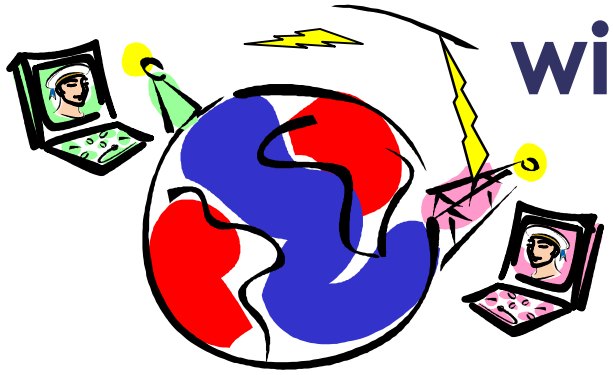
# Spectrum issues for HF wideband communications



HFIA meeting, York (UK), Sept. 6th, 2012

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Thales Communications & Security

# Presentation outline

## Context and motivation

- HF high data rate communications
- Spectrum availability and spectrum management issues

## Spectrum measurements

- Equipment used and measures done
- Measures analysis principle
- Occupations observed in Coulommiers, France

## Application to HF wideband communications

- Taking into account circuit reliability (propagation predictions)
- Comparing achievable throughputs

## Conclusions

# Context and motivation

## Need for tactical BLOS services at an affordable price → IP over HF (64 to 128 kb/s requirements)

→ use more bandwidth (higher spectrum efficiency won't be sufficient)

## … while remaining in a tactical context …

- Avoid using multiple radios (unsuitable except in larger ships/infra sites)
- Use reasonable power figures and tactical antennas

## … keeping capability to interoperate with legacy equipments …

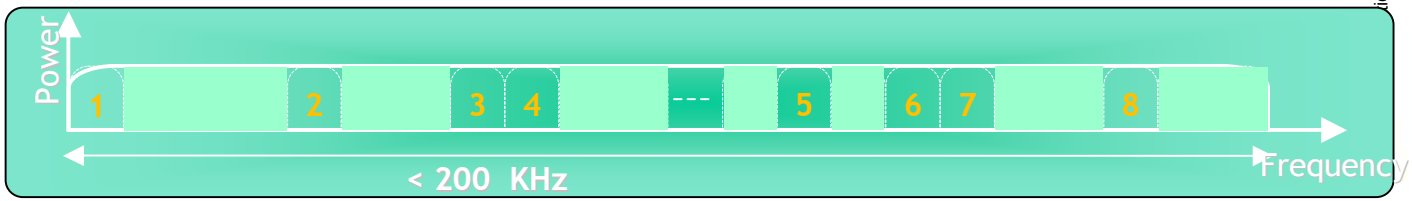
## … respecting spectrum usage & regulations …

- Availability of HF spectrum for larger than 3/6kHz sub-bands ?

## … and meeting SNR requirements for high data rate

## Possible channelizations for wideband approaches

- MIL STD 188 110 C: single carrier up to 24 kHz
- THALES HF XL approach (multi-narrow band approach) : n*3kHz in a 200kHz band



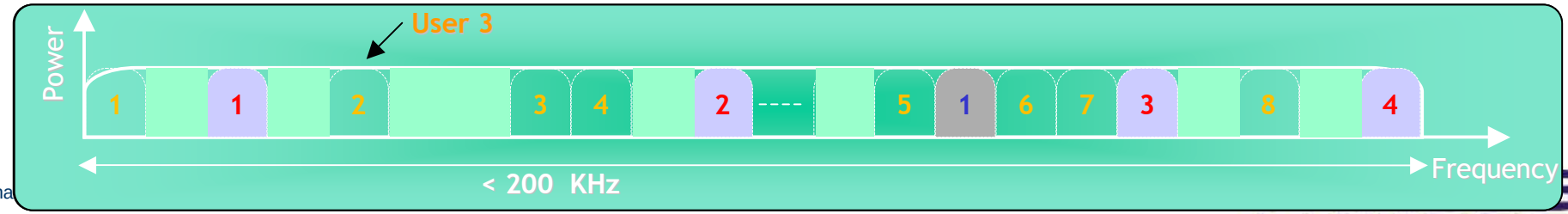
# Context and motivation

## Spectrum availability & management issues:

- Obtaining wideband emission authorizations?
- Dynamic management of wideband spectrum allocations ?
- Real-life availability of the bands (interferers, multiple use, …)

## Obviously …

- From HF users experience, 24kHz free allocations should be very difficult to obtain (impossible?)
- n*3kHz can be found much more easily than 1*24kHz
  - Typically, in 200kHz, one finds $\binom{66}{8} \approx 6.10^{9}$ possibilities for 8 non contiguous 3kHz allocations, to be compared to 59 possibilities for contiguous allocations !!
- Allowing use of non contiguous allocations will permit sharing with other users, adaptation to pre-existing allocations/unvoluntary jammers



