MEANS FOR LOCATION OF AVALANCHE VICTIMS IN THE PAST AND IN THE FUTURE

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Introduction

The initial purpose of our Foundation was to provoke the interest of both creators and users in technical instruments for location of avalanche victims. The result was very positive. Our more recent goal is to achieve a better understanding between those who are able to develop new equipment and those who will use it (trying to prevent useless instruments from coming on the market) and concentrating all efforts to create really effective location tools.

We organized a first Symposium in Davos, Switzerland (Fond. Int. "V. Eigenmann", 1963) and a second one in Sulden, Italy (Fond. Int. "V. Eigenmann", 1975). These were attended by many people from both the technical and rescue fields. All came with good intentions. However, the degree of mutual understanding was low at Davos and still limited in Sulden. Thus, I will try here to explain again what we think to be the technological possibilities for locating victims in the future, comparing advantages and disadvantages of traditional means with those that could be developed. I will limit this review to those systems which our scientists judge worthy to be developed or at least worthy to be thoroughly studied.

All new methods should be compared and evaluated against the two traditional methods: Avalanche dogs and probes. First, a brief summary of these traditional methods from data compiled by Schild (1975):

Avalanche dogs:

Coarse searching time . . . . 30 min/hectare
Fine searching time . . . . 1-2 hrs/hectare

Probes:

Coarse searching time . . 20 men require 4 hrs/hectare
Fine searching time . . 20 men require 20 hrs/hectare.

Avalanche dogs have the advantage of time and speed, but the disadvantages of requiring training and transportation. They may also fail due to stress, storm conditions, or scent

contamination. Probing may also fail due to stress of the rescuer. Training and feeding an avalanche dog may entail considerable time and expense.

Compared to dogs, any new rescue device has the major advantage of not requiring training (although the operator may require training). Since they can be stored nearer to the endangered areas, shortening the transport time, a little less speed than achieved by a dog could be accepted.

We can divide the new systems into two groups:

A. Search Instruments to be Used by Uninjured Companions

1. Transceivers
2. Probe ski poles
3. Balloons with cord.

B. Search Instruments for Rescue Teams

1. Radiometer
2. Radar
3. Secondary Radar
4. Magnetometer.

A third possible group which involves instruments for self rescue has yet to be proved feasible, but certain backup devices may deserve study.

Search Instruments to be Used by Uninjured Companions

Obviously, the uninjured companions already at the accident scene will have the greatest chance of finding the victim still alive, if they are equipped with an effective search instrument and are able to use it correctly. There will not be any loss of time for transport of needed equipment, so even a slow system will provide still more chance of finding the victim alive than a rapid one brought along by the rescue team, sometimes hours later.

1. Transceivers. The time required to explore an avalanche surface with a receiver depends on:

a) range of the system
b) walking speed of the rescuer
c) time elapsing until the rescuer picks up the first signal (Mainly depending again upon the range)

d) delays to adjust the attenuator and to listen to the signal better

e) time for final accurate location of the victim.

Should we take into consideration the pure walking speed of the rescuer (generally 0.5 m/sec) equipped with a receiver with a range of about 24 m, it would take him 10 minutes to explore an avalanche surface of one hectare. The time factors c), d) and e) under normal circumstances, will at the most triple that value, i.e., the rescuer will need, at the most, the speed the avalanche dog needs for coarse searching (30 minutes). When the rescuer is aware of the range of his system, searching with a receiver, however, is more thorough than coarse searching, either by dog or by probe, since no part of the avalanche will remain unexplored! Also, and this cannot be repeated often enough, one can eliminate the time normally needed to alert a rescue crew and deliver its equipment.

The success of the operation by means of transceivers, however, depends mainly on the following conditions:

For the victim's transmitter:

a) energy supply is assured

b) switch is at "on" position

c) the transmitter has not been lost in the avalanche

d) the transmitter is working.

