

UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
HORACE M. ALBRIGHT TRAINING CENTER
Grand Canyon, Arizona

P&VP-73

MOUNTAIN RESCUE TRAINING

INTRODUCTION

It is most important that you realize the purpose of this training session. It is not to make you a competent or even qualified mountain climber. Our primary purpose is to make you a useful and valuable member of a rescue team (not a climbing team). In this session we will teach only those mountaineering skills that are necessarily used in a normal mountain rescue operation. If you have never climbed before, you will find that this session will make you much more conversant with experienced mountain climbers because of the similar equipment, knots, techniques, etc., used in both climbing and rescue. Do not delude yourselves that because you speak the language that you are automatically a climber. Use this knowledge and these skills as intended--as a member of a rescue team under a better qualified leader.

HANDOUT AND REFERENCE - "Mountain Search and Rescue Operations"

CLASSROOM TRAINING SESSION

- I. Mountain Rescue Equipment
- II. Ropes, knots and rope management

Rope, types and characteristics, 7/16"

1. Manila, 2,500¹⁵⁷⁵⁰ lb., 50% over carabiner, 12% elongation
2. Sisal, ~~12,780~~¹⁵⁷⁵⁰ lb., 68% over carabiner, 12% elongation
3. Mountain nylon, 3,500 lb., 79% over carabiner, 55% elongation
4. Perlon solid core, 5,400 lb., 55% elongation

10/14/64

5. Plymouth Goldline, 5,200 lb.
6. Braided Goldline, 4,700 lb.

Knots

1. Terms

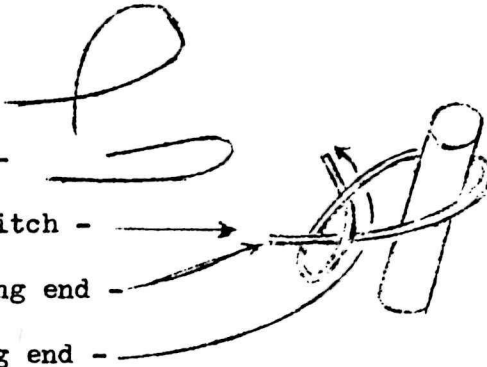
a. Loop -

b. Bight -

c. Half Hitch -

d. Standing end -

e. Running end -



2. Tie two ropes together.

a. Square knot, for equal size ropes - right over left, left over right.

b. Double sheet bend, for unequal ropes.

3. End of the rope knots.

a. For anchor - round turn and 2 half-hitches.

b. Bowline.

c. Bowline on a coil.

4. Middle of the rope knots.

a. Butterfly.

5. Special knots.

a. Prussick (Junior Ascender).

6. Knot efficiency, nylon rope.

a. Square - 54%

b. Double sheet bend - 62%

c. Bowline - 65%

d. Butterfly - 63%

7. Rope coil.

III. General mountain climbing terms and techniques.

Signals

1. On belay, 2 jerks

2. Climbing, 2 jerks

Test - Testing (optional)

3. Slack, 1 jerk - pull steady

4. Up rope, 3 jerks

5. Tension, 3 jerks - pull steady

6. Off rappell

7. Off belay

8. 10 feet

9. Falling

10. Rock

Measure of Climbing Difficulty

Class 1 - walking.

Class 2 - scrambling, using hands.

Class 3 - easy climbing, rope may be worn.

Class 4 - moderate climbing, exposed, belaying essential.

Class 5 - difficult climbing, very exposed, pitons or other anchors used to protect leader.

Class 6 - extremely difficult climbing, pitons or other equipment used for direct aid.

Class 7 - impossible climbing, supernatural aid required.

- IV. NPS training, setting up rescue teams, and use of outside organizations.

CLIMBING AND RESCUE TECHNIQUES - FIELD

- I. Belays and Practice Falls.

Chain of belaying - maximum load (in pounds) that each link may be expected to stand -

1. The human body - 1,750
2. 7/16" nylon rope (79% over carabiner) - 2,760
3. Carabiner - 2,000
4. Piton - 3,000
5. Rock crack (not sandstone) - 2,200

Static and dynamic belays.

