seaCHIRP 3D

MULTIBEAM SUB-BOTTOM PROFILER

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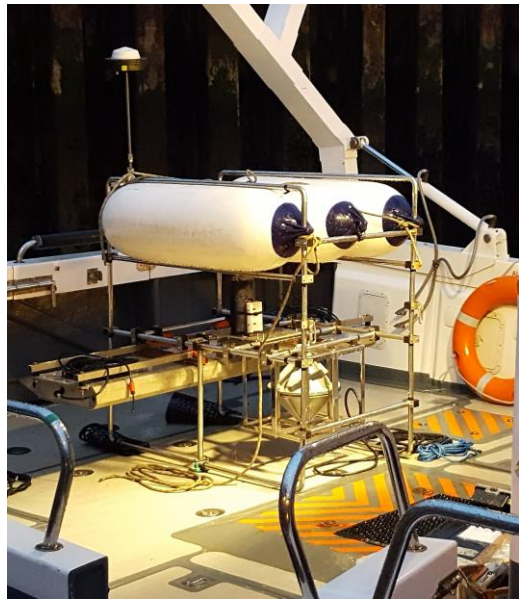
The seaCHIRP 3D - Presentation

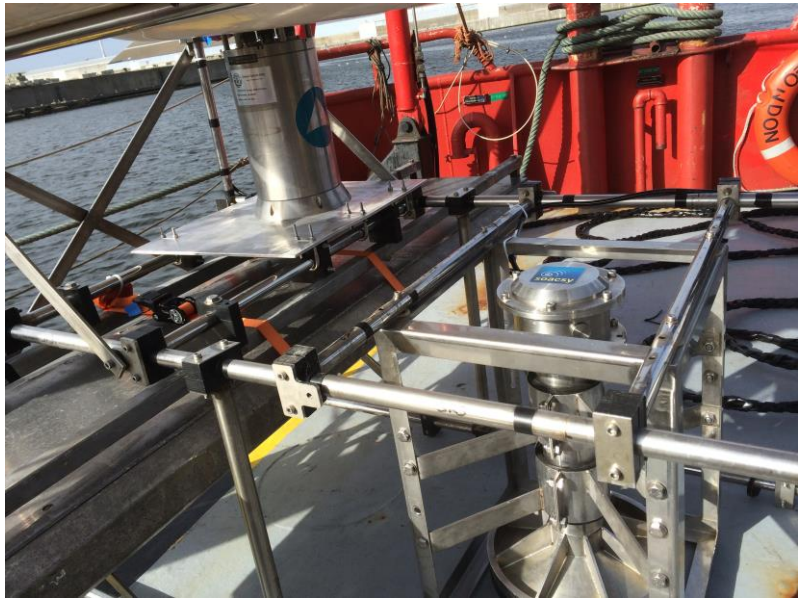
Philippe Plantevin, PhD
CEO

SOACSY SAS - 1, rue Copernic BP 62074 - F13646
Arles
Tél. +33 (0) 4 90 49 06 91
Email: pplantevin@soacsy.com

The seaCHIRP 3D

Precise and efficient seabed and geohazard assessment





- Unexplosed ordnances (UXO)
- Boulders
- Buried pipelines / cables
- Sedimentary studies
- Marine archeology

- 3D view of the backscattered arrivals either side of the survey line
- Very High Resolution seismogram along the survey line
- Shallow water 3-50 m
- Large swath (1,7 x water depth) / Narrow beams (10°)
- High speed (up to 5 knots) / high firing rate
- Minimised Acquisition/Processing time

- Rugged, compact and lightweight (120 kg)
- Versatility to meet client requirements/available vessels
- Quick and easy set-up

Main track records

UXO

- **HORN REV 3** (Denmark) for FUGRO/VATTENFALL – 2015 – Wind farm

Boulders

- **NORTHER** (Belgium) for GEOxyz/NORTHER - 2017 – Wind farm
- **ABERDEEN** (Scotland) for FUGRO/VATTENFALL – 2016 – Wind farm

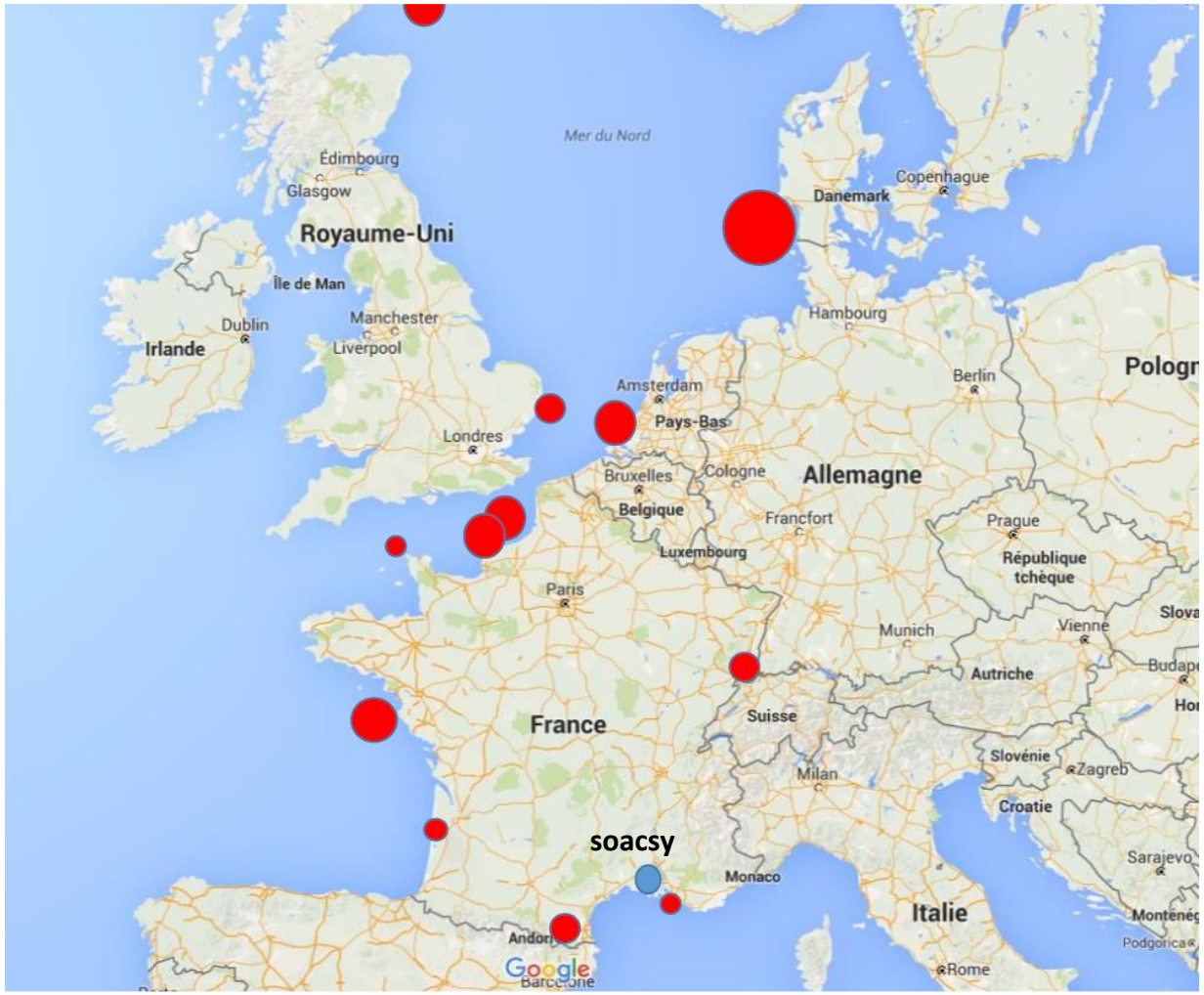
Sedimentary studies (cable/pipe route)

- **SIZEWELL** (UK) for FUGRO/EDF Energy – 2014 – Nuclear energy
- **SAINT NAZAIRE** for FUGRO/EDF EN – 2014 – Wind farm
- **FECAMP / COURSEULLE** for FUGRO/EDF EN – 2014 – Wind farm

