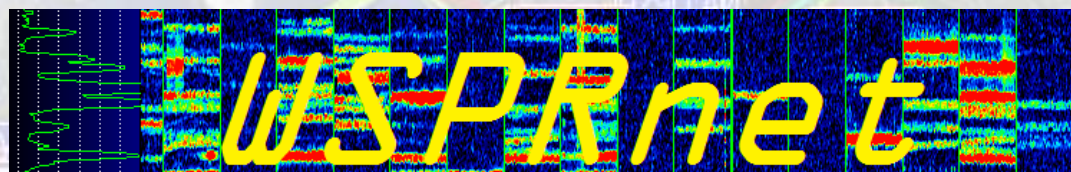


A Beginner's Intro to



Presented to the Austin Amateur Radio Club

October 6, 2020

By K5MSK, Michael Skurka

Expectations

This presentation:

- **IS**

- An introduction to WSPR and WSPRnet. Plain and simple.
- A starting point to give you *ideas* about what equipment and software is available.

- **IS NOT**

- A complete how-to guide to teach you everything to setup a WSPR beacon or receiver.
- A complete tutorial on any particular software.

A full multi-hour presentation could be done for the details and many combinations of equipment and software.

My Experience

Licensed in 2013, and I'm an amateur radio digital **N00B**! I don't know everything, but am ready, willing, and able to learn, and share along the way.

I have only been using digital modes (other than Packet and Winlink) with my transceivers for about two months. And I'm enjoying it.

I use both a Yaesu FT-991A with built-in sound card and a Yaesu FT-897D with a Signalink. Yes. It gets confusing at times.

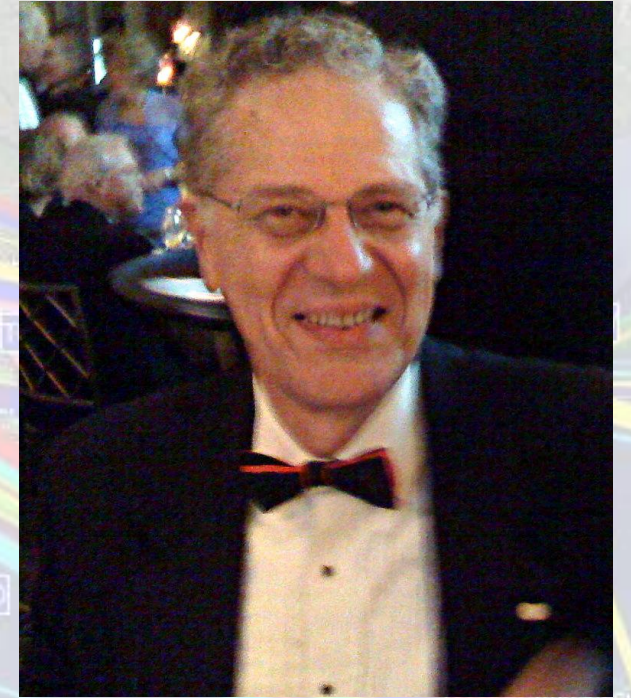
I now have considerable experience with in-depth configuration of the sound settings with Windows 10 Pro (see my August AARCOVER article for some pointers). I'm learning to *hate* Windows 10 more and more! ;)

What is WSPR?

- WSPR (pronounced “whisper”) is the *protocol* used for weak-signal radio communication. The protocol was designed, and a program written initially, by Joe Taylor, K1JT (astrophysicist and Nobel prize in Physics laureate). WSJT-X gets its name from “**W**eak **S**ignal / **J**oe **T**aylor”. Its initial release was in 2008 with coding in Python, Fortran, and C. The cross-platform software is now open source and is developed by a small team.
- The program is designed for sending and receiving low-power transmissions to test propagation paths on the MF and HF bands.

Joseph Hooten Taylor, 2008

Source: [Wikipedia](#) / [Creative Commons license](#)



What is WSPRnet?

- The **Weak Signal Propagation Reporter Network** is a group of amateur radio operators using K1JT's MEPT_JT digital mode to probe radio frequency propagation conditions using very low power (QRP/QRPP) transmissions. The software is open source, and the data collected are available to the public through the WSPRnet.org website.
- That means... It's a bunch of hams around the world who (normally) transmit using about 5-watts or less (some will use more... but why), and *commonly* in the milliwatts. And it's also a bunch of other hams who listen to these transmissions and send reports to WSPRnet for logging.

The WSPR Protocol

- The standard message is:
 - `<callsign> + <4-digit locator> + <dBm transmit power>`
- Messages with a compound callsign (i.e. ZA/K1ABC) and/or a 6-digit locator use a two-transmission *sequence*. The first transmission carries compound callsign and power level, or standard callsign, 4 digit locator, and power level; the second transmission carries a hashed callsign, 6 digit locator, and power level. Add-on prefixes can be up to three alphanumeric characters; add-on suffixes can be a single letter or one or two digits. (<http://physics.princeton.edu/pulsar/k1jt/>)



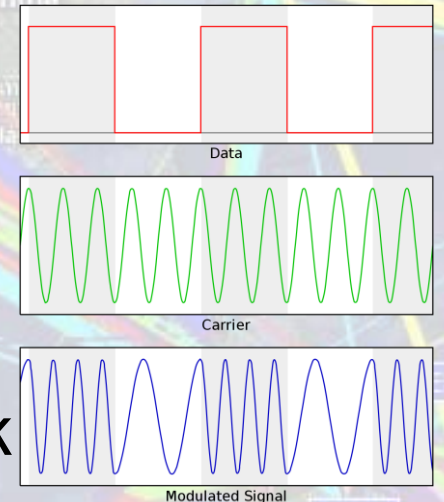
The WSPR Protocol

- Occupied bandwidth is about 6 Hz. For comparison, SSB voice uses *approximately* 3,000 Hz bandwidth.
- Keying rate is very sloooooow... $12000/8192 = \mathbf{1.4648 \text{ baud}}$.
- Synchronization is via a 162-bit pseudo-random sync vector.
- Duration of transmission is $162 \times 8192/12000 = 110.6$ seconds.
- Transmissions nominally start one second into an even UTC minute: e.g. at hh:00:01, hh:02:01, etc.
- Minimum S/N for reception is around -34 dB.

The WSPR Protocol

FSK Basics

- Frequency-shift keying (FSK) is a frequency modulation scheme in which digital information is transmitted through discrete frequency changes of a carrier signal.
- The technology is commonly used for communication systems such as telemetry, weather balloon radiosondes, caller ID, garage door openers, and low frequency radio transmission. (Your wireless thermometer likely uses FSK.)
- The simplest FSK is binary FSK (BFSK). BFSK uses a pair of discrete frequencies to transmit binary (0s and 1s) information.[2] With this scheme, the "1" is called the mark frequency and the "0" is called the space frequency.



The WSPR Protocol

- Modulation is continuous phase **4** FSK, with 1.4648 Hz tone separation.
- Each channel symbol conveys one sync bit (LSB) and one data bit (MSB).
- See the **four** different frequency steps in the image on the right?

