THALES

# HFXL Sea Trials on French BPC in Mediterranean sea

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# Mediterranean sea trials - Introduction

## Introduction

- After successful ground and ionospheric trials in December 2016 between Toulon and Paris, the French MOD has decided to set-up a sea conditions trial in the Mediterranean sea


Image source: O H 237/Wikipedia
https://commons.wikimedia.org/wiki/File:Carte_Mediterranee_02.jpg

## Objectives for the trials

- Validate the HF XL concept with sea-wave propagation
- Analyze the sea-wave to sky-wave (ionospheric) transition
- Prove HF XL high data-rate and link reliability over sea

all this with using Vertically polarized antennas (to avoid NVIS propagation)

# Mediterranean sea trials – set-up

## Trials conditions

- Tests performed in June 2017 between Toulon (fixed, shore site)
  - 10 m whip antenna+antenna tuning unit on the beach
  - 400 W Amplifier / SALAMANDRE demonstrator nr 1
- and Dixmude, Mistral class amphibious assault ship
  - 10 m vertical wide-band antenna
  - 400 W Amplifier / SALAMANDRE demonstrator nr 2
- Various services tested, simultaneously operated for performance and reliability assessment
  - Chat (very useful to exchange trial/field information, …)
  - HTML
  - Automated Mail
  - FTP (file transfer for position reporting)

French MOD test facility (shore station)
10 m whip antenna at beach level

Par Simon Ghesquiere/Marine Nationale — Travail personnel,
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# Mediterranean sea trials - Results

## Before seeing the “official” trial results, let us give the floor to the “real HF experts in the world”, namely … HAM guys!!


Image source: http://cliparts.co/clipart/2734452

- SWL I5-56578 Antonio and some of his friends recorded “strange HF signal”
- They made a detailed analysis of the signal, you can see at
  - http://i56578-swl.blogspot.it/2017/06/stanag-4539-in-multichannel-mode-thales.html
  - http://i56578-swl.blogspot.it/2017/06/thales-hfxl-modem-salamandre-tests-go-on.html

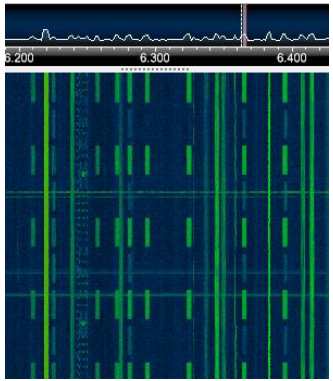
# Mediterranean sea trials – Results from HAM analysis



**10 June 2017**

## STANAG-4539 in multichannel mode: Thales HF XL modem (likely "SALAMANDRE" tests)

tags:HFXL,STANAG-4539,STANAG-4539 Annex H,THALES




This system has been copied on 9 different simultaneous channels from ~6200 to ~6400 KHz on USB during 9 June morning. The analysis reveals it's a STANAG-4539 modem (frame length is 287 PSK-8 symbols) running at different data signaling rates at constant 2400Bd data rate. The system uses bursts and (possibly) ARQ mode. My friend Karapuz too copied this system but on a different HF segment.

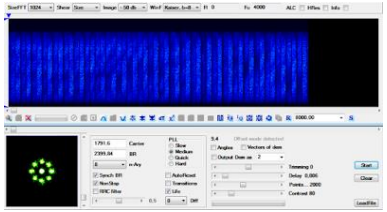


Fig. 1

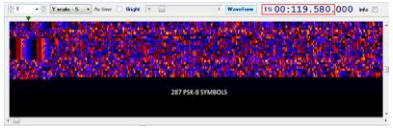



Fig. 2

The decisive contribution for the identification of the signal came from my friend ANgazu: he suggested that these transmissions could be the Thales HFXL modem, since they use up to 16 narrowband channels in 200 Khz bw just using 4539 waveforms. Most likely, the heard transmissions are tests related to the Thales /French MOD contract: PEA "SALAMANDRE".

