

Communications and
propagation below
30MHz – as a hobby?

Amateur ham radio

- A internationally recognized, social, and scientific hobby
- Is regulated by ITU and national authorities (e.g. FCC, PTS)
- Requires a license from a accredited authority (CEPT HAREC)
- ITU removed the Morse code skill requirement in 2003
- Over 2.6 million licenses globally
- Approximately 10,000 licenses in Sweden

Some well-known Swedish hams



Prof. Jens Zander
Head of School, EE & CS,
Royal Institute of Technology
Director of Wireless@KTH



Peter Hultqvist
Swedish secretary of
defense



Christer Fuglesang
Astronaut
Professor, Royal
Institute of Technology



Peter Löthberg
Swedish Internet
legend

And many more: Erik Bergsten, Egon Kjerrman, Bengt Feldreich, Johan Ekelund, ...

Famous international hams



Prof. Ted Rappaport
Founder and Director, NYU
Wireless Center



Prof. Joe Taylor
Physics Department,
Princeton University
Nobel Laureate



Sir Cliff Richard
Artist and musician

And so many more: Yuri Gagarin, Jack Kilby, John Sculley, Marlon Brando, Walter Cronkite, Patty Loveless, Tony Bonjovi, Bob Heil, Sergey Rebrov, Joe Walsh, Feargal Sharkey, Cliff Richard, Chet Atkins, King Juan Carlos, King Hussein, Priscilla Presley, Tony Dolby, Francesco Cossiga, Barry Goldwater, Rajiv Gandhi, Augusto Pinochet, ...

The Reverse Beacon Network

A free cloud service supported by a global network of robot receivers

Franke-Taylor 8-PSK a.k.a. FT8

A modern digital communications protocol for shortwave communications

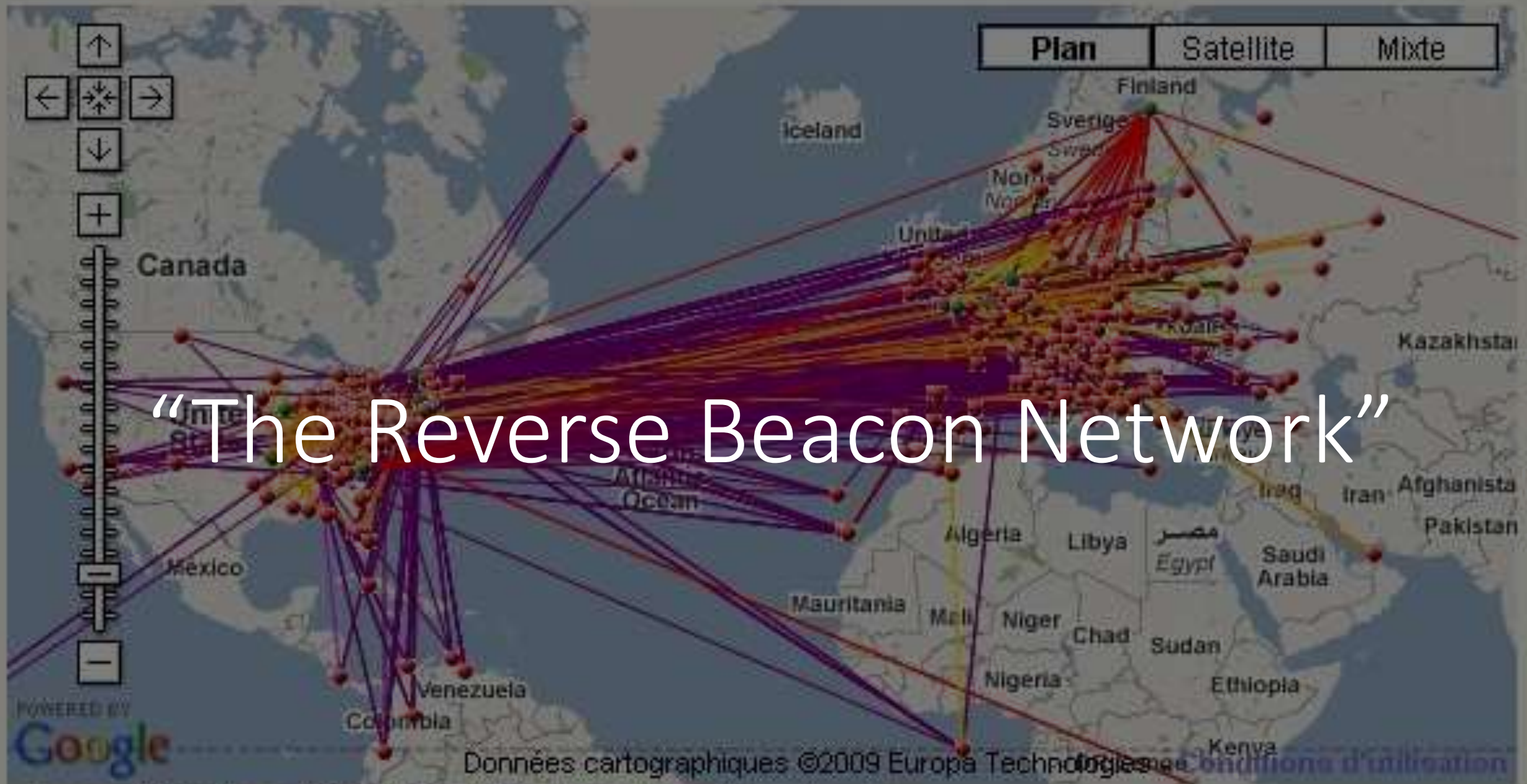


Beacons?

NCDXF/IARU International Beacon Project

Transmission Schedule

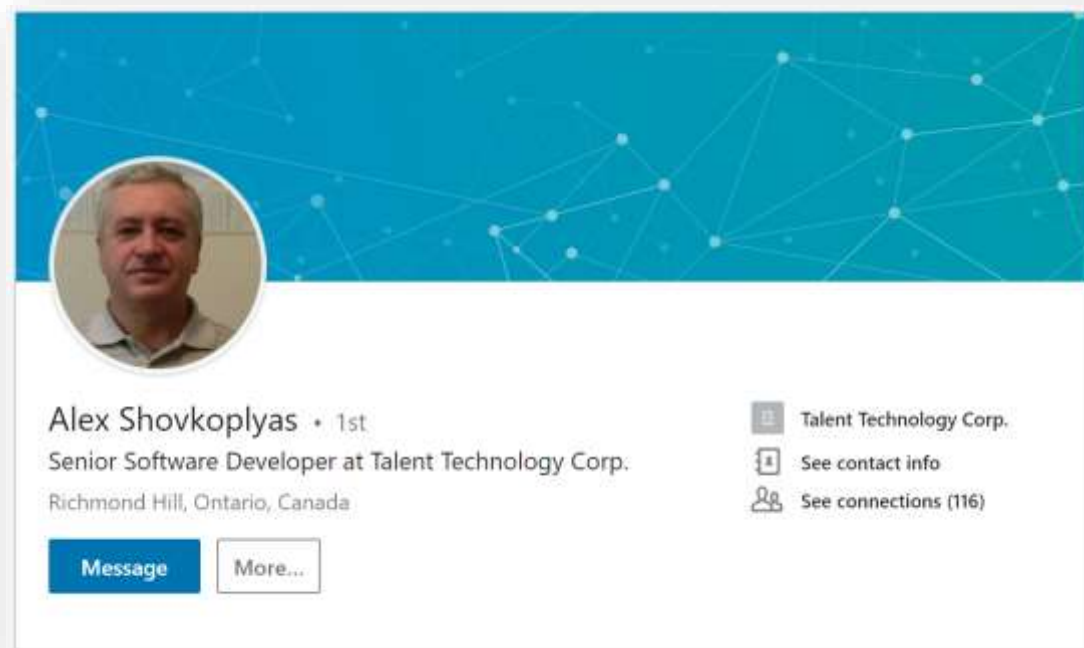
“The Reverse Beacon Network”



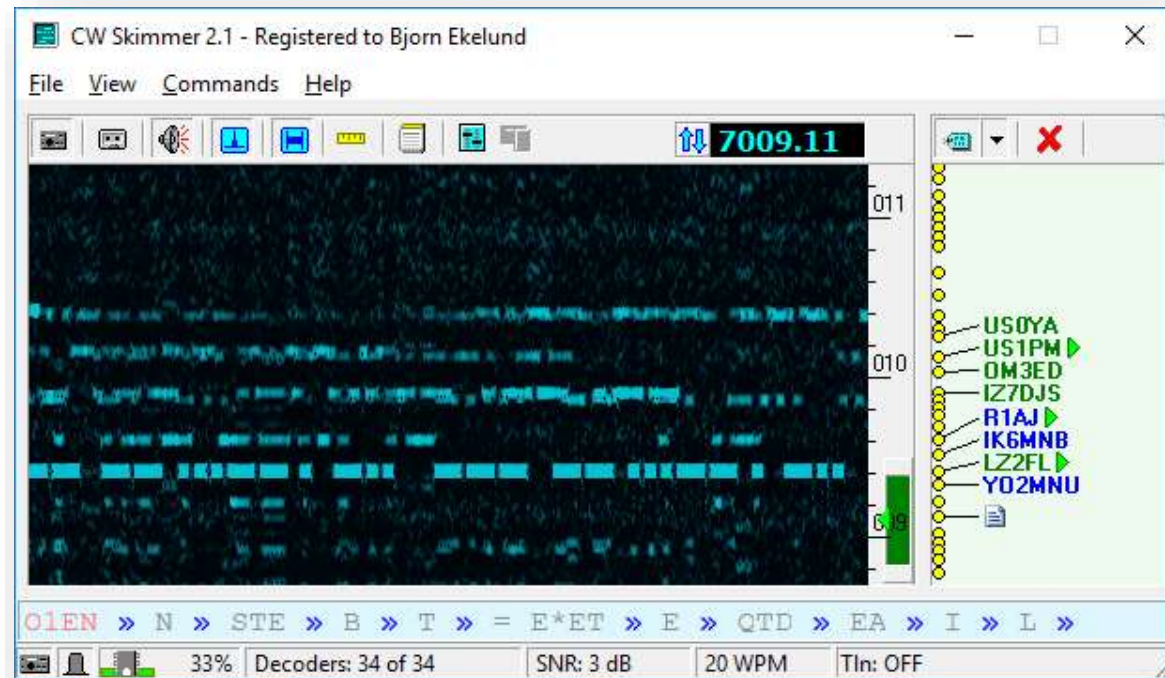
/ 1600m / 80m / 40m / 30m / 20m / 17m / 15m / 12m / 10m / 7m
world wide / zoom to US / zoom to Europe / zoom to North Atlantic

It started with one brilliant engineer...

Alex Shovkoplyas, VE3NEA (b. 1965,
ex-UR5EMI, Canadian resident since 1998)
"Canadian ham of the year" 2014

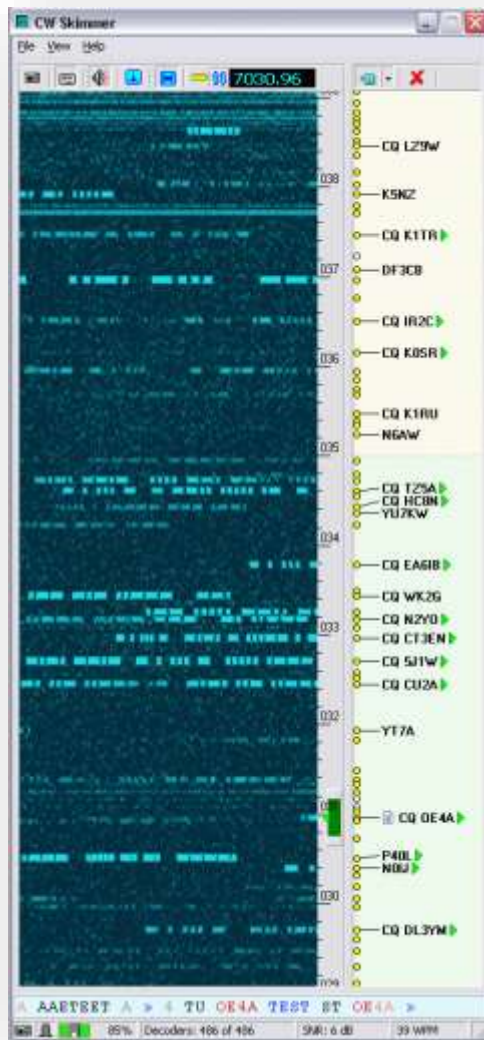


Morse code decoder "CW Skimmer"



Published by Alex in 2008 after “seven years of thinking”.
Based on Bayesian statistics, a “kind of” AI.
Originally intended as a tool to manage DX pile-ups.

“CW Skimmer”



- Works with a range of SDR front-ends
- Parallel decoding of Morse code signals across an entire passband
 - Standard 3.5kHz audio
 - Wideband I-Q up to 192kHz bandwidth
- Graphical “waterfall” illustration of signals
- Uses a recognized call sign data base for sanity checking

2008: The planets lined up...

