

Recommendation on how avoid Interference Issues in companion and organized avalanche rescue

Manuel Genswein, Switzerland
Dale Atkins, Recco AB and Vice President of the ICAR Avalanche Commission
Joe Obad, CEO Canadian Avalanche Association
Emily Grady, Education Officer Industry Training Programs, Canadian Avalanche Association
Marc Piché, Technical Director, Association of Canadian Mountain Guides
Todd Guyn, Mountain Safety Manager, Canadian Mountain Holidays
Rob Whelan, Technical Advisor and Ski Guide, Canadian Mountain Holidays
Kjetil Brattlien, Senior Engineer, Norwegian Geotechnical Institute

Electronic avalanche rescue devices such as 457kHz transceivers and Recco are today the primary search tools in companion and organized rescue. The requirement for a long receive range in order to shorten rescue time asks for highly sensitive receivers. Such highly sensitive receivers are vulnerable to be influenced by interference from other electronic devices, but as well metal parts and passive electronics may detune the antennas or act as a unwanted reflector in the case of a Recco search. The percentage of users who carry a wide range of electronic devices such as mobile phones, helmet cameras, music players, heart rate monitors etc in the outdoors has considerably increased over time and therefore the negative influence on an efficient search effort has in several cases lead to loss of valuable rescue time and greatly disturbed the rescuers on the accident site. The study includes a detailed analysis on the mechanisms of interference, a matrix of influence and potential consequences as well as a new, user group specific recommendation on how to avoid interference issues in companion and organized rescue.

Keywords: Avalanche rescue, interference, Transceiver, Recco

Introduction

Metal parts, magnets and any kind of passive or active electronics potentially cause interference for a transceiver. This may lead to the following effects:

- detuning of the antennas (TX and RX)
- persistent magnetization of the antennas (TX and RX)
- increased power consumption (TX)
- reduction of transmitted field strength (TX)
- inability for proper signal detection in digital search modes (RX)
- reduction of receive range due to receive filters opening up to a broader frequency range (RX)
- increase of noise in analog sound (RX).

Whereas metal parts may detune the antennas and shield the signal, active electronic devices are likely to cause interference resulting in a higher noise floor and/or arbitrary distance and direction indications. The mass, dimension and characteristics of metals and the amplitude and frequency spectrum of the electronic and electromagnetic interference influence the extent of problems created for the transceiver. It is important to understand that for many sources of interference, the amplitude of the harmful interference increases with proximity by a power

Corresponding author address:

Manuel Genswein
General Willestr. 375
CH-8706 Meilen
Switzerland
Mobile +41 79 236 36 76
E-Mail: manuel@genswein.com

of three to distance, i.e. if a certain electronic device causes an interference ring amplitude of level 2 to the transceiver at 20cm distance, the interference reaches an amplitude of level 8 at 10cm distance.

Concept of Interference and Consequences for Transceiver Technology

When speaking about electronic and electromagnetic interference, it is important to understand that an interfering signal may directly influence the electronic circuits of the transceiver and / or be picked up by the antennas of the transceiver. The frequency spectrum of interference often includes frequencies exactly on or close to 457'000Hz, in particular when taking into account that multitudes of harmonics may be in this spectrum. Therefore the interference is in the avalanche rescue transceiver frequency range and can make exactly the same impression to the receiver as the signal of a buried subject. Electronic and electromagnetic interference with different characteristics influence the transceiver in different ways, however, it is crucial to understand that an incoming interfering signal may look to the receiver exactly the same as a "real" signal transmitted by a buried subject. Therefore, rescuer may experience that the transceiver shows arbitrary distance and direction indications exclusively caused by interference in an area where there is no buried subject or the distance to the buried subject is much greater than the maximum range of the receiver (signal search phase). The difference in amplitude of interference compared to the amplitude of the real transmit signal of a buried subject is an important factor which influences to what extent the search may be compromised (SNR = Signal to Noise Ratio).

Therefore, we may conclude:

- 1:
The weaker the signal of the buried subject, the lower the tolerance for interference
- 2:
A transceiver with high sensitivity has the capability to pick up very weak signals from buried subjects in a far distance (=long range),

however, this equally means low tolerance for interference.

