THE D-KAZ COOKBOOK
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with input from Neil Kazaross and Nick Hall-Patch
12/2018

SECTION ONE: Antenna Performance, Attributes, Operation, Construction

SECTION TWO: Measurements and Non-Traditional Applications

SECTION TWO—During June and July 2018 we conducted a battery of D-KAZ performance measurements under controlled conditions. Our primary metric was "Front-to-Back" ("**F/B")**, or antenna directivity. We first compared a 170-foot D-KAZ to a 140-foot version, and then we deliberately perturbed the geometry of the 140-foot version, to see what happens when antenna wires are casually misaligned. Extensive recordings and loggings were made. We present our results informally below, presenting the measurements on tables for comparison.

At the end of this section, we discuss **non-routine D-KAZ applications.**

2018 MEASUREMENTS: The antennas were situated in a tree-lined, electrically-quiet location, well away from strong radio signals. The antenna line was 330/150 degrees (NW/SE). This orientation placed the backside null area toward densely populated areas with high-power radio signals (Figure 2-1).

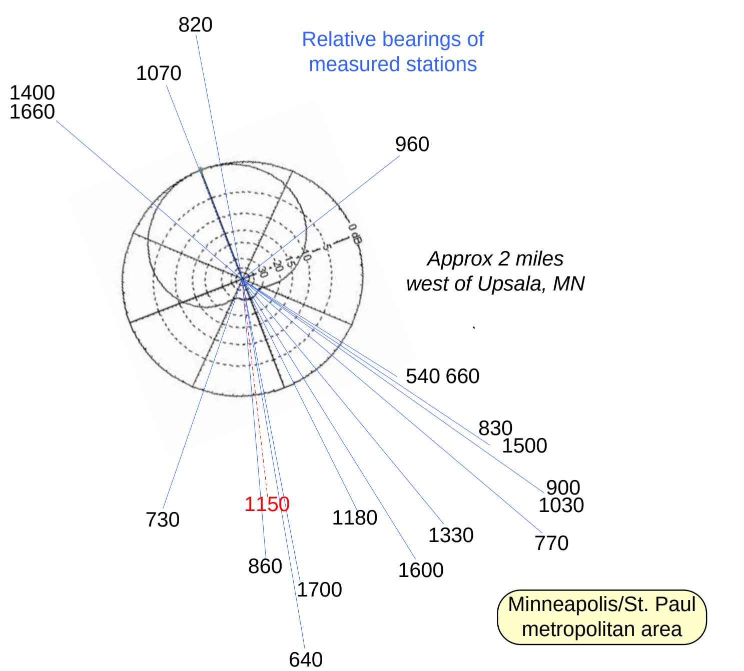

Figure 2-1--POLAR PLOT

Target stations were selected for their location and for signal reliability. Some of the initial targets had to be discarded, because when they were nulled, co- or adjacent-channel stations came up and got in the way…*or* the targets' *nulled* signals went too far down into the noise. The signals on a regional map are shown in Figure 2-2.

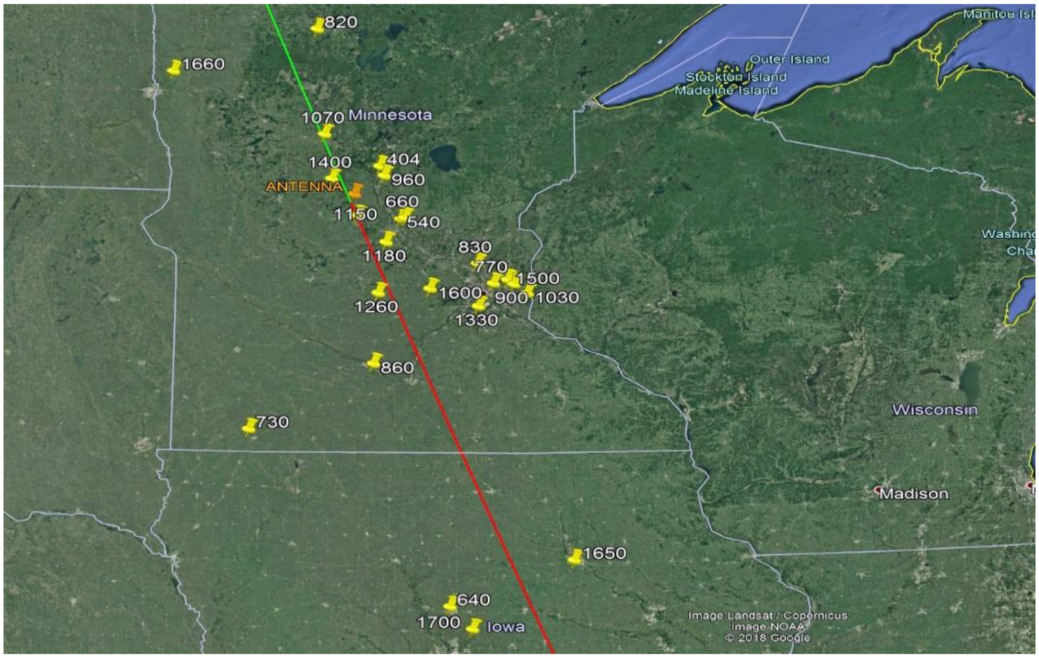

Figure 2-2

You'll note that most of the higher-frequency stations are a fair distance away, and that contributed to some mid-day skywave-ing…even in the middle of summer! We did our best to work around that but weren't always able to defend higher-frequency results.

The 170 ft. D-KAZ was built first. Once the 170-foot measurements were "in the can" we shortened the antenna to 140-feet along the same antenna line, re-adjusting the wires and the support post locations, for the shorter length. Measurements were made on two identical Perseus SDR receivers and full-bandwidth recordings were made for data verification and later retrieval. The lead-in and amplifier combination was that labeled as DXE-CATS in **Figure 1-2** (Section One).

A. THE CASE FOR SINGLE-FREQUENCY NULLING: We first wanted to verify our earlier observations that only minor null-readjusting might be necessary once a representative signal had been nulled. Not only would that make DX-ing easier but it would simplify our data presentation. So we set out to prove that this 'single-null' concept was valid for our work.

