Avalanche Scenario With Double Burial
The effectiveness of different rescue equipment, specific operational methods and their benefits for companion rescue

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ABSTRACT: For this study a field test was carried out to determine the total time needed by independently working test persons to locate two active transmitters, placed 15m apart in a 50x50m area of simulated avalanche debris.
A main point is to evaluate the effectiveness of electronic probes with an acoustic hit indication and/or a “deactivating function” for the transmitter.

The interpretation of the results indicates that compared to other combinations, modern equipment (triple antenna beacons with marking function) brings significant benefits to resolving a double burial situation.

Experts profit more from modern combinations than beginners. This clearly shows that special training and personal knowledge of all aspects of companion rescue are imperative in a slide scenario.

Using specific searching techniques (Three Circle Method) did not prove significantly beneficial. However it is noted that only very few of the test persons know such techniques and are able to perform them correctly under stress.

The use of an electronic probe is shown to be a big advantage, both with acoustic support only as well as with acoustic hit indication and a deactivating function. The latter brought the greatest improvement in overall search time. This result can in certain ways be seen as an assignment for manufacturers to develop fully compatible equipment.
KEYWORDS: Triple Antenna Beacons with marking function; Beacons without marking function; Three Circle Method; Electronic probe; Micro strip Searching;

1 INTRODUCTION

During the last ten years there have been major developments in the 457kHz-based methods of locating avalanche burials. While the standard of the industry used to be analogue devices with one antenna and only an acoustic signal output, there are now single, double and triple antenna beacons, which aid the locating process by means of a mainly visual signal output.

Only a few years ago multiple burial scenarios were by default linked to complicated searching techniques (Three Circle Method, Micro strip searching). Now modern beacons are able to separate and block signals as needed.

The pros and cons of various combinations of equipment (Three antenna beacons with and without marking function, one- and two antenna beacons) and other technical emergency gear are discussed in the analysis. The question of whether beginners or experts can profit more from such combinations is also addressed.

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Further investigations consider the effects of specific searching techniques (Three Circle Method, Micro strip Searching) on the time needed to locate the transmitters.

The final goal of all manufacturers is of course to optimise the time needed to locate the victim, thus allowing a faster rescue.

Based on practical field tests this paper addresses the following questions:

- Do modern triple antenna beacons with a signal blocking function have significant advantages over single, double and triple antenna beacons without a marking function in a double burial scenario?
- Do beginners profit more from combinations of modern equipment than advanced and expert searchers?
- When using single, double and triple antenna beacons without a marking function, are specific searching techniques (Three Circle Method, Micro strip searching) on average significantly beneficial?

- Is the use of an electronic probe with acoustic hit indication of advantage?
- Is the use of an electronic probe with acoustic hit indication and deactivating function of advantage?

2 FIELDWORK AND METHODOLOGY

The data was collected during field tests. Test persons were participants of national alpine training courses in Austria (exam preparation for ski instructors), members of mountain rescue organisations as well as interested amateurs. The test persons were divided into two groups. People without knowledge or training regarding practical beacon searching were classified as beginners. Experts already have experience with beacon searches and have had at least one detailed instruction in the matter.

3 EXPERIMENTAL SET-UP

The test field consisted of a 50x50m area. Seven externally activatable transmitters were buried exactly 15m apart from each other (hexagonal arrangement, one central transmitter) in a depth of 50cm to 100cm. For each test run two transmitters 15m apart from each other were activated. The set-up allowed for 12 different combinations of two active transmitters with a distance of 15m from each other. The surface of the buried transmitters (transmitter plates) was covered with foam pads to make it easier to recognize probe hits. Depending on the location of the experiment walking conditions varied from easy to difficult. Variations in walking conditions were not significant for the overall results.

Each test person used their own equipment and was told without additional instruction to locate the two activated transmitters with beacon and probe. A hit was defined as either a mechanical hit with a conventional probe or an “electronic” hit (constant acoustic signal) with an electronic probe.

Each test person started out under conditions similar to a real life scenario i.e. a transmitting beacon on the body and backpack with emergency gear. After the first hit, a second probe was given to the test person by a helper.

After ten minutes test runs were stopped for exceeding the set time limit.

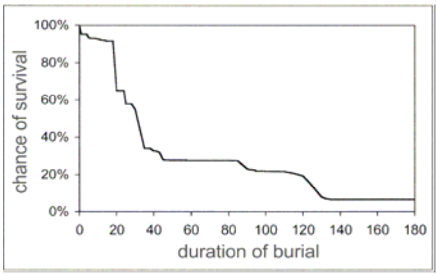

Fig. 1: Chance of survival as a function of burial time in an avalanche, Switzerland (1981-1998, n=735), (Brugger, Falk, o. J.)

