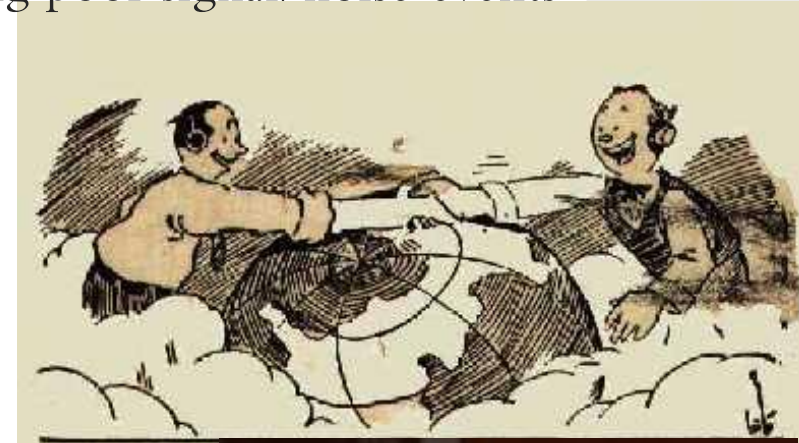
A dramatic landscape featuring a range of mountains partially obscured by large, billowing white clouds. The sky is bright, and the clouds are illuminated from the side, creating a sense of depth and texture. The overall mood is serene and majestic.

OVERVIEW OF POPULAR AMATEUR RADIO DIGITAL MODES

Jeff Schmidt N5MNW- AARC Mtg 5 Sept 2023

WHY SHOULD I TRY DIGITAL??

- Advances the Radio Art and International Good Will!
- ARRL petitioning FCC change the HF baudrate limit(300bd) to a max BW limit(~2.8-3kHz)
- FCC allows >>300baud using PACTOR4 during EMCOMM events
- Most Digi Modes S/N ratio -20 to -30dB, better than Voice & CW during poor signal/noise events
- Generally less BW than voice modes(but not always)
- Allows information to be automatically “stored & forwarded”
- Enables QRP & Field Stations much smaller antennas 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 an access to ALL modes through FREE & lots of open-source software
- **Any other reasons?**
- It makes Crusty Old Codgers cringe?
- Keeps the kids off TikTok?



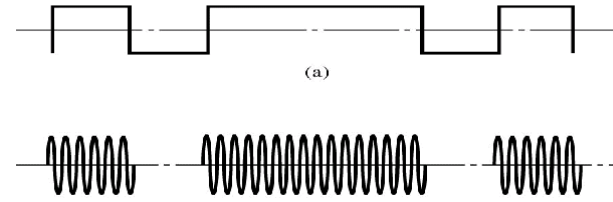
ISS HAS DIGITAL AMATEUR RADIO!

- One of the Ham (VHF) antennas on the ISS
- Used for Voice & Digital Comms



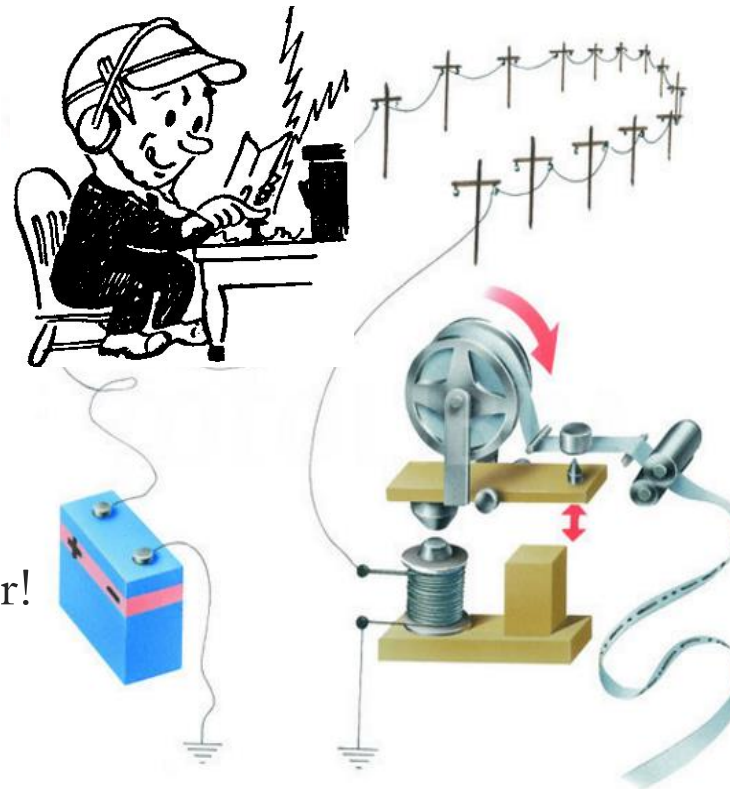
FIRST “DIGITAL” MODE WAS CW- MORSE CODE

Figure 9-31 CW waveforms, or On-Off Keying (OOK).



- Came from wireline Telegraph lineage
- Not –initially- meant for humans to interpret
- File “Saved-As” Ticker Tape (and thrown out windows at Parades...)
- CW Proved Superior to Voice Modes, especially in poor conditions
- These advantages passed along to Digital Modes

- CW is still superior in –certain- ways when contrasted to modern digital modes:
- Very simple TX/RX gear & compromise antennas can work effectively
- No computers/software necessary
- “Grey Matter” encoding & decoding computer!



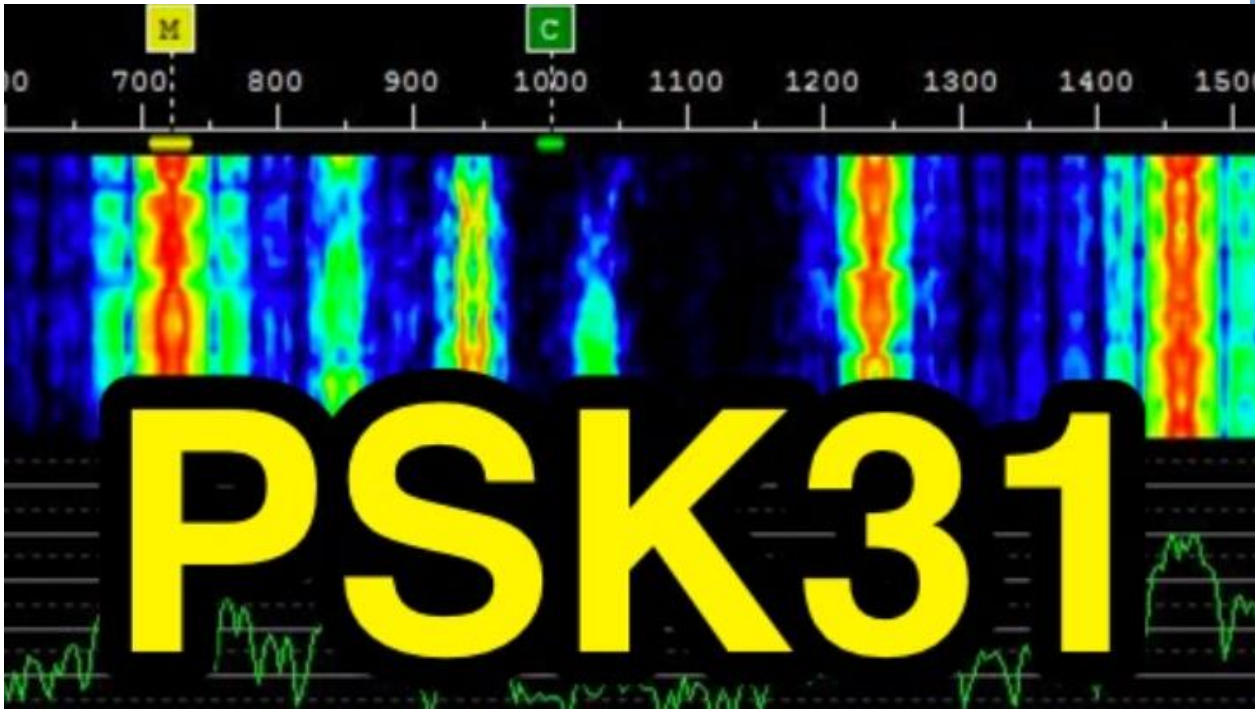
1ST-GEN DIGI MODES - RTTY, AMTOR & PACTOR

