Level I Avalanche Course
Student Manual
2009/2010

Decision Making in Avalanche Terrain
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# American Institute for Avalanche Research and Education

## Level 1 Avalanche Course

## Student Manual

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Mission

The mission of the American Institute for Avalanche Research and Education is to:

‘Save lives through avalanche education.’

Goals

The specific goals of AIARE are:

- Increase the 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.

AIARE

AIARE is a registered 501 c (3) not-for-profit organization.

Further information is available from:

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Decision-Making in Avalanche Terrain
Course Goals and Objectives

Course Goals
• Provide a basic understanding of avalanches.
• Describe a framework for decision-making and risk management in avalanche terrain.
• Focus on identifying the right questions, rather than on providing “answers.”
• Teach concepts that have observable characteristics

Learning Outcomes
As a result of this course, students will demonstrate the ability to:
• Learn and utilize a decision-making framework.
• Plan and prepare for travel in avalanche terrain.
• Learn to recognize avalanche terrain.
• Learn and apply effective companion rescue.

Specifically this course addresses
• Decision-making
• Types of avalanches
• Characteristics of avalanches
• An introduction to how avalanches form and release
• Trip planning and preparation
• Avalanche terrain recognition, assessment, and selection
• Travel techniques
• Human factor perceptions and traps
• Companion rescue

Most of the understanding and techniques addressed in 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. In addition, backcountry travelers should continually seek to update and deepen their understanding of avalanche and snow science as new research becomes available to the public.

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 and 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.

The instructors who teach this course, the course provider, and the American Institute for Avalanche Research and Education takes no responsibility for your safety after the course ends.
AIARE Decision Making Framework
Anatomy of a Decision

Backcountry decision making is much more than whether or not to ski or ride a slope. It is a continuous cascade of questions and thought processes that starts before the trip begins and constantly affects our actions until the trip ends. Our most critical decisions in the backcountry fall into two categories: Terrain Selection and Travel Techniques.

Terrain Selections are the actions that determine where we go. This is our primary decision making tool in the backcountry. Terrain Selection is done on a mountain-scale, slope-scale, and micro-scale. An example of mountain-scale terrain selection is when we choose to ski White Mountain instead of Black Mountain. An example of slope-scale would be to decide to ski the North Ridge of White Mountain instead of the Northeast Bowl. Micro-scale terrain selection might be a decision to avoid steep convex rollovers.

Travel Techniques are the actions that determine how we go. Once we make terrain selection decisions, we can further reduce our exposure to risk by using appropriate travel techniques. Techniques must be evaluated on a case-by-case basis to determine if they will actually have the desired risk minimizing effect. A technique that works well in one situation may only make matters worse in another context. It is important never to use travel techniques to justify otherwise inappropriate terrain selection decisions. Travel techniques should be discussed and selected after terrain is chosen.

Decision making is the product of the three interwoven components of good terrain selection: 1) trip planning and preparation, 2) observations of avalanche danger factors, and 3) human factors:

- **Trip Planning and Preparation** sets us up for good decision making by planning appropriate objectives and realistic safer alternatives before the trip begins. Much of the macro, meso, and even micro scale (in many cases) terrain selection that we do can be done in the trip-planning phase. Trip planning ensures that we know when we will arrive at a given destination and facilitates navigation in poor visibility. Trip preparation makes sure our group is prepared to manage a situation where things go wrong and an accident occurs. Trip Planning and Preparation helps prevent accidents from occurring in the first place, and the process encompasses the first, and often most important, critical decision making we do on a backcountry tour. This is why planning and preparation must incorporate the other two components of decision making: observations of avalanche danger factors and human factors.

- **Observations of Avalanche Danger Factors**: before terrain selection can occur, even at the planning phase, observations must be made and considered. These observations are made in the three data-class categories of avalanche activity, snow pack, and weather. We must learn to assess when our observations may indicate avalanche danger. The AIARE Observation Checklist can help us with this. Before the start of a trip it is important to get a bulletin from an avalanche information center, if possible. Avalanche bulletins contain information from all the data classes and also help us interpret these observations. Once on our trip, we must actively and constantly observe and gather information from the data classes that will be useful for decision making. The reliability of our decisions depends on the quality and quantity of our observations and our ability to compare them to an avalanche bulletin discussion to get a picture of current avalanche danger on the slopes where we want to travel.

- **Human Factors**: also before Terrain Selection can occur, we must evaluate our group and ourselves. We must learn to recognize how appropriate terrain selection factors in the questions of: Who is coming? What are their experience, skill, fitness, ability, and avalanche rescue training and practice levels? What other group or individual human factors may affect our ability to make good decisions? Why are we all going on the trip? The answers to these questions affect terrain selection on all scales in both the planning and preparation phase as well as constantly throughout a tour.
The prior description of decision making is graphically represented below:

**AIARE Decision Making Framework (DMF)**
Accident Report: April Bowl, Hatcher Pass, Alaska

Date: November 9, 1997
Location: April Bowl, north face of Peak 4811, one mile south of Hatcher Pass, Talkeetna Mountains.
Author of original accident report: Doug Fesler, Alaska Mountain Safety Center.
Summary: On November 9, 1997 two snowboarders were caught in a self-triggered soft slab avalanche; one was killed. This was the first avalanche-related snowboarder fatality in Alaska.

Report
A group of seven experienced snowboarders ascended the ridge along the eastern flank of April Bowl, a cirque measuring roughly 1000 feet wide by 600 feet vertical. Winds along the ridge were blowing in a westerly direction at 45 - 60 mph at the time, so visibility and voice communication were hampered. Along the route two snow pits were dug by the victim, Andy, age 25. The first pit was dug along a ridge near the false summit in a wind roll area of deeply deposited snow. His second pit was dug in the crown region about 10 feet below the corniced ridge on the eastern side of the main face.

His snow stability evaluation indicated to him that the snow stability looked "good" and he communicated this information to other members of the group within earshot. A second group of three other boarders arrived at the top about this time.

Andy then descended from his pit onto the 38-degree open slope below, making three jump turns in the process. At the same time, perhaps unknown to Andy, his friend, Pat, age early thirties, jumped off a cornice and dropped into the bowl on the western flank, following a line of descent down a generally uniform 31 to 33 degree slope. Three campers bivouacked beyond the base of the cirque said they observed the two snowboarders and two dogs jump into the bowl at nearly the same time. When the boarders had made approximately three turns, the whole slope ripped out above them and accelerated rapidly down the slope.

As the two were carried down the slope, the remaining boarders carefully observed their trajectory. Pat was able to board out of the avalanche to safety beyond the western flank, while Andy was carried over a steep convexity and taken temporarily out of sight. Spotted by his friend Colin, Andy reappeared in the runout zone still in a standing position. At the bottom of the slope the terrain changed from 35 degrees to 4 degrees and the last wave of the avalanche overran Andy and buried him.

Colin and Pat arrived within moments and began a visual and transceiver search. A signal was picked up almost immediately. Within minutes 10 people were digging. After 10 - 15 minutes of digging, Andy’s exact position remained unknown. Colin removed a basket from a ski pole and began probing the walls of the hole and struck Andy almost immediately about four feet beyond the western wall of the pit. Within two minutes his head was uncovered about four feet below the surface. Resuscitation efforts by a qualified nurse on site were unsuccessful.

Footnote
Andy was found nearly upright in a bent-over position with a hand seemingly reaching for his board. The location of this accident is only a short distance from where a 20-year-old skier, Shaun Sande, died in an avalanche on November 2, 1994. Over the years, many others have been caught by avalanches in April Bowl. In all known cases, the avalanches were triggered by the victims.
Accident Report

Terrain Selection:
- Start zone incline mostly high 30s to low 40s.
- April Bowl is predominantly northerly in aspect.
- The bowl is primarily leeward.
- April bowl has numerous concavities and convexities interspersed with 2-to 3-foot rock outcrops on alpine tundra and scree.
- Three turns down from Andy's pit the terrain changed from 38 degrees to 45 degrees at a convexity.

Observations:
Avalanches:
- On the day prior to the accident a natural release to the ground was observed on a similar aspect and elevation one-half mile to the west.

Snowpack:
- Early season, shallow snowpack.
- Several layers of wind-deposited snow.
- Andy's second pit was clearly visible as part of the crown. At its base was the weak layer observed in the fracture line of the avalanche.

Weather:
- Winds blowing 13 - 15 hours prior to the accident.
- Temperatures on the 4th - 6th were high teens to mid-twenties. On the 7th and 8th they climbed to the mid-thirties, and on the 9th, 37 degrees was recorded two miles away at 3,200 feet.
- 15 inches of recent new snow accumulation.

Planning and Preparation:
- All party members carried avalanche rescue transceivers; most had shovels.
- None had avalanche probes.
- Andy's board had non-releasable bindings.
- Rescuers had trouble pinpointing Andy's location with transceivers.
- Most people had little formal avalanche training.
- Park rangers and ski patrollers were aware of the danger in the area.

Human Factors:
- This group was comfortable with exposure and accustomed to risk.
- All were proficient boarders/skiers and several were certified instructors.
- All were strong and in good shape.
- Andy had boarded April Bowl numerous times over the previous 10 years and twice on the previous two weekends without incident.
From the report, list the “red flags” and “obvious clues” that were missed in each of the following categories…

PLANNING AND PREP:  

HUMAN FACTORS:

OBSERVATIONS:  

TERRAIN SELECTION:

- AVALANCHES:

- SNOW PACK:

- WEATHER:

TRAVEL TECHNIQUES:
Accident Report: Microdot Peak, Hatcher Pass, Alaska

Date: March 1, 2003, Time: approximately 12:30 pm  
Location: The south face of Microdot at Hatcher Pass, approximately 1.5 miles north-northeast of the Hatcher Pass Lodge  
Author: Ed Kamienski, Anchorage Nordic Ski Patrol  
Summary: One skier caught, carried, partially buried & injured. Two caught in powder blast.  
Weather: Partly cloudy to sunny, temperatures 25-30 degrees F, winds calm.

Background Weather and Snow Conditions:
When the Anchorage Nordic Ski Patrol (ANSP) contacted Alaska State Parks on Friday, February 28, to inform them of the planned Saturday patrol, Alaska State Parks reported avalanche hazard at Hatcher Pass was “Considerable to High.”

Heavier snowfalls with moderate temperatures occurred during the week preceding the accident. Between February 20 and February 28 the Hatcher Pass NOAA/National Weather Service station (Elevation 3450) recorded an additional 17” of snow. Though no large wind events were recorded by the National Weather Service station prior to the event, adjacent slopes were moderately wind loaded. A test pit dug two days after the incident on an adjacent slope revealed 50 inches of new snow, on a layer of faceted snow, which rested on a knife-hard layer of rounded melt-freeze snow.

Terrain Factors
The main section of the south face averages more than 35 degrees, with some steep convex “rollover” sections exceeding 40 degrees. The overall runout angle for the slide event was measured at 30 degrees. The starting zone was estimated at 38-42 degrees. Multiple known avalanche slide paths and starting zones exist on the face.

The Accident
A group of seven experienced backcountry skiers and one snowboarder, each equipped with an avalanche beacon, probe and shovel, ascended Microdot. One person from the party reported that all of them had skied backcountry over 100 days. They also reported having previously triggered avalanches and skiing out of them.

The group dug a snow pit during the ascent and determined that snow conditions were unstable, but decided to continue on the ascent anyway.

Upon reaching the top, the party chose to descend individually. They also filmed the descents with a video camera. Two reached the bottom without incident. At approximately 12:30 p.m., the fifth person in the party began to descend, fell and triggered a slab avalanche that carried him over a rock outcropping down to the foot of the peak, approximately 700 vertical feet below. He was partially buried with his head and one arm extending from the debris. Two party members who had already descended ran, but were enveloped by the powder blast, which knocked at least one of them over. The remaining three members of the group were able to descend without further incident to aid their partially-buried companion.

The Rescue
The location of the partially-buried skier was observable by the members of the party who were still at the top. They descended and, with another member of the party, immediately started to dig their companion out. One member from the group immediately proceeded to ski down to the Hatcher Pass Lodge parking lot to report the accident and procure aid.

A group of three skiers including two ANSP members had arrived to patrol the Hatcher Pass Bowl area that day and checked in with Alaska State Parks by radio at approximately 12:15 p.m. At 12:45 p.m., a skier and witness from the group approached ANSP members in the lodge parking lot and reported the avalanche, its location and that one skier was “being dug out.” The incident was immediately reported to State Parks by radio and to personnel at Hatcher Pass Lodge. The group of three skiers immediately started for the accident scene with the
The Alaska State Parks notified the Alaska State Troopers and EMS and placed Alaska Mountain Rescue Group (AMRG) and Backcountry Avalanche Awareness Response Team (BAART) on standby. A helicopter was dispatched.

Two skiers from another party witnessed the avalanche and proceeded to the scene to aid in the rescue. One of the skiers from the other party was a member of the AMRG. At approximately 1:05 p.m., the victim was retrieved from the avalanche debris, and set on packs and insulating pads and covered with extra clothing by the skiers. One skier from the initial ski party and a member of the Alyeska Resort professional ski patrol performed an initial assessment and took baseline vitals. The initial assessment indicated pain in the right shoulder, right abdomen, ribs, back, and right knee, but no external bleeding.

ANSP members reached the accident scene at 1:30 p.m. The victim was conscious, continued to complain of back and shoulder pain and shivered from being cold. ANSP members provided medical support and coordinated rescue operations at the site. A helicopter landing zone was prepared.

Six snow machines attempted to access the accident scene to deliver equipment from the rescue cache. The snow machines became bogged down in the snow until, at 2:15 p.m., two snow machines successfully delivered a hypothermia bag and marking media for delineating the helicopter landing zone.

Lifeguard helicopter arrived at 2:30 p.m. EMS personnel assumed responsibility for medical. ANSP members and others assisted with applying the cervical collar, back boarding and transporting the victim to the helicopter. The Lifeguard helicopter departed with victim at 2:55 p.m. for Alaska Regional Hospital in Anchorage.

Injuries
The victim was admitted to Alaska Regional Hospital. Injuries included a broken scapula, ribs, and a fracture in his lower back. The victim was encouraged that the injuries would heal completely and would not likely be debilitating in the long term. The victim expressed thanks to ANSP and all who assisted with the rescue.

