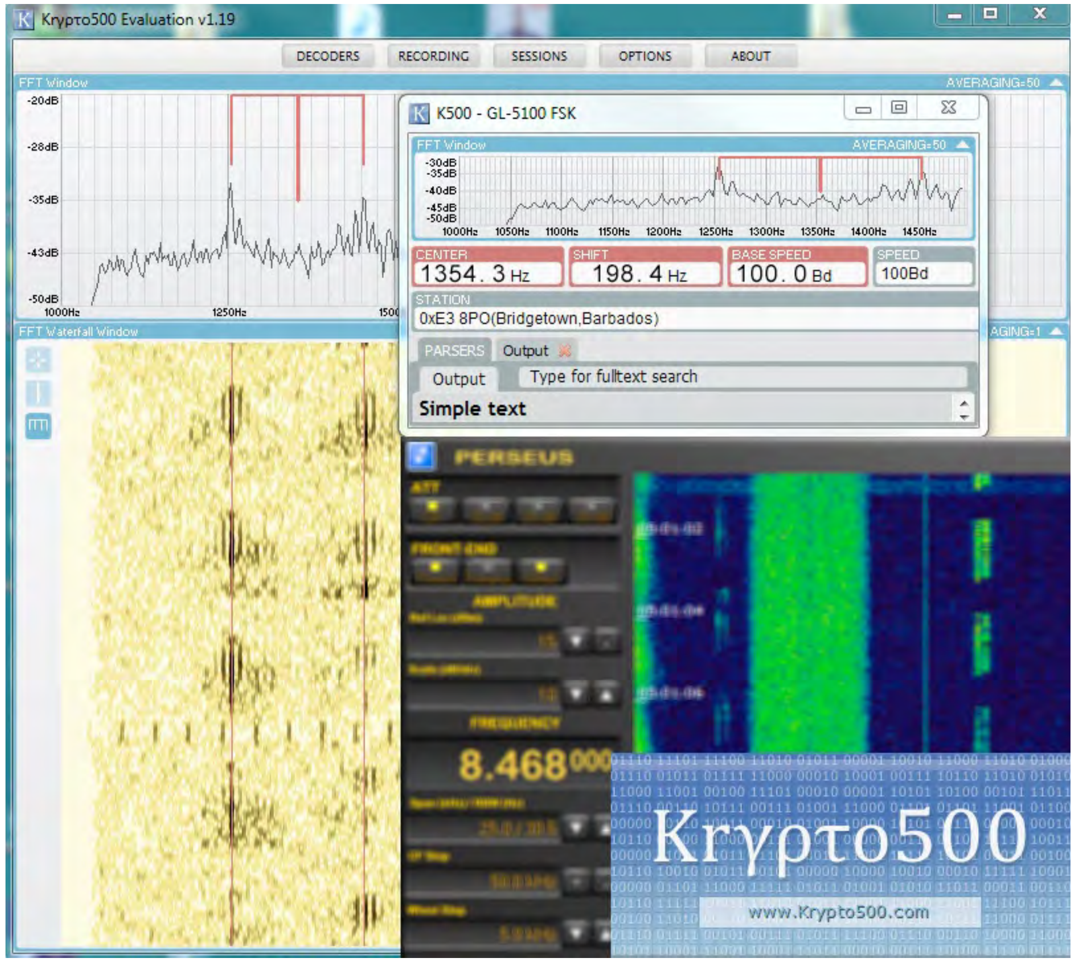
Utility DXing: A Primer

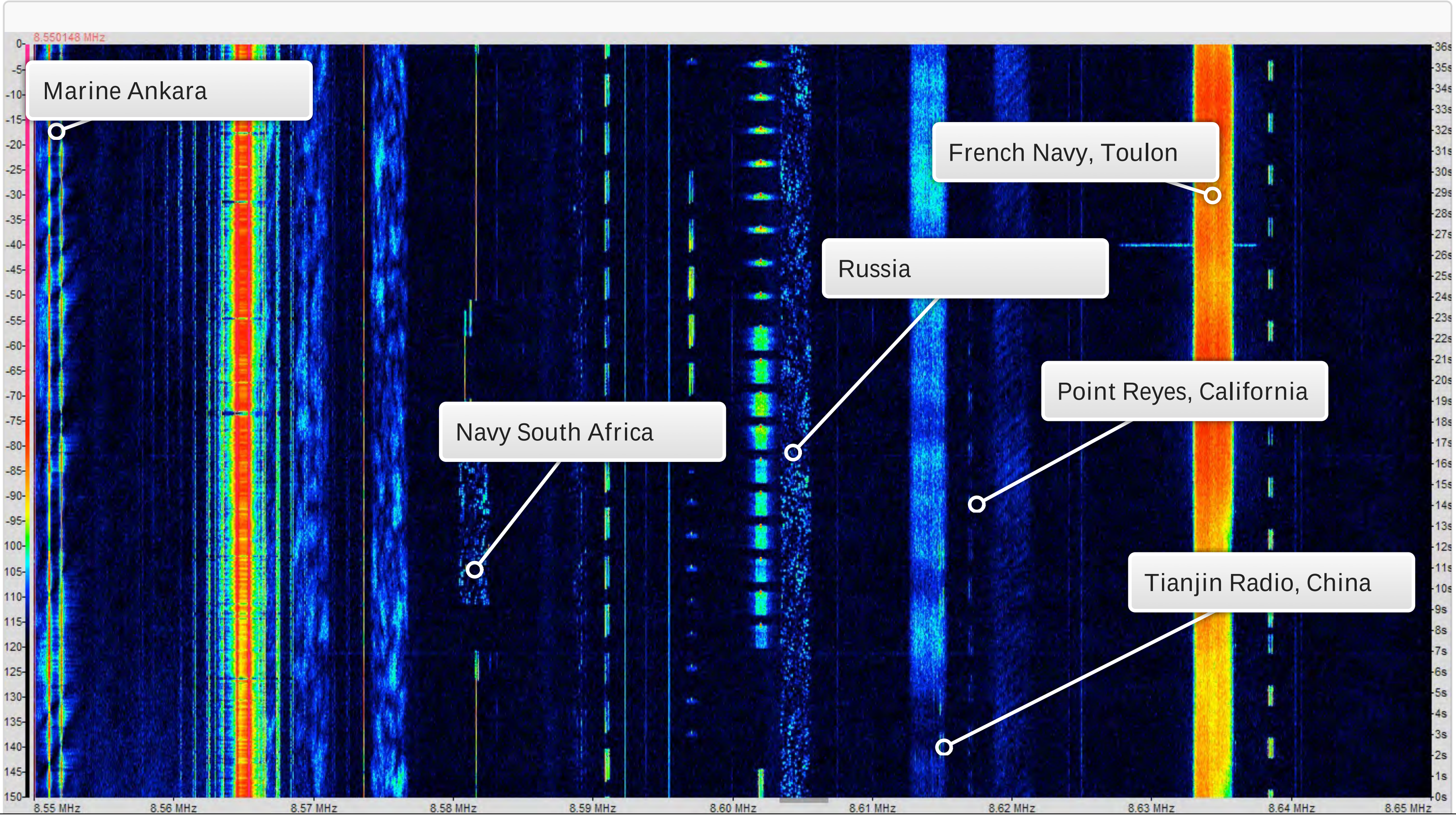


NILS SCHIFFHAUER, DK8OK

HF: Still full of Signals

Shortwave is still full of signals, mostly digital. Many of them can be demodulated and even decoded with some sophisticated software decoders. This iBook focuses on the new Krypto500 decoder, mainly using this new piece of software for a very short introduction into utility DXing. You will also find some hands-on comparisons with other high-tech decoders like GX430 by Rohde & Schwarz, Code3-32P by Hoka and W-Code by Wavecom.

Below: Some signals around 8600 kHz show many different modes and stations from all over the world.



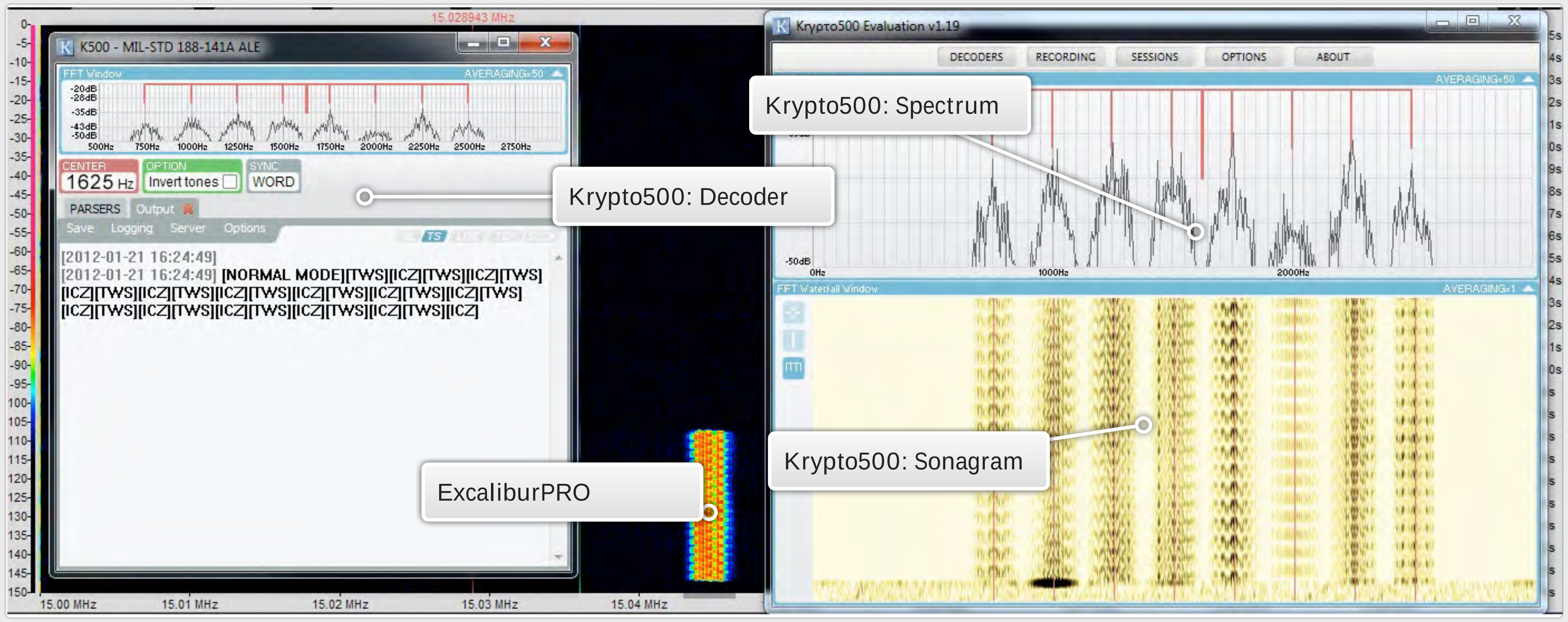
First Steps

Connecting Krypto500

The signal from the receiver must reach the input of the decoder. Krypto500 does accept audio and I/Q signals. Receiver and decoder are usually connected by a so-called virtual soundcard (VSC) or virtual audio cable (VAC).

Krypto500 presents the audio in two windows: spectrum and sonagram. Both can be tailored regarding e.g. colors, resolution, dynamic range, span and some more features. Use *that* combination which fits best to your signal. An „overlap“ function will dramatically increase time resolution, thereby often revealing some characteristics of a signal or mode.

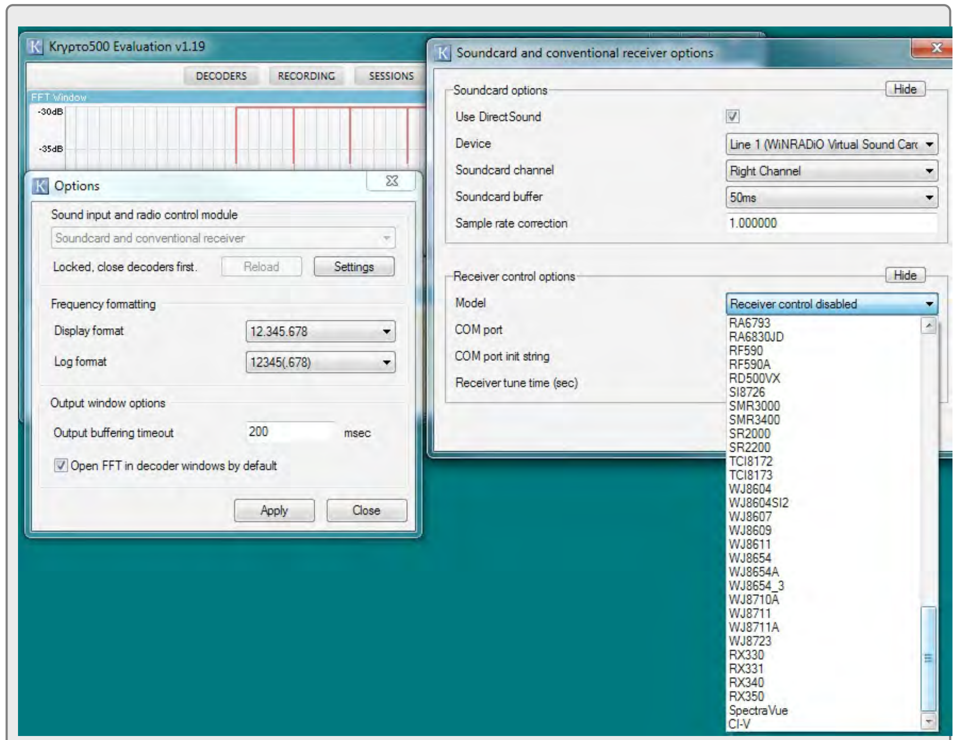
Reception of U.S. Navy Napoli/Italy „ICZ“ on 15043 kHz in ALE, MIL-SD 188-141A: tuning and decoding



Receiver Control

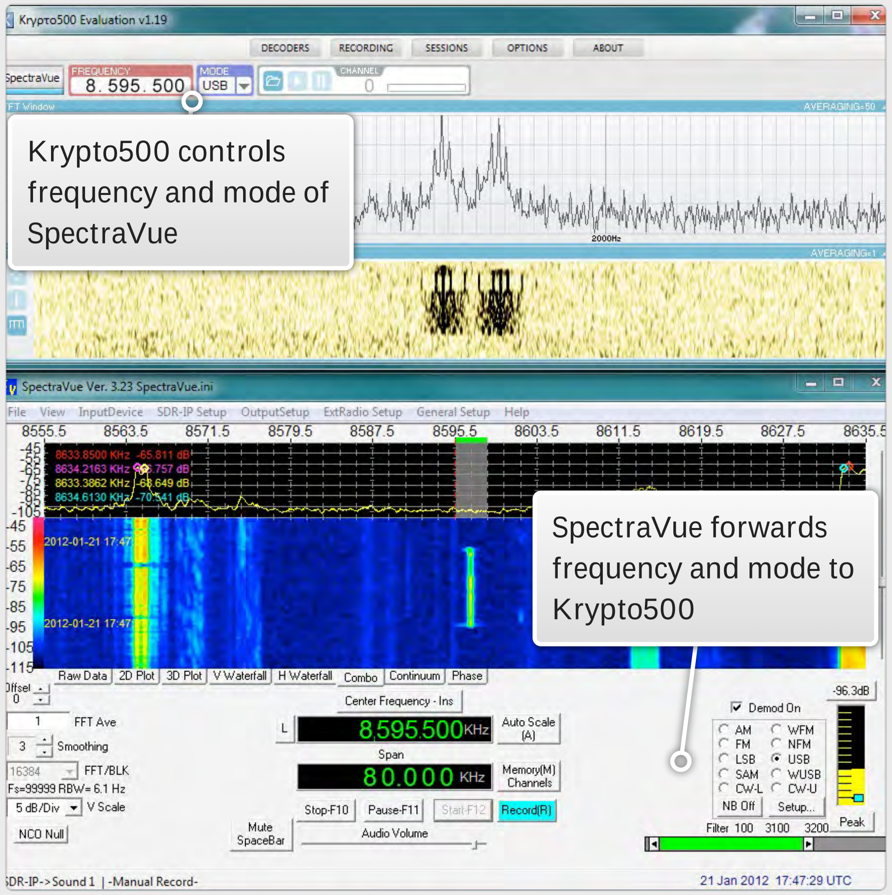
Krypto500 still recommends to use the graphical user interface (GUI) of the receiver. Nevertheless, the software provides connection for controlling at least some features of a vast selection of professional receivers, among SDRs also Perseus plus some of RFSpace., and Icom's CI-V. With this feature, you can e.g. scan all ALE channels of a network.

See on the right, how a combination of SDR-IP, SpectraVue and Krypto 500 works: Control the receiver either by SpectraVue or some features (e.g. frequency) by Krypto5oo.



Krypto500 offers a really back selection of receivers, also Spectra Vue for all SDRs by RFSpace, CI-V and Perseus.

SpectraVue can be controlled by Krypto500 and vice versa.



You can e.g. tune the receiver by the frequency control of SpectruVue or Krypto500, and the other frequency display will change accordingly. Some goes for the mode. You can also just click onto a signal in SpectraVue sonagram, and as SDR-IP changes to this frequency, also the audio stream will deliver this signal towards Krypto500. Alas, in the version tested, in this case the frequency display of Krypto500 did *not* change.

Part of receiver control is a scanning and a recording feature.

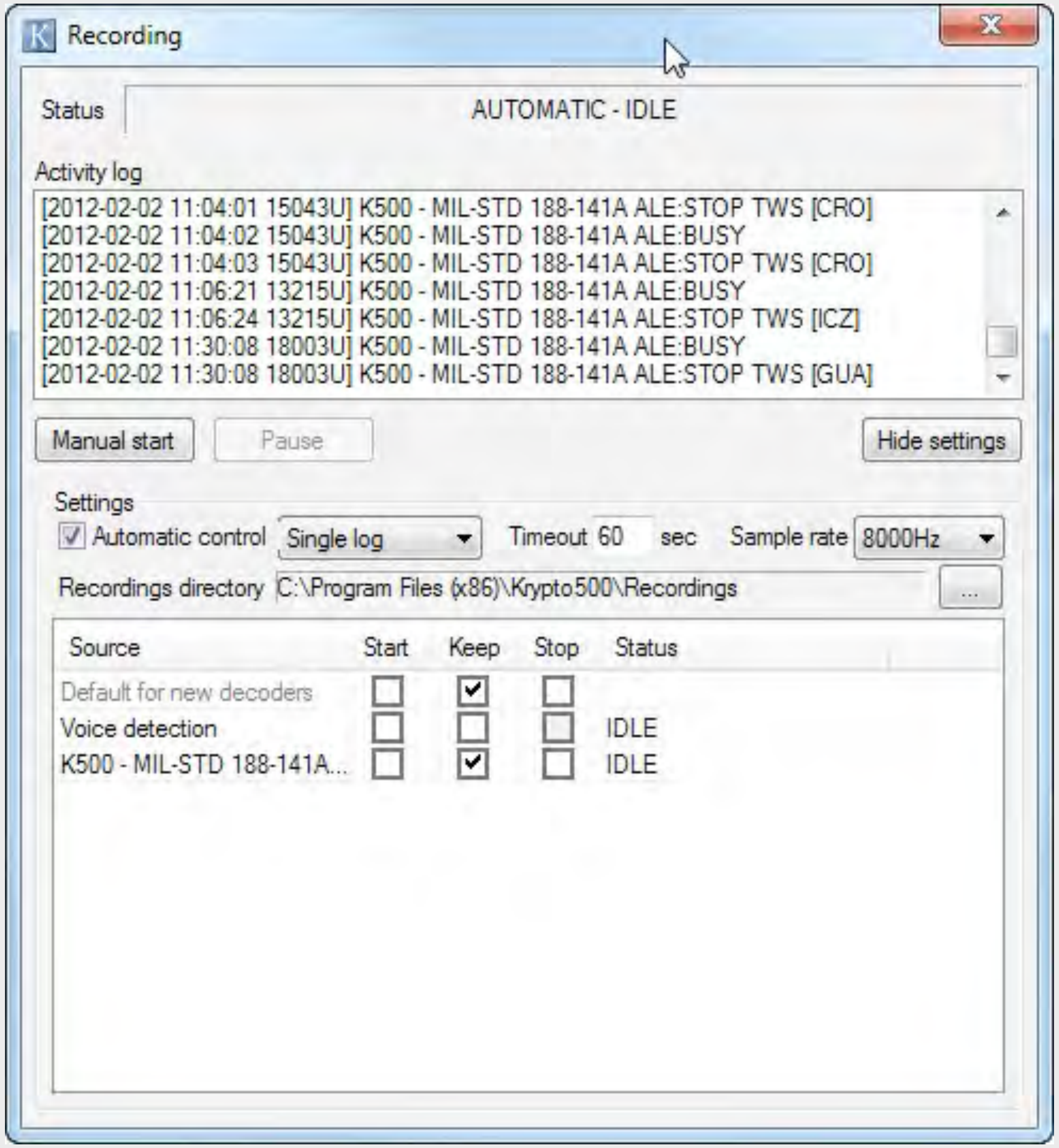
The scanner can be programmed with a set of frequencies, modes and bandwidths. The dwell time can also be set. After being started, it will look up channel by channel, stopping on each for the defined dwell time. If it notes some activity, it may stop and record and demodulate.

A typical example is a net of stations using automatic link establishment ALE to choose the best channel for a following communication which may be in SSB oder ARQ or any other mode.

Krypto500 detects those ALE calls, decodes them, and documents them with timestamp plus frequency.

Additionally, a recorder might be automatically activated, writing a log and records the communication.

Typically log of some scanned ALE channels, namely 15043 kHz, 13215 kHz and 18003 kHz in USB (U). It caught stations from Chroughton/U.K (CRO), Naples/Italy (ICZ) and Guam (GUA).