Indeed, as depicted in Thales presentation of the HFXL modem:
http://www.hfindustry.com/meetings_presentations/presentation_materials/2013_jan_hfia/presentations/8-HFIA_HF_modemXL.pdf
they uses an evolution from the SANAG-4539 frame structure, mainly differing in the preamble parts as shown in Figure 3

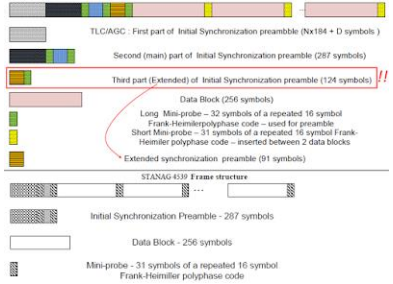



Fig. 3

Other than the long miniproble (32 symbols length rather than 31), they added a third 124 PSK-8 symbols part (termed "Extended") to the S-4539 initial synchronization preamble. The data block length (256 symbols) and the mini probe length (31 symbols) remain unchanged so that the period counts 287 symbols as in S-4539 (Figure 2). The extended synchronization preamble is specific to HF XL. This part, not included when operating according to S-4539 or MS 188-110C ISB modes, is combined with the main preamble to carry all information necessary to the HF XL waveform, in particular information on modulation choice for each channel. Furthermore, a specific redundancy capability is introduced, that ensures resilience to the loss of a channel as long as the number of channels is greater or equal to 3.

A deeper look at the preamble of one heard transmission confirms the Thales HF XL modem, as depicted in Figures 4,5

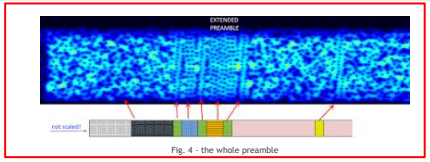



Fig. 4 - the whole preamble

Fig. 5 - the 124 symbols (51.6 msec) added by Thales

As further confirm, ANgazu measured the parts of the preamble (Fig. 6) and time durations fit perfectly:

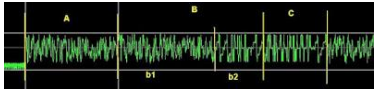



Fig. 6 - parts durations in HF XL preamble

A: syncronization preamble (76 ms)
B: initial sync 287 symbols (b1 of 184 and b2 of 103 symbols)
C: extended Thales preamble (124 symbols)

The adaptive wideband HF waveform termed "HF XL" relies on the usage of several non-contiguous 3 kHz channels spread over a 200 kHz wide sub-band.

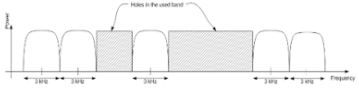



Fig. 7

Expanding on the high performance of the serial tone modem technology standardized in STANAG 4539 for 3 kHz sideband to conjugate a plurality of channels in a multi narrow band (MNB) waveform, this approach can be seen as an extension of the US MIL-STD-188-110C appendix F "ISB", with the addition of specific redundancy capabilities to provide resistance to the highly variable HF channel conditions. As illustrated in Figure 7, these channels do not need to be contiguous, which allows to select only good quality and authorized channels. A 4G ALE alternate proposte ? *(continue in this post)*

Thanks to ANgazu for the identification and collaboration.

Links:
https://events.thalesgroup.com/euronaval/en/article/778731/SALAMANDRE-HF-with-wideband-

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# Mediterranean sea trials – Results from HAM analysis



**21 June 2017**

## THALES HFXL modem, "SALAMANDRE" tests go on

tags: HFXL, STANAG-4539, STANAG-4539 Annex H, THALES

Likely another "SALAMANDRE" test session for the new Thales HFXL modem spotted this morning on the 7MHz band. This time the modem uses 12 non-contiguous 3 kHz channels from 7505.8 KHz up to 7656.1 KHz (~150 KHz bandwidth). The HF waveform is a modified STANAG-4539 with the extended preamble of 124 symbols added by Thales developers; further info about the modified waveform and the modem, as well as useful links, can be read in this post.

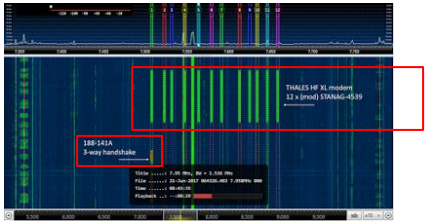



Fig. 1

It's interesting to note in Figure 2 the use of a double 188-141A 2G link setup exchange before the beginning of the HFXL session: the ALE exchanges happen just on the first and last channel of the next HFXL transmission as to negotiate/announce the used band; anyway, the HFXL session starts after the usual 2G 3-way handshake as in Fig. 1). This initial link setup part is termed by Thales as the "3KHz phase" and it is illustrated in one of their presentations.

