



# An electromagnetic system on underwater vehicles for detection of buried objects and cables

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# Outline

Argeo Listen – An electromagnetic receiver system

Argeo Whisper – A controlled electric current source system

Detection and tracking of buried objects and cables

Tracking and depth estimation of buried active cables

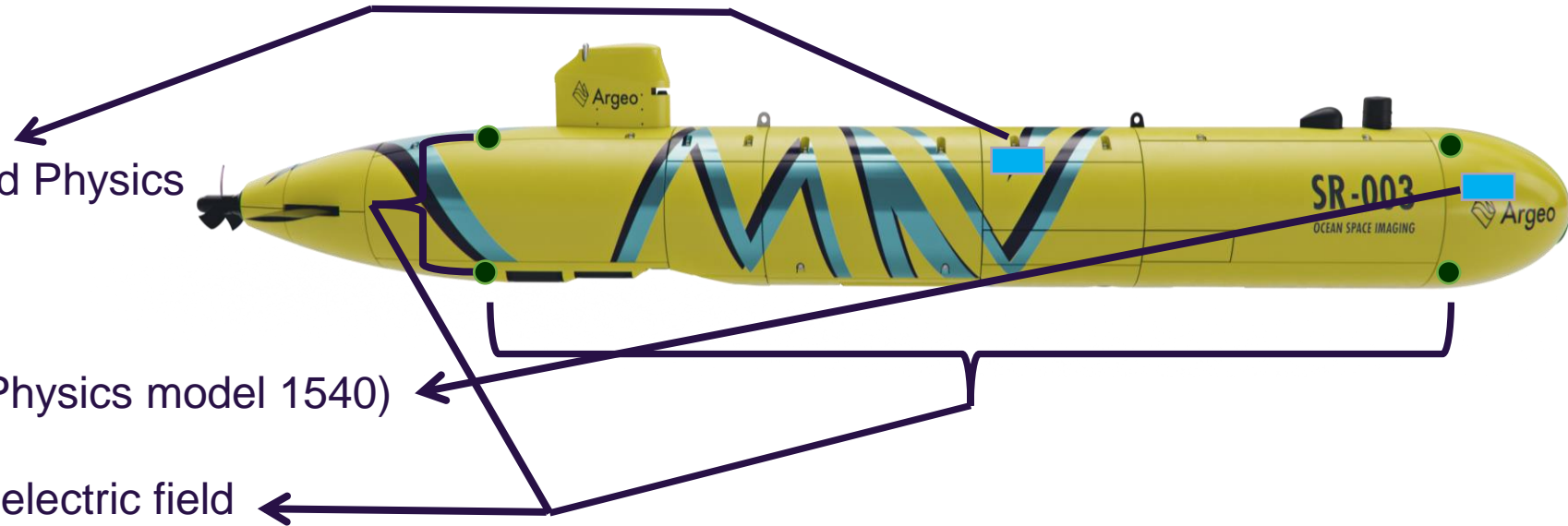
# Outline

- ▶ **Argeo Listen – An electromagnetic receiver system**

# An Electromagnetic receiver system (Argeo Listen) for underwater vehicles

System configuration Argeo Listen:

- Receiver electronics and an Applied Physics magnetometer model 539
- Separate magnetometer (Applied Physics model 1540)
- Eight flush mounted electrodes for electric field measurement
- A fully integrated system with real time processing capability.
- The system is modular and can be installed on other underwater platforms



# AUV Searaptor - Payload specifications

## Electrode receiver system:

- Frequency range < 200 Hz
- Dynamic range:  $10^{-8}$  –  $10^0$  V
- Noise/Sensitivity:  $0.1 \cdot 10^{-6}$  V/m
- Power consumption: 7.2 W
- Depth rating: 6000 m
- Data storage: 250GB
- Processing unit: Raspberry Pi Compute Module 4
- Communication interface: Ethernet (RS232)

