North Texas NTMS Microwave Society

Automated beacon receivers Part 2 plus propagation studies

KM5PO – Jim McMasters

August 8, 2026

Update since last meeting

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- Low-cost automated beacon monitor designs established.
- Beacon monitors built and tested.
- The actual beacons in EM12IL were upgraded on Monday 8/3/26 and have one more upgrade coming.
- We have learned what works and why and built numerous software tools to do the “lab” work.
- Today we will look back on the items above but first…

What has been accomplished

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- Several fixed stations have provided beacon reporting including first-of-a-kind WSJT-X Q65-60D SNR decode data. *When combined with propagation analysis, this is a novel empirical development in amateur microwave propagation studies*.
- Case studies became possible August 3rd to 6th. We will look at the following:
  - Urban vs. Rural simultaneous jitter study 8/3/26
  - Urban vs. Rural two different atmospheres 8/4/26
  - 24 GHz tied to dew point. 8/5/26
  - Parallel 10 and 24 GHz analysis over near-same 100 km urban paths 8/6/26 Refraction + dew pt

Q65-60D successful decodes

- W5LUA 10 & 24 GHz
- WB5ZDP 10 GHz
- K5MNZ 10 GHz
- K5DOG 10 GHz
- DX:
- W5LUA 95 km
- WB5ZDP 99 km
- K5MNZ 106 km
- K5DOG 254 km

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Rural versus Urban jitter study

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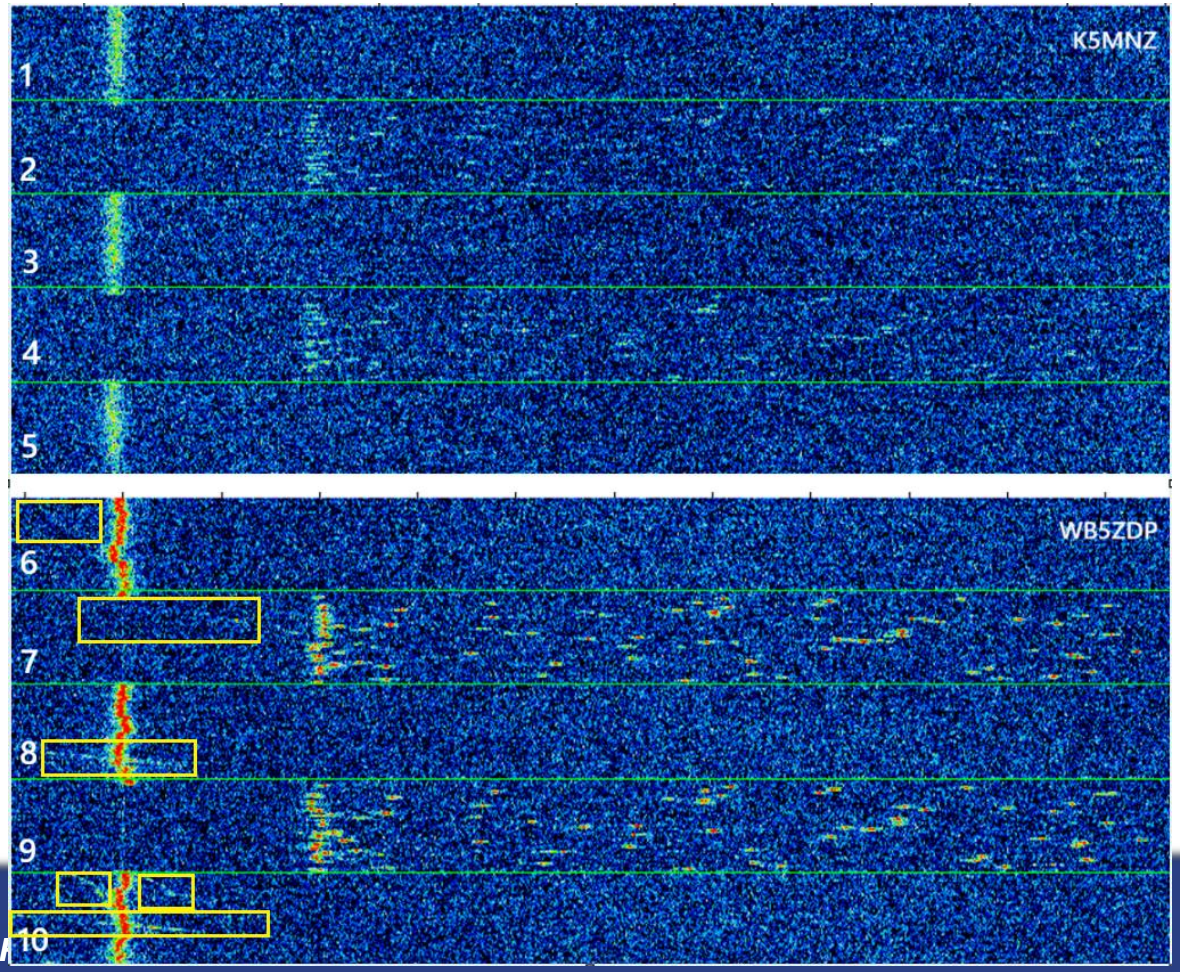
- Aside from AC scatter (boxed in yellow), which signal has more spread?



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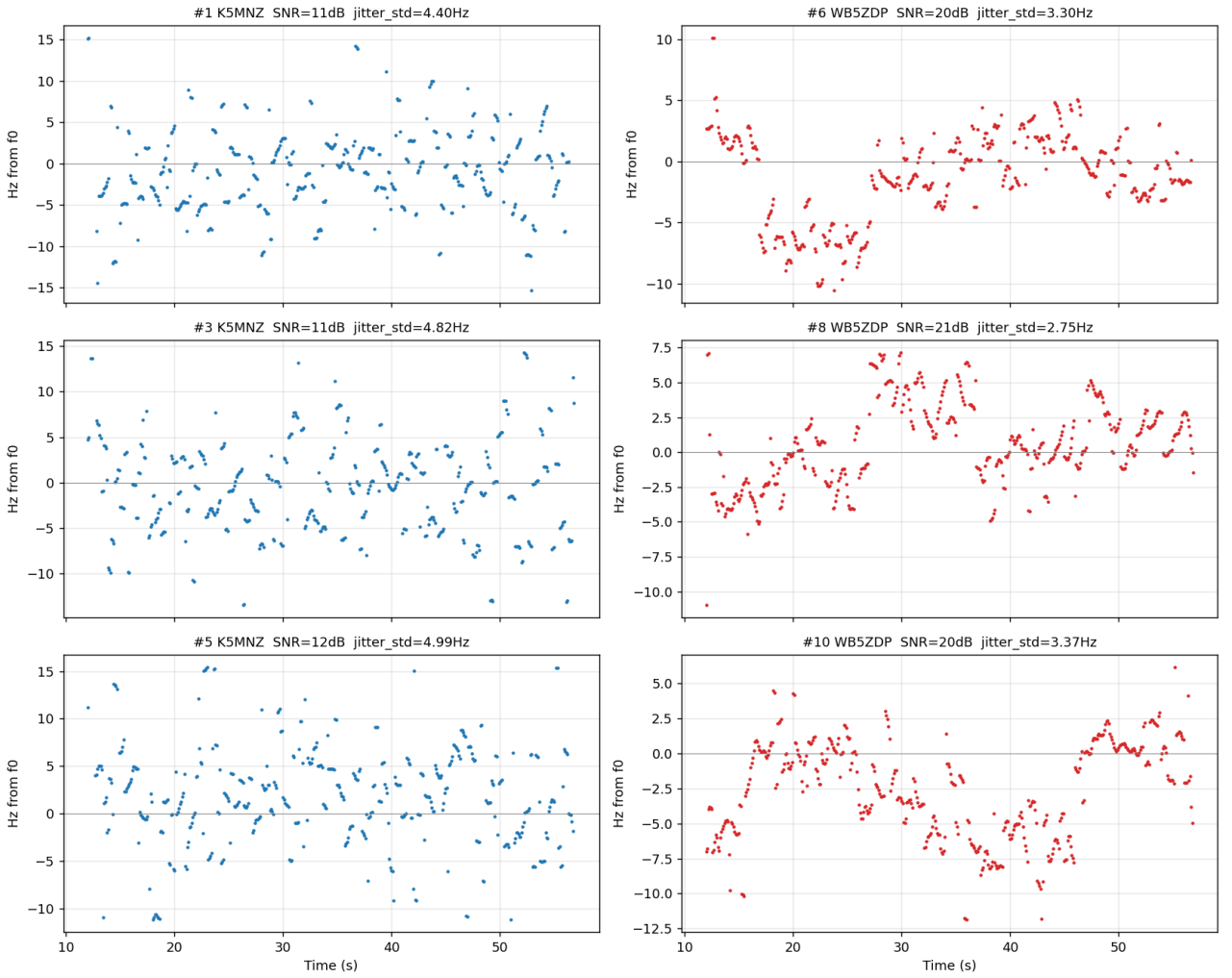
Sub Hertz resolution

CW/carrier frequency tracks -- K5MNZ (rural) vs WB5ZDP (urban)
genuine carrier sequences only (#2, #4, #7, #9 were Q65, excluded)



Sub Hertz resolution

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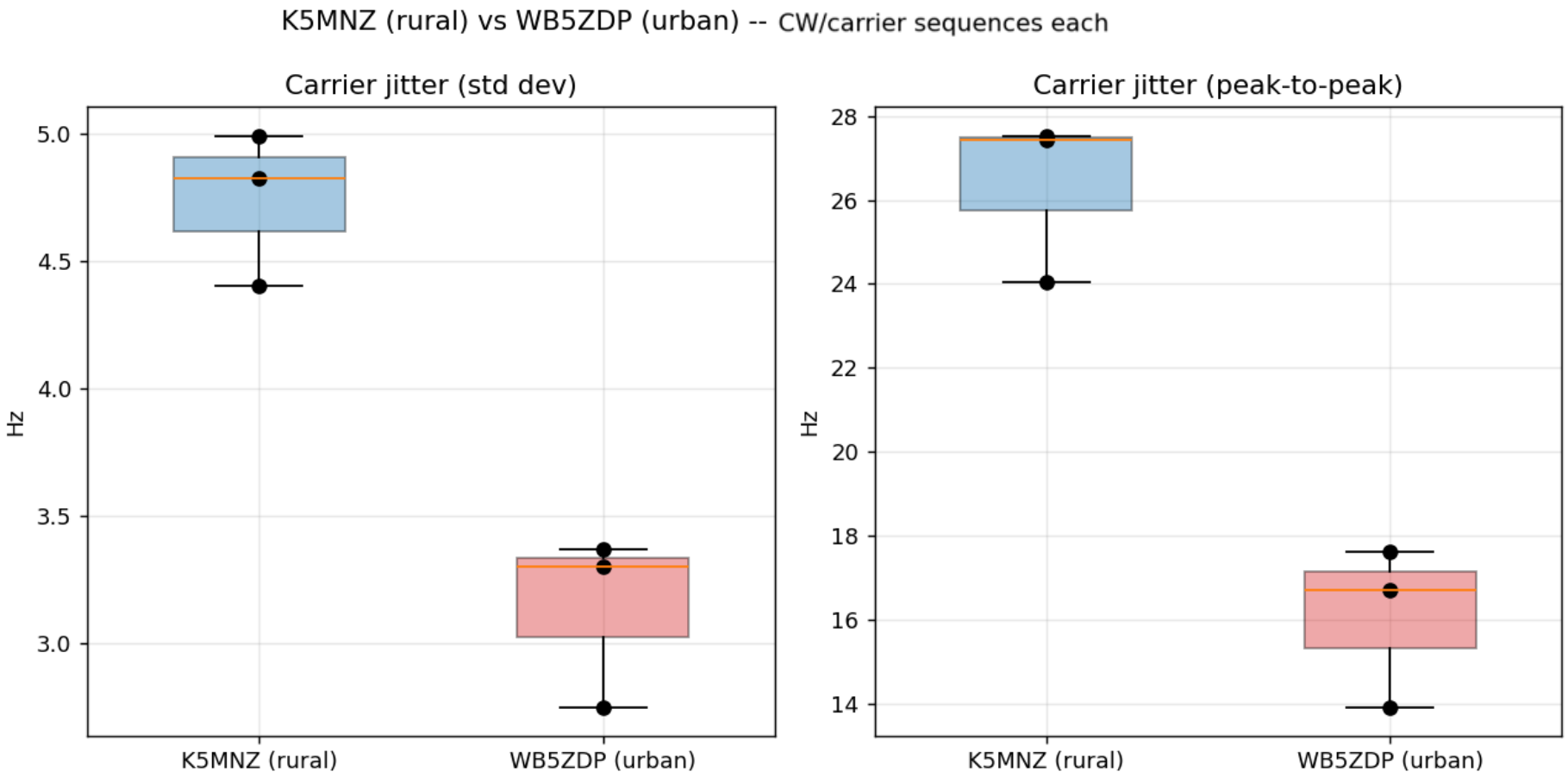

Effect on Q65 payload

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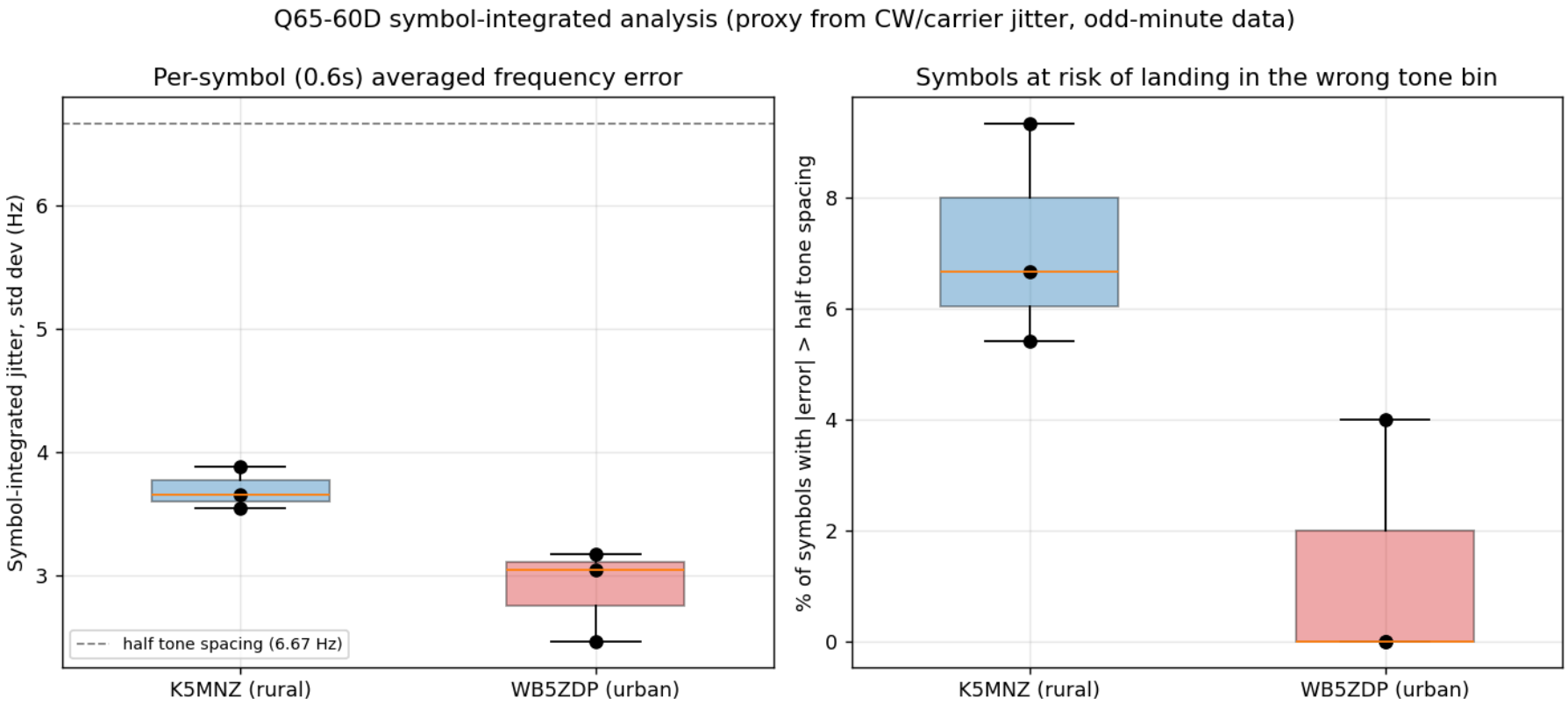

85 symbols, 0.6 s/symbol, derived from the mode's 13.33 Hz tone spacing — same pattern holds.

Does it survive decoding?

Yes, easily. If you were on the receive side, you saw it.

Metric	K5MNZ (Rural)	WB5ZDP (Urban)
Native (0.1s) jitter std dev	4.4–5.0 Hz	2.75–3.37 Hz
Symbol-integrated (0.6s) jitter std dev	3.55–3.88 Hz	2.47–3.18 Hz
Native samples exceeding half-tone (6.665 Hz)	14.6–17.8%	1.8–4.0%
Symbols exceeding half-tone after integration	5.4–9.3%	0–4.0%

- Aside from AC scatter (boxed in yellow), which signal has more spread?

