How to: Receive, decode and display three ARINC Channels in parallel

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Software-defined radios (SDR) offer the possibility to receive and demodulate several audio/IQ channels in parallel. ELAD's FDM-DUO and FDM-S2 offer up to four channels within a range of e.g. 5 MHz. Some people asked, what this stunning feature is about, why they should use it and how they can do this. This paper gives one answer by showing step-by-step how to receive, decode and display three ARINC channels in parallel - as just one example of exploiting and exploring this technology.

Since 2013, Rockwell Collins provides automated packet-like data communications called HFDL between ground and planes and vice versa on shortwave. A good overview on the system can be found at ARINC's website. Each of the 15 ground stations uses four (two of them just two) frequencies in parallel to follow propagation. Coverage of this system is essential global and covers even the polar regions with great reliability, where SATCOM is difficult or even impossible.

For the purpose of this paper, you need nothing to know about these PSK signals at a symbol rate of 1.800 bps, but: They strictly follow a GPS-disciplined schedule (TDMA/FDMA), last for 1,8 or 4,2 seconds, and they sound like noise with a pre-carrier of 249 milliseconds length at the centre frequency of this signal, namely 1.440 Hz.

The channels of the ground stations are clustered. So I took the following stations/channels:

- ARINC Agana/Guam, #16, 21.928 kHz
- ARINC Canary Islands, #17, 21.955 kHz
- ARINC Al-Muharraq/Bahrain, #15, 21.982 kHz

Unfortunately, Agana changes this channel in favor to a lower range soon after starting my monitoring (due to propagation around Agana). Reception was made on August, 23rd with FDM-S2 receiver and an active loop of about 20 m circumference.

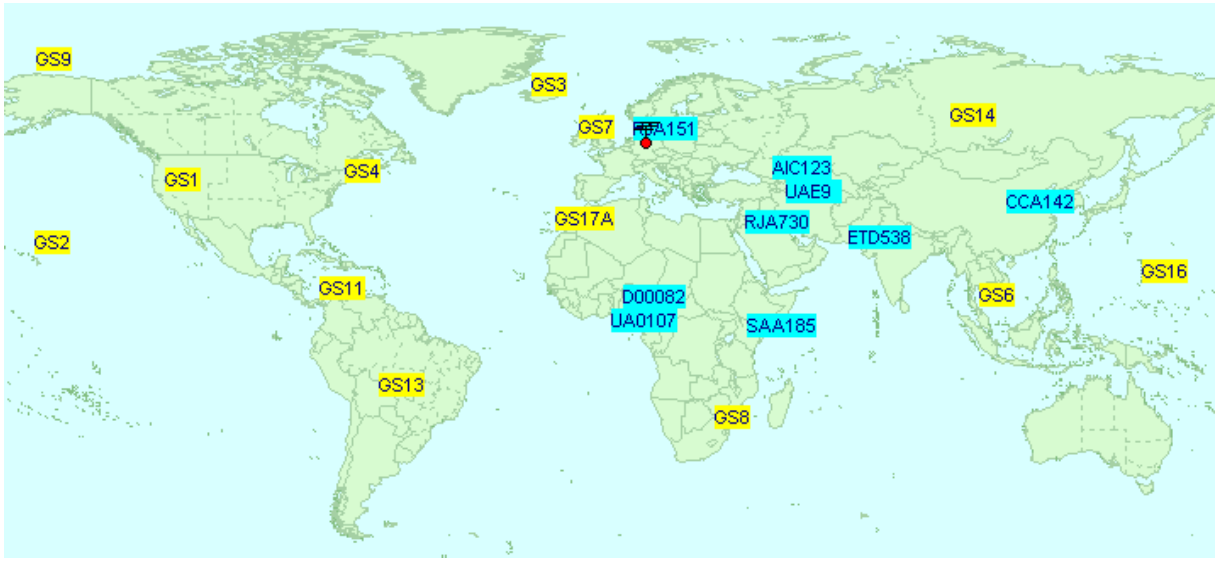

Figure 1: ARINC ground stations (GS) in the view of DX Atlas, with some planes.

Three channels, three decoders, three times audio

First an *overlook* of how it generally works:

Within the covered "slice" of FDM-S2 between up to 192 and 6.144 kHz (*SET → Advanced → Device Configuration*), you can place up to four independent demodulators RX1 … RX4 at frequencies, you want.