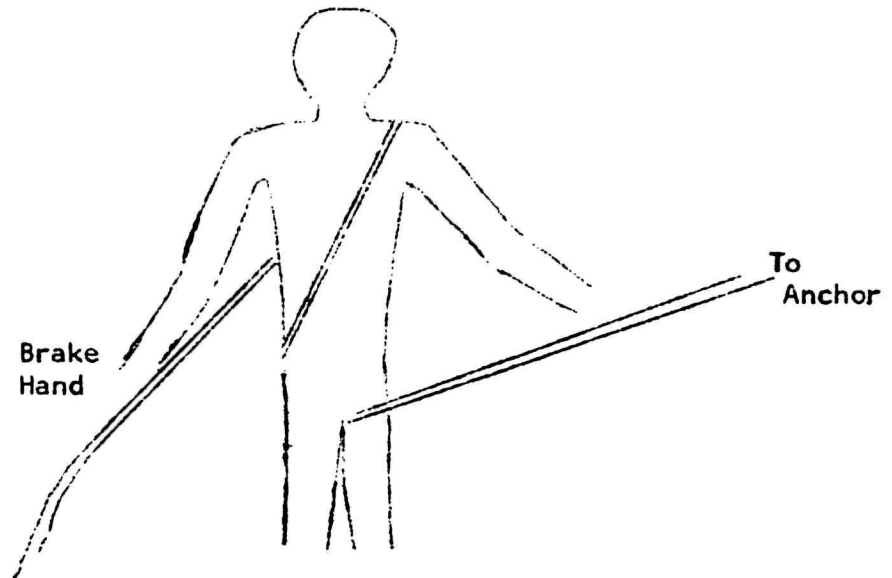
Practice belay - signals

1. Belayer - "On belay"
2. Climber - "Climbing"
3. Climber - "Ready to fall"
4. Belayer - "Fall"
5. Climber - "Falling"

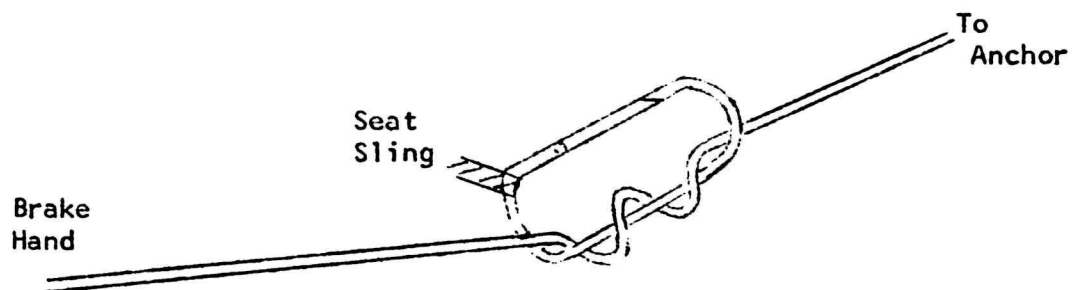
- II. Piton Placement, demonstration party climb.

III. Rappelling - always with belay.

Body rappell

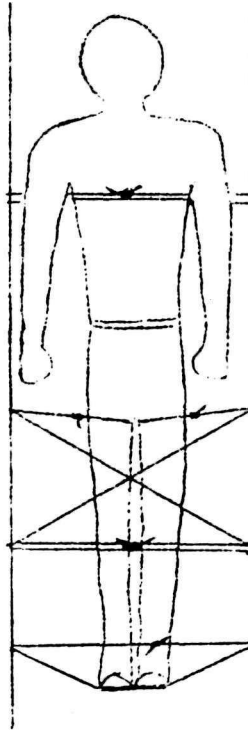


Carabiner rappell - remember, slack taken between you and anchor, always test.



