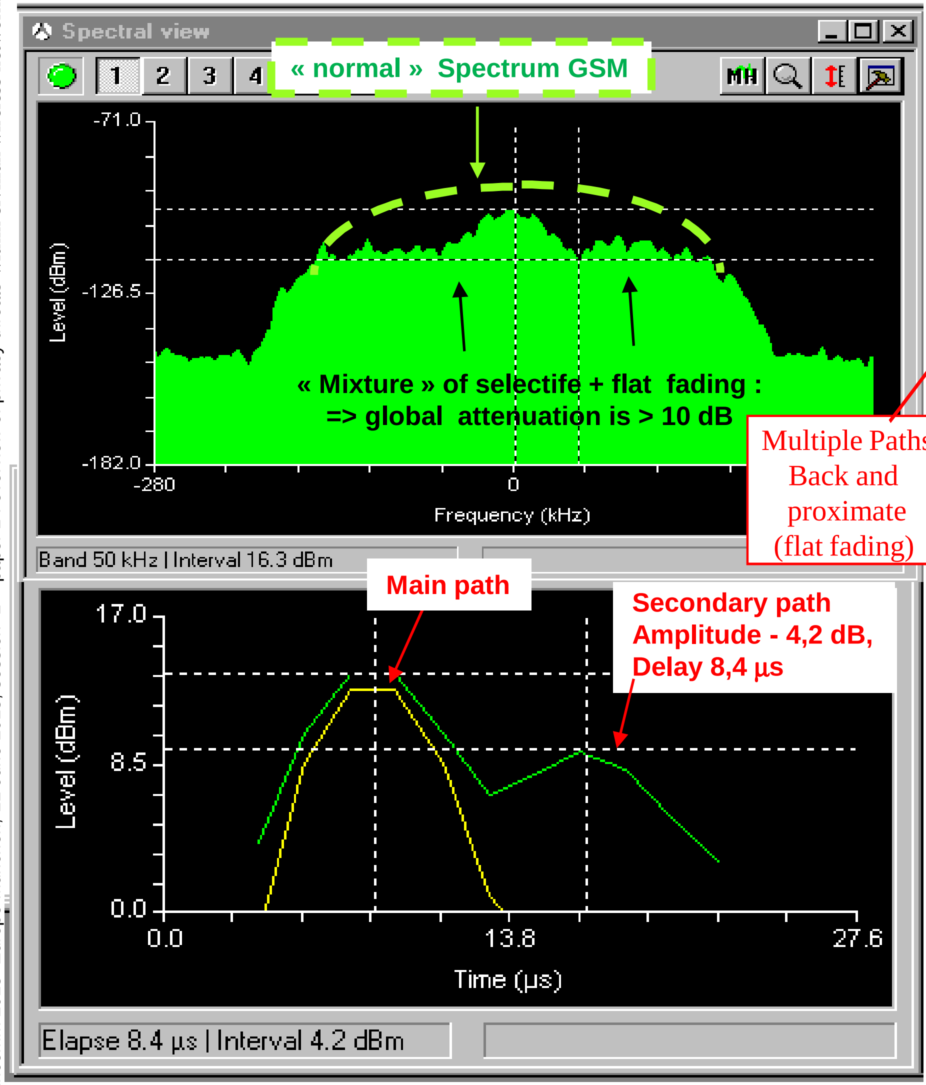
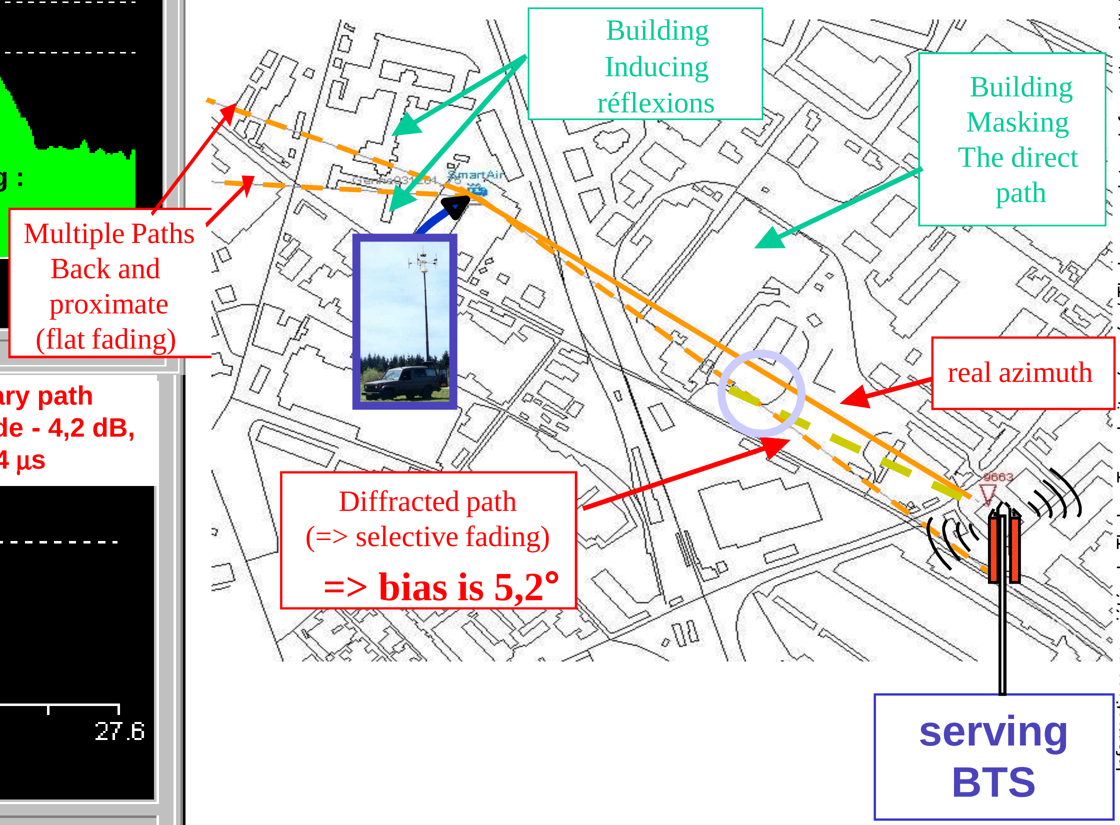
Annex - Propagation environment: real field example