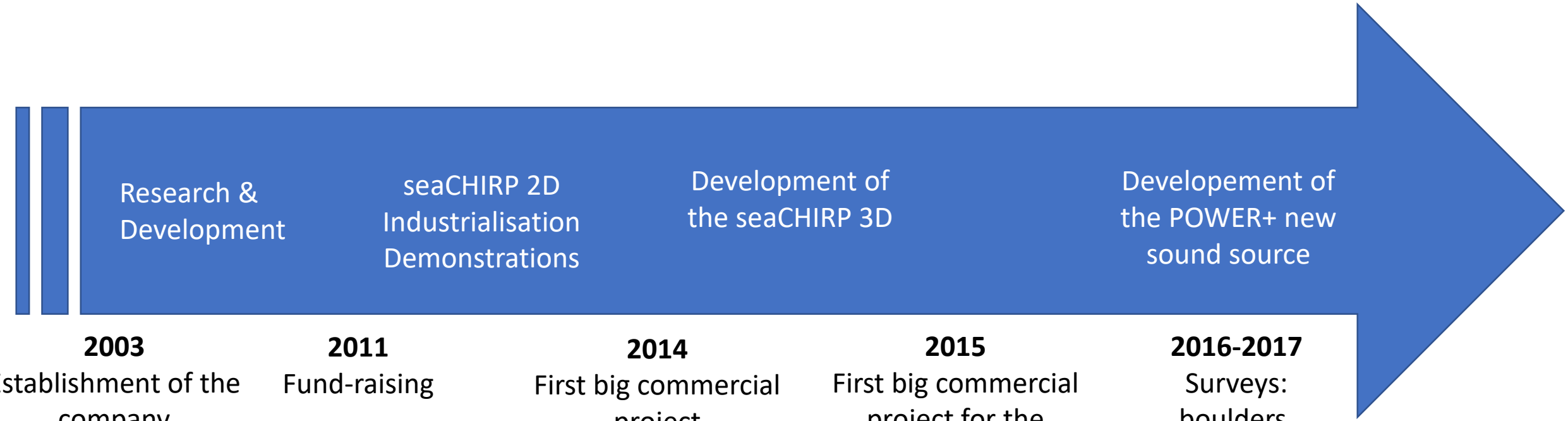
Inland

- **KEMBS** (France) for EDF – 2015 – Hydroelectic energy

- Linear kilometer surveyed from 2014 **> 1600 km**
- Data volume collected **≈ 1 Terabytes**
- Vessels from **4,5 m to 40 m long**
- Waves **up to 1 m height**



Timeline



2003
Establishment of the company

2011
Fund-raising

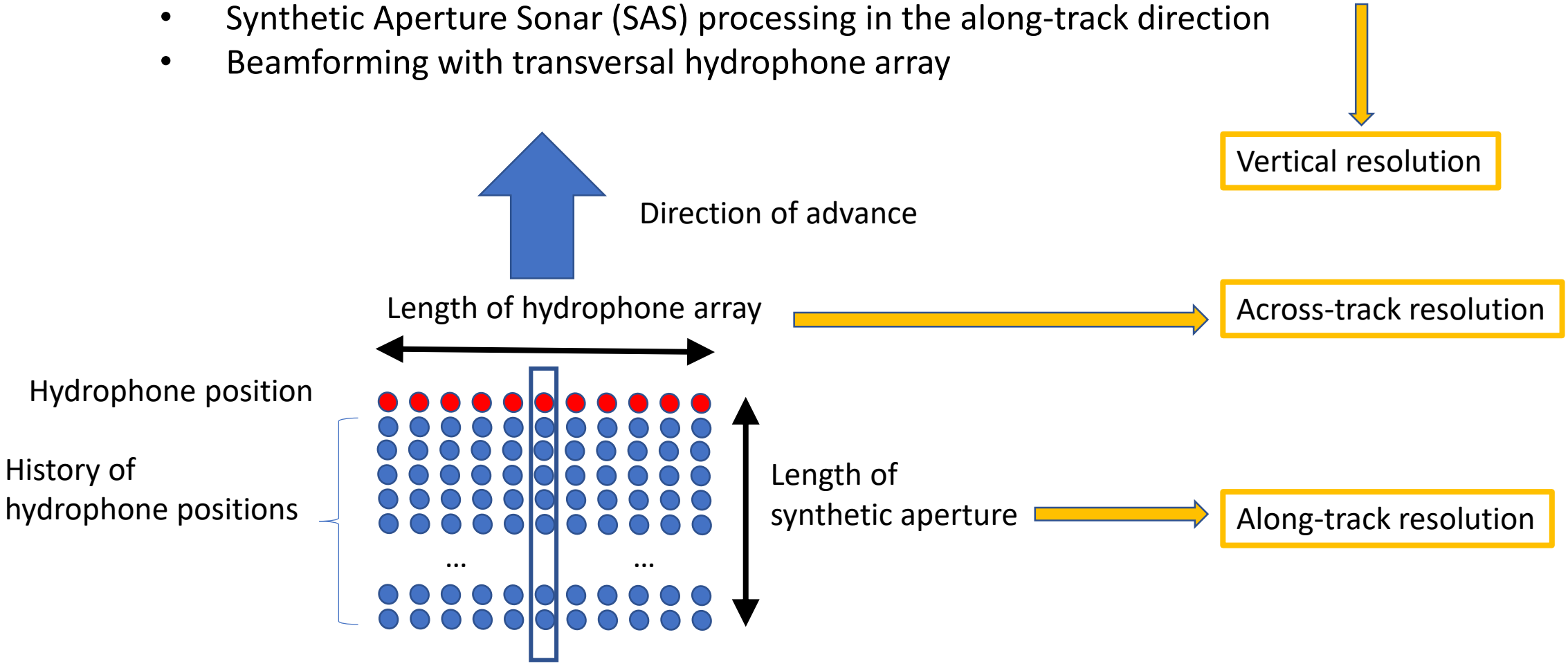
2014
First big commercial project (Fecamp/Courseule/ Saint Nazaire for EDF EN)

2015
First big commercial project for the seaCHIRP 3D (HORN REV 3 for Vattenfall)

2016-2017
Surveys: boulders, sedimentary,…

The Technology

- Super wideband Frequency Modulated pulse (« Chirp ») transmission (**4.5 octaves**)
- Synthetic Aperture Sonar (SAS) processing in the along-track direction
- Beamforming with transversal hydrophone array



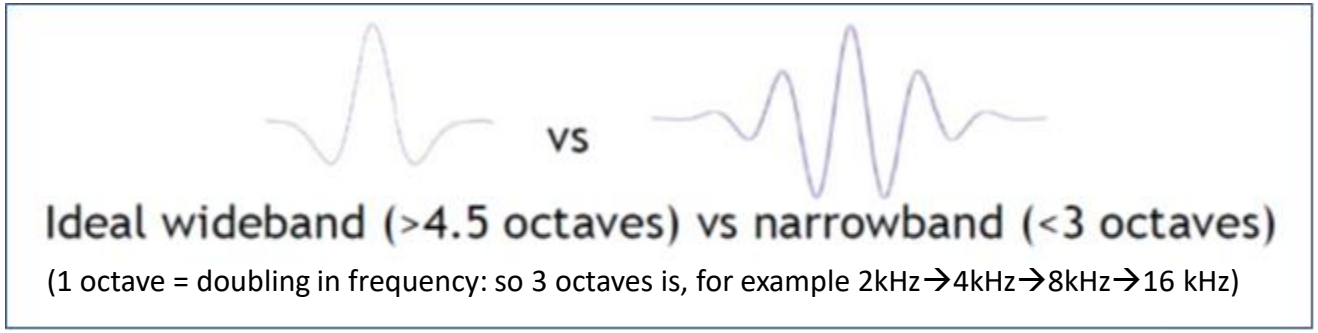
Super wideband Chirp system

- Tunable frequency range between 0.5 and 10 kHz (4.5 octaves)
- Vertical resolution of < 10cm (full frequency range)
- Frequencies below 4kHz give penetration in harder sediments
- PRF up to 13Hz giving along-track sampling ≈ 0,2 m @ 5 knots
- Energy (hence SNR) can be increased by a longer duration Chirp

Benefits

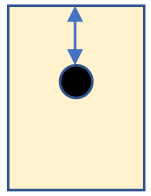
- Versatility to meet client requirements

- The wavelet (after chirp processing) has less ripples, allowing to use the **full wavelet** and not only the envelop → **better resolution and images**



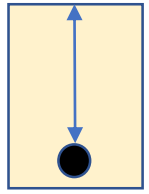
- Sediment attenuation is wavelength dependant: e.g. sand 1 dB/λ
  → **low frequency means better penetration and Signal to Noise Ration SNR (performance)**