## AUV SeaRaptor (Length 6.5 m, 50 h endurance)

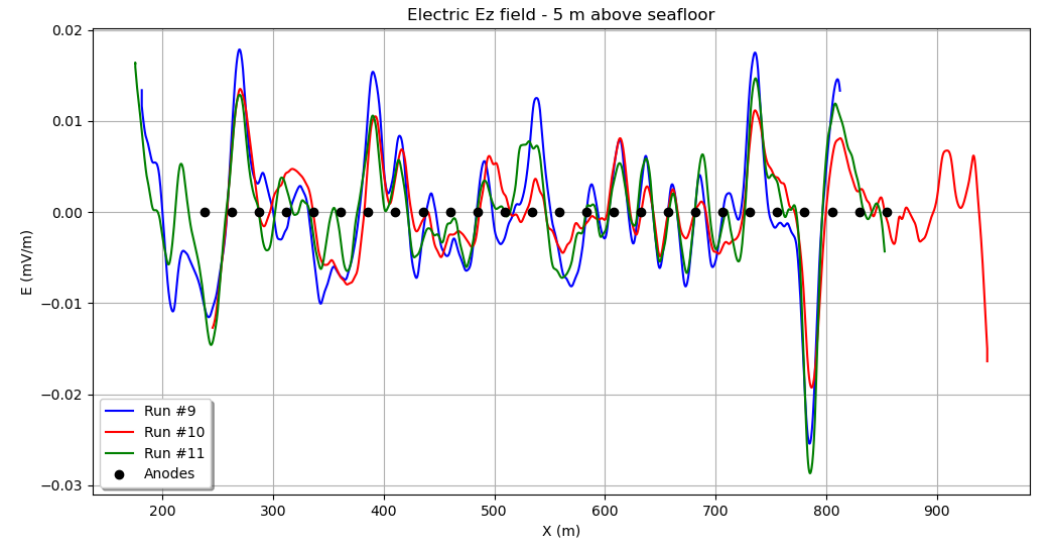
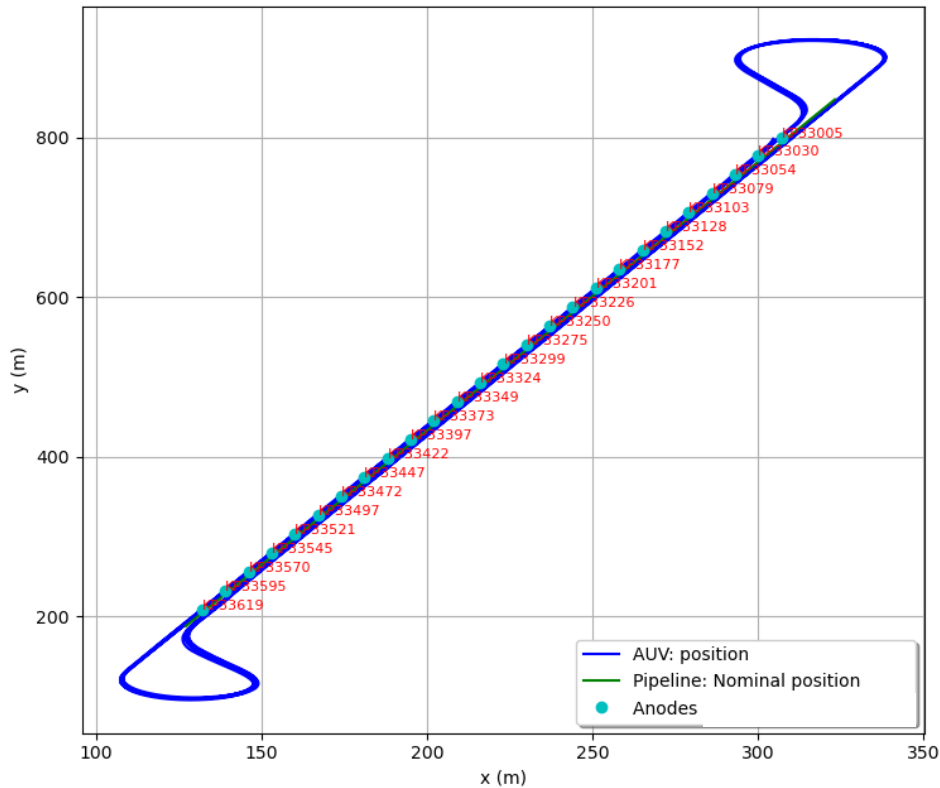
Safety and communication sensors	
Purpose	Product
Collision avoidance sonar	Blueview MB450
Acoustic communication	Sonardyne AvTrack 6
Emergency release	Benthos acoustics
Surface communication	RF and Sat com
Navigation & Environmental sensors	
Purpose	Product
INS	iXblue rovins 6000 (0.01% Distance Travel)
DVL	RDI tasman DVL (300 kHz w/ADCP)
CDT	Valeport uxSVP
Environmental pack	RBR Maestro (CDT, Oxygen, Methane, pH, Turbidity, Redux)
Payload sensors	
Purpose	Product
Multibeam	Reason T50 DF (200/400)
Sub-Bottom Profiler	Benthos Chirp III
Synthetic Aperture Sonar	Kraken minSAS 120 w/Real-Time onb. proc
Camera and Laser	CathX Hunter twin laser UHD
EM measurements	<b>Argeo EM tool pack</b>
Onboard data processing	Caris Onboard and EIVA



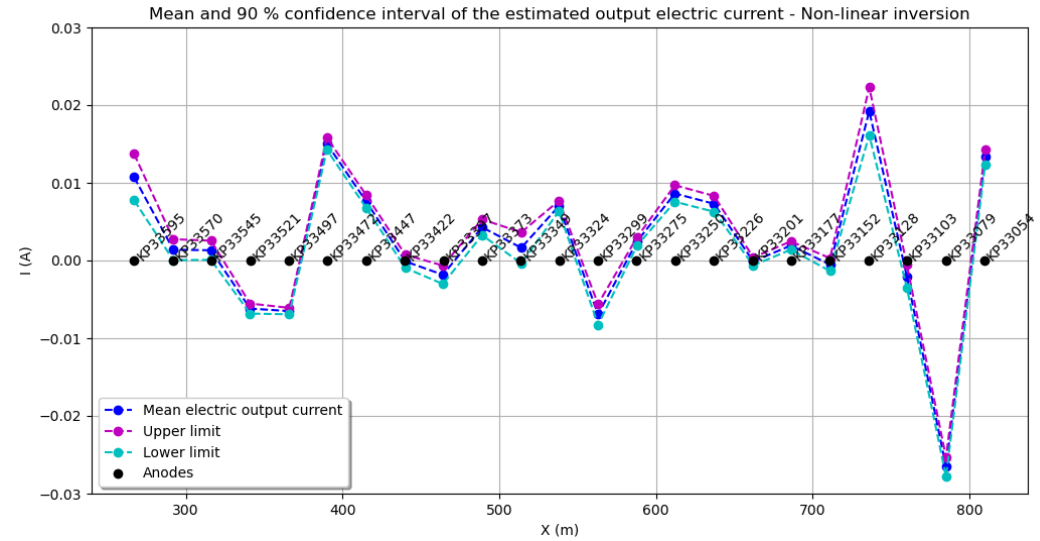
# Cathodic Protection measurements – A real data case