Each of these output has to be fed into a separate virtual audio cable (VAC) or virtual sound card (VSC). I use VAC which provides up to 99 virtual audio cables.

For decoding, you need a software capable of opening at least three instances - accepting a different source of each instance. I use Charles Brain's PC-HFDL for years.

To show the results in a combined form (plus on Google Earth), I use Mike Simpson's software PC-HFDL-Display.

Figure 2 shows, how all is connected just via software.

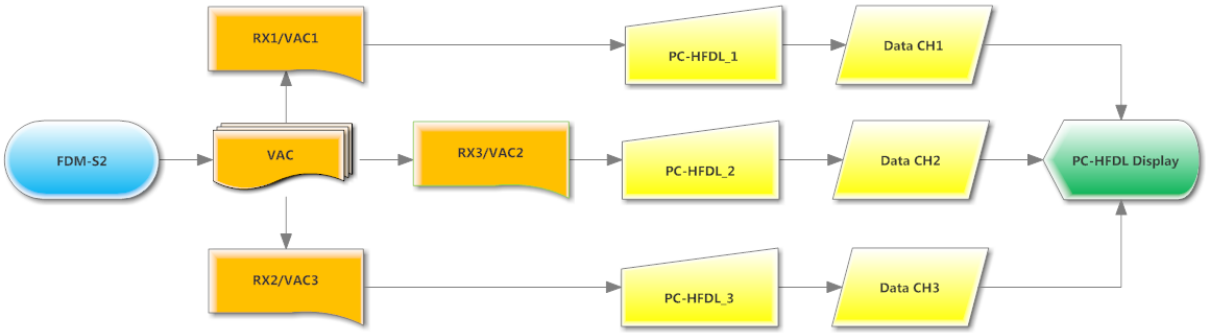

Figure 2: FDM-S2 delivers via VAC software three demodulated channels RX# → VAC#. Each of these outputs feeds a different instance of PC-HFDL decoding software. Each of its "logfile" is sent to software PC-HFDL Display.

Now for some details, step by step.

- **Software VAC:** In the Virtual Audio Cable Control Panel, make at least *three* VACs available ("Cables"), see *Figure 3*.

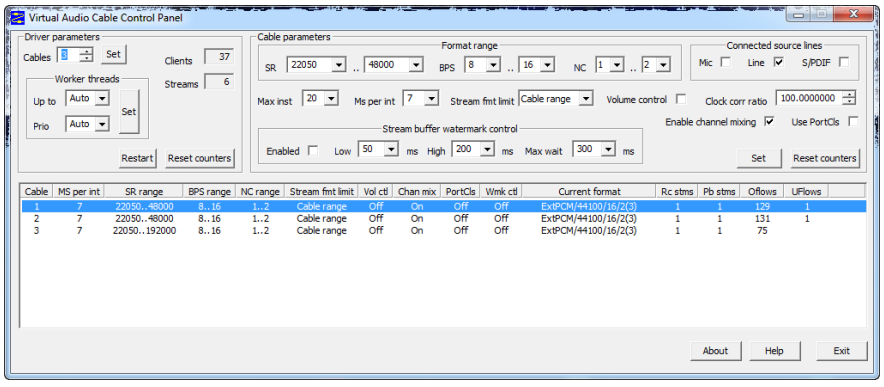

Figure 3: Driver Parameters → Cables - make at least three "cables" available.

- **Receiver FDM-S2:**
  First - in the SET menu, activate “Audio” output for *VRX1* … *VRX3* at *Line 1 (Virtual Audio Cable)* … *Line 3 (Virtual Audio Cable*), see *Figure 4*.
  Secondly - activate RX1 and tune it in USB to the first frequency. Then activate RX2 and tune it in USB to the second frequency. Eventually activate RX3 and tune it in USB to the third frequency - see *Figure 5*.
  Now *RX1* sends it demodulated output to *Line 1*, *RX1* to *Line 2* and *RX3* to *Line 3*