The Avalanche
The fracture line of the main slab avalanche occurred an estimated 40 feet below the main peak at approximately the 4,600-foot level. The depth of the crown face was estimated to be about 3 feet and 150–200 feet across. The skier was carried with the debris over a rocky ledge and down an estimated 700 vertical feet to the valley below. The debris pile at the bottom was estimated at 30 feet wide by 30 long and 4-6 feet deep. The pile contained debris from the main (skier-triggered) slide as well as a smaller adjacent slide that also released during the event.
From the report, list the “red flags” and “obvious clues” that were missed in each of the following categories…

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- AVALANCHES:

- SNOW PACK:

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Avalanche Types and Characteristics

Avalanche Types
There are two main types of avalanches: **loose-snow avalanches** and **slab avalanches**. **Powder avalanches** are considered an offshoot of the two main types. Avalanches in general are often referred to as **slides** and the word “avalanche” is often used interchangeably with the word “slide.”

Loose-Snow Avalanche

Loose-snow avalanches begin as loose, unconsolidated snow. They usually start from a point and gather mass and speed as they flow down the slope. Because they have a characteristic **start point**, loose-snow avalanches are commonly referred to as **point releases**. When they are so small as to be essentially inconsequential, they are often called **sluffs**. The surface left behind after an avalanche is the **bed surface**. The pile of debris an avalanche leaves behind is usually referred to as the **deposit**.

**Appearance**: Generally a characteristic teardrop shape starting at a small point and ending in a deposit. Large, wet, loose avalanches often leave grooves or striations in the bed surface.

**Moisture**: Snow moisture content at the start point is generally either dry or very wet to slushy.

**Deposit**: The deposit of dry loose-snow avalanches generally consists of small, fine-grained snow crystals. Wet debris generally consists of larger, rounded chunks or snowballs up to or greater than 50 cm/1.5 ft in diameter. Channels or runnels and ribs or ridges in the surface of the wet deposits are common.

**Depth**: Loose-snow avalanches may involve only surface snow (common in cold, dry conditions), deeper layers in the snowpack, or the entire depth of the snowpack (sometimes in warm, wet conditions).

**Weather**: Often, loose-snow avalanches occur in cold, dry weather or during very warm periods. They may be associated with clear sunny weather when solar radiation effects are strong but can also occur when cloud cover enhances solar radiation effects.

**Speed**: Generally relatively slow, especially when small, somewhat faster on steeper terrain. Perhaps up to 200kph/125 mph when airborne. On flatter terrain, wet loose-snow avalanches may move as slow as 5kph/3 mph or so.

**Area**: Small loose-snow avalanches may involve only a small portion of a slope (a few square meters/yards). Large ones might include portions of an entire slope of thousands of square meters or more.

**Volume**: From a few cubic meters for sluffs to thousands of cubic meters or more for large slides.

**Mass**: Small, dry sluffs may contain 50 kg/110 lb of snow or less. Large, wet avalanches may involve 10,000 metric tons/55,000 tons or more.

**Impact Force**: Sluffs likely have very low impact forces, perhaps less than 100 kg/m². Large loose-snow avalanches might have impact forces of 10,000 kg/m² or more, especially when wet or slushy.

**Destructive Potential**: Generally less destructive than slab avalanches. While small loose-snow avalanches are relatively insignificant in terms of volume or impact force, they often occur on steep terrain. Even a sluff can have significant consequences if a person is in a precarious position or a hazard exists below (e.g., a climber on steep, technical ground; cliffs, water, or confined terrain where snow could pile up deeply). Due to the high density of slushy snow, large wet loose-snow avalanches can have very significant destructive potential—enough to destroy mature timber and buildings.

**Predictability**: Loose-snow avalanches are somewhat easier to predict than slabs. The conditions that produce them and the characteristics of the snow at the time and point of 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 destructive potential or size can have serious consequences.

**Slab Avalanches**

Slab avalanches start as a unit of cohesive snow. The unit of snow becomes separated from the surrounding snow when the bonds between it and the snowpack fail. 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. 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*. The failure layer is often thin (<1 cm/0.5 in) 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*.

**Appearance:** A slab avalanche generally has an angular shape, with the fracture line usually running horizontally 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.

**Hardness:** Slabs can be very hard and cohesive (e.g., hard enough to walk on; so hard that skis do not penetrate) or quite soft (for example, soft enough that they are almost powder skiing snow).

**Moisture:** Snow moisture content at the start point can range from dry to wet.

**Deposit:** Large, dry slab avalanches create a deposit that generally consists of small, fine-grained particles of snow. In smaller dry slabs, debris may contain angular chunks. Deposits from wet slabs often look similar to wet loose-snow avalanches and may contain rounded chunks or snowballs and ridges, channels, or runnels in the deposit surface.

**Depth:** Slab avalanches may involve only a thin layer of surface snow, deeper layers in the snowpack, or the entire depth of the snowpack. The slab itself may actually be buried below the upper layer of snow, so that surface conditions provide little clue as to the actual location of the slab on a slope.

**Weather:** Slab avalanches can occur in all weather conditions, from the midst of severe storms to long-term clear, sunny periods.

**Speed:** Significant speeds are possible, up to 200 kph/125 mph in the case of dry avalanches on steep terrain or when airborne. On flatter terrain and smaller slopes, speeds will likely be considerably lower—as low as 40-kph/25 mph or less.

**Area:** Small slabs may involve only a portion of a slope, perhaps a few square meters, while large ones might include entire mountainsides, tens of thousands of square meters or more. In extreme cases, slabs will involve more than one mountain or slope as the fracture line moves across aspects, over significant terrain features, and from one elevation zone to another over distances of several kilometres.

**Volume:** From a few cubic meters for very small, localized failures to hundreds of thousands of cubic meters or more in the case of large occurrences.
Mass: A small slab may contain only a few hundred kilograms of snow. Large slabs made up of dense snow layers may involve 100,000 tons or more.

Impact Force: Small soft slabs likely have very low impact forces, perhaps less than 100 kg/m². Large slab avalanches might have impact forces of 50,000 kg/m² or more.

Destructive Potential: Generally more destructive than loose-snow avalanches. Small slabs may be relatively insignificant in terms of volume or impact force. If they occur on steep terrain, even a small slide can have significant consequences if a person is in a precarious position or a hazard exists below (e.g., a climber on steep, technical terrain; cliffs; water; or confined terrain where snow could pile up deeply). With their higher density and greater speeds, large slab avalanches can have very significant destructive potentials—enough to destroy large areas of forest or entire villages.

Predictability: Slab avalanches are significantly harder to predict than loose-snow avalanches. The conditions that produce them, the stability of the snow at a given time, and the point of failure are relatively difficult to observe and assess. Much of the science and technology of avalanche hazard assessment and forecasting is directed at slab avalanches. Most courses, this one included, focus heavily on slab avalanches.

**Powder Avalanches**

A true powder avalanche consists of snow particles suspended in air (an aerosol) with no associated dense core. Powder avalanches form when the core of a dry slab stops or is diverted and the powder cloud continues, leaving the core behind. Powder avalanches may also form when a slab becomes airborne and the powder component is separated from the main mass, or when loose snow avalanches become airborne and dissipate into an airborne suspension.

Because it is mostly air and contains little mass, the destructive potential of a powder avalanche is less than a similar speed “flowing” avalanche. This may not be an insignificant hazard if they are large enough, moving at high speeds or affecting a person who is in a precarious position with hazards below.

Large, dry slab avalanches are often mistakenly referred to as powder avalanches due to the large powder clouds that often occur. The cloud makes it look as though they consist only of airborne powder. In reality they still contain a dense core most of which is running at or near the ground, obscured by the powder cloud.

**Air Blast**

Anecdotal accounts attribute significant damage to air blasts associated with large avalanches. Research shows that these air blasts precede the main mass of an avalanche as a pressure wave and affect people or structures even when the main mass does not.

Air has a much lower density than the cloud of snow that forms a powder avalanche and is very low in density compared to the main mass of snow in a large avalanche. Thus, it seems unlikely that air blasts generate significant impact forces.
Avalanche Motion

Gliding Motion

- Speed: 0-25 kph/0-15 mph.
- Movement Characteristics: Some break-up of the initial mass may occur. Chunks, 30 cm in diameter, 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 often 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 25-60 kph/15-37 mph
- Movement Characteristics: Break-up of the initial mass occurs. Rounded particles of up to 10 cm/4 in. 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: Wet flowing motion avalanches tend to follow terrain features and are easily constrained or stopped. They often follow or flow around 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.
Dry Flowing Motion

- Speed: 25-120 kph/15-75 mph
- Movement Characteristics: Break-up of the initial mass occurs. Rounded particles of 10-30 cm/4-12 in 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.

Notes:
Escape Strategies

- If watching a slide in the path above you, rapidly move down and across towards nearest safe area beyond the avalanche path.
- If caught, the first few seconds are the most critical in terms of your chances of avoiding injury and burial. Do whatever is necessary to get off the fracturing slab, including clawing, swimming, rolling, grabbing trees, or whatever one has to do to get to the edge or to snow that has stopped moving.
- If unable to escape, get rid of skis, poles, etc.
- Keep pack on unless it is restricting attempts to escape. (A pack increases your volume and helps keep you higher in the debris. Also, it may protect your back.)
- Once the snow is moving quickly, survivor evidence seems to indicate that there isn't much one can do (short of getting rid of your skis and pulling the trigger on your airbag if so equipped). The best tactic is to roll into a ball with your arms and legs together reducing the chance of injury and protecting your airway.
- As the avalanche begins to slow down, focus on protecting your airway.
- If buried, fight to the surface.
- If unable to get to the surface, push snow away from face to create an air pocket.

Notes:
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:

- **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 skier in Colorado were talking to a climber in California, 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 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 skier in the Columbia Mountains can discuss a D3 avalanche with a climber in the South Coast Mountains and, to some extent, convey the magnitude of the event by simply stating the classification.

A destructive-potential-based classification 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).
Avalanche Terrain

Appropriate terrain selection is the ultimate goal of backcountry decision-making. Developing the knowledge and skill 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 be sure that you are minimizing risk if you are traveling in terrain where avalanches can’t start and will not run. While weather, snowpack, and other factors are in a constant state of change, terrain is a relatively static part of the avalanche puzzle that changes little over time. This makes terrain one of the easiest variables to understand. Therefore, terrain is a key component in decision making, especially for travelers with little training or experience.

To understand terrain and decide if an avalanche might occur and with what results, we need to be able to quickly and effectively:

- Identify avalanche terrain.
- Assess if the terrain is more or less likely to produce avalanches.
- Determine if avalanches might run through the terrain.
- Identify safer areas and more dangerous areas.

Classic avalanche paths have relatively easy to identify start zones, tracks, and runout. However, it is important to recognize that small, poorly defined paths can also be deadly.

The observations we use to assess whether we are in terrain where avalanches might start or run are:

- Incline
- Aspect (Wind/Sun Exposure)
- Configuration factors:
  - Slope shape
  - Terrain traps
  - Slope support
  - Trigger points
  - Variability
  - Anchors
  - Elevation
  - Ground cover
  - Interaction with weather

Skiing avalanche terrain

You may choose not to travel in areas where avalanches start. This does not mean that you are safe. Even though an avalanche may not start where you are traveling, it might run through the area. In some circumstances, when the snowpack is highly unstable, failure occurs in terrain that is clearly not a start zone and at a considerable distance from the start zone. A resulting avalanche can then affect you even though you are some distance away from the start zone.

Travel in avalanche terrain is often reasonable and appropriate. Always look for the best routes to travel and the terrain where, if something should happen, you have the best chance of survival.

The discussion and use of “islands of safety” in avalanche terrain is often overrated. Small stands of trees and rock outcroppings are likely trigger points given their shallower and uneven snow cover. If an “island of safety” is in the path of a potential avalanche, it may be subject to a tsunami wave! Safe areas are not “islands” within an avalanche path, but rather safe ground that will not be hit by a potential avalanche. Do not get the impression that using “islands of safety” is a license to travel in conditions when and where avalanche danger exists.
Recognizing Avalanche Terrain

Classic 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 classic and easily recognizable features: the start zone, the track, and the runout zone.

The start zone is where avalanches typically start in a classic avalanche path. 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 path where avalanche runs is almost indistinguishable from the surrounding terrain.

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 best 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.)
Starting Zone Factors

Incline

Inclines of 30°-45° are ideal angles for skiing, snowboarding, AND avalanches. Not surprisingly, this is where a large proportion of skier triggered slab avalanches start. Slopes at this inclination allow unstable snow to slide readily yet are flat enough to promote significant accumulations of snow before an avalanche starts.

<table>
<thead>
<tr>
<th>Angle of Incline</th>
<th>Avalanche Characteristics</th>
<th>Slope Equivalent in a Resort Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>0° – 25°</td>
<td>Infrequent wet snow avalanches and slush flows.</td>
<td>Beginner to intermediate slopes – green slopes</td>
</tr>
<tr>
<td>25° – 30°</td>
<td>Infrequent slabs in unstable conditions. Those that do occur tend to be large.</td>
<td>Intermediate slopes – blue slopes</td>
</tr>
<tr>
<td>30° – 35°</td>
<td>Slabs in very unstable conditions.</td>
<td>Advanced slopes – black diamond</td>
</tr>
<tr>
<td>35° – 45°</td>
<td>Frequent slab avalanches of all sizes.</td>
<td>Advanced to Expert terrain – double black diamond</td>
</tr>
<tr>
<td>45° – 55°</td>
<td>Many loose avalanches start, often dry; some slabs, usually small</td>
<td>Out of Bounds: cliffs and couloirs</td>
</tr>
<tr>
<td>55° +</td>
<td>Few avalanches start, sometimes loose dry.</td>
<td>Out of Bounds: alpine climbing terrain</td>
</tr>
</tbody>
</table>
**Wind**
Wind has a powerful influence on snow. Its greatest effect is to move snow from one place to another. This process is sometimes referred to as redistribution of snow. The slope exposed to the wind, where the snow is blown away, is the windward slope. The slope sheltered from the wind where the snow accumulates is the lee slope.

**Cross Loading**
Cross loading occurs when wind moves snow across a slope and snow settles into hollows or gullies. The wind originally loaded this slope from the south to north (right to left) (A). After the storm the northeast wind cross-loaded the slope from northeast to southwest/top to bottom (B).
Common Trigger Points
If you choose to enter avalanche terrain and perhaps even decide to travel through an area where avalanches occur, you need to learn more about trigger points. A trigger point is a specific location within a start zone where localized failure begins and leads to the propagation of an avalanche. These trigger points often occur at places where stress on the snowpack is concentrated or weak areas in the snowpack.

Slope Shape

Convex

Concave

Irregularities

Shallow

Protruding

Below Rocks/Cliffs

Below Cornices
The Formation of Layers in the Mountain Snowpack

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. The size and shape a snow crystal will have depends 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, it 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.