IV. Litter evacuation - watch out for falling rock.

Stretcher tie-in -



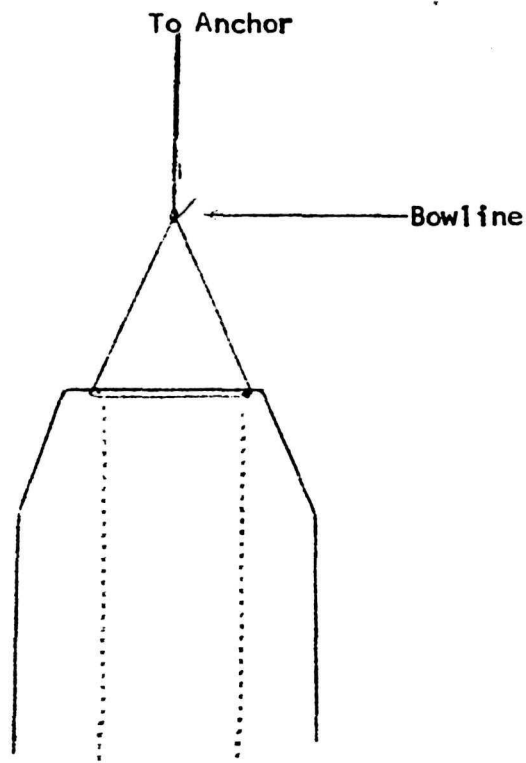
Square knot

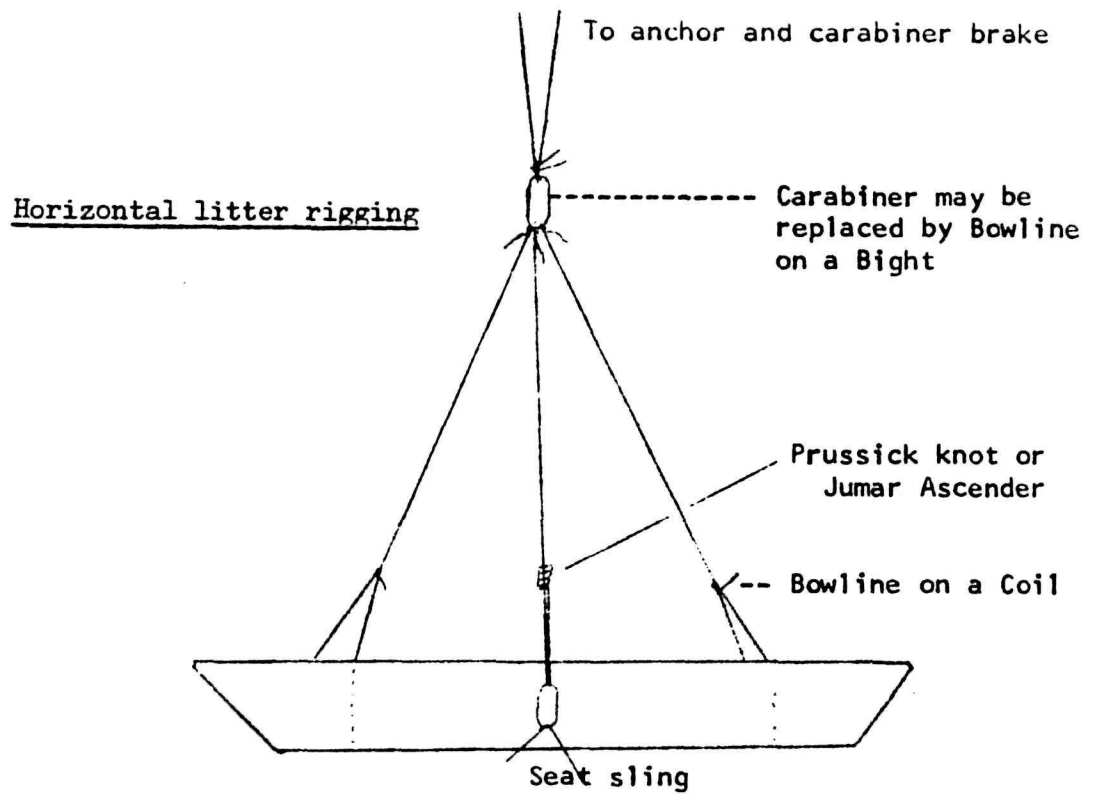
Bowline around leg

Square knot

Square knot

Vertical litter rigging





- V. Rescue winch demonstration (see "Mountain Search and Rescue Operations" book for 4-piton anchor).