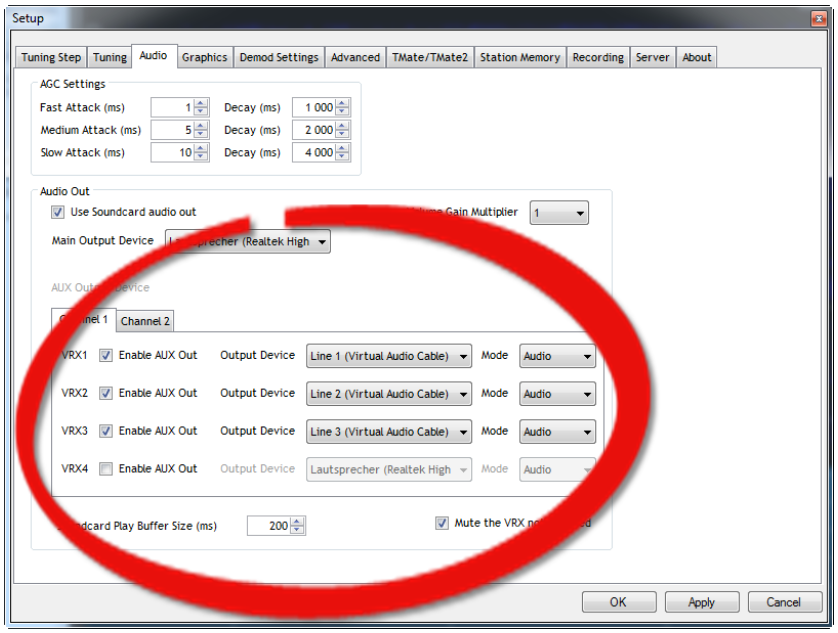

Figure 4: Activate Line 1 … Line 3 output for VRX1 … VRX3.

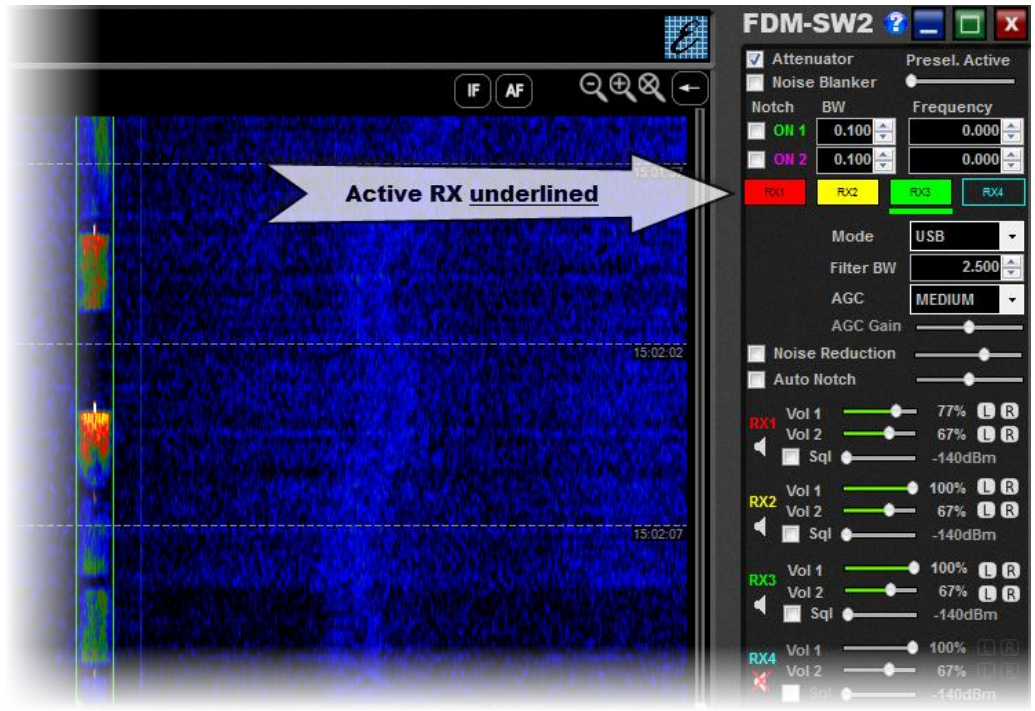

Figure 5: Activate RX1 … RX3, and tune into the wanted frequency/mode. Here RX3 has been activated for tuning.

- **Decoding software PC-HFDL:**
    - Download this software and place it into e.g. folder “PC-HFDL”
    - Copy this folder three time and name them “PC-HFDL_1”, PC-HFDL_2” and PC-HFDL_3” (Why separate folders? Because each carries a “logfile” which then is needed to feed each of the three data input of software “PC-HFDL Display”.)
    - Open “PC-HFDL” from each of the folders “PC-HFDL_1” … “PC-HFDL_3”
    - Each of these three instances now has to be feed with a different input *Line 1* … *Line 3* (Systems Option → Soundcard Configuration). I suggest to feed “PC-HFDL_1” by “Line 1”, “PC-HFDL_2” by “Line 2” and “PC-HFDL_3” by “Line 3”.
      Figure 6 shows the three windows lined up plus with the opened menu for changing the soundcard input.