2 m



3 kHz	5 kHz	9 kHz
-8 dB	-13 dB	-24 dB

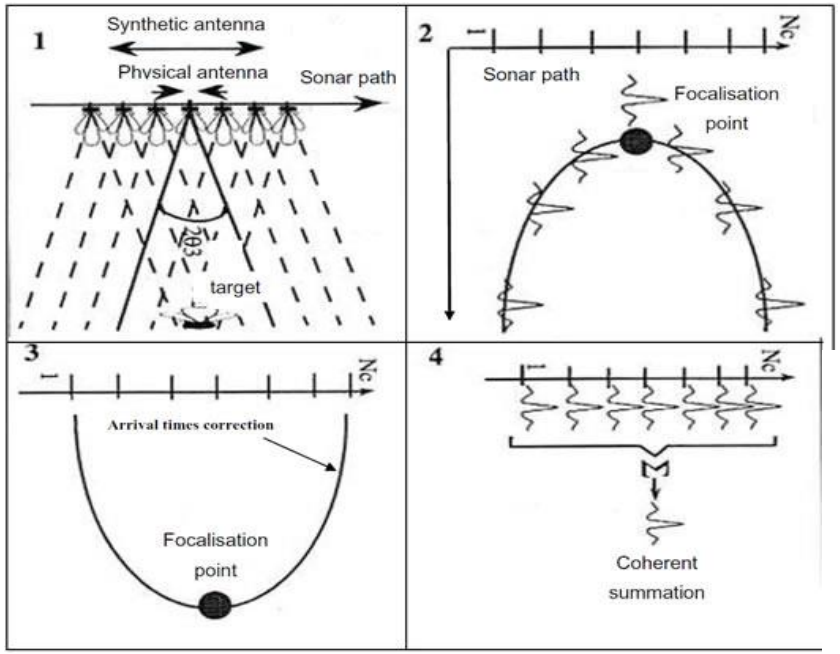
5 m

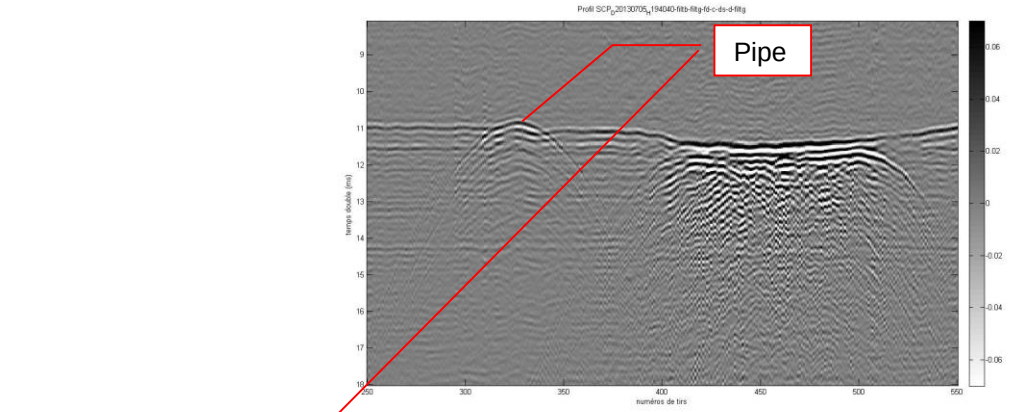


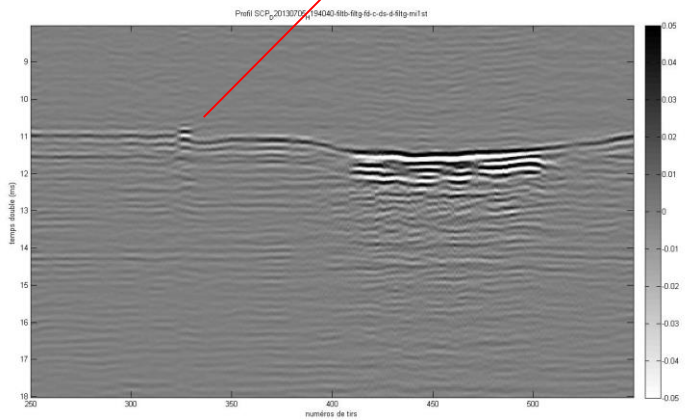
3 kHz	5 kHz	9 kHz
-20 dB	-33 dB	-60 dB

SAS processing

- Each point of the sub-surface is sampled multiple times as the seaCHIRP 3D passes over it
- A coherent reorganization of the collected data enables to create a long synthetic antenna
- The process improves along-track resolution, object positioning, SNR (detection and positioning performance), and collapses diffractions (better images of first 2 m, etc.)







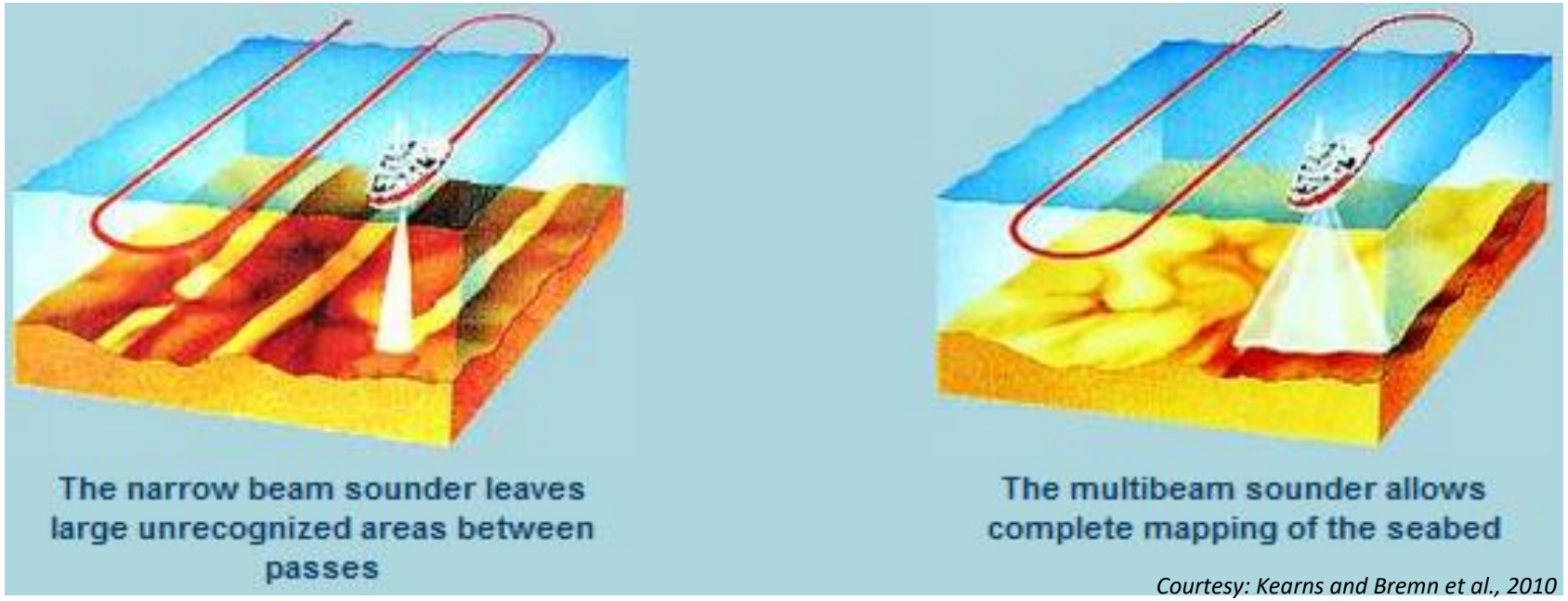
Seismogram before and after SAS processing (Central beam)

→ Achievable resolution ≈ 1 λ
- ≈ **0.3 m** (full frequency range)

→ SNR gain function of water depth
- **> 30 dB** @ 20 m water depth

Beamforming

- The signals collected on the hydrophone array are re-arranged in order to calculate beams with different steering angles.

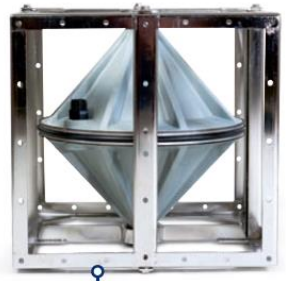


Courtesy: Kearns and Bremn et al., 2010

→ 80° Swath (1,7 x Water depth)
→ 10° beam apperture
→ Up to 1° angular sampling (81 beams)

→ Total seabed coverage
→ Rapid survey
→ Good object detection and separation
→ Accurate object positioning

seaCHIRP 3D equipement



Emitter
0.4 – 8 kHz (4.5 octaves)

On-board ruggedized electronics
Amplifier: 2.5 kW power output
Acquisition system: 24-bit resolution ADC/DAC (118 dB dynamic range)

Super wideband chirp technology › Deep penetration with high resolution, enabling analysis of difficult seabeds (coarse or consolidated) - Detection of small buried objects (e.g. 6" pipes).

SeaWING Advanced Design

Enhance performance by using 2 seaWING at the same time !!

