
High Power Transmit Mag Loop
Build Project
Ron Schwartz K2RAS

Summary of Project Build

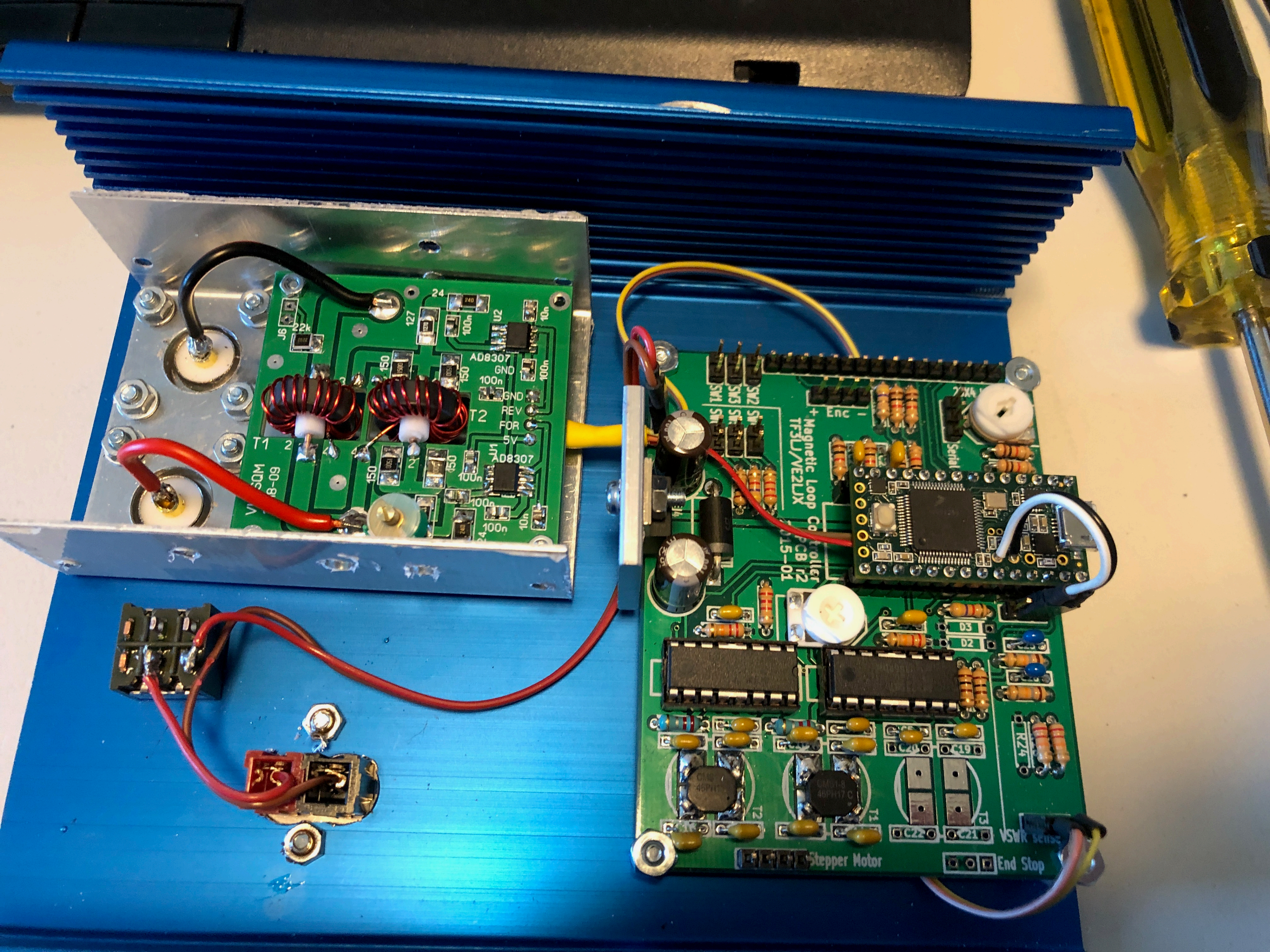
- 1” copper tube loop, approx 13’ in length (40” dia)
- Russian variable vacuum capacitor 5 – 250 pf
- Homemade Arduino (Teensy) based autotuner
- Serial cables for ICOM 7300 and Flexradio
- Calculated tuning range 5.5MHz to 35MHz
  - *Actual tuning range 6.2 MHz to 28.4 MHz*
- Resistance of loop and all connections 0.06 ohms

Some Performance Data

- Calculated tuning range 5.5MHz to 35MHz
  - *Actual tuning range 6.2 MHz to 28.4 MHz*
- Resistance of loop and all connections 0.06 ohms
- Calculated 40M loop voltage at 100W is 4,800V (cap rated at 5KV)
- Calculated 40M loop voltage at 500W is 11,000V


Radio: 14.074.020 Hz
Tuned: 14.113.745 Hz
StepP: 4.063 4.068
Range: 14 Motor:Off
RECALIBRATE
AUTOTUNE
START TUNE
MENU/ACCEPT
TUNE UP
TUNE DOWN

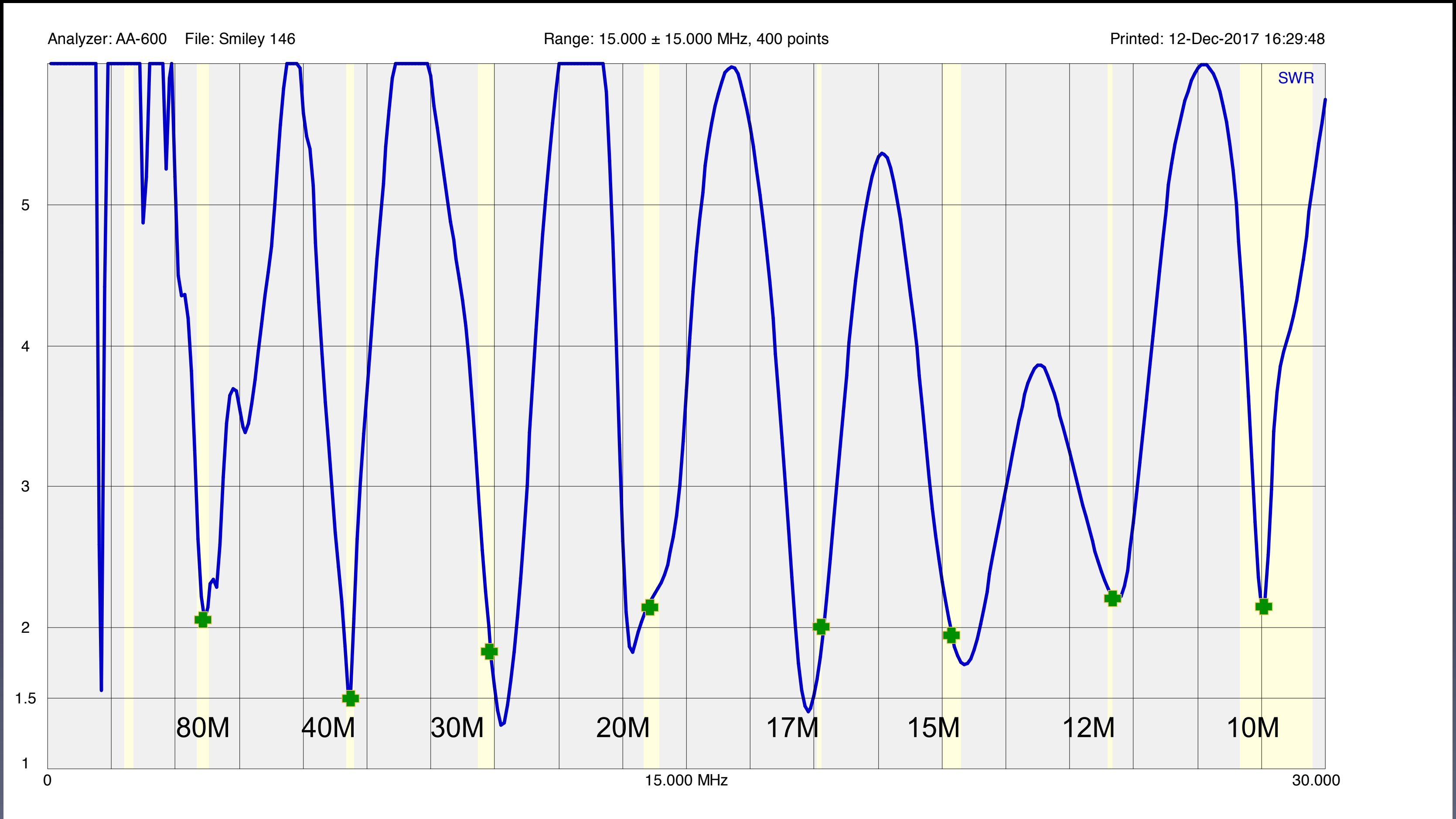

2.5mm
RST
H_CS1_L
CP1
CP2
JCS1
C5
D1
C22
RB2
RD2
C21
U2
U1
U3
Patent
RoHS
EH002004A REV.C
E 243002
BY-002 94V-0


AD8307
GND
REV
FOR
5V
T1
T2
AD8307
Enc
TF3LJ/VE2LJX
Stepper Motor
End Stop


NITT
Magnetic Loop Controller
TF3LJ/VE2LUX
PCB r2
2015-01
20X4 LCD
Serial
Enc
VSWR
End Stop
Stepper Motor

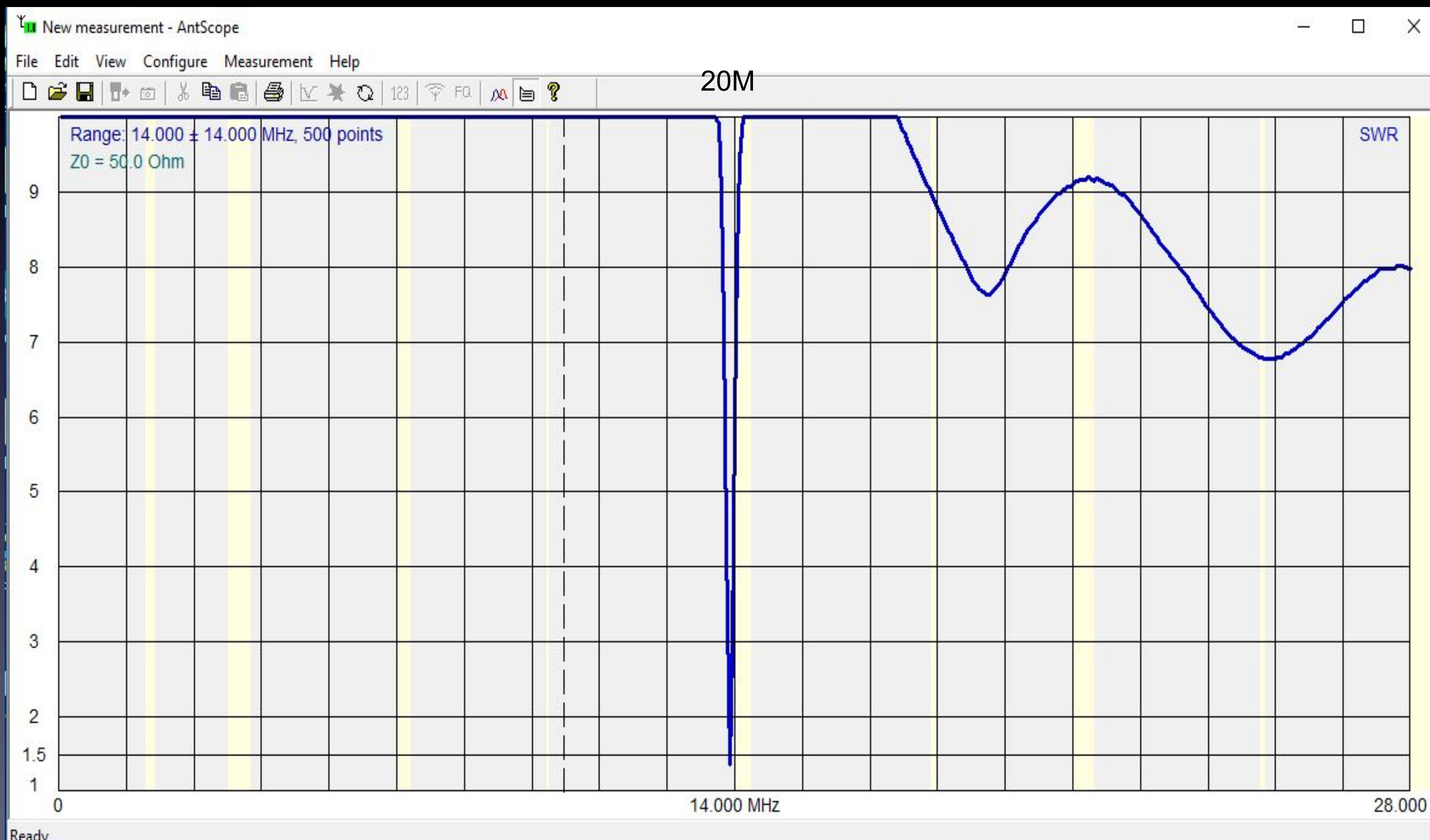
Some Measurements

SWR Range of 80M Endfed (for comparison)