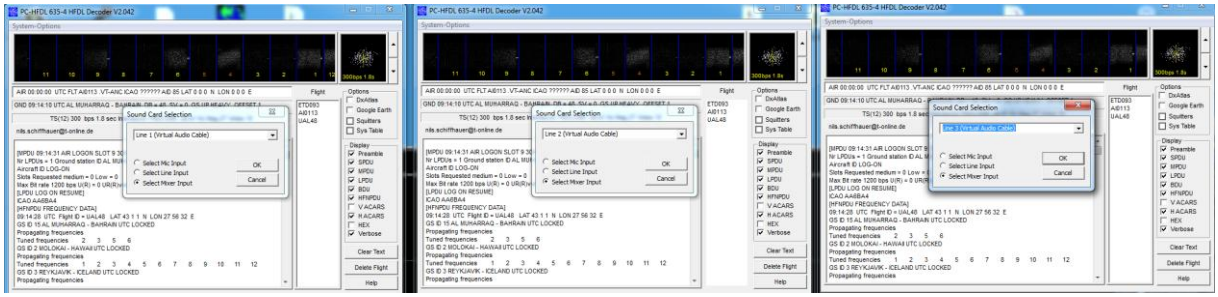

Figure 6: Each instance of software PC-HFDL has been assigned to a different input.

Now reception and decoding should start, see *Figure 7*. Each window of PC-HFDL is fed by the output of a different ARINC frequency and decoding it independently.

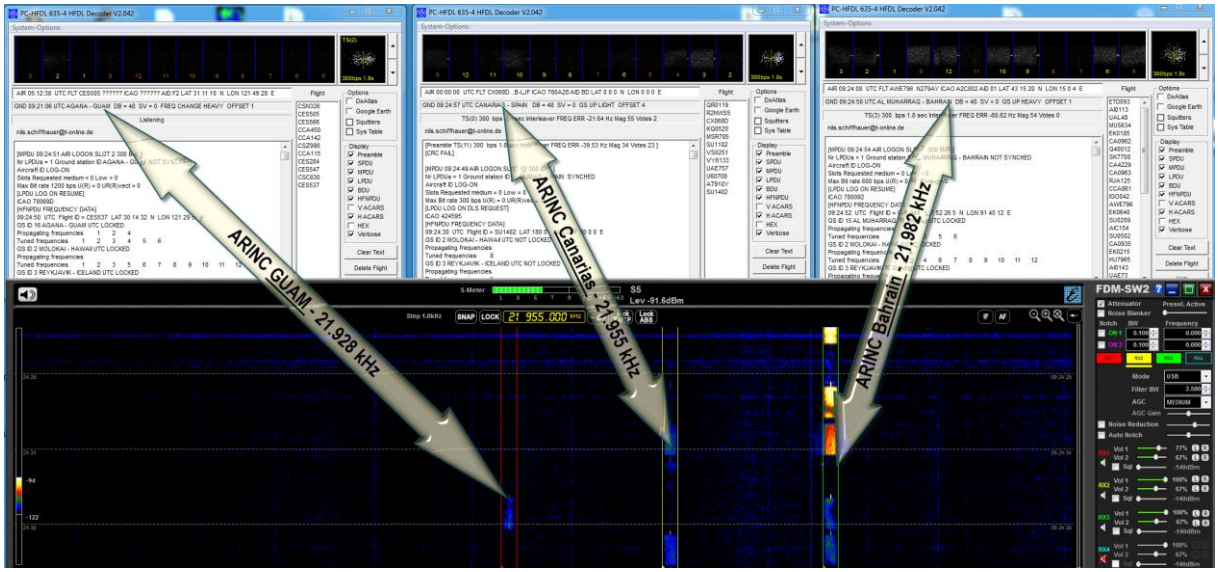

Figure 7: Three channels, three demodulators, and three decoders - the system is working! RX2 has been activated here for listen via loudspeaker. But as you see, all three channels/demodulators have been also activated and delivering in parallel their output via VAC1 … VAC3 to the input of the three opened instances of PC-HFDL decoder software.