# Context and motivation

## Is it better to use contiguous vs. non contiguous n*3kHz sub-bands?

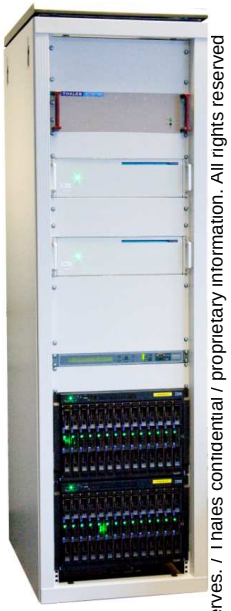
- **Let's imagine that**
  - the whole HF band is available
  - no other distant user will be disturbed by our emissions if we cannot detect them
- **and evaluate availability of contiguous and non contiguous spectrum allocations**
  - Placing us in real life conditions
  - Counting the number of "free" (i.e. not used) channels, whether 3kHz, 12kHz or 24kHz

Let us address in the following the issue of spectrum availability (for contiguous or non-contiguous n*3kHz) **independently of emission rights**

# Measures done

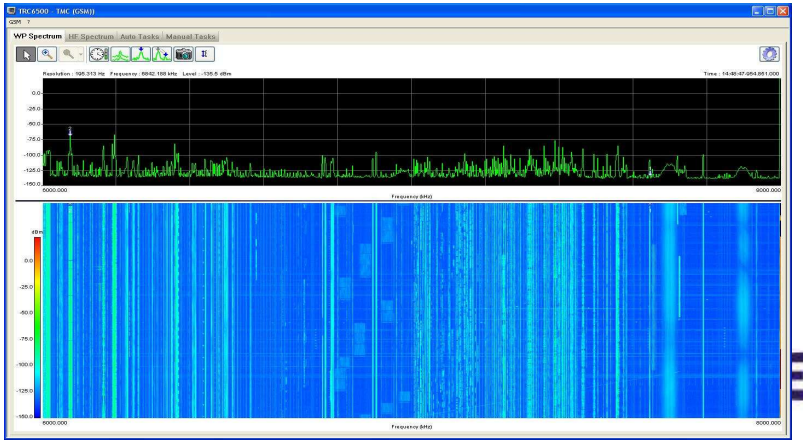
## Spectrum acquisitions for off-line analysis

- Location : Coulommiers, France
- Acquisitions in : Oct. 2011, Jan., March, April and May 2012
- Using THALES TRC6500 electronic warfare product for signal acquisition in HF band



## Acquisitions resolution for each spectrogram

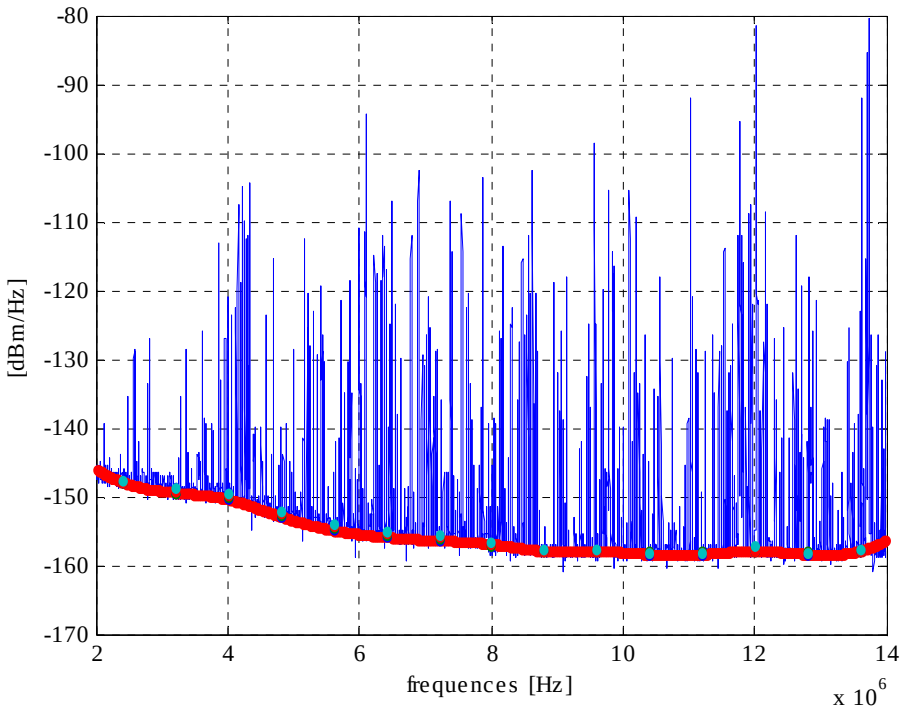
- 12 MHz band
- 24 hours continuous acquisition



# Measures done

## Exploiting the measures done

- **Step 1: estimation of noise level by statistical derivation of the noise level for each spectrogram**
  - Window considered: 1MHz x 15s
  - Hypothesis : normal distribution model