Sensors: Receiver electrodes + Nav, MBES and Camera  
Operation: 5 -10 m above the pipeline

12 runs in total over the pipeline section

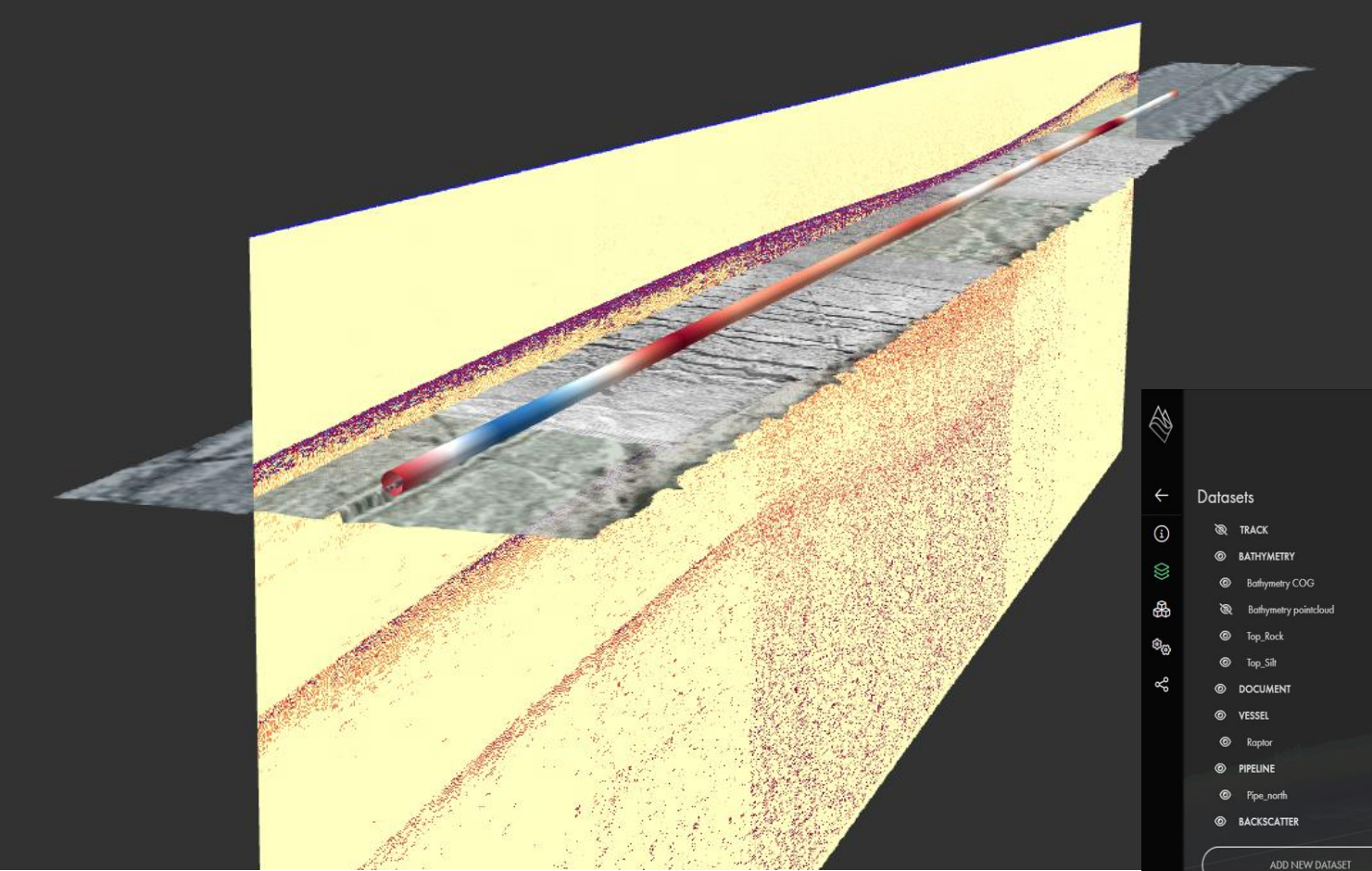


Inversion of electric field data to get the output electric current on the pipeline surface and accurate position (xyz) of the pipeline