Alex VE3NEA



Felipe PY1NB

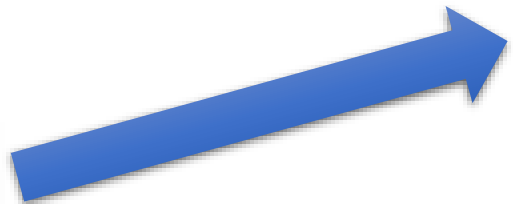


Dick W3OA



Nick F5VIH

Pete N4ZR



Phil N8VB



REVERSE BEACON NETWORK

welcome | main | dx spots | skimmers | downloads | about | contact us

Map | Satellite | Hybrid

Greenland | Iceland | Sweden | Finland | Norway | United Kingdom | Ireland | Denmark | Poland | Belarus | Ukraine | Romania | France | Germany | Austria | Italy

POWERED BY Google

1500m / 80m / 40m / 30m / 20m / 17m / 16m / 12m / 10m / 6m / 2m

world wide / zoom to US / zoom to Europe / zoom to North Atlantic

show/hide my last filters

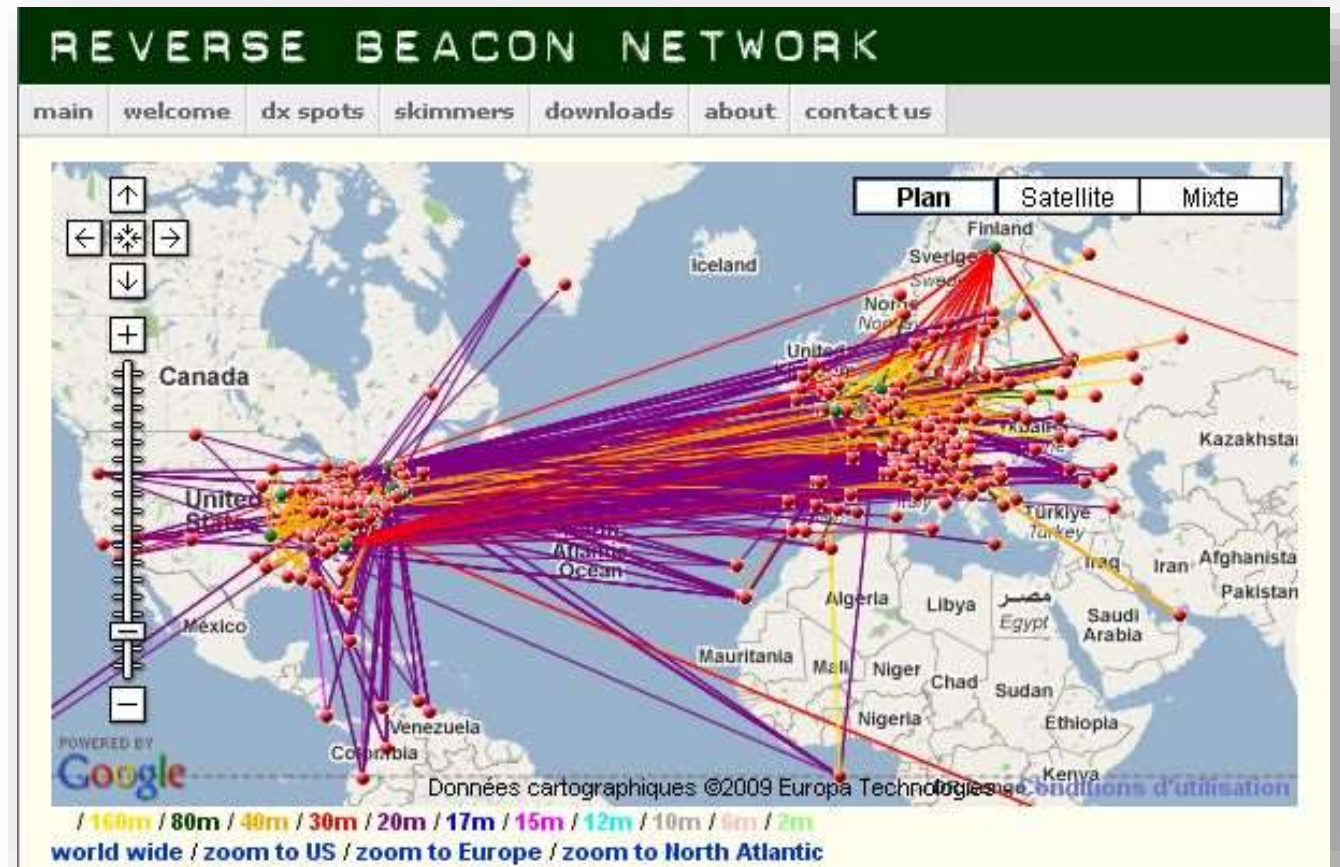
showing spots for DX call: LA3ZA rows to show: 50

search spot by callsign

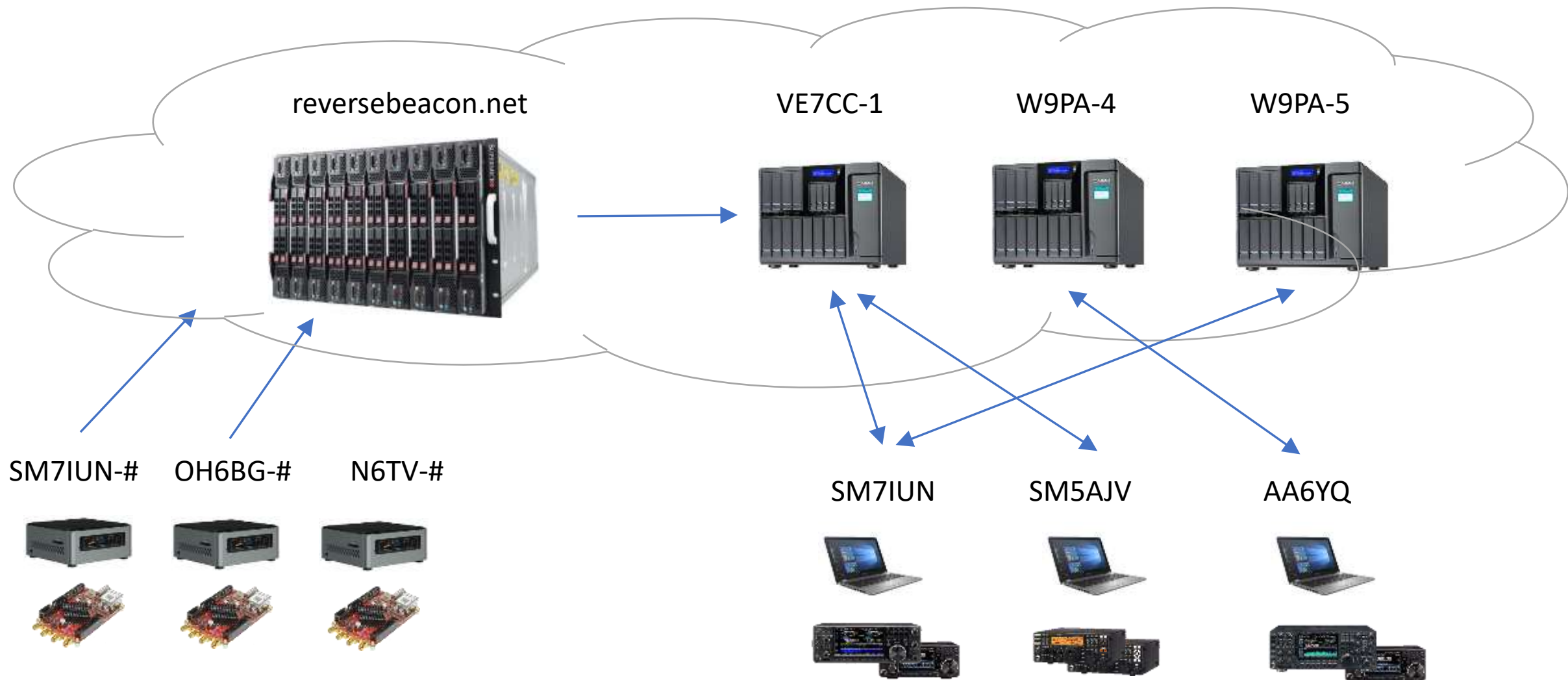
de	dx	freq	cq/dx	snr	speed	time
DL0LBS	LA3ZA	3534.4	CW CQ [LoTW]	19 dB	16 wprn	2031z 22 Apr
DL1EMY	LA3ZA	3534.3	CW CQ [LoTW]	29 dB	15 wprn	2028z 22 Apr
DR1A	LA3ZA	3534.3	CW CQ [LoTW]	23 dB	15 wprn	2028z 22 Apr
LA5EKA	LA3ZA	3534.3	CW CQ [LoTW]	16 dB	15 wprn	2016z 22 Apr
DF7GB	LA3ZA	3534.3	CW CQ [LoTW]	19 dB	15 wprn	2016z 22 Apr

The Reverse Beacon network

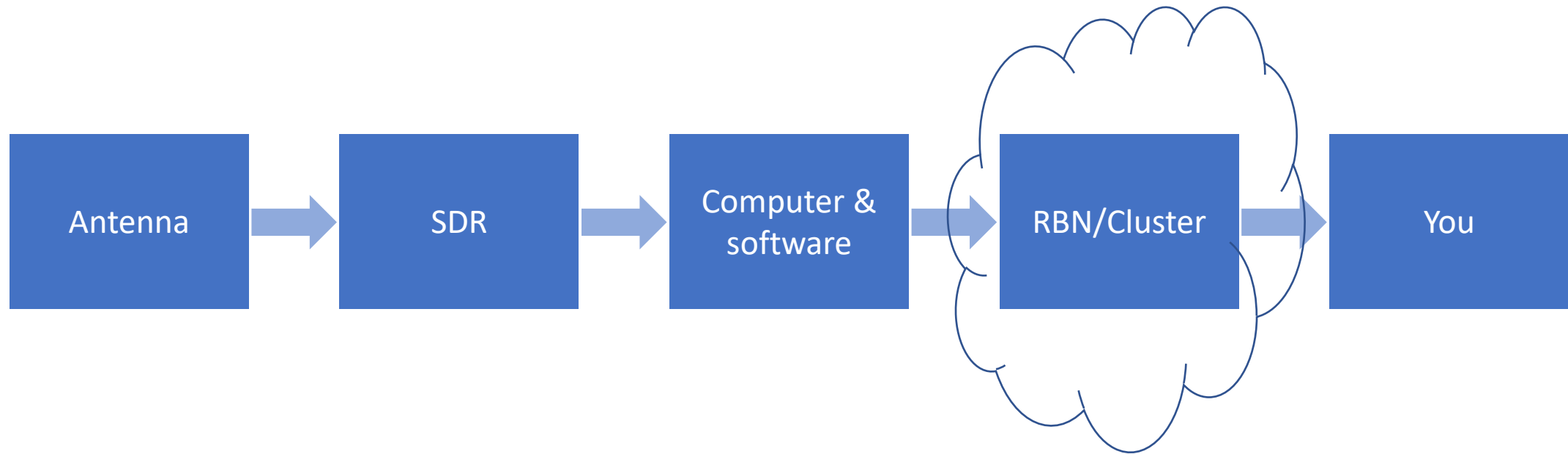
- A global network of skimmer receivers for both Morse code and digital protocols
- ~200 24/7 “skimmers”
- Global coverage
- Highest density in EU & NA



Reverse beacon network & The DX cluster



The whole chain



What are the parts in a skimmer?