Some Measurements

SWR Range of Mag Loop Antenna



Some Measurements

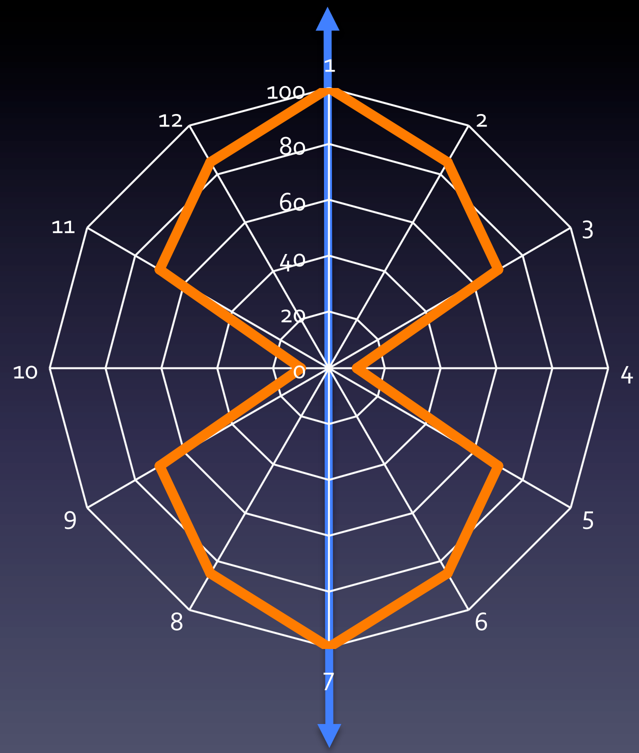
Actual Bandwidth to 2:1 SWR (11% reflected power)

Frequency (MHz)	Min SWR	Calc Bandwidth KHz	Actual Bandwidth KHz**
7	1.0	5	8
14	1.1	31	25
18	1.2	72	45
21	1.3	140	60
28	1.4	426	100

**Measured with RigExpert AA-600

Some Measurements

Actual Transmit Radiation Pattern at 20M (3’ above ground)**

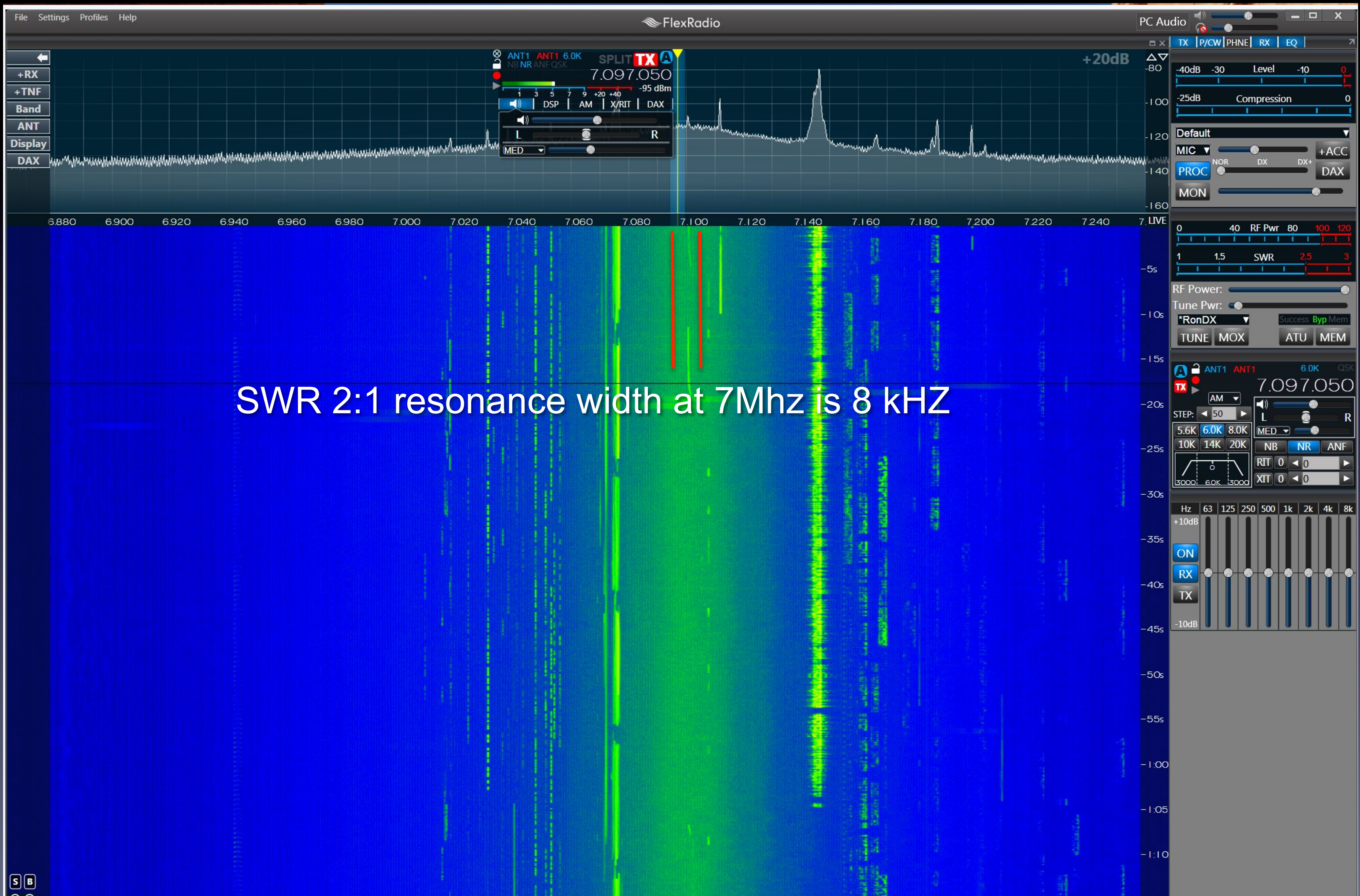


- 85% radiated within 20° of axis
- 45% radiated within 70° of axis
- 15% radiated (null) at 90 degrees

***Tested in nearfield with uncalibrated diode field strength meter*

Magnetic Loop
Transmit Performance

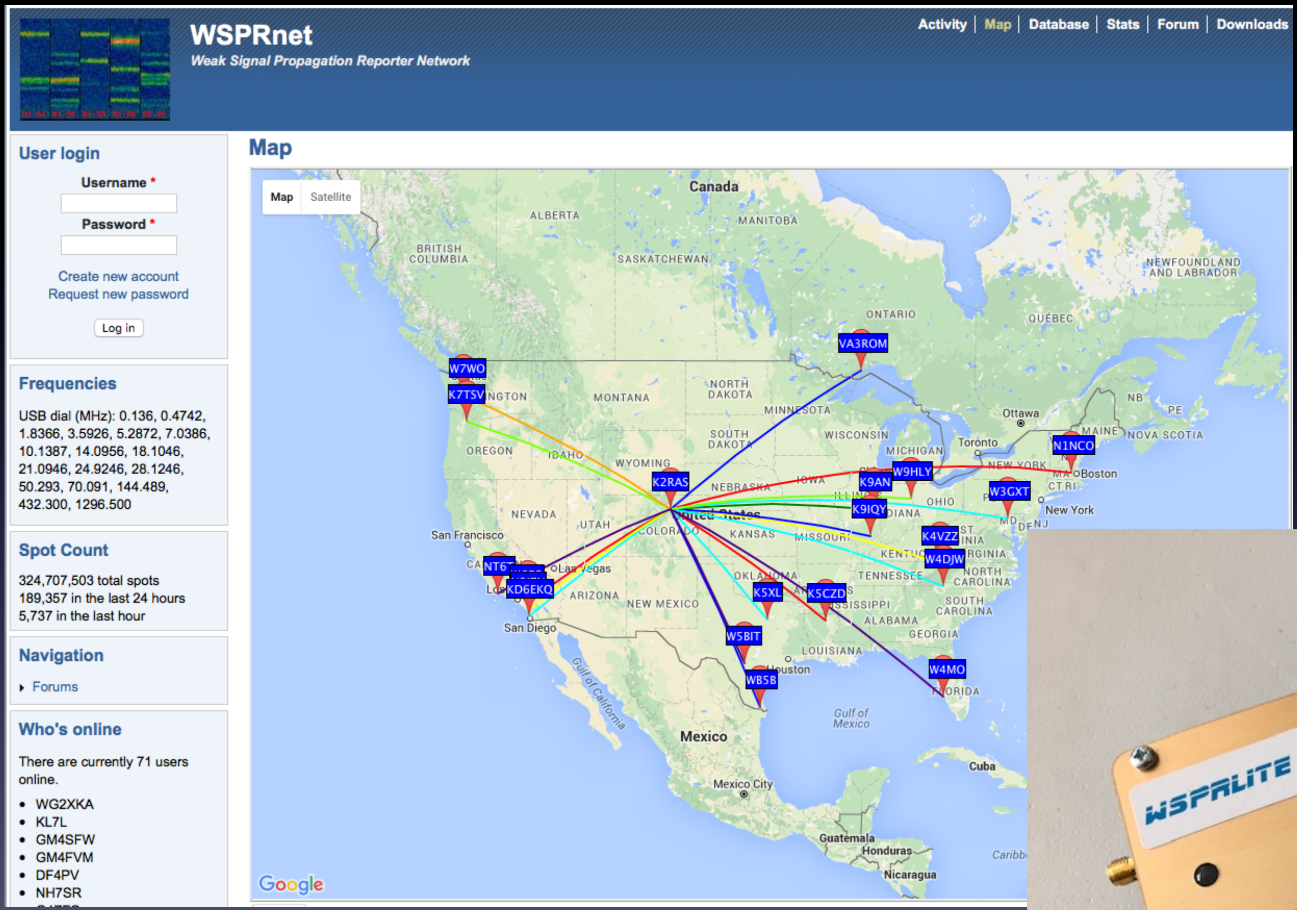
Transmit Resonant Range



Measuring Transmit Performance

- Weak Signal Propagation Reporter (WSPR)
- Provides comparison of multiple antennas coincidently received at a remote location using identical transmitters
- Used (2) WSPRLite 200mw transmitters
  - Sends beacon signal containing callsign, grid locator, power level
  - Compresses data, 4-FSK modulation, uses FEC, 2 minute cycle
- Used to quantify actual transmit performance
- Real-time signal reports available on global map

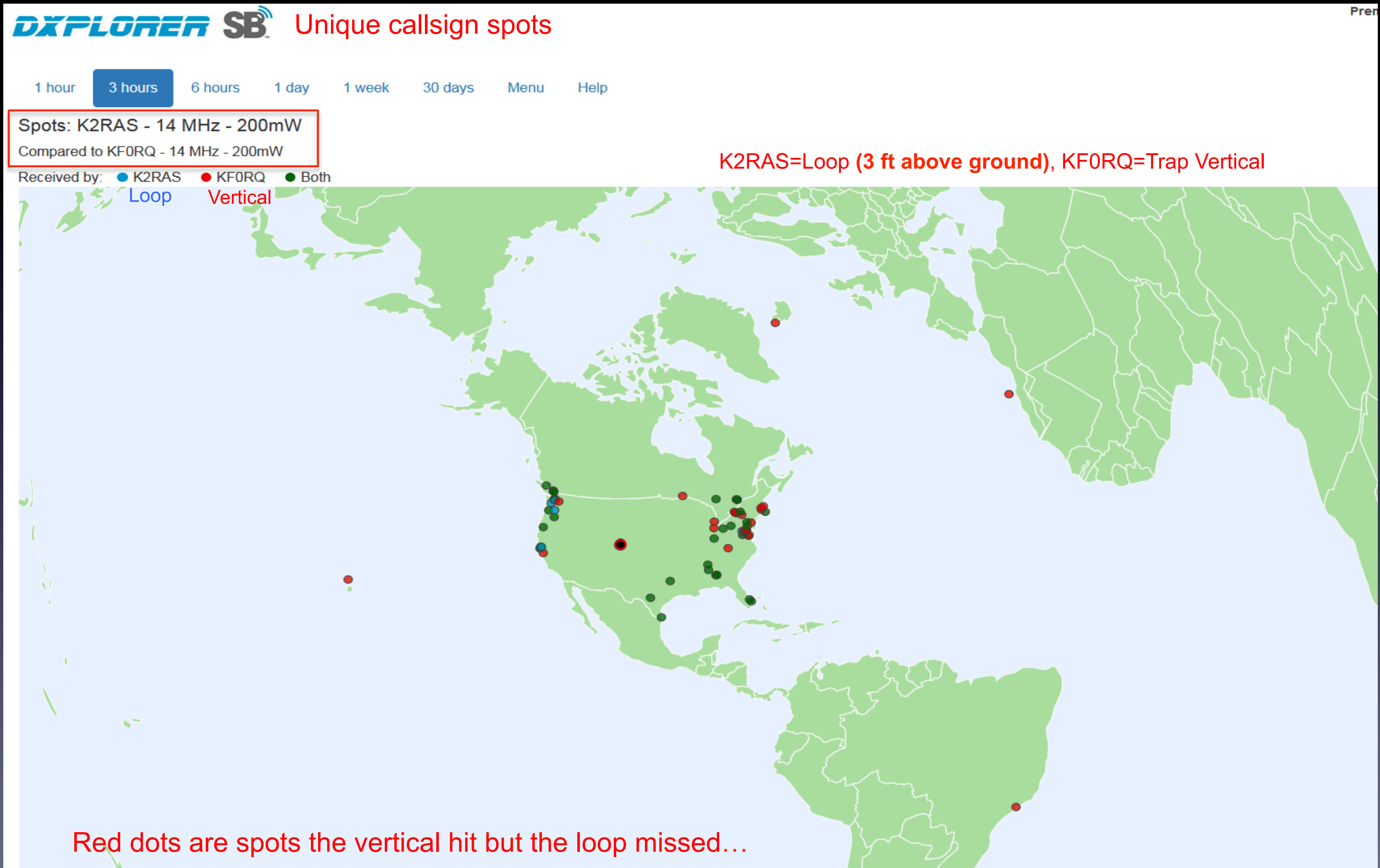
Weak Signal Propagation Reporter (WSPR)