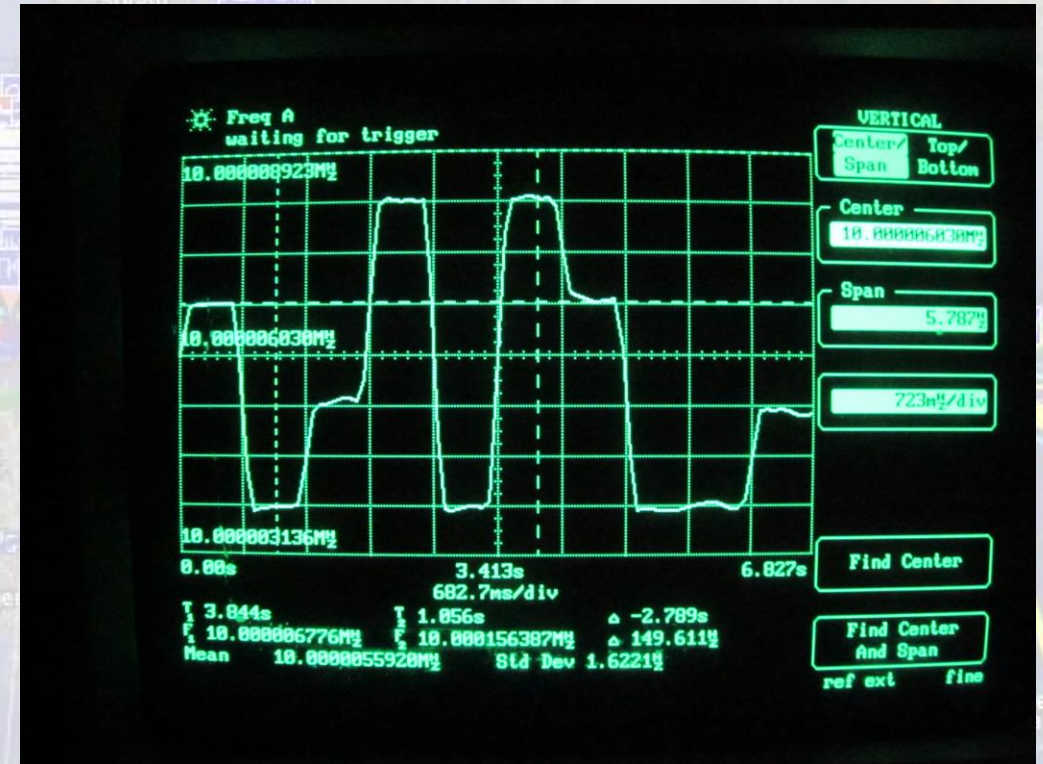
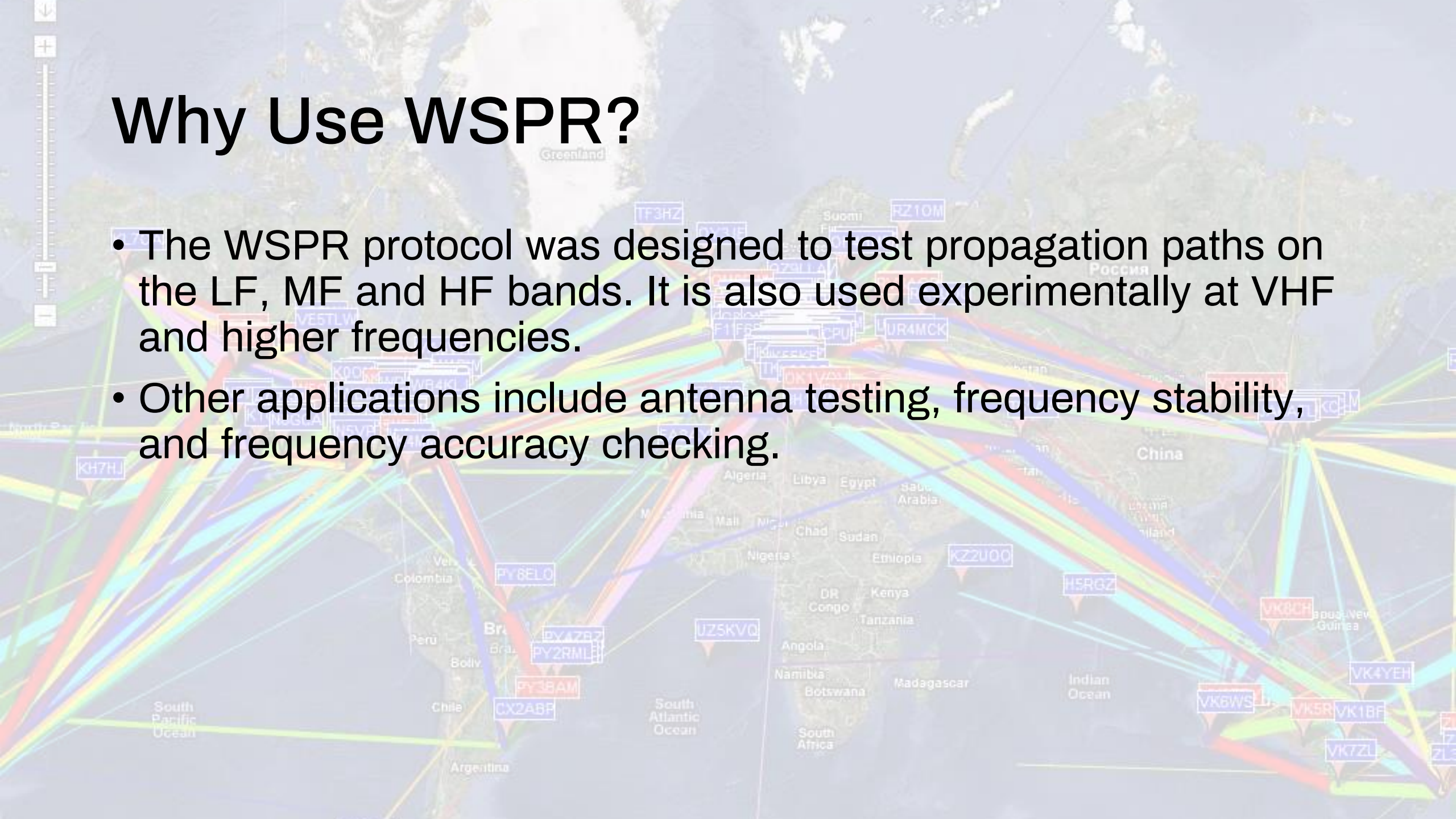


Image by Louis Taber - Own work, CC BY-SA 4.0,
<https://commons.wikimedia.org/w/index.php?curid=75422613>

Why Use WSPR?

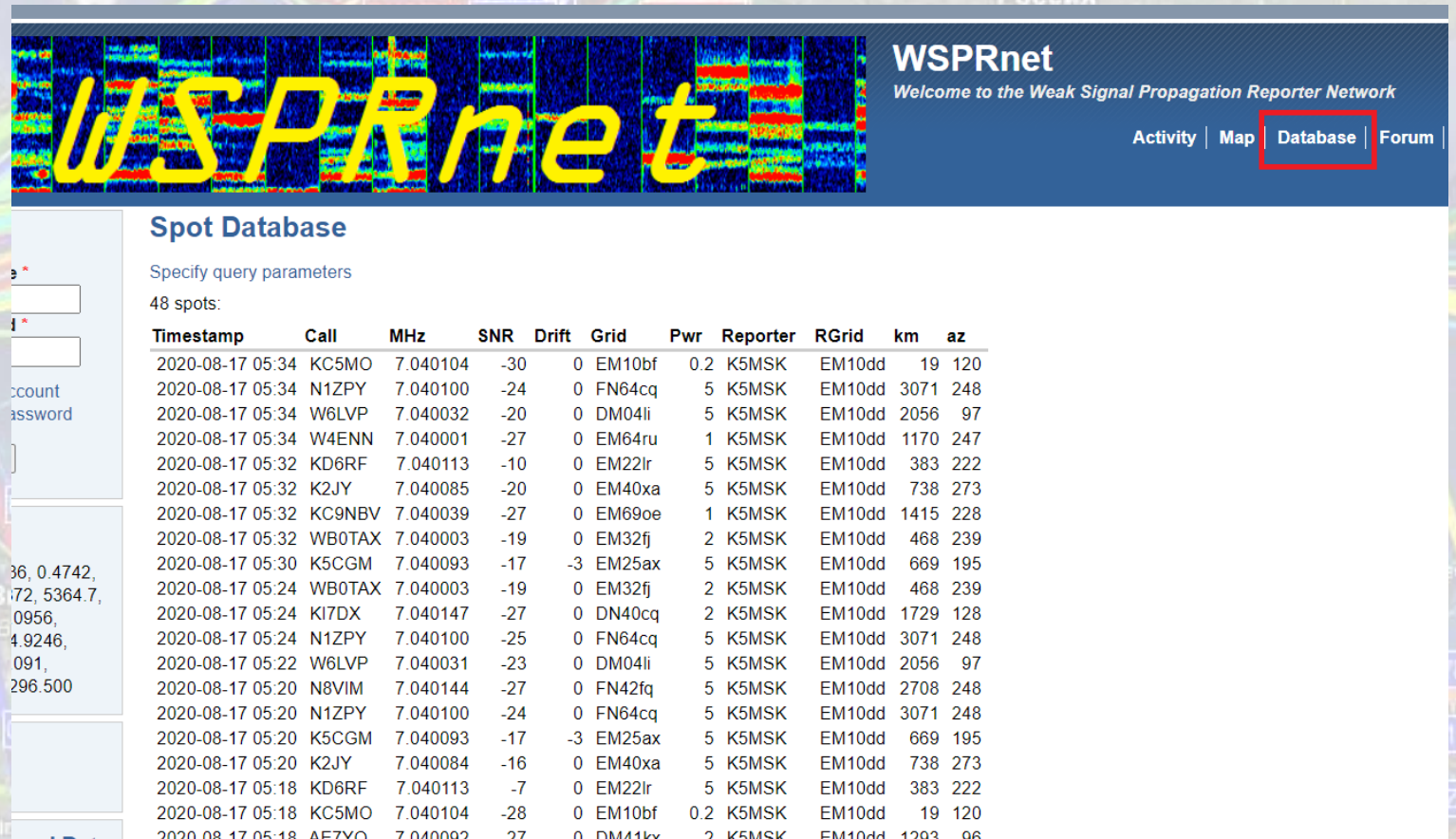
- The WSPR protocol was designed to test propagation paths on the LF, MF and HF bands. It is also used experimentally at VHF and higher frequencies.
- Other applications include antenna testing, frequency stability, and frequency accuracy checking.



WSPRnet.org

The WSPRnet.org website has maps and database to visualize current reporting.

This is an example of me “spotting” in the database (about 16 minutes of spotting).



