OVERVIEW OF POPULAR AMATEUR RADIO DIGITAL MODES

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AARC Mtg

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YOUR PRESENTER- JEFF N5MNW

- Owned a "Mom & Pop & Son" Elx repair store in San Marcos 1976-1983
- Attended DeVry Institute of Tech in Dallas, TX 1978-1980 (EET Grad)
- Joined Motorola in 1981 > Freescale > NXP
- Still Impersonating EE & ME (occasionally successful!)
- Amateur Radio- Advanced Class 1988, Extra 2000
- Married one of my students! Lori KM5MQ, Extra 1999?
- Retired MOT/FSL/NXP 2023(42yrs) as Sr. Eng. Tech.
- Enjoy Tinkering & Teaching E/M and Radio Technology
- Music- singing and entertaining(anyone surprised?)
- Woodworking, Metalworking, etc.

DISCLAIMERS

- This presentation is not an exhaustively intricate look at every technical detail of digital comms.
- It's a fun, lite-tech history & overview of a few fascinating and powerful digital modes.
- Definitely not a "How To Guide" or "Digicomms For Dummies" :0)

- N5MNW is –not- a Digimode Technical Guru. Much of the following was gleaned from harvesting the interwebs, interleaved with my bulleted ramblings…
- I have attempted to give acks to the original articles and websites/pages. I'm sure I've missed a few…

BIG NEWS IN FCC RULES(PER ARRL PETITION)

- On November 13, 2023, the Federal Communications Commission (FCC) adopted a Report and Order that eliminated the baud rate limitation for most Amateur Radio HF bands. (Still 300 baud in 2200m and 630m LF/MF bands)

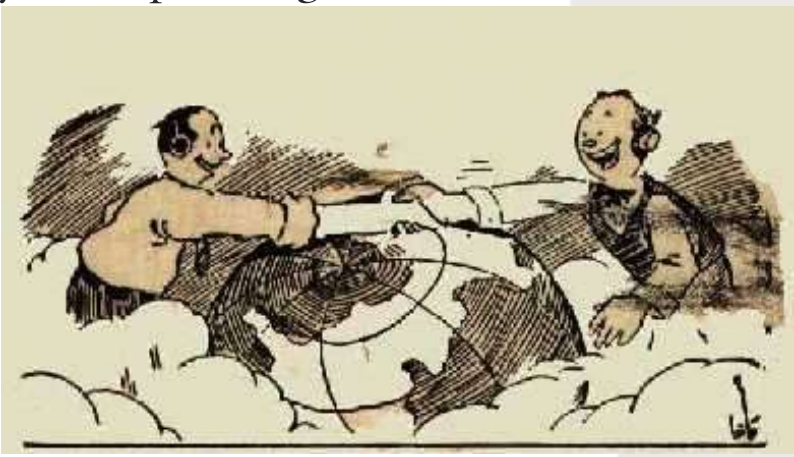
- Baud rate, also known as symbol rate, is the rate at which the amplitude, frequency, and/or phase of a carrier waveform is varied to transmit information. With RTTY & other legacy modes, increased meant speed proportionally increased Bandwidth.

- FCC replaced the baud rate limitation with a 2.8 kilohertz (kHz) bandwidth limitation in the affected bands. Reference part 97.307(f)

- FCC says this change will promote continued sharing in these bands and incentivize innovation and experimentation by allowing licensees to use modern digital emissions.

WHY SHOULD I TRY DIGITAL??

- Advances the Radio Art and International Good Will!
- Per ARRL Petition, FCC changed the HF baudrate limit(300bd) to a max BW limit(2.8kHz)
- FCC already allowed >>300baud on HF using PACTOR4 during actual EMCOMM events
- Most Digi Modes S/N ratio are -20 to -30dB better than Voice & CW, especially with poor signal/noise
- Generally less Bandwidth than voice modes(but not always)
- Allows information to be automatically "stored & forwarded"
- Enables Antenna-Compromised, QRP & Field Stations to Work the World!
- Enables Moderate-Power EME!
- Modern computers allow for sophisticated & affordable signal processing
- No need to update hardware for (most)new modes, everything is in the software
- You have access to most modes through droves of open-source & FREE software



- **Any other reasons?**
- It makes Crusty Old Codgers cringe?
- Keeps the kids off TikTok?

THE ISS HAS DIGITAL AMATEUR RADIO!

- What better way to keep your station abreast of science? SPACE!!!

- Red Arrow points to one of the Ham (VHF) antennas on the ISS
- Used for Voice & Digital Comms
- Frequent Overflies

- 1200 bd FM Packet: 145.825
- FM crossband Repeater:

  145.99(67Hz)up

  437.800down
- SSTV/Other: 145.800

https://www.amsat.org/amateur-radio-on-the-iss/

https://www.ariss.org/current-status-of-iss-stations.html

LATEST STATUS OF ISS HAM RADIO STATIONS - ARISS.ORG

Columbus Module radio: IORS (Kenwood D710GA) – **STATUS - Configured.**

Default mode is for voice repeater (145.990 MHz up {PL 67} & 437.800 MHz down).

Powering **OFF Jan 7 at 18:45:00 UTC**

Powering **ON Jan 9 at 07:40:00 UTC**

- Capable of supporting USOS scheduled voice contacts, packet and voice repeater ops.Ham TV – **STATUS - Configured.** Default mode is for scheduled digital amateur television operations (2395.00 MHz).

  Powering **OFF TBD**

  Powering **ONTBD**

- Capable of supporting USOS scheduled school contacts with video.

Service Module radio: IORS (Kenwood D710E) – **STATUS** - Not in APRS configuration; only being used for voice contacts at this time. Default mode is for packet operations (145.825 MHz up & down) but occasionally used for SSTV (145.800 MHz down).

Powering **OFF Jan 7 at 18:50:00 UTC**

Powering **ON Jan 9 at 07:45:00 UTC**

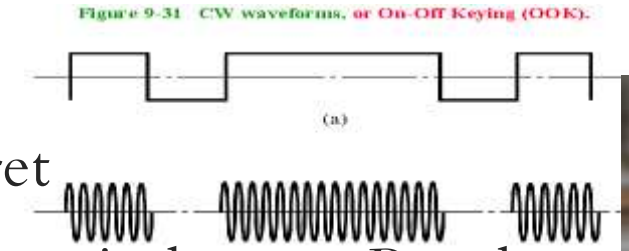
SSTV Activity: **ONTBD OFF TBD**

Pauses in SSTV expected in support of school ham radio contacts.

- Capable of supporting ROS scheduled voice contacts, packet, SSTV and voice repeater ops.

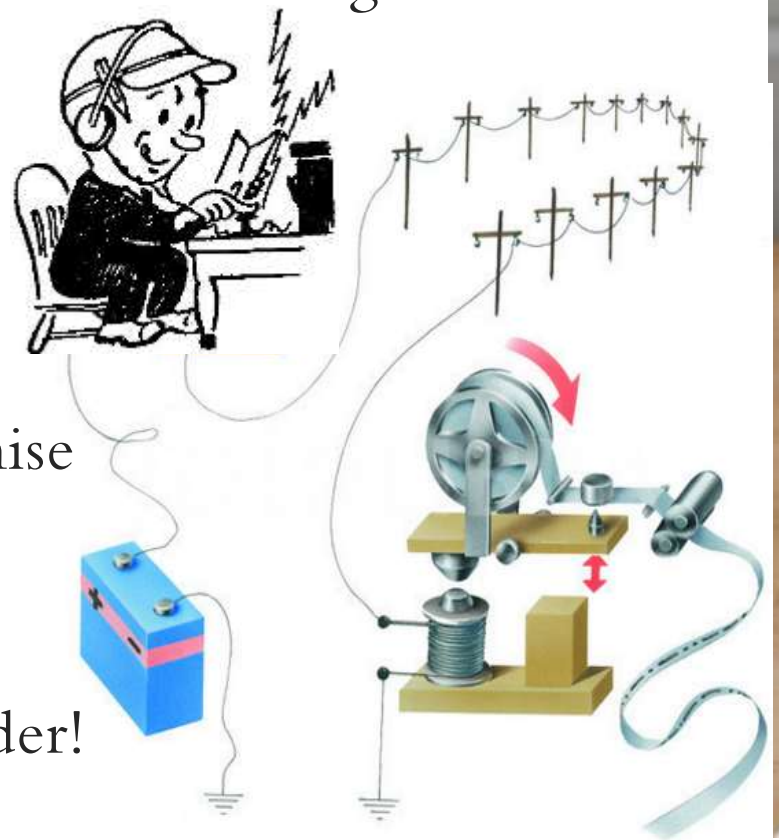
FIRST "DIGITAL" MODE WAS CW - MORSE CODE

- Came from wireline Telegraph lineage
- Not –initially- meant for humans to interpret
- File "Saved-As" Ticker Tape(and thrown out windows at Parades…
- CW Proves Superior to Voice Modes, especially in poor conditions
- CW's advantages compare to most narrow-band Digital Modes



CW is still superior in –certain- ways as contrasted to modern digital modes:

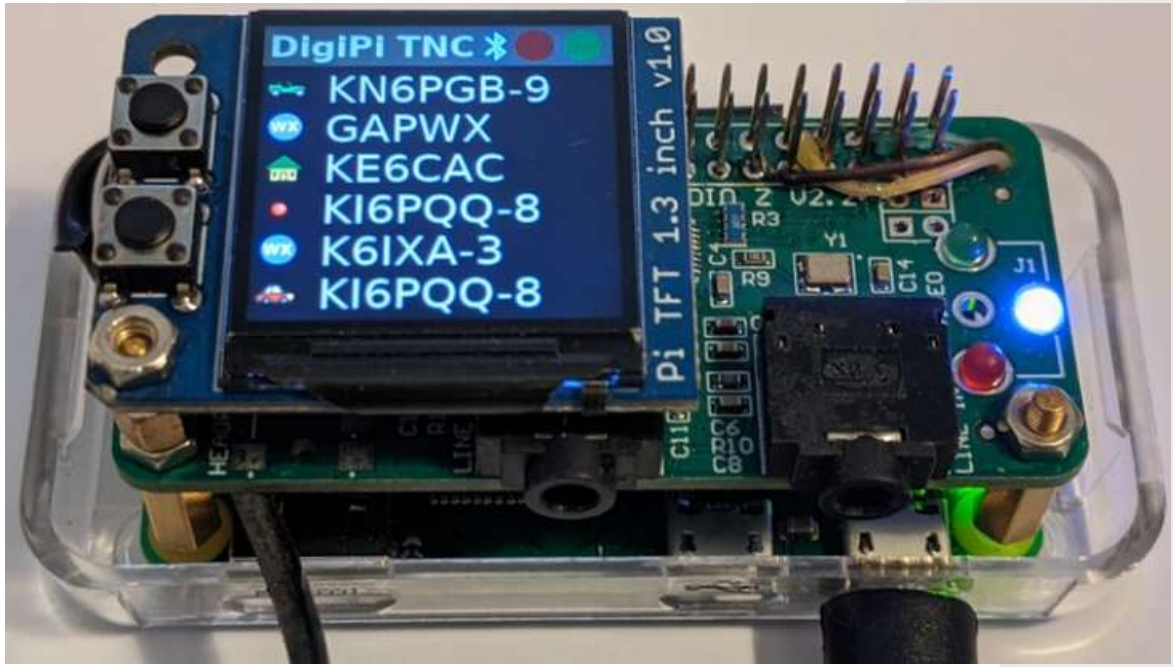
- Very simple TX/RX gear & compromise antennas can work effectively
- No computer/software necessary
- "Grey Matter" is CW's encoder/decoder!

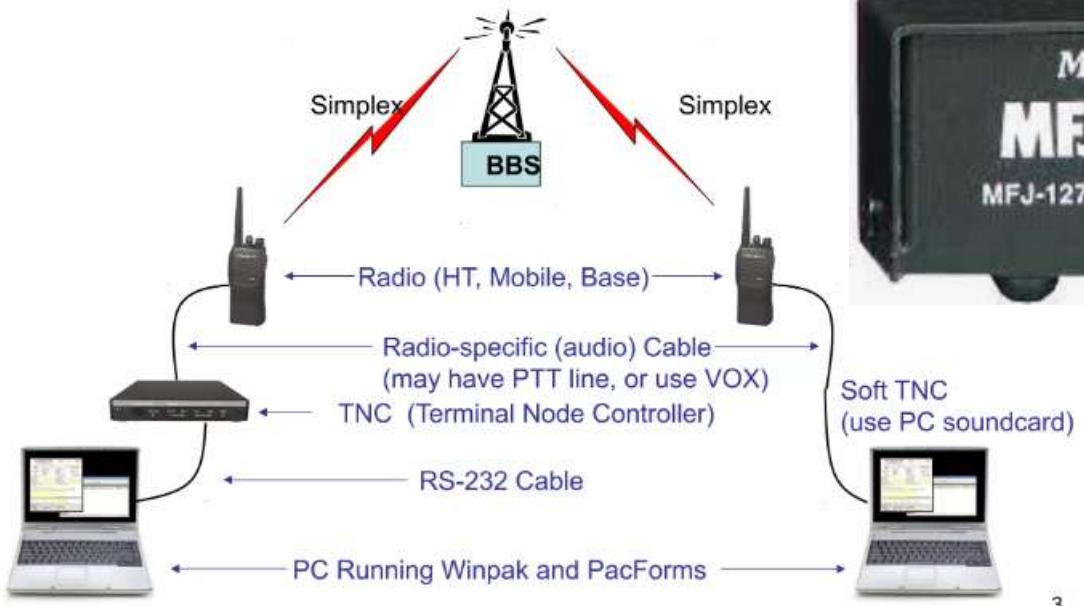


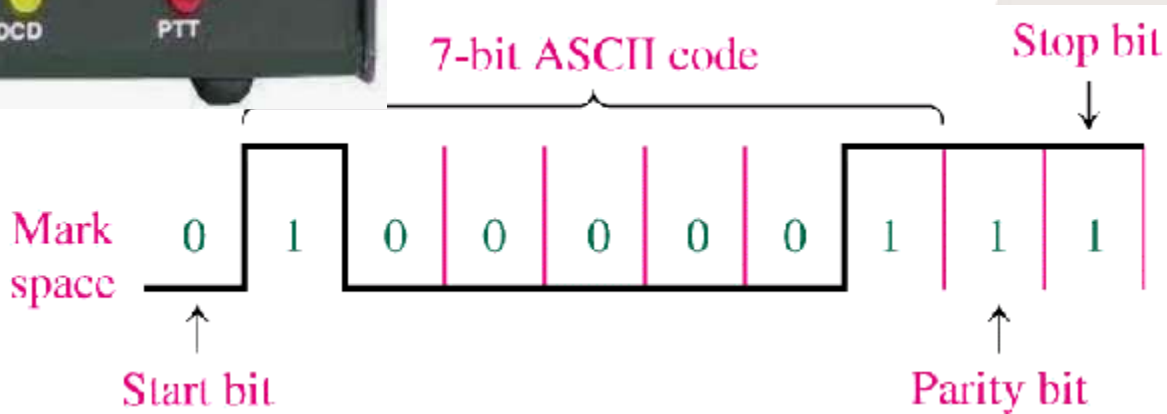
1ST-GEN DIGI MODES - RTTY, AMTOR, PACKET & PACTOR

- **RTTY**(Radio Tele-Type)- ~1930's-60's first widely accepted mode of digital radio communication, initially used mechanical encoders & decoders.
- Commercial RTTY systems were in service between San Francisco/Honolulu Apr1932 and between San Francisco/New York City by 1934.
- US military used radioteletype in the 1930s, expanding usage during World War II.
- **Packet**(data bursts)orig from early packet-switched data networks like ALOHAnet in 1970 and DARPA's PRNET in 1973. These helped develop the internetworking concepts later used in TCP/IP. Amateur radio operators adapted in 1978.
- **AMTOR**(Amateur Teletype Over Radio)- added basic error detection/correction.
- Developed 1978 by Peter Martinez, G3PLX, 1st contact Sept 1978 w/G3YYD on 2m
- Coded-up on homemade Motorola 6800-based microcomputers in assembler code!
- **PACTOR**(Packet Transmission Over Radio)- more advanced FEC/ARQ, requires relatively expensive proprietary TNC & licensing.
- Speeds range from 20 to 9000 bits per second (bit/s net rate)
- Pactor other than level 1 (P1) are not open source
- Winmor complements the PACTOR modes with no $$ TNC or license fees
- Recent modern & capable protocols, such as ARDOP(I'm not familiar w/that one)

GOOD OL' PACKET RADIO: APRS(MAINLY VHF/UHF)