Figure 1 shows that the chance of survival in a complete burial drops rapidly after 15 minutes. If the time required to dig out the victim in the average scenario of an 80cm (Tschirky et al., 2000) burial is considered to be a main factor in the overall rescue procedure, the time needed to locate the victim should be significantly lower. For this reason the time limit during the tests was set at 10 minutes. The following data was collected for each test run:

- Sex
- Age
- Level of fitness
- Ability (beginner or expert)
- Type of beacon
- Type of probe (mechanical or electronic)
- Total time to locate both transmitters
- Comments (observations during test run)

4 STATISTICAL ANALYSIS

The data was tested for normal distribution with a Kolmogorov-Smirnov test (Andrei Nikolajewitsch Kolmogorow and Nikolaj Wassiljewitsch Smirnow, K-S test). The K-S test is a statistical test for equality of two probability distributions. The distributions of two samples can be compared (two-sample K-S test), as well as the probability distribution of a sample and a reference distribution (one-sample K-S test). (Wikipedia.org)

An F-test (probability of error 5%) was used to determine variance equality in the samples to be compared. This is a statistical test to show whether samples from different populations differ significantly in their variance. It serves as a general test for differences in statistical populations. (Wikipedia.org)

The samples were further tested for equality of the mean with a T-test (probability of error 5%). Using the arithmetic mean of two samples the two-sample T-test compares the expected values of two populations. (Wikipedia.org)

The null hypothesis (H0) describes the expected advantages and disadvantages according to the practical experience of the authors and scientific doctrine. Ha is the alternative hypothesis, which is the case if H0 is discarded.

5 RESULTS

Out of a total of 221 participants, 172 were men and 49 women. There was an age spread from 18 to 50, the most frequently occurring age being 21 (men and total) and 22 (women), respectively.
There were 86 beginners and 135 experts.

Participants	Male	Female	Beginners	Experts
Total	172	49	86	135
Male	172		63	109
Female		49	23	26
Beginners	63	23	86	
Experts	109	26		135

Table 1: Distribution of test persons

Comparison of triple antenna beacons with a marking function and single, double and triple antenna beacons without a marking function
H0: Triple antenna beacons with marking function are beneficial to resolving a double burial.
Ha: Triple antenna beacons with marking function are not beneficial to resolving a double burial.

	N	Mean [s]	Standard deviation
Beacon with marking fact.	130	278,78	120,656
Beacon without marking fact.	78	320,49	204,050

Table 2: Mean and standard deviation of total time for beacons with/without marking function

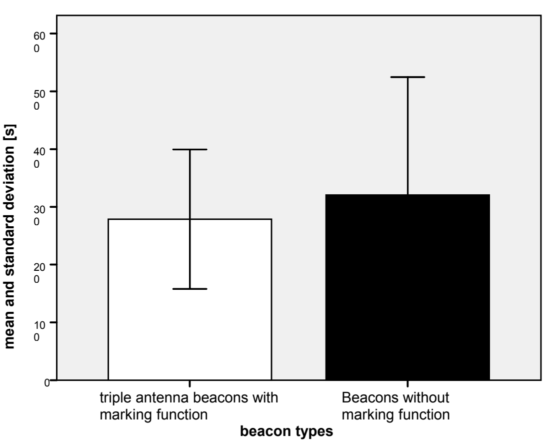

Fig. 2: Mean and standard deviation for beacons with/without marking function

H0 holds with a significance of p=0.033 (one sided). This means that using modern equipment combinations (triple antenna beacons with a marking function) clearly leads to better overall times in the resolution of a double burial scenario.

Do beginners profit more from modern equipment combinations than experts?
H0: Beginners are slower in the resolution of a double burial scenario than experts.
Ha: There is no difference between beginners and experts in the resolution of a double burial scenario.

	N	Mean [s]	Standard deviation
Beginners total	88	295,89	125,918
Experts total	136	265,51	185,257
Beginners, beacons with marking fact.	39	311,97	119,590
Experts, beacons with marking fact.	88	268,93	118,504
Beginners, beacons without marking fct.	47	295,13	118,937
Experts, beacons without marking fct.	31	310,90	107,214

Table 3: Mean and standard deviation of beginners and experts with various combinations of equipment

