



Avalanche Rescue Operations

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An introductory course in avalanche rescue designed for ski patroller and search and rescue mountaineer who may be required to participate in an avalanche rescue. The section entitled "Determining Where to Conduct Probe Lines" assumes the student has a basic knowledge of Probability of Area (POA) and Probability of Detection (POD).

About the Authors

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Avalanche Rescue Operations

Objective

The Mountain Rescue Association (MRA), a volunteer organization dedicated to saving lives through rescue and mountain safety education, has developed this basic level “Avalanche Rescue Operations” program. It is designed to be used by any organization that may be required to respond to an avalanche rescue. Although these materials are valuable for individuals, they are largely developed for search and rescue teams.

At the conclusion of this program, students should be able to:

1. Understand and follow the National Ski Patrol Three Stage Rescue approach;
2. Understand the steps of the Hasty Search phase of avalanche rescue, and;
3. Understand how to determine where to conduct probe lines using Probability of Area (POA) and Probability of Detection (POD).

This program would not have been possible without the kind assistance of the American Avalanche Association, the National Ski Patrol, the National Forest Service, and the Colorado Avalanche Information Center (CAIC). Our thanks to all whom offered assistance.

Introduction

In the past decade, there has been a dramatic increase in popularity of mountain recreation. Advances in equipment and skills have made it possible for mountaineers to delve further and higher into the winter backcountry. And with the increased interest in adventure, there lies an increase in the need for qualified rescue mountaineers. Each year, winter backcountry users will make decisions that result in avalanche accidents. Whether by bad decision-making or by simple bad luck, backcountry users will often lose the war against Mother Nature. As such, it is critical that rescue groups work to fine-tune their skills at avalanche rescue operations.

Not a Moment to Waste

When it comes to avalanche rescue operations, time is of the essence. For this reason, your first few actions are critical. The most significant skill we must have is that of decision-making. Avalanche rescues are all about timing, and knowing which events need to precede others is an essential skill of the rescuer.

Much like other rescue situations, your actions during the first few minutes of the rescue operation are critical to the success of the rescue. This is especially true in the hasty search phase of the avalanche rescue. During this early phase, the avalanche rescue is more like a search than a rescue. This is due to the fact that rescuers must focus on searching for clues to discover the victims. Much like the field search for a lost subject, time can be wasted searching unnecessary areas if important clues are overlooked or if the search is performed in an unorganized manner.

In the 1987 Peak 7 avalanche at Breckenridge Colorado, the hasty team was able to gather enough clues to determine that only half of the debris field (which totaled nearly 25 acres) was worthy of searching. This was accomplished in less than one-half hour.

Decision Making

An avalanche accident occurs. At that moment, the clock starts ticking. Survival of the buried subject(s) depends on quick notification and rescuer action.

The reason that rescuers must focus on quick decision making skills is that after 30 minutes, buried avalanche victims have a survival rate of less than 50%. Quick, decisive action is the key to locating survivors.

We must also remember that victims have survived burial times of many hours. The longest live recovery in North America, for example, is 25.5 hours (ironically, this victim was an "avalanche lookout" during a rescue operation and was located only after he was reported missing after the rescue.) Victims trapped in structures and vehicles have survived for days. For this reason, avalanche rescues involving vehicles or structures should continue for many days. Much like field searches, the rescuers should assume that subjects are still alive.

The Avalanche Rescue

The National Ski Patrol "Three-Stage" Rescue Approach

The National Ski Patrol has developed a three-stage avalanche rescue approach. While this rescue approach is designed around avalanche accidents near developed ski areas, it is a good model for avalanche rescue in general. The concept is a good one, and familiarity with this concept and the terms used is important. The overall concept should be applied to avalanche accidents by backcountry search and rescue teams.

In the three-stage rescue approach, the first stage typically consists of 4-8 rescuers who are dispatched immediately to the scene, with minimal equipment. Their objective is to find survivors. The second stage consists of 10-12 rescuers who take medical and evacuation equipment to the scene. Their objective is to provide evacuation for any survivors found by the first stage. Finally, the third stage consists of the remainder of the rescuers, who provide the personnel for the tedious process of probe lines.

Stage I

In the three-stage rescue approach, Stage I begins upon notification of the accident. The rescue headquarters is contacted and the rescue leader sounds the alarm. At that point, a "Stage I column 1 leader" is appointed and the column is dispatched to the scene of the accident.

Stage I member's respond directly to the accident scene. They travel quickly, with minimal equipment. Their objective is simple, find survivors. They travel with avalanche rescue beacons, shovels and collapsible probe poles. Stage I members know that medical and evacuation

assistance will be directly behind them, should they locate survivors. It should be noted that Stage I generally takes no more than 10 minutes. Stage I can be viewed as the initial rescue "attack," with the sole purpose of locating survivors.

Although stage I members respond with very little equipment, they must carry personal survival gear, in the event that the weather turns bad and they are forced to bivouac. They must remember that in bad weather, Stage II and Stage III may be held back from the accident scene.

(To the National Ski Patrol, the term "column" is loosely associated with the term "field team" to search and rescue personnel. Furthermore, the "Stage I column 1 team" is synonymous with what search and rescue personnel refer to as the "hasty team."). The leader of this column takes responsibility for the "hasty team" and its actions. A Rescue Leader is also appointed at this time. The Rescue Leader is the rescuer who for many years was referred to as the "Rescue Leader."

The responsibilities of the hasty team are listed in detail later in this manual.

Stage II

During Stage II, medical personnel are contacted. A Stage II leader is appointed and a medical/evacuation column is dispatched. Essentially, the Stage II operation is designed to assure that medical and evacuation personnel arrive on scene quickly, so that any victims located initially by the Stage I column can be treated and evacuated by fresh, medically trained personnel. Stage II is generally accomplished within the first 20 minutes of the initial accident report.

Stage II personnel can be used to replace Stage I personnel, as necessary. Remember that the first hasty team members (Stage I column 1) have responded to the scene with great urgency and, therefore, may be exhausted in a relatively short period of time.

Stage III

The primary objective of Stage III is to provide support to the personnel in Stages I and II. A Stage III leader is appointed, and support groups are contacted. Once they arrive at the dispatch point, these support columns are dispatched to the scene. This stage generally occurs within 60 minutes of the initial accident report.

The objective of Stage III is to provide replacements for Stage I and Stage II columns. Stage III members generally will be involved in the laborious process of probe lines.

