

# TERRESTRIAL AND HELICOPTER BASED RECCO SEARCH

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**ABSTRACT:** Since its introduction in 1983, the harmonic radar based Recco search system was applied in numerous rescue missions and saved many lives of people caught in avalanche. Search units are available in organized rescue, rescue helicopters, armed and police forces, ski patrol, mining operations etc. For a fast and efficient Recco search, it is indispensable to follow a strict protocol to achieve a high probability of detection and avoid interference by other rescuers. The analysis of failed Recco searches, often resulting in lack of trust in the search device, has shown the need for an update of the search protocol and course curriculum for terrestrial and helicopter based Recco searches. In a first step, the search characteristics of the current R9 device have been verified in several field trials. Based on the technical characteristics of the device, a most optimal search strategy has been defined. As for other electronic search devices, interference issues have become a major issue resulting in searches being disturbed or even unsuccessful. Many reflections leading to “false positives” in Recco searches are caused by the rescuer himself or the rescue helicopter. It is therefore an integral part of the new search protocol to verify at the start of every search that there are no interfering reflections.

**KEYWORDS:** Avalanche Rescue, Harmonic Radar, Recco Search Strategy

## INTRODUCTION

The Recco search technology is based on harmonic radar and is available since 1983. Compared to avalanche transceivers, the advantage is that the person only needs to carry a very light-weight and small reflector that is inexpensive to produce and does not need any energy. However, the range is as well considerably lower compared to devices which use active transmitters, in particular due to signal attenuation in snow with a higher content of liquid water molecules as well as the human body of the buried subject. Practical surveys in several ski resorts have shown that the percentage of skiers which produce a Recco reflection is considerably higher than the percentage of skiers who transmit a 457kHz transceiver signal. This is based on the fact that every electronic device acts as a reflector for the harmonic radar principle applied by Recco.

However, this positive side effect is constantly shrinking as the progress in the miniaturization of electronic components makes that modern electronic devices produce less and less reflection, thus leading to a strong reduction of range. With the exception of some extreme cases of burial depth and signal attenuation, the system allows to reliably find buried subjects in snow avalanches. In despite of this, many rescues have suffered from inefficient Recco searches either by terrestrial rescuers or by helicopter based Recco search. This has unfortunately led in some cases and countries to the impression that the system itself is unreliable and should not be considered to be life-saving. This paper analyses the issues which have led to inefficiency in the application of the system with the goal to modify the search procedure and training to ensure a high probability of detection and efficient application of the device.

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## METHODS

In order to identify the reasons for inefficient searches, the problem analysis has been focused on two specific points for the terrestrial as well as the helicopter based search:

- 1: Factors influencing probability of detection
- 2: How to minimize “false positives”, thus reflection caused by the rescuer, rescue gear or the rescue helicopter

### *Optimization of probability of detection*

The Recco search system is highly directional. The position of the buried subject on the debris as well as the orientation of the reflector on the buried subject is unknown to the rescuer. It is therefore required to actively rotate the search device to provide a systematic coverage for all possible orientations of the reflector and relative orientation between rescuer and buried subject. In practical field testing, the characteristics of the search system concerning its horizontal and vertical receive angle as well as decrease of amplitude relative to different angles between reflector and search device have been investigated. In the setup of the test, the search device and the reflector were held in 1,5m height about ground. The test fields had to be on flat ground to exclude signal attenuation or reflection in soil or rock. The search device and in particular the reflector were held clearly away from the body of the test personnel to avoid bias due to liquid water in close proximity.

### *Horizontal and vertical receive angle*

In the first part of the test, the search device and reflector were held horizontally. Whereas the person holding the search device never changed his physical location throughout the test, the person holding the reflector did change his position according to the test protocol:

- 1: The person holding the reflector slowly approached towards the search device in its long axis, thus in the best possible range configuration, further mentioned “center line”. As soon as the first signal was audible in the built-in loudspeaker, a flag was put in the ground to mark the position.

- 2: For the second measurement, the rescuer holding the reflector approached the search device by another few meters, then stepped out on a perpen-

dicular axis until the signal was lost. Then, he slowly walked back towards the center line. This procedure was applied to avoid measuring the extended range of the hysteresis, when walking away from a search target. As soon as the first signal was audible in the built-in loudspeaker, a flag was put in the ground to mark the position.

- 3: Step two was repeated until the entire forward looking receive cone has been mapped.