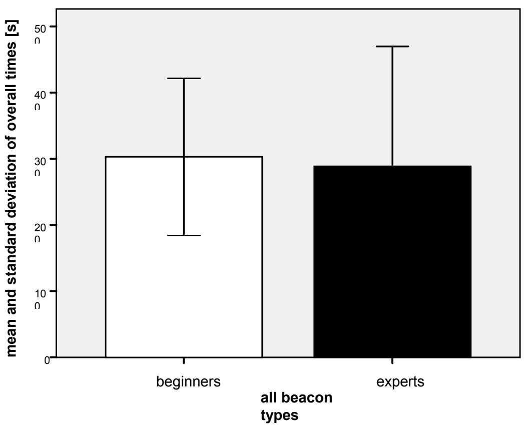

Fig. 3: Mean and standard deviation of overall times of beginners and experts, independent of beacon type

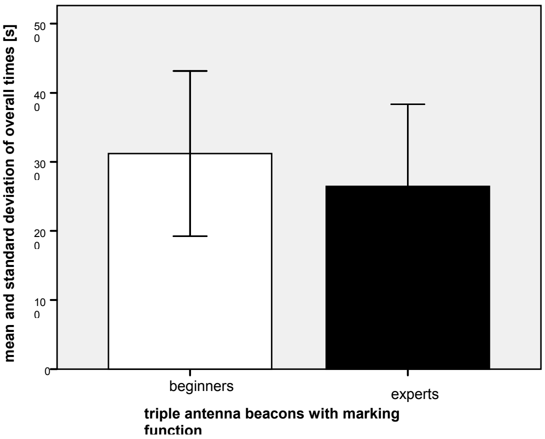

Fig. 4: Mean and standard deviation of overall times of beginners and experts with triple antenna beacons with marking function

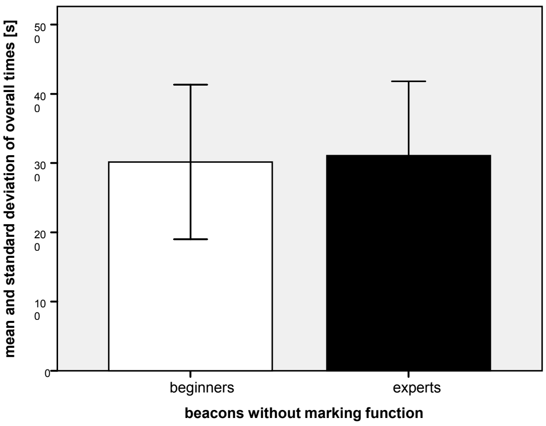

Fig. 5: Mean and standard deviation of overall times of beginners and experts with beacons without marking function

Comparing beginners and experts independent of beacon type does not show a significant difference (p=0.18 two-sided). However, comparing beginners and experts using modern beacons with a marking function a significant advantage for experts becomes apparent (p=0.031 one-sided). The comparison of beginners and experts with old equipment without a marking function does not show a significant advantage for experts (p=0.279 one-sided).

When using single, double and triple antenna beacons without a marking function, are specific searching techniques (Three Circle Method, Micro strip searching) on average significantly beneficial?
H0: Using specific searching techniques (Three Circle Method, Micro strip searching) is beneficial to the resolution of a double burial scenario.
Ha: Using specific searching techniques (Three Circle Method, Micro strip searching) is not beneficial to the resolution of a double burial scenario.

The sample of all test persons with equipment where employing a special search technique (Three Circle Method, Micro strip searching) makes sense, i.e. single, double and triple antenna beacons without a marking function was investigated.

	N	Mean [s]	Standard deviation
Users of Three Circle Method	11	329,000	104,932
Users of Micro strip searching	67	297,134	115,516

Table 5: Mean and standard deviation with and without Three Circle Method

Using the Three Circle Method when locating the second signal is not significantly advantageous over not using any specific strategy (p=0.207 one-sided). It is noticeable that only a small percentage of users employ a specific searching strategy.

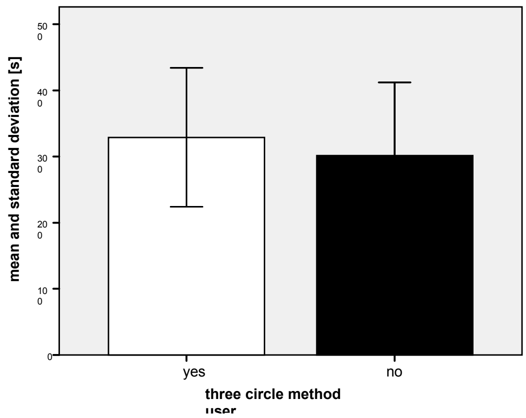

Fig. 6: Mean and standard deviation of test persons with and without use of the Three Circle Method

Is the use of an electronic probe with acoustic hit indication of advantage?
H0: The use of an electronic probe with acoustic hit indication is of advantage when resolving a double burial scenario.
Ha: The use of an electronic probe with acoustic hit indication is not of advantage when resolving a double burial scenario.