It should be noted that column members might be dispersed once they arrive at the accident site. This is true of SAR team rescues as well as National Ski Patrol responses. It is generally the Rescue Leader who will determine the use of any resources, once they arrive at the accident site.

The Hasty Search

The hasty search is that part of the rescue operation conducted by the first SAR members on scene – the Phase I column. The leader of the hasty search team should be one with experience in rescue leadership in general, and avalanche rescue techniques in particular. This team leader must be proficient at snowpack analysis as well, in order to evaluate the risk to rescuers. The

success of the rescue or recovery operation is due, in a large part, to the experience of the hasty team leader.

Hasty team members should use the same method of snow travel (e.g. skis, snowshoes, etc.). Furthermore, they should be in peak physical condition and should carry the minimum equipment possible. Time is of the essence, and this first team to the scene can be replaced, if necessary, as subsequent rescuers arrive at the scene. Still, the hasty team should travel to the site with the expectation that no other rescuers will follow. For this reason, minimal bivouac gear should be taken into the field.

In addition to medical and communications equipment, hasty team members must carry specialized avalanche rescue equipment into the field. Avalanche rescue beacons are critical. Shovels are important as well, and sturdy, large grain shovels should be considered. Finally, portable avalanche probe poles are a requirement for this team.

The hasty team should be careful to flag their route to the accident site so that subsequent rescuers can easily find their way to the scene. This is especially important because witnesses or reporting parties may be brought to the scene with the hasty team. Future directions to the site may be difficult if the RP is in the field with the hasty team.

Upon arrival at the accident site the hasty team must identify safe areas, a staging area for caching gear, and an escape route or routes. This information must be known by all, and be relayed to all rescuers whom later arrive on scene.

As with any search operation, the number of clues found improves the chances of success and reduces the area to be searched, even if the avalanche is quite large. Conversely, the lack of clues can greatly lengthen the time spent at the accident scene.

The attached flow chart, developed by Dale Atkins (Colorado Avalanche Information Center, National Ski Patrol, Mountain Rescue Association) is a decision making model. It details the steps of the hasty search and gives a general order for when each step in the hasty search should be performed. Still, flexibility is required of the hasty team leader (who may often become the Rescue Leader). Different situations require adaptation, and the hasty team leader must adapt this model to the situation presented him or her.

Approach Search

Hasty team members should begin their task as they approach the slide area. Verbal attempts to contact the subject should be used throughout their journey to the area. After all, the subject may have extricated him/herself and may be wandering around in the general area, or may be en route back to the trailhead. There is one documented case of a young boy who extricated himself from an avalanche but died of hypothermia in the woods while rescuers worked on the avalanche debris alone.

Furthermore, any undisturbed snow above the avalanche area should be considered while away from the slide zone. How much snow remains above the accident site? How much snow remains to the sides? This hazard may be difficult to see once at the site.

Once the avalanche site is in view, the hasty team must seek clues that may be impossible to see once at the base of the slide. Rescuers should also perform a visual/audible search. In doing so, rescuers are attempting to locate:

1. victims
2. clues, tracks, clothing, equipment

Are any distinguishable tracks entering the slide area? Exiting? Are any clues (clothing, equipment, etc.) lying on top of the debris? Count the number of tracks and assess the type of tracks (Rescuers have been called to the scene of avalanches with tracks in, no tracks out only to later determine that the tracks were produced by wildlife.). If so, rescuers should make a note on paper of what they see before they get too close to the avalanche debris.

Visual Search

Once rescuers arrive at the scene of the avalanche, they should first assess whether there are any unburied victims at the site. If so, these individuals must be given medical care immediately. If it is determined that there are no other victims in the slide (everybody is accounted for), rescuers should evacuate the area immediately, while providing appropriate care for the victims.

If there are no unburied victims, or those that are unburied do not account for all victims, rescuers must further assess the danger of additional avalanches. If the hazard is considered to be more than minimal, rescuers must arrange for control work and retreat from the area until this has been accomplished.

During visual search phase of the hasty search, the rescuers should make a close-up visual inspection of the avalanche area. Again, are any distinguishable tracks entering or exiting the slide area? Are any clues lying top of the debris? If so, other hasty team members should be alerted of the clues. Rescuers should make sure that there are no victims attached to these clues (The immediate area around the clue should be probed.). In the case of an accident with numerous victims, effort must be made to determine to whom the equipment belongs. After all, a clue can generally be eliminated from consideration once the owner of the clue has been located.

The hasty team leader must be made aware of any clues, and to whom they belong. The leader should then note the location of these clues on his/her map of the accident site. The clues should be well marked (e.g. clothing hung from a ski pole, skis stood up vertically in the snow) so wind or snow do not move or bury the clue.

Rescuers must occasionally yell and listen for voices throughout the hasty search phase. Often, victims may be buried just below the surface. There are several accounts of victims who, despite being unable to move, heard their rescuers and were able to respond.

Beacon Search

Even if any witnesses or reporting parties insist that none of the victims were using beacons, a beacon search is essential. Give then minimal amount of time required to perform a beacon search, it is well worth the effort. . A thorough beacon search will quickly confirm a buried beacon or that no beacons were buried. Hasty team members must be experienced in the use of avalanche beacons and should practice continually to refine their beacon skills.

A note about avalanche rescue beacons... More often than not, rescuers will forget to test their beacons before entering the field. As Rescue Leader, you should remind the Incident Command Post to ensure that all rescuers' beacons are tested before they enter the field. Furthermore, rescuers are at times unfamiliar with the use of an avalanche rescue beacon and will travel to the

scene with their beacons on "receive," without being told to do this, and prior to their arrival at the scene.

Inexperienced rescuers may believe that they should always have beacons on "receive" while working any phase of the avalanche rescue. Remember that beacons are used on "receive" ONLY during the beacon search phase of the hasty search, which is usually completed well before most rescuers arrive. Beacons should be kept on transmit unless instructed otherwise.

Scuff search

The scuff search is designed to locate victims or clues. Rescuers should scuff the surface of the debris in an attempt to "turn over" the surface snow. Clues will often rest on the surface, but may be lightly covered by subsequent snowfall, spindrift, or debris.

Spot Probing

The next step consists of rescuers spot probing likely burial areas. These include:

1. Rocks and trees in the slide path (in front of and behind)
2. The toe of the slide
3. Curves in the debris field
4. Benches and other terrain features

"Last Seen Area"

Unlike search teams, avalanche professionals do not refer to a "Last Seen Point." History has shown that the reporting party's memory of the **exact** location of the victim(s) is often sketchy, at best. Yet, when asked to point out exactly where the victim was last seen, RP's often choose a point that is well ahead of the actual last seen point (in terms of direction of travel). For this reason, the area referred to by the RP as the last seen point should be considered the center of a "Last Seen Area."