Table 2-1 and **Table 2-2** contain the results: the null-depths resulting from the 'one-at-a-time' nulling of test signals. You will see the null-depths resulting from a resistive nulling on *each* 'test station as well as that specific null's impact on the nulls of the other stations.

After each test signal was minimized, the signal levels on all other stations were recorded, before we moved on to the next test signal. After all signal levels were posted, we derived the null-depths by subtracting that station's residual signal level from its original signal level in the "w/no null" column.

FREQ Value	Signal w/no null dbm	Signal after nulling @730 dbm	Null depth w/730 nulled db	Signal after nulling @830 dbm	Null depth w/830 nulled db	Signal after nulling @1150 dbm	Null depth w/1150 nulled db	Signal after nulling @1330 dbm	Null depth w/1330 nulled db	Signal after nulling @1500 dbm	Null depth w/1500 nulled db	VAR FROM AVG db
540	-51	-76	**25**	-76	**25**	-77	**26**	-77	**26**	-77	**26**	**1**
640	-69	-97	**28**	-95	**26**	-98	**29**	-96	**27**	-98	**29**	**3**
660	-34	-64	**30**	-64	**30**	-71	**37**	-72	**38**	-66	**32**	**8**
730	-64	-93	**29**	-89	**25**	-92	**28**	-91	**27**	-92	**28**	**3**
770	-61	-90	**29**	-97	**36**	-96	**35**	-98	**37**	-93	**32**	**8**
830	-48	-74	**26**	-90	**42??**	-78	**30**	-81	**33**	-78	**30**	**16??**
860	-58	-90	**32**	-85	**27**	-91	**33**	-91	**33**	-90	**32**	**6**
900	-49	-79	**30**	-85	**36**	-80	**31**	-81	**32**	-80	**31**	**6**
1030	-55	-82	**27**	-86	**31**	-84	**29**	-84	**29**	-86	**31**	**4**
1150	-22	-50	**28**	-49	**27**	-52	**30**	-51	**29**	-51	**29**	**3**
1180	-28	-57	**29**	-55	**27**	-62	**34**	-59	**31**	-60	**32**	**7**
1330	-57	-81	**24**	-77	**20**	-81	**24**	-80	**23**	-81	**24**	**4**
1500	-53	-74	**21**	-69	**16**	-70	**17**	-73	**20**	-72	**19**	**5**
1530	-59	-75	**16**	-68	**9**	-73	**14**	-76	**17**	-76	**17**	**8**
Average null depth			**25.7**		**25.8**		**27.2**		**26.2**		**26.9**	

Table 2-1: 170-foot D-KAZ

FREQ	Signal w/no null	Signal after nulling @730	Null depth w/730 nulled	Signal after nulling @830	Null depth w/830 nulled	Signal after nulling @1150	Null depth w/1150 nulled	Signal after nulling @1330	Null depth w/1330 nulled	Signal after nulling @1500	Null depth w/1500 nulled	VAR FROM AVG
Value	dbm	dbm	db	dbm	db	dbm	db	dbm	db	dbm	db	db
540	-55	-79	24	-76	24	-78	23	-77	22	-77	22	2
640	-73	-98	25	-96	25	-99	26	-98	25	-98	25	1
660	-37	-65	28	-68	28	-86	49	-75	38	-83	46	21
730	-68	-93	25	-90	25	-92	24	-92	24	-92	24	1
770	-65	-92	27	-95	27	-102	37	-100	35	-101	36	10
830	-52	-76	22	-85	22	-82	30	-85	33	-83	31	11
860	-61	-93	32	-89	32	-99	38	-93	32	-96	35	6
900	-54	-80	26	-89	26	-89	35	-97	43	-94	40	17
1030	-57	-82	25	-83	25	-84	27	-84	27	-84	27	2
1150	-25	-53	28	-55	28	-64	39	-60	35	-63	38	11
1180	-31	-60	29	-61	29	-79	48	-65	36	-71	40	19
1330	-59	-84	25	-87	25	-92	33	-94	35	-90	31	10
1500	-57	-80	23	-85	23	-87	30	-89	32	-86	29	9
1530	-60	-90	30	-87	30	-86	26	-93	23	-85	25	7
Average null depth			25.1		25.1		31.5		29.8		30.4	

Table 2-2: 140-foot D-KAZ

Note the **far right column** displays the maximum variance from the average null at each frequency. This is useful in evaluating the use of a specific frequency as the 'set-and-forget' null.

The bottom-row **Average null depth** values in the table help you decide which frequency to choose for single-frequency nulling.

We believe a proper conclusion based on our Minnesota work is that a single-frequency null is valid. It's likely not possible to find a single channel null that represents the *best* minima across the Medium-Wave band, but you can do pretty well. If you have the choice, a higher-frequency channel is probably better; in our case 1150 was chosen because it's close to the antenna boresight and near the middle of the MW band.

This is a useful procedure for broad-band recording; leavened by Neil Kazaross's comment: *"I find it useful when recording live to tweak the Vactrol to get a few dB more null on a freq. of interest…knowing that this small Rt tweak is unlikely to do any major damage elsewhere."*

Nick Hall-Patch adds this: *"A single null set-and-forget is good I would think. But position the antenna (if you can) so that the null (wide as it will be) knocks down the worst of the potential interference to your target area."*

This 'single-null simplification' may expose us to questions regarding the validity of null-depth numbers, but we recorded each session and can provide more data on request.

Having made the point, we move on, using a single 1150-null as the data anchor where we could…and remembering too that our drill was about *comparison*, not absolute measurement.

SPECIFIC COMPARISONS--170-foot to 140-foot D-KAZ ANTENNAS: You can use appropriate columns from the tables above to investigate certain relationships. For example, a comparison of the signal efficiency of the two antenna lengths can be taken from the two "signal w/no null" columns. Note the added length of the 170-foot D-KAZ not only improves low-end F/B but band-wide signal improvement is around 3+ db; the advantage decreasing slightly with the increase in frequency.

B. EFFECT OF MISALIGNMENTS: Next we embarked on several measurements of *symmetry* in the wire deployment of a 1**40-foot D-KAZ** occurring when things weren't in good alignment. We observed the null-depth impact from *unpurposeful misalignments* of supports or wire runs.