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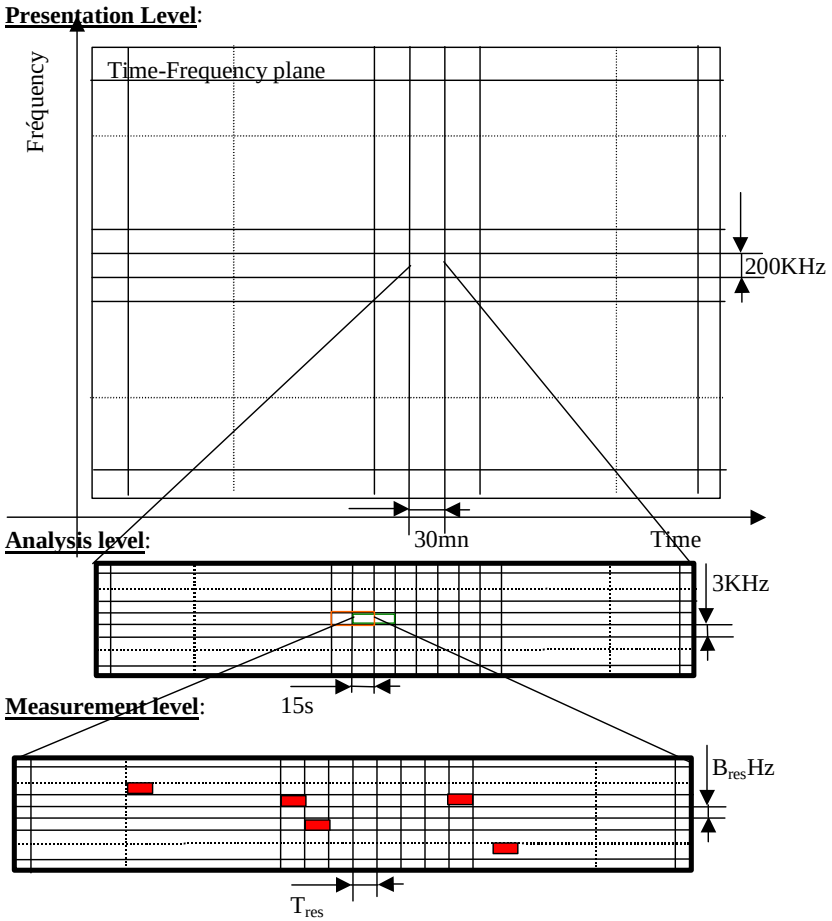
# Measures done

## Exploiting the measures done

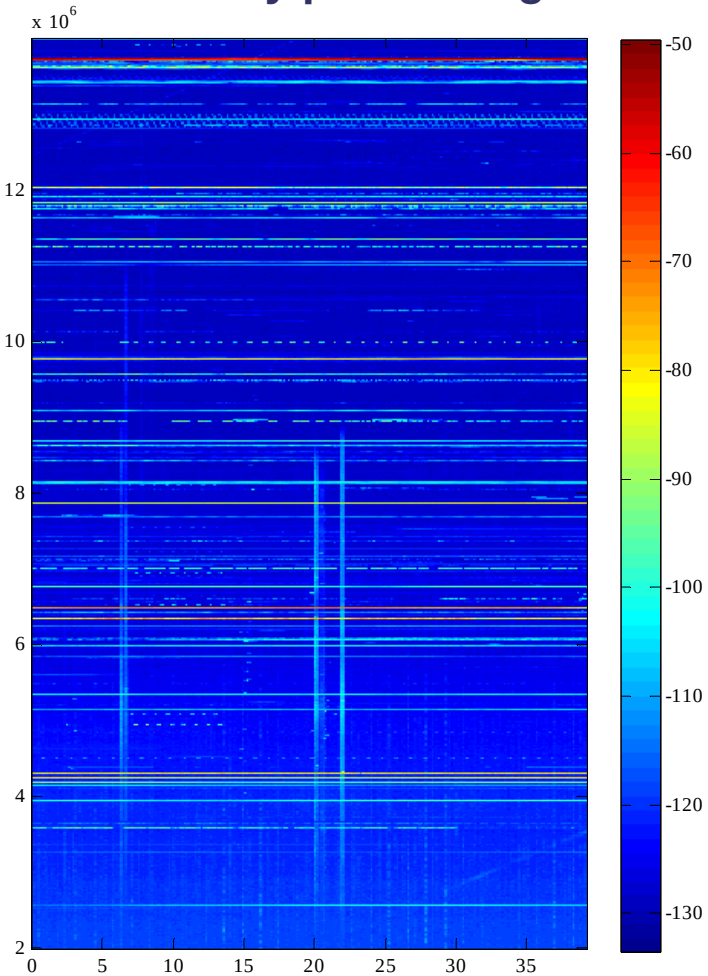
- **Step 2 : estimating availability of time/frequency elementary cells**
  - Threshold : INR < 3dB (no interferer accepted above twice the estimated noise level)
    - This includes power test over each cell to remove strong pulse interferers
  - Counting number of cells with respect to 3/4 ratio corresponding to error correction capability



