iXblue

Subsea Positioning and Communication Solutions

ENSTA – Sub-Meeting 2019

June 2019

iXblue Corporate presentation

iXblue

Independent, High-Technology, Industrial Company

600+
employees

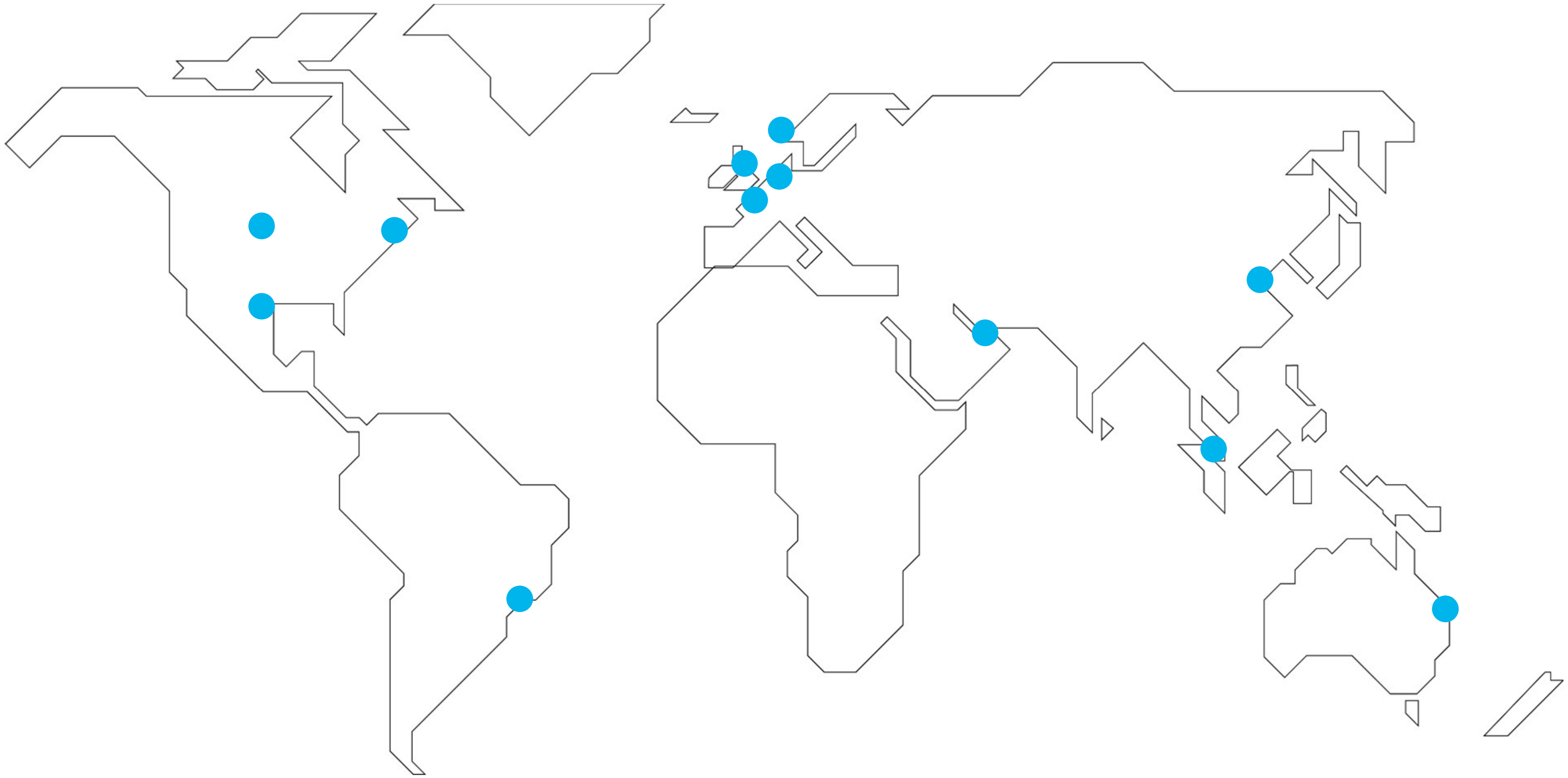
120M€+
turnover

80%
export

Founded in 2000

iXblue

Global Footprint



24/7
support

12 offices
worldwide

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Products & Services

Artificial intelligence

Specialty fibers and components

Modulation solutions

Inertial sensors

Underwater acoustic communication and positioning

Motion simulators and Pan & Tilt

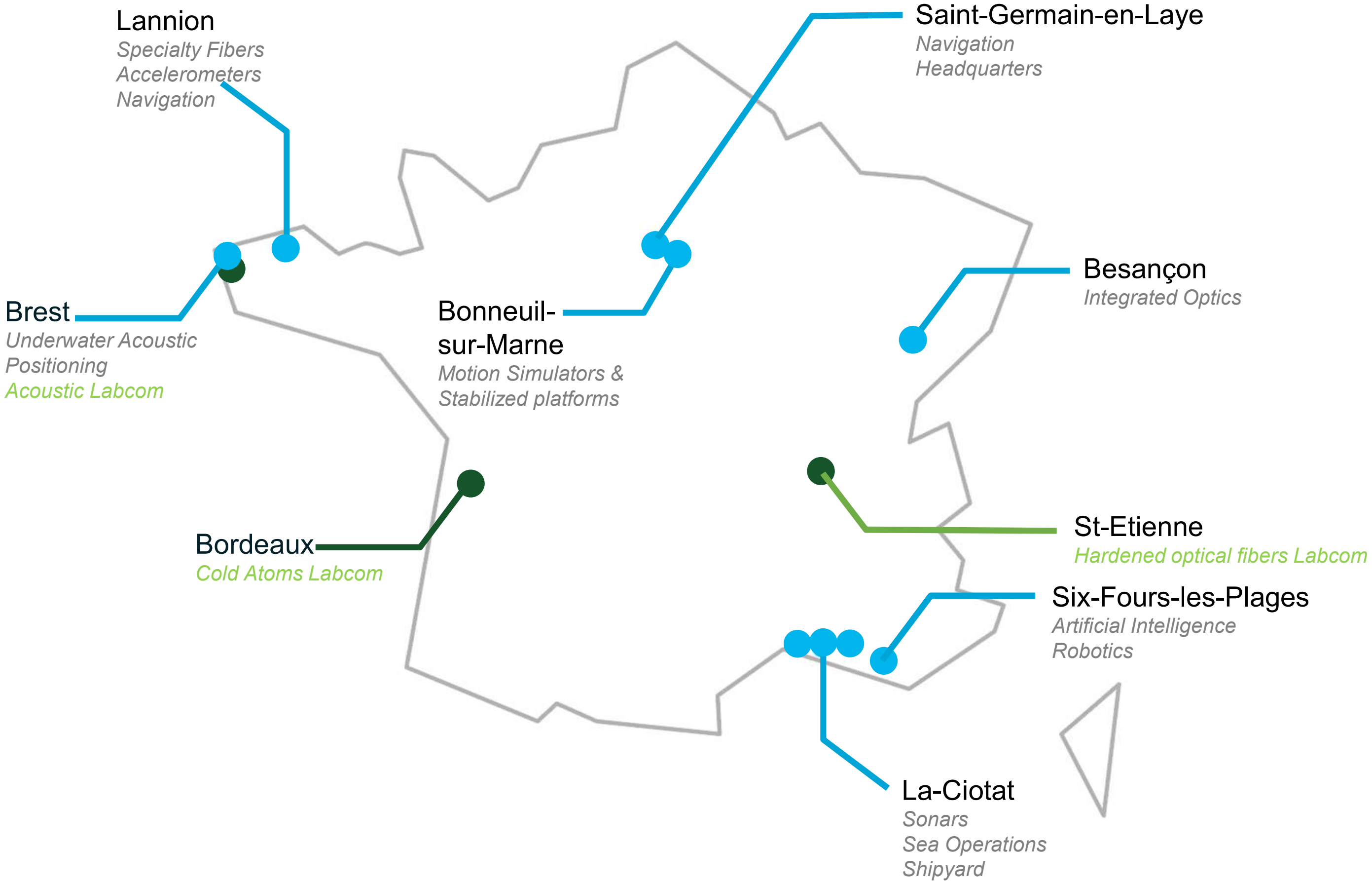
Navigation systems

Sonars

Ships and drones

Sea operations

iXblue in France



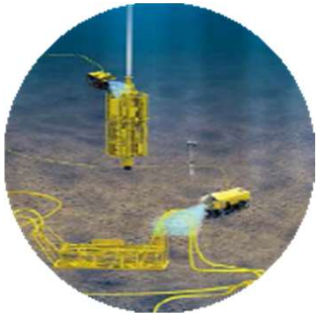
9 industrial sites

R&D and Production

3 Joint Research Laboratories

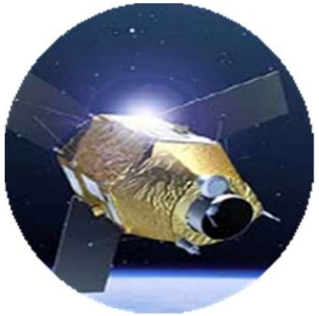
Several EEC R&D programs

Applications



Energy and Renewables

Hydrography



Space

Defense

Navigation

Autonomous vehicles

Science

Fishing and fishery research

Our products are used from the depths of the oceans to outer space in very diverse applications. We encourage strong cross-fertilization, technical and methodological synergies between those applications.

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Our vision

We master the key technologies for the development of autonomous vehicles, marine exploration and photonics. In these fields, we contribute to the mutations of the world and we open up new horizons. On and under the sea, underground, on land, in the air and in space.

Autonomous Vehicles

Marine Exploration

Photonics

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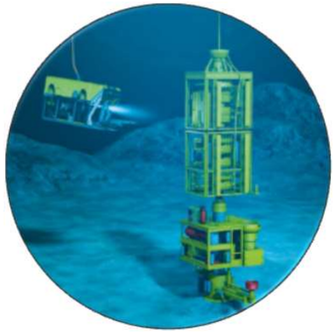
QUADRANS OCTANS PHINS

M3 M5
M7
MARINS SERIES

C3 C5 C7
PHINS COMPACT SERIES



OCTANS NANO | OCTANS 3000G4 | ROVINS NANO | ROVINS | PHINS 6000

URSA LYRA VEGA
ADVANS SERIES

1090 120 200
ASTRIX SERIES

ATLANS C AIRINS

INERTIAL PRODUCTS RANGE

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Subsea Positioning and Communication