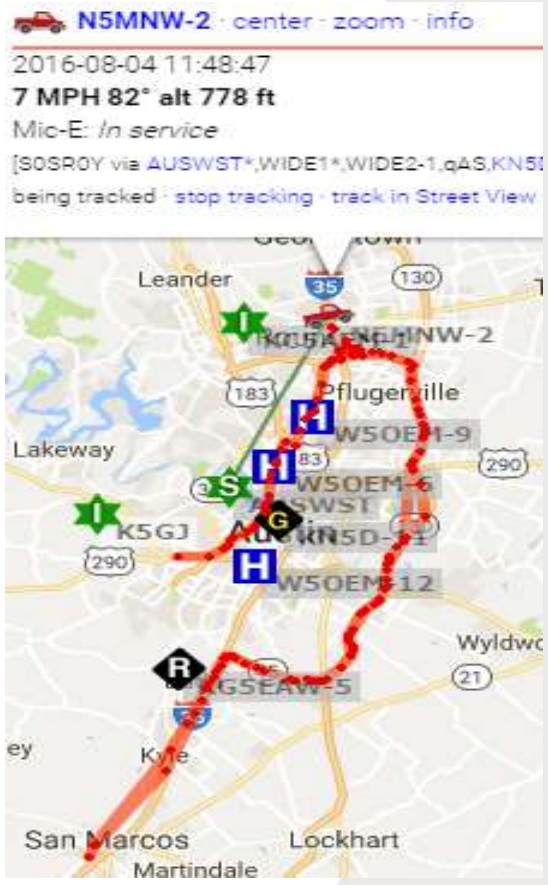






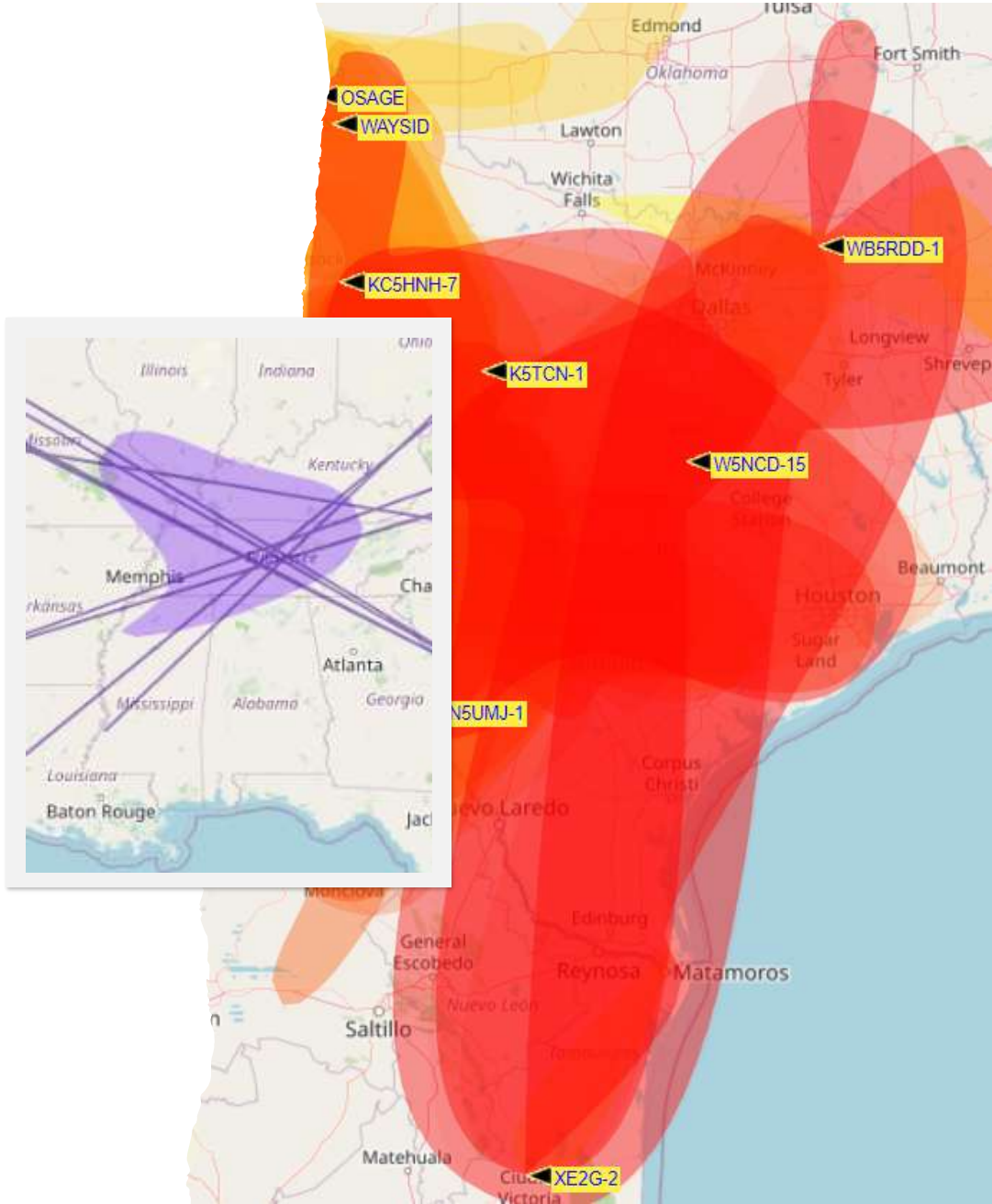
APRS-AUTOMATIC PACKET REPORTING SYSTEM

- Developed by Bob Bruninga, WB4APR(SK), for digital communication and tracking mobile stations equipped with a GPS and (usually)a VHF radio on 144.390 FM Simplex(in the US).
- Position and status data is included in many modern digital modes
- Yaesu Fusion & ICOM D-Star radios report and calculate azimuth and range
- Used for following support/emergency vehicles, runners, bicycles, model rockets and balloons.
- Used for search and rescue, marathons, special events, races, and severe weather

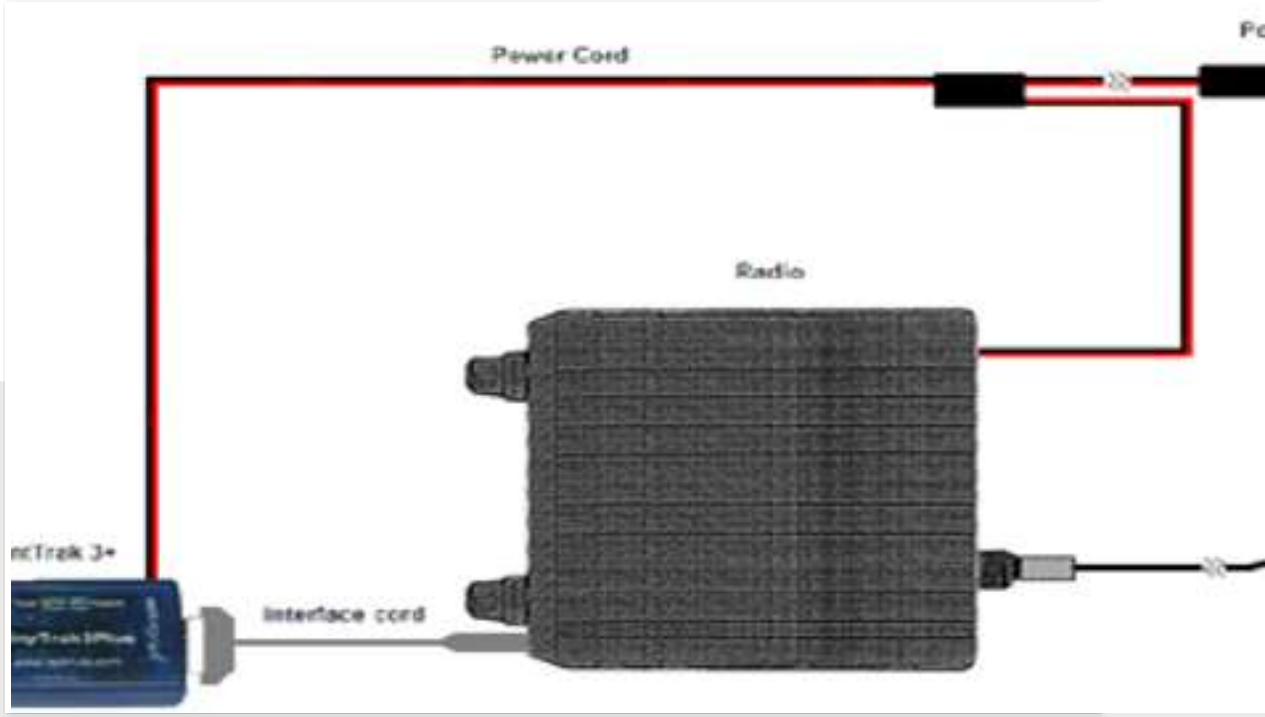


APRS DATA USED TO INDICATE VHF PROPAGATION

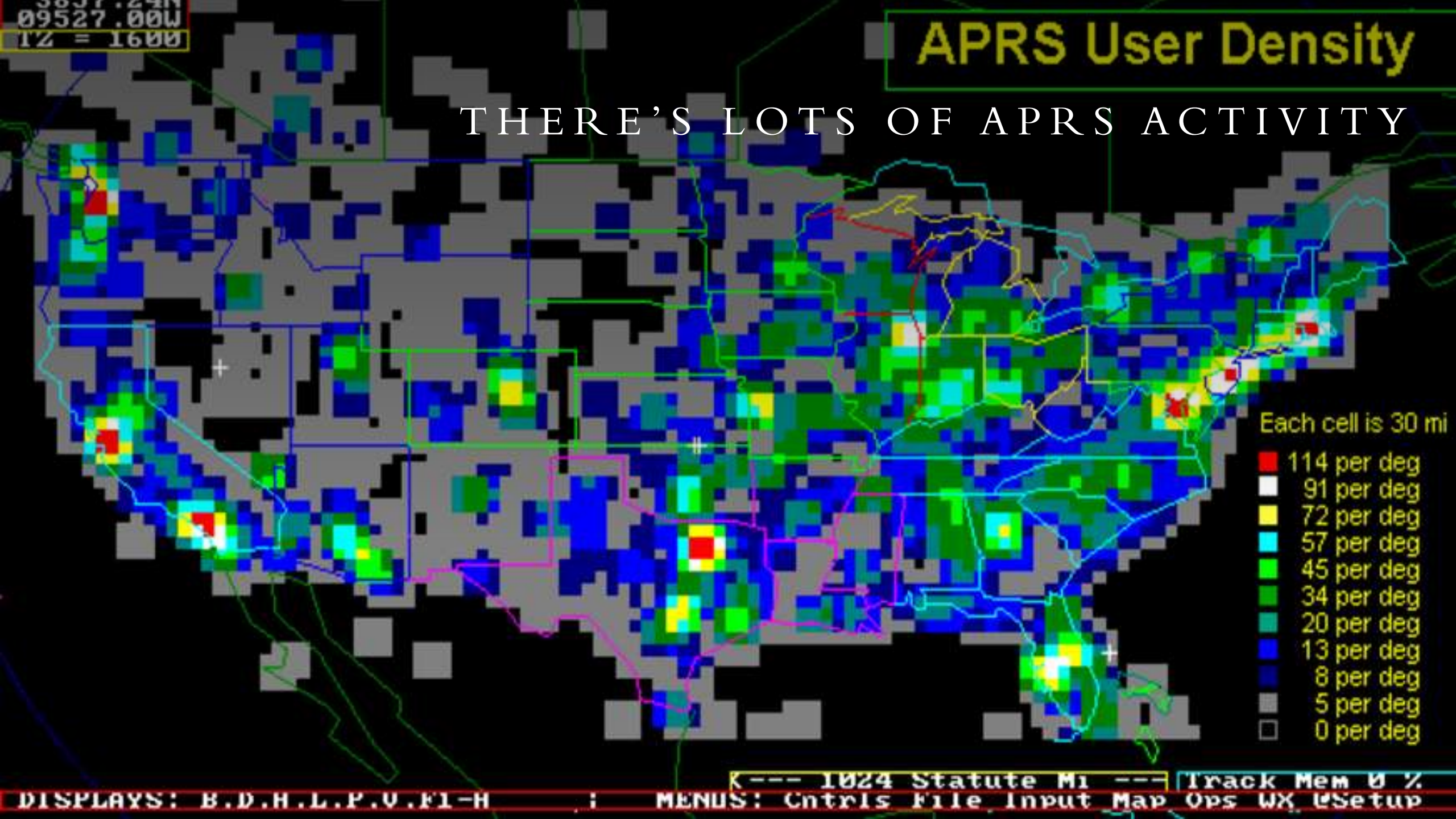
- https://vhf.dxview.org/
- Baseline range stats calc'd
- Compares "normal" range to currently-heard signals.
- Paints map to indicate condx, even long e-skip(purple)
- Very useful for VHF contesters and Rovers