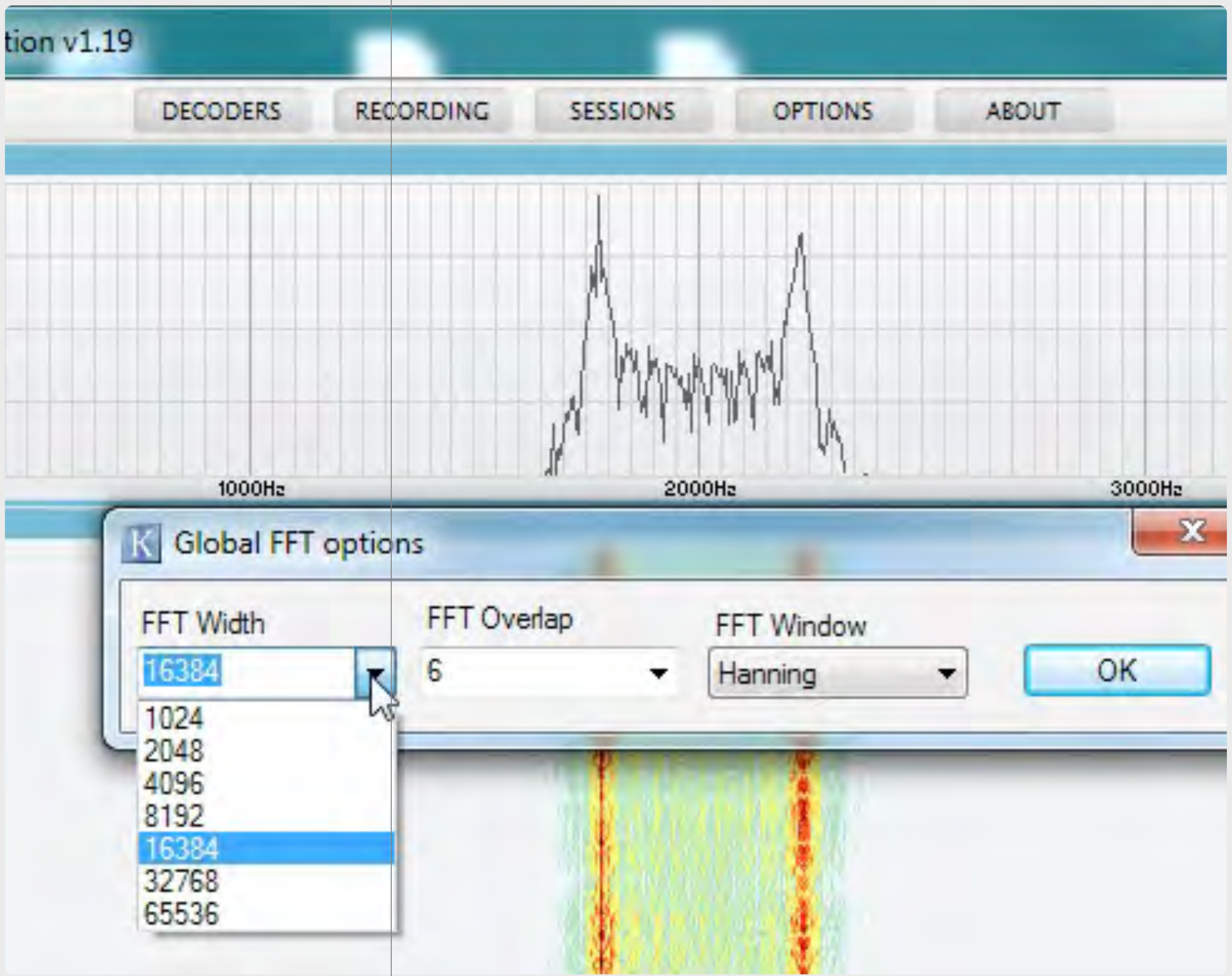


Spectrum and Sonagram

Both spectrum and sonagram do show the signal. With most decoders, you have the choice between several FFT width and an “overlap“ function. Adjusting both, you can accent time or frequency resolution.

Four pictures in the gallery on the right will give some examples of a RTTY station at 50 Baud.

How FFT width and overlapping will stress different views onto a signal



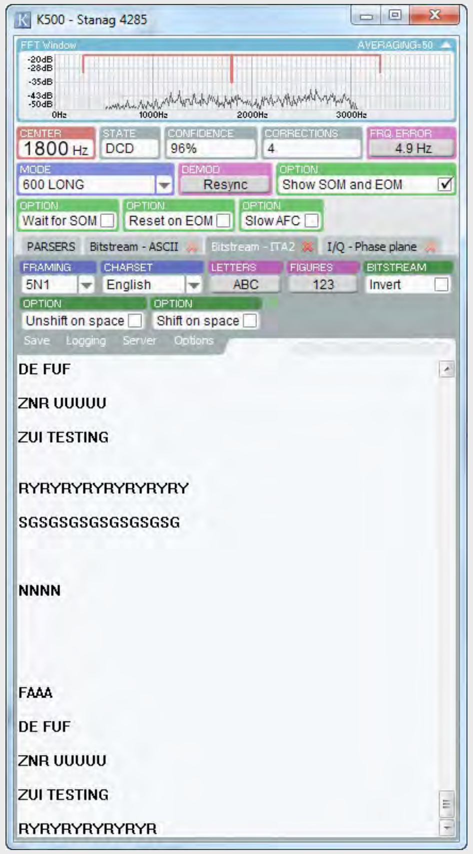
Above you have the spectrum, below the sonagram. You can change the representation of the signals by choosing different values for „FFT Width“ and „FFT Overlap“.

Utility DXing today

Despite the decline of international shortwave broadcast, this bands are full of signals from professional stations like aviation, maritime, military, and NGOs, to name just a few of them. Increasingly, they shift from SSB to data communications.

Thanks to advances in both signal theory and digital encoders/decoders, the use of shortwave still is rising. This part of the solar cycle does reveal many new of them. Shortwave provides a worldwide channel free of charge and secure communications with a modest setup. ONEMI of Chile, for instance, runs a nationwide network covering also their Pacific entities like Easter Island and Robinson Crusoe Island with mere amateur radio transceivers delivering nor more than 110 watts to a small antenna. Automatic Link Establishment, or ALE, does the trick of automatically choosing the optimum channel out of a pool of assigned frequencies. Their ALE signals can be heard and decoded worldwide.

Same goes for the ARINC aviation network, relying on short bursts between air and ground. Or take the maritime networks like Global Wireless and SEAMAIL with also worldwide coverage. Still some old buddies are making waves: FAX transmitters with weather charts and news in Japanese, a few RTTY stations, NAVTEX maritime reports or the Global Maritime Distress Safety System GMDSS, both in SITOR-B and even some morse code (CW).



French Navy Martinique, FUF, 8478,5 kHz in STANAG4285

Encryption and legal issues

Plenty of communications is “open”, i.e. not encrypted. And even with usually encrypted signals, sometimes there is some open operators chatter. Many channels do run in an idle mode or are just transmitting tests over and over again. Take the net of the French Navy with stations from Tahiti to Djibouti, which all can be clearly read in a code called STANAG4285.

Are you allowed to tune in? It depends. In a law suit of German Authorities against me it was judged that the *source* of communications takes control of what is “public” and what is “secret”. At this stage of technical development it can be stated that all communications which can be read with freely

QSL cards and letters from all over the world: Most utility stations do verify reception reports of shortwave listener if they report on some general „open“ contents like weather reports or CQ/RY calls. Among them: EMBRATEL, Global Wireless, ONEMI Juan Fernandez Island, Rogaland Radio and U.S. Coast Guard Puerto Rico.

available hardware and software is considered to be “open”. Hundreds of stations do even verify reception reports. However, there are some stations and some countries disliking this view.

Decoders: Focusing on Krypto500

Key to this world is a software decoder. The most recent one is named Krypto500. At a price tag of US-$ 7400 or nearly 6000 Euros, it plays in the same league as e.g. Wavecom’s W-PC or Hoka’s Code300-32P. In this realm of decoders, GX430 of Rohde & Schwarz reigns king.
Thanks to generous loans, I had the chance of testing all of them. This publication focuses on Krypto500.

Professional Monitoring vs. SWLing

Professional monitoring differs significantly from what the shortwave listener (SWL) is doing. Whereas SWLs want to receive some rare stations and identify them by a clear callsign, professionals are more interested in just *patterns* of modes and activities. Most transmissions are encrypted anyway. Done professionally, it can be cracked only within a time, after which no tactical use can be made of its contents. On the other hand, frequency hopping is increasing. There, the communications is split up into short portions in the millisecond range or below and transmitted on many channels in a distinctive pattern. Thus, you have to know this pattern as well as the code to actually read the contents. With sophisticated methods of direction finding, however, you can pinpoint the geographical location of the transmission and doing a finger printing on each transmitter. You can also log their activity.

Sounds disappointing in the ears of an ordinary SWL? Needn't! There are literally thousands of stations which can be received, and many of their transmissions can be decoded by a professional decoder like Krypto500. But this is only one part of the fun. You also need a good receiver, most preferably a software-defined radio, or SDR. Mainly for two reasons: they provide exceptionally linear filters of flexible bandwidths, and a large spectrum of HF can be recorded; like up to 4 MHz with Winradio's ExcaliburPRO. Most Utility DXing should be made with recorded files which you can repeat playing and changing e.g. bandwidths, AGC or passband tuning.

Three steps to monitoring

SDRs do also provide a sonagram, or "waterfall". This is a panorama of frequency and time. It considerably helps in revealing short-time activity and often assists in classifying the mode due to some distinctive patterns.

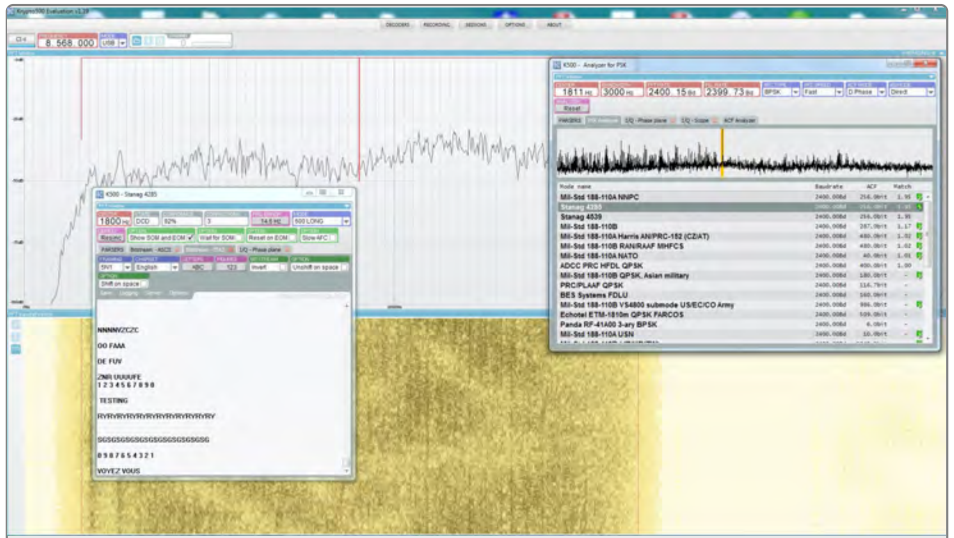
In general, monitoring proceeds in three steps:

- unearthing a signal
- classifying the mode
- decoding

To find a signal, a sonagram (page 1) is a must. In classifying the mode, functions of "analyzers" or even "classifiers" as part of professional decoders will do the bigger part of this work. For "decoding", the decoder must have a great selection of up-to-date codes which nowadays are filling the air.

Helping hands

If you are a mere newbie to utility DXing, you surely will get lost between all the signals. But not only in this case, I would like to recommend two valuable reference books, namely Michael Marten's "Spezial-Frequenzliste" with about 30 000 detailed entries and Joerg Klingenfuß' "Guide to Utility Radio Stations", covering around 8 300 frequencies. To dive deeper into monitoring, Roland Proesch's excellent "Technical Handbook for Radio Monitoring HF" is a reliable guide through most of the modes you encounter on shortwave.



In action: Krypto500 has analyzed STANAG4285 (right) and decodes French Navy, Djibouti (left).

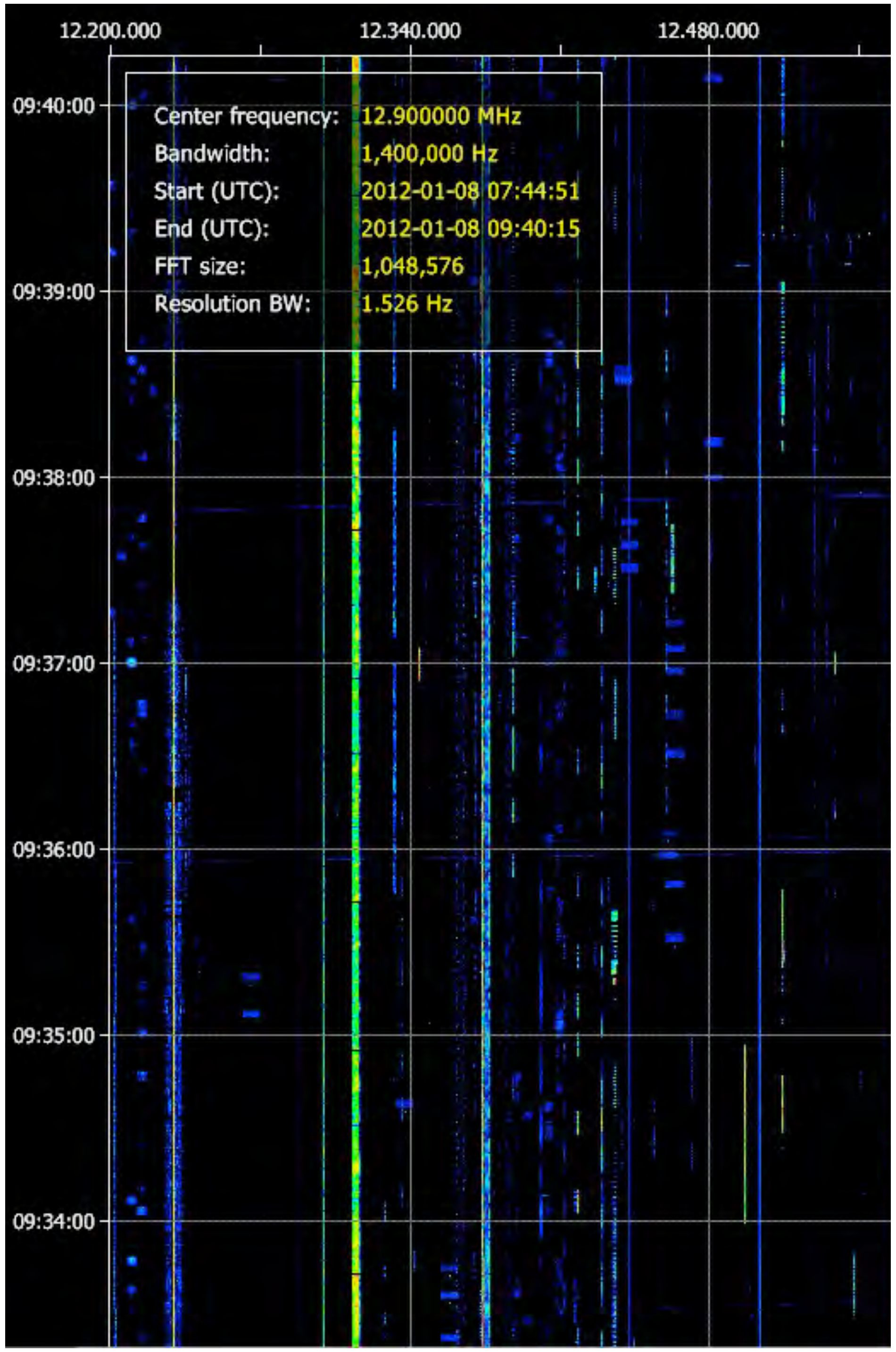
Eventually, there are several Yahoo Newsgroups dealing with utility DXing, most notabliy that of UDXF. Among the many websites providing audio bites of several modes, Leif Dehio‘s one is a first to stop.

On the next pages, I will proceed the “Three steps of Monitoring“.

USB dongles are the key to professional decoders: Krypto500, Code3-32), W-Code and GX430 - from above.

Unearthing Signals

The best way to catch signals is to *record* a part of the shortwave band and to make a *sonagram* (right) of it.
Then you can tune into the wanted channels at the right time, when they are active, and propagation allows for a steady, strong and clear signal. See the figure on the right for an example of some 150 kHz around 12340 kHz, recorded with SDR-IP of RFSpace and software SDR-Radio. You see many short-time activities which are worthwile to be scrutinized.



Exploring an ALE Net

A sonagram is the tool of choice to get an overview of activities in the utility bands. I use the software SDR-Radio by Simon Brown, together with RFSpace's SDR-IP for its excellent HF performance, and because it can be locked onto GPS for ultra stable and precise frequencies.

These are some general steps to follow:

Choose the band you like to monitor, and the time. Make a recording, analyze it by SDR's function "IQ Data File Analysis".

Write down time and frequency of the signal. Take *that* part of the recording, where the signal performs best. Replay exactly this part of the recording. The "loop" function will help you with the next steps of analyzing the signal.

Have a look at the three pictures of the *gallery* on the next page, showing this step-by-step:

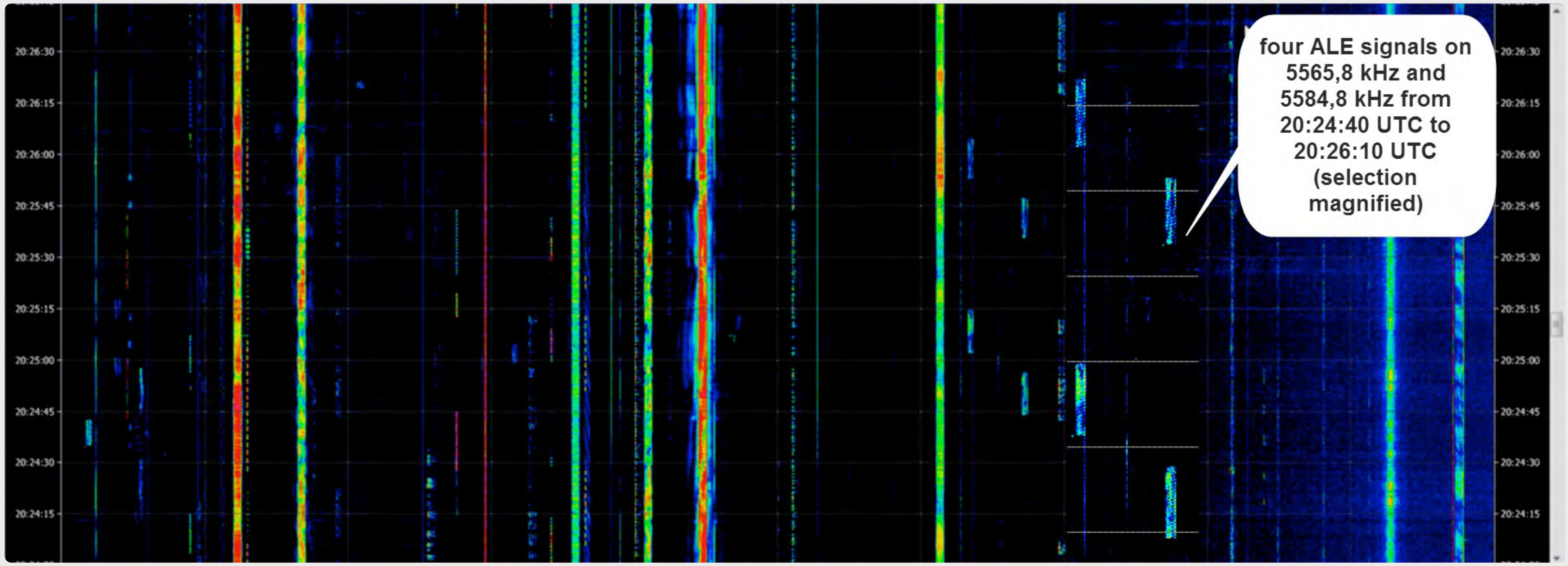
- Firstly, we have a look at a sonagram, 500 kHz wide, and showing two hours of activity on 15000 lines. As our brain has a good pattern recognition (some optical illusions also rely on this fact), we soon discover some distinctive ALE selcalls. They last for just twelve seconds and will be easily missed at tuning with a conventional radio.
- Secondly, note time and frequency of this activity and set up a loop of this recording from 20:24:40 UTC to 20:26:10 UTC [hh:mm:ss].
- Thirdly, decoding. Tune into the wanted frequency and match it to the decoder which is quickly done by the loop.

In this case, results were as follows:

- At 20:24:44 UTC "DB5" calls "DBE" on 5584,8 kHz and changes at 20:25:02 UTC to 5565,8 kHz with the same call.
- At 20:25:36 UTC "DB3" calls "DBE" on 5565,8 kHz and changes at 20:25:54 UTC to 5584,8 kHz with the same call.

DBE stands for Iraqi Border Enforcement. DB3 is "III Border Police Region, Special Troops Batallion, Kut Central Iranian Border", whereas "DB5" stands for "V Border Police Region, Special Troops Batallion, Najaf Saudi Arabien Border". DBE is the headquarter. [Thanks to Tom at UDXF for these infos!]

Three steps from discover the signal to decoding, just leaf through the screenshots.

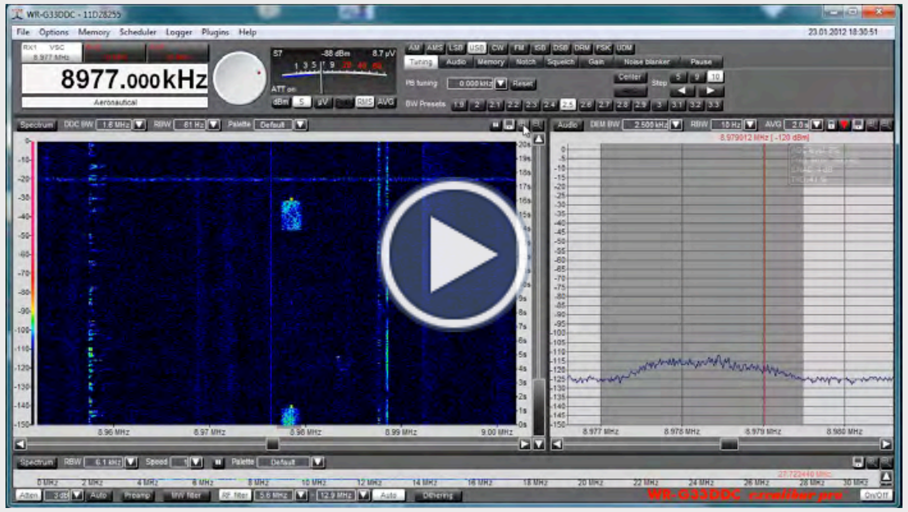


Step 1: Identify some interesting signals within the complete sonagram. Here, four ALE signals have been magnified.

What mode?