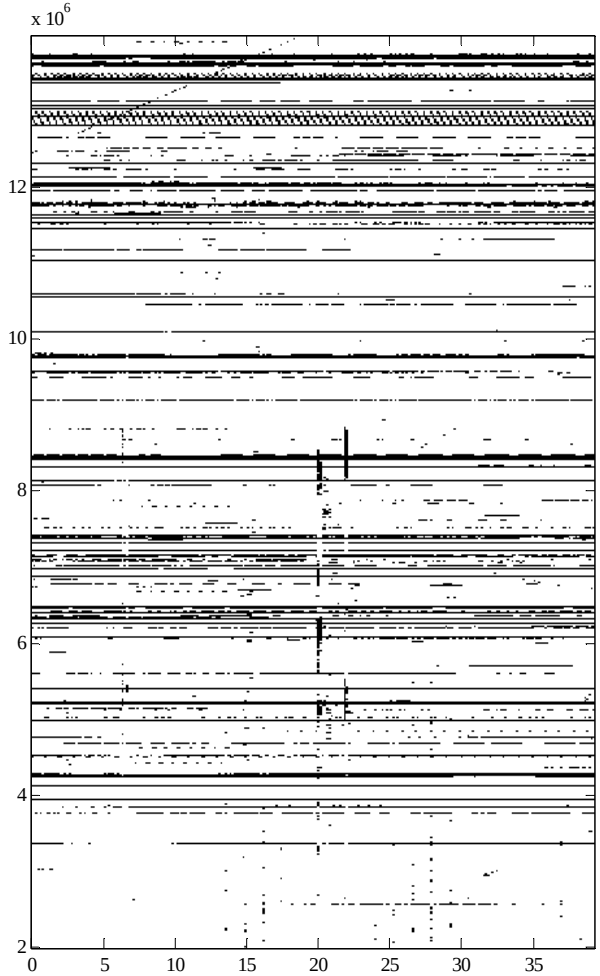
# Measures done

## Illustrations: elementary availability

- Obtained by processing with respect to noise level : INR<3dB




Acquired spectrogram (subset)




Elementary availability (white: available)







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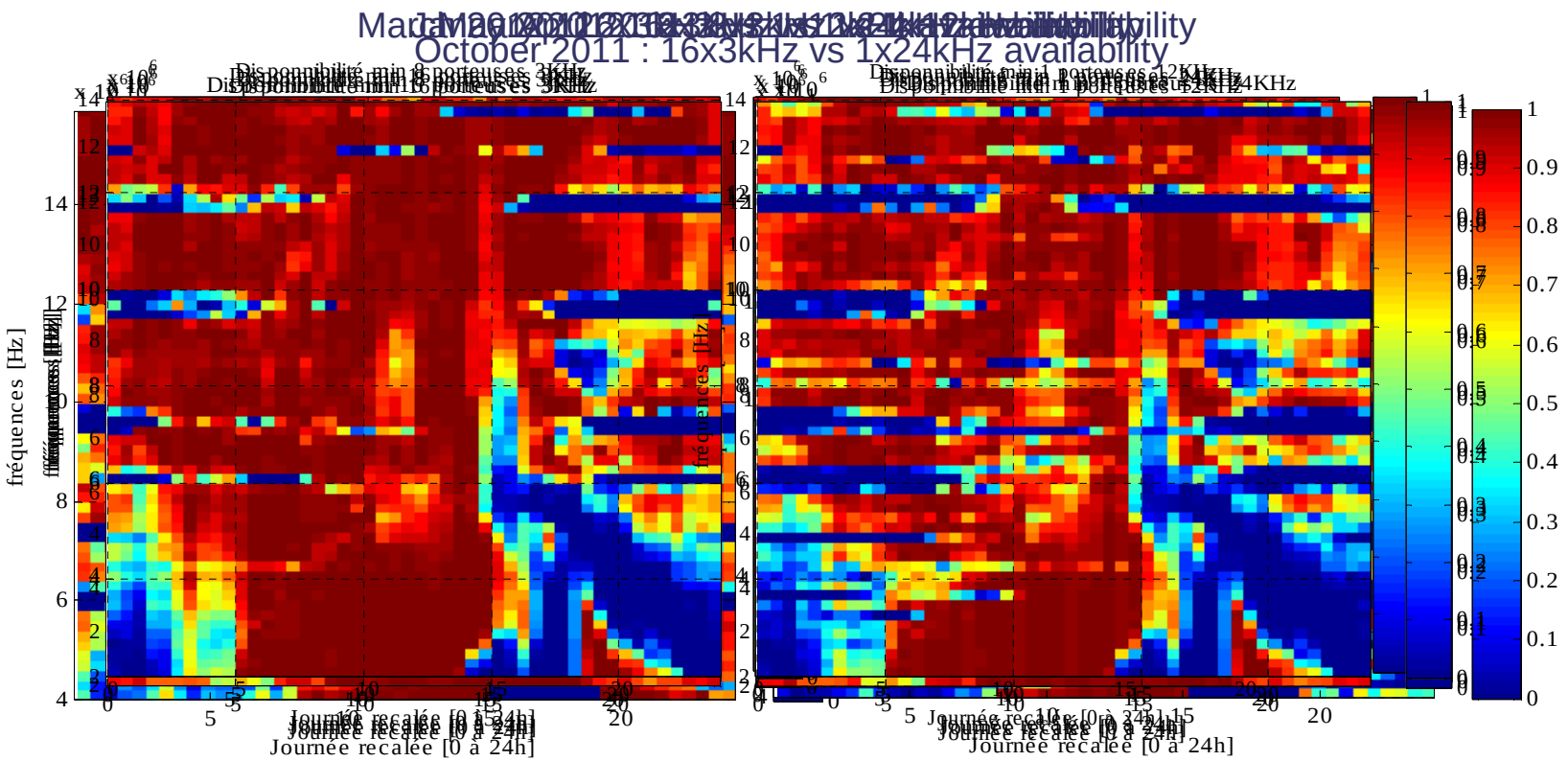
# Disponibility values