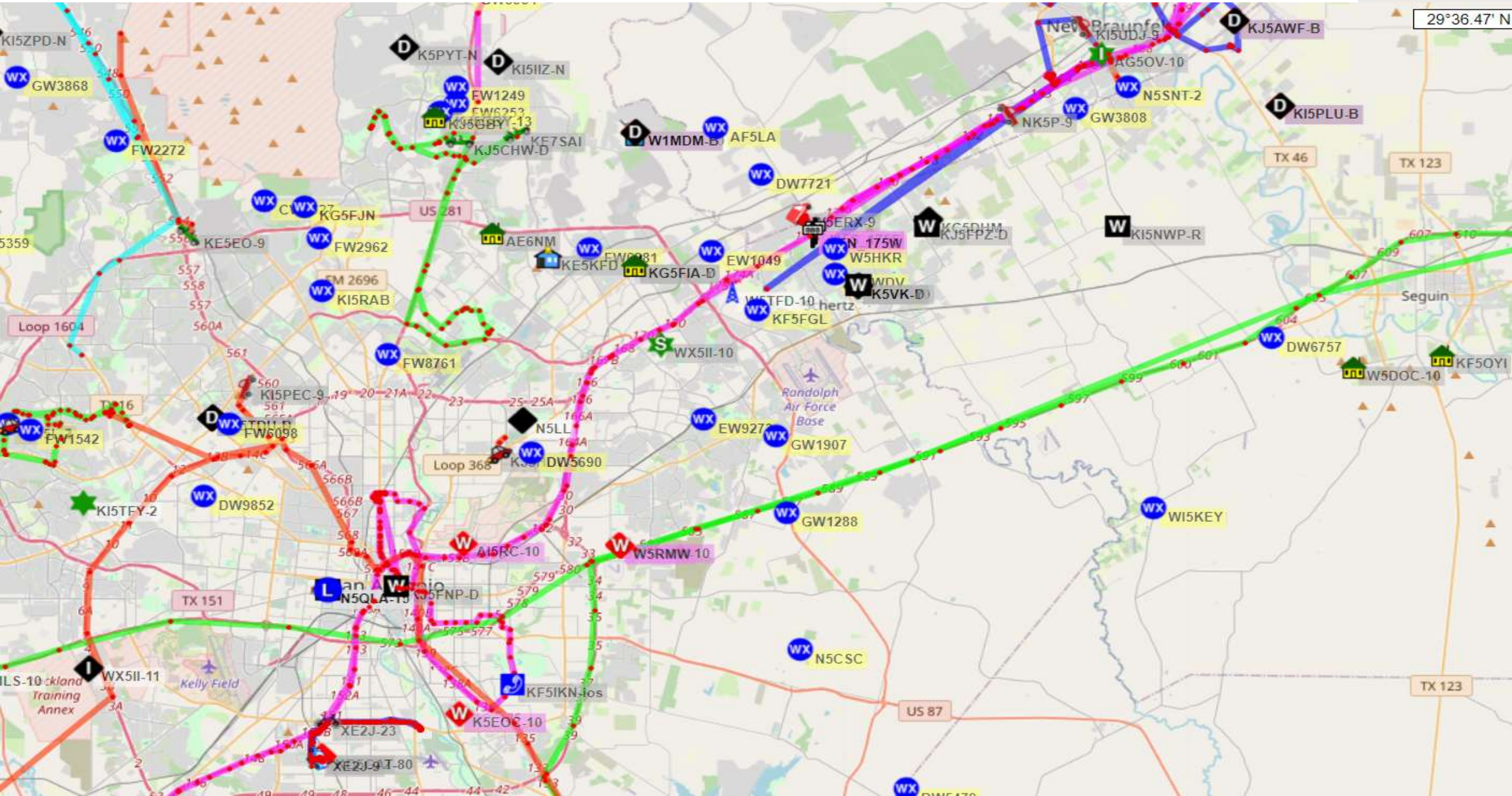
APRS TRACKER/BEACON



- The typical tracker consists of a GPS receiver, a terminal node controller, and a VHF transceiver to transmit the signal out into the digital APRS system
- HF can be used(usu Marine) but the vast majority of land & air stations use VHF


APRS User Density
THERE'S LOTS OF APRS ACTIVITY
09527.00W
TZ = 1600
Each cell is 30 mi
114 per deg
91 per deg
72 per deg
57 per deg
45 per deg
34 per deg
20 per deg
13 per deg
8 per deg
5 per deg
0 per deg
1024 Statute Mi
Track Mem 0 %
DISPLAYS: B,D,H,L,P,V,F1-H
MENUS: Cntrls File Input Map Ops WX Setup

APRS ACTIVITY N.B.-SCHERTZ-SAN ANTONIO

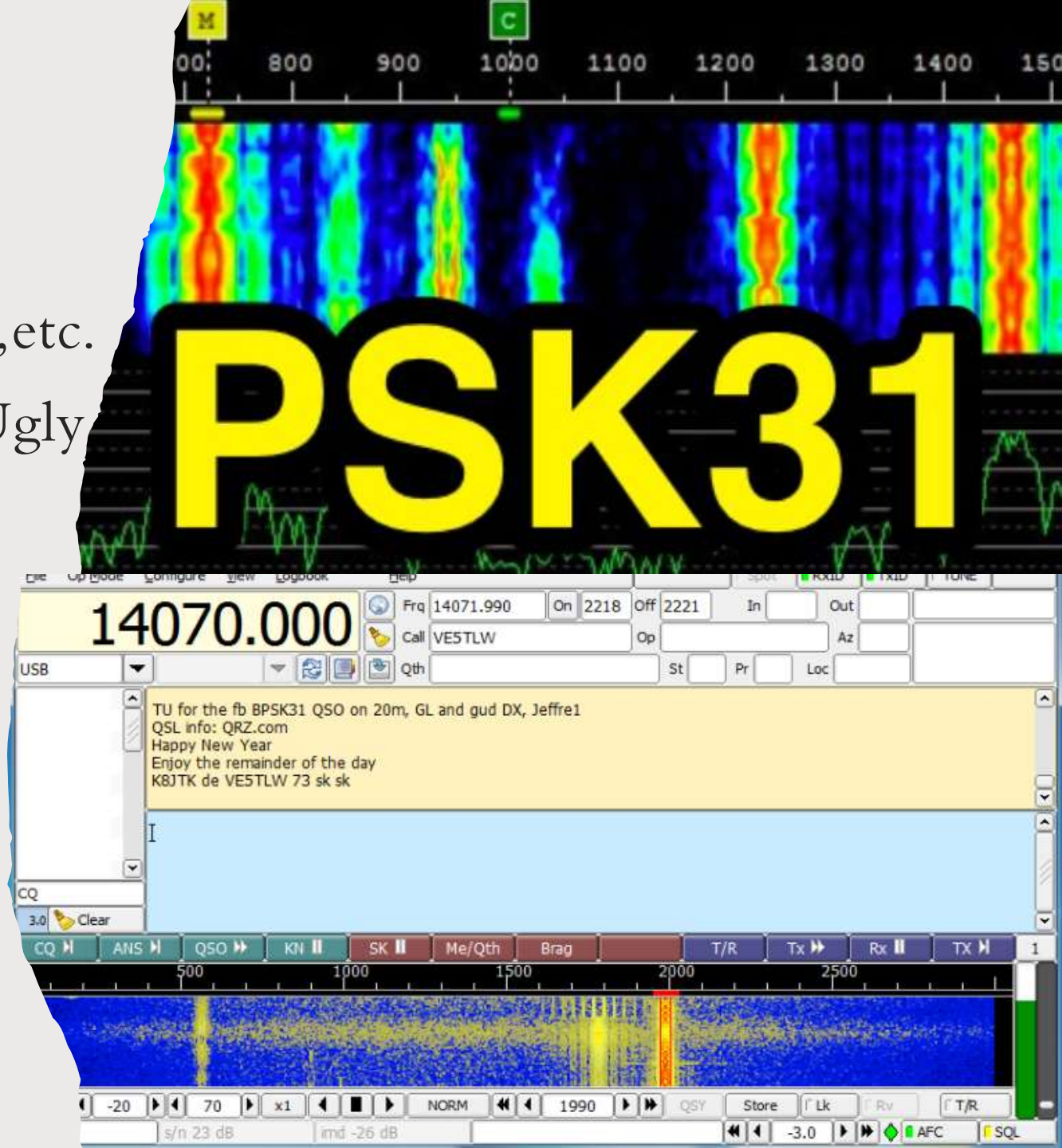


APRS LINKS

- www.aprs.org/
- www.aprs.fi/
- www.findu.com/
- www.byonics.com/
- aprsisce.wikidot.com/
- aprsdroid.org/

2ND -GEN DIGI MODES - PSK31 & DERIVATIVES

- www.dxzone.com/catalog/Software/
- Olivia, Contestia, Throb, MT63, ROS,etc.
- Each one of them has Good, Bad & Ugly
- Most second-generation modes allow free-form text that lets the operators conduct keyboard-to-keyboard rag chews on the air if they desire.