New custom analysis tool created - ntms-cw-jitter-analysis/

Tools reveal ducting and temperature inversion

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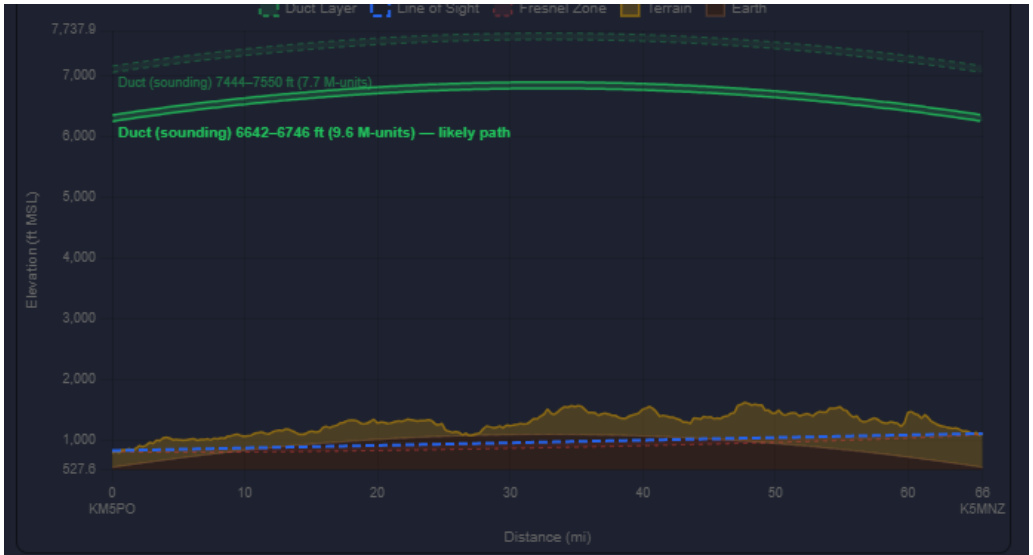

Propagation Analysis

Path is terrain-obstructed at 0.8 mi (1.2 km) from KM5PO. Signal likely propagated via atmospheric ducting (sounding-detected layer at 6642–6746 ft, 9.6 M-units), bending over the terrain obstruction. At 10 GHz, the elevated moisture (PWAT 35.5 mm) enhances refractivity and ducting potential.

Antenna heights: KM5PO @ 35 ft AGL, K5MNZ @ 8 ft AGL.

Refractivity gradient: -138 N-units/km (super-refractive).

Boundary layer depth: 86 m – shallow boundary layer favors ducting.

Ducting detected by soundings at: Fort_worth TX/US, Fort Worth Area -- KFWH KFWD.

Most likely propagation duct: sounding-detected layer at 6642–6746 ft, 9.6 M-units.

Tools reveal ducting and temperature inversion

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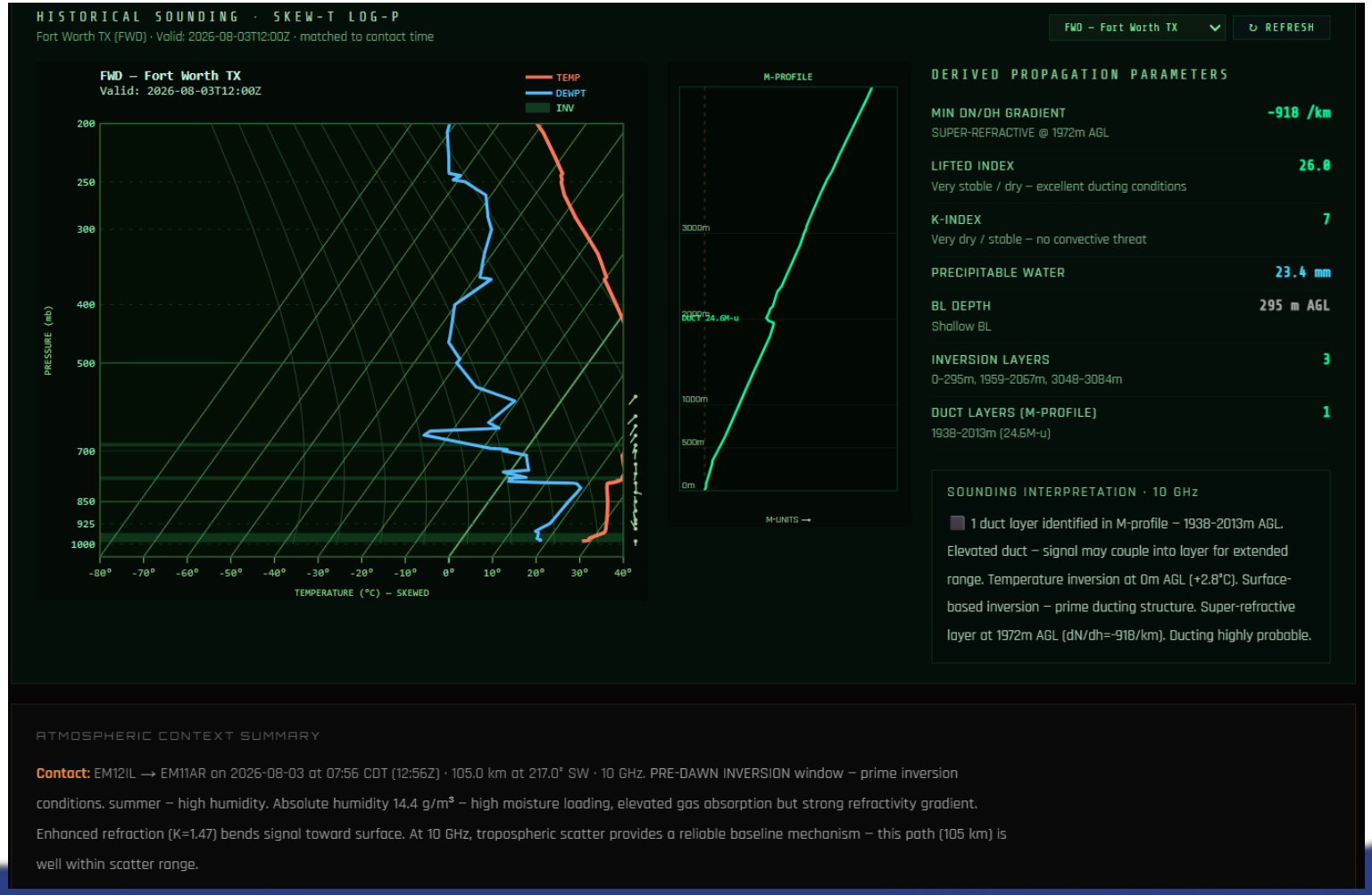

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Same day – two atmospheres

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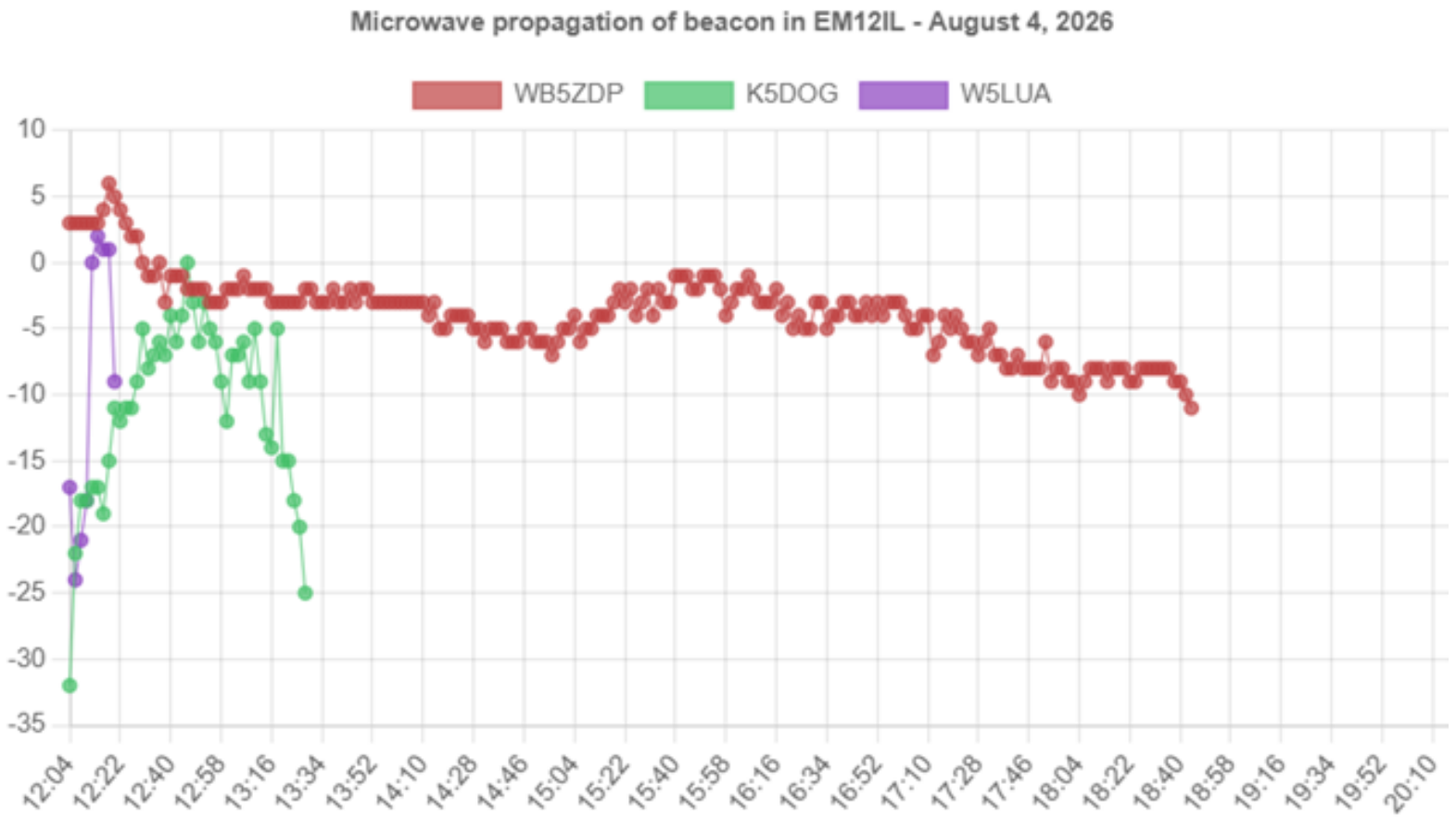

+30 Db lift

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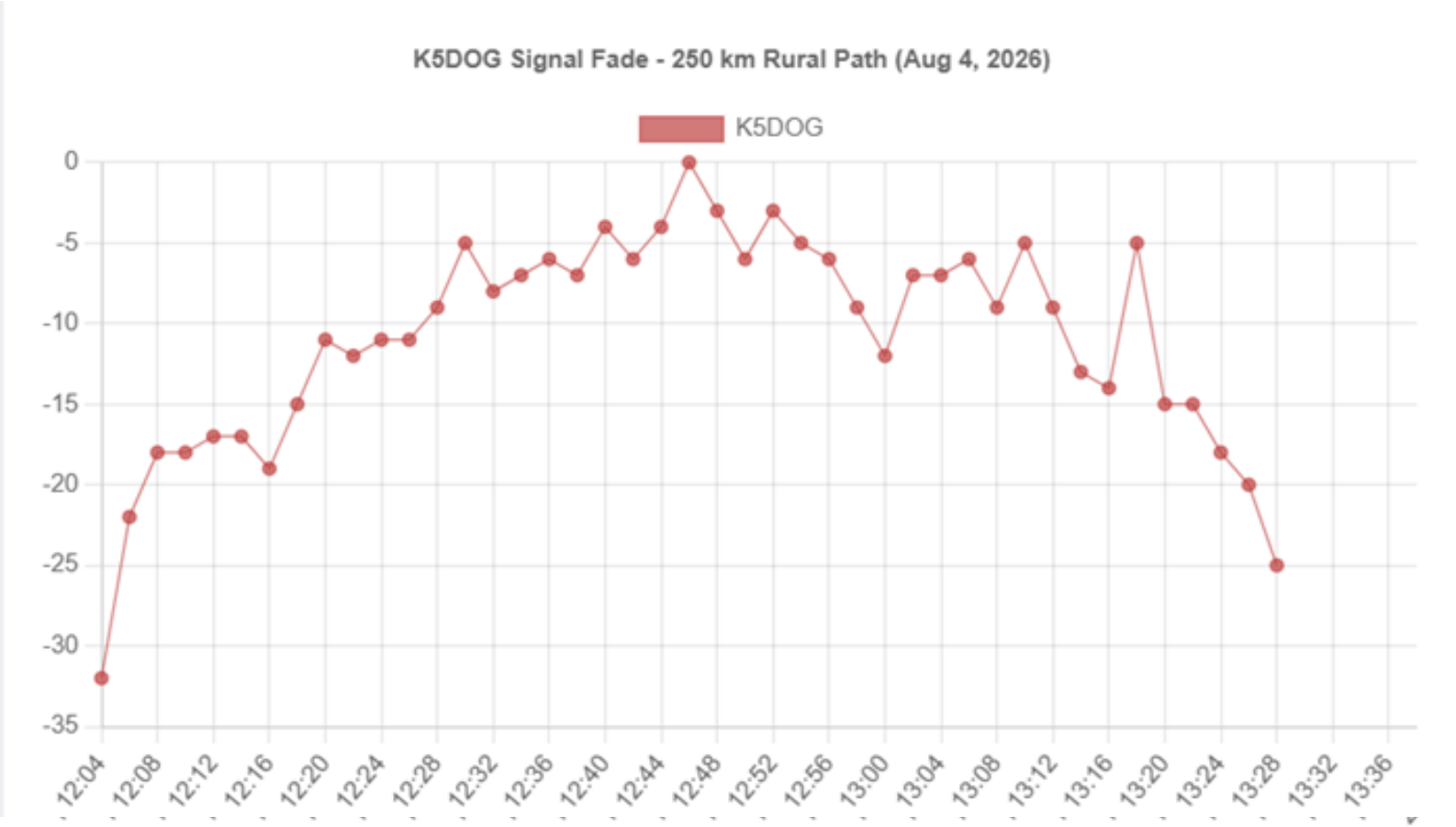

Extract prop data

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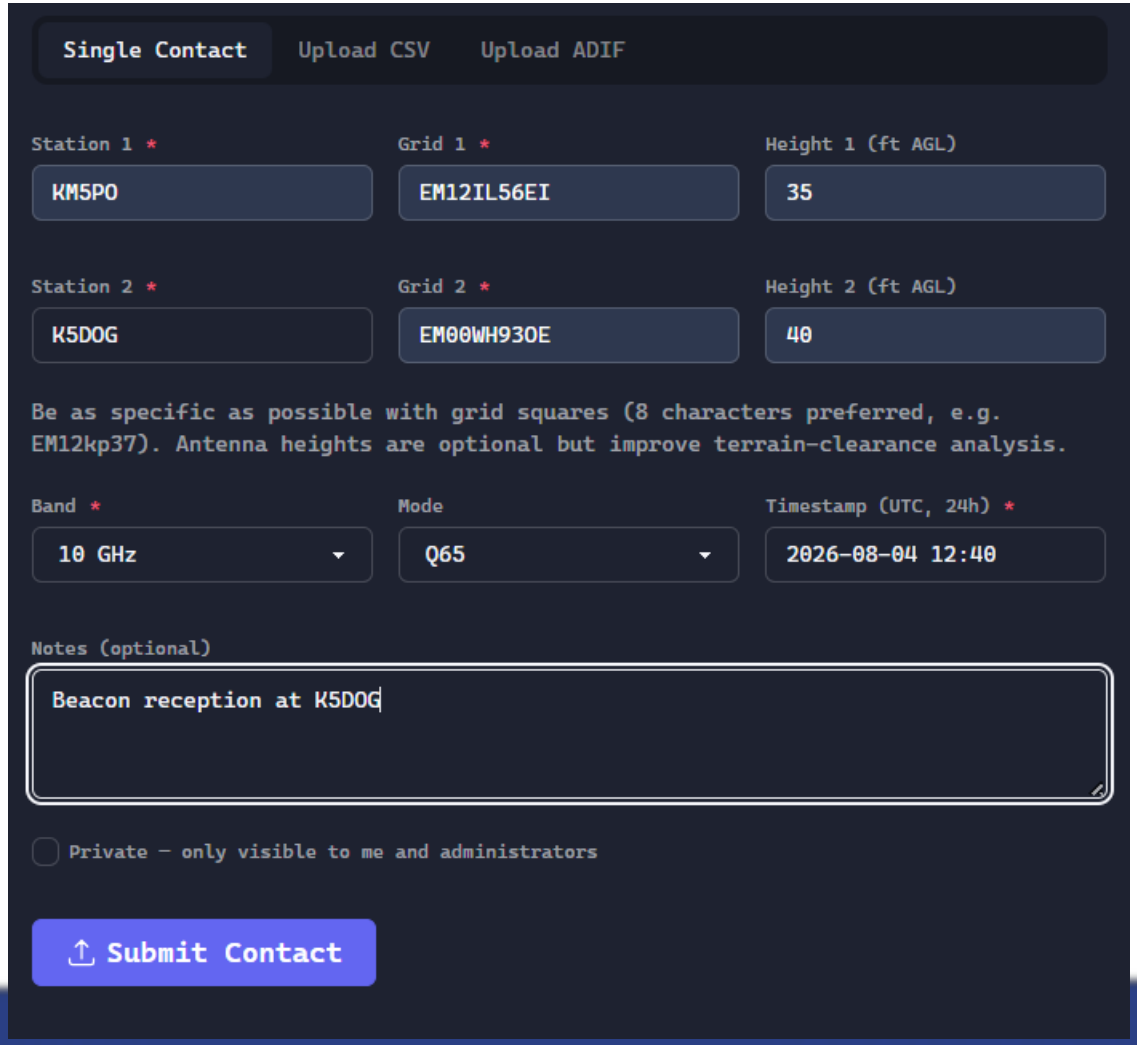