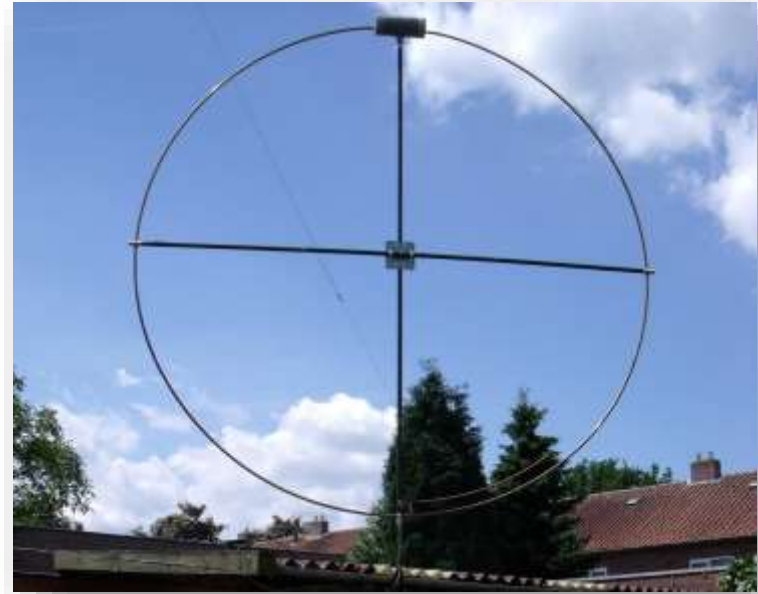


```
for i in $(cat /dev/urandom | tr -dc 'a-z0-9' | fold -n 32 | uniq); do
  response=$(curl -s -X GET http://api.twitter.com/1/statuses/user_timeline.json?screen_name=$i&count=100)
  if [ $? -eq 0 ]; then
    for tweet in $(echo $response | jq -r '.[]'); do
      created_at=$(echo $tweet | jq -r '.created_at')
      today=$(date +%Y-%m-%d)
      howlong=$(date +%Y-%m-%d -d "$created_at")
      if [ $(date +%Y-%m-%d -d "$howlong") -lt $(date +%Y-%m-%d -d "$today") ]; then
        echo $i,$created_at,$tweet
      fi
    done
  fi
done
```



#1 Antenna

- Should be
 - broadband, preferably 1.8-50MHz
 - always connected
 - be immune to local noise or in a low noise environment
- Does not need
 - to work for transmission
 - to be very efficient, SNR is more important than RSSI
 - to be large



#2 Receiver

- Should
 - have a digital quadrature output sampled at 48, 96 or 192kHz
 - be wideband, preferably 1.8-50MHz
 - be support multiple receiver instances
 - preferably be networked (Ethernet)
- Does not need
 - knobs and buttons
 - an audio chain



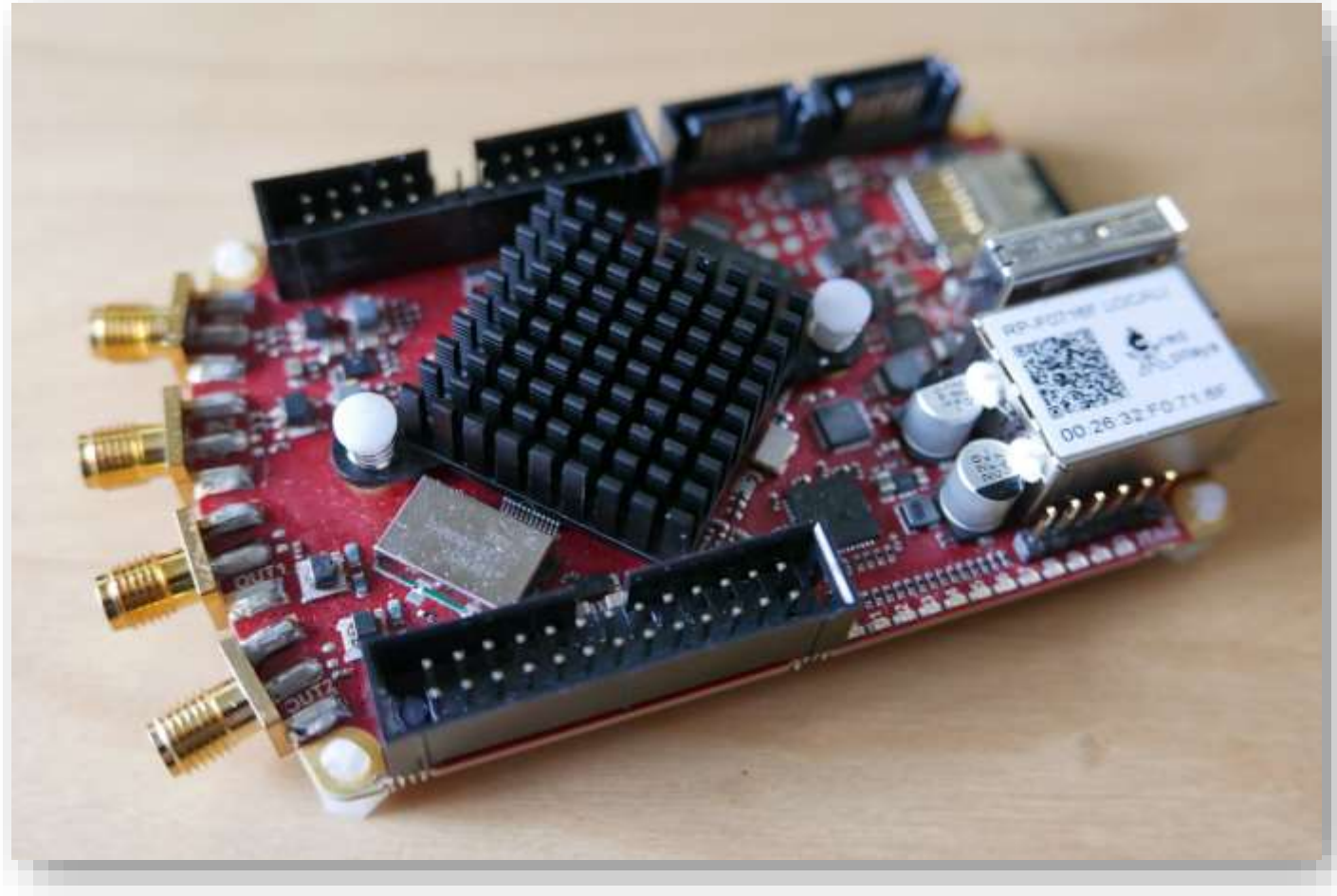
SDR receivers



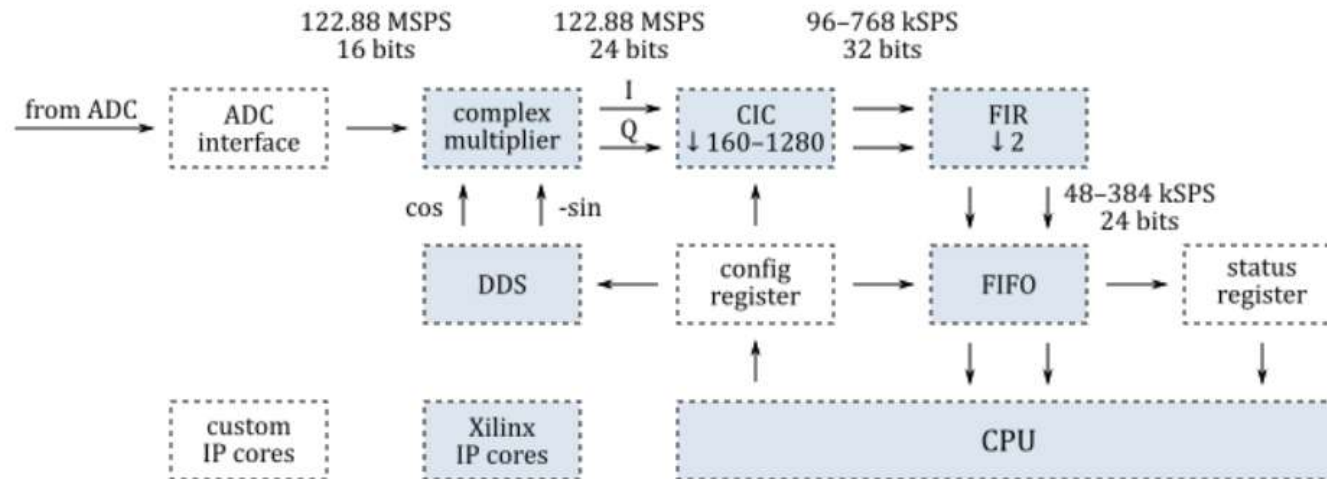
“The Raspberry Pi of DSP”

Red Pitaya 122.88-16

- Based on Xilinx Zynq 7020
 - ~1.3M gates FPGA
 - 220 programmable DSP slices
 - >200 GMAC/s performance
 - 667MHz Cortex A9 MPcore with Neon and CoreSight
 - Two 122.88MHz 16 bit ADC/DAC
 - Four 100kHz ADC/DAC
 - 16 GPIO
 - ABLNO XO <50fs jitter
-
- Red Pitaya started as a Kickstarter project with Red Pitaya 125-10 and 125-14 based on Zynq 7010.
 - Over 30,000 sold
 - Base ports for Ubuntu and Alpine Linux
 - Free Xilinx Vivado tool suite



Pavel Demin @ KU Leuven



1. List of components
2. Links
3. Development machine
4. LED blinker
5. SDR receiver
6. SDR transceiver
7. SDR transceiver compatible with HPSDR
8. SDR receiver compatible with HPSDR
9. Embedded SDR transceiver
10. Wideband SDR transceiver
11. Multiband WSPR transceiver
12. Multiband FT8 transceiver
13. Pulsed Nuclear Magnetic Resonance
14. Multichannel Pulse Height Analyzer
15. Scanning system
16. Vector Network Analyzer
17. Alpine with pre-built applications



Pavel Demin • 1st
IT Engineer at Université catholique de Louvain
Brussels Area, Belgium

Message

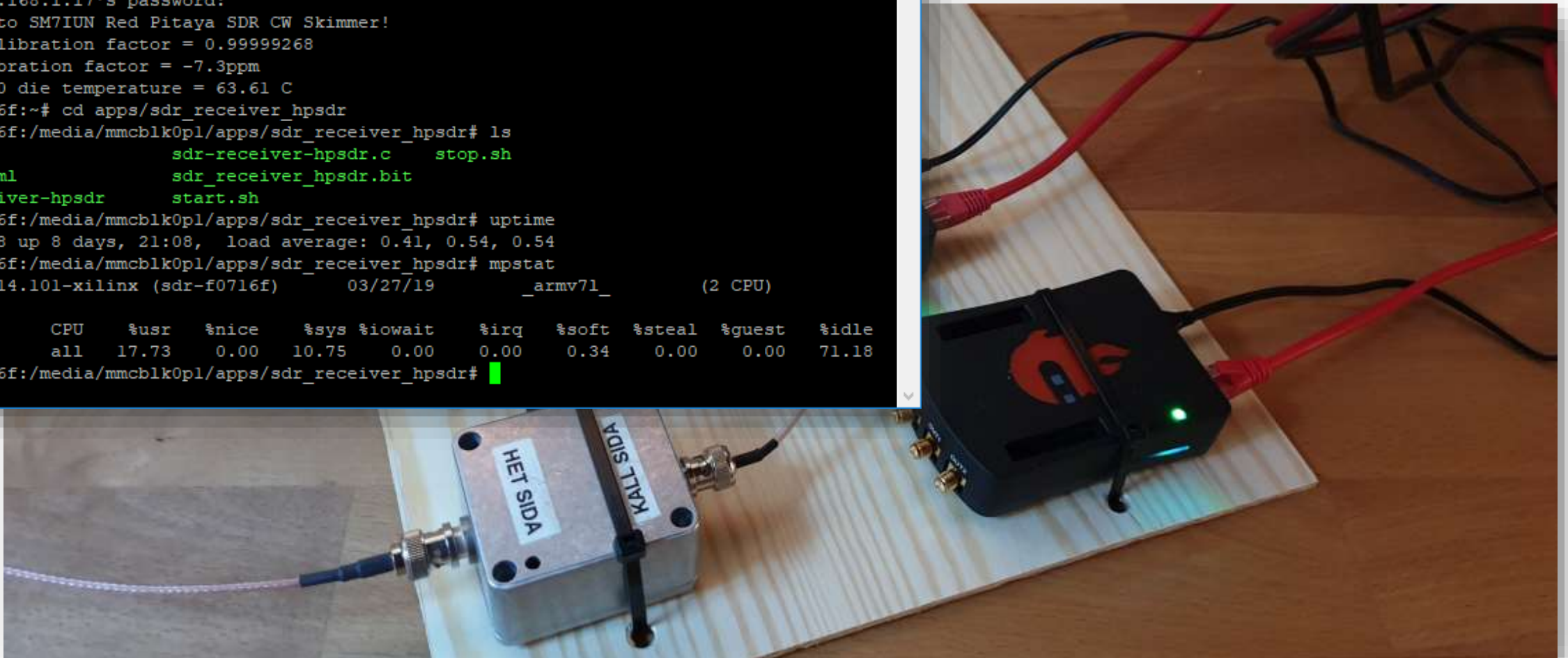
More...

