SASSO – Expendable arrays of sensors

SASSO (*Sistema Acustico di Sorveglianza con Sensori Ottici*) project deals with opto-acoustic sensors for underwater surveillance and is part of the Italian Military National Research Program.

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Project and goals (1 of 2)

SASSO project has the purpose to explore a new concept of underwater surveillance by means of expendable arrays of sensors based on interferometric FO hydrophones, using fibre laser strain sensors (FLS).

The aims of the project are:

- To operate without limiting the platform maneuvrerability;
- To reduce the LCC of the towed array compared to a piezoelectric one;
- To obtain a system that could be managed and maintained autonomously by the Navy.

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Project and goals (2 of 2)

SASSO project is divided in 4 phases:

1. Feasibility Analysis, Technical Specification and Definition of a set of trials for validation of the demonstrator (18 March 2016 – 13 April 2017);
2. Realization of all the components of a first technological demonstrator (7 March 2018 – 30 June 2019 *scheduled*);
3. Implementation of an array made up of two sub-arrays each of 6 sensors and realization of the SW to manage the array (1 year, expected to start at the end of 2019);
4. Trials at lab and at sea to validate the demonstrator (1 year, expected to start at the end of 2020).

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Overview Architecture (1 of 2)

The SASSO system is composed of:

1. A wet part, constituted of a sensing FLS array and a connecting FO cable;
2. A deployment system;
3. An optical pump;
4. An interferometer module;
5. An opto-electronic receiver.

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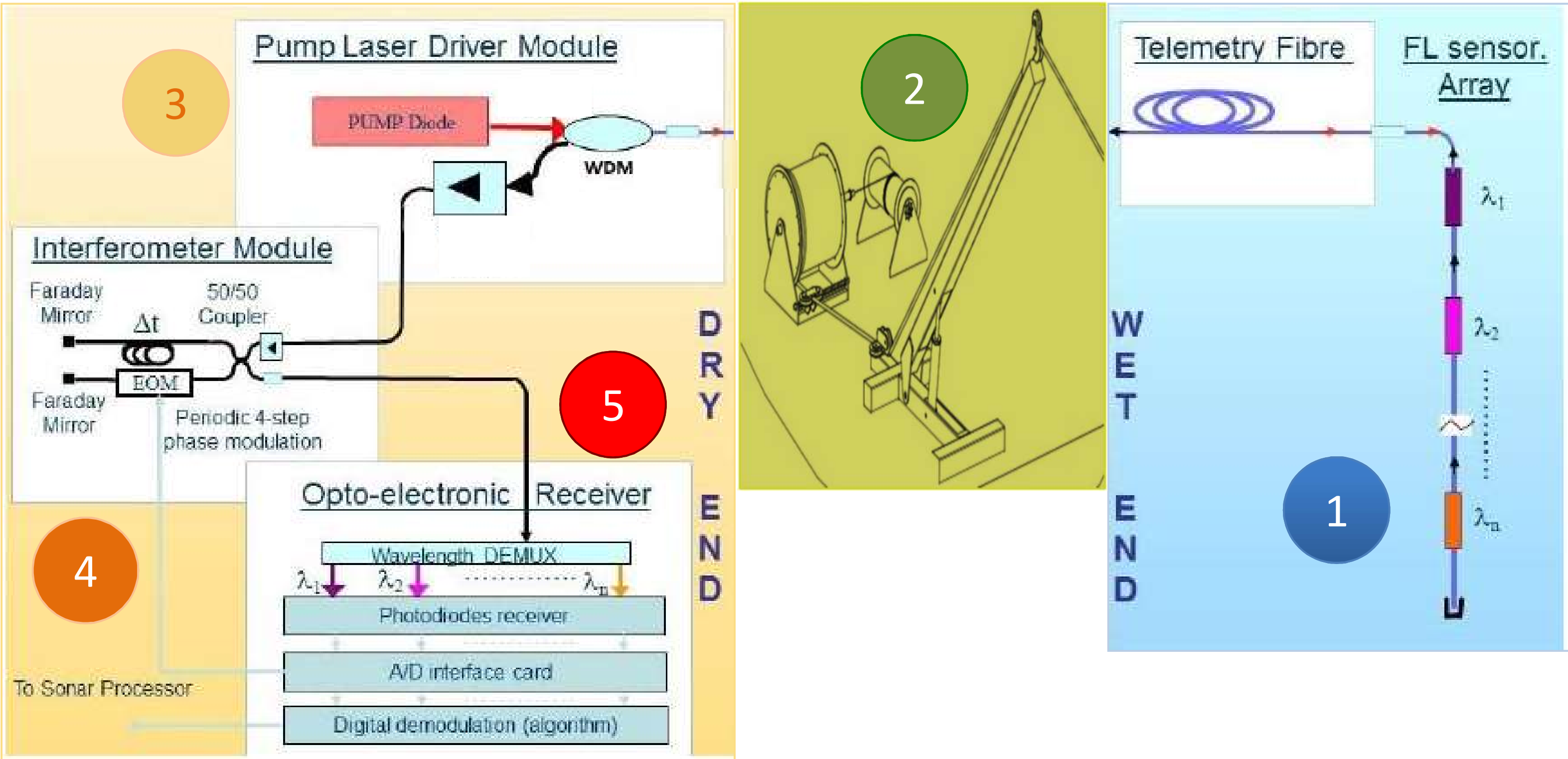
Overview Architecture (2 of 2)