And don't forget the big sale on "Little Gem" Suction Cups - sponsored by your friendly Horace M. Albright Training Center Recreation Association.



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SEARCH AND RESCUE

Discussion Outline

I. Introduction

- A. Obligation of National Park Service to provide search and rescue service
 - 1. Derived from jurisdiction conferred by law through Congress
 - 2. Moral and humanitarian considerations
 - 3. Qualified manpower and available equipment
- B. Importance of area rangers having a thorough knowledge of likelihood of occurrence of search and rescue situations in their areas and a knowledge of:
 - 1. Terrain, cover and weather
 - a. How they create situations
 - b. How they affect behavior of subjects of various age, sex, and experience
 - 2. Recreational use (types)
 - 3. Age, sex and use patterns of employee groups
 - 4. Availability of equipment and manpower
 - 5. History of past search and rescue operations
 - 6. Importance of pre-planning and training
 - 7. Effecting safeguards

II. Search Operations

- A. General: Three basic phases of search operations
 - 1. Investigation
 - a. Determine positively that a search or rescue situation exists
 - b. Detailed description of subject
 - c. Circumstances of disappearance
 - d. Protection of site where last seen, also clothing
 - e. Record all information in written notes
 - 2. Patrol or physical search

- a. Compute possible time and distance factors in relation to time and place subject last seen and time of report. Make determination of initial methods of search to be employed and probable area to be covered. Consider such factors as:
 - (1) Current and forecast weather and subjects likely period of survival, if unhurt.
 - (2) Density of forest cover and feasibility of aerial observation
 - (3) Terrain hazards and likelihood of injury
 - (4) Reasonable egress routes for subject from area and ingress routes for searchers
 - (5) Availability of trained and experienced manpower and of special equipment
 - b. Put preplanned search or rescue procedures into gear
 - (1) Dispatch searchers to areas of greatest hazard and known attraction (especially for children)
 - (2) Notify nearby campers and visitors of lost person near their area
 - (3) Set up perimeter patrol as well as center patrols
 - (4) Provide experienced leadership
 - (5) Be systematic with grid divisions or natural terrain divisions of the search area
 3. Service and supply
 - a. Plan a step ahead in case of failure of present step for such as:
 - (1) Hounds, horses, loudspeakers
 - (2) Airplanes, helicopters
 - (3) Additional manpower and relief
 - (4) Food, coffee, etc.
 - b. Arrange for handling families and friends including accommodations
 - c. Provide comprehensive communications system to channel information to search direction center and information to search groups
 - d. If search or rescue runs into second day, wire information to Director and Regional Director prior to information to press or radio of a continuing search that promises to be newsworthy
 - e. Arrange for continuing information to press and radio in a manner that will assure greatest accuracy of reporting and least special considerations
- B. Searches and rescues involving special considerations
 1. Water areas
 - a. Knowledge of boats, grappling hooks and nets

- b. Knowledge of water currents
- 2. Desert areas
 - a. Use of vehicles and horses
 - b. Must provide adequate water supply
- 3. Glacier areas
 - a. Use only trained men
 - b. Need special equipment
- 4. Winter conditions
 - a. Many areas call for use of experienced men only
 - b. Need special equipment
 - c. Consider added dangers of cold and avalanches
- 5. Snow avalanches
 - a. Consider flow properties of snow avalanches
 - b. Plot likely site of body
 - c. Guard against danger of second avalanche
 - d. Use probing poles in parallel lines or dig parallel ditches
- 6. Cliff or canyon areas
 - a. Requires pretraining of manpower
 - b. Need for ropes, basket litters and other special mountain climbing equipment
 - c. Pick out easiest and safest route
 - d. Consider danger of falling rocks and rock slides

Mtn. Search & Rescue

L. E. Bridge

New Zealand

Morhead → "Best"



At the present moment, most SAR units and resources are oriented solely to finding the victim by whatever method they feel is the best or whatever system they employ. It's the "call us, and we will find the victim" effect. Thus, units and resources are racing towards the victim "wherever" he is. As the search area becomes smaller, there is a crowding effect and units start competing with one another to find the victim. Furthermore, as the crowding effect becomes more intense, methods start to interfere with each other. Visual trackers begin to have difficulty in picking out tracks in areas where large groups of people have just raced thru in anticipation of finding the victim just because the visual trackers earlier indicated a direction. The same becomes true of tracking dogs. Sign cutting is a very useful method, but useless after untrained grid searchers have gone thru. In many cases, a helicopter can spot a victim, but it becomes far more difficult if the searchers below are wearing the same colored clothing as the victim.