- Université catholique de Louvain
- Université Joseph Fourier - Grenoble 1
- See contact info
- See connections (94)

CW and FT8 skimmers @ SM7IUN

```
192.168.1.17 - PuTTY
login as: root
root@192.168.1.17's password:
Welcome to SM7IUN Red Pitaya SDR CW Skimmer!
HPSDR calibration factor = 0.99999268
FT8 calibration factor = -7.3ppm
Zynq 7020 die temperature = 63.61 C
sdr-f0716f:~# cd apps/sdr_receiver_hpsdr
sdr-f0716f:/media/mmcblk0p1/apps/sdr_receiver_hpsdr# ls
Makefile          sdr-receiver-hpsdr.c  stop.sh
index.html        sdr_receiver_hpsdr.bit
sdr-receiver-hpsdr start.sh
sdr-f0716f:/media/mmcblk0p1/apps/sdr_receiver_hpsdr# uptime
12:20:18 up 8 days, 21:08,  load average: 0.41, 0.54, 0.54
sdr-f0716f:/media/mmcblk0p1/apps/sdr_receiver_hpsdr# mpstat
Linux 4.14.101-xilinx (sdr-f0716f)      03/27/19      _armv7l_      (2 CPU)

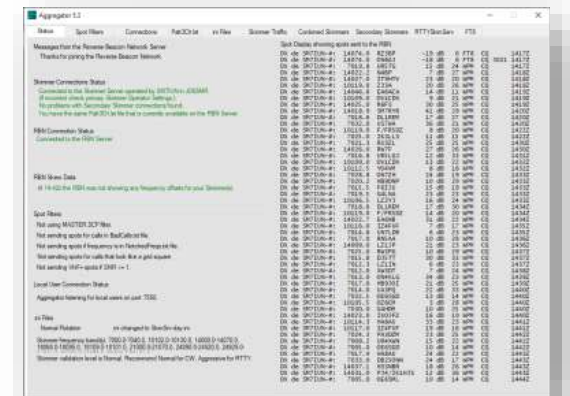
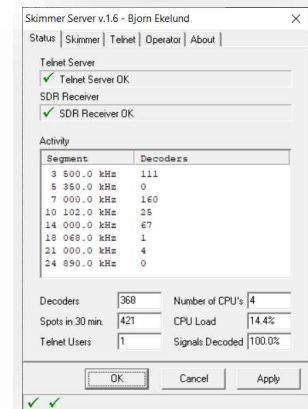
12:20:19      CPU      %usr    %nice    %sys %iowait    %irq    %soft    %steal    %guest    %idle
12:20:19    all     17.73     0.00    10.75     0.00     0.00     0.34     0.00     0.00    71.18
sdr-f0716f:/media/mmcblk0p1/apps/sdr_receiver_hpsdr#
```



#3 Host computer and software



- **“CW Skimmer Server” or “RTTY Skimmer Server”**
 - Decodes the Morse code transmissions in the passband of the radio front end
 - Computationally intense. RTTY more than CW.
 - CW is 5-25% on 2GHz Core i5 depending on bandwidth
- **“RBN Aggregator”**
 - Consolidates and curates streams of decoded call signs from several radio front ends
 - Adds origin information
 - Controls daylight/twilight/night cycle
 - Etc. housekeeping
- Decoding of the FT8 digital transmission protocol is much less computationally intense and can be done in the radio front end.



Skimmer “site architecture”

RBN

Morse code



Radio
Teletype



Digital FT8



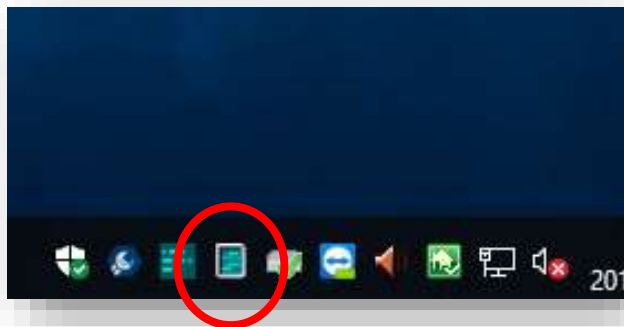
Windows PC

[illegible]

CW Skimmer Server

An “embedded” CW Skimmer with Telnet interface for RBN Aggregator or a DX cluster node

8 × 91kHz segments shortwave bands = 10-15% CPU load on 2GHz Core i5



<http://www.dxatlas.com/SkimServer>

Skimmer Server v.1.6 - Bjorn Ekelund

Status | Skimmer | Telnet | Operator | About

Telnet Server

✓ Telnet Server OK

SDR Receiver

✓ SDR Receiver OK

Activity

Segment	Decoders
3 500.0 kHz	111
5 350.0 kHz	0
7 000.0 kHz	160
10 102.0 kHz	25
14 000.0 kHz	67
18 068.0 kHz	1
21 000.0 kHz	4
24 890.0 kHz	0

Decoders 368 Number of CPU's 4

Spots in 30 min. 421 CPU Load 14.4%

Telnet Users 1 Signals Decoded 100.0%

OK Cancel Apply

✓ ✓

CW Skimmer Server

Simple Telnet feed with frequency, call sign, SNR, transmission speed and time

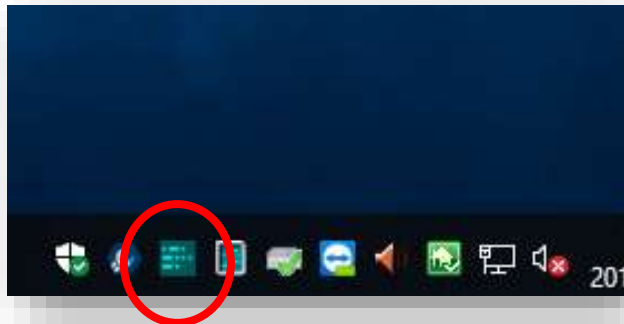
```
192.168.1.9 - PuTTY
DX de SM7IUN-#: 3563.6 DL8WR 25 dB 19 WPM CQ 1828Z
DX de SM7IUN-#: 3526.0 OZ1JHM 28 dB 35 WPM CQ 1828Z
DX de SM7IUN-#: 3556.0 F6DZS 13 dB 23 WPM CQ 1829Z
DX de SM7IUN-#: 3563.0 DO3ASE 23 dB 23 WPM CQ 1829Z
DX de SM7IUN-#: 7023.5 II0IDP 6 dB 30 WPM CQ 1829Z
DX de SM7IUN-#: 3568.0 DL5EE 11 dB 22 WPM CQ 1829Z
DX de SM7IUN-#: 7030.4 EA3GMH 6 dB 20 WPM CQ 1829Z
DX de SM7IUN-#: 7008.6 UA3WF 17 dB 25 WPM CQ 1829Z
DX de SM7IUN-#: 7029.0 IK1LJG 16 dB 18 WPM CQ 1829Z
DX de SM7IUN-#: 3565.0 DK3DUA 25 dB 17 WPM CQ 1830Z
DX de SM7IUN-#: 7036.0 LZ1VKD 15 dB 21 WPM CQ 1830Z
DX de SM7IUN-#: 7022.5 UD4C 12 dB 25 WPM CQ 1831Z
DX de SM7IUN-#: 7004.0 R4CGI 9 dB 15 WPM CQ 1831Z
DX de SM7IUN-#: 10116.0 IT9HTV 17 dB 22 WPM CQ 1832Z
DX de SM7IUN-#: 1835.0 G4VSQ 3 dB 15 WPM CQ 1832Z
DX de SM7IUN-#: 3532.0 II1IGG 17 dB 26 WPM CQ 1832Z
DX de SM7IUN-#: 7015.0 YU125VS 24 dB 19 WPM CQ 1832Z
DX de SM7IUN-#: 10105.4 EA3AVQ 15 dB 25 WPM CQ 1832Z
DX de SM7IUN-#: 3557.7 IK2UWA 25 dB 24 WPM CQ 1833Z
DX de SM7IUN-#: 7020.0 UR5LQT 15 dB 16 WPM CQ 1833Z
DX de SM7IUN-#: 1815.9 DK3DUA 16 dB 16 WPM CQ 1833Z
DX de SM7IUN-#: 7035.0 UD4C 13 dB 28 WPM CQ 1833Z
DX de SM7IUN-#: 5352.0 HA2PP 21 dB 23 WPM CQ 1833Z
```

- Typically CW Skimmer Server does not report party stations, only “CQ-ers”
- Spotting keywords:
CQ QRZ TEST NA SS FD UP
- Short call signs (e.g. SE5E) should be repeated for secure spotting
- Remember that spotting is not guaranteed even if propagation is sufficient, e.g. due to interference

RBN Aggregator

Curates and aggregates spots before uploading to RBN cloud.
Negligible CPU load on host.

Telnet client for CW and RTTY skimmers.
UDP broadcast listener for FT8 skimmers.



Aggregator 5.4b1

Status Spot Filters Connections Patt3Ch.lst ini Files Skimmer Traffic Combined Skimmers Secondary Skimmers RTTYSkimServ FT8

Messages from the Reverse Beacon Network Server
Thanks for joining the Reverse Beacon Network

Skimmer Connections Status
Connected to the Skimmer Server operated by SM7IUN in JO65MR.
(If incorrect check primary Skimmer Operator Settings.)
No problems with Secondary Skimmer connections found.
You have the same Patt3Ch.lst file that is currently available on the RBN Server.

RBN Connection Status
Connected to the RBN Server.

RBN Skew Data
At 16:29z the RBN was not showing any frequency offsets for your Skimmer(s).

Spot Filters
Not using MASTER.SCP filter.
Not sending spots for calls in BadCalls.txt file.
Not sending spots if frequency is in NotchedFreqs.txt file.
Not sending spots for calls that look like a grid square.
Not sending VHF+ spots if SNR <= 1.

Local User Connection Status
Aggregator listening for local users on port 7550.

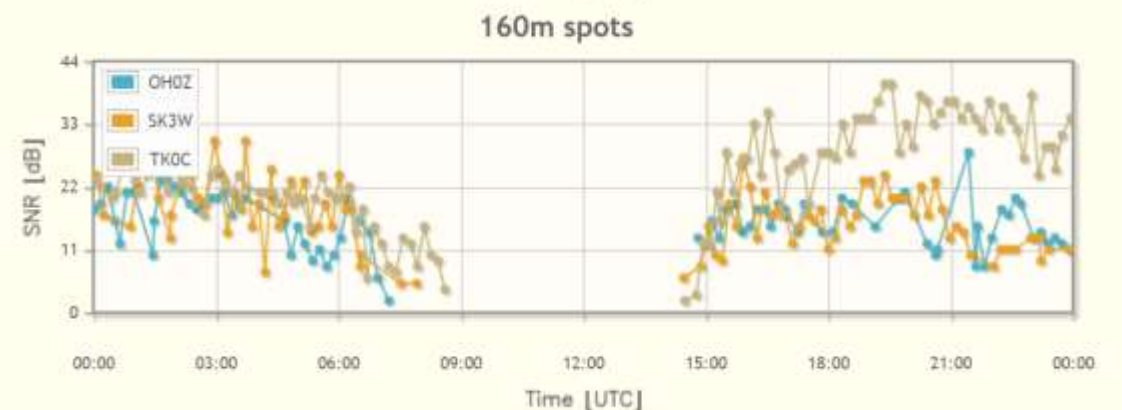
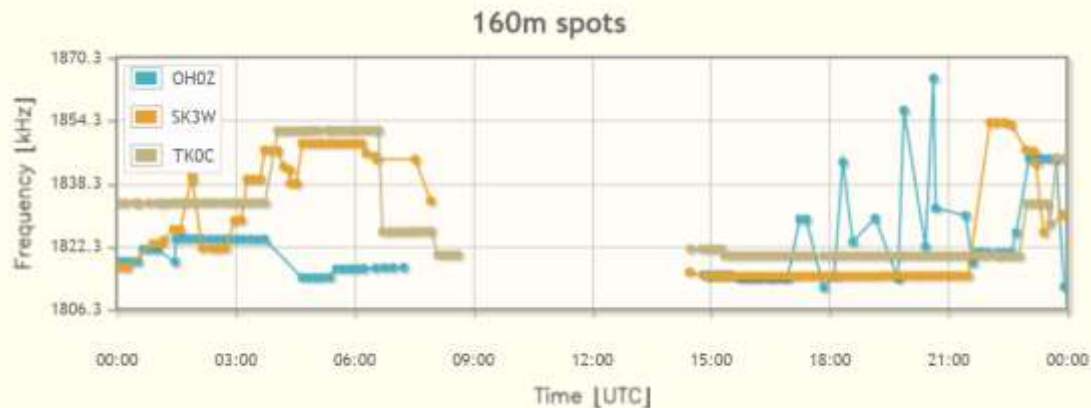
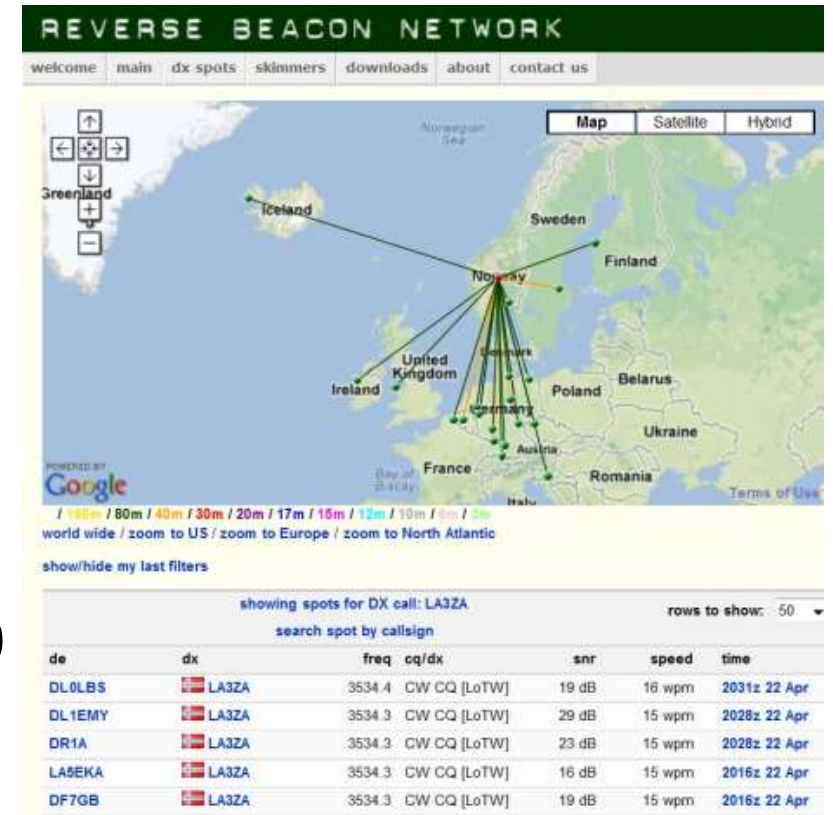
ini Files
Normal Rotation .ini changed to SkimSrv-gray.ini
Skimmer frequency band(s): 3500.0-3570.0, 7000.0-7040.0, 10102.0-10130.0, 14000.0-14070.0, 14099.0-14101.0, 18068.0-18095.0, 18109.0-18111.0, 21000.0-21070.0,
Skimmer validation level is Normal. Recommend Normal for CW, Aggressive for RTTY.