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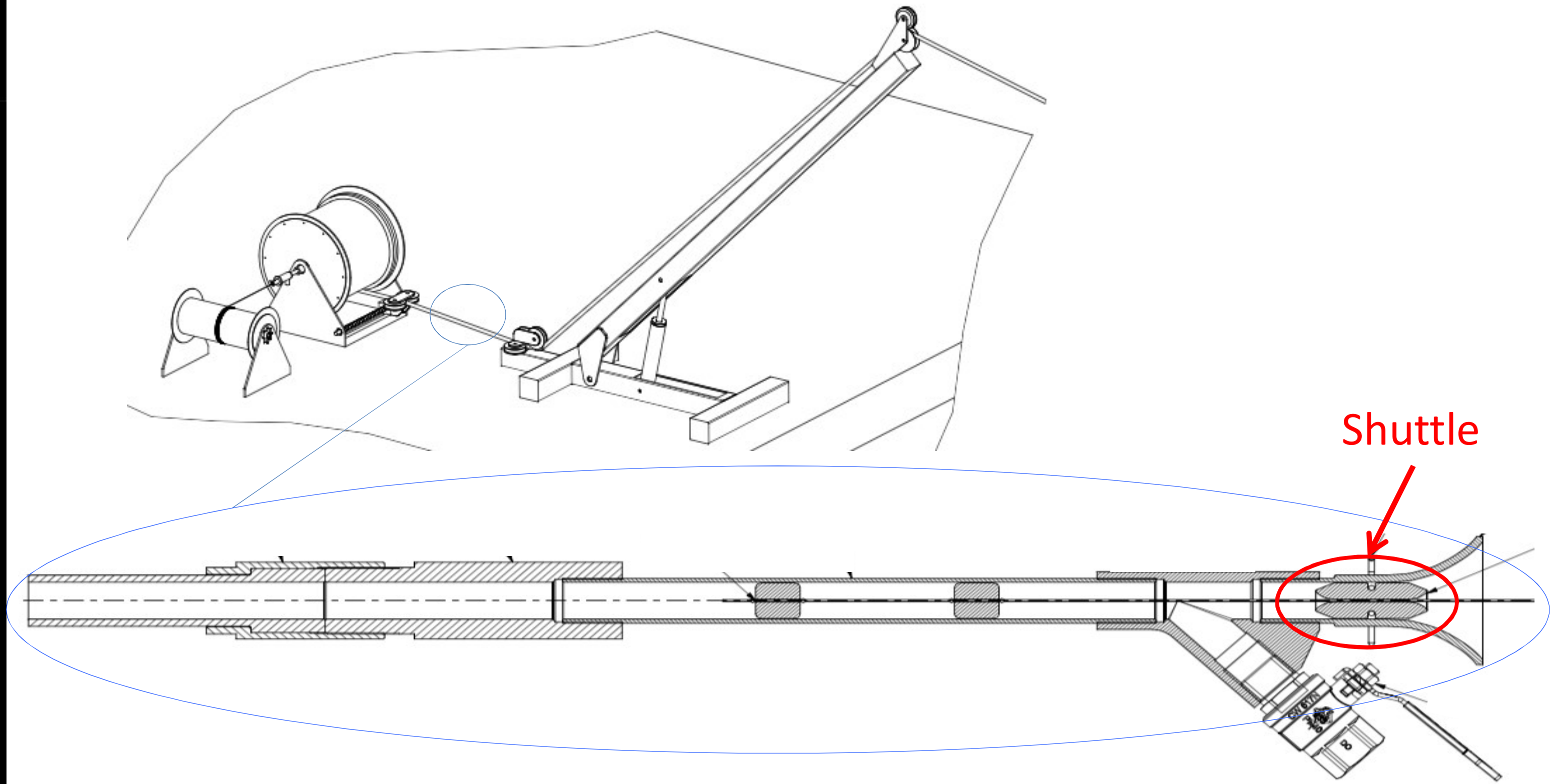
Deployment system - Ejector