- => the longer the range of a device, the more it is susceptible to interference
- => the shorter the range, the lower the sensitivity of the device for „real“ signals as well as for interference.
- => long range and high interference tolerance are antagonists
- => long range leads to shorter burial times and therefore increased survival chances (1)
- => users have to know that their degree of compliance to the rules on avoidance of interference directly influences the efficiency of the rescue actions

In cases where rescuers experience strong interference despite full compliance to the rules of avoiding interference, such as in proximity to high-voltage power lines, antenna masts, cableways, buildings etc. , where the source of interference cannot be removed or turned off, switching the device to analog mode with manual volume control may be the only option to allow to search for the buried subject. Often this measure needs to be combined with a reduction of search strip width. Devices targeting the advanced recreational or professional user groups with the aim to provide a solution for 100% of the potential rescue situations such as an Ortovox S1, ARVA Link or Pulse Barryvox therefore offer such analog search options. The reason behind the much higher tolerance for interference in an analog search compared to a digital search is the better performance of human hearing to detect to the "real" signal when a lot of interference is present and when the signal to noise ratio (SNR) is bad.

At last, interference degrading the performance and efficiency of the transmit function should be discussed: Transmit mode is less sensitive to interference than receive mode, therefore acceptance of interference is higher and most of the equipment and "gadgets" can be used with only minor restrictions such as respecting a minimum distance of 20cm between metal parts, electronics (active or passive) and the transceiver in transmit mode. In case the recommended safety distance is compromised as the equipment and clothing gets dislocated on the body during the course of the avalanche,

the transmitted field strength within the nominal transmit frequency range may be reduced leading to a shorter range in which the buried subject can be received. However, range reductions of more than 30% are seldom and would require detuning of the antenna and/or shielding of the signal by a massive or large metal object. In particularly negative cases, this may lead to the fact that the weaker signal of the buried subject is not picked up when applying the search strip width recommended by the

manufacturer. The appropriate rescue tactical measure in such cases is to cut the search strip width in half, which practically means to search on the middle lines of the signal search pattern (i.e. if in the first phase, 50m search strip width has been applied without success, in the second phase, the signal search strip width pattern is shifted by 25m. This approach is equal to a second coarse search in a probe line with a shifted probing pattern when the first grid did not lead to success.

Matrix of Influence and Potential Consequences

| Distance between rescue and buried subject | Interference at rescuer's position | Interference at buried subject's position | Amplitude of Interference at rescuer's location | Amplitude of signal of the transceiver of the buried subject at rescuer's location | Outcome |
|---|---|--|--|---|--|
| Out of range, signal search | Low interference, all rescuers on scene compliant to rules | Irrelevant for rescuer's position | Very low | Lower than maximum receiver sensitivity | Signal search not compromised, no arbitrary distance and direction indications, white noise on low level in analog sound |
| Out of range, signal search | Strong interference, from interfering device with normal interference level closer than 50cm or strongly interfering device in greater distance than 50cm or on other rescuer | Irrelevant for rescuer's position | Medium to Strong | Lower than maximum receiver sensitivity | Signal search compromised, arbitrary distance and direction indications, increased noise level in analog sound |

| | | | | | |
|---|--|---|------------------|-----------------------|--|
| Coarse search, 80+m distance, analog sound only | Low interference level, all rescuers on scene compliant to rules | Irrelevant for rescuer's position | Very low | Very weak signal | Coarse search not compromised, weak, but detectable analog sound |
| Limit of digital range, i.e. 50m distance | Low interference level, all rescuers on scene compliant to rules | Irrelevant for rescuer's position | Very low | Weak signal | Coarse search not compromised, no arbitrary distance and direction indications, multiple burial algorithms work properly, clean analog sound |
| Limit of recommended signal search strip width, i.e. 25m distance (2x25m = 50m) | Low interference level, all rescuers on scene compliant to rules | Rescuer/receiver: Irrelevant for rescuer's position Buried subject/transmitter: Very strong, caused i.e. by mobile phone turned on, running video camera with wireless functions or larger metal object and <u>safety distance compromised</u> due to displacement of equipment on the body during the course of the avalanche | Very low | Very weak signal | Search strip width may be compromised, if search with recommended search strip width does not lead to success, cut search strip width in half. |
| Limit of recommended signal search strip width, i.e. 25m distance (2x25m = 50m) | Strong interference, from interfering device with normal interference level closer than 50cm or strongly interfering | Irrelevant for rescuer's position | Medium to Strong | Weak to medium signal | Search strip width may be compromised, arbitrary distance and direction indications possible, performance of multiple burial algorithms compromised, |