- 4: During the measurements protocolled in points 1-3, the search device and the reflector were several times held in the vertical position to measure the difference between the horizontal and the vertical receive characteristics. It was found that there are only very little differences, which are within the tolerance of the measurement setup. Therefore, we concluded that the horizontal and the vertical receive characteristics are so similar that we assume them to be identical for the further search technical considerations.

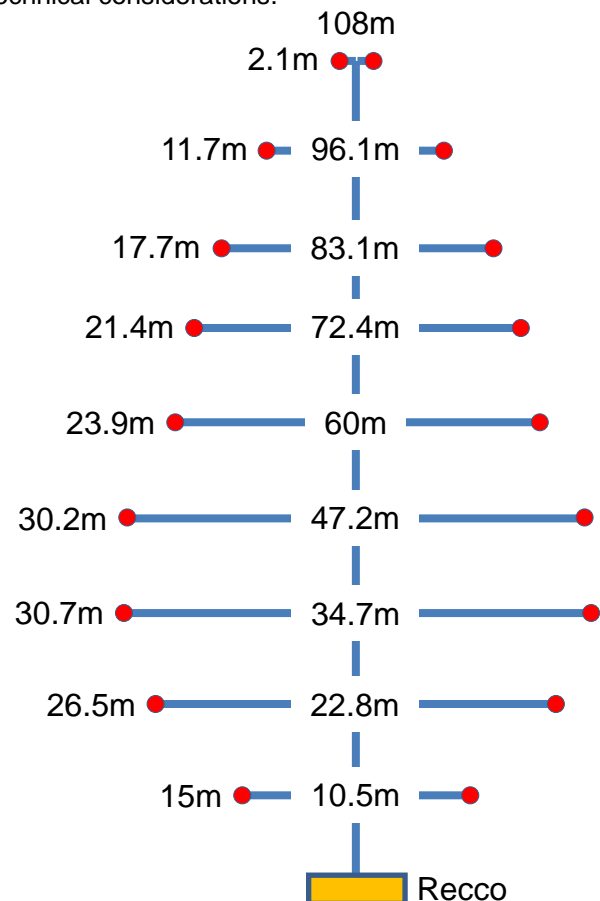


Figure 1: Horizontal and vertical receive angle receive characteristics of the Recco R9.

### *Reduction of range due to non-parallel search device to reflector orientation*

In the second measurement series, loss of range due to poor orientation between search device and reflector has been measured.

Deviation from parallel	Range
0°	98m
10°	88,5m
20°	69m
30°	65m
40°	66,5m
50°	51m

Table 1: As soon as the deviation exceeds 40 degrees, severe loss of range has to be expected.

The tests were carried out with a total of 3 search device, two of them with a North America (FCC/IC) frequency setting, one of them with a European (ETSI) frequency setting. The differences between the different devices were found to be very small and within the measurement error of the chosen measurement setup.

## **RESULTS**

The vertical and horizontal receive angle is with approx. 30 to 40 degrees smaller than most rescuers have anticipated. The measurements have shown that the differences between the horizontal and the vertical receive angle is for rescue related purposes identical.

If the angle between the search device and the reflector exceeded 40° loss of range was considerable.

## **DISCUSSION**

In order to optimize the probability of detection in terrestrial as well as in air-borne Recco search, an updated search strategy needs to take the technical characteristics of the search device into account.

The rescuer needs to systematically sweep the 180° search horizon in the direction of the search. The 30° receive angle fits six times into this 180° search horizon. Theoretically, the rescuer should check for different reflector orientation in each one of the six 30° receive angles.

In order to avoid severe range reduction due to suboptimal antenna orientation, the device should

be constantly rotated +/- 50 degrees during signal search.

Coverage of the 180° search horizon is achieved by sweeping the device 150° in direction of the search. Simultaneously, the device needs to be rotated +/- 50° to check by try and error for different reflector orientations.

To apply six full +/- 50° rotations within one sweep is not feasible. The rescuer should therefore simply apply the rotation motion at a sustainable speed. As a rescuers never applies a 100% synchronized sweep and rotation speed, every 30° sweep angle will be searched over time with a sufficient variance of rotation angles. In average, a rescuer applies about three full rotation motions within one full sweep.

The proposed +/- 50° rotation motion purposely avoids that the search device is ever held in a 90° vertical orientation. A vertical antenna orientation makes it difficult to limit the search horizon in order to avoid unwanted false positive signals caused by reflections from other rescuers or rescue equipment.