Analysis with a high resolution Direction Finder



GSM Radio-cellular
Real propagation case with masks and proximate rrflections



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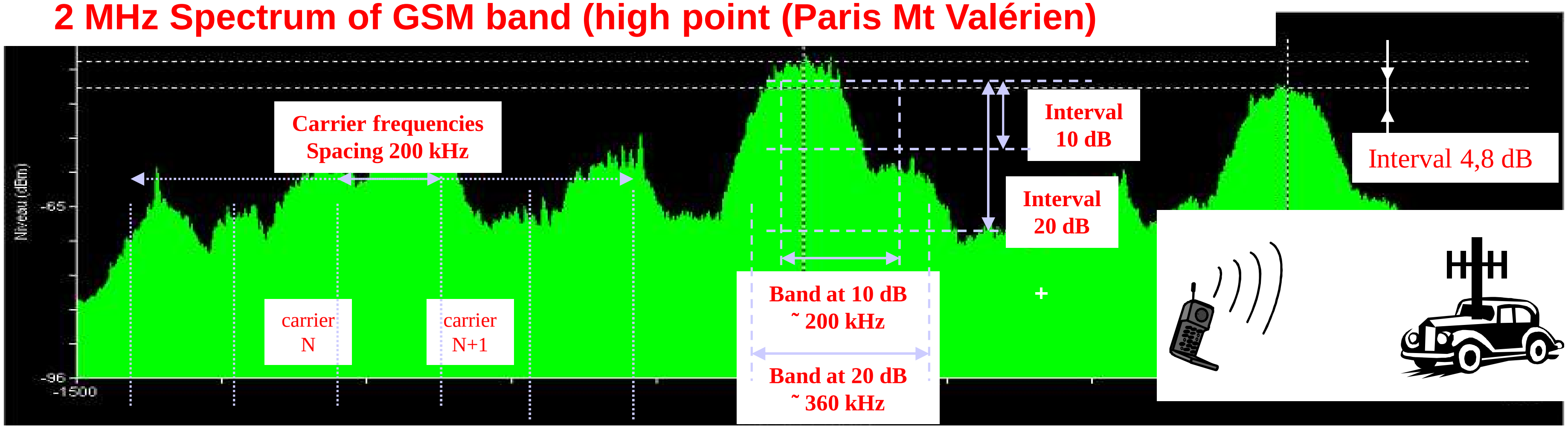
Annex - Propagation environment: real field example

