Wideband HF transmissions: towards wideband ALE

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Context

On the interest of wideband reception for ALE improvement

◆ **Proposed mechanism principle**

Principle of application to asynchronous ALE

Principle of application to synchronous ALE

Preliminary Results

Conclusions

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Several issues raised on the capacity for the end-user and a system to use in practice the wideband HF capability

◆ **Finding the "good" frequency**

   ⭘ Not anymore only one that is available and between LUF and MUF

   ⭘ Issue of bandwidth actually available

➔ **Obviously the answer is an ALE/ALM mechanism adapted to wideband capability**

Question raised by M Jorgenson last BLOS Comms meeting : "what sort of next generation ALE do we need?"

◆ **Accelerating ALE phase (only ?)**

◆ **Considering the total time of transmission rather than establishment**

   ⭘ in particular for large data transmissions

◆ **Backward compatibility ? Which ?**

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A need for both capabilities : quick & good quality

◆ **Accelerating link setup (especially for voice)**

◆ **Optimise linking time to required service and protocols**

- High quality channel for large data blocks
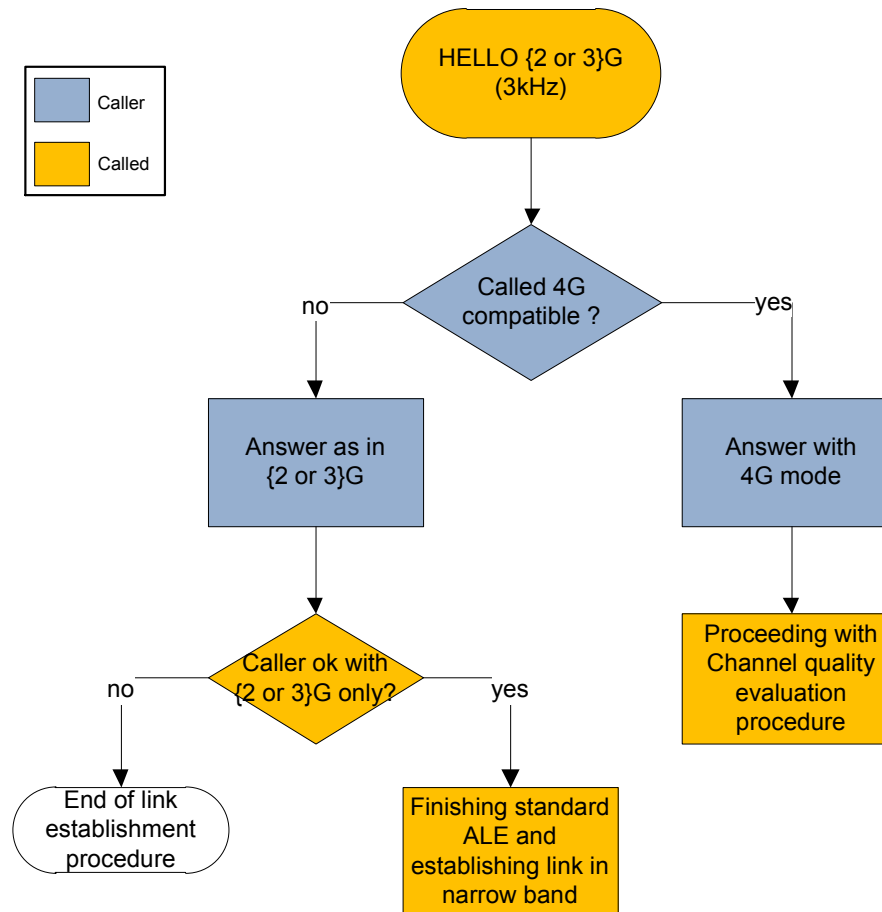- Short latency for short messages

