Today's Transceivers Part 2
Understanding the Marking Function: Pattern Recognition
By Rob Whelan

In the previous issue of this journal, we examined the disconnect between marketing messages, user expectations, and the real-world performance of modern avalanche transceivers. One of our conclusions was that modern devices with digital technology and multiple antennas are a vast improvement over the old analog transceivers, especially for recreational users. With distance and direction indications displayed to the user, searching for a single burial is pretty straightforward. Multiple burials, however, can still be a challenge.

Manufacturers have differing design philosophies when it comes to managing multiple burials. There are two fundamentally different approaches. The first is to use a search strategy that does not rely on any special function of the transceiver, but rather on a strategic search pattern that is applied by the rescuer, such as searching in parallel[1] or the Three Circle Method[2]. The second approach is to use properties of the incoming signals to separate the signals, allowing the searcher to "mark" a burial when it is pinpointed. This method is used by Pieps (DSP series), Barryvox (Pulse, Element), Ortovox (S1, 3+) and Arva (Evo).

Among the devices that employ this "marking" function, there are two different strategies for separating the signals from multiple transceivers. The first strategy is signal separation by amplitude. At any one time, one signal will be stronger than the others, allowing it to be separated and identified. The second strategy is signal separation by pattern recognition. Pattern recognition takes advantage of the concept that each transmitter has a unique transmit pattern, allowing it to be identified by this pattern. In this article, we will focus on the pattern recognition strategy, and examine its strengths and weaknesses.

Signal separation by pattern recognition is used by Barryvox, Ortovox and Arva transceivers. Although each manufacturer has its own proprietary twist on this basic concept, here is roughly how it works. Within the specification for avalanche transceivers, there is a range of allowed pulse widths (the "on" time of the beep sound) and a range of pulse periods (the length of time between beep sounds)[3]. This allows manufacturers to somewhat randomize these parameters, assigning each device a slightly different pulse period. Modern transceivers have high quality oscillators, and as a result they have very precise and reliable timing. If my beacon starts up with a pulse width of 80 ms (milliseconds) and a period of 900 ms, then the 80 ms pulse width and the corresponding pulse period will remain consistent as long as the device is transmitting.

When you look at this pattern on an oscilloscope, you can see the distinct leading edge of the signal pulse every 900 ms. This is known as a "positive edge" and is what a Pulse, S1, 3+ or Arva is "seeing." Once the searcher has received a certain number of these positive edges, the searching device can assign a unique identity to that particular signal. Every 900 ms, it expects a positive edge from that transmitter. This particular pattern is now confirmed, and the pattern can be assigned to a buried

[1] Dieter Stopper, Franz Hohensinn and Bruce Edgerly, "Harnessing Manpower in Transceiver Rescues," < http://backcountryaccess.com/index.php?id=106>

[2] Steve Christie, "The Three Circle Method: A Standardized Approach for Avalanche Professionals," <http://www.backcountryaccess.com/index.php?id=163>

[3] Rob Whelan, "Today's Transceivers," *avalanche.ca*, vol 96, p 56-58.

subject. The searcher's display is updated to show that there is one buried subject, and that their signal is unmarked.

Now imagine that the searcher moves within range of a second transmitter. The searching device now has another signal to analyse. The arrival time of the positive edge of the new signal will be different from the arrival time of the signal from the first buried subject. If you listen to the analog beep sounds, you will hear "BEEP-beep...BEEP---beep...BEEP------beep...." The louder beep is coming from the first buried subject. You will also notice that the signal pattern from the second transmitter is slightly different. The beep sounds do not have the same cadence, so the signals migrate away from each other over time. This makes signal separation easier for the searching device—the two signals have unique pulse periods and pulse widths.

Once again, the searching device confirms that the new signal is unique, then assigns an identity to the signal and updates the display to notify the searcher that a second buried subject has been added to the list. The search continues, using the distance and direction indication to move to the first buried subject. It is important to understand that now we are getting distance and direction for the first buried subject ONLY; all the other signals are still being processed, but are not displayed to the searcher. This means that if we wander off and do not follow the direction indicator, we could end up standing right on top of the second buried subject—and still seeing the distance and direction indication for the first buried subject who has not yet been found.