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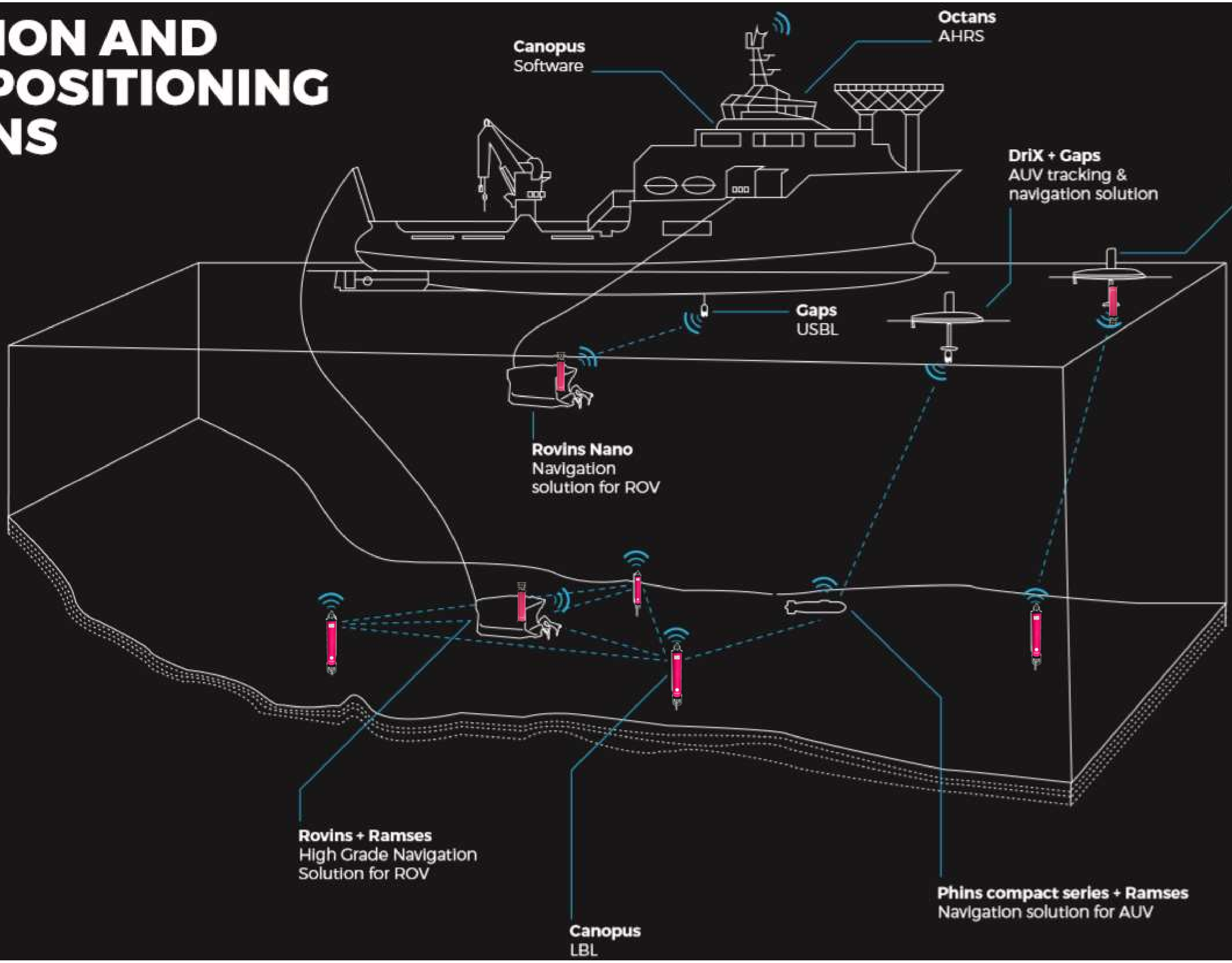
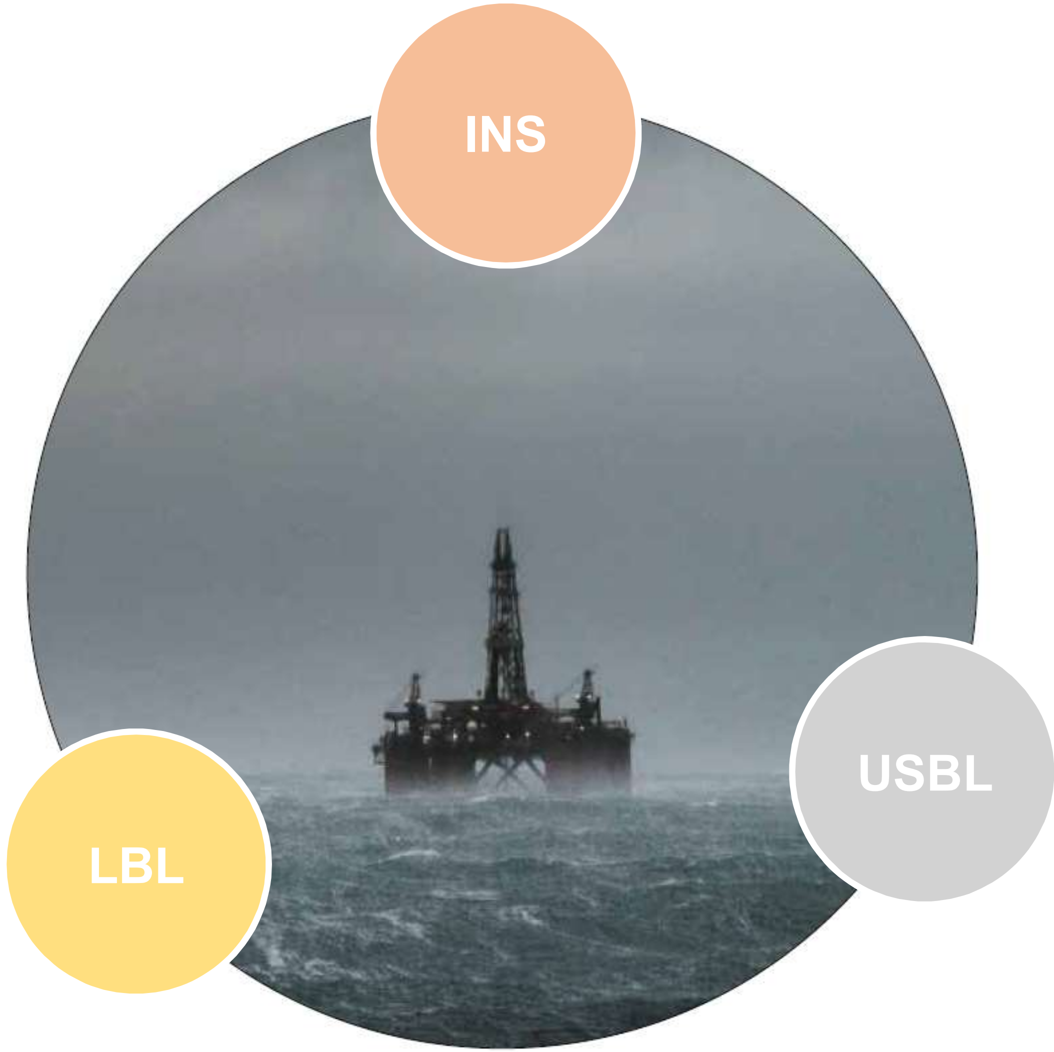
NAVIGATION AND SUBSEA POSITIONING SOLUTIONS



CANOPUS system

Principles of subsea positioning

- INS, Inertial Navigation Systems
- LBL, Long BaseLine acoustic positioning systems
- USBL, Ultra Short BaseLine positioning systems



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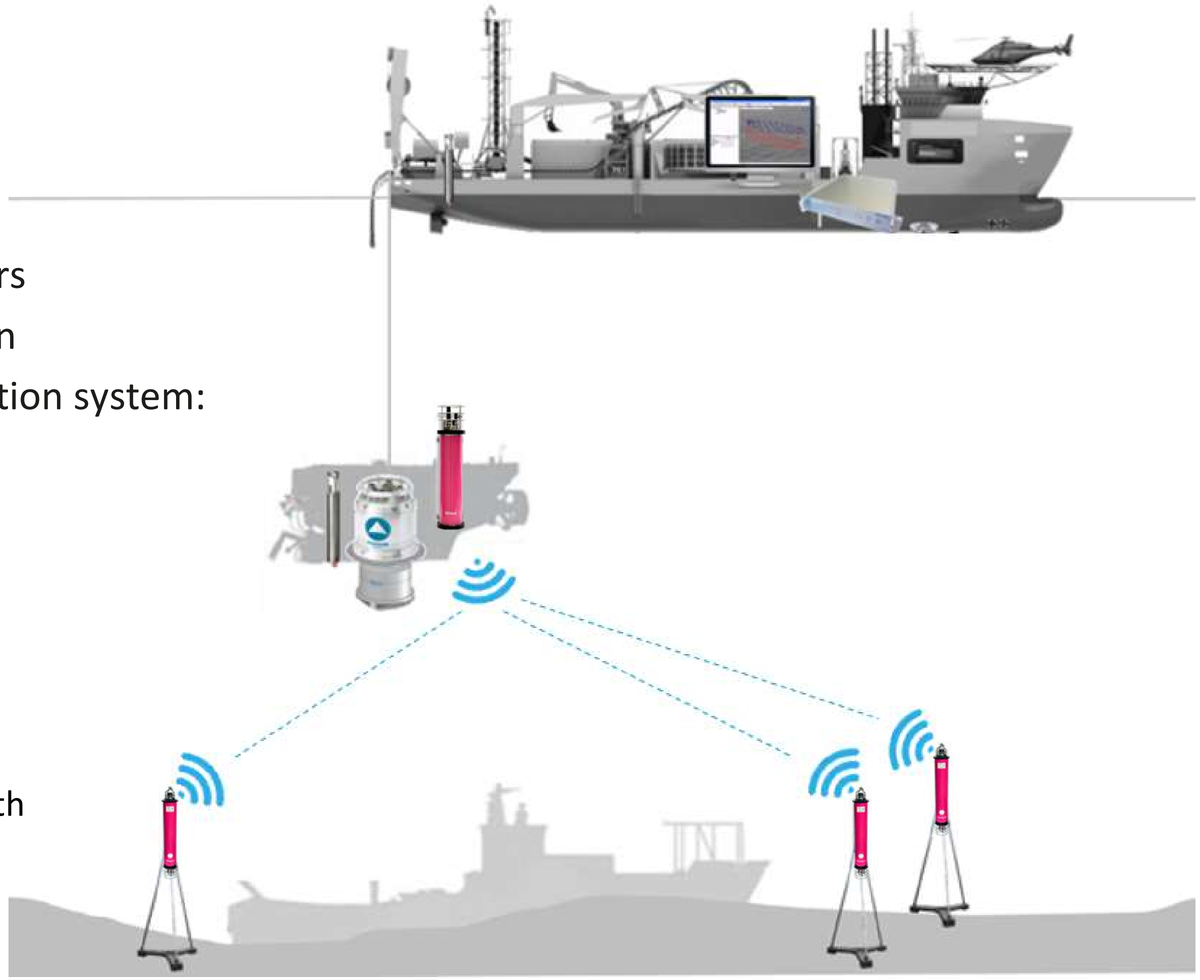
CANOPUS system

Principles of subsea positioning

- In **LBL** mode…
  - ✓ Range measurement to fixed transponders
  - ✓ Algorithm calculates the resulting position
  - ✓ Possible combination with inertial navigation system:
    - Robustness
    - Sparse array navigation
    - Increase positioning accuracy

- Require to deploy fixed transponders on the seabed
- Require to box-in the fixed transponders
- Decimetric positioning accuracy whatever the water depth
- Autonomous positioning method



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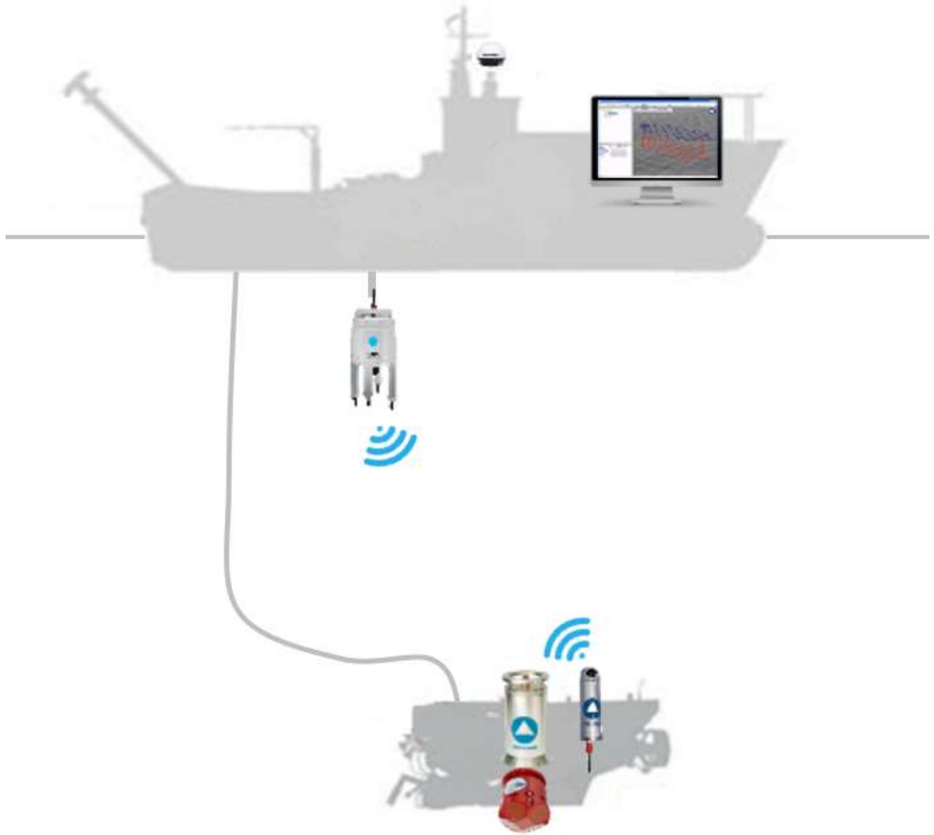
CANOPUS system

Principles of subsea positioning

- In **USBL** mode …
  - ✓ Slant range + bearing estimation
  - ✓ Estimation of the position of the transponder
  - ✓ Possible combination with inertial navigation system:
    - Robustness
    - Increase positioning accuracy



- Does not require to deploy fixed transponders on the seabed
- Does not require to box-in the fixed transponders
- Positioning accuracy is a % of slant range
- Position of the transponder is known remotely