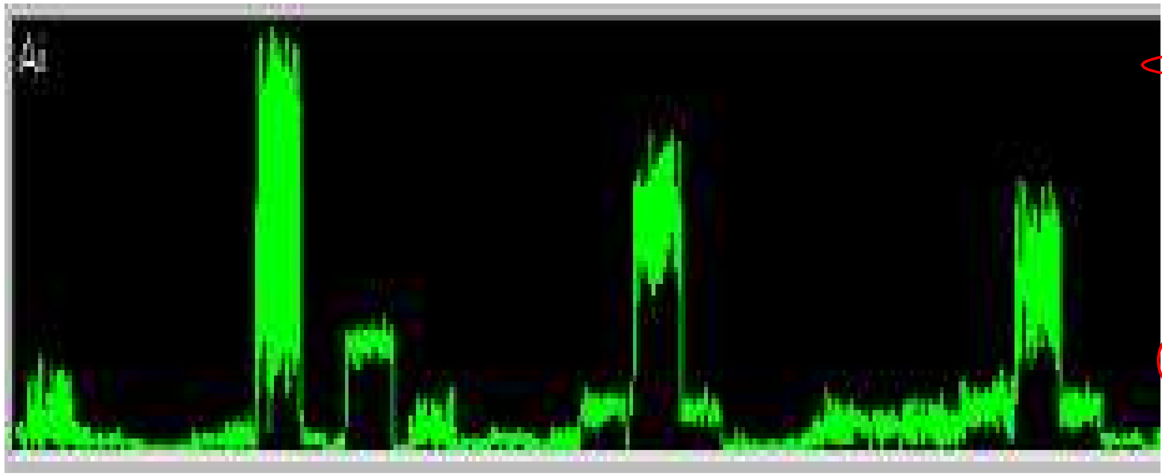
Analysis with a high resolution Direction Finder

Detection and counting of GSM Tx GSM. Dedicated smart antennas

2 MHz Spectrum of GSM band (high point (Paris Mt Valérien)



Measurement at one traffic GSM carrier (0,2 MHz) > 20 TCH – same location



Channel	ARFCN	TSC	Level (dBm)	C/I (dB)
TCH1	885	1	-73.3	0.4
TCH2	885	1	-57.8	16.7
TCH3	[illegible]	[illegible]	-74.7	-2.0
TCH4	[illegible]	[illegible]	-79.8	-7.6
TCH5	[illegible]	[illegible]	-86.2	-10.5
TCH6	885	5	-67.1	3.8
TCH7	885	6	-74.8	-4.4
TCH8	885	4	-76.7	-5.6
TCH9	885	4	-74.6	-4.1
TCH10	885	6	-78.5	-7.4
TCH11	885	7	-60.5	12.7
TCH12	885	4	-80.8	-5.7
TCH13	[illegible]	[illegible]	-84.0	-7.5
TCH14	[illegible]	[illegible]	-82.4	-8.9
TCH15	[illegible]	[illegible]	-78.5	-4.8
TCH16	[illegible]	[illegible]	-83.2	-13.6
TCH17	[illegible]	[illegible]	-79.2	-4.1
TCH18	885	2	-83.7	-9.6
TCH19	885	7	-83.5	-11.9
TCH20	885	3	-71.5	1.3

dominant

Highly
interfered

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Annex - Propagation environment: real field example

Examples of SIMO measured CIR at 900 MHz

Winncomm 2013 Europe Munchen, 11 June 2013, session 1 - paper 1 : overview of privacy threats within civilian wireless networks

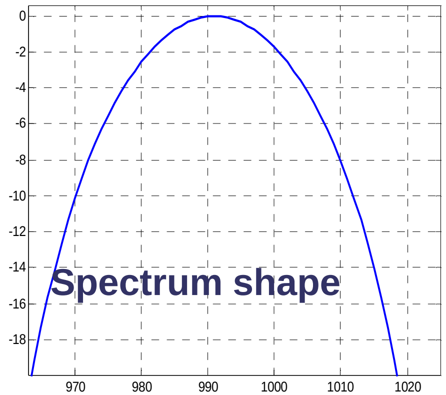
Reference scalar signal

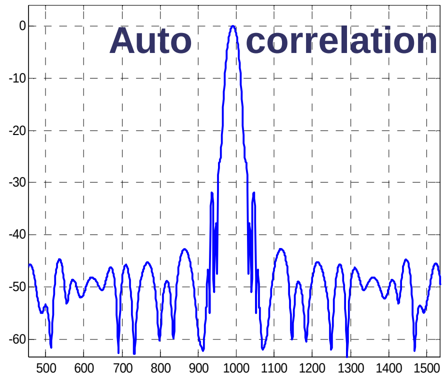
$[s(l.T_e)]_{l=0\dots L-1}$

PN long period L, 40 MHz

Low side lobes

Time resolution ~ 33 ns

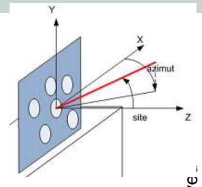




Received N_{ant} x1 vector signal

$[\underline{x}(l'.T_e)]_{l'}$ scalar coordinate $[x_{\underline{n}}(l'.T_e)]_{l'}$