Krypto500 is among the few decoders which assists you in analyzing the signal to specify the mode – or a choice of modes. To speed up, you have to do a kind of pre-selection: is the signal frequency-shift keyed (FSK), or is it phase-shift keyed (PSK)?
A frequency-shifted signal usually consists of two (FSK) or more (MFSK) single tones, keyed in the rhythm of the information. See some modes for example in the video on the right.

Some six modes - how they look, how they sound



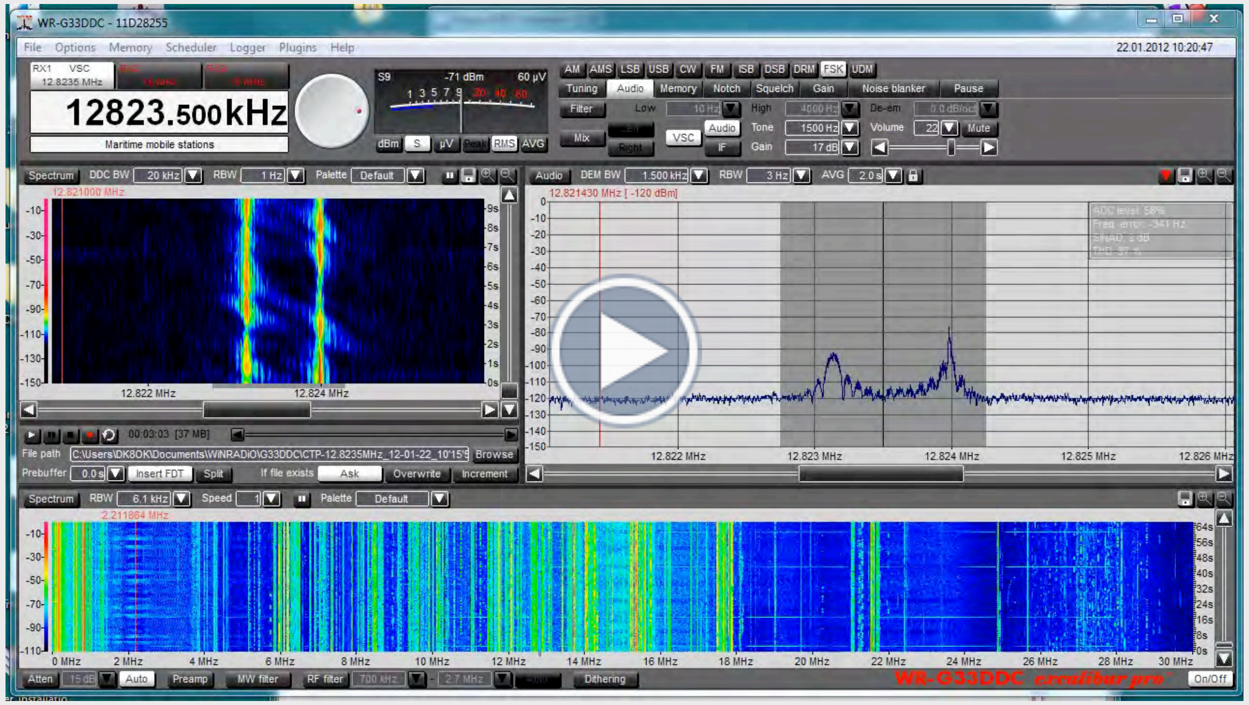
Experienced listeners often recognize a code just in a sonagram or by its audio. This video shows six typical examples: ARINC 635, SELCALL ICAO, FAX (FM), Morse, Saab Grintek MHF-50 and GW-FSK.

Automatic Classification

GX430 and W-PC (with options) do offer a general and automatic classification. GX430 does the best job ever seen in this respect, identifying even FAX transmissions correctly. W-Code is most convincing with continuous signals, but burst signals are another animal. Code3-32P also has a classifier, working remarkably well in many cases.

All classifiers try to determine specific parameters of the signal – like bandwidth, baudrate, number of tones of phase constellations. They check these specifications against a look-up table, giving their vote, often with a figure of probability. As there is a big number of combinations to check, classification can take some time. Noisy, weak and distorted signals will make the job even more difficult as ambiguity – (nearly) the same pattern for different modes – will add up to the challenge.

How classification works, live and on the air.



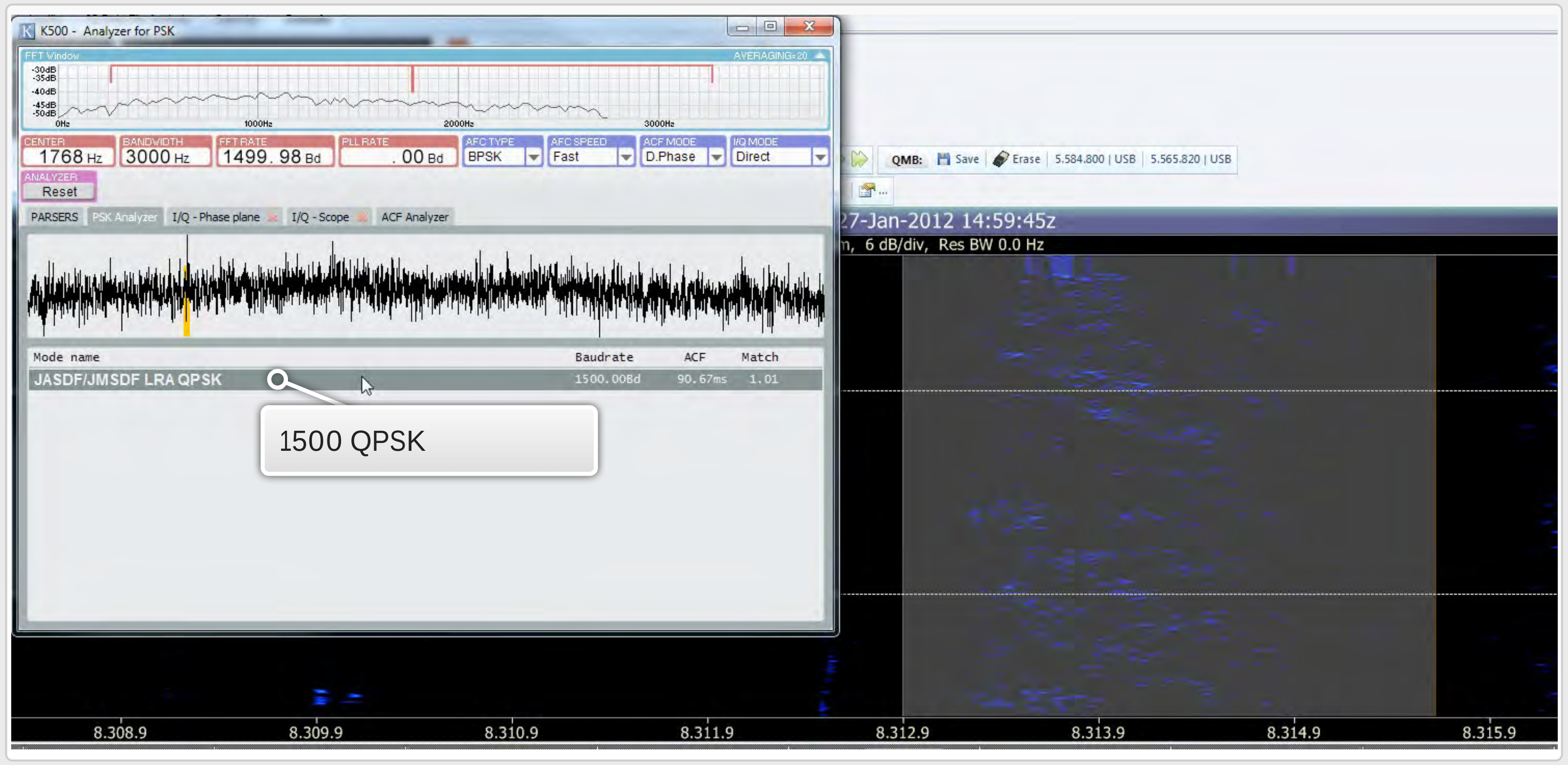
Automatic classification and decoding of an RTTY signal can place some challenge. This live example compares GX430, W-Code, Krypto500 and Code3-32P. For all decoders, there has been used the same snippet of an HF recording of the strong signals of NATO Lisbon, 12823,5 kHz.

The video compares several decoders in classifying a 75 Baud FSK signal of NATO Lisbon. To sum up: automatic classification with all decoders without GX430 is giving you nothing more than a bit of assistance.

To get a knowledge of how different codes look like in a sonagram or how they sound, and to choose the right code *manually* will be often faster and more successful. The video on this page shows some typical examples.

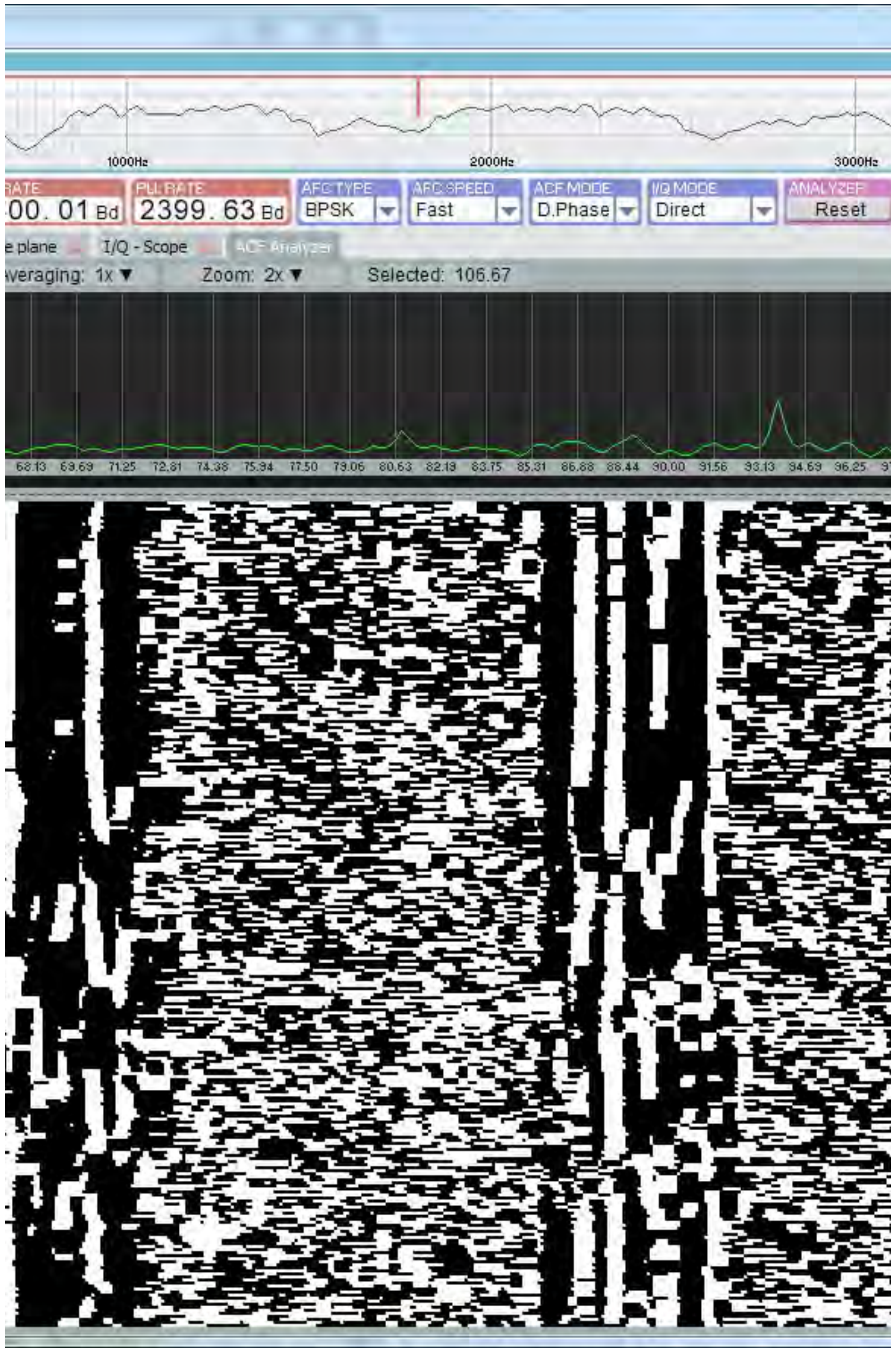
Krypto 500 is quite generous. The software even identifies many of those signals which in at least this version it cannot decode. Take for example the 1500 QPSK of the Japanese Navy. Yes, mostly those channels carry an 8-tone ASK (amplitude shift keying) signal called “Slot Machine“, but this is sometimes replaced by a QPSK signal, Krypto500 correctly determines - see the screenshot.

JJF on 8313 kHz with a 1500 baud QPSK signal, correctly analyzed as originating from the Japanese Navy. Alas, there is no green arrow behind the mode. Thus, this version of Krypto500 will not decode this signal.



The next chapter will deal with identifying also exotic signals manually by analyzing their specific characteristics.

How high the ACF?



Some decoders do have sophisticated modules to take measurements of e.g. frequencies, channel spacing and phase constellation - some not. At first sight, Krypto500 seems a bit sparse in this field. But many things are done automatically under the hood. These functions will considerably help in identifying a mode, and can here just be scratched on the surface.

FSK and PSK, X-rayed

As the manual of Krypto500 provides an instructive step-by-step introduction in analyzing a signal, I here just want to give a few examples.

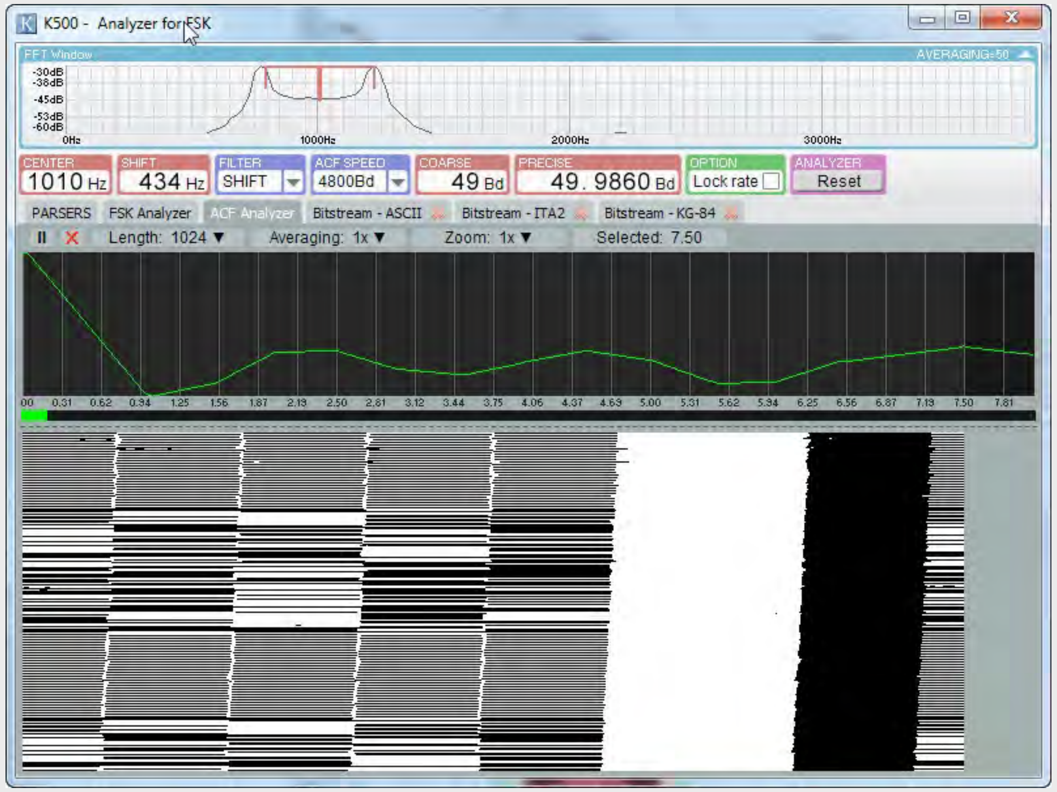
The software provides two analyzers: for FSK or frequency-shifted signals and for PSK or phase-shifted signals. Both analyzers do have the goal to get as much information on the signals as possible to get a clue of their specific mode - even if Krypto500 may not have a decoder aboard, as for e.g. the 1500 Baud QPSK Mode of the Japanese Navy.

Let‘s start with FSK, then switch to PSK. We will do this with real-world examples, and not with modes from a generator. As some signal maybe weak, noisy and distorted, some results may give no perfect pictures either. Don‘t blame Krypto500 for that - it‘s just live.

FSK

FSK in its easiest form consists of two frequencies, switched alternatively according to the information. The shift between these two signals is as important as the Baud rate, and the pattern of these bits. ACF, or auto correlation function, will show this bit pattern. Krypto500 also most automatically will find both signals, and will determine the shift between them by „FSK Autotune“.

A RTTY station with 7,5 Bit (ACF) will show this window. Above you see both tones, followed by some measured values, starting with „Center Frequency“, followed by „spectrum“ of ACF, and its graphical representation below.

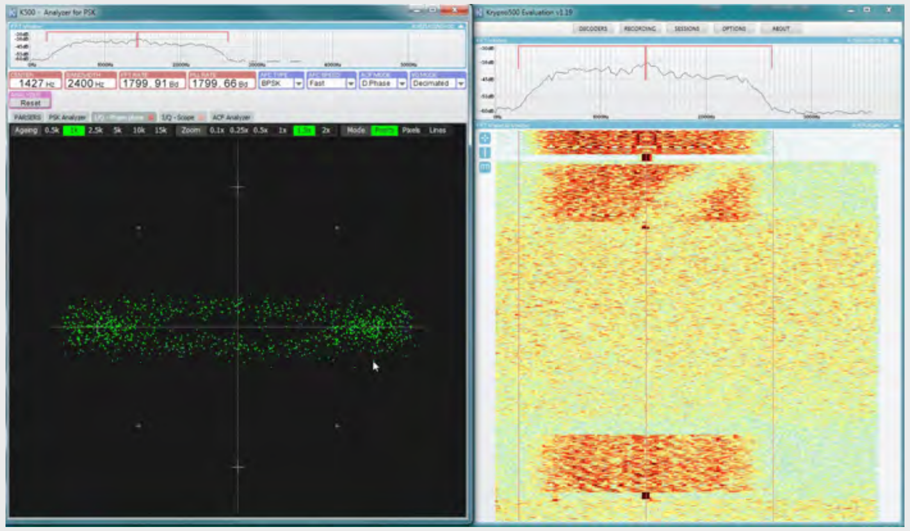


PSK

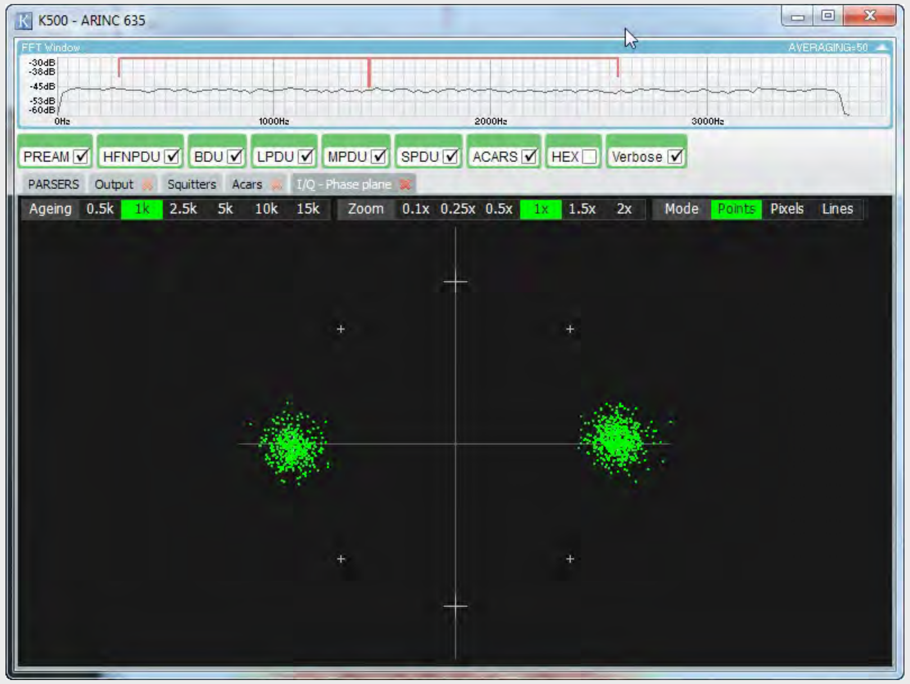
In PSK, phase shifting carries the information. With data communications within a bandwidth of 3000 Hz, two to 16 phases are common. They are represented by the phase plane.

Krypto500 will determine Baud rate as well as center frequeny automatically in most cases.

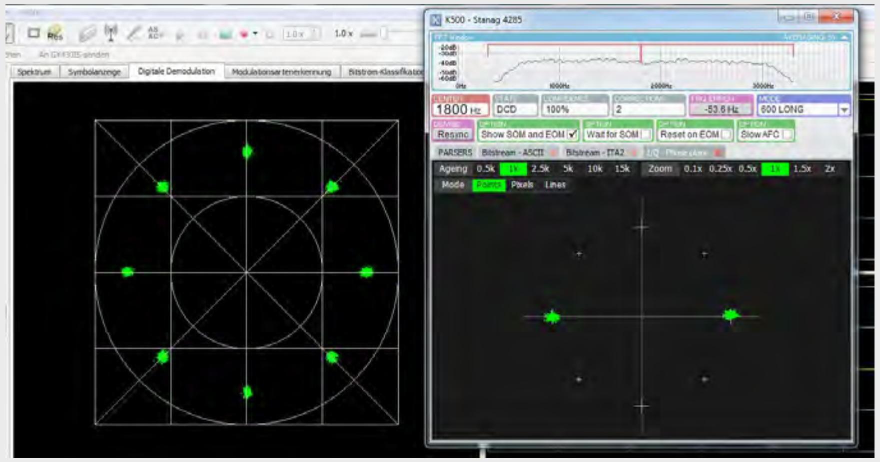
ARINC-635, 2-PSK transmission with 1800 Baud. On the left, you see the phase plane, on the right the usual sonagram.



Switched to decoding ARINC-635, the phase gets sharper.