## **CONCLUSIONS**

The field test results have shown that the receive angle of the device is narrower than previously anticipated. The required modifications of the search protocol were identified and implemented.

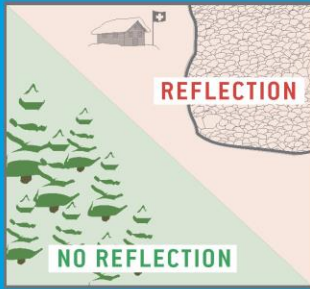
Furthermore a strict protocol to avoid searching for reflections caused by equipment on the rescuer's body was established and implemented. The entire search process is structured in search preparation followed by the four standard phases of the search, signal search, course search, fine search and finally pinpoint search by the means of the probe.

The proper actions of each search phase are clearly defined and illustrated in a formalized course curriculum and search protocol.

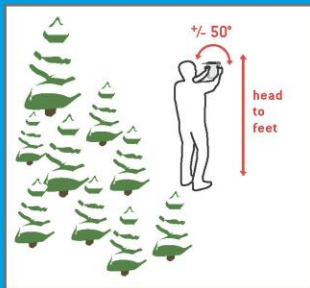
Concerning the helicopter based application of the Recco search device, the same approach was taken as above. Recco search from a helicopter remains an advanced search technique which requires a professional initial setup on the aircraft as well as a strict training and search protocol for the rescuer operating the device and the pilot. A training video has been made in collaboration with OeAMTC Austrian Air Ambulance (available for free download at [www.genswein.com](http://www.genswein.com))

# SEARCH PREPARATION

## 1. IDENTIFY REFLECTION FREE HORIZON

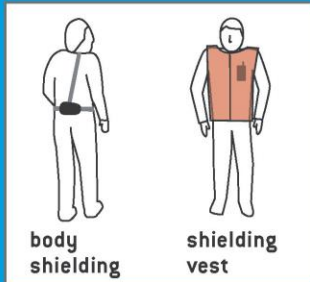


## 2. POSITION YOURSELF IN FRONT OF REFLECTION-FREE HORIZON AND POINT DEVICE IN FULL RANGE SETTING TO YOU



Point antenna towards your body. Rigorously search yourself from head to feet in different antenna orientations.

## 3. REMOVE STRONGLY REFLECTING OBJECTS



For rescue critical devices (radio, transceiver), use body shielding and / or shielding vest.

## 4. Final Pre-Search Check

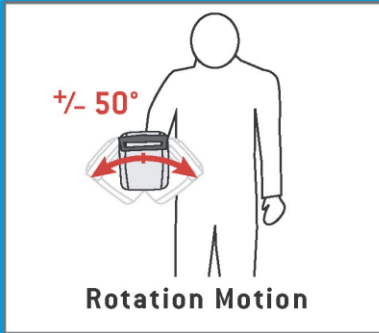


Point device to reflection-free horizon. Make signal search motion.

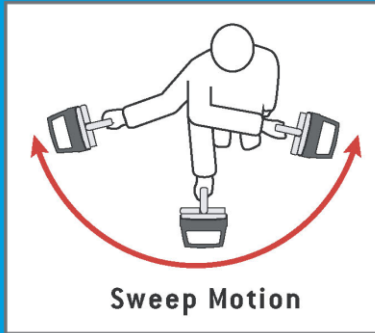
Illustration 1: Search Preparation for a terrestrial Recco search



## SIGNAL SEARCH



Rotation Motion



Sweep Motion

Apply the sweep and rotation motion simultaneously!

Illustration 2: Signal Search



## COARSE SEARCH

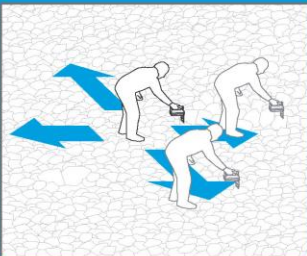


### First Signal:

- Stop rotation and sweep motion
- Last optimization of search direction (sweep) and antenna orientation (rotation)
- Fix visual reference
- Move towards buried subject
- Reassess search direction while approaching target (sweep motion)



## FINE SEARCH



- If signal abruptly ceases, tilt antenna straight down to snow surface without changing antenna orientation
- Apply fine search in a cross. Hold device in front of you. Walk with device.

Illustration 3: Coarse and Fine Search

## ACKNOWLEDGMENTS

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