Unmanned and Autonomous Offshore Exploration Technology

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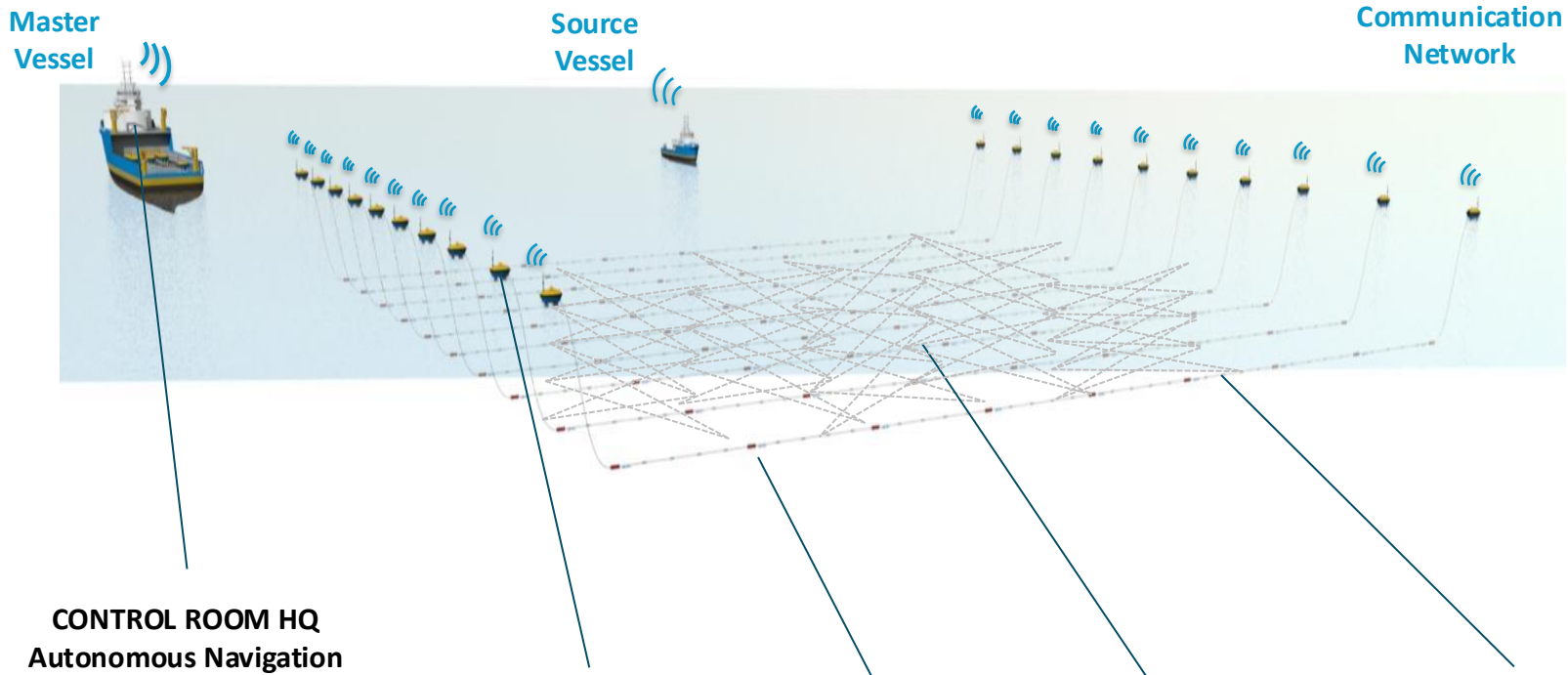
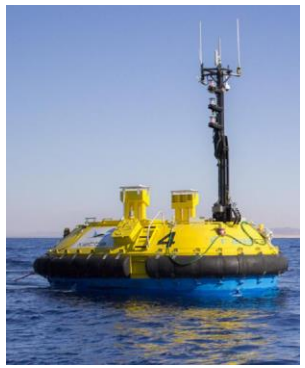
Autonomous Marine Seismic Acquisition using a Fleet of Unmanned Vessels