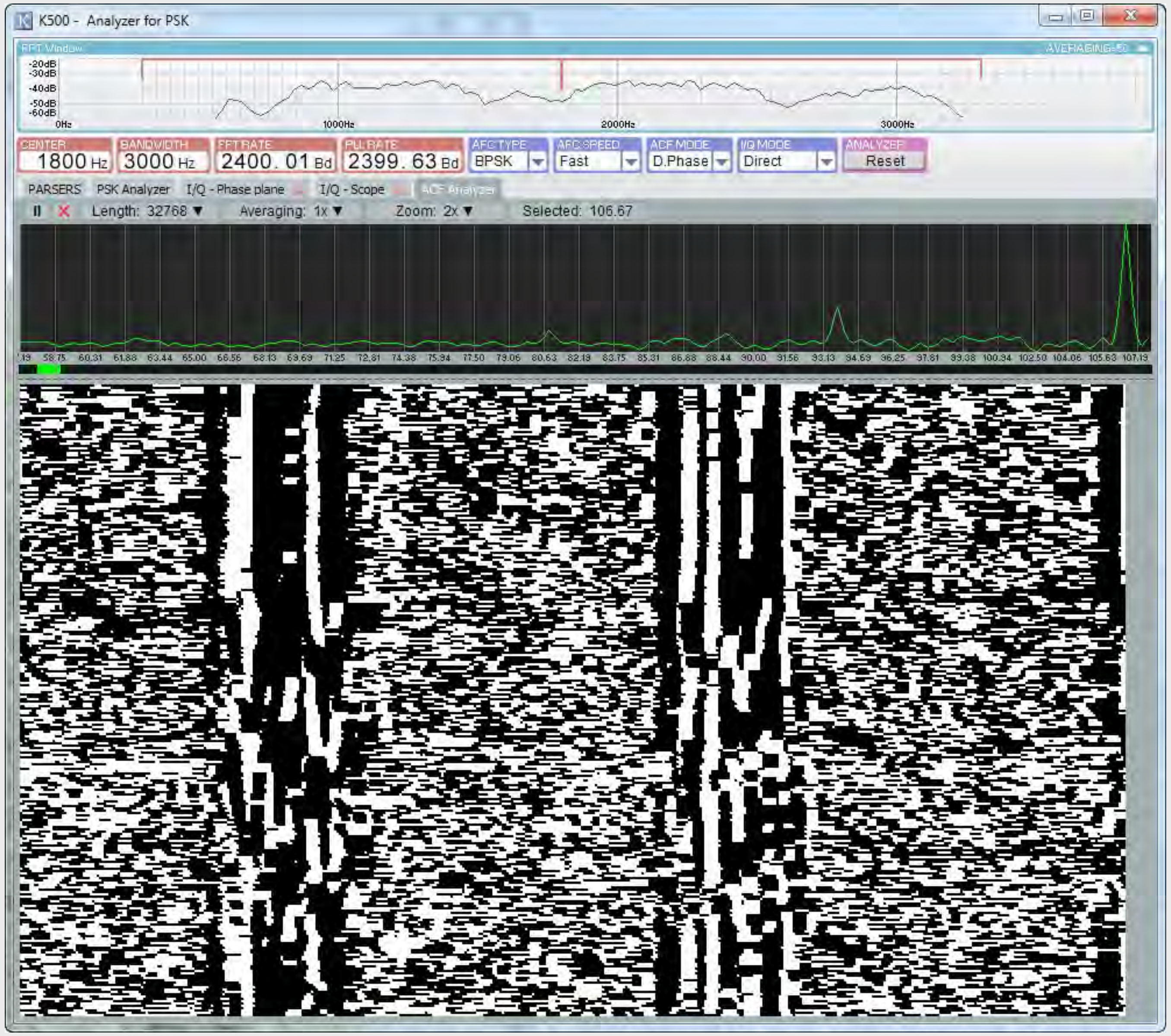


Phase plane of STANAG4285 in 8-PSK, left of GX430. Right the same signal, showing the 2-PSK *descrambled* symbols at Krypto500.



ACF can also be detected and shown in PSK signals. Here a STANG4285 signal, exhibiting an ACF of 106,67 millseconds.

Autocorrelation function ACF of a STANAG4285 signal, 106,67 milliseconds.

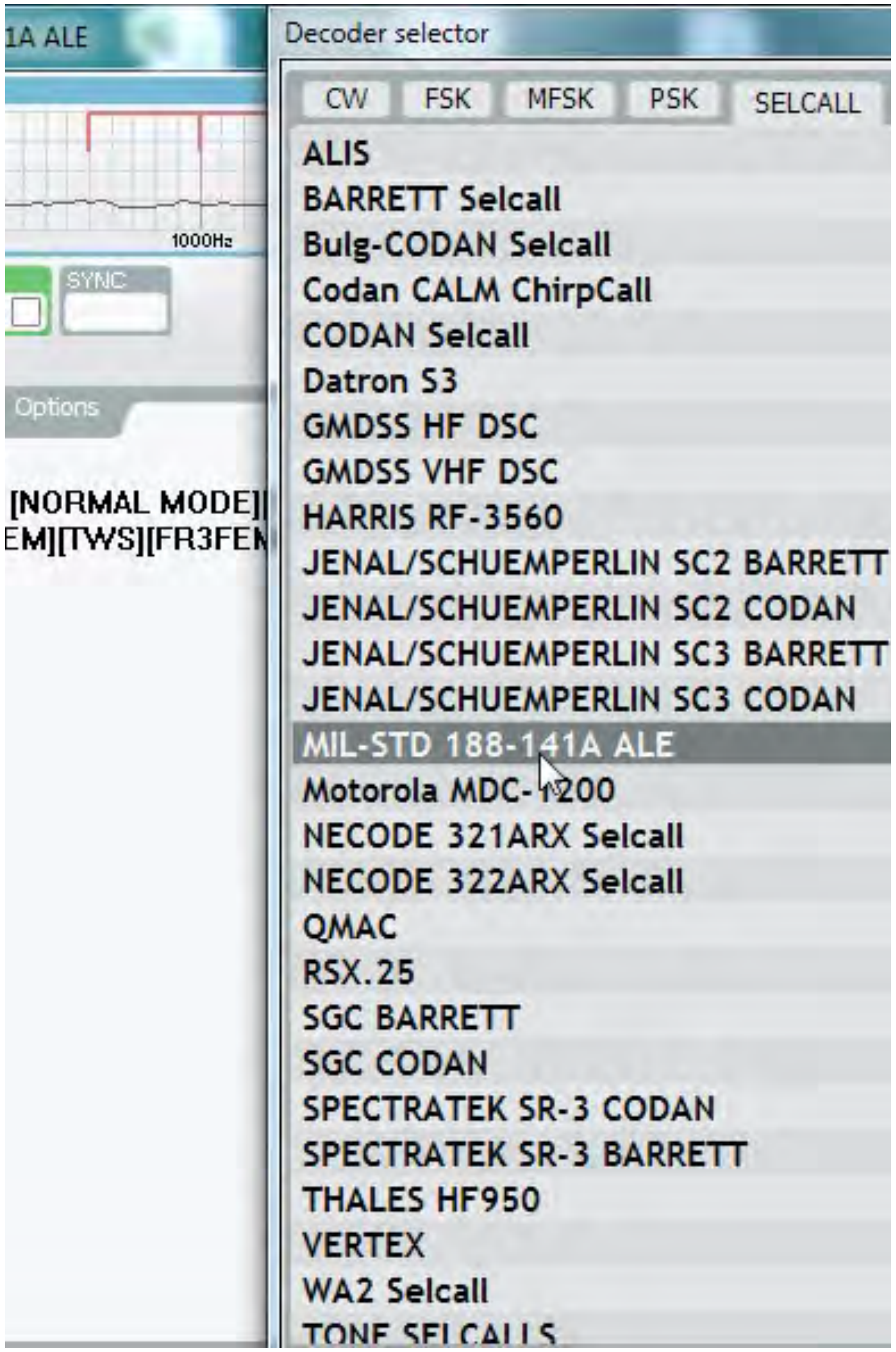


iBooks Author

Some Modes

The following pages will show some annotated examples on how Krypto500 decodes live signals.

See an example on the right:
SELCALL menue has been choosen, “MIL-STD 188-141A ALE“ clicked, and FEMA Region 3 with their Headquarters in Philadelphia PA/USA received on 12216 kHz and decoded (“FR3FEM“).

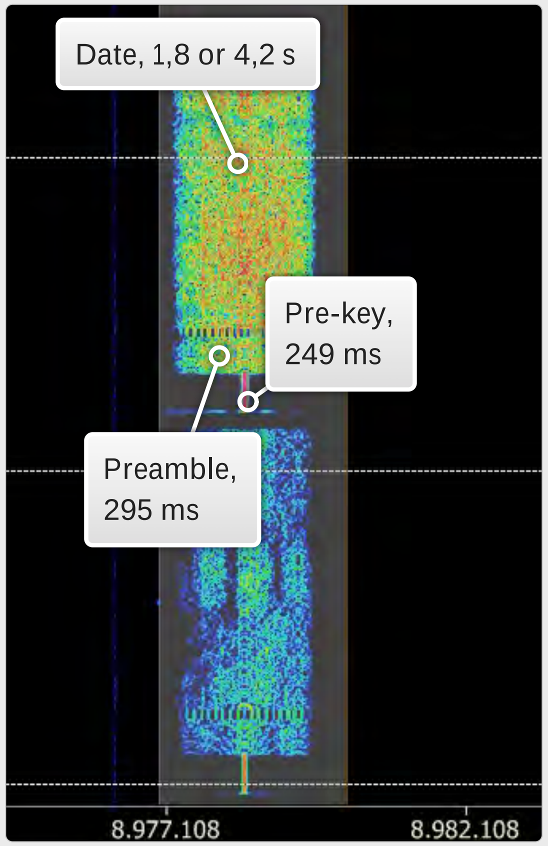


ARINC 635

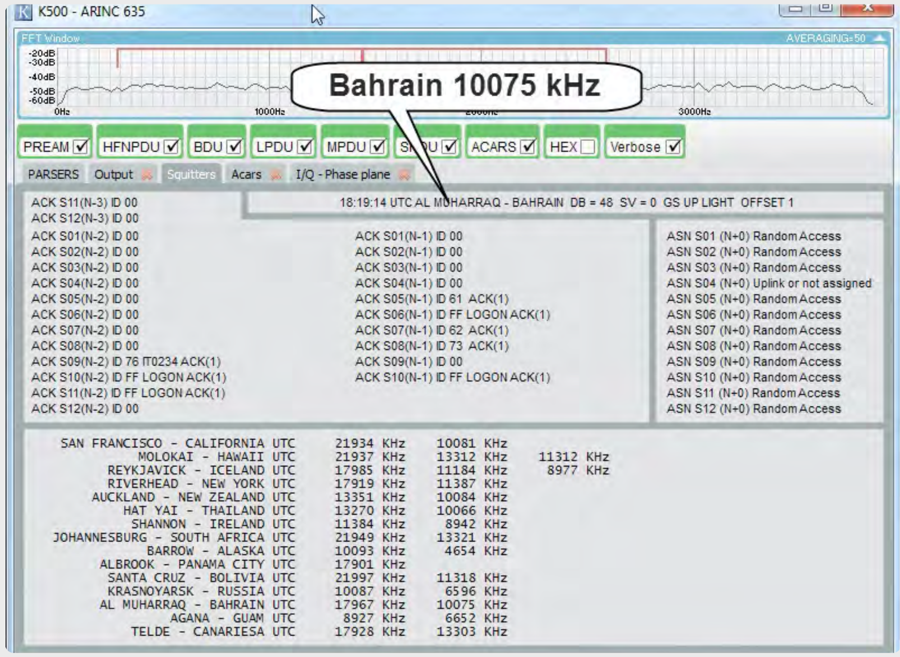
This is a system of worldwide ground stations, built by "Aeronautical Radio Corporation Inc." of Annapolis MD/USA. You can receive and decode telegrams of ground stations as well as airborne stations which are sent in a GPS-controlled time pattern on numerous frequencies. The so-called „Squitters" from the ground stations do carry the identification plus those stations and frequencies on this net which this specific station is able to receive. Thus, you can tune into exactly their frequencies to check whether the ionospheric path is open.

Exactly that has been done for the three pictures at the gallery on the right, starting with Bahrain on 10075 kHz, switching to Guam 6552 kHz and eventually toJohannesburg on 13321 kHz.

ARINC 635, structure of the signal



Three ground stations

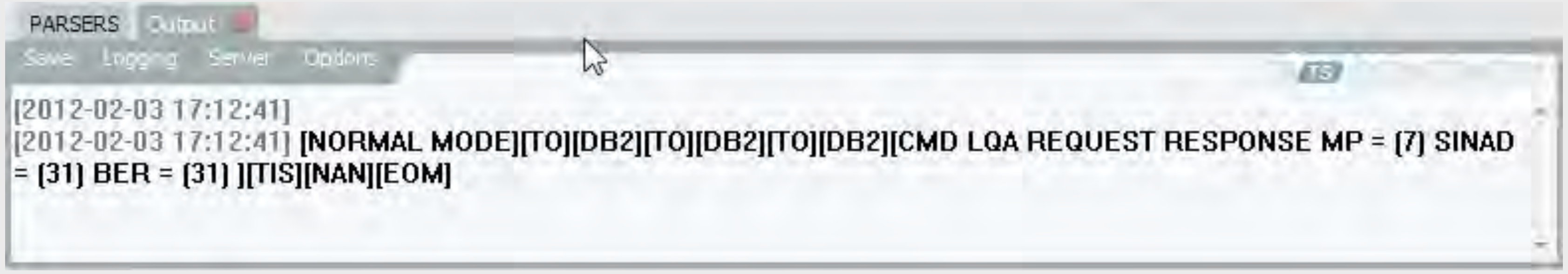


Tuned to 10075 kHz, I received Bahrain transmitting a list of ARINC station they hear.

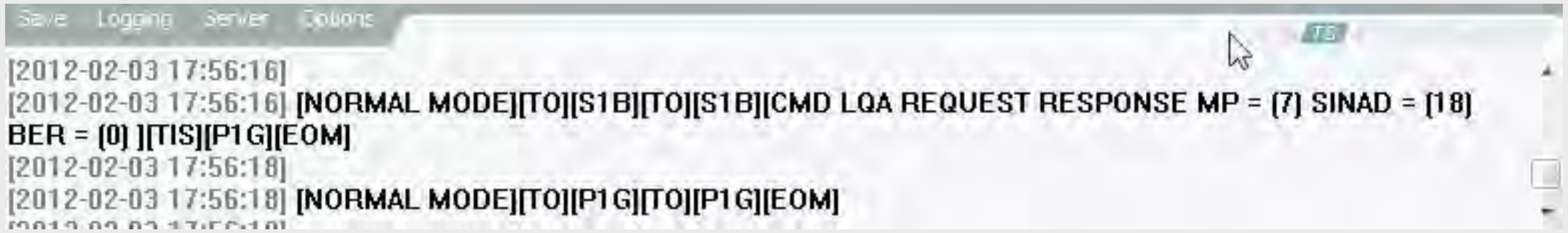
ALE

This „Automatic Link Establishment“ is somewhat ubiquitous on the bands as in this publication. A few some quickly picked up examples below.

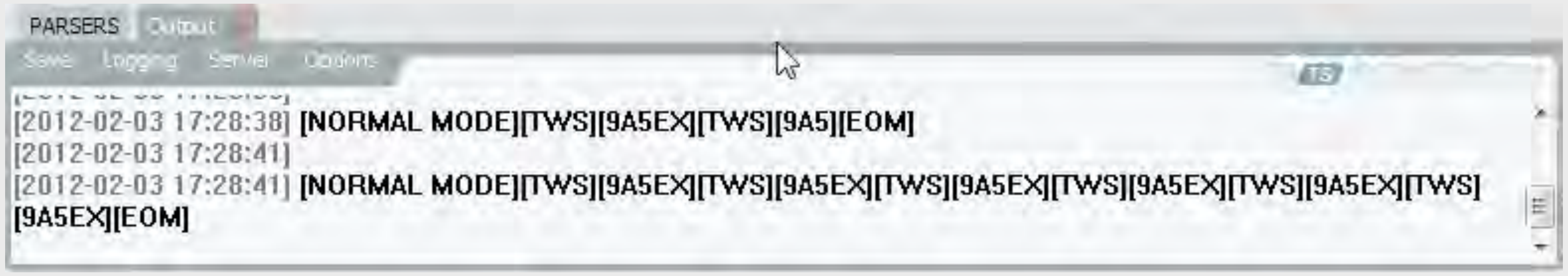
Iraqi Army, 7th Brigade Special Troop Bataillon, Ninawa („NAN“) calling Iraqi Border Police Tikrit („DB2“), 5493 kHz, 17:15 UTC



Navy Lithuania („P1G“), calling another Lithuanian station („S1B“), 8166 kHz, 17:45 UTC



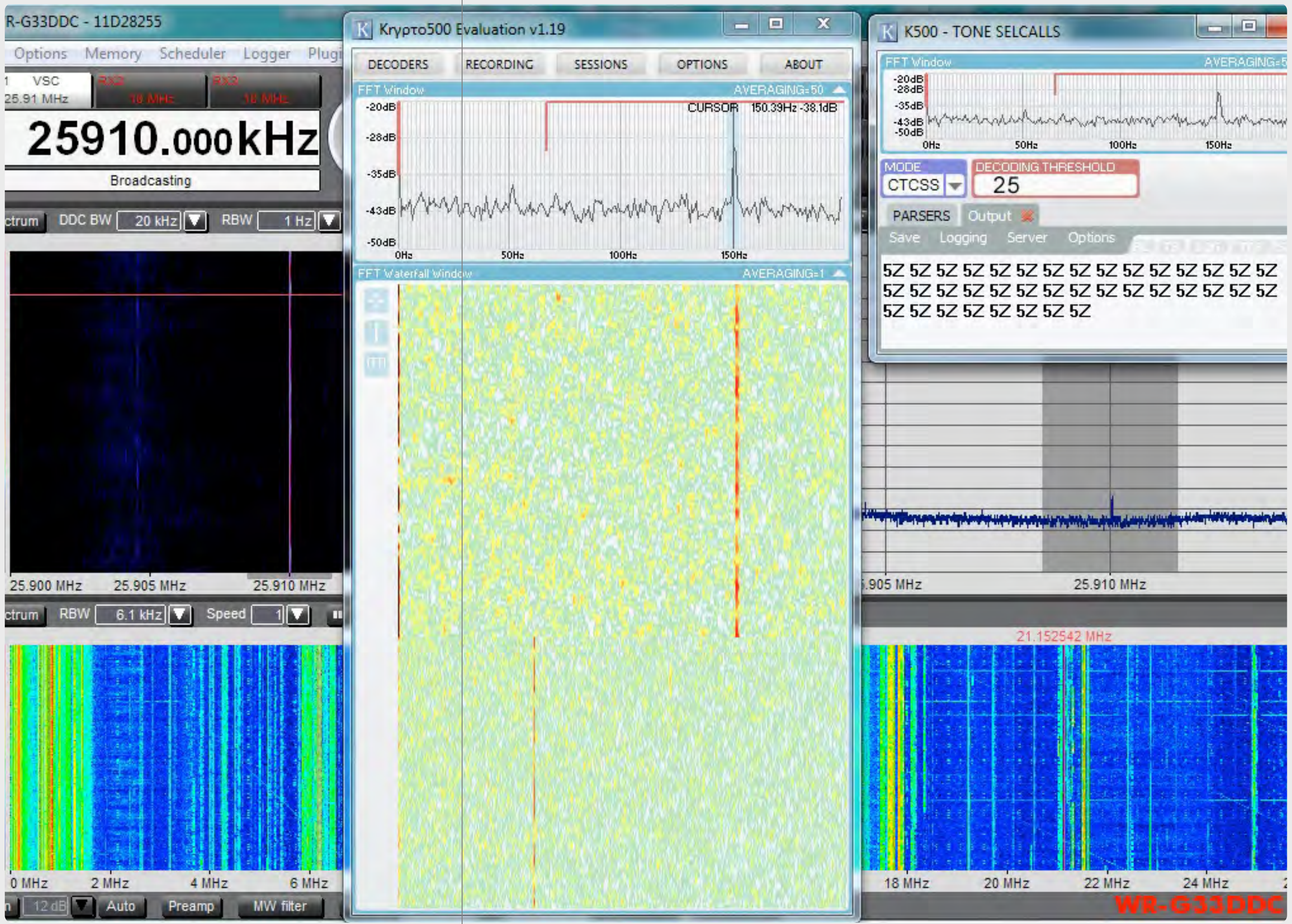
Croation Amateur Radio Emergency Operation Network (HRSVKS), near Samabor/south-east of Zagreb („9A5EX“), 5403,5 kHz, 17:20 UTC



CTCSS

In FM, some transmitters add a special tone in the lower audio range to open up e.g. the receiver of a relay station. This „continous tone-coded squelch system“ is used by hams in the 10 m band, as well asmin CB radio, and also among radio stations with some feeder transmitters from the studio to the main transmitter. CTCSS tones range from 67.0 Hz to 250.3 Hz, and are filtered out („notched“) at the co-operating receiver. Krypto500 decodes these tones and shows their PL (private line) code, introduced by Motorola. Two examples are given in the picture gallery, both with feeder transmissions from the U.S.

Open, sesame!