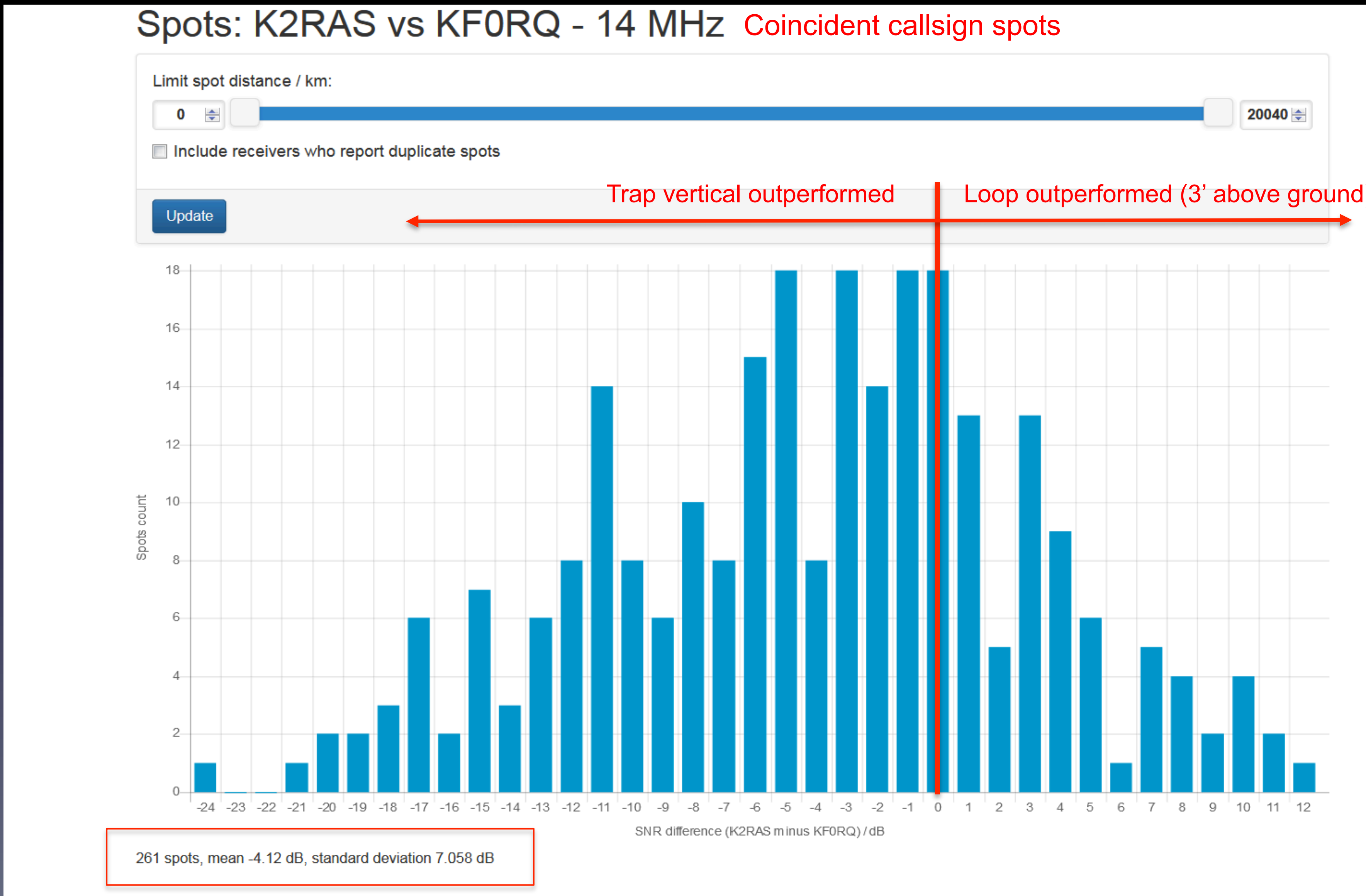
KF0RQ Trap Vertical / Magnetic Loop

TRANSMIT Comparison Tests

20M KF0RQ Trap Vertical



20M KF0RQ Trap Vertical Coincident Spots



So the trap vertical outperformed the transmit loop, lets try to dig deeper into why…