A need for interoperability

◆ **To ensure the cohabitation of narrow band only users with wideband ones**
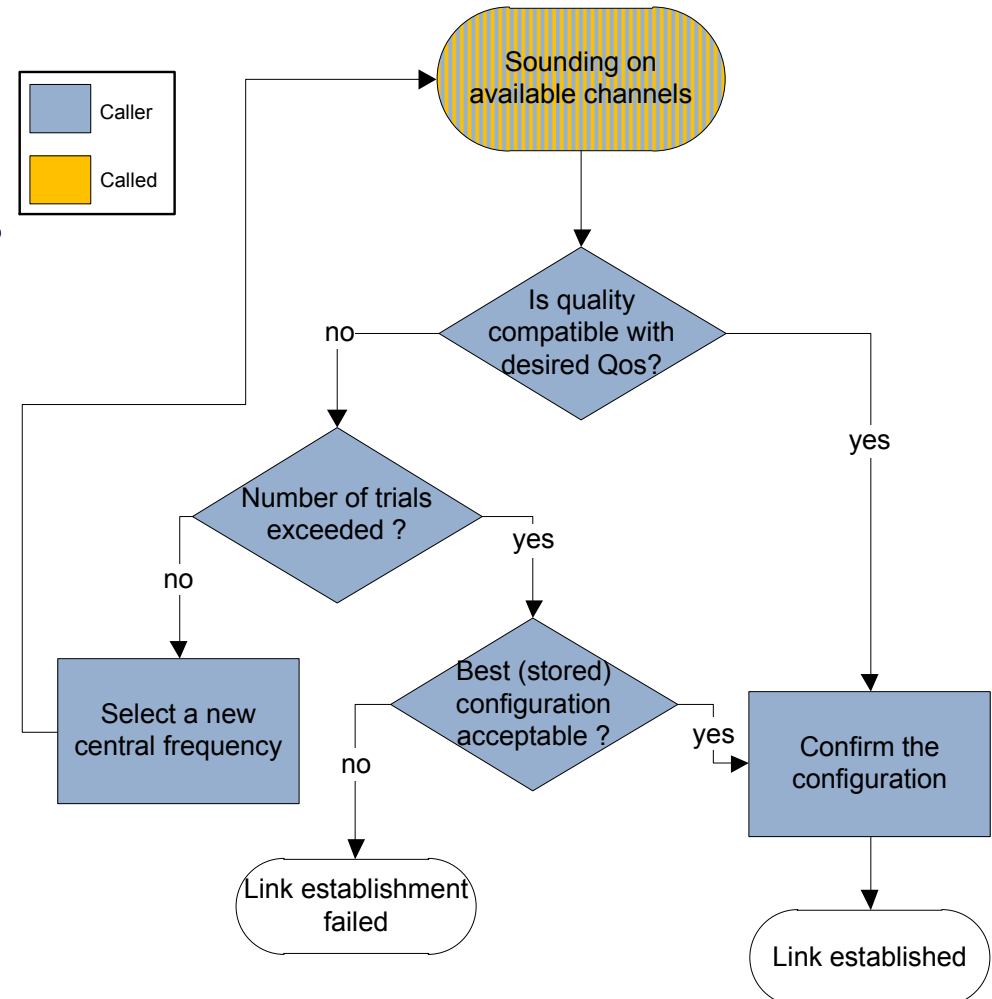
ALE Process principle

◆ **Narrow band link set up (asynchronous or synchronous)**

- Allows for interoperability

◆ **Sounding phase and 4G link establishment**

- Capable of WBHF or HFXL

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Phase "3kHz" : Compatibility with legacy radios

- Caller
- Called

HELLO {2 or 3}G (3kHz)

Called 4G compatible ?

no → Answer as in {2 or 3}G

yes → Answer with 4G mode

Caller ok with {2 or 3}G only?

no → End of link establishment procedure

yes → Finishing standard ALE and establishing link in narrow band

Proceeding with Channel quality evaluation procedure

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Phase "wideband" : Principle

- ◆ **Performing a sounding for the different channels available**
    - ○ Allowed for transmission
    - ○ Not already estimated (LQA)
- ◆ **Possibly iterating over different central frequencies**

■	Caller
■	Called

Sounding on available channels

Is quality compatible with desired Qos?

no

yes

Number of trials exceeded ?

no

yes

Select a new central frequency

Best (stored) configuration acceptable ?

no

yes

Confirm the configuration

Link establishment failed

Link established

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Phase "wideband" (cont.) : applicability

- ◆ **Foreseen application for WBHF waveform**

  - ○ determine the available 3kHz channels to determine max usable bandwidth and offset

- ◆ **Foreseen application for HF XL waveform**

  - ○ Determine the central frequency and n contiguous or non-contiguous channels usable for transmission

- ◆ **Foreseen application for efficient HF transmission**

  - ○ Taking into account CALLED capabilities, requested QoS and channel quality, determine the best waveform to use and its configuration