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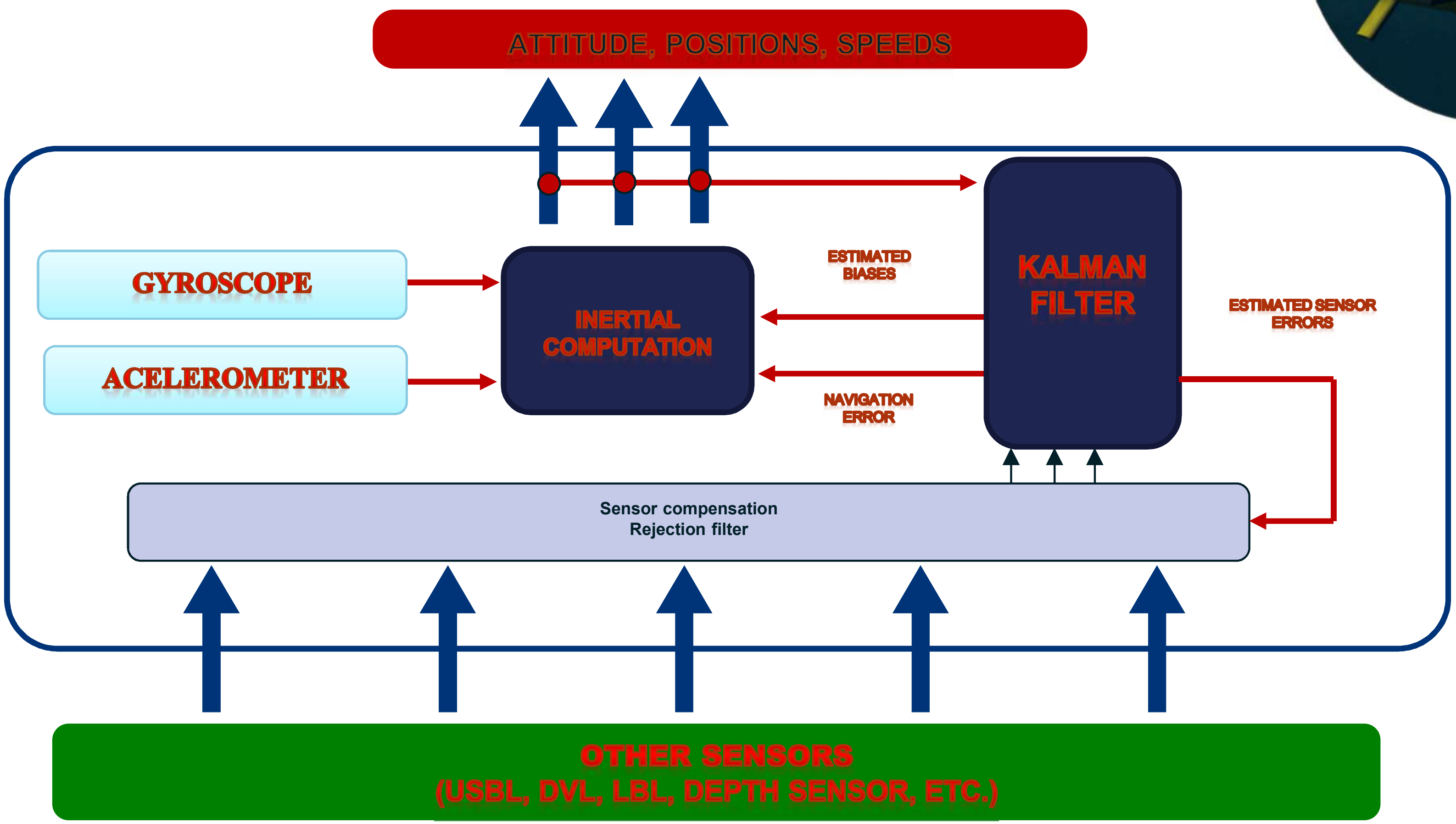
CANOPUS system

Principles of subsea positioning with an INS



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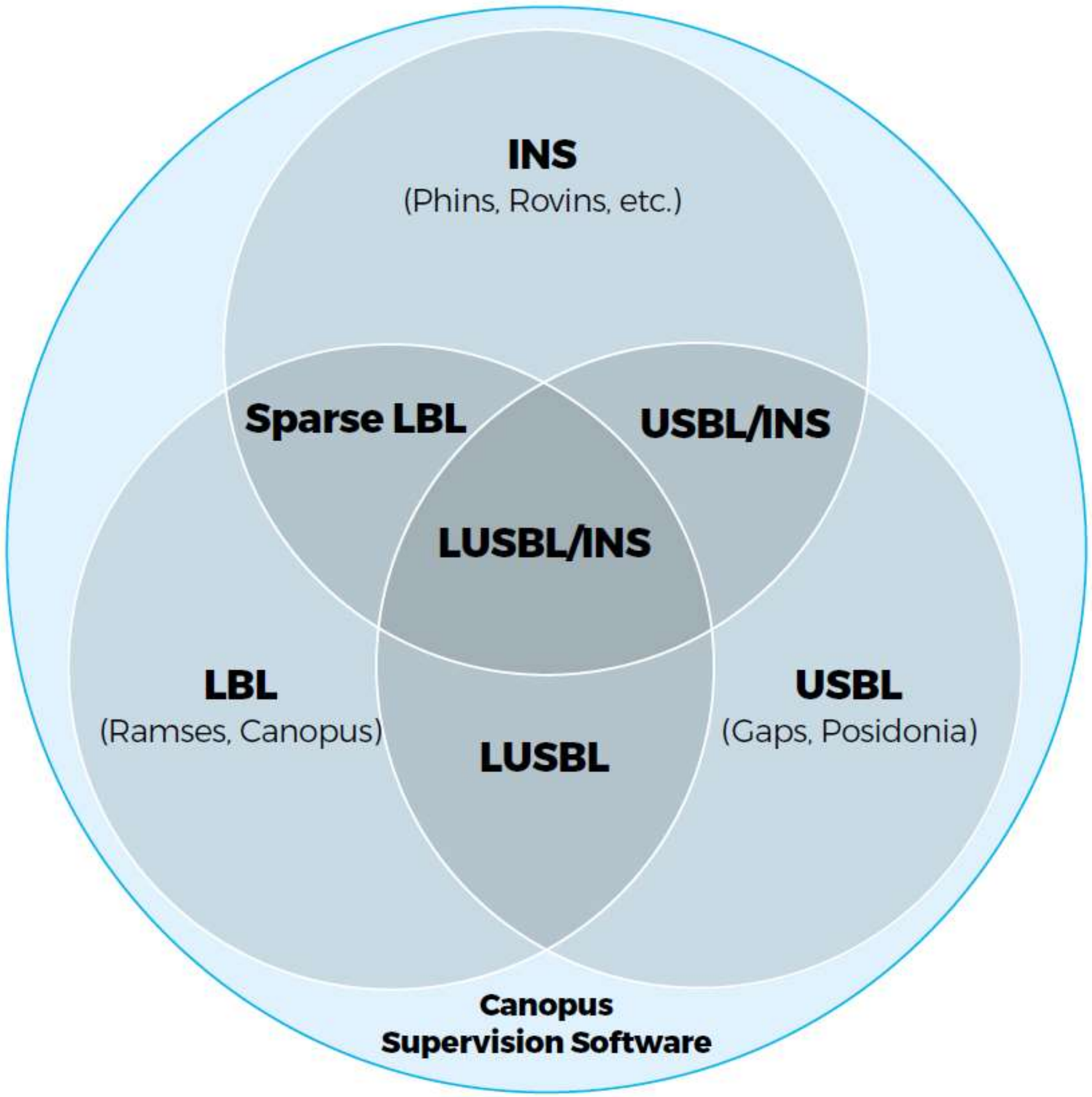
CANOPUS system

iXblue offer

- Master each technology individually
- Combine them and provide a robust system
- Reach simplicity and performance



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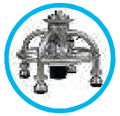
CANOPUS system

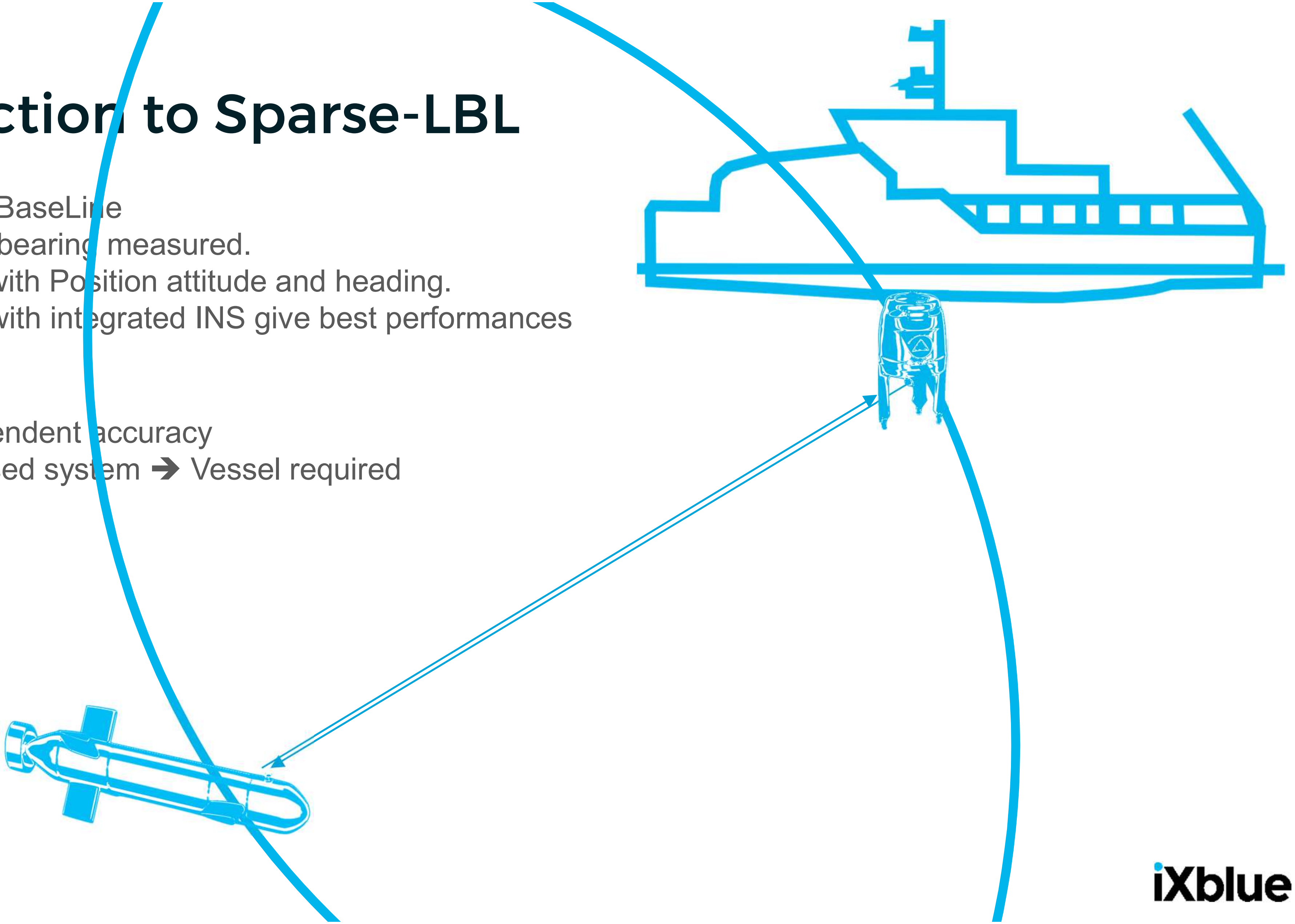
A range of sensors

	GAPS	The fully integrated, portable and pre-calibrated USBL for universal applications
	POSIDONIA	Long range USBL positioning system
	INS	A range of FOG based INS for all applications
	RAMSES	An Acoustic Synthetic BaseLine positioning system, a complementary approach to LBL
	Transponders	Low or medium frequency transponders to operate with iXblue acoustic systems

Introduction to Sparse-LBL

USBL
- Ultra-Short BaseLine
- Range and bearing measured.
- Combined with Position attitude and heading.
  ➔ USBL with integrated INS give best performances

WEAKNESS:
- Range dependent accuracy
- Surface based system ➔ Vessel required



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Introduction to Sparse-LBL

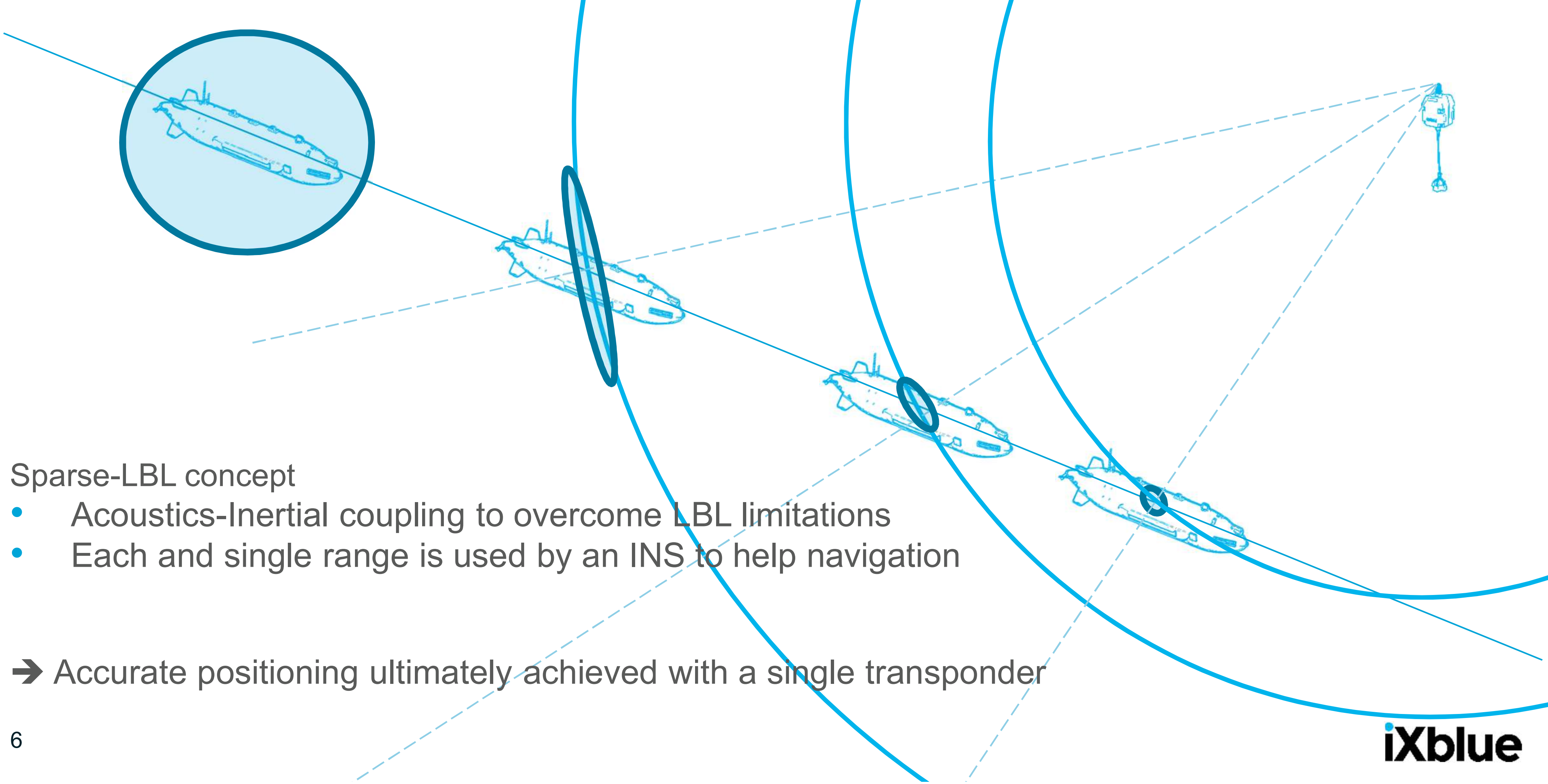
LBL

- Long BaseLine
- Position computed from ranges to known seabed transponders

WEAKNESS:

- More than 3 Transponders required to produce a single position
- Time consuming calibration
- Low time-stamping precision
- Slow update rate (<1Hz)

Introduction to Sparse-LBL



Sparse-LBL concept

- Acoustics-Inertial coupling to overcome LBL limitations
- Each and single range is used by an INS to help navigation

➔ Accurate positioning ultimately achieved with a single transponder

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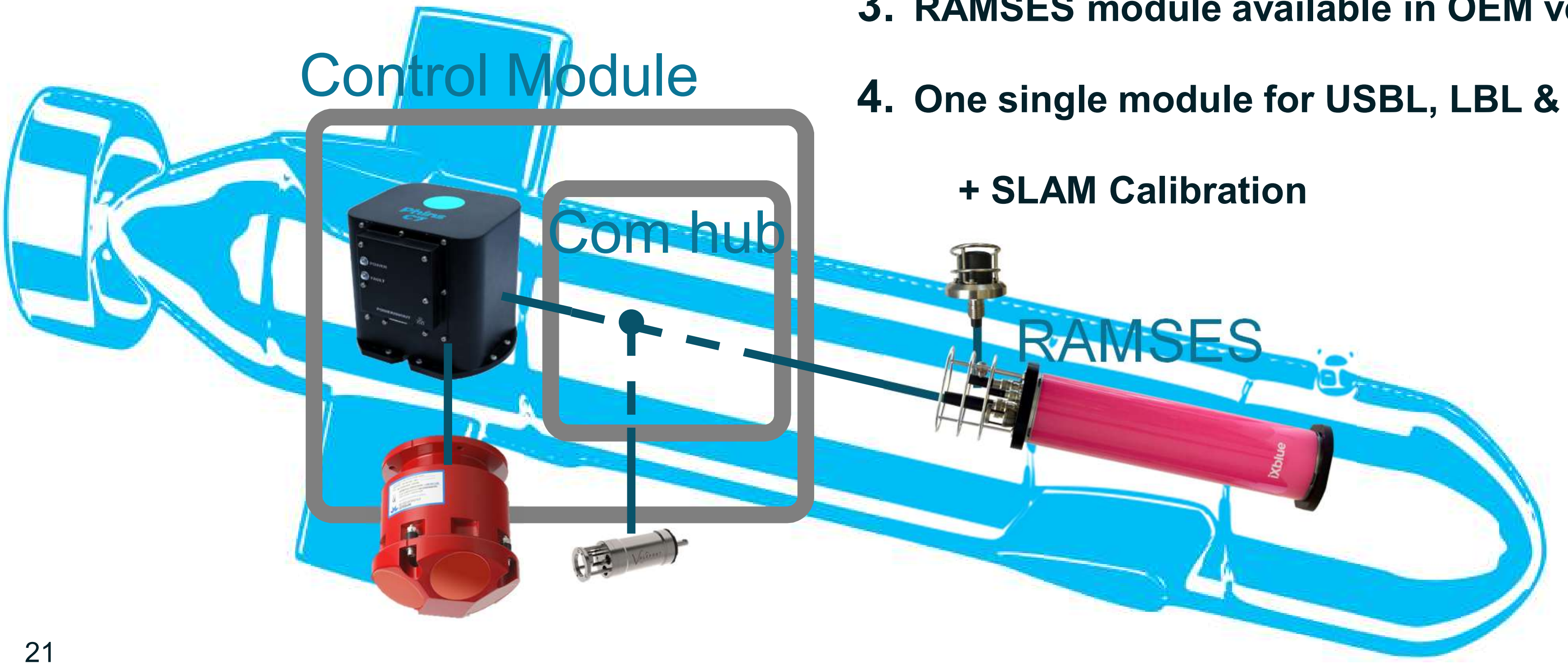
System Architecture

Connection diagram

1. **Seamless integration with IXBlue range of INS**
2. **Minimum connection : 12-36VDC power**
   Ethernet link
3. **RAMSES module available in OEM version**
4. **One single module for USBL, LBL & sparse positioning**

   + SLAM Calibration



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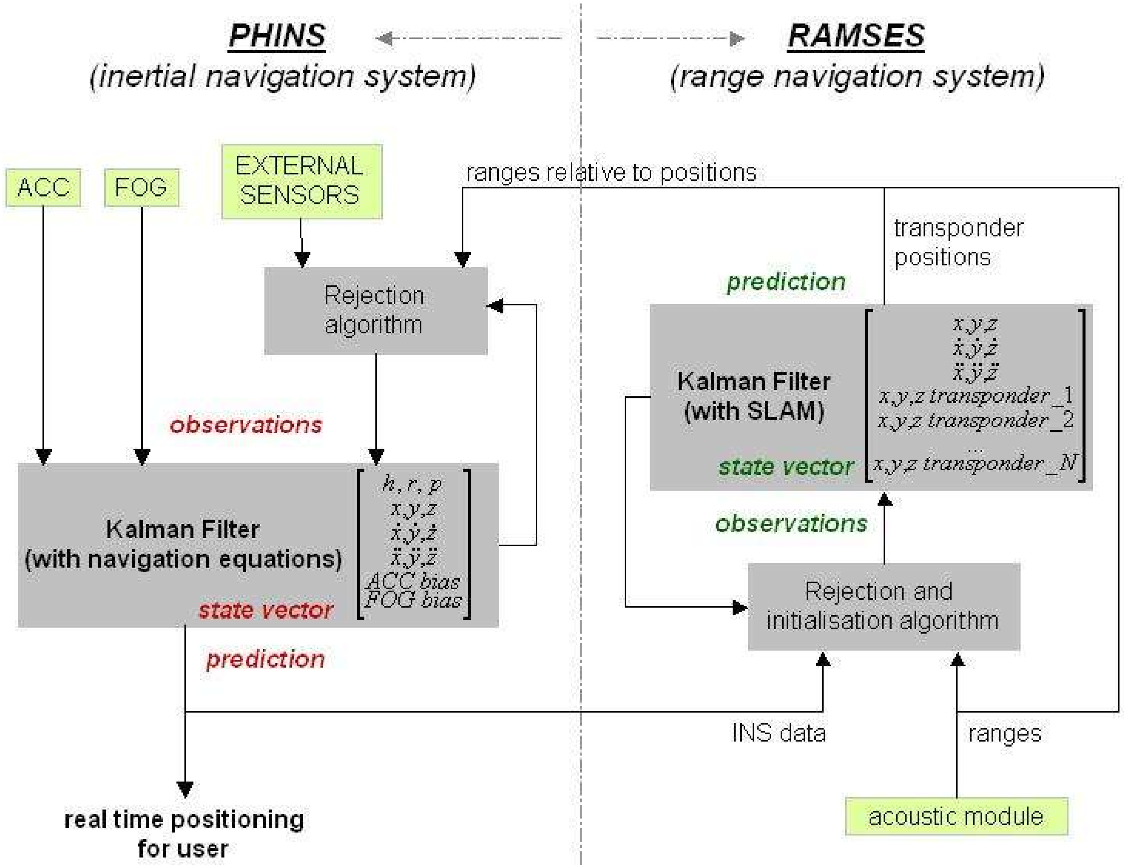
System Architecture

INS – RAMSES coupling diagram



- Both C-PHINS and RAMSES algorithms are based on **Kalman filtering techniques**

- INS Kalman filter is dedicated to navigation
- RAMSES Kalman filter can
  - Compute its own position
  - Calibrate a set of transponders (SLAM)

- When coupled to C-PHINS INS:
  - **INS navigates** using RAMSES ranges
  - **RAMSES calibrates** using INS positions
  - **RAMSES QC INS position**, to fix it if required

- Dual Kalman architecture offers an optimum flexibility to upgrade a standard navigation system with Sparse-LBL capability

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Canopus Software

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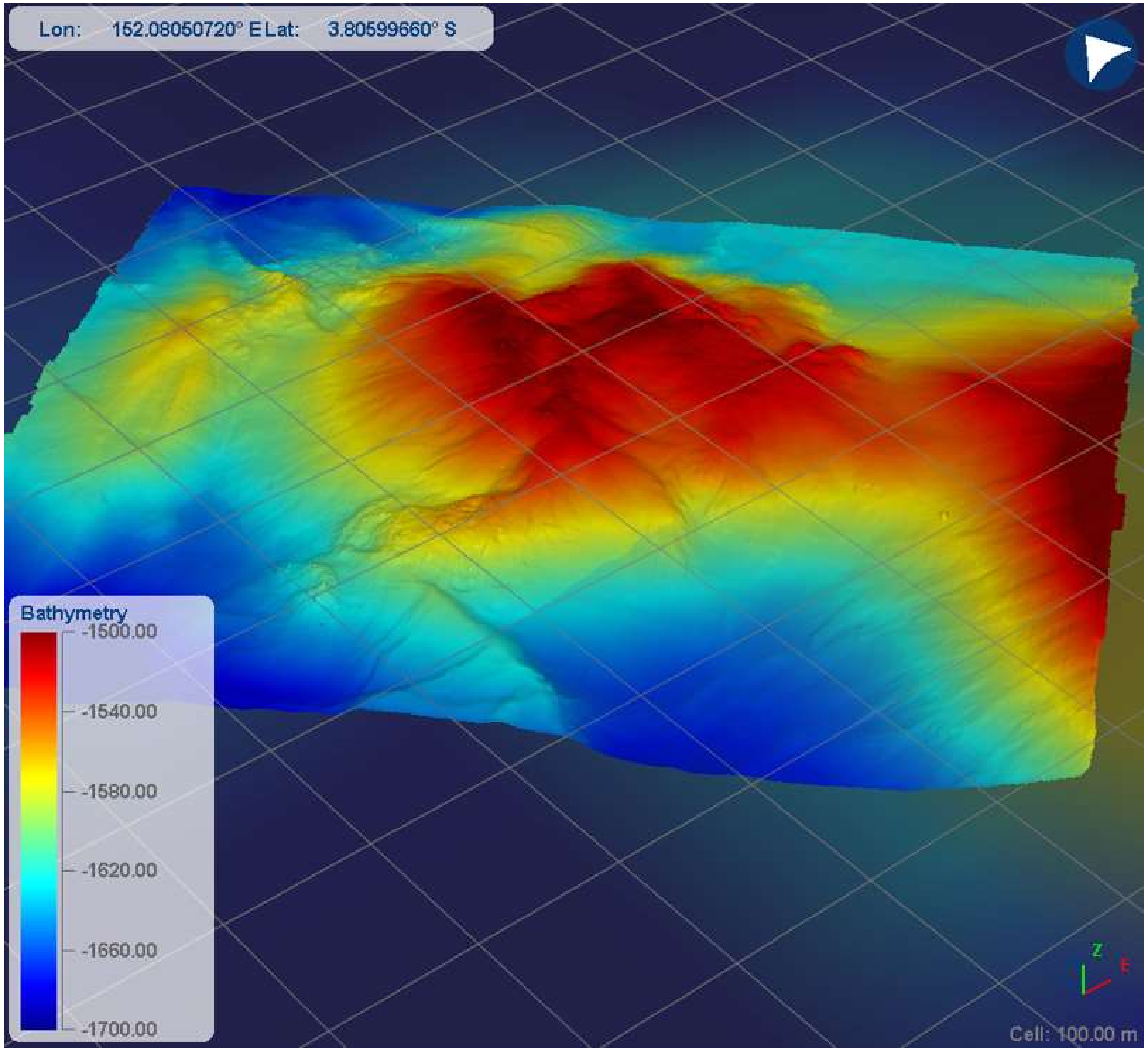
CANOPUS Software

Plan
Prepare the job (how many TP's, where, expected performance, etc).