WSPRnet
Welcome to the Weak Signal Propagation Reporter Network

[Activity](#) | [Map](#) | [Database](#) | [Forum](#)

Spot Database

Specify query parameters

48 spots:

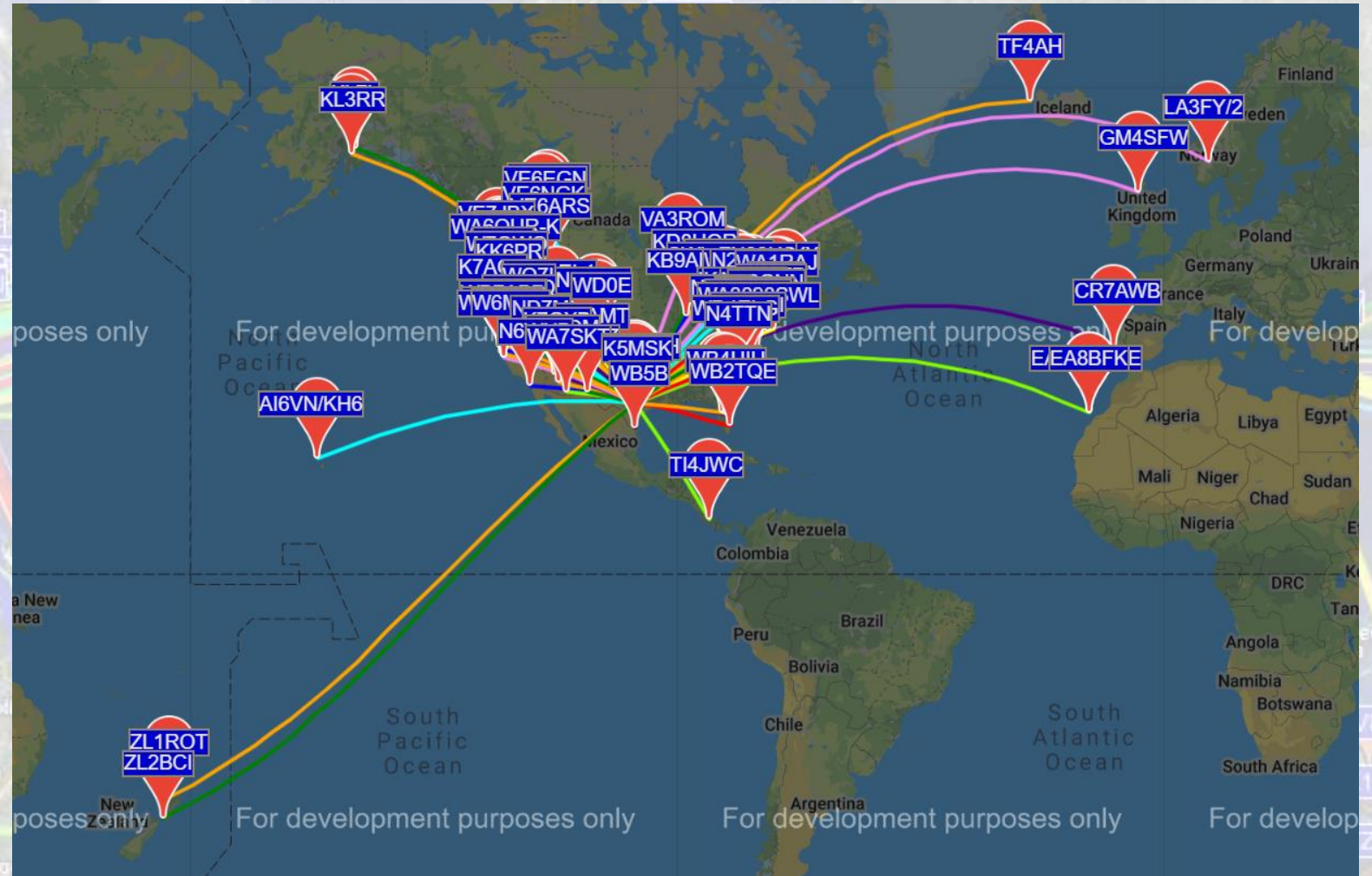
Timestamp	Call	MHz	SNR	Drift	Grid	Pwr	Reporter	RGrid	km	az
2020-08-17 05:34	KC5MO	7.040104	-30	0	EM10bf	0.2	K5MSK	EM10dd	19	120
2020-08-17 05:34	N1ZPY	7.040100	-24	0	FN64cq	5	K5MSK	EM10dd	3071	248
2020-08-17 05:34	W6LVP	7.040032	-20	0	DM04li	5	K5MSK	EM10dd	2056	97
2020-08-17 05:34	W4ENN	7.040001	-27	0	EM64ru	1	K5MSK	EM10dd	1170	247
2020-08-17 05:32	KD6RF	7.040113	-10	0	EM22lr	5	K5MSK	EM10dd	383	222
2020-08-17 05:32	K2JY	7.040085	-20	0	EM40xa	5	K5MSK	EM10dd	738	273
2020-08-17 05:32	KC9NBV	7.040039	-27	0	EM69oe	1	K5MSK	EM10dd	1415	228
2020-08-17 05:32	WB0TAX	7.040003	-19	0	EM32fj	2	K5MSK	EM10dd	468	239
2020-08-17 05:30	K5CGM	7.040093	-17	-3	EM25ax	5	K5MSK	EM10dd	669	195
2020-08-17 05:24	WB0TAX	7.040003	-19	0	EM32fj	2	K5MSK	EM10dd	468	239
2020-08-17 05:24	KI7DX	7.040147	-27	0	DN40cq	2	K5MSK	EM10dd	1729	128
2020-08-17 05:24	N1ZPY	7.040100	-25	0	FN64cq	5	K5MSK	EM10dd	3071	248
2020-08-17 05:22	W6LVP	7.040031	-23	0	DM04li	5	K5MSK	EM10dd	2056	97
2020-08-17 05:20	N8VIM	7.040144	-27	0	FN42fq	5	K5MSK	EM10dd	2708	248
2020-08-17 05:20	N1ZPY	7.040100	-24	0	FN64cq	5	K5MSK	EM10dd	3071	248
2020-08-17 05:20	K5CGM	7.040093	-17	-3	EM25ax	5	K5MSK	EM10dd	669	195
2020-08-17 05:20	K2JY	7.040084	-16	0	EM40xa	5	K5MSK	EM10dd	738	273
2020-08-17 05:18	KD6RF	7.040113	-7	0	EM22lr	5	K5MSK	EM10dd	383	222
2020-08-17 05:18	KC5MO	7.040104	-28	0	EM10bf	0.2	K5MSK	EM10dd	19	120
2020-08-17 05:18	AF7YO	7.040092	-27	0	DM41kv	2	K5MSK	EM10dd	1293	96

WSPRnet.org

Here is a map of what stations heard me one night when I was transmitting with only 5 watts.

New Zealand to Norway and Iceland!

Don't tell me the bands are "dead".



How Can I Use WSPR?

A WSPR station is *normally* comprised of a **radio** and a **computer**.

The radio must have audio connections to/from the computer.

The computer will run software to decode (listen) or encode (transmit) the WSPR protocol.

If you're using digital modes with WSJT-X or fldigi, you already have everything you need!

How Can I Use WSPR?

TO LISTEN (and optionally report, i.e. “spot”)

- Computer
 - Computer can even be a Raspberry Pi.
 - WSJT-X and fldigi are popular programs
 - An accurate clock is needed! Windows OS time sync is usually not good enough. Other free software is available.
- Receiver
 - Receiver can be an amateur radio or a small, an inexpensive DVB-T dongle, i.e. RTL-SDR (\$25), NooElec (\$30 for the premium version), or the more robust SDRplay RSP series (\$120 to \$280).

How Can I Use WSPR?

Example devices
for receiving



RTL-SDR



SDRplay (several
models available)

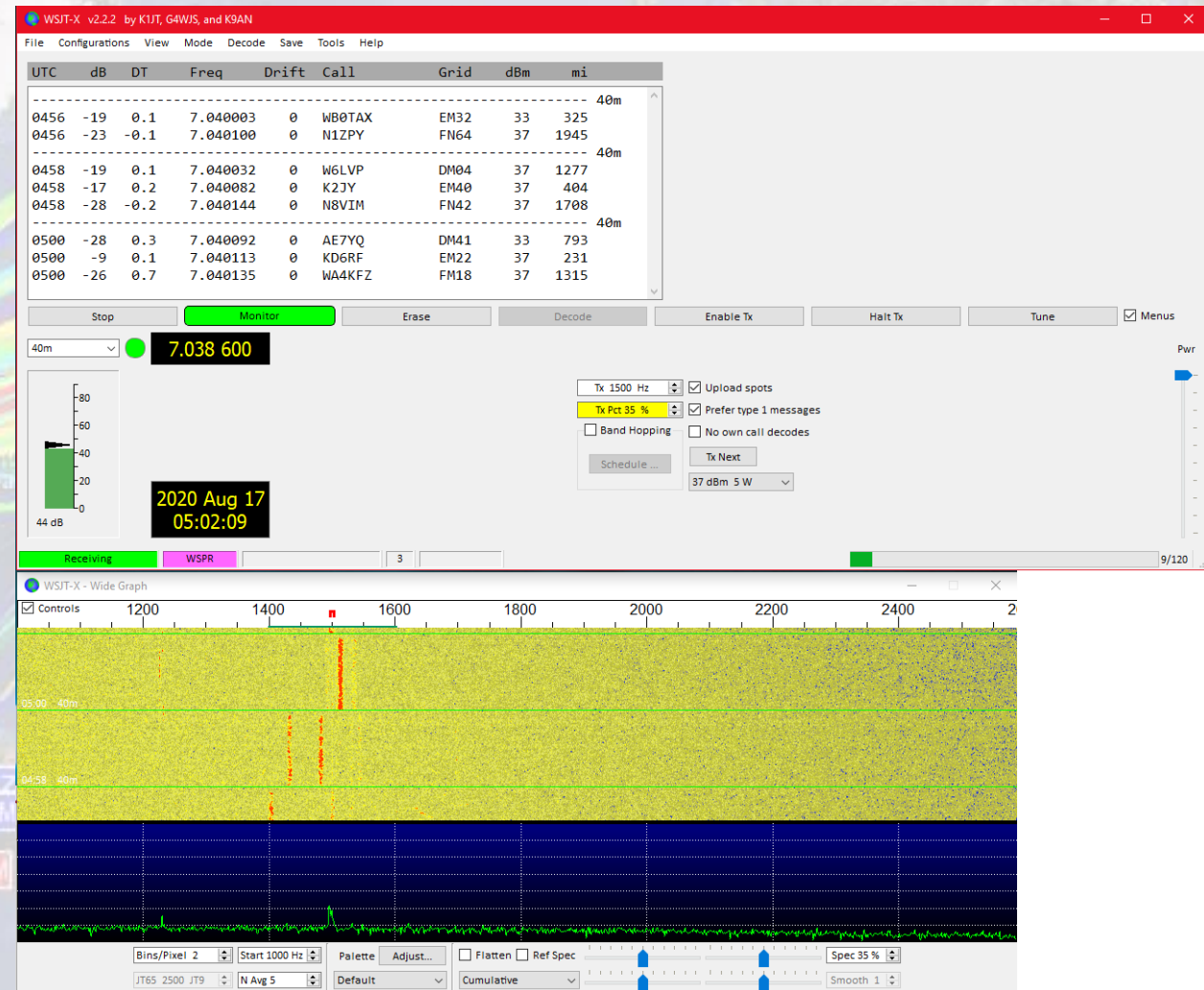
NooElec DVB-T (SDR)