- **RTTY**(Radio Tele-Type)- ~1930's-60's first widely accepted mode of digital radio communication, used mechanical encoders & decoders.
- Commercial RTTY systems were in service between San Francisco/Honolulu Apr 1932 and between San Francisco/New York City by 1934.
- US military used radioteletype in the 1930s, expanding usage during World War II.
- **AMTOR**(Amateur Teletype Over Radio)- added basic error detection/correction.
- Developed in 1978 by Peter Martinez, G3PLX, 1st contact Sept 1978 with G3YYD on 2m
- It was developed on homemade Motorola 6800-based microcomputers in assembler code.
- **PACTOR**(Packet Transmission Over Radio)- more advanced FEC/ARQ, requires \$\$ 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
- Now more modern and capable protocols, such as ARDOP(I'm not familiar with this one)



2ND - GEN DIGI MODES - PSK31 & DERIVITAVES

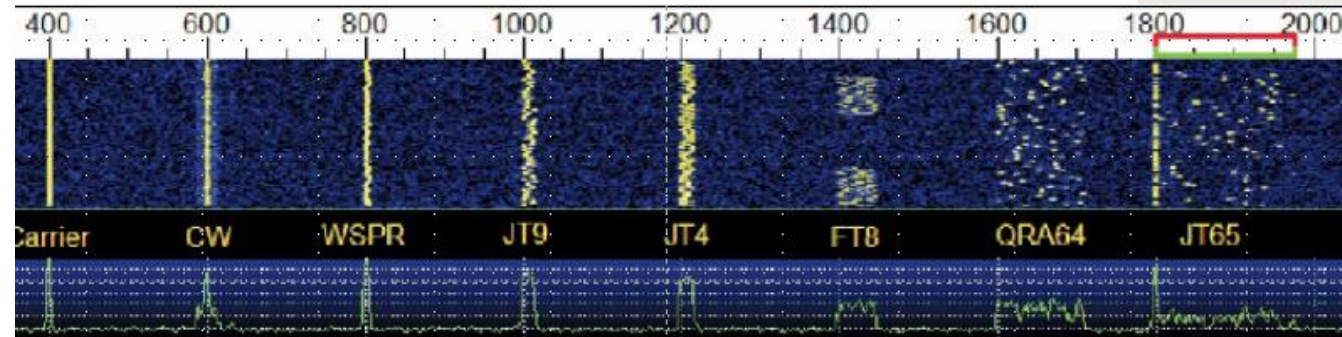
- <https://www.dxzone.com/catalog/Software/PSK31/>
- Olivia, Contestia, Throb, MT63, ROS, etc
- Each one of them has its own merits and demerits.
- All these second-generation modes allow free-form text that lets the operators conduct keyboard-to-keyboard rag chews on the air if they desire.



A screenshot of the fldigi software interface (version 3.23.18) running on a Windows system. The window title is 'fldigi ver3.23.18 - K8JTK'. The main display area shows a frequency of 14070.000 kHz. The call sign 'VESTLW' is entered in the 'Call' field. The message window contains the following text: 'TU for the fb BPSK31 QSO on 20m, GL and gud DX, Jeffre1', 'QSL info: QRZ.com', 'Happy New Year', 'Enjoy the remainder of the day', and 'K8JTK de VESTLW 73 sk sk'. The interface includes various control buttons and a status bar at the bottom showing 'BPSK31', 's/n 23 dB', 'imd -26 dB', and other parameters.

3RD - GEN DIGI MODES - FT8 & DERIVATIVES

- New modes like JT65, JT9, FT8, FT4, etc came into being.
- 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 carry only the callsigns, signal report, location, perhaps a few more characters to include CQ, 73, etc as the maximum permitted payload.
- Structured modes that are non-conversational in nature, containing very limited QSO-ability
- The newest kid around the block is JS8 and JS8Call
- Allows a conversational free-form text format thus making it more flexible and ham-radio-like.
- JS8Call is still under active development and we can expect other exciting features over time.

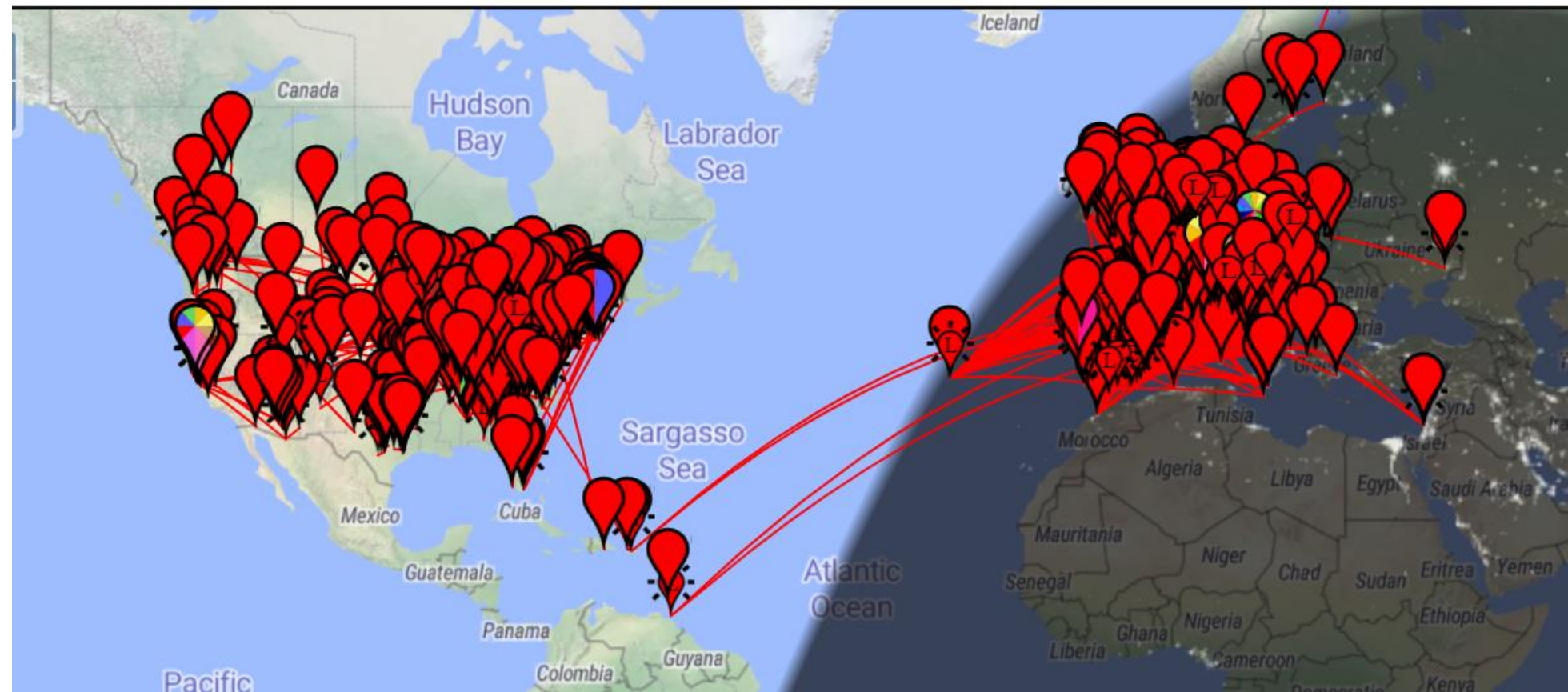
HOW'S MY SIGNAL? WWW.PSKREPORTER.INFO

- Using PSK Reporter, you can see data from thousands of receiving stations.
- Summarize all signals heard, yours or that exotic DX station.
- See how well signals are being heard around the world
- This works for about all modes, not just FT8).

