

## Notes on EbNaut decode process

Software:

As indicated by Paul Nicholson in his website page [http://abelian.org/ebnaut/software\\_ms.shtml](http://abelian.org/ebnaut/software_ms.shtml) , it is possible to use Spectrum Lab for receive and prepare a signal for EbNaut decoding.

Receiver setup:

Set the dial to e.g. 136 kHz USB (so that 137.5 kHz makes 1.5 kHz audio, like for WSPR). Or 135.5 kHz with 2 kHz audio. The frequency of the receiver's LO should be stable and known to better than 0.1 mHz accuracy.

Setting up SpecLab:

On Spectrum Lab, the soundcard Sample Rate calibration function must be activated. So it is necessary to feed the 1pps signal from a GPS or any other suitable reference signal (i.e. from Rb) to the R-Channel of the soundcard.

One "NTP client" program is needed to synchronize the PC clock with UTC during the recording. I suggest Wolfgang Buescher's rsNTP <https://www.qsl.net/dl4yhf/rsNTP/rsNTP.htm>

Better to activate also the Spectrum Lab's Resample function.

Resampling is not really necessary, I have never used it here. You can also record with the (deciated) original samplerate if you enter the measured value into sr.txt (see later).

But in any case we need to activate the samplerate detector to track samplerate changes due to PC temperature. The preferred method would be locking to 1pps (with or without NMEA), and ticking "GPS phaselock" because this will restore the receive phase after an audio dropout occurred. If NMEA is used, it can be used as a time source instead of NTP.

Recording data files (Method 1):

These are the author Wolfgang Buescher's detailed instructions for setup a Spectrum Lab session: [http://www.qsl.net/dl4yhf/speclab/EbNaut\\_Rcvr.htm](http://www.qsl.net/dl4yhf/speclab/EbNaut_Rcvr.htm).

This method is based on the use of the WAVE RECORDER block.

Result of the process is an output 'wave' file that can be entered directly in the Paul Nicholson's **EbNaut-rx.exe** decode program.

Recording data files (Method 2):

People often ask which method is better. Method 2 is the only method used at DF6NM. Some years ago method 1 has been tested at IZ7SLZ and we found that a few dB of sensitivity were loosen. This statement needs to be better investigated .

There is also another possibility to use Spectrum Lab for recording audio: this is the Markus Vester's configuration for his 'opds32' program. See <http://df6nm.bplaced.net/opera/opds.zip> If you want to run opds (Opera Deep Search) please use the latest 32 bit version in

<http://df6nm.bplaced.net/opera/opds2h6.zip>

This configuration sets Spectrum Lab for a FFT-bin of 477 uHz and a FFT-window time of 2909 s = 34' 57" suitable for analysis of opera32 deep search signals.

In this configuration, each time that a new line is appended to the waterfall display (10 minutes), Spectrum Lab exports, in a text file, the results of the FFT (raw data).

The name of these files is formatted as **MMDDhhmm.txt** i.e. the time of the middle of the FFT acquisition period.

Note that you need to create a folder "data" in SpecLab's main directory, e.g. c:\spectrum\data. The short 8.3 filenames are a relict from an old 16-bit version of opds which could not handle long filenames. In SpecLab's "FFT export" tab, you could also define more meaningful filenames like "ebnaut\_LF\_YYYYMMDD\_hhmm".

Make sure that in FFT settings, the FFT Output type is "Complex", and a "Rectangle" window function (i.e. no windowing) has been selected.

So the first step, for one operator who wants to use this method for EbNaut, is to install and 'tuning' the opds32 program on LF. Use the Spectrum Lab configuration file named **\_LF\_Op32\_FFTextport\_130512.USR** included in Markus's opds.zip suite and make all necessary modifications for the proper hardware setup (sample rate, center frequency,...)