Once on the ground, the layers of the snowpack 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 and density, grain size and type may change, etc. Metamorphism can also change the nature of the bonds between layers. The bonds may gain or lose strength and failure characteristics may change over time as the layers above and below are metamorphosed or as the layer between a slab and a bed surface (the failure layer) changes over time.

The Effect of Weather at the Snow Surface

Weather effects play a role in changing the layers at or near the surface.

<table>
<thead>
<tr>
<th>Event</th>
<th>Effect on Snow Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>Creates thin stiff layers called wind crusts and dense snow deposits called wind slabs</td>
</tr>
<tr>
<td>Rain</td>
<td>Rapidly changes and weakens the surface layers, also freezes into a hard crust which could later become a buried weak layer or sliding surface.</td>
</tr>
<tr>
<td>Temperature</td>
<td>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</td>
</tr>
<tr>
<td>Sun</td>
<td>Solar radiation can soften and consolidate the snow surface and enhance the effects of above freezing temperatures.</td>
</tr>
</tbody>
</table>

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 is a complex special case. It is important to be able to observe this grain type as it becomes the failure layer for many avalanches. Surface hoar grows on the surface of the snow and is recognizable as a larger multi-layered crystal. This, often feathery, crystal grows large enough to be visible to the naked eye. It forms during cold, clear nights with near calm conditions. Some snow specialists describe it as “winter’s dew.” When surface hoar is buried by subsequent storms, it can become a persistent weak layer.

Surface hoar may form a failure layer
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. Weather factors influence the environment in the snowpack rather than 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 major 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 become more angular, less dense, and more loosely packed. This process is called faceting and creates a softer, less dense layer of snow.

Faceting is common in areas where the snowpack is shallow and air temperatures are cold, e.g., continental snowpacks and/or early season snowpacks. Near Surface Faceting can occur during periods when little or no new snow results in loose surface snow being exposed to clear skies and cool temperatures. Observers' notice the loose and larger grains 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. The faceted grains are relatively quick to form and slow to deform, and may persist as a buried weak layer for extended periods of time.

Rounding

Under certain conditions, usually when the snowpack is deep and air temperatures are consistently warm for extended periods of time, snow grains tend to become more rounded, denser, and more tightly packed. Bonds between grains become stronger through necking and sintering.

This process is called rounding and creates a harder, denser layer of snow. Rounding is common in areas where the snowpack is deep and air temperatures are warmer, e.g., maritime snowpack and/or late season snowpack.

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 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 becoming 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, ice-like 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.
Melting and freezing creating challenging travel conditions

Notes:
## Snow Climates

<table>
<thead>
<tr>
<th></th>
<th>Maritime</th>
<th>Continental</th>
<th>Intermountain (USA) Interior (Canada)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Weather</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Precipitation</td>
<td>High Rate</td>
<td>Low Rate</td>
<td>Mod-High Rate</td>
</tr>
<tr>
<td></td>
<td>Large Accumulation</td>
<td>Small Accumulation</td>
<td>Medium – Large Accumulation</td>
</tr>
<tr>
<td>Wind Transport</td>
<td>Much pre-storm</td>
<td>Little pre-storm</td>
<td>Little-to-some pre-storm</td>
</tr>
<tr>
<td></td>
<td>Much in-storm</td>
<td>Some-to-much in-storm</td>
<td>Some-to-much in-storm</td>
</tr>
<tr>
<td></td>
<td>Little post-storm</td>
<td>Much post-storm</td>
<td>Some post-storm</td>
</tr>
<tr>
<td>Temperatures</td>
<td>Warm</td>
<td>Cool</td>
<td>Cool</td>
</tr>
<tr>
<td><strong>Snowpack</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depth/Distribution</td>
<td>Deep, uniform</td>
<td>Shallow, variable</td>
<td>Mod–deep, variable early season; uniform later</td>
</tr>
<tr>
<td>Layering</td>
<td>Uniform</td>
<td>Strong over weak</td>
<td>Variable, faceted early season; Uniform and rounded late season</td>
</tr>
<tr>
<td></td>
<td>Rounded</td>
<td>Faceted</td>
<td></td>
</tr>
<tr>
<td>Temperatures</td>
<td>Warm</td>
<td>Cold</td>
<td>Cool</td>
</tr>
<tr>
<td><strong>Avalanches</strong></td>
<td>“Direct action”</td>
<td>“Delayed action”</td>
<td>Direct and delayed action</td>
</tr>
<tr>
<td></td>
<td>Many in-storm events, associated with significant storms. Some post-storm events, usually ending within 24 – 36 hours.</td>
<td>Some in-storm events often associated with minor storms. Many post storm, days or even weeks later, often not associated with significant weather.</td>
<td></td>
</tr>
<tr>
<td><strong>Avalanche Danger</strong></td>
<td>Quick to rise</td>
<td>Slow to rise</td>
<td>Quick to rise</td>
</tr>
<tr>
<td></td>
<td>Quick to fall</td>
<td>Often very slow to fall</td>
<td>Often slow to fall early season; quicker to fall late season</td>
</tr>
</tbody>
</table>

The three main snow climates have particular weather, snow pack, and avalanche characteristics. The characteristics of the various climates are general rules of thumb. Some areas in a maritime climate may look continental and vice versa. A cold, dry season in a maritime range may create a more continental snowpack in an atypical year and vice versa.

Many geographic variations exist, notably the American northeast that is considered an “Arctic Maritime” climate, and Alaskan/Canadian Territories climates that combine the “classic” 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. If you are from the Sierra, Pacific Northwest, or other maritime regions where the avalanche danger tends to improve fairly quickly after a storm ends and you are skiing the steeps 24 – 36 hours after it clears, do not use this approach in the Colorado Rockies where avalanche danger is often much slower to improve due to the climate.
Avalanche Danger

Avalanche danger takes into account a variety of factors that lead to a conclusion about what risk is posed to travelers and what actions might be appropriate to mitigate that risk.

Avalanche danger to backcountry recreationists is defined as:

“The potential for avalanches to cause death or injury to backcountry recreationists” – Greene, 2004

Avalanche danger is sometimes referred to as avalanche hazard.

For avalanche danger to exist, three conditions must be met.

- **Unstable snow** failure is likely to occur in the snowpack
- **Avalanche terrain**: if failure occurs in the snowpack, an avalanche will likely start and run
- **People, equipment, or facilities**: if an avalanche starts and runs, it will affect something that will suffer as a result

*If any one of the three conditions is missing, there is no danger.*

Assessing stability is a complex process that requires extensive training and experience. Whenever possible, Level 1-students should defer to the regional avalanche bulletin when ascertaining the stability. Specialists at regional centers watch and record the snowpack throughout the entire season. Their insights are valuable and should be a part of your risk management plan.

Avalanche terrain is the easiest avalanche danger factor to learn and assess, therefore, it is the most important in terms of this course. With relatively little training or experience, travelers can determine whether they are in avalanche terrain and avoid it if necessary.

If people, equipment, and facilities are exposed to avalanche terrain and/or unstable snow, it is (or should be) a conscious decision and therefore this relates strongly to decision-making. Decision-making is addressed in some detail in this course.

If all three conditions exist, then there is avalanche danger. Avalanche forecasters take a number of factors into account and determine the level of risk. They rate conditions based upon an internationally standardized scale to provide an avalanche danger rating.

Avalanche danger, as rated by trained and experienced professionals, is a significant part of the decision making process discussed in this course. Therefore, you must be aware of and familiar with the ratings and what they mean.

**Notes:**
Avalanche Danger Scale*

<table>
<thead>
<tr>
<th>Danger Rating</th>
<th>Color</th>
<th>Probability &amp; Trigger</th>
<th>Distribution</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODERATE</td>
<td>Yellow</td>
<td>Natural avalanches unlikely. Human triggered avalanches possible.</td>
<td>Unstable slabs possible on steep terrain.</td>
<td>Use caution in steep terrain on certain aspects (often described in avalanche bulletin).</td>
</tr>
<tr>
<td>CONSIDERABLE</td>
<td>Orange</td>
<td>Natural avalanches possible. Human triggered avalanches probable.</td>
<td>Unstable slabs probable on steep terrain.</td>
<td>Be increasingly cautious in steep terrain.</td>
</tr>
<tr>
<td>HIGH</td>
<td>Red</td>
<td>Natural and human triggered avalanches likely.</td>
<td>Unstable slabs likely on a variety of aspects and slope angles.</td>
<td>Travel in avalanche terrain is not recommended. Safest travel on windward ridges of lower angle slopes without steeper terrain above.</td>
</tr>
<tr>
<td>EXTREME</td>
<td>Red with Black Border</td>
<td>Widespread natural or human triggered avalanches certain.</td>
<td>Extremely unstable slabs certain on most aspects and slope angles. Large and destructive avalanches possible.</td>
<td>Travel in avalanche terrain should be avoided and travel confined to low angle terrain well away from avalanche path run-outs.</td>
</tr>
</tbody>
</table>

*Greene, 2004

Avalanche danger ratings are often accompanied by or augmented with additional information about weather, snowpack, avalanche activity, as well as more specific travel advisories or recommendations. The avalanche danger rating for the areas in which you plan to travel is a primary part of the decision making process. Danger ratings and accompanying information apply to large areas and are generally not specific on a small scale. Reports give a general idea of overall risk to travelers, but should not overrule common sense or decision making while in the field. Local conditions often vary from the general ratings provided by public bulletins and forecasts. Travelers are advised to use caution at all times when in or exposed to terrain where risk is increased (i.e., inclines 30° or above, lee, cross-loaded and solar effected aspects, around trigger points and when terrain traps are present).
Avalanche Danger Factors

Observation Techniques and Clue Gathering
Avalanche Danger Factors are the main factors that affect or influence avalanche danger. The factors that affect avalanche danger are organized into Information Categories, and then into Observations or Obvious Clues for each category. Red flags are observations that meet or exceed critical parameters. Red flags indicate that avalanche danger is likely high or increasing. The danger factors include: avalanche activity, snowpack, and weather. By looking at these danger factors we can seek clues that help us ascertain avalanche danger.

Avalanche Activity

Information Category: *When*

Obvious clues and red flags:
- **Current**: Any avalanche that is observed or is <12 hours old
- **Recent**: Any avalanche 12-36 hours old (Maritime climate) or 12-48 hours old (Continental climate)
- **Past**: Any avalanche >36 hours old (Maritime climate) or >48 hours old (Continental climate)
  
  Red Flag if conditions that caused it may still exist

Information Category: *Where*

Obvious clues and red flags:
- **Area**: Widespread
- **Terrain configuration**: Any avalanche on terrain similar to where you are
- **Terrain traps**: Any avalanches that involve terrain traps similar to where you are

Information Category: *What*

Obvious clues and red flags:
- **Natural triggers**: Any naturally-triggered avalanches
- **Human triggers**: Any human-triggered avalanches (or triggers similar to human loads)
- **Remote triggers**: Any avalanches triggered from a location away from the trigger point (trigger point does not avalanche)

Information Category: *How*

Obvious clues and red flags:
- **Destructive potential**: ≥ Size D2 (large enough to bury or injure a person)
- **Propagation**: Wide fractures and running far
- **Failure layer**: Loose, unconsolidated, angular grains

Snowpack

Information Category: *Snow cover*

Obvious clues and red flags:
- **Height**: Average less than 1.5 meters
- **Strength**: Weak
- **Variability**: Highly variable

Information Category: *Layers*

Obvious clues and red flags:
- **Strength**: Strong over weak (especially if strong over thin and weak)
- **Temperature**: Near or = 0°C (32°F)
- **Grain characteristics**: Large, loosely packed, angular

Information Category: *Snowpack Tests*

Obvious clues and red flags:
- **Strength**: ≤ Compression test CTV, CTE, CTM, ≤ Rutschblock 4
- **Plane characteristics**: Smooth, clean, planar
- **Failure layer**: Large, loosely packed, angular grains
Information Category: **Whumphing** (Instability Signs)

Obvious clues and red flags:
- Initiation: Human or machine triggered
- Propagation: Far
- Extent: Widespread

**Weather**

Information Category: **Precipitation**

Obvious clues and red flags:
- Type: Rain (obvious) or dense snow (how does it feel as you travel?)
- Intensity: ≥ 3 mm of water per hour (approximately 3 cm of snow/hr)
- Accumulation: ≥ 30 mm of water in a 12-hour period (approximately 30 cm of snow)

Information Category: **Wind**

Obvious clues and red flags:
- Speed: Strong enough to move snow
- Direction: Moving snow onto or across slopes where we want to travel
- Duration: Long enough to move significant amounts

Information Category: **Temperature**

Obvious clues and red flags:
- Current temperature: Near or ≥ 0°C
- Maximum and minimum: Near or ≥ 0°C
- Trend: Rapid changes (≥ 5°C in a three-hour period) especially from cold to warm and even worse if rising to above 0°C

Information Category: **Solar Radiation**

Obvious clues and red flags:
- Cloud cover: Allowing a lot of radiation to enter or intensifying radiation
- Intensity: Strong (how does it feel on your face?) or rapid onset
- Duration: Long

The avalanche danger factors, information categories, and obvious clues discussed here are a significant part of the decision making process. However, people often de-emphasize “non-technical” data and emphasize what is perceived as more scientific and therefore more important. **In fact, less-technical information is easier to gather, takes less training to interpret, and generally is more useful to less experienced decision makers.** This is not to discourage you from collecting precise observations, like looking at grain types under a magnifying lens or doing snowpack tests - just don’t put too much emphasis on this data until you have more experience and training.

The system described here is intended neither as a set of hard and fast rules nor as a formula or calculation that will provide you with the “right answer.” It is intended to get you to ask the right questions, ensure you don’t miss the obvious, and encourage the use of common sense. Even for experts, analyzing and forecasting snow stability and avalanche danger is an inexact science loaded with extrapolation and probability. Even the most experienced decision makers generally allow for a margin of error, margins being greater when uncertainty is higher.

Those with less training and experience should always err on the side of caution when selecting terrain. This is especially so when conditions are ambiguous, when you feel uncertainty, and/or when conditions are beyond the scope of your training or experience. Few or no special tools are required to determine obvious clues. Many of the observations require only that you be observant. **The AIARE Observation Checklist is a tool that we can use to help us organize and prioritize the many observations we make.**
AIARE Observation Checklist

How to use the AIARE Observation Checklist

The Observation Checklist is a tool that can organize and prioritize observations in order to make them more useful for terrain selection. Use it during pre-trip planning, in the field, or at the day’s end as part of a debrief. Think of it as ONE of several tools used in the decision making process. Consider that decisions based upon inaccurate assumptions have resulted in avalanche fatalities.

Step 1: Review the Avalanche Bulletin and Professional Opinions
First, get the recent avalanche bulletin from a reputable source. Transfer and circle the reported danger rating. Consider the forecast trend. Circle information on the Checklist that can be gathered from the bulletin.