## Occupations observed in Coulommiers, France

- Comparing contiguous (1x12kHz or 1x24kHz) and non-contiguous (8x3kHz or 16x3kHz availability)







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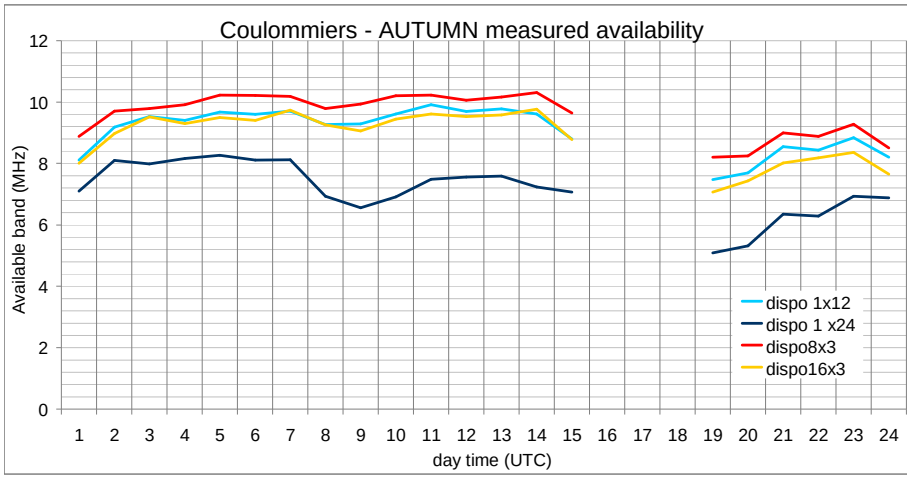
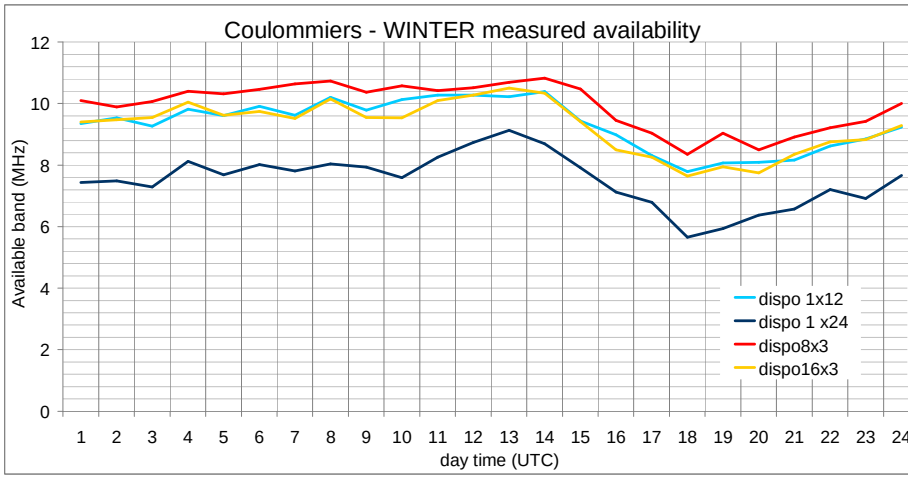
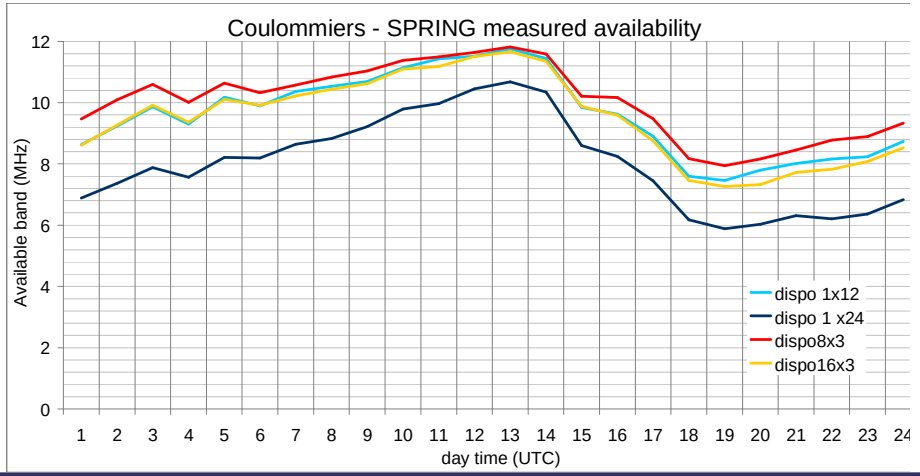
# Measures done