Running Ebnaut together with opds: (Note that is opds not really required)

In EU it is possible to receive often some good OP32 signals (SM2DJK, RN7T,...)  
So, if all settings are ok, should be possible to get some detections like these:

Wed 01/30/2019\_ 7:46:21.48  
IZ7SLZ loc.JN80NU OPDS Correlation Detector (opds2h6 by DF6NM)

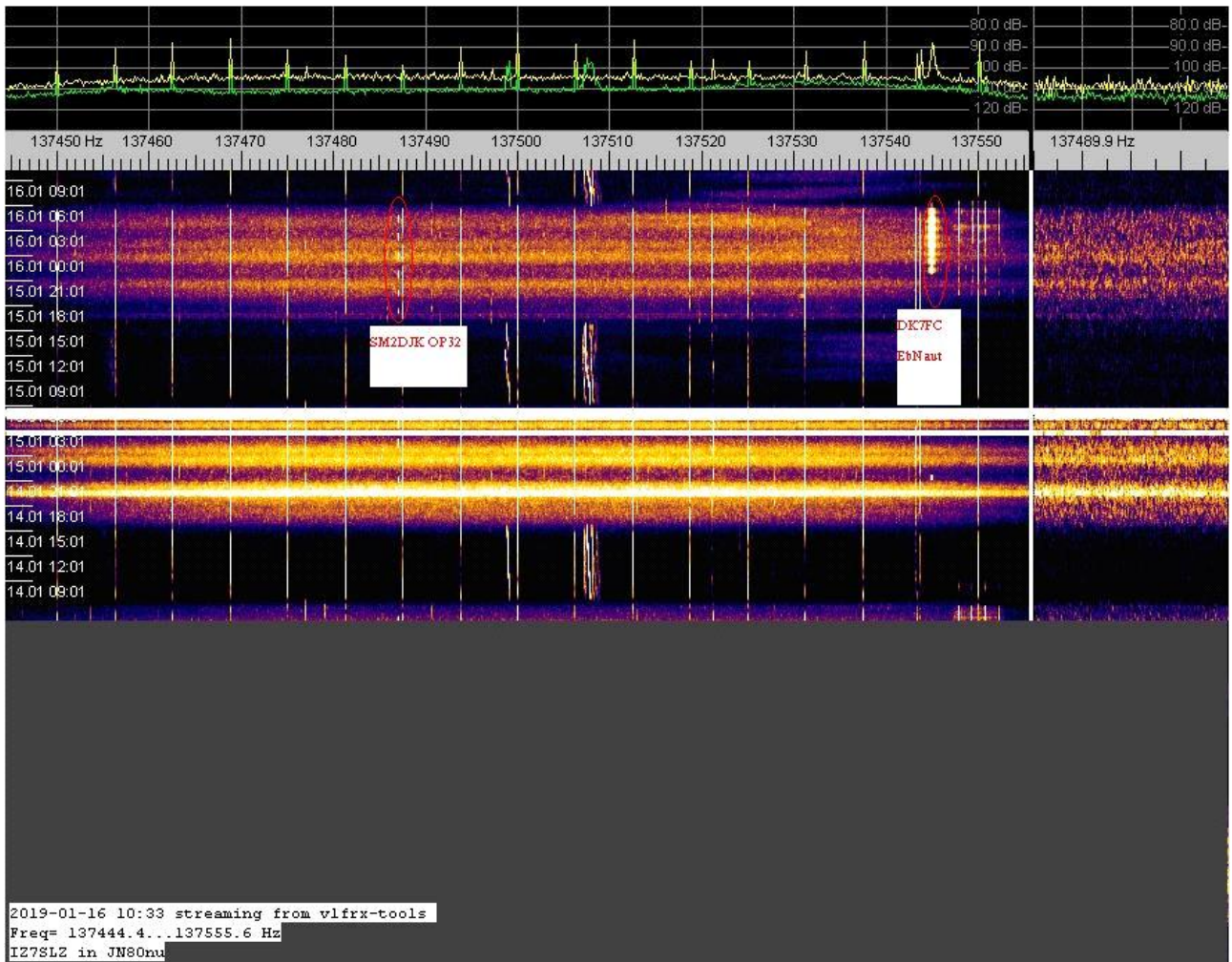
date	time	call	distance	frequency	bandwidth	snr	correlation
2019-01-29	20:56:27	SM2DJK	2565km	137486.989Hz	2mHz	-41.3dBOp	100% 19.6dB
2019-01-29	18:43:07	SM2DJK	2565km	137486.989Hz	2mHz	-39.8dBOp	100% 20.5dB
2019-01-29	17:49:08	IK1HGI	843km	137480.000Hz	9mHz	-45.4dBOp	92% 15.4dB
2019-01-26	04:55:48	SM2DJK	2565km	137486.990Hz	1mHz	-45.4dBOp	97% 19.0dB
2019-01-26	00:29:08	SM2DJK	2565km	137486.990Hz	2mHz	-37.8dBOp	72% 19.4dB
2019-01-25	22:15:47	SM2DJK	2565km	137486.990Hz	2mHz	-44.1dBOp	62% 15.0dB
2019-01-25	20:02:29	SM2DJK	2565km	137486.989Hz	2mHz	-42.2dBOp	100% 19.6dB
2019-01-25	17:49:09	SM2DJK	2565km	137486.989Hz	2mHz	-45.9dBOp	100% 17.5dB
2019-01-23	03:33:41	R7NT	1876km	137541.001Hz	2mHz	-44.7dBOp	96% 17.8dB
2019-01-23	03:26:40	SM2DJK	2565km	137486.989Hz	2mHz	-43.9dBOp	87% 18.5dB