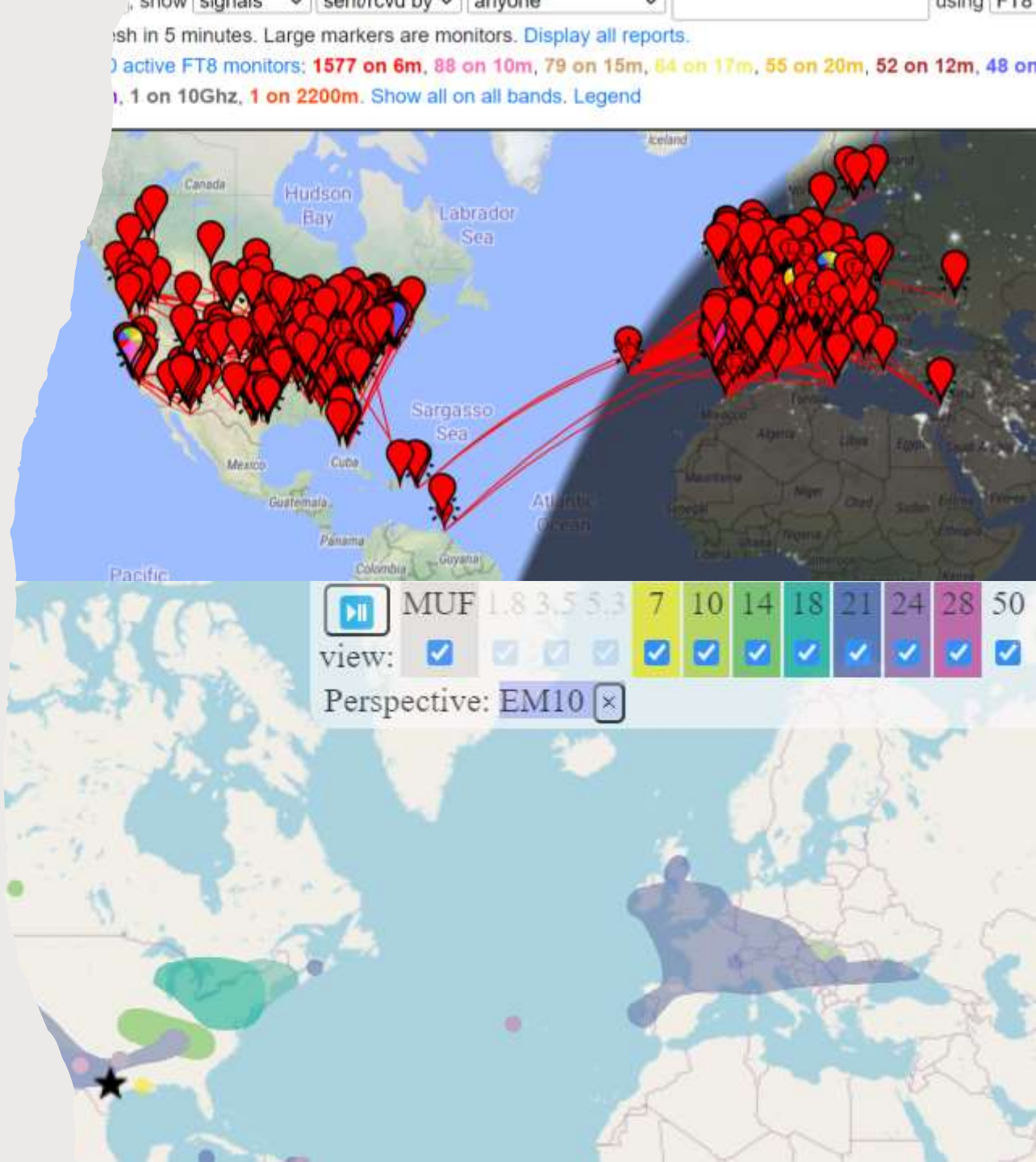
HOW'S MY SIGNAL?

WWW.PSKREPORTER.INFO

&

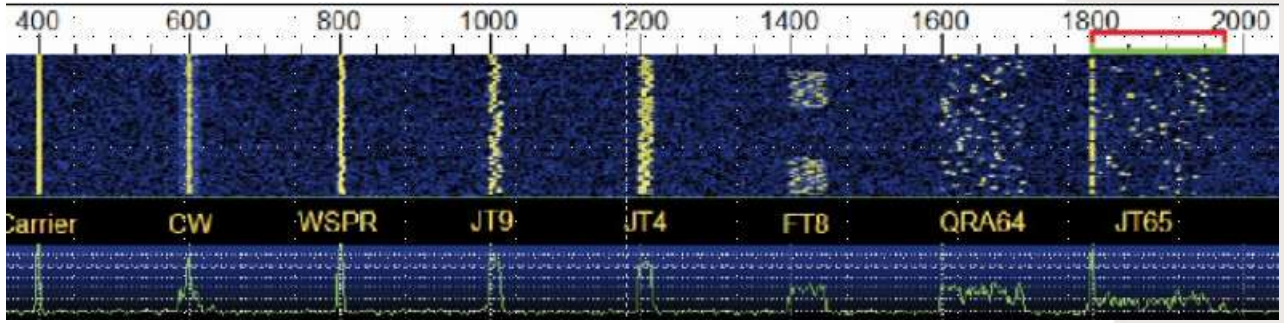
WWW.HF.DXVIEW.ORG

- Using these, you can see live data from hundreds of receiving stations.
- See how well signals on various bands are being heard around the world!
- This works for about all CW & Digi modes.
- Summarize all signals, your own or who's hearing that exotic DX station.
- Regardless of "dead-band" perception, CALL CQ at –least- 1 to 3 times!



3RD -GEN DIGI MODES – FT8 & DERIVATIVES

- New modes like JT65, JT9, FT8, FT4, etc came along, now rivalling RTTY in Contests.
- Encoded/Decoded by the freely available WSJT-X software bundle created by Joe Taylor.
- Brilliant work of science that requires very narrow TX BW and even far narrower RX BW
- JT65 FSK symbol detection BW = 2.692 Hz
- JT9 FSK symbol detection BW = 1.736 Hz
- FT8 FSK symbol detection BW = 6.25 Hz



- Typical JT65 or FT8 transmission "frames" carry only the callsigns, signal report, location, perhaps a few more characters to include CQ, 73, etc as the maximum permitted payload.
- Structured modes are non-conversational, containing very limited QSO-ability
- A new kid on the block is JS8 and JS8Call (well.. As of 2024 anyway… :0)
- Allows a conversational free-form text format, making it more flexible and ham-radio-like.
- JS8Call is still under active development, expect other exciting features over time.

WHAT IS NEEDED FOR HF DIGITAL?

- Practically everything is already in your shack:
- Standard SSB-capable transceiver (most modes use Upper Sideband)
- Any relatively modern personal computer (Linux, Windows, MAC)
- Audio interface (acoustic or simple wires work, shielded/choked cables recommended)
- PTT switch interface (Preferably)
- CAT/CIV interface (Preferably)
- It is a good idea to electrically decouple TRX and computer(hum/EMI pickup)

Typical Configuration

- Latest rigs now feature USB Sound Cards, greatly simplifying hookup.

AN ENTIRE GALAXY OF FREE SOFTWARE

- Free and open source software is available for all modes:
- FLDIGI (RTTY, PSK31, etc.) www.dxzone.com/catalog/Software/
- SSTV - just google "best sstv software" (e.g. MSSTV)
- WSJT-X (JT65, JT9, FT8, WSPR, MSK144 etc.)
- JS8Call(conversational variant of FT8)
- MultiPSK
- MixW
- DM-780 (Ham Radio Deluxe new versions not actually free anymore)
- Lots of software source code is available as well
- There is an active community, it will continue to be developed no matter what
- It's comforting to know that your favorite (open source) software will not be abandoned or sold to a big corporation

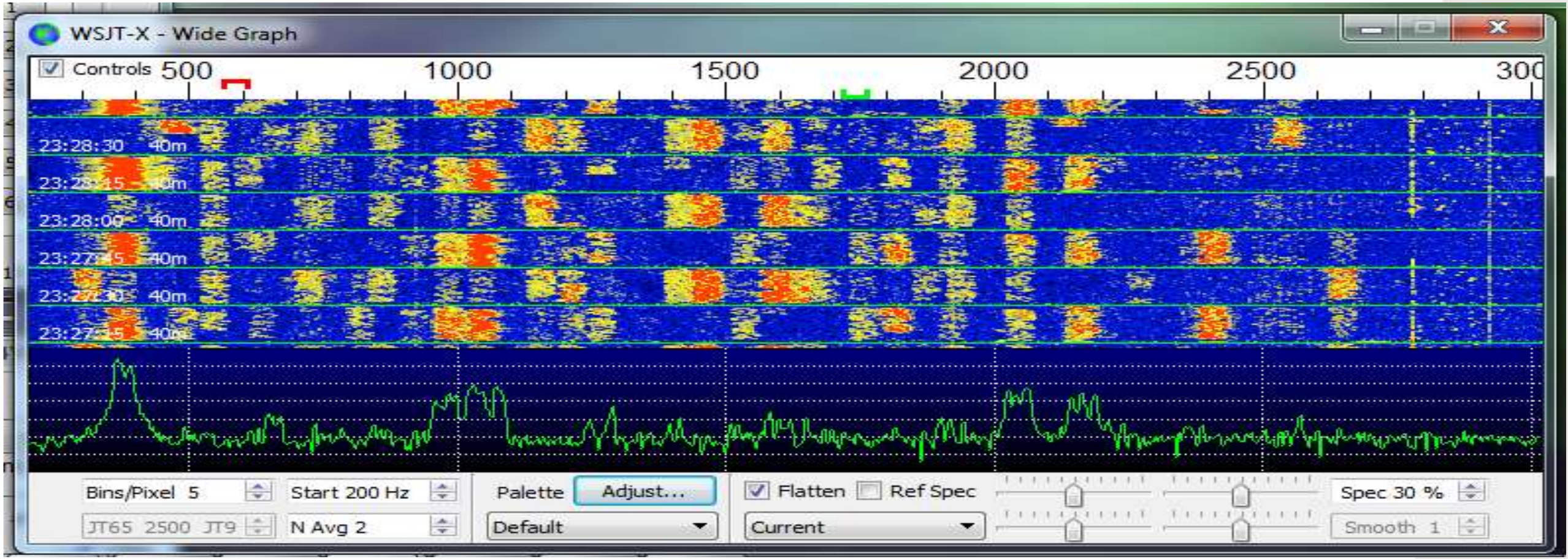
JOE TAYLOR K1JT (DIGIMODE GURU…)

- Previously K2ITP, WA1LXQ, W1HFV, and VK2BJX (yes, an Aussie call!)
- The very first mode JT65 -designed for EME.
- Current usage - HF weak signal around the globe communication
- The most popular now and the most recent FT8 – initially designed for sporadic-E
- Current usage - LF, MF, and HF DXing.
- High interest in FT8 made WSJT-X very popular, making all these modes easily accessible to everybody.
- FT8 is named after its developers, Steven **F** ranke , K9AN, and Joe **T** aylor, K1JT.
- The “8” denotes mode's 8 frequency shift keying format.