20M KF0RQ Trap Vertical

DXPLORER SB Unique callsign spots

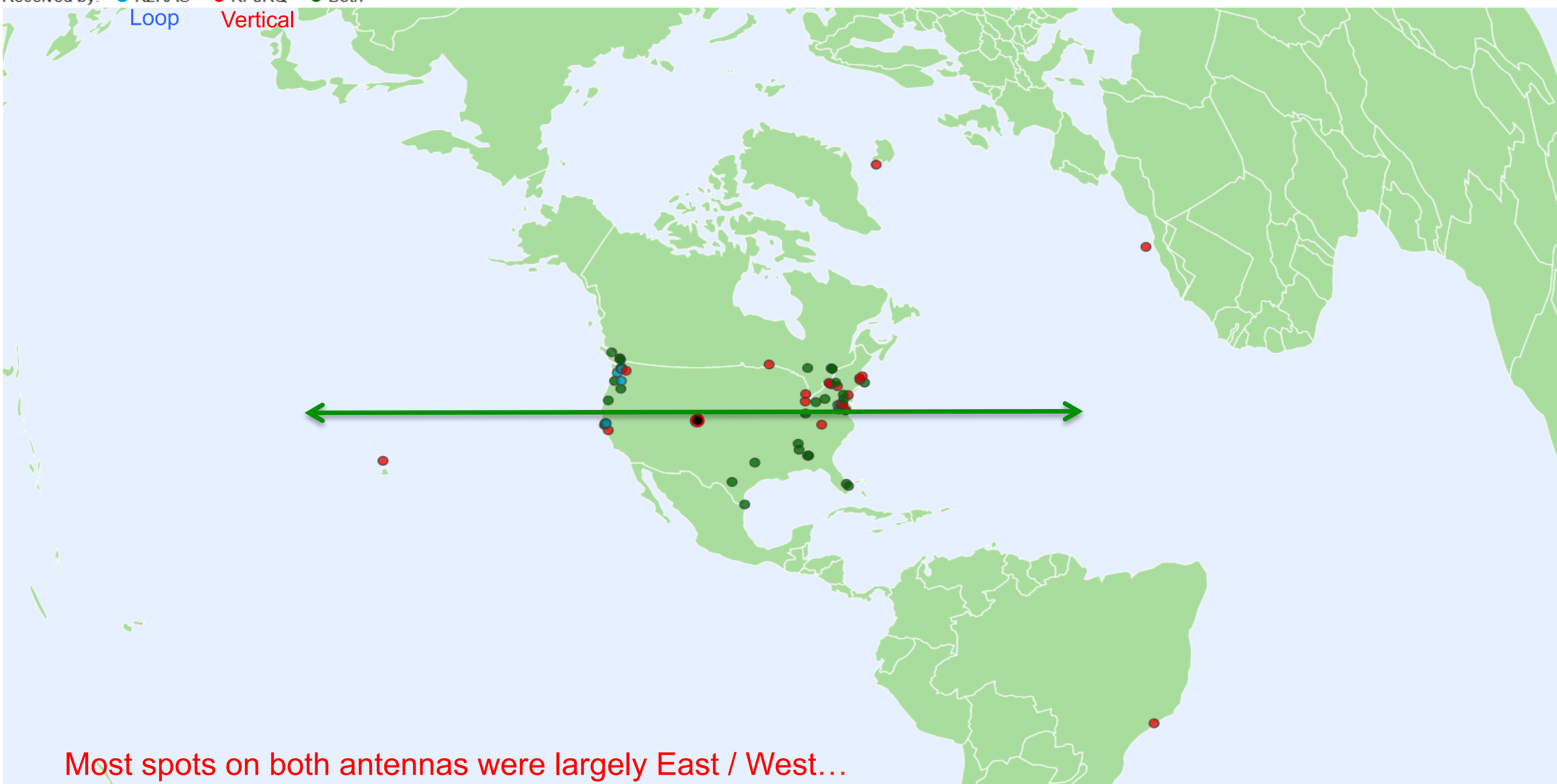
Pren

1 hour | 3 hours | 6 hours | 1 day | 1 week | 30 days | Menu | Help

Spots: K2RAS - 14 MHz - 200mW
Compared to KF0RQ - 14 MHz - 200mW

K2RAS=Loop **(3 ft above ground)**, KF0RQ=Vertical

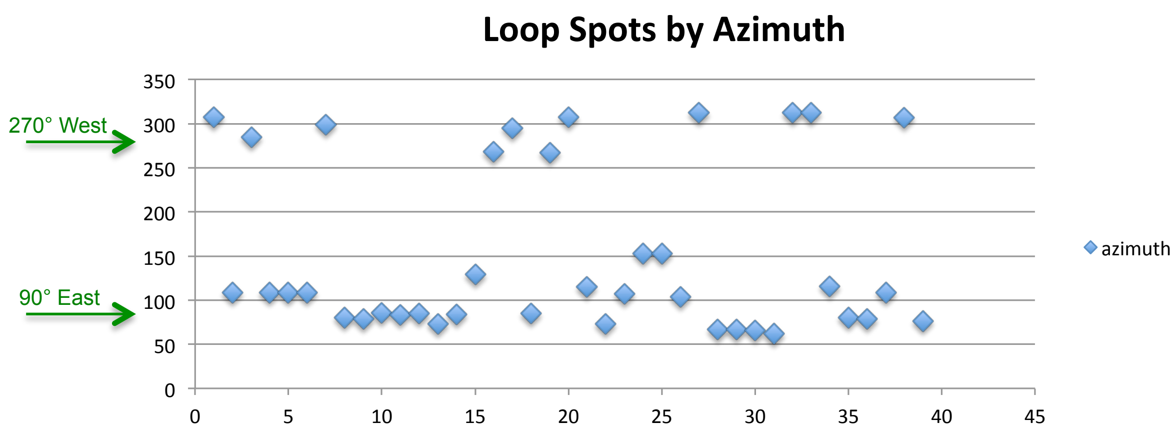
Received by: ● K2RAS ● KF0RQ ● Both

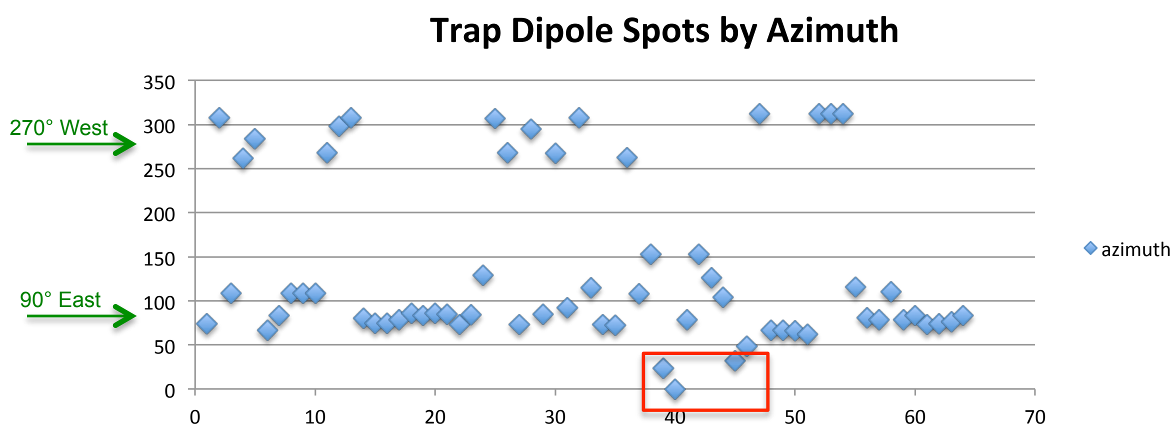


Most spots on both antennas were largely East / West…

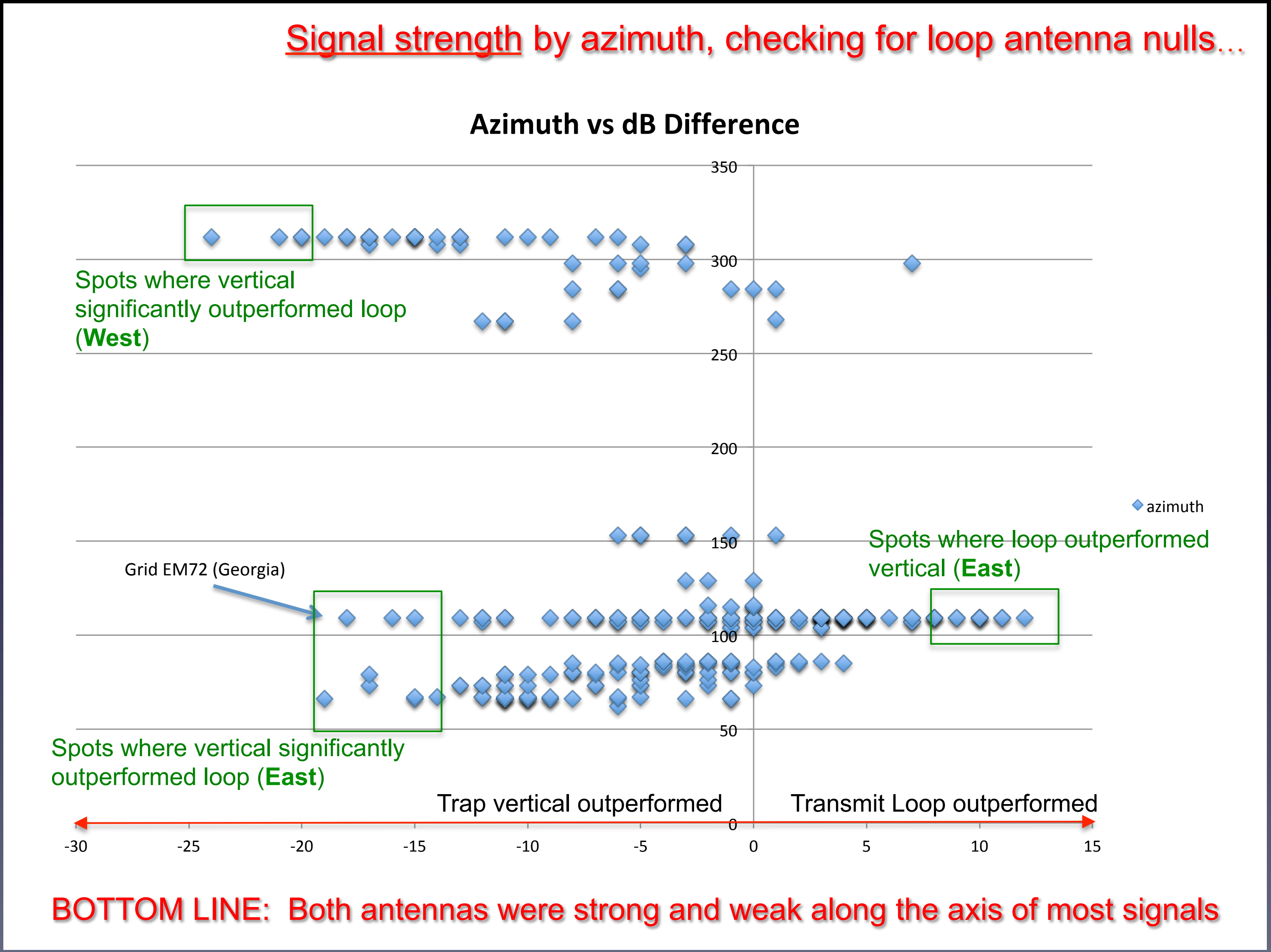
20M Unique Spots by Azimuth

The loop covered esentially the same azimuth range as the trap dipole





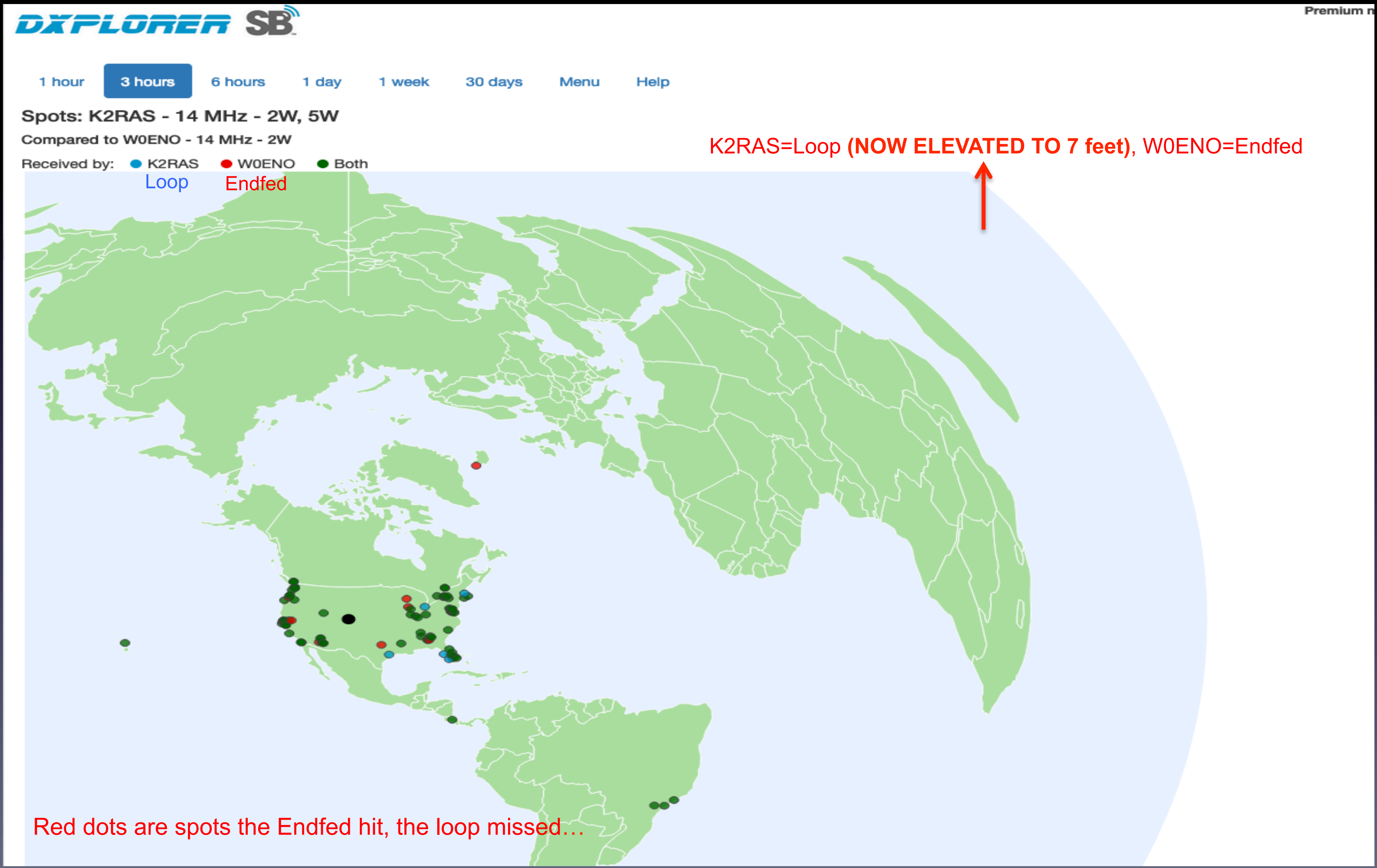
20M Trap Vertical Coincident dB



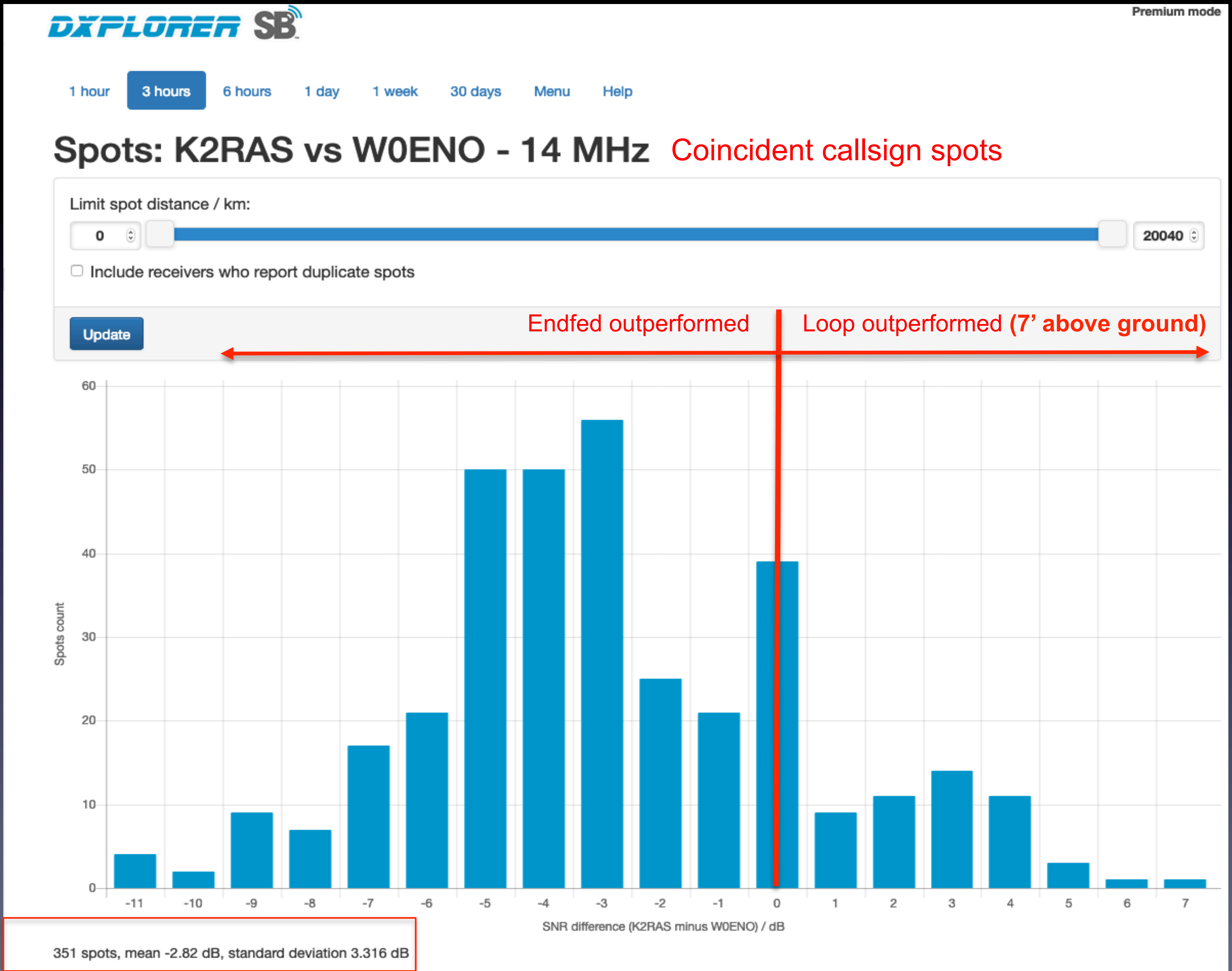