The first asymmetry was **POLE MISALIGNMENT**: We deliberately skewed one of the support poles so its *top* was tilted about a foot from 'straight-up' alignment. That may seem like a lot, but without lateral guying of the typical fiberglass wind-pole, a shift like this can happen in a decent wind.
With the poles misaligned, ***maximizing null-depths required a good deal of individual re-nulling at each frequency.*** Not good. And even with individual nulling, we found the null-depths weren't as impressive. Here, our measurements produced uncertain results, so you won't see tabulated data although it's

available on request. Instead, we observe that “a D-KAZ with misaligned support poles delivers unpredictable null-depths and makes difficult a single-frequency broadband-null.” We suggest that D-KAZ support poles should at least be *eyesight-aligned* and lateral guy-supports should be used, orthogonal to the antenna axis.

Of course, all bets are off when winter arrives… ☺...see **Photo 2-1**

Photo 2-1: Kaz’s backyard, November 2018, including lateral guy-supports

C. Let’s move on to **END-WIRE TERMINATION**: Now we're interested in the impact on the 1150-nulled depth, from the way we terminate the antenna at the end-post insulator(s). In **Figure 2-3** are two ways to terminate the D-KAZ end-wires, “single anchor” and “split anchor”.

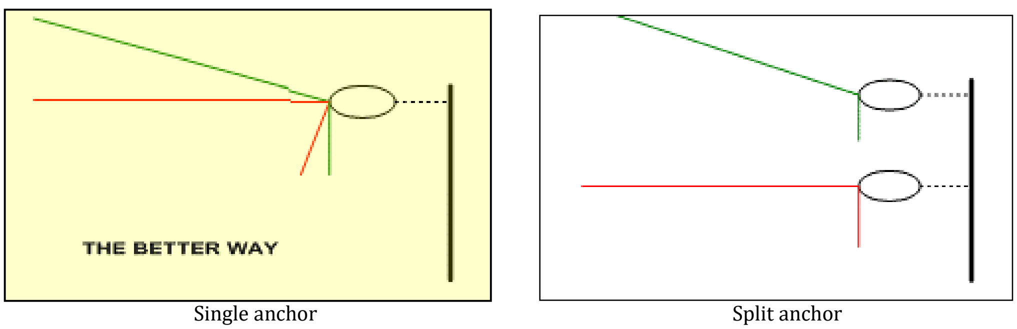

Figure 2-3

Null-depths observed using the two different end-wire terminations are in **Table 2-3** for both a 140-foot and 170-foot D-Kaz.

	140-foot D-KAZ			170-foot D-KAZ		
	Single anchor	Split anchor		Single anchor	Split anchor	
FREQ	1150 null depth db	1150 null depth db	Loss db	1150 null depth db	1150 null depth db	Loss db
540	**23**	**22**	**1**	**26**	**23**	**3**
640	**26**	**23**	**3**	**29**	**25**	**4**
660	**49**	**36**	**13**	**37**	**40**	**-3**
730	**24**	**22**	**2**	**28**	**25**	**3**
770	**37**	**32**	**5**	**35**	**35**	**0**
830	**30**	**29**	**1**	**30**	**30**	**0**
860	**38**	**43**	**-5**	**33**	**35**	**-2**
900	**35**	**37**	**-2**	**31**	**29**	**2**
1030	**27**	**27**	**0**	**29**	**27**	**2**
1150	**39**	**39**	**0**	**30**	**29**	**1**
1180	**48**	**43**	**5**	**34**	**33**	**1**
1330	**33**	**29**	**4**	**24**	**24**	**0**
1500	**30**	**29**	**1**	**17**	**19**	**-2**
1530	**26**	**26**	**0**	**24**	**19**	**5**

Table 2-3

So, using a single tie-point DOES make a difference and, as usual, 'exceptions prove the rule.'

D. CENTER CROSSOVER MISALIGNMENT: For the effects of this deliberate misalignment we first measured null-depth with the bottom return-wires and crossover ***level*** and then we deliberately *lowered the center crossover height* by a few inches and re-measured. (We were skewing the relationship of the deltas, as could happen with a less-than-fastidious install). See **Figure 2-4.**

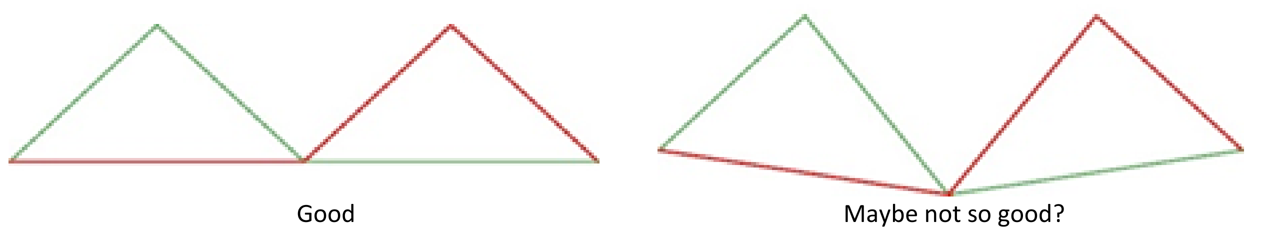

Figure 2-4

Results are in **Table 2-4.** The Null cost column is simply the difference between the two **Null depth** columns, and where an advantage was gained by misalignment, that value is shown in **blue**.

CALL	FREQ	Crossover "level" w/ wire run			Crossover moved "off-level"			
		No null dbm	1150 null dbm	Null Depth db	No null dbm	1150 null dbm	Null Depth db	Null cost db
WXYG	540	-55	-78	23	-55	-77	22	1
WOI	640	-73	-99	26	-73	-96	23	3
WBHR	660	-37	-86	49	-38	-70	32	17
KWOA	730	-68	-92	24	-68	-91	23	1
KUOM	770	-65	-102	37	-65	-100	35	2
WCCO	830	-52	-82	30	-52	-83	31	-1
KNUJ	860	-61	-99	38	-61	-97	36	2
KTIS	900	-54	-89	35	-55	-88	33	2
WCTS	1030	-57	-84	27	-58	-83	25	2
KASM	1150	-25	-64	39	-24	-69	45	-6
KYES	1180	-31	-79	48	-30	-72	42	6
WLOL	1330	-59	-92	33	-59	-92	33	0
KSTP	1500	-57	-87	30	-56	-87	31	-1
KQSP	1530	-60	-86	26	-66	-90	24	2
KPNP	1600	-55	-83	28	-54	-83	29	-1

Table 2-4: Results of Crossover Misalignment (North signals are omitted.)