$\underline{x}(l'.T_e) = (H*s)(l'.T_e) + \underline{b}(l'.T_e)$



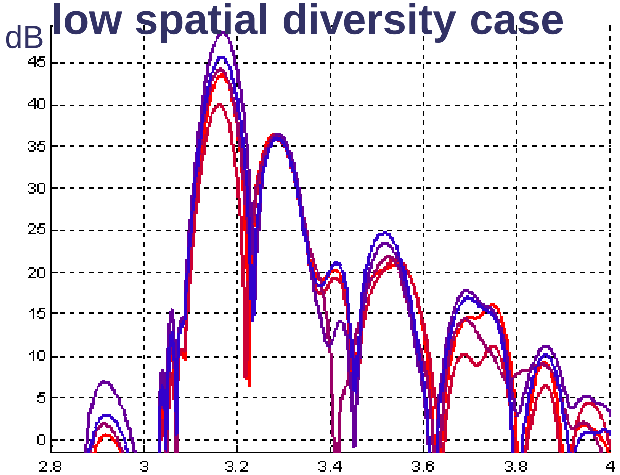
Example of WB CIR estimator per antenna build with :

$\underline{S}=[s(0),\dots,s((l'+L-1).T_e)]$

for n = 1.. N_{ant}, time vector signal $\underline{X}_n(l'.T_e)=[x_{\underline{n}}(l'.T_e),\dots x_{\underline{n}}((l'+L-1).T_e)]$

for l'=0,… $H_n(l'.T_e) \propto \underline{R}_{\underline{XnS}}(l'.T_e) = \underline{X}_n(l'.T_e).\underline{S}^H$ (scalar)

Ex of SIMO CIR
900 MHz frequency ranges
~ 100 m sub-urb. outdoor propag.
low spatial diversity case



Ex of SIMO CIR
900 MHz frequency ranges
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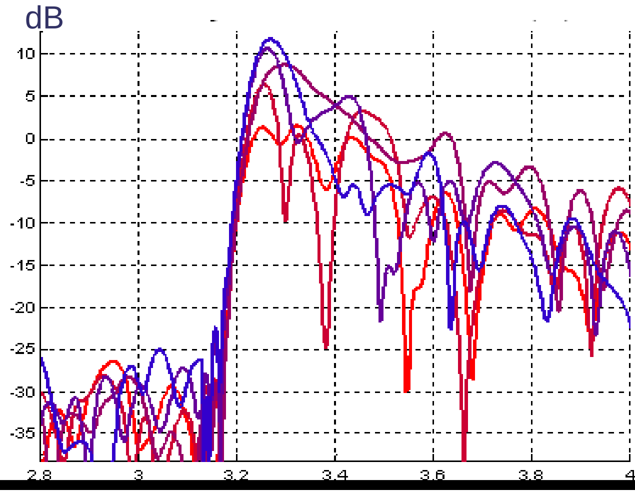

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Annex - Oriented processing of communication signals