# Pipeline inspection – A real data case

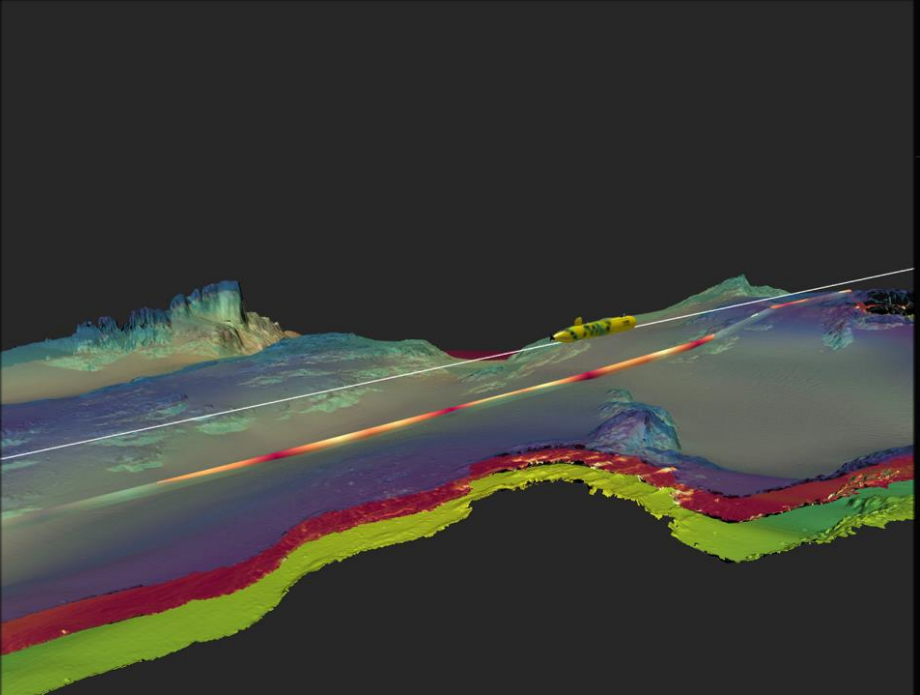
Joint 3D data visualization in Argeo's cloud and web based SW platform



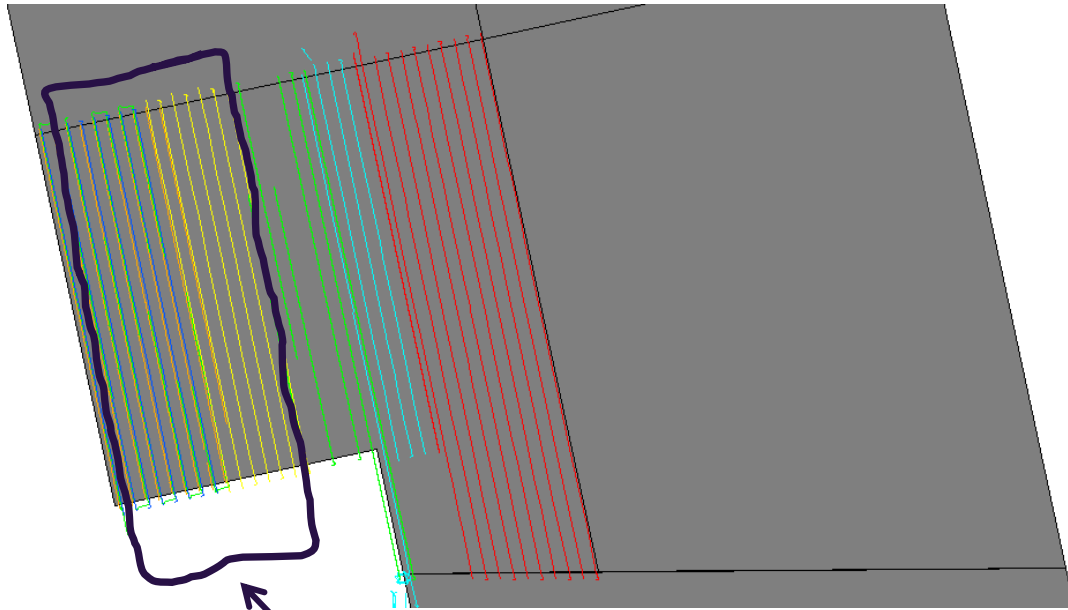
← Datasets

- TRACK
- BATHYMETRY
  - Bathymetry COG
  - Bathymetry pointcloud
  - Top\_Rock
  - Top\_Silt
- DOCUMENT
- VESSEL
  - Raptor
- PIPELINE
  - Pipe\_north
- BACKSCATTER

