SIMPLIFYING THE SIGNAL SEARCH: WHY YOU DON'T NEED TO ROTATE YOUR TRANSCEIVER VERTICALLY

INTERNATIONAL SNOW SCIENCE WORKSHOP 2018 INNSBRUCK, AUSTRIA

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ABSTRACT: In companion rescue and avalanche search-and-rescue (AvSAR) courses, most avalanche instructors will tell you to rotate your transceiver on all three axes when performing the signal search. This is counter-intuitive to most users, especially now that most have digital transceivers: these use visual directional indicators that have no value when the searching transceiver is vertical. However, covering the vertical orientation is unnecessary: the receive range of a transceiver is equal or slightly greater when the longest receiving antennae are on the horizontal plane—even if the transmit antenna is vertical. BCA technicians performed a series of tests in the spring of 2018, confirming that, with a vertical transmit antenna, the signal search is just as effective when the searching transceiver is rotated only on the horizontal plane than if rotated on all three axes, including the vertical plane. By maintaining a horizontal search transceiver orientation, consistent signals are acquired slightly earlier in the signal search. This simplified procedure should be adopted in future companion rescue and AvSAR courses—and in the instruction manuals for all avalanche transceiver products.

KEYWORDS: Avalanche transceiver, avalanche beacon, signal search, primary search, optimal coupling, effective range, maximum range, search strip width

1. BACKGROUND

In the days of analog transceivers, it was common during the signal search phase to rotate the receiving beacon on the x, y, and z axes. This way, according to conventional wisdom, optimal coupling between the transmit and receive antennas would be achieved earlier, theoretically shortening the overall search time. If the victim's transmit antenna were oriented vertically, then the searcher would achieve parallel orientation with that antenna when he or she rotated their searching beacon into the z axis, picking up the signal sooner than if the searching beacon were only rotated on the x and y axis.

This made good theoretical sense and had no cost in terms of user-friendliness. Since the search was conducted on an audible basis only, it made no difference whether the searching unit was horizontal, vertical, or somewhere in between: the difference in volume could still be used to determine if the searcher was traveling in the right direction. In the modern era of digital transceivers, however, there is a cost. The user interface is now primarily visual, with distance displays shown in meters and directional arrows that lead the user to the victim along the electromagnetic lines of flux propagating from the transmit beacon. Since the user is traveling along a horizontal plane (the snow surface), these directional arrows are not useful when the display is held vertically. In fact, to the modern recreational user, it is counterintuitive to rotate the searching unit into the vertical plane when they know that the lights will not make sense once the signal is detected.

To this day, this technique is still being taught, primarily by manufacturers of transceivers that still have analog functions (Mammut, 2016) and by instructors that believe that rotating on all three axes optimizes the search strip width (Genswein and Schweizer, 2008).



Figure 1. This manual from a Swiss manufacturer recommends rotating the searching transceiver on all

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three axes, keeping it near the ear so the searcher can listen for audible clues.

This technique is not only counterintuitive to users of modern digital transceivers, but it is not supported by the laws of electromagnetic physics. With a vertically oriented transmit antenna, equivalent or more receive range can actually be gained by keeping the searching transceiver on the horizontal plane and rotating only on the x and y axis, not the z axis. This is because at the edge of signal detection, the electromagnetic flux lines propagating from a vertical antenna are so disperse that there is a nearly equivalent amount of horizontal component to the flux lines as there are vertical component. Electromagnetic field strength is an inverse cubic function as you move away from the transmitting antenna: the field strength is significantly weaker the further away you are from the transmitter. Therefore, the differences in orientation are less significant, especially between the horizontal and vertical positions.

This is supported by tests performed in the spring of 2018 by technicians from snow safety equipment manufacturer, Backcountry Access, Inc. (BCA).

2. METHODOLOGY

BCA ran a series of tests in April of 2018 to determine if a significant increase in receive range is achieved by rotating the searching transceiver on all three axes. The tests were conducted on a frequently used test strip ("Beacon Alley") on the Skunk Creek Bike Path behind BCA headquarters in Boulder, CO. They were performed by technicians supervised by both a company vice president and an electronics category director.