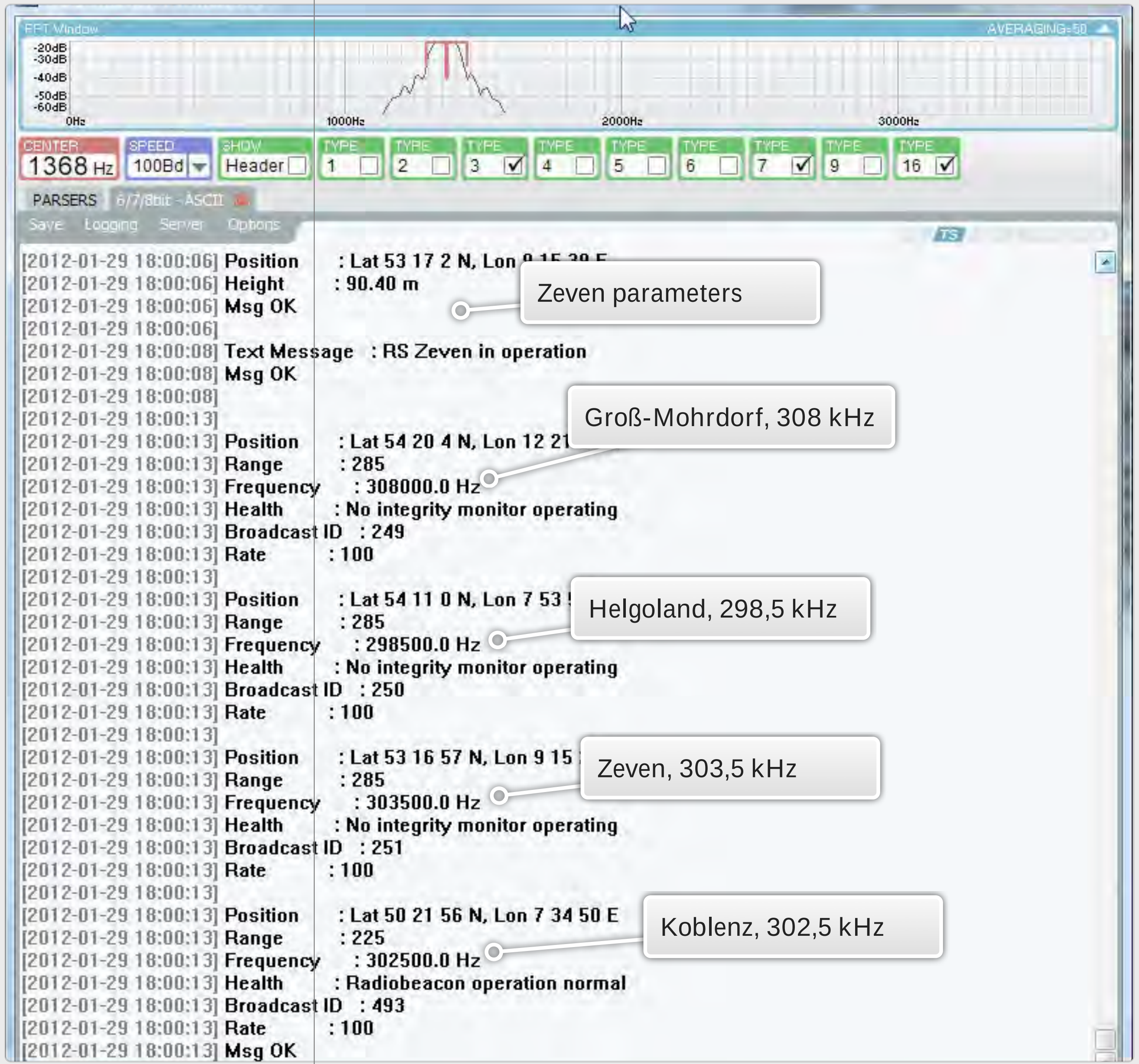


WBAP from Dallas/Texas provides their transmitters on 820 kHz AM and 96,7 FM by an FM feeder on 25910 kHz from their studios at 3090 Olive Street, Dallas. They secure the input of their transmitters - „relay“, technically speaking - by a CTCSS tone of 151.4 Hz. This corresponds to a PL designation of „5Z“. See also the peak at this frequency in the spectrum of Krypto500.

[M823] Differential GPS

A service on longwave, providing GPS receivers with information for correcting their values for most demanding resolution of the 3D geographical position. Also called “DGPS“ for short.

DGPS transmitter Zeven with its parameters and the Radio Beacon Almanac of this station plus some in its vicinity (chain 3D4x). Received on 303,5 kHz.



STANAG4285

You will find this mode nearly everywhere on shortwave, but only few signal can be decoded by the ordinary listener. Most of those do belong to the French Navy and include such rare spots like Noumea, Point-a-Pitre, Papeete and Djibouti. You may already have seen some of them in this iBook, and more are to come.

On the right, you see a short video of KRYPTO500 decoding the weak to fair signal of French Navy Djibouti, just fading in on a January morning on 22447 kHz. Please also note some interference by PLC, or power line communications.

FUV Djibouti - French Navy „East of Suez“

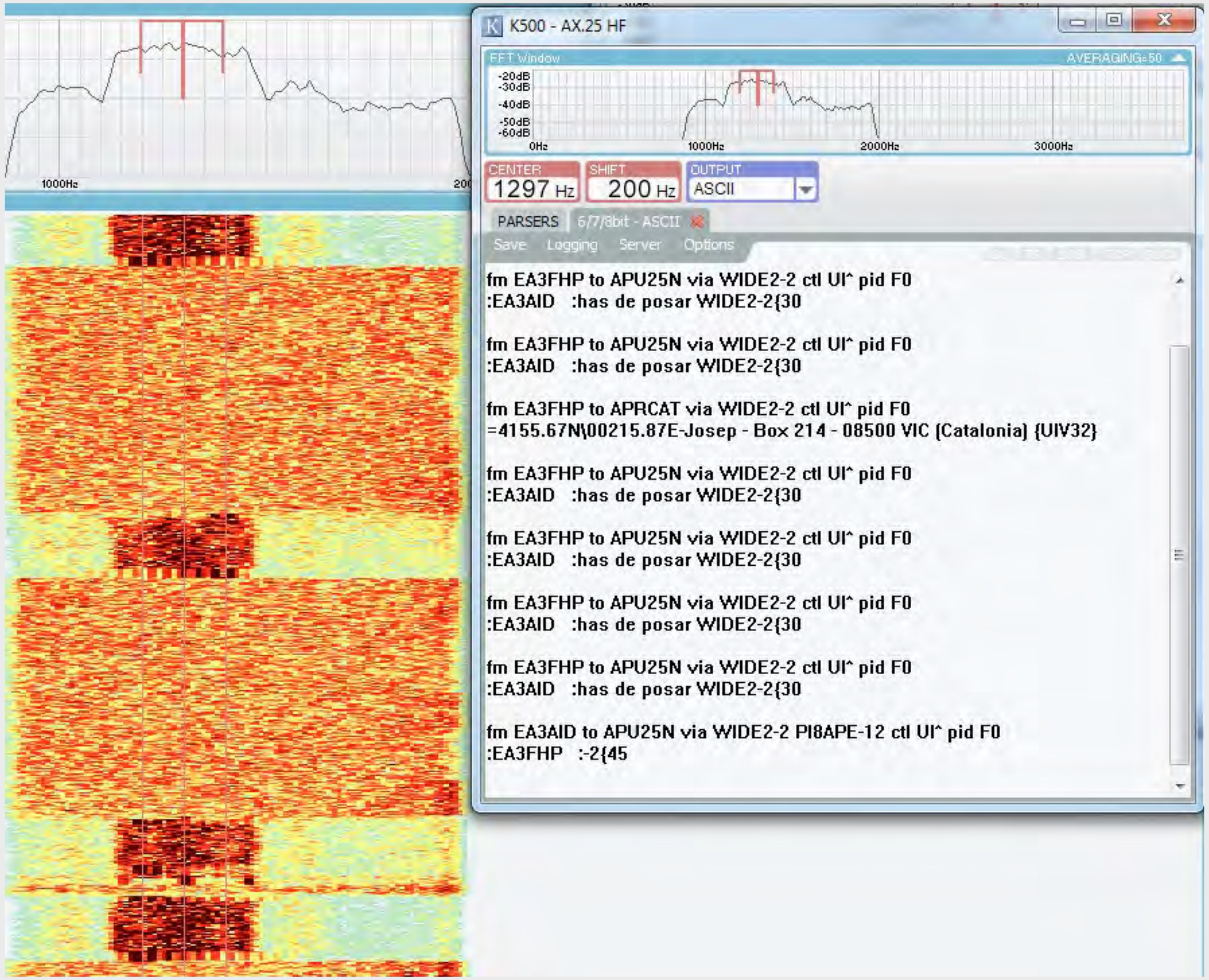
Signal fading from weak to fair, plus some interference of PLC. Nevertheless, Krypto500 provides a near-perfect copy.

AX25 - Packet Radio

For years, Packet Radio has been widely used by hams, on shortwave as well as on the higher bands.

Mainly, you find mailboxes using this, on shortwave, a bit outdated mode. See picture on the right.

Amateur Radio mailbox on 14113 kHz.

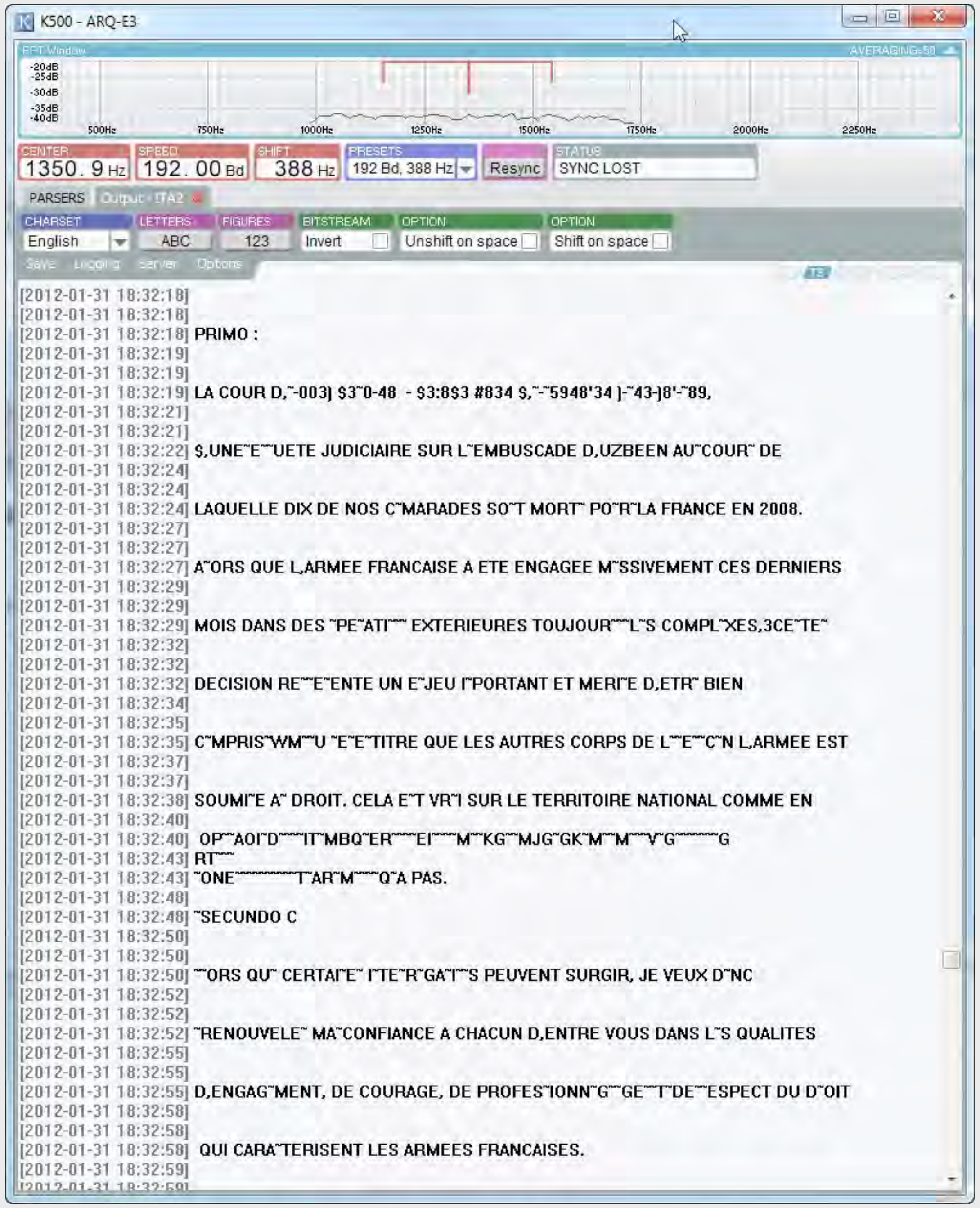


ARQ-E3

A mode, which nowadays is rare on shortwave. One of few stations can still be found on 11421,7 kHz. This is listed as DTRE Base Alfred-Faure Crozet Island, far south in the Indian Ocean. Most of the time idling, the few five-letter-groups and texts in French are regularily received here under just marginal conditions. Krypto500 is among the few decoders reading at least parts of these transmissions, and is doing this first class - see screenshot on the right.

In autumn 2011, there has been a discussion on the actual location of this transmitter. Professional direction finding points more to Djibouti than to exotic Crozet. But also Mayotte has been rumoured.

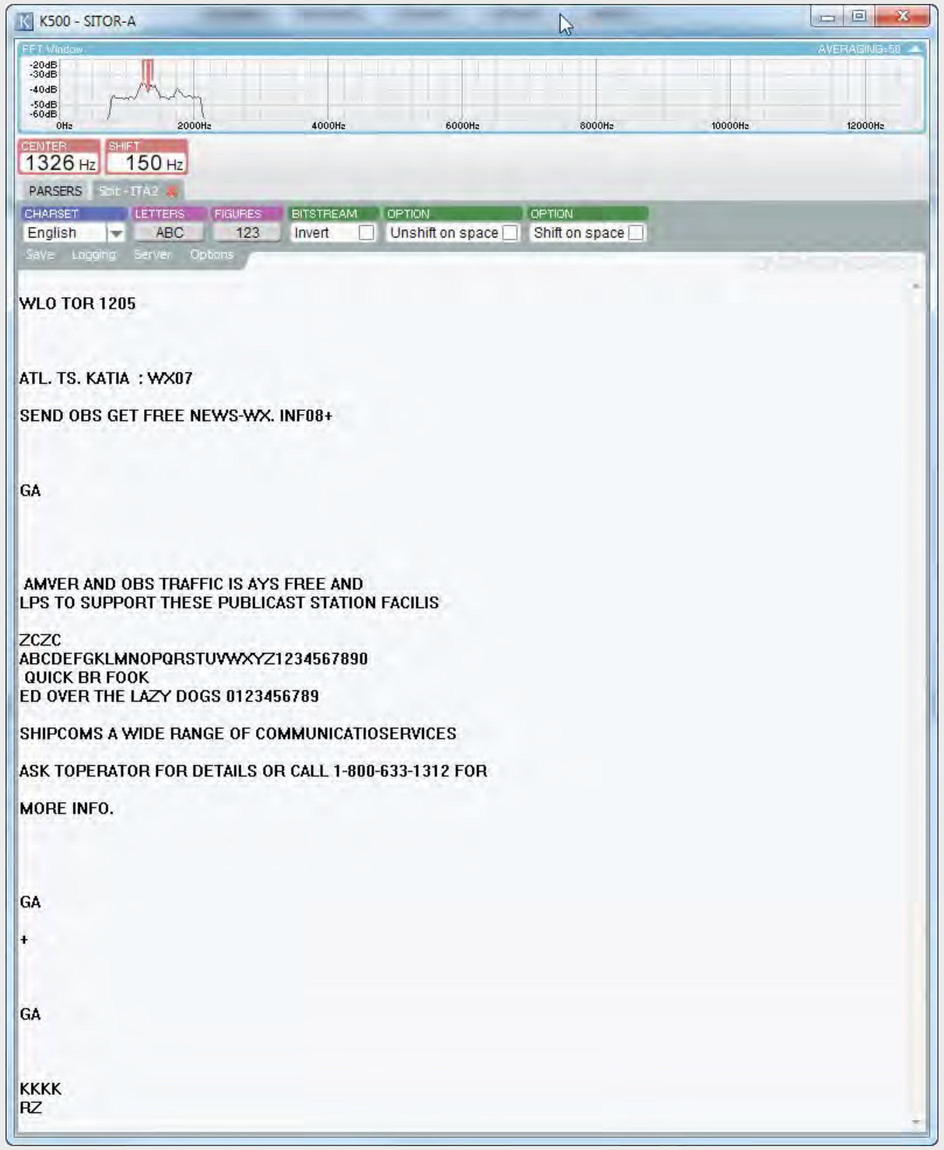
ARQ-E3 signal, 192 Baud, 388 Hz, 11421,6 kHz: Crozet, Mayotte, Djibouti?



SITOR-A, ARQ

A mode with automatic request, or ARQ. The transmitter sends out the message in small packets. The receiver has to check each packet by a special algorithm and to acknowledge that this packet almost certainly has been received correctly or not (checksum). In the latter case, this packet is repeated by the transmitter. If you only listen, you may miss some packets, because you cannot acknowledge, neither aks for a second try. Still used for communications between ship and shore in the maritime bands.

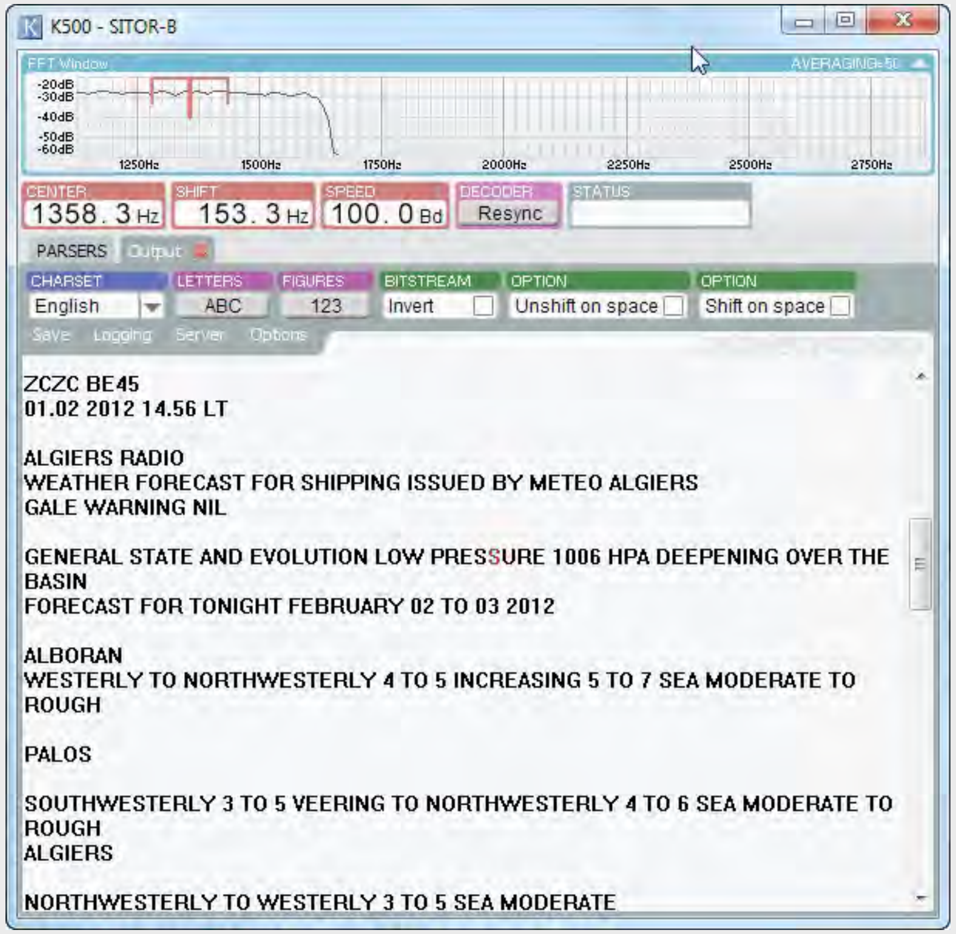
WLO, Mobile Radio AL/USA on 1258,5 kHz with a TOR massage (teletype on radio). The QBF („quick brown fox“) text has been received, but not completly



SITOR-B, FEC

A mode with so-called „forward-error correction/FEC“, which in fact is redundancy. Still used e.g. for weather broadcasts in the maritime bands.

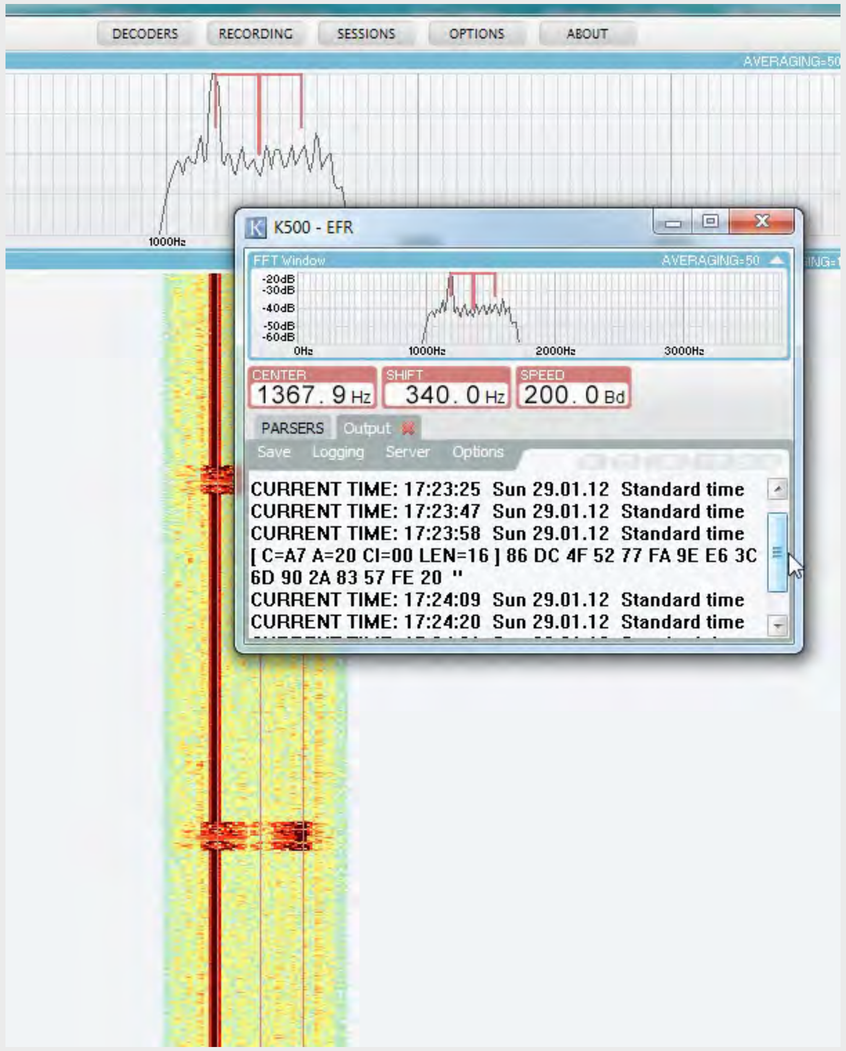
Algiers Radio on 518 kHz with a weather report.



EFR - Europäische Funk-Rundsteuerung

Kind of a remote control service, operated by three longwave stations; one of them in Germany, the other one in Hungary.

135,6 kHz, transmitter Lakihegy/Hungary. Transmitting time information between the control signals.