In the planning stages of a search, efficiency dictates that the problem be solved as quickly as possible using the least amount of resources. Resources, on the other hand, utilize different methods of finding victims, but also have different inherent logistics. Grid searchers deal with manpower thus take time to assemble and administer. Good visual trackers are very skilled in their technique, but are not readily available. Tracking dogs are limited by time, weather, etc. Resources tend to specialize in one technique and feel that the same technique should be used to finally find the victim regardless of the inherent shortcomings.

At the onset, most search missions encompass a very large area. A good search plan aims at reducing the size of the area as quickly as possible. This can be accomplished thru clues. Clues, however, appear in different forms. The type of terrain is a clue to the possible direction of the victim. The circumstance of the loss may yield some information. The finding of several footprints going downhill may be invaluable. The weather is a very good indicator of possible hypothermia and subsequent behavior of the victim. There are many other clues and evidence of the victim's whereabouts.

In view of this, a search director should consider his available resources and ask himself "what can this unit do for me, and what information can it provide to the ongoing planning"? It is not enough for the resource to say that they have "not" found the victim. They have also not provided any other information. Furthermore, they may have destroyed evidence that could have been used by some other technique.

In order to get a better view of an overall strategy, it is necessary to subdivide resources into the following categories:

1. Clue Finders - this category would include: visual trackers, sign cutters, interrogation teams, tracking dogs.
2. Clue/Victim Finders - this would include hasty teams, and/or searching dogs.
3. Victim Finders - to include grid searchers, helicopters, etc.

This breakdown of categories also indicates the call-out priority and defines to both the director and the resource, what is expected.

Since the reduction of the size of the search area is the first step in a good plan, this can be accomplished by the Clue Finders.

They should be called first and quickly. They are skilled and small in number, thus the logistics are reduced. However, clue finders (eg. visual trackers) should be aware that their main function is to find the clues as quickly as possible. Once finding the clues, thus indicating a direction which in turn reduces the search area, their job may well be done. At this point, the Clue/Victim Finders can be called upon as the search area is now smaller than the original, but still larger than they, themselves, can handle.

The clue/victim finders represent a slightly larger number of personnel but still small compared to grid searchers. Furthermore, they have to be trained, to some degree, in several skills. Their main function is to search the areas ahead of, and, as indicated by the clue finders. They perform the function quickly (eg. searching dogs). In their task, they do not overlook possible routes or barriers of victim travel, victim attractions, or any dropped article by the victim. They are contributing, ongoing, information that is vital to the overall strategy. Once their task is completed, further clues are added to the planning and the search area is further reduced.

By this time, the area is reduced to the degree that the victim finders (grid searchers) can be effectively employed. Furthermore, it would be expected that they would search the terrain quickly and efficiently and in the end - find the victim.

The above system depends on several ingredients. Clue finders must be highly skilled within their own specialization. Clue/victim finders must have several skills to some degree, but not necessarily to the degree of the clue finders. Victim finders must thoroughly and quickly search designated areas. Clue finders should expect that their main contribution is the finding of clues, thus reducing the search area. They may well not be the resource that finds the victim. Clue/victim finders must not overlook any clue that is available, and only occasionally will find victims. Victim finders would usually find the victim, however, must always remember that it was accomplished thru the talents of the other two categories.

Selecting units will be done on the basis of the "function" that the search director desires. Furthermore, the units should be aware of the function that they are assigned. The problem will be judging the degree of skill of the different resources.

The system is "function" oriented in the integration of many skills in quickly and efficiently finding the lost victim. It may require that present day search and rescue units align themselves to the functions that are required in affecting a successful mission.

Strategy also includes confinement (road patrol), as well as attraction (beacons), however, that will be covered in overall planning. Not all search directors will have the resources that fit into all three categories. It will be in his best interests to either develop them in his own area, OR, be aware of where the resources are available.