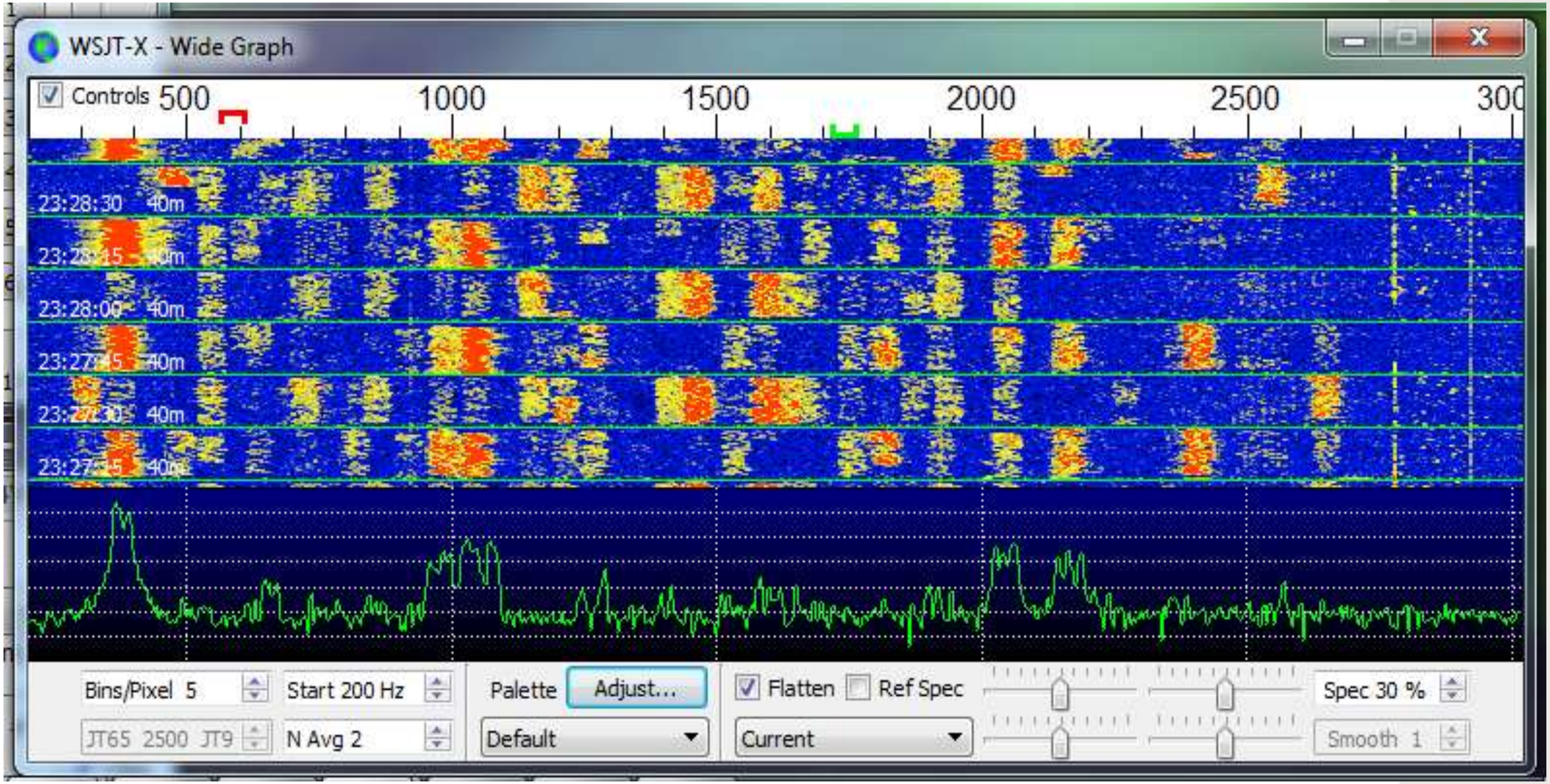
- Main sources of information about JT-modes:
- "Work the World With JT65 and JT9" by Steve Ford (WB8IMY).
- Articles by Joe Taylor, Steve Franke, Bill Somerville "Working the World With WSJT-X: QST Oct/Nov 2017.
- Joe Taylor web-site:
- https://physics.princeton.edu/pulsar/k1jt/wsjtx.html (just google "WSJT-X download")

PACKING THEM IN!

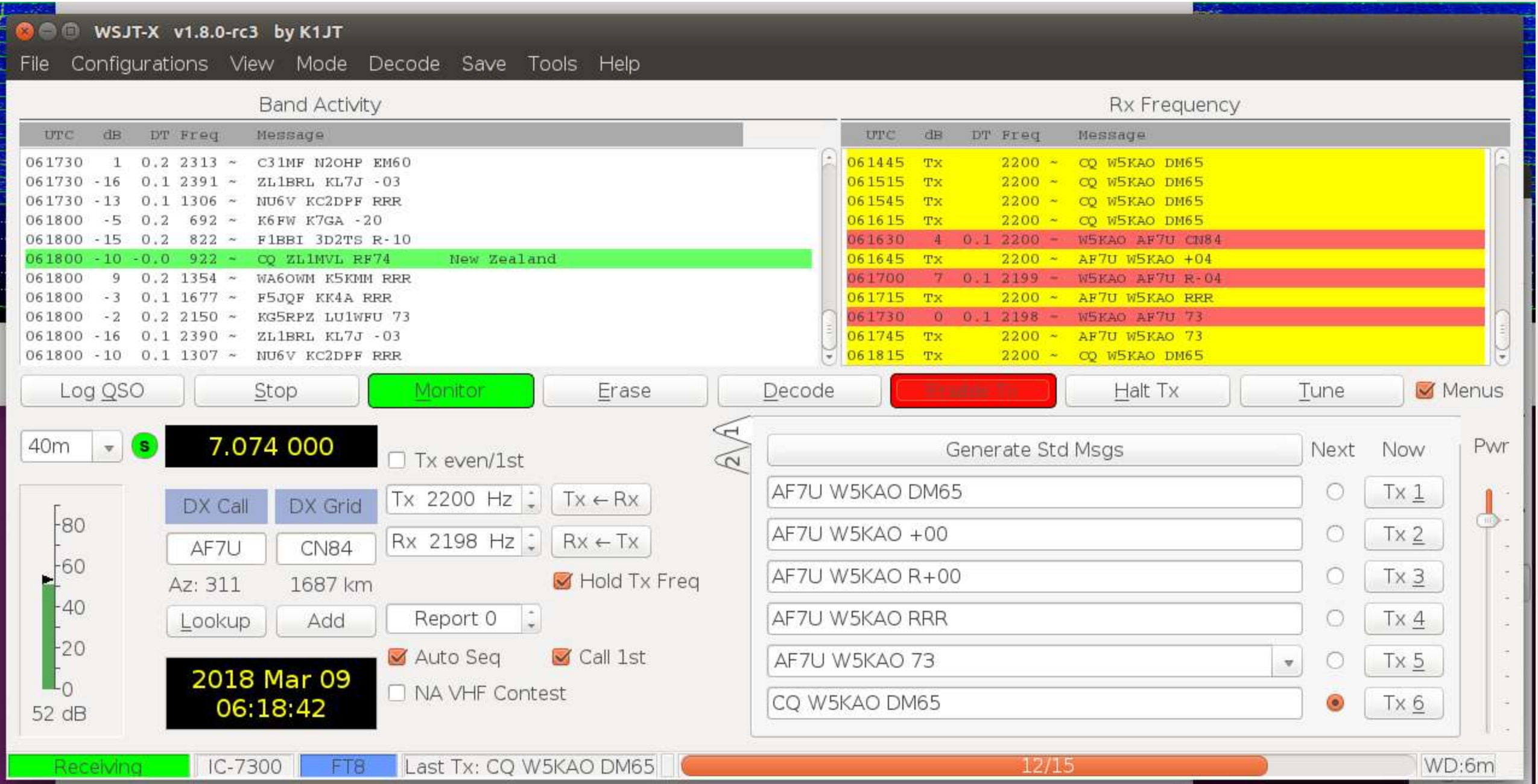
- Note the numbers in the top white strip.
- That's right, HERTZ! Typical FT-8 is a slow ~6 Baud but only ~50Hz wide.
- Can you see the "frames"? Can you see splatter?
- There's at –least- 30 QSO's ongoing at 14.074MHz in this ~3kHz slice of the 20m band!
- 3kHz is the Bandwidth of a typical SSB Voice emission!



FT8 WSJT-X WIDE GRAPH- A CLOSER LOOK



WSJT-X CONTROL PANEL USING FT8



OTHER DIGI-MODE TECHNICAL DETAILS

- Different modes have different parameters.
- BW ranges from 177.6 Hz (JT65) down to 5.9 Hz (WSPR). Practically all modes use 1 minute time sequence,
- FT8 uses 15 seconds and WSPR uses 2 minutes.
- IMPORTANT:Your computer has to synchronize time within ~1 second of UTC!
- https://time.is/, www.time.gov , etc
- Many other RTP servers https://tf.nist.gov/tf-cgi/servers.cgi
- Nettime.pool.ntp.org,

Table 1: Parameters of the Slow *WSJT-X* Protocols

Bandwidths (BW) are for the narrowest submodes. S/N threshold is referenced to a 2,500 Hz bandwidth at a 50% probability for decoding of an unfading signal.