Step 2: Gather Additional Relevant Information
Next, draw upon information gathered from your own or other’s skilled field observations as well as any other reliable sources. Circle confirmed or verified observations in each column in the Checklist. Identify any gaps or “holes” that would be useful to your decision making process that remain unknown or uncertain. Mark those missing observations with a big “?” and plan how to acquire this info.

Step 3: Re-assess and Look for Obvious Clues or “Red Flags”
After identifying known and unknown factors, try to form an overall picture of the relative danger. The more circles on the right side of the Observation Checklist, the higher the danger, the more circles on the left, the lower the danger. Note that an experienced observer’s interpretation of how weather and snowpack factors influence avalanche danger may be different than yours. However, some critical factors should always indicate high danger even to a novice (i.e. rain on snow; significant new snowfall + moderate winds + rising temperatures, or widespread avalanche activity). Many of these “red flags” are typed in bold print in the checklist.

Step 4: Consider Any Factors That Can Reduce Your Ability to Make Accurate Observations
Assess the quantity and quality of your information and identify the source. Have you used information from this location previously? Who in your group is experienced at interpreting weather and snowpack data? Did your trip allow you to gather relevant information useful to your terrain choices? Did fatigue, visibility or route errors compromise your information gathering? Did group members accurately convey their observations to each other?

Step 5: Relate Circed Critical Factors to Your Decision Making Framework
Prior to your trip, use this information and your group profile information to choose appropriate terrain. Discuss options and travel techniques when previewing the map and terrain photos.

Step 6: “Greater Uncertainty Requires A Greater Margin of Safety” - C. Stethem
In the backcountry, reassess your decisions throughout the day. Try to make additional observations that reduce the number of question marks to raise your confidence in your ability to perceive avalanche danger trends. As you acquire more information, you must also reassess human factors and your trip plan. Be prepared to enact an alternative trip option.

Through regular practice with this checklist, you should eventually be able to internalize these avalanche danger factors and integrate the process of efficiently gathering observations and obvious clues into your terrain selection process.
## AIARE Observation Checklist ©

### AVALANCE DANGER RATING

<table>
<thead>
<tr>
<th>Current DANGER RATING?</th>
<th>Low (Green)</th>
<th>Moderate (Yellow)</th>
<th>CONSIDERABLE (Orange)</th>
<th>HIGH / EXTREME (Red)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Danger TREND?</td>
<td>Decreasing or no change</td>
<td>Decreasing or no change</td>
<td>INCREASING</td>
<td>INCREASING RAPIDLY</td>
</tr>
</tbody>
</table>

### AVALANCE ACTIVITY

<table>
<thead>
<tr>
<th>WHEN?</th>
<th>Past</th>
<th>Past</th>
<th>Recent or CURRENT</th>
<th>CURRENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHERE in the terrain?</td>
<td>No avalanches or isolated to extreme terrain</td>
<td>Limited to specific features on steep/extreme terrain; No to few naturals</td>
<td>LOCALIZED to areas w/ certain snowpack characteristics; Few to some naturals in steep terrain</td>
<td>Any moderate to steep terrain; NATURAL AVALANCHE CYCLE</td>
</tr>
<tr>
<td>Size / Character?</td>
<td>Sloughs or small slabs</td>
<td>Small to medium slabs</td>
<td>Some small to medium slabs Isolated larger slabs w/ GREATER RUNOUT EXTENT</td>
<td>WIDESPREAD SLABS w/ FULL RUNOUT POTENTIAL all sizes</td>
</tr>
</tbody>
</table>

### SNOWPACK OBSERVATIONS

<table>
<thead>
<tr>
<th>Cracking, Whumps &amp; Test skiing results</th>
<th>None or few</th>
<th>Isolated</th>
<th>Instability localized to specific terrain features</th>
<th>WIDESPREAD Instability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storm Snow and Wind?</td>
<td>Little or none</td>
<td>&lt;8” (20cm) storm snow &amp; a few thin wind slabs</td>
<td>≈12” (30cm) RECENT STORM SNOW &amp;/or wind slabs on lee or cross-loaded slopes</td>
<td>&gt;12” (30cm) STORM SNOW + RECENT WIND LOADING + RISING TEMPS</td>
</tr>
<tr>
<td>Slab stiffer (&gt;1 hardness step) than underlying weak layer?</td>
<td>No</td>
<td>Possibly in specific terrain</td>
<td>Yes, localized by aspect, elevation &amp; terrain configuration</td>
<td>WIDESPREAD &amp; REACTIVE PERSISTENT WEAK LAYER UNDERLYING A SLAB</td>
</tr>
<tr>
<td>Weak layer includes persistent grain type?</td>
<td>No</td>
<td>Possibly in specific terrain</td>
<td>Possibly, localized by aspect, elevation &amp; terrain configuration</td>
<td></td>
</tr>
<tr>
<td>Weak layer can be triggered? ≈ 8”– 36” deep (20 - 85cm)?</td>
<td>No</td>
<td>Possibly in specific terrain</td>
<td>Yes, localized by aspect, elevation &amp; terrain configuration</td>
<td></td>
</tr>
<tr>
<td>Snowpack Tests?</td>
<td>No results / Breaks</td>
<td>Mostly Resistant fractures (Q2) or inconsistent Large Column Tests</td>
<td>Mostly SUDDEN fractures (Q1) or positive Large Column Test results</td>
<td>Consistent SUDDEN fractures (Q1) &amp; positive Large Column Test results</td>
</tr>
</tbody>
</table>

### WEATHER OBSERVATIONS

<table>
<thead>
<tr>
<th>Precipitation Type / Rate?</th>
<th>NO or Light Snow &lt;0.5” (=1cm) / hr</th>
<th>Moderate Snow &lt;1”hr (=2cm) / hr</th>
<th>HEAVY SNOW ≈2” (=5cm) / hr or RAIN</th>
<th>PROLONGED STORM VERY HEAVY SNOW &gt;2” (&gt;5cm) / hr or RAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blowing Snow?</td>
<td>None</td>
<td>Light; Limited &amp; localized blowing snow</td>
<td>Moderate; Some LEE/CROSS SLOPE LOADING</td>
<td>Moderate; EXTENSIVE LOADING</td>
</tr>
<tr>
<td>Temps / Radiation?</td>
<td>Cold - Cool</td>
<td>Cool - Warm Moderate Radiation</td>
<td>RECENT WARMING EVENT ≥32°F (0°C) air temp w/ strong radiation or rain on snow</td>
<td>RAPID WARMING</td>
</tr>
<tr>
<td>Last Red Flag Storm Ended?</td>
<td>&gt; 48 hours ago</td>
<td>36 - 48 hours ago</td>
<td>&lt; 36 HOURS AGO</td>
<td>ONGOING</td>
</tr>
</tbody>
</table>

Consider any factors that can reduce your ability to make quality observations.
Circle critical factors and relate this checklist to your Decision Making Framework.
Notes:

Hyak avalanche, Snoqualmie Pass, WA

Photo: K. Fitch
Human Factors

Terrain selection in the backcountry should involve a thorough consideration of human factors. Human factors are the qualities of being human that serve us well in many aspects of our lives, but that often lead us to make inappropriate decisions in the backcountry. Every human is unique, so each of us is susceptible to a countless number of human factors.

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).

Human factors play major roles in most avalanche accidents. By becoming familiar with some of the specific pitfalls, we can hope to recognize similar factors playing a role in our own decision making. If we can learn to recognize when our own human factors are affecting a decision, we may be able to stop ourselves before we do something that leads to a serious accident. This is often the most daunting obstacle faced by backcountry travelers.

Given the difficult task of dealing with inevitable human factor problems that may arise, some recent research (The better the team…, 2004) is giving us tools with which to deal with these problems.

In many instances, a day in the backcountry with friends is seen as great way to get together, catch up, and have fun. We are sometimes reluctant to admit that if we are heading into avalanche terrain, we will be traveling in a high-risk environment. Much of what the AIARE Level 1 course focuses on is to give you the tools and beginning knowledge to recognize avalanche hazard and to assess the risk. The following are some ways to approach troublesome human factors before they arise:

- Choose partners who have similar risk acceptance levels and with whom you can easily communicate. Your partners should have similar and agreed-upon goals, objectives, and route options as well as comparable travel skills.
- Become a team. In a team, everyone is responsible for the outcome. Encourage group members to communicate observations and to challenge group decisions when uncomfortable. Everyone has veto power should they feel the risk is unacceptable.
- When no “group leader” is assigned, the group must “self manage”. To do this the “team mentality” must be employed. If a group leader is assigned, buy-in is better achieved by including all in the decision making process.
- Communication within the group is the only way any of these approaches can be employed. Start the day out asking what everyone in the group feels the avalanche danger is and what their recommendations are for avoiding trouble. Revisit this discussion often during the day.

The goal of all backcountry ski trips is to return safely. The objective of a trip may be to ski “Big Bowl” or climb “Mellow Mountain,” but the goal is always to return safely. Making a clear distinction between the goal and the objective at the start of the trip and utilizing the communication methods mentioned above may set the stage for dealing with human factor problems before they become problematic.

The following list contains some other common human factor issues. These factors, while less technical and generally of less interest to most decision makers, probably account for more accidents and incidents than avalanche danger factors alone. They warrant serious consideration in and throughout any decision making process. If you sense that any of these factors is arising during your tour, consider it a human factor “red flag” and reassess.
• **Age and Gender:** In general, younger males (typically aged 17 – 27) are more willing to accept risk than older people and females. As the baby boomers age, the high end of this age group is rising.

• **Dependents:** In general, people who have dependents (especially young children) tend to be less willing to accept risk than those with no dependents.

• **Technical Proficiency/Physical Condition:** Those who have a high level of technical proficiency and are in excellent physical condition are often more willing to accept risk than novices.

• **Blue Sky Syndrome:** Conditions never seem as bad when the sun is shining and the skies are blue, so people tend to be more aggressive in good weather than in bad.

• **Fun Factor:** The enjoyment derived from skiing, boarding, or sledging provides a powerful urge to have fun in spite of suspecting or knowing avalanche conditions may be less than ideal. People are less apt to turn back when they are having or anticipating fun.

• **Goal Seeking:** The more important the objective, the more people are willing to ignore risks to achieve it.

• **Logic vs. Emotion:** People often make emotional decisions when anticipating a good time, nearing a goal, or seeking validation in a group. In such cases, emotion can overpower the logic that indicates conditions are marginal.

• **“Real” Risk:** At times, perceived risks can obscure real risks. For example, someone who is afraid of falling may perceive that to be the main hazard while on an unstable slope, when in actual fact the real risk is an avalanche. Someone may perceive the risk of avalanches is low when on a small feature while the real risk is a terrain trap below.

• **Back to the Barn Syndrome:** The urge to simply “get it over with” and return to safety, food, and shelter is powerful. Late in the day, when people are tired and nearly home, is a time when poor decisions are often made.

• **Negative Event Feedback Loop:** If people are unaware of exposure to risk, or if they deliberately expose themselves and nothing happens, they eventually become hardened to that risk and may, in time, expose themselves without undertaking a proper decision making process. At that point they are simply taking chances instead of making a calculated, conscious decision to accept risk.

• **The “Risky-Shift” Effect:** Groups find security in numbers and tend to accept risks that no individual in that group would be willing to accept if alone.

• **Communications and Empathy:** People who do not communicate well and/or have little empathy for others may “bully” a friend or acquaintance into accepting and playing along with a poor decision.

• **Stress and Pressure:** Decision making is compromised when under stress or pressure to perform. Stress and pressure are often perceived to be coming from external sources (employer, client, peer group, etc.) when in reality they often are a result of internal factors (desire to meet expectations, fear of failure, inexperience or uncertainty, etc.).

• **Low Self-confidence:** Lack of self-confidence can lead people to distrust their instinct 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.

• **Unwillingness to Listen to Others:** In many cases, “more experienced” leaders are unwilling to listen to the concerns or feelings of “less experienced” group members who may have information or knowledge that is pertinent.

• **Overconfidence:** Often, “experienced” and “knowledgeable” people misinterpret the data they have observed and recorded. In many cases, this is due to overconfidence in one’s training, personal knowledge, and/or experience.

• **Limited Observations:** Looking at one or even several variables in isolation does not account for the infinite potential combinations and permutations. In many cases accidents result not from a single variable but from a combination. The cumulative effect of one variable acting in combination with others greatly compounds the problem and increases the complexity of assessing conditions.
• **Lack of Experience**: Effective decision making in the complex game of avalanches relies primarily on a broad and deep experience base accumulated over time in a variety of situations. If someone lacks experience in a given situation, “intuition” can let down even the “experts.”

• **Lack of Leadership**: When clear leadership or command is absent, the decision making process often stalls. This is especially true in peer groups that lack any formal command structure to facilitate the process of taking in information, analyzing it, and acting. In some cases, inaction is as dangerous as making the wrong decision.

• **The Big Picture**: It is easy to narrow one’s focus and concentrate closely on one or two factors, especially in a difficult situation, if an error is made, or when experiencing problems. This may lead to missing significant, critical factors in other areas of concern or missing the cumulative effect of several, apparently minor factors, working in concert. Decision makers must maintain a clear view of the overall situation and maintain their awareness of all pertinent factors (Snow Sense, 1984).

**Heuristic Traps in Avalanche Accidents**

Ian McCammon has conducted considerable research on recreational avalanche accidents (McCammon, 2004). His findings on “heuristic traps” may help us identify when we might be likely to fall into one of these traps. A “heuristic” is considered a “rule of thumb that guides most of our decisions in everyday life.” While heuristics may work most of the time, they don’t always translate to decision making in avalanche terrain. We are most likely to fall into these “traps” **during times of uncertainty** that recreationists often times experience in the backcountry.

• **Familiarity**: People often feel comfortable in familiar areas. Statements such as “I’ve never seen it avalanche here before,” mean nothing. If a slope steep enough to slide has unstable snow and a trigger, then it can avalanche, no matter how familiar it is to you.

• **Social Proof**: Others are at the trailhead and heading out, so it must be safe! Similar to the busy restaurant; the food must be good, though in both cases this may not be correct.

• **Commitment/Consistency**: Stating a goal and committing to it prior to the actual day of the trip can lead to problems. We all want to be true to our word. Sometimes the commitment needs to be re-examined given the existing conditions as opposed to when the commitment was made.

• **Scarcity**: Powder Fever! The idea that all the powder will be skied up by the others at the trailhead makes us rush our decisions and filter out the more important data.

• **Acceptance**: The tendency to engage in activities that we think will get us noticed or accepted by our peers or people we want to respect us.