80M Endfed / Magnetic Loop

TRANSMIT Comparison Tests

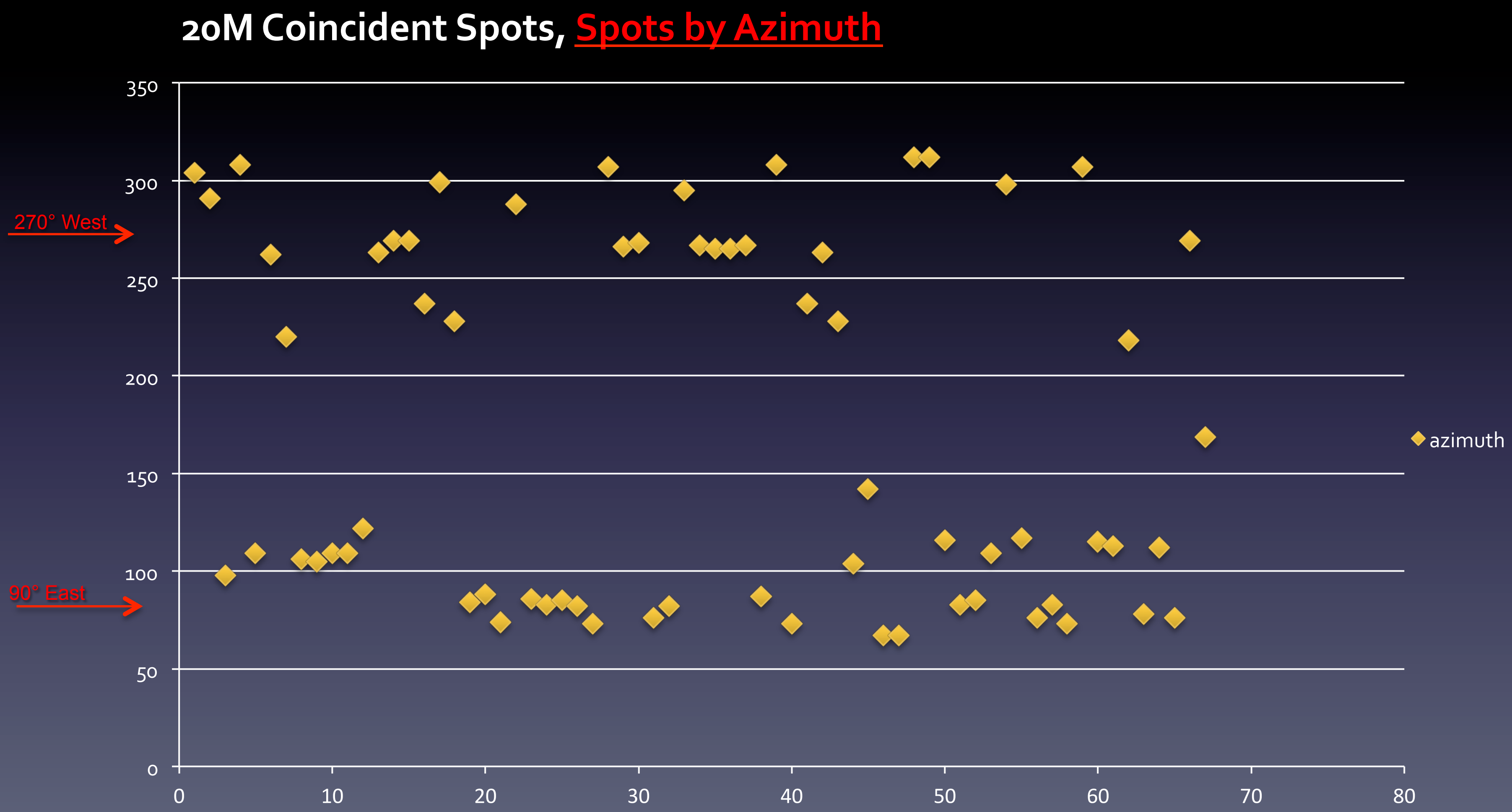
20M Endfed Transmit Comparison



20M Endfed Coincident Spot Comparison

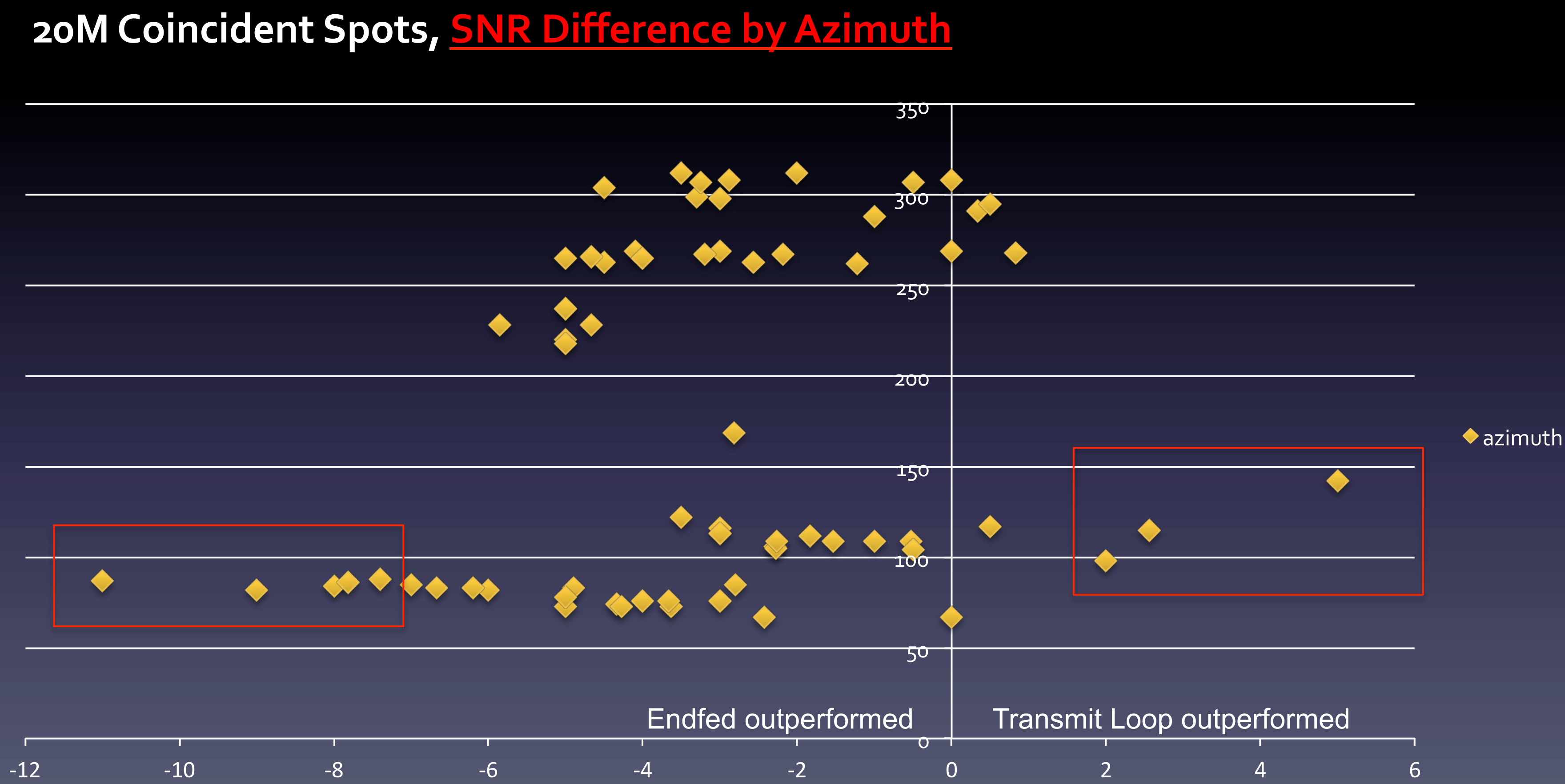


20M Endfed Coincident Spot Comparison



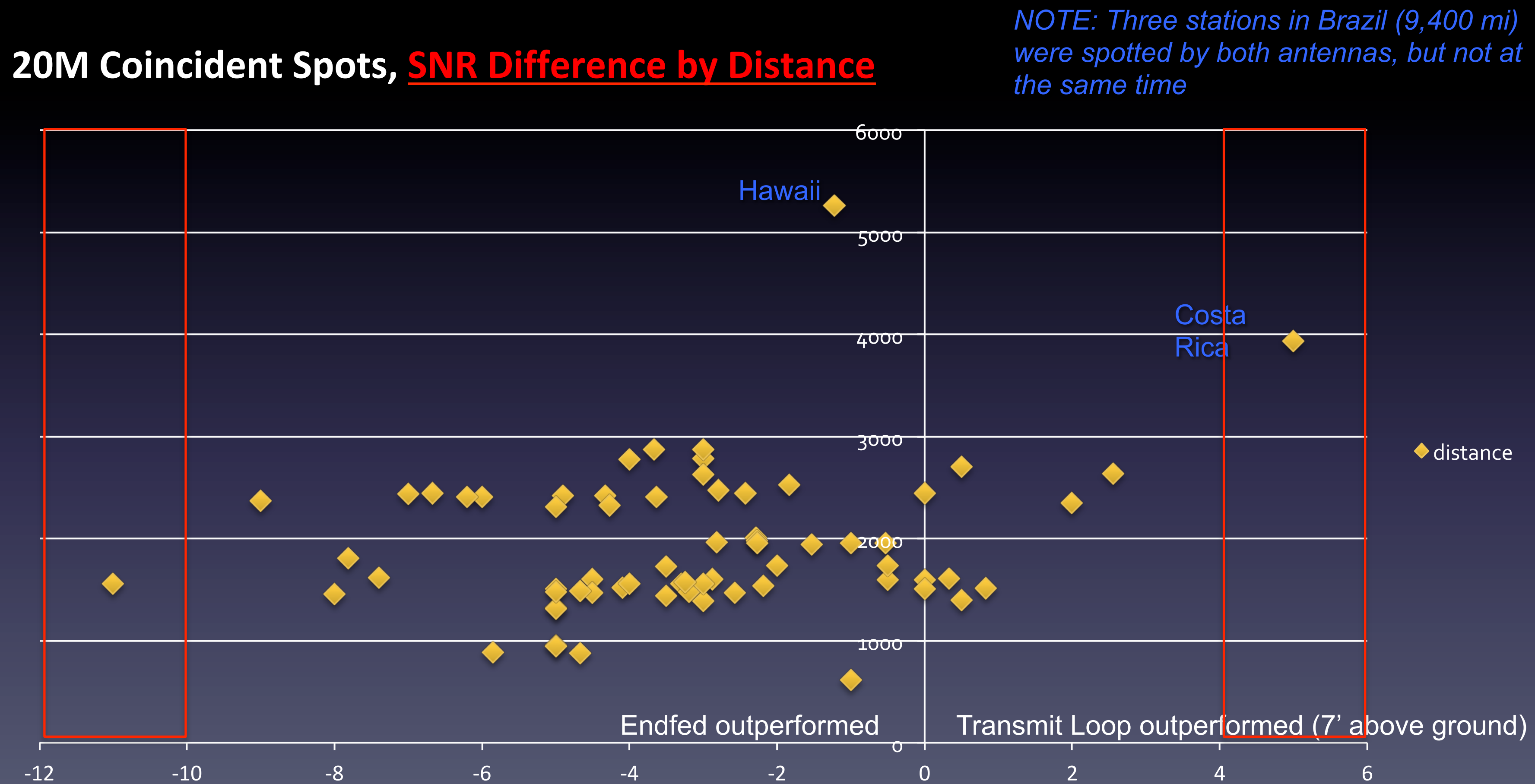
BOTTOM LINE: Again most spots were East / West

20M Endfed Coincident Spot Comparison



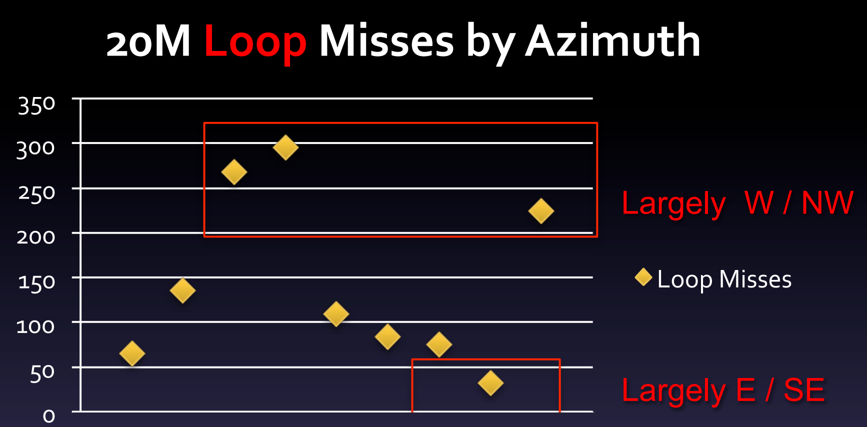
BOTTOM LINE: Interesting, both antennas outperformed each other along the East / West axis

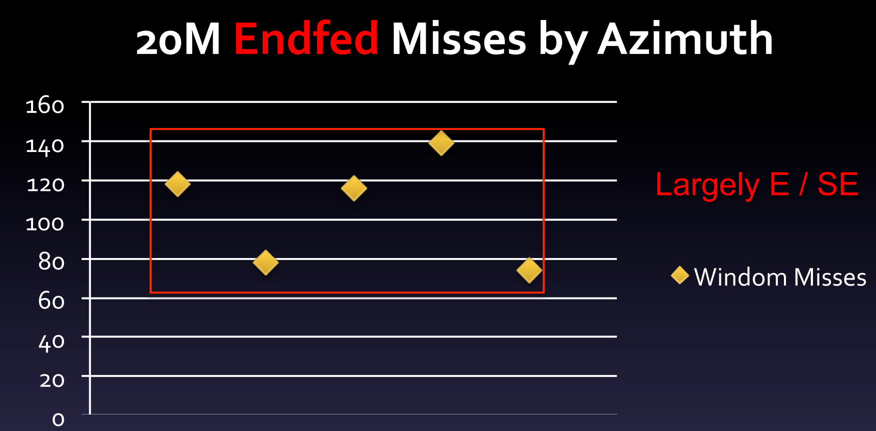
20M Endfed Coincident Spot Comparison

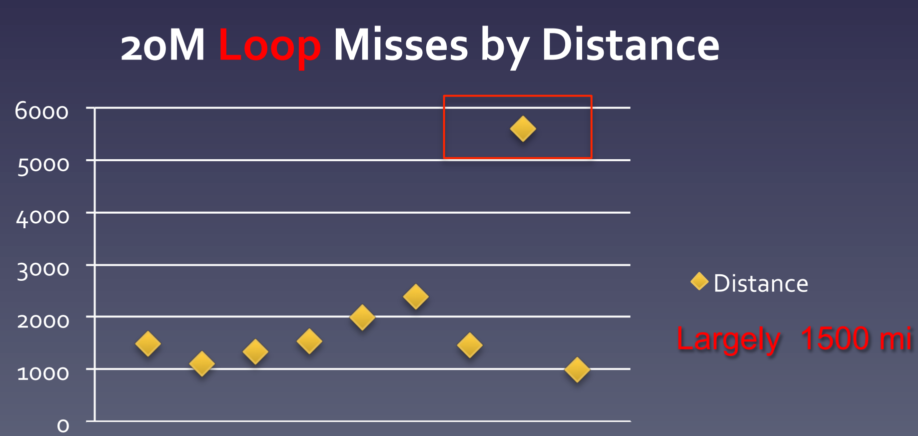


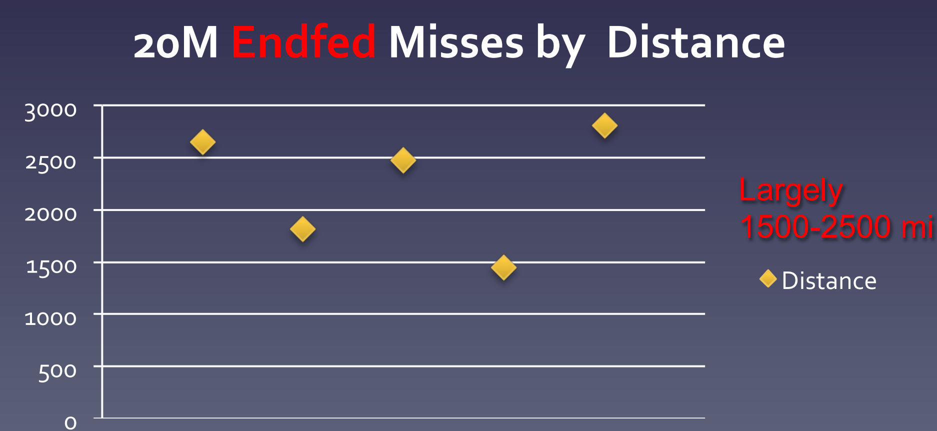
BOTTOM LINE: Neither antenna outperformed outside the rage of 1000-3000 miles

