorphose differently. Metamorphism within the snowpack generally occurs more slowly than metamorphism near the snow surface. The most easily observed factors that influence metamorphism deep in the snowpack are air temperature and snowpack depth.

Faceting

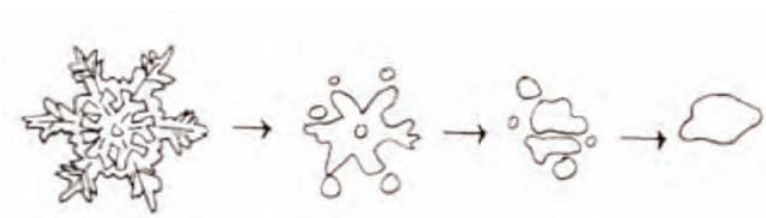
Under certain conditions, usually when the snowpack is shallow and air temperatures are consistently cold for extended periods of time, the snow grains tend to grow into angular shapes with a “sugary” texture, with less cohesion between the individual grains, known as *facets*. The process by which they form is called faceting, which develops porous, weak layers in the snowpack.

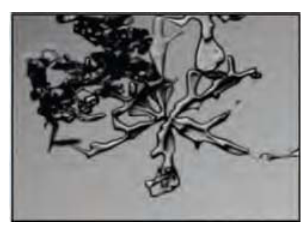


Faceting is common in areas where the snowpack is shallow and air temperatures are cold, e.g., continental snowpacks or early season snowpacks. Faceting can occur throughout the entire snowpack, or it can be isolated to specific layers. Near Surface Faceting can occur between storms, when surface snow is exposed to clear skies and cool temperatures. Observers’ notice the loose, angular grains that may sparkle in the sun, feel different than new snow, and make more noise under the ski base. When buried, these grains can form a weak layer. Given the right conditions, faceted grains can form at the snow surface in hours. Older snow layers that facet for weeks develop into advanced faceted grains, called Depth Hoar. Depth Hoar forms within the snowpack after weeks of faceting; it is quite different from a layer of buried Surface Hoar. Whether facets form near the snow surface, or closer to the ground, they may persist as a buried weak layer for weeks or for months if cold and shallow snowpack conditions persist.

Rounding

Under certain conditions, usually when a deep and well-compacted snowpack is exposed to consistently warm air temperatures for extended periods of time, snow grains tend to become smaller and more rounded in shape, know as rounds. Bonds between grains become stronger. This process is called rounding and creates a stiffer, stronger layer of snow.





As the process continues for weeks, bonds between the grains grow in size, “sintering,” and form an exceptionally strong layer. Rounding is common in areas where the snowpack is deep and air temperatures are warmer, e.g., maritime snowpack or late season snowpack. Rounding also tends to occur within thick and hard snow layers like old wind slabs. When thick layers of rounded snow rest above a persistent weak layer (commonly faceted crystals or surface hoar), the rounded snow grains comprises the slab component of persistent or deep-persistent slabs. A strong snowpack develops when layer upon layer of rounded snow rest upon the ground, with no weak layers between the rounds.

SUN CRUSTS, RAIN CRUSTS AND SPRING CORN SNOW

Melt-freeze metamorphism is a common result of above-freezing temperatures, strong solar radiation, or rain. This type of metamorphism repeatedly melts and refreezes the upper layer of the snowpack. Common in warm climates and in spring, melt-freeze layers are very weak when melted and “free” or liquid water is present and very strong when the “free” water freezes. As this process continues over time, the free water percolates deeper into the snowpack, eventually driving the dominant metamorphic process in the spring.

This process leads to large uniform grains. Each night these grains freeze together forming a very hard, dense, icy layer. The depth to which this freeze occurs depends on how cold it became and for how long. During the day, solar radiation and warm temperatures loosen the once frozen connection between the grains. The perfect “corn snow” develops when the snow surface has become partially loosened and wet, but the grains below the surface are still frozen together. Once the melting process penetrates to a certain depth, the snow may become subject to wet avalanches.

PRESENTATION NOTES:

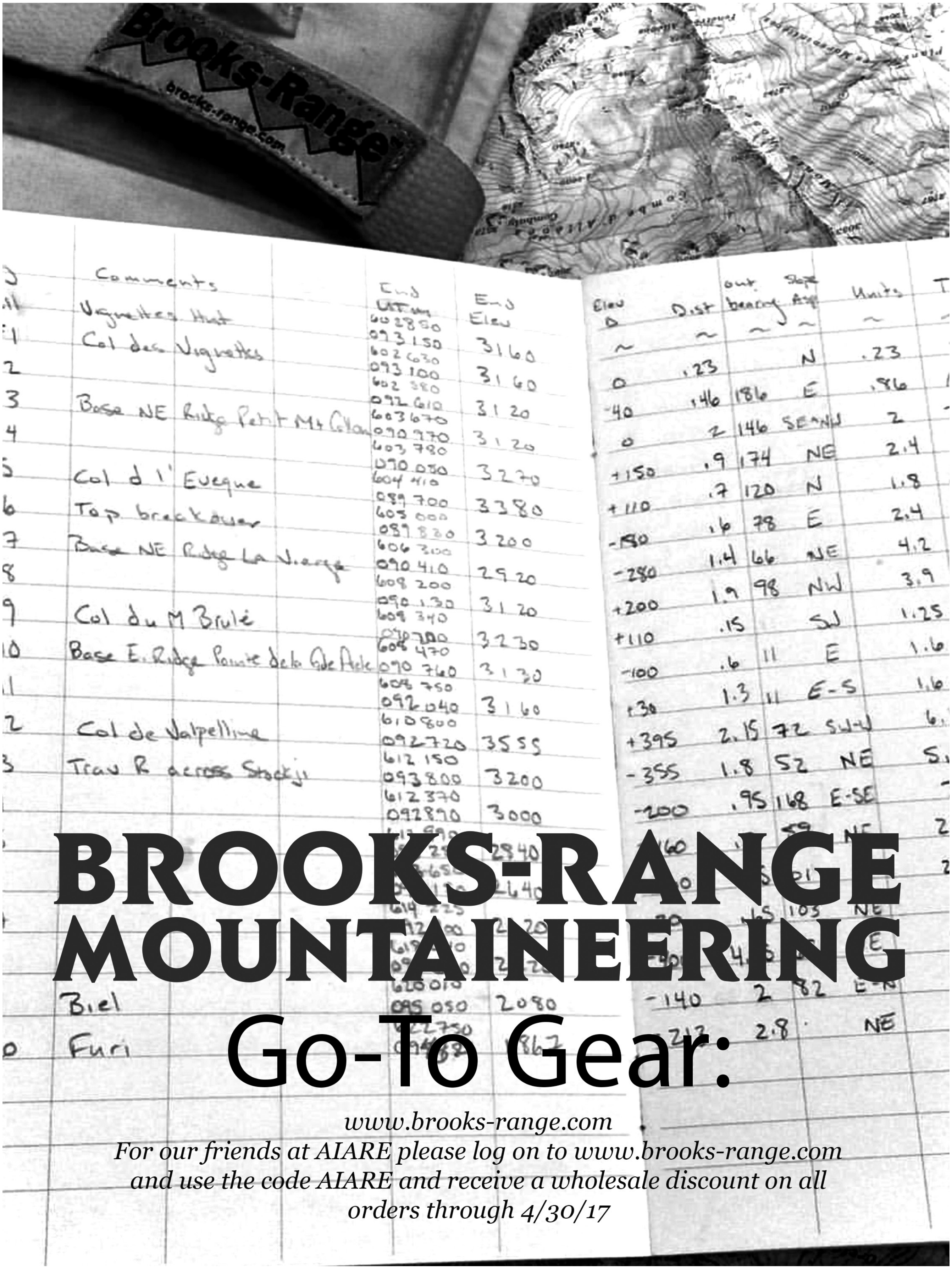
QUESTIONS TO TEST UNDERSTANDING:

1. How are layers formed in the snowpack? Describe the weather conditions that form snow grains that once buried become a “weak” layer in the snowpack?

2. What is the process that tends to form sugary snow grains with straight edges ?

3. Describe the process that forms strong well bonded layers in the snowpack? Name the snow grains and the process that binds the snow grains.

4. How is surface hoar different than depth hoar? Why are weak layers composed of these grains so slow to change, bond to each other and gain strength?



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Part 3: Plan

Learning Outcomes:

- Plan for group travel in avalanche terrain, using the AIARE Trip Plan page.
- Build a complementary backcountry team.
- Describe the North American Public Avalanche Danger Scale, and how to use the rating and discussion when trip planning.
- Explain why teamwork in the planning process can mitigate some human factors.
- Incorporate terrain information from maps, photos and online resources into terrain choices.
- Relate how terrain options chosen during planning critically affect hazard management in the field.

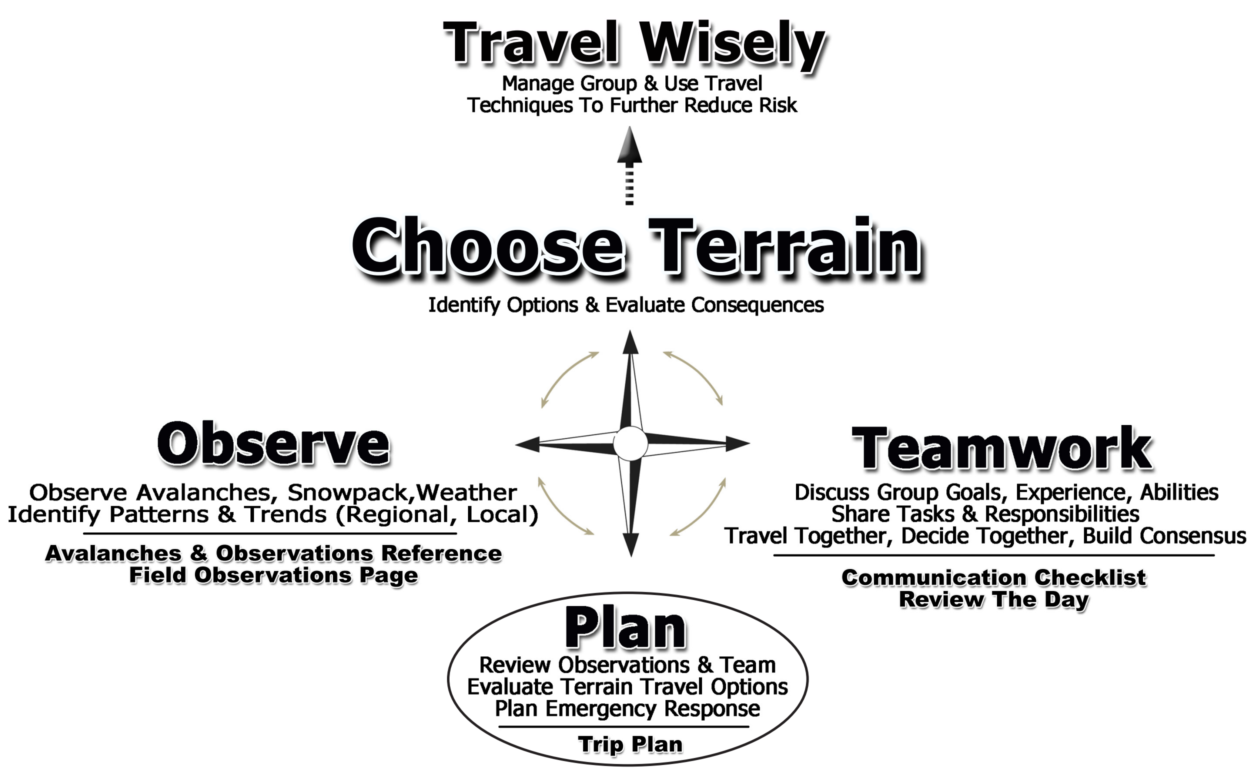
3.1 – Trip Planning

Trip Planning, prior to going into the backcountry, is essential for anticipating and properly managing risk. Backcountry adventures generally start with a desire to go into terrain. Sometimes the plan starts with the group members, other times a team is built around an objective. Rather than letting emotions and desires guide the plan, the process should begin with information gathering. “Who is coming along?” “What is happening out there?” “Where is the best snow right now?” “What is the current avalanche danger?” “What kind of avalanches are expected, and where in the terrain?” “Where shouldn’t we go?” Often specific desires and goals are incompatible with the day’s situation and one should alter them accordingly. An intelligent trip plan has factored in these variables and has options to accommodate changing opinions or unexpected circumstances.

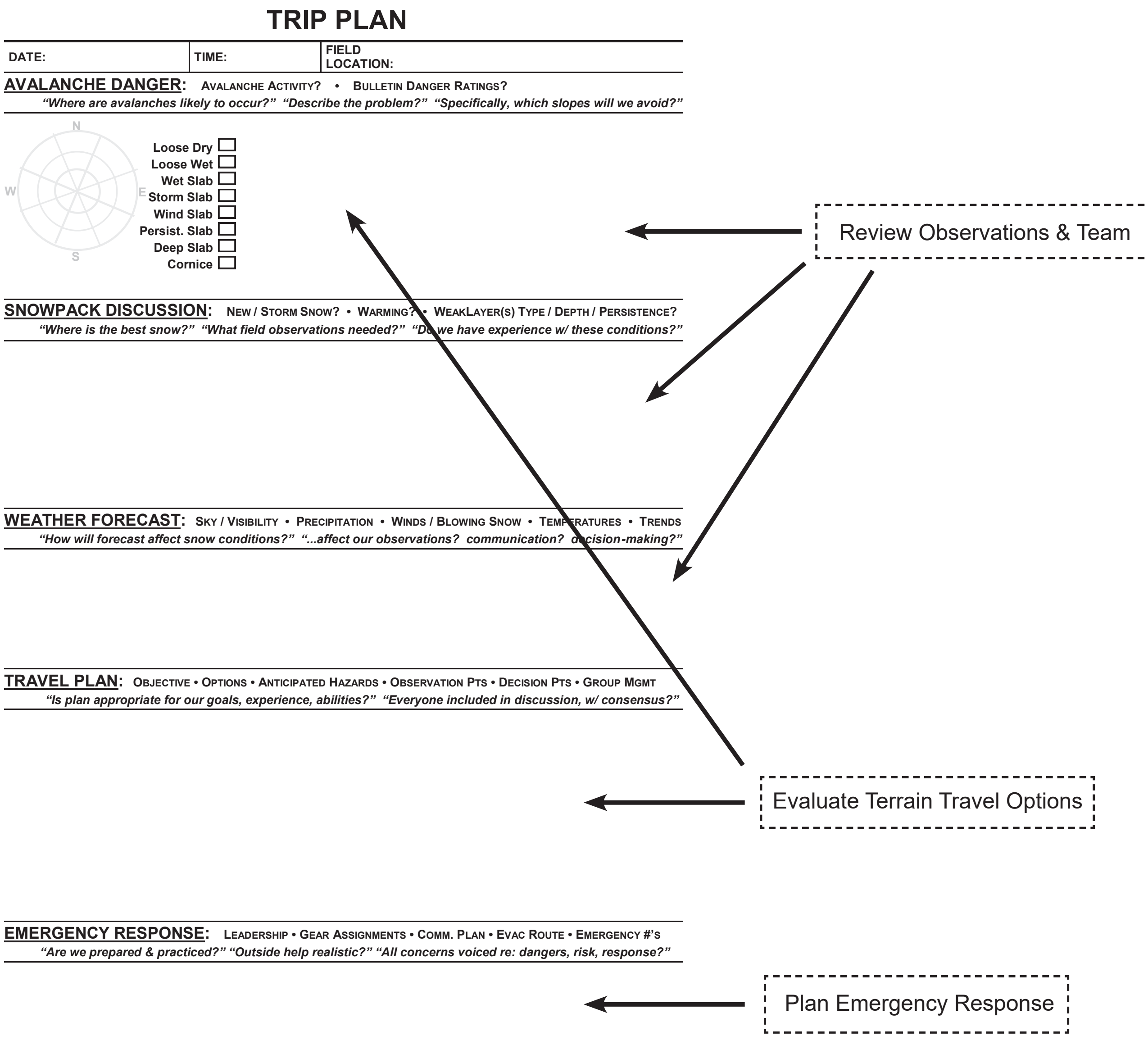
Trip Planning sets the group up for making good decisions in the terrain. Experienced trip planners understand that some of the most critical decisions are made prior to the start of any trip and they tend to go through a ritual process before each trip.

Within the AIARE Decision Making Framework (DMF), the components of the Trip Planning process are:

- Gather the group and commit to a planning session; share tasks and responsibilities
- Gather and share observations, and evaluate and forecast conditions
- Choose terrain; eliminate hazardous options; develop a terrain use plan
- Plan for an emergency response



3.2 – The Trip Plan / AIARE Field Book



"The group plan and hazard forecast in action."

(***Trip Plan**: page 8 of Field Book)

ABOUT CHECKLISTS AND DOCUMENTATION

Use of checklists in complex decision making environments is beneficial and highly recommended. Professional avalanche operations (ski patrol, guiding, highways and others) rely on checklists for forecasting and for field work. They use waterproof field books in the mountain environment to document field observations and decisions. Checklists ensure the process is organized and transparent. Checklists help the decision maker remain objective and free from bias. Importantly for pros and recreationists alike, checklists ensure the human tendency to take shortcuts is mitigated.

Documenting prevents a reliance on guesswork and memory. The human memory is notoriously unreliable, especially when distracted by fatigue, workload, time pressures, or even a fantastic ski run! Documentation either written or graphic allows for daily or weekly comparison and can illustrate important patterns and trends. Documentation allows for post trip reflection and promotes the value of lessons learned from experience.

The trip planning checklist used in this course is conveniently called the **Trip Plan** located in the **AIARE Field Book**. This checklist considers factors critical to an effective trip plan and helps to anticipate and forecast conditions and plan for safe terrain use. The AIARE Trip Plan is the essential pre-trip hazard forecast checklist for daily use. The **AIARE Field Book** makes it easy to bring the morning thought process into the field and to update and continue the decision making process, applying this information during critical junctures and decision making points during the day. The **Communication Checklist**, located at the front of the Field Book, is an important tool that helps to facilitate field decisions and anticipate and pre-empt the human factors that so often play into errors and unfortunate decisions.

PRESENTATION NOTES:

UNDERSTANDING AVALANCHE DANGER

Before beginning the Trip Plan it is good to have an understanding of the concept of avalanche risk and avalanche danger (also referred to as hazard). Avalanche risk can be simplified to a backcountry traveler as the probability of harm occurring as a result of the existing avalanche danger.

The North American Public Avalanche Danger Scale (Statham et al., 2010) describes the avalanche hazard to backcountry recreationists in local public bulletins issued for mountain regions. The incremental level of avalanche danger is determined by a combination of:

- The **likelihood** of an avalanche to be triggered
- The destructive **size** of the avalanche and **distribution and extent** of the avalanche problem across the terrain

These factors and the descriptions that accompany the ratings help to illustrate the avalanche character and problem. As the level of danger is determined in part by the terrain on which the snowpack lies, the public bulletin issues travel advice with the caveat *"Safe backcountry travel requires training and experience. You control your own risk by choosing where, when and how you travel."*

North American Public Avalanche Danger Scale

Avalanche danger is determined by the likelihood, size and distribution of avalanches.

Danger Level		Travel Advice	Likelihood of Avalanches	Avalanche Size and Distribution
5 Extreme	4 5	Avoid all avalanche terrain.	Natural and human-triggered avalanches certain.	Large to very large avalanches in many areas.
4 High	4 5	Very dangerous avalanche conditions. Travel in avalanche terrain not recommended.	Natural avalanches likely; human-triggered avalanches very likely.	Large avalanches in many areas; or very large avalanches in specific areas.
3 Considerable	3	Dangerous avalanche conditions. Careful snowpack evaluation, cautious route-finding and conservative decision-making essential.	Natural avalanches possible; human-triggered avalanches likely.	Small avalanches in many areas; or large avalanches in specific areas; or very large avalanches in isolated areas.
2 Moderate	2	Heightened avalanche conditions on specific terrain features. Evaluate snow and terrain carefully; identify features of concern.	Natural avalanches unlikely; human-triggered avalanches possible.	Small avalanches in specific areas; or large avalanches in isolated areas.
1 Low	1	Generally safe avalanche conditions. Watch for unstable snow on isolated terrain features.	Natural and human-triggered avalanches unlikely.	Small avalanches in isolated areas or extreme terrain.

Safe backcountry travel requires training and experience. You control your own risk by choosing where, when and how you travel.

(ADFAR: Statham, G.,et.al 2010)

Danger ratings alone are not necessarily enough to be useful as a risk management tool. Consider that a significant number of fatal accidents occur when the danger is rated as *Moderate* and *Considerable*, as well as *High*. (Greene et al., 2006). This suggests that one's level of "risk" of being caught in an avalanche does not directly correspond to the level of avalanche danger in the mountains. Even with a Moderate danger rating visualizing the consequence of an avalanche involvement is critical to managing one's risk level. When avalanche danger is Considerable, the stability of the slope is more unpredictable and people become more uncertain. Some professionals have stated that when risk takers face uncertainty they are more likely to make risky decisions (see Part 5: Choose Terrain and Travel Wisely) as opposed to increasing the margin of safety. Risk management here equates to "uncertainty management" in a high-stakes environment.