• **Expert Halo**: The tendency to assign the “expert” moniker to someone within the group who may not be fully qualified to deserve that designation.

In the above discussion on human factors, we have identified many of the “perception traps” and “heuristic traps” that we potentially could encounter or fall prey to in the backcountry. Many of these traps can be avoided by using the tools and information you have received in this course. Begin with accurate planning and preparation: prior to getting in the field ask yourself “Who am I going with?” Can you communicate well with these team members; is their risk acceptance level similar to yours? Make sure you use team concepts and avoid becoming just another random group with no plan or options in place. Have everyone in the group be responsible for the trip outcome.

In some instances you may find yourself in a group where you can sense they may be oblivious to the fact that they are recreating in a high-risk environment. They may also be unaware of these human factors we just mentioned. You will need to set the platform for communication within this group. One simple “ice breaker” in such a group is to ask what they think the avalanche danger is that day. This can get the communication ball rolling and from there attempt to foster a strategy to deal with the tour. If you can see your efforts are falling on deaf ears, reconsider becoming part of such a group.

Use your “Observation Checklist” to help you ascertain what the danger trend is. You now know what avalanche terrain looks like, so when you travel through it, utilize appropriate terrain selection for the conditions and your group’s abilities along with proper travel techniques to further minimize risk. During this formative stage of your backcountry experience, err on the side of caution. Take little bites and you’ll live to eat the whole pie!
Common Errors

Analysis reveals certain errors common to many accidents.

**Errors Related To Avalanche Activity Observations**
- Missing or ignoring avalanches that have occurred recently
- Getting surprised when slab avalanches propagate over wide areas

**Errors Related To Snowpack Observations**
- Not recognizing layers deep in the snowpack
- Missing thin, weak layers
- Missing or ignoring cracking and whumphing

**Errors Related To Weather Observations**
- Underestimating the effect of wind action
- Underestimating the effect of rapid temperature changes
- Forgetting that snow can lose strength very quickly on sun-exposed slopes

**Errors Related To Terrain**
- Getting surprised when avalanches are triggered from "safe" zones (i.e., flat terrain below)
- Not recognizing terrain traps
- Underestimating runout potentials
- Not realizing that snow-filled gullies are often heavily cross-loaded
- Forgetting that even small slopes can have serious consequences

**Errors Related To Travel Techniques**
- Losing a member of the party
- Leaving a member of the party behind
- Allowing a member of the party to travel alone
- Traveling alone

Notes:
Planning and Preparation

Planning and preparation form the foundation for managing risk. In this phase of a trip, we gather the necessary information to make a route plan from home, and we manage potential future risk by setting ourselves up for success and preparing for possible emergencies.

Planning and preparing for a trip requires a full assessment of the group’s human factors and the avalanche danger factor observations. These two factors are essential to consider as a trip plan is created. The trip planning we do at home involves our first, and often most important, terrain selection decisions. We need to figure out where we want to be, and when. Route planning, time planning, map reading, and navigation are skills required for safe backcountry travel. We must also be practiced and familiar with rescue techniques and equipment well before the trip. Group and personal equipment must be prepared and packed for each and every trip.

Make and use a trip checklist.

Sample Pre-Trip Checklist

- Read the latest avalanche information bulletin and gather other available avalanche danger information
- Assess human factors
- Create a group profile
- Set appropriate goals and objectives
- Research trip and route
- Prepare a route and time plan
- Prepare options and alternatives
- Establish a risk management plan with an emergency plan and a line of command
- Prepare and pack equipment

All advice, information, analyses, etc. that are not firsthand should always be taken with a grain of salt. Consider the source, their experience and knowledge base, their motivations are for providing information, etc., before placing value or trust in the information or its source.

Group profiles and lines of command are perhaps more important on professional trips where guides or companies offer a service. Groups of people not known to each other, such as club or school members with assigned leaders, should probably use profiles and command structures that are more formal rather than less. Peer groups and friends may need to do little in the way of profiling and creating a command structure. However, some basic information about members of your group can be very useful if an accident occurs (even if not avalanche-related) and medical care is required. This is especially true in cases when a trip takes place away from home where family or emergency contacts are not immediately available. Establishing a line of command in advance is a well-proven strategy for dealing with critical incidents. In an emergency, when time is critical, having one leader and several rescuers is almost always more effective than having many leaders attempting to control the situation.

Group Profiles and Lines of Command

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

- Name and emergency contact information
- Food and/or drug allergies
- Medical conditions or prescription medications
- Fitness
- Skill level
- Goals

In addition, the following roles and issues should be clarified:

- Trip coordinator
- Field leader
- Objectives

By gathering personal information and addressing group issues, a profile of the group and clear lines of command can be established. Having personal information on hand makes a significant difference to medical caregivers should an emergency arise (even if it is not related to avalanches). Knowing who is in charge (even if nominally)
gives people who have questions or concerns someone to go to discuss things. Compatibility between people in terms of skills, fitness, and goals/objectives helps the trip run more smoothly.

**Emergency Response Plan**

It is important that all groups have and verbalize an emergency response plan. If group members share a mental picture of what to do in case of an accident, they will react more efficiently. This plan should address the following considerations:

- Skills, abilities, and training of each group member with rescue procedures, techniques, and equipment
- Skills, abilities, and training of each group member in emergency medicine (first aid, CPR, EMT, etc.) and/or wilderness medicine (WFR, WEMT, etc.)
- Line of command
- Communications: VHF radio with local emergency frequencies, cell phone and/or satellite phone with emergency phone numbers
- Remoteness: amount of time to reach reliable communications and subsequent definitive medical care
- Availability of resources (equipment, people) to move an injured person if necessary, or to keep the condition stabilized until help arrives
- Availability of resources to enact a rescue while caring for an injured patient

Discuss this plan in detail as a group prior to the trip. Imagine that a serious accident has happened on the trip and visualize a group response. Go through this exercise carefully to be sure you have addressed all possible considerations. If you plan to travel to a new or unfamiliar location, research local resources to create a useful and effective plan.

**Avalanche Danger Information**

An important component of terrain selection and decision-making is the collection of information about avalanche danger factors. We can gather only a limited number of direct observations about the area we are going to before we get out there, but invaluable information is available from a variety of other sources.

Before your trip gather the following information:

- Current and forecasted avalanche danger information
- Recent weather observations, current conditions, and forecast
- Snowpack observations (both formal snow profiles and/or informal information)
- Past avalanche activity
- Recent avalanche activity
- Current avalanche activity

Pay special attention to red flags and document them in a field book. Use the Observations Checklist to help you process the information you have gathered.

**Trip Planning**
Trip and Route Planning

Trip and route planning 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
- Periodicals (magazines, newsletters)
- Internet: backcountry sites
- Aerial photographs
- Google Earth
- Topographical maps
- Private industry
- Local recreationist
- Historical accounts

Below, a slide path is outlined in black on a photograph and map. From the map you can determine that the slope is north facing and suitably steep. Upon arriving at the location you see two large slide paths that end in the trees. What are your options?

Berthoud Pass, CO. Images courtesy of the Colorado Avalanche Information Center.

A Trip Plan Includes

- Ideal trip: what the group would like to do and is capable of doing.
- Safer trip: safer trip(s) in the area that minimize exposure to avalanche hazards. Suitable for use if risk increases.
- Safest trip: the safest trip in the area that avoids avalanche hazards. Suitable for use when risks are great and the conditions encountered are more dangerous than expected.

Route planning involves taking all the information you have gathered and applying it to the trip you hope to do. Break the trip into a series of legs that start and end at recognizable points. Each leg can be described using a route card.

- Start and end points for each leg
- Compass bearings, out and back
- Elevation difference
- Distance of leg in miles or kilometres
- Estimated time
- Actual time
- Notes of navigation plan, handrails, UTM coordinates
Sample of what might be considered a more formal tour plan.

**Time Planning**

Determine at what time you need to be where. Generally, add extra time when it is critical (i.e., before dark, or when avoiding time-related hazards).

You 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. Give yourself a margin of error for unforeseen factors. Some rules of thumb to experiment with include:

**Calculating the Time per Leg of Trip**
- Estimate ~1-3 mph average horizontal speed
- Estimate ~1000 vertical feet per hour - ascent
- Estimate ~2000-3000 vertical feet per hour - descent
- Estimate ~10-15 minutes per hour for breaks

**The Swiss Formula**
- Every 100m (330 ft) of ascent or descent = 1 point
- Every 1 km (0.6 mi) of horizontal distance = 1 point
- Time in hours = add points and divide by 4 for ascent time, divide by 10 for descent time

**Total Trip Time**
- Add up each of the legs to get a total travel time.
- Add up any breaks to get a total break time.
- Sum the total travel and total break time to find the total trip time.

---

<table>
<thead>
<tr>
<th>Leg#</th>
<th>Start/End Elev.</th>
<th>Elevation Difference</th>
<th>Distance of Leg</th>
<th>Time Estimated</th>
<th>Time Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11,260'/11,803'</td>
<td>+540'</td>
<td>0.7km</td>
<td>.35 min</td>
<td>.50 min</td>
</tr>
<tr>
<td>2</td>
<td>11,900'/12,155'</td>
<td>+365'</td>
<td>0.8km</td>
<td>.26 min</td>
<td>.20 min</td>
</tr>
<tr>
<td>3</td>
<td>12,165'/12,203'</td>
<td>-14' / +176'/ -35 net</td>
<td>0.8km</td>
<td>1.05 min</td>
<td>1.17 min</td>
</tr>
<tr>
<td>4</td>
<td>12,200'/12,570'</td>
<td>+370'</td>
<td>0.8km</td>
<td>.29 min</td>
<td>.25 min</td>
</tr>
<tr>
<td>5</td>
<td>12,670'/12,693'</td>
<td>+13'</td>
<td>0.4km</td>
<td>.11 min</td>
<td>.10 min</td>
</tr>
<tr>
<td>6</td>
<td>12,685'/12,003'</td>
<td>-682'</td>
<td>1.3km</td>
<td>.20 min</td>
<td>.15 min</td>
</tr>
<tr>
<td>7</td>
<td>12,000'/11,435'</td>
<td>-600'</td>
<td>1.0km</td>
<td>.17 min</td>
<td>.13 min</td>
</tr>
</tbody>
</table>

---

**Navigation Strategies (handrail, bearing, UTM, etc.) Comments**

- Bearing out: 106 135, 340709, 43168109 Easy cruise up - make even switchbacks.
- Bearing out: 150 135, 341259, 4317820 Pop over 1st ridge, watch altimeter.
- Bearing out: 158 135, 341527, 4316851 Reach next ridge handrail but keep good distance, travel techniques.
- Bearing out: 26 135, 341665, 4316176 Steady traverse up to Pearl Pass - chop slopes? travel techniques.
- Bearing out: 114 135, 342015, 4316078 Reassess stability. Glide left and avoid guiles.
- Bearing out: 180 135, 343063, 4314209 Hut in trees on small knoll. Use Star Col back-bearing if needed.
**Calculate Start Time**

Time the start of your trip to put you where you want to be, at the time you want to be there. Subtract estimated total time to get to a critical point from the time you would like to be there. 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 9:00 a.m.

Assess if any hazards on the trip are time related. For example, if you know that you need to cross a steep south-facing slope late in the spring and are concerned about solar radiation, then you might want to ensure you cross that slope early in the day. You may need to adjust your start time to allow for this. In the above example, if you calculate the south-facing slope is 3 hours into the trip and you want to cross it before noon, you will have to move your start time up to at least 8:00 a.m.

**Notes:**
Options and Alternatives
Once you have planned a trip or route, review it to determine where avalanche and other hazards might affect you and whether you can use alternative trips or routes to avoid hazards. You may not need trip options or route alternatives, but it is wise to have them well thought out in advance. This will give you pre-planned choices for when you get to the trailhead or to a particular point in the trip and feel that avalanche danger (or other hazard) is worse than expected or conditions have deteriorated.

Specifically, think about and design safer and safest route options. Draw these options on your map. Create tour plans and time estimates for each option. Try to create flexible route options and still meet group goals. In addition, plan for total “bail-out” trips or routes. These are trip options or route alternatives that change the goals and objectives to minimize risk. A bailout gives you an alternative if the avalanche danger (or other hazard) is unacceptable on the planned trip/route and safer options/alternatives do not exist or are unsuitable.

Planning options and alternatives on the spot is very difficult. Often the weather is poor, there is pressure from the group, and stress is high. Under these conditions, it is all too easy to make the situation worse rather than better. The more options you have thought about before, the easier it will be to extricate yourself under pressure. Discuss options with your group prior to the tour. It is important that the group has discussed these options and is agreeable to enacting them should the need arise.

Equipment
The following lists outline personal and group equipment recommended for travel in avalanche terrain:

<table>
<thead>
<tr>
<th>Personal</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extra clothing</td>
<td>Cell phone or two-way radio</td>
</tr>
<tr>
<td>Food and drink</td>
<td>Emergency rescue sled and hauling system</td>
</tr>
<tr>
<td>Avalanche transceiver</td>
<td>Bivouac sack</td>
</tr>
<tr>
<td>Avalanche probe</td>
<td>Personal locator beacon or similar device</td>
</tr>
<tr>
<td>Avalanche shovel</td>
<td>First aid kit / repair kit</td>
</tr>
<tr>
<td></td>
<td>Map, compass, GPS and altimeter</td>
</tr>
</tbody>
</table>

The process suggested here for planning and preparation is relatively formal. This is not to say that this is the only way to successfully run a trip. Many groups, especially small ones consisting of close friends, get together and go on safe, successful trips with little or no formal process. When examining these trips, however, you will generally find that even if the process was not formal, many or most of the points discussed here were dealt with in some way and that the trip was not as spontaneous as outward appearances might suggest.

Navigating in white-out conditions

Photo: T. Murphy
Using the Pre-Trip Avalanche Hazard Forecast

Complete this form prior to each trip. It provides a pre-trip checklist of critical avalanche danger factors and a place to summarize available information generated by the local avalanche bulletin. Backcountry users are advised to seek out additional information generated by the community of snow experts including professional guides, forecasters and veteran travelers prior to departure. This information is to be referenced to field observations noted on the facing page of your field book during the decision making process.

Fill out the form as a group and include each person’s opinion. Small groups make better evaluations than individuals.

Pre-Trip Avalanche Hazard Forecast


AVALANCHE DANGER RATING
What is the chance of avalanche encounters today?  •  Where in the terrain?  Which slopes could be triggered with light loads?

CONSIDERABLE  CAIC Fx: Alpha—CONSIDERABLE, @ Treeline—CONSIDERABLE NE-SE, MODERATE elsewhere, Below Treeline—LOW.