Duct revealed at 842-1188 ft

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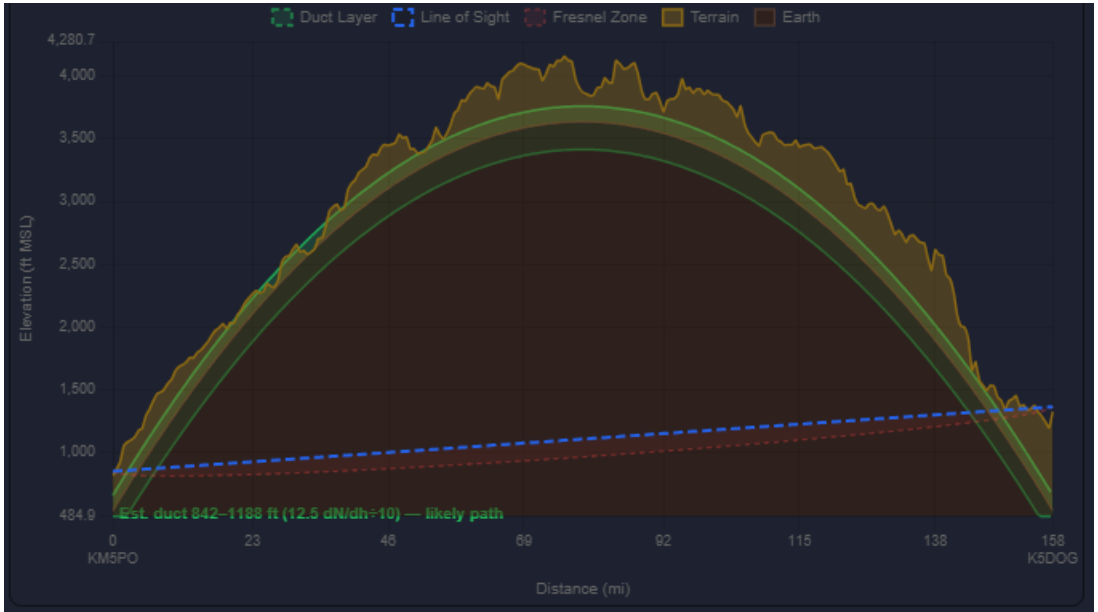

Propagation Analysis

Path is terrain-obstructed at 0.6 mi (1.0 km) from KM5PO. Enhanced refraction (dN/dh = -109 N-units/km) likely bent the signal over the obstruction. Conditions are super-refractive but below full ducting threshold. At 10 GHz, the elevated moisture (PWAT 31.6 mm) enhances refractivity and ducting potential.

Antenna heights: KM5PO @ 35 ft AGL, K5DOG @ 40 ft AGL.

Refractivity gradient: -109 N-units/km (super-refractive).

Boundary layer depth: 160 m — shallow boundary layer favors ducting.

Most likely propagation duct: estimated layer at 842–1188 ft, 12.5 M-units.

High to lower refractivity

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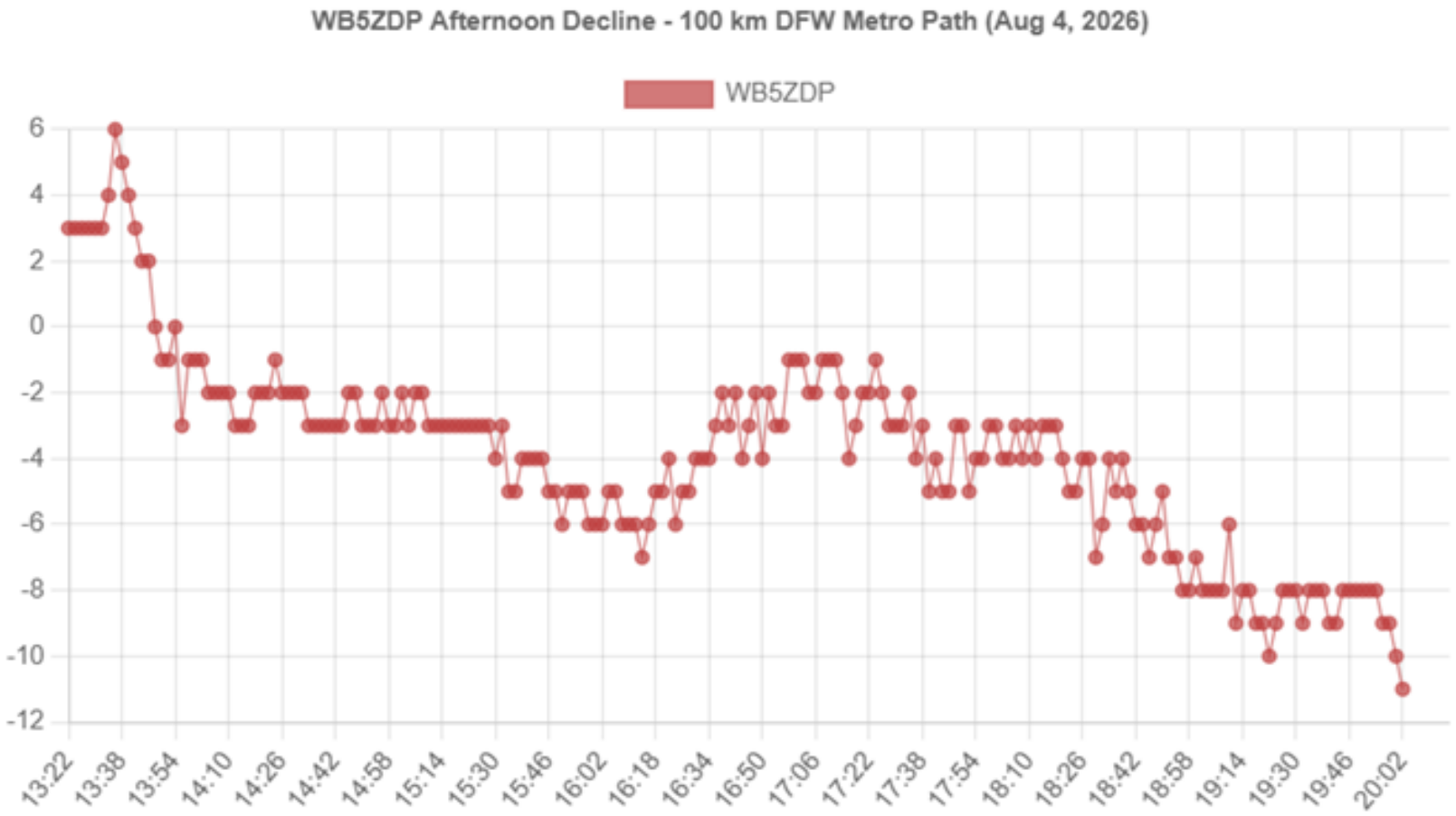

High to lower refractivity

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K5DOG

Factor	Score	Weight	Contribution	Notes
Rain	100/100	14%	14.3	None
Humidity	88/100	13%	11.1	19.8 g/m³ (beneficial at this band)
Season	79/100	11%	9.0	Aug (summer peak band)
Pressure	88/100	10%	8.5	971.2 mb (low)
Refractivity	82/100	10%	8.1	dN/dh = -125 (super-refractive)
PWAT	70/100	11%	8.0	31.8 mm (refractivity aid)
T-Td Depression	75/100	10%	7.6	T-Td = 3.6°F (moist)
Sky Cover	50/100	8%	4.2	–
Wind	50/100	8%	4.2	–
Time of Day	100/100	4%	3.8	Solar hour ~6 (dawn)
Composite	79/100		GOOD	

WB5ZDP

Factor	Score	Weight	Contribution	Notes
Rain	100/100	14%	14.3	None
Humidity	95/100	13%	12.0	14.3 g/m³ (beneficial at this band)
PWAT	90/100	11%	10.3	23.4 mm (refractivity aid)
Season	79/100	11%	9.0	Aug (summer peak band)
T-Td Depression	85/100	10%	8.6	T-Td = 9.8°F (moderate)
Refractivity	82/100	10%	8.1	dN/dh = -116 (super-refractive)
Pressure	82/100	10%	7.9	985.1 mb (low)
Sky Cover	50/100	8%	4.2	–
Wind	50/100	8%	4.2	–
Time of Day	100/100	4%	3.8	Solar hour ~6 (dawn)
Composite	82/100		EXCELLENT	

Same day – two atmospheres

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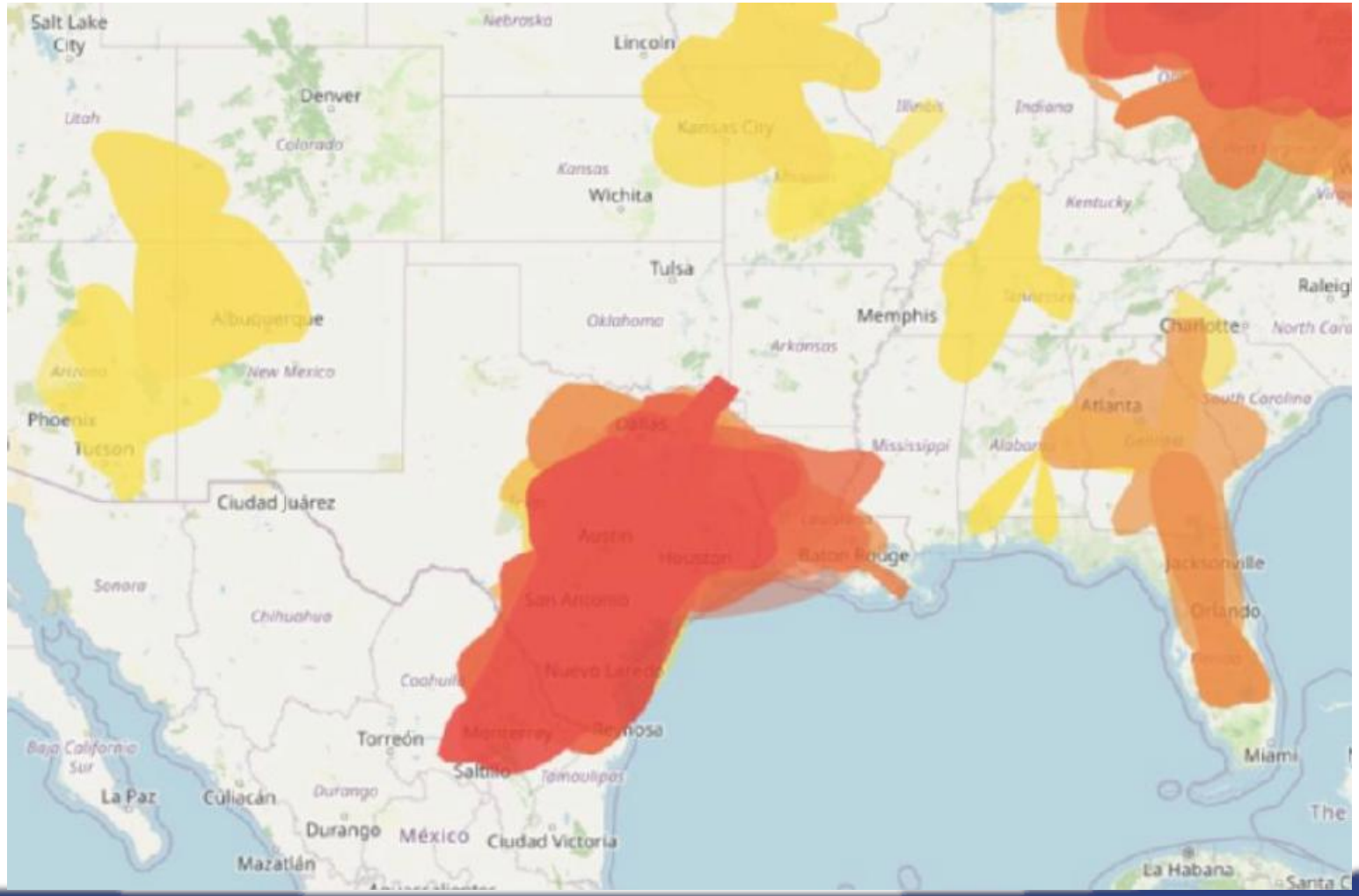

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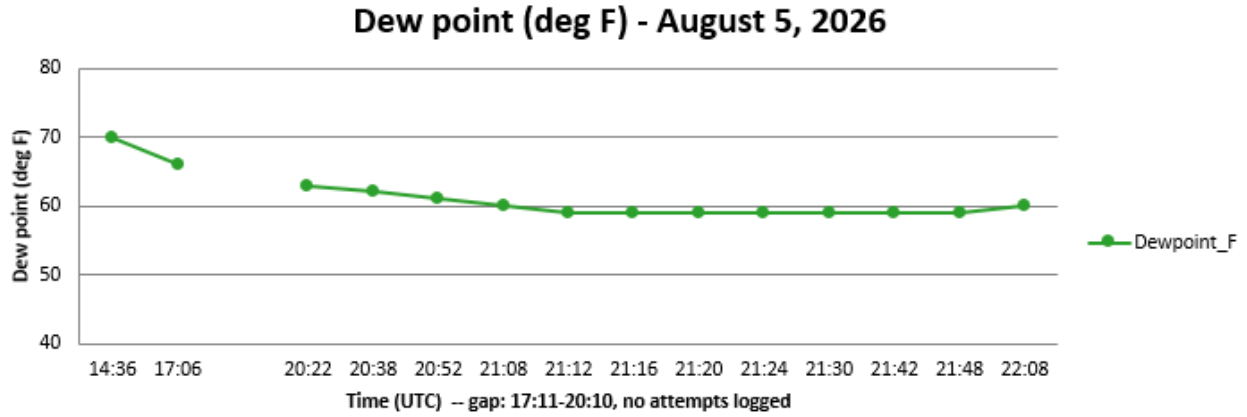
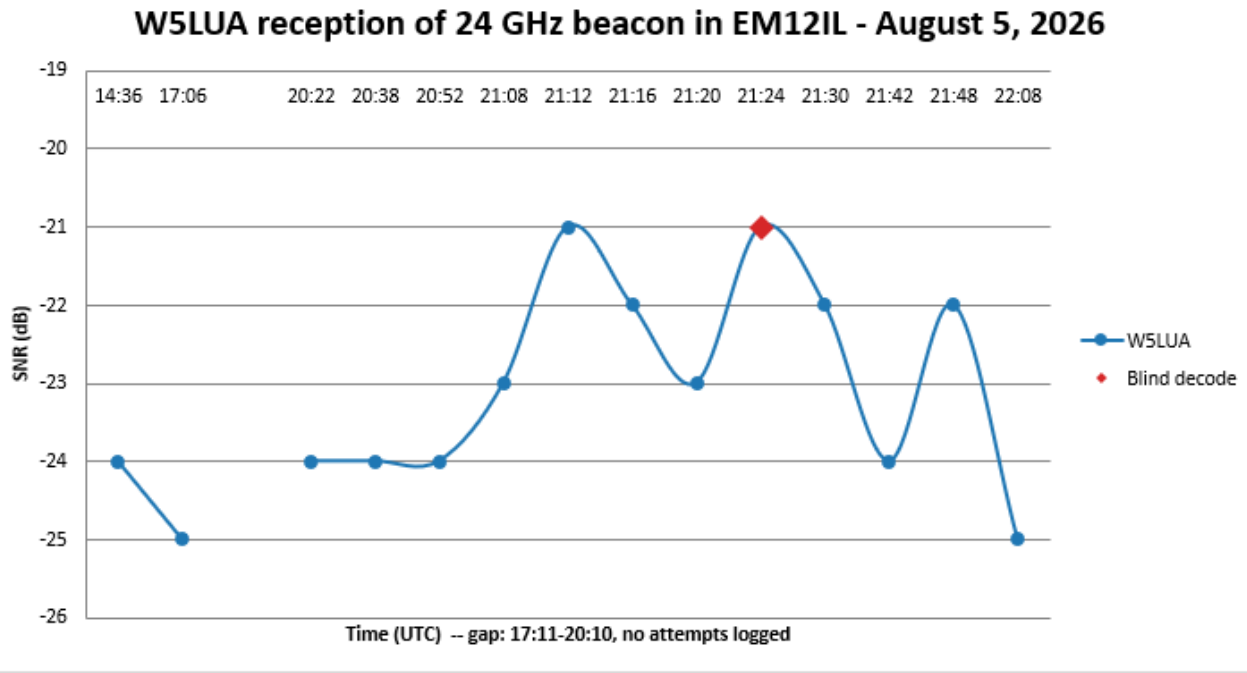
24 GHz tied to dewpoint?