Manage uncertainty by understanding the danger ratings - and importantly - by applying the critical information in the bulletin discussion to daily terrain choices. These comments from the forecasters contain details about weather, properties of the snowpack, the nature of the avalanche danger, avalanche characteristics, and in what types of terrain or times of day the danger may be elevated. They generally include terrain travel recommendations. Don't leave this valuable information on the computer screen; use the Trip Plan each day to consolidate this information and bring it into the field.

MAKING THE AVALANCHE ADVISORY RELEVANT

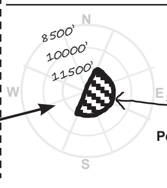
The Trip Plan prompts you to compile and organize relevant information from the avalanche advisoryand to include your opinion! Relevant information refers to avalanche danger ratings and discussion, recent avalanche activity, snowpack (strength and structure), and weather (past, current, and forecast). Through analysis and discussion of observations you can identify patterns and trends.

TRIP PLAN

Avalanche Rose
An aspect and elevation diagram of where avalanche problems are expected.

DATE: 20130419	TIME: 0730	FIELD LOCATION: Up Gold Glade, down Green Glade or Blue Bowl

AVALANCHE DANGER: AVALANCHE ACTIVITY? • BULLETIN DANGER RATINGS?
"Where are avalanches likely to occur?" "Describe the problem?" "Specifically, which slopes will we avoid?"



- Loose Dry ☑ Steep & sheltered
- Loose Wet ☐
- Wet Slab ☐
- Storm Slab ☐
- Wind Slab ☑ Above Treeline on NE to S.
- Persist. Slab ☐
- Deep Slab ☐
- Cornice ☐

- Danger rating: MODERATE near and above treeline, LOW below treeline.
- Expecting touchy wind slabs.
- Yesterday, size 2 wind slab, E aspect, @ 12,000' on Red Ridge.
- Will avoid any wind slabs in upper Blue Bowl (N) by decsending to Green Glade (NW).

SNOWPACK DISCUSSION: NEW / STORM SNOW? • WARMING? • WEAKLAYER(S) TYPE / DEPTH / PERSISTENCE?
"Where is the best snow?" "What field observations needed?" "Do we have experience w/ these conditions?"

25cm storm snow fell two days ago on a stable spring snowpack. Storm began w/ SW wind, ending w/ NW wind. No significant warming trend since storm. Wind slabs expected on E'ly slopes and below ridgelines. Sheltered slopes still hold nice powder.

Obs to take: plan route to view avalanche activity; track storm snow depth w/ probing & hand tests; check wind slab depth/stiffness; ski tests on small safe slopes.

WEATHER FORECAST: SKY / VISIBILITY • PRECIPITATION • WINDS / BLOWING SNOW • TEMPERATURES • TRENDS
"How will forecast affect snow conditions?" "...affect our observations? communication? decision-making?"

Forecast @ 10,500': Clear sky, NO precipitation, L NW winds, High −2.5°C. Expecting great visibility / gentle weather -easy visual observations and no weather stress. Watch temps today, but expecting dry snow during intended descent. Snow surfaces may get wet at the valley floors by PM and on steep southerly aspects.

Synopsis of the group's discussion, including information from the bulletin and other sources.

Integrating the public avalanche advisoryinto your own hazard forecast process is like having an expert with a lot of experience and resources as an advisor to your group! Realize that public bulletins are designed for all recreational backcountry users over a large area. While the bulletins provide an opinion written by an expert(s), they summarize point observations and expert interpretation from the forecast area. Some zones have fewer observers and fewer point observations. Expect localized variations from the regional analysis, and make it a goal to find out what the differences are. Use the **Trip Plan** to synthesize critical factors into a daily plan. Bring it in the field to help target field observations, identify the avalanche problem, encourage the gathering of key information to fill gaps in knowledge, and to support and facilitate key terrain decisions.

ANTICIPATING HUMAN FACTORS WHILE TRIP PLANNING - TEAMWORK

The second important factor for Trip Planning is interacting with the proposed group. Use the prompts in the Trip Plan as a template to open communication on the day's decisions.

Generally describe terrain use plan and options. Include areas of concern (general or specific). Identify possible locations for relevant, useful field observations.

TRAVEL PLAN: OBJECTIVE • OPTIONS • ANTICIPATED HAZARDS • OBSERVATION PTS • DECISION PTS • GROUP MGMT

"Is plan appropriate for our goals, experience, abilities?" "Everyone included in discussion, w/ consensus?"

Up Gold Glade (SW), w/ small detour to knob @ 11,300' to scan area for avalanche activity.

Decision pt. @ 12,200'. Need to see no wind slab / scoured snow surface at Blue Bowl entrance (N) for that option to go. Otherwise, drop (NW) into Green Glade.

Either way, traverse W ≈ 9,400'on road grade back to lower Gold Glade.

Decision point planned, with evaluation criteria outlined.

EMERGENCY RESPONSE: LEADERSHIP • GEAR ASSIGNMENTS • COMM. PLAN • EVAC ROUTE • EMERGENCY #'S

"Are we prepared & practiced?" "Outside help realistic?" "All concerns voiced re: dangers, risk, response?"

Radios Ch. 11.11; 911 w/ cell; Joe bivy sac/pad/sled; Keys under Jack's rear bumper;
Jen knows tour plan, call her @ 970.349.0000 upon return.
Evacuation route back down Gold Glade skin track."

Detail emergency plans, contact #'s, equipment, communication and transport options, and other resources (hospital, ski patrol, heli-service etc...).

Every fatal avalanche accident involves a poor decision made by a fellow human. Pre-conditioned bias and the human tendency to default to behavior patterns is termed *human factors*. They can lead us to make poor decisions in the backcountry. "We have met the enemy and he is us," said Walt Kelly, the animator of Pogo! Human factors may influence us without awareness of their effects and without conscious intervention. Working as a team includes knowing your group and anticipating motivation, interaction, bias, skills, strengths, and challenges. Be aware of common human factor traps and how to address them using teamwork solutions that may help to mitigate these biases. This could be the most important skill learned in this course!

Working as a team begins in the trip planning process and continues throughout the day in the field and concludes with a review of the day. To start, take a critical look at the group synergy. Look specifically at:

- Objectives/motivation: Who is the team? Do they get along? Do they share ambitions and objectives? Are the objectives of the tour within the capabilities of group members? Will the group need to reach its objective at all costs? How will these various issues affect decision making?
- Experience: What is the level of familiarity with the terrain? Who is the most familiar with the season's snowpack and avalanche events? Is this person willing to share this with the group? How will the awareness or lack of awareness of the snowpack history/terrain affect decision making?
- Skill/Fitness: How often do members of the party travel in the backcountry? What is the group's avalanche training and how will that affect group decisions and risk? What is the level of technical skill and fitness and how will that affect decision making?
- Share Tasks/Responsibilities: Is the leadership shared or is one person willing to step into this role? Are tasks well facilitated? Does the group have a "team mentality" sharing, monitoring observations? Is the group communicative, asking questions and challenging opinions? Do they understand that the backcountry is risky and operating in a hazardous environment will required them to manage their risk?
- Team Commitment: Is the group committed to traveling together and regrouping at pre-determined locations? Is the group committed to making the decisions together? Has the group agreed to the principle of empowering the least-experienced member, ensuring and requesting that everyone has a voice and each individual has a veto to any field decision? Is the group committed to making decisions unanimously, achieving consensus rather than a majority?
- Trip Factors: What is the difficulty level? Is the terrain complex and challenging? How will the terrain, difficulty and commitment level of the trip affect group decisions and risk acceptance?

- **Environmental Factors:** What are the weather and snow conditions? Excellent weather and snow? Blue sky syndrome? How will these factors affect the decision making process?
- Any other factors you can identify?

The above solutions are summarized in three easy to remember steps on the Decision Making Framework (DMF):

1. Discuss group goals, experience, abilities
2. Share Tasks and Responsibilities
3. Travel Together, Decide Together & Build Consensus

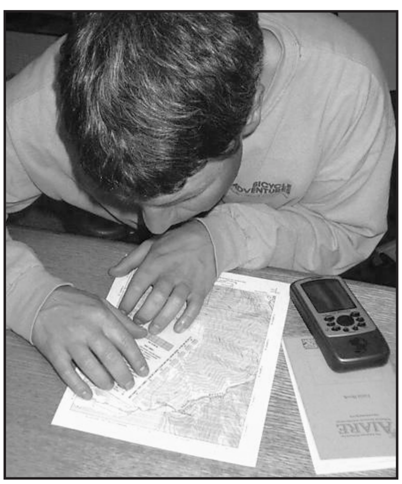
Write down critical group factors that may affect decisions in your trip plan!

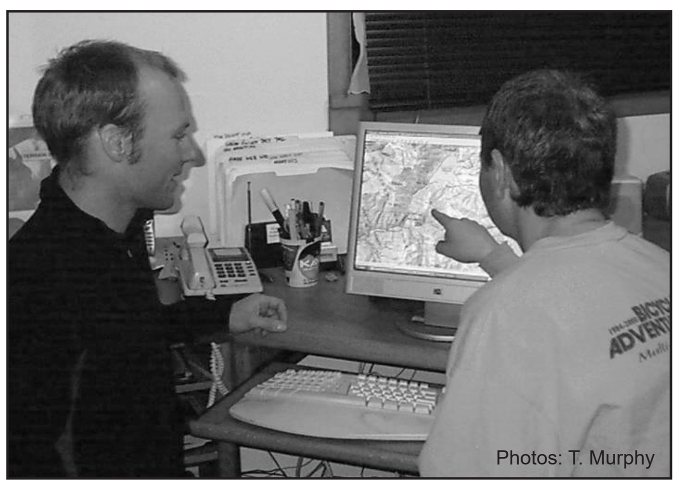
Refer to Part 5: Choose Terrain and Travel Wisely to review how the above factors are applied to field decisions. In that chapter the *Communication Checklist* is introduced as an important field decision making support tool The checklist asks the group to commit to a process, to build consensus and uses straightforward questions to play the role of the devil's advocate. The Communication Checklist goes one step further and asks the team where are you going, why are you going there, what will happen if you do, and are you prepared for the result? Refer also to the Part 7: Epilogue that provides a supplementary list of common human factor traps that affect decisions. Play the game of matching any traps applicable to your past trip and review the provided teamwork solutions that apply. Human factors are a consideration that may profoundly affect where we go (the group's terrain choices) and how we go—the group management and travel techniques employed to minimize the encountered risks.

CREATING TERRAIN TRAVEL OPTIONS

Next in the trip planning process is choosing terrain options. Carefully evaluate the hazard and choose terrain prior to departure as this may prevent an unfortunate and impulsive decision on the summit of the ridge, minutes before the descent! Manage risk by matching options to conditions and then consider the group skill level. Plan to travel where there are several options available. Avoid "go or no go" terrain.

Terrain that provides several options allows the group to consider and respond to new information or changing conditions. Consider uncertainty. Verbalize what isn't known about terrain or conditions! The greater the uncertainty or the greater the consequence, the more important it is to go with well known lower risk terrain. Uncertainty is easier to verbalize and consider during the planning stages than in the field where peer and time pressures and communication challenges affect the group dynamic.





Photos: T. Murphy

Terrain Information

Terrain information is available through a variety of sources. The following list is not specific or complete but provides a starting point for obtaining information at a variety of levels.

- Guidebooks with photos and illustrations
- Periodicals (articles, newsletters)
- Websites: trip info, trip forums
- Google Earth
- Topographical maps
- Aerial and personal terrain photos
- Local guiding companies suggested trips
- Locals information exchange
- Historical account

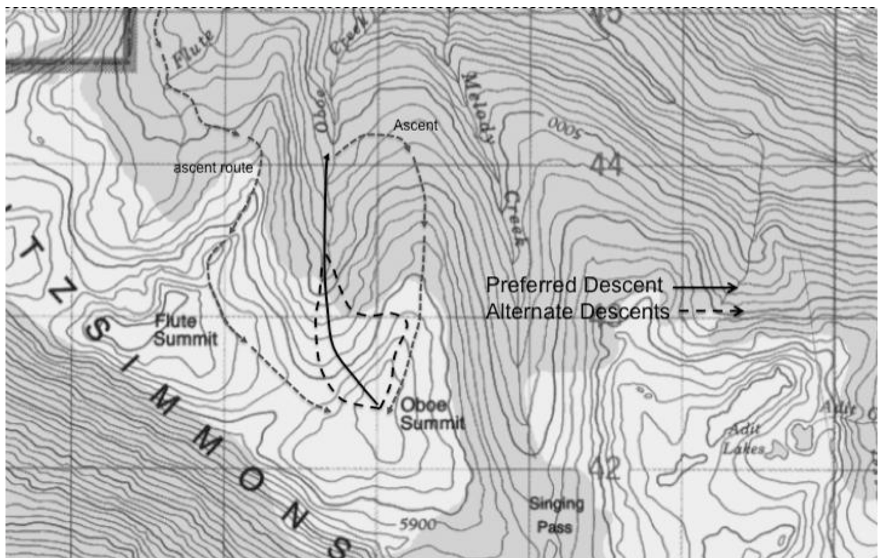
Identify Terrain to Avoid

Using the field book Trip Plan page that you used to compile information about conditions and the group, describe specific terrain features that the group will definitely avoid on this trip. Consider drawing this terrain out of bounds on a printed map or terrain photo to ensure everyone agrees this terrain is avoided today. Next, create options that seem appropriate given the described conditions.

Create Options in a Tour Plan

- **Preferred:** The first choice determined to be appropriate for the group and the conditions.
- **Alternate:** The alternative choice of travel/ascent/ descent in the area with decreased exposure to avalanche danger. Suitable for travel if level of risk and/or degree of uncertainty are greater than anticipated.
- **Exit/Evacuation Option:** The safest route(s) in the area that avoids anticipated danger(s). Suitable for use when the conditions or group factors become incompatible with travel in avalanche terrain. Good possible route option for error correction and/or emergency evacuation.

It is recommended to plan route options on a topographical map; and draw on a photo preferred routes and alternative options to take into the field.



Planning route options on the spot is more difficult than doing it pre-trip. The weather may complicate dealing with the map, and the environment may not be so comfortable. Without pre-planned options, a group may be more likely to force the original plan through. During planning, consider what information or situation might trigger changing options. The more you have planned terrain options in advance, the quicker and easier it will be to adjust plans in the field.

Sample of what might be considered a more “formal” tour plan.

Tour Plan					
Leg#	Start/End Elev.	Elevation Difference	Distance of of leg	Time Estimated	Time Actual
1	11,260’/ 11,800’	+540’	0.7km	:35 min	:30 min
2	11,800’/ 12,165’	+365’	0.6km	:26 min	:20 min
3	12,165’/ 12,200’	-116’/ +178/ +35 net	0.9km	↓:05 min ↑:17 min	:25 min
4	12,200’/ 12,570’	+370’	0.8km	:29 min	:25 min
5	12,570’/ 12,683’	+113	0.4km	:11 min	:20 min
6	12,683’/ 12,000’	-683	1.3km	:20 min	:15 min
7	12,000’/ 11,405’	-600	1.0km	:17 min	:13 min

Tour Plan
Navigation Strategies (handrail, bearing, UTM, etc.) Comments
Bearing out; 174 13S,340769,4318770 Use tree line/last trees to take bearing.
Bearing out; 106 13S,340708,4318109 Easy cruise up - make even switchbacks.
Bearing out; 150 13S,341256,4317820 Pop over 1st ridge; watch altimeter.
Bearing out; 158 13S,341527,4316951 Reach next ridge handrail but keep good distance; travel techniques!
Bearing out; 96 13S,341666,4316176 Steady traverse up to Pearl Pass - chop steps? Travel techniques!
Bearing out; 114 13S,342015,4316078 Reassess stability. Glide left and avoid gullies.
Bearing out; 160 13S,343063,4314299 Hut in trees on small knoll. Use Star Col back bearing if needed.

Time Plans

Determine at what time the group needs to be at a given location. Generally, add extra time when it is critical (i.e., before dark, or when avoiding time-related hazards).

One can estimate time in many different ways. Accurate time estimation takes practice with many different groups, in different types of terrain, in various snow conditions, and with other variables. Provide a margin of error for unforeseen factors. Generally it is best to break the trip into legs and waypoints. Waypoints are the points on the map where legs begin and end. Legs are the travel sections between waypoints. It is best to calculate time estimates for each leg for easier monitoring and adjustment in the field.

Estimating Time for each Leg

- Estimate ~1-3 mph average horizontal speed.
- Estimate ~1000 vertical feet per hour – ascent.
- Estimate ~3000-4000 vertical feet per hour – descent.

Total Trip Time

- Add up each of the legs to get a total travel time.
- Estimate ~10-15 minutes per hour for breaks and add the total break time.
- Sum the total travel and total break time to find the total trip time.

Calculate Start Time

To calculate a start time, work backwards through your timed legs from a critical time juncture (often it is when the group needs to get home). The result is your latest start time! For example, the ideal return time is 5 p.m. Total travel time is 6 hours, and you figure you need 1 hour of total break time for a trip time of 7 hours. By subtracting 7 hours from 5 p.m. your latest start time should be 10 a.m.
Determine whether any hazards on the trip are time related. For example, if the plan marks the crossing of a steep south-facing slope on a spring day—and the group voices a concern regarding sun warming—then plan to cross that slope early in the day. Adjust your start time to reduce your risk.

Navigation Planning

Accurate navigation using a map, compass, GPS, altimeter and watch requires knowledge and practice. It is beyond the scope of the AIARE 1 course. It is important that all travelers in backcountry terrain know how to navigate and know how to error correct. Navigation plans should be factored into tour plans whenever there is the possibility of losing clear visibility or making a navigation error. Use the weather forecast, local knowledge and terrain choices to simplify the task. Navigation plans are generally done both on a map and in a field book for quick reference in the field.

Navigating in a whiteout

Photo: T. Murphy

EMERGENCY RESPONSE PLAN

Be prepared for an incident or accident. Initiate a group discussion to ensure that the group is comfortable with the level of preparedness for the day and increase safety measures as necessary. Visualize and verbalize what could go wrong and ensure the group has the resources to facilitate self rescue.

Ensure the group has practiced companion rescue, a member has a current first aid certificate, and that in the case of an emergency a leader will step forward to help organize a response. Ensure the group has practiced with the evacuation sled, the improvised splints etc. The winter emergency, where onset of shock and hypothermia occurs in minutes, is no place to learn skills!

Write down who is carrying important group equipment in your Trip Plan.

1. Companion Rescue equipment is carried by each person and is checked at the trailhead to be in good working condition. Response plan in field book:
    a. Probe, shovel, transceiver required
    b. Avalanche airbag system or Avalung optional
    c. Spares in the car: skins, batteries, extra map, extra transceiver
2. Group gear has been checked prior to departure.
    a. First Aid including splints, bleeds.
    b. Repair kit.
    c. Survival gear: bivy sac, extra cloths and XL warm down parka, extra food, thermos, extra gloves, hat, glasses.
    d. Evacuation kit: ski toboggan, haul rope etc…
    e. Navigation gear: GPS, altimeter, watch, map, compass, guidebooks.
3. Communication between field groups and from the field to the outside work has been established.
    a. Emergency numbers/frequencies are in each group member field book.
    b. Sat phone or SPOT if no cell or VHF radio.
    c. Research the available resources that can provide assistance. What is the response time?
4. The safest evacuation route has been predetermined.
5. Vehicles used in car shuttles have keys in known locations (maps in vehicle to nearest hospital).

Medical Profiles

Developing a medical profile for each team member is recommended. The following information for each participant should be gathered:

- Name and emergency contact information
- Medical insurance provider, if applicable
- Food or drug allergies
- Current or recent injuries
- Current or recent medical conditions or procedures
- Prescription medications
- Other relevant physical or mental condition or limitation

Having the above personal medical information documented makes a significant difference to medical caregivers should an emergency arise that requires medical care or hospitalization.

Summary

The Trip Plan should be done with all members of the group prior to the trip. This will allow everyone to exchange and share all information used to plan terrain options and prepare for an emergency. The process of doing this as a group assists in enacting solutions to human factors that will improve the quality and objectivity of your decision making. It will also create an important reference for making observations and decisions in the field. The next chapter will discuss more about the art and science of making useful field observations.

QUESTIONS TO TEST UNDERSTANDING:

1. What is meant by “size and distribution” of avalanches when discussing the Avalanche Problem in a public bulletin?

2. How does bringing the Trip Plan into the field with you help your terrain decisions in the field?

3. Why is gathering and recording information still SO IMPORTANT when the bulletin rating is Moderate and Considerable and not just doing so when the rating is High?