By the way, the used ALE calls are XLA and XLB and almost surely they stand for (HF)XL modem-A and modem-B and belongs to French Forces network.

```
[2017-06-21 08:25:15] K500 - MIL-STD 188-141A ALE:START TIS [XLA] TO [XLB]
[2017-06-21 08:25:16] K500 - MIL-STD 188-141A ALE:START TIS [XLB] TO [XLA]
[2017-06-21 08:25:18] K500 - MIL-STD 188-141A ALE:START TIS [XLA] TO [XLB]
```

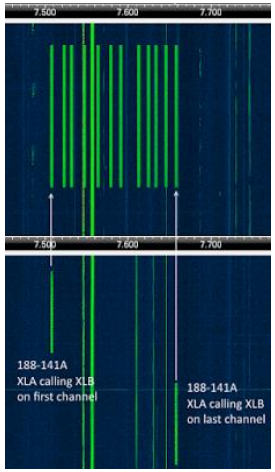



Fig. 2

The HFXL modem 12 channels have been tracked using SDR-Console v3 software configured for twelve simultaneous receivers, in this sample all the channels exhibit a PSK-8 modulation at 2400 symbols/sec (Figs. 3,4): the channel #4 is damaged by an adiacente FSK-2 transmission.

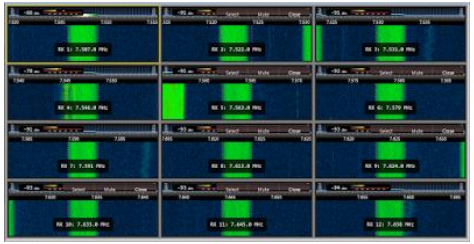
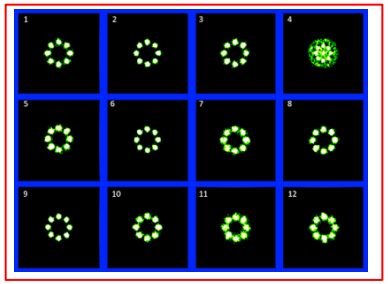


Fig. 3

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# Mediterranean sea trials – Key Results

## Experiment results – key findings

- Throughput measurement: compliant with previsions
  - Up to 134.4 kb/s
  - Up to 170 Nm in sea wave propagation

- With transmissions that
  - Were Asymmetrical, due to the ship transmitting antenna having lower efficiency than the shore based (tuned) antenna one
  - Were Limited when an island was in the way, behavior typical of sea-wave propagation, the ground greater resistivity on the island attenuates significantly the wave

  ➔ this is why most ships use NVIS antennas for close to shore transmissions
  - Showed easy sea wave/sky wave transition

# Mediterranean sea trials – User services and applications deployed during the trials

## User services in action during the trial

- Automatic ACP message transmission
- Automatic message transmission via Emails
- XMPP Chat client-server connection
  - Note this chat room was basically the way the two trial teams (ship and shore) were communicating, exchanging info, about conditions rest time and more. It was more convenient than the standard satellite phone.
- WEB Client-server manually activated and Image On Demand to check the QoS on the user / application level