Except for a few frequencies where things get loopy, variation due to crossover misalignment isn't as dramatic as might be expected. However, the deliberate physical skewing *is* messing with the consistency of F/B performance (note the 660 anomaly and the alternate swings in null-depth-advantage at 1150 and 1180). The null cost column demonstrates that Good Engineering Practice is always valid.

E. POLE *HEIGHT* IMBALANCE: Photo 2-2 shows what the camera saw after a mid-summer storm, definite pole height imbalance. *The tree would have missed the support pole, had it fallen a few inches in either direction ☺*

Photo 2-2

When we rebuilt this pole we added a PVC sleeve that let us change the pole height several inches up or down from 'nominal,' to observe the ***effects on F/B of support poles of unequal height.*** **Table 2-5** shows the effects on null depth at various frequencies when the height of the south pole is different from the height of the north pole. Each time that the south pole's height was adjusted, the null pot was adjusted for the greatest null on 1150kHz.

	140-foot D-KAZ		
	Equal pole heights **null depth (1150 max null)**	South pole plus 10" **null depth (1150 max null)**	South pole minus 10" **null depth (1150 max null)**
FREQ	**db**	**db**	**db**
540	**24**	**37**	**29**
640	**23**	**29**	**27**
660	**26**	**43**	**29**
730	**24**	**31**	**27**
770	**26**	**29**	**28**
830	**25**	**28**	**28**
860	**40**	**28**	**36**
900	**27**	**36**	**32**
1030	**19**	**32**	**24**
1150	**41**	**30**	**38**
1180	**41**	**32**	**38**
1330	**34**	**26**	**27**
1500	**26**	**25**	**32**
1530	**23**	**27**	**21**

Table 2-5

The unpredictable results in **Table 2-5** point us toward additional pole-height measurements in 2019.

F. Finally, **RETURN-WIRE HEIGHTS.** *Speculation by others*: "If acting as a terminated loop, a D-KAZ might be considered a 'free-space antenna' and, as such, might be relying on transfer from one section to the other… *via a sympathetic element."* (Meaning*: the ground?* Hmmm…)

This gives rise to the thought that F/B on a D-KAZ is probably related to the ground conductivity beneath the antenna. More info will be sought.

The 2018 return-wire data in **Table 2-5** is from a 140-foot D-KAZ mounted above 'normal' grass on a mixture of gravel and clay. Our "test bed" was clearly limited by having only one type of ground beneath the D-KAZ. In a reach for additional definition, each of the six signals was individually nulled. Null-depths are posted for several heights ("Above Ground Level") of the return-line (the first four columns). Then, after the run with the three-foot wire height, a counterpoise was added from end to end, directly beneath the return wires (it was a floating single run of wire on the ground). The support-pole heights are unchanged, so the antenna *aperture* varies slightly with these changes.

			RETURN-WIRE ON 140-FOOT D-KAZ		Counterpoise
	1 ft AGL	18" AGL	2 ft AGL	3 ft AGL	w/3 ft AGL
Individual nulls	**null**	**null**	**null**	**null**	**null**
	depth	**depth**	**depth**	**depth**	**depth**
FREQ	**db**	**db**	**db**	**db**	**db**
730	**24**	**26**	**25**	**28**	**26**
770	**24**	**29**	**30**	**29**	**27**
830	**27**	**27**	**28**	**26**	**25**
900	**33**	**35**	**32**	**30**	900 TEMP OFF-AIR
1150	**35**	**49**	**42**	**31**	**33**
1180	**39**	**44**	**52**	**29**	**31**
1330	**30**	**29**	**33**	**27**	**31**
1500	**24**	**35**	**26**	**32**	**26**

Enough is still *not* known, to suggest we need to better understand the *F/B impact of the ground beneath the antenna*. What we've gathered from this data is that different return-wire heights do affect F/B. But what about ground composition? Further study will be performed.

MIS-ALIGNMENT SUMMARY: From all these observations it's clear that attention needs to be paid to the physical alignment of the D-KAZ antenna. Not only do some misalignments perturb the directivity, but they can do so in unpredictable ways. And the *cumulative* effect of too-casual wire-alignment can negate the superior F/B performance of the antenna.

From all of this, the best takeaway for me is: ***There's plenty to learn about D-KAZ geometry!***

NON-ROUTINE D-KAZ APPLICATIONS

1. THE BROADSIDE D-KAZ: This version of the D-Kaz has great promise. Two matched D-KAZ antennas in parallel will narrow the beam-width and reduce side-lobes. **Figure 2-3** illustrates the signal-flow for a Broadside configuration:

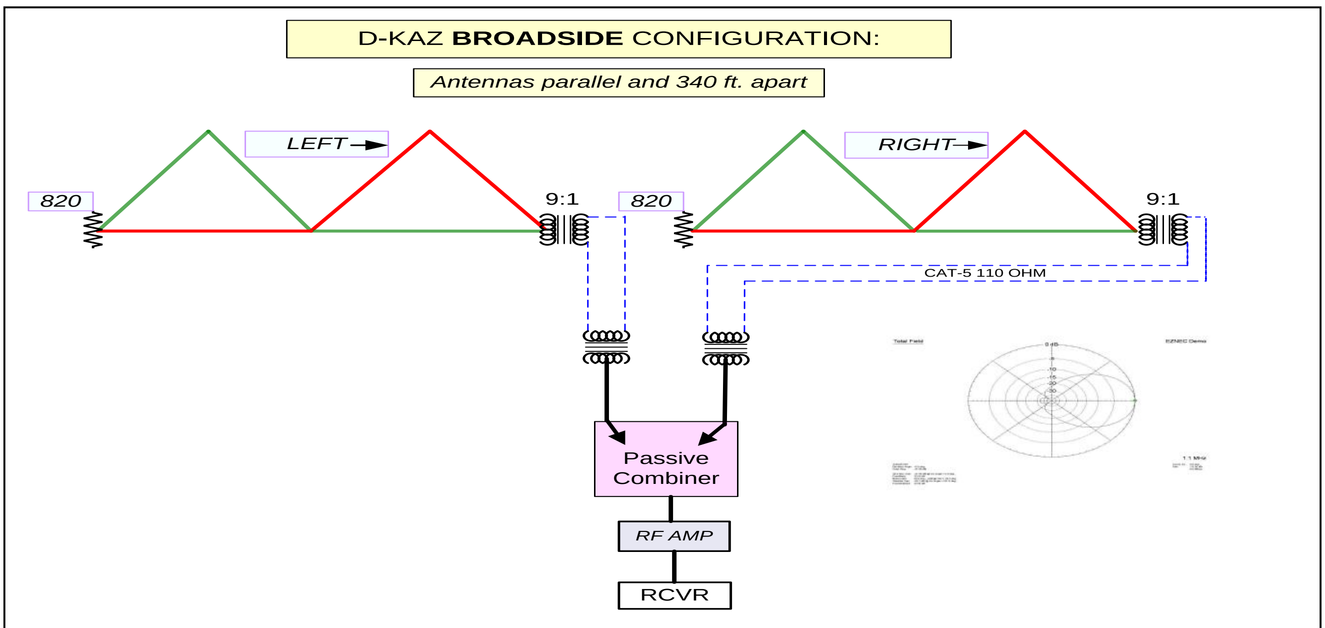

Figure 2-3

We tried the “Broadside” on a recent Utah desert DXPedition. We certainly had the room (**Photo 2-3)**

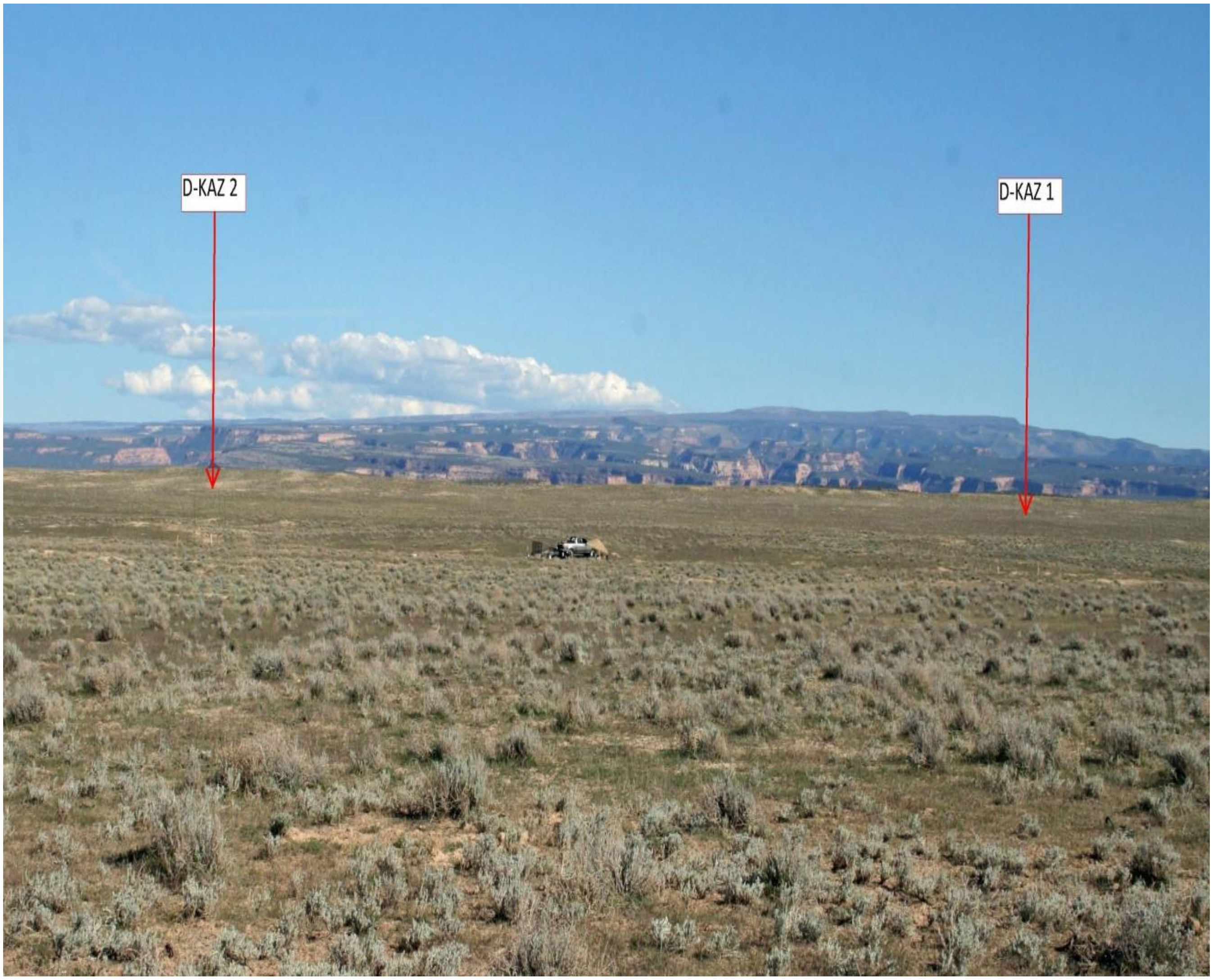

Photo 2-3

Figure 2-4 is the eagle's view of the Utah desert layout (the antenna is oriented NW, and the "900 ohm" terminations were actually 820 ohms):