When time permits, the Rescue Leader should bring the RP back to the **exact** area from where s/he witnessed the accident. It is from this perspective that the RP should attempt to identify the last seen area. If the RP witnessed the slide from a chairlift at a ski area, for example, the RP should be brought back to that chairlift, if possible. After all, the accident site will probably look significantly different when viewed from below the site, as opposed to the view from the chairlift.

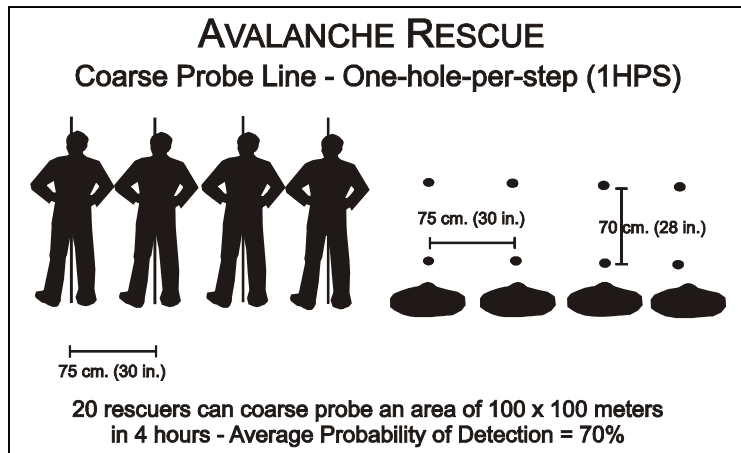
Organized Probe Lines

As opposed to avalanche rescue dogs and beacons, the probe line is an extremely slow process, one that requires large numbers of rescuers. Still, if dogs and the hasty search do not turn up the victims, the probe line is the next step. (Trained dogs can work concurrently with probe lines. An effective strategy is to have the dog revisit probed areas.)

Once the hasty search has established a likely burial area, the Rescue Leader should proceed with organized probe lines (remember that probe lines should only be considered after the hasty search is of sufficient quality to establish this likely burial area.).

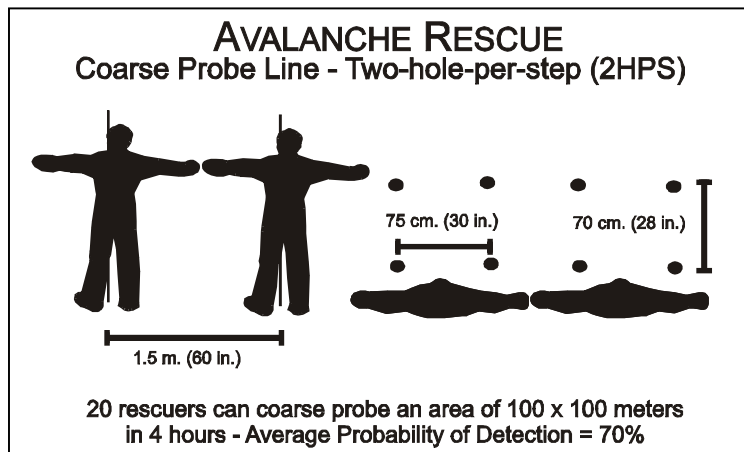
There are two general types of probe lines. The "coarse probe line" provides a 70% probability of detection, while the "fine probe line" has a 100% probability of detection, but is far slower. The coarse probe line is the preferred alternative.

Coarse Probe Lines



One-Hole-per-Step

There are three methods for conducting the coarse probe. The traditional one-hole-per-step method (1HPS) also known as the "closed-order" coarse probe is best known, most often used, but is also the least efficient. In the 1HPS coarse probe, rescuers stand hands on hips elbow-to-elbow, which leaves probes 75 cm (30 inches) apart from center to center. They then probe once, at the center of the straddled span. Probes must be inserted vertically. On command, rescuers advance 70 cm (28 inches) to the next probe position.



On the average, 20 rescuers can coarse probe an area of 100 x 100 meters in 4 hours using the coarse probe. Multiple passes can be made, increasing the probability of detection.

Two-Hole-per-Step

The second coarse probe method is the two- holes-per-step (2HPS)

method. Also known as the "open-order" coarse probe, it is the most efficient way to search small areas (up to about one-half the area of a football field), or to search any area with a low POD. In the **2HPS** method, probers stand fingertip-to-fingertip and probe once to the outside of their right foot, and once to the outside of their left foot. On command, rescuers advance 70 cm (28 inches) to the next probe position.

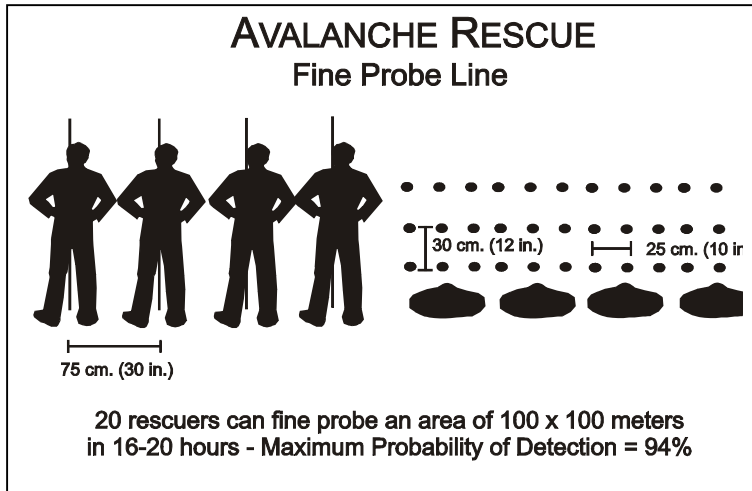
Three-Hole-per-Step

The third coarse probe method is the three-holes-per-step (3HPS) method. The version presented here is a slight variation of the Canadian method where probes are inserted at a slight angle and at different spacings. In the US method probes are inserted vertically and at a uniform spacing. The US method insures a higher POD than the Canadian method.

In the 3HPS method, probers stand hand-to-hand and probe once to the outside of their right foot, once in the center, and once to the outside of their left foot. This yields a spacing of 60 cm (24

inches) between probes and a much higher POD. On command, rescuers advance 70 cm (28 inches) to the next probe position.