Going further: ALE set-up time reduction

- ◆ **Analysis of ALE procedure shows the large impact of scanning**

- ◆ **Interest to find a solution to improve ALE performance**

- ➔ **An axis that must be studied: determine the possible usage of (very) wideband reception for improving ALE performance**
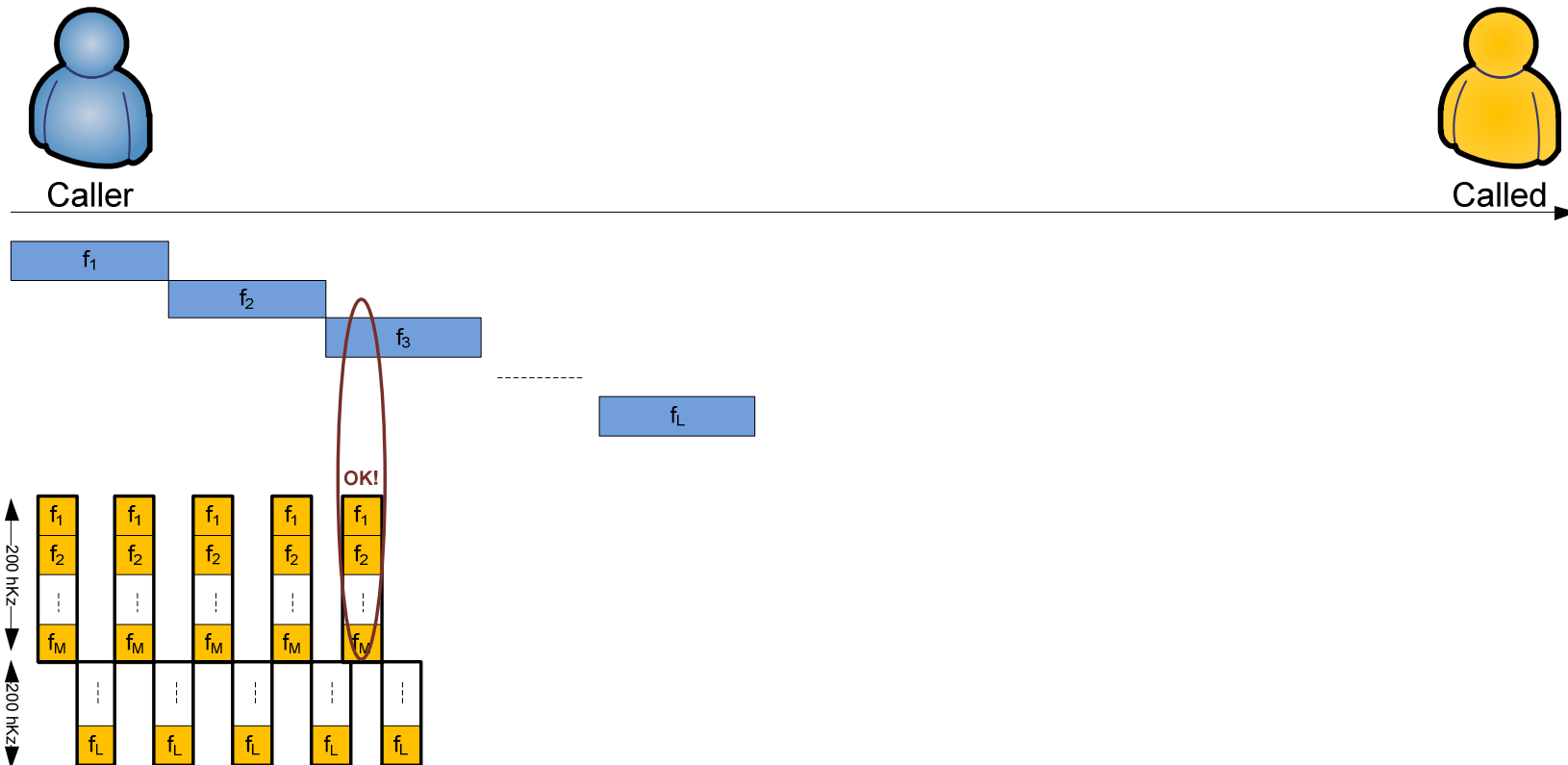
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Wideband capability ... that is:

◆ **Going beyond the classical paradigm of channel scanning 3kHz by 3kHz (or even 24kHz by 24kHz for WBHF)**