These tests were done in three stages. The first stage was a baseline series of tests with in-line coupling, to ensure the scenario was reliable, free of electrical interference, and that the results were consistent with the maximum range experienced in previous tests by the authors, other manufacturers, and in published product reviews. A Tracker3 transmit unit was placed on a cardboard box approximately 18 inches above the ground, with the transmit antenna pointed directly down Beacon Alley. The searcher approached from the opposite direction, at about 2 meters per second, beginning 60 meters away, with the searching unit pointed along the same axis as the transmit antenna. The receive range was recorded when at least three out of every five transmit pulses were shown on the display, including both a distance and a direction. This test was repeated ten times to obtain an average maximum distance reading. This, in turn, was performed using 10 different transceiver models, for a total of 100 tests. This resulted in an average maximum distance reading across all ten tests and all ten models.

In the second series of tests, the searcher held the searching beacon in his hand and approached a vertically oriented transmitter, placed on the same cardboard box. This was done first with the receiving unit oriented vertically. The maximum range was recorded ten times for each model. Then it was done another ten times with each model with the searching unit pointed 90 degrees from the transmit unit, on the horizontal plane. Finally, each model was tested another ten times with the searching unit pointed directly at the vertically oriented transmit unit.



Figure 2. Transceiver testing box on "Beacon Alley," with vertical transmit antenna. The transmit antenna on Trackers are at a 45-degree angle to the long axis of the plastic casing.

In the third series of tests, the searcher approached the same vertically oriented transmitter, rotating the searching beacon on the x, y, and z axes. As above, this was done ten times with all ten transceiver models. Then the searcher did the same tests, but this time rotating the searching transceiver only on the x and y axes.

3. RESULTS

The results of these tests confirm that including the z axis during the signal search provides no benefit to the user in acquiring an initial signal. The average maximum range in the baseline in-line tests was 49.4 meters, which is consistent with previously published tests. The lowest maximum range recorded was 34.8 meters and the highest maximum range was 59.7 meters. With a vertically oriented transmit antenna, the average maximum range was actually the lowest

when the searching unit was rotated on all three axes (horizontally and vertically),



Figure 3. BCA technician searches along Beacon Alley with the searching unit in the horizontal x-axis position, pointing directly at the transmit unit.



Figure 4. Each test was performed ten times with ten different transceiver models.

with an average of 19.94 meters. The average was 21.16 meters when rotated only on the x and y axes (horizontal only). While holding the searching unit stationary, the greatest average maximum range of 21.08 meters was obtained with the unit pointed zero degrees—or directly at—the vertically oriented transmit unit. The lowest average, of 20.14 meters, was obtained by holding the searching unit vertically.

SIGNAL SEARCH TEST PLAN - APRIL 2018

Transmitter Position: In-Line	
	Average
Position: In-Line	**49.37**
Transmitter Position: Vertical	
	Average
Position: Vertical	**20.14**
	Average
Position: 90 Degrees	**20.55**
	Average
Position: 0 Degrees	**21.08**
Transmitter Position: Vertical	
	Average
Position: Rotate on all 3 Axes	**19.94**
	Average
Position: Rotate on 2 Horiz Axes	**21.16**

Figure 5. Average range across all ten transceivers under various orientations

These results also confirm that 20 meters is a reasonable basic guideline for the “effective range” of modern digital transceivers under poor orientation scenarios (with vertical transmit antenna). However, several models had average maximum ranges slightly beneath this threshold, especially if the unit was held stationary (without rotating) either vertically or at a 90-degree angle from the transmitter. Furthermore, this was under relatively quiet conditions with respect to electromagnetic interference. Therefore, effective ranges of 15 meters or less can be expected in scenarios involving poor coupling and high interference.

4. CONCLUSION

In the interest of simplifying the process of transceiver searching, students should be instructed to rotate the transceiver on the horizontal plane during the signal search, but not on the vertical plane. This slightly increases the probability of detecting a signal earlier in the search. More important, it also provides a more intuitive technique for the modern digital beacon user, as the directional lights on digital beacons are not useful when the searching unit is held vertically. Secondly, instructors should advise students that most manufacturer guidelines are ambitious

regarding maximum range and search strip width, even in clean electrical environments. Users should be advised that “effective” ranges can dip below 20 meters in poor coupling scenarios, especially in environments with higher levels of electromagnetic background noise.

REFERENCES

Mammut Barryvox Pulse Reference Manual, 2016.

Genswein, M. and Schweizer, J., Numerical Simulation of the Survival Chance Optimized Search Strip Width, *ISSW Proceedings, 2008*.