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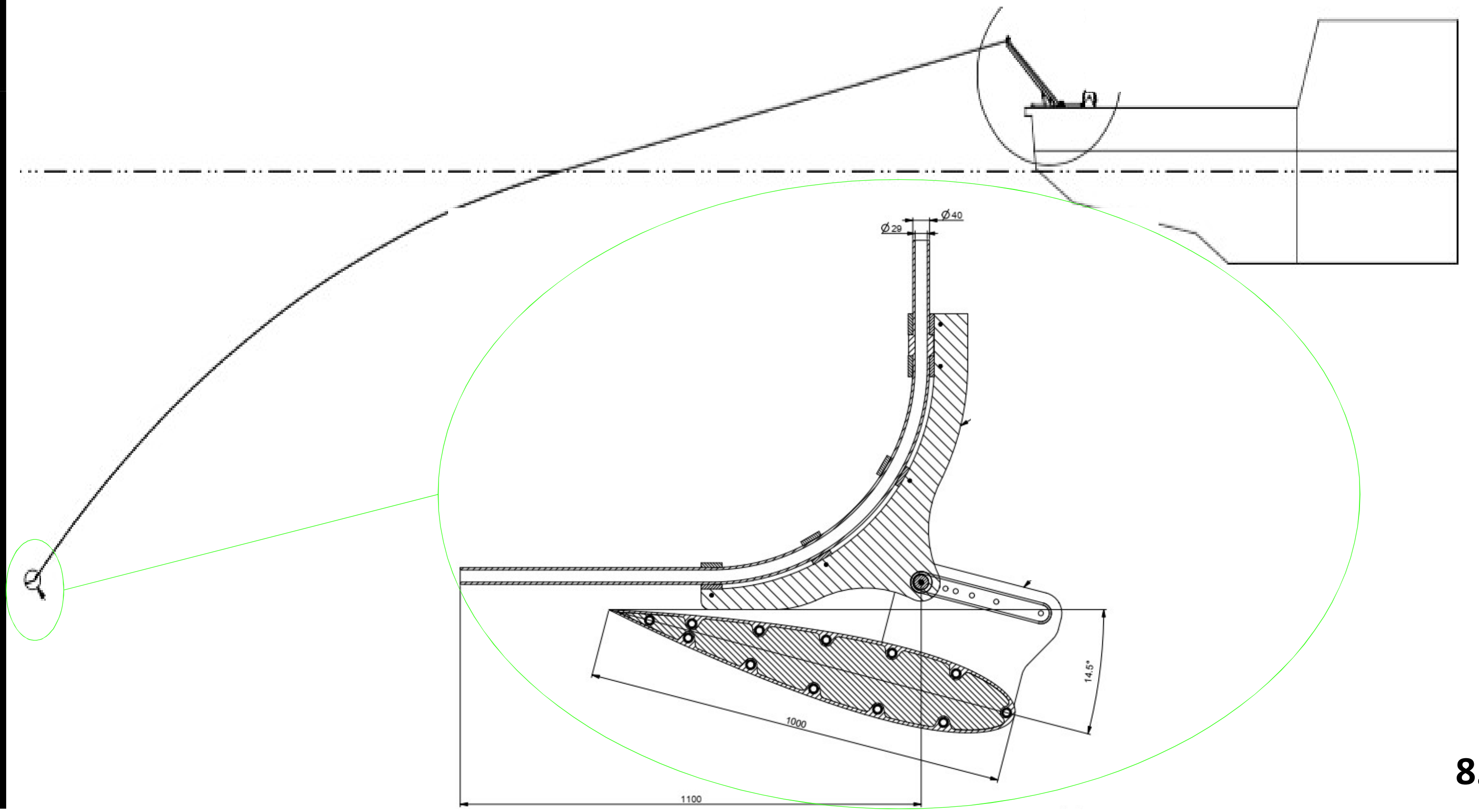
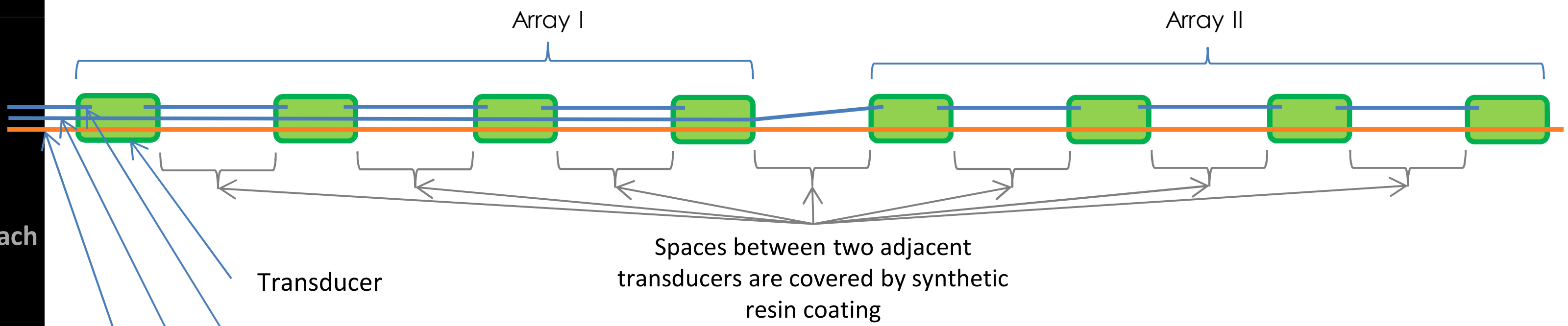
Deployment system - Hydrodynamic depressor