Global Wireless FSK (GW-FSK)

This U.S.-based organisation is responsible for a good part of today‘s maritime communications. Their FSK channel markers are daily visitors from numerous locations around the world. As some of their identifiers are ambigous, you have in these cases you have to consult a frequency handbook.

The picture gallery below presents you with a choice of some 16 Global Wireless stations with their channel marker.

It‘s a fast ship to China: 16 channel markers of GW-FSK. Have a look at the slighty differing shifts.

6379,5 kHz: 8PO, Barbados

1 von 16

CW - Morse Code

This oldest mode of wireless communications presents a hard nut to crack for most decoders. Even when given by a machine with consistent length of dit, dah, and the pause, it remains reluctant to be automatically decoded. The ever-existent noise and crackling on shortwave makes this case even more diffcult. Rohde & Schwarz‘ GX430 excels in this field. But as ham with some knowledge on reading the code by heart, you are often disappointed by the performance of any decoder. Krypto500 plays in the middle with W-Code and GX430 in front of it.

Now for the good news: Nowadays, there is only little professional communication in CW. The video on the right shows some stations, which I found, mostly Navy. You will easily see that automatic decoding of CW calls for a stable and clear signal. Please observe: not all signals in these examples are perfectly keyed by the transmitter!

Dah-dah-didah di-da-dit dah: Not every CW station has gone QRT (Q-Code for: closing down)

Five examples, very different in ionospheric conditions and quality of keying. But that‘s live at HLG/Seoul, RJH66/Kyrgyzstan, RJH69/Belarus, AQP/Karachi and 4XZ/Haifa.

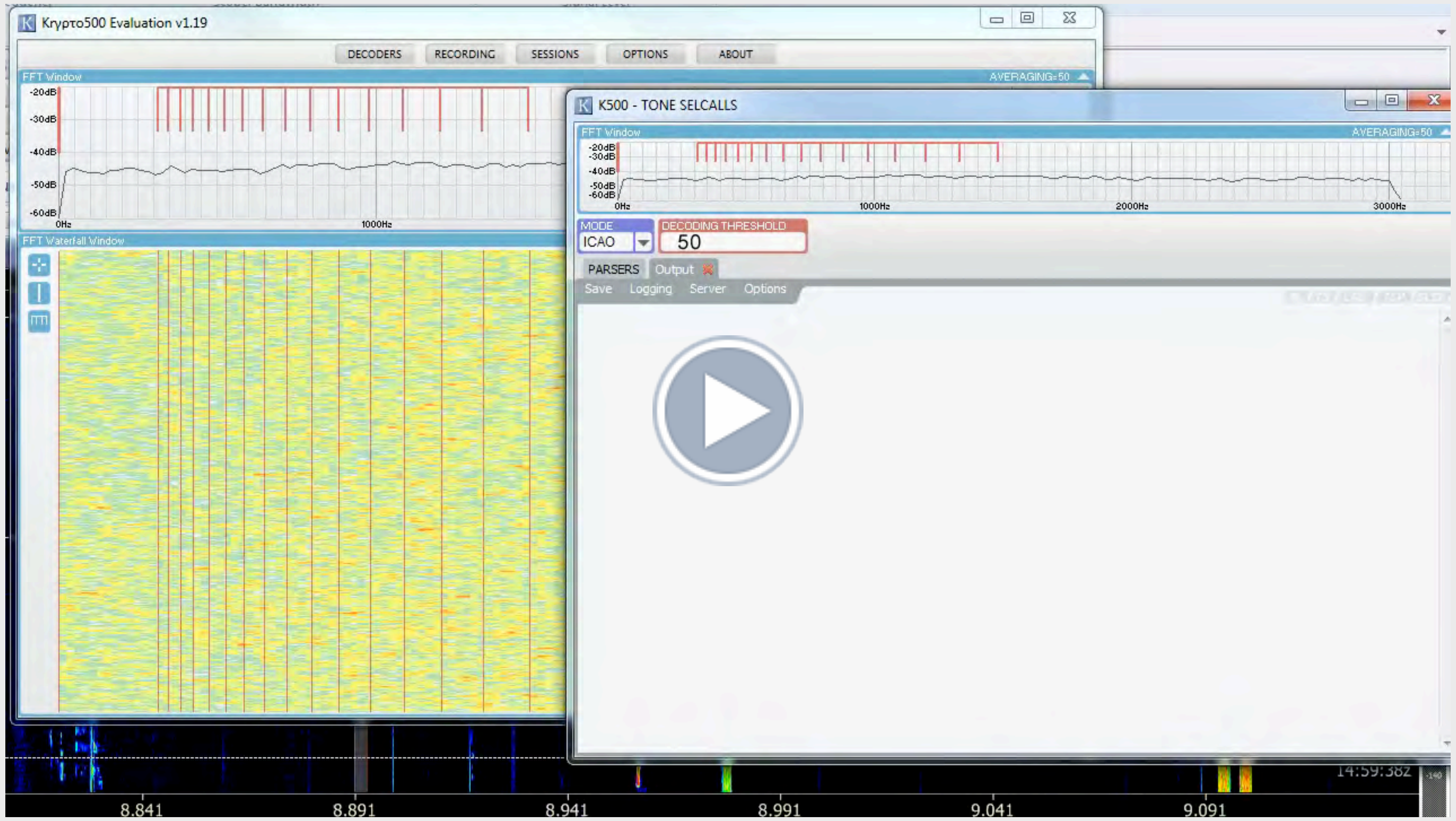
ICAO Selcall

Most airplanes do identify themselves in the aero bands by a so-called „ICAO Selcall“ check. This is a combination of a two two-tone signal, coding the „callsign“ of this aircraft by four letters, grouped into two.

The video on the right show as example Aeroflot 315 flying between Moscow and New York, and calling Iceland Air on 8891 kHz. After some exchange in voice mentioning its selcall („echo-lima-sierra-bravo“), the airplane is transmitting its ICAO Selcall „EL-JS“.

It‘s decoded correctly. Inadvertently, some speech formants can also fall into the secall pattern. Hence, they are also „decoded“. Just ignore them or change Krpto500‘s dcoding threshold.

Over Iceland: Flightnumber Aeroflot 315

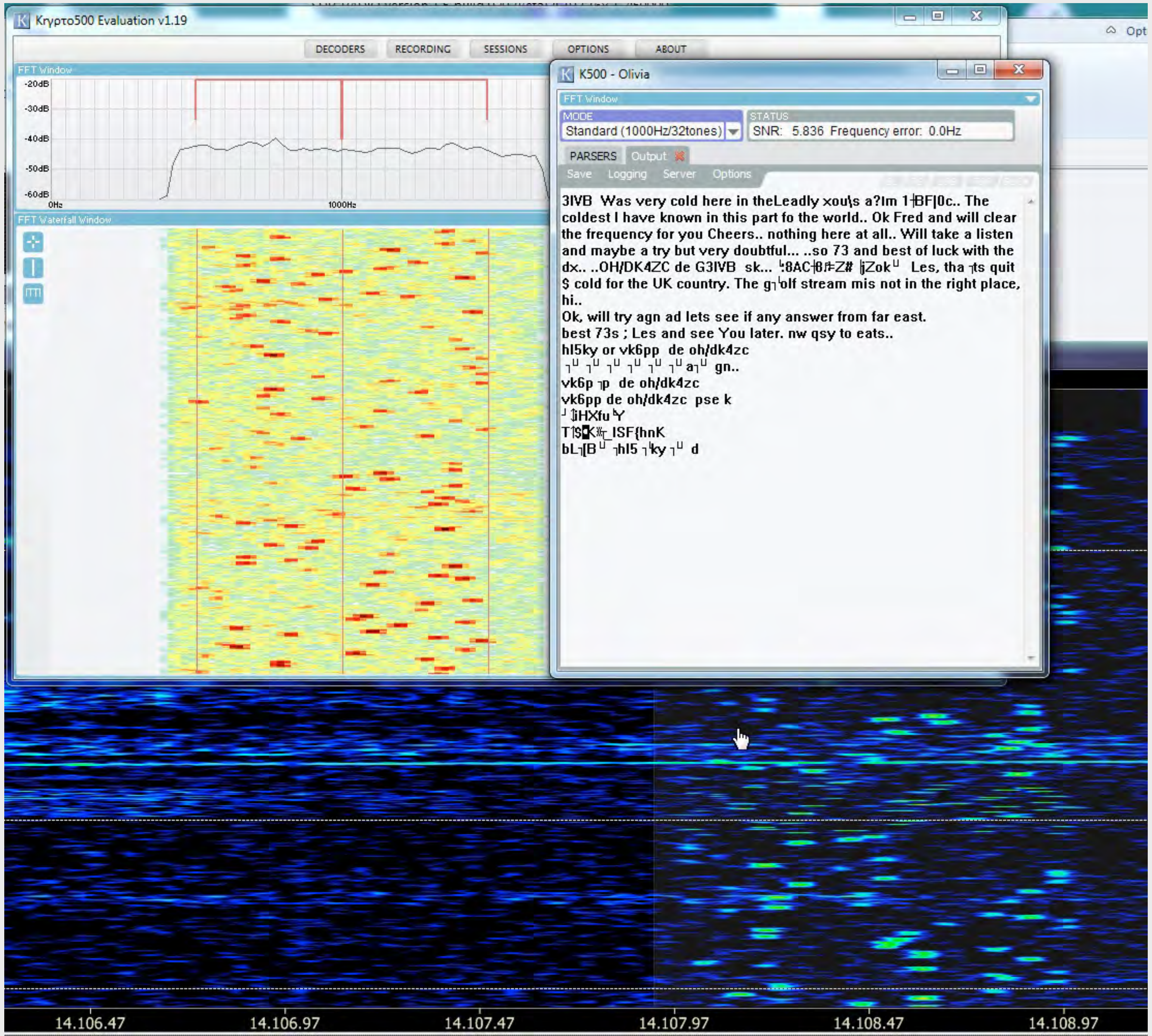


On route from Moscow and New York, Aeroflot‘s Airbus A330-343 (VQ-BQZ) does a selcall check with Iceland Air, 8891 kHz.

OLIVIA

This multi-tone mode is mostly used by hams. It refers to the PICCOLO system which tried to keep together Britain's empire in the 1950s - HF-wise, at least. It's rather robust, and comes in different bandwidth and numbers of tones. The screenshot shows a QSO between OH/DK4ZC and G3IVB on 14107,5 kHz. Mode: standard, 32 tones.

Like music: Olivia is a multitone mode.

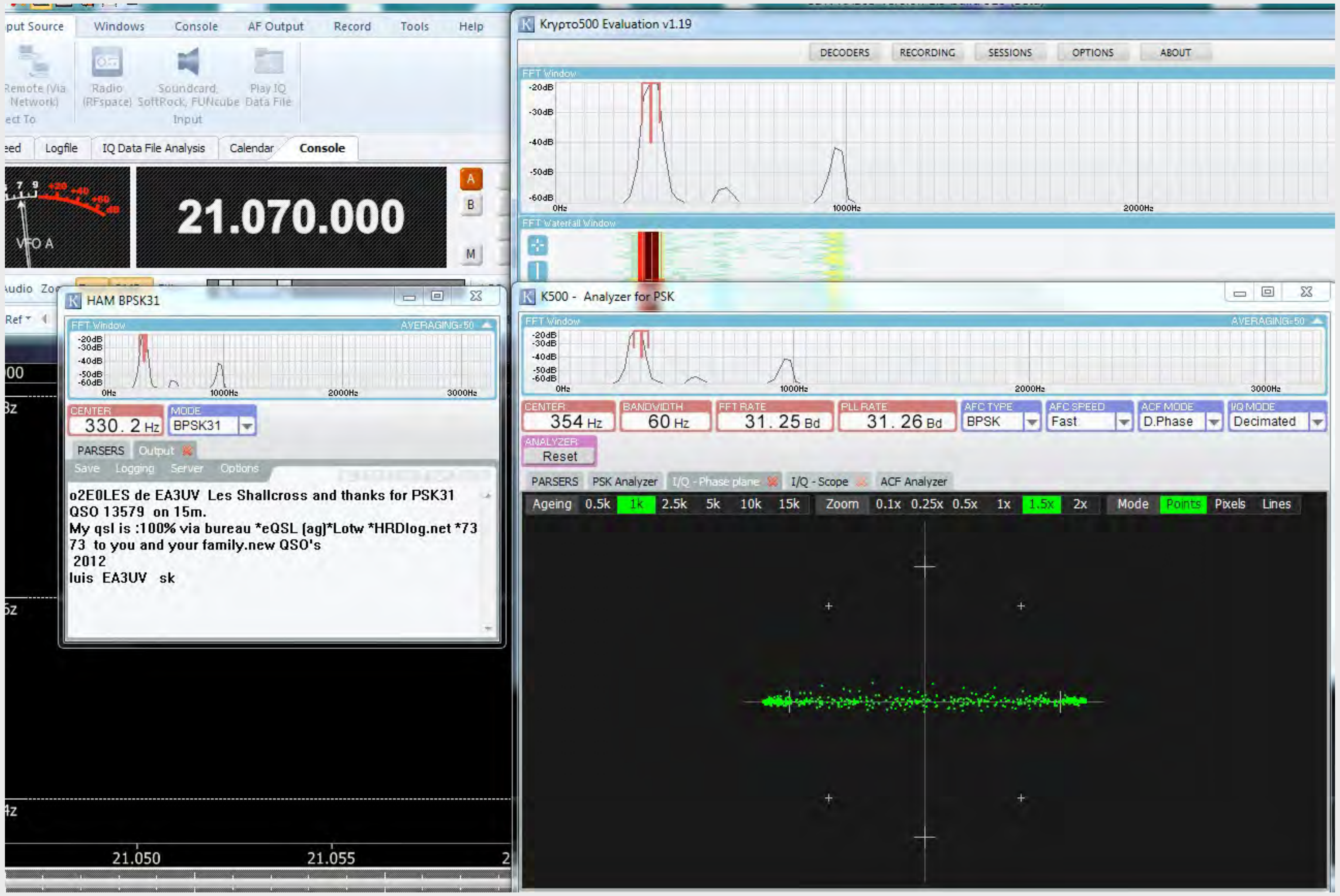


PSK31

This BPSK mode of Peter Martinez, G3PLX, nothing more than revolutionized amateur radio communications with low power. PSK31 also created a family of similar codes, some faster, some slower; some broader. Still, original PSK31 is one of the best and frequency-efficient rag-chew modes on shortwave.

On the right a QSO between EA3UV from Spain and 2E0LES from the U.K. on 15 m. The decoder window is on mid-left. On the right you find the main window, and below the phase constellation.

Two phases within a bandwidth of 31 Hz: PSK31

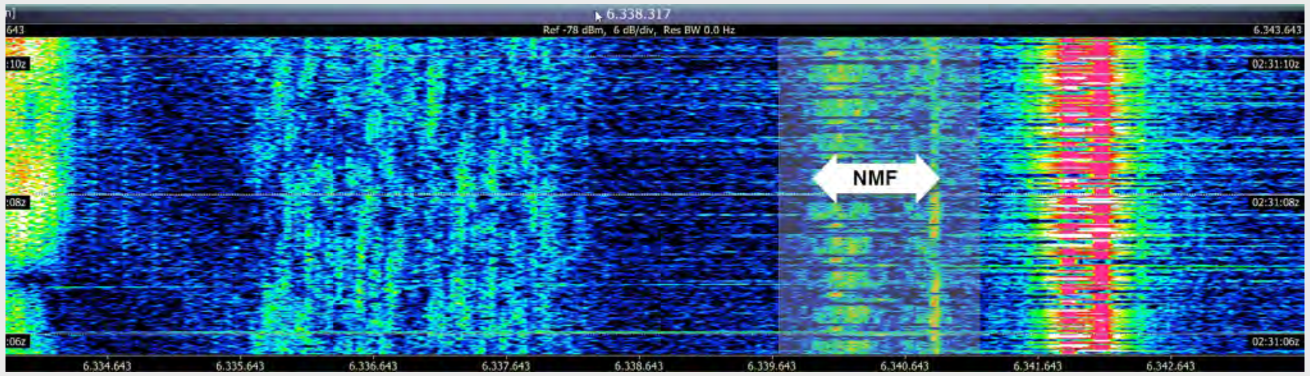


FAX

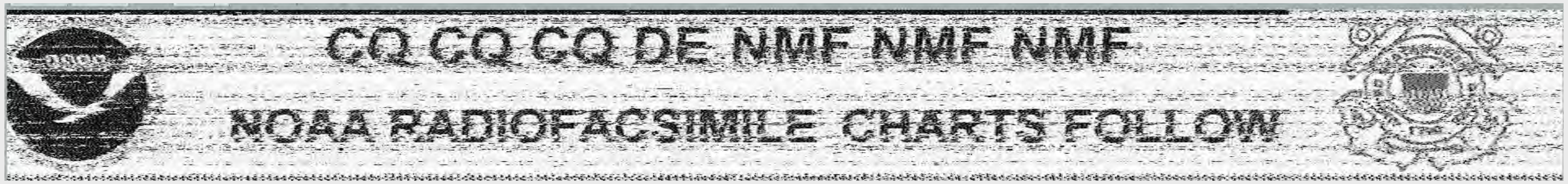
This mode is mostly used by some weather stations. Here a comparison of W-Code/Krypto500, receiving the identifcation of USCG Boston, NMF, von 6340,5 kHz at 02:30 UTC with a fair signal in a noisy channel.

The pictures were made as JPG screenshots. They may lack some detail which may be found in the original BMP files (7 MB, for W-Code, e.g.).

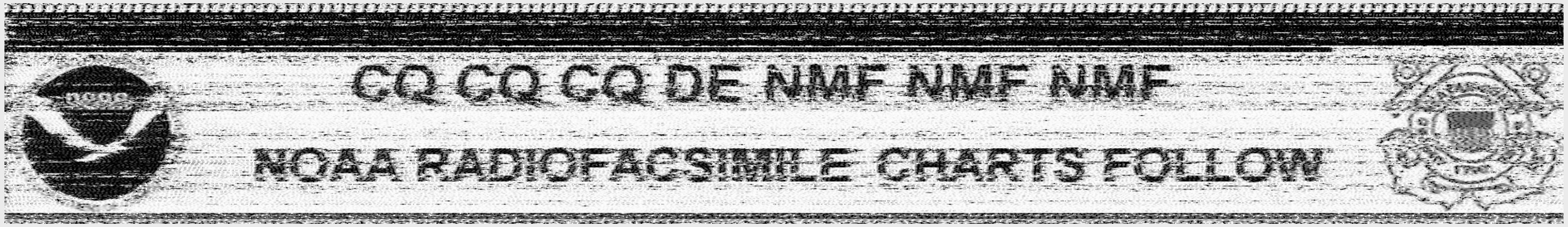
Fair signal, but noisy: NMF von 6340,5 kHz at 02:30 UTC.



Decoded with Krypto500



Same signal, decoded with Wavecom W-Code



PACTOR-I

Packet Teleprinting over Radio, or PACTOR has been developed by German SCS, and is widely used by hams and professionals. It seems to be the tool of choice to many NGOs. PACTOR nowadays comes in four flavours, each of them has variants. Software like Krypto500 and W-Code is capable up to Pactor-III (there even is a PACTOR IV), and will decode many variants.

On the right, one example: Deutsches Rotes Kreuz (Berlin/DEK88?), calling unidentified outposts DEK38 & DEK39. After establishing contact in PACTOR-I, it automatically switched to Pactor-III.

Here Krypto500 has the advantage to cover with three decoders Pactor-I, -II and -III in parallel. Plus: many different forms of CRC - including that used by ICRC.

Deutsches Rotes Kreuz (German Red Cross), establishing contact on 3819,5 kHz, calling outposts DEK38 and DEK39.

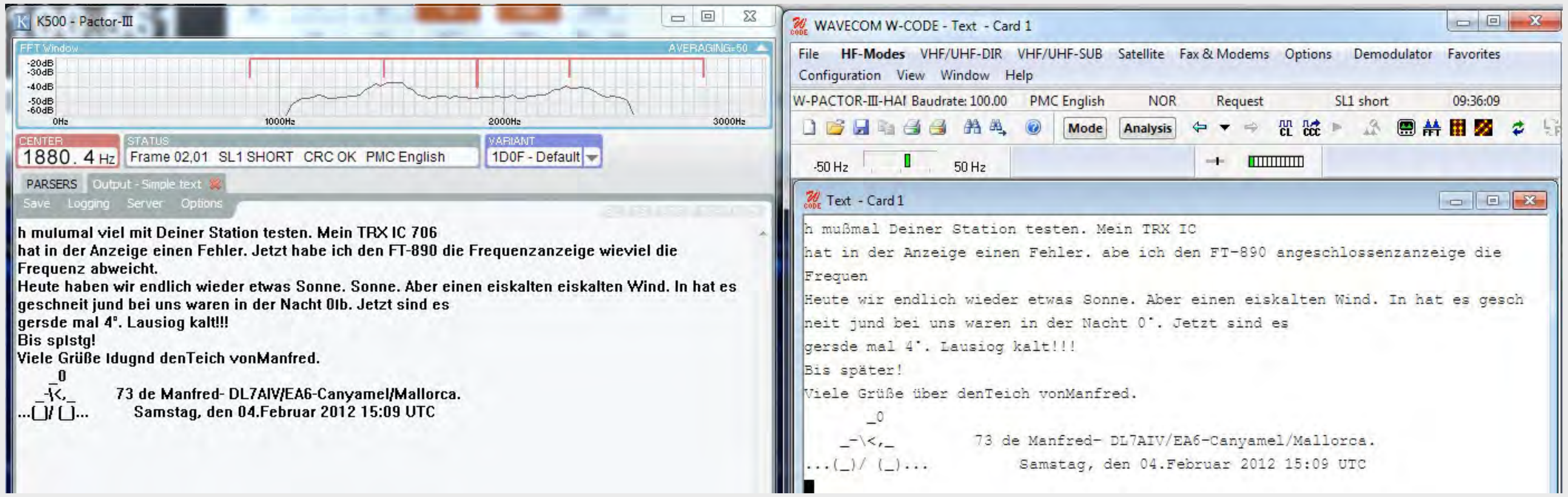
PACTOR-II

Among hams, this mode is used with mailboxes. There are many professional applications as well.

Station EA8/DF5JR from the Canary Islands drops a mail to DJ9TA.on 20 m, using PACTOR-II.