Increased POD can be achieved by using more searchers and spacing them closer together OR by re-searching the area using the same spacing. Using a 50% POD spacing and searching an area twice, results in a POD of 75%. If it is searched a 3rd time, the coverage becomes 87.5%. The number of searchers has not been increased, but it takes a longer time.

Other ways to increase POD are:

- (a) Repeated Expansion
- (b) Creeping Repeated Expansion
- (c) Directional Overlay

Re-searching areas is common. First the area may be looked at by helicopter; next a hasty search using searching dogs; then a grid sweep of a 50% POD spacing. To compute the final coverage, use the following formula:

1.00 - POD of 1st coverage = a
 1.00 - POD of 2nd coverage = b
 1.00 - POD of 3rd coverage =

then $1.00 - (a \times b \times c) = \text{final coverage}$

If the helicopter had a coverage of	40%	POD
The dogs went thru with a	70%	POD
And the grid sweep was	50%	POD

Then

$$1.00 - (.6 \times .3 \times .5) = 1.00 - .09 = .91$$

The final coverage of the area is 91%

From this, it can be seen that there are various ways of achieving an adequate coverage using different resources and different methods. It is up to the search director to select the best configuration based on time and available resources.

STRATEGY & TACTICS

Determining Area Size - for Grid Searching

In order to determine the optimum size of area to be searched, it is first necessary to establish a reference point for planning. It can be any one of the following:

- (a) Point Last Seen (PLS)
- (b) A Predicted Position (PP)
- (c) An Estimated Position (EP)

Separate POA tables are available for each reference

The number of grid searchers available to any search director will vary for any given search and will further vary from day to day on that particular search mission. To calculate the optimum size area, it is only necessary to know the number of searchers available for that day, and select the reference point. Varying the spacing between searchers determines the POD, then multiplying this POD by the appropriate POA produces the probability of success. The spacing that produces the highest POS is considered the optimum size of area to search with that number of searchers.

To demonstrate the principle, start by placing searchers very close together (high POD), increase the spacing by steps of 10. Then select a small area to search (low POA), and increase the size of area in steps of 10. The resultant figures appear:

POD		POA	POS
90	area A	50	45%
80	area B	60	48%
<u>70</u>	area C	<u>70</u>	<u>49%</u>
60	area D	80	48%
50	area E	90	45%

The optimum size of area would be "C", and it should be searched with a 70% coverage. This demonstrates that searching a small area too thoroughly results in a lower POS. Searching a large area less thoroughly also results in a lower POS. Somewhere in between is optimal area based on the number of searchers available.

The following table demonstrates a search for a lost hiker in the mountains, with 75 grid searchers. The table displays calculations for "Point Last Seen" and "Predicted Position" planning.

STRATEGY & TACTICSAdjusting Probabilities

At the beginning of a search there are specific areas with a higher probability of containing the victim. As each area is searched with neative results, the probability of the subject being in another area increases. For example, if we have 4 areas, and there is an equal probability that the subject might be in any one of them, then we have a distribution of:

area A	area B	area C	area D
25%	25%	25%	25%

If we search area A, with 100% coverage, then area B, and then area C, the probability of the victim being in area D is as follows:

area A	area B	area C	area D
25%	25%	25%	25%
/	33.3%	33.3%	33.3%
/	/	50%	50%
/	/	/	100%

In search work, 100% coverage is seldom possible due to time or resource limitations. A coverage with less than 100%, and a negative answer when one specific area has been searched, results in one of two alternatives:

- (a) the subject was missed by the searchers
- (b) the subject was not in the area

By considering the probability of (a) missing the victim, then the likelihood of (b) can be calculated. This can be done using the following formula:

$$POA = \frac{Pa \times Pm}{Pa \times Pm + Pn}$$

Pa is the original probability.
Pm is the prob. of the subject being missed
Pn is the prob. that the subject was not there in the first place

Using the above example, and searching area A with a 70% coverage, the probability of the victim being in area A is:

$$POA = \frac{.25 \times .3}{.25 \times .3 + .75} \quad \text{equals} \quad \frac{.075}{.825} \quad \text{equals} \quad .09 \text{ or } 9\%$$

There is now a 9% chance that the victim is still in area A.