APPENDIX

SIGNAL SEARCH TEST PLAN - APRIL 2018

Transmitter: Tracker 3
Position: In-Line

Recorded Range on Beacon Alley grid (3 out of 5 pulses)

Test #	1	2	3	4	5	6	7	8	9	10
Receiving Unit										
Position: In-Line										
Model 1	42	43	47	45	46	45	45	44	44	41
Model 2	55	55	58	55	55	59	52	54	55	52
Model 3	45	44	48	47	47	52	51	55	53	46
Model 4	52	61	60	62	61	62	62	61	56	60
Model 5	52	43	49	42	47	47	47	43	45	42
Model 6	38	39	40	40	42	45	43	43	41	46
Model 7	50	51	50	53	43	51	57	54	53	44
Model 8	37	37	35	37	34	35	34	33	33	33
Model 9	55	56	56	55	57	61	53	57	50	50
Model 10	58	58	59	57	59	61	57	61	57	55

Transmitter: Tracker 3
Position: Vertical

Test #	1	2	3	4	5	6	7	8	9	10
Receiving Unit										
Position: Vertical										
Model 1	14	18	18	19	19	18	18	19	18	18
Model 2	22	23	22	23	20	22	22	21	22	22
Model 3	20	21	21	18	19	18	19	21	19	19
Model 4	21	21	20	22	22	21	22	22	20	22
Model 5	18	18	18	18	17	20	19	17	20	18
Model 6	18	19	19	20	20	19	18	20	18	18
Model 7	17	20	20	18	20	21	21	19	18	18
Model 8	17	17	18	17	17	18	17	18	17	18
Model 9	22	20	21	20	22	21	22	21	22	22
Model 10	26	24	29	25	27	26	26	24	24	26

Test #	1	2	3	4	5	6	7	8	9	10
Receiving Unit										
Position: 90 Degrees										
Model 1	13	15	12	15	14	12	13	13	12	15
Model 2	20	21	20	20	20	19	21	20	19	20
Model 3	18	19	19	21	18	18	18	19	17	17
Model 4	23	26	25	26	27	24	24	25	25	23
Model 5	20	22	24	24	24	23	23	24	22	23
Model 6	22	24	22	23	21	24	23	24	19	23
Model 7	24	21	23	23	22	22	21	21	24	24
Model 8	15	14	16	16	16	16	16	16	15	15
Model 9	21	23	20	23	23	20	21	19	20	21
Model 10	23	25	23	25	25	26	27	22	23	25

Test #	1	2	3	4	5	6	7	8	9	10
Receiving Unit										
Position: 0 Degrees										
Model 1	18	19	20	20	20	17	18	19	19	17
Model 2	24	23	24	24	23	23	23	24	20	24
Model 3	24	23	23	23	23	20	23	18	19	20
Model 4	25	23	27	23	25	24	23	24	23	23
Model 5	23	23	20	20	22	20	21	22	20	19
Model 6	18	23	20	20	20	19	20	21	20	19
Model 7	22	23	22	20	21	23	22	21	22	20
Model 8	18	17	15	15	15	17	17	17	16	15
Model 9	23	23	23	20	24	20	23	22	21	22
Model 10	23	23	23	22	23	24	21	20	24	21

Transmitter: Tracker 3
Position: Vertical

Test #	1	2	3	4	5	6	7	8	9	10
Receiving Unit										
Position: Rotate on all 3 Axes										
Model 1	14	14	18	18	18	18	18	18	17	18
Model 2	22	22	22	22	21	22	22	24	22	21
Model 3	22	22	20	21	22	20	20	20	21	22
Model 4	24	23	20	21	22	22	22	21	23	23
Model 5	21	19	21	20	20	19	21	18	20	19
Model 6	23	20	19	18	19	17	21	19	19	20
Model 7	24	20	21	20	19	18	21	22	20	21
Model 8	14	17	15	15	14	15	15	14	14	15
Model 9	22	14	22	20	20	20	20	20	21	22
Model 10	22	22	24	22	21	21	21	24	23	24

Test #	1	2	3	4	5	6	7	8	9	10
Receiving Unit										
Position: Rotate on 2 Horiz Axes										
Model 1	17	18	18	19	17	19	21	16	19	20
Model 2	21	23	21	23	22	21	21	21	22	22
Model 3	22	19	22	25	22	21	21	22	21	20
Model 4	25	24	22	25	25	24	22	23	23	24
Model 5	23	21	21	22	22	19	23	23	21	22
Model 6	22	21	21	18	20	21	22	19	21	21
Model 7	22	21	22	21	23	21	21	23	22	22
Model 8	14	15	14	15	14	14	14	13	15	15
Model 9	22	20	23	22	20	23	22	20	23	23
Model 10	27	24	28	25	35	25	26	22	24	25