In April 2017 SOACSY introduced its enhanced POWER+ transducer

Main Features

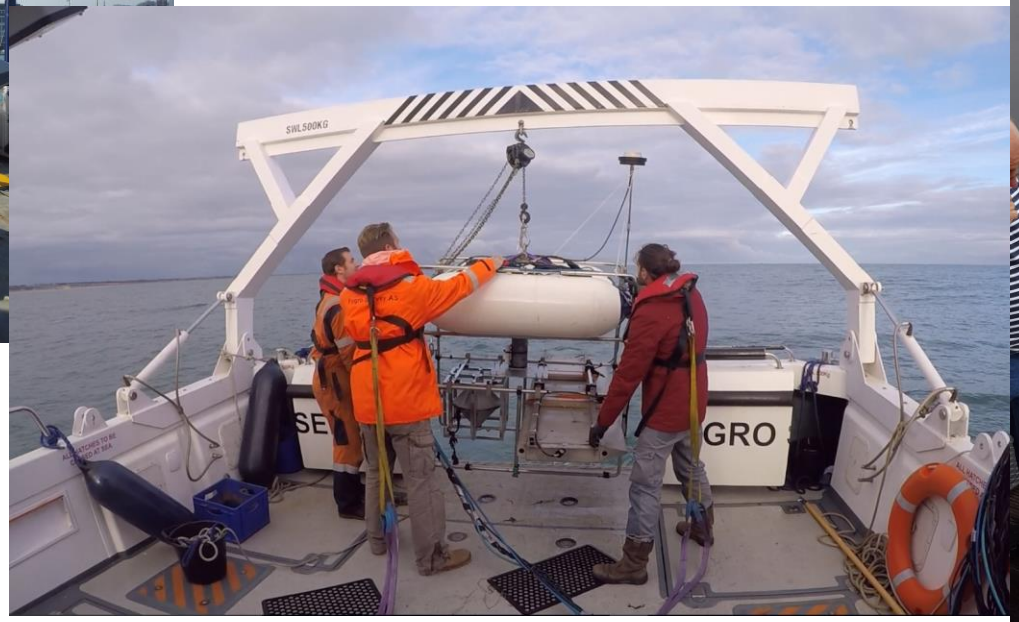
Frequency	0.5 - 10 kHz
Emitted Level	+6 dB / previous source
Operating Depth	- 40 m without compensation - 350 m with compensation
Weight	~ 40 kg
Dimensions	55 cm x 35 cm