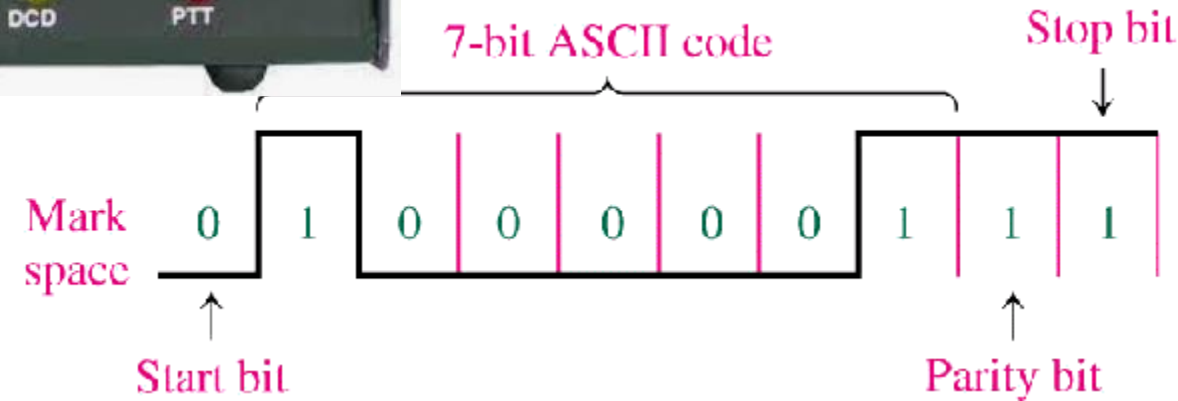
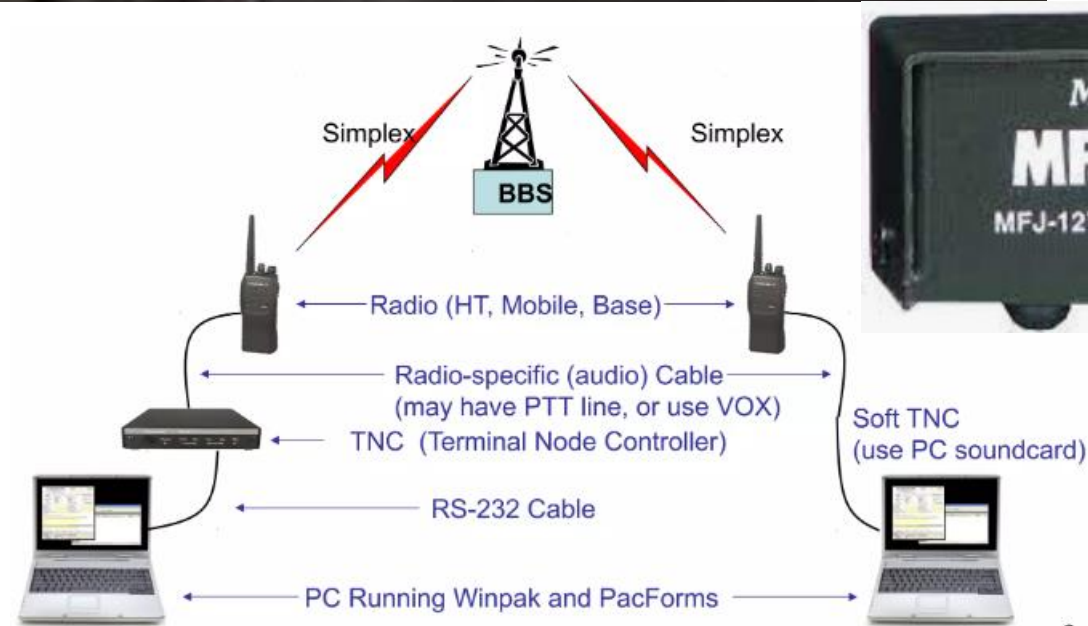
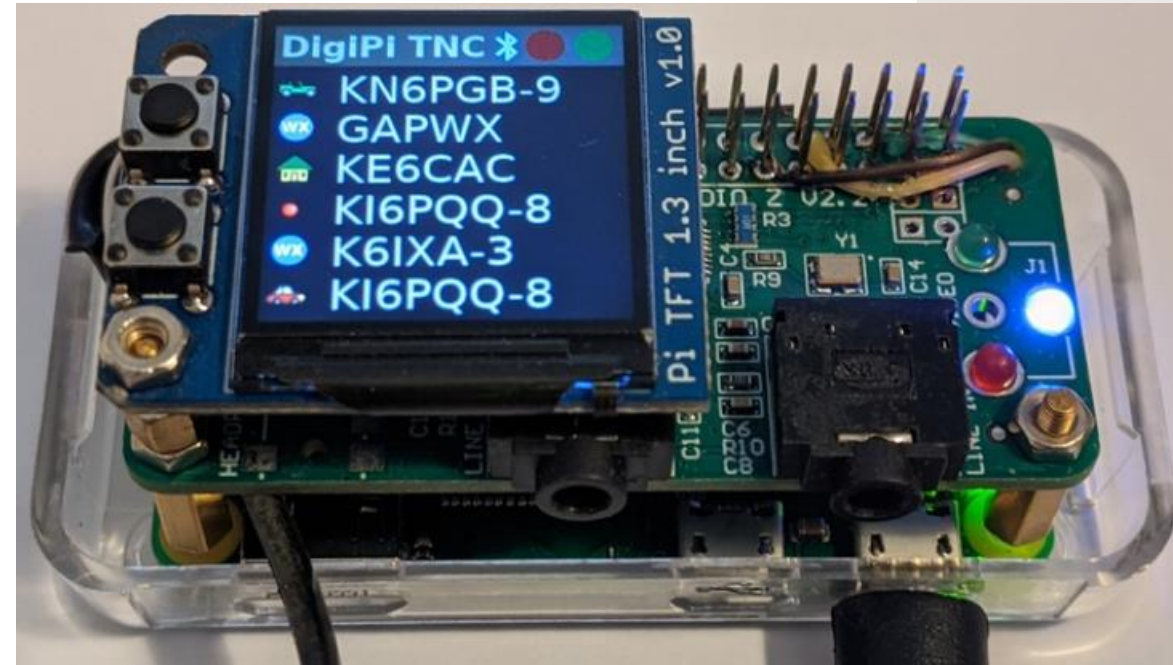
6m , show using

Automatic refresh in 5 minutes. Large markers are monitors. [Display all reports.](#)

There are 1600 active FT8 monitors: 1577 on 6m, 88 on 10m, 79 on 15m, 64 on 17m, 55 on 20m, 52 on 12m, 48 on 30m, 1 on 8m, 1 on 10Ghz, 1 on 2200m. [Show all on all bands.](#) [Legend](#)