How Can I Use WSPR?

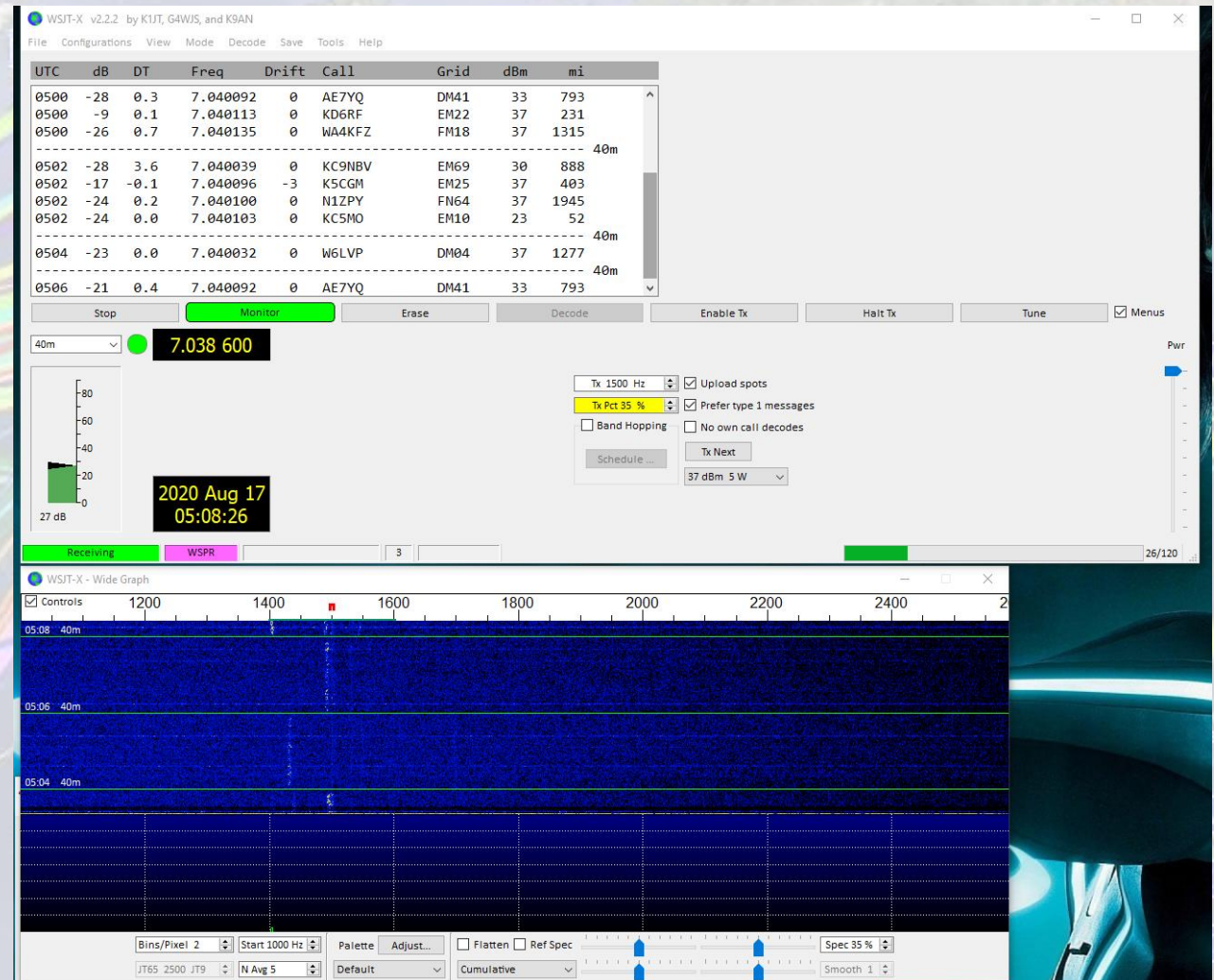
This and following slides show examples of using WSJT-X to listen and spot.

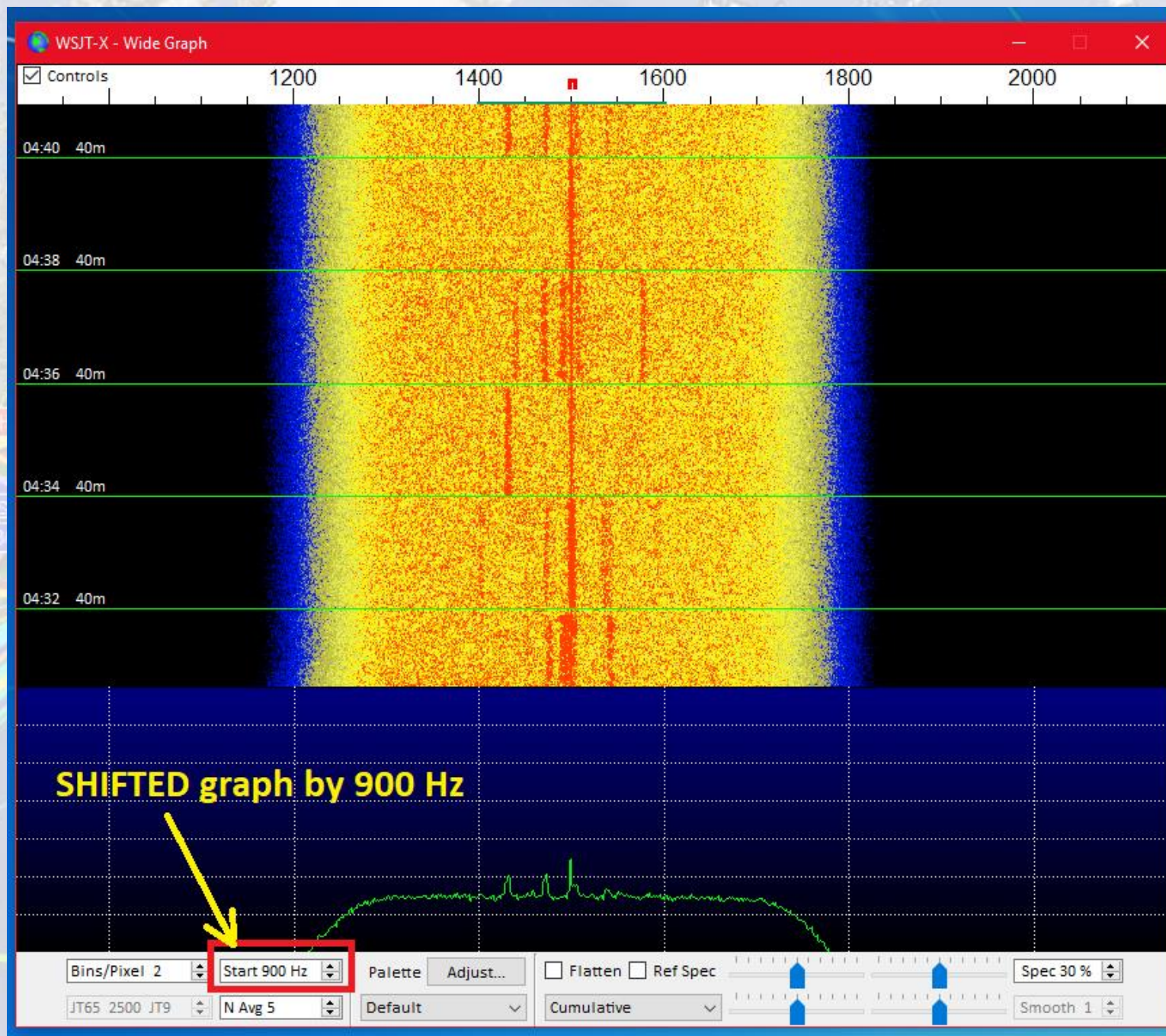
Here, RF Gain is way too high!