# 2017-June sea Trials

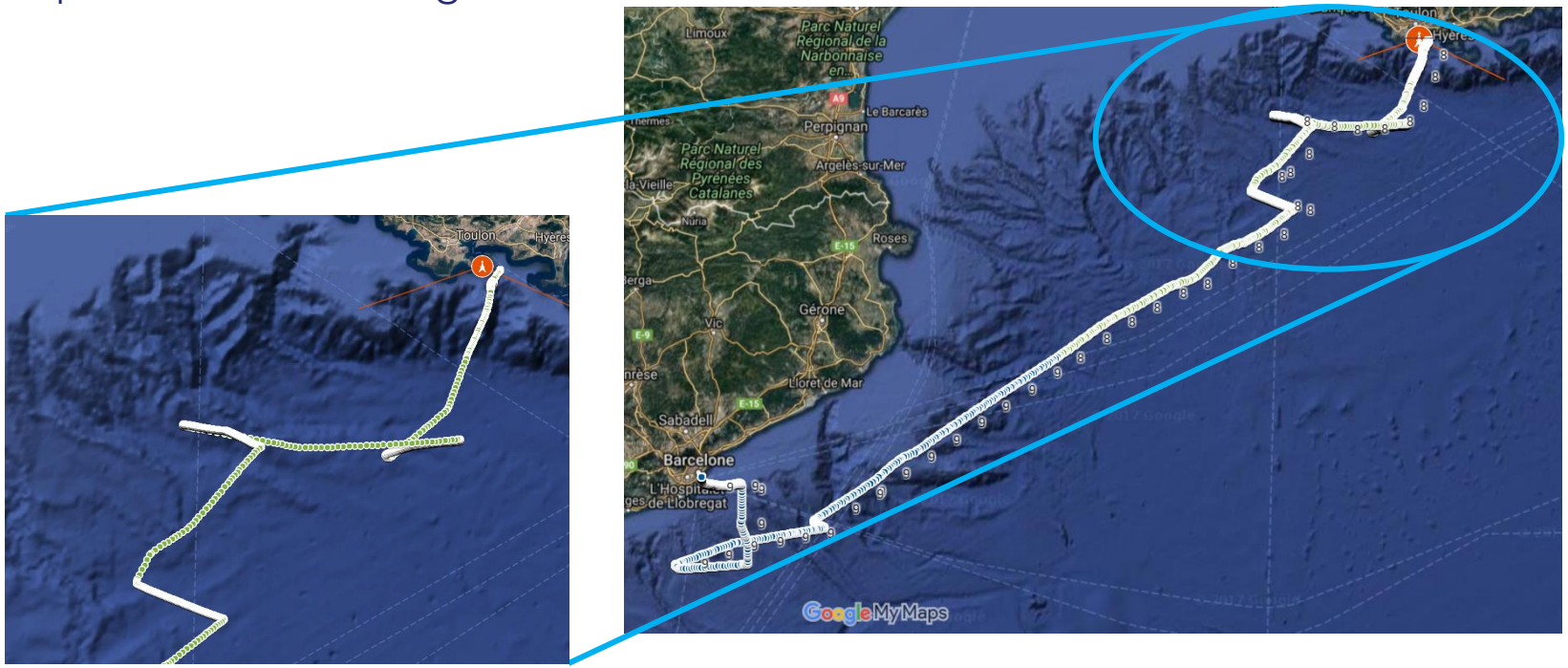
## Typical performances for sea-shore transmission

- Sea Wave 60 kb/s up to 100 Nm
- Stable, continuous and resilient connection
- Smooth transition from sea-wave to sky-wave