Fresh, small & sensitive wind slabs expected in wind loaded terrain.

- Yesterday, size 1.5 soft slab below cornice on E aspect @12,000’ on Mt. Emmons. Avoid similar slopes today!

SNOWPACK DISCUSSION
New/storm snow?  •  Warming?  •  Weak layer type/depth?  •  Sensitivity to triggering?  Does my trip plan allow me to avoid unstable snow?

On 04/17-18, 4cm storm snow fell on 04/03 dirt layer. Storm ended 24 hours ago. Light SW-NW winds early in the storm built isolated soft wind slabs on a strong spring base. No new avalanches observed from town or reported this morning. Today we’ll look for sheltered slopes for the best snow.

WEATHER DISCUSSION & FORECAST
Consider: Sky/Visibility • Precip • Winds & Blowing Snow • Temps • Pressure  How will today’s forecast weather affect the snow conditions?  How will weather conditions affect my ability to make a decision and make obs?

Fx @ 20,000’: Clear sky, NO precip, E NW winds, NO BLOW snow, High Temp -2.0°.  Expecting storm snow settlement today w/ storms developing by this evening on sunny slopes.  Expecting dry snow during intended descent. Snow surfaces may get wet at the valley floors by afternoon and on steep southerly aspects. Great visibility expected and gentle weather conditions.

TRAVEL PLAN / ANTICIPATED HAZARDS
Primary Concern?  •  Turn around time?

Route option 1: Red Well Tour—Need no wind slab below the ridge. Retreat if we see fresh avalanches on similar slopes, or start/summit is holding a fresh slab.

Route option 2: Red Lady Bowl—Looking for minimal wind effect. Likely trend skier’s left/side (to avoid cross-wind effect / wind slabs). 1030 drop in time at the latest.  Obs: Track HST, Air temps, recent wind effects, CT’s & ECT’s on HST/dirt layer interface.

EMERGENCY RESPONSE PLAN
Gear assignments  •  Communication plan  •  Emergency contact #s

Radios Ch. 11:11; 911 w/ cell ph; Joe blog sacl/pad/sled; Keys under Jack’s rear bumper; Jon knows tour plan, call her @ 970.349.0000 upon return.

- The date provides a record of your pre-trip and field trip observations. Re-read yesterday’s info prior to writing today’s obs.
- In the absence of a bulletin, forecast your own danger rating utilizing the Observation Checklist.
- Trend’s are the most important addendum to point observations.
- Be vigilant when reported layers of concern include “persistent grain types” like surface hoar, depth hoar or facets. Avalanches may be triggered on these layers when few or no avalanches are occurring naturally.
- Summarize the terrain to avoid (for example, slopes on NE aspects, steeper than 30 degree, wind-loaded slopes) by shading the terrain in the “rose” (noting range of aspect and elevation). Also write in the elevations on each representative line (example 6000, 9000, 12000). You can also write notes adjacent to the rose as a reminder of observed recent avalanches or recently observed wind-loading.
- Always leave a copy of your trip plan including options with a friend or neighbor.
Using Today's Field Weather (Wx) and Snowpack Observations Page

This form allows for one day’s field observations. Record significant field weather, snowpack, and avalanche observations that contribute to your field decisions and hazard analysis.

This form allows for 4 separate observations over the course a tour in the vertical columns.

### Today’s Field Wx & Snowpack Observations

<table>
<thead>
<tr>
<th>Location</th>
<th>Time</th>
<th>Elevation</th>
<th>Aspect</th>
</tr>
</thead>
<tbody>
<tr>
<td>0800, Red Lady TH, 9,000' valley floor</td>
<td>0900, Red Lady Summit 12,100'</td>
<td>1000, Upper Red Well Basin (800m below ridge), N</td>
<td>1130, Wrong Chute, 10,800' N aspect</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sky</th>
<th>Temp</th>
<th>Wind</th>
<th>Snow</th>
</tr>
</thead>
<tbody>
<tr>
<td>☀, NO</td>
<td>Tₕ=6.0°</td>
<td>Calm</td>
<td>est storm snow, (HST) 400m Steliers &amp; D/P's</td>
</tr>
<tr>
<td>☀, NO</td>
<td>-3.5°</td>
<td>Light N Winds, None</td>
<td>&gt;300cm HST on ridge (normally windswept)</td>
</tr>
<tr>
<td>☀, NO</td>
<td>-3.0°</td>
<td>Light N Winds, None</td>
<td>HST=500cm, up to 600cm just below ridge</td>
</tr>
<tr>
<td>☀, NO</td>
<td>-2.0°</td>
<td>Calm</td>
<td>HST=400cm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trends &amp; Notes</th>
<th>TERRAIN USE • SIGNS OF UNSTABLE SNOW • COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Little wind effect noted driving to TH</td>
<td>Red flags • Avalanches • Snowpack tests • Other observations</td>
</tr>
</tbody>
</table>

- Climbing Up: no instability signs noted, no new avalanches, but we saw yesterday’s natural cornice fall on Mt. Axell (12,200' E aspect sloughed in storm snow).
- Approaching Summit Ridge: Looking around, most prominent SW-NW features that are typically wind swept were only lightly covered (NW ridge of Gothic, NW face of Whetstone, Mt. CB W-side). Quick Profile at 12,200' on E aspect convex roll over (28°).
- Red Well Decision Point: Dropped block of old hard cornice on Nly slope @12,200' W no results. Max 600cm on dirt layer below ridge, all F hard. Not slabby. Jane entered & did one more set of tests—confirmed earlier results—no slab above frozen old snow.

Remember to describe the terrain where the observations were taken.

Record names and date across the top row.

Refer to this example each time to assist you in deciding upon which observations are significant.

Use the lower open space to record a variety of observations that may include quick hand tests, ski tests, partial profiles, surface and avalanche observations.
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Decision-Making

Decision-making can be defined as examining, choosing, and carrying out options. In our backcountry travels, decision-making amounts to terrain selection—where we go—and the use of travel techniques—how we go there.

Terrain is the only variable affecting the formation of avalanches that we can learn to assess with relative confidence any time and in any snow condition. Terrain does not typically change much over the course of an avalanche season. Snowpack constantly changes. This simplifies our assessment of where to go and allows us to use maps and photographs ahead of time to plan a trip. Still, the art of terrain selection is a very complex one because it involves assessing how terrain interacts with the weather to produce different snowpack qualities across a slope or mountain range. Also, terrain can change quickly on a tour, especially on descent, requiring quick decision-making responses.

Terrain Avoidance
If you understand avalanche terrain, avoiding it is always an option. When your ideal trip is such that you can reduce risk by simply avoiding avalanche terrain, terrain selection is fairly straightforward. In this case, you simply need to be aware of the nature of avalanches and be able to identify potential avalanche terrain that you wish to avoid. Most of us engage in winter activities that require us to move through avalanche terrain for at least part of the trip. Backcountry skiers and snowboarders may seek out avalanche terrain intentionally for descent because that terrain may be an enjoyable place to recreate.

Catch-22
The Catch-22 of risk management in avalanche terrain is that we often want to be exactly where avalanches are most likely to occur. The art of terrain selection requires learning when an avalanche slope is safe enough for travel. Sometimes it is and sometimes it isn’t. Most of the time you are unable to know with absolute certainty whether or not someone in your group could trigger a deadly avalanche.

How do we decide when a slope is safe?
We would like to think that the snowpack could be understood well enough to be 100% certain we avoid death in an avalanche. Unfortunately, this is not the case. “Understanding” basically amounts to learning to minimize the probability that you will be in the wrong place at the wrong time. To minimize the probability of being caught in an avalanche, we have available the tools of timing, terrain selection, and use of travel techniques.

Timing
Timing is an obvious tool that we can use to avoid being in the wrong place at the wrong time. To use timing effectively, we have to fully understand the nature of the instability and to know, with confidence, exactly when to be where. In late-season conditions, or in certain snow climates, predicting this timing can be easier. For most of the avalanche season, however, timing is much more difficult to assess, or requires that we wait an impractically long time for the snow to stabilize. In such conditions, terrain selection becomes our prime risk management tool.

Terrain Selection
Terrain selection is a complex art form that takes knowledge and lots of practice. First, we must have a good understanding of which terrain is more or less likely to produce an avalanche under the current conditions. We need to know how to identify places where we are more or less likely to be in the path of an avalanche and/or trigger an avalanche. We also need to be able to estimate the likely consequences of an avalanche that may occur. This all takes education about the nature of avalanches and of avalanche terrain.

Next, we need to understand the factors that effect avalanche danger. Easier said than done! A lifetime of study and experience is necessary to develop a good understanding of these factors and, even then, we can be surprised. We can gain valuable information and insights about this through a local avalanche bulletin. Beginners have the most difficulty interpreting danger factors. Avalanche bulletins give us the perspective of an experienced professional forecaster. However local bulletins are sometimes issued after the start of a trip, represent a large geographic area, are based on limited field observations, become irrelevant because conditions change, or are sometimes simply inaccurate. As backcountry decision makers, we need to make direct observations and learn to interpret them. In this course, we use the Observation Checklist to make sure we consider all of the relevant danger factors, in all of the data classes, and to help us prioritize their importance.
Arguably, the most important component of terrain selection is our own self-awareness of the human factors that lead us to make poor terrain selection decisions. Again, think of our Catch-22, we want to ski avalanche slopes! The fact that we want to ski a slope colors our perception of the danger. When the forces of human nature are acting on us, they are difficult, if not impossible to resist. Human nature entails doing what we want to do, even when we know or suspect that danger exists. The most difficult skill in backcountry decision-making is honest self-assessment. When choosing terrain through which to travel, in the planning phase or in the field, ask yourself honestly if you are experiencing any human factors that are causing you to choose terrain that is probably too risky given the current conditions and the group. This awareness alone can prevent us from making a catastrophically wrong choice. We must consider how human factors are affecting our group as we make terrain selection decisions.

**Travel Techniques**

Last but not least, we employ travel techniques to help minimize the probability of being caught in a serious avalanche. Travel techniques further minimize our risks and/or the consequences of an avalanche in the terrain we have chosen to travel. These techniques dictate how we travel through the terrain.

**Sample Travel Techniques**

- Travelling through specific terrain one at a time
- Travelling close together as a group, or travelling with moderate spacing
- Controlling pitch length on descents
- Stopping the group together in safer locations with better visibility
- Maintaining visual contact with group members
- Stacking tracks near or on top of each other on a descent
- Stopping to plan a strategy for managing certain terrain

Performing a beacon check at the start of and during a tour or practicing and discussing rescue procedures are travel techniques. If it serves the purpose of further minimizing the overall risk in your situation, then it is a valid technique.

Proper application of travel techniques is critical—“Use the right technique in the right place at the right time.” If application is off, the result may be that the technique only increases risk. Or, it may help manage one risk while increasing another thus increasing the overall risk. Travel techniques can be evaluated only on a case-by-case basis. What works in one situation may not work in another. The art of using travel techniques requires learning to apply them appropriately. We often have to be creative to adapt techniques to specific situations.

From a human factor perspective, our travel techniques cannot be allowed to override our terrain selection. Skiing one at a time does not necessarily make a dangerous slope safe to ski. It may reduce the amount of stress on the slope and it may reduce the consequences of an avalanche. But, even one person caught in an avalanche can have unacceptable consequences.

**Confidence Level**

We should always ask ourselves about our confidence level when we make decisions. Recognize that predicting where and when an avalanche will occur is very tricky. In avalanche prediction, we don’t have the opportunity to learn from our mistakes until we make one and usually by then it is too late. Decision-making mistakes in the backcountry can lead to irreversible and unacceptable consequences.

Before you make terrain selection decisions, assess your confidence level as low, moderate, or high. Confidence can be affected by many factors, such as the quality and quantity of observations, the quality of the avalanche bulletin discussion, who is in the group, familiarity with the area, the nature of the avalanche hazard, the snow
climate, and the quantity and quality of your route options. There are many other factors as well. Often when the avalanche danger rating is moderate to considerable, confidence is lower than when it is rated low or high. In these conditions, the snowpack is difficult to judge. Most people get caught in avalanches during these conditions.

**Consequence**
The final consideration for any decision should be an assessment of the consequences of an avalanche in case our judgment is in error. People with less backcountry decision-making experience and less avalanche education tend to have less reliable judgment about avalanche danger and the likelihood of being caught in an avalanche. That said even very experienced avalanche professionals make poor assessments of snow stability on a regular basis. We must recognize that errors occur and we should continuously ask ourselves the question, “What would be the likely consequence if an avalanche were to happen?” As part of your decision making process you will have to ask yourself, “Am I prepared to deal with the consequences?” Be sure to factor in, among other things, the remoteness of the setting and the difficulties of evacuation, weather conditions, and the risk to others in the group if an accident occurs.

It is always best to avoid major errors. When we spend time in the mountains the possibility of a poor decision is always present. Equipping and preparing ourselves with our avalanche rescue equipment, practicing rescue scenarios regularly, and carrying communication devices, extra food and clothing, first aid and repair kits, emergency shelter, and rescue sleds gives us a better chance of reducing the consequences of a serious error in judgment.

Remember that the arrows represent the interconnectedness of the components in the diagram and the continuous assessment and reassessment that occurs throughout a trip. The dashed line to travel techniques reminds us not to let these techniques override appropriate terrain selection decisions.
NOTES:
Companion Rescue

Overview
Learning companion rescue is essential. “Companion rescue” refers to search and recovery actions taken by fellow group members when an individual is caught in an avalanche and buried. The basic search techniques can also be used to find and recover an individual who falls into a tree well and is not visible on the surface of the snow.

The buried victim’s best chance of survival comes from action taken by fellow group members, i.e., the survivors left on the surface after an avalanche occurs. Organized professional rescue will almost always take too long to arrive at an avalanche scene. Case studies reveal that after only 18 minutes the chance that a completely buried avalanche victim will survive begins to rapidly decrease, see graph at right.

Prior to any winter travel, recreationists and experts both plan and prepare for the possibility of avalanche rescue. Just like snowflakes, each avalanche accident scenario is unique. Rescue is not intuitive. A successful response requires a combination of practiced skills and leadership that must be regularly rehearsed. Even with practiced skills, a group list (for head count purposes) and “rescue card” can help to prompt the rescue leader’s response in a stressful emergency situation. The AIARE Field Book includes rescue response procedures in short form on the two back pages. Skilled terrain selection, route finding and hazard management are the primary tools used to reduce the risks from the threat of avalanches. Companion rescue is a necessary skill that all backcountry travellers require in the unlikely situation that something goes wrong.