ADD NEW DATASET

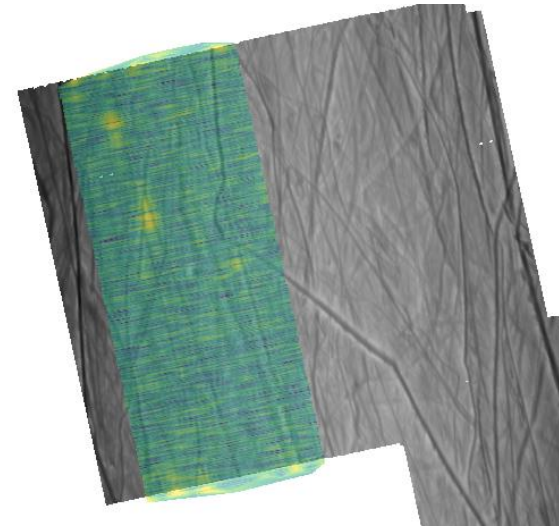


# AUV site survey – A real data case

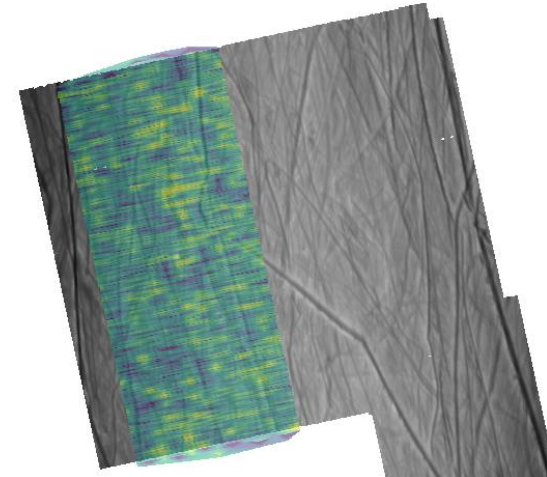


EM-data analysis: 13 lines

Vertical electric Ez-field data on top of MBES data



AUV inline magnetic data on top of MBES data





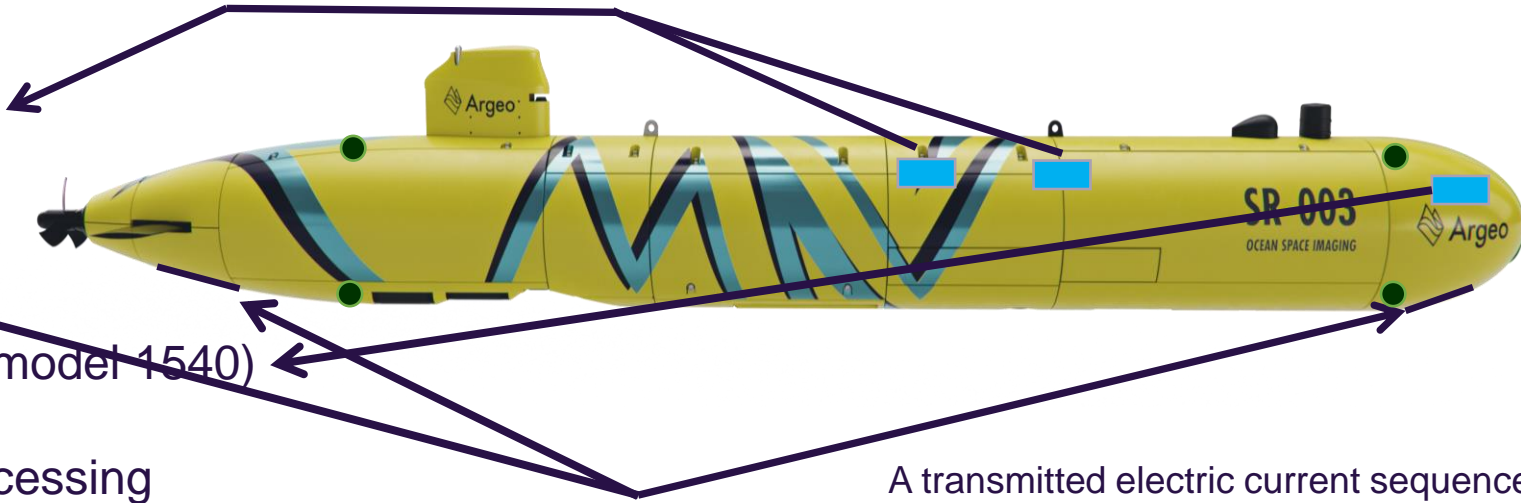
# Outline

- ▶ **Argeo Whisper – A controlled electric current source system**

# An active Electromagnetic system (Argeo Whisper) for underwater vehicles

System configuration:

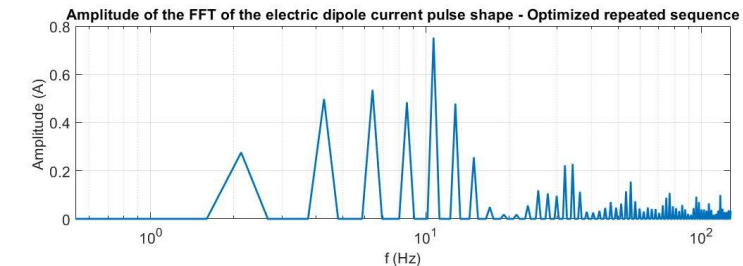
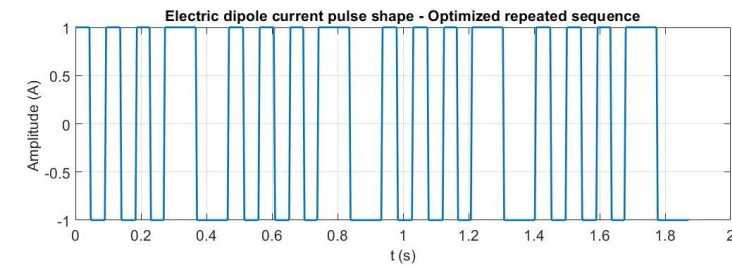
- Source and receiver electronics and an Applied Physics magnetometer model 539
- Two flush mounted source electrodes
- Separate magnetometer (Applied Physics model 1540)
- A fully integrated system with real time processing capability.
- The system is modular and can be installed on other underwater platforms