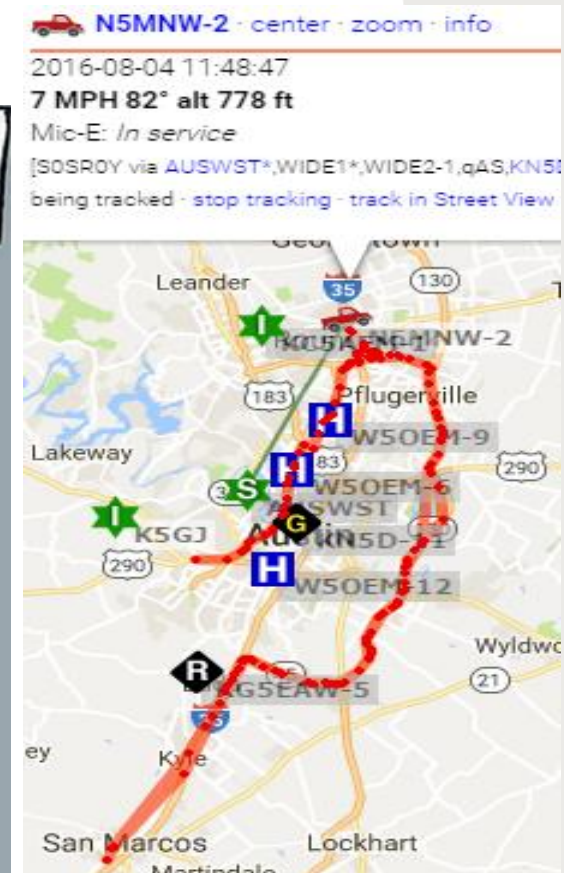


PACKET RADIO: APRS, VARAFM, WINLINK, EMCOMM



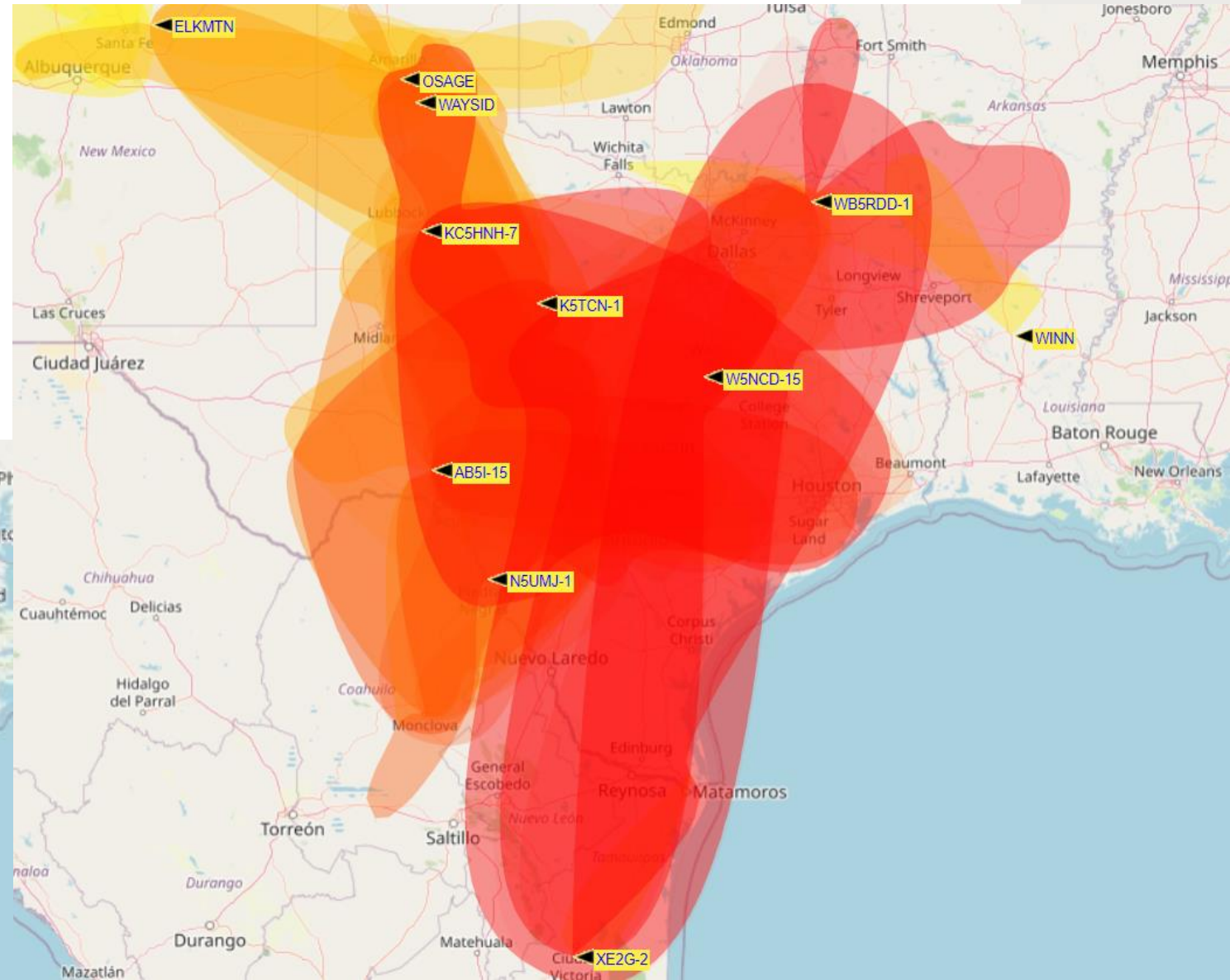
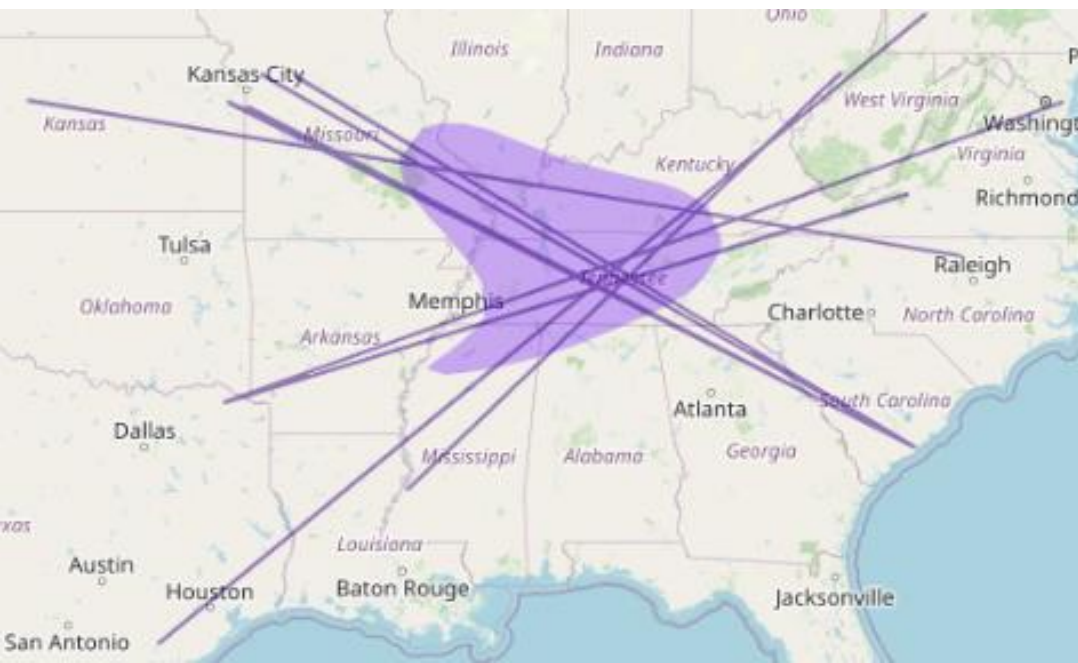
APRS - AUTOMATIC PACKET REPORTING SYSTEM

- 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.
- 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



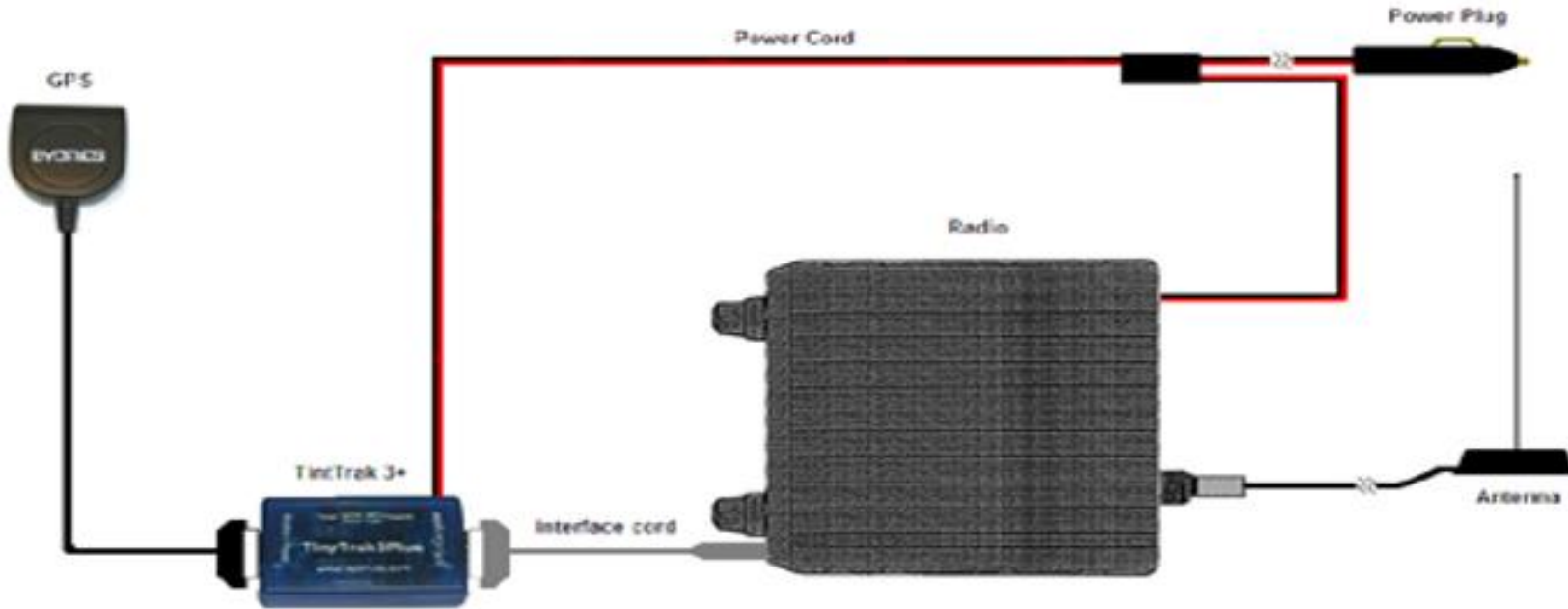
APRS DATA USED TO INDICATE VHF PROPAGATION