| | | | | | |
|--------------|---|---|-------------|------------------|--|
| | device in greater distance than 50cm or on other rescuer | | | | increased noise level in analog sound |
| 10m distance | Low interference level, all rescuers on scene compliant to rules | Strong, buried subject uses strongly interfering device in minimum allowed safety distance such as mobile phone turned on, running video camera with wireless functions etc. | Low | Strong | Coarse search not compromised, no arbitrary distance and direction indications, multiple burial algorithms work properly, clean analog sound |
| 10m distance | Extremely strong interference due to high voltage power line, antenna mast. Affected radius may be larger than 150m, depending on voltage / transmit power. | Extremely strong interference due to high voltage power line, antenna mast. Affected radius may be larger than 150m, depending on voltage / transmit power. | Very strong | Strong | Digital signal detections are likely to fail completely, multiple burial algorithms are very likely to fail completely, maybe only analog search with manual volume control possible, apply strongly reduced search strip width. |
| 1m distance | Low interference level, all rescuers on scene compliant to rules | Strong, buried subject using strongly interfering device in minimum allowed safety distance such as mobile phone turned on, running video camera with wireless functions etc. | Strong | Extremely Strong | Fine search not compromised, no arbitrary distance and direction indications, Tracking of multiple burials in medium to longer distance compromised, clean analog sound on low volume/sensitivity level |

Recommendations Concerning Potentially Interfering Equipment for Professional and Institutional Users and Special Applications (Detailed)

General Rules

Clothing

Avoid wearing clothes with magnetic buttons or larger metallic and/or conductive parts (e.g. nets of heated gloves)!

Storage

Do not store the transceiver close to strong magnetic fields as they can magnetize the antennas with a long term effect.

Magnets and electromagnetic fields

Some transceivers of several brands have a magnetic ON / OFF or OFF / SEND / SEARCH switch and therefore magnets in close proximity can turn the unit OFF, to SEARCH or SEND at any given moment.

Some transceivers of several brands contain an electronic compass and are, especially during search, highly sensitive to magnets and electromagnetic fields.

Transmit mode

In transmit mode a minimum distance of 20cm has to be respected between the avalanche rescue transceivers and any metal object or electronic device. Although the distance where serious interference of transmit mode has to be expected is for many objects and devices considerably shorter (<3cm), the likely displacement of a carrying system, clothing and potentially interfering objects due to the mechanical impact to the person taken by an avalanche has to be taken into account and therefore the recommended distance has to leave some safety margin.

Search mode

In search mode, a minimum distance of 50cm has to be respected between the beacon and the listed objects below which can be used with a transceiver.

Definitive List of Equipment Which Can Be Used With a Transceiver

List of objects and equipment (conclusive), which can be used with a transceiver respecting the rules as mentioned above. This conclusive list includes rescue or operationally critical equipment and equipment which is an integral part of mountain excursions.

For equipment which is critical for rescue or operationally, but require more restrictive rules than the 20cm safety distance in transmit and 50cm in receive mode, the exceptions are specifically mentioned.

General equipment:

- metallic frames of backcountry backpacks
- camping and cooking equipment, metallic vacuum bottles
- non engine driven snow sport equipment (skis, snowboards, snowshoes)
- climbing gear (carabineers, ice axes, crampons, etc.)
- electric head lamps excluding headlamps with switching power voltage regulators
- snow study kits incl. metallic snow saw
- improvised repair equipment and tools like pocket knives and pocket multi-purpose repair tools
- writing tools
- wrist watch without radio functions on the wrist; large, multi-functional watches with large screens should not be worn on the same hand like the searching transceiver is held.
- Any kind of food, candy or cigarette box wrapping with metal foil

Search, rescue and survival equipment:

- flotation devices (incl. remote release device), Avalung, Avalanche Ball
- avalanche rescue transceivers
- devices providing a backup transmit function in case of a secondary avalanche
- RECCO search devices (3m distance and do not point directly to another rescuer)
- RECCO reflectors (reflectors may be placed at any distance without any risk of interference)
- avalanche probes and shovels (metallic and carbon probes may not be placed parallel to the snow surface during fine and pinpoint search)
- high performance lights and generators for

night searches in organized rescue (strong interference may occur and affect a larger zone around the equipment. Interference should be checked with an analog receiver on the highest sensitivity setting and appropriate measures taken accordingly)