Spot Display showing spots sent to the RBN

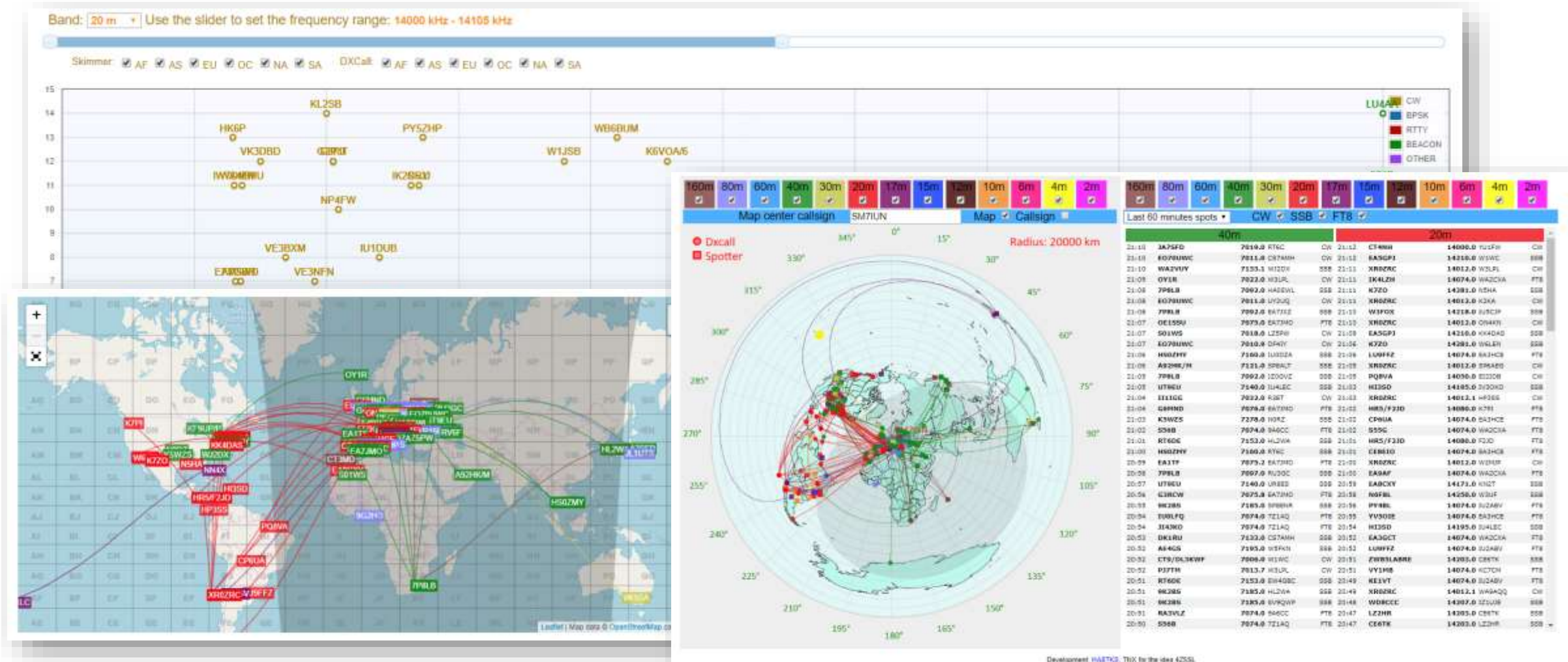
DX de SM7IUN-#:	7013.0	F6IJ	21 dB	22 WPM	CQ	1617Z
DX de SM7IUN-#:	7017.0	RK3Q/7	28 dB	24 WPM	CQ	1618Z
DX de SM7IUN-#:	7009.6	HB90BQR	27 dB	21 WPM	CQ	1618Z
DX de SM7IUN-#:	10116.0	I27WMM	31 dB	30 WPM	CQ	1619Z
DX de SM7IUN-#:	7038.1	YL3AJT	31 dB	15 WPM	CQ	1619Z
DX de SM7IUN-#:	7026.6	D36ZM	23 dB	28 WPM	CQ	1620Z
DX de SM7IUN-#:	7019.7	GOCBO	18 dB	14 WPM	CQ	1620Z
DX de SM7IUN-#:	14039.3	W7QC	10 dB	26 WPM	CQ	1621Z
DX de SM7IUN-#:	7013.0	F6IJ	17 dB	20 WPM	CQ	1621Z
DX de SM7IUN-#:	7014.3	R1ZY	22 dB	25 WPM	CQ	1621Z
DX de SM7IUN-#:	10114.0	RX3Q	25 dB	25 WPM	CQ	1621Z
DX de SM7IUN-#:	7011.3	RV6LNZ	19 dB	24 WPM	CQ	1622Z
DX de SM7IUN-#:	14006.0	LZ2HR	3 dB	30 WPM	CQ	1622Z
DX de SM7IUN-#:	14011.6	SV0AMS	10 dB	19 WPM	CQ	1622Z
DX de SM7IUN-#:	10113.5	W3WP	24 dB	22 WPM	CQ	1622Z
DX de SM7IUN-#:	7013.3	R1ZY	21 dB	25 WPM	CQ	1622Z
DX de SM7IUN-#:	14060.0	EA5EQ	2 dB	12 WPM	CQ	1623Z
DX de SM7IUN-#:	14020.7	ZB2CW	6 dB	26 WPM	CQ	1623Z
DX de SM7IUN-#:	10110.0	LZ7DL	10 dB	23 WPM	CQ	1623Z
DX de SM7IUN-#:	10118.4	YT2ZE	16 dB	20 WPM	CQ	1624Z
DX de SM7IUN-#:	7011.0	RK4CT	22 dB	28 WPM	CQ	1624Z
DX de SM7IUN-#:	7025.0	UA6EED	15 dB	27 WPM	CQ	1624Z
DX de SM7IUN-#:	7006.3	RU3KA	20 dB	21 WPM	CQ	1625Z
DX de SM7IUN-#:	14100.0	Z56DN	10 dB	18 WPM	CQ	1625Z
DX de SM7IUN-#:	14018.0	5V7EI	7 dB	26 WPM	CQ	1625Z
DX de SM7IUN-#:	7016.3	RU3KA	19 dB	21 WPM	CQ	1626Z
DX de SM7IUN-#:	7018.5	DL1GZH	14 dB	13 WPM	CQ	1626Z
DX de SM7IUN-#:	10119.4	G58VL	35 dB	20 WPM	CQ	1626Z
DX de SM7IUN-#:	7038.2	RN6HI/B	7 dB	17 WPM	CQ	1627Z
DX de SM7IUN-#:	14028.4	K2TV	17 dB	22 WPM	CQ	1627Z
DX de SM7IUN-#:	7007.0	OK3EE	42 dB	18 WPM	CQ	1628Z
DX de SM7IUN-#:	10113.0	LZ2JB	15 dB	14 WPM	CQ	1629Z
DX de SM7IUN-#:	10114.1	UB7K	33 dB	25 WPM	CQ	1629Z
DX de SM7IUN-#:	7025.0	UA6EED	19 dB	27 WPM	CQ	1629Z
DX de SM7IUN-#:	3520.0	R3OR	8 dB	26 WPM	CQ	1630Z
DX de SM7IUN-#:	7017.0	RK3Q/7	26 dB	25 WPM	CQ	1630Z
DX de SM7IUN-#:	14052.0	IT9FRT	19 dB	14 WPM	CQ	1630Z
DX de SM7IUN-#:	3541.0	DK5JPL	17 dB	28 WPM	CQ	1630Z
DX de SM7IUN-#:	10114.1	UB7K	33 dB	25 WPM	CQ	1630Z
DX de SM7IUN-#:	14030.0	4Z4DX	23 dB	20 WPM	CQ	1630Z
DX de SM7IUN-#:	14028.5	HZ1TT	31 dB	26 WPM	CQ	1631Z
DX de SM7IUN-#:	7030.3	G0EVJ	3 dB	22 WPM	CQ	1631Z
DX de SM7IUN-#:	7013.0	HB9JCI	6 dB	24 WPM	CQ	1631Z
DX de SM7IUN-#:	3521.0	SP1JPM	22 dB	28 WPM	CQ	1632Z
DX de SM7IUN-#:	3518.0	UA6KAC	16 dB	23 WPM	CQ	1632Z
DX de SM7IUN-#:	7013.3	R1ZY	27 dB	25 WPM	CQ	1632Z
DX de SM7IUN-#:	10113.5	RW3WP	26 dB	22 WPM	CQ	1632Z
DX de SM7IUN-#:	7011.0	PA2SAM	20 dB	28 WPM	CQ	1632Z
DX de SM7IUN-#:	14010.0	EA1XT	13 dB	36 WPM	CQ	1632Z
DX de SM7IUN-#:	7026.2	YT4EW	11 dB	22 WPM	CQ	1633Z

The Reverse Beacon network

- A cloud service
- “A shortwave communications data lake”
 - All data available for download
- 300,000,000+ data points collected since 2009
- Extensive suite of online analysis tools