This drives people crazy. "I walked right over one and went past it!" Well, of course we did. That is not the signal we are currently looking for. The searching device can only show one distance and direction at a time, and if the device "switches" to another closer signal, we become like a pinball in a pinball game—and risk missing even more burials. So, the best strategy is to search in a concentrated manner, being attentive to the balance between speed and precision in our search technique.

Sounds easy enough—one single burial search after another. So why does it sometimes just not work? The short answer: signal overlap. When we listen to the analog beep sounds from two transmitters, the beeps migrate away from each other for a time, and then they start to converge again. At some point, the two beeps sounds will be so overlapped that it will sound like just one signal. For a searching device, when the signal is overlapped like this, there is no usable information to process. Which of the two signals is getting stronger? Which of the two directions is the correct one? The processor needs a minimum separation between the incoming signals to provide useful information to the user.

At this point, with the signal overlapped, it's all about the transmitters. If the pulse period of the transmitters is nicely randomized, then the duration of the signal overlap will be short. We can say that they have a good migration rate. However, if the migration rate is poor, and/or there are transmitters with long pulse widths (Ortovox F1, SOS, M1) then the signal overlap can persist for a long time—a long time in the context of an avalanche rescue.

When this signal overlap condition persists for more than a few seconds, the searching device has no more useful information to process, and is forced to warn the user. At this point we might see a Stand Still message, or the Stop icon displayed. This is often misinterpreted as "processor overload." The processor is not overloaded. In fact, the processors in these devices are so fast they spend 80 – 90% of the time just idling, waiting for the next pulse to arrive so they have something to process. This warning is just telling the user that there is no usable information available, and to wait for the signal overlap condition to resolve itself.

So now for the hard part. If we want to use the marking function as our search strategy, we have to actually heed the advice of the searching device, and STAND STILL! Not the easiest thing to do in a rescue situation. The signal overlap may last for several seconds, which seems like an eternity in a rescue (or even a practice, for that matter). However, once those seconds have passed, we will once again be on the most efficient path to the buried subject.

Sometimes, though, the search can get totally frustrating. You've been there. Multiple "Stop" and "Stand Still" messages. Confusing and conflicting distance and direction indications. Returning to a previously marked burial. These are all signs of repeated or prolonged signal overlap. The incoming signals are such that just as one signal overlap problem starts to resolve itself, another one is developing. I see this most commonly in practice scenarios and on avalanche courses. Which two brands of transceiver are inexpensive, readily available and most likely to be used as search targets? The popular Tracker DTS and the trusty Ortovox F1. Which two beacons are most likely to have signal overlap? Sure enough—the Tracker DTS and the Ortovox F1. They are both totally reliable devices, and meet current specifications, but the properties of their signals are not friendly for pattern recognition algorithms.

The Ortovox F1 has a relatively long pulse width (long beep sound). This means that its signal is taking up more of the space in the pulse period than other devices, and increases the chance that this long pulse will overlap another signal. The Tracker DTS was designed with a narrow set of possible pulse widths. Therefore, even though the pulse width is short, the migration rate is slow. This means that when two Tracker DTS are sending, they will very slowly migrate to a condition of signal overlap. And once that overlap condition is reached, it will last for a long time (again, a long time in the context of a rescue).

The ideal situation for successful pattern recognition is transmitters with short, randomized pulse widths, which results in fast migration rates. There will still be lots of signal overlap, but those overlap periods will be brief.

In conclusion, when using pattern recognition to solve multiple burial scenarios, the transmitter is an important factor regarding the success of the search strategy. In the next article of this series, we will look at other marking strategies—signal separation by amplitude, the Pieps Smart Transmitter, and the W-Link support for multiple burials available from Barryvox and Arva.

SIDEBAR

For a visual representation of some of the concepts in this article, check out these videos on YouTube:

Transceiver Transmit Patterns: http://youtu.be/oVvbs4OaX1U

Migration rate: http://youtu.be/wxcoB94OTU0

F1 signal overlap : http://youtu.be/Fjvn4QxGgbg

Tracker DTS signal overlap: http://youtu.be/sHNYSR4sj90

Pulse/Tracker/Opto3000 good signal separation : http://youtu.be/4mt7GOFT9bU

Ortovox F1 / Tracker signal overlap : http://youtu.be/Cnq8EQT-JoM