Specifications:

- Nominal output current 20 A, 140 W
- Possibility to design frequency content between 1-100 Hz
- Electrode plate separation 5.5 m
- Total run time before recharging battery 48 hours
- Time synchronization with receiver systems 1 ms over 24 hours

A transmitted electric current sequence

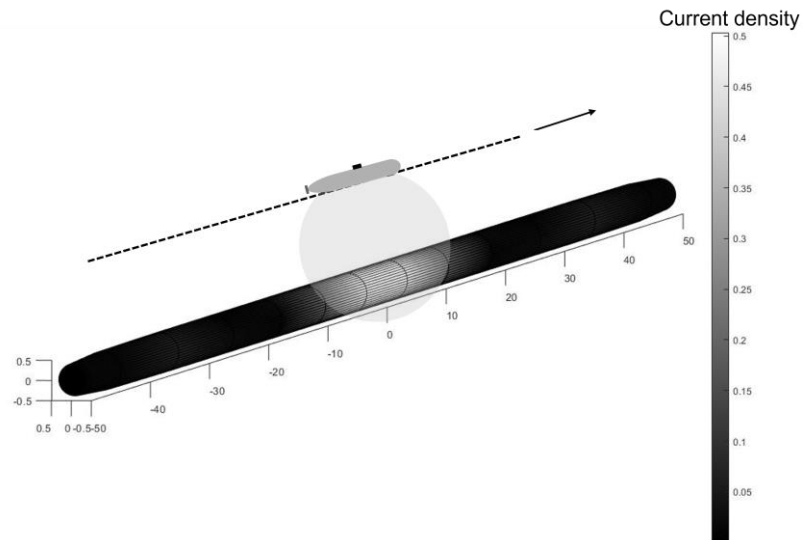


## Outline

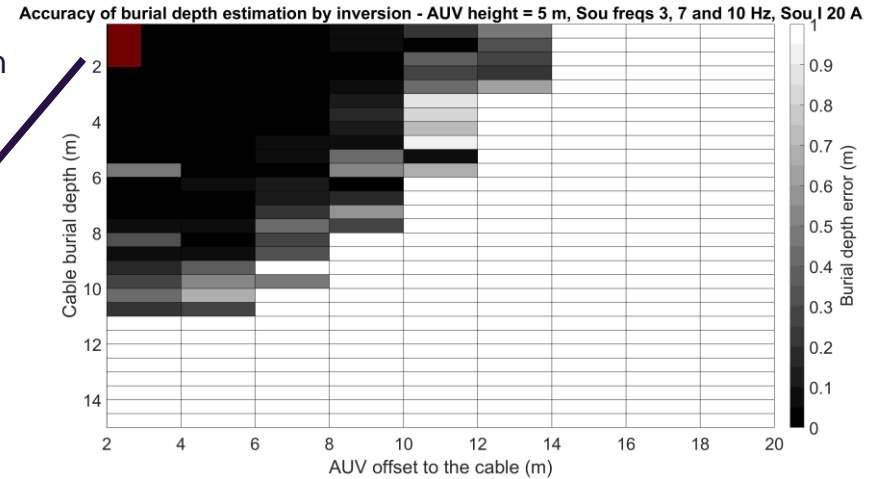
- ▶ Detection and tracking of buried objects and cables

# Burial depth estimation using Whisper and magnetometers

- Inversion for burial depth of “dead” power line cables.
- Transmission of electric current from the source and measurements of the magnetic field.

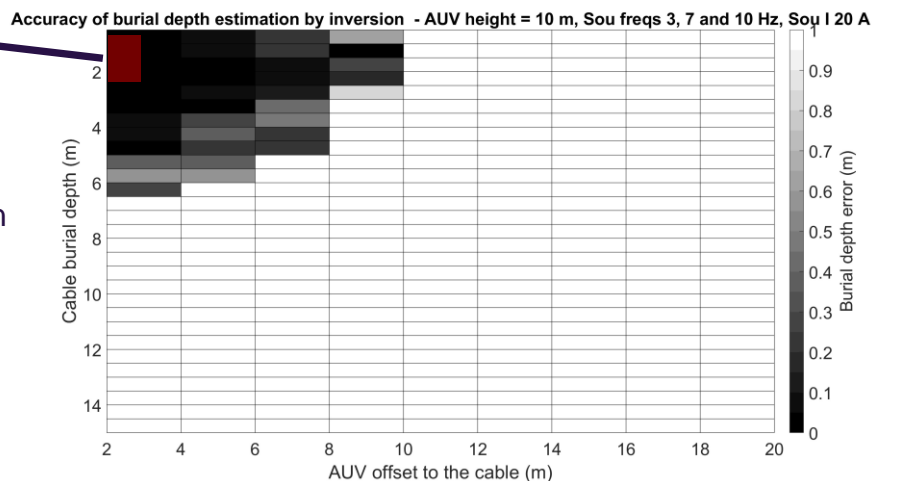


AUV height above seafloor = 5 m  
 → **Whisper**: Accurate depth estimation down to **10 m** burial depth.