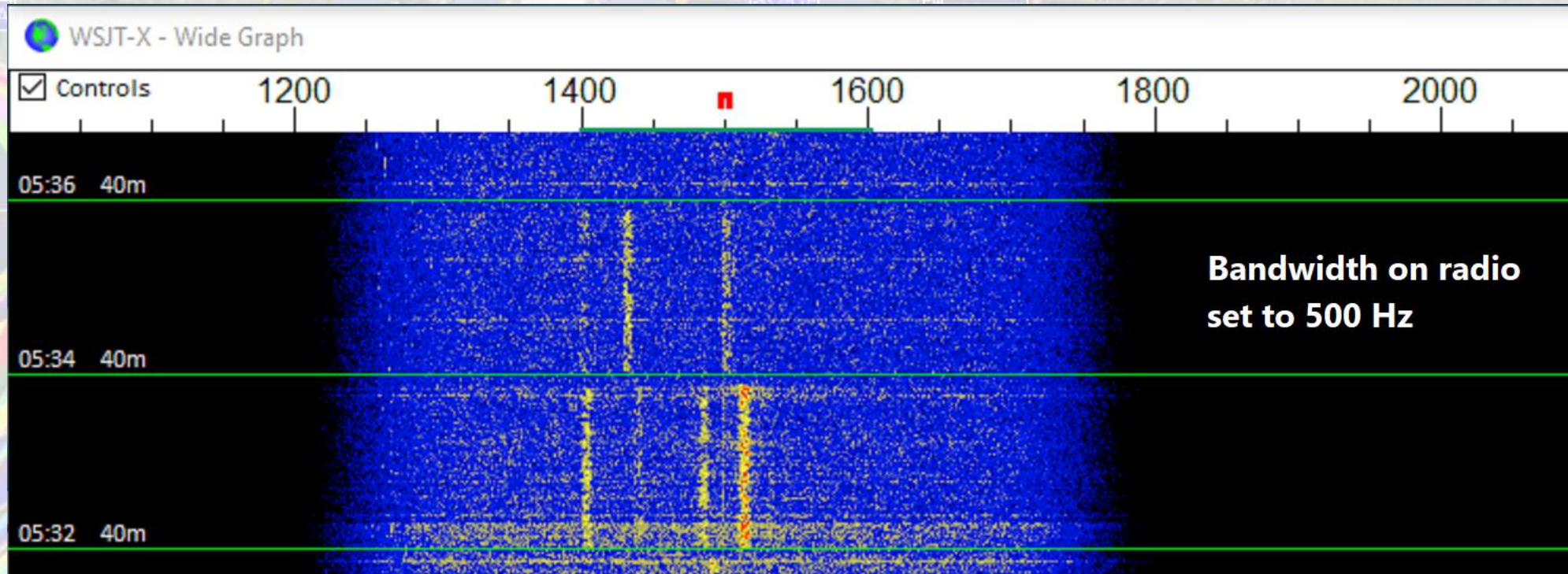
How Can I Use WSPR?

RF gain set to 30dB for best results at my QTH. YMMV. Adjust as needed for your location/setup.



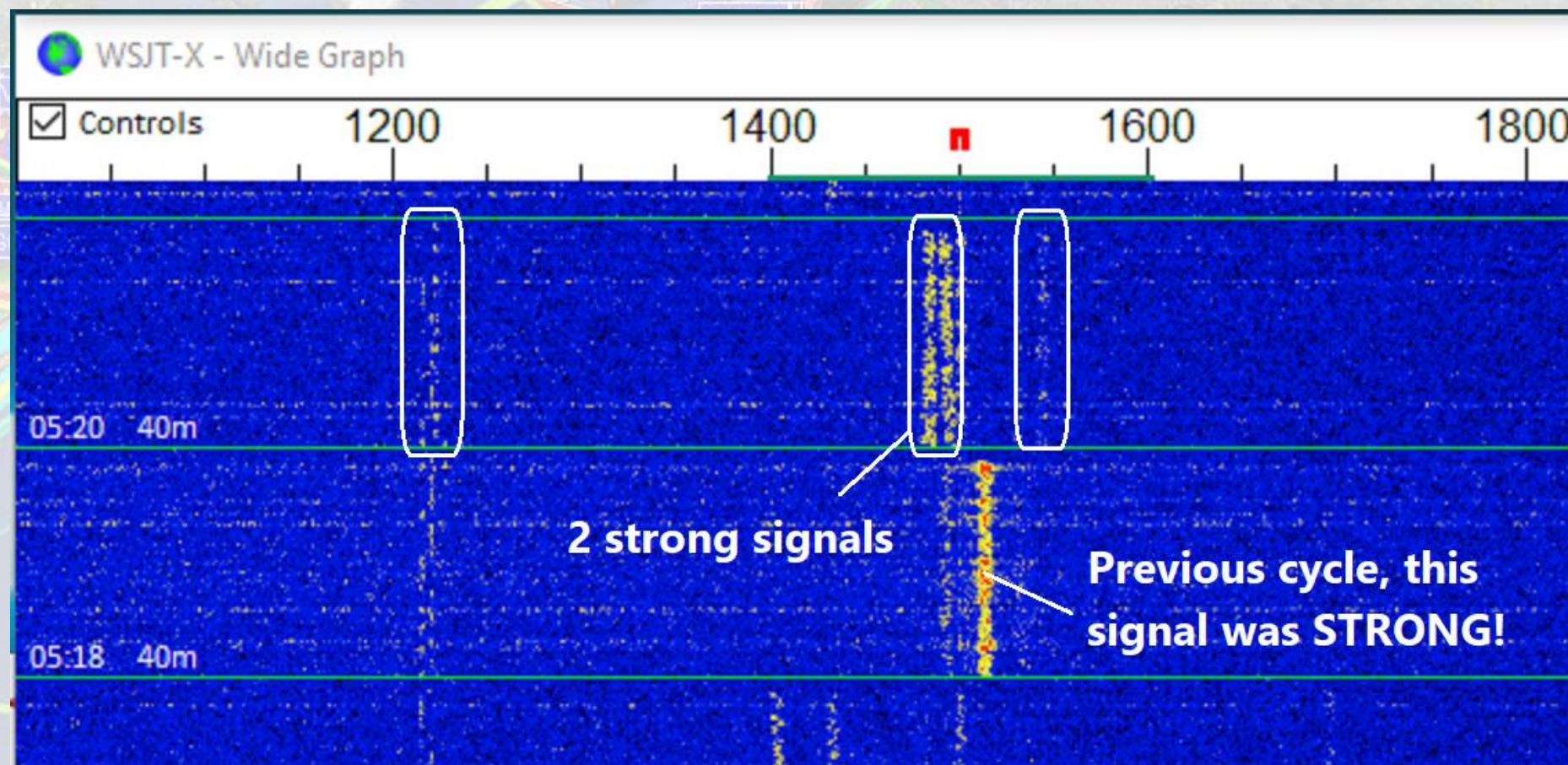


How Can I Use WSPR?



How Can I Use WSPR?

Example



How Can I Use WSPR?

Spot Database

Specify query parameters

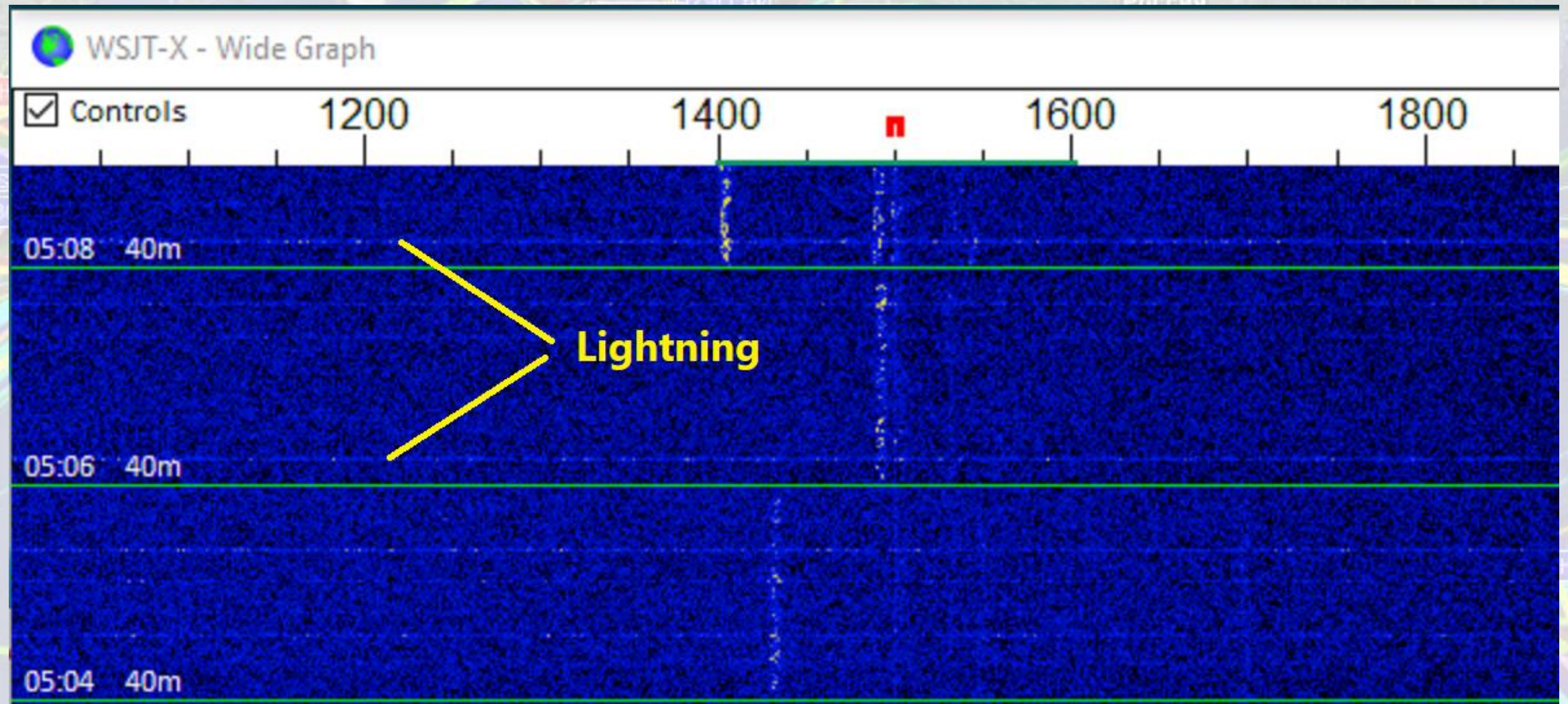
35 spots:

Timestamp	Call	MHz	SNR	Drift	Grid	Pwr	Reporter	RGrid	km	az
2020-08-17 05:20	N8VIM	7.040144	-27	0	FN42fq	5	K5MSK	EM10dd	2708	248
2020-08-17 05:20	N1ZPY	7.040100	-24	0	FN64cq	5	K5MSK	EM10dd	3071	248
2020-08-17 05:20	K5CGM	7.040093	-17	-3	EM25ax	5	K5MSK	EM10dd	669	195
2020-08-17 05:20	K2JY	7.040084	-16	0	EM40xa	5	K5MSK	EM10dd	738	273
2020-08-17 05:18	KD6PE	7.040113	7	0	EM22lr	5	K5MSK	EM10dd	383	222

Spot database updates quickly:

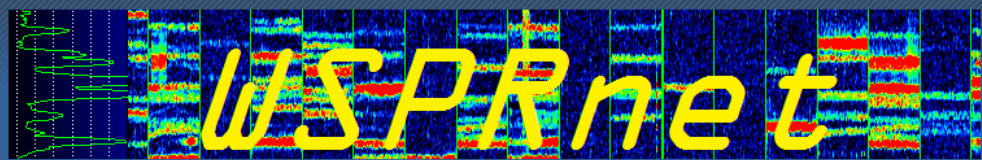
How Can I Use WSPR?

Interesting observation: Lightning splatters the spectrum



How Can I Use WSPR?

Go to
WSPRnet.org
to view spots



WSPRnet
Welcome to the Weak Signal Propagation Network

User login

Username *

Password *

Create new account
Request new password

Log in

Database

Band

All

Show only spots on this band.

Count

50

Maximum number of spots to show (10000)

Call

Only show spots of this callsign. Use * at the end (only) for wildcard searches.

Reporter

Only show spots reported by this call. If same as "Call", then show spots of this call OR heard by this call. Use * at the end (only) for wildcard searches.

In last

24 Hours

Consider spots only of this recent time period

Sort by

Timestamp

Field to sort by

☒ Reverse
Check to reverse sort order

☐ Unique
Check to show only unique call/reporter combinations

☒ Exclude Special Callsigns
Excludes calls starting with Q and 0, typically used for balloon telemetry

Update

Frequencies

USB dial (MHz): 0.136, 0.4742, 1.8366, 3.5686, 5.2872, 5364.7, 7.0386, 10.1387, 14.0956, 18.1046, 21.0946, 24.9246, 28.1246, 50.293, 70.091, 144.489, 432.300, 1296.500

Navigation

► Forums

3rd Party Maps and Data

M0XDK Map
KB9AMG Monthly Stats
WA2ZKD Spot Analysis
DJ2LS WSPR Spot Heat Map

Who's online

There are currently 84 users online

How Can I Use WSPR?

Database

Band

All ▼

Show only spots on this band.

Count

50

Maximum number of spots to show (10000)

Call

Only show spots of this callsign. Use * at the end (only) for wildcard searches.

Reporter

Only show spots reported by this call. If same as "Call", then show spots of this call OR heard by this call. Use * at the end (only) for wildcard searches.

How Can I Use WSPR?

In last

24 Hours ▾

Consider spots only of this recent time period

Sort by

Timestamp ▾

Field to sort by



Reverse

Check to reverse sort order



Unique

Check to show only unique call/reporter combinations



Exclude Special Callsigns

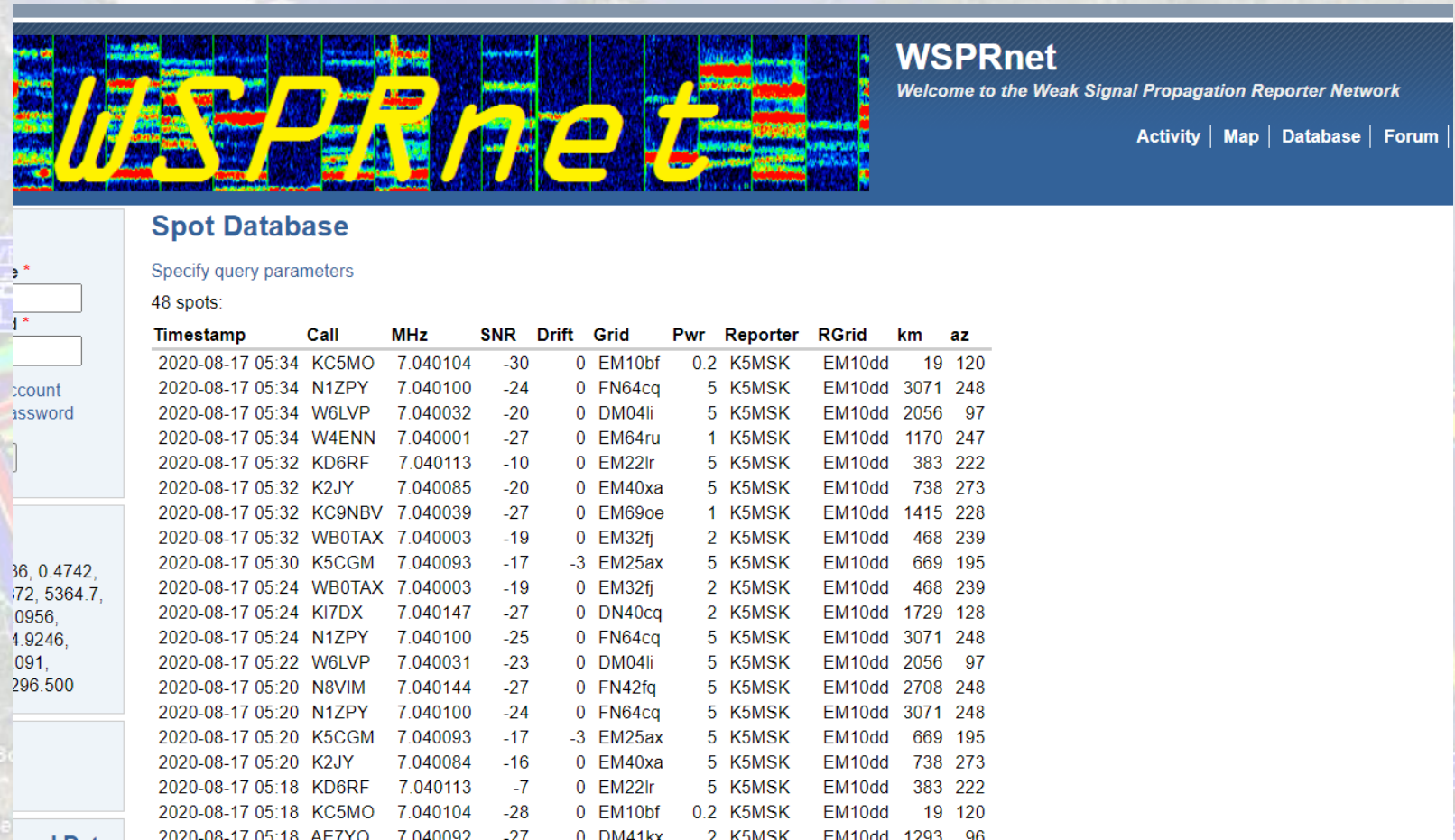
Excludes calls starting with Q and 0, typically used for balloon telemetry

Update

How Can I Use WSPR?

Example of spotting

- Time
- Call sign
- Frequency
- SNR
- Grid (transmitter)
- Power (self report)
- “Me”
- My location
- Distance
- Direction (azimuth)



The screenshot shows the WSPRnet website interface. At the top, there's a header with the WSPRnet logo and the tagline "Welcome to the Weak Signal Propagation Reporter Network". Below the header, there are navigation links: Activity, Map, Database, and Forum. The main content area is titled "Spot Database" and includes a section for "Specify query parameters" with a search bar and a "48 spots:" label. Below this is a table of 48 spots, each with columns for Timestamp, Call, MHz, SNR, Drift, Grid, Pwr, Reporter, RGrid, km, and az.