- <https://vhf.dxview.org/>
- Baseline Digi range established
- Compares “normal” range to currently-heard signals.
- Paints map to indicate condx, even e-skip(purple)
- Very useful for VHF contesters and Rovers

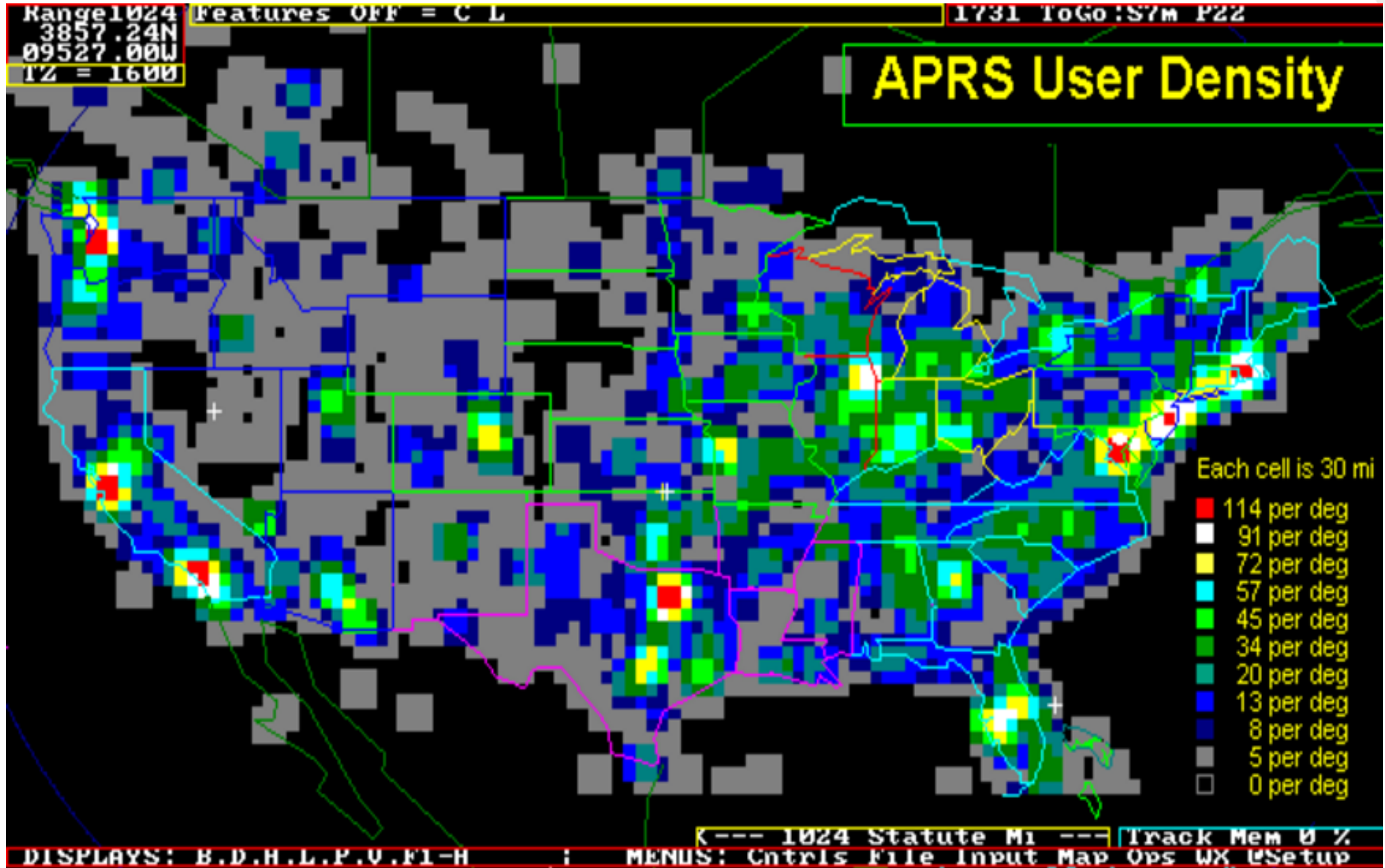


APRS TRACKER / BEACON

- 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(Marine) but the vast majority of land & air stations use VHF



THERE'S LOTS OF APRS ACTIVITY



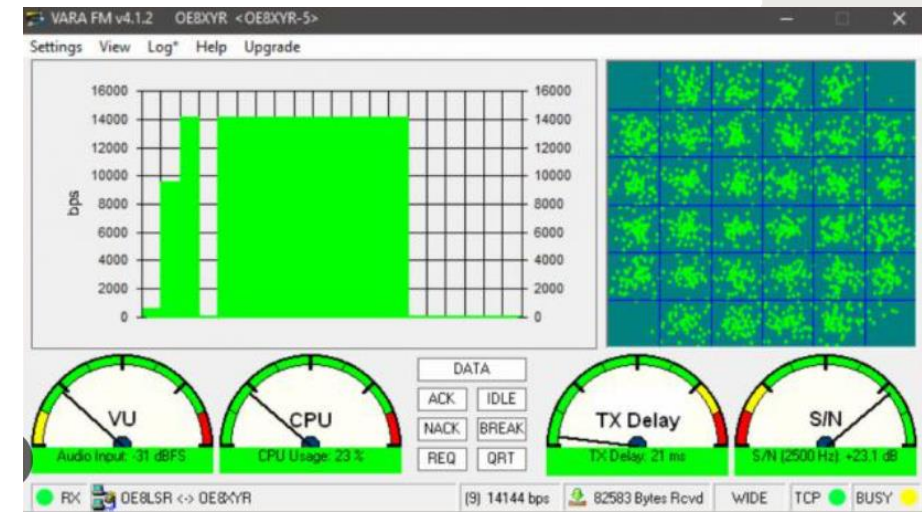
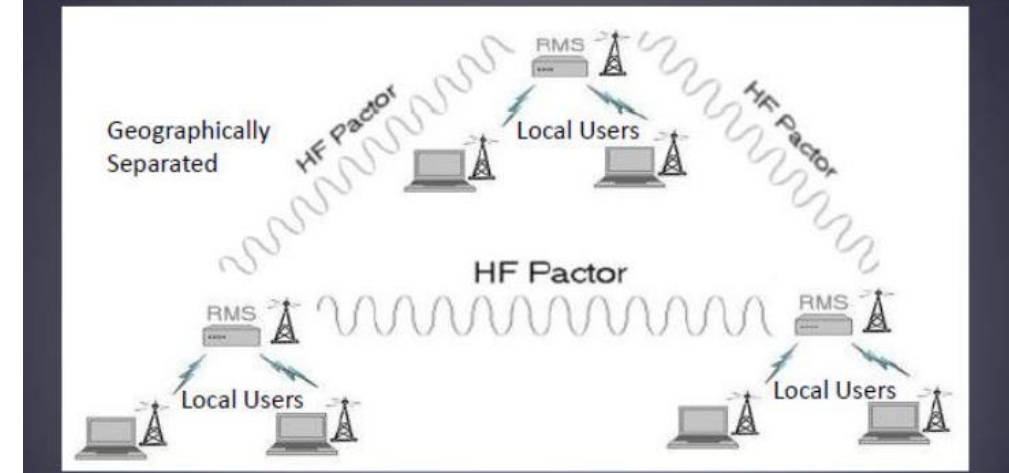
APRS LINKS

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

WINLINK, VARA & EMCOMM



Local networks connected by HF, regional or long distance



- Winlink has been in use since the late '90's
- Uses AX25 ~1200 Baud speeds on VHF-UHF
- Can use ICS forms and protocols
- Provides what looks like regular email to a served agency
- VARA FM is an updated form(9600 baud) of good ol' AX25 Packet, VARAHF offers similar enhancements using HF
- HF, VHF and Satellite versions by EA5HVK
- <https://rosmodem.wordpress.com/>
- Radio email networking systems for MARS, UK Cadet, Austrian Red Cross, the US Department of Homeland Security SHARES HF Program, and other EMCOMM groups.