20M Missed Spot Comparison

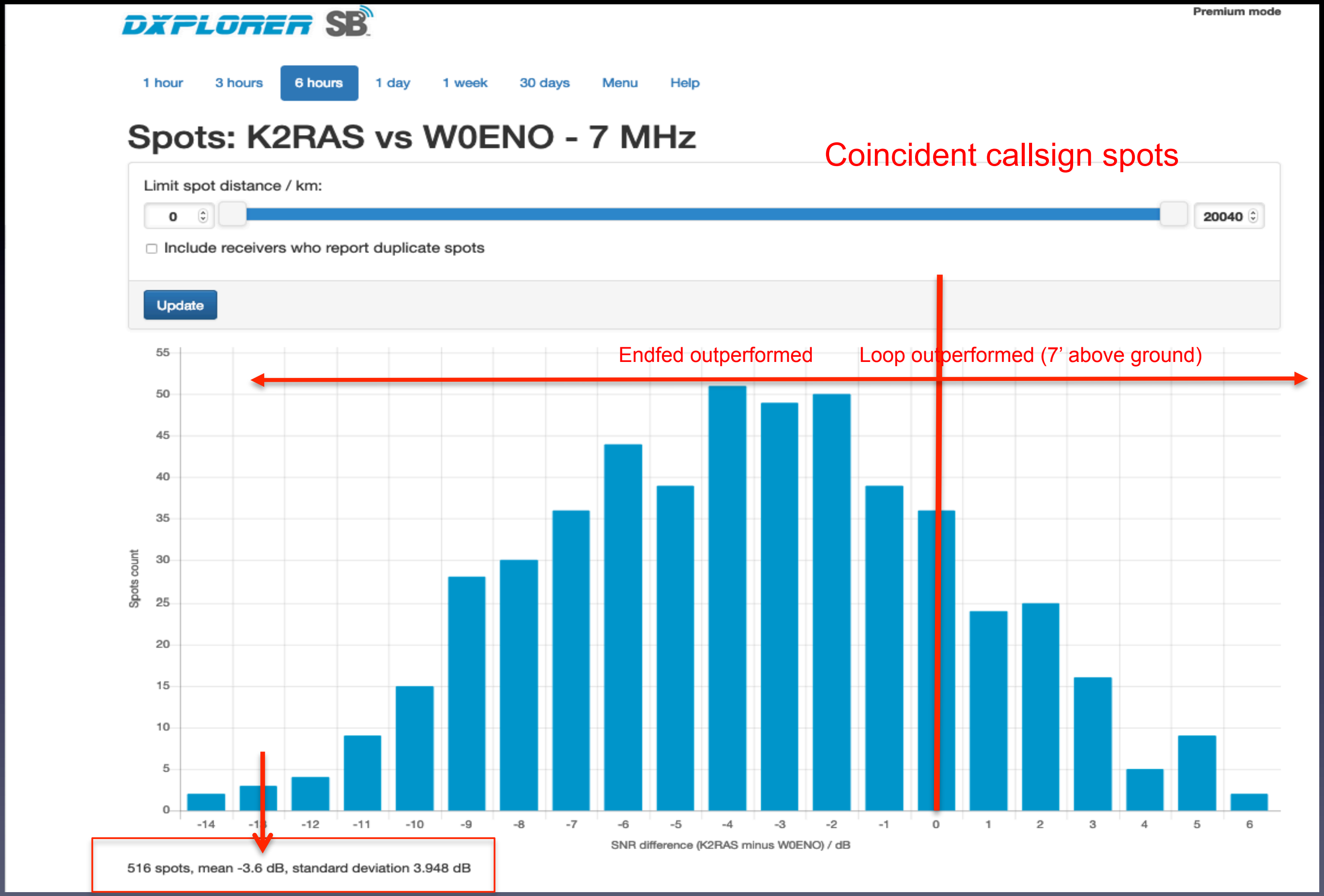








40M Endfed Coincident Spot Comparison



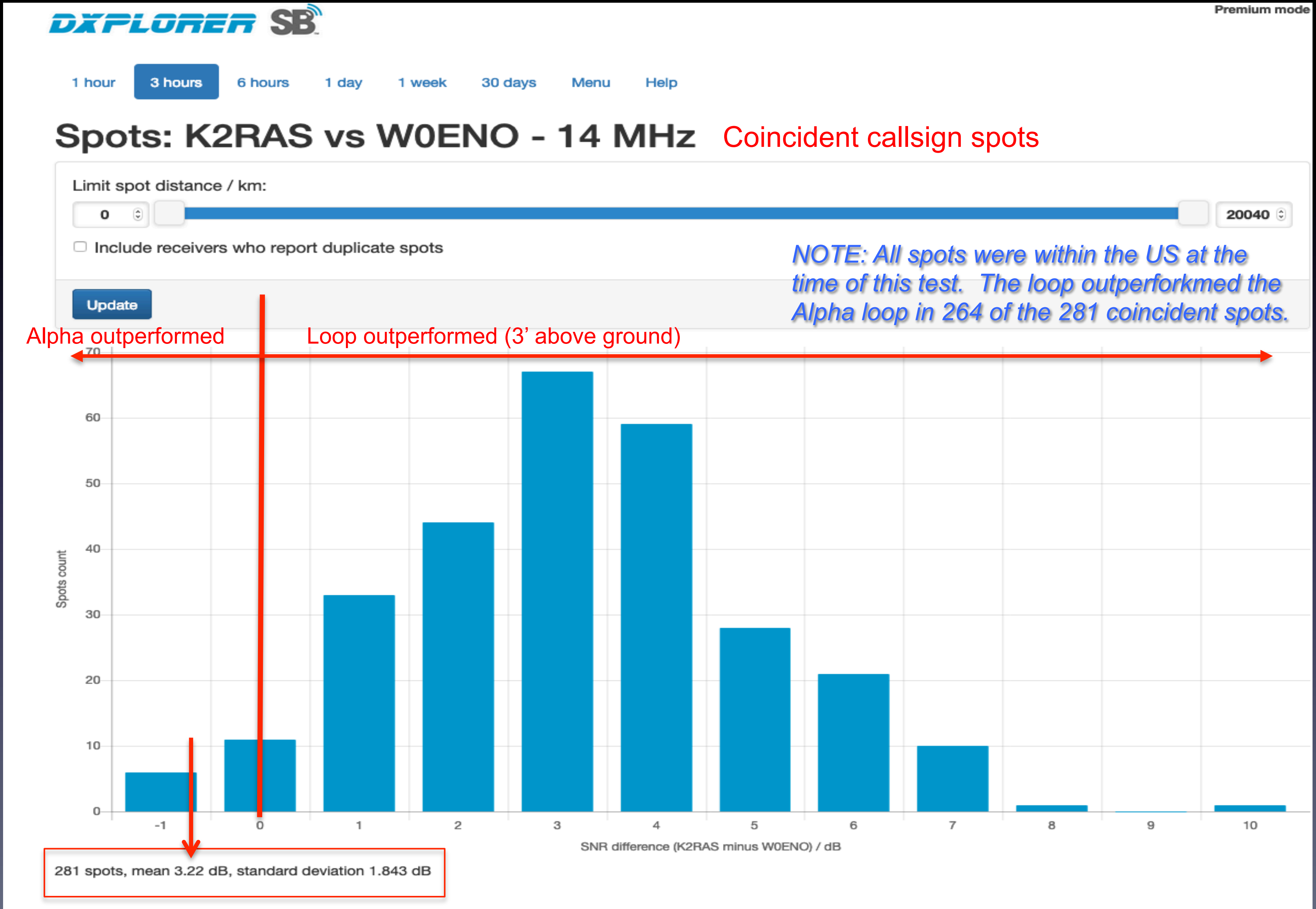
BOTTOM LINE: Roughly the same performance on 40M as 20M

20M Alpha Loop** / My Loop

TRANSMIT Comparison Tests

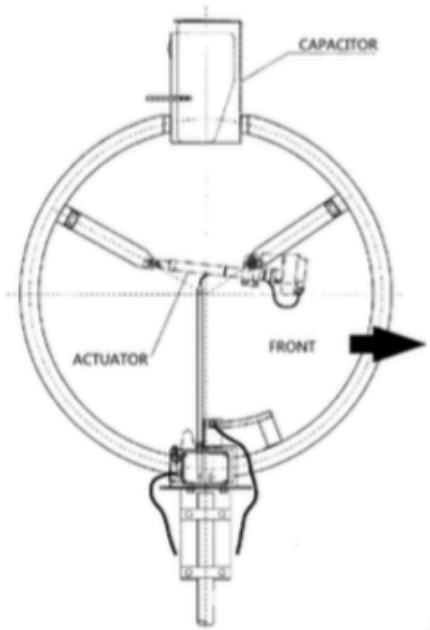
** The Alpha Loop is a commercial 15W 10-80M magnetic loop built using LMR400, priced at $400

20M Alpha Loop Coincident Spot Comparison



Ciro Mazzoni Loop Comparison**

Electrical and mechanical specifications of BABY LOOP

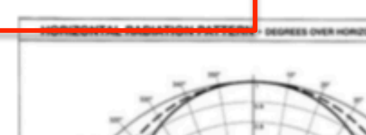


Electrical specifications

Continuous frequency coverage 6.6-29.8 MHz
S.W.R. 1,3:1 (typical)
Front to back ratio: 6 dB
Front to side ratio: 25 dB
50 Ohm input with gamma match short circuited (electrostatic discharge protection)
Negligible noise and harmonics
L = 3 μH   Q = 1.100 a 7 MHz
C = 400 pF a 17 KV r.m.s.
Power rating: 450 W up to a 21 MHz **
1 KW from 22 to 29.8 MHz**
Bandwidth : 4 KHz @ 7 MHz
6 KHz @ 14 MHz
12KHz @ 21 MHz
20KHz @ 28 MHz

Gain compared to λ/2 dipole (1 point "S" = 6 dB)
- 4 dB @ 7 MHz
- 0.3 dB @ 28 MHz