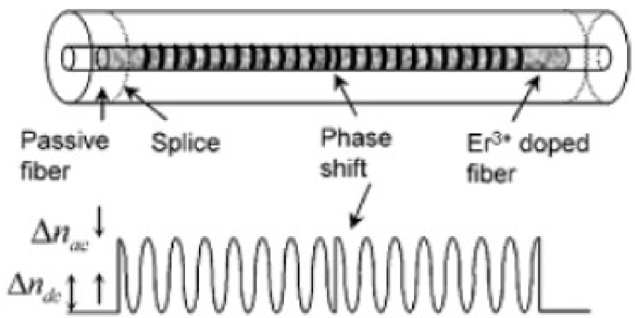
Prototypical Array structure



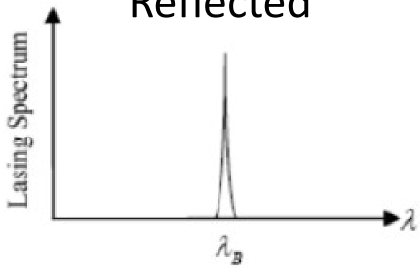
Prototypical Transducer dimensions	L = 120 mm W = 16 mm H = 12,1 mm

Fibre Laser sensor principle

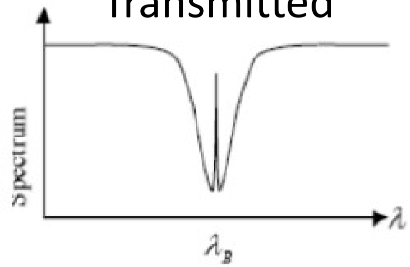
The fibre laser is printed in an Erbium doped optical fibre. When illuminated by an optical source emits a very pure laser beam. The external pressure changes the frequency of the emitted beam.