Last, but not least, the last step: visualizing the data by software PC-HFDL-Display.

- **Visualizing software PC-HFDL-Display:**
  This software collects decoded information from the “logfile” folders of PC-HFDL. It accepts up to three different data input *Log1* … *Log3* in parallel. To do so, you just have to assign the appropriate “logfile” folder:
    - Open “Options”, click on the “PC_HFDL Log# Path”, and double-click onto the appropriate entry “PC-HFDL# → logfiles → MonthXX.txt” - see *Figure 8* and *9*.
    - Soon the nearly all fields are being populated and updated. The software does even take the name of the ground station (*GS1* … *GS3*) from the “logfiles”, but you have to input their frequency manually - see *Figure 10* on page 6.

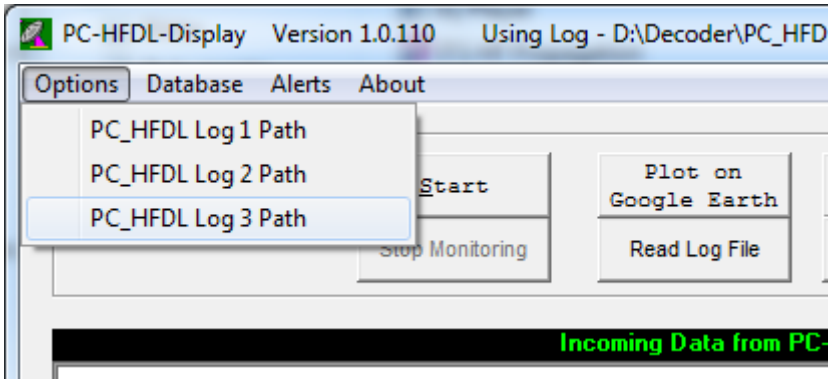

Figure 8: Assign the three inputs of PC-HFD-Display …

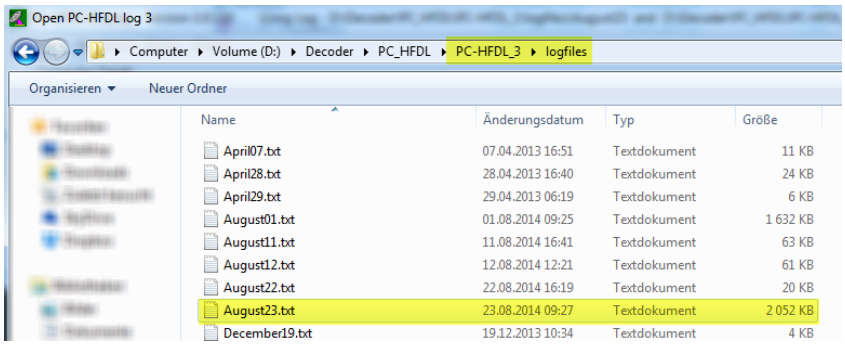

Figure 9: to the appropriate output logfile - done.