Mode	FEC type (n,k)	q m	Modulation	Keying rate, baud	BW, Hz	Sync energy, fraction	TX duration, s	S/N threshold, dB
FT8	LDPC(174,87)	1 3	8-FSK	6.250	50.0	0.27	12.6	–20
JT4	C(206,72)	1 2	4-FSK	4.375	17.5	0.50	47.1	–23
JT9	C(206,72)	1 3#	9-FSK	1.736	15.6	0.19	49.0	–27
JT65	RS(63,12)	6 6#	65-FSK	2.692	177.6	0.50	46.8	–25
QRA64	QRA(63,12)	6 6	64-FSK	1.736	111.1	0.25	48.4	–26
WSPR	C(162,50)	1 2	4-FSK	1.465	5.9	0.50	110.6	–28

#Modulation includes one additional tone used for synchronization.

SHAPES OF SIGNALS FOR DIFFERENT JT-MODES

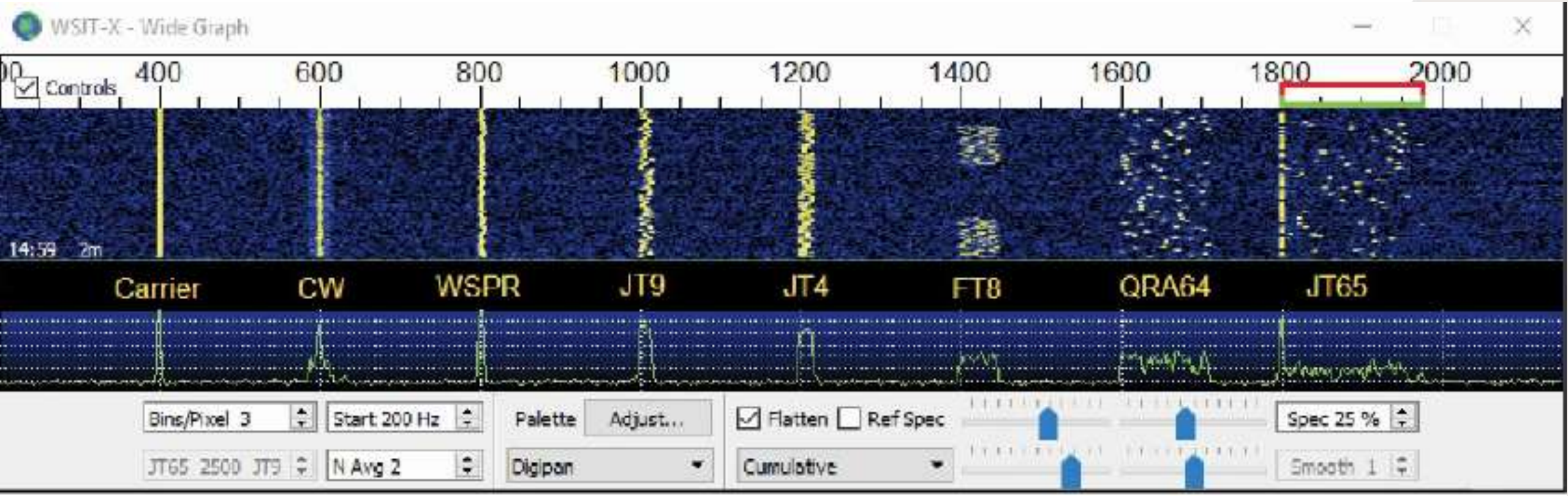
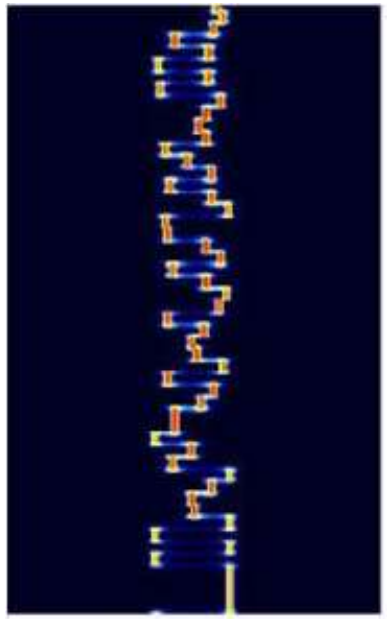
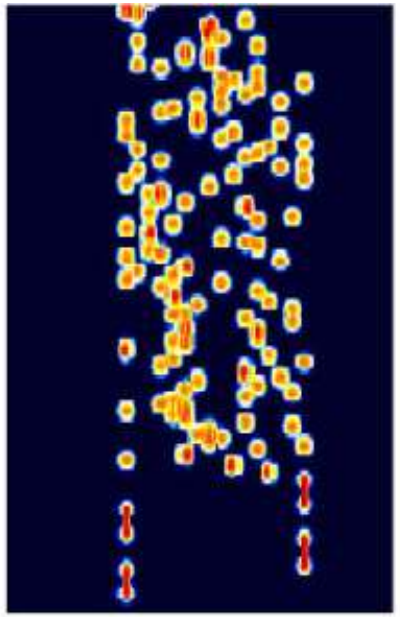


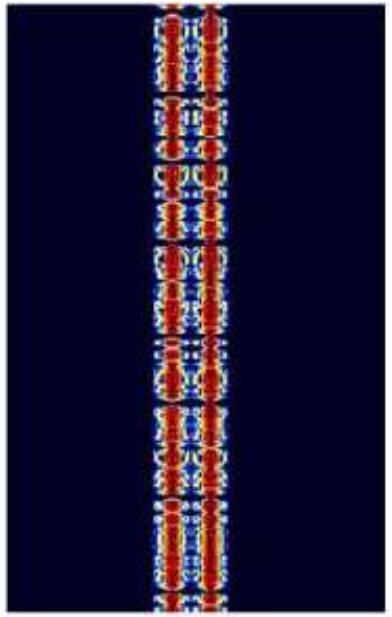
Figure 2 — Simulated signals for an unmodulated carrier, a 25 WPM CW signal, and the *WSJT-X* slow modes WSPR, JT9, JT4, FT8, QRA64A, and JT65. The slow modes are shown in their "A" submode, in increasing order of occupied bandwidth. All signals have S/N of –10 dB in a 2,500 Hz reference bandwidth. The vertical extent of the waterfall corresponds to 50 seconds. Two successive FT8 transmissions are shown.



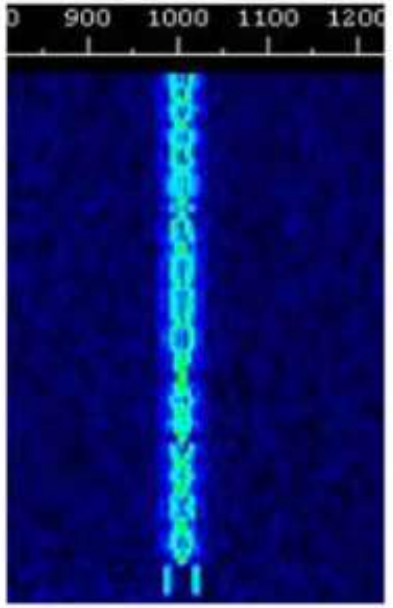
MFSK-8



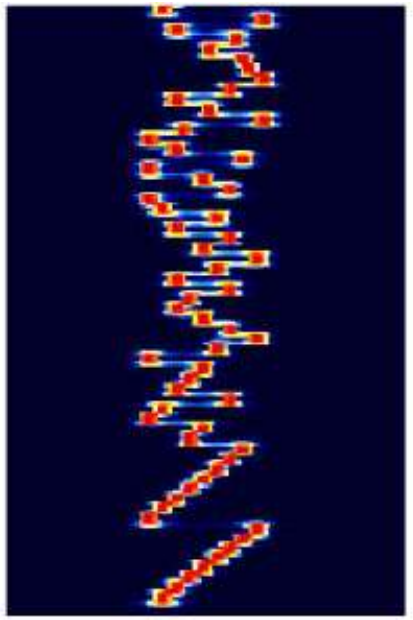
Olivia 16-500



RTTY



PSK31



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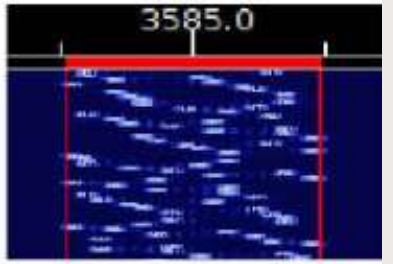
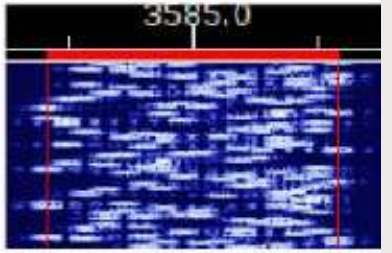


Domino EX11



MFSK16

Preferred HF Band Frequencies of Popular Digital Text Modes for Amateur Radio Communication

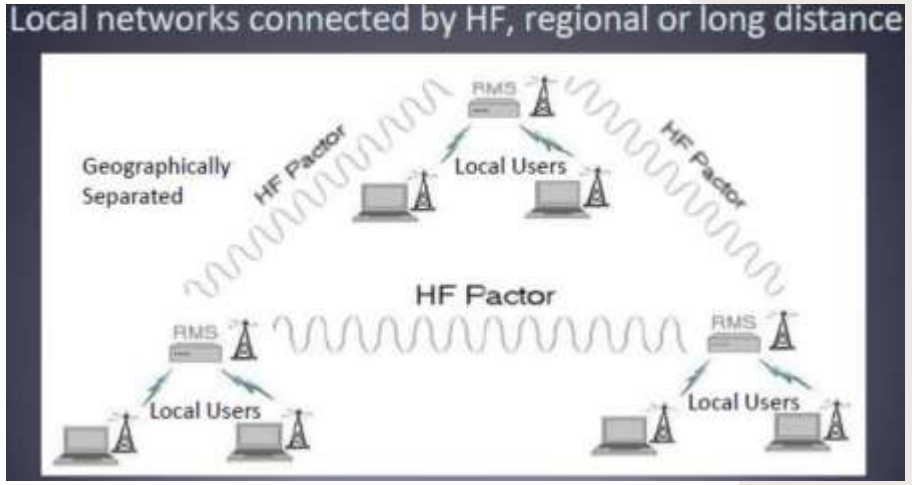
Mode	160m	80m	40m	30m	20m	17m	15m	12m	10m
RTTY	1.838	3.590	7.043	10.143	14.080	18.105	21.080	24.925	28.080
PSK31	1.838	3.580	7.070	10.142	14.070	18.097	21.080	24.920	28.120
Olivia	1.838	3.583	7.072	10.141	14.077	18.103	21.086	24.921	28.076
MT63	1.807	3.585	7.035	10.137	14.109	18.100	21.070	24.920	28.130
JT65	1.838	3.570	7.076	10.138	14.076	18.102	21.076	24.917	28.076
JT9	1.839	3.572	7.078	10.140	14.078	18.104	21.078	24.919	28.078
FT8	1.940	3.573	7.074	10.136	14.074	18.100	21.074	24.915	28.074
JS8Call	1.842	3.578	7.078	10.130	14.078	18.104	21.078	24.922	28.078
ROS	1.840	3.558	7.046	10.133	14.101	18.108	21.122	24.912	28.140