◆ **Listening not only over 3 or 24kHz but 200 kHz or more**

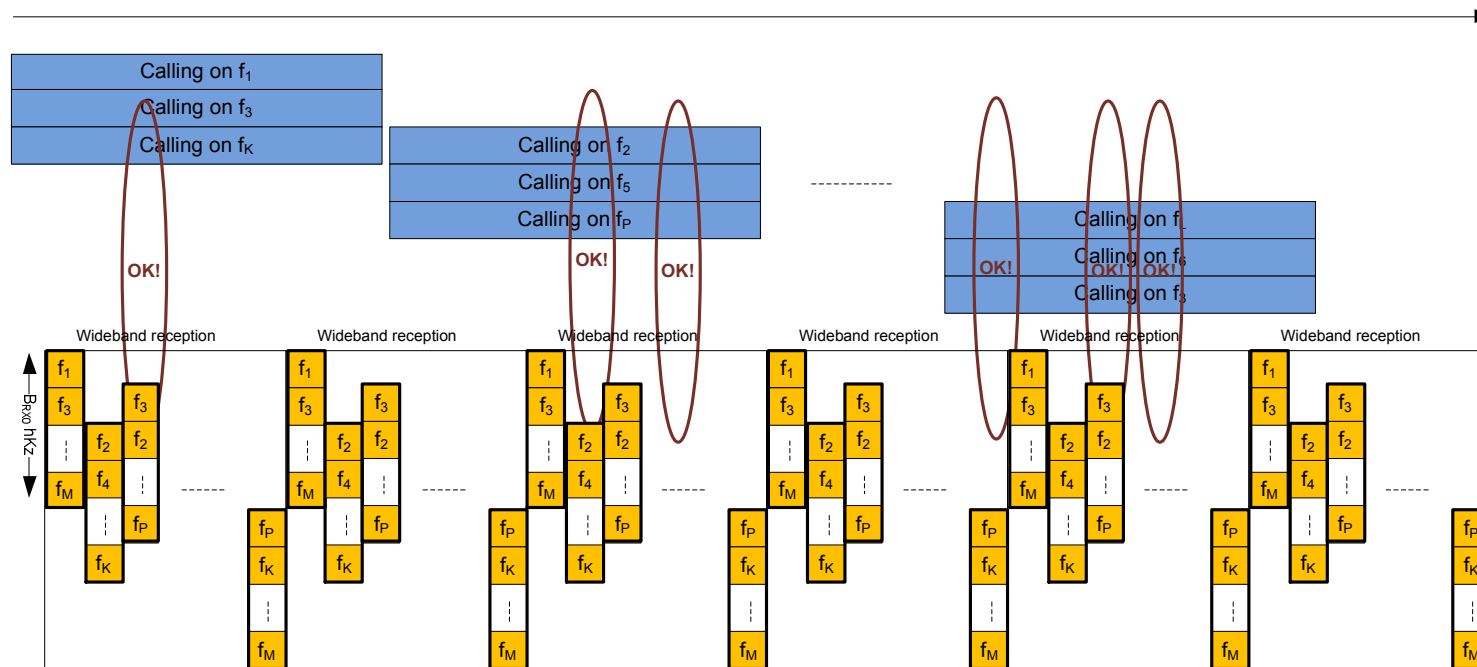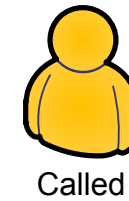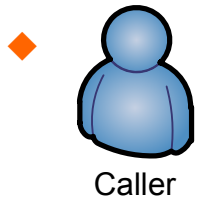 ○ Capability to listen over several 3kHz channels at the same time, possibly entwined
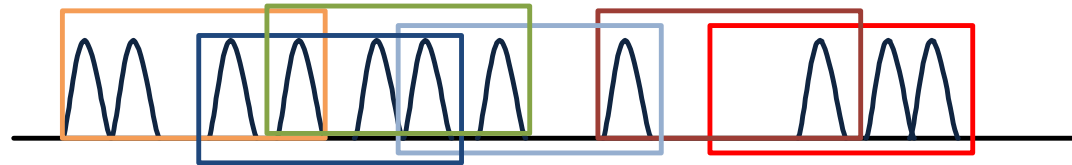
◆ **This will result in quicker average set-up link time … but also in a better capability to estimate several channels and consequently to select the best one !**
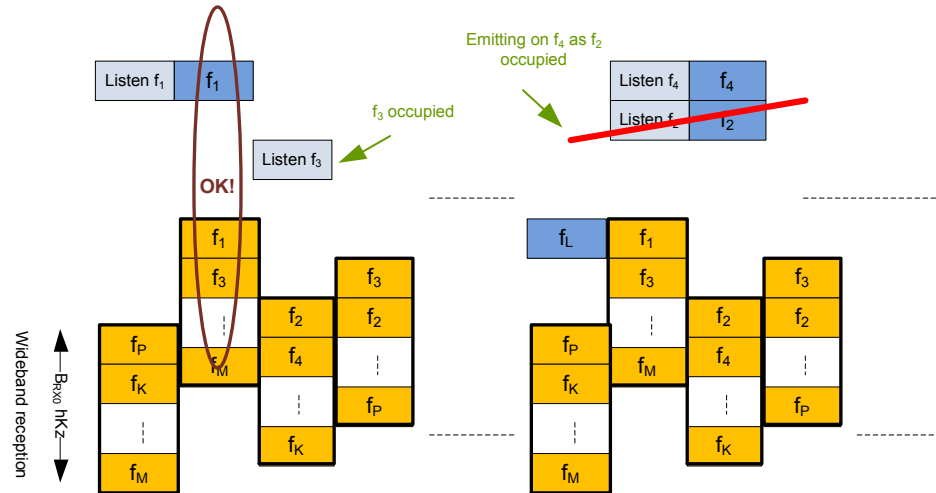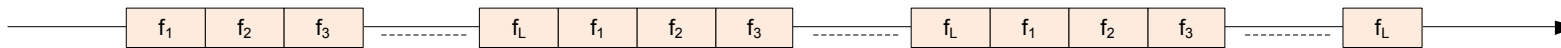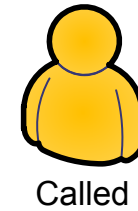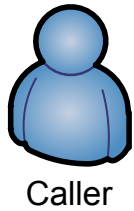
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Listening over wideband for ALE : asynchronous case