Some loran lines can be observed on the opds waterfall and by the use of the Markus table

[http://df6nm.bplaced.net/opera/Loran\\_lines\\_in\\_LF\\_slots.txt](http://df6nm.bplaced.net/opera/Loran_lines_in_LF_slots.txt)

you can check if the frequency calibration of your receiving setup is 'EbNaut ready'.

Note that the list of Loran lines is outdated as all American and most European Loran chains have been shut down. In Europe, we currently have only GRI 8000 from Russia (multiples of 6.250 Hz) and GRI 6731 from Anthorn, UK (multiples of 7.42831674 Hz)



If you decide to run opds32 program during an EbNaut reception session, please note that opds program deletes, after every detection process (each ten minutes) the raw text file. In this manner we loose the recordings file for EbNaut.

```

File Modifica Formato Visualizza ?
@copy headline.txt + DETECTED.TXT + detecoId.txt c:\dropbox\public\detected.txt >nul
::@del c:\spectrum\data\*.txt
::@copy dirw.txt dirdone.txt >nul

```

Linea 3, colonna 34

So the batch file **cleanup.bat**, included in the opds suite (see above picture), needs to be modified deactivating the second and third line of instructions by adding "::"

So, recording process starts as soon Spectrum Lab is started with this 'tuned' configuration.

Once the reception of signal is ended and you want to start the decode process, then you have to select the proper raw file and convert it in 'wave' audio file.

This is easily done by using another suite of programs from Markus [http://df6nm.bplaced.net/VLF/fec\\_tests/df6nm\\_ebnaut\\_utilities.zip](http://df6nm.bplaced.net/VLF/fec_tests/df6nm_ebnaut_utilities.zip)

Note that a corrected version ebnaut\_ifft3b is at [http://df6nm.bplaced.net/VLF/fec\\_tests/ebnaut\\_ifft3b.zip](http://df6nm.bplaced.net/VLF/fec_tests/ebnaut_ifft3b.zip)

First of all, you have to find the raw (MMDDhhmm.txt) file that contains all the period of the EbNaut transmission you want to decode. Since each raw file contains FFT data for 34 minutes, this means that **the method we are using is able to manage EbNaut transmissions less than 30 minutes.**

This seems to be almost a 'standard' for the operators transmitting EbNaut at moment, so it is not a big problem. If necessary, should be possible to program different FFT settings for longer transmissions.