4. Describe the three human factor solutions that help facilitate teamwork during the trip planning stages.


mountain hub
YOUR REAL-TIME NETWORK FOR THE OUTDOORS
New Snow
D2 Avalanche
Snowpack Test
Trip Report
Discover
Research real-time observations and plan your routes.
Experience
Understand the risks in real-time, and stick to a plan.
Share
Contribute your trip reports, observations, and routes.
Avatech is now Mountain Hub. Learn more at www.mountainhub.com.
Download on the Mac App Store
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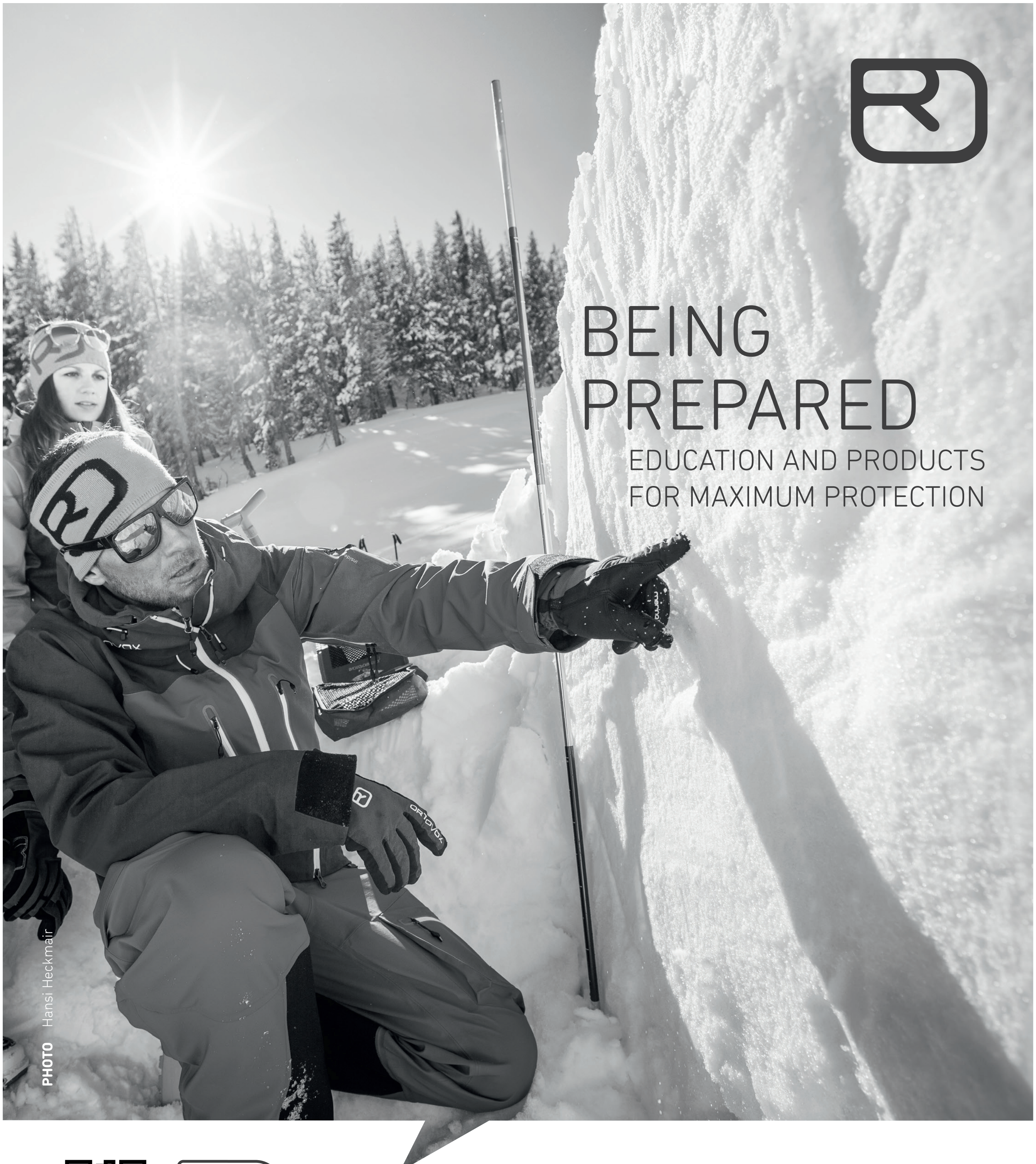

BEING
PREPARED
EDUCATION AND PRODUCTS
FOR MAXIMUM PROTECTION
PHOTO Hansi Heckmair

Part 4: Observe

Learning Outcomes:

- Gather morning observations and verify their relevance to conditions with field observations.
- Relate the importance of applying observed trends to field decisions.
- Describe “red flag” observations that relate to the immediate possibility of avalanches in the terrain.
- Compare one’s own field observations to expert opinion derived from the bulletin.
- Identify snowpack layers as described in the bulletin.
- Perform several informal snowpack tests.
- Explain the value and limitations of snow profiles, compression tests and Rutschblock tests.
- Use the Avalanches and Observations Reference table during planning and in the field.

4.1 – Field Observations

Field Observations - clues as to how weather and snowpack conditions are affecting the formation of avalanches in the terrain—play a vital role in contributing to the good decision, the appropriate terrain choice, and the appropriate travel technique. When discussing and completing the AIARE Trip Plan forecast and checklist, information is gathered about past and current avalanche activity, changes to snowpack strength and structure, and seasonal and recent influences of weather on both travel options and terrain choices. Both current *observations and trends* are noted and discussed by the group.

These are the components of the *Observe* side of the Decision Making Framework (DMF). The primary source for this information is generally the local public avalanche bulletin. Public avalanche bulletins contain valuable information that forms a local, expert opinion on “what is happening in your area.” The forecast center will summarize with a description of the “avalanche problem”, also termed the “avalanche issue” or “primary concern.” This refers to the avalanche type and characteristics and includes the forecast distribution and extent of the problem in the terrain. When the bulletin writers forecast for specific regions, their comments, while providing general insight, may not be *precisely* relevant to the specific location your tour may be planned. The same is true of information gathered from friends, local “experts,” books, and Internet or ski area avalanche forecasts. For this reason, backcountry travelers should make it a priority to gather site specific real time field observations during their field trip. It is important not to base terrain choices entirely on information obtained in the trip planning process but look with a trained eye for observable clues in the field.

Observations compare *actual* conditions observed in the terrain to the second-hand information gathered, analyzed and discussed at home or in the office. This comparison can be very powerful for improving one’s own comprehension of avalanche danger in terms of where, when, and why avalanches could be triggered. As understanding improves, backcountry travelers have the opportunity to re-evaluate terrain choices in light of newly gained information. Ability and willingness to observe and adjust is key to increasing the accuracy of your assessments.

Be observant - like a detective searching for clues. The trip plan will help target observable clues and avoid knowledge “gaps.” During the discussion the group develops a strategy when and where to make field observations. Note the usefulness of the information gathered depends on the quantity and quality (e.g. site selection, craftsmanship) of the observations and the observer’s experience interpreting the observation. Backcountry travelers often have limited opportunity to observe in the terrain. *Consider that conditions, hazards and weather may significantly limit where relevant observations can be obtained; and conclusions made from less relevant information can be dangerous!* Lastly, the trip plan checklist can help illustrate the unknown; managed by choosing terrain and travelling wisely.

OBSERVING AVALANCHE ACTIVITY

Current or recent avalanche observations are unequivocal evidence of snowpack instability—at the location of the observation—and extrapolation can be made to nearby terrain. When observing avalanches take careful note of the characteristics:

- **WHEN:** Current, recent or past? Was the occurrence associated with recent warming or snowfall or wind? Are the reports more than 48 hours old? Did you witness the avalanche?
- **WHERE:** Where in the terrain did it occur? What elevation range and aspect? What type of terrain feature(s)? How widespread is the activity? Is it isolated to specific terrain or is there activity in many different types of places? How does the terrain where it occurred compare to the terrain travel advisory discussion in the public bulletin?

- **SIZE, CHARACTER:** Slab or loose snow; or cornice fall? Dry or wet? Wind slab or a persistent slab? How wide does the slab propagate and what is the extent of the runout?
- Do you know the **weak layer?** Did the bulletin describe this concern? Can you relate this to nearby terrain?
- Does it appear to have been triggered by a human, or naturally? By a cornice?

A monocular or pair of binoculars is a useful tool for observing avalanches. Sometimes it works to use a digital camera and zoom in on the display to see closer than the naked eye. These are some of the most valuable observations you can make because they give you direct evidence of the potential for avalanches in specific locations. Take every opportunity to make sure the group observes and considers avalanche activity into terrain selection decisions.

Recording Avalanche Activity

Make notes about the characteristics of avalanches you observe on the **Field Observations Page** of your AIARE Field Book. Practice using the Avalanche observation abbreviation codes in the back of your AIARE Field Book.

OBSERVING THE SNOWPACK

Snow is an amazing and dynamic substance that continually changes from the moment it falls from the sky until it melts away in the late spring or summer. Observers attempt to look at avalanche activity and snowpack structure and answer the simple question "where in the terrain is the snow unstable?"

The bulletin usually summarizes the important snowpack factors that create the avalanche problem. This includes recent affects of weather on the snowpack **(recent snowfall, rising temperatures or rainfall, or increased wind** that is depositing a wind slab on steep lee slopes). Many of these important field clues can be observed without digging into the snow.

The most important observation when travelling through the terrain other than recent avalanche activity is observing shooting cracks called **cracking**, and below surface fracturing called **whumpfing** (or collapsing). Quick inspections of the layers near the snow surface include **ski pole probing, hand tests, and kick tests**. These can reveal shallow slabs over weak layers in the upper snowpack. While on your tour track these layers through varied terrain. Observers strive to make connections between field clues observed during travel, field tests performed at relevant locations and observations made by others in nearby terrain to piece together the evolving puzzle involving snowpack structure and *potential* instability. The AIARE Avalanches and Observations Reference guide found in the end of this chapter is a useful field tool. This reference guide is located near the front of the AIARE Field Book and helps to *forge a link* between the avalanche and snowpack concerns described in the bulletin and each person's observations taken in the field.

The Snow Profile

The bulletin also refers to snowpack structure or layering—and will discuss weak layers and overlying slab formation. A proper inspection of these layers can only be done using a quality snow profile techniques and years of experienced interpretation. However, when the bulletin reveals weak layers of note, a non-expert can dig an **informal test snow profile** (in a safe site) to identify and verify the layer of concern. Then you can compare the depth and character from a given site to the public bulletin. To determine whether the layer you see is the layer of concern, one can compare the depth of the observed weak layer in the profile to the estimated depth of crown fractures on nearby terrain.

Key observations to consider in a snow profile include **depth, stiffness, and grain type of** layers.

- Can you identify the recent storm snow? How much new snow is there?
- Is there evidence of recent wind slab formation?
- Identify whether there is a stiffer layer over a less stiff layer (strong over weak; slab over weak layer)?
- With the naked eye, closely inspect the less stiff layers. Are the grains larger, square, sugar-like grains? These are likely buried persistent grains often present in weak layers.
- Is there a layer of wet grains?
- Is the slab over the weak layer deep enough to create an avalanche? Is it shallow enough that it can be potentially triggered?
- Does what I see in the profile relate to what I see in the terrain (cracking, whumpfing)? Would it help to also complete a few snowpack tests (Rutschblock or Compression Tests; see below) to better identify the layering?

Answers to these questions can provide very useful comparisons to the public bulletin discussion, or to your expectations during planning. The Trip Plan in your AIARE Field Book helps make the bulletin more relevant by targeting observations and comparing them to the observations and interpretations of the experts.

Snow Profile Procedures

Plan Ahead
Using the Trip Plan hazard forecast, the Avalanche and Observation Reference and other field notes from the day, determine what information will be investigated or verified in a snow profile. Consider which observations and tests will be most useful for answering relevant questions or addressing uncertainty. Use a map to plan possible site locations for snow profiles on the tour.


Photo: M. Wheeler

Site Selection
Select a site that is relevant:
- Not exposed; safe.
- Similar to the one you hope to cross or ski (aspect, elevation, terrain configuration).
- Has a nearby site given you useful information in the past?

If information cannot be gathered safely, then it may be best to choose safer terrain options. Remember the snowpack varies greatly over terrain and that it is impossible to broadly generalize about snowpack layering - let alone slope stability - especially from observations made in one snow profile. A truly slope representative profile site is elusive at best, and hazardous at worst.

Digging
Dig the profile so that there are at least two smooth perpendicular walls, where one of these walls is perpendicular to the fall line of the slope and one is parallel to it. If planning to complete snowpack tests afterward (RB, CT), it is recommended to dig the perpendicular wall approximately two meters wide and the parallel wall at least 1 meter long (measure or estimate this using your skis or poles). Column tests will be done on the perpendicular wall (“Test wall”). The parallel wall can be used to identify and mark layers of concern (“Observation wall”). Dig down to at least 10-20cm below any snow layers of concern. Digging more than 1.5 meters is often too difficult to manage. Dig at least enough of a floor out in the bottom of the pit to be able to squat down and look at deeper layers comfortably. Throw snow downhill and do not disturb the snow surface above or to the sides of the pit walls.

Layer Identification
Look at layers using a variety of layer identification techniques. Gently brush the wall with the back of a mitt or glove to see prominent layer interfaces. Poke or run a finger, or another thinner object vertically down the wall to feel differences in layer strength.

Hand Hardness
Using the layers identified and marked, use the hand hardness test to gauge the relative strength of each layer. Start at the top and press a fist into the pit wall at that layer. Push with around 2 lbs. of force (try pushing on your nose until it hurts). If the gloved fist penetrates to the wrist then the layer has a hardness of “F.” If it does not penetrate to the wrist then test the layer using the same amount of force, using four gloved fingers, seeing if it penetrates for the entire finger length. If not, continue the process according to the table below. Forecasters and competent observers will often use terms like “Fist,” “1 Finger,” “Pencil,” etc. to describe layer hardness (Greene et al, 2010).

Symbol	Hand Test
F	Fist in glove
4F	Four fingers in glove
1F	One finger in glove
P	Sharp end of pencil
K	Knife blade
I	Too hard to insert knife


Photo: M. Wheeler

Snowpack Tests: The Compression Test (CT)

This is a good test to identify important layers, particularly thin weak layers hard to observe in a profile wall. The CT puts a controlled vertical force (downward taps) on an isolated column of snow to observe the effect and results.

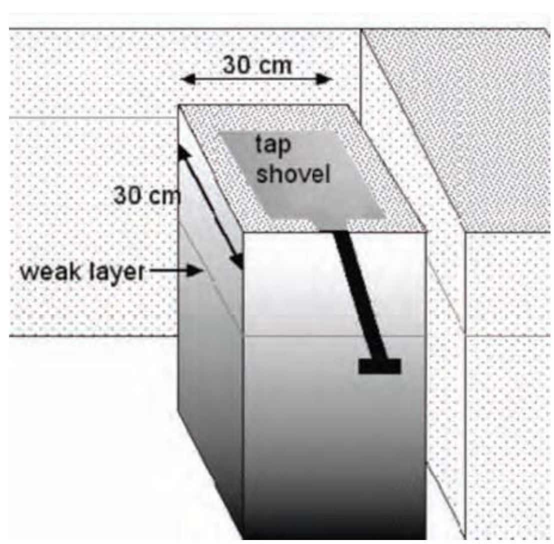
Prepare the Column

Dimensions of the compression test are a column approximately 30 cm wide (across the fall line), 30 cm on each side (up the fall line), and somewhat deeper than the suspected failure layer (to a maximum of about 1.2 m / 4 ft). Dimensions should be measured to ensure continuity from one test to the next and from one observer to another.

1. Dig a pit with a wall of approximately 1.5 - 2 m across the fall line (Test wall). This wall should extend below the suspected failure layer if one has been identified or to a maximum of about 1.5-m deep. Clean the wall so it is plumb and very smooth.
2. Assess where failure planes may exist by examining the layers. Look for strong layers that overlie weak ones, significant changes in the look or feel of the grains, hard crusts, or other anomalies in the snowpack. These are areas to observe closely as the test proceeds.
3. Measure and gently mark a 30 x 30 cm square on the surface of the snow. Be careful not to disturb the snow that will become the upper part of the column.
4. Using a snow saw, cut one side of the column to the appropriate depth. Cut as plumb and square as possible.
5. Using a snow saw and/or shovel, excavate a chimney on the side of the column. This chimney should extend beyond the back of the column and should be wide enough so a snow saw can be used horizontally to cut the back of the column later. Take care not to pry on or damage the side of the column as you shovel.
6. Remove a wedge of snow on the side of the square opposite from the chimney. The wedge should reach the same depth as the chimney.

Conduct the Test

1. Place an observer in a position to watch the column for failure.
2. Carefully cut the back of the column with a snow saw to a depth that matches the side cuts.
3. Apply load to the column as described below.
   - Place the shovel: Carefully place the shovel so that it lies flat and flush on the top of the column.
   - Tap 10 times: Using the tips of the fingers and moving the hand only from the wrist to shovel blade.
   - Tap 10 more times: Using fingertips with moderate taps from elbow to shovel blade.
   - Tap 10 more times to complete the test: Using the palm or fist with whole arm to shovel blade.
4. If at any point during the taps the observer sees a fracture cross the block, stop, inspect the fracture and describe the fracture character. See the fracture character/shear quality comparison table below. Continue tapping until the test is complete.



5. Carry out at least two compression tests in the same pit to see if results are repeatable. The second column can be cut immediately adjacent to the first. The hole left by the first column can be used as the chimney for a second; otherwise use the same process for the second test as for the first one.
6. If results from the first two tests differ significantly, additional tests should be carried out to see if a consistent pattern develops. Observing similar fracture character when comparing tests is more significant than the specific number of taps, which can be generalized into easy, moderate or hard. Refer to the paragraph, “Interpreting Snowpack Observations” on pg. 57. Additional compression tests from other locations may also be useful if results and the danger rating over terrain vary significantly.

	Loading Steps and Compression Test Scores (Dimensions 30 x 30cm column, isolate to 100-120cm max depth from snow surface)
Term	**Description**
Very Easy	Fractures during cutting or insertion of shovel
Easy	Fractures within 10 light taps using fingertips only
Moderate	Fractures within 10 moderate taps from elbow using fingertips
Hard	Fractures within 10 firm taps from whole arm using palm or fist
No Fracture	Does not Fracture

In cases where a weak layer of concern is buried more than 1 meter deep, a variation of the Shovel Compression Test can be used (called the Deep Tap Test). With a shovel or snow saw, shorten the column so that the top of the column is 15cm above a suspect weak layer, measured vertically at the back of the column. Conduct the same series of taps to observe the characteristics of any fracture at the deeper layer of concern. This test requires targeting one weak layer at a time.

Comparison of Fracture Character & Shear Quality Scales		
Fracture Characteristics	Fracture Character (Data Code)	Typical Shear Quality
A thin planar fracture suddenly crosses column in one loading step AND block slides easily on the weak layer	Sudden Planar (SP)	Q1
Fracture crosses the column w/ a single loading step and is associated with a noticeable collapse of the weak layer	Sudden Collapse (SC)	Q1
Planar or mostly planar fracture that requires more than one loading step to cross column and/or the block does NOT slide easily on the weak layer	Resistant Planar (RP)	Q2
A fracture of noticeable thickness (non-planar fractures often >1cm), which usually crosses the column with a single loading step, followed by step-by-step compression of the layer with subsequent loading steps.	Progressive Compression (PC)	Q2 or Q3
Non-planar breaks	Break (BRK)	Q3

Snowpack Tests: The Rutschblock Test

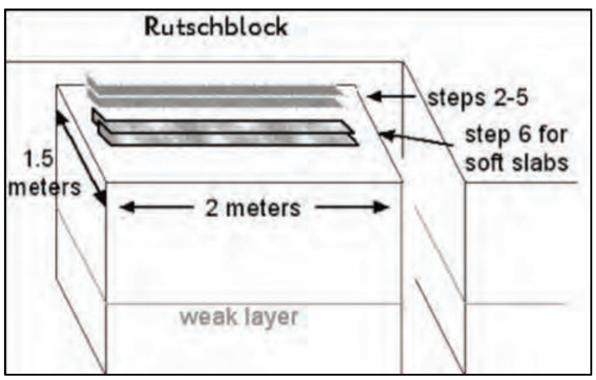
The Rutschblock Test is a much larger sample of snow (approx. 30x the sample area) than that observed in a compression test. The Rutschblock is a large column test that puts a skiers load on an isolated column of snow to identify potential weak layers. It is a good test to prioritize which of several identified layers is important. The slope for this test should be as close as possible to 30 degrees. It is used to test layers at a maximum depth of 100-120cm.