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10 & 24 GHz - same day/path

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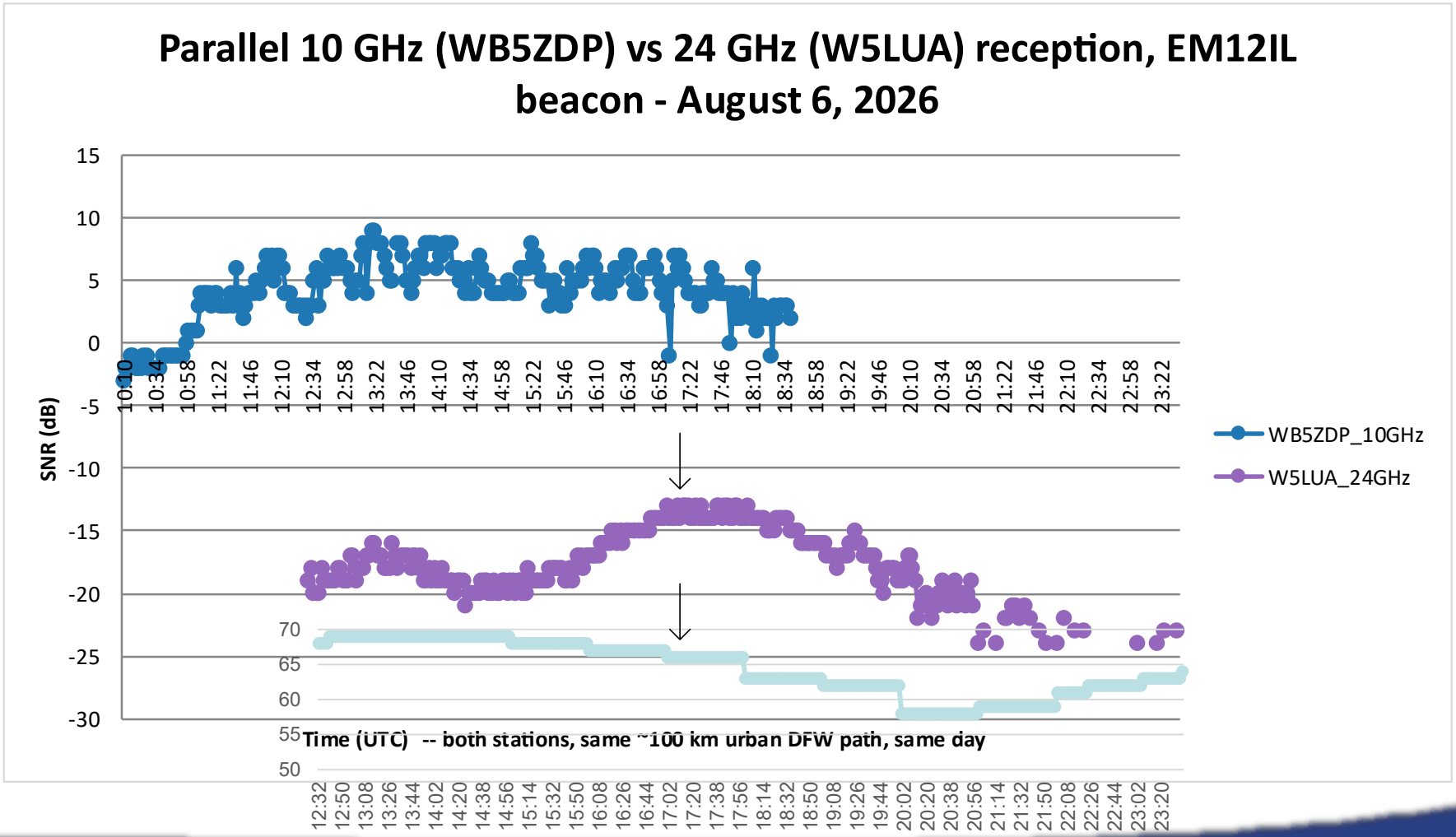

24 GHz tied to dewpoint

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Propagation Analysis

Path is terrain-obstructed at 2.5 mi (4.1 km) from KM5PO. Signal likely propagated via atmospheric ducting (sounding-detected layer at 2257–2515 ft, 15.3 M-units), bending over the terrain obstruction. At 24 GHz, high moisture (PWAT 34.8 mm) causes significant water vapor absorption.

Antenna heights: KM5PO @ 35 ft AGL, W5LUA @ 70 ft AGL.

Refractivity gradient: -105 N-units/km (super-refractive).

Boundary layer depth: 1378 m.

Ducting detected by soundings at: Fort_worth TX/US, Fort Worth Area -- KFWH KFWD.

Most likely propagation duct: sounding-detected layer at 2257–2515 ft, 15.3 M-units.

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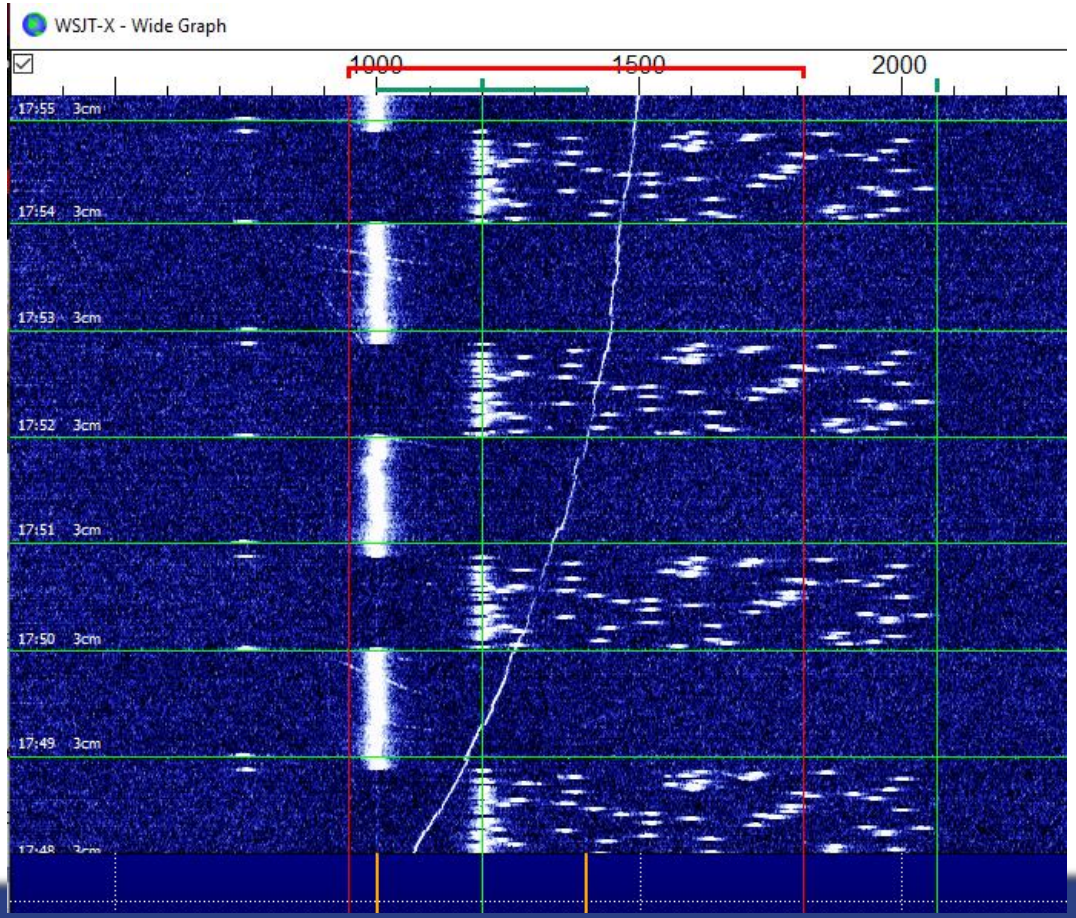
W5HN/B Denton thermal drift

- The Denton beacon reaches 10368.370 MHz at approximately 100° F.



What has been accomplished

North Texas NTMS Microwave Society

- Low-cost automated beacon monitor designs established.
- Beacon monitors built and tested.
- The actual beacons in EM12IL were upgraded on Monday 8/3/26 and have one more upgrade coming.
- We have learned what works and why and built numerous software tools to do the “lab” work.
- Now the monitor designs…

Monitor Designs

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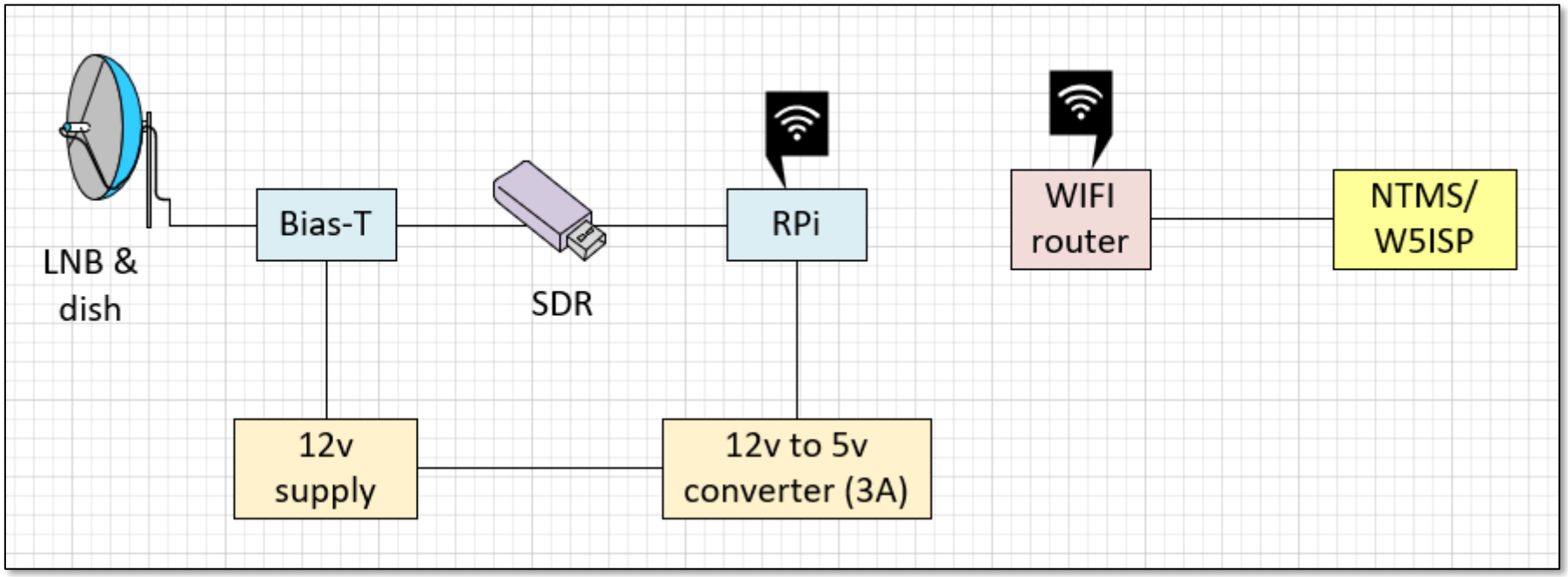
- Model #1, indoor & outdoor version



10 GHz Monitor Design

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- Model #1, indoor & outdoor version, LNB IF = 618 MHz

Part	Description
Dish	Surplus
LNB	FTA Universal Ku Band LNB 0.1 dB Model 300101
Bias-T	Needs to pass 12v to LNB and IF freq. of ~618 MHz
SDR	NooElec NESDR Smart V5 or RTL-SDR
Processor	Raspberry Pi 4 B 2 GB
DC conv.	DC to DC converter like Amazon DROK 180080AFA
Coax/cable	Various short SMA male to SMA male coax and DC wiring
Software	Available on GitHub public repo: NTMS https://github.com/North-Texas-Microwave-Society/SDR-based-beacon-receive-systems

Model #1 -10 GHz Monitor

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Monitor Designs

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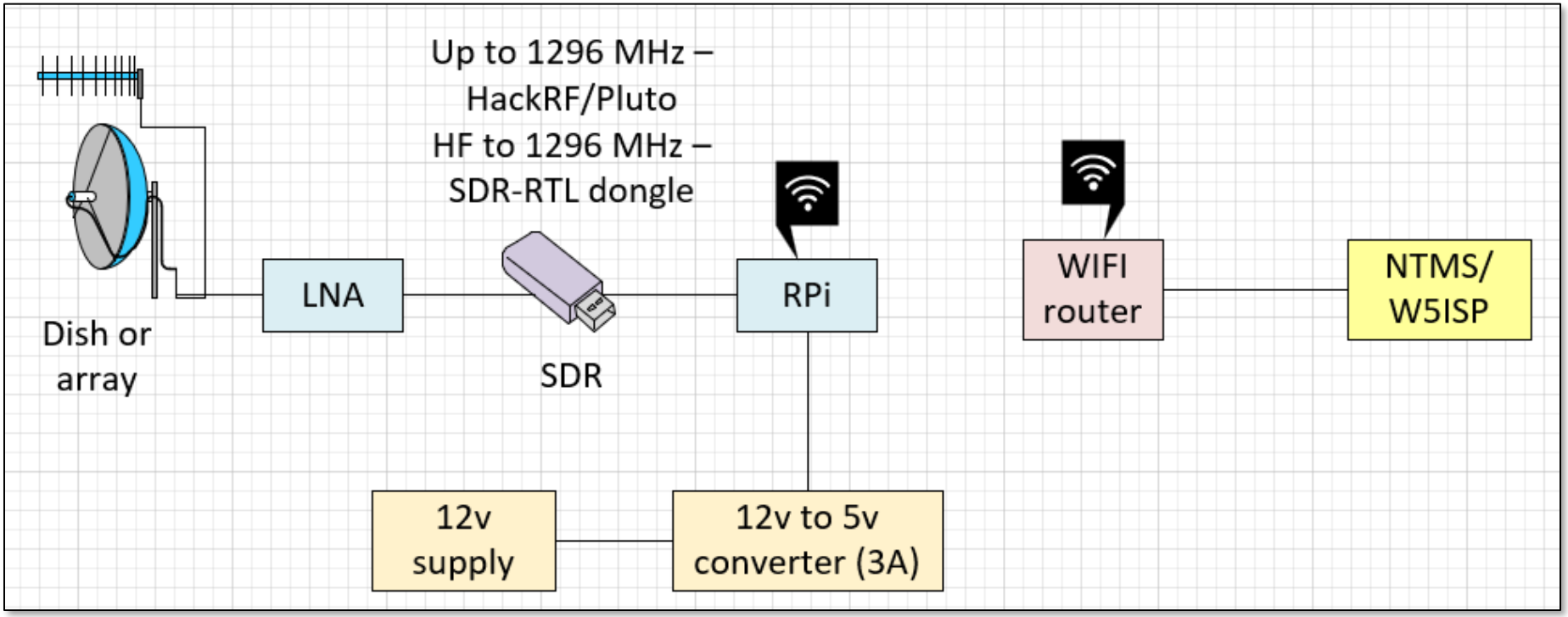
- Model #2, for bands < 10 GHz (HamSCI, others)



Monitor Designs

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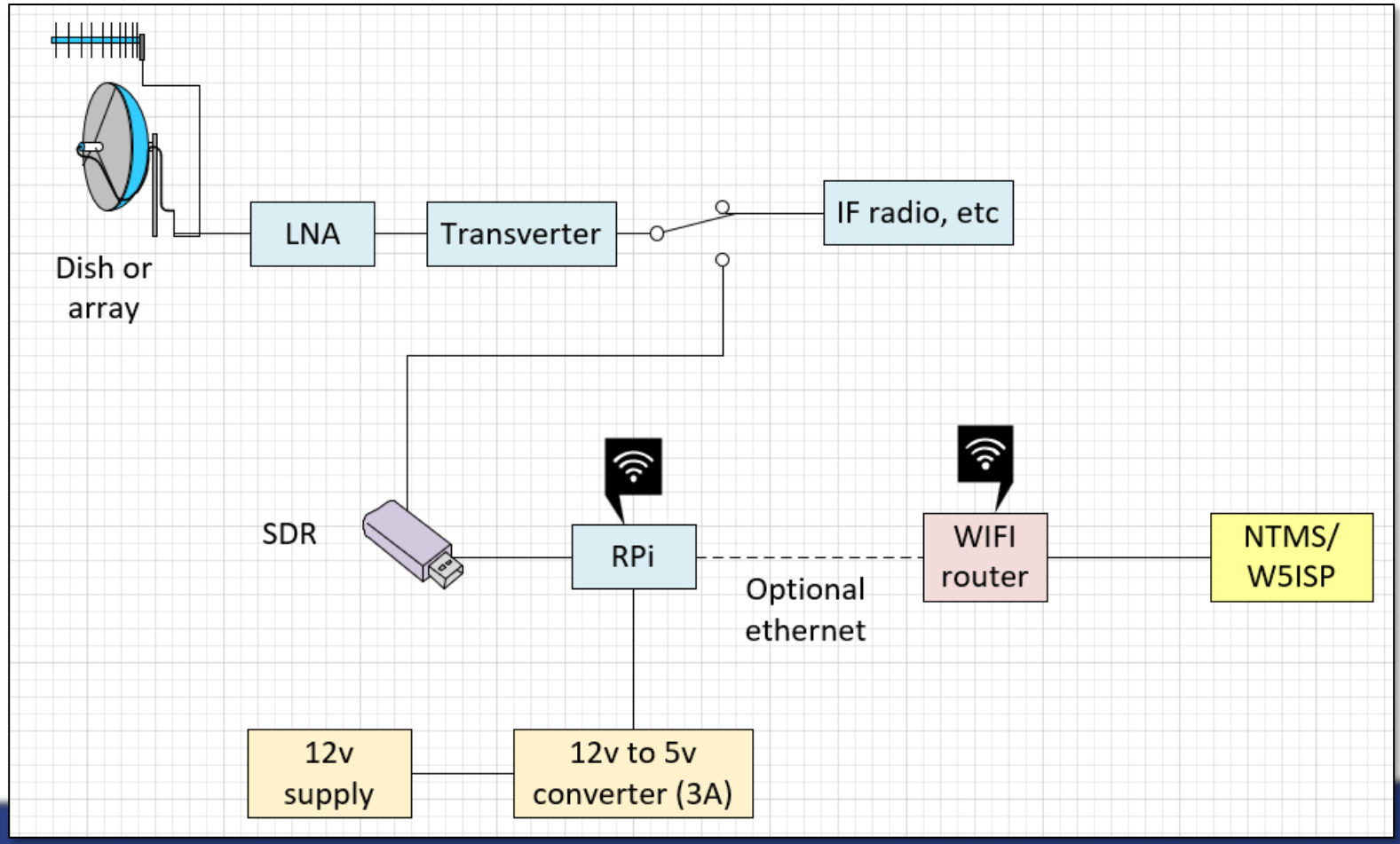
- Model #3, use existing equipment.