## Averaging in terms of measured availability:




**Availability of non contiguous 16x3kHz close to availability of contiguous 1x12kHz !!**

**Free contiguous 24kHz bands are rare … and often found in spectrum parts that won't be usable in practice (impossible to establish circuit)**

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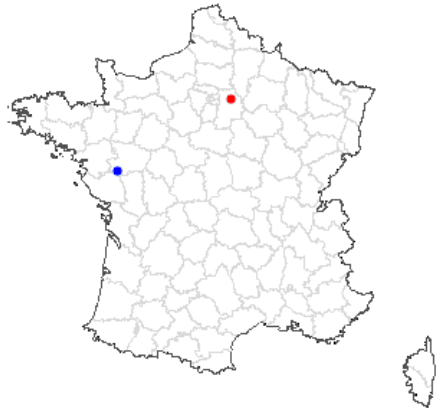
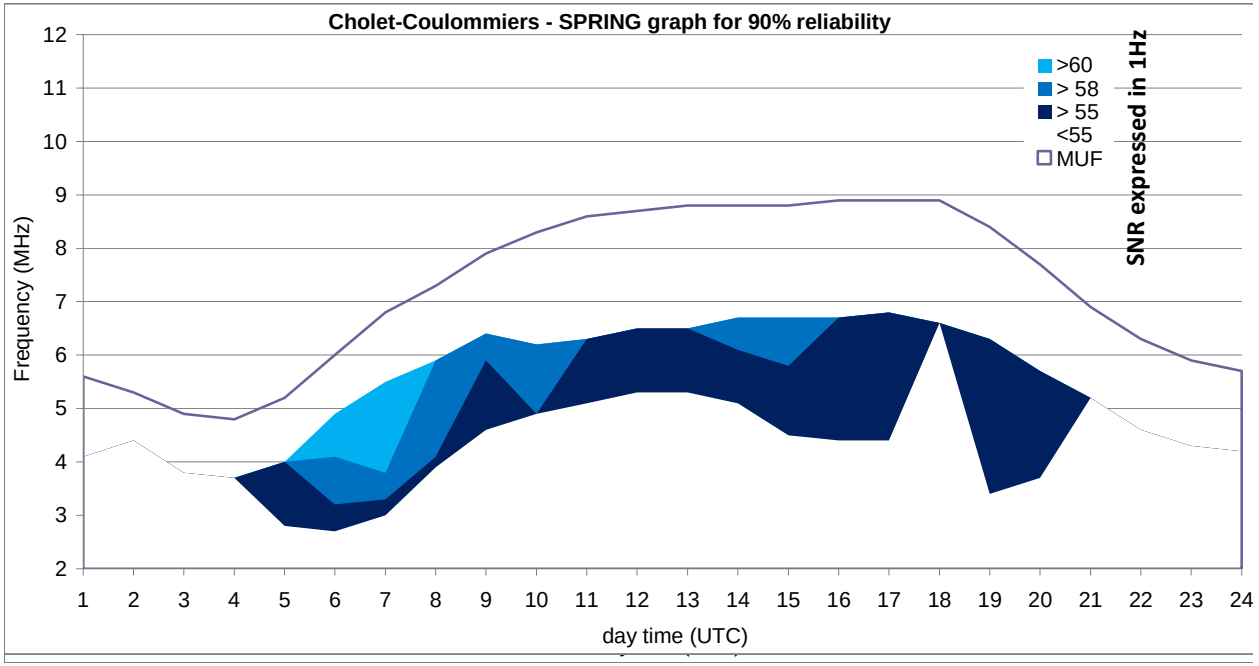
# Measures analysis

## Circuit considered: Cholet → Coulommiers



- **ICEPAC**
  - THALES NVIS wideband antenna “Butterfly”
  - TX power: 400W PEP
  - RX noise: rural calm
  - Required SNR : based on MIL STD 188 110C requirements