Clean off and expand existing snow profile walls to accommodate a 200cm wide column face. Dig trenches 150cm up the slope on the sides to isolate the sides of the column and clean all walls to make them plumb and smooth. Mark the back cut line with a probe and cut the column in the back, ideally using an extendable snow saw and/or a Rutschblock cord to complete the block isolation. Conduct the test as described below:

Rutschblock Test (Dimensions: 2.0 m wide x 1.5 m deep or 6.5 ft x 5ft)	
Loading Steps That Produce a Clean Fracture	**Score**
The block slides during digging or cutting.	RB1
The skier approaches the block from above and gently steps down on to the upper part of the block (within 35 cm of the upper wall).	RB2
Without lifting the heels, the skier drops once from straight leg to bent leg position (feet together), pushing downwards and compacting surface layers.	RB3
Skier jumps up and lands in the same compacted spot	RB4
Skier jumps again into same compacted spot	RB5
* For hard or deep slabs, remove skis and jump on the same spot. * For soft slabs or thin slabs where jumping without skis might penetrate through the slab, keep skis on, step down another 35 cm (almost to mid block) and push once, then jump three times.	RB6
None of the loading steps produces a smooth slope-parallel failure	RB7

Note specifically if any fractures observed were sudden, how they propagate across the column in a single step. Rate the release type using the terms in the table below:

Release Type: Portion of the block that did slide	
Whole block	90-100%
Part of the block (usually below skis)	50-80%
Edge of the block	10-40%



Interpreting Snowpack Observations

Current avalanche activity provides direct evidence of both snowpack instability and avalanche release. Shooting cracks, “whumpfing” and layers fracturing and displacing on small rolls provide direct evidence of unstable snow. However, relating these compelling clues to actual avalanche release on adjacent and distant avalanche paths takes experience interpreting and applying the information. Beyond that, interpreting snowpack observations, even for the experts, is challenging. In a recent paper presented at the 2010 ISSW experts Bellaire, Jamieson, and Schweizer stated backcountry “recreationists with basic knowledge should follow the advice given in the bulletin in absence of signs of instability” (selected quote below).

Snowpack layering may vary significantly over the terrain and often without any noticeable difference on the surface. The snow layers near the trailhead will generally be very different from the layers found near ridgetop. In the trees the layers will be different from open areas. North-facing slopes will have a completely different snowpack from south-facing slopes. The profile one digs within the sheltered treeline may not represent the avalanche path directly above that may have slid three times during the winter months. Even on a smaller scale, tests done in separate profiles within several meters of each other can yield different results. It would be foolish to think that just looking at the properties of the snowpack alone in a couple of profiles will lead to reliable avalanche predictions in the surrounding terrain.

> “...Digging is only recommended for very experienced recreationists under specific conditions. In most cases digging is not required. Nevertheless, snow cover observations – performed and interpreted correctly – can contribute to informed decision making in avalanche terrain, especially if little or nothing is known about the snowpack conditions and stable conditions cannot be assumed.“ (Bellaire et al, 2010)

Factor in the time in the field to answer site-specific questions about the snowpack, but try to do so in a relevant site to where the group's questions can be addressed. These questions have been identified during the Trip Plan checklist. It is not always possible to safely access a relevant snow observation site. The less representative your site is of avalanche slopes of concern, the more uncertain an interpretation will be of what is observed. Even when the site seems representative, the variability of the snowpack across the slope can fool one into thinking the snowpack is more stable rather than less stable.

The best way to interpret snowpack observations is to always put them in the context of the avalanche advisoryand the Trip Plan. For example, "How does what we observe in the snowpack relate to the characteristics that contribute to avalanche danger as described in the bulletin?" Profiles may reveal a weak layer described as a less stiff layer under a stiffer layer; or compression tests may produce classic "pop or drop" sudden fractures. Before drawing conclusions regarding snow stability observers attempt to identify and date the layering to weather and snowpack changes over time. Verify with several tests over several locations. Determine whether this is the layer of concern, whether the layer is "persistent" or likely to change in the short term. The "pop and drop" fractures observed in Compression Tests may point to a larger, persistent and reactive grain type and may correlate to nearby whumpfing. Rutschblock "whole block release type" may be compared to observed cracking from ski tips in lower angled safer terrain and may also indicate a persistent grain type and weak layer. It is always important to remember that snowpack tests are a small sample as compared with large open start zones. While avalanches are evidence of an unstable slope, most of the other snowpack observations relate to a stronger or weaker parcel of snow and require experienced interpretation. Whumpfing and cracking are powerful warning signs but snow profile observations and snowpack tests should be referred to as clues used to piece together a complex puzzle. Local knowledge or the history of what has affected the slope of concern is as important as any other observations: past and current avalanches, wind redistribution of snow, cornice formation and fall, sun and past warming events, ski compaction etc. Observers don't trust a big decision in avalanche terrain on a snow profile or a few snowpack tests. And in the short term observers ask themselves, "given all of our observations over the past few days, can we identify an obvious pattern or trend, or do our observations leave us with a greater sense of uncertainty?"

Recording Snowpack Observations

Record field snowpack observations on the Field Observations Page in the AIARE Field Book. If you have the familiarity or experience to do so, fill out the Snow Profile Page—otherwise summarize the observations on the Field Observations Page as a daily journal, with notes, drawings and comments. Use the references in the back of the Field Book to help conduct and record column tests.

OBSERVING WEATHER

Weather factors are important because of their effects on the snowpack and the characteristics of its layers. The primary reason that snowpack varies over terrain is that weather effects vary over terrain. The weather factors that affect snow layering are:

- **Precipitation** – Type (snow/rain) and Rate.
- **Wind and Blowing Snow** – Speed, Duration, and Direction.
- **Solar Radiation** – Factor in cloud cover, timing, length of exposure.
- **Air Temperature**
- **Trends** (warming, cooling, rapid, slow).

Observations described as red flags are critical values known to cause avalanching. Red Flags when observing weather factors include:

- **Precipitation Type/Rate/Duration:**
  Snowfall > 1" (2-3cm) / hour for a period of 10 hours or more.
  - Snow accumulations of > 1 foot (30cm) in 10 hours.
- **Rainfall:**
  - Winter snowpack: Any amount, for any duration, at any time.
  - Spring snowpack: Conditions where the snowpack has gone through a lengthy melt freeze cycle can tolerate light to short duration moderate rainfall without avalanching.
- **Blowing Snow:**
  - Strong enough to transport snow (> 12mph or 20kph). Direction gives clues as to which slopes are becoming loaded. Visible plumes at ridgetop strong enough to transport snow consistently for 4 hours or more. Commonly, during storms blowning snow can deposit 3-5 times faster than snow falling in sheltered areas, therefore mod-heavy snowfall plus wind is even more of a red flag.

• **Solar Radiation Intensity/Duration:**
  - Strong radiation resulting in melt at the snow surface. Timing is critical for safe terrain choice. Beware of slopes subject to rapid temperature change or lengthy exposure to radiation. Travelers would feel significant warmth on the skin or face.

• **Air Temperature:**
  - Above 32ºF or 0ºC.
  - Rapid warming.

Recording Weather Observations

Record observations on the Field Observations Page of the AIARE Field Book. Try to get information from multiple locations at different elevations, aspects, terrain types, and/or slope angles. Use the information compiled in the Trip Plan to focus on the most relevant observations and where to get them. Try to verify the weather forecast in the bulletin and relate it to forecasted avalanche danger.

FIELD OBSERVATIONS

NAMES:	Joe J., Jane J., Jack J.			
Location •Time •Elevation •Aspect	0800, Trail-head, 9,000' valley floor	0930, Gold Glade knob, 11,300' S	1015, Gold Glade ridge / Blue Bowl entrance, 12,200'	1130, Blue Bowl exit, 9,400', N
Sky •Cloud cover •Precipitation	○ , NO	○ , NO	○ , NO	○ , NO
Temperature •Air •Surface & 20cm↓	T_{Air} -6.0° T_{Surf} & T_{20} N/O	-3.5° N/O	-3.0° N/O	-2.0° N/O
Wind •Speed / direction •Blowing snow	Calm None	Calm None	Light N winds, None	Calm None
Snow •Surf form / size •New snow •Snow height •Pen boot / ski	est HST 20cm Stellars & D/F's Boot Pen ↓ crust	>10cm HST on ridge (normally windswept)	HST ≈30-40cm just below ridge Boot Pen 45cm	HST ≈25cm Boot Pen 35

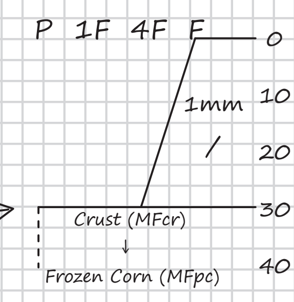
TERRAIN USE • SIGNS OF UNSTABLE SNOW • PATTERNS

Red Flags • Avalanches • Snowpack Tests • Other Observations • Comments

0800 – no fresh avalanches observed on the drive to trailhead. Recent cornice growth above treeline on SE-E aspects.

0930 – seen from Gold Glade knob: 3 wind slabs >12,000' on E and SE aspects below ridge crest (R1-D2) on Red Ridge, Purple Pk. and Maroon Mt. In general, less wind effect on south end of the range closer to town. Soft conditions with no cracks, whumpfs or fresh wind slabs seen so far on S-SW aspects.

1015 – Blue Bowl decision pt: No wind slabs in upper bowl. Dropped block of old hard cornice on N'ly slope @ 12,200' w/ no result. Fist hard snow still on ridge crest. Jane entered Blue Bowl and did two sets of tests, (see profile →) confirmed no slab on frozen old snow.



1200 – sunny slopes getting moist below treeline; crusts tomorrow.

CTM (PC,Q2) ↓30cm
on 1mm DF's
ECTN

REVIEW THE DAY: ***"Were our choices in line w/ our forecast / plan?" "When were we most at risk?" "Where could we have triggered a slide?" "What would we do differently next time?"***

4.2 – Avalanches and Observations - making the link

The Avalanches and Observations Reference on the next page is a useful tool for relating the forecast avalanche problem to field observations. It also helps to identify the field observations and tests that most relate to the forecast problem in specific or general terrain features.

The table can be used during morning preparations to identify which field observations to take, and where. Located in the front of the AIARE Field Book the reference is used in the field to help summarize observations, note important patterns and link to decisions. In addition, at the end of the day the tool is used to supplement the daily debrief and analysis of observations.

Print copies of page 60 (Avalanches and Observations Reference). Circle the key factors during the discussion. Relate these factors to the other components in the DMF when discussing the Trip Plan the following morning.

Mt. Crested Butte, Colorado

AVALANCHES & OBSERVATIONS REFERENCE			
"The Problem"	**Critical/Red Flag Observations**	**Field Tests & Relevant Observations**	**Important Considerations**
Loose Dry Snow	- Recent fan-shaped avalanches on steep slopes: debris fine - Loose surface snow ≥12" (30 cm) deep	- Boot/ski penetration ≥12" (30 cm) - Slope tests/cuts result in sluffs - Loose snow surface texture (as opposed to wind-affected, refrozen, or other stiff snow textures)	- Can be triggered by falling snow, cornice fall, rock fall, a brief period of sun, wind, or rider - Sluffs can run fast and far - Small slides dangerous with terrain traps/cliffs - Sluffs can trigger slabs in certain conditions
Loose Wet Snow	- Rain &/or rapid warming - Air temp > 0ºC for longer than 24 hours; cloud cover may prevent nighttime cooling - Pinwheels or roller balls on steep slopes - Fan shaped avalanches: debris lumpy & chunky	- Observed & forecast temp trend - Air, Surf, T20 and freezing level indicate near surface snow temps at 0ºC - Note slopes receiving/will receive intense radiation - Wet snow surface: water is visible between the grains w/ a loupe, may be able to squeeze water out with hands	- Timing is critical - danger can increase quickly (minutes to hours) - No freeze for multiple nights worsens condition - however, nighttime freeze can stabilize - Gullies & cirques receive more radiation and retain more heat than open slopes - Shallow snow areas become unstable first - may slide to ground in terrain with shallower, less dense snowpack - May initiate from rocks or vegetation - Can occur on all aspects on cloudy days/nights - Conditions may also include cornice fall, rockfall or increased icefall hazards
Wet Slab	- Rain on snow, especially dry snow - Current or recent wet slab avalanches: debris has channels / ridges, high water content, at times entrains rocks & vegetation - Prolonged warming trend, especially the first melt on dry snow	- Consider Loose Wet Snow observations - Observed melting snow surface (rain or strong radiation) of a slab over weak layer - Tests show change in strength of weak layer due to water &/or water lubrication above crust or ground layer - Identify the depth at which the snow is 0ºC - Monitor liquid water content & deteriorating snow strength using hardness & penetration tests - Nearby glide cracks may be widening during rapid warming	- Snow temp of slab at or near 0ºC - Loose wet snow slides can occur just prior to wet slab activity - Possible lag between melt event & wet slab activity
Storm Slab	- Natural avalanches in steep terrain with little or no wind - ≥12" (30cm) snowfall in last 24 hrs or less with warmer heavier snow - Poor bond to old snow: slab cracks or avalanches under a rider's weight	- Observe storm snow depth, accumulation rate & water equivalent - Observe settlement trend: settlement cones, boot/ski pen, measured change in storm snow (>25% in 24 hrs is rapid) - Tests illustrate poor bond with underlying layer; ID weak layer character - Denser storm snow over less dense snow (boot/ski pen; hand test: profiles)	- Rapid settlement may strengthen the snowpack, or create an avalanche condition if the strengthening snow lies over a weaker snow - When storm slabs exist in sheltered areas, wind slabs may be also present in exposed terrain - May strengthen and stabilize in hours or days depending on weak layer character - Potential for slab fracturing across terrain can be underestimated
Wind Slab	- Recent slab avalanches below ridge top and/or on cross-loaded features - Blowing snow at ridgetop combined with significant snow available for transport - Blowing snow combined with snowfall: note this can deposit into start zones 3 to 5x the snowfall accumulating in sheltered areas below tree line	- Evidence of wind-transported snow (drifts, plumes, new cornice growth, snow surface penetration) - Evidence of recent wind (dense surface snow or crust, snow blown off trees) - ≥ Moderate wind speeds observed for significant duration (reports, weather stations and field observations)	- Often, it is hard to determine where the slab lies & how unstable & dangerous the situation remains - Slope-specific observations, including watching wind slabs form, are often the best tool - Strong winds may result in deposition lower on slopes - Often trigged from thin areas (edges) of slab - Wind transport and subsequent avalanching can occur without snowfall or days after a snowfall
Persistent Slab	- Bulletins/experts warn of persistent weak layer (surface hoar, facet/crust, depth hoar) - Cracking, whumping	- Profiles reveal a slab over a persistent weak layer - Make quick tests that will verify the location of this condition in terrain - Small column tests (CT, DT) indicate sudden (Q1) results; large column tests (ECT, PST, RB) show tendency for propagating cracks	- Instability may be localized to specific slopes - often more common on cooler N and NE aspect - and hard to forecast - Despite no natural occurrences, slopes may trigger with small loads - more likely when the weak layer is 8-36" deep (20-85cm) - Human triggered avalanches are still possible long after the slab was formed
Deep Slab	- Remotely triggered slabs - Recent and possibly large isolated avalanches observed with deep, clean crown face	- Profiles indicate a well preserved but deep (≥1m), persistent weak layer - Column tests may not indicate propagating cracks; DT and PST can provide more consistent results - Large load (cornice drop or explosives test) tests may be needed to release the slope - avalanches tend to be large and destructive	- May be aspect/elevation specific - very important to track weak layer over terrain - Slight changes, including mod. snowfall, and warming can re-activate deeper layers - May be dangerous after nearby activity has ceased - Tests with no results are not conclusive - May be remotely triggered from shallower, weaker areas - Difficult to forecast & to manage terrain choices
Cornices	- Recent cornice growth - Recent cornice fall - Warming (solar, rain at ridge tops)	- Note rate, extent, location & pattern of cornice growth & erosion - Photos tracking change over time	- Cornices often break further back onto ridge top than expected - Can underestimate sun's effect on the back of cornice when traveling on cool, shaded aspects

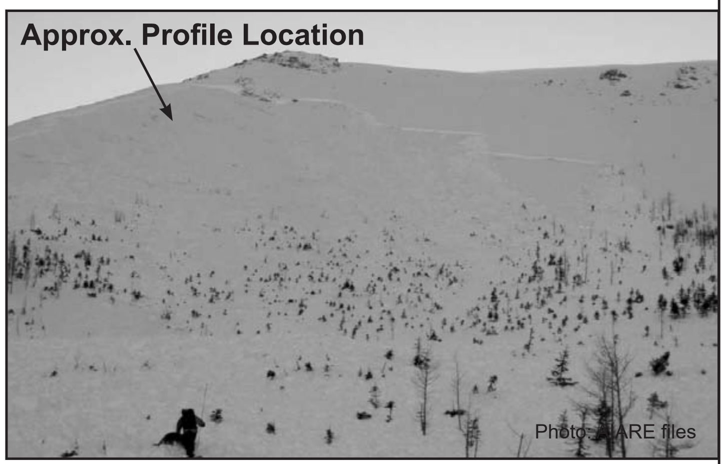
4.3 – Human Factors and Observations

A conclusion to this chapter on observing and recording in the field would be incomplete without a discussion of the effects of human factors on making high-quality observations. Part 5 and the Epilogue discuss the human factors that affect decisions in avalanche terrain. Many of these traps apply to our tendency to inadequately observe and interpret conditions. It is important to be willing to maintain open eyes and an objective mindset when gathering and interpreting observations. When drawing conclusions from field tests and observations, ask:

- Were my observations consistent with the bulletin and what others are seeing?
- Do I have the experience to correctly assess and relate the field conditions to terrain choices?
- Are my conclusions based on assumptions or fact?
- Would I have done anything differently if I hadn't looked in the snowpack?

REALITY CHECK! OBSERVE...AND MANAGE RISKS

AVALANCHE INVOLVEMENT REPORT, CANADIAN AVALANCHE CENTRE
Date/Time: 2007-12-08 13:30
Description: NE of Tent Ridge-Kananaskis Country-2 Fatalities
Mtn Range: Rocky Mountains Province: AB
Type: Activity: Backcountry Skiing



AVALANCHE INFORMATION
Number: 1 Size: Size class 3 Type: slab avalanche
Trigger: Skier accidental (While digging profile)
Dimension: 250m wide; ran for 750m; average slab depth of 100cm.
F**ailure Plane:** Old snow; Weak layer: Facets
Starting Zone: Alpine, at approx. 2450m.
Character: NE; 35 degrees; Lee Slope(s); Planar Slope.
Comment: Trauma a factor.
Another party of 3 came to the rescue

INVOLVEMENT INFORMATION
Number of people involved: 2 completely buried.
Number of people injured: 2 deceased.

"The two backcountry skiers were in the middle of a bowl in Spray Valley Provincial Park on Saturday, checking the avalanche conditions (digging a snow profile) when they likely triggered one themselves, say officials."

"In hindsight, when looking at the terrain, it (the location where the two skiers gathered information) was not the best choice," said search and rescue official George Field.

"Several people snowshoeing and skiing nearby helped dig the men out in about 20 minutes, but the avalanche knocked them into some trees and they likely died from the trauma, said Field." (CBC NEWS Dec. 10th, 2007)

"Another group of skiers, which had stopped for lunch about 100 metres behind the pair, were the first on the scene. The three skiers quickly homed in on transmitters the two men were wearing and had dug them up within 25 minutes. "Their efforts were heroic," said George Field, public safety specialist with Kananaskis Emergency Rescue. "They did everything they could."

"The avalanche danger was rated as considerable at treeline and alpine elevations and moderate below the treeline on Saturday." (Calgary Herald, Dec. 10th, 2007)

QUESTIONS TO TEST UNDERSTANDING:

1. What is a “red flag” observation?

2. If it is difficult to ensure relevant site selection and interpret snow profiles or column tests for a recreational backcountry traveler, what is the value in completing these tests?

3. What is the compelling, obvious evidence of unstable snow? How does this compare to cracking and whumping?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Part 5: Choose Terrain and Travel Wisely

Learning Outcomes:

- Explain why a terrain choice is the most important hazard management decision, and should reflect everything one knows about the weather, snow and avalanche conditions.
- Relate group management and travel techniques to safe movement through avalanche terrain.
- Explain why small groups plan and decide more effectively with teamwork and organized communication.
- Relate how acknowledging and managing uncertainty can lead to safer decisions.
- Develop a better “eye for terrain”—make terrain choices that minimize consequence and likelihood of an avalanche.
- Bring the trip plan into the field, agree to a consensus process, and follow the communication checklist at critical field decisions to pre-empt human factors.
- Facilitate a constructive review of the day.

Artful terrain selection and skillful terrain management are essential to day-to-day safe travel in avalanche terrain. Easier said than done, as survivors of avalanche involvements will testify. Choosing terrain and travelling wisely are the critical steps after the preparation is complete, the observations made, and terrain options considered. The group makes a choice and implements a course of action. *You are making a decision in avalanche terrain.* The terrain option considered should reveal more than a compelling interest to descend a slope. This choice should reveal everything the group knows about how terrain and snow interact to create the mountain snowpack. Where is the snow unstable? Where could avalanches be triggered? And, if the avalanche occurs what is the size and consequence? Your **terrain choice**—the best option given the conditions—is therefore your *hazard forecast*. **Traveling wisely**—your terrain and group management and travel technique employed—is your *hazard management* and risk reduction strategy.