Fine Probe Lines



It is important to have an awareness of the fine probe. This high-density probe-search method is horribly inefficient and will likely never be used. However, because it is still widely taught, a simple description is mentioned here. Rescuers stand in the same position as with the first coarse probe line described above (elbow-to-elbow). However, as opposed to the coarse probe, rescuers probe once in front of their left foot, once in the center of their straddle and once in front of their right foot. This creates a probe spacing of 25 cm (10 inches). On

command the line advances 30 cm (12 inches). The probe line advances 30 cm. (one foot).

The fine probe has a maximum POD of 94% (assuming probing to 3 meters), but it also takes 20 rescuers 16 to 20 hours to probe an area 100 x 100 meters. Three passes of a coarse probe gives the same cumulated POD, but in only about 12 hours. The fine probe should be used as a last resort, or when the victim's location is certain and there is no longer a sense of urgency to the search (generally 24-36 hours after the avalanche accident.)

General Probe Line Considerations

When deciding which probe method to use, search leaders must consider speed, probability of detection, and the size of the search area. In smaller areas (one-half of a football field) the 2HPS method is slightly more efficient than the 3HPS method, but in larger areas (one football field or two football fields) the 3HPS method is more efficient. The reason these methods are more efficient than the traditional 1HPS method is because both methods put more holes into the snow with less walking. They require less walking-per-unit-area than the traditional 1HPS method. Also the 2HPS and 3HPS methods allow fewer probes to probe wider areas. In the 3HPS method two probes can cover almost the same width as five probes, and the 2HPS requires only one-half as many searchers compared to the traditional 1HPS method. Both methods can utilize smaller probe lines that are easier to manage and thus can search faster.

Intuition says that the shallower the probing depth, the faster the probe line. The victim can, however, be buried at any depth up to the maximum thickness of the debris. In comparison, the little time gained by probing a limited depth is not worth the increased likelihood of missing the buried victim. Therefore, probing depth should be the entire length of the probe pole, except when strong evidence indicates a shallower burial. The strongest evidence is the ground, an ice layer or a creek. Undisturbed snow underneath debris is often difficult to recognize.

Probe lines must be well disciplined and properly spaced for probing to be effective. In the traditional 1HPS method, up to 20 members in a probe line is manageable. In the 2HPS and 3HPS methods, 4 to 10 members are easy to manage. Probing uphill helps sets the proper pace and order. Downhill probing is difficult to control. The boundaries of the probed area should always be marked as the probe line advances.

The probe line does not halt when a strike is made. The prober calls out "strike," leaves his/her probe in place and calls for another probe. The probe line continues to advance, while a shovel crew standing by digs down to investigate. Generally, 2 to 4 shovellers should be assigned to each probe line. They also carry extra probes. If probers become cold, rotating probers into the shovel detail will quickly warm them.

Probe line leaders may position themselves outside of the probe line when managing large probe lines or when there is no shortage of workers. When probe lines are small and/or few probers are available, the probe line leader should join the line. Verbal commands to the probe line should be short and easily understood. Typical commands for the 3HPS method would be: "Probe left. Probe center. Probe right. Step." The leader should set a steady but quick pace that will not exhaust probers. When probers drift too far apart, it is important to stop and redress the line. Probers should do their best to not contaminate the debris with their spit, food scraps, or urine. Also, rescuers must not drop or leave behind extra clothes, as they could be seen as clues to the buried victim.

Guidon Cords

When there are enough rescuers to do so, one should include the use of a guidon (pronounced "GUY-don") cord to assure that a probe line maintains. This is especially important when using the recommended Open Order coarse probe line – as the probers stand far apart and the line can become quite wide. A Swedish study proved that using these cords could cut search time by 20%. Less time is wasted having to stop and "re-dress" the line.

Two rescuers kneel at opposite ends of the probe line. When the probers are probing the snow, the rescuers with the guidon cord advance the cord the recommended 70 cm. (roughly 28 inches). Then, when the probers advance, they do so up to the guidon cord, and probe at that location.

Other Considerations

When Victims are Located

When rescuers discover any victims, prompt medical attention must be given. Remember that it is a common belief among the emergency medical community that "a victim is not dead until warm and dead." This is especially true of young children, and is called the "Mammalian Diving Reflex." Seemingly miraculous recoveries have been documented where drowning victims have survived without oxygen for up to 45 minutes in ice-cold water. It must be noted, however, that the speed with which the body is cooled is directly proportional to the rate of survival. Unlike drowning accidents in cold water, where the body is cooled rapidly, the avalanche victim will not cool as

quickly, therefore similar recoveries are unlikely. Still, every effort to revive the victims with aggressive CPR should be maintained until the rescuers either cannot, or should not continue.

Who Declares a Victim to be Dead?

Rescue members generally do not declare any person to be dead. An emergency room physician or coroner often makes this decision. Rescuers should contact their local Trauma Center Emergency Room (ER) and describe to the physician the condition of the victim, the estimated length of burial, whether the victim had an air space and/or an open airway as well as the medical attention given to the victim. This can often be done over the radio, with the assistance of local dispatch that might contact the ER physician by landline and relay the required information. In the meantime, rescuers should continue aggressive life support, including CPR, until they cannot or should not continue.

The Avalanche Rescue Leader

The Incident Commander at an avalanche rescue will often remain at the trailhead coordinating resources, law enforcement officials and the media. The Rescue Leader, on the other hand, will coordinate efforts at the site of the accident. The Rescue Leader is ultimately responsible for the safety of all field personnel as well. S/he is also responsible for the on-scene coordination including coordination of resources, record-keeping, etc. Primary among these responsibilities is the need to follow rigid discipline. Certain actions must be taken in a relatively specific order, and it is the responsibility of the Rescue Leader to assure that this occurs.

Except perhaps in the very early stages of the rescue operation, the Rescue Leader generally does not participate in the efforts at the site. Rather, s/he serves as a coordinator of those efforts.

Safety

As mentioned, the Rescue Leader's first responsibility is the safety of all field members. S/he might find it necessary to keep all involved (rescuers, media, volunteers, etc.) out of the area before the rescue can even begin, in the case of additional avalanche hazard, worsening weather or darkness, for example. Still, in the absence of these issues, the decision to proceed with the rescue is a complex one that cannot be taken lightly.