CONTROL ROOM HQ
Autonomous Navigation
Spread Control
Fleet Supervision
Data QC and Production

Unmanned and Autonomous Vessels

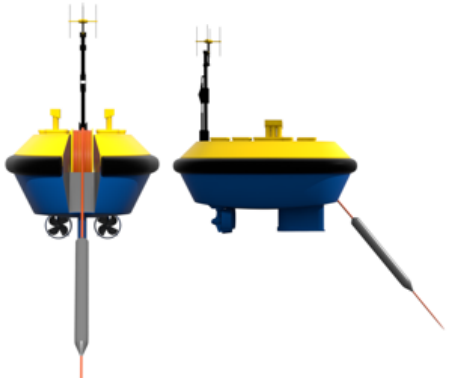


Dynamic Ballast

Acoustic Positioning

Seismic Cable 4C sensors

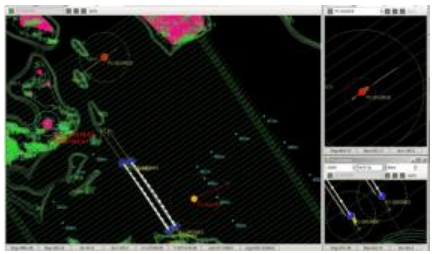
Technology Bricks specifically designed



Recording Autonomous Vehicle (RAV)

Ballast unit

Seismic Cable

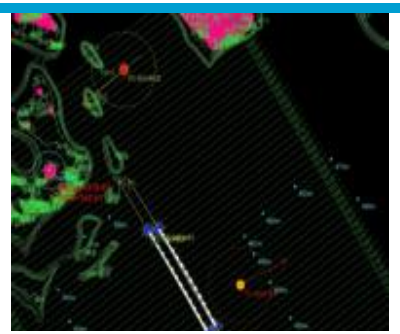


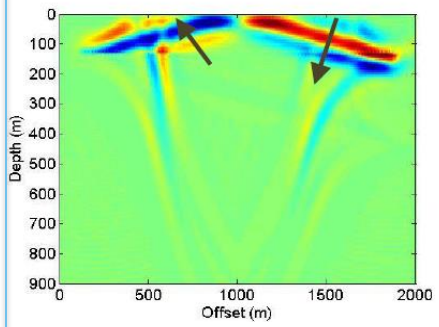
Real-time control and QC system

Patent families: FR2945356, FR2961317, FR2990028, FR3043791, FR3046129, FR3054890

Recording Autonomous Vessel (RAV)

Real-time Spread and Quality Control



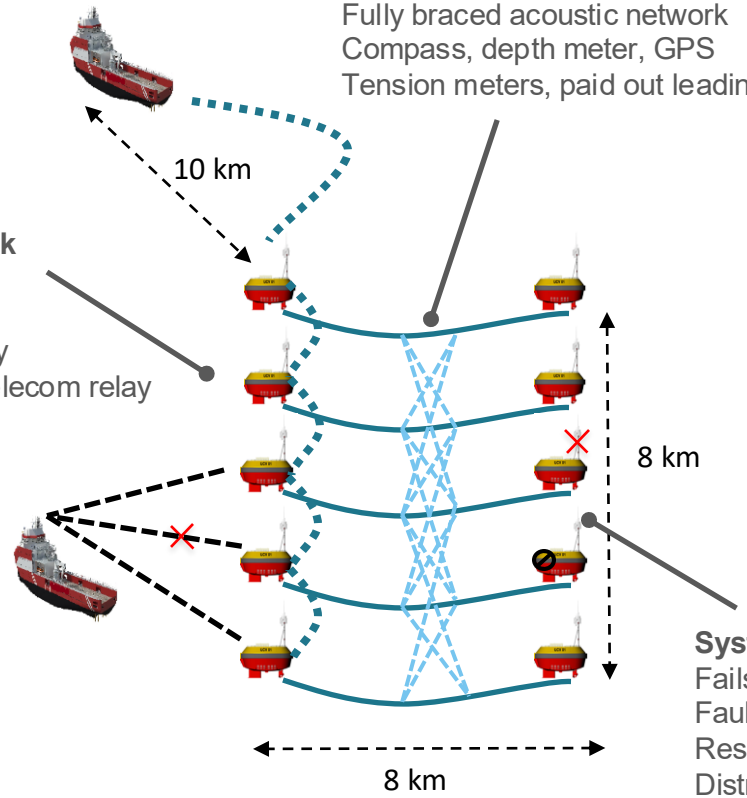


Control room
Navigation, Spread Control
Position and Seismic QC
Data production and delivery