Vehicles:

- snow mobiles, snow grooming machines, cars, snowploughs, snow blowers
(The search from such vehicles can be severely disturbed by interferences from the running engine, metal plates and the vehicle electronics. In transmit mode, reduction of range is possible depending on proximity of the transmitter to metal parts of the vehicle. Search accuracy might be compromised in close proximity of the vehicle.)
- helicopters
(The search from a helicopter is only efficient with specialized transceivers)

Medical equipment:

- pacemakers and ICDs
(Users of pacemakers/ICDs are advised to carry the device on their right side (adjust the length of the carrying straps. Consult the manufacturer's instructions of the pacemaker with regards to the interference impact.)
- portable heart rate monitors
(needs to be switched off during search or in 50cm distance to the receiver)
- first aid equipment incl. metallic splints
- toboggan, immobilization equipment, stretchers

Communication equipment:

- analog VHF and UHF radios up to 5W transmit power (interference may occur during transmit of the searching rescuer. Loudspeakers of radios produce a strong electromagnetic field and should therefore not directly point towards the transceiver)
- digital VHF and UHF radio up to 5W transmit power (interference may occur during transmit, radio needs to be turned off during search)
- cellular phones, satellite phones, PLB (personal locator beacon)
(interference may occur during communication (incl. synchronization with the network, communication of text messages and data), devices need to be turned off during search for all searching rescuers. As long as the search

is in progress, use of these device on the entire avalanche should be restricted to short-lasting emergency calls in minimum distance of 25m to the closest searching rescuer. Based on new measurements, actively searching rescuers must completely turn off cellular phones as some specific, but popular models show even in "air plane mode" in distances up to 100cm interferences which trigger erratic distance / direction indications on the screen in areas where there is no real transceiver signal).

Orientation equipment:

- electronic and mechanical altimeters
- electronic and mechanical compasses
- handheld GPS receivers (except devices with radio transmit functions)

Equipment of armed forces and law enforcing agencies:

- guns and pistols, ammunition
(weapons incl. optics, but excluding electronic systems; if the weapon is carried diagonally on the front side of the body, the transceiver must be carried sidewise)
- body armor systems (carry transceiver sidewise)

Non Rescue, Mountain or Operationally Relevant Equipment (= all equipment not listed above)

The variety of electronic equipment (entertainment, video, photo, remote controls, etc) that rescuers have been trying to use in combination with their avalanche rescue transceiver has tremendously grown in the past years. Whereas some of the equipment might not cause an interference problem in combination with a particular transceiver, it does with others and vice versa. It is therefore impossible to make a recommendation for each individual device and transceiver. Several reports from failed or severely disturbed and delayed rescue action in the last years have shown that electronic equipment can have a very unpredictable and severe influence on avalanche rescue transceivers.

Therefore, while a search is in progress on the avalanche, all equipment not listed above must be turned off and remain off on the entire

avalanche for the short duration of the search compared to the entire duration of rescue.

High voltage power lines and radio towers may as well dramatically reduce the performance of an avalanche rescue transceiver. Often, the digital search mode completely fails and it is necessary to carry out an analog search by applying signal search strips with a very limited width.

Recommendations Concerning Potentially Interfering Equipment for Recreational Users (Short Version)

Avoid wearing clothes with magnetic buttons or larger metallic and/or conductive parts (i.e. heated gloves). Be aware that food, candy or cigarette box wrapping often include thin metal foils which therefore count as a metal object!

In transmit mode a minimum distance of 20cm has to be respected between the avalanche rescue transceivers and any metal object or electronic device.

In search mode, a minimum distance of 50cm has to be respected between the transceiver, electronic equipment and metals parts.

All equipment *on the searching rescuer* has to be turned off, except:

- radio
- head lamp without switch power voltage regulator (usually found in high power devices with external battery packs)
- wrist watch without radio functions on the wrist; large, multi-functional watches with large screens should not be worn on the same hand like the searching transceiver is held.
- devices providing a backup transmit function in case of a secondary avalanche

All equipment *on all non-searching rescuers on the avalanche* has to be turned off, except:

- Cellular phones, satellite phones, PLB
As long as a search is in progress on the avalanche, use is restricted to short-lasting emergency calls/messages in minimum distance of 25m to the closest searching rescuer.
- devices providing a backup transmit function in case of a secondary avalanche
- head lamp

Source of Interference in Recco Searches

RECCO reflectors use a specially tuned diode to cast back the directional signal. Diodes are generally used to control the direction of current but can be used to modulate or shift radio frequencies. RECCO reflectors use a diode to double the RECCO frequency. There are four situations where diodes or diode-like materials can result in interference or distracting RECCO signals:

Electronic Devices

Potentially, any device – even when turned off – with a diode can produce a reflected RECCO signal. However, for most devices this range is only millimeters to centimeters but can range up to several meters.