Deploy and calibrate
Configure and calibrate.

Operate and monitor
Produce QA/QC, reach expected performance. Raise alarms.

Post-process
Improve performance and additional QC.



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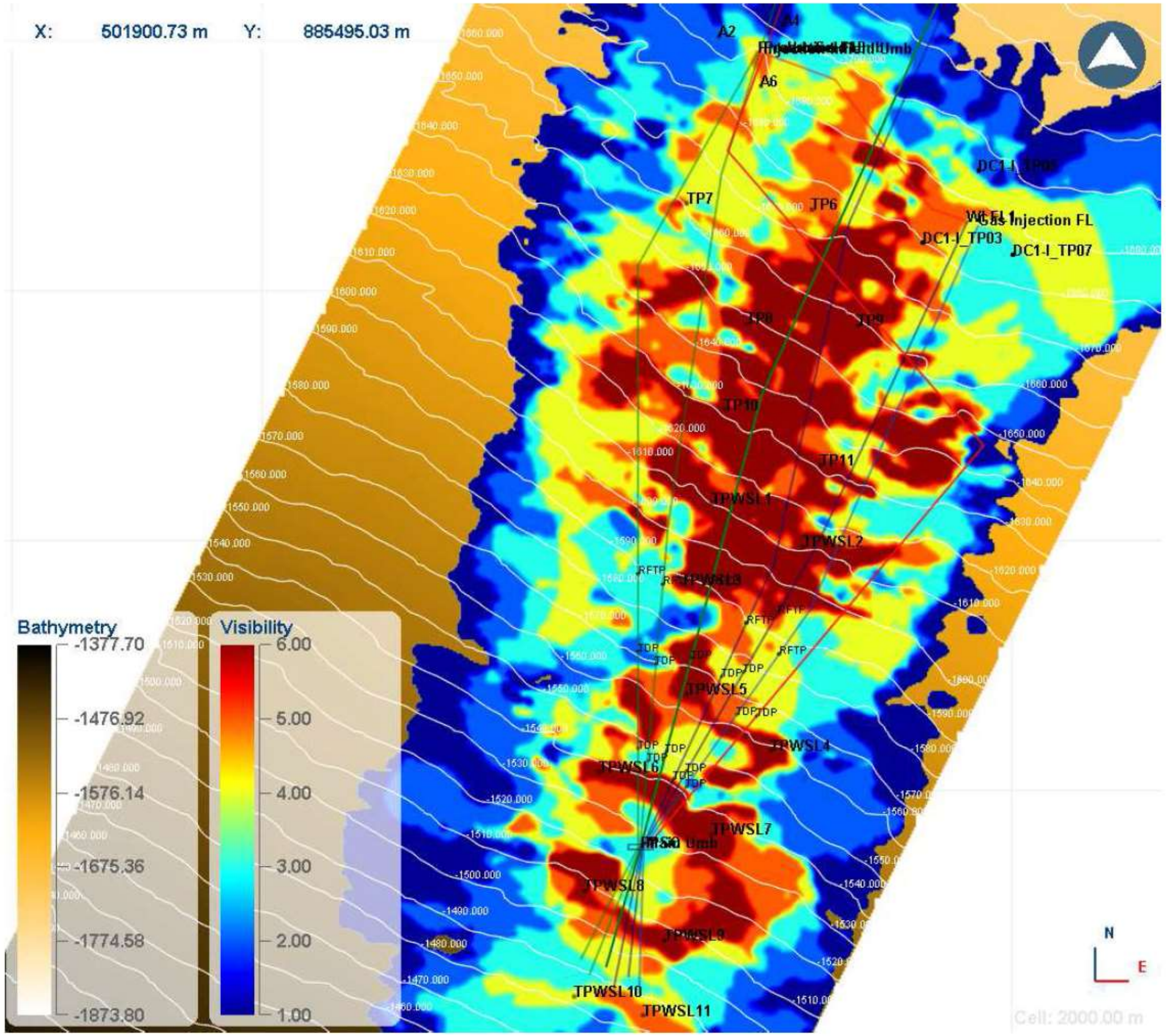

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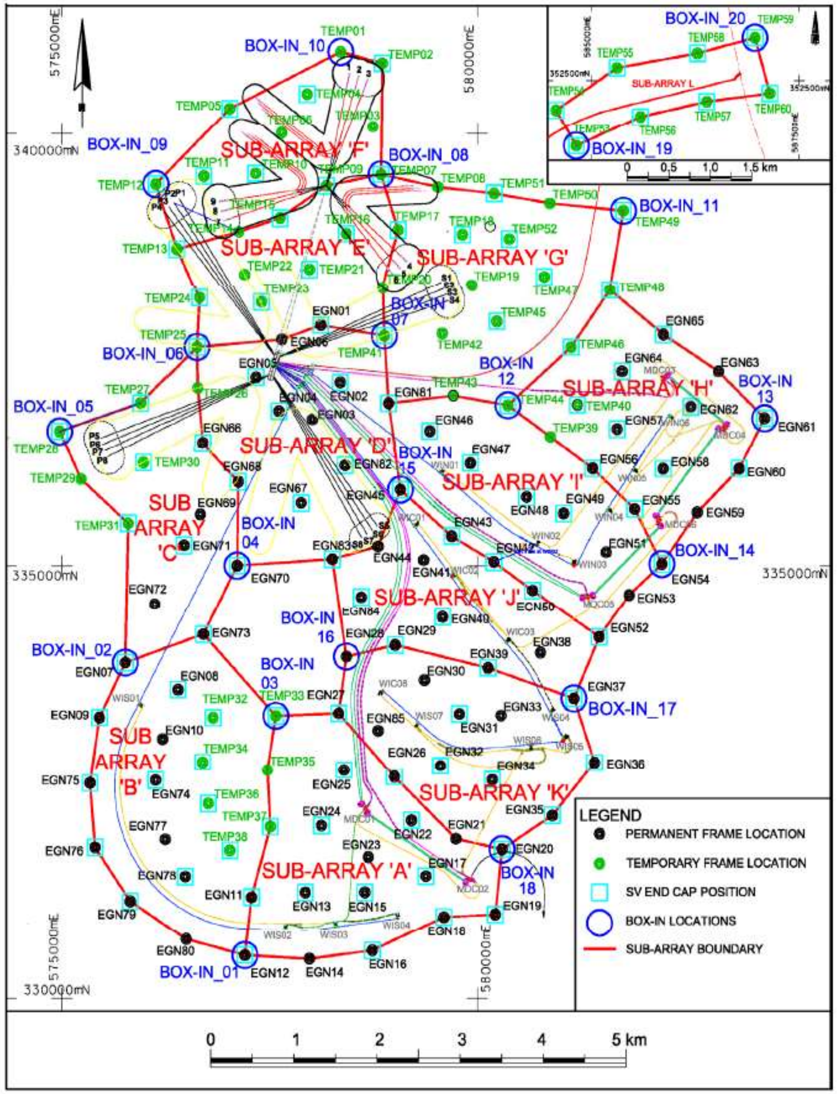

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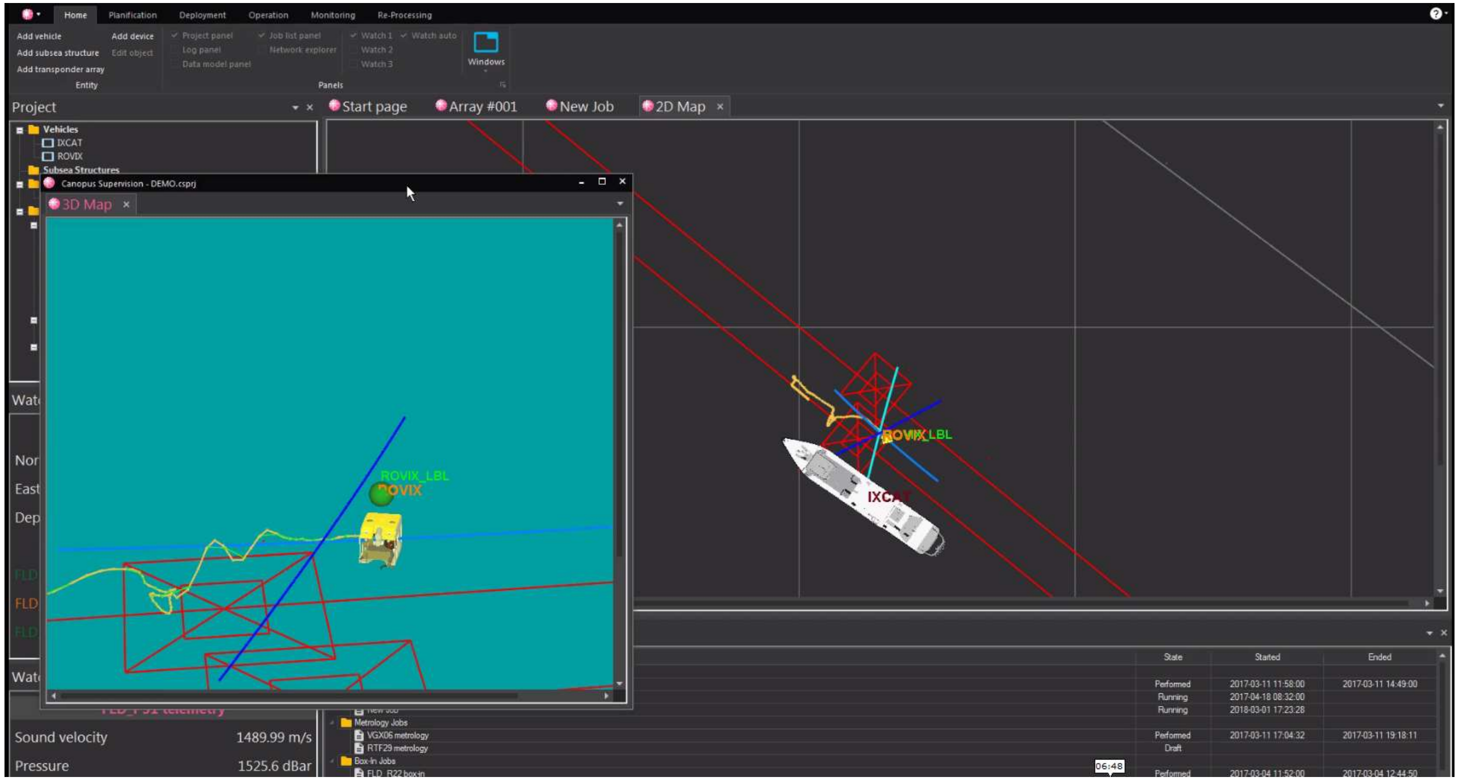

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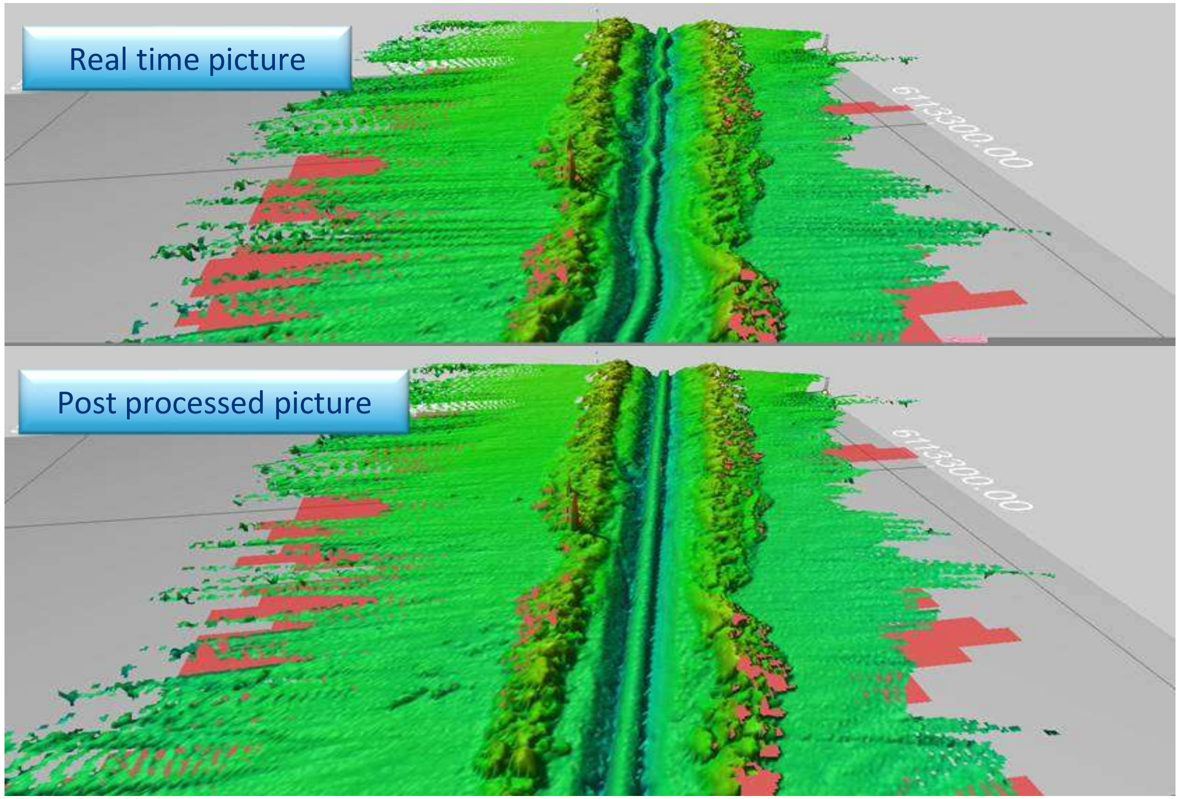