IF 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 “last point seen” your chance of being quickly found increases.
Try to quickly exit to the side. Snow moves slower on the edges of the avalanche.
Discard equipment: skis, poles, snowboard, snowshoes.
Try to grab trees and rocks to allow snow to slide past you.
Kick, swim, and fight to stay on the surface and 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.

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, and 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 when rescuers are near.
Stay calm.
ORGANIZING THE RESCUE

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:

COMPANION RESCUE PROCEDURES (see inside back cover of AIARE field book as well)

— DO NOT GO FOR OUTSIDE HELP —

1) **TAKE CHARGE** or assign a leader

2) **ASSESS SAFETY** of the party:
   - Risk of further avalanche
   - Route to safety
   - Post avalanche watch (if necessary)
   - Limit people exposed during rescue

3) **HEAD COUNT** How many missing?
   - Check group list!

4) Avalanche **TRANSCEIVERS TO “SEARCH MODE”**
   - (PHYSICAL CHECK)

5) **IDENTIFY** (mark) LAST POINT SEEN

6) Determine **WHERE TO SEARCH**:
   - Fall line below “last point seen”
   - Areas of deposition, in terrain traps
   - In line with clues

7) **BEGIN SYSTEMATIC SEARCH**: (For visual clues and transceiver signal)
   - Spread searchers out in an effective pattern to cover slope
   - LOOK/LISTEN to transceiver info and for clues
   - Search strips max. 20m apart
   - Search edges of avalanche debris

8) **YELL TO OTHERS WHEN YOU HAVE A SIGNAL** or find a clue
   - (Pull clue out of snow, leave in place)

9) **ASSEMBLE PROBE/SHOVEL**:
   - (If required) two searchers work together on first burial while others continue search in the case of multiple burials

10) **FOLLOW TRANSCEIVER SIGNAL TO BURIAL**:
    - SLOW DOWN!
    - Transceiver near snow surface on final approach
    - BE PRECISE!
11) **TARGET BURIAL SITE:**
- MARK (with gloves or ski poles) the last 3m line of approach to burial
- 2\textsuperscript{nd} SEARCHER PROBE on the line ahead of searcher approaching burial
- BRACKET and mark each side of line at “strongest signal point”

12) **LOCATE VICTIM WITH PROBE:**
- Carefully
- Use circular pattern from “strongest signal point” outwards
- Probe Strike = Burial Location. DO NOT REMOVE PROBE!

13) **SHOVEL AS FAST AND HARD AS POSSIBLE:**
- Consider burial depth and size of hole
- Start downhill and away from probe
- Dig towards probe; throw snow far away
- CHANGE SHOVELERS OFTEN
- Careful as you reach burial

Graphics courtesy of BCA

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**NOTES:**

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Graphics courtesy of BCA

In burials deeper than 2 meters, it can be difficult to clear snow from the hole. Instead it should be lifted to the next terrace, where it is removed by a secondary shoveler (Edgerly and Atkins, 2006).

Companion rescue presents a stressful environment for those left on the surface after an avalanche. Missing visual clues, not understanding the intricacies of individual transceivers, and inefficient shovelling techniques often lead to failed rescue attempts.

You may never have to perform a backcountry “companion rescue,” but you must be well versed and practiced in the techniques covered in this chapter. Practice as often as you can with your backcountry partners, set up rescue scenarios, use your shovels and probes and discuss rescue protocol each time you head out for a backcountry adventure.

Notes:
Avalanche Rescue Equipment

Avalanche rescue equipment has been developed to

- Reduce burial time
- Prolong survival time
- Minimize burial depth

Each strategy has its strengths and limitations. As backcountry travellers, we should be familiar with the uses and limitations of all of the available rescue tools currently on the market. Note that all of this equipment requires competent rescuers equipped with shovels and avalanche probes.

Reducing Burial Time
Currently the most effective tool for reducing burial time is an avalanche transceiver. 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.

At this time, long-term statistics are not available on whether digital transceiver technology has led to decreased search or burial times. Technology is evolving rapidly and further developments are being made constantly to make transceivers easier to learn and use.

At a recent International Snow and Science Workshop (2006), Bruce Edgerly and Dale Atkins presented a paper on “Strategic Shovelling.” Their research suggests a reduction in burial time can be achieved by better shovelling techniques. Their “strategic” method suggests dropping back down slope 1.5 times the burial depth as indicated by the probe strike, dropping to your knees and beginning to throw the snow sideways, and working in toward the victim from the side vs. the top. Their research shows promise and we discuss it in-depth during our field companion rescue session.

Prolonging Survival Time
The only known equipment designed for this strategy is an apparatus called 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.

This product is relatively new, but victims using it have survived documented complete burials. No data can show whether these victims would have survived the same avalanches without the Avalung. In controlled tests in actual snow burial, the Avalung has proven effective in prolonging sustainable blood oxygen levels of up to one hour.

Sufficient statistical data is not available at this time to make accurate conclusions about the effectiveness of the Avalung in actual avalanche burials. Some questions have been raised about the feasibility of keeping the mouthpiece in place during an avalanche’s turbulent flow. Also, the Avalung requires that the user be able to breathe. In deeper and more forceful burials, the victim often dies of suffocation because the thorax does not have enough room to expand for effective inhalation.

The Avalung may be able to prolong survival time during burial. Actual recovery, however, still depends on the use of transceivers, probes, and shovels, and the skill of companion rescuers to be able to find, pinpoint, and dig out a buried victim.

Minimizing Burial Depth
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%.

Avalanche airbag packs are designed to decrease burial depth by using a physical principle of particle size in a flowing mass. Larger, less dense objects tend to float to the top much as the larger nuts surface as you shake a
can of mixed nuts. Airbag packs have a canister of pressurized air or nitrogen gas that rapidly fills multiple or single balloons that are attached to the sides or top of the pack. This increases size without adding weight and makes a victim more buoyant in a flowing avalanche. The airbag is deployed with an accessible shoulder strap ripcord that triggers inflation from the cartridge. Various manufacturers are now offering airbag backpacks.

Including deployment errors and gear failures, the airbag pack has been shown to reduce burial likelihood and reduce mortality rates from 23% to 2.5%.

The drawbacks of airbag packs are:

- **Weight:** The packs weigh more than packs without such built-in mechanisms.
- **Reusability:** Once the ABS is deployed; a new cartridge must be inserted or refilled.
- **Cost:** Packs typically range in price from about $500- $1000. Replacement cartridges and refilling/exchanging cartridges costs vary.
- **Manual deployment required.**
- **Possible limitations in certain locations with carrying ABS for heli-skiing although some heli-ski operations are using ABS.**
- **Possible limitations and complications for commercial air travel, especially for flights originating in the U.S.**
- **Still requires all group members to carry a transceiver, shovel, and probe.**

**Notes:**
Snowpack Tests

Introduction
A number of snowpack tests are used in avalanche work, including the compression test, the shovel shear test, the tilt test, the Rutschblock test, and variations on those themes. The tests covered in this course will provide basic snowpack observation skills. Understand that these tests are used in conjunction with a Test Profile, a systematic observation of snowpack layers and interfaces. While you may hear these tests referred to as “instability tests” or “stability tests,” these tests offer limited insight into the actual stability or instability of the snowpack. Most of these tests isolate a column of snow that at best represents a miniscule sample size of the surrounding snowpack.

Of these tests, the ones most useful to novices are the compression and Rutschblock tests. These two are simpler than many others to carry out, somewhat easier to interpret, and can be used in most situations.

The Rutschblock and compression tests are merely small parts of a very large and complex puzzle. Results from these tests are seldom conclusive and require interpretation with other Test Profile observations. The tests and their results should not be used alone as an indication that a slope or conditions are safe—they are treated as a single observation and interpreted in combination with other information in the decision making process.

Objectives
The primary objective of compression tests and Rutschblock is to identify potential failure layers in the snowpack.

If failure occurs the relative strength of the shear plane, at the site tested, may be indicated by the test score. This strength rating is not quantifiable, but if the tests are performed consistently, they may help decipher patterns in strength between test locations and over time.

If carried out correctly and in a representative site, test scores may be a useful part of the decision making process.

Site Selection: Terrain and Snowpack Considerations

Site Selection
A representative site should take both terrain and snowpack into consideration. Finding a representative site is the hardest part of conducting good tests. Site selection requires an excellent understanding of avalanche terrain and care in examining the general characteristics of the snowpack. Terrain should be assessed with a critical eye and the snowpack examined by simple techniques such as probing, feeling how the snow reacts under skis or foot, and looking for clues.

If a site is highly representative of the terrain and snowpack in the start zone or at trigger points, test results probably relate more closely to actual conditions. The less representative a site is in terms of terrain or snowpack, then the less directly the test results will apply to the actual conditions.

Perhaps more difficult is interpreting and extrapolating data from sites that are less than perfectly representative; this takes training and experience.

The difficulty of finding a representative site and the challenge of interpreting less than perfect information does not negate the Rutschblock or compression tests as useful tools, even for novices. Recognizing how representative a site is should be an important part of applying test results in decision-making. Understanding that one’s training and experience are limited and taking that into account should be a part of the process of interpreting test results. In the following discussions, some basic tools are presented to help anyone, novice or professional alike, conduct good tests and interpret the results.

The Start Zone
The most representative site for Rutschblock and compression tests is in the start zone of the avalanche path being assessed, however exposing oneself to the avalanche hazard they are attempting to assess is unwise in most situations for obvious reasons. A site that closely mimics the characteristics of the start zone in terms of incline, aspect, elevation, and wind loading patterns is therefore often used as a safer alternative. Even in the start zone, variations can and do exist due to the topography and snowpack. The terrain often varies from one place to another in the start zone due to configuration, ground cover, etc. Anomalies in the snowpack will exist
due to a number of factors including when, where, and how the snow originally formed, what factors have affected it since it was created, and what changes have occurred as the snow has lain on the ground.

**Representative Terrain**

Of course, entering the start zone may not always be appropriate. Rutschblock (and other) tests are often used precisely when one is unsure of avalanche conditions. It is not reasonable to enter an avalanche path or a start zone if the avalanche danger is uncertain.

When entering the start zone is impossible or unsafe, conventional thinking suggests a “representative site” be chosen for tests and that the data or results gathered there be interpreted and extrapolated. A representative site is commonly described as one that has the same aspect, inclination, elevation, and terrain as the slope being assessed.

Needless to say, finding a site where the terrain is truly representative yet safe can be very difficult.

**Representative Snowpack**

In addition to choosing the right piece of terrain, the snowpack must be considered when choosing a site. At a given site some areas the snowpack may vary significantly from the average in depth, strength, and layering.

Determine how the snowpack at the test site relates to the snowpack that exists in the start zone and/or at trigger points where an avalanche may start. For example, if testing a deep, strong, uniform area of the snowpack when trigger points or the start zone contain shallower, weaker, and/or variable layering, then the results and scores at the test site may not relate very well to the actual avalanche danger.

Traversing Mt. Blanc, France
The Rutschblock Test

Overview

The Rutschblock (RB) test was developed in Switzerland in the 1960s. In 1987, Dr. P. Föhn carried out an analysis of this test. Further studies were made in Canada by Jamieson and Johnston of the University of Calgary in 1993 and 1995. As a result of the research in the '80s and '90s, this test has become very popular with professionals and recreationists alike. Carrying out the actual test requires little experience and minimal training. The results appear to be more conclusive, less subjective, and more “realistic” than other tests because the load applied is a person. It is easier to relate to a skier standing or jumping on a block of snow than to more theoretical tests, such as various shovel tests where loads are not directly related to a skier and results must be interpreted.

The RB test is very graphic, especially when a failure occurs. Seeing a person stand on a large block of snow and observing failure (or lack of it) seems to be more directly related to avalanche danger and decision making than other observations and tests. As a result, the RB test is often weighted heavily in the decision making process. This can and in many cases, has resulted in serious errors in decision making with catastrophic results on the slopes.

<table>
<thead>
<tr>
<th>Field Score</th>
<th>Loading Steps That Produce a Clean Shear Fracture</th>
<th>Data Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The block slides during digging or cutting.</td>
<td>RB1</td>
</tr>
<tr>
<td>2</td>
<td>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).</td>
<td>RB2</td>
</tr>
<tr>
<td>3</td>
<td>Without lifting the heels, the skier drops once from straight leg to bent leg position (feet together), pushing downwards and compacting surface layers.</td>
<td>RB3</td>
</tr>
<tr>
<td>4</td>
<td>Skier jumps up and lands in the same compacted spot</td>
<td>RB4</td>
</tr>
<tr>
<td>5</td>
<td>Skier jumps again into same compacted spot</td>
<td>RB5</td>
</tr>
<tr>
<td>6</td>
<td>* 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.</td>
<td>RB6</td>
</tr>
<tr>
<td>7</td>
<td>None of the loading steps produces a smooth slope-parallel failure</td>
<td>RB7</td>
</tr>
</tbody>
</table>

Rutschblock interpretation should also take into account the release type of the block (see chart below after Schweizer, 2002). The most recent research by Schweizer, McCammon and Jamieson (2006) on correlating Rutschblocks with slope stability indicates that whole-block releases best predict conditions that favour skier triggering. Additionally, the release type appears to vary less over space than do RB field scores. RB’s are most reliable when interpreted using the release type, the field score, and the physical properties of the layers (such as the yellow flags). The Schweizer et al. (2007) paper provides more details on RB interpretation.
<table>
<thead>
<tr>
<th>Release Type</th>
<th>Portion of the block that did slide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole block</td>
<td>90-100%</td>
</tr>
<tr>
<td>Part of the block (usually below skis)</td>
<td>50-80%</td>
</tr>
<tr>
<td>Edge of the block</td>
<td>10-40%</td>
</tr>
</tbody>
</table>

As stated earlier, the Rutschblock test is only one part of a very large and complex puzzle. It should not be used alone as an indication of stability or instability. It should always be treated as a single observation and must be combined with all other information and tests before determining the reasonableness of skiing a given slope.

The RB test has a number of variations. Some of them are generally accepted (such as the rutschkeil) while others are simply incorrect application of the idea (for example, not cutting the back of the block before applying the loading steps). In the case of the former, variations that are carried out according to accepted procedure may be just as effective as the actual RB test. In the latter case, where the test is not carried out according to accepted practice, the exercise is not a RB test and the results should not be interpreted according to the RB scoring system.

**Objectives**
The primary objective of the RB test is to identify potential shear planes in the snowpack.

If carried out correctly and in a representative site, the resulting score may be a useful part of the process of deciding whether or not a slope is likely to avalanche.