Different Metals (generally found in equipment)

Diodes are made of two different conductive materials or metals, so a reflected RECCO signal can be produced from items made of different metals. This can include boot buckles, skis and snowboards, bindings, rusted steel, or even rivets made of a different type of metal from steel shovel blades.

Mineralization (rocks)

Since diodes are made of two different conductive metals, rocks that are heavily mineralized may reflect RECCO signals. The signal is generally very weak and is often more problematic early in the winter when the snow cover is shallow. Because the signal is so weak, it generally disappears when the power is reduced one or two steps. A RECCO reflector will continue to produce a strong signal unless the snow is exceptionally deep or wet.

Reflectors on Rescuers

Reflectors on rescuers produce a very strong source of interference and should be avoided by principle. An experienced Recco operator may be able to work around reflecting rescuers - thus avoiding to point the device towards them - but the avoidance strategies at the same time may increase the risk to oversee a weak reflection of a deeply buried subject. Backup- / Rescue SEND functions of modern avalanche transceivers are a more appropriate solution to

allow fast rescue in case of a secondary avalanche accident.

Solution to Manage Distracting RECCO Signals

While the reasons for interference are varied and different, the solution is the same for all situations. There are five techniques that will help minimize distracting RECCO signals. In some situations one technique may solve any challenges, while in other situations all the techniques will need to be applied.

Aim

Strictly limit the search horizon by aiming the detector downwards the snow and avoid rotations motions which make the antenna temporarily point towards other rescuers, equipment or towards the sky.

Manage

The detector operator should, ideally, keep rescuers behind the operator; basically don't point the detector towards other rescuers. Searching uphill makes it easier to avoid an undesired extension of the search horizon. Searching sidewise/traversing on an inclined slope needs special attention of the rescuer in the moment where the device is pointed downslope as the search horizon quickly includes the entire debris. Searching downhill in step terrain is therefore strongly suboptimal and should be avoided if possible.

Position

The detector operator should wear their transceiver and other electronic devices on their back. If the transceiver is equipped with a reflector, the reflector side should worn securely against their back. As previously mentioned, reflectors on rescuers add unnecessary challenges to a rescue operation, which should be avoided.

Shield

If the previous three techniques are not reducing distracting signals for the detector operator, RECCO makes available a specialized metalized fabric that can shield a reflector or other device(s) from the RECCO signal. The

detector operator, if necessary, can wrap their transceiver or other device with a shield or Pouch. Even a vest is available by a third party. When used over a transceiver the fabric will not affect the transceiver's signal.

Train

The detector operator should practice in the presence of interference. This means searching while wearing radios, cameras, mobile phones, GPS, etc. and amongst other reflector-equipped rescuers. However, this should only be done once the operator has good skills and experience with the detector. Novice instructors should learn initial skills free from the challenges of interference. With good skills they can then add interference issue into their trainings and practice.

Reducing power to eliminate interferences?

Only reduce the power to limit interference as a last resort. Reducing power reduces range and is therefore a highly unattractive solution.

Acknowledgements:

The author would like to thank to the following individuals and organizations for their corrections, linguistic review and contributions to this paper:

Joe Obad, CEO Canadian Avalanche Association
Emily Grady, Education Officer Industry Training Programs, Canadian Avalanche Association
Todd Guyn, Mountain Safety Manager, Canadian Mountain Holidays
Rob Whelan, Ski Guide and Technical Advisor, Canadian Mountain Holidays
Marc Piché, Technical Director, Association of Canadian Mountain Guides
Daniel Forrer, Head of Software Engineering, Adaxys Solutions

References:

(1) Genswein, M., Reiweger, I. and Schweizer, J., 2009. Survival chance optimized search strip width in avalanche rescue. Cold Regions Science and Technology, 59(2-3): 259-266.