WHAT IS NEEDED?

- Practically everything is already in your shack:
- Standard SSB-capable transceiver (most modes use USB)
- Any relatively modern personal computer (Linux, Windows, MAC)
- Audio interface (can be just wires but shielded/choked cable assemblies recommended)
- PTT switch interface (Preferably)
- CAT/CIV interface (Preferably)
- It is a good idea to electrically decouple TRX and computer.

Typical Configuration

- Latest rigs now feature USB Sound Cards.



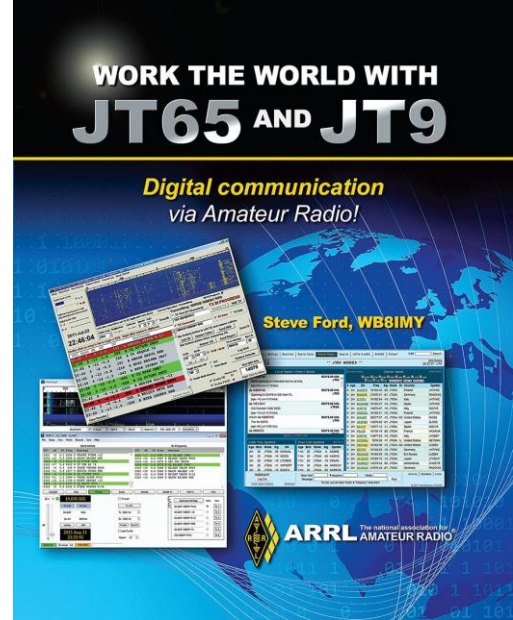
AN ENTIRE WORLD OF FREE SOFTWARE

- Free and open source software is available for all modes:
- FLDIGI (RTTY, PSK31, etc.)
- 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 is a good feeling to know that your favorite (open source) software will not be abandoned or sold to a big corporation

JOE TAYLOR K1JT (OUR HERO...)

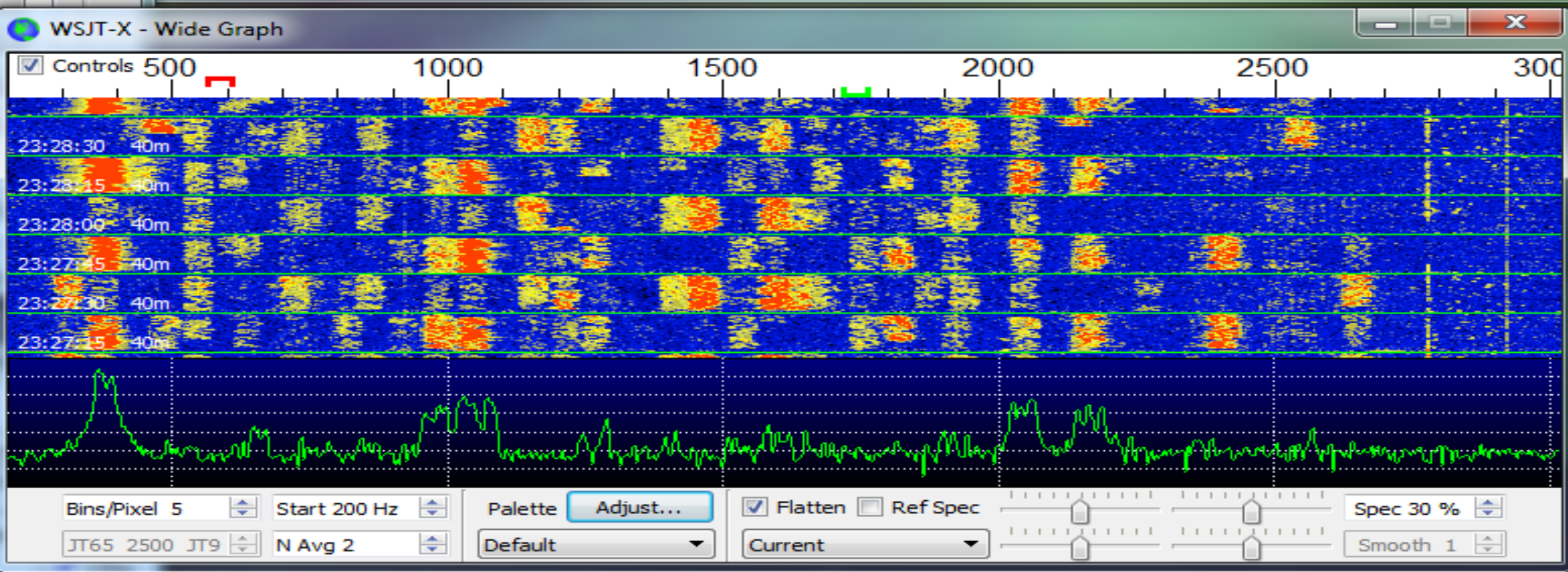
- Previously K2ITP, WA1LXQ, W1HFV, and VK2BJX (yes, an Aussie call!)
- The very first mode JT65 -designed for EME.
- Current usage - HF weak signal around the globe communication
- The most popular now and the most recent FT8 – initially designed for sporadic-E
- Current usage - LF, MF, and HF DXing.
- High interest in FT8 made WSJT-X very popular, making all these modes easily accessible to everybody.
- FT8 is named after its developers, Steven Franke, K9AN, and Joe Taylor, 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, and Bill Somerville "Working the World With WSJT-X: QST Oct/Nov 2017.
- Joe Taylor web-site:
- <https://physics.princeton.edu/pulsar/k1jt/wsجتx.html> (just google "WSJT-X download")