Timestamp	Call	MHz	SNR	Drift	Grid	Pwr	Reporter	RGrid	km	az
2020-08-17 05:34	KC5MO	7.040104	-30	0	EM10bf	0.2	K5MSK	EM10dd	19	120
2020-08-17 05:34	N1ZPY	7.040100	-24	0	FN64cq	5	K5MSK	EM10dd	3071	248
2020-08-17 05:34	W6LVP	7.040032	-20	0	DM04li	5	K5MSK	EM10dd	2056	97
2020-08-17 05:34	W4ENN	7.040001	-27	0	EM64ru	1	K5MSK	EM10dd	1170	247
2020-08-17 05:32	KD6RF	7.040113	-10	0	EM22lr	5	K5MSK	EM10dd	383	222
2020-08-17 05:32	K2JY	7.040085	-20	0	EM40xa	5	K5MSK	EM10dd	738	273
2020-08-17 05:32	KC9NBV	7.040039	-27	0	EM69oe	1	K5MSK	EM10dd	1415	228
2020-08-17 05:32	WB0TAX	7.040003	-19	0	EM32fj	2	K5MSK	EM10dd	468	239
2020-08-17 05:30	K5CGM	7.040093	-17	-3	EM25ax	5	K5MSK	EM10dd	669	195
2020-08-17 05:24	WB0TAX	7.040003	-19	0	EM32fj	2	K5MSK	EM10dd	468	239
2020-08-17 05:24	KI7DX	7.040147	-27	0	DN40cq	2	K5MSK	EM10dd	1729	128
2020-08-17 05:24	N1ZPY	7.040100	-25	0	FN64cq	5	K5MSK	EM10dd	3071	248
2020-08-17 05:22	W6LVP	7.040031	-23	0	DM04li	5	K5MSK	EM10dd	2056	97
2020-08-17 05:20	N8VIM	7.040144	-27	0	FN42fq	5	K5MSK	EM10dd	2708	248
2020-08-17 05:20	N1ZPY	7.040100	-24	0	FN64cq	5	K5MSK	EM10dd	3071	248
2020-08-17 05:20	K5CGM	7.040093	-17	-3	EM25ax	5	K5MSK	EM10dd	669	195
2020-08-17 05:20	K2JY	7.040084	-16	0	EM40xa	5	K5MSK	EM10dd	738	273
2020-08-17 05:18	KD6RF	7.040113	-7	0	EM22lr	5	K5MSK	EM10dd	383	222
2020-08-17 05:18	KC5MO	7.040104	-28	0	EM10bf	0.2	K5MSK	EM10dd	19	120
2020-08-17 05:18	AE7YO	7.040092	-27	0	DM41ky	2	K5MSK	EM10dd	1293	96

How Can I Use WSPR?

TO TRANSMIT

- Computer
 - WSJT-X is popular software used for digital modes using your HF transceiver connected to your computer.
- Transmitter/transceiver
 - Standalone beacon devices are also readily available - and a separate device will free up your transceiver and computer.

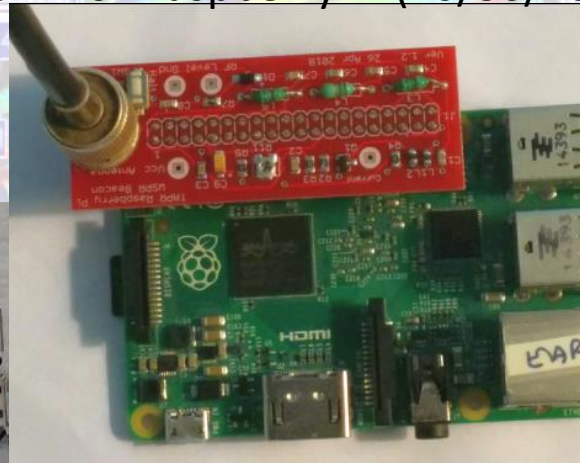
How Can I Use WSPR?






Hand-built and tested by a ham

- Example beacons

WSPR for Raspberry Pi (20/30/40)

A homebrew RaspPi beacon



<p>20mW power out. 10ppm frequency accuracy. Internal GPS antenna.</p>  <p>WSPR-TX Mini</p>  <p>Add-On 600mA LiPo</p> <p>Low current, low cost 1 band</p>	<p>350mW power out. 2.5ppm frequency accuracy. External GPS antenna with 3m cable.</p>  <p>WSPR-TX_LP1</p>  <p>Add-On Mezzanine LP4</p> <p>Flexible, Expandable 1 to 4 bands</p>	<p>350mW power out. 2.5ppm frequency accuracy. External GPS antenna with 3m cable.</p>  <p>WSPR-TX Desktop</p> <p>No Construction. Ready to put on the air. 4 bands</p>
--	---	---

How Can I Use WSPR?

WSJT-X v2.2.2 by K1JT, G4WJS, and K9AN

File Configurations View Mode Decode Save Tools Help

UTC	dB	DT	Freq	Drift	Call	Grid	dBm	mi
0502	-17	-0.1	7.040096	-3	K5CGM	EM25	37	403
0502	-24	0.2	7.040100	0	N1ZPY	FN64	37	1945
0502	-24	0.0	7.040103	0	KC5MO	EM10	23	52

0504	-23	0.0	7.040032	0	W6LVP	DM04	37	1277

0506	-21	0.4	7.040092	0	AE7YQ	DM41	33	793

0508	-17	0.1	7.040003	0	WB0TAX	EM32	33	325
0508	-21	0.1	7.040090	0	N5GG	EM13	27	237
0508	-24	0.2	7.040100	0	N1ZPY	FN64	37	1945
0508	-29	-0.3	7.040144	0	N8VIM	FN42	37	1708

Stop Monitor Erase Decode Enable Tx Halt Tx Tune ☒ Menus

40m ● **7.038 600**

2020 Aug 17 05:10:32

How often to transmit

Tx 1500 Hz ☒ Upload spots
Tx Pct 35 % ☒ Prefer type 1 messages
☐ Band Hopping ☐ No own call decodes
Schedule ... Tx Next
37 dBm 5 W

To start on next cycle, else will wait per Tx Pct.

Receiving WSPR 3 32/120

How Can I Use WSPR?

Maximum

Update

Band
30m **Band**
Show only spots on this band.

☐ Use Band Colors
When checked on, path colors are coded according to band

Call
 Call sign heard
If non-blank, show only those spots involving the specified call

Latitude
20 **Map center**
Center of map latitude

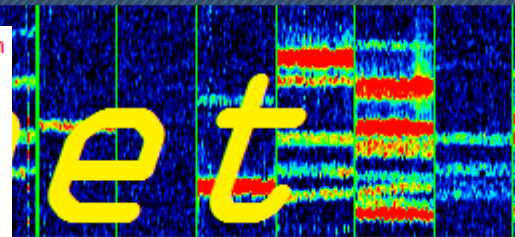
Longitude
20 **Lat/Long**
Center of map longitude (east positive, west negative)

Default Zoom
2 **Zoom level**
Preferred zoom factor (2 = whole world)

Time period
10 minutes **Time period**
Show spots in this period of time

☐ Day/Night overlay
Shows which areas of the earth are in daylight.

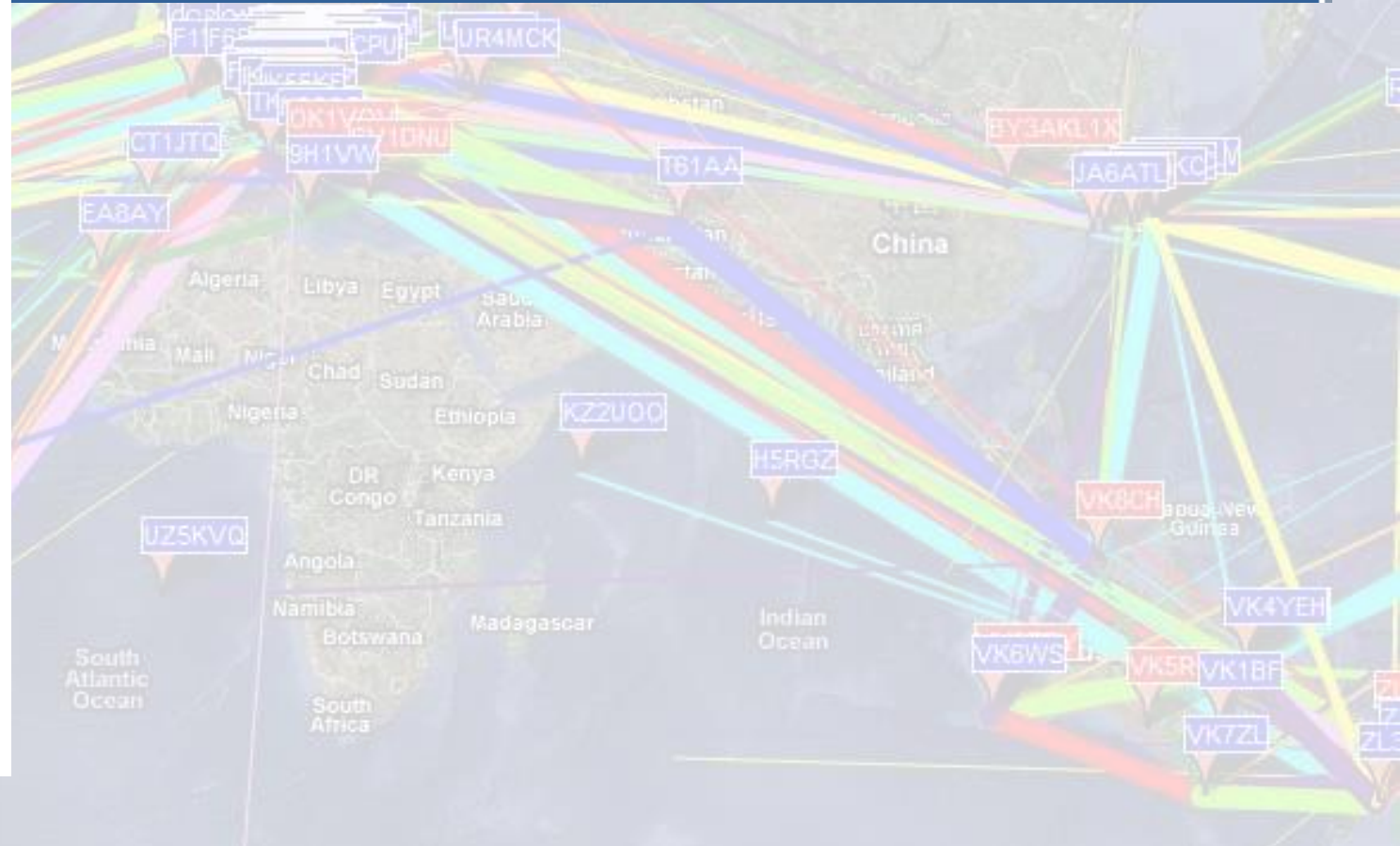
☒ Exclude Special Callsigns **Exclude special calls**
Excludes calls starting with Q and 0, typically used for balloon telemetry