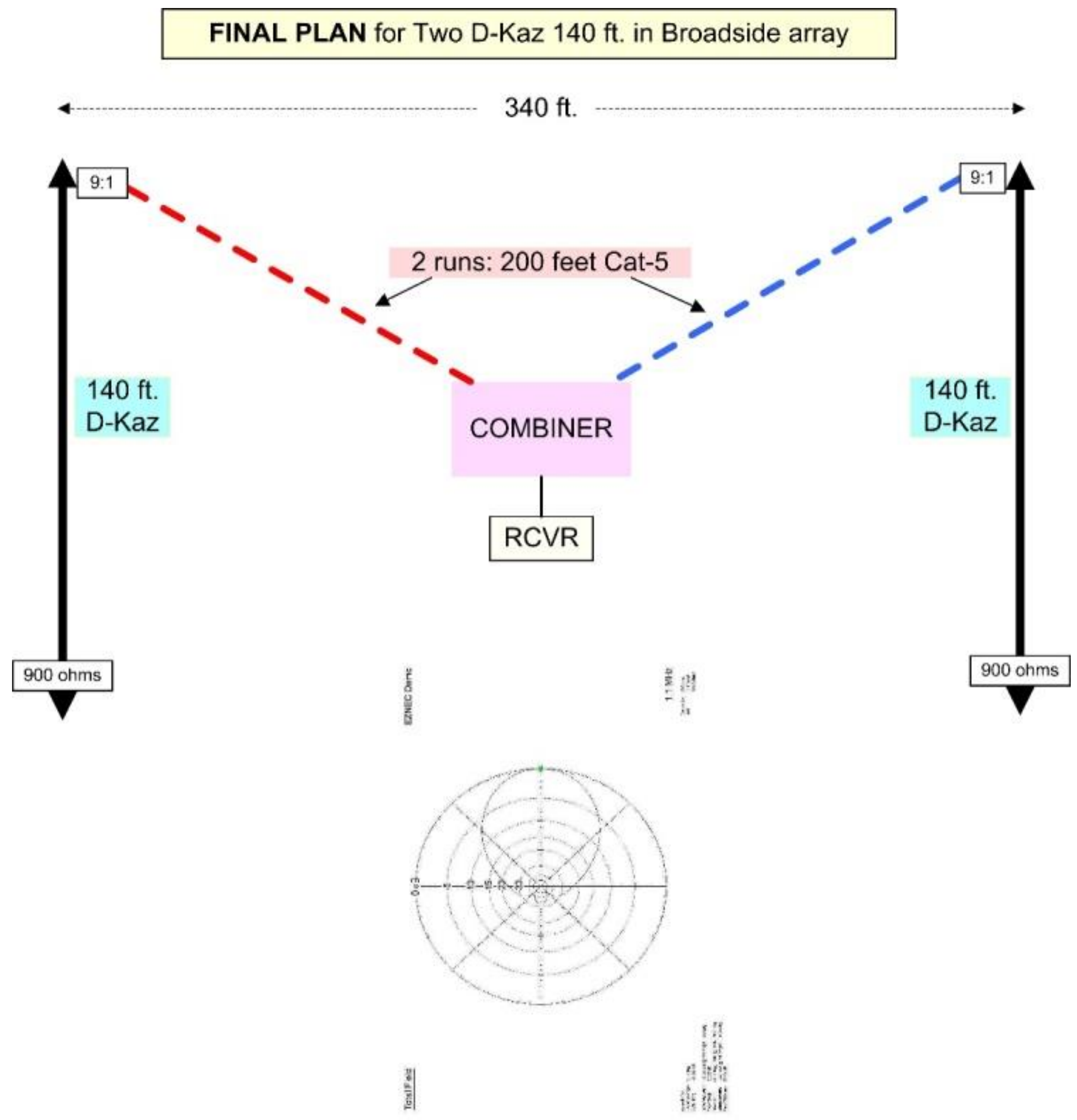

Figure 2-4

Why 340 feet apart? The EZNEC modeling predicts the best separation for two elements is from 0.53 to 0.55 wavelengths. Neil Kazaross advises: ***"****Once you get beyond that, while the main beam becomes even more narrow, side-lobes start creeping up. And with less separation, the main beam is not as narrow as it could be."*

A two-element Broadside array requires that the antennas be combined in phase. For the desert, we built an "RF mixer" using three 10-dB Kiwa low-noise amplifiers, arranged as seen in **Figure 2-5.** These amplifiers can be bypassed and a single low-noise amplifier inserted ahead of the SDR.