PACTOR-III

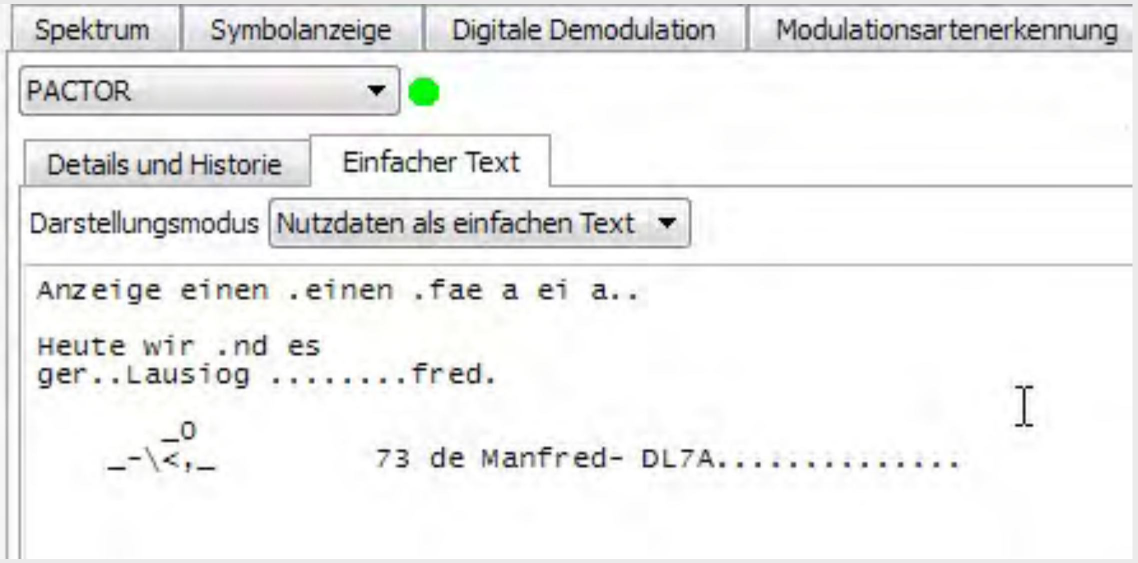
Comparing Krypto500 (left) and W-Code (right) at exactly the same PACTOR-III transmission.



The highest level of PACTOR, which state-of-the-art decoders can cope with as of early 2012, where there just had been introduced a PACTOR-IV. Of those decoders, I had at hand, only W-Code, Krypto500 and GX430 were able to decode also PACTOR-III.

Here a comparision on a station in the 20 m amateur radio band. There are many professional applications as well - see a Seamail example in the last chapter.

GX430 decoded just very few parts of this same transmission. That's all ...



iBooks Author

GMDSS-DSC HF

This Global Marine Distress and Selective Calling System is used to establish contact between ships and coastal stations. Both are identified by their specific MMSI, or Maritime Mobile Service Identiy number, each consisting of nine ciphers. Coastal stations‘ start with „00“. As all software fluently decodes those messages, only MultiPSK has an internal lookup table which will present at least the coastal stations in open language.

See examples on the right, where MMSI 006010001 or MRCC Capetown calls MMSI 538004051, oil tanker „Libra Trader“, delivered by Mitsui Engineering & Shipbuilding Co., Ltd. to Legend Transport, Inc. This 330 meters long ship covers 354.689 cubic meters of oil, and is registered in the tax-friendly Marshall Islands.

Krypto500: decodes all date, but gives no further information on MMSI. EOS = „End of Sequence“

```
[2012-02-05 10:51:02] [DSC 05/02/2012 10:51]
[2012-02-05 10:51:02] Format:              Individual
[2012-02-05 10:51:02] Category:            Safety
[2012-02-05 10:51:02] Destination:         MMSI 538004051
[2012-02-05 10:51:02] Originator:          MMSI 006010001
[2012-02-05 10:51:02] First Telecommand:   Test  Acknowledge
[2012-02-05 10:51:02] Second Telecommand:  No Information
[2012-02-05 10:51:02] EOS:                 BQ
[2012-02-05 10:51:02] [CRC GOOD]
```

W-Code: Looks up the country code of the ship (Marshall Islands), and grouping the call.

```
05 Feb 2012, 10:51:02  FORMAT SPECIFIER: Call to an individual station
05 Feb 2012, 10:51:02  ADDRESS (Ship): 538 004051
05 Feb 2012, 10:51:02  COUNTRY: Marshall Islands
05 Feb 2012, 10:51:02  CATEGORY: Safety
05 Feb 2012, 10:51:02  SELF IDENTIFICATION (Coast): 601 0001
05 Feb 2012, 10:51:02  TELECOMMAND 1: Test
05 Feb 2012, 10:51:02  TELECOMMAND 2: No information
05 Feb 2012, 10:51:02  CALLED STATION RECEIVE FREQUENCY: No information
05 Feb 2012, 10:51:02  CALLED STATION TRANSMIT FREQUENCY: No information
05 Feb 2012, 10:51:02  ACKNOWLEDGEMENT: Reply to call requiring acknowledgement
05 Feb 2012, 10:51:02  Checksum OK
```

MultiPSK‘s lookup table unveils MMSI 006010001 correctly as „MRCC Capetown“

```
<10:51:07> <Selective call to a particular individual station>
<10:51:07> Called MMSI station address: 538004051 [Ship] (Marshall Islands)
<10:51:08> Category: Safety
<10:51:08> MMSI self-identifier: 006010001 [Coast station: Capetown MRCC Capetown] (South Africa)
<10:51:09> Telecommand 1: Test
<10:51:09> Telecommand 2: No information
<10:51:09> Neither RX/TX frequencies nor position supplied
<10:51:10> Check Sum: OK
<10:51:11> Date and time of decoding: 05/02/2012 10:51:11
```

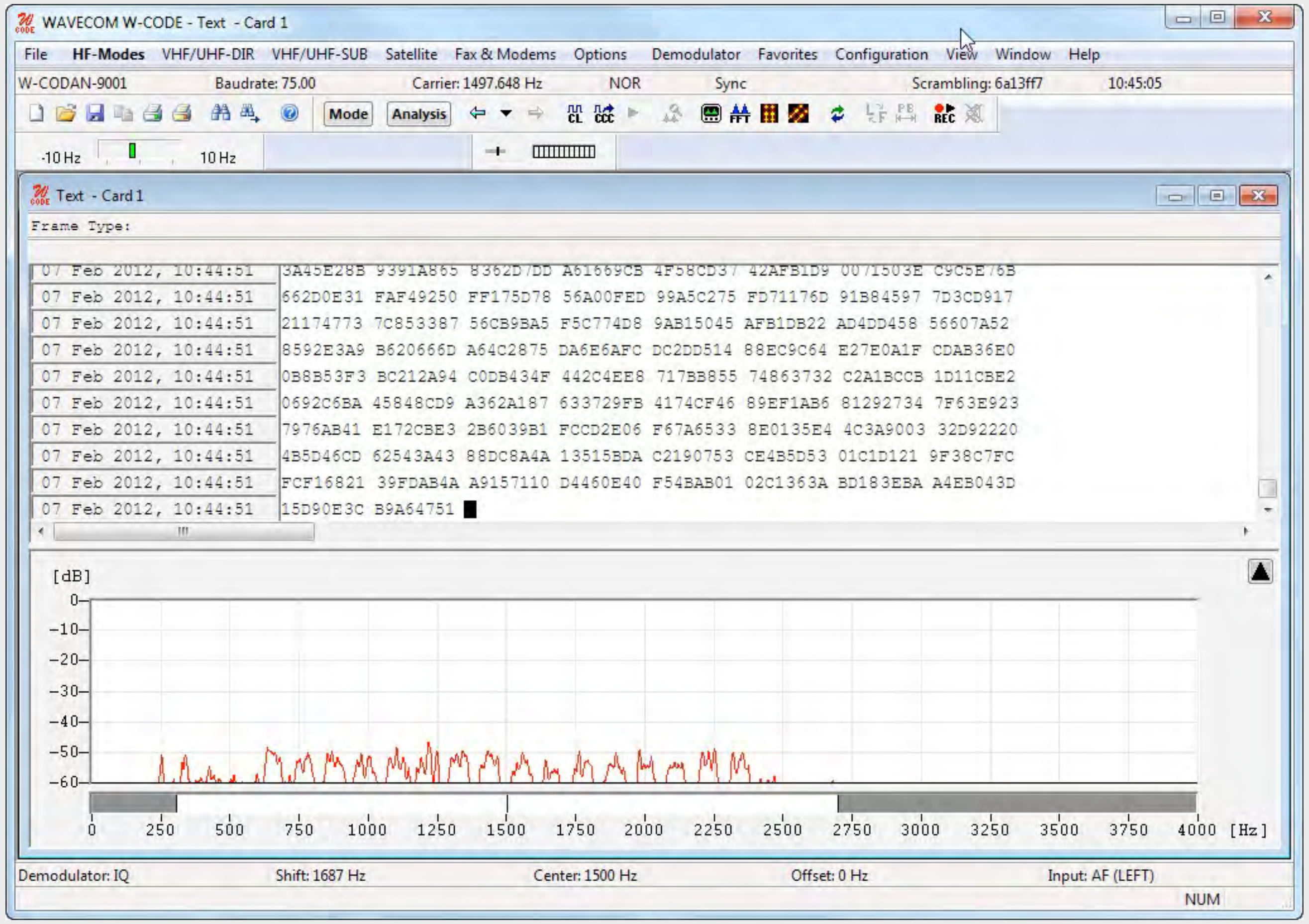
CODAN 9001

This mode works with 16 tones, each of them QPSK-modulated. It is decoded by W-Code, and available as option Code3-32P.

Krypto500 in the tested version refrains from it. GX-430 doesn't recognize this decoded signal of Cairo's Ministry of Foreign Affairs' transmission to Embassy Kuala Lumpur on 19055 kHz.

The content of this transmission is scrambled, but the contact was beforehand established in SITOR-A, calling „oovs“ (i.e. Egypt Embassy, Malaysia).

Scrambled: Communications in 16-tones CODAN (see spectrum) on 19055 kHz.

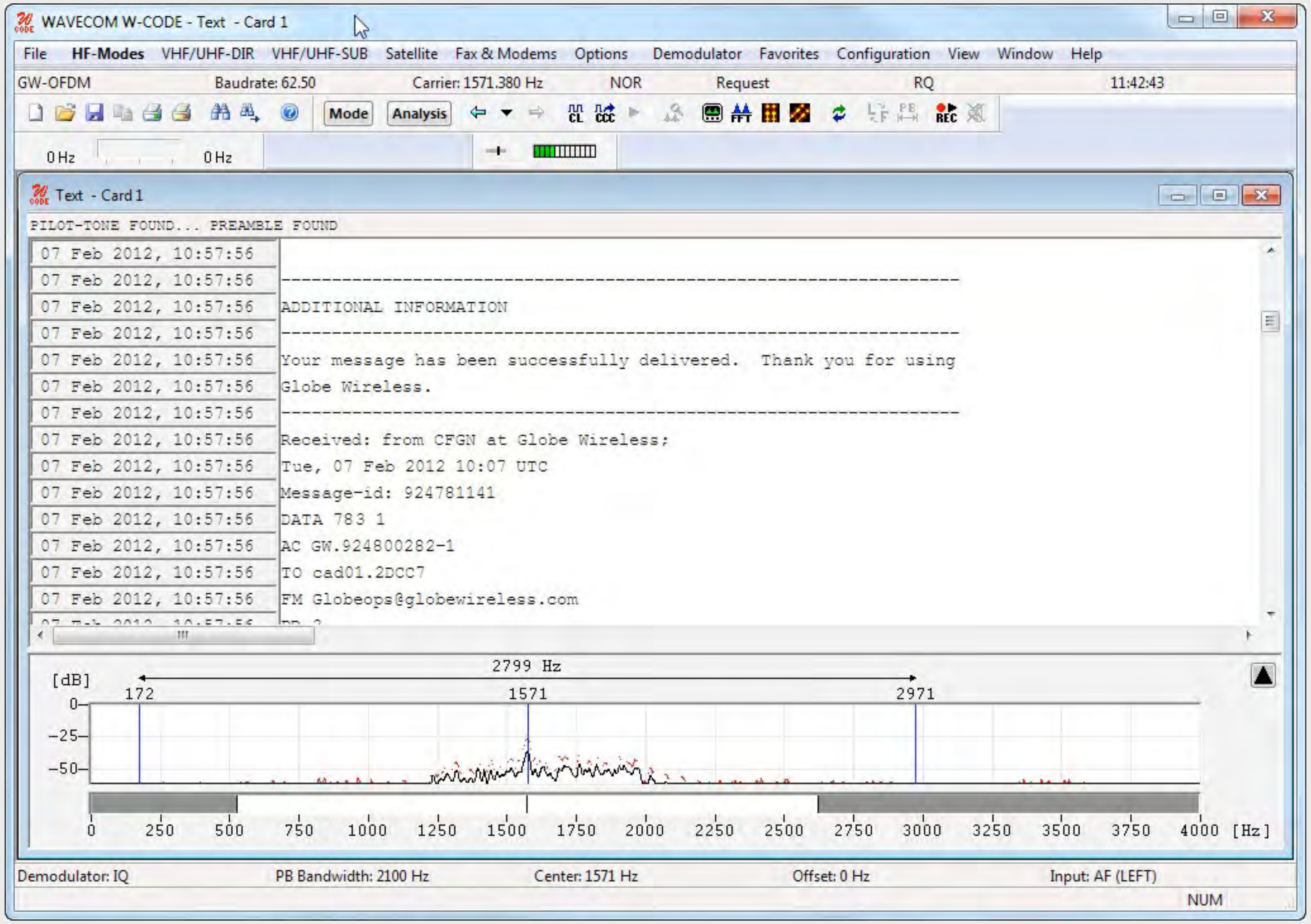


GW-OFDM

This mode works with 12 to 30 tones. It is decoded flawlessly by W-Code.

Krypto500 and Code3-32P in their tested versions refrain from it. And GX-430 doesn‘t recognize the decoded signal of Global Wireless Bern Radio, HEC, on 10341 kHz, thus presented here by the screenshot of W-Code.

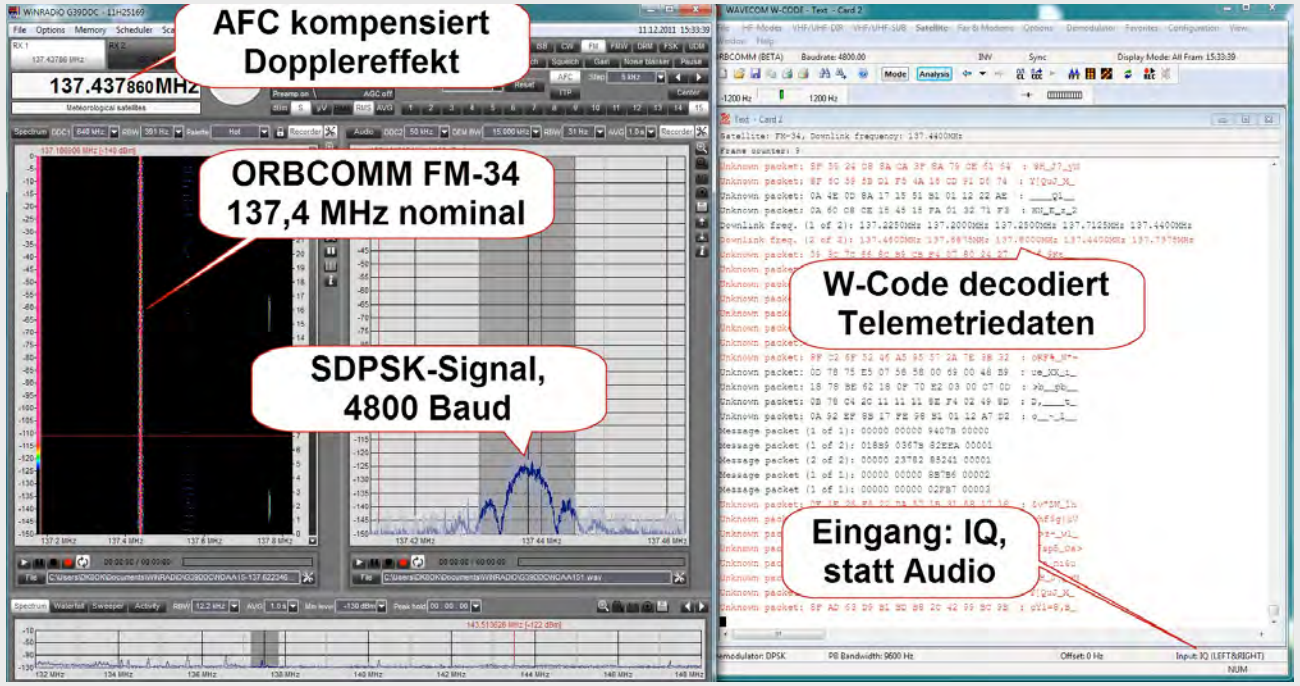
At a rate of 62,50 Baud, Global Wireless Bern Radio transmits in their proprietary GW-OFDM mode.



And beyond ...

There are many more modes between earth and ionosphere. Many of them hasn‘t been mentioned here due to time limitations. Take the Chinese 4+4 mode, which Krypto500 decodes and even shows the phase constellations of all signals in parallel. There is also a bunch of selcall modes like Pocsag - some of them used on shortwave, but mainly above 30 MHz.

Listening to telemetry data from an ORBCOMM satellite on 137,4 MHz with Winradio‘s Excelsior, decoded with Wavecom‘s W-Code



In the left window you see Excelsior‘s GUI, tuned to a frequency of 137,437860 MHz, with AFC compensating for the Doppler effect. You also see sonagram (left) and spectrum (right) of the SDPSK (Symmetric Differential Phase Shift Keying) signal of ORBCOMM‘s FM34 satellite. The data are transferred from Excelsior to W-Code via I/Q, instead of audio, and decoded (right window).

As Krypto500 concentrates on the modes found below 30 MHz, Wavecom‘s W-Code has a huge suite of modes aboard (option), heard above 30 MHz. A striking example are the different INMARSAT modes, with which you can read e-mail, as well as messages and FAX.

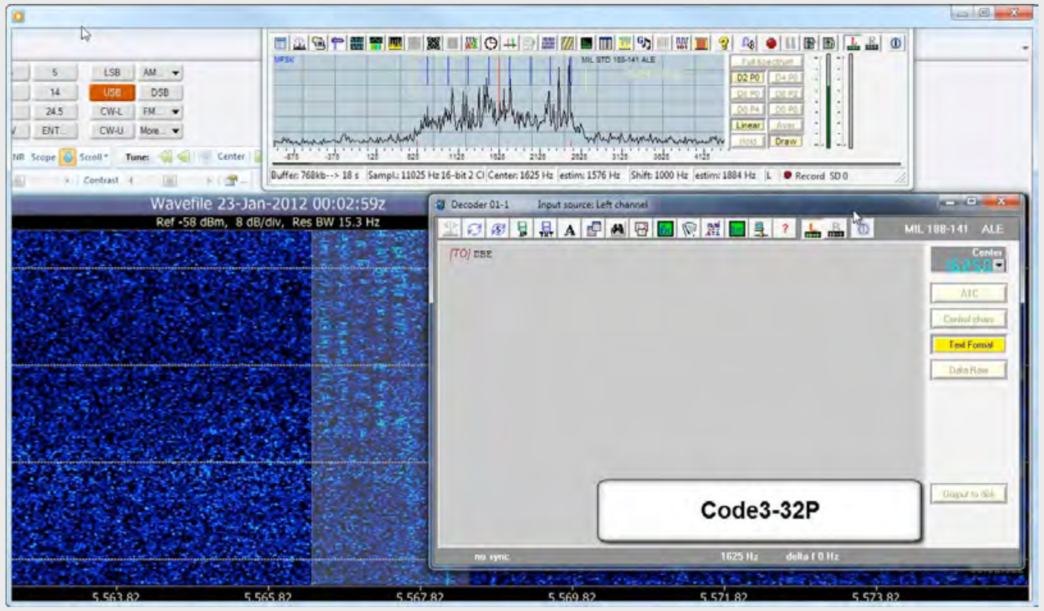
Krypto500, in turn, comes with some unique modes like that SITOR-B variant, used by the Czech Military Intelligence Agency. It also covers a parser for KG84 encryption.

Keep in mind that all software will be further developed: as I write this in mid-February 2012, Hoka already has announced a new version of Code3-32P, and Wavecom will spend some further thoughts in workings around the disadvantages of the Window‘s soundcard system. Also Krypto500 has plans for a further development, whereas Sigmira stopped working since January 2012: you have to change the date of your PC to a date before, to open up it‘s stunning STANAG4285 capabilities. There might be already a more professional solution available, as you read this.

Compare!

There is only one professional way to compare decoders: take the same test text, encode and modulate it with a signal generator, send it through a fading simulator, capable of different channel characteristics (like: „CCIR poor“), let it decode and measure the bit error rate (BER). Compare them.
As I don‘t have all this equipment, I had to find an alternative. This maybe not perfect, but will give some impression.