WSPRnet

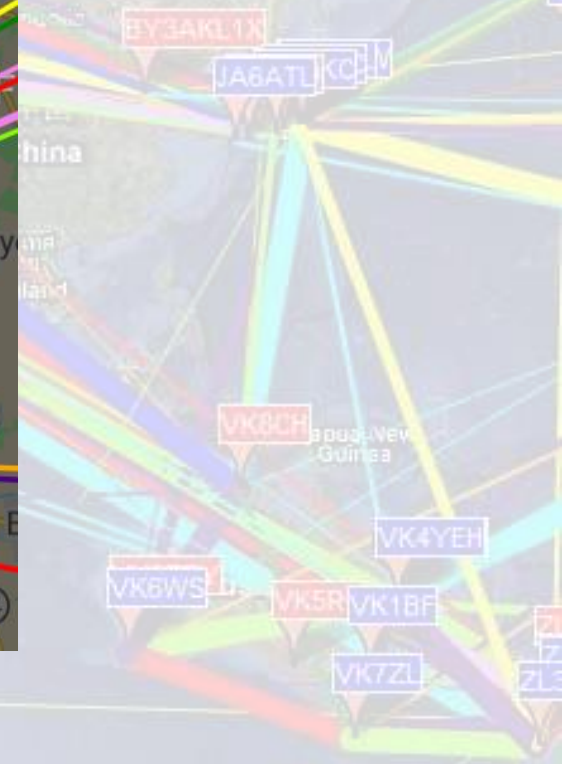
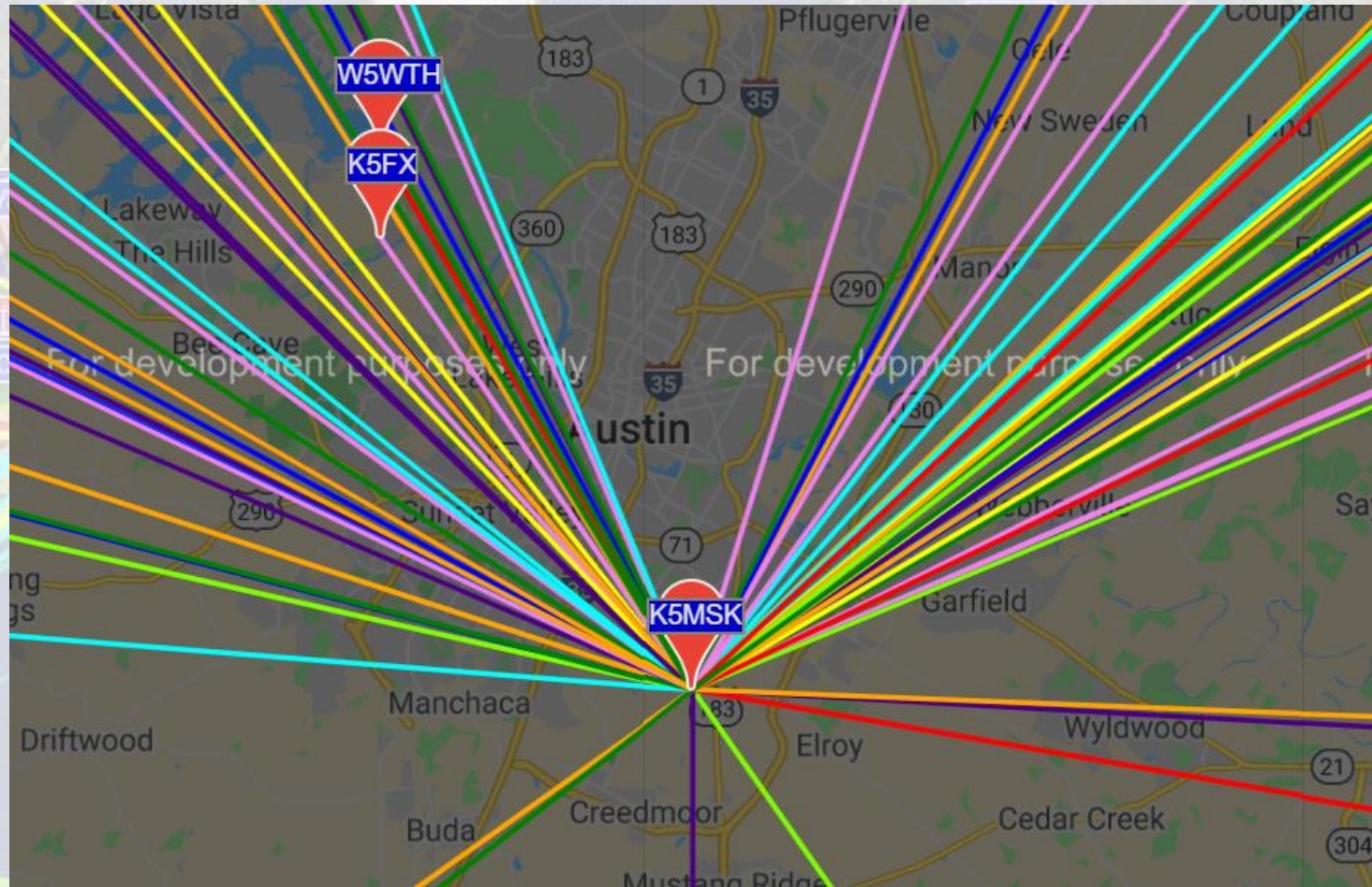
Welcome to the Weak Signal Propagation Reporter Network

Activity | **Map** | Database | Forum | Downloads



How Can I Use WSPR?

EVERY
line is
a station
that heard
ME!





The background is a world map with a network of colorful lines (red, yellow, green, blue, purple) connecting various call signs. The call signs are distributed across the map, with a high concentration in North America and Europe. The lines represent connections between these call signs, creating a complex web. The text "LIVE DEMO!" is centered over the map.

LIVE DEMO!



Questions?

Questions?

Comments?

Your Experiences?

Resources

- WSPRnet.org
 - The main site.
- WSJT Home Page – Weak signal communication software
 - <http://physics.princeton.edu/pulsar/k1jt/>
- The Complete Guide to Weak Signal Propagation Reporter
 - <https://www.amateur-radio-wiki.net/wspr/>
- JTAlert – Audio and visual alerts for WSJT-X and JTDX
 - <https://hamapps.com/>

Resources

- Low-Cost WSPR with Raspberry Pi and SDR
 - <http://sjcars.org/blog/wp-content/uploads/2016/03/WSPR.pdf>
- WSPR decoding/reporting
 - WSJT-X
 - <http://physics.princeton.edu/pulsar/k1jt>
 - fldigi
 - <http://pa0rob.vandenhoff.info/article/fldigi-digi-modes>

Resources

Windows Software for SDR Receiver Control:

- SDR#
 - <https://airspy.com/download/>
- HDSDR
 - <http://www.hdsdr.de/>
- SDR-Radio
 - <http://sdr-radio.com/Software/Download/Download-Kits>
- SDRUNO
 - <https://www.sdrplay.com/downloads/>

Resources

WSPR Beacons

- WSPR for Raspberry Pi, 20/30/40 meters (\$32)
 - <https://tapr.org/product/wspr-without-tears-30-or-40m/>
- Standalone Beacon Transmitter (assembled, tested; only need power and antenna)
 - <https://www.zachtek.com/>
- Raspberry Pi WSPR Transmitter
 - (Using a GPIO pin with a 14MHz bandpass filter and only 0.01 watt)
 - <http://wb6cxc.com/?p=5>

Resources

Time Sync Software for Windows

- Avoid using the built-in Windows sync (it's not accurate enough)
- NTP from Meinberg
 - (runs as a Windows service; based on open source NTP)
 - <https://www.meinbergglobal.com/english/sw/ntp.htm>
- Dimension 4
 - runs as a Windows service; won't check if Windows time service was re-enabled; uninstall leaves service running
 - <http://www.thinkman.com/dimension4/>

Time Sync for Linux

- Use built-in ntpd

Time Sync for Mac OS X, best to do a search for current utils

- <https://www.sync-mac.com/list-of-mac-synchronization-software.html>