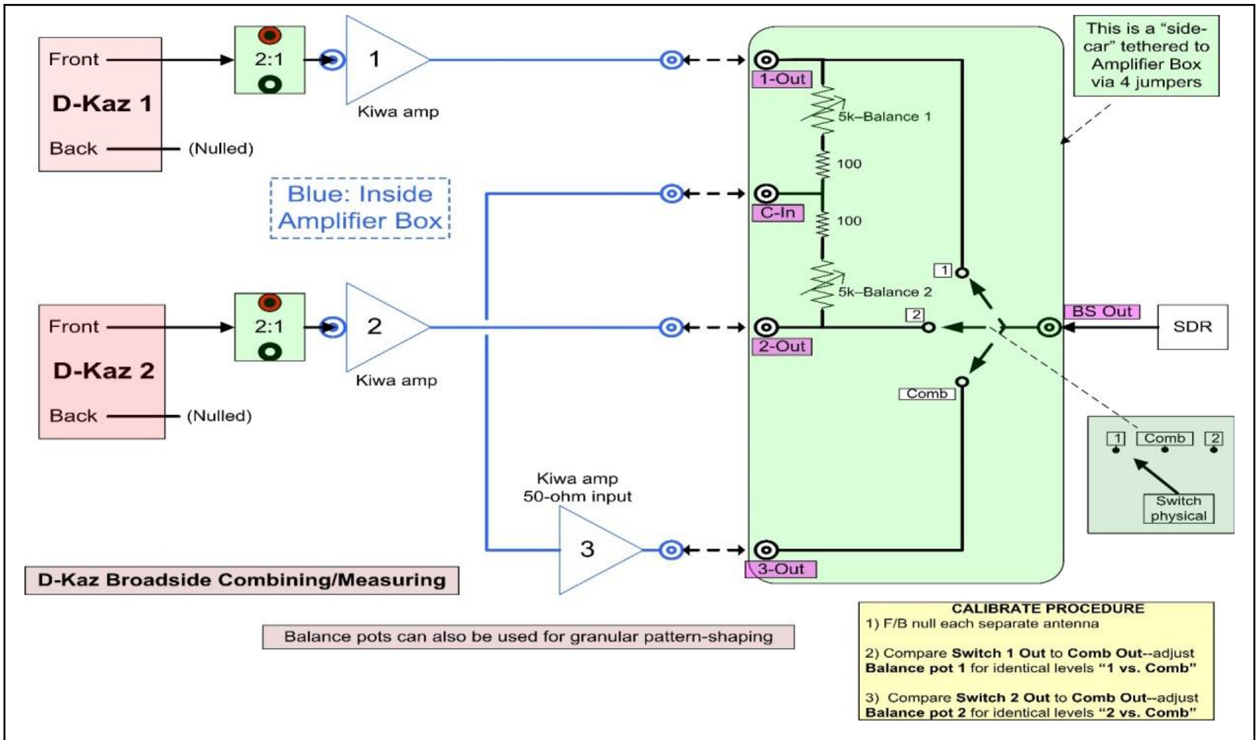

Figure 2-5

The "balance pots" also allowed us to calibrate the array with a good surface-wave signal (KSL 1160). (During calibration, one of the D-Kaz antennas was flipped out-of-phase and the balance pots were adjusted for best *null* of KSL.)

Again, Kazaross points out: *"Broadside arrays for those with the room are certainly the way to go. They also can be phased somewhat as I have done, to create some deep nulls at some side angles and to steer the main beam."*

Figure 2-5 shows the EZNEC comparisons.

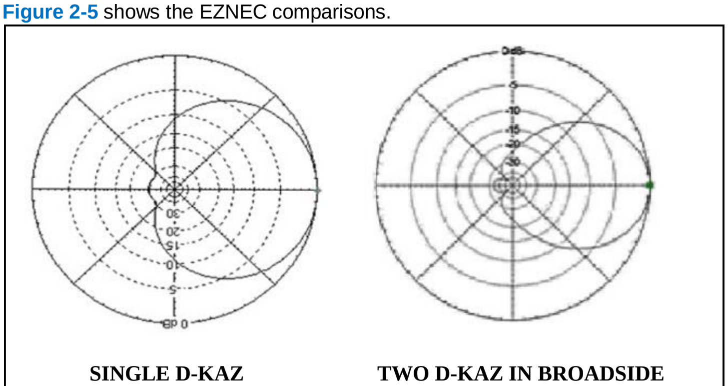

Figure 2-5

UPON FURTHER REVIEW: A few seconds after we started listening to the recordings, it became obvious that a Broadside D-KAZ was very good at scrunching side-lobes and furthering F/B performance, while tightening the main (NW) front lobe. The result was that we found stations sneaking through, over other co-channels that would have shown up on an antenna with a wider acceptance angle. For example:

580: KIDO over nearby KUBC
590: KID and KQNT over nearby KSUB
690: Tiny KRCO over KEII just north of us (even if KRCO was on day power, it's just a kilowatt).
770: KTTH and CHQR wiped out powerhouse KKOB behind us.
790: 61-watt KSPD stood out among six or seven co-channel neighbors (day power is but 1kw).
1060: Daytimer KBGN still on after Sunset; over flamethrower-jokester CKMX and nearby KDYL.
1090: KFNQ overcame closer hotshot KBOZ.
And so on. 1270 KAJO held up over several closer neighbors. We copied three of seven available on 1300 (KAPL, KLER and even KKOL)…all three in the Broadside's bore-sight. On 1450, KCLX came up from Colfax WA, among dozens of GY'ers. All in all, nearly a hundred new call letters for the log book.

"BROADSIDE-BROADSIDE?" Kaz continues to stay a few steps ahead. His modeling suggests we could add at least one or two *more* elements to a broadside array. This of course is appealing to those who are gluttons for punishment (and have a spare desert lying around, for the space needed).

2. THE ENDFIRE D-KAZ: This one is intriguing. D-KAZ Endfires are built along the lines of a theoretical array recently measured by Neil Kazaross. His virtual antenna is composed of two 120-foot antennas with 21-foot apex, and separated by 40 feet. Kaz suggests: "*The real issue with making an EF array work well across the entire band is that both antennas must act electrically the same, and provide identical response. You can end up with both having good back nulls and providing about the same forward gain, but still have some phase errors between them as frequencies change…and then you can't create deep broadbanded nulls.*" But done correctly, one might expect to see patterns as seen in **Figure 2-6.**

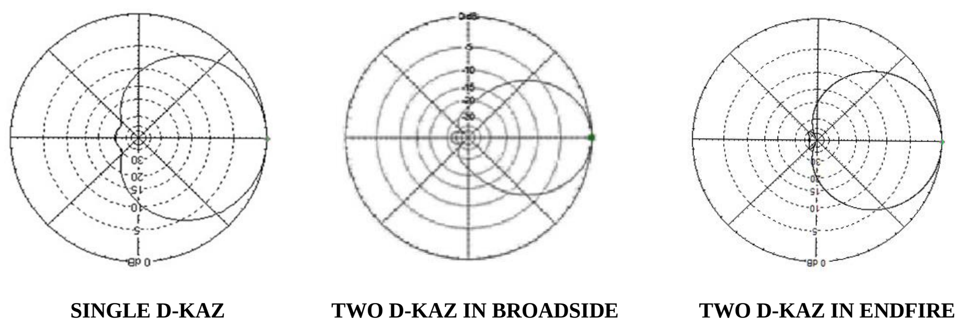

Figure 2-6

Neil Kazaross: *"The back null in the elevation plane is also deep and covers high angles well. Compared to Broadside, Endfire is somewhat more sensitive to errors."* Nick Hall-Patch suggests: F*or me personally, I'd be curious to compare the **high angle nulls** of an Endfire array with a regular DKaz and with a Broadside DKaz array. It's the broad high angle nulls which help give the single DKaz its edge…and if those nulls are better yet (in Broadside or Endfire compared with a single DKaz), then it's definitely a point in their favor.)*

3. PATTERN-REVERSAL: A final iteration is *antenna pattern-reversal* and this is applicable to most antennas with two feed points. The D-KAZ really shines in this arrangement. Reversal is a simple matter of relay-logic, swapping the receiver and null-pot ends. Pattern-reversal is as easy as flipping the switch. **Figure 2-7** is a block diagram of a remote-controlled reversible D-KAZ.