A/ Wave Form Structure characterization

Narrow band / wide band signal

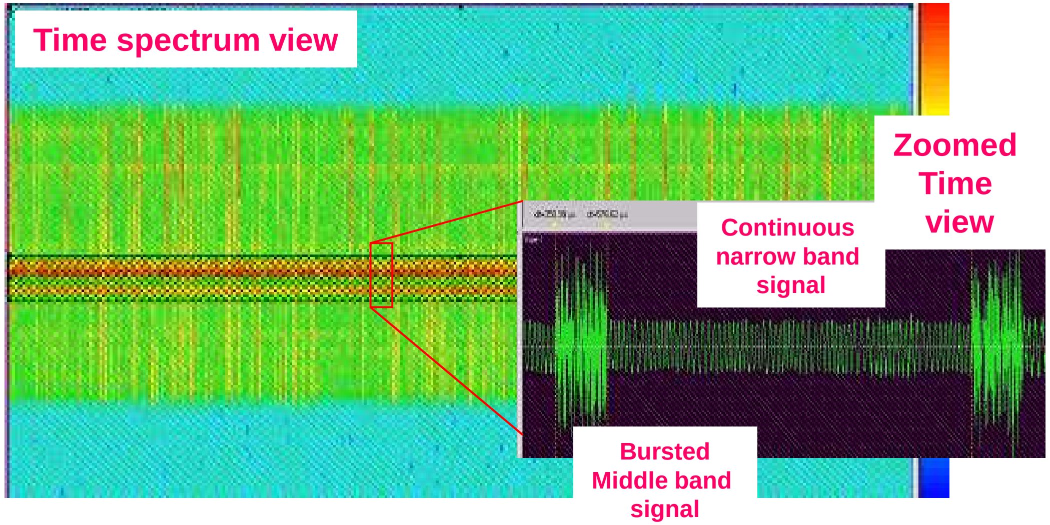
Continuous / bursted signal

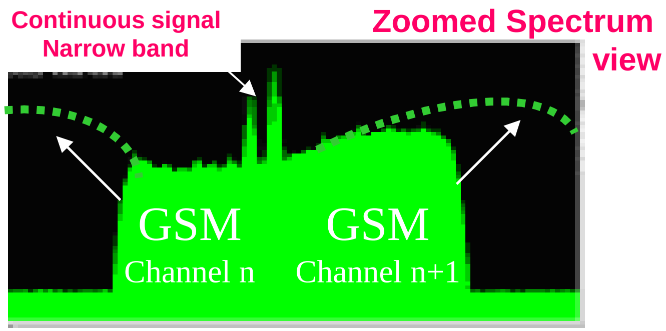
Frame characteristics

Synchronization characteristics

Radio Access protocol characteristics

(FDMA,TDMA,CDMA, ...)





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Oriented processing of communication signals

B/ Estimation of modulation parameters

Carrier center frequency

Signal bandwidth, Symbol rate,

Number of states, Constellation

Shift (FSK and CPM), FM depth, AM index...

Signal demodulation

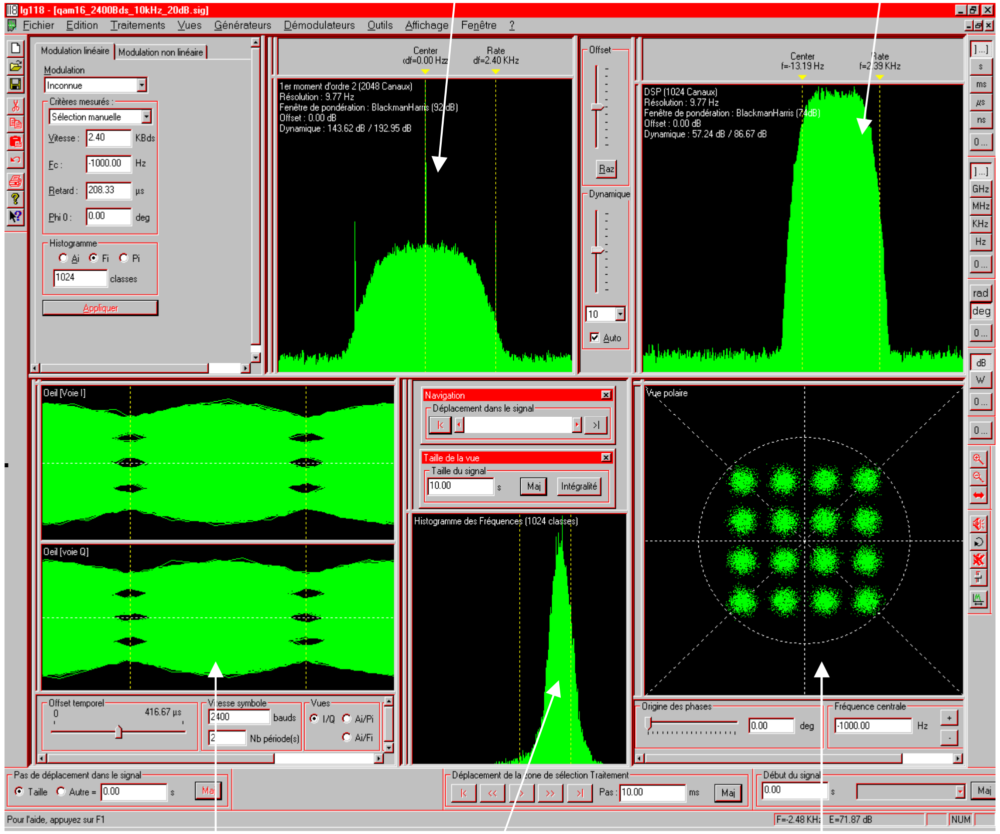
Single carrier AM/FM,CPM, PSK, QAM, FSK…

Multi carrier OFDM, etc.

Analyses of coding scheme

Signal identification

Data bases, semantic descriptions.