◆

Caller

Called

f$_1$

f$_2$

f$_3$

- - - - - - - - -

f$_L$

OK!

f$_1$	f$_1$	f$_1$	f$_1$	f$_1$
f$_2$	f$_2$	f$_2$	f$_2$	f$_2$
⋮	⋮	⋮	⋮	⋮
f$_M$	f$_M$	f$_M$	f$_M$	f$_M$

←200 hKz→

←200 hKz→

| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| f$_L$ | f$_L$ | f$_L$ | f$_L$ | f$_L$ |

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Listening over wideband for ALE : taking into account wideband emission capability (example of asynchronous case)

◆

Caller

Called

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Listening over wideband for ALE : synchronous case

◆

Caller

Called

| f_1 | f_2 | f_3 | ---- | f_L | f_1 | f_2 | f_3 | ---- | f_L | f_1 | f_2 | f_3 | ---- | f_L |

Emitting on f_4 as f_2 occupied

Listen f_1 | f_1

Listen f_4 | f_4

Listen f_2 | f_2

f_3 occupied

Listen f_3

OK!

Wideband reception
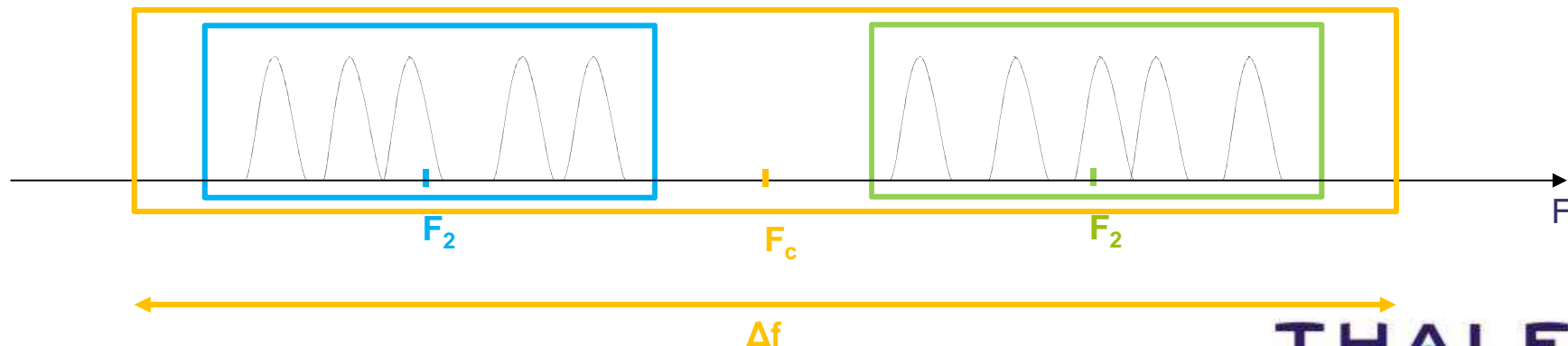
B_{RX0} hKz

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Proving the feasibility of the very wideband ALE approach