Reflected



Transmitted



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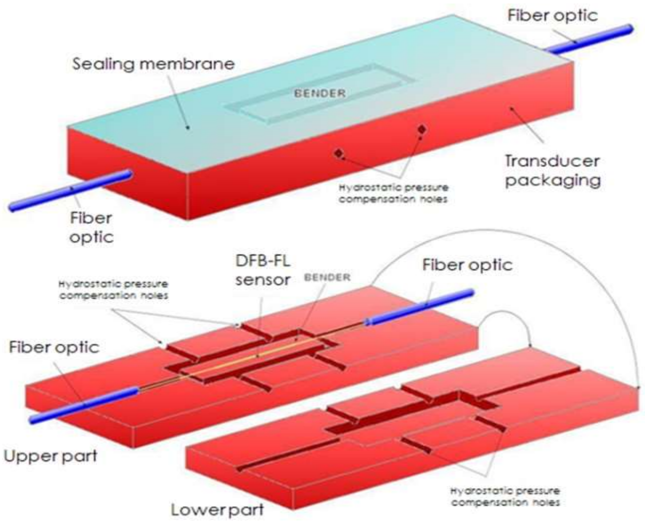
Sensitivity of FLS with bender

The sensitivity (S) of the FLS with bender mechanical amplifier is defined by:

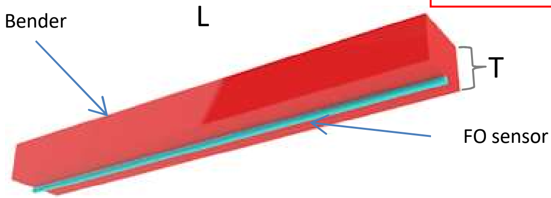
$$S(\omega) = \frac{|\Delta\nu(\omega)|}{p} \sim \frac{3\nu(1-e_z)L^2}{4T^2E}$$

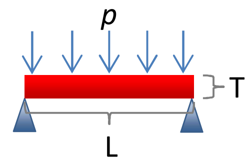
Definitions
ν = intermediate frequency of the C-band
ez = opto-elastic coefficient
E = Young modulus of the bender material
T = thickness of the bender
L = length of the bender
p = pressure applied to the bender
c_b = speed sound in the bender



1° resonance frequency (in air)