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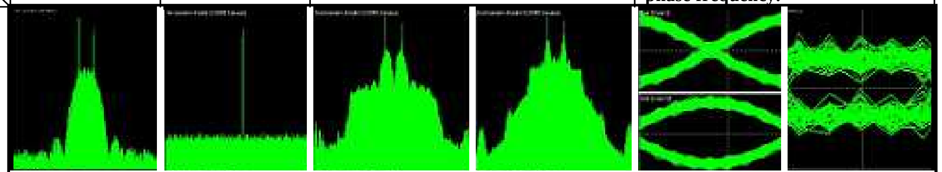
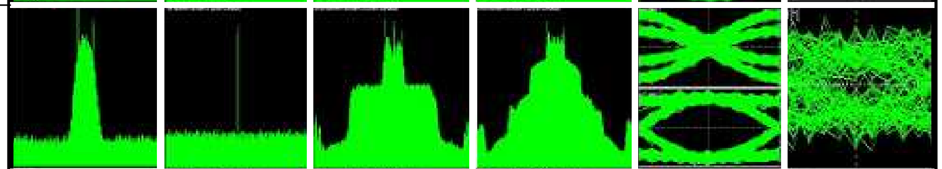
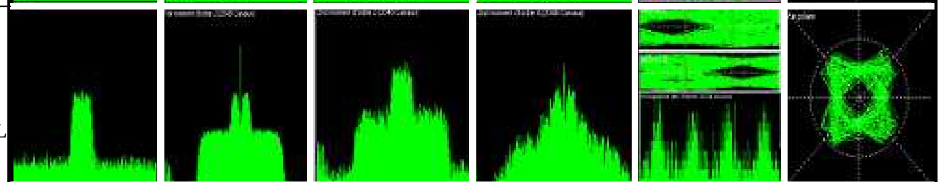
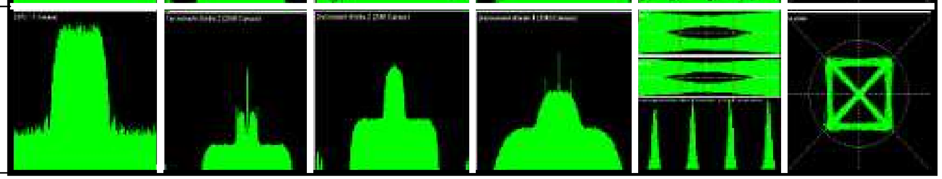
Oriented processing of communication signals

C/ Regular statistical estimators leading to measurement of modulation parameters

Technical purpose	Power measurement	Estimation of center frequency	Estimation of Symbol rate		Synchronization of symbol + demodulation	
Statistical estimator / Signal example	Spectrum Power Density	Spectrum 1st moment order 2 $E[\|x\|^2]$	Spectrum 2nd moment order 2 $E[x^2]$	Spectrum 2nd moment order 4 $E[x^4]$	Eye Diagram & Histograms I/Q, Amplitude phase frequency.	Eye Diagram & Polar Diagram
FSK2 Ind. 1 SNR 20 dB "PMR like"						
GMSK Ind. 0,5 SNR 20 dB "GSM like"						
O-QPSK Roll off 0,25 SNR 20 dB "CDMA 2000 UL like"						
QPSK Roll off 0,25 SNR 20 dB "UMTS like"						

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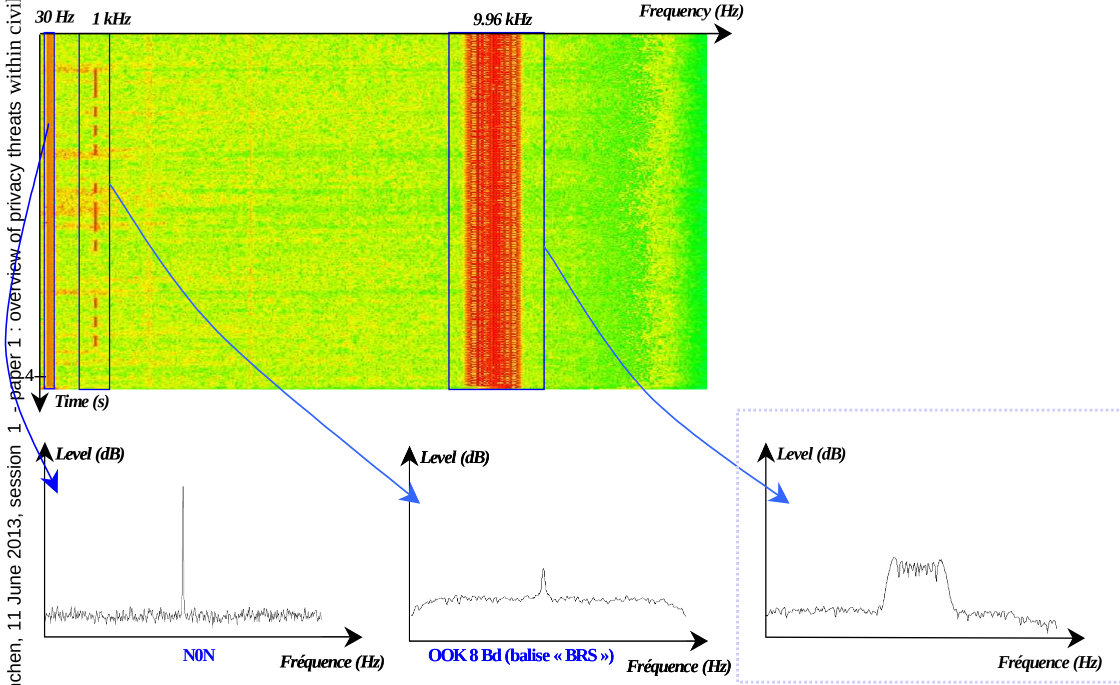
Annex - Oriented processing of communication signals