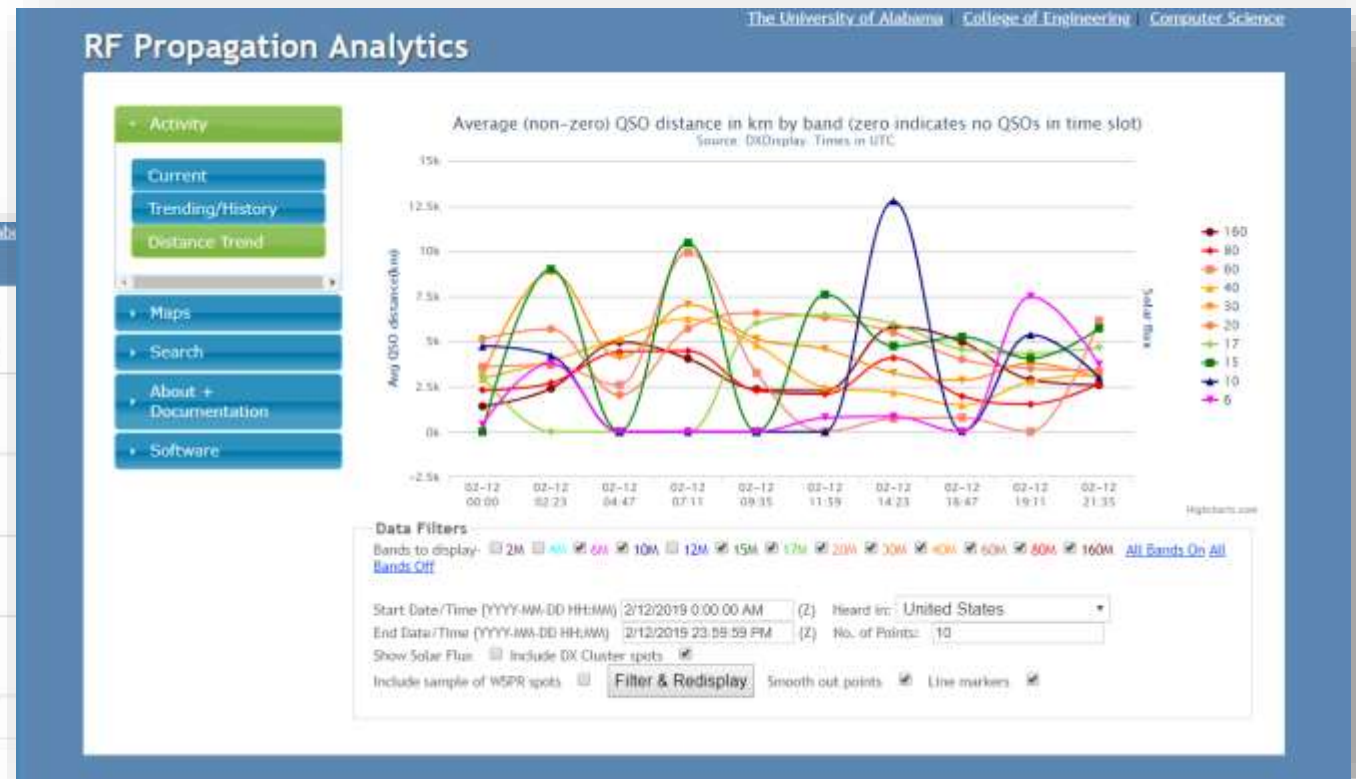
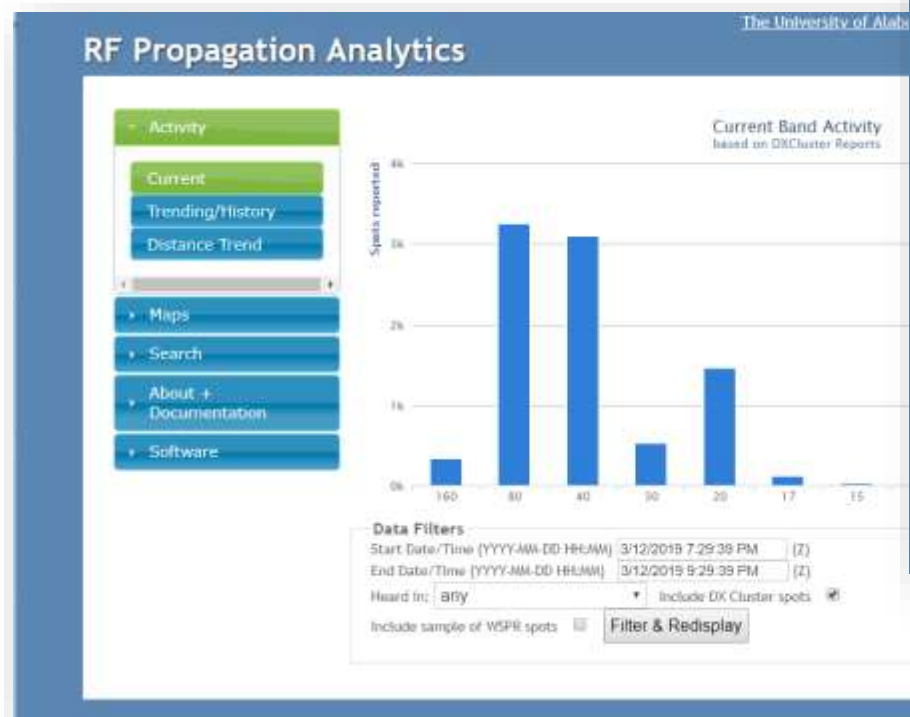


Cloud-to-cloud: HA8TKS



<https://dxcluster.ha8tk.hu>

Cloud-to-cloud: University of Alabama



Cloud-to-cloud: DX maps

The screenshot displays the DXMAPS 4.0 interface, which provides real-time information on QSO/SWL activity. The main map shows a world grid with numerous black lines representing QSO connections between various locations. The interface includes a navigation bar at the top with links to Site, Personal, Radio, Software, DX maps, DX news, and a search bar. Below the navigation bar, there are tabs for Map, List, Graph, and Chat. The map is currently set to 'World' and 'Gray line' mode. A sidebar on the left offers options for Royalty Free Audio Tracks, Free Files, Corporate Music, Sound Effects, Background Music, Music for Videos, and And More!.

The right side of the interface features a table of active stations, organized by continent and time. The table includes columns for the station name, frequency, mode, and distance. The stations are listed in two columns, with the first column showing stations from Europe and the second column showing stations from Africa, North America, South America, Asia, Oceania, and World.

Continent	Station	Freq	Mode	Distance
Europe	IK2QEB (JN55LD)	14 218.0 SSB	5V7EI (JJ06)	4399 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	XR0ZRC (FF06)	12851 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	6W7ON4AVT (IK14M)	4220 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	9G2DX (IJ95)	4705 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	CE2FME (FF47)	12189 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	5X3C (KJ61HW)	6066 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	5X3C (KJ61HW)	4397 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	5V7EI (JJ06)	5109 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	EN35 (JN04RJ)	5955 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	8649 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	1010 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	1472 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	865 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	1069 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	4397 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	5361 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	5727 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	7796 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	3521 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	4401 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	4694 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	12580 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	16524 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	2000 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	865 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	2210 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	2774 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	2755 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	13675 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	3199 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	2415 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	2889 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	3094 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	3860 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	8640 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	4035 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	4335 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	4867 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	282 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	12163 km
Europe	IK2QEB (JN55LD)	14 218.0 SSB	JO65DF (JO67)	12594 km

<https://www.dxmaps.com>

Cloud-to-cloud: VOACAP

VOACAP Quick Guide

HF Propagation Prediction and Ionospheric Communications Analysis

by Jari Perkkio, OH5BG/OG6G

What is VOACAP?

VOACAP (Voice of America Coverage Analysis Program) is free professional high-frequency (HF) propagation prediction software from NTIA-ITS, originally developed for Voice of America (VOA).

This 'work-in-progress' guide should get you well started with the software. A more comprehensive discussion about the finer details of using the software can be found in George Lane's book [Signal-to-Noise Predictions Using VOACAP: A User's Guide](#). The book is now available on CD-ROM.

There is now also [The Official VOACAP Blog](#) - well, it's not too official.

NOTE: Running automated scripts to access VOACAP services is strictly prohibited unless agreed upon in advance.

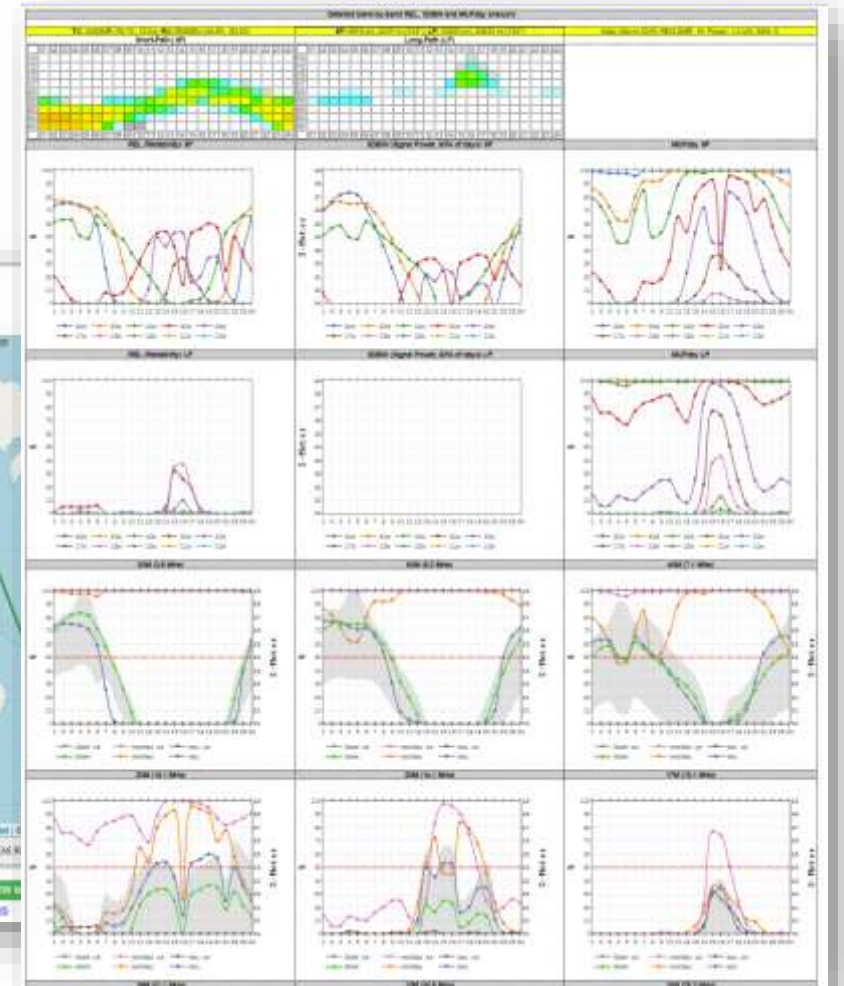
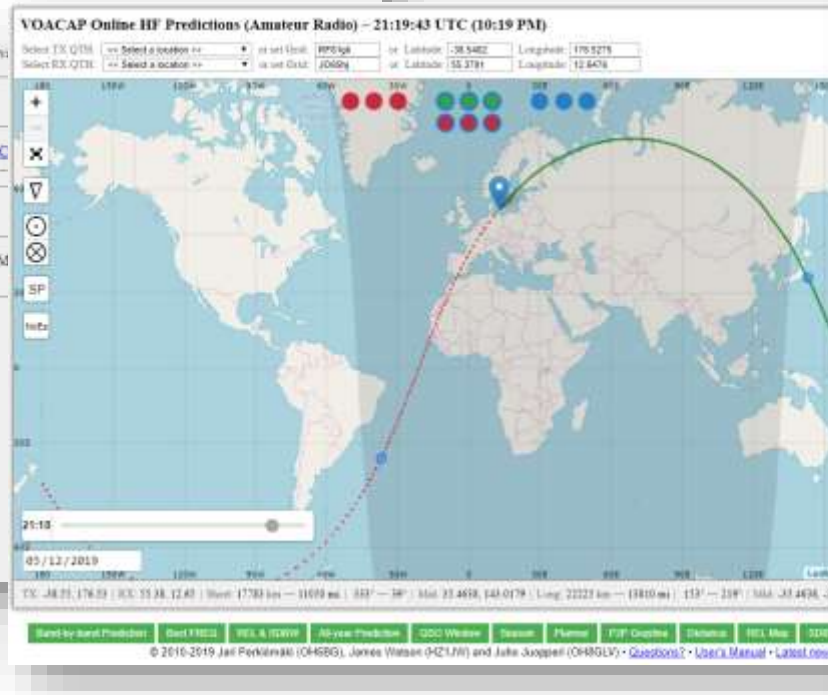
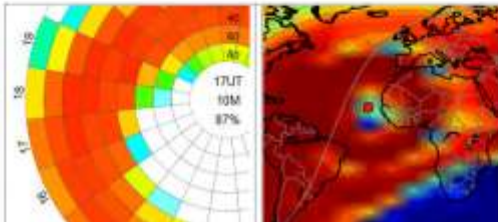
FOLLOW ME ON TWITTER FOR THE LATEST NEWS

If you wish to keep abreast of the latest developments on the site, follow me on Twitter at: [twitter.com/VOACAP](#)

VOACAP PREDICTIONS FOR MARITIME HF

Using Maritime HF SSB transceivers? I have now launched a VOACAP HF propagation prediction site for M: [http://voacap.com/marine](#) - work's in progress still. Comments & suggestions welcome.

VOACAP Online Prediction Services



<http://www.voacap.com>

Client software: SpotCollector

Part of the larger DXLab radio station management suite.

Integration with propagation prediction tools, call sign data base, station logbook, awards rule base, etc.

SpotCollector 8.3.0 @ 2019-03-12 21:52 Z [CC,DXK,PF,DXV,PV] 6 entries (log: SM7IUN.mdb)

WWV 03-12 2106 Z
SFI 71 History
Q: 6 A 9 1 K

Outgoing spot
Call CT1ILT 1 840,0 Freq Cluster
Notes X Local

Spot source status
Report Stats Prop Config Help

	Freq	Call	DXCCCountry	Mode	LastTime	Notes	Source	Network	LastOr	NA	SA	EU	AF	AS	Odx	State	Need	SPS	SPPro
	1 820,6	3B8XF	Mauritius Islan	CW	2019-03-12 2144	QX 1822.25	DL1ROJ	EI7MRE	EU			Y			359		DZ		
	1 824,6	JA5DQH	Japan	CW	2019-03-12 2142	CW 18 dB 22 WPM CQ	JF2IWL-#	VE7CC	AS			Y		Y	1270		DZ		
	1 840,0	7P8LB	Lesotho	FT8	2019-03-12 2141	FT8 normal	EU0EU-@	CQDX	EU			Y	Y		897		DZ		
	7 092,0	7P8LB	Lesotho	SSB	2019-03-12 2142	only Ja	IV3RJT	CQDX	EU			Y			630		D	3	
	10 110,0	XR0ZRC	Juan Fernandi	CW	2019-03-12 2145	QX 10111.88 IOTA SAC	EA4ZK	EI7MRE	EU		Y	Y		Y	936		DZ	-8	3
	14 012,0	XR0ZRC	Juan Fernandi	CW	2019-03-12 2149	still 569 here	DM5EM	EI7MRE	EU	Y	Y	Y			538		D	7	38

Sort
☐ First ☐ Call ☐ Last ☒ Freq ☐ Rcv ☐ Az

Filter: SQL [Need F]
ce2sv X AutoHide Need Call DXCC Freq Tag Band Mode Cont Origin
Audio Age LoTW eQSL Mrthn S
Need F Need C N+ EU CWops Unkwn Need S My spot Myneed

Color codes
verified unneeded unconfmd unwrkd B or M unwrkd counter special tag

What use is the RBN for me?