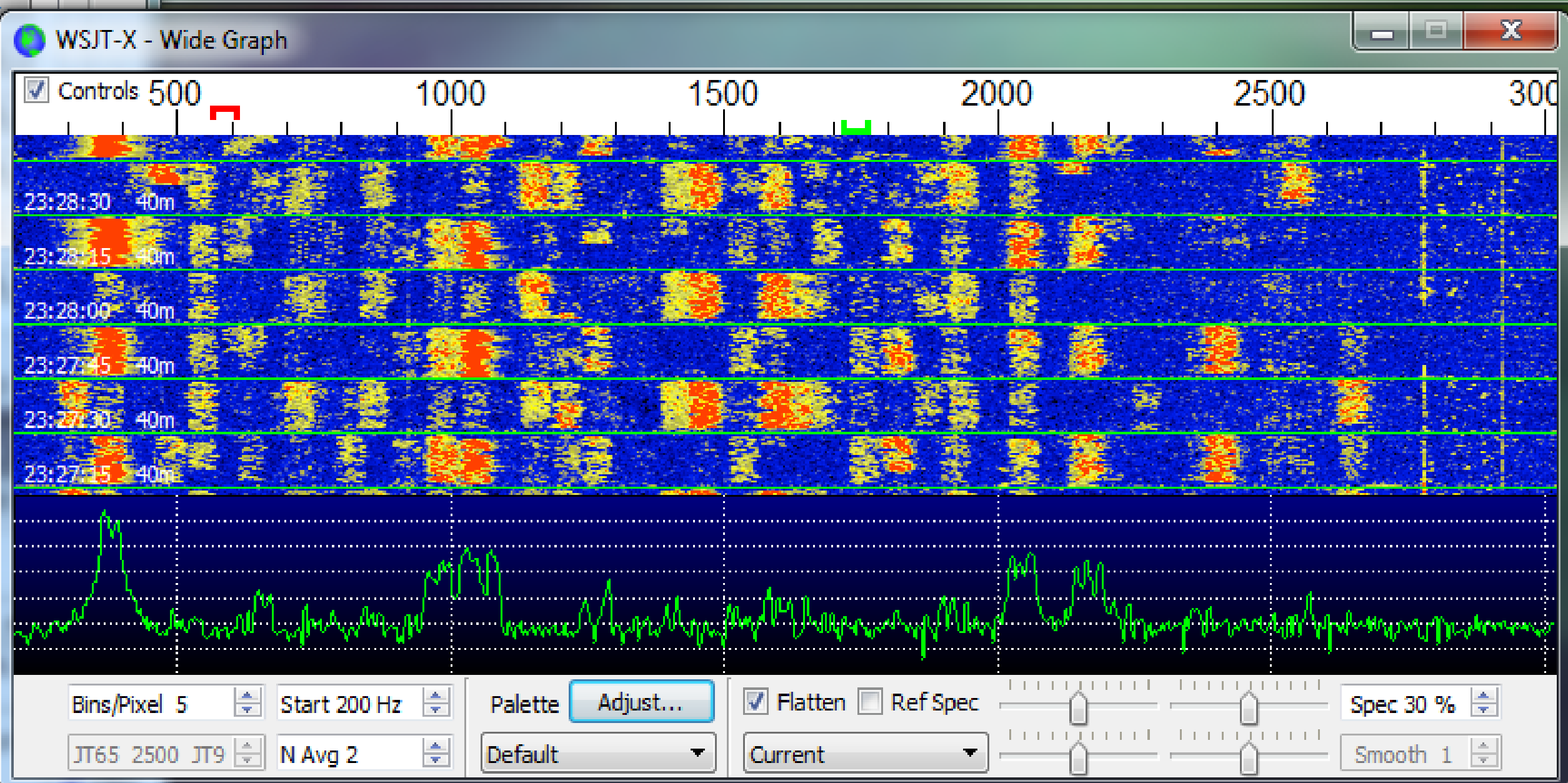


PACKING THEM IN!

- Note the numbers in the top white strip.
- That's right, HERTZ!
- There's at -least- 30 QSO's ongoing in this ~3kHz slice of the 20m band!
- 3kHz is the BW of a typical SSB Voice emission!



FT8 WSJT-X WIDE GRAPH - A CLOSER LOOK



WSJT-X CONTROL PANEL USING FT8

WSJT-X v1.8.0-rc3 by K1JT

File Configurations View Mode Decode Save Tools Help

Band Activity

UTC	dB	DT	Freq	Message
061730	1	0.2	2313	~ C31MF N2OHP EM60
061730	-16	0.1	2391	~ ZL1BRL KL7J -03
061730	-13	0.1	1306	~ NU6V KC2DPF RRR
061800	-5	0.2	692	~ K6FW K7GA -20
061800	-15	0.2	822	~ F1BBI 3D2TS R-10
061800	-10	-0.0	922	~ CQ ZL1MVL RF74 New Zealand
061800	9	0.2	1354	~ WA6OWM K5KMM RRR
061800	-3	0.1	1677	~ F5JQF KK4A RRR
061800	-2	0.2	2150	~ KG5RPZ LU1WU 73
061800	-16	0.1	2390	~ ZL1BRL KL7J -03
061800	-10	0.1	1307	~ NU6V KC2DPF RRR

Rx Frequency

UTC	dB	DT	Freq	Message
061445	Tx		2200	~ CQ W5KAO DM65
061515	Tx		2200	~ CQ W5KAO DM65
061545	Tx		2200	~ CQ W5KAO DM65
061615	Tx		2200	~ CQ W5KAO DM65
061630	4	0.1	2200	~ W5KAO AF7U CN84
061645	Tx		2200	~ AF7U W5KAO +04
061700	7	0.1	2199	~ W5KAO AF7U R-04
061715	Tx		2200	~ AF7U W5KAO RRR
061730	0	0.1	2198	~ W5KAO AF7U 73
061745	Tx		2200	~ AF7U W5KAO 73
061815	Tx		2200	~ CQ W5KAO DM65

Log QSO
Stop
Monitor
Erase
Decode
Enable Tx
Halt Tx
Tune
 Menus

40m

7.074 000

Tx even/1st

DX Call

DX Grid

AF7U

CN84

Az: 311 1687 km

Lookup

Add

Tx 2200 Hz

Rx 2198 Hz

Hold Tx Freq

Tx ← Rx

Rx ← Tx

Report 0

Auto Seq

Call 1st

NA VHF Contest

2018 Mar 09
06:18:42

Generate Std Msgs

Next	Now
AF7U W5KAO DM65	<input type="radio"/> Tx 1
AF7U W5KAO +00	<input type="radio"/> Tx 2
AF7U W5KAO R+00	<input type="radio"/> Tx 3
AF7U W5KAO RRR	<input type="radio"/> Tx 4
AF7U W5KAO 73	<input type="radio"/> Tx 5
CQ W5KAO DM65	<input checked="" type="radio"/> Tx 6

52 dB

Receiving
IC-7300
FT8
Last Tx: CQ W5KAO DM65
12/15
WD:6m

OTHER DIGI-MODE TECHNICAL DETAILS

- Different modes have different parameters. Bandwidth ranges from 177.6 Hz (JT65) 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>

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

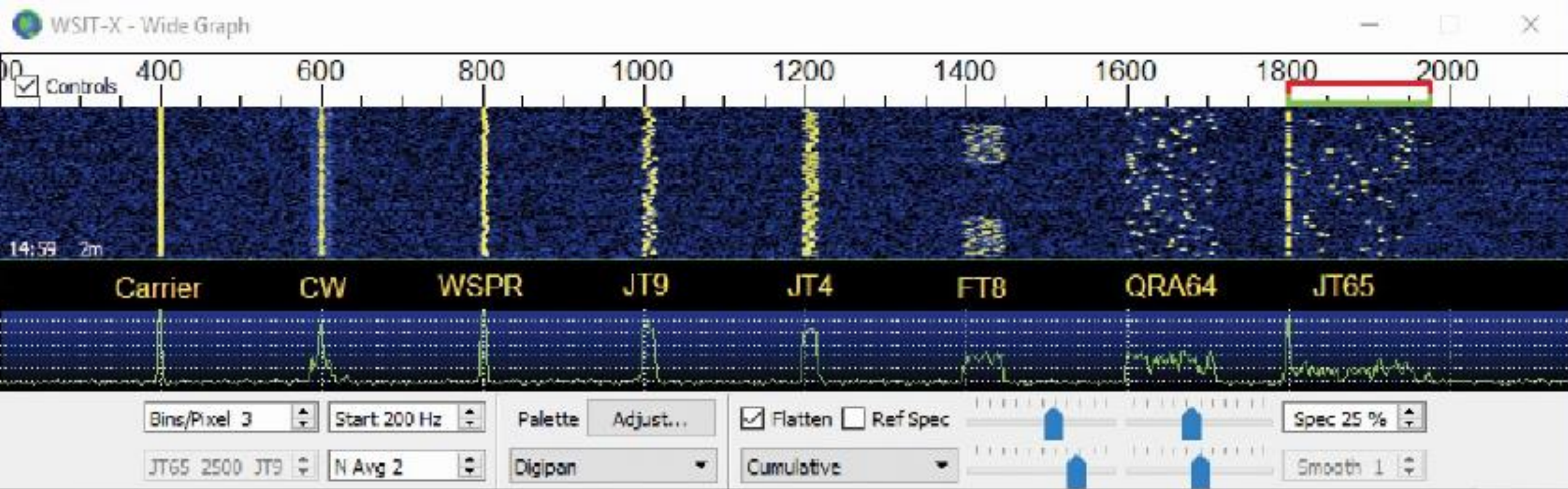
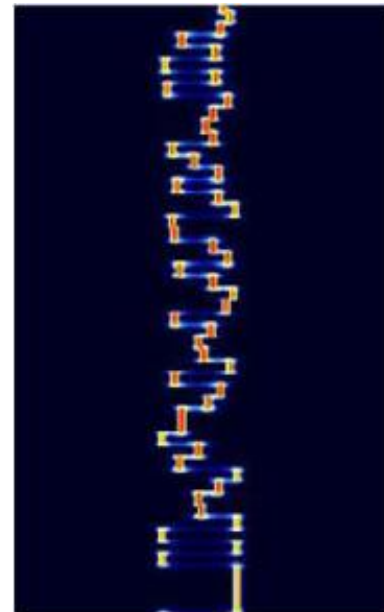
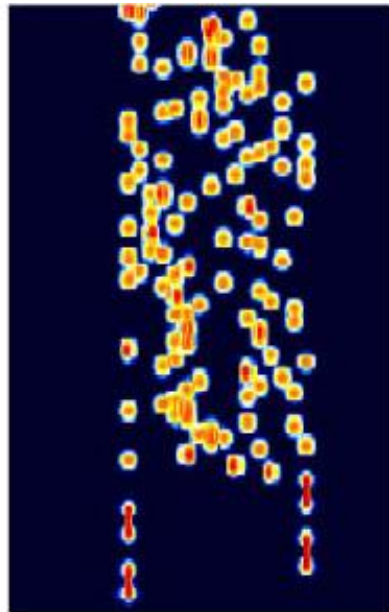