Mobilisation

- Versatility to meet client available vessels
- Quick and easy set-up

Under the hull of a small boat

On our specific frame



On a pole

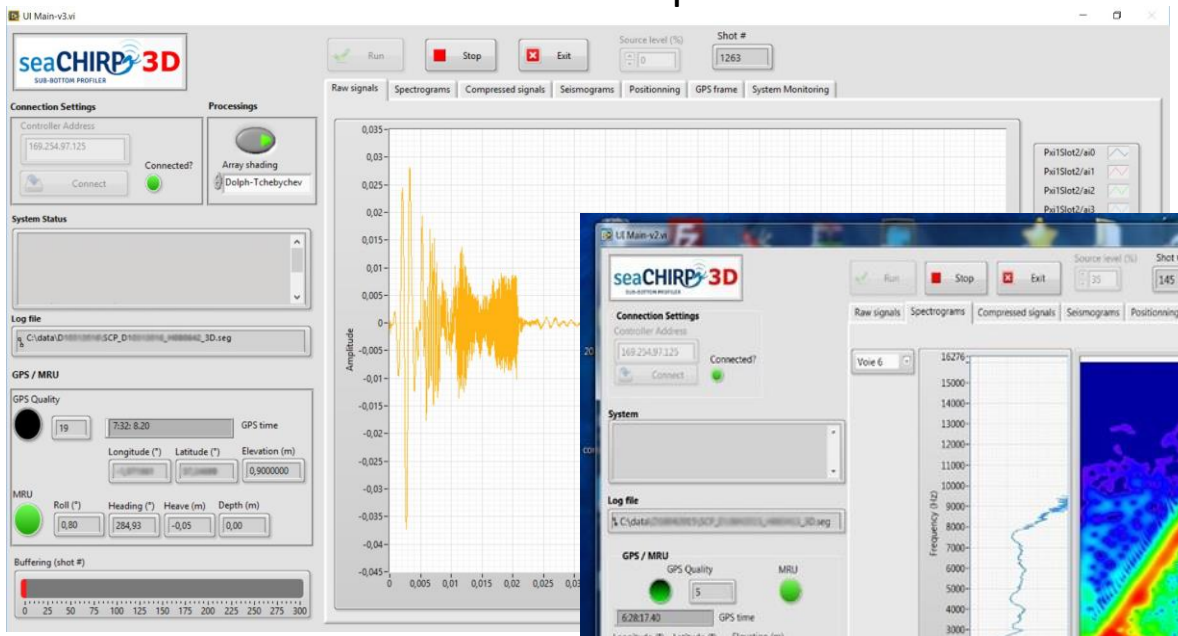
Mobilisation

Offshore

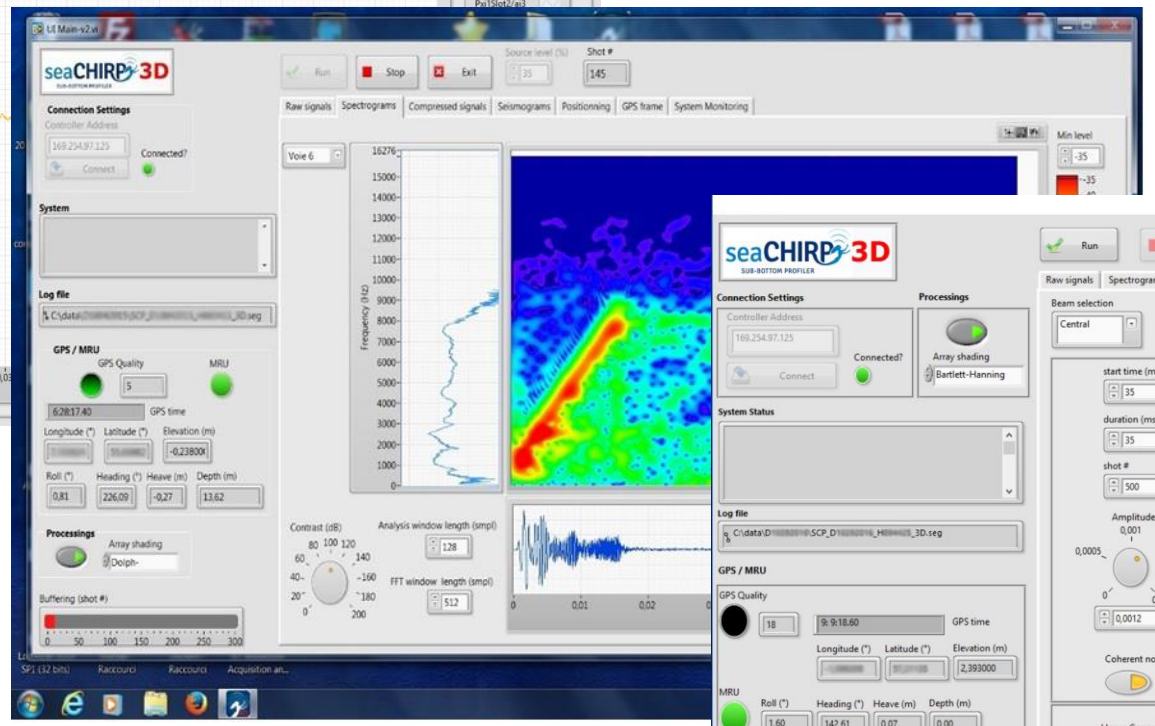
Nearshore / Inland

Acquistion and on-line QC

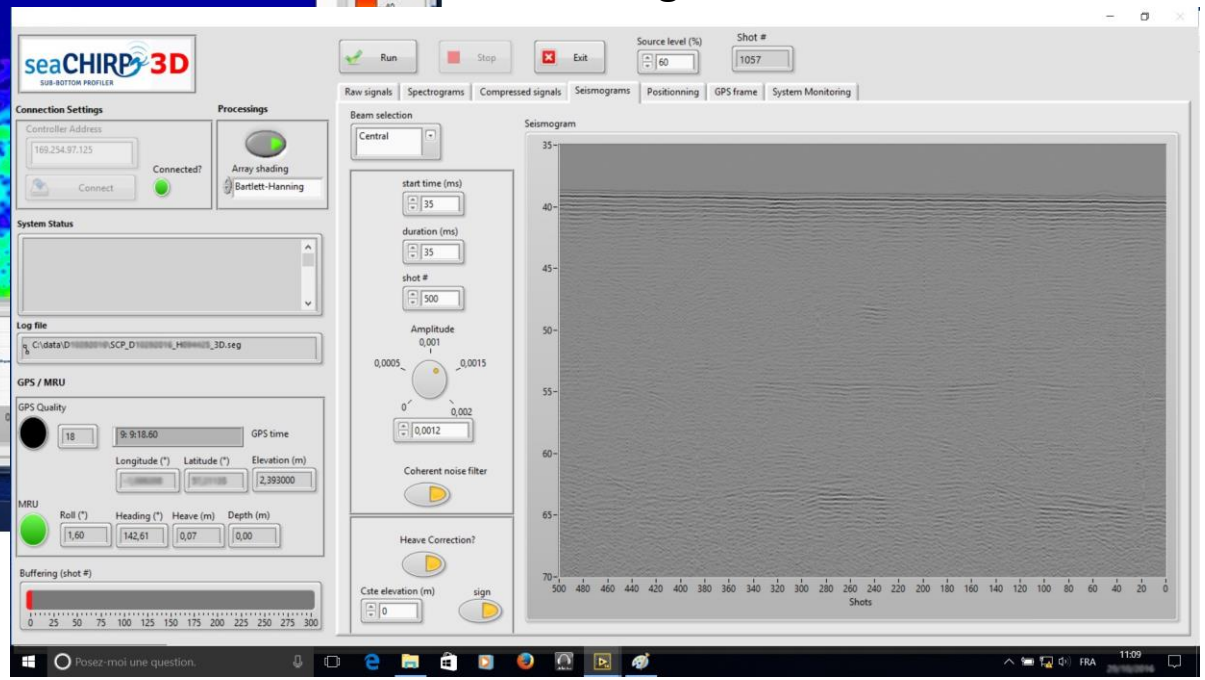
Oscilloscope



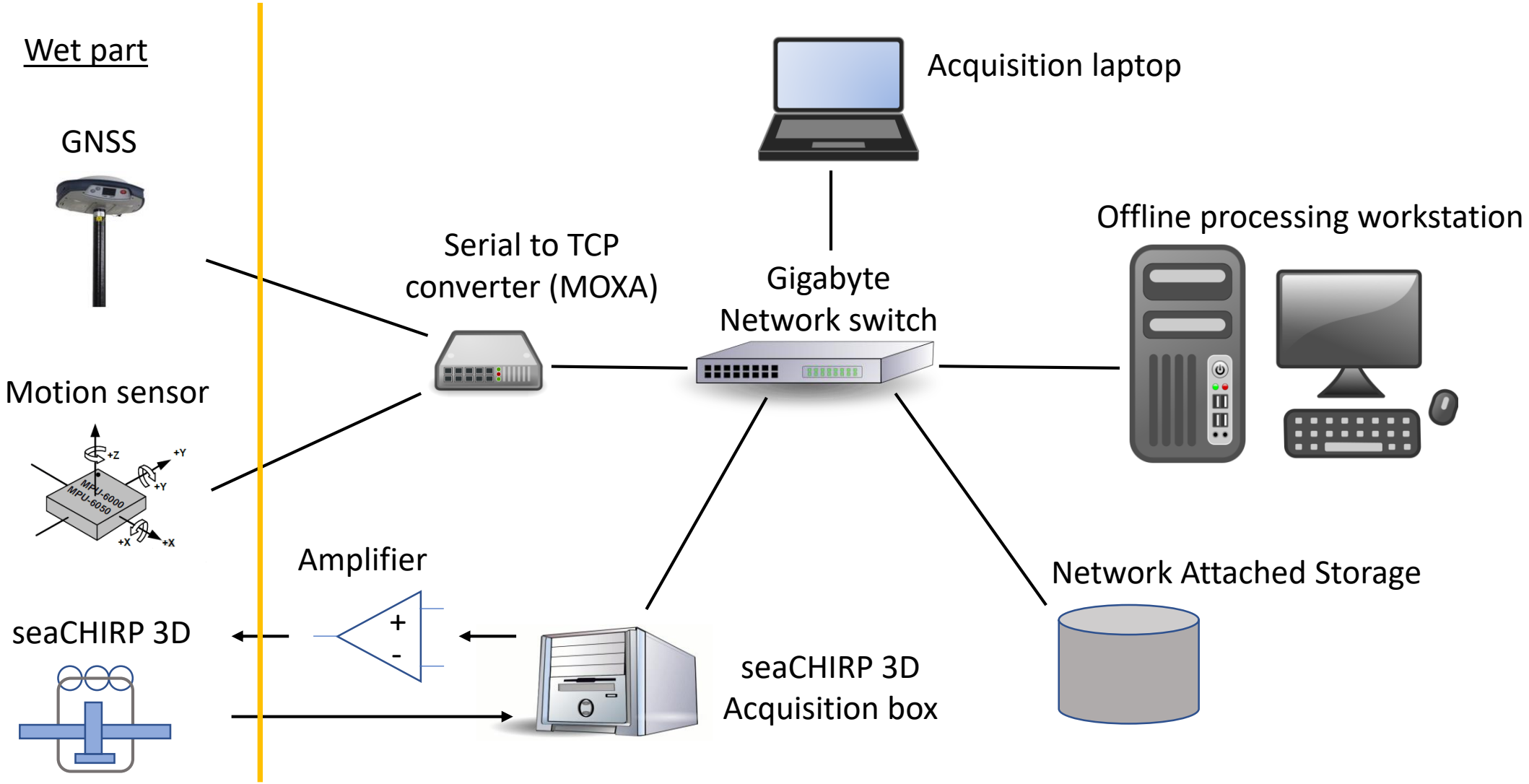
Spectrogram (time frequency)