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Tests at sea
Sparse navigation
Shallow water

IXBLUE CANOPUS

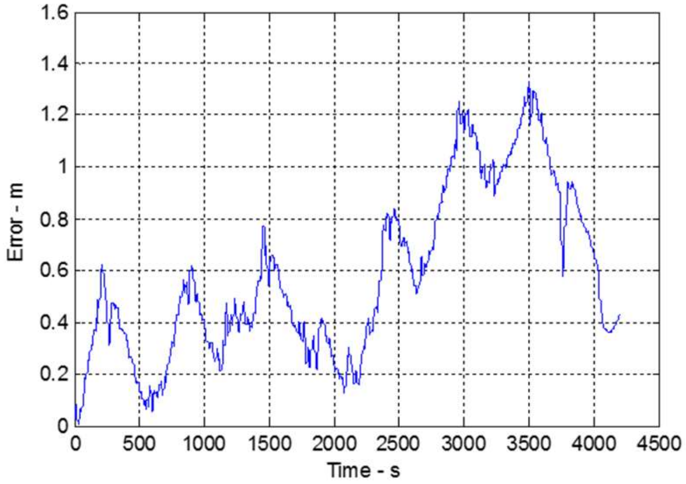
Typical Navigation Performance

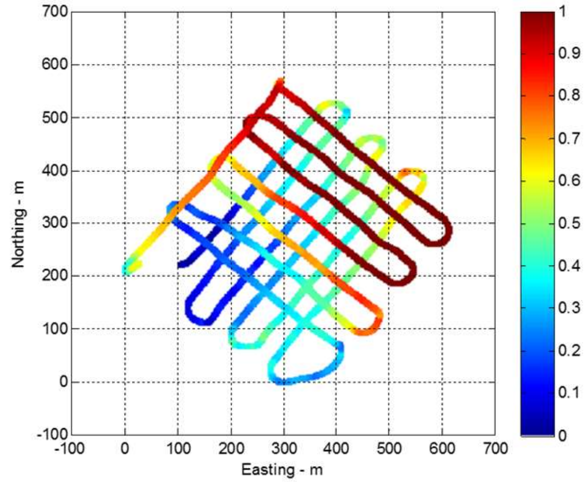
INS / DVL-BT

- Travelled distance: 6 000 m
- Speed: 2,5 knots

Error Type	Longitude	Latitude	Horizontal
RMS 1σ	0.29m	0.25m	0.39m
Mean (bias)	0.49m	0.21m	0.53m

INS / DVL
⇔
Smooth Error Drift





⇨ Metric precision, function of the travelled distance and of the considered trajectory
Max error ~1,2 m with 6000 m max horizontal distance (⇔ 0,02% T.D)

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Typical Navigation Performance

+ DELPHINS
Backward
POST-PROCESSING

INS / DVL-BT / Sparse LBL (1 x TP)

+ forward/backward Post Processing

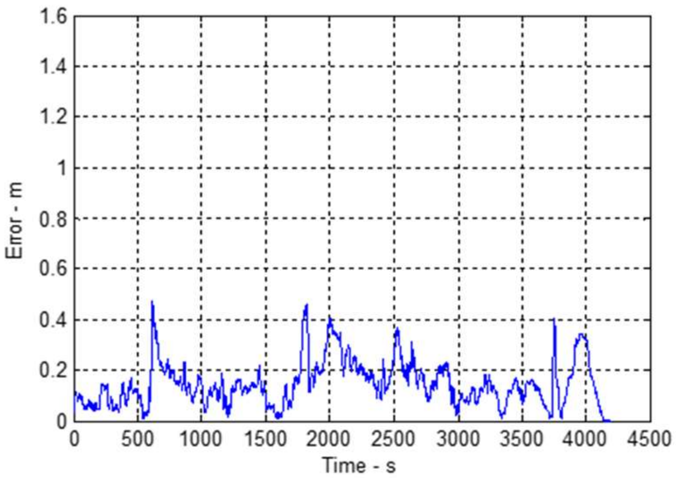
- One single TP used

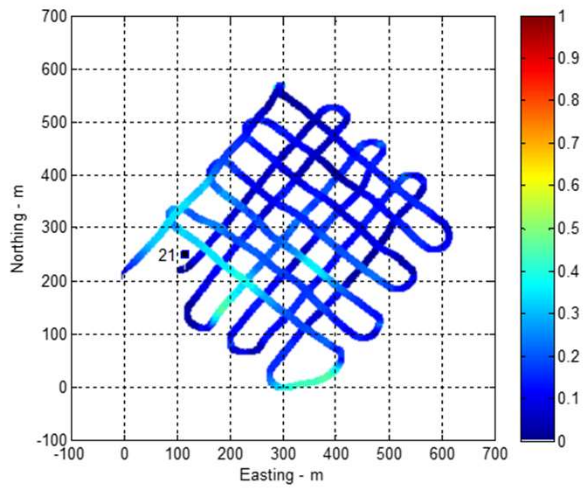
Error Type	Longitude	Latitude	Horizontal
RMS 1σ	0.10m	0.12m	0.15m
Mean (bias)	0.05m	-0.05m	0.07m

INS / DVL / LBL (1xTP)

⇔

Smooth error
No drift





⇨ Live non drifting navigation
Precision almost equivalent to the one achievable with a full LBL array
Post-processing brings back full accuracy: smooth navigation, with rare error pikes

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Tests at sea
Sparse navigation
Deep water

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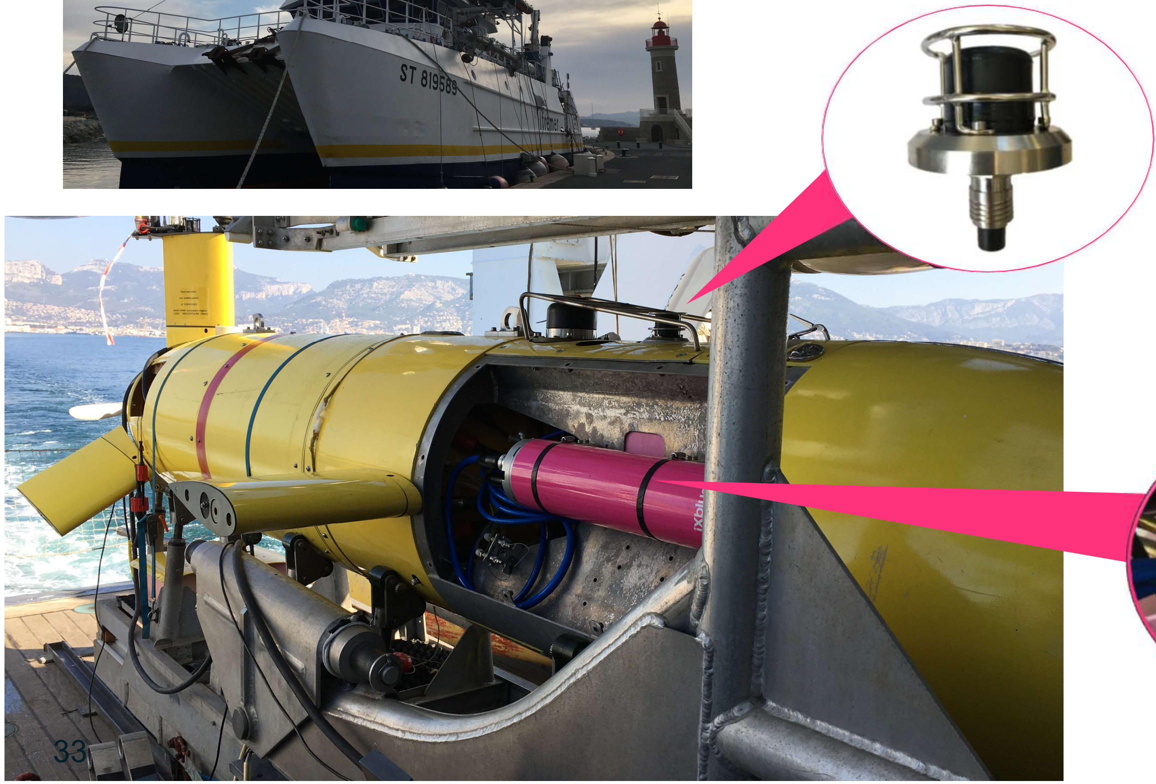
Results at sea



Integration on Ifremer EUROPE vessel

GAPS mounted on a pole, coupled to DGPS

IdefX AUV equipped in standard with

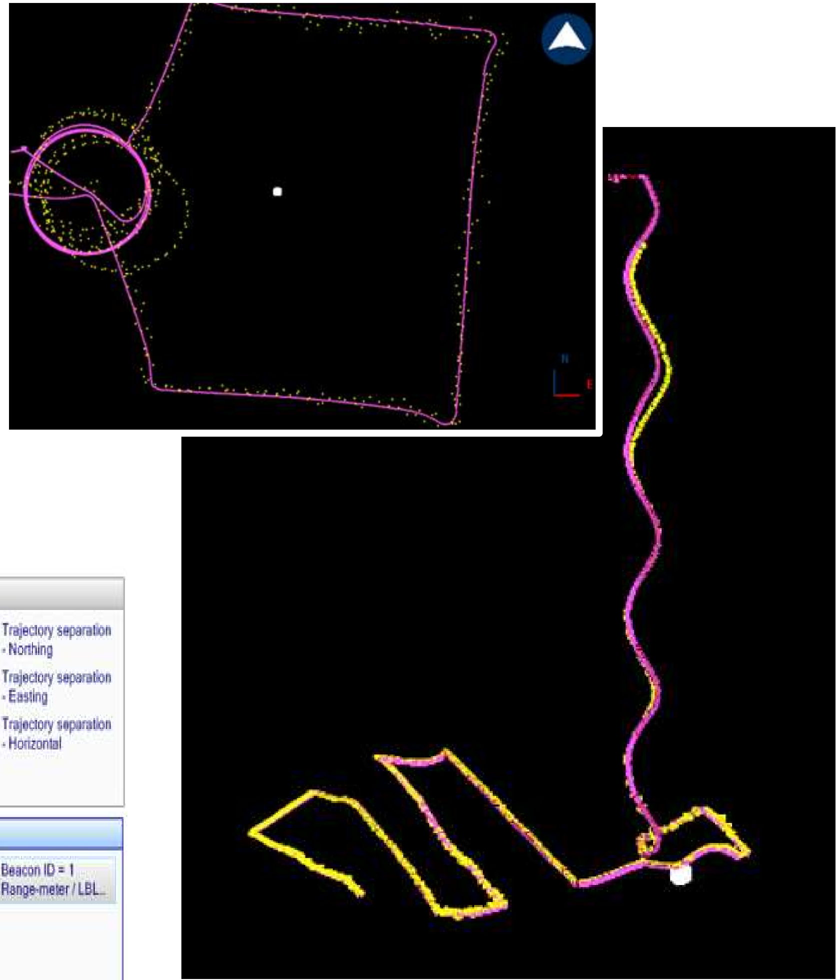
- C-PHINS in AUV dry compartment
- RDI DVL, CTD in wet section
- KM EM2040 multibeam echo sounder

Ramses temporarily integrated in wet section for test duration

Results at sea

Dive, with only 1x aiding transponder

- ✓ Real time observation:
  - ✓ Small drift in water column, w. AUV on top of the transponder…
  - ✓ … which is then perfectly compensated when reaching seabed
- ✓ No USBL fix required as well with one single TP