$$f_0 = \frac{Tc_b\pi}{2\sqrt{12}L^2}$$





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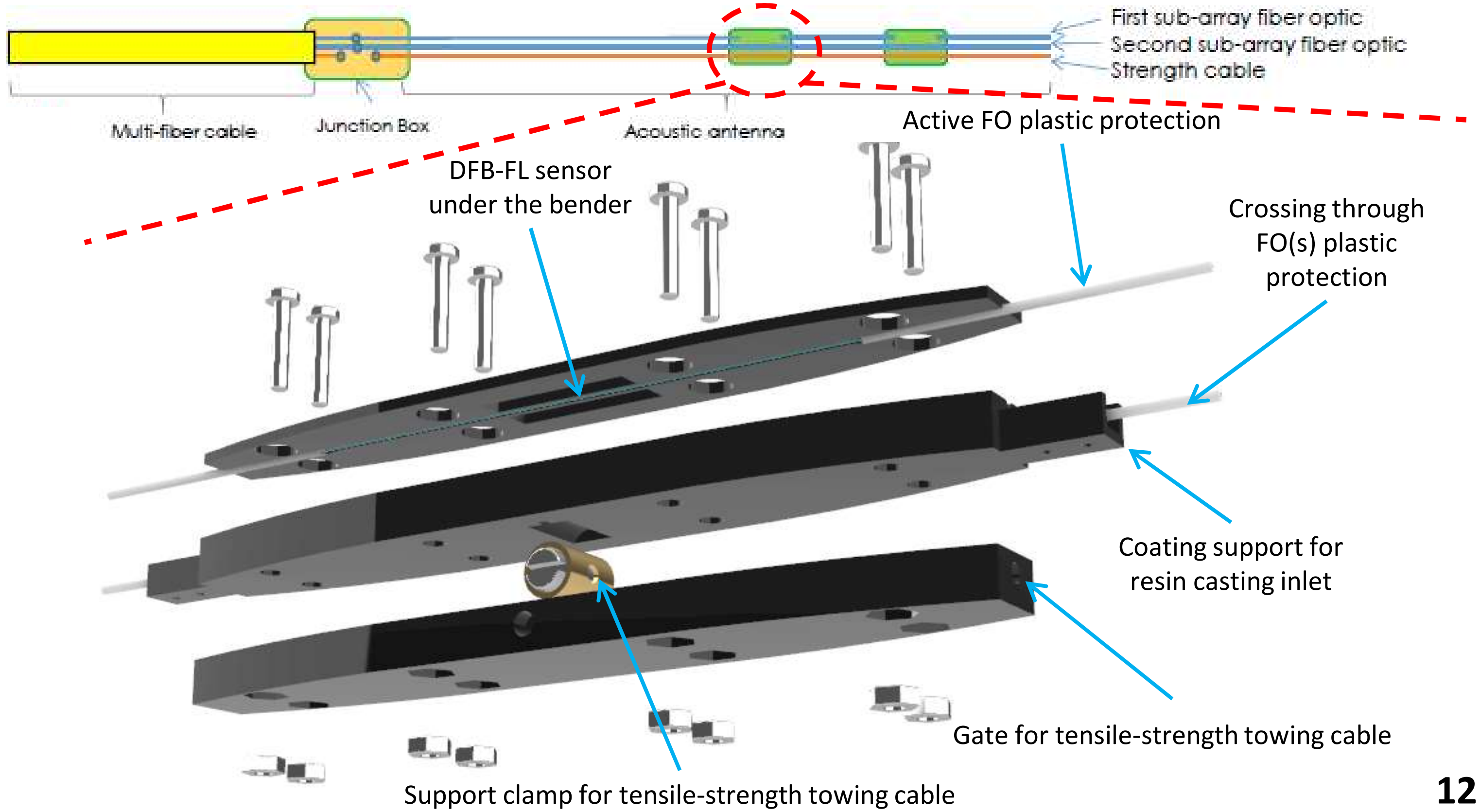
Sensor structure



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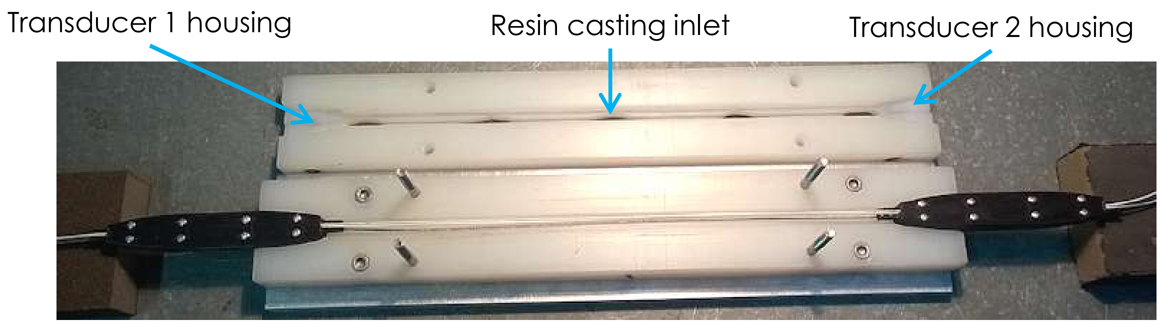
Prototypical Transducer coupling



Preparation phase with two real transducers and three lines

Demolding phase after 48h curing @ room temperature

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Laboratory test

Test on the DFB-FL transducer: measurement of the optical efficiency of the sensor after hydrophone casing

Main test guidelines on the FL

- p-shifted FBG on Erbium doped fibre
- L = 49 mm
- Pump power 650 mW @ 980 nm
- Lasing efficiency > 15%