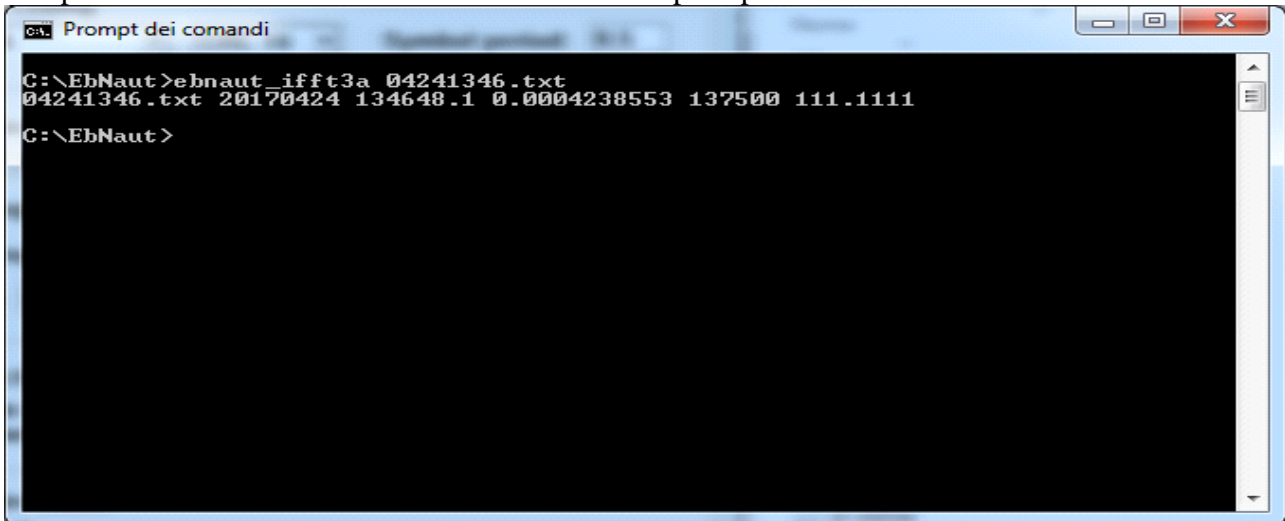
Note that transmissions extending beyond the recorded window can still be decoded but at a loss of sensitivity.

Remember that, actually, we have a file of 34 minutes every 10 minutes and the middle-time of the period is indicated by the file name.

Suppose, for instance, that we choose the file 04241346.txt (it contains approx. FFT from April 24, 13:27 to 14:07 UTC)

It is necessary to use the dos program **ebnaut\_ifft3b.exe** that performs the inverse Fourier Transform taking data from the selected file and creates a wave file in the same directory.

It is possible to use with the command from the dos prompt:

A screenshot of a DOS command prompt window titled "Prompt dei comandi". The window shows the following text:

```
C:\EbNaut>ebnaut_ifft3a 04241346.txt  
04241346.txt 20170424 134648.1 0.0004238553 137500 111.1111  
C:\EbNaut>
```

The file 04241346.wav is now created in the same working directory.

Note that ebnaut\_ifft can also be invoked in Windows Explorer, simply by drag-and-dropping the data file icon over the ebnaut\_ifft3b icon. Latest version of this program is ebnaut\_ifft3b.

The program ebnaut\_ifft3a.exe uses a configuration file named **sr.txt**. This file needs to be modified according your setup. This informations are needed to generate meta data for the wave file header, which will later be displayed and used in the ebnaut-rx program.

It contains four numbers, which are the soundcard samplerate, the FFT decimation factor, the FFT length (usually 524288), and the center frequency (i.e. the receiver LO plus the audio center frequency from the FFT settings tab).

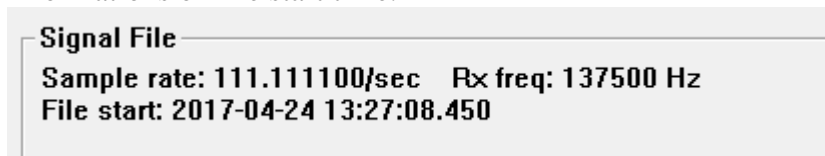
So enter the correct values into sr.txt prior to run ebnaut\_ifft3a.exe.

Note that for the purpose of hiding decimation-filter rolloff, SpecLab displays and exports only the middle half of the FFT. This means that the "number of exported bins" should be half of the FFT size, and the samplerate shown by ebnaut-rx is half the decimated samplerate.

Now, before running EbNaut-rx.exe program, it is important to calculate the correct time offset to enter. So it is necessary to know exactly the start time of the audio file created.

The easy method is to start EbNaut-rx.exe, select this file, leave all other default setting, press RUN button and STOP it immediately.