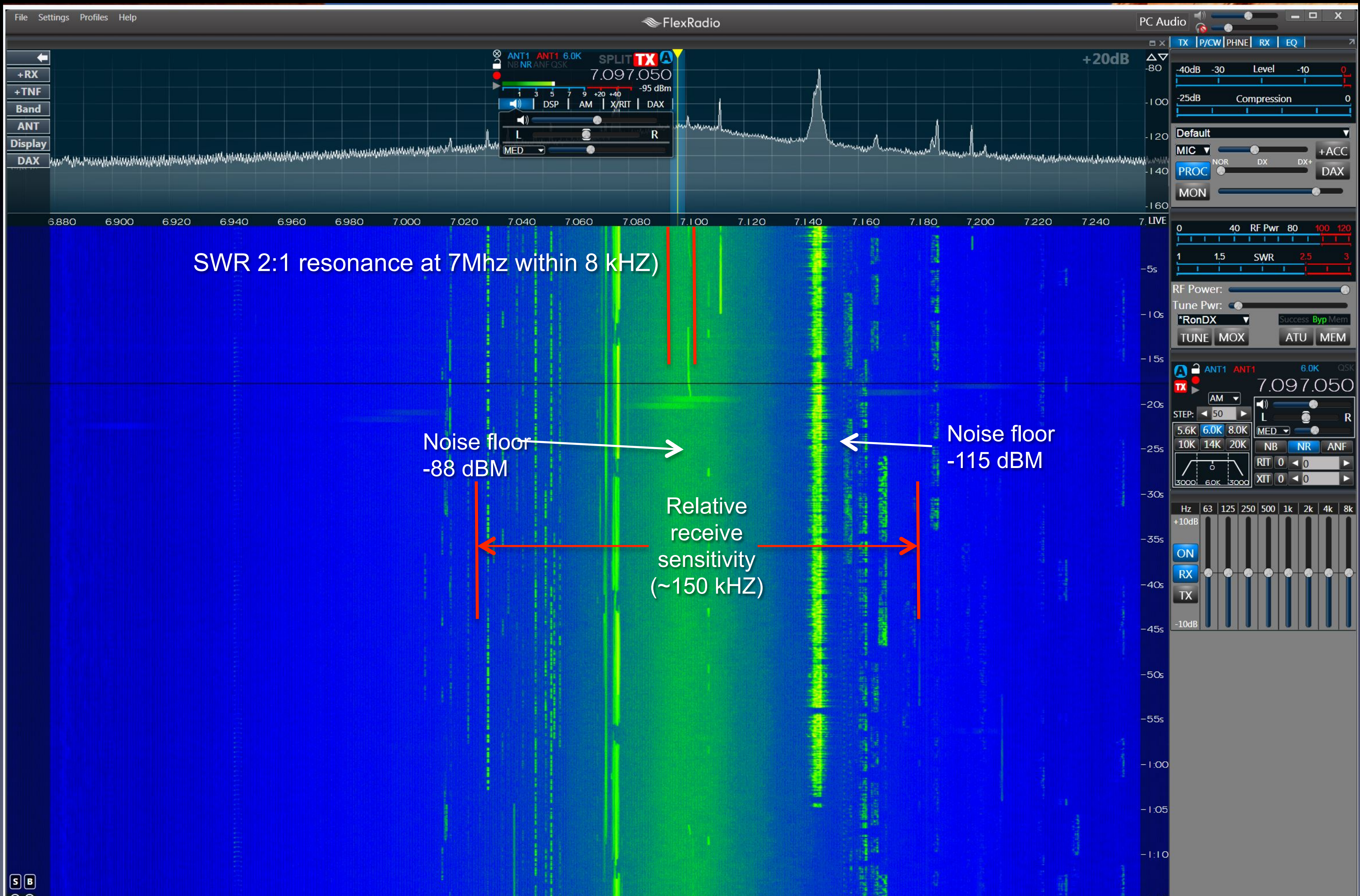
**NOTE:
with this LOOP ANTENNA the peak power is equal to the continuous power



**Best commercial transmit loop, priced at $2500

Magnetic Loop
Receive Performance

40M Resonant Range



40M WSPR Receive (Receive Loop)

DXEngineering 40M WSPR Receipts (on Flexradio)

WSJT-X v2.0.0 by K1JT

File Configurations View Mode Decode Save Tools Help

UTC	dB	DT	Freq	Drift	Call	Grid
0202	-26	0.5	7.040040	0	K4APC	EM81
0202	-18	1.9	7.040081	-1	W8LN	EM64
0202	-24	0.4	7.040100	0	N0XXX	DM04
0204	-1	0.4	7.040030	0	W6LVP	DM04
0204	-18	0.5	7.040044	0	K4APC	EM81
0204	-21	2.0	7.040081	0	W8LN	EM64
0204	-23	0.3	7.040095	0	VA7BBG	CO65
0204	-24	0.3	7.040150	0	VA3UAL	EN94
0204	3	-2.7	7.040169	-1	W6LVP/A	
0206	-11	0.4	7.040020	0	AE6GD	DM04
0206	-21	0.5	7.040048	0	K4APC	EM81
0206	-27	2.6	7.040081	0	KD4OTA	EM74
0206	-25	0.3	7.040091	0	WW6CC	DM13
0206	3	1.1	7.040100	-1	KF6BL	DM13
0206	-17	0.5	7.040100	0	N0XXX	DM04
0206	-24	0.2	7.040152	0	KA3JIJ	EM84
0206	-22	0.5	7.040162	0	W5GHU	DM41
0206	-2	0.3	7.040165	0	K6MCS	CM98

Transmit Loop 40M WSPR Receipts (on IC-7300)

WSJT-X v2.0.0 by K1JT

File Configurations View Mode Decode Save Tools Help

UTC	dB	DT	Freq	Drift	Call	Grid
0202	-19	0.1	7.040032	0	ZS3D	KG01
0202	-12	0.3	7.040042	0	K4APC	EM81
0202	-13	1.7	7.040083	0	W8LN	EM64
0202	-15	0.2	7.040102	0	N0XXX	DM04
0204	3	0.2	7.040032	0	W6LVP	DM04
0204	-12	0.3	7.040046	0	K4APC	EM81
0204	-18	1.7	7.040083	0	W8LN	EM64
0204	-22	0.0	7.040097	0	VA7BBG	CO65
0204	-14	0.1	7.040152	0	VA3UAL	EN94
0204	6	-3.0	7.040171	0	W6LVP/A	
0206	-6	0.2	7.040022	0	AE6GD	DM04
0206	-15	0.3	7.040050	0	K4APC	EM81
0206	-20	2.3	7.040083	0	KD4OTA	EM74
0206	8	0.9	7.040102	0	KF6BL	DM13
0206	-11	0.1	7.040102	-1	N0XXX	DM04
0206	-18	0.1	7.040154	1	KA3JIJ	EM84
0206	9	0.1	7.040167	0	K6MCS	CM98

Other antenna did not hear spot
Stronger signal received
Weaker signal received

The transmit loop strongly outperformed the DXEngineering loop receiving performance on 40M

20M WSPR Receive (Endfed)

Endfed Antenna **20M** WSPR Receipts (on Flex)

WSJT-X v2.0.0 by K1JT

File Configurations View Mode Decode Save Tools Help

UTC	dB	DT	Freq	Drift	Call	Grid
1924	-16	0.1	14.097138	0	[illegible]	DN70
1928	-------------------	Transmitting WSPR	-----------			
1926	-23	1.5	14.097029	0	KC9NBV	EM69
1926	-23	0.5	14.097061	0	K8JBV	EN91
1926	-26	0.5	14.097076	-1	W2ASX	EM93
1930	-------------------	Transmitting WSPR	-----------			
1932	-18	0.4	14.097062	0	K8JBV	EN91
1932	-20	1.0	14.097074	0	N4DPH	EM64
1932	-23	0.3	14.097129	0	K7FET	CN85
1932	-14	-1.5	14.097141	0	AA7FV	DM42
1934	6	0.2	14.097034	-1	AL7CR	CN82
1934	-15	1.5	14.097084	0	W4DNR	EM64
1934	-22	-0.6	14.097153	0	NR7V	CN88
1936	-------------------	Transmitting WSPR	-----------			

Transmit Loop **20M** WSPR Receipts (on IC-7300)

WSJT-X v2.0.0 by K1JT

File Configurations View Mode Decode Save Tools Help

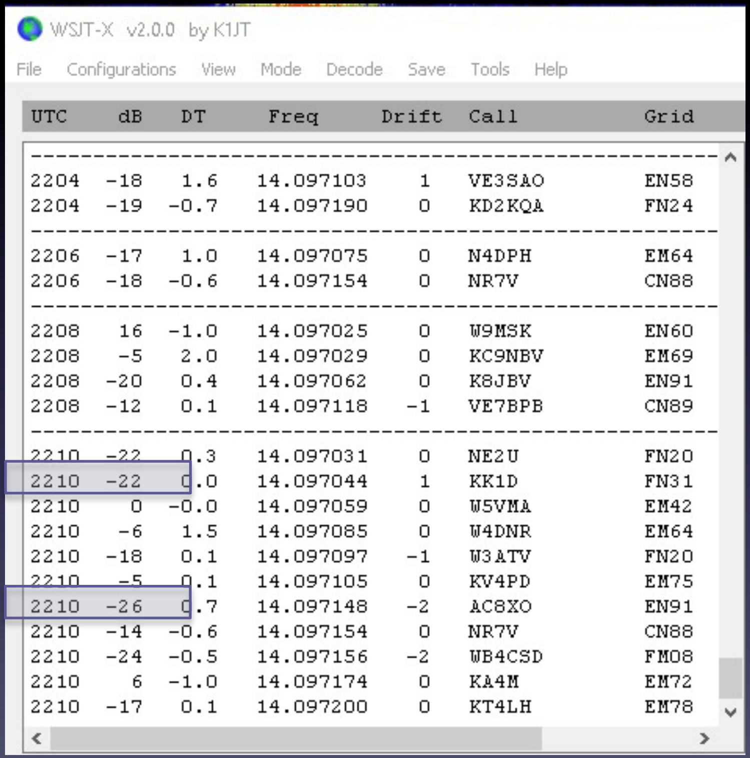
UTC	dB	DT	Freq	Drift	Call	Grid
1926	-14	0.6	14.097073	-1	W2ASX	EM93
1926	-14	0.5	14.097091	0	K6PZB	CM88
1926	-20	0.5	14.097094	0	W3ATV	FN20
1926	-17	0.3	14.097126	0	AE5HO	EM13
1926	-19	2.5	14.097131	1	KD5LBK	EM13
1926	-23	-0.4	14.097137	0	KD9ISN	EN41
1926	-18	-0.4	14.097151	0	NR7V	CN88
1926	-22	1.3	14.097171	0	W3CSW	FM19
1928	-------------------	Transmitting WSPR	---------			
1930	-------------------	Transmitting WSPR	---------			
1932	-26	0.2	14.097051	0	KR6ZY	CM95
1932	-9	0.6	14.097059	0	K8JBV	EN91
1932	-22	0.4	14.097064	0	KC2HJR	EM57
1932	-10	1.3	14.097071	0	N4DPH	EM64
1932	-31	0.2	14.097089	-2	VA7BBG	CO65
1932	-12	0.8	14.097115	0	KD6RF	EM22
1932	-11	0.6	14.097126	0	K7FET	CN85
1932	-16	2.6	14.097131	0	KD5LBK	EM13
1932	-6	-1.2	14.097138	0	AA7FV	DM42
1932	-21	0.1	14.097145	0	KA3JIJ	EM84
1932	-24	0.4	14.097192	0	K7KRR	CN87
1934	16	-0.0	14.097031	0	AL7CR	CN82
1934	-12	-0.0	14.097055	0	W5VMA	EM42
1934	-7	1.5	14.097082	0	W4DNR	EM64
1934	-26	1.5	14.097100	0	VE3SAO	EN58
1934	-8	-0.7	14.097151	0	NR7V	CN88
1936	-------------------	Transmitting WSPR	---------			

The transmit loop strongly outperformed the endfed on 20M with a 10db average higher signal

- Other antenna did not hear spot
- Stronger signal received
- Weaker signal received

20M WSPR Receive (Receive Loop)

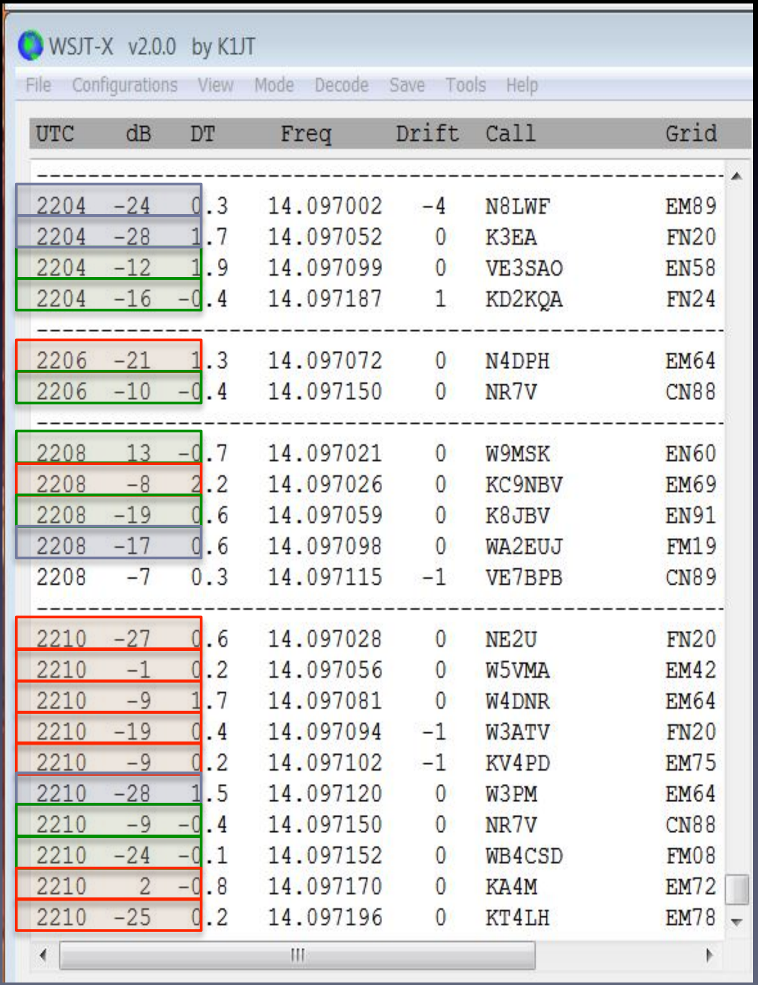
DXEngineering **20M** WSPR Receipts (on Flex)