**Limitations**
The Rutschblock test is NOT effective for assessing the characteristics of potential failure layers when:
- The site chosen for the test is not representative of the area being assessed.
- The RB test results are not combined with all other pertinent data (e.g., a Test Profile).
- The RB test is not carried out according to the procedures outlined above.
- Potential failure layers are more than 1.0 meter below the snow surface.
- Skis penetrate deeper than the potential failure layer being assessed (e.g., the layer being tested is at 20 cm and skis penetrate to > 20 cm).

If any of the above conditions exist, the results of the RB test are at best inaccurate and at worst completely unreliable in the process of assessing avalanche danger.

**Site Selection: Terrain and Snowpack Considerations**
The ideal place for carrying out RB tests is in the start zone of the avalanche area being assessed. Even in the start zone, variations can and do exist due to the topography and snowpack. The slope can vary from one place to another in the start zone due to the terrain configuration, ground cover, etc. Anomalies in the snowpack stem from a variety of factors, including when, where, and how the snow originally formed, what factors have affected the snow since it was created, and what changes have occurred as it has lain on the ground and/or was affected by weather.

Of course, entering the start zone may not be reasonable. RB (and other) tests are often used when one is unsure of avalanche conditions and hence when it is not reasonable to enter a start zone or even an avalanche path because of significant uncertainty about avalanche danger.

If entering the start zone is impossible or unsafe, conventional thinking suggests a "representative slope" be chosen and the data gathered there interpreted when assessing avalanche danger in the actual start zone or avalanche path. A representative site is commonly described as one that has the same aspect, incline, elevation, ground cover, and terrain configuration as the slope being assessed. Needless to say, finding such a site that is safe enough to enter and test can be very difficult.
Whether in the start zone or elsewhere, the difficulty of finding a representative site does not negate the RB test as a useful tool that can help assess avalanche danger. However, recognizing whether a site is representative or not and how close to truly representative it is should be an important part of interpreting and applying the results. If the site is considered to be highly representative, the results of a RB test probably relate more closely to actual conditions. The less representative a site is, the less directly the RB test results likely apply to the actual conditions.

Once a site has been chosen for the test, the slope angle must be measured to ensure that test results can be accurately interpreted. The ideal slope angle for a RB test is greater than 30°. In addition to choosing the right piece of terrain, the snowpack must be considered when choosing a site. In a given site, in some areas the snowpack may vary significantly from the average in depth, strength, and layering. When carrying out a Rutschblock test, determine how the snowpack at the test site relates to the snowpack that exists in the start zone where an avalanche may start, as well as to the snowpack around trigger points where failure may be initiated. For example, if digging a Rutschblock test in a deep, strong, uniform area of the snowpack when trigger points or the start zone contain shallower, weaker, and/or variable layering, the RB result/score may not relate very well to the actual avalanche danger. The less the snowpack at the RB represents the place(s) where failure might initiate or avalanches might start, the less the RB results apply to the conditions on the slope and the actual avalanche danger.

Finding a representative site is the hardest part of carrying out a good RB test. Site selection requires care and an excellent understanding of avalanche terrain. Interpreting data from sites that are less than perfectly representative requires training and experience.

Clean profile walls lead to better observations
Compression Test

Overview
The compression test has been in use for several decades. Some literature suggests that park wardens in the Canadian National Parks public safety programs developed this test in the 1970s. Whatever its origins, it was initially popular with avalanche workers in continental climates where the snowpack is often weak and unconsolidated and because other commonly used tests were not effective in these conditions.

In the last 10 years, discussion and research have brought the compression test into the mainstream as procedures, observation and recording standards, and interpretation have been formalized. In recent years it has spread into common use throughout the avalanche industry in North America and is now applied in all climates and in a variety of operations.

It is somewhat less popular than the Rutschblock test in recreational circles, probably because it is perceived as a lesser cousin. While perhaps not as simple and intuitive as the Rutschblock, the compression test requires less training and experience to carry out and interpret than the more subjective shovel shear test.

The great advantage of the compression test over the Rutschblock is that it requires less time and energy. The disadvantages are that it is somewhat harder to perform and its results require a bit more interpretation.

Limitations
The shovel compression test is NOT effective in decision making when:

- The site chosen for the test is not representative of the area being assessed.
- Test results are not combined with all other available and pertinent data (e.g., a Test Profile).
- The test is not carried out according to the procedures outlined below.
- Potential failure layers are more than 1 - 1.2 m deep.

If any of the above conditions exist, the results of the compression test are at best inaccurate and at worst completely unreliable in the process of assessing avalanche danger.

The compression test is of limited effectiveness when testing very soft layers on the surface of the snowpack (e.g., freshly fallen snow). Additional care is required when using this test under these circumstances.

Site Considerations
Once a site has been chosen, the compression test can be carried out on any incline. The flatter the slope, however, the more skill is required to interpret the results. Also, avalanches do not start on flatter ground, so low-angle terrain is likely not as representative of start zones as steeper terrain. That said the compression test is very useful if trigger points are on flat ground (e.g. when avalanches might be triggered remotely—far from the actual start zone or fracture line). While research indicates that scores do vary slightly due to slope incline, in common practice results are not adjusted to account for slope angle.

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 kept close to these parameters to ensure continuity from one test to the next and when conducted by different people.

1. Dig a pit with a wall of approximately 1.5 - 2 m across the fall line. This wall should extend below the suspected failure layer if one has been identified and/or to a maximum of about 1.5-min depth. This allows observations to 1.2 m or so which is the maximum effective depth for this test.
2. Clean the wall so it is plumb and very smooth.
3. 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.
4. 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.
5. Using a saw cut one side of the column to the appropriate depth. Make sure this cut is plumb and square.
6. Excavate a chimney on this side of the column with a shovel. 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.
7. Using a snow saw, remove a wedge of snow on the side of the square opposite from the chimney. Again, take care to make the cut beside the column plumb and square and not to damage the side of the column. The wedge should reach the same depth as the chimney.

**Compression 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. If the test is performed on a slope, the top of the column may be flattened with a snow saw. If flattening the top of the column might disturb a potential weak layer or might skew the effect of applying load to the column, the top of the column should not be flattened.
4. Apply load to the column as described below.
5. Observe and record any results.
6. Generally, at least two compression tests will be carried out in the same pit. 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.
7. If results from the first two tests differ significantly, a third or more tests should be carried out to see if a consistent pattern develops. Additional compression tests from other locations may also be indicated if the results vary significantly.

**Applying Load**

Load the column as follows:

1. *Place the shovel:* Carefully place the shovel so that it lies flat and flush on the top of the column.
2. *Tap 10 times:* Using the tips of the fingers and moving the hand only from the wrist to shovel blade.
3. *Tap 10 times:* Using fingertips with moderate taps from elbow to shovel blade.
4. *Tap 10 times:* Using the palm or fist with whole arm to shovel blade.

Keep a running count of the number of taps that have been applied.

While tapping, watch the snow below the shovel. If it crumbles or crushes to the extent that the shovel is no longer in full contact with the full surface area of the column, the damaged snow should be removed and testing resumed.

If a failure is observed, stop applying load and record the failure. Do not remove the snow above an observed and recorded failure, leave it in place and continue the test to completion.

The test is completed when the 30th tap has been applied.
<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
<th>Data Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Easy</td>
<td>Fractures during cutting or insertion of shovel</td>
<td>CTV</td>
</tr>
<tr>
<td>Easy</td>
<td>Fractures within 10 light taps using fingertips only</td>
<td>CT1-CT10</td>
</tr>
<tr>
<td>Moderate</td>
<td>Fractures within 10 moderate taps from elbow using fingertips</td>
<td>CT11-CT20</td>
</tr>
<tr>
<td>Hard</td>
<td>Fractures within 10 firm taps from whole arm using palm or fist</td>
<td>CT21-CT30</td>
</tr>
<tr>
<td>No Fracture</td>
<td>Does not Fracture</td>
<td>CTN</td>
</tr>
</tbody>
</table>

Mt. Crested Butte, Colorado

Photo: T. Murphy
**Shear Quality**
Shear quality (Johnson and Birkeland, 2002) refers to the nature of the fracture produced in the various bonding tests. The shear quality score can be included in the results of any bonding test and provides additional information about the resulting fracture.

**Procedure**
1. Conduct any of the tests described above.
2. Carefully observe how the fracture occurs and examine the nature of the fracture plane.
3. Record the results in accordance with shear quality definitions.
4. The results can be included at the end of any snowpack test.

**Shear Quality Scores**

<table>
<thead>
<tr>
<th>Shear Quality</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>Unusually clean, planar, smooth and fast shear surface: weak layer may collapse during fracture. The slab typically slides easily into the snow pit after weak layer fracture on slopes steeper than 35 degrees and sometimes on slopes as gentle as 25 degrees. Tests with thick, collapsible weak layers may exhibit a rougher shear surface due to erosion of basal layers as the upper block slides off, but the initial fracture was still fast and mostly planar.</td>
</tr>
<tr>
<td>Q2</td>
<td>&quot;Average&quot; shear: shear surface appears mostly smooth, but slab does not slide as readily as Q1. Shear surface may have some small irregularities, but not as irregular as Q3. Shear fracture occurs throughout the whole slab/weak layer interface being tested. The entire slab typically does not slide into the snow pit.</td>
</tr>
<tr>
<td>Q3</td>
<td>Shear surface is not-planar, uneven, irregular and rough. Shear fracture typically does not occur through the whole slab/weak layer interface being tested. After the weak layer fractures the slab moves a little, or may not move at all, even on slopes steeper than 35 degrees.</td>
</tr>
</tbody>
</table>

Photo: C. Zacharias
Epilogue

In the AIARE Level 1 Avalanche Course, we give you the framework for making good decisions in the backcountry. You have now learned in the classroom and in the field:

- About the formation and release of avalanches.
- How to recognize avalanche terrain and the terrain factors that make snow more, or less, prone to avalanche.
- About the mountain snowpack and how the layers are formed and change over time.
- About the importance of observations and the critical avalanche danger factors we call “red flags.”
- How human factors play an important role in terrain selection and the importance of self and group assessment.
- About the importance of the planning and preparation phase and how to create useful trip plans complete with time estimates and options.
- To obtain the local avalanche bulletin and make it relevant to your tour in both the planning phase and in the field.
- How to integrate your observations of the avalanche danger factors, the human factors, and the planning and preparations into terrain selection on a micro, meso, and macro scale.
- How you can use travel techniques to reduce your exposure to risk and/or the consequences of an error.
- And how to rescue your companions most effectively 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 Level 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.

**Where to go from here**

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 someone who is more experienced than you who you can trust and mentor you. Use your field book every time you tour. 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 Level 2 course.

We encourage you to further your knowledge through the many excellent books, websites, and reference papers. Avalanche education is a lifelong endeavour 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 website:

- **www.avtraining.org**
Self Evaluation Form
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. In Planning and Preparation what critical decisions are made?
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”?
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?
## AIARE COURSE OFFERING OVERVIEW

<table>
<thead>
<tr>
<th>Course and Length</th>
<th>Student</th>
<th>Objective</th>
<th>Hazard Management Outcomes</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avalanche Awareness 1-2 hours</td>
<td>General Public (tailored to):</td>
<td>Public awareness of risks associated with recreating in the winter backcountry.</td>
<td>-Provide information to access the avalanche bulletins, local info.</td>
<td>Suggest a Level 1 Avalanche Course for further education.</td>
</tr>
<tr>
<td></td>
<td>-Middle &amp; High School</td>
<td></td>
<td>-Provide information regarding “observable clues” that indicate avalanche danger.</td>
<td></td>
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<tr>
<td></td>
<td>-Snowmobilers</td>
<td></td>
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<tr>
<td></td>
<td>-Skier, Boarders</td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>-Mixed user groups.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 1 Decision Making in Avalanche Terrain 3 days 24 hr course</td>
<td>-Introductory student</td>
<td>-Introduces the avalanche phenomena.</td>
<td>-Basic hazard management course.</td>
<td>-Stand alone course.</td>
</tr>
<tr>
<td></td>
<td>-Recreational backcountry leader and party member</td>
<td>More than an avalanche “awareness” course.</td>
<td>-Uses rule based tools in combination with introductory knowledge based decision making</td>
<td>-Provides link to level 2 course for backcountry leaders</td>
</tr>
<tr>
<td></td>
<td>-Advanced</td>
<td>-Introduces planning and prep for travel in avalanche terrain, human factors, terrain</td>
<td>tools.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Backcountry team leader</td>
<td>recognition, “red flag” observations, terrain selection, travel techniques.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Introductory professional: ski patrol, guide,</td>
<td>-Basic companion rescue</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Advanced Avalanche course</td>
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<tr>
<td></td>
<td></td>
<td>-SWAG module, standardize observation, recording guidelines</td>
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<tr>
<td></td>
<td></td>
<td>-Advances understanding of mountain snowpack.</td>
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<tr>
<td></td>
<td></td>
<td>-Advanced rescue skills</td>
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<tr>
<td></td>
<td></td>
<td>-Improves decision making and terrain skills.</td>
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</tr>
<tr>
<td>Level 2 Analyzing Snow Instability and Avalanche Hazard 4 days</td>
<td>-Professional</td>
<td>-Review of snowpack processes</td>
<td>-Introduces instability factors/checklist and other hazard evaluation tools.</td>
<td>Introductory professional course or advanced recreational team leader course.</td>
</tr>
<tr>
<td></td>
<td>-Education for:</td>
<td>-Review of new research</td>
<td>-Adds snowpack structure evaluation to hazard/risk management model.</td>
<td>-The SWAG module for the level 3 course</td>
</tr>
<tr>
<td></td>
<td>-Patrollers</td>
<td>-Operational forecasting course.</td>
<td>-Defines professional observation and recording guidelines</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Guides</td>
<td>-Advanced decision making in avalanche terrain.</td>
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<td></td>
<td>-CPD for forecasters</td>
<td>-Advanced rescue skills</td>
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<td></td>
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<tr>
<td></td>
<td>-Advanced Backcountry users</td>
<td></td>
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<td>Level 3 Advanced Avalanche Training for Professionals and Recreational Leaders 7 days</td>
<td>-Professional</td>
<td>-Operational style stability analysis/forecast.</td>
<td>Combination of levels 2/3: plus completion of Level 3 assessment leads to pass/fail certificate.</td>
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<td>-Education for:</td>
<td>-Independent and team decision- making.</td>
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<td>-Patrollers</td>
<td>-Knowledge based tools used in hazard forecasting</td>
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<td>-Guides</td>
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<td>-CPD for forecasters</td>
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REFERENCES


The better the team, the safer the world: Golden rules of group interaction in high risk environments: Evidence based suggestions for improving performance. 2004. Gottlieb Daimler and Karl Benz Foundation, Ladenburg (Germany), and Swiss Re Centre for Global Dialogue, Rumlschlikon (Switzerland).


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