D/ A complete real field example performed with basic estimators

Base Band Filtered VOR signal with three Sub carrier (VHF Omni directional Range for aeronautical radio navigation)

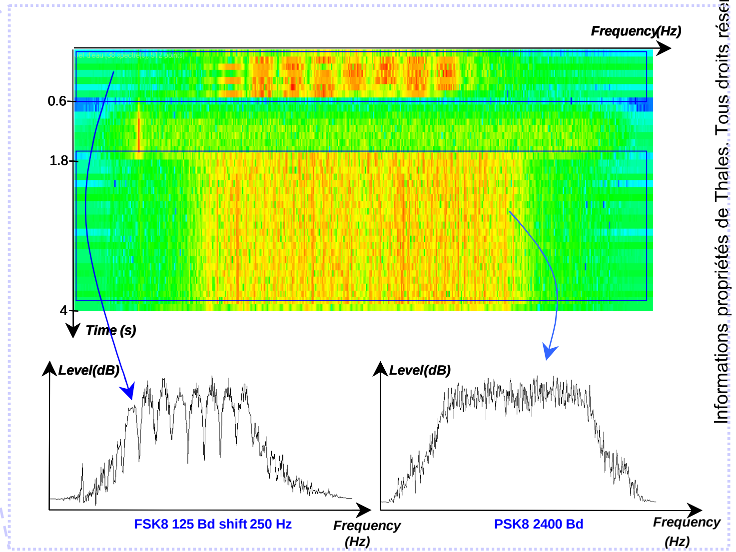


Sub-carrier 1
Synchronization
Tone

Sub-carrier 2
Beacon

Sub-carrier 3
Datas

Deeper analysis of Sub-Carrier 3 : modulation changes



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Annex - Oriented processing of communication signals

E/ Advanced statistical estimators of modulation parameters (cf. ICT QoSMOS)

- **Cyclic Correlations:**
  - First moment order 2:

    2D Fourier Transform (t->α)

    of the correlation

    $R_{1x}(t,\tau)= E[x(t)\ x^*(t+\tau)]$
  - Second moment order 2:

    2D Fourier Transform (t->α)