# 2017-06-08 and 09 Trials crossing to Barcelona

## Trajectory from Toulon to Barcelona

- The ship did not went straight

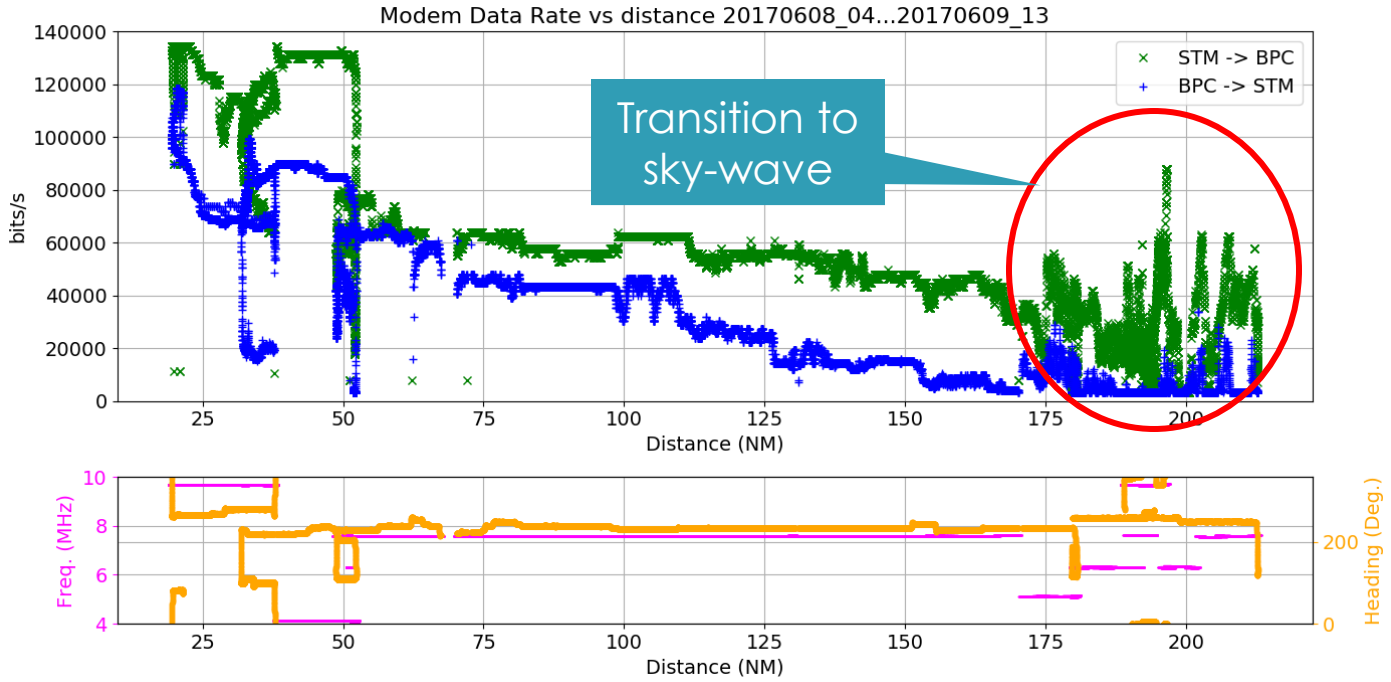


# 2017-06-08 and 09 Trials crossing to Barcelona

## Data rate vs distance from Toulon to Barcelona

- Asymmetrical link due to asymmetrical link budget (tuned antenna on shore vs broadband antenna in the BPC)