After area A has been searched, then the probabilities of the victim being in areas B,C, and D are as follows:

area A	area B	area C	area D
9%	30.3%	30.3%	30.3%

By subtracting the POA of 9% from the original POA of 25%, it is now possible to say that there was a 16% possibility that the victim was not there in the first place.

When areas B and C are searched with the same coverage, then the POA's are as follows:

	area A	area B	area C	area D
Original	25%	25%	25%	25%
	9%	30.3%	30.3%	30.3%
	11.5%	11.5%	38.45%	38.45%
	15.8%	15.8%	15.8%	52.6%

When area C has been completed, then there is a 52.6% chance that the victim is in area D, and only a 15.8% chance that the subject is still located in areas A, B, or C.

In the original example, the probability of the subject being in any of the areas was equal (25%), and each area was searched with equal coverage (70%). Seldom does this occur on real searches as areas usually have unequal POA's, and are searched with unequal POD's. For calculations under these conditions, the following formula is used:

$$POA = \frac{Pa \times Pm}{K(Pa \times Pm + Pn)}$$

Pa = prob. of being in the area

Pm = prob. of being missed

Pn = prob. of not being there

K = Pa x Pm + Pn of the previous area searched

This data is used solely to predict victim behavior. (See also Table 1 - initiation of a SAR mission). Predicting subject behavior and performance is an integral part of strategy (or where do you search).

Predicting subject behavior - four calculations to consider:

1. Time frame for survival
2. Period of subject mobility
3. End of search (max time for survival or 100% search area coverage)
4. Search area (predict max size)

Strategy - Where are you going to look!

POA = Probability of Area

1. Historical Data
2. Statistical Analysis
3. Gut-feeling
4. Deductive reasoning
5. Statistical data and gut-feeling

Historical data, if applicable, usually has a high degree of successful prediction. However, it is very limited in application as it is only applicable in specific areas. Of the remaining alternatives, the gut-feeling plus statistical data is the best. The Mattson method (see handout- Establishing Search Areas, by R. Mattson) combines the experience of others into a common consensus. Statistical data provides a probability chart which indicates "where" along the route, and the size of the area to be searched.

"How" do you search?

Effective search planning, depending on the priority, follows in the following modes:

1. Passive - have the subject come to you by:
 - a. Waiting until the subject walks out on his own
 - b. Confining the subject within a perimeter manned by a minimum of your resources
 - c. Attracting the subject to a specific location
2. Active - you now have to search for the victim by:
 - a. Clue finding, by specialists, in order to localize the area
 - b. Hasty searching, by trained personnel in order to reduce the size of area
 - c. Grid searching, by trained personnel by preference or untrained by necessity, in order to find the victim.
3. Combination - using the methods of confinement, attraction, and detection all at the same time.

Base Line	Spacing	POD	PLS POA	POS	PP POA	POS
.2	14.08	.9096	.0116	.0105	.1034	.0940
.4	28.16	.8592	.0232	.0199	.1379	.1184
.6	42.24	.7888	.0348	.0274	.1551	.1223
.8	56.32	.7184	.0863	.0619	.1724	.1238
1.0	70.40	.6480	.1379	.0893	.2413	.1563
1.2	<u>84.48</u>	.5776	.2068	<u>.1194</u>	.3793	<u>.2190</u>
1.4	98.56	.5072	.2240	.1136	.3946	.2001
1.6	112.64	.4368	.2413	.1053	.4099	.1790
1.8	126.72	.3664	.2585	.0947	.4252	.1557

This table shows that the best spacing is 85 feet between searchers (forming a base line of 1.2 miles), for both the PLS as well as the PP reference points. However, the probability of success is quite different. Planning this search from the PLS has a predicted success of 12%, while searching from the PP has a predicted success of 22% - a 10% gain.

Search directors should use such tables to determine the area size, and the reference point that yields the highest probability of success.