Before the hasty team enters the field, a hazard assessment must be made regarding the potential of further avalanches. Remember that indications of earlier avalanches are the first clue to the existence of significant avalanche hazard. Certainly we would not be going into this area were there not an avalanche to begin with. We know, therefore, that the hazard is already high. Subsequent risk evaluations, therefore, must focus on the hazard encountered on the route to the scene as well as at the scene itself.

Assessment of the hazard of additional avalanches in the area ("hang-fire"), or along the access route, is certainly one of the most difficult decisions the Rescue Leader and rescuers may have to make, since it may effect the speed at which rescuers are on scene. Unlike professionals such as Ski Patrol personnel, SAR workers may not work daily in the mountains. For this reason, hazard evaluation may need to be made with the assistance of local professionals in the area.

Some avalanches will have hang-fire, some will not. Probably the most important clue we have to making a hazard assessment is by noting the trigger of the original avalanche. Since most victims trigger their own avalanches, we as rescuers can work very safely on the debris, as long as there are no other triggers (people) above the site, and weather conditions do not worsen. If the avalanche was a natural release, however, predicting the hang-fire is nearly impossible, and the likelihood increases. Hang-fire becomes especially dangerous if there are adjacent starting zones that feed the same runout zones.

Nearly all highway workers killed by avalanches were clearing the debris from one small slide when a second (or third) release occurred. Rescue leaders should consider explosive work when accidents are due to a natural release or when weather (storm or thaw) conditions worsen the danger.

Certainly, the Professional Patrol Director of the nearest ski area(s) may have further information regarding the history of the snowpack. At the very least, the avalanche forecaster at the local avalanche forecast office should be called for forecast information specific to the general area (In addition to receiving an up-to-date forecast, this call also alerts the forecaster to what is happening, since the media often calls the forecast center for information.).

Avalanche Reduction Using Explosives

If the Rescue Leader determines that the risk to rescuers is anything more than minimal, something must be done to reduce the danger. If the danger of additional avalanche cannot be controlled, or if the weather is such that the risk of the rescuers is too great, the safest action is for rescuers to retreat. Remember that, to any rescuer, the safety of the rescue team is second only to the safety of rescuer him/herself. The safety of the victim is third.

After the initial hazard assessment is made, the team's leadership/Rescue Leader may decide that further avalanche control work is necessary before rescuers can enter the field (or the accident site). In this case, professionals experienced in avalanche control using explosives should be consulted. This may include, but is not limited to, the local Ski Patrol staff, the Forest Service and/or the State Highway Department. With luck, this has been arranged for in the SAR team's pre-plan and has been communicated with the above-mentioned agencies before the season begins. SAR team Rescue Leaders should ensure that this pre-plan is complete and up-to-date prior to each season. Certainly, most SAR workers have neither the experience nor the training in avalanche control work.

When explosives are to be used in avalanche control, the Rescue Leader must assure that s/he has radio communications with the control team leader. Furthermore, all associated personnel must be made aware that control work is underway.

If field personnel perform control work (e.g. the nearby professional Ski Patrol), certain procedures are followed to advise all people involved of the pending explosives. As the control team prepares to detonate explosives, they will announce, "Fire in the hole in X minutes." The term "fire in the hole" indicates that explosive charges have been set and will be detonated in "X" minutes.

If State Highway Department officials perform control work using their "Ava-launcher" or their "Howitzer," explosives are launched from vehicles located on the road. These explosives detonate on impact. Unlike field control work, where the control personnel are in the immediate

area of the target, explosives launched from a distance present a greater hazard. For this reason, it is critical that rescuers have assured that nobody is in the area of the target zone. Shrapnel from artillery can extend more than 1,000 meters from the target.

Parking lots, trailheads and any access point to the backcountry must be checked before highway department explosives are to be used. Also, any vehicles near the launch vehicle should be moved away, if possible. If vehicles cannot be moved, one window should be opened in these vehicles, since the shock wave of the launch is great enough to cause implosion of windows if the interior compartment of the vehicle is completely closed.

If the potential control work slide zone includes any portion of road, sirens should be sounded to alert all that control work is imminent. The road must, of course, be closed. In this case, **all** vehicles (rescuers' or otherwise) must be moved well away from the potential slide area. Remember that avalanches triggered by control work can often result in a slide significantly larger than even "experts" may anticipate. The Disney photographer would attest to that today, had he survived the Berthoud area avalanche.

As the rescue operation continues, sometimes over a matter of days, the Rescue Leader and Incident Commander must continually assess the possibility of further avalanche activity. Additional control work may be necessary, and might be performed from helicopters. This work should be accomplished at first light.

Again, further resources may be called to assist with the assessment, and control work may be desired prior to insertion of rescuers. When considering this decision, remember that the chances of subject survival have already dropped to nearly zero after the first several hours of the operation. A very conservative evaluation should be made, especially after these first several hours have elapsed.

In the case when explosives are used later in the rescue operation, the Rescue Leader **must** assure that all rescuers are accounted for as they exit the area so that the control workers may be given clearance to perform the control work.

In the case when explosives are to be used in the vicinity of a ski area or a highly populated backcountry use area, precautions must be taken well in advance of the control work to assure that no unsuspecting backcountry users are in the area. Trailheads near the area should be checked for vehicles that are not accounted for. Access gates from the developed ski areas to the backcountry must be closed well in advance of any control work.

Avalanche Rescue Dogs

Whenever possible, rescue teams should utilize avalanche rescue dogs. If qualified dogs are part of your rescue pre-plan, be sure to include the dog and handler in team trainings. Rely on the handler to teach your group how to work with his/her dog.

Rescue Leaders must remind resources as they arrive that avalanche dogs either are or may be on scene. Care must be taken to assure that individuals on scene do not compromise the effectiveness of dogs by any of the following actions:

Individuals who must urinate or defecate must do so far away from the site at a designated place. Human feces can contaminate the area and compromise the effectiveness of dogs.

Rescuers should not spit in the area. This is especially important if rescuers who use chewing tobacco are dispersed into the field. These individuals should refrain from this activity, since any human body fluids can further compromise the effectiveness of avalanche rescue dogs.

Some avalanche rescue dog handlers maintain that only trained rescue dogs should be used at avalanche accidents. It is believed that untrained dogs will urinate more frequently on the accident site, and that this action will again compromise the effectiveness of trained dogs. For this reason, and unless the dog is the victim's dog, untrained dogs should not be allowed in to any avalanche rescue scene.

Rescue Leaders should maintain the contact phone numbers for all accredited avalanche rescue dogs since local sheriff's offices may not have this phone number.