For the rescuer's receiver:

a) energy supply is assured

b) the receiver is working

c) the rescuer is able to use it correctly

d) the receiver operates at the same frequency as the transmitter.

As far as I know, there is no transceiver on the market able to guarantee these requirements. Many people think they are too severe, but I am sure there are ways to solve the problems. The transmitter must be incorporated into something inseparable from the victim. This surely can be done. The transceiver can be incorporated into a belt, and the apparatus has to be provided with a battery check device.

We should explain why we emphasize that the rescue transceiver should be contained in a belt. When you have to dig out an avalanche-covered person with only the help of your skis, it will take you 40 minutes to move 1 cubic meter of snow (Good, 1975). The first parts of the body which must be set free for breathing are the mouth and the chest. Consequently, the transmitter has to be as near as possible to these parts of the body. It will be useless to have a very precise location instrument and then to need 40 minutes or more to reach the chest and mouth of the victim.

We should also keep in mind that it is easier for an inexperienced rescuer to use a receiver with a directional antenna as he will be able to determine immediately the direction of the signal source before moving towards it. Today, the most popular systems operate on the audio-induction principle at approximately 3000 Hz, but with much higher frequencies we can raise the range of the system to 100 m, reduce weight and size of the equipment, and possibly introduce directional properties.

These new technological possibilities were one of the main reasons why, during the Sulden Symposium, it was not possible to reach an agreement on the choice of one unique frequency of the location transceiver. We do not underestimate the problem of compatibility, nor do we think it will be easy to overcome certain difficulties connected with high frequency systems (strong attenuation by wet snow, suitable receiver antenna and necessary licences), but we think it is too early to stick to a unique frequency when there is so little experience in this field.

To avoid misunderstandings, I have to emphasize that we consider audio-induction equipment very effective and precise, but we think that it is not sufficiently foolproof to become a means of location for general use. To be effective, its use needs special training, units can be lost, and batteries can be exhausted too easily when the endangered person keeps his transmitter working at all times during his run.

I think that an audio-induction system is really useful only for skiers or mountaineers belonging to an organization which will provide for training and control, i.e., for ski patrolmen, ski associations, the Army, and those very expert people who, starting with one or more friends, will organize their trip in all details.

Dr. Lawton's development of the audio-induction transceiver (Skadi) was a great step forward and later devices have their merits too (only ten years ago there were no location beacons on the market at all), but we have to consider

these devices not as a point of arrival but as a point of departure. Therefore, we must try to convince the manufacturers to do more and to do better.

Anyone interested in more detailed information on the subject should consult the article by Monti-Guarnieri (1976) (English translation available on request from Vanni Eigenmann Foundation).

Finally, we emphasize that, irrespective of the brand of transceiver, it is important that the user practices a few times each season with the transceiver on realistic search problems, and that the user periodically checks to ensure that batteries and circuits are operable.

2. Probe Ski Poles. In comparison with traditional probes, ski poles have the only (but very important) advantage of being immediately available at the scene of the accident. Mr. Hauser, now President of the Rescue Organization of the Swiss Alpine Club, proposed a model that has been partially improved by our Foundation. The model of the U.S. Ski Patrol has been examined also in Europe by Fritz Gansser who found it very useful as well. We do not know if the designers have been able to solve the problem of basket removal in a satisfactory way, but think the best solution would be a basket fastened to the pole by a screw cap of nylon which tightly sticks to the pole thanks to a knurling of the respective site of the pole. Basket, clamping ring stop, and screw cap should be molded in one piece with the screw prevented from coming fully out of the cap. Then the basket will prevent the whole lot from being lost in the snow when detached from the pole. Anyone interested in seeing this solution can get a design from our Foundation.