Monitor Designs

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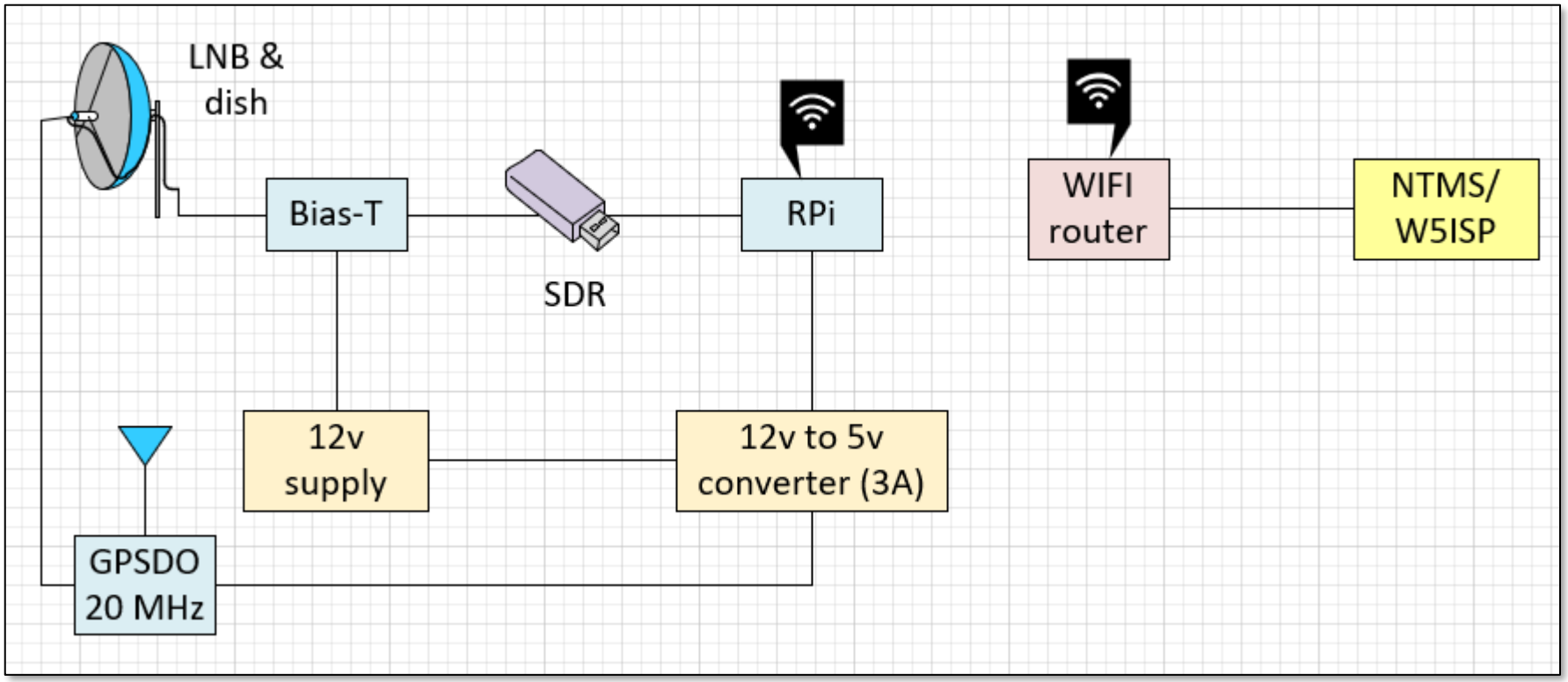
- Model #4, high stability – enables WSJT-X decode.



Monitor Designs

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Model	Basic config	Function	Pro/Con
1	Indoor/Outdoor 10/24/47/? GHz	Microwave propagation	Low cost to high cost based on freq.
2	Indoor/Outdoor Less than 10 GHz	VHF/UHF propagation	Low cost to high cost based on freq.
3	Use existing (ops) equipment	Any frequency – our demo used this model	Low cost
4	Hi stability – can decode WSJT-X	Very weak signal	Higher cost

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Model #4 Hi res system

- Bullseye modified to use external reference.
- Bodnar or other programmable GPSDO ref.
- Other components the same as Models 1 – 3.

Install the monitor

- Choose a location.
  - Consider how the device will be powered.
  - Needs to be in-range of the WIFI connection or use an ethernet cable.
    - Indoor units in plastic case use WIFI antenna printed on Rpi PCB but can be fitted with external WIFI antenna.
    - Outdoor units in metal casing use external WIFI antenna.

Software load and configuration

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- For volunteer ops, NTMS can perform the configuration. We will use a short info form.
- For others:
  - Establish connection with Rpi.
  - Pull code from NTMS GitHub.
    - This will download the latest code.
  - Run calibration script (optional).
  - Update monitor script to use gain/threshold values from calibration recommendation.
  - Start the monitor.
  - Validate the beacon is being received.

Optimize beacon monitor receive chain

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- Gain levels of receive stages.
  - The system noise floor is dominated by the fixed noise figure of the LNB so by the time the signal hits the SDR, the LNB thermal noise is well above the SDR's internal noise at moderate gain.
  - Need to find the SDR "knee".
  - Below the knee, then ADC quantization noise dominates – noise floor in dBFS appears artificially low and flat.
  - Past the knee, LNB noise dominates – noise floor in dBFS rises 1 dB per 1 dB of added gain (good-seeing real noise, not ADC artifacts)
  - Too high: ADC clips.
  - We want to be just above the knee. The threshold then sits some margin (6-10 dB?) above the noise floor.

Identify gain and threshold (one time calibration)

- While pointed to cold sky, step through all SDR gain values (29 steps, 0-49.6 dBFS).
- Take n FFT sweep at each step, averaging each.
- Compute noise floor as median power across spectrum centered on beacon frequency (+/- 500 kHz)
- Print a table: gain_dB | noise_floor_dBFS | delta_from_previous_step.
- Identify the knee and recommend gain & threshold.
- Also create .csv file for comparison across stations/LNBs.

Calibrate options

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- Here is the internal code for monitor_calibrate.sh

```
# --- RF chain ---
FREQ=618.245        # IF center frequency (MHz) after Bullseye LNB
LO=9750.0           # LNB LO frequency (MHz)
PPM=0               # PPM correction

# --- Calibration sweep settings ---
DWELL=2.0           # Seconds of IQ data collected per gain step
SETTLE=0.5          # Seconds to wait after each gain change
EXCLUDE=500         # Exclusion zone (kHz) around center when measuring noise
MARGIN=10.0         # dB above noise floor for suggested threshold
GAINS=all           # 'all' for full R820T2 sweep, or e.g. '28.0,29.7,32.8,33.8,36.4'

# --- Output ---
# Timestamped CSV saved automatically if --output not specified

sudo $PYTHON $SCRIPT \
    --freq    $FREQ \
    --lo      $LO \
    --ppm     $PPM \
    --dwell   $DWELL \
    --settle  $SETTLE \
    --exclude $EXCLUDE \
    --margin  $MARGIN \
    --gains   $GAINS
```

dBFS

- **dBFS = "decibels relative to Full Scale."**
- It's not an absolute physical unit (not watts, not volts at an antenna)
- it's purely a statement about how "loud" a digital sample is *relative to the maximum value the file format can represent*.
- For 16-bit PCM audio (what all WSJT-X WAV files are), the full-scale reference is the largest representable sample value, 32768. The formula used:
- dBFS = 20 * log10(RMS_amplitude / 32768)
- 0 dBFS is the ceiling, not a target.
- RMS vs. peak matters.
- It is a property of the digital recording, not the RF signal.

Test setup for demo

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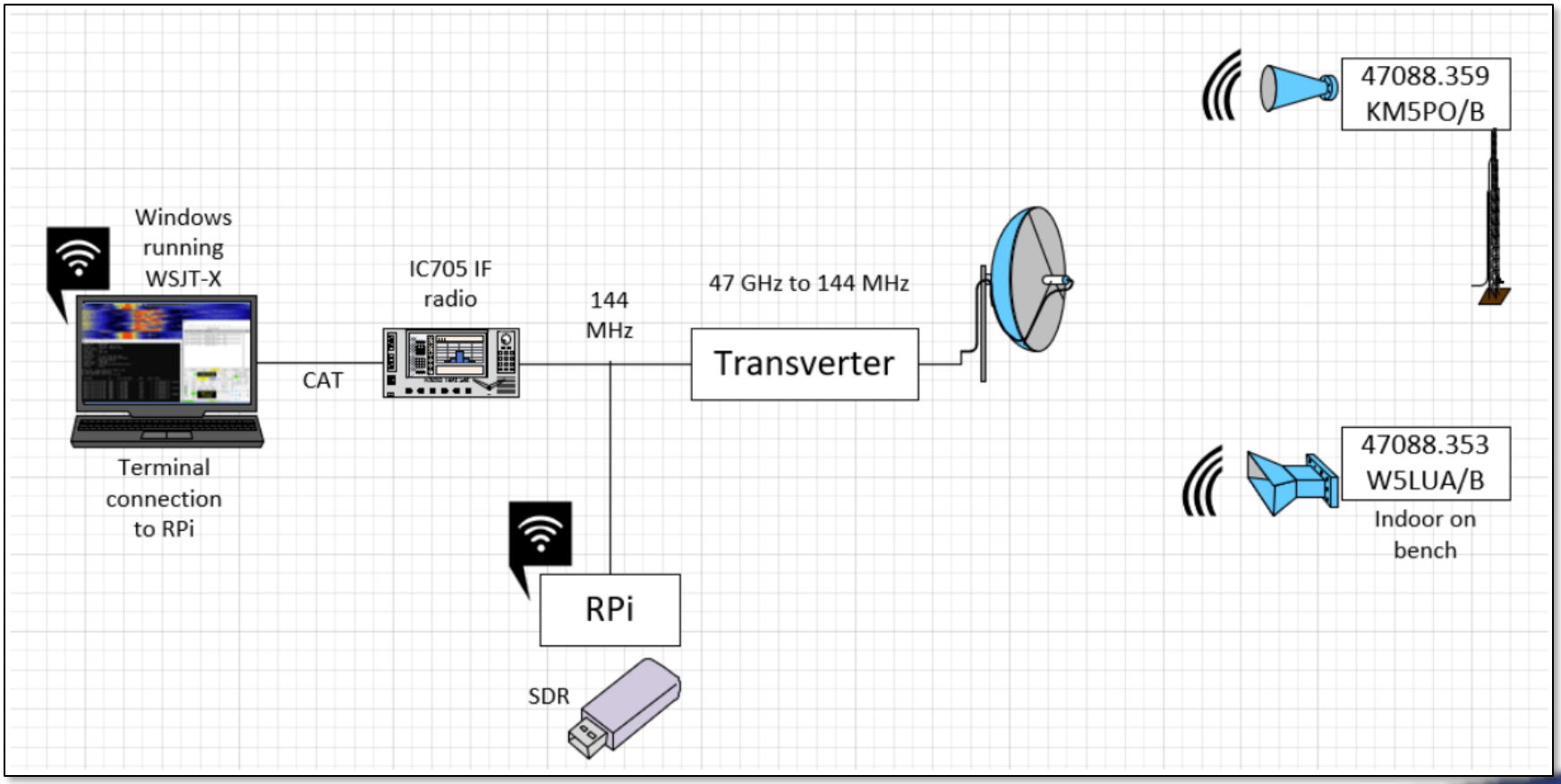
A splitter was used to feed transverter output two directions



Beacon monitor options

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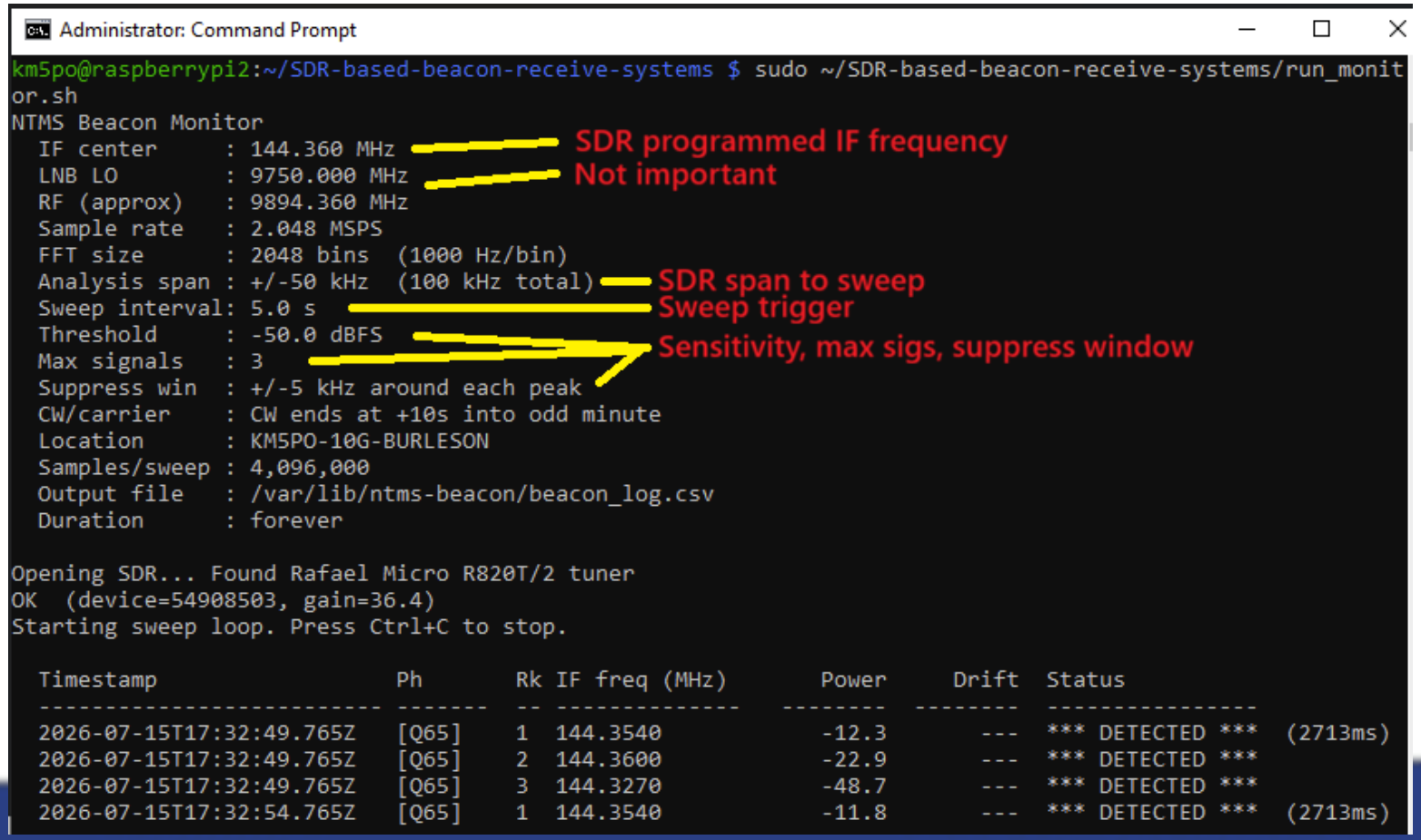
- Shell script options are printed to screen output at startup