Sub-meter underwater positioning
Fully braced acoustic network
Compass, depth meter, GPS
Tension meters, paid out leadin length

Meshed network
Dynamic routing
Load balancing
Path redundancy
RAV-to-RAV; Telecom relay

Radio link diversity (WiFi, UHF, Satellite)
High-speed and long range
High antenna gains
Maximum transmit power
Link aggregation

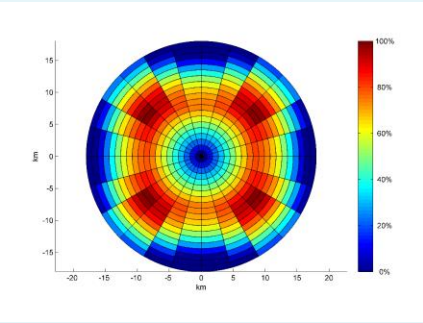


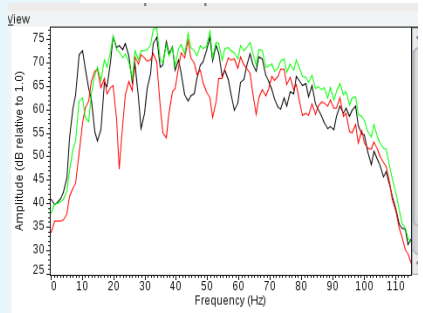
System architecture
Failsafe ; Redundancy
Fault tolerance
Resilience
Distributed intelligence

What we bring to the seismic market

- **High productivity**
  - **Reduced acquisition time** compared to existing technologies for a given data quality
  - **Potential for improvement**: ready for simultaneous operations
- **HSE higher standards and environmentally friendly**
  - Autonomous vessels leading to less people on-site
  - Less fuel consumption / Less pollution
  - No impact on sea bottoms, no damage on sea flora, no risk with sea bottom installations
- **Streamlined operational expenses**
  - Only vessels of opportunities required for operations
  - Optimized set up of operations thanks to system flexibility
- **Superior Data Quality**
  - Full azimuth illumination, full band
  - Low Acquisition Noise
  - Real Time Data Access (Superior Data Quality Control)