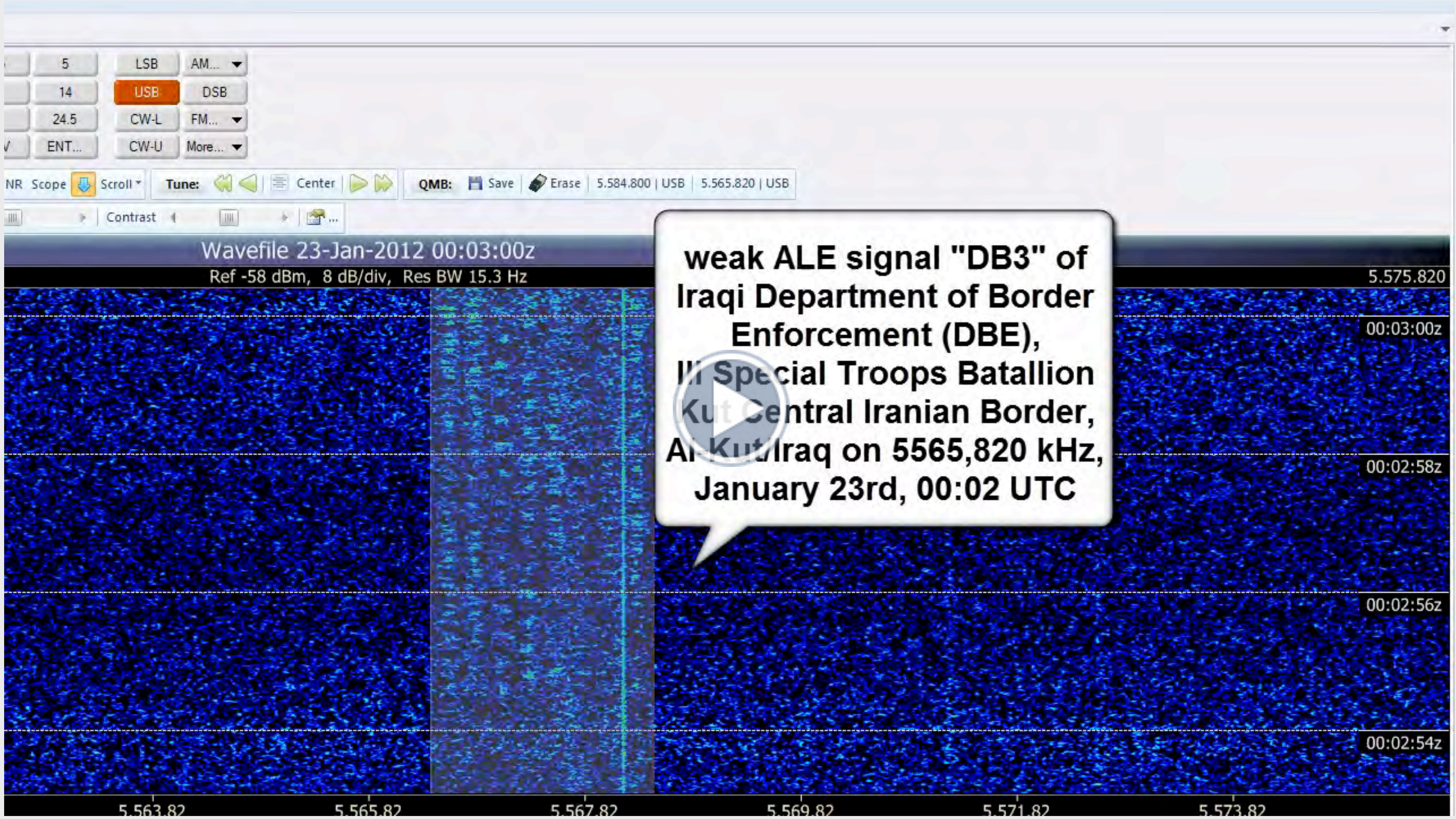
Screenshot of a comparison - see videos on the next pages



I compared several decoders at different modes. To do so, I took an HF recording of some signals live on the air with receivers like Winradio‘s ExcaliburPRO and RFSpace‘s SDR-IP. These same files where then played and decoded by different decoders. The results are not scientifically representative, but will mostly point into the right direction.

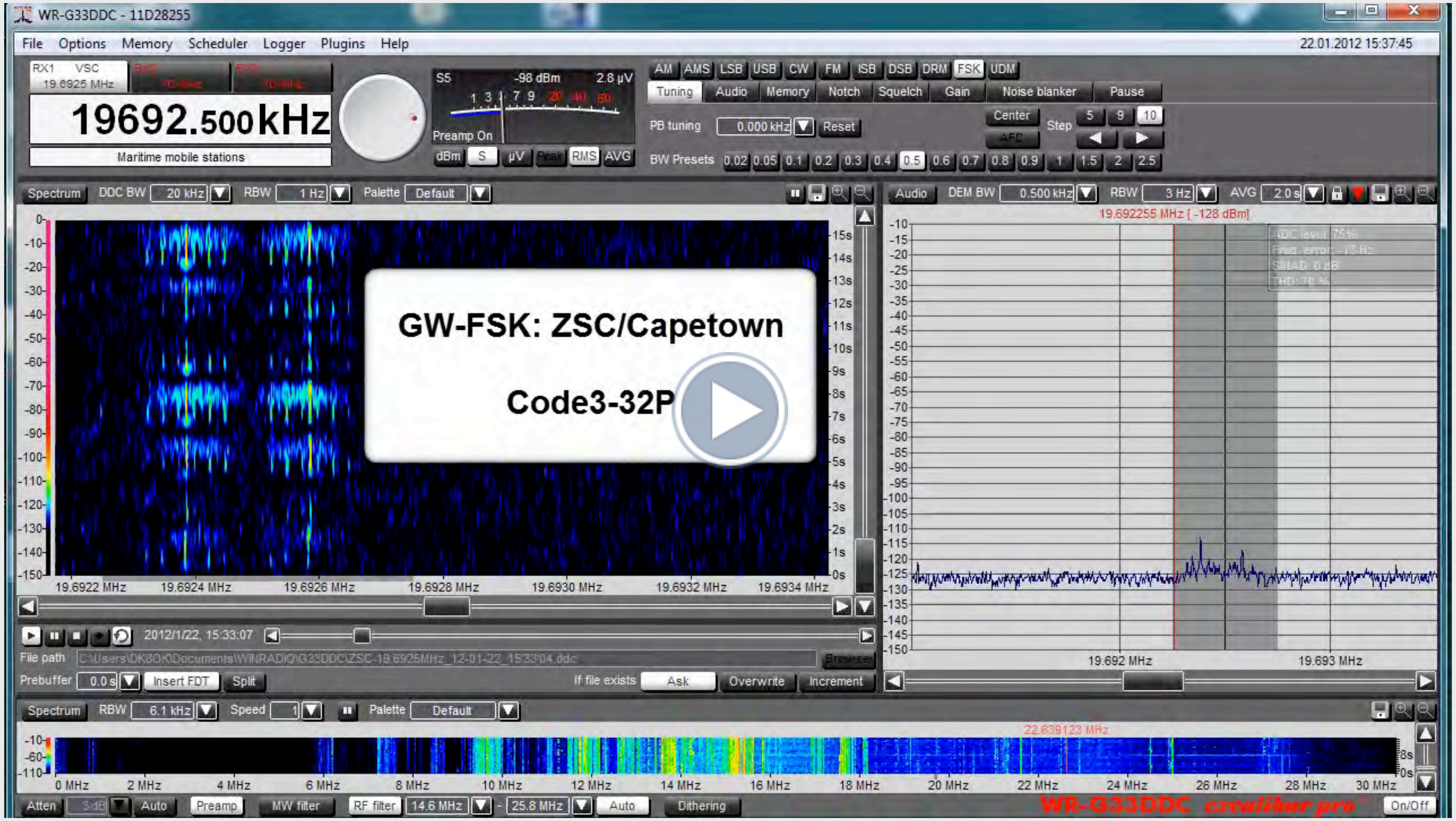
All comparisons are documented by videos - there have been made no tricks. It‘s like you looking me over the shoulder when testing and comparing.

ALE - a weak signal



Copy of the weak ALE signal on 556,820 kHz out of Al-Kut/Iraq: first the signal, then decoding with Code3-32P, Krypto500 and W-Code. Krypto500 performs best.

GW-FSK - a weak signal



ZSC Capetown on 19692,5 kHz: Code3-32P, Krypto500 and W-Code. Krypto500 delivers fastest aquisition, followed by W-Code. Also Code3-32 P gave perfect copy, but a bit slower.

Difficult signals: STANAG4285

Alle decoders are quite similar fine performers with fair to good signals (see next). But weak signals combined with doppler, multipath and interference reveal significant differences. For this comparison, I took three different HF recordings, each of about 30 seconds time (Perseus .WAV) and let them decode *in parallel* by Krypto500, W-Code and Sigmira. The results are summed up in the table below and illustrated by the annotated video on the next page. This is, what you can expect in real life. Sigmira was taken, because of its stunning performance. Code3-32P had remarkable difficulties with all of these signals (i.e. no synchronisation), but performs fine on better signals. GX430 also hadn‘t been used for this software lacks a 4285er decoder.

SYNC = text becomes correctly decoded

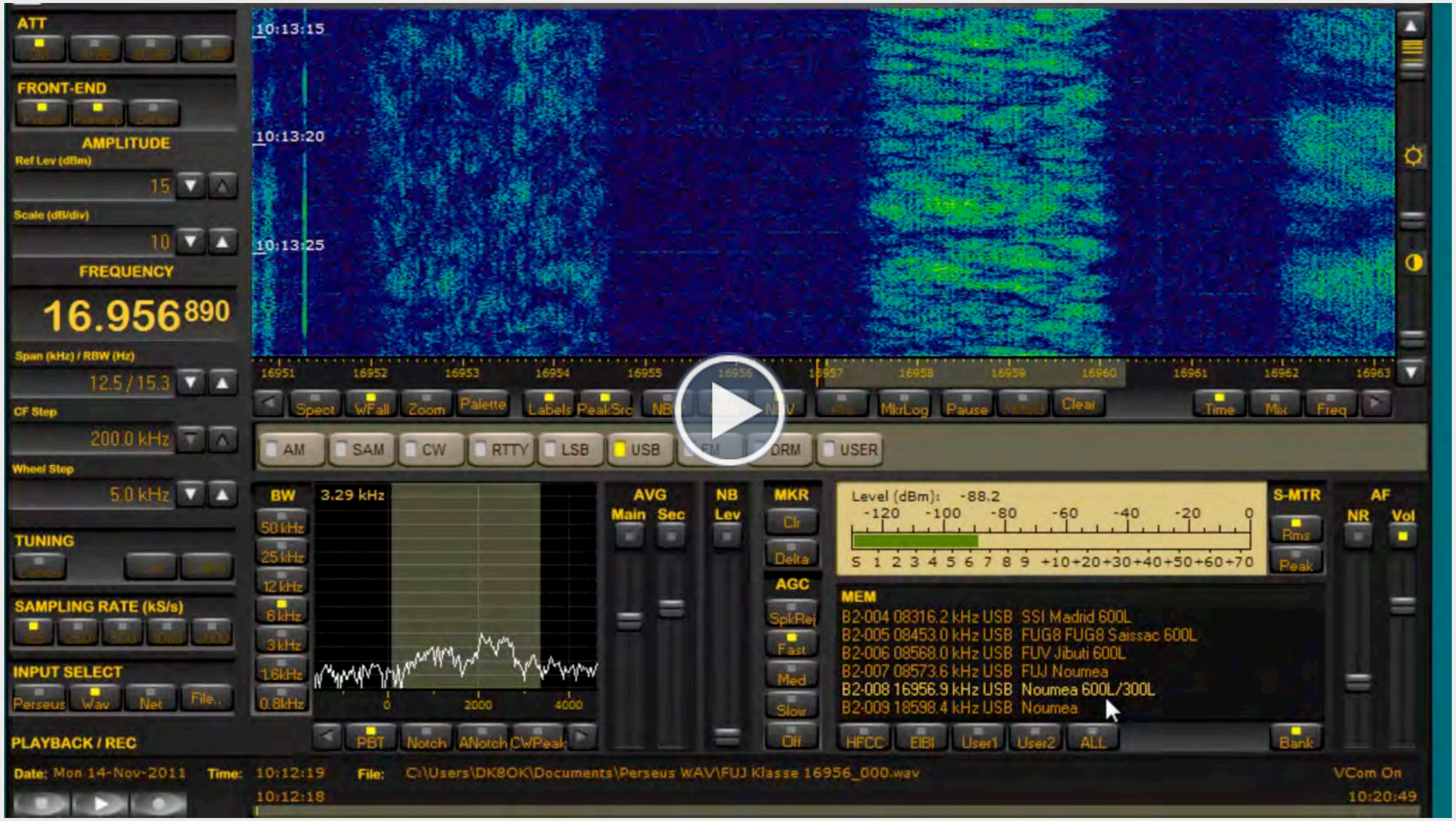
Each signal has been analyzed by PSKSounder software, from where you can read the exact center frequency of the signal (here tuned to 1800 Hz, plusminus 1 Hz), doppler spread in Hz and multipath spread in milliseconds. Only the video of the first example shows a screenshot of also PSKsounder when analyzing Noumea on 16957 kHz.

The results are quite puzzling: Sigmira outperforms each other decoder, I tested under these difficult signals.

To my knowledge, no specialist‘s journal for hams and shortwave listeners did ever publish such a detailed comparison. Mostly, they use only one decoder per „test“, and this with generally „good“ signals; in Germany usually that of “Deutscher Wetterdienst“ in mere ITA2-FSK (Baudot, 50 Bd). My test and the video documentation took some time, but the results are rewarding.

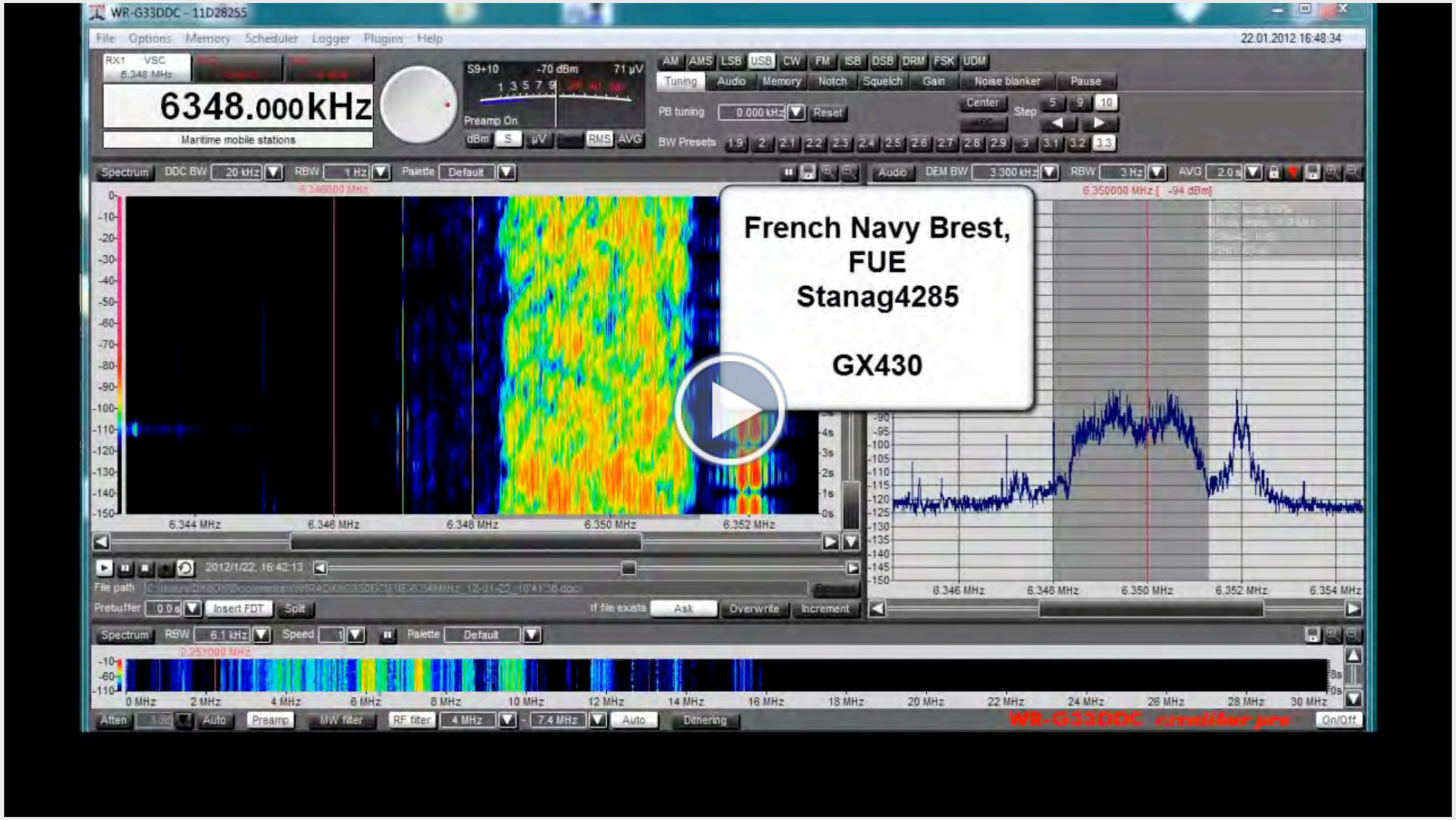
	KRYPTO500	W-CODE	SIGMIRA
FUJ Noumea 16957 kHz fair signal strength, fair multipath, slight doppler	no SYNC within 30 seconds	SYNC after 17 seconds, but quickly loosing it without recovering	SYNC after 10 seconds, and holding it
FUV Djibouti 8568 kHz fair signal strength, fair multipath, a bit unstable	SYNC after 8 seconds, and holding it	SYNC after 12 seconds, but loosing it after 5 seconds, maybe due to irritation by an ionosonde or noise, not recovering	SYNC after 11 seconds, and holding it
FUJ Noumea 22461 kHz weak signal strength, heavy PLC interference, fair multipath, fair doppler	no SYNC within 30 seconds	no SYNC within 30 seconds	SYNC after 10 seconds, and holding it

Comparision of three STANAG4285 signals with three decoders in parallel



Signals from Noumea/New Caledonia and Djibouti are decoded with Krypto500, W-Code and Sigmira. The results are puzzling. Hint: There is a considerable chance, that this mode tests also the Windows Sampling Converter, which Sigmira might pass by. I/Q input or e.g. a decoder on a PCI card (like W-PCI) might help. Further tests in this direction have to be made.

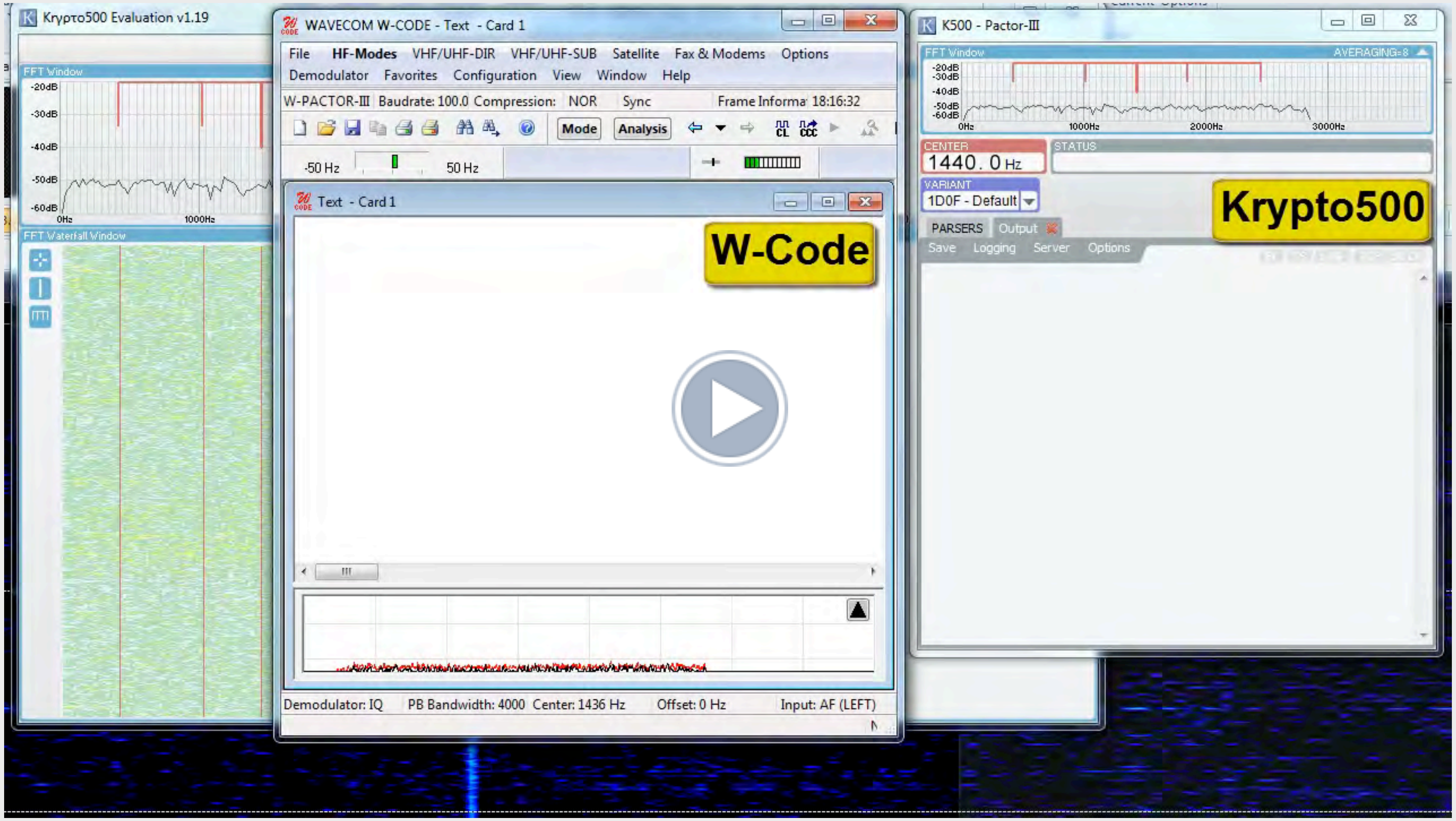
Strong STANAG4285 signal



FUE Brest on 6348 kHz in STANAG4285, strong with only slight multipath: GX430 (no decoder, but fast acquisition), Krypto500 (fast and clear decoding), Code3-32P (fast classification, slower start of nevertheless clear decoding).

PACTOR-III

Only few decoders do have PACTOR-III aboard. Here a comparison between W-Code and Krypto500.



Sailmail station R17, South Daytona, Florida/USA, callsign WPUC469, on 18465 kHz in contact with sailing boat „Kalista“ (16 m long), callsign WDE9992.

Bio & §

Born 1955, Nils studied Historic Science and German Literature (M.A.). Since 1979, he writes for Frankfurter Allgemeine Zeitung on science and technology. He co-founded the German edition of MIT‘s „Technology Review“, and is doing Corporate Publishing. There he develops and edits globally distributed magazines (B2C, B2B, B2E), published via print, iPad and internet, including You Tube, for some German leading companies (DAX30).

Under his ham radio callsign DK8OK he gained ARRL „Honor Roll“(mostly CW & QRP), wrote 20+ books on shortwave receivers and listening. For over a quarter of a century, he played a leading role writing also for specialist‘s journals like the former renowned „funk“ magazine (meaning „wireless“). Vividly, he promoted a future-orientated view towards amateur radio, thus setting him in opposite to the German amateur‘s radio club. He was thrown out, and banned from publishing in all freely available hobby magazines in Germany.

Furthermore, he was denounced by ham radio officials at German Authorities for listening to utility stations. Two house searches by police later, he unconditionally won a law suit against Germany in this case. Otherwise, he would have been fined by up to 50.000 US-$ or two years in jail ...

Nils is married, has two grown-up daughters and likes to read books, biking and cooking.

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