Posting an Avalanche Lookout

Utilizing a "lookout" (an avalanche guard) is not a safe alternative to control work. In fact, although avalanche lookouts are suggested for "self-rescues" by backcountry users, an avalanche lookout may not be desirable during a "professional" rescue, since these rescuers are expected to better understand the existing dangers during the rescue operations. Their involvement in the area implies that trained professionals have evaluated the hazard, and the risk has been determined to be acceptable. There are times, however, when an avalanche lookout can, and probably should, be used. This might include rescues during the spring, when the threat of slow moving, wet slides are possible; or for small paths with multiple starting zones. In addition, lookouts are suggested when the scene is a popular backcountry area. In such situations, lookouts can be posted to alert rescuers and to keep people away from potential starting zones.

Record-Keeping

Certainly one responsibility of the Rescue Leader is that of thorough record keeping. It is essential that the Rescue Leader draw a detailed map of the accident site. Initially, any tracks into and/or out of the avalanche should be carefully noted, including number of tracks, type of snow travel equipment that made those tracks (e.g. snowshoes, skinny skis, randonnée skis, or wildlife, etc.). This is crucial, since later winds may cover these tracks.

Much like any backcountry search, the avalanche Rescue Leader must anticipate the possibility of an extended search of the debris effort with numerous probe line sweeps. For this reason, site diagrams should be used with acetate overlays so that each day's efforts are thoroughly documented yet the original site diagram remains intact.

As the rescue effort progresses, any clues found by rescuers in the field should be marked on the original map, and the location of any victim's located should be marked as well.

The thorough documentation of the accident site and subsequent rescue efforts is critical and is an on-going responsibility of the Rescue Leader. As with any SAR operation, thorough documentation is essential if there is to be a daily debriefing and in order to facilitate a transition to other leadership personnel.

Witness Interviewing

Interviewing witnesses is often one of the most difficult tasks in avalanche rescue work. Certainly the information these witnesses can provide is essential. Still, these individuals may be emotionally distraught, since they are often friends or relatives of the buried victim(s). For this reason, the interviewer must not only be knowledgeable in the areas of avalanche and avalanche rescue, but also must be prepared to act as a counselor to the witnesses. The Incident Commander may choose to bring a member of the clergy to the area for the benefit of the witnesses, friends and family members.

Interviewers should avoid asking leading questions. As the interviewer assembles a chronology of the events, the best questions are, for example: "What did you do next?" instead of "Did you try to locate him/her?"

Throughout the interview process, and beyond, the interviewer should take time to explain to the witnesses exactly what is happening in the rescue operation. The interviewer must also be honest about the survival chances of the victim(s). If indeed the buried victim(s) is not in a vehicle or structure, the witnesses should be told that the chances of survival are not good.

In the case of multiple witnesses, the interviewer should separate the parties and ask them not to discuss the accident with each other. This will assure that witness recollection will not be affected by discrepancies between perceptions from one witness to another. Furthermore, each witness should be interviewed in private, away from the others.

Witnesses should not only be brought back to the accident site to identify a last seen area, but they should be brought back to the actual location from which they witnessed the slide. Remember that we refer to a "last seen **area**," since witnesses often project the victim's last seen point further down slope. As the witness describes the last seen location, the interviewer should position a person on the site in the same area. Often, a rescuer standing in the same place gives a better sense of perception to the witness, who may have a different recollection once they see the relative size of a person at the given area.

The interviewer should start by identifying the last seen area. Other important information includes a description of the victim(s) clothing and equipment.

Considerations must be given to the emotional aspect of the witnesses. If the witnesses did indeed attempt a self-rescue before seeking help, the interviewer should reaffirm that this action was indeed correct. Often, self-rescuers feel they made a mistake by not seeking help immediately. In fact, the victim's best chance for survival was during this self-rescue effort. In addition, witnesses will often be fearful, embarrassed and may feel "at fault" for the accident. While further counseling by professionals is often indicated, the compassion and understanding of the interviewer may be key to the witnesses' emotional recovery from the trauma of this event.

Larger Avalanche Accidents

In the event of larger avalanches, or those slides which may involve more than one victim, the Rescue Leader should be aware of the following issues:

Rescue Leader Responsibilities

With larger accidents, the Rescue Leader may wish to assign another rescuer to assist with is/her functions. This may include, but is not limited to, a scribe, a radio person and/or a check-in/check-out person. The Rescue Leader must assure that s/he is able perform the most critical functions at the scene, that of coordinating the activities on the debris field. This "assistant" must insulate the Rescue Leader from unnecessary interruptions.

In the case of large avalanches and/or rescues extending several days, the Rescue Leader may request that a large "map board" be brought to the scene so that the accident site can be documented in a way that many people may review the documentation. Doing so at the Peak 7 accident simplified the briefing/debriefing process.

In the case of accidents involving numerous victims, the Rescue Leader may wish to request that a portable "medical tent" be erected at the scene. Again, using the Peak 7 accident as an example, this tent allowed for medical examination using a cardiac monitor as well as positive identification of the victims in a private manner, away from the media, family members and/or friends.

Accidents that Block Roadways

If an accident occurs which crosses a roadway, there may be significant pressure from city, county and/or state authorities to see that the road is reopened as soon as possible. Snow removal equipment will generally be brought to the scene quickly, often sooner than the rescue personnel are capable of declaring the area clear of victims. In this case, the Incident Commander and/or Rescue Leader must remember that our responsibilities are as follows:

1. Ourselves
2. Fellow team members
3. The victim

Any responsibility to quickly reopen the roadways is secondary to our responsibility to the victim. Still, we must understand the responsibility of highway personnel who are under extreme pressure from their superiors to see that the road is reopened as quickly as possible. Clear and frequent communication with these authorities can ensure that both the SAR personnel and the highway personnel clearly understand each other's objectives.

Remember that avalanches that block roadways are often natural releases. This increases the hazard to rescuers and highway workers in the area. In addition, rescuers must monitor whether vehicles on the road (their own or others) are parked in runout zones of known avalanche paths.

Family Members or Friends

Often, the Incident Commander and/or Sheriff's Deputies will keep family members or friends away from the scene. In the event that family members or friends do arrive at the scene, the Rescue Leader should seek the assistance of the Incident Commander to get a qualified individual to accompany these individuals so that the Rescue Leader may continue his/her function. This individual should be competent in areas relative to the emotions that the family or friends are feeling. This person should constantly monitor the condition of the family members or friends, and be prepared to evacuate them if they become cold.