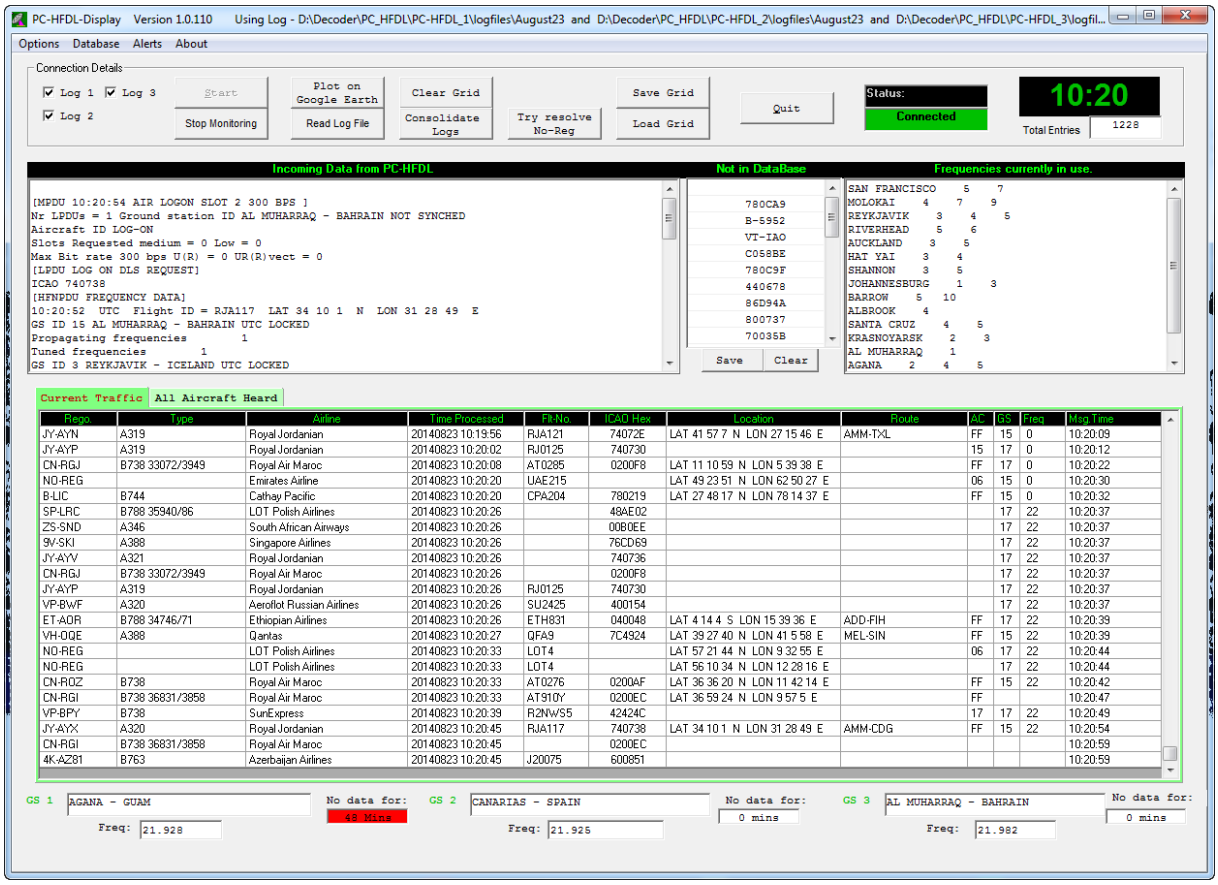

Figure 10: Here we have all data from three ARINC stations in parallel at hand. Unfortunately, 18 minute after having activated the software, ARINC Guam changed to a lower frequency. So we have only 18 minutes of Guam, but Canarias and Bahrain for hours at my location in Northern Germany.
A click on "Plot on Google Earth" will show the following pictures.