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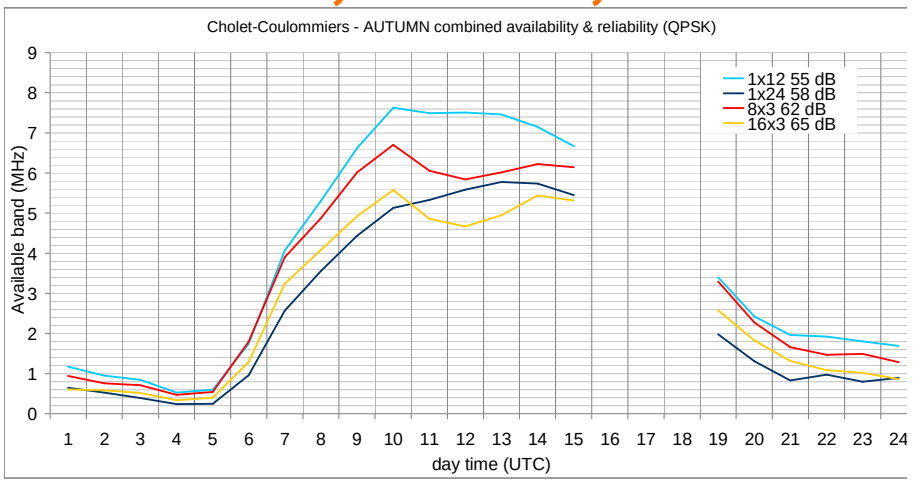
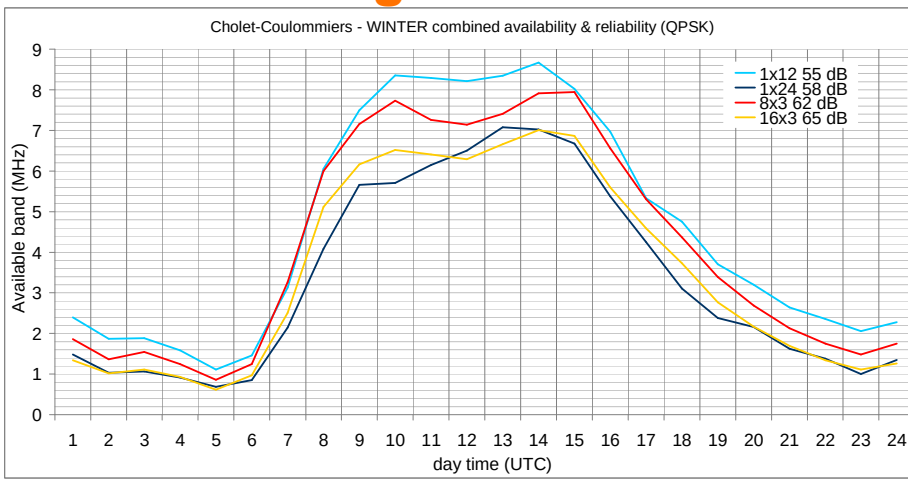
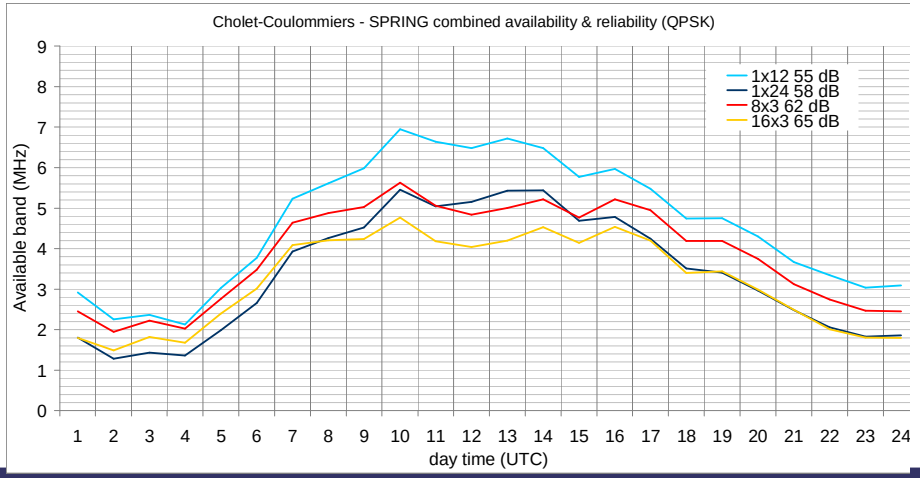
# Measures analysis