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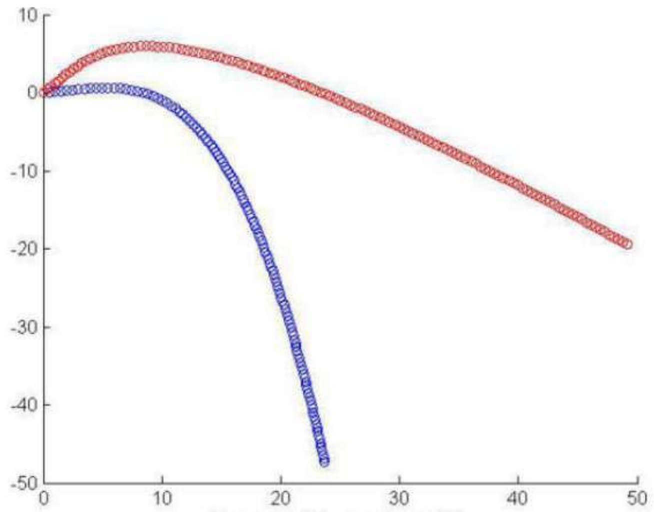
Array linearity detection algorithm

1. Detection of transducer signals and choice of a possible source

2. Determination of the correlation matrix of the complex sensor acquisitions at the frequency of the chosen possible source

3. Analysis of the phase profile



The absolute error in position reconstruction can be very high.

The relative error reconstruction is a function of the Signal to Noise Ratio, with a maximum 0.4 ° at SNR = 0

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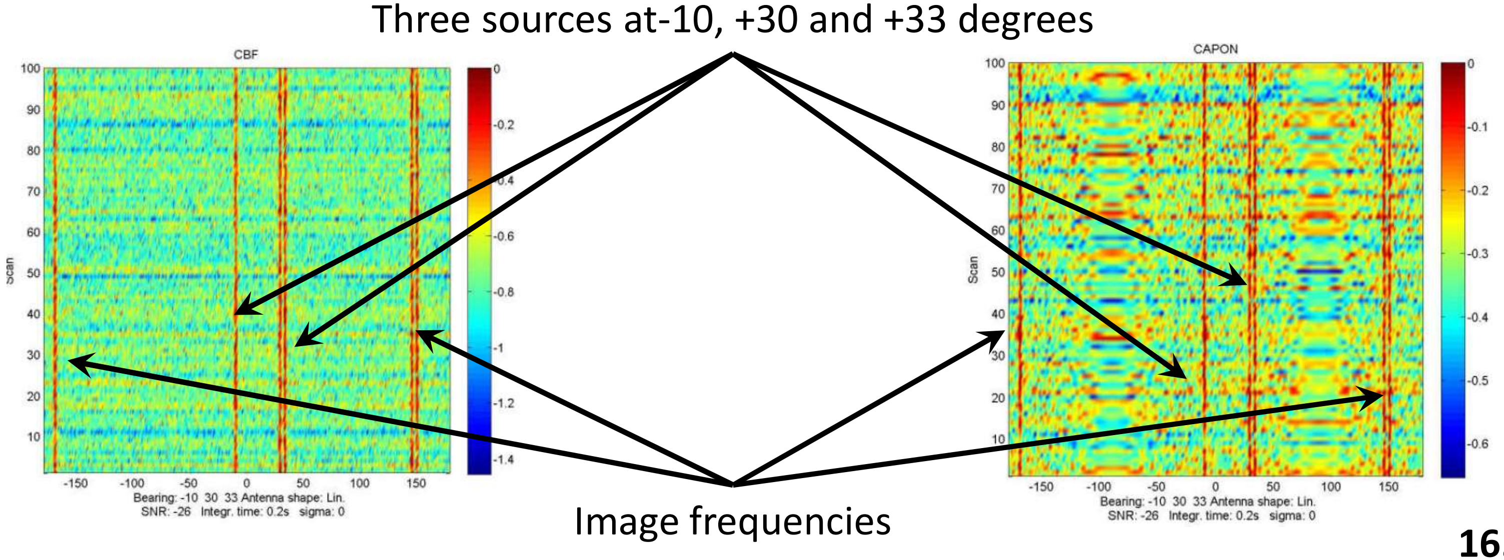
Direction of Arrival algorithms

The performance in Direction of Arrival has been measured in simulation using the Conventional Beamforming, CAPON and MUSIC algorithms.

The Conventional Beamforming has good performances up to -40 dB SNR, while CAPON and MUSIC cannot be used at SNR lower than -30 dB.