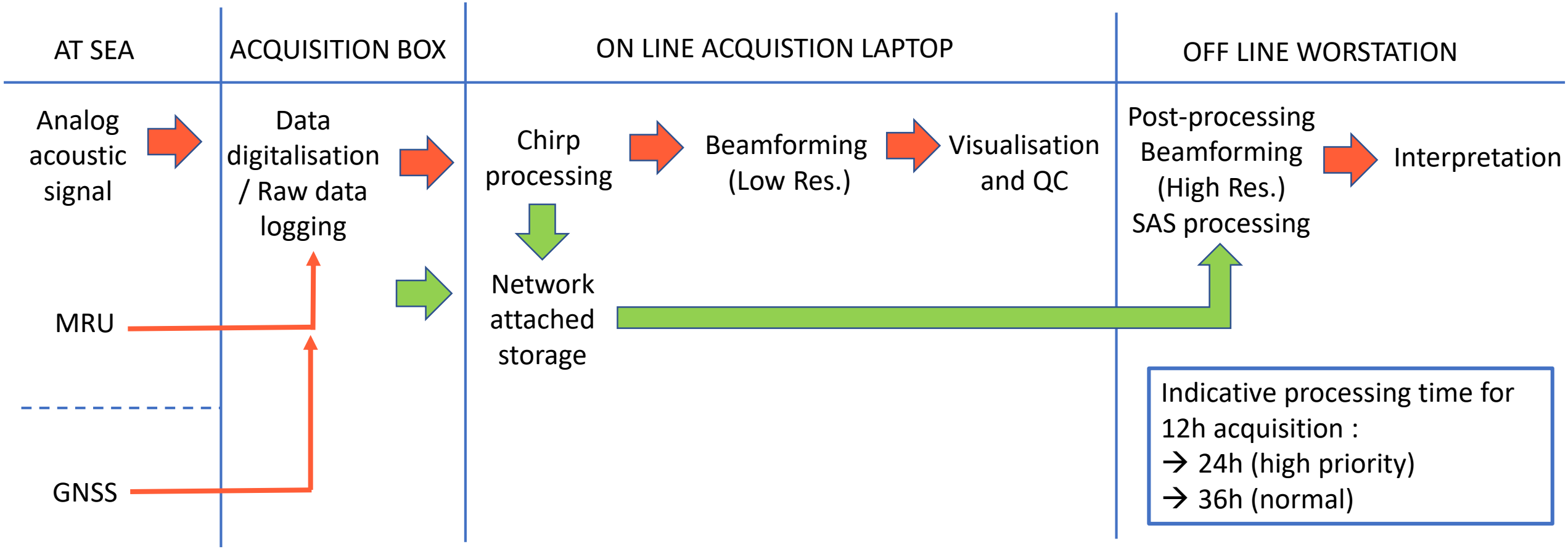
Seismogram for the selected beam



On board network



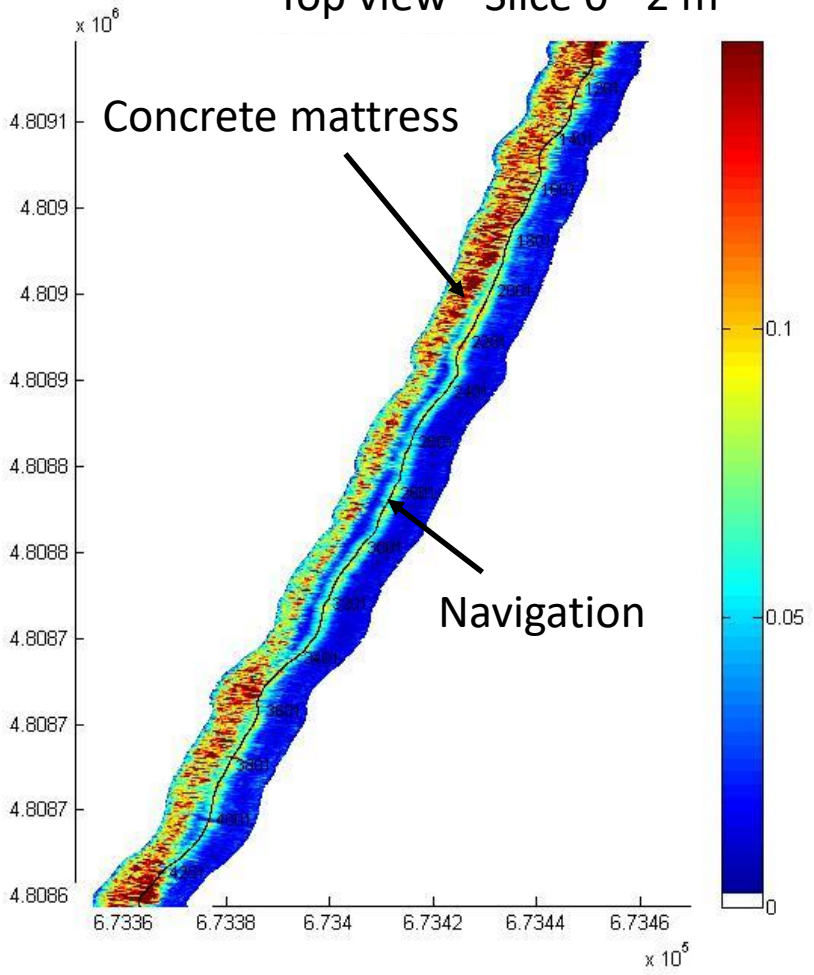
Data flow diagram



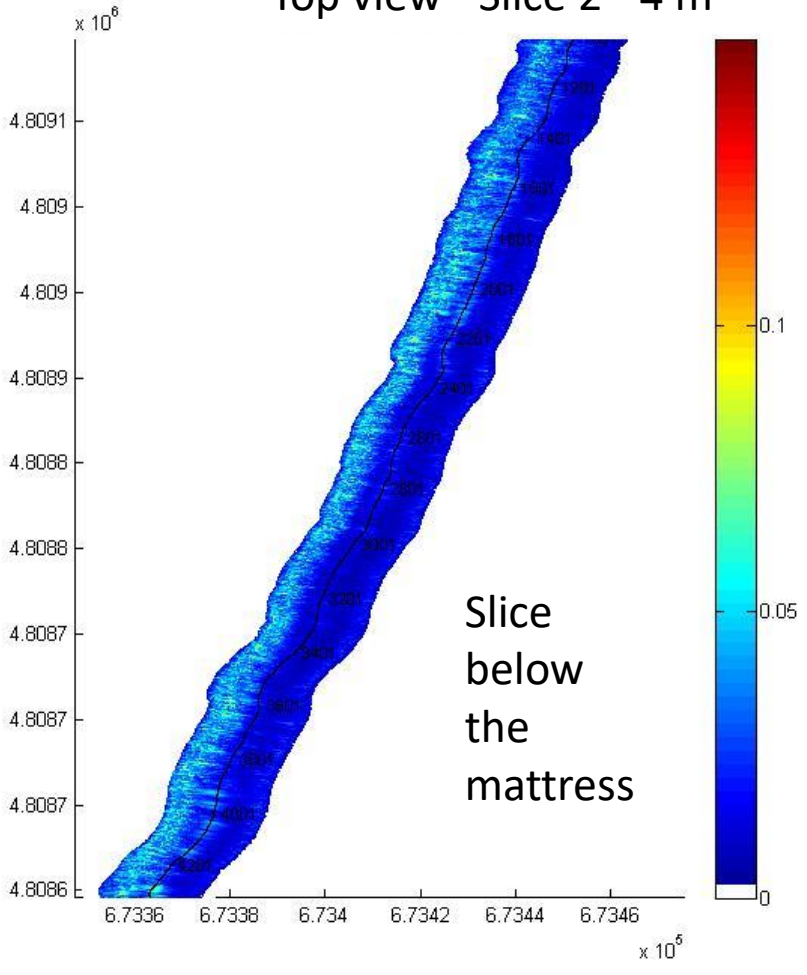
Field example

Etang de Berre (near Marseille) – Line along a concrete mattress

Top view - Slice 0 - 2 m



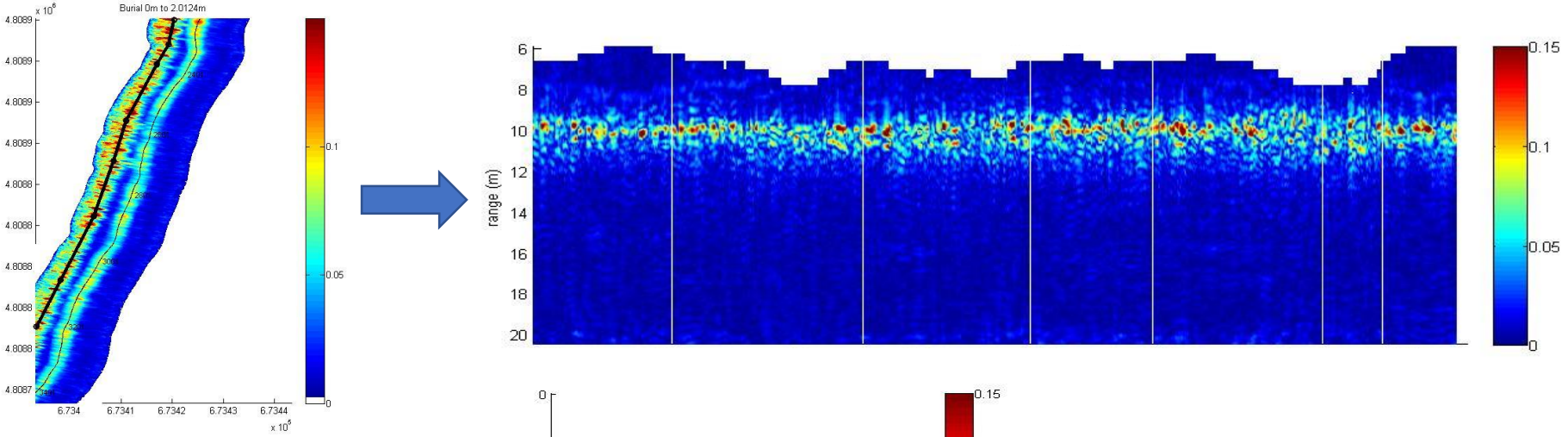