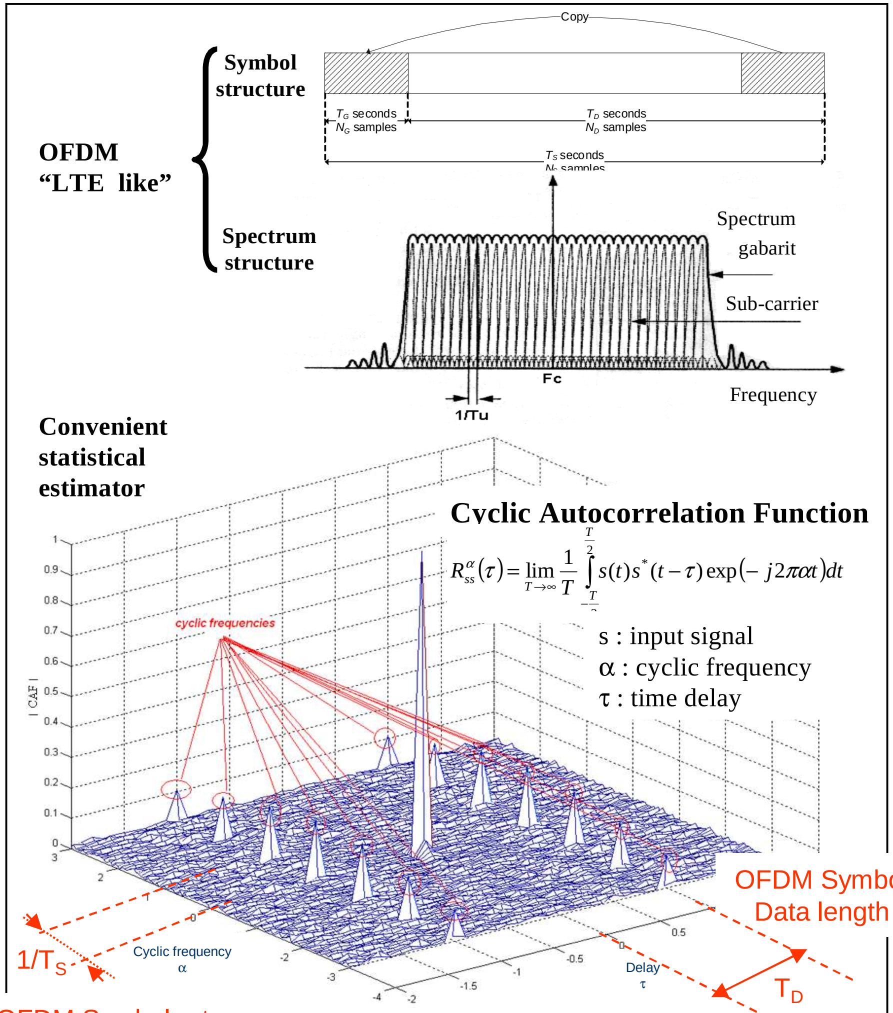
    of the correlation

    $R_{2x}(t,\tau)= E[x(t)\ x(t+\tau)]$
- **Extracts the periodic statistical characteristics of the signal**

  (guard time repetition=>OFDM symbol length)
- **3D representation:** Level versus **and 2D cuts**

  delay τ,

  cyclic Frequency α



Source: COSMOS project

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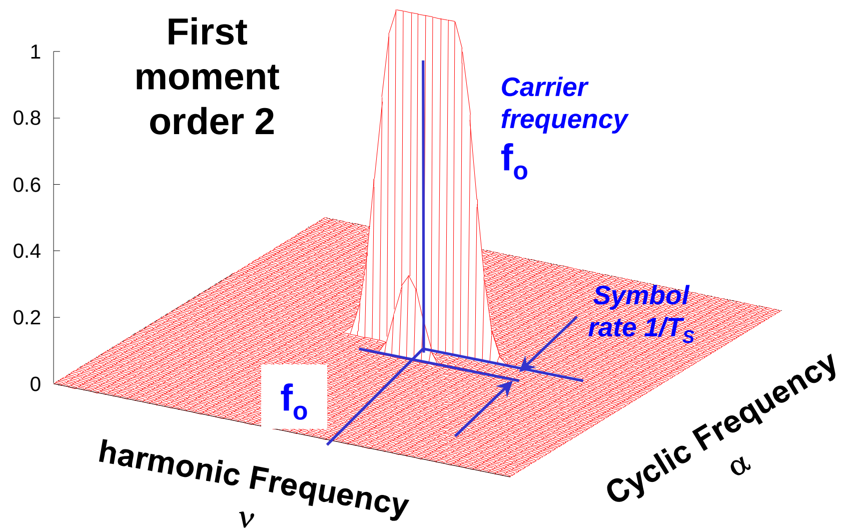
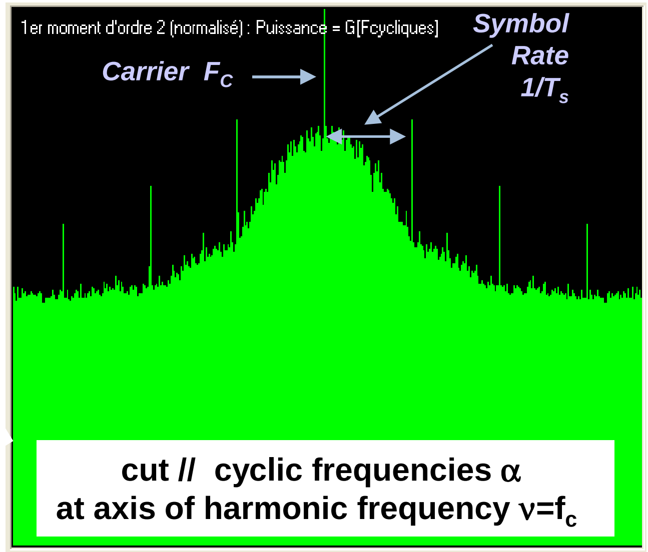
E/ Advanced statistical estimators of modulation parameters

- **Spectrum Correlations**:
  - First moment order 2: 2D Fourier Transform (t->α, τ–>ν) of correlation $R_{1x}(t,\tau)= E[x(t)\ x^*(t+\tau)]$
  - Second moment order 2: 2D Fourier Transform (t->α, τ–>ν) of correlation $R_{2x}(t,\tau)= E[x(t)\ x(t+\tau)]$
- **Extracts characteristics of periodic statistical properties** of the signal (carrier, modulation rate) **without any a priori knowledge (exotic signals)**
- **3D representation and 2D cuts:** Level versus { harmonic Frequency ν / cyclic Frequency α }





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