The two 47 GHz beacons

- Outdoor KM5PO/B 47088.359
- Indoor W5LUA/B 47088.353

W5HN

Demo

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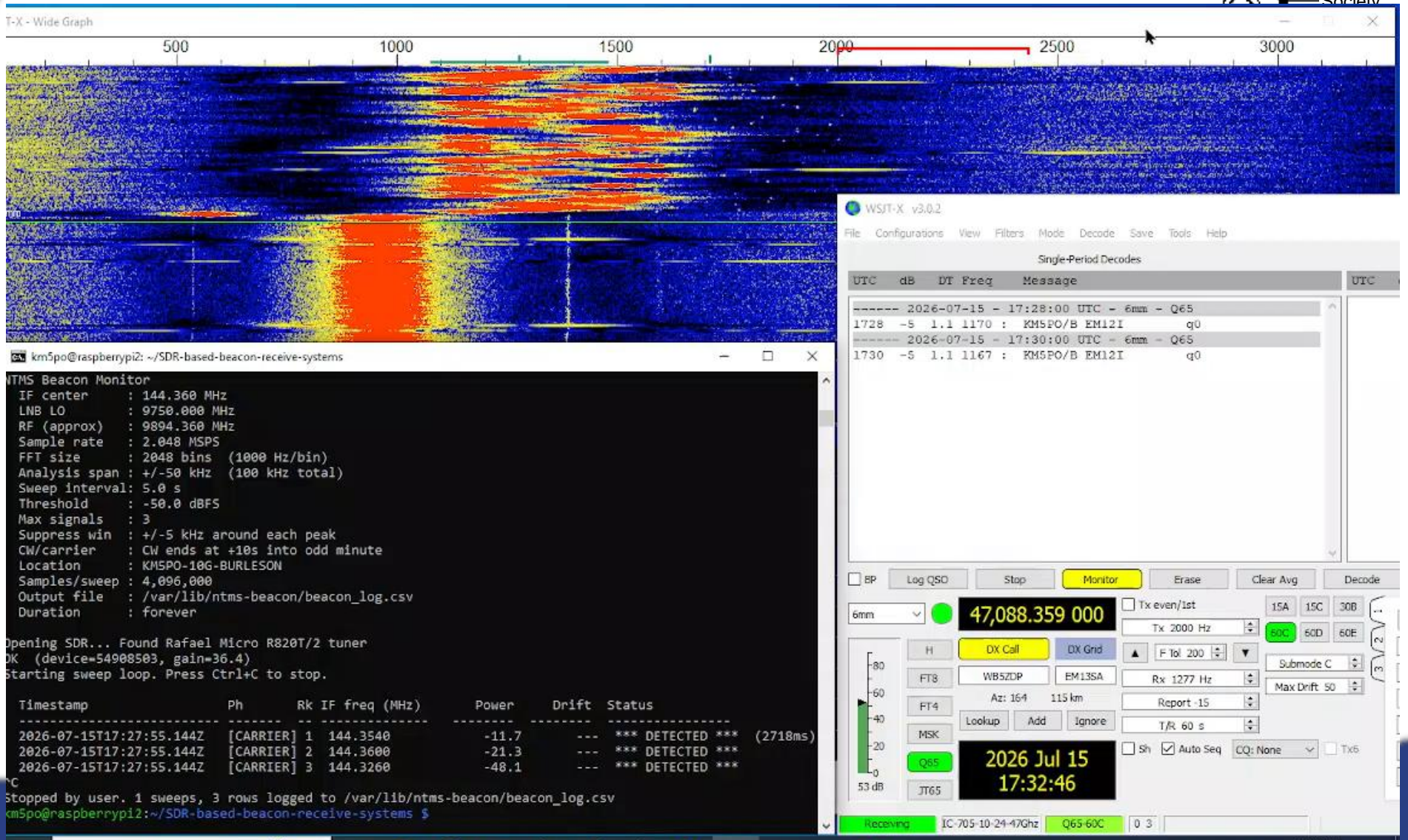

Beacon monitor display

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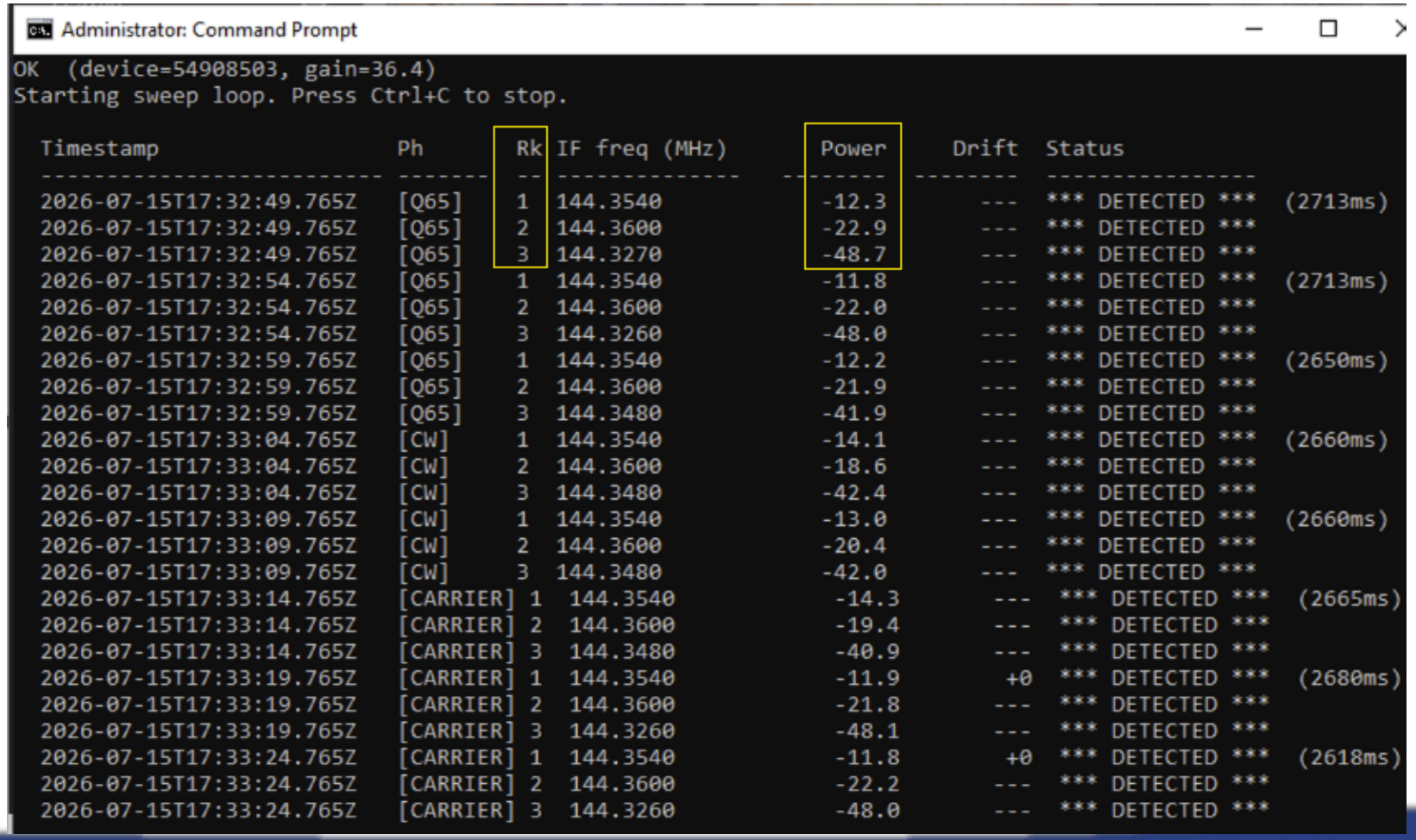


Timestamp	Ph	Rk	IF freq (MHz)	Power	Drift	Status	
2026-07-15T17:32:49.765Z	[Q65]	1	144.3540	-12.3	---	*** DETECTED ***	(2713ms)
2026-07-15T17:32:49.765Z	[Q65]	2	144.3600	-22.9	---	*** DETECTED ***	
2026-07-15T17:32:49.765Z	[Q65]	3	144.3270	-48.7	---	*** DETECTED ***	
2026-07-15T17:32:54.765Z	[Q65]	1	144.3540	-11.8	---	*** DETECTED ***	(2713ms)
2026-07-15T17:32:54.765Z	[Q65]	2	144.3600	-22.0	---	*** DETECTED ***	
2026-07-15T17:32:54.765Z	[Q65]	3	144.3260	-48.0	---	*** DETECTED ***	
2026-07-15T17:32:59.765Z	[Q65]	1	144.3540	-12.2	---	*** DETECTED ***	(2650ms)
2026-07-15T17:32:59.765Z	[Q65]	2	144.3600	-21.9	---	*** DETECTED ***	
2026-07-15T17:32:59.765Z	[Q65]	3	144.3480	-41.9	---	*** DETECTED ***	
2026-07-15T17:33:04.765Z	[CW]	1	144.3540	-14.1	---	*** DETECTED ***	(2660ms)
2026-07-15T17:33:04.765Z	[CW]	2	144.3600	-18.6	---	*** DETECTED ***	
2026-07-15T17:33:04.765Z	[CW]	3	144.3480	-42.4	---	*** DETECTED ***	
2026-07-15T17:33:09.765Z	[CW]	1	144.3540	-13.0	---	*** DETECTED ***	(2660ms)
2026-07-15T17:33:09.765Z	[CW]	2	144.3600	-20.4	---	*** DETECTED ***	
2026-07-15T17:33:09.765Z	[CW]	3	144.3480	-42.0	---	*** DETECTED ***	
2026-07-15T17:33:14.765Z	[CARRIER]	1	144.3540	-14.3	---	*** DETECTED ***	(2665ms)
2026-07-15T17:33:14.765Z	[CARRIER]	2	144.3600	-19.4	---	*** DETECTED ***	
2026-07-15T17:33:14.765Z	[CARRIER]	3	144.3480	-40.9	---	*** DETECTED ***	
2026-07-15T17:33:19.765Z	[CARRIER]	1	144.3540	-11.9	+0	*** DETECTED ***	(2680ms)
2026-07-15T17:33:19.765Z	[CARRIER]	2	144.3600	-21.8	---	*** DETECTED ***	
2026-07-15T17:33:19.765Z	[CARRIER]	3	144.3260	-48.1	---	*** DETECTED ***	
2026-07-15T17:33:24.765Z	[CARRIER]	1	144.3540	-11.8	+0	*** DETECTED ***	(2618ms)
2026-07-15T17:33:24.765Z	[CARRIER]	2	144.3600	-22.2	---	*** DETECTED ***	
2026-07-15T17:33:24.765Z	[CARRIER]	3	144.3260	-48.0	---	*** DETECTED ***	

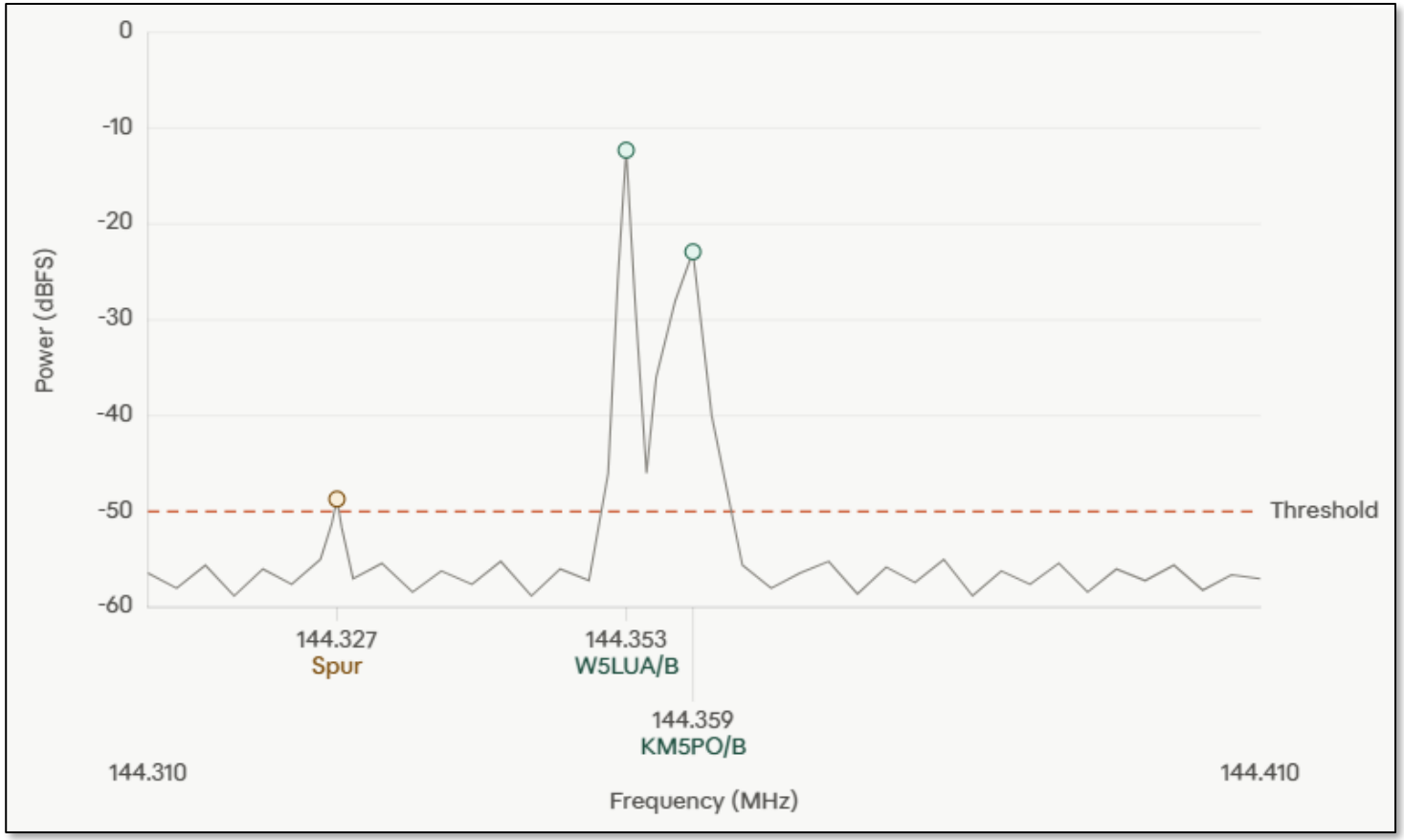
Excel beacon log

North Texas NTMS Microwave Society

/var/lib/ntms-beacon/beacon_log.csv

	A	B	C	D	E	F	G	H	I	J
1	timestamp_utc	monitor location	phase	rank	IF frequency	Actual	dBFS	over thresh		
2	2026-07-15T00:00:01.586Z	KM5PO-EM12IL56EI	Q65	1	144360000	144.353	-29.41	1		
3	2026-07-15T00:00:01.586Z	KM5PO-EM12IL56EI	Q65	2	144366000	144.359	-48.63	1		
4	2026-07-15T00:00:01.586Z	KM5PO-EM12IL56EI	Q65	3	144334000	144.327	-56.62	0		
5	2026-07-15T00:00:06.586Z	KM5PO-EM12IL56EI	Q65	1	144360000		-30.94	1		
6	2026-07-15T00:00:06.586Z	KM5PO-EM12IL56EI	Q65	2	144366000		-48.58	1		
7	2026-07-15T00:00:06.586Z	KM5PO-EM12IL56EI	Q65	3	144328000		-56.83	0		
8	2026-07-15T00:00:11.586Z	KM5PO-EM12IL56EI	Q65	1	144360000		-28.87	1		
9	2026-07-15T00:00:11.586Z	KM5PO-EM12IL56EI	Q65	2	144366000		-49.06	1		
10	2026-07-15T00:00:11.586Z	KM5PO-EM12IL56EI	Q65	3	144328000		-56.80	0		
11	2026-07-15T00:00:16.586Z	KM5PO-EM12IL56EI	Q65	1	144360000		-30.31	1		
12	2026-07-15T00:00:16.586Z	KM5PO-EM12IL56EI	Q65	2	144366000		-49.06	1		
13	2026-07-15T00:00:16.586Z	KM5PO-EM12IL56EI	Q65	3	144335000		-56.95	0		
14	2026-07-15T00:00:21.586Z	KM5PO-EM12IL56EI	Q65	1	144360000		-30.20	1		
15	2026-07-15T00:00:21.586Z	KM5PO-EM12IL56EI	Q65	2	144366000		-48.35	1		
16	2026-07-15T00:00:21.586Z	KM5PO-EM12IL56EI	Q65	3	144380000		-56.82	0		
17	2026-07-15T00:00:26.586Z	KM5PO-EM12IL56EI	Q65	1	144360000		-29.85	1		
18	2026-07-15T00:00:26.586Z	KM5PO-EM12IL56EI	Q65	2	144366000		-48.27	1		
19	2026-07-15T00:00:26.586Z	KM5PO-EM12IL56EI	Q65	3	144334000		-56.78	0		
20	2026-07-15T00:00:31.586Z	KM5PO-EM12IL56EI	Q65	1	144360000		-28.24	1		
21	2026-07-15T00:00:31.586Z	KM5PO-EM12IL56EI	Q65	2	144366000		-48.26	1		
22	2026-07-15T00:00:31.586Z	KM5PO-EM12IL56EI	Q65	3	144392000		-56.84	0		

How it sweeps spectrum



How it sweeps spectrum

- Step 1 Compute averaged power spectrum from IQ samples.
  - Splits the sample buffer into non-overlapping FFT frames, windows each, computes magnitude squared, and averages across frames.
- Returns:
  - freqs_offset: array of frequency offsets from center (Hz), FFT-shifted. power_db: array of power values in dBFS (dB relative to full scale).