It should be noted that it might be emotionally healing to the family members or friends of an avalanche victim to assist in the search efforts, or at least to visit the site. This is one decision that the Rescue Leader may wish to consider. If the individuals seem physically prepared (in shape, well dressed, etc.), the Rescue Leader may indeed choose to allow them to assist. In so doing, the Rescue Leader may wish to add these individuals to probe lines in the least likely areas, so as not to expose these individuals to any unnecessary sights. In any case, the family members or friends should be identified to field team leaders and, if possible, field team members. Also, a rescuer should stay near them so that they may be monitored. This is especially important if a search team locates a body in the snow. SAR members may want to take the family member away from the scene at this time. In this case, a rescue member should stay with the family and describe what actions will be taken.

It may also be beneficial to have a clergy member available at mission base to meet with the family, if time permits.

Media

In the event of the larger slides, or avalanches with known victims, media attention will certainly be high. In this case, it may be difficult to keep the media away from the accident site (This was certainly proven at the Peak 7 slide near Breckenridge). The decision to allow the media to the accident site is made only after the absolute safety of the area is determined. Allowing the media to the site does not necessarily present a problem if the Rescue Leader is careful to rope off an area beyond which the media is not allowed. Furthermore, isolation of the RP or any other family members from the media is important. These family members or friends must know that the decision to talk to the media is theirs.

The decision to allow the media to the site is often made by the Incident Commander and/or Sheriff's Deputies, with the input from the Rescue Leader. Remember that the media is our friend, especially the TV stations that provide helicopters for search activities during all seasons.

In the event that TV helicopters do fly over the accident site for aerial video of the area, Rescue Leaders should know that the noise of helicopters alone will **not** add to the avalanche hazard. Still, the Rescue Leader may choose to call off the helicopters if they distract the rescue efforts.

Certainly the weight of a helicopter on top of a mountain is significant and could cause the snow to slide.

Resource Management

With most avalanches, there may be a large number of rescuers at the scene, often from numerous different agencies. In this case, the Rescue Leader should use flagging to create an Entry/Exit gate through which all rescuers must pass. Furthermore, one rescuer can perform the function of check-in/check-out so that all rescuers can be accounted for.

The numerous agencies that work at avalanche rescues usually work well together. Still, the Rescue Leader can be critical to the successful integration of numerous agencies. The following should be considered:

Have agencies from similar disciplines (e.g. SAR teams members, Ski Patrol personnel, etc.) work together on the same field teams. Furthermore, assign members from the same agency to the same field team, since these individuals know each other's strengths and weaknesses.

Utilize leaders from each discipline as field team leaders. In other words, use a Ski Patrol leader for a Ski Patrol team, etc., if possible.

Identify a known leader from the various disciplines (e.g. Ski Patrol leader) who can assist the Rescue Leader or who, at a bare minimum, is accessible to the Rescue Leader via radio.

Determining where to Conduct Probe Lines

POA's/POD's

Avalanche Rescue Leaders should be familiar with the theories of POA (Probability of Area) and POD (Probability of Detection).

As with any normal backcountry search, an avalanche area can be divided into separate segments. Each segment is assigned a POA that is equivalent to the subjective percentage possibility that the victim is in that area. A POA of 25% means that the person(s) who developed the POA's believe there is a 25% chance that the victim is in that particular segment. Certainly, the area outside the avalanche should be considered as a separate segment as well, and Rescue Leaders should strongly consider developing POA's with the help of other trained individuals, since this is purely a subjective process and multiple input will reduce the possibility of subjective bias. Remember that the cumulative POA's for all areas must equal 100%. For example:

Segment #	POA
1	40%
2	15%
3	40%
ROW*	5%
Totals	100%

* Rest of world

Once probing begins, the POD's for each segment of the avalanche are computed (easy... coarse probe = 70%, fine probe = 100%). POD means the percentage chance that the victim would have been found in the prescribed segment (A 70% POD means that 70 of 100 buried victims would have been found within that segment).

After POD's are computed for the individual segments, a POS (Probability of Success) for each segment can be computed. POS is simply POA * POD. Using the example above, if segments 1 and 3 are coarse probed, the POS's would be as follows:

POS = POA * POD

Segment #	POA	POD	POS
1	40%	70%	28%

2	15%		
3	40%	70%	28%
ROW	5%		
Totals	100%		

Now, let's assume we coarse probe segment 1 again. What is the "cumulative POD" for that segment (it is certainly greater than the 70% of each individual pass. To compute the new "Cumulative POD", we must do the following math:

$$\text{Cumulative POD} = \text{Old POD} + ((100 - \text{old POD}) * \text{new POD})$$

Segment #	POA	POD 1st pass	POD 2nd pass	Cumulative POD
1	40%	70%	70%	91%
2	15%			
3	40%	70%		70%*
ROW	5%			
Totals	100%			

* No change, we probed it only once.

Now that we have coarse probed segments 1 and 2, isn't the POA for those segments now lower (in other words, haven't we reduced the chance that the victim is in those areas)? The answer is yes. To compute the new "adjusted" POA, we must do the following math:

$$\text{Adjusted POA} = (100 - \text{cumulative POD}) * \text{last POA}$$

Segment #	Original POA	Cumulative POD	Adjusted POA
1	40%	91%	3.6%
2	15%		15%*
3	40%	70%	12%
ROW	5%		5%*
Totals	100%		35.6%

*No change, since no POD's have yet been applied.

Now, since the total of the adjusted POA's does not equal 100, we must "normalize" or "shift" them. To do so, we do the following math:

$$\text{Shifted POA} = (\text{Adjusted POA} / \text{sum of all POA's}) * 100$$

For segment 1, for example, the shifted POA is as follows:

$$(12/44) * 100 = 27\%$$

Using this same math we come up with new POA's for the four segments as follows:

Segment #	Original POA	Cumulative POD	Adjusted POA	Shifted POA
1	40%	91%	3.6%	10.1%
2	15%		15%	42.1%
3	40%	70%	12%	33.7%
ROW	5%		5%	14.1%
Total	100%		35.6%	100%

Notice that the new shifted POA for segment 2 indicates that this is now the highest probability area. Furthermore, segment ROW (rest of world) is a higher probability as well. Since we have probed segments 1 and 3 (segment one with two passes, segment 3 with one pass), it stands to reason that the new POA for these areas has dropped. The POA for segment 1 has dropped sharply!

You can see from these examples, that using POA/POD can help you turn the subjective part of avalanche probe lines into an objective process. This helps reduce personal biases and other emotional issues that have little place in the probe line process.