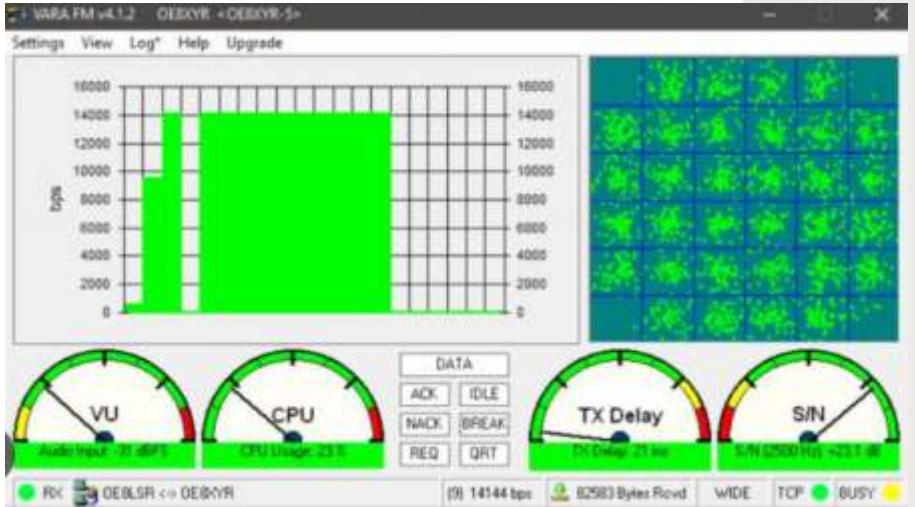
WINLINK, VARA & DATA EMCOMM

- Winlink has been in use since the late '90's
- AX25 ~1200 Baud speeds on VHF-UHF
- Familiar NTS or EMCOMM ICS forms and protocols
- Provides what looks like regular email to a served agency

- VARA FM is an updated(~9600 baud) form AX25 Packet
- VARA HF offers similar thruput enhancements on HF
- HF, VHF and Satellite versions by EA5HVK
- https://rosmodem.wordpress.com/

- Radio email networking for MARS, UK Cadet, Austrian Red Cross, the US Department of Homeland Security SHARES HF Program, and other EMCOMM groups.

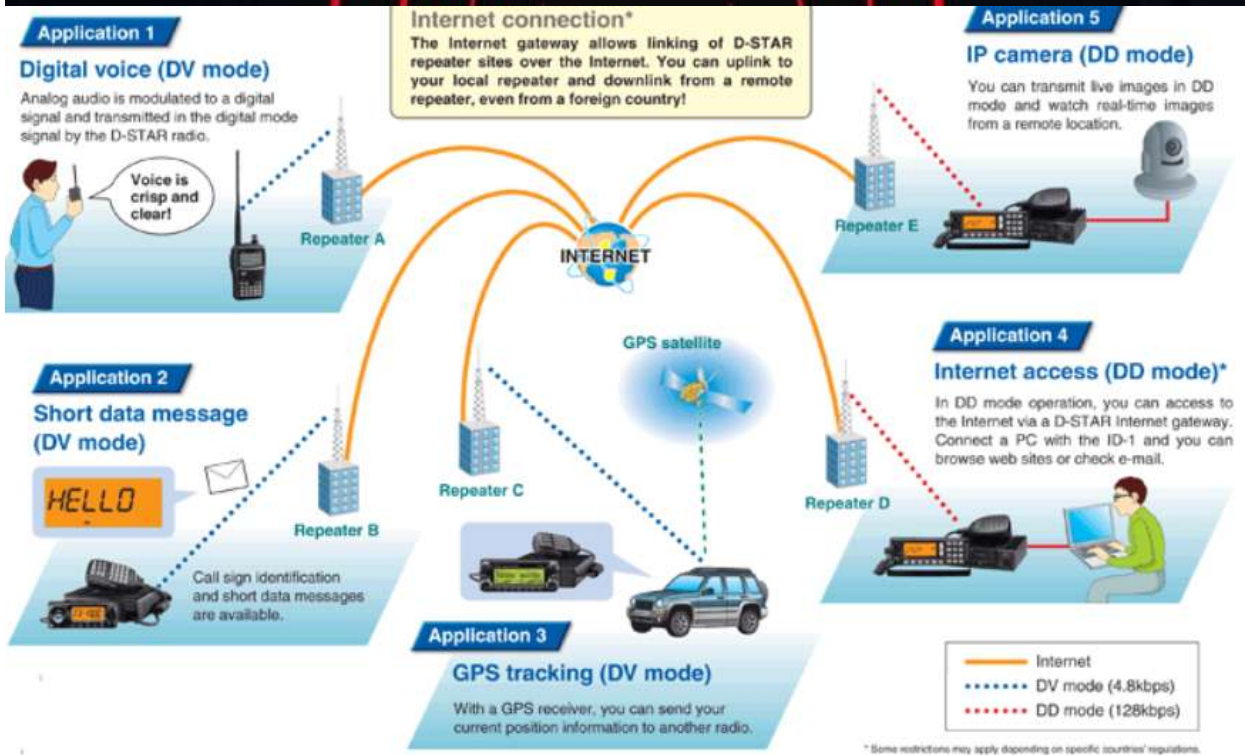




DIGI VOICE MODES, TOO!

- Yaesu Fusion
- ICOM/Kenwood D-STAR
- P25 & DMR
- FreeDV (Open-Source Digital Voice)
- VOIP Echolink/Allstar Internet linking is easy & commonplace
- Mostly VHF/UHF
- Digital SSTV
- Other Digi Modes?

DIGITAL VOICE OVER HF CODEC2 & FREEDV



Q&A TIME

- There are no Dumb Questions!
- But a Valid MNW Answer may be:

  "I Don't Know"…

THOUGHTS REGARDING DIGIMODE CONTESTING

- Lori KM5MQ and I have had numerous chats and have our opinions
- Computer control enables programmable/scriptable fully-auto & unattended "operation"
- This kind of unattended operation allows someone to "make" thousands of "QSO's" & win Awards(WAC,WAS,DXCC, etc) in a short time with minimal(to no)effort.
- Likely a core reason for the "FT8 Hate"
- Not all Digi users employ these methods. Many are (HOA/Budget/Space)-Limited
- FT8 and similar Digi modes offer someone in a severely marginalized station EIRP situation a viable Ham Radio station capable of worldwide contacts.
- Please consider that when Hatin' on FT8… :0)
- It's not the mode, it's the operator…
- Someone with a 100' tower, HF directional array, a KW using a script to make hundreds of Q's/hour **should "score" differently than a manual op with a few mW of EIRP.**

THOUGHTS REGARDING DIGIMODE CONTESTING

- The ops that spend days, weeks & months working and legit tabulating Q's should be recognized differently and above those made unattended fully-automatically with a script.
- The current awards don't(AFAIK) differentiate between manual, semi-auto or fully-auto methods
- We suggest different categories based on how Digi Contest Q's are acquired & logged.
- FCC rules don't allow(in fact, prohibit) most fully-automatic unattended HF operation.
- Another rule change is warranted but considering the impact is only for Contesting, likely low-priority(for the FCC, anyway…)
- Winter Field Day Association(WFDA) rules disallow FT8/FT4 as they are:"…not suitable to relay standard emergency messages…".
- Other digital modes that are capable of exchanging emergency information, such as JS8Call, are permitted.

- H.R. 9664 (IH) - Amateur Radio Communications Improvement Act

- Congressional Bills. 117th Congress. Introduced in House. Wednesday, December 21, 2022.

- ...-239, shall-- (1) repeal the symbol (or baud) rate limits in part 97.307(f) of title 47, Code of... to amend part 97.307(f) of title 47, Code of Federal Regulations

ADDITIONAL REFERENCES AND LINKS

- WSJT User Guide:
- http://physics.princeton.edu/pulsar/k1jt/wsjtxdoc/wsjtx main 1.7.1 devel.html

- The World's Ugliest Music TED Talk
- https://www.youtube.com/watch?v=RENk9PK06AQ

- Download link for WSJT X:
- https://physics.princeton.edu/pulsar/k1jt/wsjtx.html

- FT8 Operating Guide:
- http://www.physics.princeton.edu/pulsar/K1JT/FT8_Operating_Tips.pdf

ADDITIONAL REFERENCES AND LINKS

- DX Lab Suite including Commander:
- http://www.dxlabsuite.com/commander/

- Digital modes for the beginner:
- http://ve6mvp.com/beginnersdigital.htm

- Buxcom Rascal Mark IV soundcard + interface:
- https://packetradio.com/catalog/index.php?main_page=index&cPath=50

- CQ article, "The Genius of Joe Taylor"
- http://www.cq amateur radio.com/cq_highlights/2017cq/2017 09 cq/2017 09 cq zero bias.html

END