Part 1 introduced this process and the use of the Decision Making Framework (the DMF) to illustrate “the good decision,” and Part 3 introduced Trip Planning as the foundation of the process. This chapter, Part 5, emphasizes the critical nature of terrain choices and suggests several tools and considerations to help balance human nature and assist the good decision. This section takes the decision into the field with the understanding that making good decisions is not easy. Case histories illustrate human error is common, even at the expert level. Failure to manage the avalanche problem can result in serious consequences.

Good decision makers employ common sense. Common sense is when one makes decisions that reflect his or her experience with similar conditions and similar terrain, and makes decisions that demonstrate an understanding of the potential risk, and importantly, simplifies the process. As the measure of unfamiliarity or complexity increases so does uncertainty. When in doubt, for any reason, increase the margin of safety - choose simpler, less consequential terrain that reduces the chance of an avalanche and manage the group more carefully.
Whether riding in the backcountry or embarking on a control route at a ski area consider:

- **“Where we go?”** (Route Finding)
- **“When we go?”** (Timing)
- **“How we go?”** (Group Management and Travel Techniques)

5.1 – Choosing Terrain – “Where we go?”

By the time a group departs into the backcountry, they make many important decisions using components of the DMF. The group collects observations and information about conditions. The trip planning process helps to rule out and select certain terrain options. The prior-to-departure decision that determines where not to go is the first and often most critical terrain selection of the trip.

Consider The Terrain Choices Of Others…And Ask Why?

Why do backcountry travelers go where they go? Experienced backcountry skiers and riders likely have specific and relevant reasons why given current conditions they choose particular routes and terrain. Terrain use may reflect years of observation and recognition of the patterns of avalanche occurrence. The experienced terrain choice may be valuable information indicating where avalanches are likely not to occur. Locals who are in the terrain all winter may know how much stabilizing skier compaction a “near country” slope has received. They may have watched the wind load a slope earlier in the week, or watched yesterdays sun crust get buried by the evening’s storm. There could be a reason the locals are avoiding one slope, choosing another, and still having a fun day.

The *Catch 22* is an obvious one. People are creatures of habit. The terrain choice may suggest familiarity and lack of willingness to go elsewhere. The choice may result regardless of changing and deteriorating conditions. In addition, the conditions may be atypical or unfamiliar even to the experienced traveler. Persistent and deep slab conditions are the avalanche problems most often underestimated or missed by the experienced. Prudent observers ask why before committing to similar terrain chosen by others.

Reassess And Evaluate-

Use Reminders And Checklists To Support Field Decisions and Mitigate Human Factors

Once in the field the group reassesses its plan given current conditions and re-evaluates options. What is the best terrain that suits both conditions and the group objectives? At this point human factors such as desire, peer pressure, inexperience or poor observation skills can result in poor choices and a nasty consequence. Two key decision making support tools are available to improve the decision making process in the field:

1) Bring the Trip Plan into the field-
The Trip Plan serves as the hazard forecast. Consider it "speculation" until field observations support the theory. The AIARE Trip Plan page contains the unanimous group decision as to which terrain the group planned to avoid given the current avalanche problem. Decisions made at home without the environmental pressures of fatigue, fresh powder, blue skies and unbridled excitement may be more accurate and rational—and may avoid creating a "wish list" approach to terrain.

2) Use the Communication Checklist-
The AIARE Communication Checklist, found on the first page of the AIARE field book, is a fundamental decision making support tool designed for use in the field. The questions are inserted at key points—whether departing from the lift, on a control route, or on a tour—and promote individual and group commitment to a good process To combat the common but often benign human factors that combine to undermine the group decision, it is important prior to departure for the group to agree to use the checklist and to read the questions aloud. The group is asked to respect the pause, reflection, and the often silent voice—the devil's advocate—that the checklist promotes.

TEAMWORK
"Agree to travel together? Agree to decide together?"
"Agree to respect everyone's voice and anyone's veto! "

AT THE POINT OF DEPARTURE
"Is there anything wrong with our Trip Plan?"
"Transceiver check?" Batteries, SEARCH, SEND?"

CHOOSE TERRAIN
"Have we ID'd the avalanche problem? What's changed?"
"What's a realistic choice given what we see now?"
"Why should we go there?"
"What's the consequence if we have a problem"?
"What's the likelihood this problem will occur?"
"Would another route option be better?"

TRAVEL WISELY
"How are we going to move as a group?"
"Exactly, which terrain features will we avoid?"
"Can we see/hear each other?"
"Do we have an escape plan? Cell coverage?"

Develop An Eye For Terrain and Anticipate Consequence

Part 2 of this manual discusses the avalanche problem in terms of type, characteristics, motion and escape strategies. It also identified avalanche terrain and introduces terrain traps and trigger points where one is more likely to initiate avalanches. This chapter identifies the importance of knowledge and subtle observations when making terrain choices. Unlike the changing weather and snowpack the terrain shape is the constant throughout the season. One's ability to reduce and mitigate avalanche risk depends on the ability to assess both potential size and potential harm given the avalanche problem. Even small slopes may be problematic if the small avalanche runs into a creek, a canyon or off a cliff. Terrain traps include benches in the terrain where debris rapidly accumulates. Avalanches rapidly accelerate given a smooth start zone and tracks over 25 degrees. If the avalanche moves through even small trees and rocks the slide that is simply scary on an open slope becomes deadly if running through obstacles. Imagine the damage that would occur if one jumped out of a pickup truck at 20kph (12mph) and grabbed onto a telephone pole to slow himself down! It only takes a portion of an open slope for an avalanche to accelerate well beyond 20kph. Besides estimating the consequence of terrain it is important to develop an eye for terrain characteristics and to visualize how they interact with the avalanche conditions to create the problem.

See the avalanche path - not only the ski run

Photo: H. Schwartz

Photo: AIARE files

Every piece of terrain should be assessed with a mind to the potential consequence should an avalanche occur. Estimate where the slide would initiate, the width affected and the slope length involved. If one can't accurately guess at the nature of the problem it is always better to choose a less consequential option. Before entering a slope consider "Why should we go there" and "what's the consequence" should an avalanche occur! If in doubt...don't.

<u>Identify "indicator" avalanche paths and "warm up runs" in each geographic area</u>

Look for warning signs in the terrain. Often along a steep, complex ridge or cirque at the head of a valley, one specific slope is the first to avalanche during or following a storm cycle. Backcountry travelers can use this as an early warning sign that other slopes may have similar conditions, may be unstable and prone to avalanching.

Similarly, riders often choose a "safe and easy" warm-up run of comparable aspect and elevation to gather information, to correlate the opinions formed in the morning meeting, to see how things have changed since their last visit, and importantly, to gain a feel for the day's conditions.

<u>Remember which slopes have slid previously this winter</u>

Particularly when avoiding slopes with persistent weak layers like (depth hoar, facets or surface hoar), it is crucial to keep a record of when and if avalanches occurred on those slopes. One can assume that slopes that haven't slid on the weak layer are still suspect - even if no activity has occurred locally for days, a week or more. Photos are better than memory. Particularly when only a section of the start zone has slid leaving the weakness present on the rest of the slope.

Photo: N. Bardeen

<u>Recognize when the wind has made changes</u>

Chapter 2 described wind slabs and mentioned these conditions that may be challenging to forecast accurately. Lee slope wind slabs are often overlooked by newcomers to the backcountry and cross loaded features can be overlooked by even experienced riders. Looking for early warning signs is important to anticipating when the wind has made changes overnight:

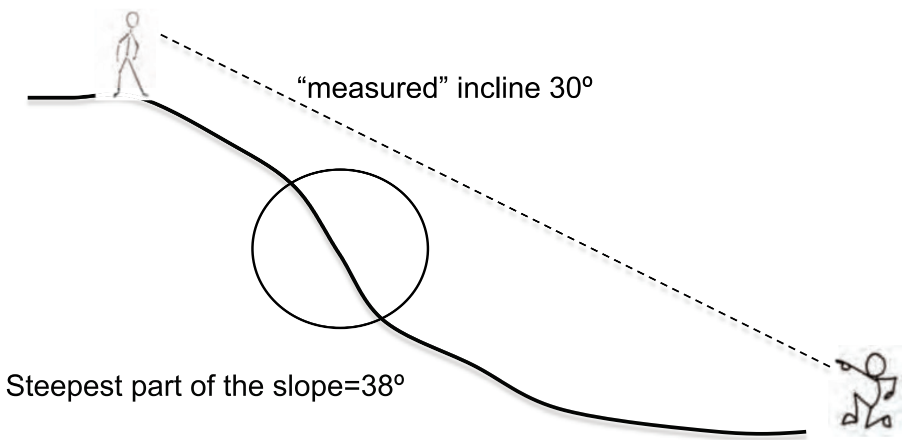
- Wind readings from the local ski area or highway are moderate or stronger
- Snow blown from trees
- Surface texture and ski penetration changes across terrain
- Snow blowing off ridgetop
- Fresh cornice formation at ridgetop
- Wind coming from a different direction than it was yesterday
- Clean thin avalanche fracture lines right below ridgetop

Photo: AIARE files

Measure The Slope: Accurately!

Slopes over 35 degrees are often where slab avalanches are most likely to initiate. Many “how to” avalanche books recommend carefully assessing slope angle and if in doubt avoiding those slopes in the 30-45 degree range. The problem is that only part of the start zone (>20m slope length) needs to be steep to initiate slab avalanches. Always record the *steepest part of the start zone*--not the average as the actual slope angle! Recognize why this measurement is hard to accurately and safely measure or estimate:

- Estimating slope angle from below or above the slope is challenging as the eye tends to *average* the slope angle
- From the top of the slope looking down, a small convexity in the terrain can cause a steep section to disappear
- Flat light from shade, snowfall or cloud averages or obscures slope angle
- Estimating from a safe spot away from the bottom of the slope also flattens the slope angle
- Placing an inclinometer on the steepest part of the slope can be hazardous!



Photos: C. Zacharias

<u>Recognize where the terrain in the start zone creates weaker snow</u>


Photo: T. Carter

Once terrain has been chosen the small-scale use of the terrain is critical. Avoid areas with barely exposed rocks or vegetation. Avoid freshly deposited wind slabs. Look for planar areas with uniform deeper snow. Look for the uninterrupted fall line with no terrain traps below. The photo to the left illustrates an experienced terrain choice in a shallow continental snowpack that likely has weak snow in spots. Name three reasons why the tracks avoided the fall line to the skier’s right.

Until the snowpack is deep enough to completely cover ground roughness - bushes, rocks and small trees are potential zones where larger facets and weaker snow areas can form.

Photo: T. Carter

Complex terrain without clear safer alternatives should be avoided unless LOW danger is known to exist.

Never pass up the opportunity to preview, analyze, and discuss terrain
Whenever there is visibility, view the terrain from different perspectives. Take photos from afar to review once on top. Note the character of the terrain changes with perspective. Constantly reassess and discuss as a group what has caused the snowpack to form layers—and where are the danger/safe areas. Never assume you've made the right choice, and always be prepared to error correct. Once back home, review your map, trip photos and discuss how individuals *see* the terrain. Opinions differ on the snowpack and terrain factors. Problem spots are often committed to memory during post trip discussions.

5.2 – Timing – "When we go?"

Experienced leaders factor in timing—when we go—as the priority during the decision making process. Weather, snow, avalanche and human factors (fitness, skills, wellness, and group dynamics) can change by the hour. Each trip plan considers whether any of these factors are time related. Trained decision makers monitor and review conditions and plan to be in the "right place at the right time" when reducing the avalanche risk and mitigating human factors.

Common planning considerations include:

- After a significant new snowfall wait a day for avalanche conditions to improve.
- On sunny days travel during the cool early morning before the sun and heat create more dangerous avalanche conditions.
- Be patient with persistent or deep persistent slab problems. Be prepared to wait a long time. Particularly in continental snowpack climates, backcountry riders commonly wait until spring before planning a favorite high mountain multiday tour or peak descent.
- When rain is in the forecast no time is a good time. Travel becomes immediately slow, tiring, and dangerous. Slopes may slide more than once if the rain continues.

Time related avalanche problems are complicated. Pay attention to time related suggestions in the public avalanche forecast discussion. Traveling with someone experienced at managing the time related hazard is always helpful.

5.3 – Travel Wisely – "How we go?"

Group management and travel techniques with terrain knowledge can further reduce the probability of triggering, of being caught, and decrease the consequences of an avalanche. How the group moves through the terrain can reduce their exposure and therefore further reduce the avalanche risk.

When choosing specific routes on a slope, groups discuss and clearly define their "safety margins." With respect to avalanche terrain, a margin is the physical distance the group decides to place between themselves and the avalanche. A narrow margin doesn't leave room for error: misjudging the extent of the avalanche, or misjudging the ability of the rider to stay within the boundary of safer terrain.

Example: Estimate the potential runout of the avalanche and allow a 100m margin in the terrain between your planned route and where the avalanche would likely come to rest.

Example: Deciding to descend a slope one at a time does not employ a margin of safety. This is described as a group management technique. Each group member is individually as opposed to simultaneously exposed to the consequence of the avalanche—including injury and death.

Remember to use the Communication Checklist:

TRAVEL WISELY

"How are we going to move as a group?"
"Exactly, which terrain features will we avoid?"
"Can we see/hear each other?"
"Do we have an escape plan? Cell coverage?"

Ensure the group has discussed the communication plan before entering hazardous terrain

- Verbal shouts can often be misinterpreted; discuss signals that clearly represent "stop", "don't ski past me", "come down/across one at a time", or "take the other line"
- Use personal radios to avoid miscommunication
- When skiing through the trees ski in pairs, adjacent but apart, and yell back and forth
- When discussing and agreeing on a travel strategy such as escape routes and safer zones, everyone in the group should make eye contact and nod in agreement to ensure everyone is listening, have heard and agree.

Establish the group travel strategy before entering hazardous areas.

- Check transceivers again; pros will often repeat the morning checks once during the day.
- Ensure all have the skills to manage the terrain/conditions and stay within the proposed route.
- Generous distance between skiers and riders is always a good idea—whether uphill or downhill; distance allows the descending rider an unobstructed view of the slope and the escape route, less effect on the snowpack, less likely two will collide, and less likely two would be involved in the same avalanche.
- Do all have visual contact or will the first person ski out of sight?
- Is the plan to ski or cross the slope one at a time, from safe point to safe point? Will the proposed distance apart only commit one person to the slope? Is there a better option in the terrain than crossing through what has been agreed upon as a potential threat?
- Plan to re-group on high ground or islands of safety with better visibility to reassess terrain ahead.
- Regroup with your skis or snowmobiles pointed towards an exit route. Snowmobiles have kill switches up.
- Allow a generous "safety margin" between safer and less safe terrain. The first on the slope can use his or her track to establish an obvious boundary in the terrain. Confirm the group knows for certain on which side of the track to descend!
- Use easily described terrain features to illustrate the terrain and control the group. For example, staying in the well spaced trees as opposed to the steeper wind affected open slope. Or, descend right of a group of trees. Or, stay out of the obvious gully.
- Stop and regroup in open spots away from hazards (benches, roads, large open glades) and before more complex terrain that may require a different group strategy.
- As your degree of uncertainty increases, increase the margin of safer terrain between the group and the hazard.

Applying techniques in the terrain:

Leave a spotter on the ridge with a good view of the decent and regrouping area. Note that the tracks in the photo on the left place a margin of safety between the skier and the steeper, unstable terrain and cornice hazard above and off on the lookers right. The spotter is experienced with emergency response and has a radio, cell phone and emergency/companion rescue equipment.

The photo on the right show tracks that avoid the wind loaded slope on lookers left and descends lower angle terrain that avoids the avalanche problem.

"I'll watch from a safe spot"

Photo: C. Zacharias

Avoid the wind-loaded slope

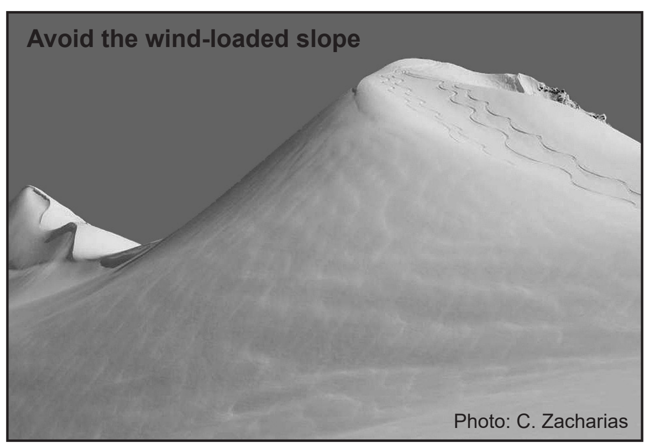


Photo: C. Zacharias

Photo: "Distance apart" Two group management strategies. What distance is adequate given the slope and stability?

Photo: "Cross high on the slope" If no other better route exists and the slope is short with no terrain trap, cross high on the slope so any fracture would occur below your track.

Photo: "Ski to the right of my track!" The first track establishes a boundary between steeper terrain that has more wind effect. The leader used the tallest trees as the obvious marker.

Group Management and Travel Techniques while important DO NOT supersede safe terrain choices
Proper application of group management and travel techniques is critical—"use the right technique, in the right place, at the right time." If the application is not appropriate for the terrain and conditions, the result may increase risk. What works in one situation may not work in another. These techniques are used to *further reduce the risk of terrain selection decisions.* Travel technique cannot be allowed to override terrain selection. For example: if a slope is unstable the slope should be avoided, rather than deciding to ride it one at a time. Ensuring the group is well practiced at companion rescue is no reason to further expose the group to avalanche terrain! Terrain selection is a far more effective way to manage avalanche risk than use of travel techniques. Even one person caught in an avalanche can have unacceptable consequences. The art of employing group management and the correct travel techniques requires experience and good leadership, good communication, a *willingness* to turn around and to error correct to a safer terrain option: a commitment to do the right thing!

Photo: "When in the trees, yodel to each other."
Even in the trees keep ample distance between skiers to ensure each rider has a good visual of the terrain ahead, potential hazards,an eye to the exit and regroup location, and can hear any warning shouts or radio calls. Don't listen to the mp3 player!

5.4 – Managing Uncertainty

"When faced with uncertainty the good decision maker embraces uncertainty"

REALITY CHECK – "THE SAFE LINE"

Skiing downhill from the pass we approached a moderately angled flank splitting two bowls known locally as "the safe line." The weather had deteriorated during the day's tour. It was late in the day. I was nervous. The poor visibility meant it would be hard to find the safe line in the pea soup.

Legend suggests the route was nicknamed after a local guide's close call on the ridge in question. He had mid way down the ridge, heard a whump, and watched as both slopes on either side of the ridge slide to size 3 leaving him with a beating heart and perched on the only undisturbed snow in the bowl!

The danger was "considerable." The accompanying paragraph warned there were slopes that had slid one month earlier and were now "high" danger due to a post-storm cold clear period that left a sugary unstable base under the newly formed and shallow snowpack. Of course no one could tell you *which* slopes had slid. We had a great day of touring: up and over a pass, long run on the north side in perfect powder on a low-angled and fun glacier. Coming home we felt "the safe line" was a reasonable "short cut" back to the lodge.

As we approached the flank I took over the lead. I knew where the "safe line" was, and wasn't trusting of my friends to find it in the fog. I skied down one 20-degree pitch and stopped as the terrain steepened below. The skiing was fantastic! I could hear the hoots behind. But I was too far right. We regrouped. Leaving my friends to wait, I set a track left and found the flank. In the poor light it didn't look like much of a ridge. It was steep and blended in with the slope on either side. I was getting worried. I should have skinned back up. I yelled back, *"I found it. I'm on the ridge. Come on over….one at a time….and stay above my track."*

I wasn't clear ….too many words…I had said the most important thing last. My stomach clenched as they all left at once, *one traversing below my track.* There was a terrible "whump" and I watch in horror as the world fell apart. Fractures shot through the group's skis, across the ridge, and under my feet. The whole bowl slid. Size 3. To ground. When the dust settled we were all standing together, and on "the safe line". The slide was 1.5m deep, 300m wide with a 4-5m deposit in a terrain trap at the bottom. The ground on which we were standing was intact, except for the cracks and fractures.

In retrospect this slightly protruding feature was the safest way down and did save the day. Yet, if it was a slightly more unstable , or different slab condition we may have all been dead, piled together like cordwood under 4m of dense avalanche debris. When we talked about it afterwards we decided it a combination of mistakes but the main one was we were (I was) too confident. Given that we were told to be cautious due to the high degree of variability, our route was too steep and connected to surrounding terrain to be a safe line in these conditions. We had gained too much confidence in one past event—one story—and it almost killed us. There was too much uncertainty (variable snowpack, high danger areas, poor light, a terrain feature that is "safe" *sometimes*). Instead of threading the needle, we should have picked lower angled terrain with a smooth, deep, snowpack. A route we could be certain hadn't slid in the past storm.