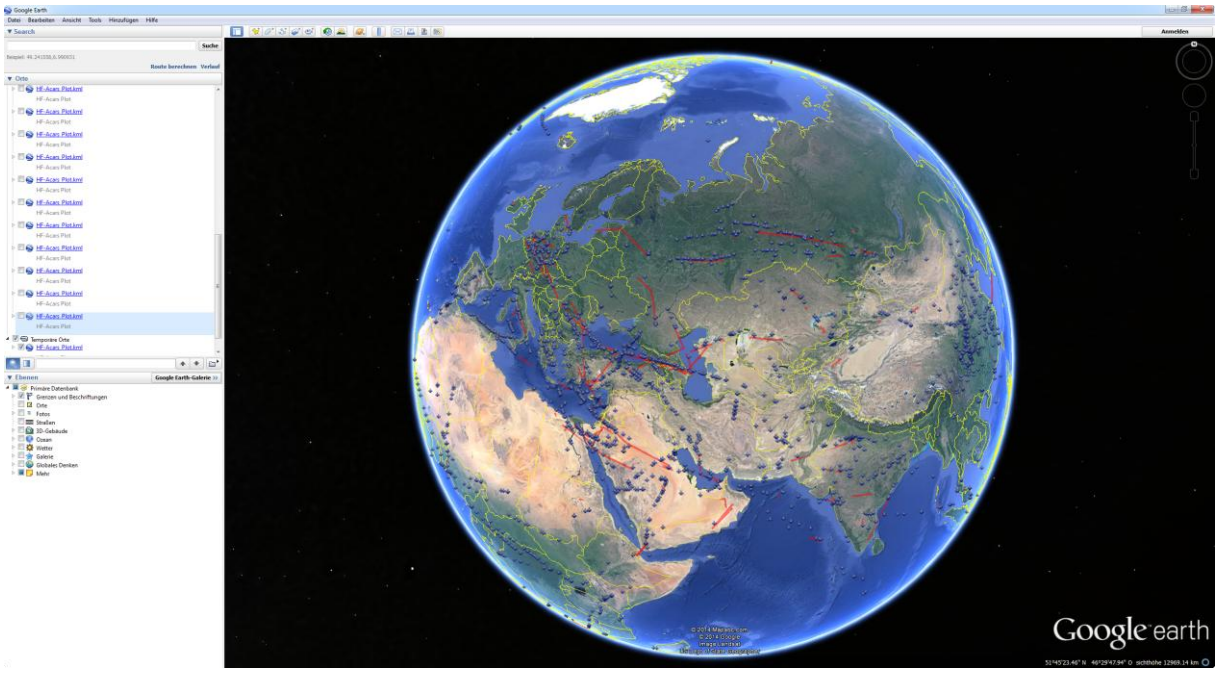

Figure 11: Here you see an overview of about 8.000 "squitters" received during six hours from planes and up to three ARINC stations. Each airborne transmission is represented by an icon and some additional information, showing up at a zoomed picture, plus a click onto the icon; see the two concluding pictures.

Figure 11: Zooming in, and the call signs of each plane appears. You can also see the routing of some planes, e.g. "A6EER", Airbus-380-361 of Emirates airline, "4K-AZ82", a Boeing 767-32LER by Azerbaijan Airlines and "MM62228", also a Boeing 767, but by the Italian Air Force, Aeronautica Militare. Airframes.org helps in decoding.

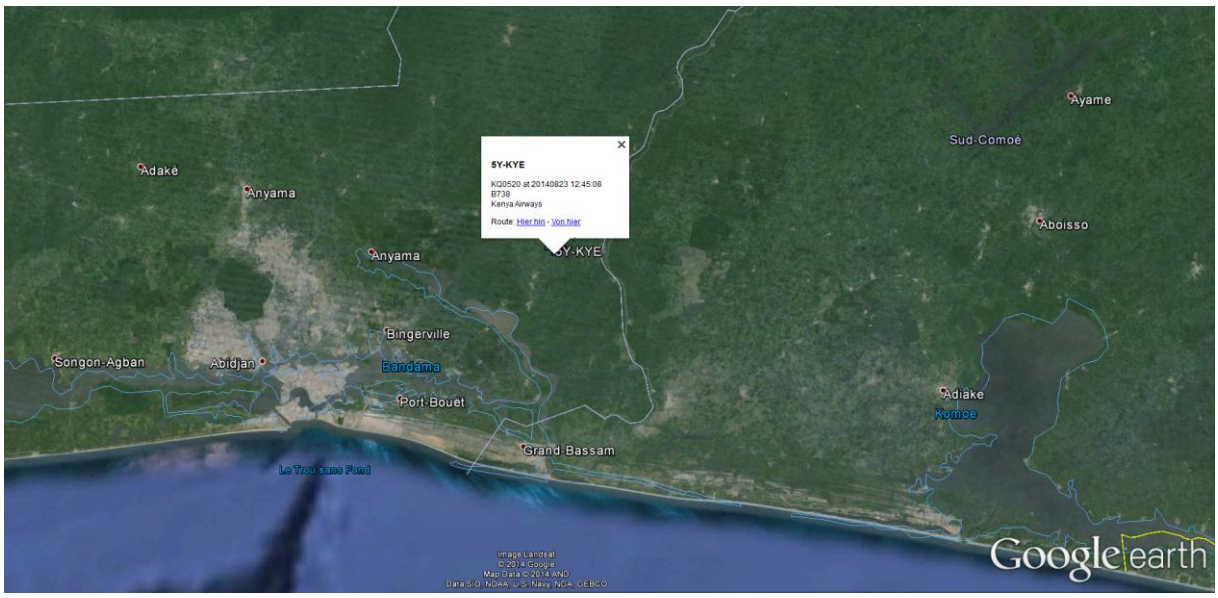

Figure 12: If you click onto an icon, all data are displayed. Here we see "5Y-KYE", a Boeing 738 from Kenya Airways, received a bit north-east of Abidjan/Ivory Coast on August, 23rd, 2014 at 12:45:08 UTC. Flight number KQ520 denotes the flight from Nairobi to Abidjan and finally to Dakar. Flightradar24 is an excellent site to find all these information but this is another story …