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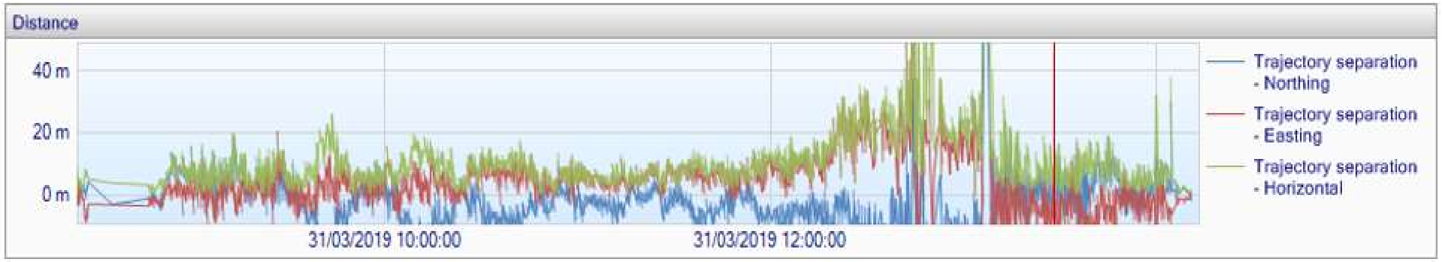
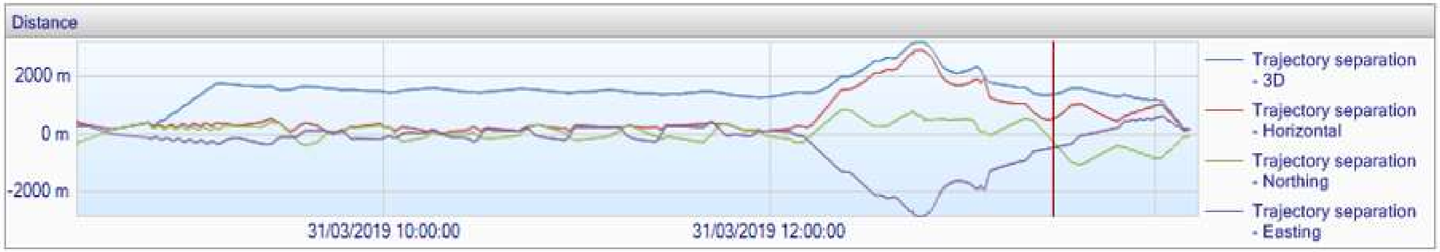
Results at sea

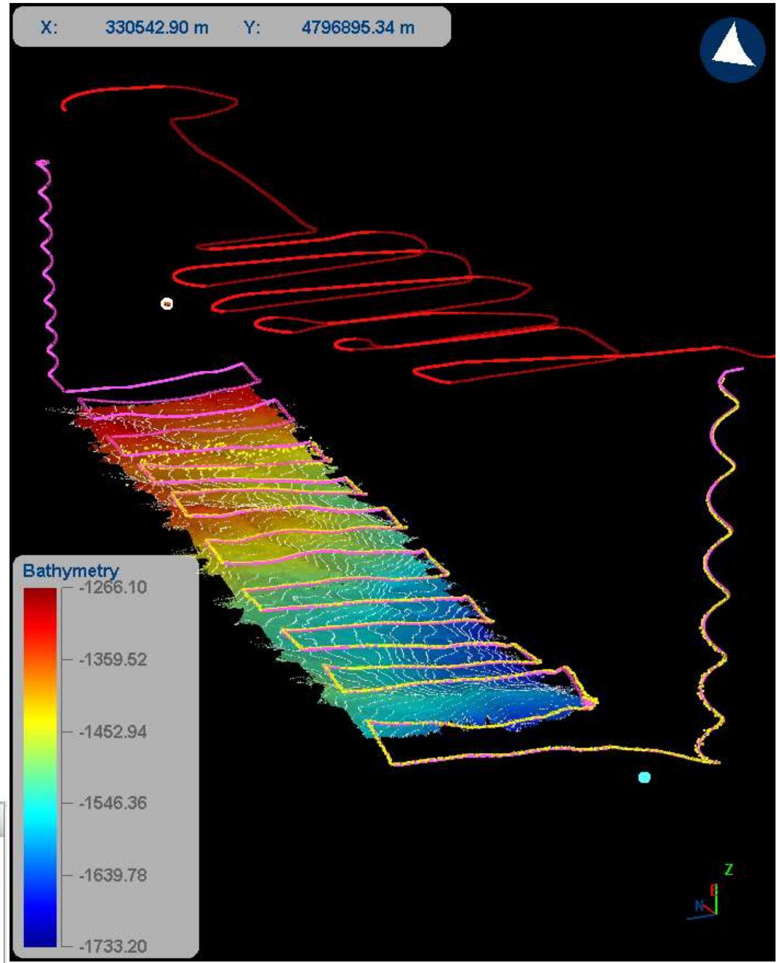
Real Time navigation performances over the dive:

- ✓ Reference = RAW USBL data



- ✓ <5m match "only" to USBL reference is achieved…
- ✓ With part of error coming from the USBL itself!





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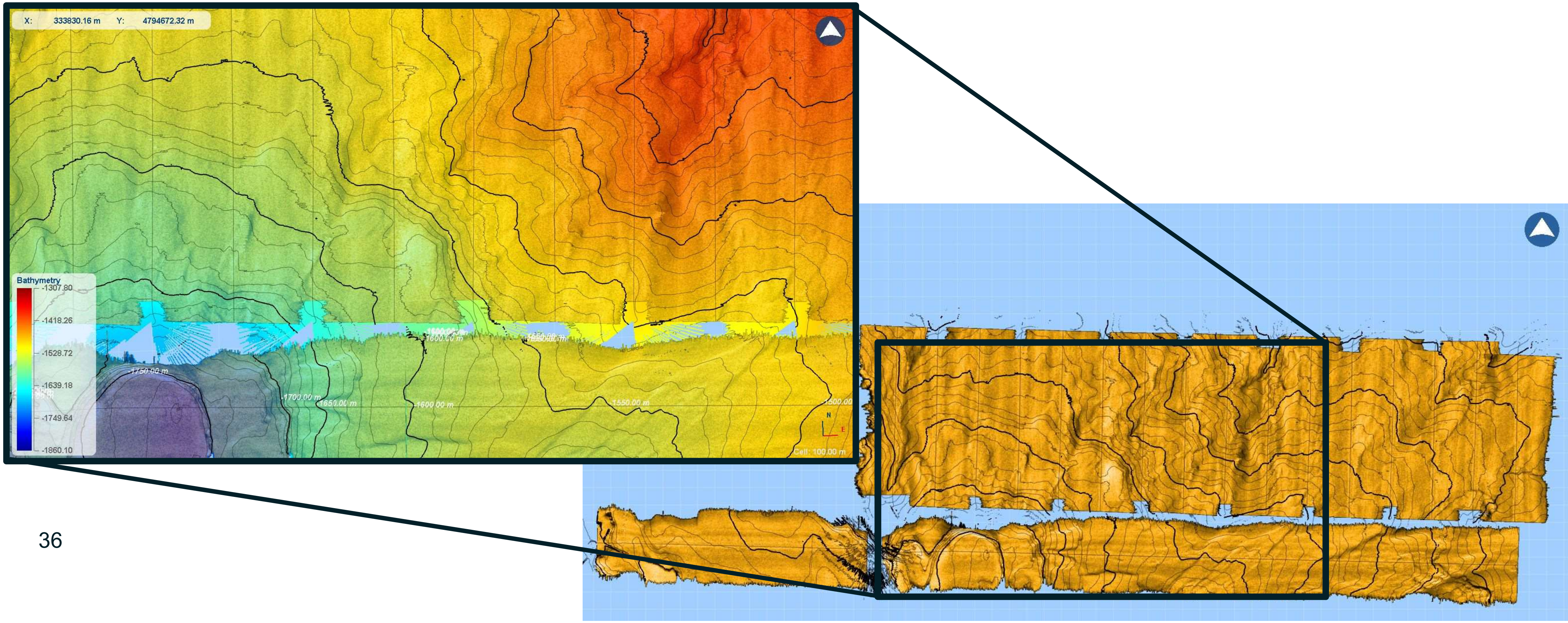
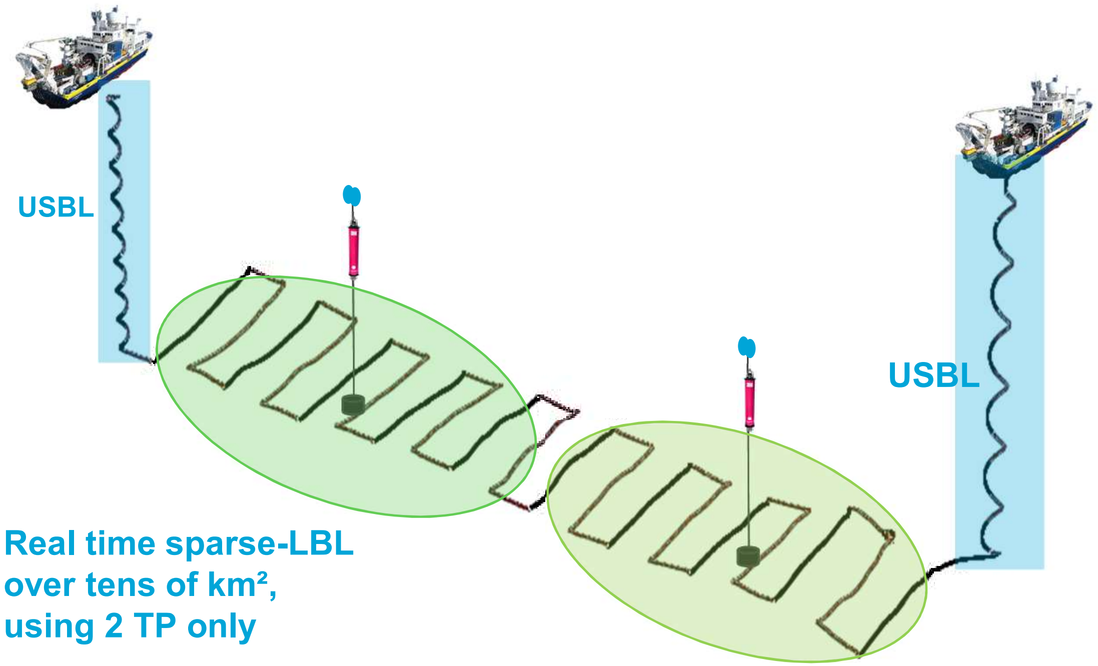
Results at sea

Isobath continuity between lines and surveys illustrate geo-referencing quality



Results at sea

✓ Experience full scalability of the system to define advanced work procedures



- ✓ Mission planning (required amount of TP, required mooring length to cover all survey area)
- ✓ Transponder deployment + fast calibration
- ✓ USBL aiding during AUV launch (helps nav in area corner)
- ✓ During AUV navigation vessel is free to deploy other vehicles
- ✓ USBL aiding during AUV recovery
- ✓ Immediate availability of survey results to plan next dives…
- ✓ … while data can be post-processed to further enhance navigation to full merge of USBL points

A case study
Deep sea mining

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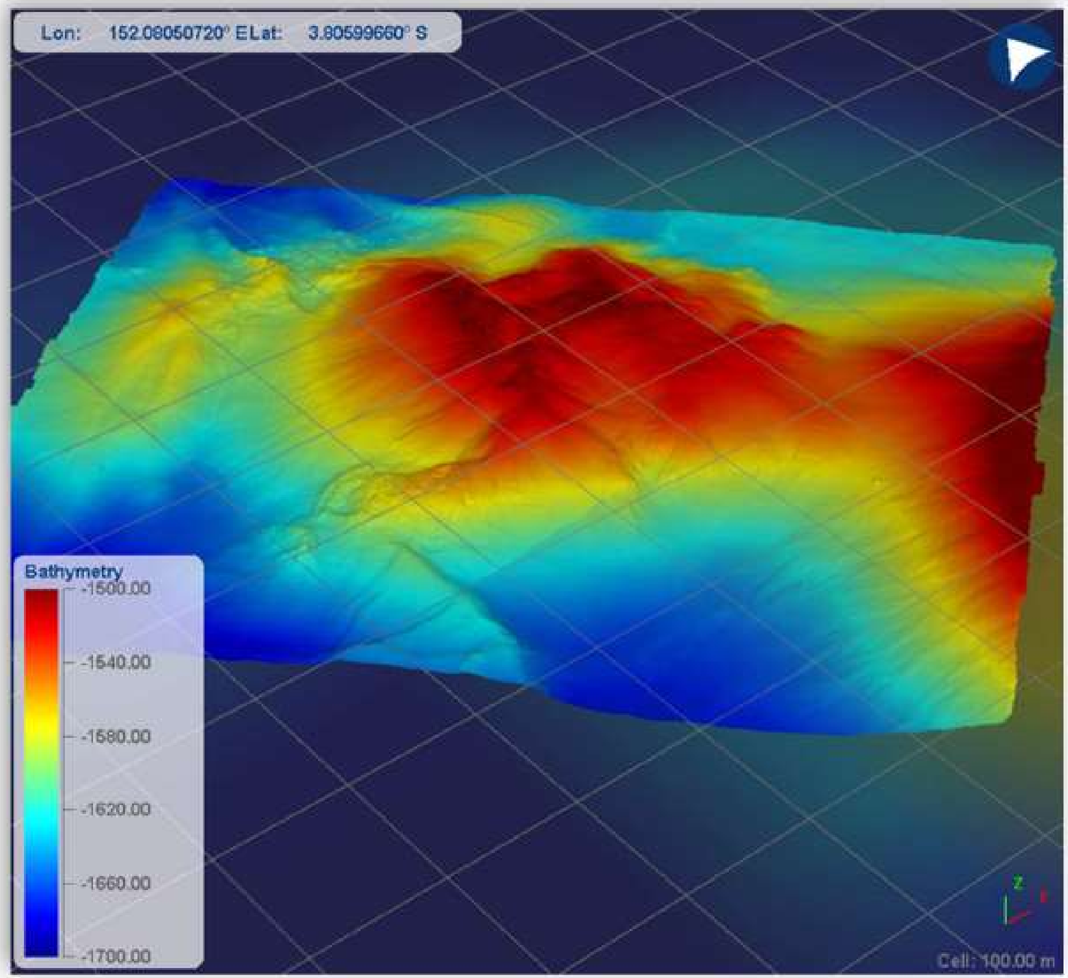
A case study:
Deep sea mining