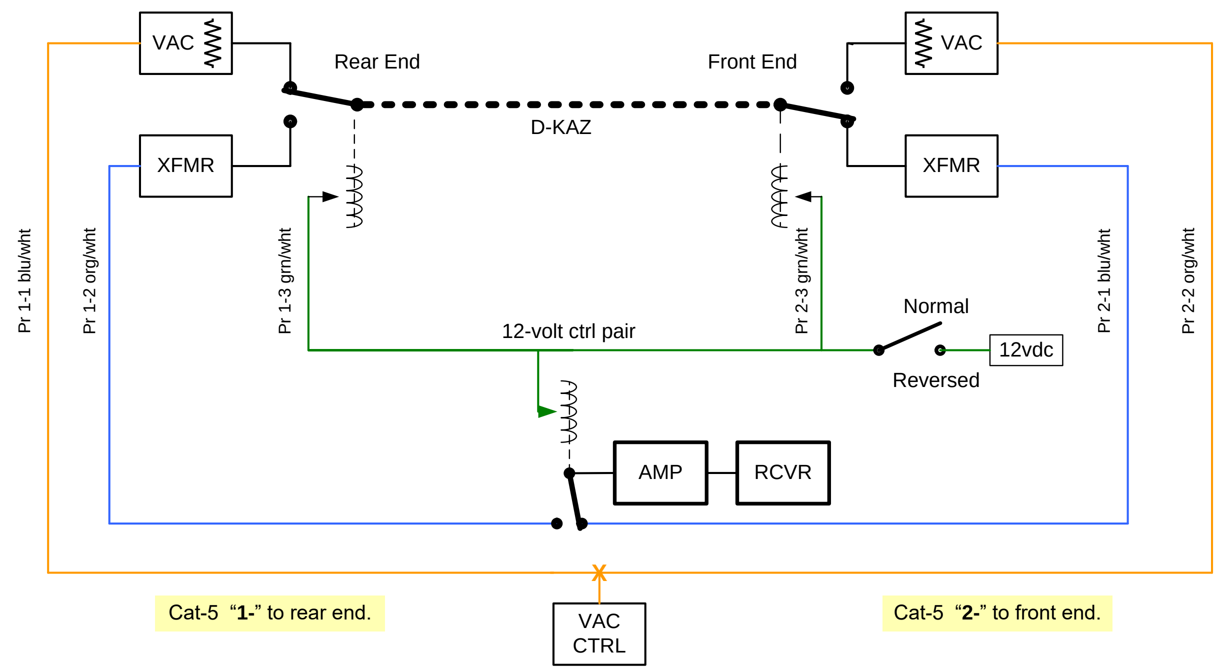

Figure 2-7 Remote-reverser (Use "Low-Signal" relays to switch the tiny signals)

Table 2-6 displays the Minnesota logs showing how well the reverser plays. This table shows the co-channel stations that appear when the antenna is flipped “South” so the “hot” side is looking for signals from the opposite direction. The “South” stations came up with no readjustment of the null-pot.

Stations heard on opposite sides of a D-Kaz 140-ft. antenna

	"North" (330 deg)		"South" (150 deg)	
600	KSJB	Jamestown ND	WMT	Cedar Rapids IA
620	CKRM	Regina, SK, CA	KNMS	Sioux City IA
680	CJOB	Winnipeg, MB, CA	KFEQ	St. Joseph MO
740	KVOX	Fargo ND	WDGY	Hudson WI
790	KFGO	Fargo ND	WAYY	Eau Claire, WI
810	KBHB	Sturgis SD	WHB	Kansas City MO
860	CBKF2	Saskatoon, SK, CA	KNUJ	New Ulm MN
880	CHQT	Edmonton, AB, CA	WMEQ	Menominee WI
890	KQLX	Lisbon, ND	WLS	Chicago IL
910	KCJB	Minot ND	WHSM	Hayward WI
950	KWAT	Watertown ND	KTNF	St Louis Park MN
970	WDAY	Fargo ND	KQAQ	Austin MN
980	KDSJ	Deadwood SD	KKMS	Richfield MN
990	CBW	Winnipeg, MB, CA	KAYL	Storm Lake IA
1080	KNDK	Langdon ND	KYMN	Northfield MN
1130	KBMR	Bismarck ND	KTCN	Minneapolis MN
1220	KDDR	Oakes ND	KLBB	Stillwater MN
1230	KTRF	Thief River Falls MN	KMRS	Morris MN
1280	KVXR	Moorhead MN	WWTC	Minneapolis MN
1300	KPMI	Bemidji MN	WQPM	Princeton MN
1310	KNOX	Grand Forks ND	KGLB	Glencoe MN
1340	KVBR	Brainerd MN	KWLM	Willmar MN
1350	KDIO	Ortonville MN	KCHK	New Prague MN
1360	KKBJ	Bemidji MN	KRWC	Buffalo MN
1370	KWTL	Grand Forks ND	KSUM	Fairmont MN
1450	KBMW	Breckenridge MN	KNSI	St. Cloud MN
1470	KHND	Harvey ND	KMNQ	Shakopee MN
1480	KKCQ	Fosston MN	KAUS	Austin MN
1520	KMSR	Mayville ND	KOLM	Rochester MN
1660	KQWB	Fargo ND	KUDL	Kansas City KS

Thus, in two sections; the 2018 **D-KAZ Cookbook**. We've reviewed the basics of operation, compared the performance of two D-KAZ lengths, looked at nulling and at ways to extend lead-ins to the shack. We presented ideas for antenna construction and reviewed the effects of misalignment of certain parts of the antenna (in the belief that a number of these misalignments, when added together, might really detract from the expected directivity of the D-KAZ). We showed you the D-KAZ in "Broadband" mode and offered one fellow's approach to switch-reversing antenna directions.

It's one wall-banger of a Medium-Wave antenna. The Broadside version will be deployed again in the desert; hopefully in Nick's company. And the Endfire shows great promise as a 'next great leap." It'll be interesting to see who runs with this…

For now, we leave to Neil Kazaross the last word: *"I strongly believe that arrays of D-KAZ represent the next step for antennas for out hobby, for those with adequate land to use and the time to build, test and maintain."*

Hope this has been useful!

Mark Durenberger

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