Never underestimate how much info you lose as the light fades, and as uncertainty increases lengthen that long arm of caution.

Colin Zacharias
AIARE Technical Advisor

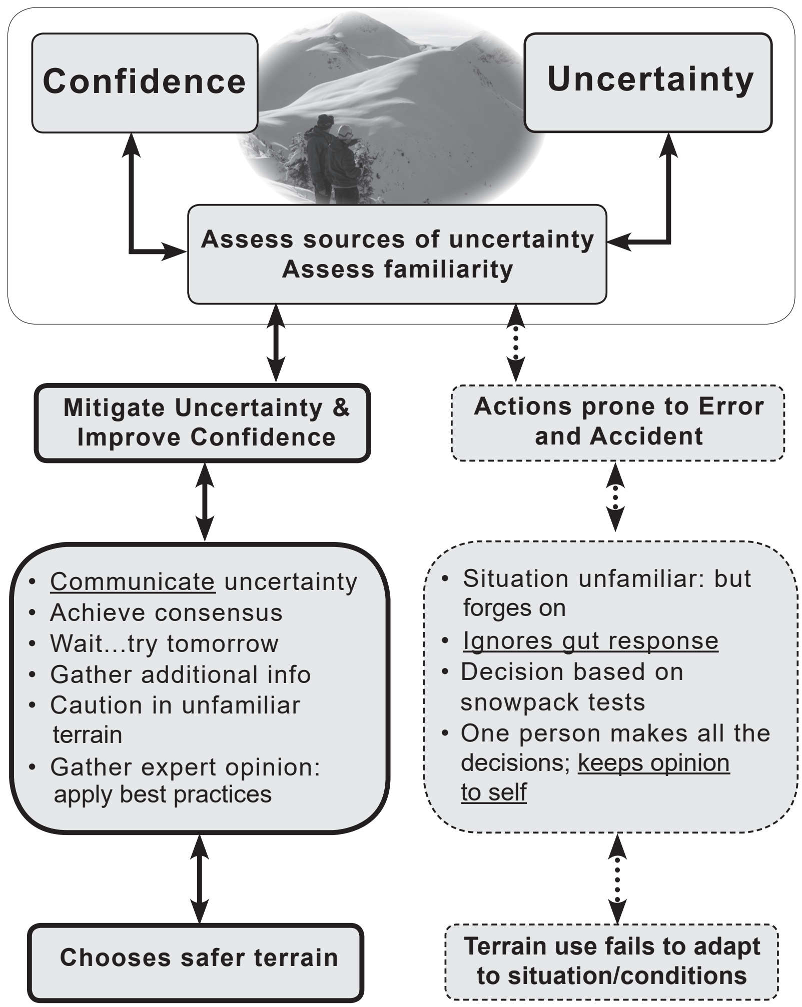
The previous chapters and discussions illustrate that when making decisions in the backcountry no one topic stands alone. The DMF shows that the components of backcountry decisions are all interconnected, and that analysis and action is ongoing.

Consider the possible consequences of any decision before you commit

The Communication Checklist asks the decision maker three important questions:

- "Why should we go there?"
- "What's the consequence if we have a problem"?
- "What's the likelihood this problem will occur?"

These above prompts question motivation, measure one's familiarity with the terrain and snow conditions, and ask one to be honest and consider probable consequence and likelihood of an event. Ironically those who have been caught or have had a close experience with avalanches are often more apt to assess a slope's potential consequence. If the decision maker struggles to answer any or all of the three questions, their inexperience with this particular circumstance becomes evident. Good decision makers assess their lack of confidence and communicate the degree of certainty as a measure of the reliability of their forecast and terrain decisions.



Assess Uncertainty

Keep decisions within your scope of experience and knowledge. Are the conditions unfamiliar (Atypical weather trend, unfamiliar snowpack layering, a new group, seeing avalanches in unfamiliar places)?

Be comfortable with any decision that will affect your risk exposure and vulnerability. Getting more information may help, but depending on one's ability to accurately interpret the information, new data may only confound the issue. When uncertain, seek an outside and expert opinion. As a default choose a simpler and more cautious option.

Factors contributing to uncertainty:

- Quantity and quality of information (relating to snowpack and terrain, as well as site selection and craftsmanship)
- Relevancy of information--relation to the extent of the problem
- Variability of snowpack characteristics over the terrain
- Variability of the mountain weather forecast
- Skills, ability and relevant experience of the decision maker
- Group Dynamic

Consider the Human Factor and Maintain a Margin Of Safety

"Small teams make better decisions than individuals."

Are your decisions being affected by personal bias? How is what you "want" affecting your perspective? Humans are the common element in all serious avalanche accidents. We all make mistakes and human factors play a key role. A detailed look at the human factor traps is listed in the Appendix following Part 7: Where To Go From Here. Throughout this manual there is an emphasis on learning to express one's own voice and importantly work as a team. It is well known that small groups make better decisions than even experienced individuals—if they employ a few checks and balances. The DMF asks the group to work as a team, to plan and prepare, to make important field observations and decisions as a group; it also points to using checklists such as the Trip Plan, the Field Observations page, Avalanche and Observation Reference and the Communication Checklist to ensure the decisions unfold as planned. Specifically, the Communication Checklist supports consensus decision making in the field. The Quick Reference: Companion Rescue checklist spells out critical tasks if the worst come into play and an A-Z response is required under the duress of looking for a lost friend.

The tools and knowledge provided in the course will assist you in making an informed decision. However, experience is the real teacher in the backcountry. It is very uncommon to be 100% certain in avalanche terrain. Each of us has to be vigilant to recognize avalanche terrain and be aware of the potential level of exposure and lay down an adequate safety margin that accounts for the likelihood of error.

Decisions made in the field will ultimately determine the success or failure of any trip—more than anything learned in this course. Good backcountry decision making takes practice. One convenient solution is to choose a travel partner and mentor who is an experienced and consistent decision maker. However some of the best have learned from their own errors. The next chapter, Part 6 is devoted to preparing to manage emergency situations in avalanche terrain.

5.4 – Review the Day

"We always make better choices when we ask ourselves what could we have done differently?"

Most people are pretty keen to improve their skill sets and increase their knowledge. One common and accepted method is to discuss and debrief significant aspects of decisions at each day's end. This can be an informal discussion or an operational style meeting where daily forms record the discussion. Use the prompts at the bottom of the AIARE field book Field Observations pages to facilitate the discussion and learn from the experience. Whether one is an experienced forecaster or heliski guide or a first timer in the backcountry the following four questions are helpful. They are condensed from common questions use by professionals.

REVIEW THE DAY:
"Were our choices in line with our forecast / plan?"
"When were we most at risk?"
"Where could we have triggered a slide?"
"What would we do different next time?"

QUESTIONS TO TEST UNDERSTANDING:

1. What are four key components to a functional team that is likely to make good decisions in the field?

2. Describe three human factor traps that you can recall from a backcountry trip. How did this affect your backcountry decisions?

3. Describe the human factor solution(s), using the tools described in this and other chapters that would have mitigated those issues.

4. Why is it so important to develop an eye for the subtleties of terrain shape in the start zone?

Part 6: Emergency Response

Learning Outcomes

- Recognize that Companion Rescue is a last-resort response, not a preventative measure of risk reduction, nor a justification for poor terrain choices.
- Explain what to do if caught in an avalanche.
- Outline all steps of the AIARE Avalanche Rescue Quick Reference card.
- Set up a realistic mock rescue scenario.
- Organize and carry out small party companion rescue, including:
  - Ensure the safety of the rescue party.
  - Lead an efficient search for multiple victims using different numbers of searchers.
  - Follow a transceiver search pattern to locate single and multiple burials.
  - Target a burial site with a transceiver and probe, both alone and with a partner.
  - Efficiently dig out a buried victim from 2-meters deep.
- Describe the utility and limitations of avalanche rescue and safety equipment.
- Recognize the requirement of pre-event practice and emergency checklist use to increase likelihood of survival.

The AIARE Decision Making Framework suggests that each team “Plan Emergency Response.” The reality is that getting caught in an avalanche can be violent, gruesome and heartbreaking. Even with modern technology, average response times are nearly 18 minutes to get buried victims on the surface. Compare that with a huge drop in survival rates at about 12 minutes of burial time. On average, it doesn’t look good if you’re fully buried; 52% of fully buried victims die. In Colorado during the winter of 2010/11, 10 people were reported fully buried, 7 died.

Trauma is no small matter either. One quarter to one third of avalanche fatalities are due to traumatic injuries, not from asphyxiation. If your partners have to dig you out consider the following. A 3-foot deep burial (less than average) requires moving at least 2,500 pounds of snow. A 6-foot deep burial requires moving no less than 10,000 pounds of snow. You’ve got minutes to get the job done, and you still have confounding factors of keeping the rescuers safe, the challenges of communication and access to the debris (with people potentially spread across a mountainside), understanding the technical details of your transceiver and the overwhelming stress of having a partner dying beneath the snow. If it’s not clear yet, consider that companion rescue isn’t something you want to ever have to do.

Bottom line: companion rescue is a daunting and challenging task. The upside is that training can improve response outcomes. Take Canadian Mountain Holidays for example. Their highly trained guides have an average response time of 8 minutes (granted they have helicopters too). Each winter, many lives are saved by efficient avalanche responses. Some undoubtedly go unreported, so it’s difficult to know the exact numbers. Read the accident reports on avalanche.org or avalanche center websites and you’ll hear of plenty of near misses, with disasters averted by quick responses.

6.1 – Avalanche Response

WHAT TO DO IF YOU ARE CAUGHT IN AN AVALANCHE:

Action taken in the first two seconds could save your life:

- ❑ **Yell. Call out for attention**. If another group member can establish a “point last seen” your chance of being quickly found increases.
- ❑ Try to **quickly exit** to the side. Snow moves slower on the edges of the avalanche. Often a diagonal trajectory down and towards the edges of the avalanche offers the best chance of escape.
  If you are just below the crown, you may be able to exit upslope off the moving snow, or with shallow slabs anchor yourself to the bed surface.
- ❑ **Deploy your avalanche balloon pack**. The sooner you pull the trigger, the sooner the avalanche balloon pack can do it’s job to bring you to the surface and reduce the chance of impacts.

If your escape fails:

- ❑ **Discard equipment**: skis, poles, snowboard, snowshoes. Keep your daypack on to help shield your spine; consider ditching a larger pack that may drag you down.
- ❑ Try to **grab trees and rocks** to slow yourself down and allow snow to slide past you.
- ❑ **Kick, swim, and fight** to stay on the surface and move toward the side of the slide path. If you feel “out of control” in a fast moving, turbulent avalanche, curl into a ball and keep your arms and legs tucked in to protect yourself with your hands close to your face (try to grab your helmet, hood or collar).

As the avalanche slows:

- ❑ **Thrust and kick to the surface** just before the snow comes to a complete stop. You might be near the surface; exposed hands or limbs increase the likelihood of a quick recovery and an air passage.
- ❑ **Protect your airway.** Try to **push the snow away from your face** to make a larger airspace. Recent anecdotal research shows that keeping your hands close to your face, rather than swimming, during the turbulent phase of the avalanche provides the best chance of making an airspace in front of your mouth and nose.

When the avalanche has stopped:

- ❑ Try to **dig yourself out**. Call out when rescuers are near. **Stay calm.**

REALITY CHECK: NICK DEVORE, PRO BIG MOUNTAIN SKIER

April 28, 2011, Nick DeVore triggered, tried to escape from, and was caught in a small wet slide near Aspen, CO.

After the accident Nick posted on Facebook:

“Well…Its official. I’m laying down in my hospital bed with a broken femur, they fixed it with a titanium rod and a few screws. A small wet pocket ripped out as I jumped a cornice into this steep but short line. I almost skied out, but a small slide sucked me in and sent me flying toward a protruding boulder where I broke my femur. I tomahawked and rolled and slid with the wet slide until I finally came to a stop and was just able to remove the snow from around my face. Only my head was popping out. The pain was far beyond what I have experienced. After about two hours the helicopter came in and took me to Aspen Valley Hospital where I will be chilling for a while… Thanks for all the love and the incredible rescue performed by my friends and the heli peeps and the hospital!“

Powder Magazine’s Tim Mutrie interviewed Nick to get more details on the accident, below are a few quotes from Nick: (read the full interview at http://www.powdermag.com/mantle/break-a-leg/**)**

“I’d skied Pyramid the other day and I’d been psyched to ski some more big lines. But the storms kept rolling in. Thursday came along—first bluebird day in a long time—and we knew there was high avalanche danger, so we went out to the M&M Chutes. They’re short, but steep.”

“I was up there with my friend Jake and he’s been to AK before. And it’s like, when you’ve skied huge lines with big exposure, these little lines aren’t as scary—if something rips out, you can just out ski it. We saw a large fracture avalanche on one of the chutes nearby, from the day before I think. But it was beautiful. I even remember Ian and Chris, down at the bottom, they radioed up: ‘Are you guys gonna dig a pit?’ And we said, ‘No, we’re just gonna send it.’”


Photo: Ian McLendon

“Some of the lines are going to be sliding, and that’s an element we’re used to. I mean, the avalanche here was something that would be called ‘manageable sluff’ in Alaska. … So we all skied one run, no worries, and the snow was thick and buttery. Then we went to these steeper lines that were slightly more east-facing and had a cornice drop to get in. It was wind-loaded and had been kinda sun baked. It was really kind of obvious. And that’s the case every time I’m in a situation like this—it is obvious. All the signs were there beforehand. I even kinda knew beforehand, just kind of neglected it.”

“So because of the size of the line and the lack of gnarliness there, we sort of overlooked potential hazards.”

“That’s how skiing the backcountry and life in general goes, right when you start to overlook the hazards or think you’re you’re bigger than that or can handle that, that’s when accidents happen… Your confidence level maxes out and you forget you’re just a small thing in the big natural world. That confidence is also the thing that drives skiing and other sports. But when confidence level gets too high you also forget about the dangers.”

“Dropping in, it was a snow type that I didn’t expect. It ripped and it was almost like a mud slide; sucked my ankles into it. I was almost able to ski out of it. I was trying to battle it.

“The crown was 6 to 18 inches max, just the new recent storm snow. It probably fell as a few feet of snow and had baked down to that. It felt like there was a fairly hard icier layer under that… The chute sort of doglegs to the right, but the fall line went right to a protruding cliff. I knew the rock was there and I was hoping I was just gonna miss it—my vision was obscured—but I didn’t. I pretty much hip-checked the cliff. I thought I broke my hip. I just smacked it.”

“I knew I had broken my hip or something, but I was battling the slide, I was tomahawked, then head down, and that was really scary, then head first. I totally lost control in the avalanche. But then I was on my feet and back and swimming down this mudslide. As the slope started to get less steep, I felt it slow down, and I just kept both of my hands free and I was moving snow away from my face. I had a nice face pocket.”

“It’s interesting watching the Go Pro footage because I wasn’t really freaking out, but there I was, stuck, up to my neck. I wasn’t really feeling the pain yet. Both my skis were still on, and my feet were torqued in an awkward position. Chris was on a snowmobile and he high-marked up super quick and shoveled me out, but he wasn’t in a serious hurry because I could breathe and talk to him. The first thing—and I only know this from the Go Pro—he said was, ‘Are you OK?’ And I said ‘Not really. I’m pretty sure my hip’s broken.’”

AIARE thanks Nick, Tim (and Powder Magazine www.powdermag.com) and Ian for sharing.

RESCUING YOUR PARTNER(S):
Below is an overview of companion rescue response organized around the checklist steps from the AIARE Quick Reference: Avalanche Rescue located in the back of the AIARE field book. How the following tasks are organized and assigned will depend on the size of the group and the experience of its members. In small groups, only one or two people may need to carry out all the tasks in a suitable order. In larger groups, tasks can be undertaken simultaneously or in conjunction with other stages of the self rescue.

—CALL FOR HELP; DO NOT LEAVE SITE—

Do not leave site: YOUR actions are the victims' best and possibly only hope for survival. If you think you will lose cell or radio reception CALL FOR HELP NOW.

❑ **STOP-ASSESS SAFETY! ENSURE NO FURTHER HAZARD**
- Risk of triggering a second avalanche
- Avalanche from above

The worst case scenario would be for an avalanche to take out a portion of your group, then in a hasty effort to rescue, the remainder of the group was caught in a secondary slide. Remember the universal rules of rescue:

1. Your own safety is your first priority.
2. Your second priority is the safety of the other rescuers.
3. Your third priority is rescuing the victims.

❑ **TAKE CHARGE or assign a leader**

Avalanche rescue is no time for democracy. With a complex problem, invariably there are multiple solutions. The goal here isn't to debate each option at each step, but rather for the most competent leader to take charge, use a checklist to ensure the steps are carried out in the right manner, and get to business. If you're the leader, stay heads-up, try to avoid getting caught up in details or tasks and focus on managing the resources available by delegating specific tasks one step at a time, with excellent communication and a systematic approach to searching. If you're not the leader, do what you're told, and tell the leader when you are ready to take on another task. Everyone has the ability to call a "STOP" if safety is in question, but otherwise keep chatter to a minimum.

❑ **HEAD COUNT. How many missing?**

Refer to the group list in your field book. Account for everyone and keep a record of who is where. Verbalize the number of missing people to everyone for confirmation.

❑ **CALL FOR HELP!** (Cell phone, radio, emergency locator)
- Tell Name, Location, Nature of Emergency
- # of involvements, # missing, # known injured

Consider your position in the terrain, the scope of the task ahead. Often at this point you want to get a quick call out for outside help. Often cell or text coverage is available from high ridges, but may be lost only feet down the slope. If that's the case, call before changing your position. Mountain professionals and savvy backcountry travelers know the cell windows and dead spots for their terrain.

Once you contact an emergency dispatcher, don't allow them to keep you tied up on the phone. Give the critical details (above) and hang up. Leader or person with cell phone reception leave your cell phone turned on as dispatch will likely call back for additional details.

❑ **Avalanche TRANSCEIVERS to "SEARCH MODE"** (Physical check)

One of, if not the most common error in avalanche rescue is chasing the signal of another rescuer. Don't let it happen. If everyone in the rescue party switches to "Search" (receive mode) right away, this problem will be much less likely to occur. Listen to your transceiver! If there is a close signal, (and you're sure you're not right next to the victim), then someone is still transmitting or "sending" a signal. Help them switch to Search, and get on with it.

Prior to entering the path, searchers turn off cell phones. The leader keeps phone on for a return call from dispatch.

❑ **DETERMINE WHERE TO SEARCH**
- Flow line below *POINT LAST SEEN*
- In line with clues
- Areas of debris, especially terrain traps

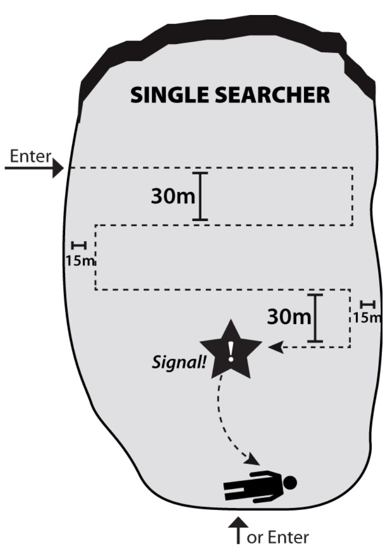
Do not search the entire avalanche path if you don't have to. Consider where victims might be in reference to where they were last seen. You want to reduce the size of the search area, but never assume something you do not know; the cost of failing to search an area is too high. Before you begin searching, make a mental note of landmarks in the path for orienting yourself later. Prior to entering the slide path searchers should turn their cell phones off.

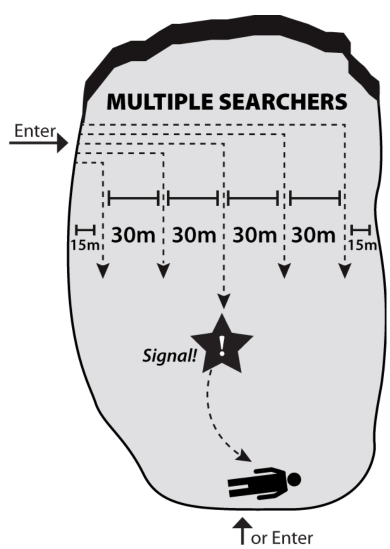
❑ **SEARCH FOR SIGNAL & VISUAL CLUES**
- Enter debris safely from side of path or toe of debris
- Determine escape route
- Spread searchers out in an effective pattern to scan debris
- Search strips max. 30m (approx. 30-40 strides)
- Search to edges of avalanche debris

This is the Signal Search Phase: searching for visual clues (skis, clothing, a hand/boot, likely burial location) and a transceiver signal.