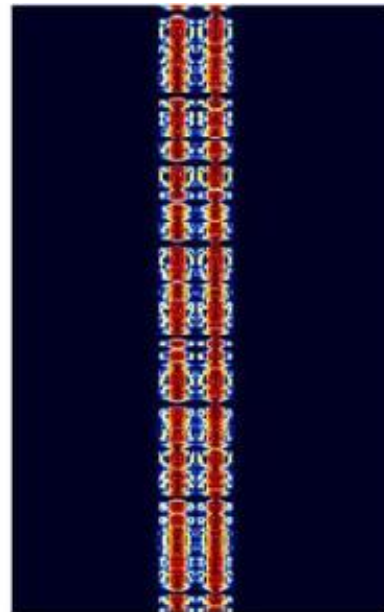
Figure 2 — Simulated signals for an unmodulated carrier, a 25 WPM CW signal, and the *WSJT-X* slow modes WSPR, JT9, JT4, FT8, QRA64A, and JT65. The slow modes are shown in their “A” submode, in increasing order of occupied bandwidth. All signals have S/N of -10 dB in a 2,500 Hz reference bandwidth. The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



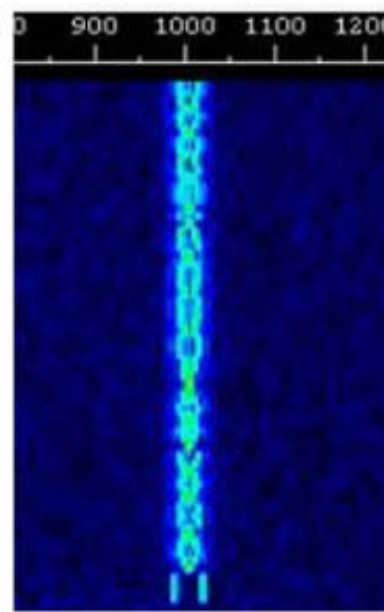
MFSK-8



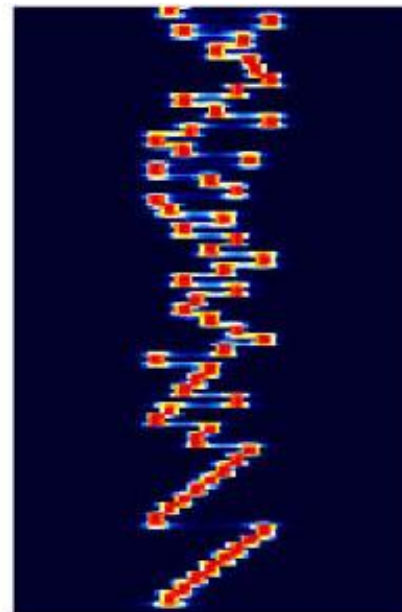
Olivia 16-500



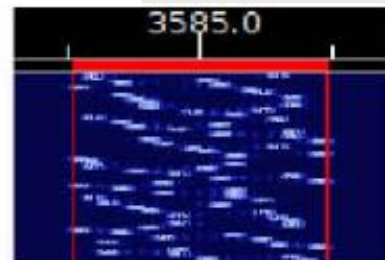
RTTY



PSK31



THOR



Domino EX11



MFSK16

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

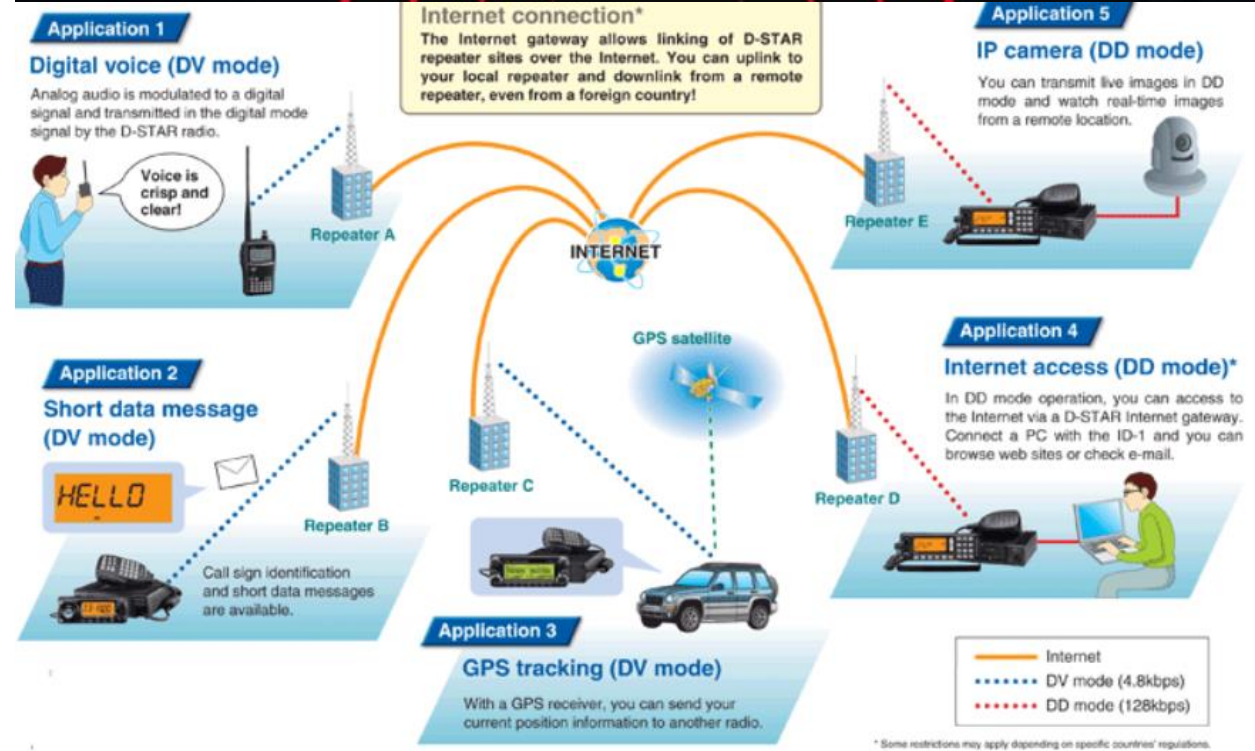
Mode	160m	80m	40m	30m	20m	17m	15m	12m	10m
RTTY	1.838	3.590	7.043	10.143	14.080	18.105	21.080	24.925	28.080
PSK31	1.838	3.580	7.070	10.142	14.070	18.097	21.080	24.920	28.120
Olivia	1.838	3.583	7.072	10.141	14.077	18.103	21.086	24.921	28.076
MT63	1.807	3.585	7.035	10.137	14.109	18.100	21.070	24.920	28.130
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

DIGITAL VOICE MODES

- Yaesu Fusion
- ICOM/Kenwood D-STAR
- P25 & DMR
- FreeDV (Open-Source Digital Voice)
- Others?

**DIGITAL VOICE
OVER HF
CODEC2 & FREEDV**

- Digital SSTV



Q & A TIME

- There are no Dumb Questions!
- But a Valid MNW Answer may be,
- “I Don’t Know”...

ADDITIONAL REFERENCES AND LINKS

- WSJT User Guide:
- http://physics.princeton.edu/pulsar/k1jt/wsjt/doc/wsjt_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/wsjt.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