Top view - Slice 2 - 4 m



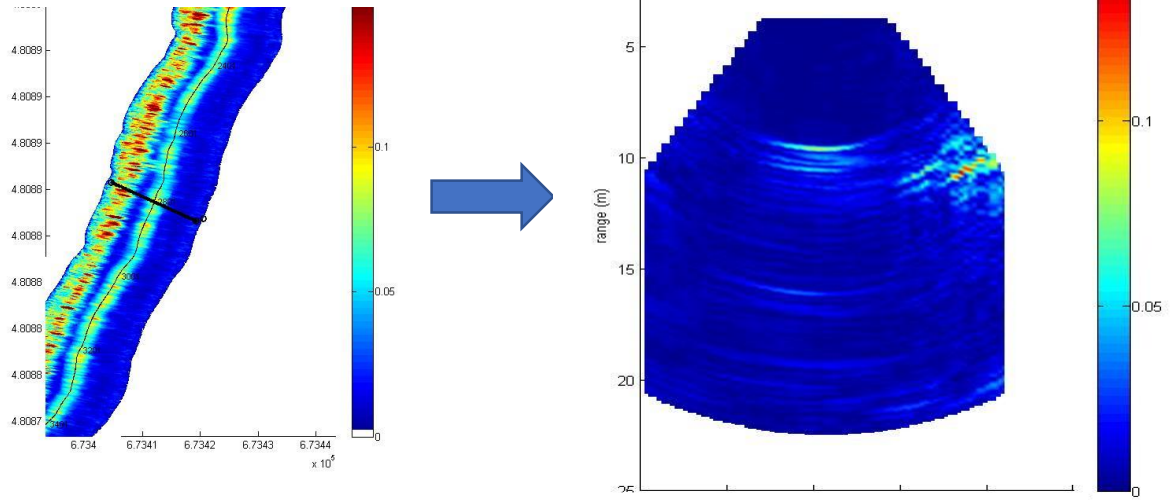
Field example

Etang de Berre (near Marseille) – Vertical Sections

Along the mattress

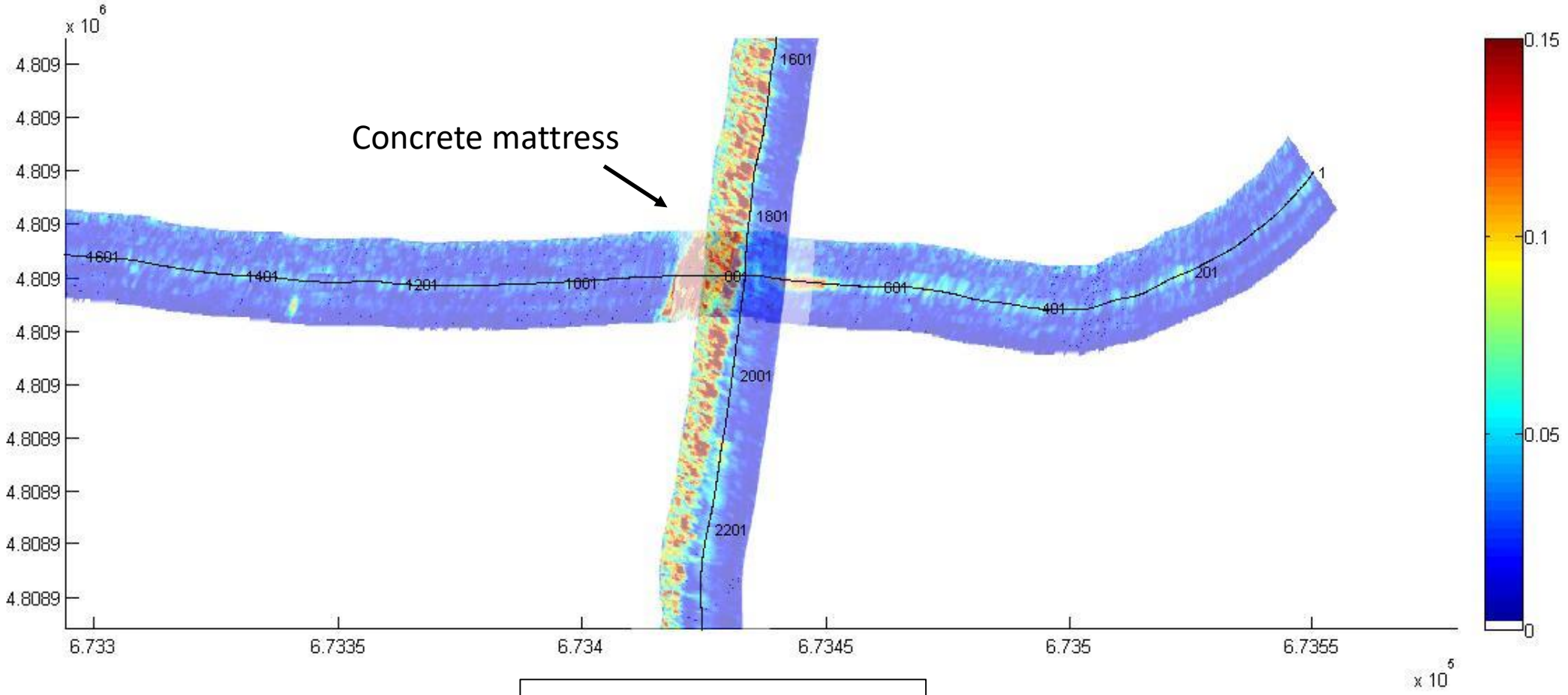


Across the mattress



Field example

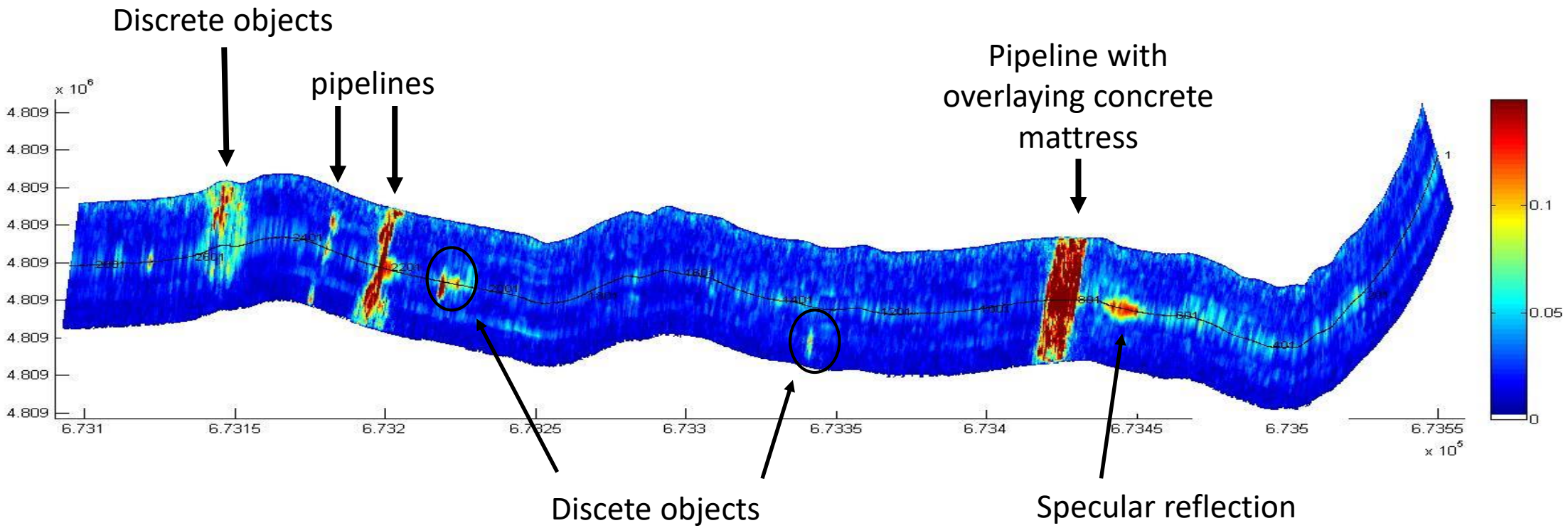
Etang de Berre (near Marseille) – Line and cross line superposition