	N	Mean [s]	Standard deviation
Electronic probe	78	253,692	116,788
Mechanical probe	143	298,480	114,432

Table 7: Mean and standard deviation of electronic and mechanical probes

The use of an electronic probe with acoustic hit indication is a highly significant (p=0.003) advantage in the resolution of a double burial scenario. The statistical result confirms observations during the field tests: Because of the acoustic support time was saved as less probe plants were necessary until the occurring of a constant signal. The investigation of Eck et al., 2008, which describes the time saved in pinpointing and probing when using an electronic probe further supports this result.

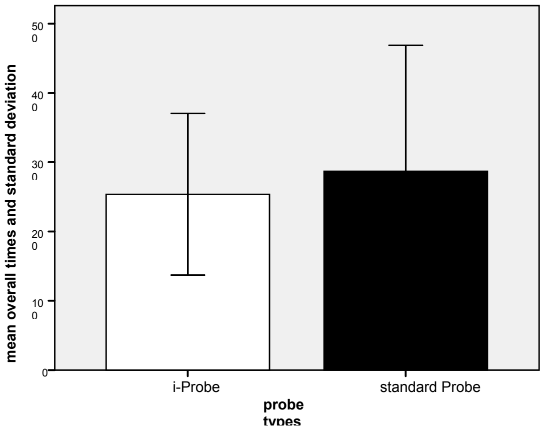

Fig. 7: Mean overall times and standard deviation for use of standard and electronic probes.

Is the use of an electronic probe with acoustic hit indication and a deactivating function of advantage?

H0: The use of an electronic probe with acoustic hit indication and a deactivation function is of advantage in the resolution of a double burial scenario.

Ha: The use of an electronic probe with acoustic hit indication and a deactivation function is not of advantage in the resolution of a double burial scenario.

	N	Mean [s]	Standard deviation
Electronic probes with deactivation fct.	13	210,231	53,292
Mech. and electronic probes without deactivation fct.	208	289,947	115,568

Table 8: Mean and standard deviation of overall times for electronic probes with deactivation function and mechanical and electronic probes without deactivation function.

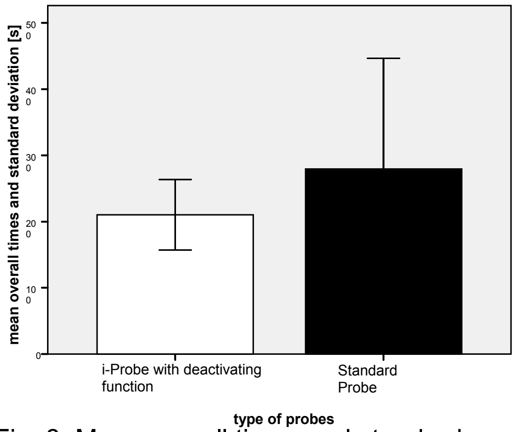

Fig. 8: Mean overall times and standard deviation dependent of type of probe

The use of an electronic probe, which can communicate with the buried transmitter and deactivate it proved to be a very highly significant advantage ($p<0.001$ one-sided). In practice the resolution of a double burial scenario is now the same as solving two successive single burials since the signal is no longer disturbed. No special searching techniques are necessary because modern beacons automatically display the next strongest signal.

6 DISCUSSION AND CONCLUSIONS

The presented results show that experts can benefit more from efficient, modern equipment than beginners. Naturally, a basic knowledge of how to solve a double burial scenario (phases of the search, moving along a flux line, pinpointing, systematic probing) is essential to be able to make the most of the advantages presented by technical equipment. The practical conclusion the user has to draw is that even with supporting and self-explanatory technical equipment the search time for an avalanche scenario with a double burial can be improved with corresponding knowledge and training.

It is notable that only a small percentage of users with beacons that do not have a marking function employed a specific technique to locate the second signal. Furthermore it was found that specific searching techniques did not improve the overall searching time.

The results of the statistical analysis show some contradictions to conventional wisdom and doctrine in instructional courses. Whether this means that users should be trained to search for the second signal more or less randomly (only movement is important) since about the same results were achieved can be subject of further discussion.

That using electronic probes with a deactivation function saves a large amount of time can be interpreted as an assignment for manufacturers. It would certainly make sense if all manufacturers were to develop mutually compatible electronic probes and beacons so that this very effective function does not remain limited to one specific combination of equipment.

In conclusion it can be said that this study contains very useful insights for developers in the industry as well as for professionals in avalanche schooling (mountain guides etc.) A major change of thought will be necessary when it comes to specific searching techniques, probes with additional electronic functions as well as in certain questions of methodology.

7 ACKNOWLEDGMENTS

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