UTC	dB	DT	Freq	Drift	Call	Grid
2204	-18	1.6	14.097103	1	VE3SAO	EN58
2204	-19	-0.7	14.097190	0	KD2KQA	FN24
2206	-17	1.0	14.097075	0	N4DPH	EM64
2206	-18	-0.6	14.097154	0	NR7V	CN88
2208	16	-1.0	14.097025	0	W9MSK	EN60
2208	-5	2.0	14.097029	0	KC9NBV	EM69
2208	-20	0.4	14.097062	0	K8JBV	EN91
2208	-12	0.1	14.097118	-1	VE7BPB	CN89
2210	-22	0.3	14.097031	0	NE2U	FN20
2210	-22	0.0	14.097044	1	KK1D	FN31
2210	0	-0.0	14.097059	0	W5VMA	EM42
2210	-6	1.5	14.097085	0	W4DNR	EM64
2210	-18	0.1	14.097097	-1	W3ATV	FN20
2210	-5	0.1	14.097105	0	KV4PD	EM75
2210	-26	0.7	14.097148	-2	AC8XO	EN91
2210	-14	-0.6	14.097154	0	NR7V	CN88
2210	-24	-0.5	14.097156	-2	WB4CSD	FM08
2210	6	-1.0	14.097174	0	KA4M	EM72
2210	-17	0.1	14.097200	0	KT4LH	EM78

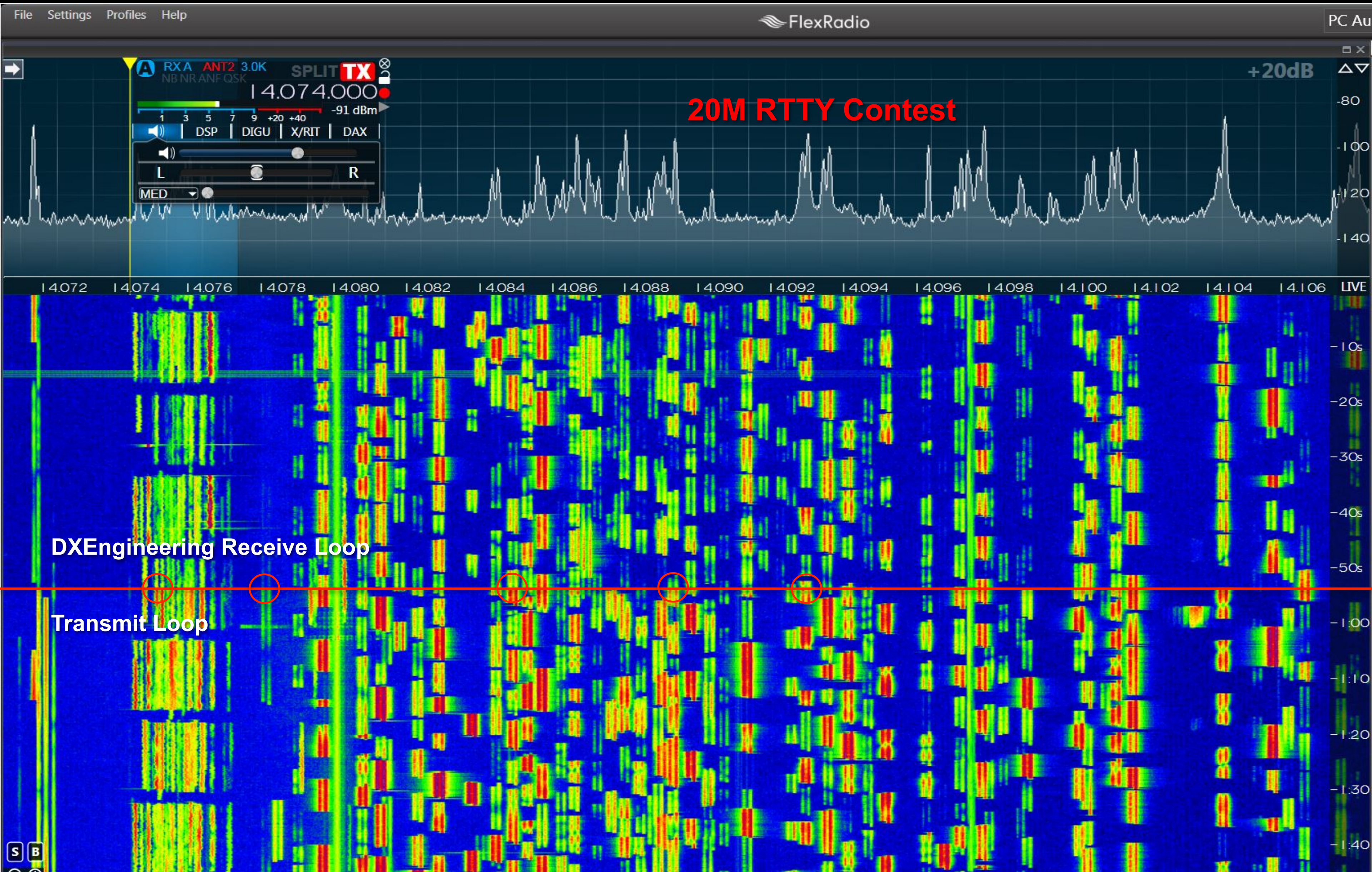
The transmit loop and DXEngineering loop had equal receiving performance in this test, but the transmit loop generally outperformed on 20M

Transmit Loop **20M** WSPR Receipts (on IC-7300)

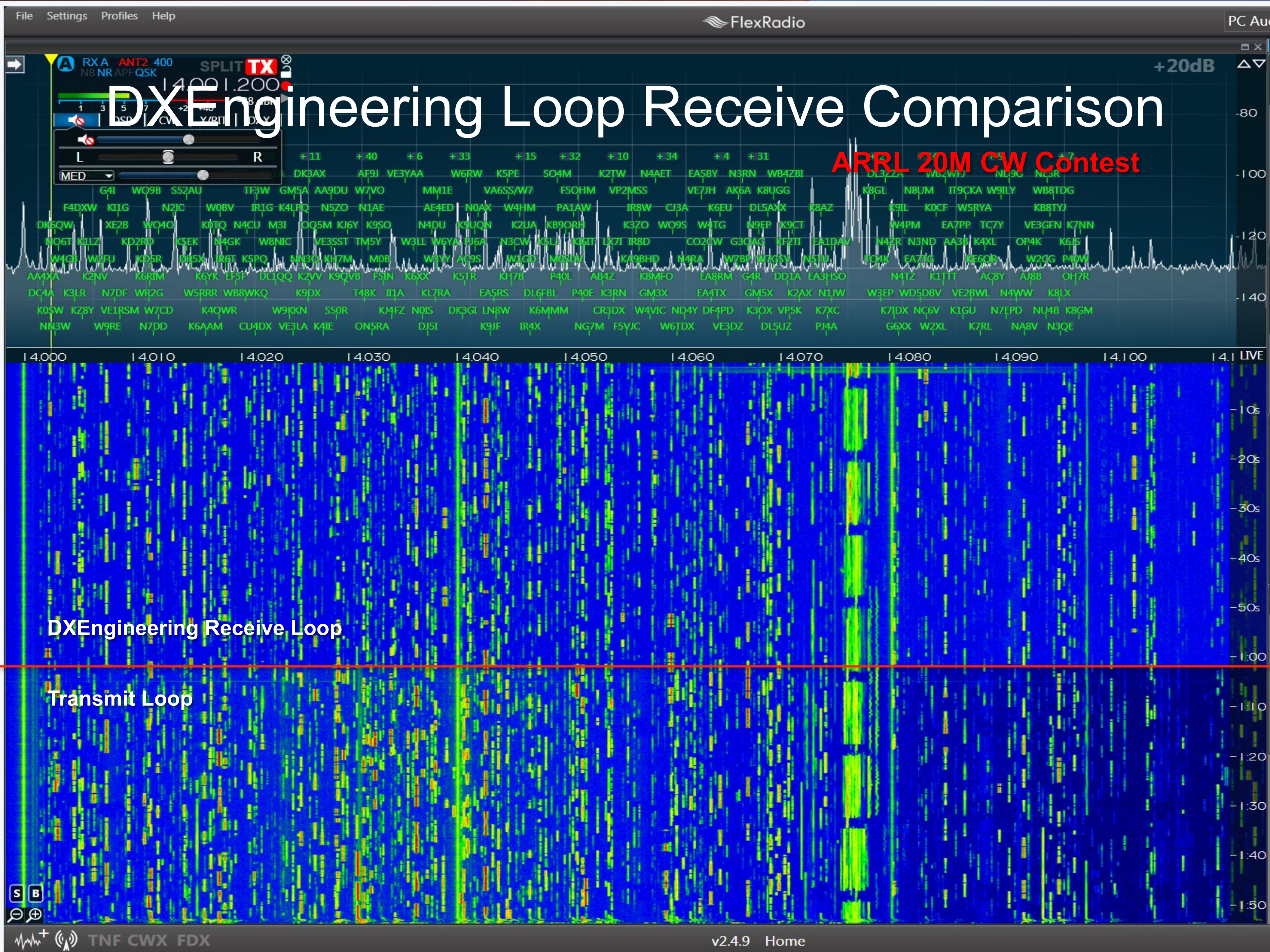


UTC	dB	DT	Freq	Drift	Call	Grid
2204	-24	0.3	14.097002	-4	N8LWF	EM89
2204	-28	1.7	14.097052	0	K3EA	FN20
2204	-12	1.9	14.097099	0	VE3SAO	EN58
2204	-16	-0.4	14.097187	1	KD2KQA	FN24
2206	-21	1.3	14.097072	0	N4DPH	EM64
2206	-10	-0.4	14.097150	0	NR7V	CN88
2208	13	-0.7	14.097021	0	W9MSK	EN60
2208	-8	2.2	14.097026	0	KC9NBV	EM69
2208	-19	0.6	14.097059	0	K8JBV	EN91
2208	-17	0.6	14.097098	0	WA2EUJ	FM19
2208	-7	0.3	14.097115	-1	VE7BPB	CN89
2210	-27	0.6	14.097028	0	NE2U	FN20
2210	-1	0.2	14.097056	0	W5VMA	EM42
2210	-9	1.7	14.097081	0	W4DNR	EM64
2210	-19	0.4	14.097094	-1	W3ATV	FN20
2210	-9	0.2	14.097102	-1	KV4PD	EM75
2210	-28	1.5	14.097120	0	W3PM	EM64
2210	-9	-0.4	14.097150	0	NR7V	CN88
2210	-24	-0.1	14.097152	0	WB4CSD	FM08
2210	2	-0.8	14.097170	0	KA4M	EM72
2210	-25	0.2	14.097196	0	KT4LH	EM78

DXEngineering Loop Receive Comparison



DXEngineering Loop Receive Comparison



KF0RQ Hytower Vertical Comparison

- The loop on 40M outperformed the vertical on receive
- The loop on 40M underperformed the vertical on transmit
- The loop on 40M matched the elevated yagi on receive

Measured using WSPR / FT8 modes

Summary

- Actual Loop Performance
  - Achieved near 1:1 SWR across the 40M to 10M bands
  - On RECEIVE, the transmit loop outperformed all antennas on all tunable bands (the transmit loop can't tune below 40M)
  - On TRANSMIT, the transmit loop signals were reported average 5 dB lower on 40M, 3dB lower on 20M than the Endfed. The number of spots were roughly the same.
  - On TRANSMIT, the transmit loop underperformed the 40M ½ wave vertical
  - The loop outperformed the closest 'equivalent' commercial loop on receive and transmit
  - Elevating the loop from 3 feet to 7 feet above ground improved DX and decreased the noise floor

Summary

- Actual loop performance
  - The loop did not hit local spots (<100 mi) as well as the endfed. It may not be good solution for NVIS
  - The loop could handle 500+ watts (with a upgraded cap), can't do that using the Endfed through the trees!
- Use the coupler loop placement to optimize antenna performance
  - Simply optimizing SWR is not enough (remember a dummy load SWR is 1:1)
  - An airgap from primary loop lowered SWR and increased performance (GOOD)
  - A smaller coupler loop decreased SWR, but decreased performance (BAD)
  - Flattening the coupler loop increased coupling and increased performance (GOOD)

Summary

- Project Build Considerations
  - The 13’ loop tunes <u>40M to 12M</u>, if it were sized for 80M it would likely only tune 80M - 20M
  - The 13’ loop is about 30 lbs and top heavy (with the cap on top). 1 ½ PVC tube with wood dowel inside supports the loop
  - I believe 80M would require a 26’ loop (over 8’ diameter). The design would likely require a double loop, creating further potential issues (weight, loop coupling…)
  - The Arduino autotuner makes tuning the resonant loop a non-issue
  - Don’t use 1/10” headers on the autotuner PCB wires, the connectors get loose and are unreliable

Summary

- So, to summarize…
  - The loop excelled on receive, outperforming the vertical, horizontal endfed, and receive only loop. Performance neared that of the elevated yagi
  - The loop is a compromise transmit solution, matching the 80M endfed, but not as good as the verticals

Summary

- What I would do next time…
  - Try to find a butterfly capacitor capable of 500W, don't know the durability of the vacuum capacitor seals in weather over time.
  - 1/10" header pin connectors are unreliable, would solder more wires on the Arduino PCB
  - Compare performance positioning the heavy capacitor on the bottom of the loop, this would make the loop less top heavy
  - The Arduino autotuner worked well, it could be used on any antenna with a variable cap

Any Questions…