Top view – Slice 0.5 – 1 m

Field example

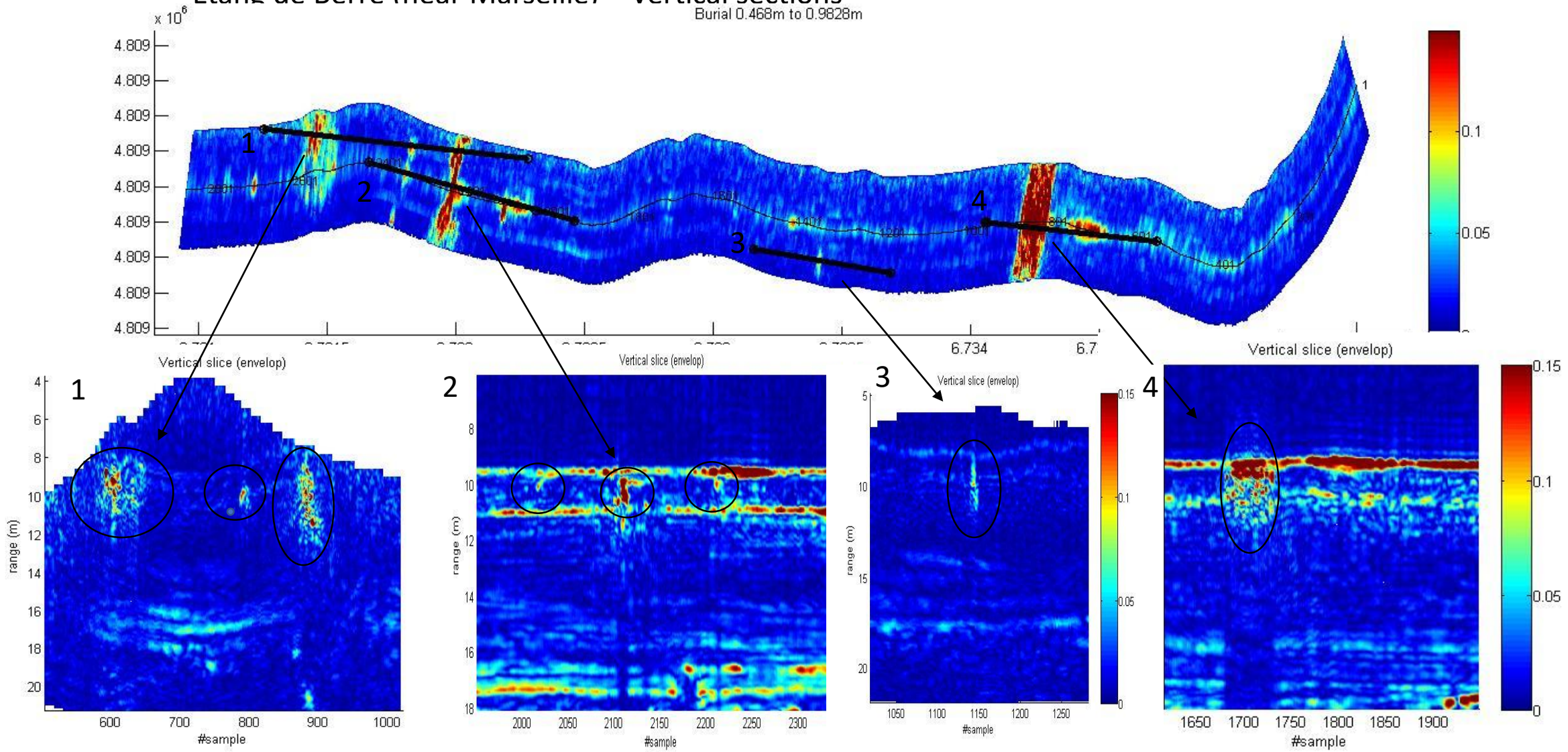
Etang de Berre (near Marseille) – Cross line



Top view - Slice 0.5 - 1 m

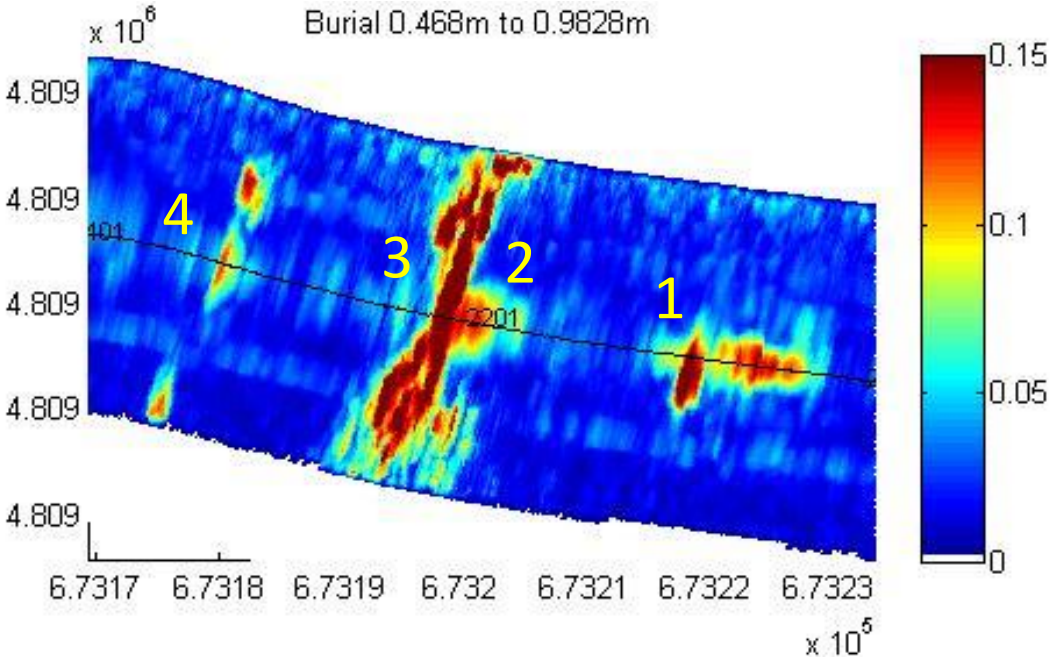
Field example

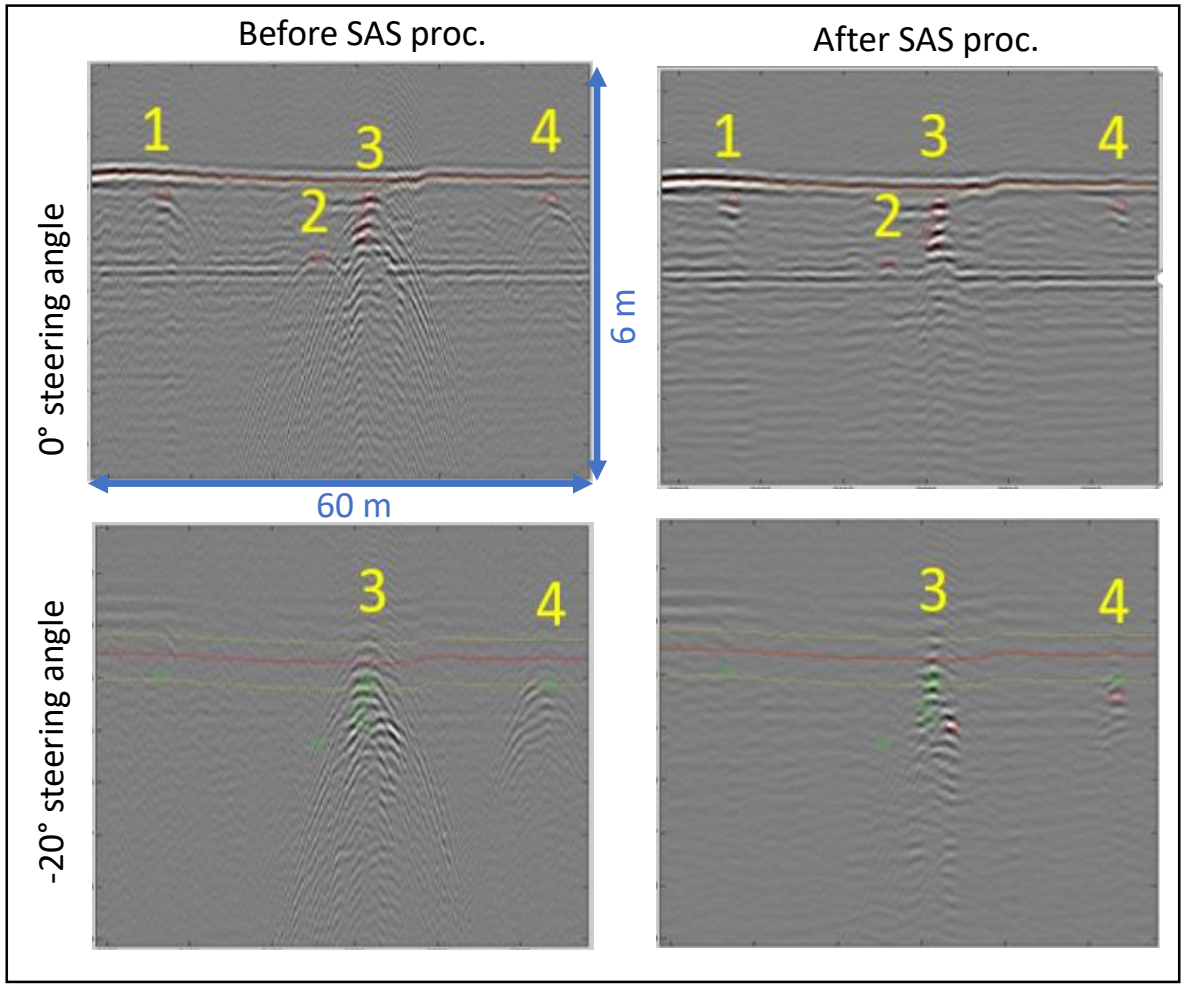
Etang de Berre (near Marseille) – Vertical sections



Field example

Etang de Berre (near Marseille) – Seismogram (full waveform)





Future Developments

- Real time 3D renderer: under progress
- Subsea version: looking for a partner…

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CGGVERITAS

TOTAL

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