◆ **Listening to several channels disseminated over several 100kHz simultaneously**
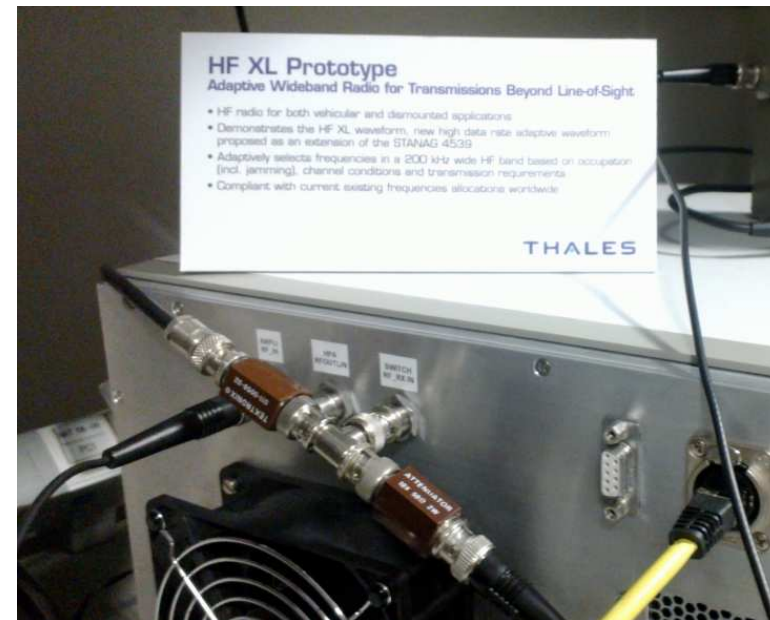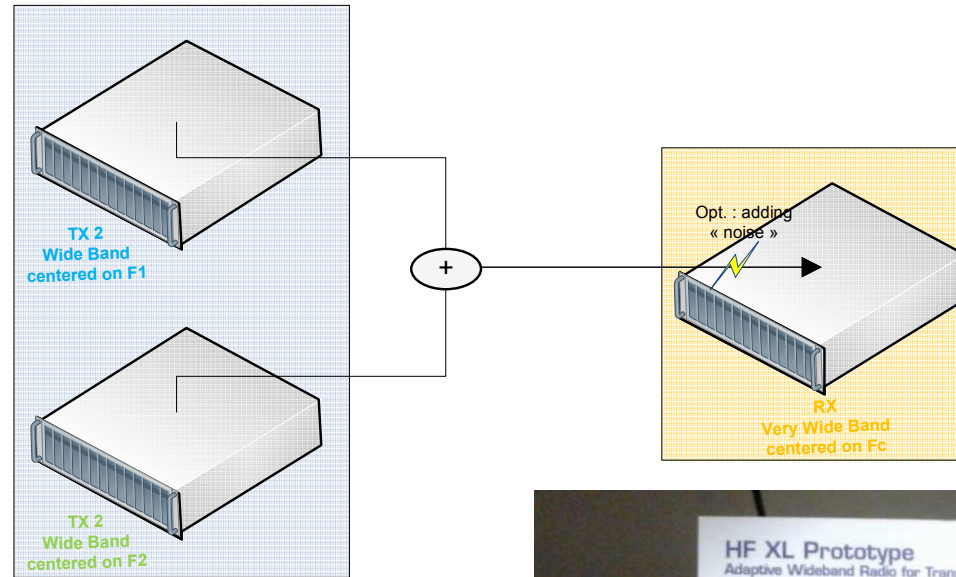
  ○ Considering a band Δf around F_c central frequency

  ○ Sending 10 carriers spread over this Δf band at the same time

◆ **HF XL test bench: used settings**

  ○ Considering a band Δf around F_c central frequency

  ○ Using two sets of 5 carriers (each over 200kHz of band with central frequency resp. F_1 and F_2)

  ○ Each carrier modulated in XL waveform with various delay to represent random access to channel

  ○ Estimating the SNR for each listened channel and selecting as ALE candidate the one with best SNR.