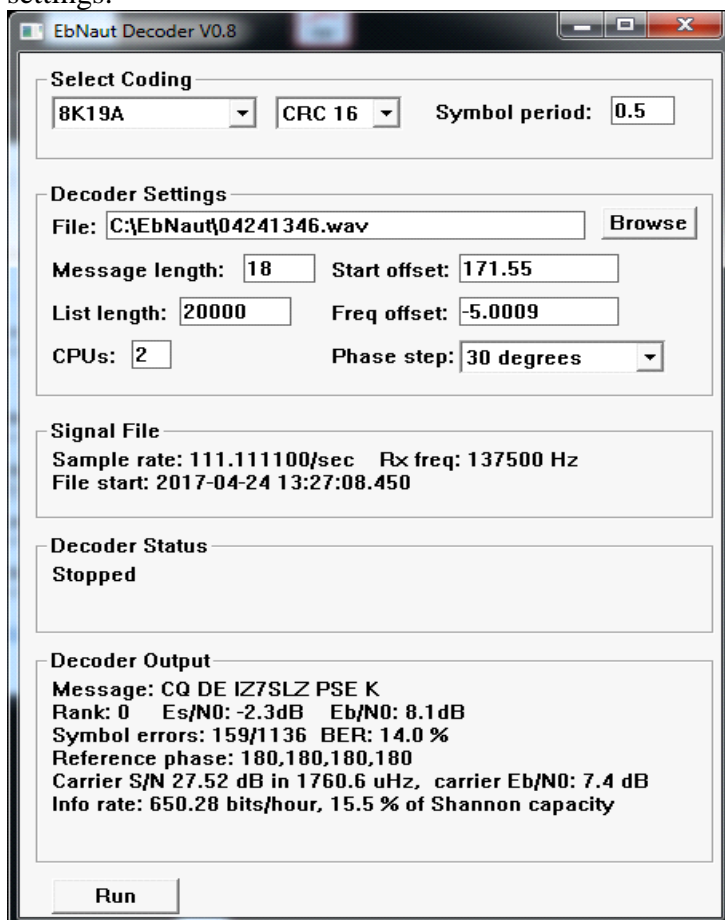
The program from Paul Nicholson, in its initial stage, reads the wave file header and shows the informations on file start time.



Take note of this 'File start' and calculate the START OFFSET i.e. the difference (in seconds) between the transmission start time and the file start time.

Then enter all the parameters, according to the transmission announce as Coding, CRC, Symbol period, message length, Start offset (calculated before), Freq. Offset (set as first attempt, the nominal value), number of CPU cores and press RUN.

For a transmission announced on 137495 Hz, 18 Char., CRC16, 8K19A, Sym=0.5 s, these are the settings:



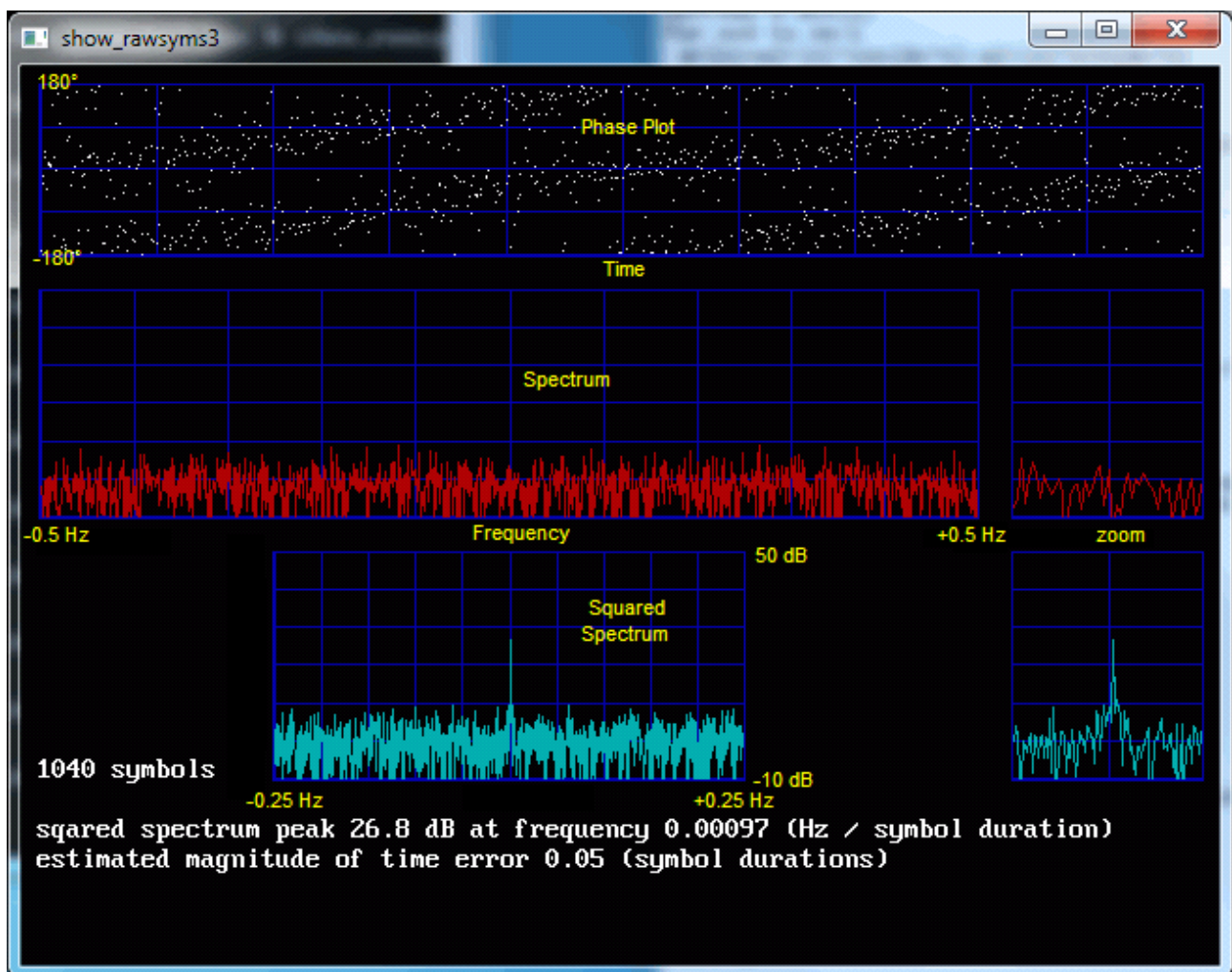
If the frequency offset is correct and no decode happens, the start time may still be wrong by an integer number of symbols periods. Then try to increase time offset in steps of one symbol duration.

With one of these offsets, the signal should be decoded successfully.

You can still play around with the time offset to reduce symbol errors and maximize EbN0. Take a note of the best start offset.

For searching the frequency offset we have to inspect the **rawsyms.txt** file, which contains the complex baseband signal at one sample per symbol. This file is created by **ebnaut-rx** immediately after pressing "start" in the same directory.

After the first decode attempt, start Markus's program **show\_rawsyms3b.exe**. This program will plot the contents of the **rawsyms.txt** showing the phase (upper plot), a calculated spectrum of the signal (red plot), and a spectrum of the squared signal (cyan). There is now also a small constellation diagram at the top right, which should ideally show two opposite blobs of points in the complex plane. If the blue peak is strong enough, the numbers at the bottom can be used as guidance for frequency and time offsets.



Ideally the phase points should be gathered along a horizontal line, indicating constant phase and zero frequency error. Usually the line will have a slope, and you will have to adjust the Freq offset field and repeat the procedure.

Unfortunately this is a lengthy procedure, and it becomes very difficult or impossible when the signal is weak. At low SNR, it is often possible to obtain valid message decodes even when the blue

peak is completely hidden under the noise. This is the reason why it's so important to have a stable and repeatable frequency. At LF, the frequency accuracy should be on the order of 0.1 mHz / 137 kHz, or  $10^{-9}$ . A simple TCXO is definitely not sufficient! We really want a Rubidium or GPS-controlled oscillator, or perhaps a well-calibrated OCXO of extraordinary stability.

Further information:

Perhaps provide links to some relevant mails from the blacksheep reflector archive:

[https://klubnl.pl/rsgb\\_lf\\_group-archives/html/rsgb\\_lf\\_group/](https://klubnl.pl/rsgb_lf_group-archives/html/rsgb_lf_group/)

Guess we would need to go through our past posts and select the most relevant ones.