STRATEGY & TACTICSEfficient Distribution of Resources

Various resources and methods have different probabilities of detection. There are also various probabilities of a subject being any given distance from the point last seen. By multiplying the probability of detection (POD) times the probability of a subject being in a given location (POA), predicts the probability of a successful find (POS)

$$\text{POD} \times \text{POA} = \text{POS}$$

The probability of success (POS) can be used to compare one resources distribution against another. For example:

- Given: 1. Helicopter - POD is 40% and takes 2 hrs to search 1 sq mile.
 2. Searching dogs - POD is 80% and take 4 hrs to search 1 sq mile
 3. Grid search - 20' spacing POD is 90% with a travel rate of
 60' spacing POD is 70% 3.5 hrs per mile
 100' spacing POD is 50%

Estimations of a POA distribution for 3 different areas are:

- (A) PLS up to 1 mile is 36% search area is 3.14 sq miles
 (B) Between 1 & 2 miles is 50% search area is 9.42 sq miles
 (C) Between 2 & 3 miles is 17% search area is 15.7 sq miles

The POS and searcher hours can be calculated for different combinations in each area to decide which combination is the most efficient (and time), with the greatest Probability of Success

	Area A	Area B	Area C	shrs	POS
1.	dogs	20' grid	helicopter	8748.04	76.6%
2.	20' grid	dogs	helicopter	2970.44	75.2%
3.	dogs	60' grid	helicopter	2945.32	66.6%
4.	dogs	helicopter	100' grid	2943.75	52.3%
5.	60' grid	helicopter	dogs	1048.74	50.8%

Note that distribution #1, with the highest POS of 76.6%, takes a large amount of time or people to accomplish. While #3 and #4 differ by only 1.5 searcher hours, however, there is a 14.3% difference in POS.

A search director may not find it feasible to pursue the highest probability of success due to time or the number of grid searchers available. Therefore, he might elect #2 with #3 as an alternative.

STRATEGY & TACTICSProbability of Detection and Methods

Probability of detection (POD) predicts the chances of spotting the victim. A 70% POD means that there is a 70% chance of spotting the subject. If grid searchers are spaced very close together, the probability of spotting the victim is high. If a helicopter flies a close track spacing, the POD is also high. On the other hand, if grid searchers are spaced far apart, their chances of finding the victim are low. Thus, changing the spacing of grid searchers, or varying the track spacing, changes the chances of spotting the subject. In grid searching, different spacings between searchers results in the following POD's:

100' apart = 50% POD
 60' apart = 70% POD
 20' apart = 90% POD

For any other distance, the POD can be calculated by:

$$100 - (.5 \times \text{spacing}) = \text{POD}$$

Under average conditions, a grid team takes 3.5 hrs. to travel a distance of 1 mile. With this knowledge, the searcherhours required to search each square mile can be calculated for the following POD configurations (consider a 1 mile base line):

(50% POD) 100' requires 53 persons x 3.5 hrs = 185.5 shrs
 (70% POD) 60' requires 88 persons x 3.5 hrs = 308.0 shrs
 (90% POD) 20' requires 264 persons x 3.5 hrs = 924.0 shrs

This shows that a 70% coverage of 1 sq. mile requires 88 men for 3.5 hrs.

With this information, we can now calculate the requirements for each type of coverage. For example:

- Q1. If 25 searchers are available for 7 hours, how large an area can be covered with a 70% POD coverage?

$$25 \times 7 = 175 \text{ shrs available}$$

$$175/308 = .56$$

In 7 hours, 25 men can search a little over $\frac{1}{2}$ square mile with a 70% POD

- Q2. If the search area is 4 sq. miles, and you want a 70% coverage, how many searchers would you need to search it in 1 day? (assume 7 hours equals 1 search day)

$$308 \times 4 = 1232 \text{ shrs required}$$

$$1232/7 = 176 \text{ searchers}$$

176 searchers would be required to search 4 sq. miles in 1 day with a coverage of 70%

Search planning then takes into consideration what resources you use and when you use them. Furthermore, it is up to the search director to decide what are the optimum deployments of the various resources. Optimum search planning should be a consolidation of opinions by knowledgeable and experienced representatives of each of the resources.

Probability chart for Hikers (Hills & Mountains)
From "Victim Behavior"