- Step 2 Find up to max_signals peaks within +/-(span/2) of center using iterative peak suppression.
- Algorithm:
  - 1. Find strongest peak in span.
  - 2. Suppress +/-suppress_hz bins around it (zero them out in a copy).
  - 3. Repeat up to max_signals times.
- Returns:
  - list of (peak_freq_hz, peak_power_dbfs) tuples, strongest first. Always returns at least one entry.

What has been accomplished

North Texas NTMS Microwave Society

- Low-cost automated beacon monitor designs established.
- Beacon monitors built and tested.
- The actual beacons in EM12IL were upgraded on Monday 8/3/26 and have one more upgrade coming.
- We have learned what works and why and built numerous software tools to do the “lab” work.
- Now the beacon upgrades…

Beacon improvements (as of Monday 8/3/26)

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- 10 GHz:
  - New PA installed raising power by 10 dB (to 3 watts)
- 24 GHz:
  - New PA installed raising power by 15 dB (to 4.5 watts) thank you K5SOP Jerry!
  - Replaced slot array with 27 dBi Len/Horn.

Next beacon upgrade

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- 10 GHz:
  - Add power divider to supply RF to two DEMI 3 watt PAs – the current PA and one new PA.
  - Add 12” dish or horn pointed South to the Steves[2] (K5MNZ and K5DOG)
  - Keep second array as (the current) slotted waveguide for omni-directional coverage.
- 24 GHz:
  - Consider a 12” dish (35 dBi) which would be higher gain but tighter pattern.

What has been accomplished

North Texas NTMS Microwave Society

- Low-cost automated beacon monitor designs established.
- Beacon monitors built and tested.
- The actual beacons in EM12IL were upgraded on Monday 8/3/26 and have one more upgrade coming.
- We have learned what works and why and built numerous software tools to do the “lab” work.
- Now “learning what works and why”…

What and Why

- Rfzero modulation = see the CW/Carrier signal before decodes occur. +2.1 dB SNR
- Understanding the decode threshold.
- Optimize receive chain on beacon monitor.
- Lab tools created:
  - Q65 Toolkit – Creates synthetic Q65 files
  - Q65 Analysis – Performs analysis on wav files

CW/Carrier but no Q65 decode

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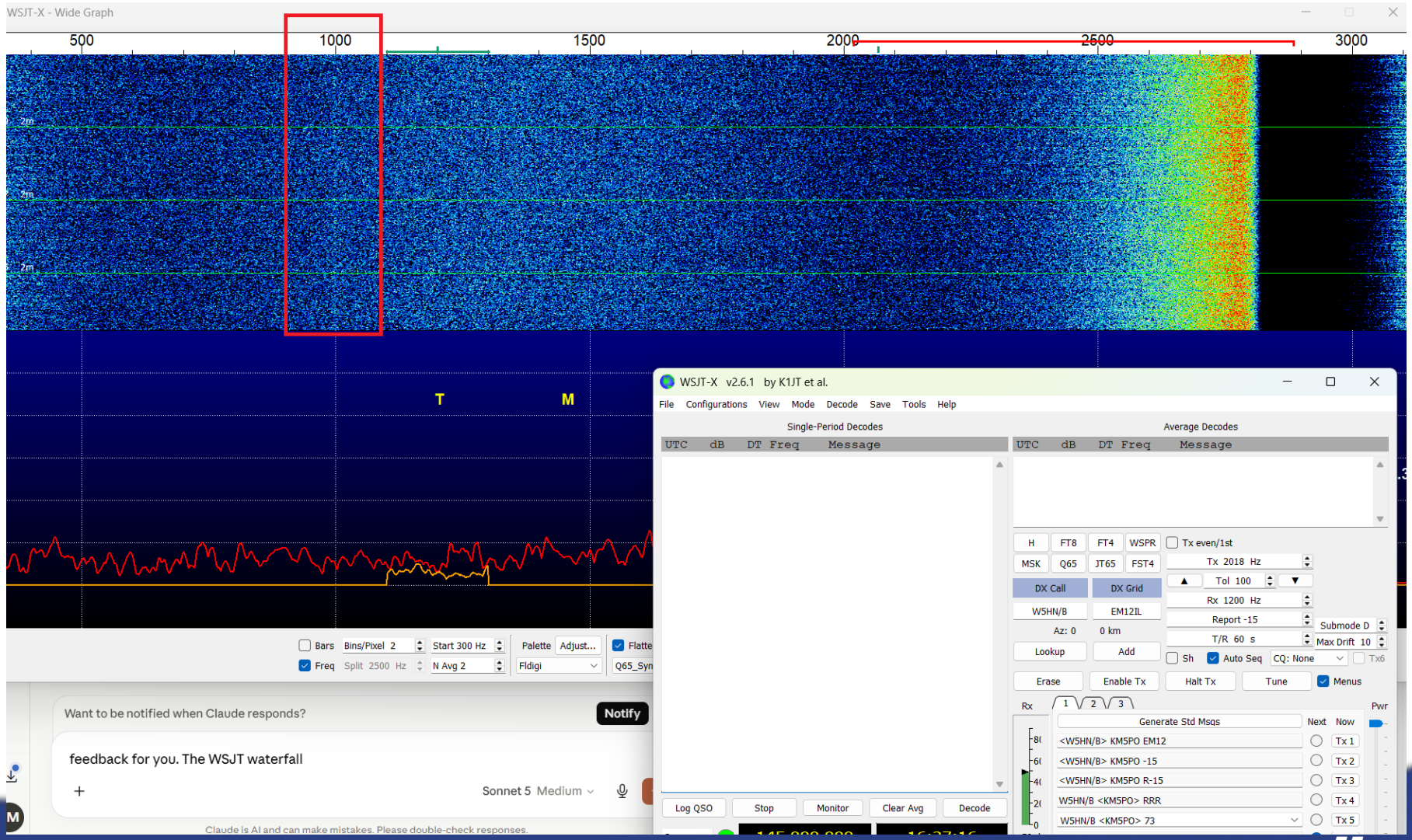

Beacon decode limit is approximately -27 / -28

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Beacon message cannot enter the AP pipeline

Basic parameters of Q65 for each of the five T/R sequence lengths and their minimum tone spacings ("A" submodes) are summarized in the table below. Threshold sensitivities (SNR in 2500 Hz bandwidth yielding 50% probability of decode) were measured for each submode using simulations over the additive white Gaussian noise (AWGN) channel. As with other recently developed modes in *WSJT-X*, a feature called *a priori* (AP) decoding improves sensitivity by several additional dB as information is accumulated during a standard minimal QSO.

50% decode probability

T/R Period (s)	Symbol Length (s)	"A" Tone Spacing (Hz)	"A" Occupied Bandwidth (Hz)	Transmission Duration (s)	SNR (dB)	Max AP SNR (dB)
15	0.150	6.667	433	12.8	-22.2	-23.7
30	0.300	3.333	217	25.5	-24.8	-26.6
60	0.600	1.667	108	51.0	-27.6	-30.2
120	1.333	0.750	49	113.3	-30.8	-32.5
300	3.456	0.289	19	293.8	-33.8	-37.4

Ordinary noise floor improvements

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	0	1	2	3	6	10	14
-26 dB	–	50%	100%	100%	100%	100%	100%
-27 dB	0%	0%	50%	100%	100%	100%	100%
-28 dB	0%	0%	0%	50%	100%	100%	100%
-29 dB	0%	0%	0%	0%	0%	0%	0%
-30 dB	0%	0%	0%	0%	0%	0%	0%

Broadband noise dip depth (dB) →

A 2 dB improvement makes possible a -27 dB decode

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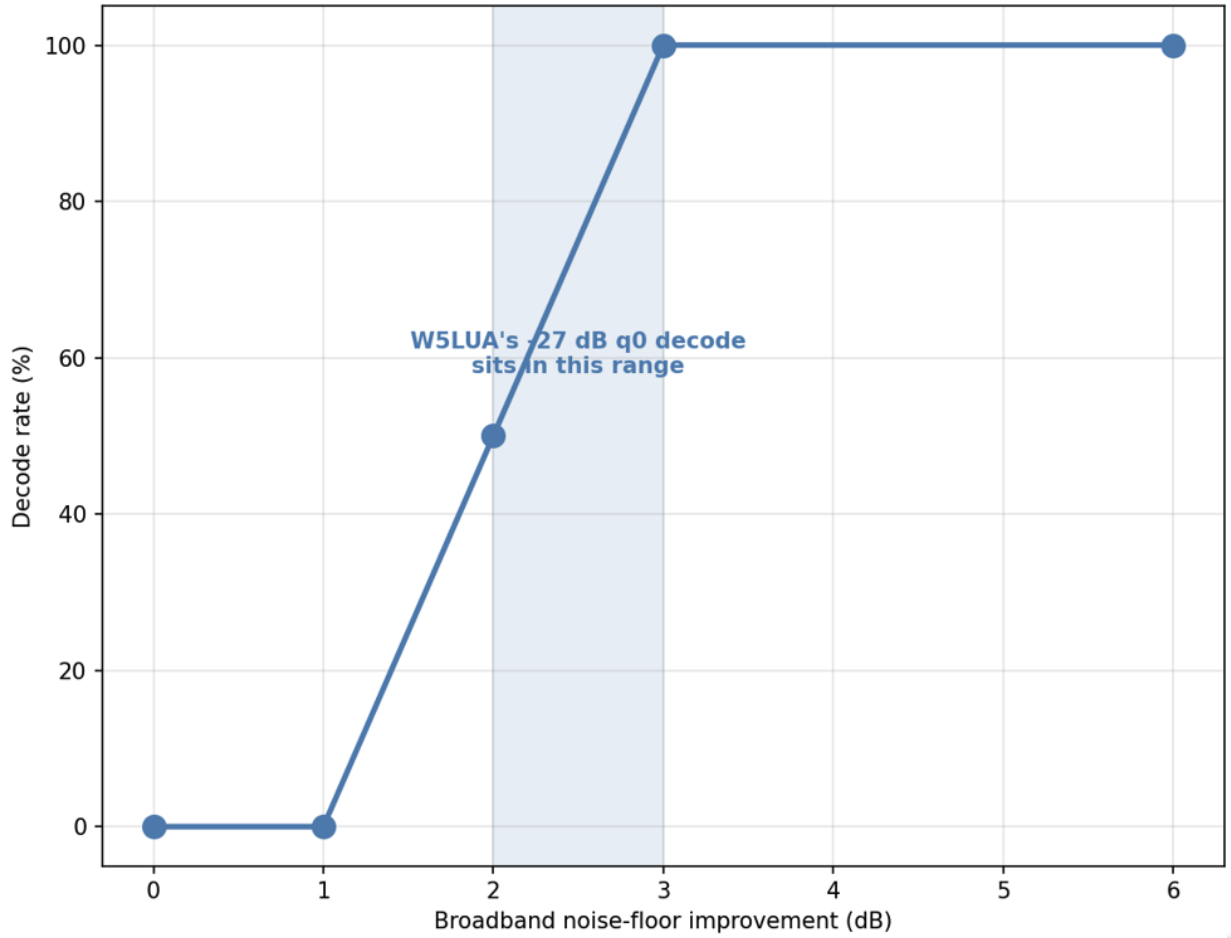

Why “AP adds ~3 dB” does not apply here

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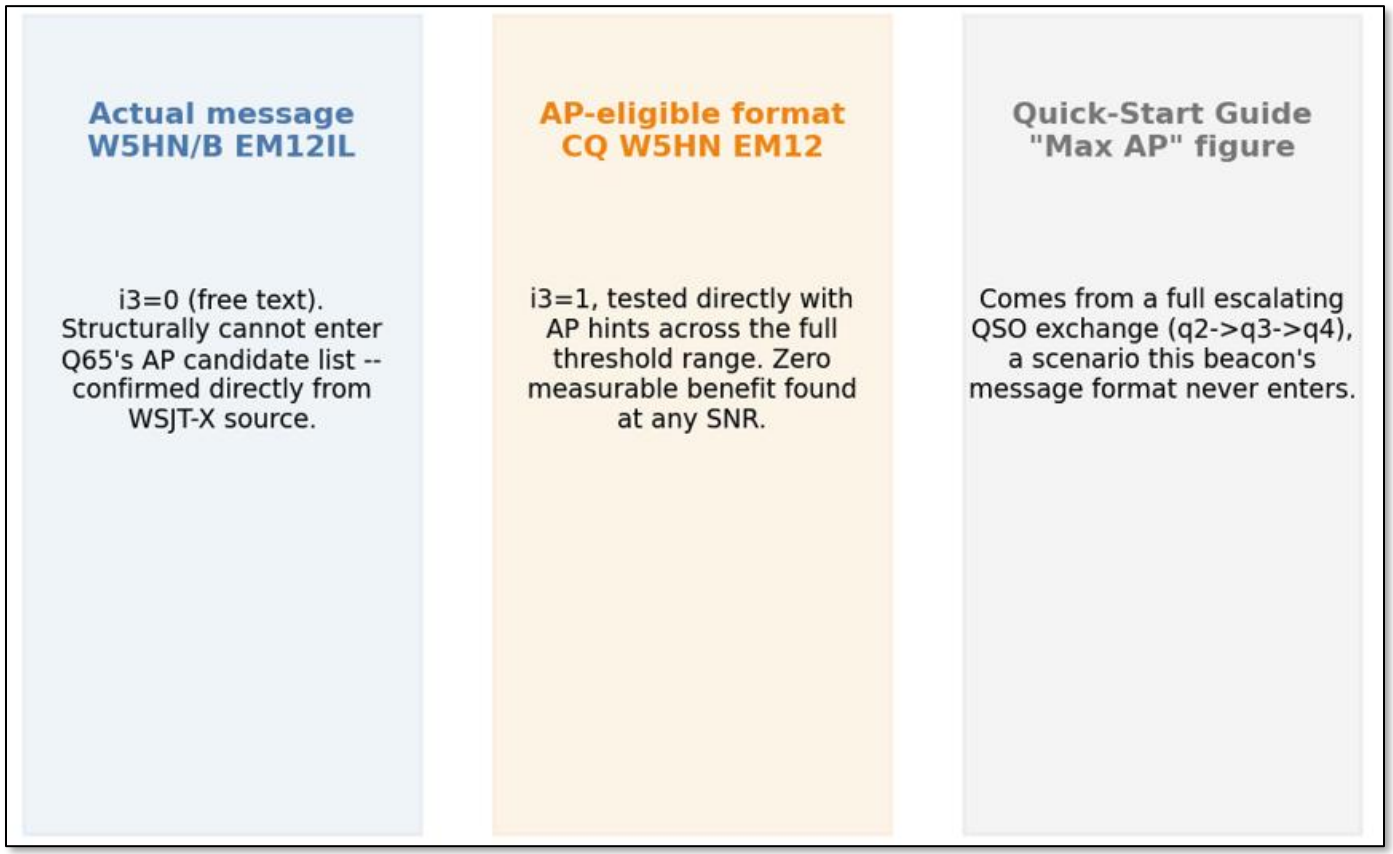