3. Balloons with Cord. Mr. Holder, a French rescue man, proposed the attachment of a self-inflating balloon to the traditional avalanche cord. The idea is certainly an improvement of the old avalanche cord which alone has too little chance of remaining on the surface of the snow. Of course, the fabric of the balloon must be very strong in order to resist cutting by ice slabs or rocks. It is a cheap solution, but one has to consider that the system can be used only once. A skier, knowing himself to be exposed to avalanche hazard, may take, for instance, the sudden noise of an airplane for that of an avalanche, pull the cord and inflate the balloon, thus losing his protection for the rest of the trip. For organized and experienced people, however, it could be a cheap means of location on the condition that shovels are on the site.

Search Instruments for Rescue Teams

In comparison with the traditional rescue means, electronic equipment for rescue teams have in common the disadvantage of transport to the scene of accident once the alarm has been given. Nevertheless, as there will always be a great number of recreational skiers completely unaware of the avalanche hazard, it is necessary to also look for better search instruments for the organized rescue teams. For the moment, no electronic instrument for this purpose is yet available, but many studies and tests have been made during the last ten years and the situation is as follows.

1. Radiometer. This instrument monitors the thermal radiation of a human body and is somewhat analogous to the avalanche dog. For the time being, however, radiometers are at the first stage of development and much more knowledge about propagation of very short electromagnetic waves in different kinds of snow is needed to make further progress. The signals received will always be very weak, so that the search instrument must amplify them greatly. This influences weight, size, and cost of the instrument. Search speed will depend on transportability of the instrument and on the range it will be able to achieve.

2. Radar. Radar is composed of a transmitter sending a signal to a target and a receiver which monitors the returning echo. The radar is more sensitive, but it is very difficult to distinguish the return from the target (i.e., the human body) from the echoes coming from pieces of ice, rocks or other debris. One possible solution would be tri-dimensional radar. A radar can be installed on a helicopter to operate from it, but there must be found a system to indicate to the rescuers on the ground the exact position of the detected victim.

Operating from a helicopter, a radar could be the quickest location instrument for rescue teams, but one has to keep in mind that a helicopter cannot fly in all weather conditions. This would limit its use. A portable radar has also been proposed, but this would not bring any advantage if the instrument is provided with the normal oscilloscope, because in bad weather conditions it would be impossible to read the signals. Certainly, earphones could be substituted for the monitor but interpretation of the signals will probably become even more difficult when the instrument is being carried by a man who will continuously shake it.

3. Secondary Radar. As one cannot foresee how long it will take to solve the above-mentioned problems connected with radiometers and radars, some technicians propose to equip

people with an inexpensive passive reflector (with no energy source of its own) either printed on a ski pass or incorporated into ski clothes. This would exclude misinterpretation of the monitored signals and we think this is a good idea on the condition that the range of the system can be raised to at least 15 m (the proposals submitted during the Symposium in Sulden refer to instruments achieving only a maximum of about 7.5 m in dry snow).

There are ideas being developed to raise the range and the capacity of the system. Advanced studies are being made by a highly qualified Italian University Institute at the request of our Foundation. Obviously, the systems without reflectors would be preferable, but reflectors could represent an interesting compromise for the near future. The search instrument could be carried in a rucksack; the antenna in one hand, and the signals could be heard by means of earphones. The instrument could be used also from a helicopter, thus increasing the speed of the search operation as opposed to the time required for an on-foot transport and search.

4. Magnetometers. We were the first to use a magnetometer to locate an avalanche victim when we searched for my nephew, Vanni Eigenmann, near St. Moritz in 1961. The method, however, turned out to be unreliable. Rejected for the location of avalanche-covered persons, these instruments turned out to be very useful for the detection of snow-covered cars, snow-cats, motor sleighs and all other kinds of machinery because of their metallic mass. Cars and snow-cats may sometimes still contain live people so that rapid locating is needed. A good and easily transportable magnetometer will do this job quite well. It is much less expensive than radar and, last but not least, it is already available on the market.

Conclusion

After this review, it appears obvious that at present and, in the near future, transceivers are the best location devices we can deploy and probably will remain so for a long time. To enhance their reliability and enlarge their use to a great number of skiers and mountaineers, we believe it is necessary to make them more foolproof. A major breakthrough would be a proven directional system. We believe that this aim is attainable only with microwave systems.