## Combined availability and reliability for QPSK modulation for 1x12kHz, 1x24kHz, 8x3kHz and 16x3kHz configurations



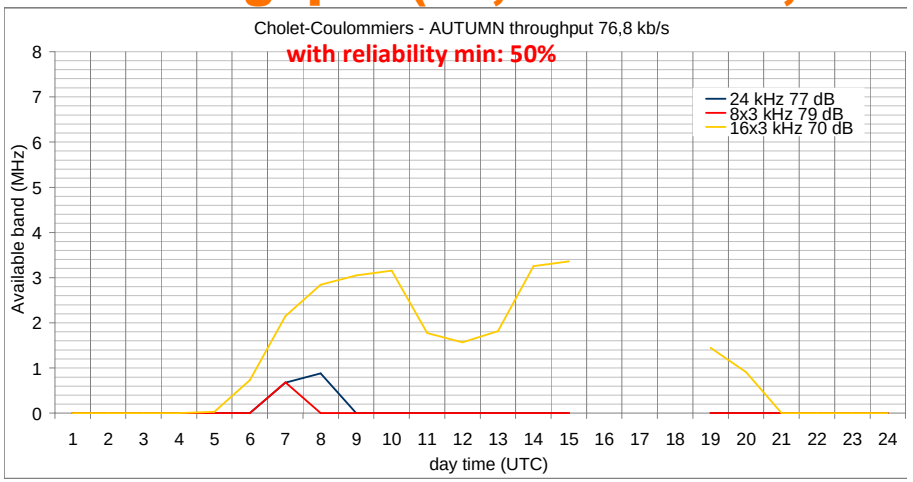

**Better availability for 12kHz due to lower SNR req. (half throughput)**

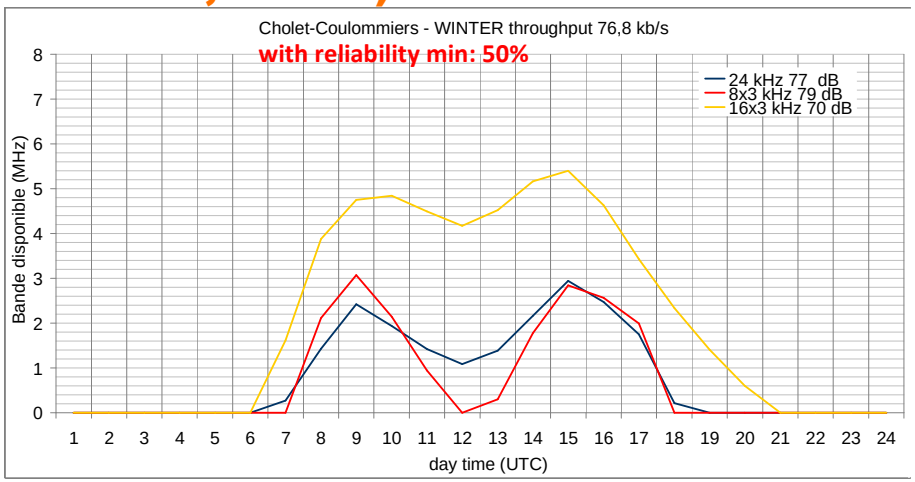
**Back-off cost for multi-carrier easily compensated for 8x3 vs. 24**

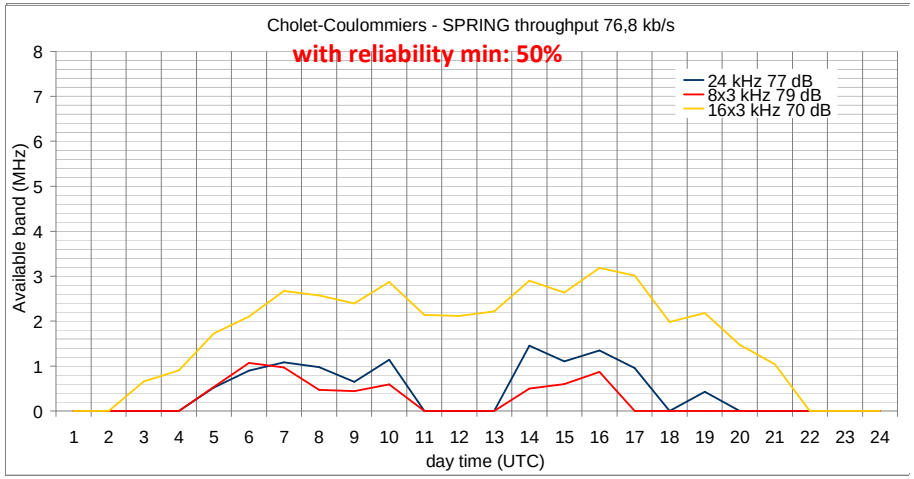
**16*3kHz often better than 24kHz (and double throughput)**

# Measures analysis

## Combined availability and reliability for same achieved throughput (25,6 kb/s – 51,2 kb/s and 76,8 kb/s)




**Reaching higher throughputs with XL approach !!**

# Conclusions

**Finding a block of 12 to 24kHz (contiguous) free and authorized spectrum in LUF/MUF is much more difficult than n*3kHz**

- Issue of pre-existing allocations (world-wide)
- Issue of dynamic spectrum management

**Furthermore, and independently of this issue, it appears that:**

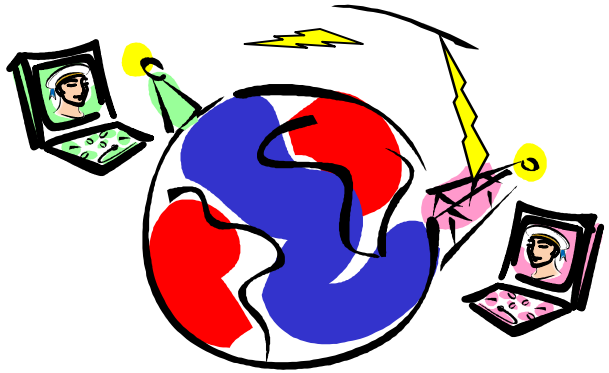
- XL multiple narrow band approach allows to reach higher throughputs
- XL multiple narrow band approach offers a better spectrum availability
- XL multiple narrow band approach is much more flexible in terms of operational use

**Key observations:**

- 8*3kHz availability better than contiguous 12kHz and obviously than 24kHz
- 16*3kHz availability ~ contiguous 12kHz availability!

**Key observations: high data rate communications (64kb/s) obtained with good reliability in XL approach (taking into account back-off cost)**

A revision of STANAG 4539 to introduce wideband modems according to MIL STD 188 110C solutions should also standardize multi narrow band (n>2) approach.



# Thanks for your attention

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and grateful thanks to our colleagues
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