Noise floor median matters

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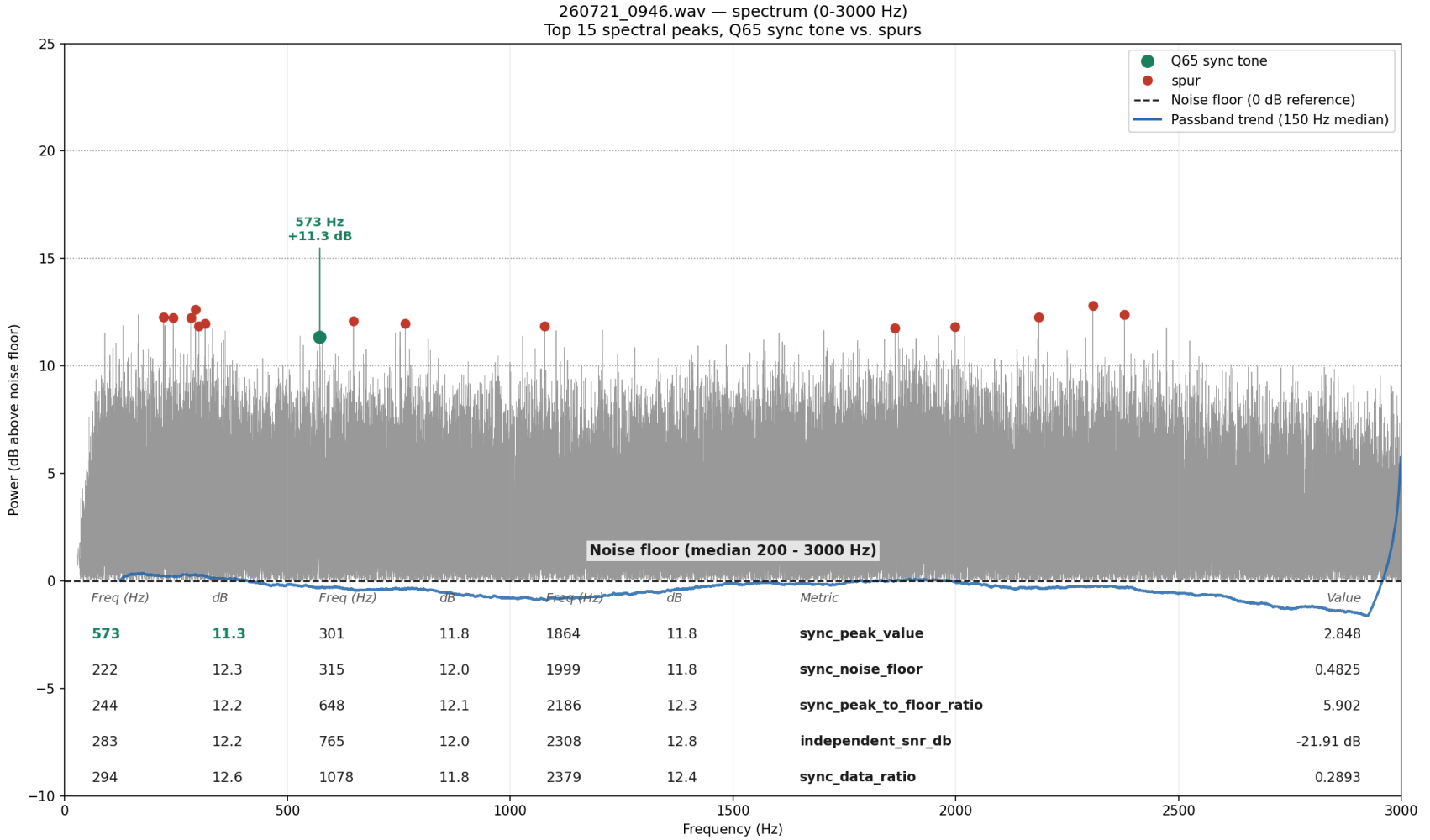
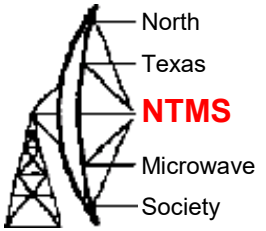
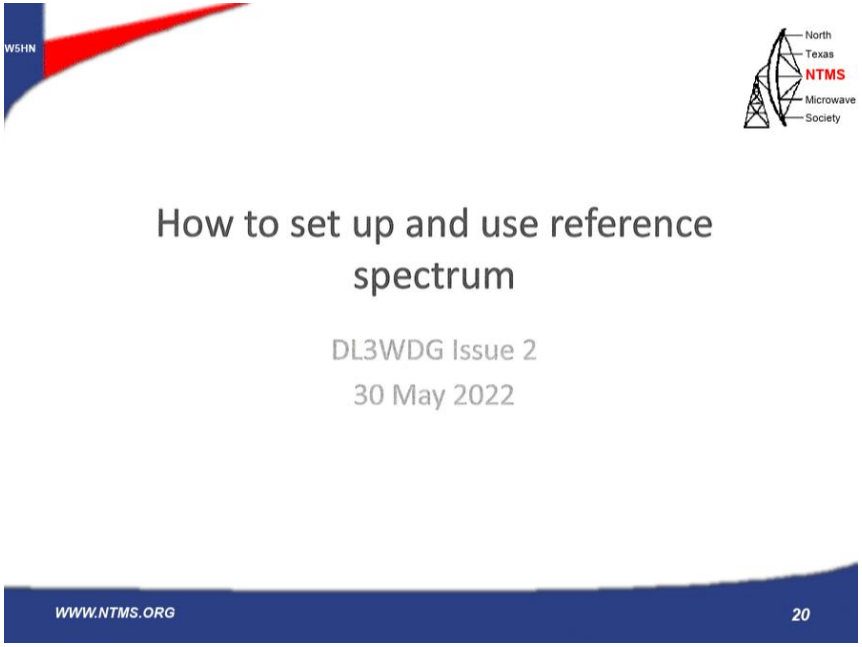
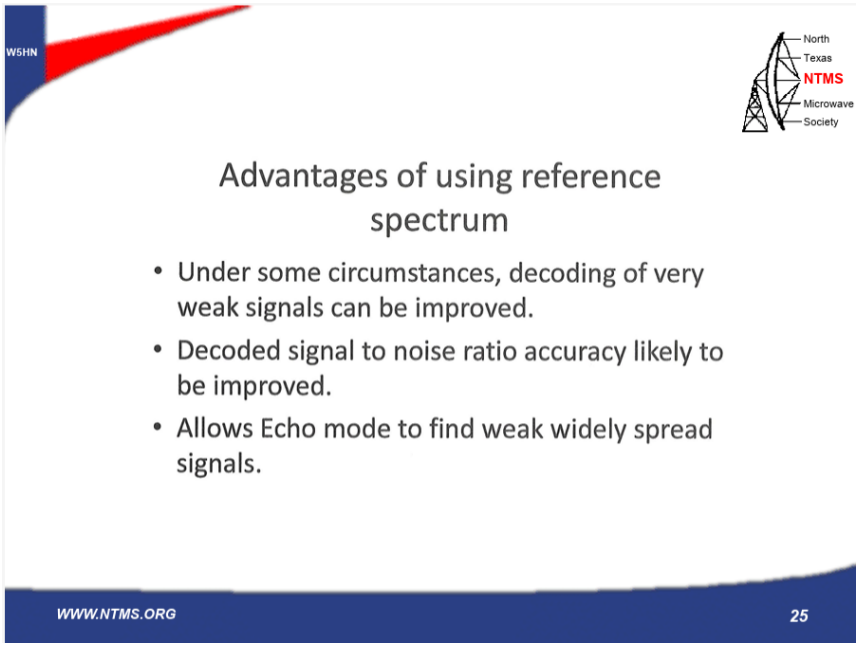


Freq (Hz)	dB	Freq (Hz)	dB	Freq (Hz)	dB	Metric	Value
573	**11.3**	301	11.8	1864	11.8	**sync_peak_value**	2.848
222	12.3	315	12.0	1999	11.8	**sync_noise_floor**	0.4825
244	12.2	648	12.1	2186	12.3	**sync_peak_to_floor_ratio**	5.902
283	12.2	765	12.0	2308	12.8	**independent_snr_db**	-21.91 dB
294	12.6	1078	11.8	2379	12.4	**sync_data_ratio**	0.2893

Tuning your RX system







W5LUA presentation from last month:
https://ntms.org/files/July2026/W5HN_BCN_EM12il_July2026_RevA.pdf

Q65Toolkit

North Texas NTMS Microwave Society

- Runs under Ubuntu (Linux).
- Generates synthetic WSJT-X Q65 .wav files

q65_synth.py

C: › Users › km5po › Downloads › q65_synth.py

```
31   Q65 TIMING (confirmed against WSJT-X source, lib/qra/q65 and map65/libm65):
35       - Tone spacing depends on submode: dfgen = 2**(mode65-1) * 12000/7200 Hz
40           mode65=5 -> E -> 26.67 Hz
41       - Tone for symbol j: f = f0 + itone(j)*dfgen, itone in [0,64].
42         itone==0 marks a sync symbol (transmitted exactly at f0).
43
44   Usage:
45       python3 q65_synth.py "W5HN/B EM12IL" --submode D --snr -18 \
46           --f0 1200 --out beacon_test.wav
47
48       # Batch-generate a set spanning a range of SNRs for calibration:
49       python3 q65_synth.py "W5HN/B EM12IL" --submode C --snr-sweep -30 -10 5 \
50           --out-dir calibration_set/
51
52       # With channel impairments -- accelerating drift, spreading that
53       # changes twice, and a slowly-fading signal:
54       python3 q65_synth.py "W5HN/B EM12IL" --submode D --snr -14 \
55           --drift-start 0.01 --drift-end 0.05 \
56           --spread-min 2 --spread-max 8 --spread-changes 2 \
57           --fade-mode varying --fade-range-db 6 --fade-timescale 5 \
58           --out spread_test.wav
59
60   See q65_channel.py for the full design rationale and caveats on the
61   drift/spread/fade models.
```

Q65Analysis

North Texas NTMS Microwave Society

- Runs under Windows.
- Batch .wav file processor
- Deep_dig .wav file processor

q65_deep_dig.py

C:\Users\km5po\q65analysis\q65_deep_dig.py

```
#!/usr/bin/env python3
r"""
q65_deep_dig.py
---------------
Deep analysis of marginal/sub-threshold Q65 recordings:
  1. Blind decode (jt9, no AP hints)
  2. AP-assisted decode (jt9, with expected callsign/grid supplied as hints)
  3. Sync-correlation curve extraction (red.dat) regardless of decode outcome,
     so we get a quantitative "was there a sync tone" answer even on total
     decode failures.
  4. Cross-file stacking of the sync curves (since a GPS-locked beacon won't
     drift file-to-file, incoherent averaging across the whole series adds
     real integration gain).

IMPORTANT jt9 quirk this script works around: red.dat/decoded.txt/avemsg.txt
are written to the *temp-path* (-t), which defaults to the current working
directory -- NOT the data-path (-a). If you run jt9 repeatedly from the same
cwd without isolating each run, later runs silently clobber earlier runs'
red.dat. This script runs every jt9 invocation in its own temp directory.

Usage:
    python3 q65_deep_dig.py /path/to/wavs --submode D --period 60 \
        --his-call "W5HN/B" --his-grid "EM12IL" --out-dir results/
```

Next steps (Part 2 updates)

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- Deploy beacon monitors in DFW area.
- Current planned beta monitor sites:
  - WA5WCP - G. Paul EM12JO88PM
  - W5ISP - Graham EM13SF88TX
  - KG5EIU – David EM13RB30JH?
  - W0LGQ – Greg EN21CI25IP (monitors KM0T)
  - K5MNZ – Steve EM11AR17DE Southern Sentinel
- Build hi-stability beacon monitor for Q65 decode reporting.

addendum

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- Upgrades to NTMS/W5ISP prop engine

Latitude-aware sunrise: The time-of-day factor now uses your actual latitude to compute sunrise hour via solar declination, instead of a single flat table. Across CONUS sunrise varies by ~2 hours north-to-south, so a station in Minnesota gets a different pre-dawn inversion window than one in Texas. The scorer now captures that.

Wind, cloud cover, and rain now live on path-scored contacts: These three factors carry ~30% of the composite weight but were previously hardcoded to neutral on every contact. Path scoring now pulls actual 10m wind speed, sky cover percentage, and precipitation rate from HRRR profiles along the path.

addendum

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- Upgrades to NTMS/W5ISP prop engine

Weights recalibrated: L2 regularization added to the weight-fitting process. Per-band factor weights were refit and written to a single source of truth. The recalibration prevents negative weights (which were physically meaningless) and enforces a held-out validation set so the test data doesn't leak into the fit.

Validation results: Out-of-sample Spearman correlation on 2025+ contacts (n=2,682) shows the algorithm beats a persistence baseline on 5 of 6 bands with ≥50 test contacts. Mean ρ = +0.18 across bands. 24 GHz is the weak spot — the algorithm underperforms persistence there (ρ = +0.17 alg vs +0.30 persistence).

addendum

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- Upgrades to NTMS/W5ISP prop engine

Forecast skill non-monotonic with lead time: On 10 GHz and 24 GHz, the 6-hour-old weather profile often produces a *better* score than current conditions, suggesting short-term noise in the current-conditions features exceeds signal at some leads (requires further study).

10 GHz profile 24 hr today

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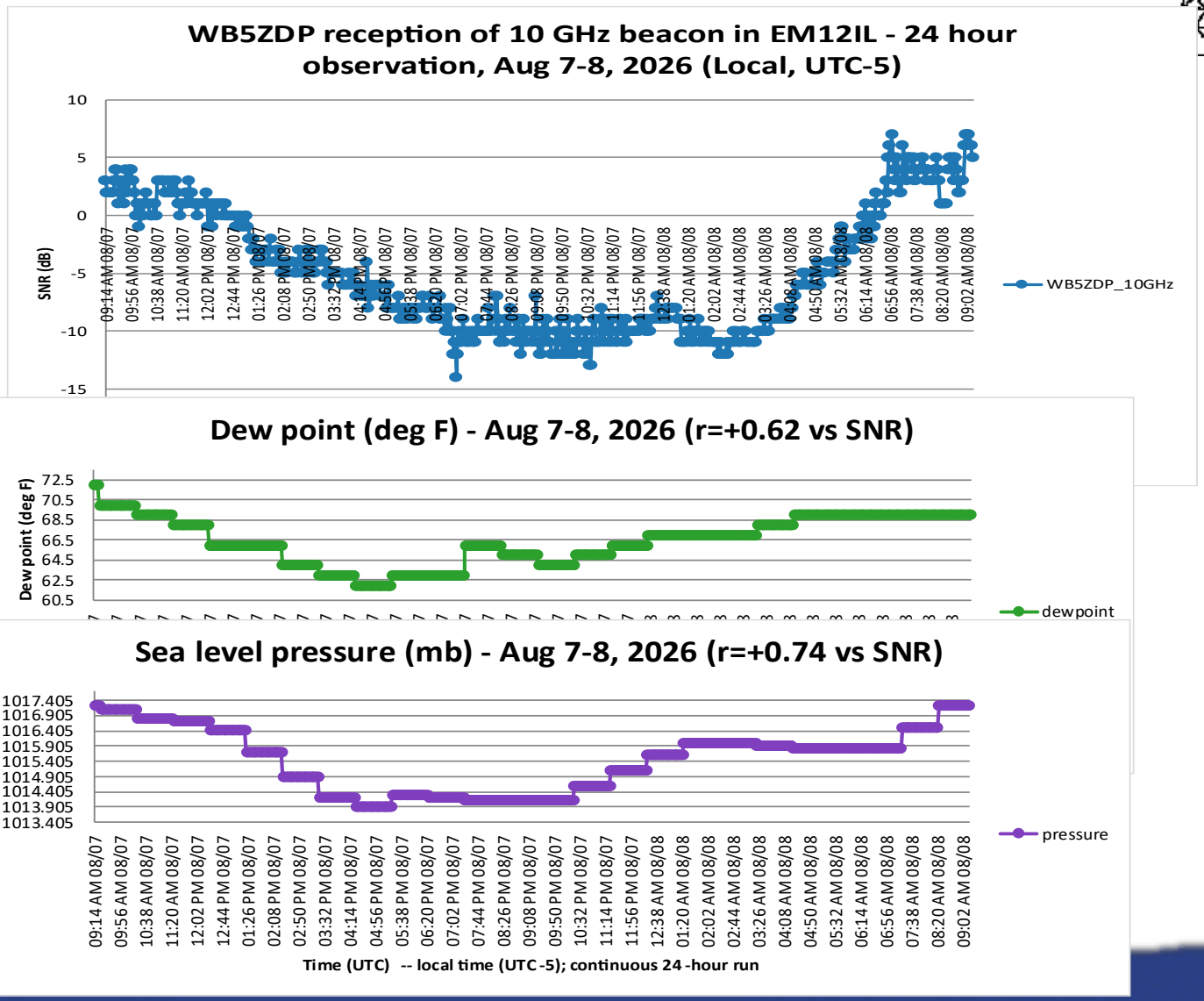


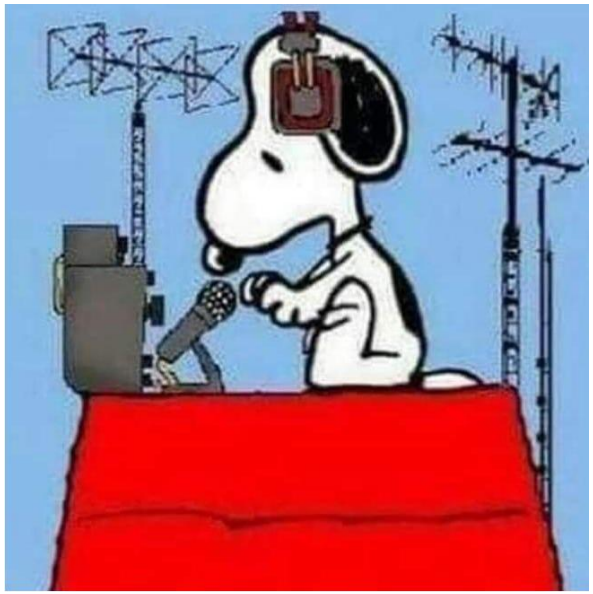
North Texas NTMS Microwave Society

Links and references

youTube Beacon demo – two 46 GHz beacons

youTube Beacon calibration run demo

W5LUA presentation from July 2026 containing DL3WDG procedure: W5HN_BCN_EM12il_July2026_RevA.pdf
Analysis and Forecasting mm-Wave Propagation – Part 1, https://ntms.org/files/Mar2026/Analysis%20and%20Forecasting%20mm-Wave%20propagatioin%20-%20Part%201.pdf
Analysis and Forecasting mm-Wave Propagation – Part 2, https://ntms.org/files/April2026/Analysis%20and%20Forecasting%20mm-Wave%20propagatioin%20-%20Part%202.pdf
NTMS propagation algorithm engine documentation, https://prop.w5isp.com/algo
NTMS contacts database, https://prop.w5isp.com/contacts
NTMS path calculator, https://prop.w5isp.com/path
NTMS real-time propagation map, https://prop.w5isp.com/map
NTMS weather / atmospheric map, https://prop.w5isp.com/weather
NTMS beacons database, https://prop.w5isp.com/beacons
Quick-Start Guide to Q65, K1JT, https://wsjt.sourceforge.io/Q65_Quick_Start.pdf
NTMS GitHub, North Texas Microwave Society · GitHub
Algorithm 1 NTMS original prop analyzer, mm-Wave Link Budget Analyzer
Algorithm 1 NTMS original mm-wave link budget analyzer, mm-Wave Link Budget Analyzer

Questions?

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