Every avalanche accident scenario is different, so expect to modify your search pattern to suit the circumstance. Consider:

- The size and shape of the terrain
- Further avalanche hazards
- Other hazards such as slick bed-surfaces, cliffs, crevasses, cornices...
- The number of victims
- The number of searchers, their position in the path relative to the debris and their mode of travel
  Zig-zags, parallel lines or a combination can be used to build you search pattern. Ensure spacing between patterns is no greater than 30m.





Graphics courtesy of: bca

❑ YELL TO OTHERS WHEN YOU FIND A CLUE OR RECEIVE A SIGNAL

- Pull clue out of snow and leave on snow surface

Avalanche rescue involves a great deal of puzzle solving. Give everyone, especially the rescue leader the chance to work with all the known details. Yell out what you've found so the leaders can place a clue in the terrain to triage and manage the scene. Pick up every glove, ski, pole etc..., you never know if there might be someone attached. Leave everything right where you found it. Clues help show a victim's trajectory.

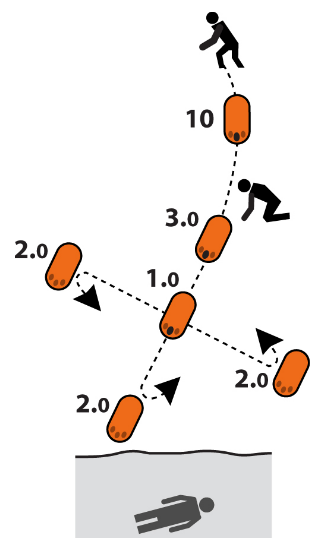
Two common mistakes are missing visual clues and a search pattern that leaves gaps in coverage. Throughout the search, keep your eyes up, look for visual clues and keep your search pattern regular and systematic. Use references like trees, rocks or terrain features to help keep yourself oriented.

❑ FOLLOW TRANSCEIVER SIGNAL TO TARGET AREA

- When possible two searchers work together
- *SLOW AND PRECISE* within 10m!
- Place transceiver near snow surface on final approach
- 2nd searcher assembles probe and shovel

The Coarse Search Phase begins once a strong signal is acquired: rescuers abandon their signal search pattern to follow a transceiver signal to the burial area.

With the improvements in transceiver technology over the last decade, following a signal to the burial site has become more intuitive. That said, the process can still be confusing, especially if you move too fast, or in a non-systematic fashion. Keep the center arrow lit, and make sure the numbers are decreasing. When you get to a distance reading of 10 get your beacon close to the snow surface. Doing so will force you to slow down, and improve the accuracy of your final trajectory. If there is only one victim, once the signal has been found, other searchers can get ready to help with a probe and shovel. If there is more than one victim, other searchers should remain in their search patterns, looking for victims within their search strips (distance readings smaller than the search strip width).



❑ TARGET BURIAL SITE WITH TRANSCEIVER & PROBE

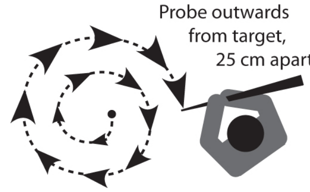
- 2nd searcher *PROBES THE LIKELY BURIAL AREA* in front of the searcher's trajectory when the transceiver signals 3 meters
- To target using the transceiver, *BRACKET and MARK* where the signal fades ahead, behind, and to the sides of the target area
- At the center of the transceiver searcher's mark *PINPOINT USING THE PROBE;* use circular pattern from the center of the target outwards
- Probe Strike = Burial Location. *DO NOT REMOVE PROBE!*

The Fine Search Phase involves bracketing with a beacon in the immediate vicinity of the buried victim. At 3m distance, the directional capability of the transceiver is lost. Look back at your approach, determine your trajectory and carry that direction forward in a straight line (mark with a ski pole if you find this helps). Make sure the beacon is on the surface and slowly work forward along a straight line ignoring any directional arrows.

As the signal fades in each direction encircling the target area, forward, back, and to each side, mark with a glove or line in the snow the point where the signal fades. This is called "bracketing." Remember to maintain the orientation of the beacon flat and forward during the bracketing. Do not rotate it side to side or tip it up and down. Look for the strongest signal (smallest distance reading) to indicate the searcher is closest to the burial.

If a second rescuer is able to help, have them probe along the trajectory in front of your 3m trajectory marker. Work together so that the prober and the transceiver searchers don't get in each other's way. This technique takes coordination and practice, but often results in a victim being probed much quicker than a single person can do alone.

Once the transceiver searcher locates the strongest signal (smallest distance reading), again mark the location. You don't want to lose this carefully gathered information. You now have a line (your first marker) pointing towards a point (your second marker). Probe around the strongest signal in a spiral or concentric circles, with each probe strike approximately 1 foot (25cm) apart. When you get a strike, <u>leave the probe in place.</u> Do not begin shoveling until a probe strikes the victim. If you have additional rescuers available, another probe strike can help to show the victim's orientation on the slope, which may reduce digging time and effort with deep burials.



❑ SHOVEL FAST & EFFICIENTLY
- Consider burial depth and therefore the size of the hole
- Start with a large step downhill and away from the probe
- Dig toward probe; throw snow far away!
- SHOVEL IN TEAMS (if rescuers are available)
- Careful shoveling as you reach your buried companion

It's true, when it comes to digging in avalanche debris Bruce Edgerly is right: "strength and motivation trump technique every time." A good backcountry partner is fit enough to maintain a hard shoveling effort. But, all things being equal (say one shoveler racing against the clock) efficient shoveling technique will shave minutes off what is often the longest and most strenuous component of companion rescue - excavating a victim.
Keep the following tips in mind:

• Step away, downhill of the probe to get off the victim. If you stand above the victim, you may crush any air space.
• Delineate the area you plan to shovel with a few quick scoops to help keep you shoveling where you planed to, not accidentally drifting to one side or another. You'll need an area at least a body length wide for an average burial depth.
• Dig into the slope, not straight down. It's much more efficient to throw snow out from the slope, as opposed to lifting it up out of a hole. To not block your throwing lane directly behind you, begin by throwing snow to the sides, then later throw snow downslope as you develop a deeper trench.
• Work in teams when possible. If you have to dig solo, pace yourself at the highest shoveling rate you can sustain for many minutes. If you've got more than 2 people, go as fast and hard as possible, then rotate out and let someone else give it their all. Rotate any time someone slows below a maximum shoveling effort (usually 30-60 seconds).
• Refine your shoveling as you near the victim. Try to dig towards the victoms head and chest, and attempt to not injure the victim with your shovel blade.
• As you get the victims face and chest exposed, plan how you will carefully move the victim onto the ramp you dug. Cold victims require careful handling. Now is a great time to place an insulating pad where you plan to move the victim.

❑ PATIENT CARE
- Keep dry/warm (insulate from snow); manage injuries
- Move to safe terrain; consider options for evacuation
- Communicate victim's condition to arriving rescuers

First Aid is beyond the scope of this course and manual, but keep in mind the basic ABC's. Open an Airway first. This may involve removing snow from a victim's mouth. Help them Breathe next. Their chest may be compressed under the weight of snow, so efforts to get them breathing require rescuers to excavate their torso so the chest has room to expand. Rescue breaths may be necessary. Manage Circulatory issues as a third priority. We'll defer to your First Aid training at this point.

Now you have a victim in a potentially hazardous place, in a hole in the snow, at the bottom of an avalanche path. Consider moving yourself and the victim to a safer location. Keep the patient dry and warm. Get them off the snow. All the clothes piled on top of a victim will do no good if the snow is robbing them of their precious body heat from below.

Treat injuries to the best of your ability. Consider the mechanism of injury here can be quite violent, so manage potential spine injuries according to your level of medical training. Loosen a victims boots, but do not remove them as any lower leg injuries may swell and make getting boots back on impossible.
Plan for your next series of events. Can you communicate with outside rescuers? Can they get to your position before nightfall? Are you able to get yourself out? Is it best to stay put and wait? Where can you get shelter?

❑ IF A HELICOPTER COMES TO YOUR AID

- Secure loose items so they do not blow away
- Wait for rescuer to come to you

Today, helicopters are a realistic rescue support tool in many areas. It's wise to know some basic helicopter safety.

Before a helicopter arrives, position yourself downhill and ideally up wind of a landing zone (LZ). The helicopter will land into the wind (12 o'clock), and should be approached from the front sides (1-3 o'clock or 9-11 o'clock). The LZ should be open, clear of trees or other obstructions for at least 100'x100' (30m x 30m) across. Within this area, make sure no items could get caught up in the rotor wash (e.g. loose clothing, straps, sticks etc.). Secure a short stick with a streamer upwind of where the helicopter will land to show the pilot where the winds is blowing from. They will probably want to bring the nose of the heli towards the stick, with the streamer blowing towards them. Place your gear in a pile and use your body to hold the items down if you're within the LZ area.

Once the helicopter lands, hold your position, make eye contact with the pilot and wait for instructions. Never approach a helicopter from uphill or from behind the aircraft. In many cases the pilot will shut down the heli and approach you. Be patient, this process may take several minutes.

— STAY CALM —

Avalanche rescue is inherently stressful. Don't be rash, think through your actions before commencing. Use the AIARE Avalanche Rescue Quick Reference to help guide your actions so you don't forget critical steps. In high stress circumstances, everyone can benefit from a checklist to stay on track. Would you want your surgeon to use a checklist to make sure they stay exactly on task? Research suggests surgeons often think they don't need one, but when asked if they were the patient would they want their surgeon to have one, almost all said yes.

REALITY CHECK: THE IMPORTANCE OF PRACTICE

Imagine the gut-wrenching emotions of helplessly watching an avalanche engulf a loved one, rag dolling over a convex roll, out of sight.... It's a gruesome worst-case scenario, but one where in order to offer the best possible chance of a good outcome, we've got to stop, think and step into action decisively, without making another mistake.

We've all heard it: "Perfect practice makes perfect performance." Pre-event rehearsal is a proven strategy to reduce stress and improve competence in completing critical life-saving actions in sequence. Beyond just practicing, it's how you practice that will improve your skills:

- ❑ Set up your practice area in a realistic scenario (e.g. not a parking lot or flat snow slope, but an area with varied terrain and deep snow, but safe from avalanches).
- ❑ Plan your actions. Verbalize what you will do before doing it.
- ❑ Practice communicating clearly and efficiently.
- ❑ Identify errors, and repeat the tasks correctly, immediately.
- ❑ Review your practice to identify how you can improve next time

Like a driver's seatbelt, having partners well-practiced in companion rescue may not change the outcome of a worst case scenario, but it may make enough difference to save a life in many accidents. Given the opportunity to wear a seatbelt, or to choose whom you travel with in the backcountry, why not give yourself and your partners the best chance of surviving.

6.2 – Avalanche Rescue and Safety Equipment

Trained partners are a key component of an avalanche rescue system, but so too is the right equipment. Following is an overview of the primary equipment options today.

TRANSCEIVER, PROBE, SHOVEL AND PARTNER SYSTEM

Currently the most effective system for reducing burial time is an avalanche transceiver, collapsible probe, shovel and trained partner. Other tools people have used (avalanche cords, balloons, dogs, etc.) are far less effective.

Transceivers have been around since 1968 and have a significant history. Most backcountry travelers are familiar with this equipment. Since the development of this technology, the mortality rate has decreased from 76% to 66%. Mean recovery time has decreased from 120 minutes to 35 minutes. The mortality rate is still relatively high due to the skill required for effective search, pinpoint, and recovery. Practice is essential both with the transceiver and with probe and shovel.

Multiple antenna avalanche transceivers are the most commonly used "beacons" used today. Once turned on, the units automatically go into a "transmit" mode continuously sending a radio signal, until they are switched into a "search" mode. At any given point in time, only a single antenna is transmitting the signal. When searching, multiple antennae units are able to electronically compare the signal strength across two or more antennas, to offer directional guidance towards a transmitting antenna. AIARE recommends multiple antennae transceivers for all travelers in snow-covered backcountry avalanche terrain.

Probes remain a critical component in this system by helping to reduce search times with exact confirmation of a victims position within avalanche debris. Pinpointing with a probe costs very little time and offers the security of knowing that you're about to dig in the correct location.

One tool that may add additional benefit with this rescue system is an Avalung. The Avalung is designed to help a fully buried victim maintain an airway beneath the snow, to reduce the effects of "ice masking," and to slow the accumulation of carbon dioxide in a buried victim's breathing space. The Avalung uses a one-way valve with a filter that enables the victim to inhale available oxygen from the snow while exhaling carbon dioxide, distributing it to the rear of the buried victim. These may be integrated into backpacks, or worn separately over one's clothes in a chest harness.

RECCO® Technology
RECCO is an additional tool to make oneself searchable to more than 800 professional (aka organized) rescue teams around the world. The RECCO reflector is a passive transponder that reflects back the directional RECCO signal to a RECCO detector used by professional-level rescue teams. These reflectors require no maintenance and come integrated into some of the gear (winter clothing, boots, helmets, etc.) you buy. Electronic search means are the best ways to be found quickly. Your transceiver makes you searchable to your companions. The RECCO reflector makes you searchable to professionals. The reflector is not a substitute for an avalanche transceiver, probe and shovel. When someone is buried it is the combination of the transceiver and reflector that give buried victims the best opportunity to be found faster whether in a ski area or far in the backcountry.

AVALANCHE BALLOON PACKS

According to Swiss statistics from accidents between 1981 and 1998, the most effective means of preventing fatality in an avalanche accident is to avoid complete burial. This study shows that the **overall buried victim mortality rate is 52%,** but the **partly buried victim mortality rate is only 4.2%. DON'T GET BURIED!**

Avalanche balloon packs are designed to prevent or decrease burial depth. Most are integrated into a backpack, some are integrated into a stand-alone vest (not compatible with a pack). Each year, avalanche balloon packs gain more traction within the avalanche industry, used by more and more operations and individuals, with more options to purchase in the marketplace.

Each design has it's own specific design parameters, but all attempt to increase the victim's surface area, effectively making the wearer larger. Larger, less dense objects tend to "float" or rise to the top much as the larger nuts surface as you shake a can of mixed nuts. Avalanche balloon packs have a canister of pressurized air or nitrogen gas that rapidly fills multiple or single balloons that are attached to the sides, front or top of the pack. The balloon(s) is deployed with an accessible shoulder strap ripcord that triggers inflation from the cartridge. Including deployment errors and gear failures, the avalanche balloon pack has been shown to reduce burial likelihood and reduce mortality rates from 23% to 2.5%.

A secondary, but potentially no less important factor is that avalanche balloon packs may reduce the chance of trauma. Depending upon the location of the inflated avalanche balloon pack (back, head/neck, or chest) certain types of impacts may be lessened. A helmet and potentially body armor may work with an avalanche balloon pack to further reduce trauma.

An important consideration, is that an avalanche balloon pack is not guaranteed to prevent burial, so a transceiver, probe, shovel and partner are still considered essential equipment regardless of whether an avalanche balloon pack is used.

PRESENTATION NOTES:

Part 7: Where to Go from Here?

Epilogue

The best thing to do is keep this manual on your coffee table all season and read through it regularly. This will keep what you have learned fresh in your mind. At the same time, go out and enjoy the backcountry, safely. Try to tour with a mentor who is more experienced than you who you can trust. Use your field book every time you tour. Read the bulletin even when you are not going into the backcountry. Make formal and informal snowpack observations as often as possible. Correlate what you see and feel to actual signs of instability such as shooting cracks, whumphing, and of course actual avalanches. The more you do this, the more knowledge you will gain. When you are ready to take a deeper look at the factors that affect avalanche danger and want to improve your decision making, you can take an AIARE 2 course.

We encourage you to further your knowledge through the many excellent books, websites, and reference papers. Avalanche education is a lifelong endeavor and, as you may soon find out, a lifetime's worth of reading and information is out there for you to absorb. Some of the best links to information can be found at the AIARE web site: www.avtraining.org

Where Do We Go From Here?

Post-Course Student Risk Reduction

Includes excerpts from an article published in Avalanche.ca (Fall 2008) and The Avalanche News (Fall 2008)

In December 2007, an avalanche occurred on Tent Ridge in Kananaskis Country, Alberta. The avalanche involvement report stated two backcountry skiers were digging a snow profile on a 35-degree northeast-facing slope when the avalanche occurred. Both were completely buried, both deceased.

As an avalanche educator, this incident made me stop and think:

> "When a student walks out the door at the course end, and given that we safely managed the terrain during the course, *will they continue to safely negotiate and manage avalanche terrain*?"

It is reasonable for an instructor to consider that, given student motivation, attention and participation, the knowledge gained and tools practiced during an avalanche course will reduce the likelihood of a future student avalanche incident. During an AIARE 1 course for example, the exercises require the student to use a decision making checklist, to implement the public avalanche advisoryinto their daily trip plan, and discuss in small groups the critical factors and trends when assessing the avalanche hazard. Importantly, students evaluate the avalanche risk and plan to manage the risk while traveling in backcountry terrain. In the field the student applies appropriate group management, communication, travel techniques and terrain avoidance. The student chooses terrain and "travels wisely" under the supervision of the course instructor. Therefore, it makes sense that the student should be able to continue this process of making good decisions in avalanche terrain long after leaving the course.

However, even experienced forecasters recognize that making good decisions in avalanche terrain is a challenge. *As a so-called "expert" in the avalanche forecasting industry, the only certainty was that after 15 years into my career, I felt that I was barely good enough to do the forecaster's job well.* With this complexity in mind, avalanche course instructors keep course content and decision making support tools basic and in line with the student's prior experience and newly gained knowledge. Whether stated or inferred through discussion and activity, the message from instructors to students is, "keep it simple, and let your opinions reflect your experience and judgment". Meaning, of course, that as the conditions become unfamiliar or complex, opt for simpler terrain choices that your experience tells you is less consequential and less likely to avalanche.

During the course introduction the student may be asked, "What do you hope to learn this week?" At the conclusion, the student may be asked, "What have you learned, and how can you safely apply the skills when you leave this course?" The student should be aware that during the course the management of the hazard and risk were coached and modified by the instructor.

A Post Course Motivational Strategy

> "The more experienced and confident recreationists are, the more likely they are to perceive the risk to be less than it actually is.." *Human Factors in Avalanche Accidents*, Atkins, 2001
>
> "In a study of 546 avalanche accidents involving 1050 recreationists, avalanche training did not appear to decrease the level of hazard to which groups exposed themselves; groups with basic training often exposed themselves to higher levels of hazards than those with less training." (McCammon, 2000), *The Role of Training in Recreational Avalanche Accidents in the United States.* Presented at the ISSW Oct. 2000
>
> "Although exact accident rates for these recreationists are unknown, we do know that between one-third and one- half of all avalanche victims had formal avalanche training prior to their accident." (McCammon, 2000: 2004), *Sex, Drugs and the White Death: Lessons for Avalanche Educators from Health and Safety Campaigns,* McCammon. Paragraph 3.2.

Looking Forward

Wrapping up each course up often involves suggesting future trips, future courses and an encouraging tone— "have fun, get out there, and here is a list of helpful resources". The instructor knows that "nothing ventured, nothing gained" is the inevitable motivation that urges the student through a lifetime of backcountry travel. Experience is always the goal and 'quality' experience can be elusive. Experience isn't *just* the number of days in the backcountry. Experience includes the history of relating local weather patterns and specific snowpack characteristics to avalanche events on *specific* terrain features. Traveling 'outside the familiar zone' in an adjacent mountain range with a different snow climate is valuable experience. Experience is also includes learning vicariously from events related by mentors and experts. Their lessons learned could be your knowledge gained. Experience includes forming opinions having those opinions critiqued or gently modified by peers and experts.

Good decisions are made within the context of each person's *relevant* and *accessible* experience. And the backcountry traveler with 'common sense' displays a natural tendency to consistently make these types of decisions. While it helps, you don't have to have years of experience to make good decisions, you simply need to exercise common sense.

The instructor also hopes that the knowledge gained from the course keeps common sense alive in a silent voice that urges the student to re-read the course workbook, to use the DMF and the AIARE Field Book when planning and making field observations, and to employ the Communication Checklist to support field decisions once the student has left the course. In the end your goal is likely the same as mine--to be able to enjoy the winter backcountry environment without experiencing the consequence of one of nature's more complex and frightening hazards, the avalanche. After all, as one of many so-called "old guys" in the avalanche industry, I can't believe that after all these years, how interesting, challenging, and absolutely fun it still is!

Safe travels,
Colin Zacharias
AIARE Technical Director

Self Evaluation Questions

Course Date:
Location:
1. What were the three most important things you learned in this course?

    a.

    b.

    c.