F_2 F_c F_2 F

Δf

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Practical implementation with HF XL test bench

TX 2
Wide Band
centered on F1

TX 2
Wide Band
centered on F2

+

Opt. : adding
« noise »

RX
Very Wide Band
centered on Fc

Preliminary results obtained with HF XL test bench

◆ **example with Δf=500kHz**

Preliminary results obtained with HF XL test bench

◆ **example with Δf=800kHz**

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Conclusions
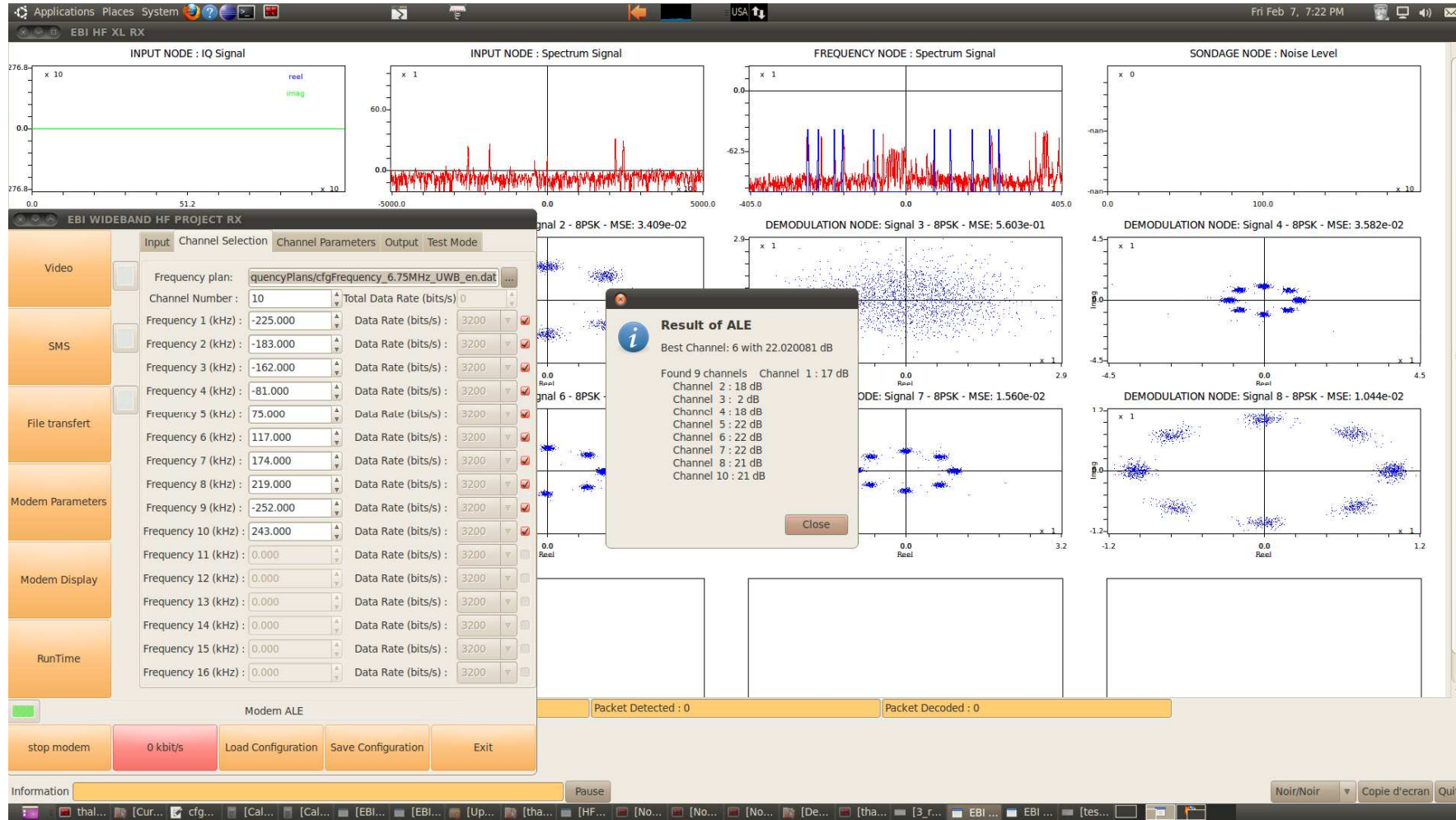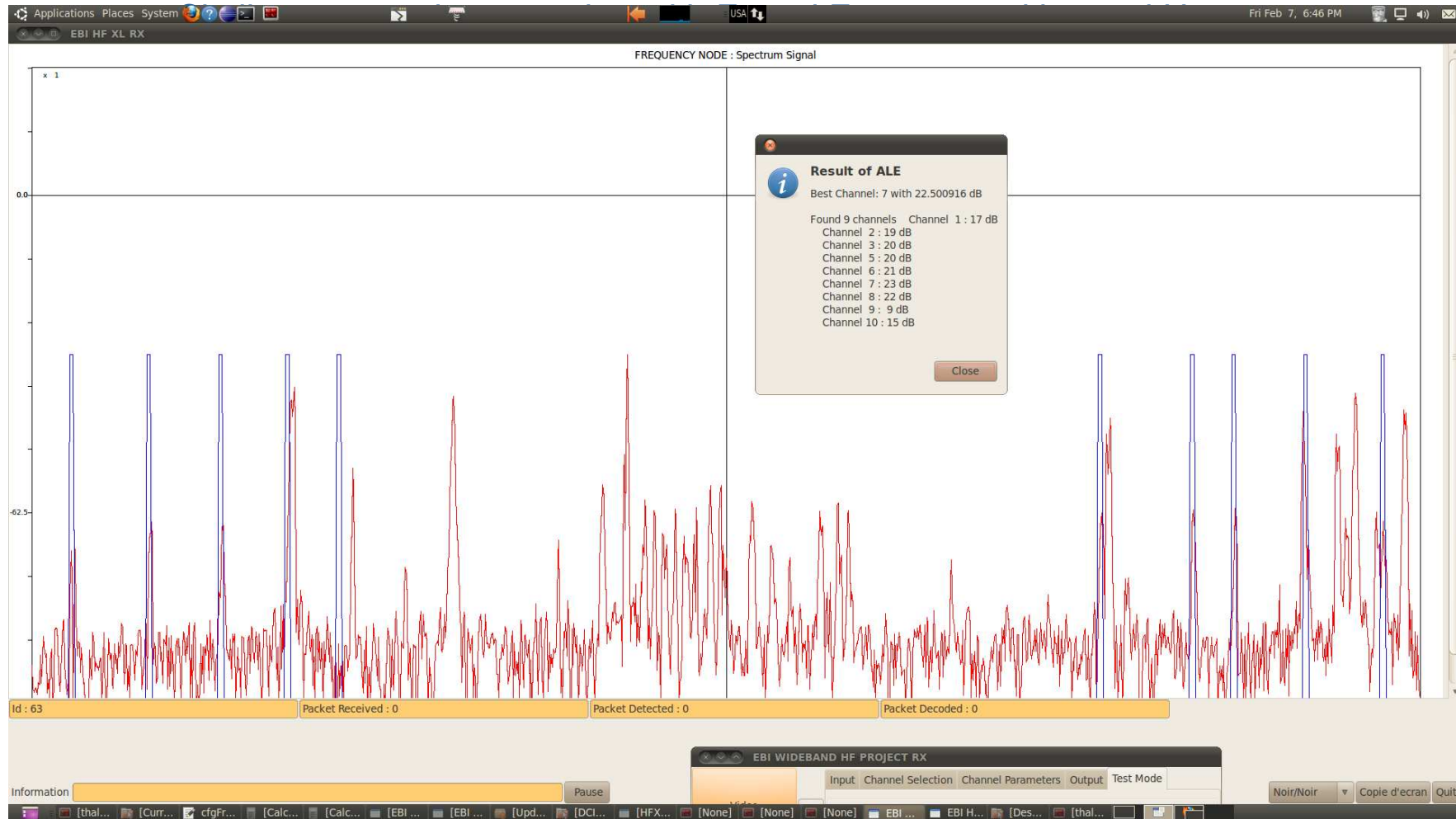
A new ALE procedure is mandatory for efficient use of new high data rate wideband waveforms proposed recently, as also pointed out by Harris and Rockwell-Collins companies

- ◆ **Large interest to have compatibility with existing ALE procedure, to ensure cohabitation of wideband radios in today's narrow band radio world …**

- ◆ **It would be interesting to have at least two profiles depending on the service**
  - ○ Maximal link establishment speed (for phony and short messages)
  - ○ Best total transmission time (for large messages)

Wideband analysis (the wider, the better under system sensitivity limits) is applicable to both WBHF and HFXL waveforms

- ◆ **One study axis is the analysis of the interest of using wideband in both asynchronous and synchronous domains, and the evaluation of its performance in both case**

- ◆ **Further work on wideband ALE will be carried on within the French MOD contract PEA SALAMANDRE.**

THALES will be happy to participate to the definition of a wideband ALE standard allowing usage of both WBHF and HFXL waveforms

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Thanks for your attention

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