The Rescue Leader "Resource Packet"

The avalanche Rescue Leader should carry a resource packet with him/her at all times during the avalanche season. Not all of these materials would be taken into the field during rescue operations, but many are required at the conclusion of the rescue operation. This packet should contain, at a minimum, the following materials:

Resource Listing

This listing should include phone numbers and call-out procedures for the following organizations:

1. Direct office line for local avalanche forecaster
2. Accredited Avalanche Rescue Dogs
3. National Ski Patrol "Pro Patrol Directors" for the developed ski areas within the team's response area.
4. State Transportation Department officials (especially avalanche control team)
5. Other SAR teams in the area

The Rescue Leader may wish to give a copy of this material to the Incident Commander before entering the field, so that the Incident Commander has this information available. Certainly, the SAR team's pre-plan should ensure that this material is already available, however, the Rescue Leader may arrive at the scene before the team's leadership has staged its mission base.

Avalanche Accident Report Forms

The Rescue Leader and/or Incident Commander should complete this form, often developed by the local avalanche forecast center, as soon as the mission is completed or suspended. It is through these forms that the avalanche rescue and forecast community is able to develop statistics with regard to avalanche accidents. A copy of this form should be submitted as soon as possible, and should also be filed with the SAR team's Mission Report packet.

SAR Team Medical Report Form

The Rescue Leader must carry Medical Report Forms (a.k.a. Trip Tickets) for his or her agency so that proper documentation regarding the condition and treatment of victims can be completed. Generally, the lead medical member completes these forms, however the Rescue Leader should ensure that this form is completed for each victim. Again, these forms should be filed with the team's Mission Report packet.

Small, waterproof notebook and pencils

This material should be carried into the field so that the appropriate documentation can be accomplished at the accident site.

Calculator

This makes calculating Shifted POA's easier.

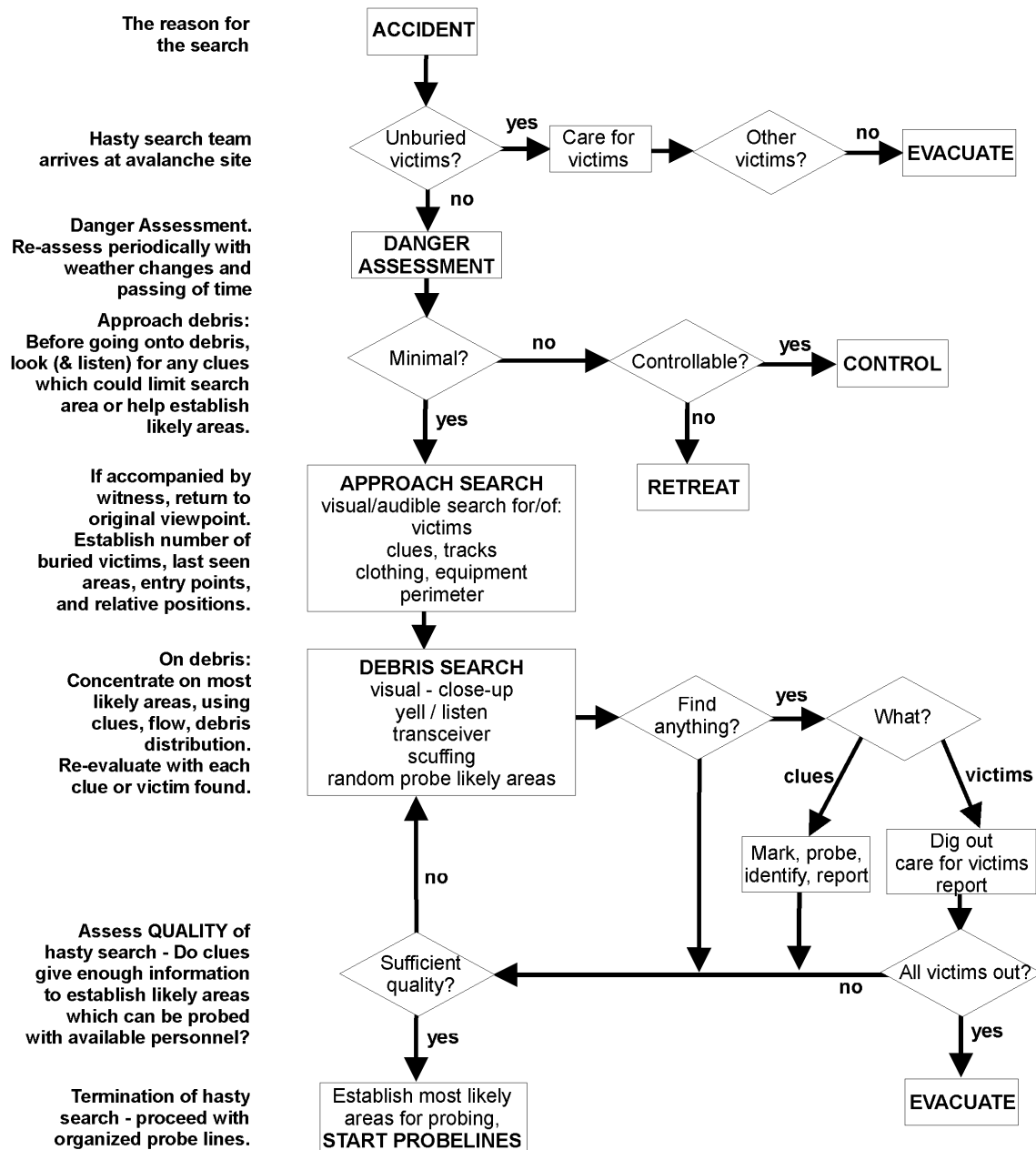
Conclusion

While the job of Rescue Leader is one filled with objective decisions, such as procedures to follow, there are many subjective decisions involved in the job, which make it a true challenge. Foremost among these is the constant assessment of the hazard of additional avalanche. Once this assessment has been made, and assuming s/he is part of the hasty operation, the Rescue Leader must assure that the hasty search is performed in an organized manner, so that the likely burial areas may be quickly identified. No victim should be penalized for the time lost due to organizational problems. After all, by the time we move on to the slow process of organized probe lines, we stand little chance of finding a survivor.

Appendix A – Hasty Search Flow Chart

HASTY SEARCH FLOW CHART

by Dale Atkins, Colorado Avalanche Information Center



Appendix B - Additional References

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