Finally, a general remark: we have spoken about various means to locate avalanche victims, but consciously avoided calling them "rescue" means. The location of an avalanche victim is not yet his rescue; it is only a very important part of it. We really save the victim only when we bring air to him quickly, and treat his injuries.

It would be off the subject to speak about other important parts of a rescue operation. We only want to emphasize the importance of being able to dig down to the victim as quickly as possible. It is often more important to deploy a shovel than anything else. All professionals at least should carry a light avalanche shovel with detachable handle. We have seen a new model, the aluminium handle of which can be used to attach two skis together to form a rescue sleigh. Shovels should be available at marked sites in endangered areas. Our Foundation is studying other digging means.

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Discussion

MCCLUNG: I question the practicality of inflatable clothing. For one thing, inflatable clothing does not breathe, and a mountaineer may find that type of garment too warm while climbing.

KUCERA: Self-inflating clothing presents certain hazards. It can restrict the body. This was pointed out in a recent US Navy Study at Port Hueneme.

PERLA: Inflatable clothing produces buoyancy in water, but it is of questionable value in a moving avalanche, and it certainly cannot help the victim who comes to rest

on top of the snow, but is then buried by the residue of the avalanche (this happened to me at Alta). As a matter of interest, we made some tests with helium-filled balloons, and found that you need a balloon about 1 m in diameter to lift its weight plus the weight of an avalanche cord. Very few ski-mountaineers would be willing to tote around such a large balloon.

EIGENMANN: We are still awaiting test results on the principles of inflatable clothing and balloons, and should not close our eyes to these possibilities. Also, the goal of the system is not only buoyancy, but to provide space for the buried victim after the avalanche stops.

GMOSER: The Technical University at Munich is presently developing a new search system that is compatible with the Skadi and Pieps, but uses a directional principle in a compact unit. It also works on the principle of change in tone, since, apparently the human ear is more sensitive to changing tone than changing amplitude.

EIGENMANN: Yes, in principle, the human ear is more sensitive to changing tone than changing amplitude, but tests made by the Swiss Avalanche Institute show that for psychological reasons rescuers will search better if they relate proximity to the victim with increase in signal amplitude.

PERLA: An important question we must ask is: Will the new type of transceiver system save an appreciable amount of time? The Skadis and Pieps represent practical solutions, although they can be optimized further in terms of dependability and costs. Any new device should be made to prove its time-saving ability over the Skadis and Pieps before being accepted by men in the field. The fact that it can save a few seconds or even a few minutes may not justify the confusion caused by introducing a new gadget.

LACHAPELLE: Looking at the technical problems, it may be true that a transceiver operating on a directional principle would not lead to a significantly faster rescue on the average. Nevertheless, the problem should be pursued on a research basis, because of the obvious potential advantage of a directional search compared to the present system of bracketing.

FUHRMANN: There appears to be a clear need for an organization to coordinate investigations of rescue transceivers and other rescue devices, and to decide if a device does really offer an appreciable advantage. The International Commission of Alpine Rescue (IKAR) has an Avalanche

Subcommittee which is actively addressing itself to these and related problems.

KUCERA: With regard to optimizing present transceiver systems, I question why the Skadi and Pieps have not incorporated an optical readout. Many of us who have worked on avalanche control (especially with artillery) have hearing problems of various degrees.

CARDINAL: In the transceivers, would there be some advantage to using the long-life lithium batteries (life up to five years)?

ANDERSON: At Snowbird, we have found that re-chargeable batteries consistently outperform non-chargeable batteries in cold temperatures. You cannot trust the manufacturer's claim about the life and performance of non-chargeable batteries.

EMSLIE: In electronics, a null signal is more easily recognized than a maximum signal. Could this principle be applied to some advantage in electronic transceivers?

EIGENMANN: Our Foundation discussed this question with electronic specialists, who felt this principle could not be applied to any great advantage.