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Flow Noise [dB re 1 µPa Hz^-0.5]

Tow speed [Kts]	100 Hz	200 Hz	300 Hz
15	SS6 + 20 dB	SS6 + 5 dB	SS3 + 5 dB
12	SS6 +13 dB	SS3 + 5 dB	~ SS3
9	SS6 + 8 dB	~ SS3	SS1 + 10 dB
6	SS6 + 5 dB	SS1 + 10 dB	~ SS1

Self noise is estimated in the Mediterranean Sea with a towed array made up of 32 elements.
Sea State refers to Knudsen curves.

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Technological Approach

- Approach to the technological challenges,
- Solutions adopted,
- Lesson learned,
- Future work.

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SASSO program – Tests

Trials at sea will be conducted at Portici (Naples) with an average depth of 50 m.
The array will be fixed at a certain depth and a ship with an active hydrophone will be displaced all around the SASSO array in order to create the radiation pattern of the array.
Then, a second source will be turned on to evaluate the angular discrimination (estimated 5°) of the array.

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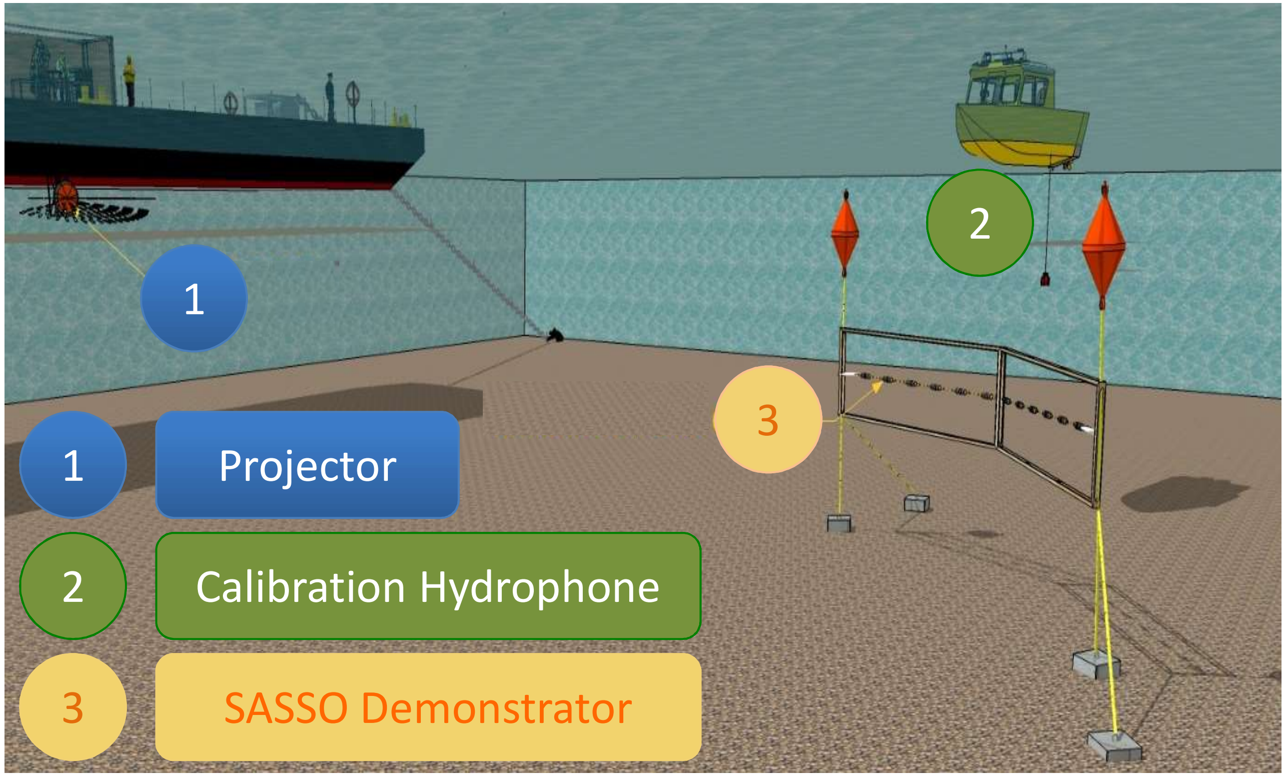
SASSO program – Test bed



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