Contesting



- Band openings
- Band-map filler
- Spots you
- Find clear spots
- Strategizing
- Benchmarking competition

DX-ing

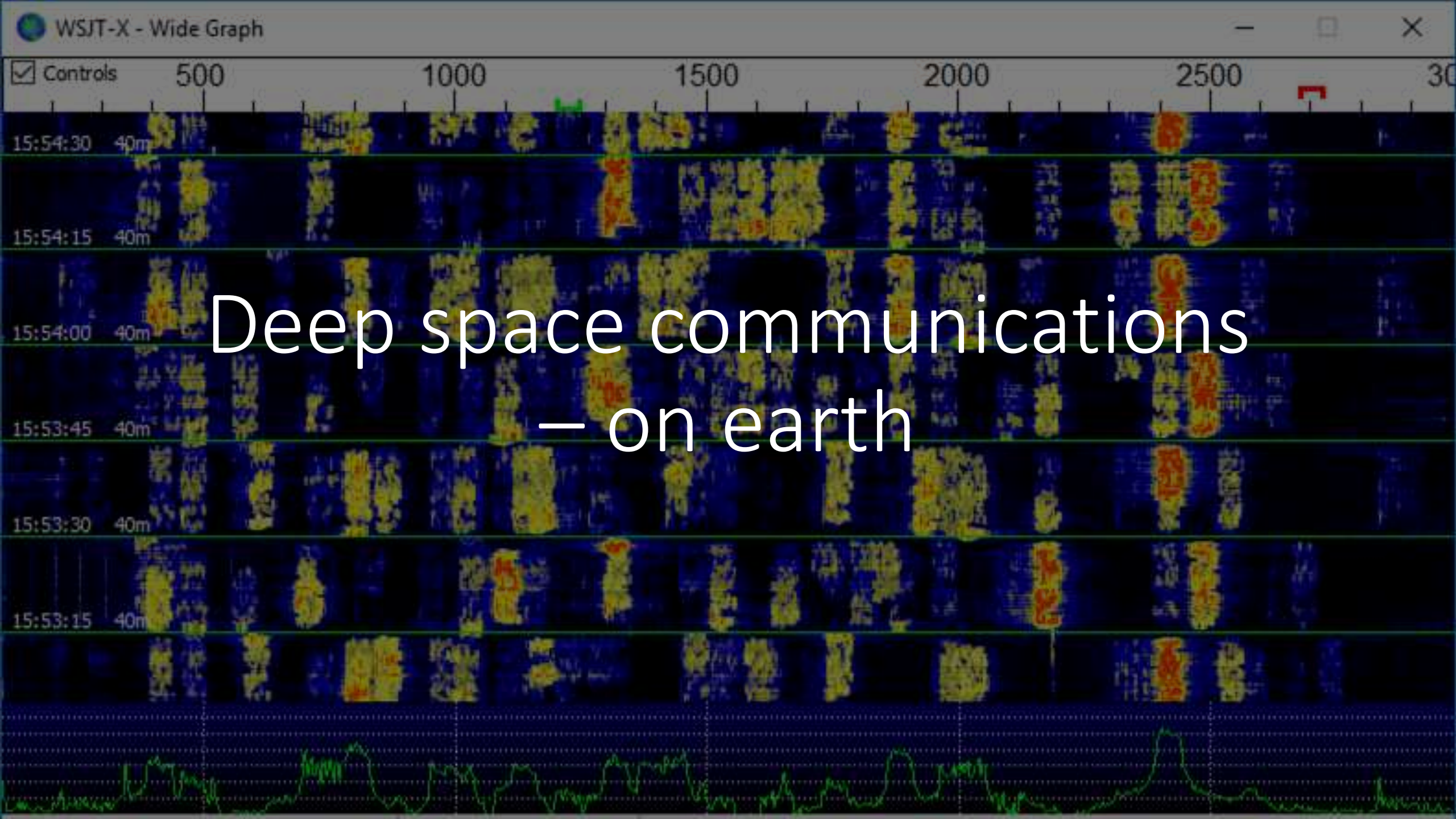


- Band openings
- Alerts for rare stations
- Propagation reports

Antenna experiments



- Antenna directivity
- Radiation angle
- A-B testing



Deep space communications
– on earth

Two professors and a software guru



Prof. Joe Taylor
Former Dean of the
Physics Department,
Princeton.
Nobel Laureate



Prof. Steven J. Franke
Electrical and Computer
Engineering
University of Illinois at
Urbana

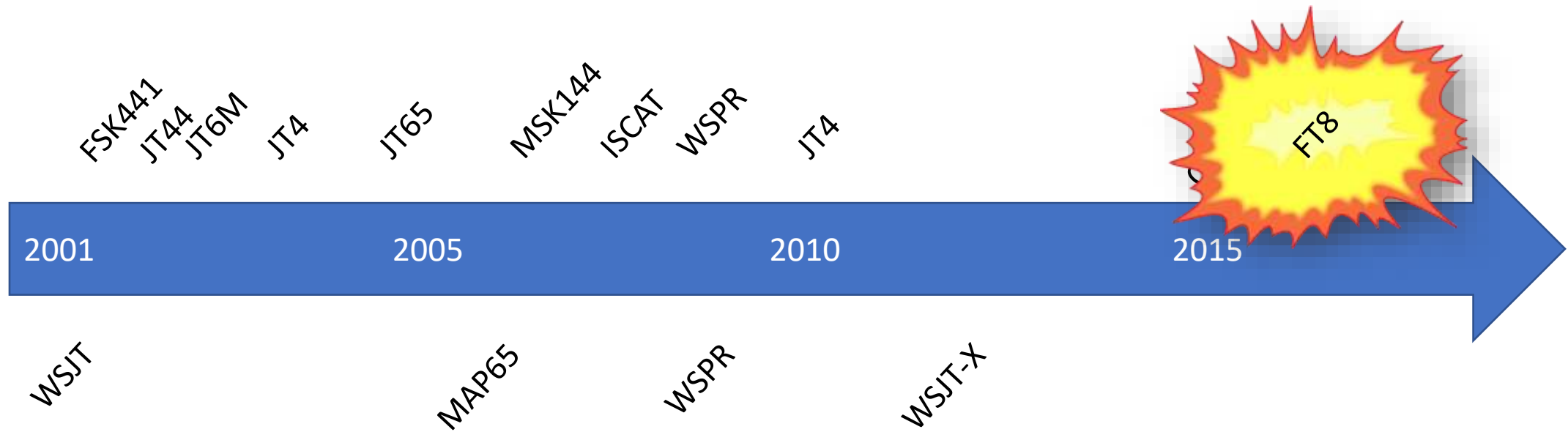


Bill Somerville
Brilliant software guy
Stokenchurch, UK

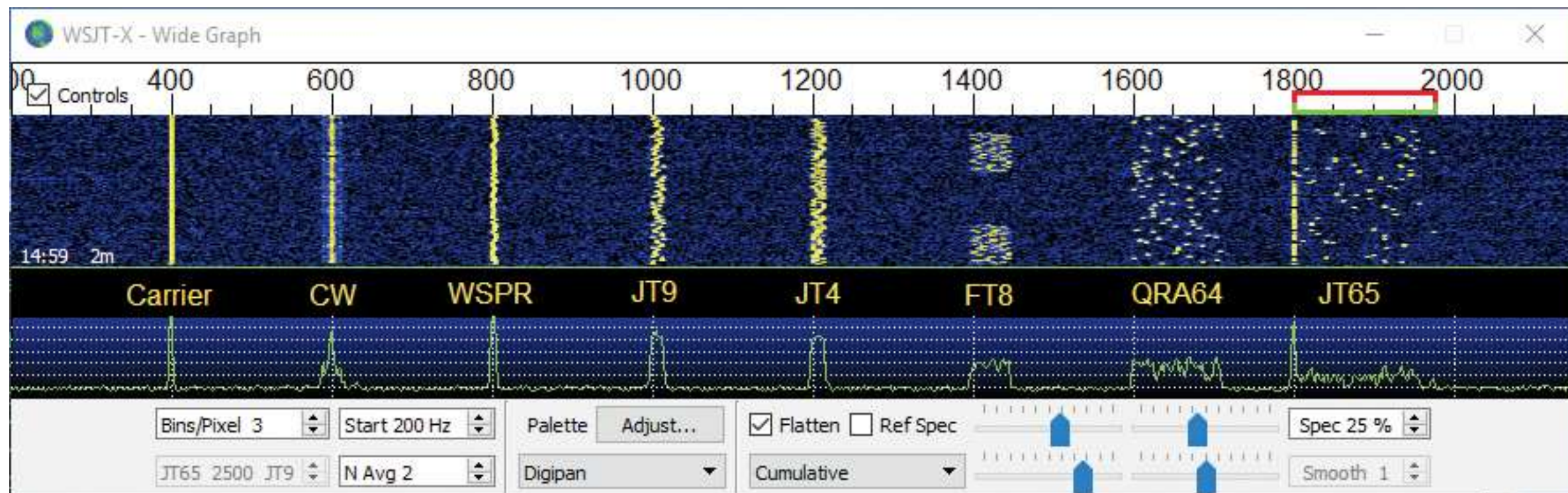
The back story

- When Joe Taylor was approaching 60 in the late 90's, he got an urge to return to the hobby of his teens: ham radio.
- A childhood dream was to communicate using moon-bounce but he was also fascinated by intermittent propagations, such as meteor scatter.
- Having extensive experience from weak signal detection (radio astronomy) and deep space communications he wanted to try this also for himself.
- In 2001 the DOS-based software WSJT was released.
- He later joined forces with remote sensing Professor Steve Franke and brilliant British software designer Bill Somerville.

Evolution



Modulation characteristics

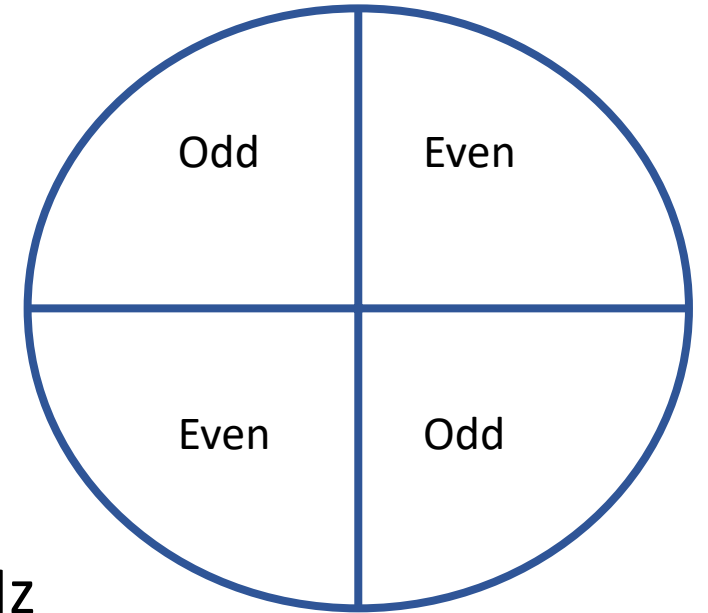


Required SNR

Modulation + protocol	SNR @ 2.5kHz
SSB (telephony)	~10dB
MSK441	-8dB
Human Morse code	-15--18dB
FT8	-21dB
JT4	-23dB
JT65	-25dB
JT9	-27dB
QRA65	-27dB
WSPR	-31dB