2. As a result of this course, how has your understanding of backcountry decision making changed? Explain.

3. What critical decisions do you make when planning a backcountry trip?

4. List as many “red flags” as you can for each of the data classes listed below.

    Avalanches:

    Snowpack:

    Weather:

5. What are critical components of terrain selection?

6. How can we avoid falling into “Human Factor” traps?

7. What are “travel techniques”?

AIARE 1 Skills Self Evaluation Checklist

Skills introduced or acquired on a AIARE 1 avalanche course require practice to retain. Some skills may improve with practice, others may be lost as time passes. The skills criteria below can provide a metric for evaluating one's learning and retention of course concepts. As an activity use this checklist right after your course, a month later, at the end of the season and again at the start of next season. Plug holes in your skill set with further practice. Consider a AIARE 1 Refresher course to target skills that are not current.

Check the first box if you are comfortable completing this task under the guidance of a mentor; check the second box when you are ready to apply this skill in a group of peers; check the third box when you feel solid enough to complete the task alone.

Mentor Peers Solo

Teamwork

❒ ❒ ❒ Self-evaluate your skills as a contributing team member.
❒ ❒ ❒ Facilitate group discussions with leadership initiative and record keeping during trip planning and backcountry decision making.
❒ ❒ ❒ Contribute to the teamwork approach using the Communication Checklist: commit to a process, share tasks, agree to consensus, read the questions aloud, listen to and recognize each opinion.
❒ ❒ ❒ Support your partners by rotating your position in the group each day (leader, support, last one down).
❒ ❒ ❒ Facilitate the day's end discussion using the Review the Day questions.

Plan (and prepare)

❒ ❒ ❒ Keep an ongoing record of each day's pre-trip discussion using the Trip Plan as a guide.
❒ ❒ ❒ Become a researcher: acquire terrain information from maps, photos or online resources.
❒ ❒ ❒ Read, discuss and track trends by keeping records of the avalanche advisories: Interpret an avalanche advisory danger rating/discussion to anticipate problems and choose terrain options.
❒ ❒ ❒ Create time plans of each day's trips and keep records of accuracy and relevancy to time related hazards.
❒ ❒ ❒ Record your own opinion and compare it to the expert's (bulletin/local expert opinion). Each week compare the forecasts for accuracy.
❒ ❒ ❒ Lead a quick but thorough gear check: who has what, transceiver function check, transceiver range check.
❒ ❒ ❒ Prepare for the unexpected: leave an itinerary and return time with someone, everyone know the car key location

Observe

❒ ❒ ❒ Each morning, plan and record in the Trip Plan which observations will be relevant for the day's given avalanche problem using the Avalanche and Observation Reference.
❒ ❒ ❒ Reference and observe red-flag observations using the Avalanche and Observation Reference.
❒ ❒ ❒ Camera ready: record upcoming terrain, unusual events or unexpected observations for review later.
❒ ❒ ❒ Observe and record avalanches in the Field Book - including identifying type, size and characteristics using Field Book reference pages.
❒ ❒ ❒ Identify cracking, whumping in the field.
❒ ❒ ❒ Use test slopes to look for cracking and identify snowpack characteristics.

Complete daily weather and snow observations on the Field Observations page:

❒ ❒ ❒ ● Changing sky conditions including precipitation type and rate.
❒ ❒ ❒ ● Recent or old storm snowfall amounts.
❒ ❒ ❒ ● Wind speed, direction and blowing snow.
❒ ❒ ❒ ● Air temperature and trends.
❒ ❒ ❒ ● Solar radiation.

Complete a snow profile including:

❒ ❒ ❒ ● Choose a safe and relevant site.
❒ ❒ ❒ ● Dig clean plumb walls to observe layers.
❒ ❒ ❒ ● Identify and note the layers, their measured heights, hand hardness and grain type.
❒ ❒ ❒ ● Relate the layering to the bulletin or an anticipated avalanche problem.

Mentor Peers Solo

Complete snowpack tests to identify weak layers and slab character including:

❐ ❐ ❐ ● Rutschblock Test.
❐ ❐ ❐ ● Compression Test.
❐ ❐ ❐ ● Deep Tap Test.
❐ ❐ ❐ ● Informal snowpack tests.

<u>Choose Terrain</u>

❐ ❐ ❐ Identify and estimate the avalanche potential and consequence for each terrain feature encountered.
❐ ❐ ❐ Identify, discuss and avoid terrain traps.
❐ ❐ ❐ Facilitate each terrain choice with a peer discussion using the Communication Checklist.

Has the skill and experience to:

❐ ❐ ❐ ● Choose terrain options based on predetermined criteria observable in the field.
❐ ❐ ❐ ● Identify and apply safe terrain margins between the group and the hazard.
❐ ❐ ❐ ● Choose an alternate route that reduces the likelihood of an avalanche involvement.

<u>Travel Wisely</u>

❐ ❐ ❐ Initiate daily checks and familiar with maintenance and use of personal avalanche rescue equipment.
❐ ❐ ❐ Take initiative to establish cell or VHF radio range for emergency communication during each trip.
❐ ❐ ❐ Facilitate discussion of safe terrain margins and group management before each questionable terrain feature.
❐ ❐ ❐ Has the skill and experience to manage a group of peers using a variety of travel techniques.

<u>Emergency Response</u>

❐ ❐ ❐ Discuss with group what to do if caught in an avalanche.
❐ ❐ ❐ Set up and rehearse a realistic companion rescue scenario, including playing both the leadership and rescue party role:

❐ ❐ ❐ ● Consider and ensure the safety of the party.
❐ ❐ ❐ ● Lead an efficient search for multiple victims using different numbers of searchers.
❐ ❐ ❐ ● Follow a transceiver search pattern to locate single and multiple burials.
❐ ❐ ❐ ● Target a burial site with a transceiver and probe, both alone and with a partner.
❐ ❐ ❐ ● Efficiently dig out a buried victim from 2 meters deep.
❐ ❐ ❐ ● Record search times for similar sites to track personal progress.


WINTER HOPS WARNING
NEW BELGIUM
RAMPANT
NEW BELGIUM
ACCUMULATION
INDIA PALE ALE
NEW BELGIUM
RANGER
NEW BELGIUM
BREWING
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Course Feedback:
We would appreciate your feedback and observations.

In what way was this course beneficial? If not beneficial, please explain.

At any time during the course did you feel you were in danger?

Do you have any suggestions on how we can improve the course?

What suggestions do you have for the instructors to improve upon?

PRESENTATION NOTES:

APPENDIX A:
STRATEGY: IDENTIFY POTENTIAL HUMAN FACTOR TRAPS

Even experienced backcountry travelers succumb to these decision making traps. Regardless of avalanche knowledge or experience, watchful team members can identify human factor traps and take deliberate steps to enact solutions and correct errors. This section outlines a list of *Common Human Factor Traps* that lead to accidents.

1. **Social Pressure**
2. **Overconfidence and/or Low Self Confidence**
3. **Closed Mindedness**
4. **Shortcuts**
5. **Impaired Objectivity**

Social Pressure

Social pressures exert an invisible and powerful force on perception and mentality. Several common Human Factor traps are related to these pressures.

- **Peer Pressure**: People are susceptible to peer pressure. It can be difficult to be the lone dissenter. Professionals such as ski patrollers and guides have additional status within the group and potential to affect decisions.

- **Social Proof / Risky Shift**: Social Proof (McCammon, 2002) is the idea that an action is correct because other people are doing it (seeing skiers on a slope of concern). The *Risky Shift* (Stoner, 1961) is a phenomenon identified where a group may accept a higher level of risk than each individual might choose alone. These two traps relate to what has been called the “herding instinct” - the illusion of safety in numbers. Avalanches are commonly triggered by the 3rd, 4th or 5th person rather than the first one down.

- **Scarcity**: Also identified as a common trap by McCammon (2002), Scarcity is a trap related to the pressures of a window of opportunity or a diminishing resource. The most common example of this is “powder fever” seen in popular backcountry areas with limited terrain. The desire to capitalize on a special, limited opportunity can cause people to make poor terrain choices.

- **Acceptance**: McCammon (2002) calls this the tendency to engage in activities that we think will get us noticed or accepted by our peers, or by people whose respect we seek. Alain de Botton (2004) refers similarly to “Status Anxiety,” or the desire for status in modern society and the anxiety resulting from a focus on how one is perceived by others. It is easy to see how this pressure can become a trap that influences people to make poor backcountry decisions.

- **Individualism**: People sometimes have a compulsion to feel uniquely individual. (Skiing alone is one example). Those who do not embrace a team mentality often show an inability to communicate effectively, a lack of empathy for other group members, and an unwillingness to listen to the group. This leads to a lack of cohesion in the team and can provoke tension and poor choices.

Overconfidence and Low Self Confidence

According to one study by Atkins (ISSW, 2000), overconfidence was the leading human factor attributed to fatal avalanche accidents by people with some level of formal avalanche training. Overconfidence is a dangerous trap as it generally results in more risky behavior.

- **Overconfidence Effect**: This effect is a well-established bias in which one’s subjective confidence in their judgments is greater than their objective accuracy. Numerous studies demonstrate that this bias can adversely affect backcountry decisions.

- **Actual vs. Perceived Risk**: There is a gap between perception and reality. Since decisions can only be based on perceptions, this trap can lead to miscalculation of risk and poor terrain choices.

- **Technology**: In the modern world, technology has made possible the inconceivable. People sometimes demand more from their avalanche safety equipment, electronics, and snow study tools than that technology is actually able to provide. This can lead to a misperception of risk.

- **Education**: "*A large percentage of people caught in avalanches had formal avalanche training"* – McCammon (2000). A little knowledge can offer just enough confidence to overreach on decisions. It takes a lot of experience on top of training to make consistently good decisions, and what experts come to realize is that it is rare to be very confident when it comes to forecasting avalanches.

- **Abilities Outperforming Experience**: Skiers and snowboarders can become expert riders as teenagers in the boundaries of a ski resort. Sometimes, it is hard for them to imagine that they might only be beginners at backcountry decision making, even though they are capable of great feats of mountain athleticism. Confidence in physical abilities has a tendency to transcend to overconfidence in terrain decisions.

- **Low Self-confidence**: Low self-confidence can lead people to distrust their instincts and allow them to agree with a decision that they intuitively feel is wrong. In some cases, people with little formal training or group members with less experience than the leader, may observe or become aware of significant data that are crucial to the decision being made. These people are often unwilling to challenge or question the "experienced" leader or status quo in the group even when they have information or knowledge that others do not.

Closed Mindedness
The filters listed below affect the ability to observe, process, and respond to information, resulting in a deceptively incomplete picture. (These excerpts come from the Avalanche Handbook, 3rd Ed., 2006)

- **Conservatism**: "Failure to change (or changing slowly) one's own mind in the light of new information or evidence" – Avalanche Handbook (2006). There is inertia changing from what was known, to what is known now following new information. Before the adjustment is made, poor decisions may result.

- **Recency**: In one's mind, recent events dominate those in the past, which may be downgraded or ignored. This trap can allow more recent information to override more relevant information from the past. For example, this trap might lead one to base terrain choices on recent habits, rather than modifying the approach to match a successful strategy used in similar snowpack conditions not seen for 3 years.

- **Frequency**: Again, in one's mind, more frequent events dominate those that are less frequent. This is a trap because smaller storm events tend to be more frequent than larger ones, but larger ones can present higher danger.

- **Availability**: This trap involves making decisions based on past events easily recalled by memory, to the exclusion of other relevant information. The availability of memories to be recalled may cause unusual or exceptional events to be treated as more common and may bias the decision maker to disregard other important data.

- **Prior Experience**: People tend to see problems in terms of their own background or experience. For example, one can imagine that a snowboarder with experience gained riding a resort terrain park might have a different approach to terrain use than an experienced backcountry snowmobiler.

Shortcuts
Decision making shortcuts are ways to simplify complex scenarios. Humans tend to find the most energy efficient path, and it is generally easier to abandon or shortcut the complex process and just go for it.

- **Stress and Logistics Pressure**: Feelings of stress and pressure can complicate decision making. Uncorrected errors often result in increased stress, as do unanticipated conditions or scenarios. Time applies pressure. When stressed or under pressure the tendency is to take shortcuts to change the immediate scenario.

- **"Rules of Thumb" or Habits**: Habits tend to shortcut thoughtful evaluation. Independent rules of thumb may be functional at times, but they often oversimplify the problem. Good terrain selection is a complex process that demands unique assessment for each situation. Dependence on rules will lead to a decrease in accuracy, and errors can be fatal.

- **Decisions from Few Observations**: Observations take time and energy to gather. Consider if the quality/quantity of observations represents reality, or simply convenient support for the group's desire to not find instability. For example, "I don't see any avalanches; it must be good to go!"

- **Back to the Barn**: The urge to simply "get it over with" and return to safety, food, and shelter is powerful. Commonly, people make poor decisions late in the day, when people are tired and nearly home.

- **Expert Halo**: People with more experience or knowledge tend to be perceived as experts. Group members often shortcut their own cognitive processes and allow someone they perceive as more competent to dominate the decision making.

Impaired Objectivity

These examples illustrate circumstances where people fail to objectively perceive reality, but rather see the world through their own subjective filter.

- **Search for Supportive Evidence**: Tremper (2001) says that people often say, "I'll believe it when I see it," when actually it is the other way around. People tend to see what they already believe to be true. People tend to gather facts that lead to certain conclusions and disregard facts that threaten them.

- **Familiarity / Non-event Feedback Loop**: McCammon (2002) pointed out that many accidents happen in familiar terrain. People often feel comfortable in familiar areas. They let their guard down or base their current decisions on past experience. The trap here relates to the "Non-event Feedback Loop" in decision making. When backcountry decisions result in no avalanche, people may believe that they made the best choice. The traveler may have been simply "lucky." It may be only a matter of time before acquired habits that seem adequate result in an accident.

- **Blue Sky / Euphoria**: Avalanche accidents tend to occur during blue sky days following storms (Tremper, 2001). When experiencing such a day with great snow conditions the hormones released during the throes of euphoria can cloud judgment.

- **Optimism**: This is a bias also known as "wishful thinking," and has been referred to as "Commitment" by McCammon (2002). The more one prefers an action, the stronger the bias toward deciding to do it. Optimism to the exclusion of disappointing information can lead to the equivalent of rearranging the deck chairs on the Titanic.

Case histories and knowledge describing common misperceptions and traps that lead to avalanche accidents can help improve self-awareness. This alone may prevent a poor decision with serious consequences. On the other hand, it may not.

Consider the following:
"A review of fatal United States avalanche accidents in the 1990's shows terrain, weather, and snowpack conditions are generally contributory factors to fatal avalanche accidents; human factors are the primary factor" (Atkins, 2000).

A choice to recreate in avalanche terrain is choosing to enter a potentially hazardous environment. Choosing to participate in this course is an effort to learn methods to actively manage risk in avalanche terrain. Ironically McCammon's 2000 ISSW paper "*The Role of Training in Recreational Avalanche Accidents"* showed that **a large percentage of people caught in avalanches had formal avalanche training**. It is true that at best, "we are estimators of snow stability." **Faced with uncertainty one can experience emotions that destroy self control that is essential to rational, constructive decision making** (Kahneman *and Tversky, 1979*). One should "think about how we think" in the backcountry.

The previous section discussed and identified human factor "traps." In addition to being able to identify these traps it's even more important to have a strategy in place that can "derail" these early. The Human Factors Solutions are a good way to manage and avoid Human Factor traps.

In the AIARE 1 Avalanche Course, we give you the framework for making informed decisions in the backcountry. In the classroom and in the field, this course offered the opportunity to learn about or practice:

- The types of avalanches and the problems they create.
- How to recognize avalanche terrain and the terrain factors that make snow more or less prone to avalanche.
- How snowpack layers form and change over time.
- Obtaining the local avalanche advisoryand making it relevant both during trip planning and in the field.

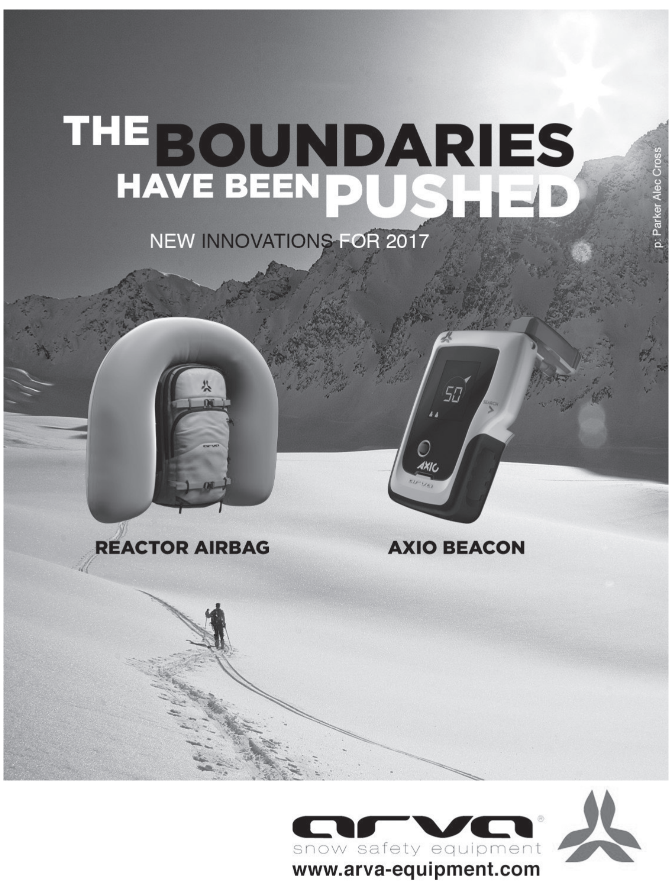
• The importance of observing critical avalanche activity, snowpack & weather factors that affect Avalanche Danger
• A process to plan for travel in avalanche terrain and how to create useful trip plans with alternate route options
• How to work as a team to benefit from group interaction and experience; and how human factors play an important role in quality observations, terrain choice and risk reduction
• How to integrate your observations of the avalanche danger factors, the human factors, and the planning and preparations into terrain choices
• How you can use teamwork, communication, group management, and travel techniques to reduce your exposure to risk and/or the consequences of an error
• How to effectively rescue your companions in case you make a terrain selection error.

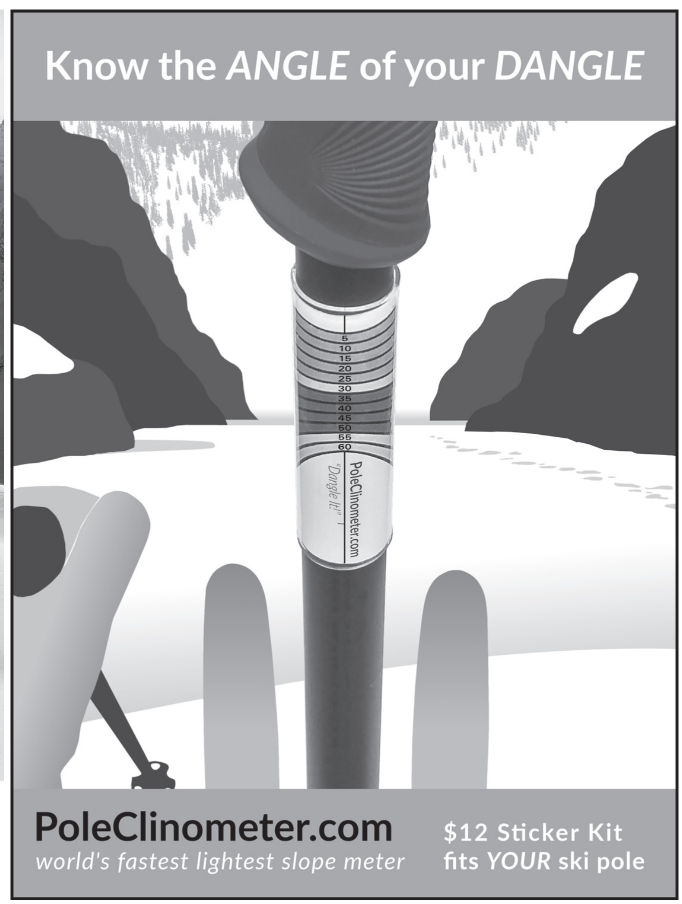
Armed with this new knowledge and experience, you will be better prepared for the complex decisions ahead. But remember:

“The avalanche doesn’t know you have taken an AIARE 1 Avalanche Course!”

In fact, more people are caught after taking an avalanche course. Perhaps it gives people a false sense of confidence, or the idea that they know all there is to know, or maybe they let their human factors override all that they learned in their course. The AIARE course instructor played a big role making your journey into the backcountry a safe one. He or she will probably not be with you the next time you head in to the backcountry. Applying what you’ve learned in this course will take time. When you’re unsure, don’t travel in avalanche terrain. You can always find terrain to recreate in that is not in avalanche terrain and still have a blast.

The bottom line is that no course can keep you from being killed in an avalanche. In the end it is the decisions you make about the terrain. Remember to always go with caution and err toward a margin of safety. When confidence is low, maximize your observations but minimize your risk exposure. This will assist your learning over time and keep you from making a poor choice with serious consequences.





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