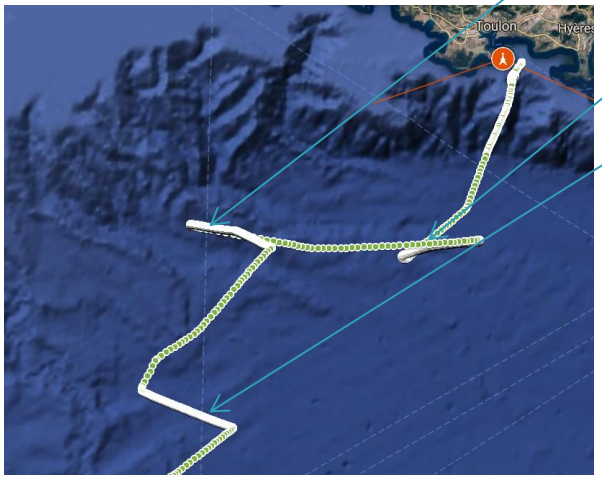
**60 kb/s over100 Nm**

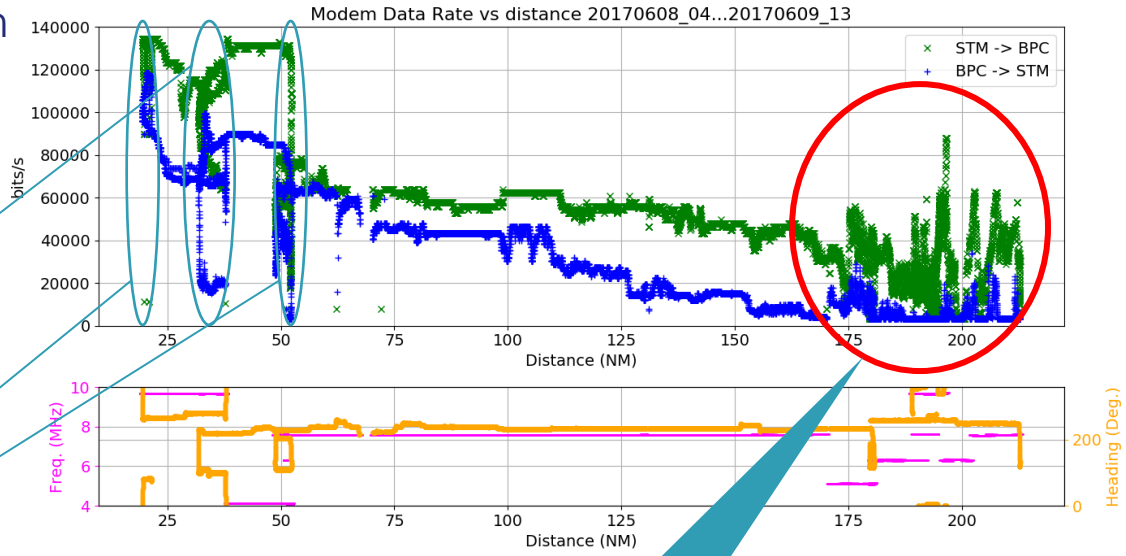


# 2017-06-08 and 09 Trials crossing to Barcelona

## Data rate variations

- ~20 Nm, ~30 Nm and ~50 Nm
- Ship radiation pattern induced variation in path loss and data speed adjustment




Transition to sky-wave







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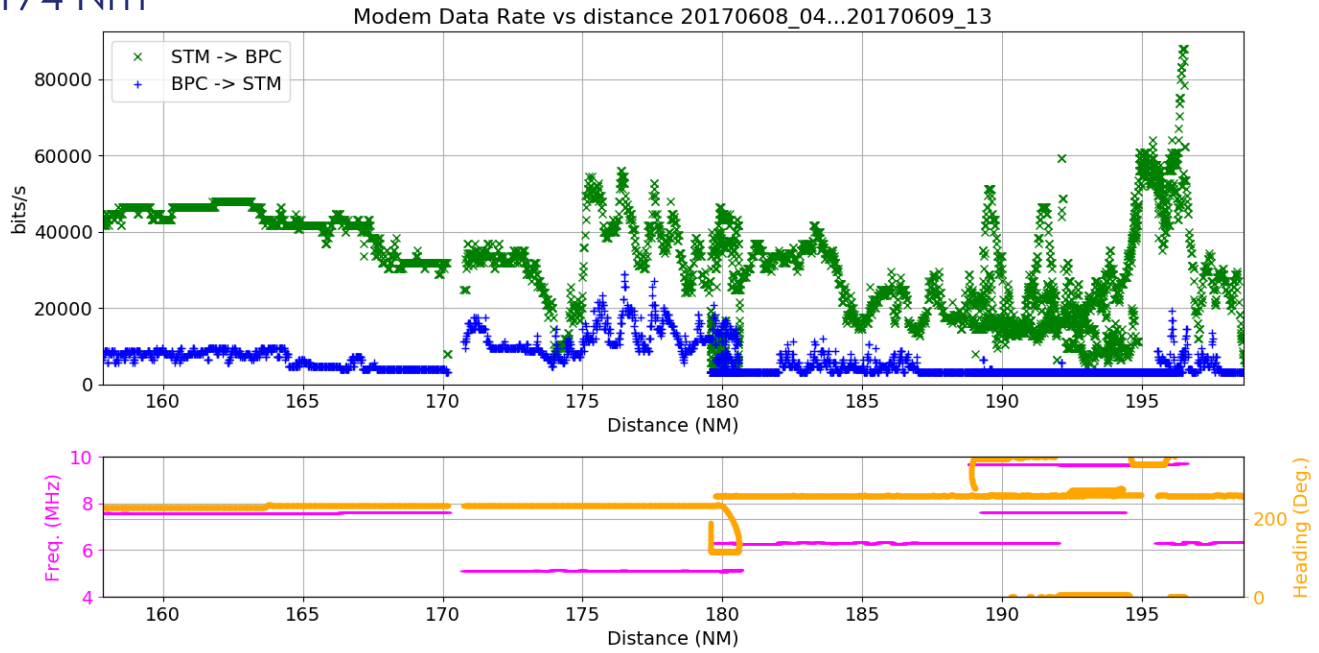
# 2017-06-08 and 09 Trials crossing to Barcelona

## Sea Wave to Sky Wave transition

- Resilient even to unmatched antennas (asymmetrical link)
- Transition is around 174 Nm
- Uninterrupted



# Conclusions

## June 2017 Mediterranean sea experiment validated HF-XL Waveform in sea-wave

- Stable and long range over the Horizon capability
- Smooth transition to sky-wave due to the 4G capabilities
- Salamandre demonstrator easily installed on the ship using onboard antenna and RF cabling.
- Sea and shore installations easily deployed with standard antenna equipment (even though performances would be even better with wideband tuned antennas)

**HF XL : your solution for HF tomorrow**

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# Thanks for your attention

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