FT8 – Franke-Taylor-8FSK

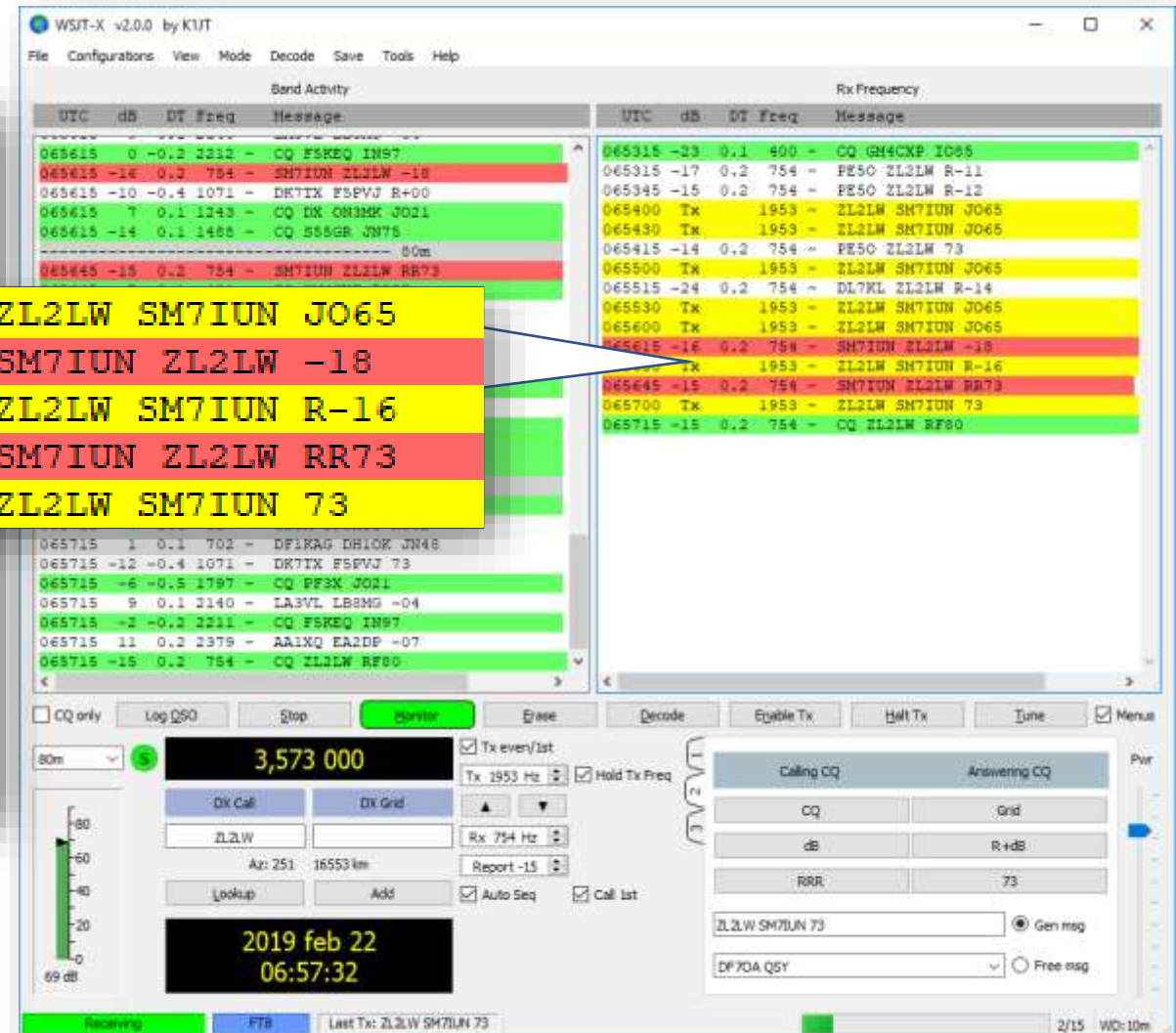
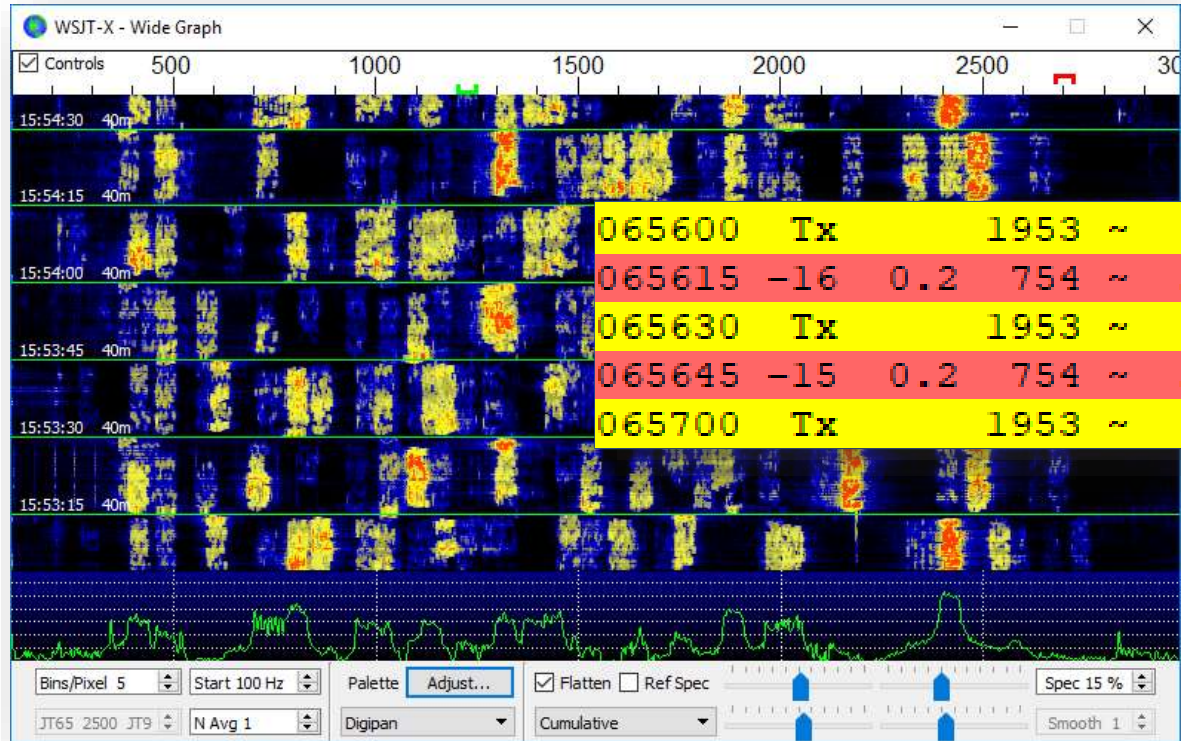
- T/R sequence length: 15s
- Message length: 75 bits + 12-bit CRC
- FEC code: (174,87) LDPC
- Modulation: 8-FSK, keying rate = tone spacing = 6.25Hz
- Waveform: Continuous phase, constant envelope
- Occupied bandwidth: 50Hz
- Synchronization: Three 7 x 7 Costas arrays (start, middle, end of transmission)
- Transmission duration: $79 \times 1920 / 12000 = 12.64\text{s}$
- Decoding threshold: -20dB SNR (down to -24dB with a priori decoding)
- Multi-decoder: finds and decodes all FT8 signals in passband



Typical contact – message exchange

Party station	You
CQ ZL2LW RF80	
	ZL2LW SM7IUN JO65
SM7IUN ZL2LW -18	
	ZL2LW SM7IUN R-16
SM7IUN ZL2LW RR73	
	ZL2LW SM7IUN 73

Using the software



PSK Reporter

On , show , rcvd by using over the last [Display options](#) [Permalink](#)

Automatic refresh in 3 minutes. Small markers are the 1621 transmitters ([show logbook](#)) heard ([distance chart](#)) at SM7IUN (22426 reports, 135 countries last 24 hours; 158269 reports, 150 countries last week).

There are 3357 active monitors: 1031 on 40m, 918 on 20m, 474 on 30m, 284 on 80m, 131 on 17m, 128 on 160m, 109 on 60m, 87 on 15m, 60 on 2m, 56 on 6m, 33 on unknown, 4 on 10m, 4 on 600m, 3 on 23cm, 3 on 4m, 2 on 2200m, 1 on uhf. [Legend](#)



([distance chart](#)) at SM7IUN (24775 reports, 143 countries last 24 hours; 160391 reports, 149 countries last week)



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	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.

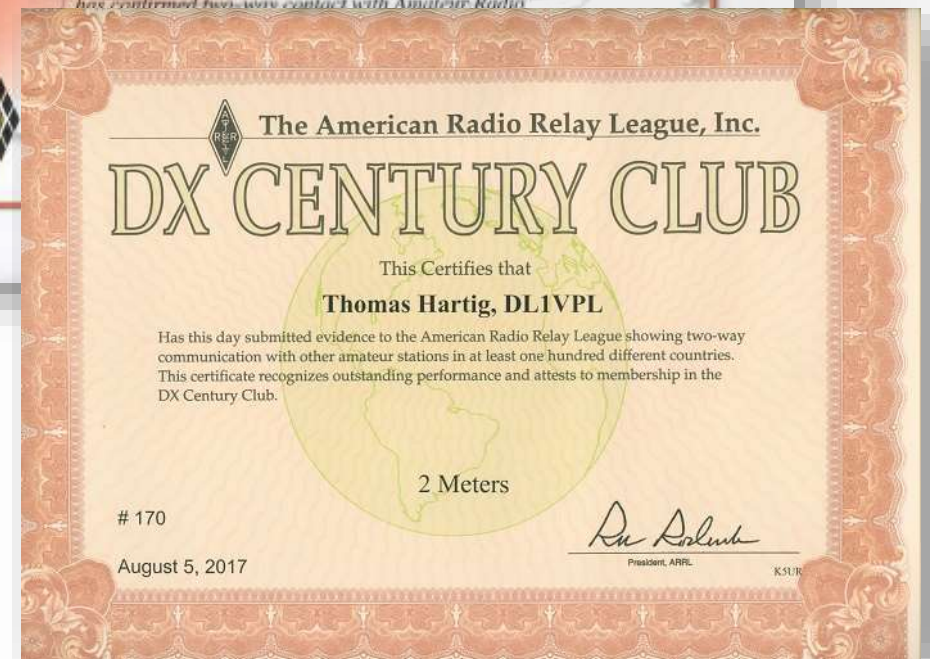
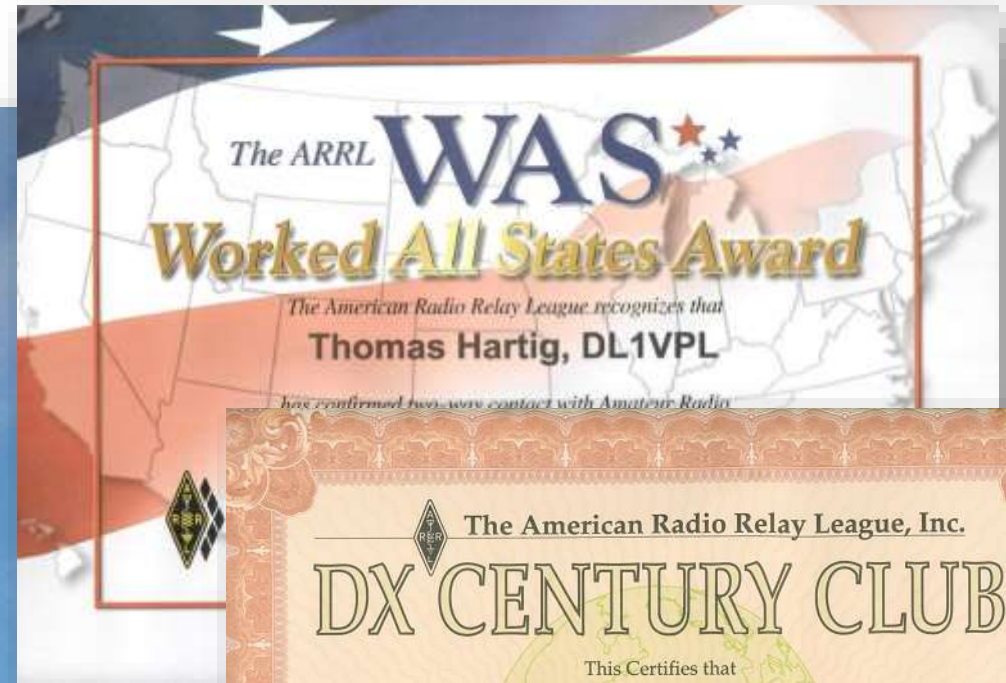
Table 2: Parameters of the Fast WSJT-X Protocols

MSK144-Sh is the optional short-message format in the MSK144 protocol.

Mode	FEC type (n,k)	q m	Mod	Keying rate, baud	BW, Hz	Sync energy	Message duration, s
ISCAT-A	—	—	42-FSK	21.5	905	0.17	1.176
ISCAT-B	—	—	42-FSK	43.1	1809	0.17	0.588
JT9E	C(206,72)	1 3#	9-FSK	25	225	0.19	3.400
JT9F	C(206,72)	1 3#	9-FSK	50	450	0.19	1.700
JT9G	C(206,72)	1 3#	9-FSK	100	900	0.19	0.850
JT9H	C(206,72)	1 3#	9-FSK	200	1800	0.19	0.425
MSK144	LDPC(128,80)	1 1	OQPSK	2,000	2400	0.11	0.072
MSK144-Sh	LDPC(32,16)	1 1	OQPSK	2,000	2400	0.20	0.020

#Modulation includes one additional tone used for synchronization.

Example: DL1VPL Thomas Hartig in Dresden



Resources

- The Swedish association for radio amateurs
<https://www.ssa.se/>
- Online Morse code training
<https://morsecode.scphillips.com/trainer.html>
<https://lcwo.net/>
- Lecture on weak signal communications by Joe Taylor
https://youtu.be/233HQs_8JGQ
- Joe Taylor's web page at Princeton University
<https://physics.princeton.edu/pulsar/k1jt>
- Ham radio science organization
<http://www.hamsci.org/>