Artimes and TSS 440 range one meter above seafloor (red)

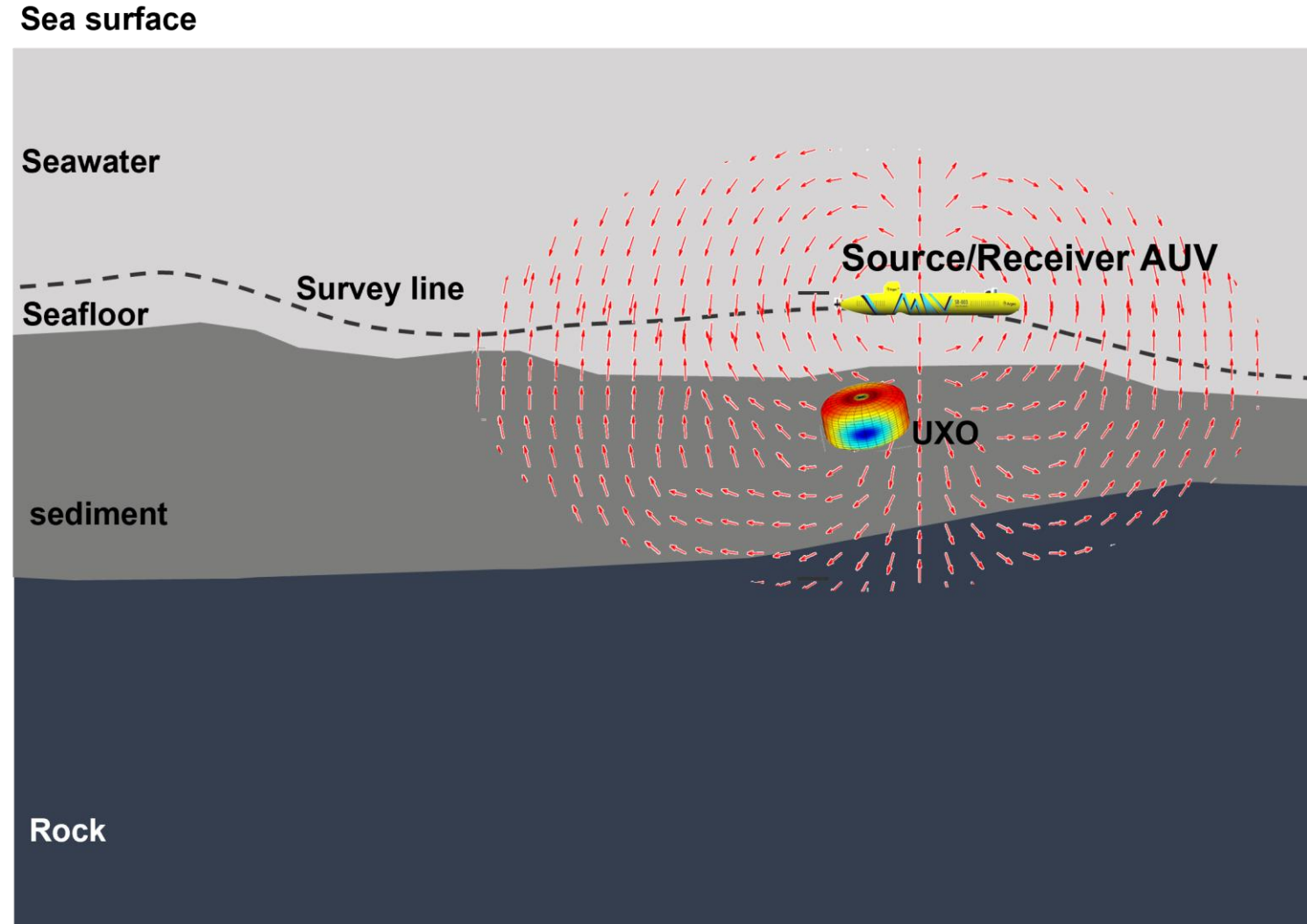
AUV height above seafloor = 10 m  
 → **Whisper**: Accurate depth estimation down to **6 m** burial depth.