Positioning of various AUV

and ROV … in a very complex

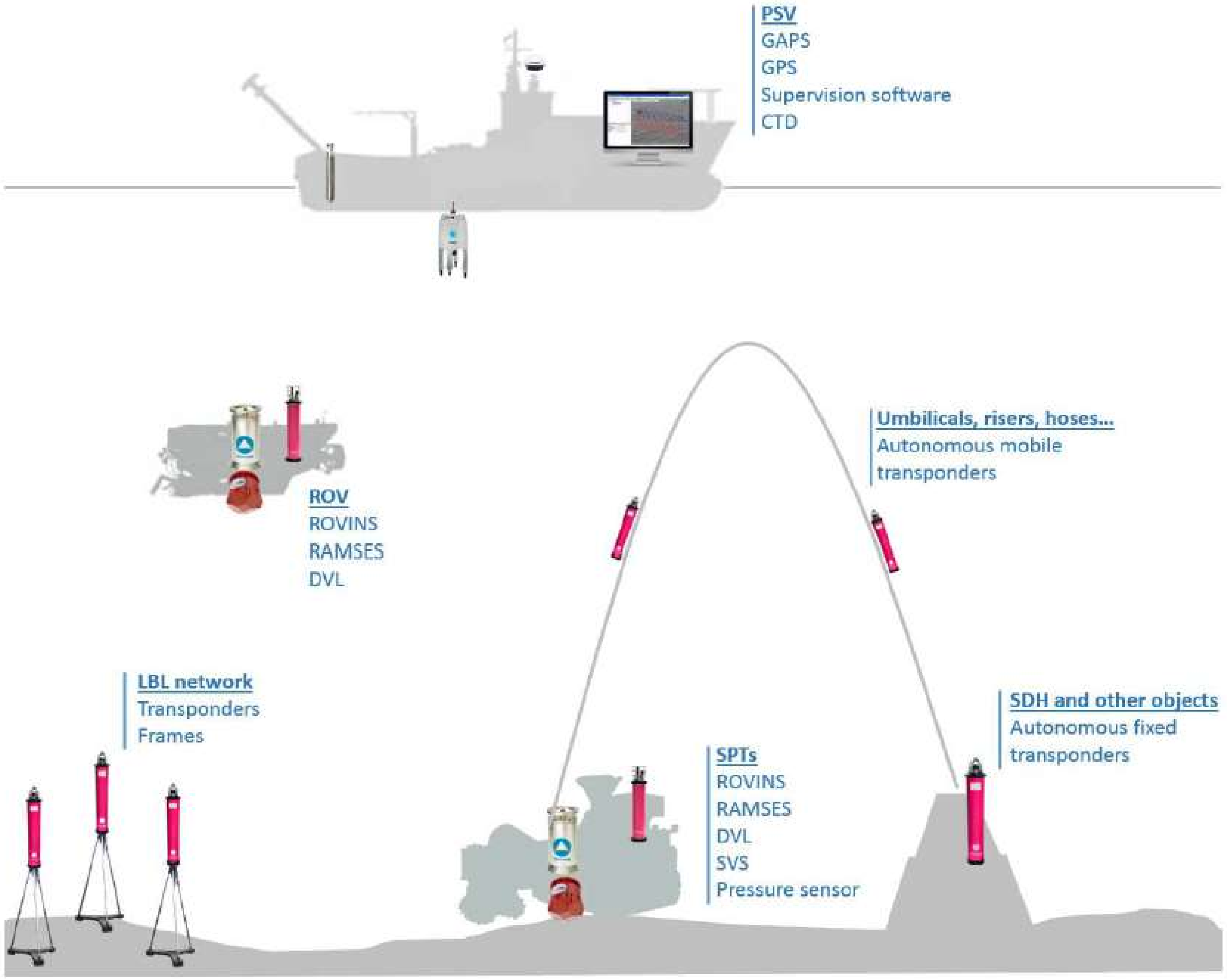
environment



A case study: Deep sea mining

Required

equipment



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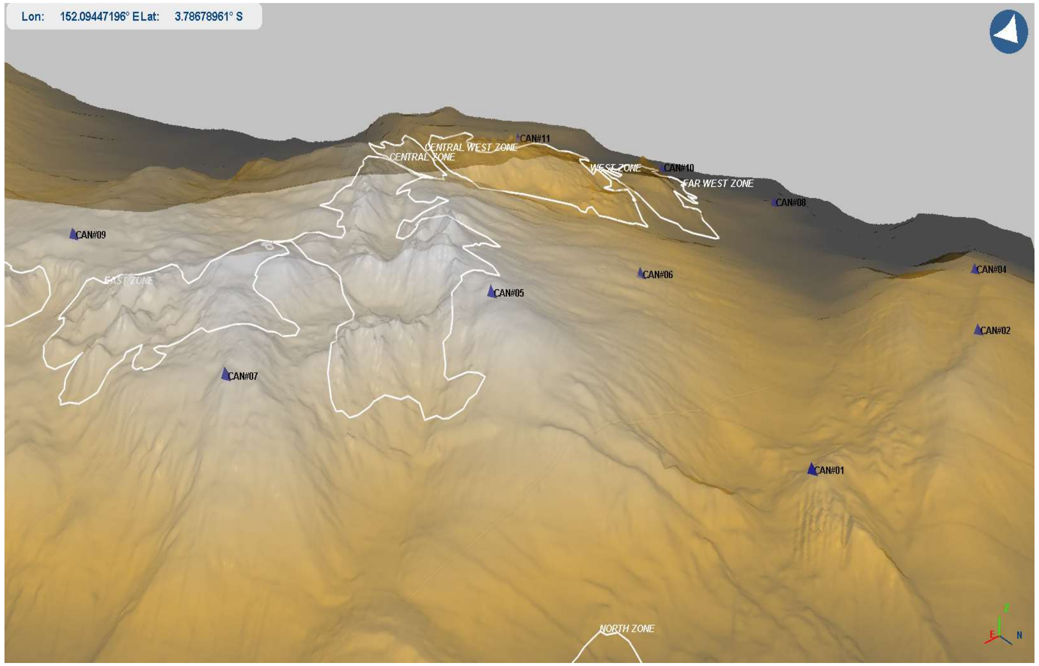
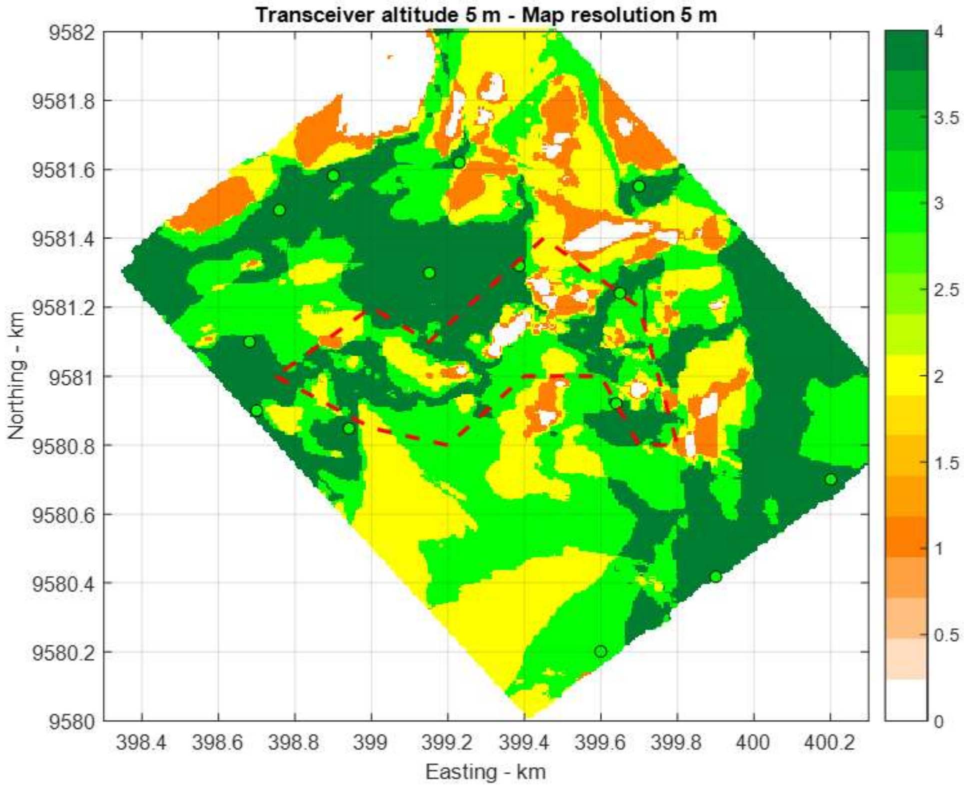
A case study: Deep Sea Mining

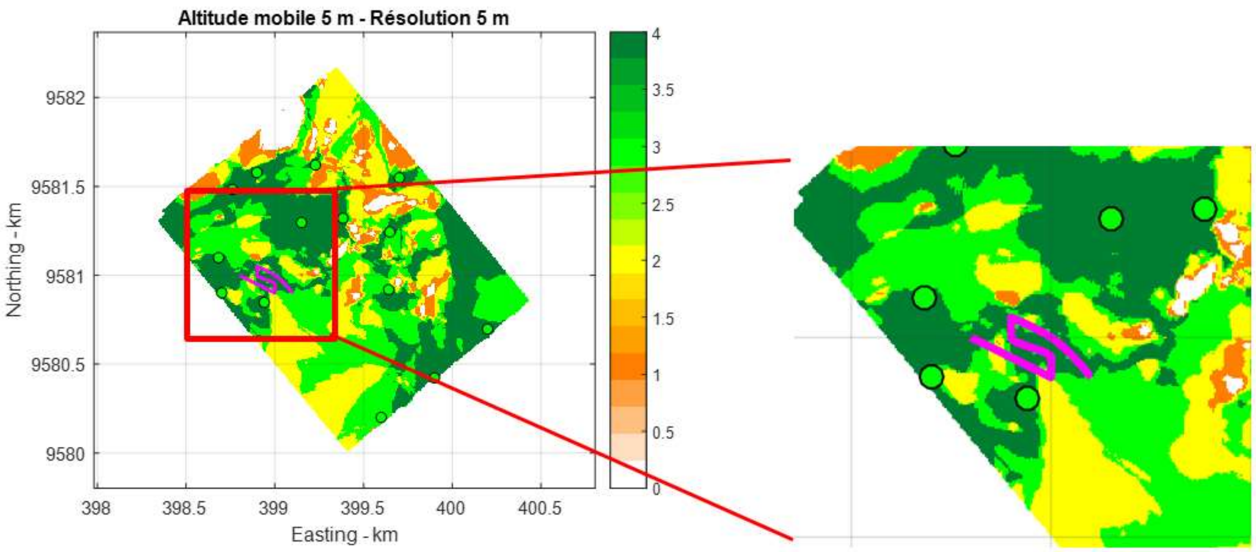
Transponder placement and visibility map

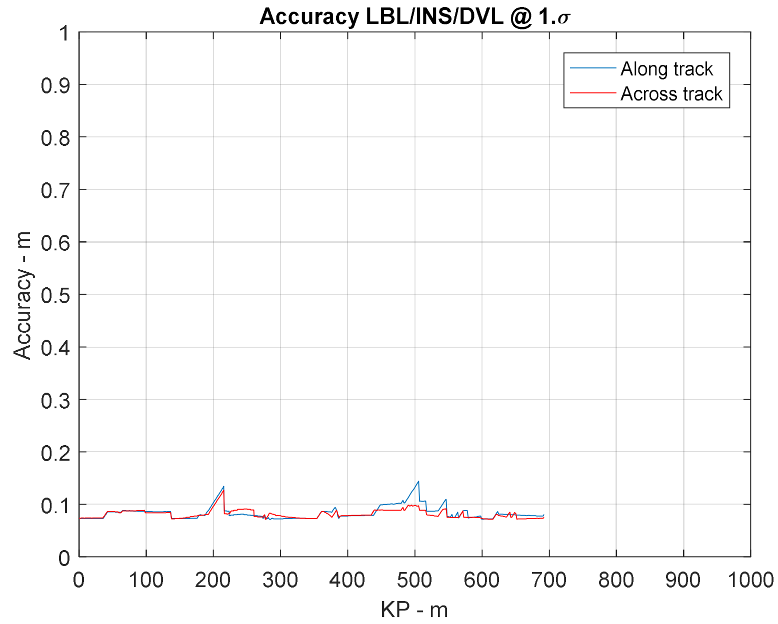




A case study: Deep Sea Mining

From the visibility map to positioning accuracy estimation





iXblue subsea positioning

- Reduction of the number of transponders on the seabed
- Robust and efficient acoustic data link between subsea devices and from subsea to surface
- Intuitive and up to date tools
- Performant and field proven hardware

Thank you !