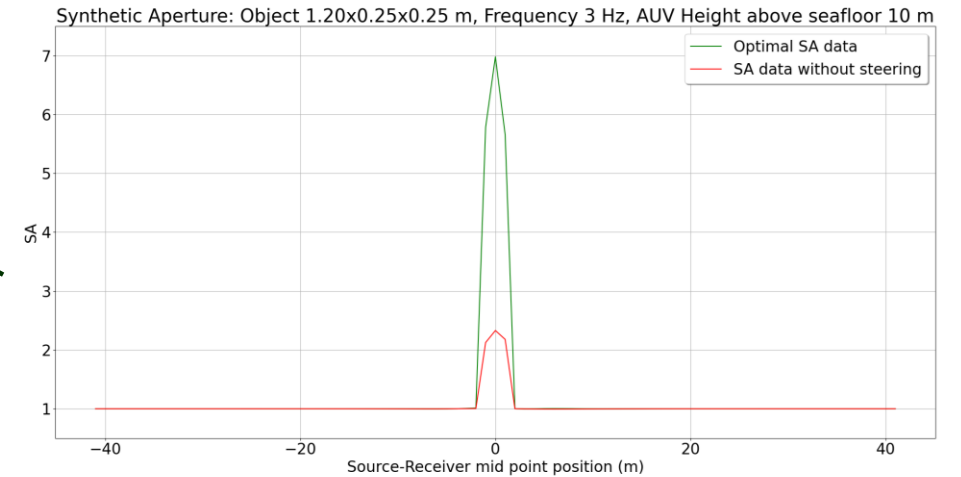
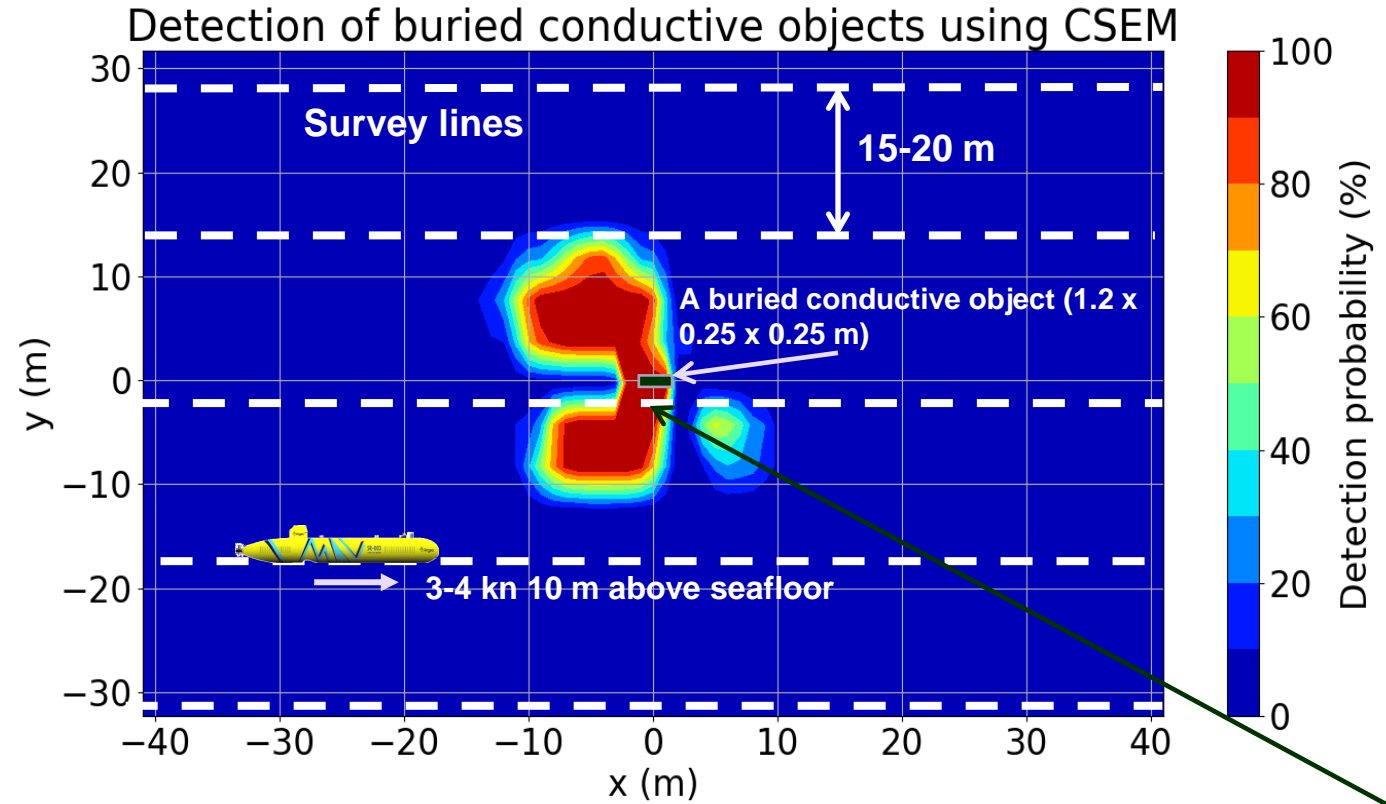
# Whisper and magnetometers: Detection and delineation of buried objects

## Method:

1. Measure the resulting magnetic field in the seawater caused by the active controlled electric source (Whisper).
2. The active field interacts with the environment and is modified when a high conductive iron object is close to the AUV.
3. This change in the measured magnetic field is used to detect the highly conductive buried object.
4. The detection range is increased by a **Synthetic Aperture** processing method.



# Probability of detection – A modelling example



## Outline

- ▶ Tracking and depth estimation of buried active cables

# Tracking of active buried power line cables and pipelines