  ⇒ Resulting in more precise subsurface imaging

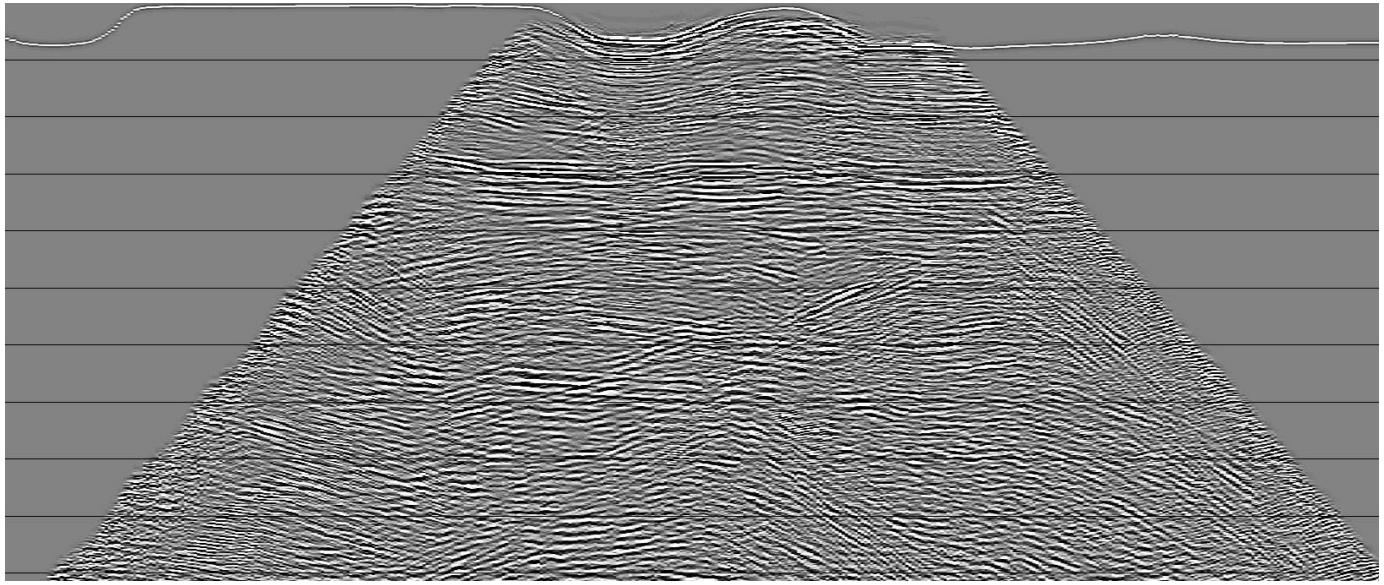




Superior Subsurface Image from Seabed Downwards

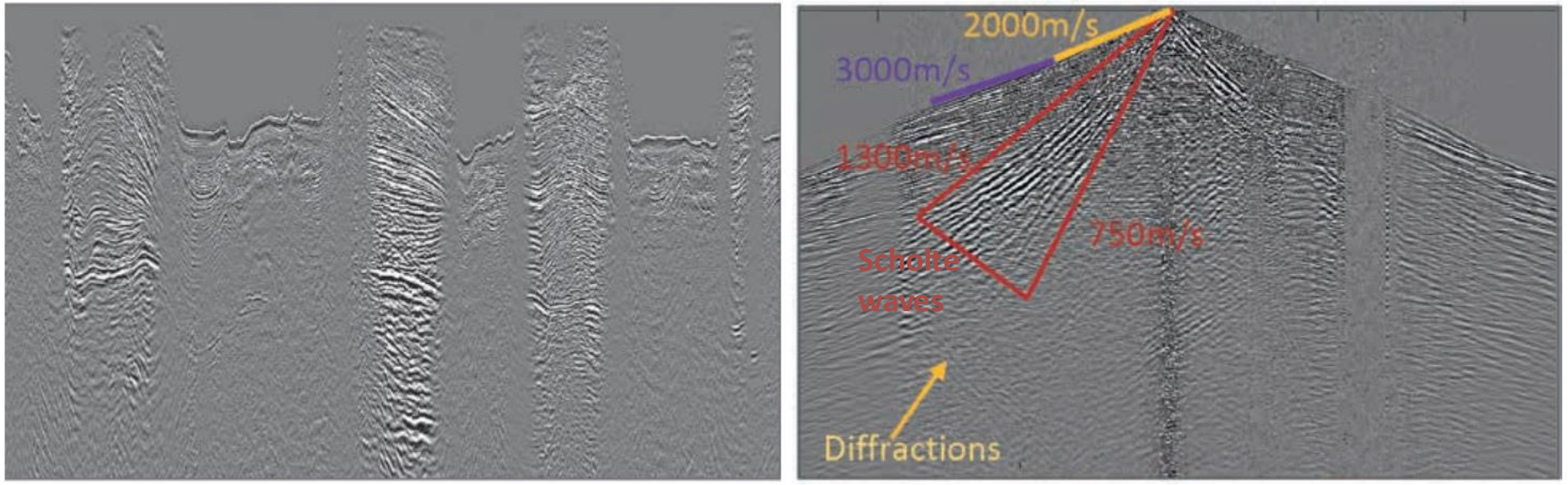
Homogeneous image with high quality

FreeCable acquisition



Heterogeneous quality with noise degradations

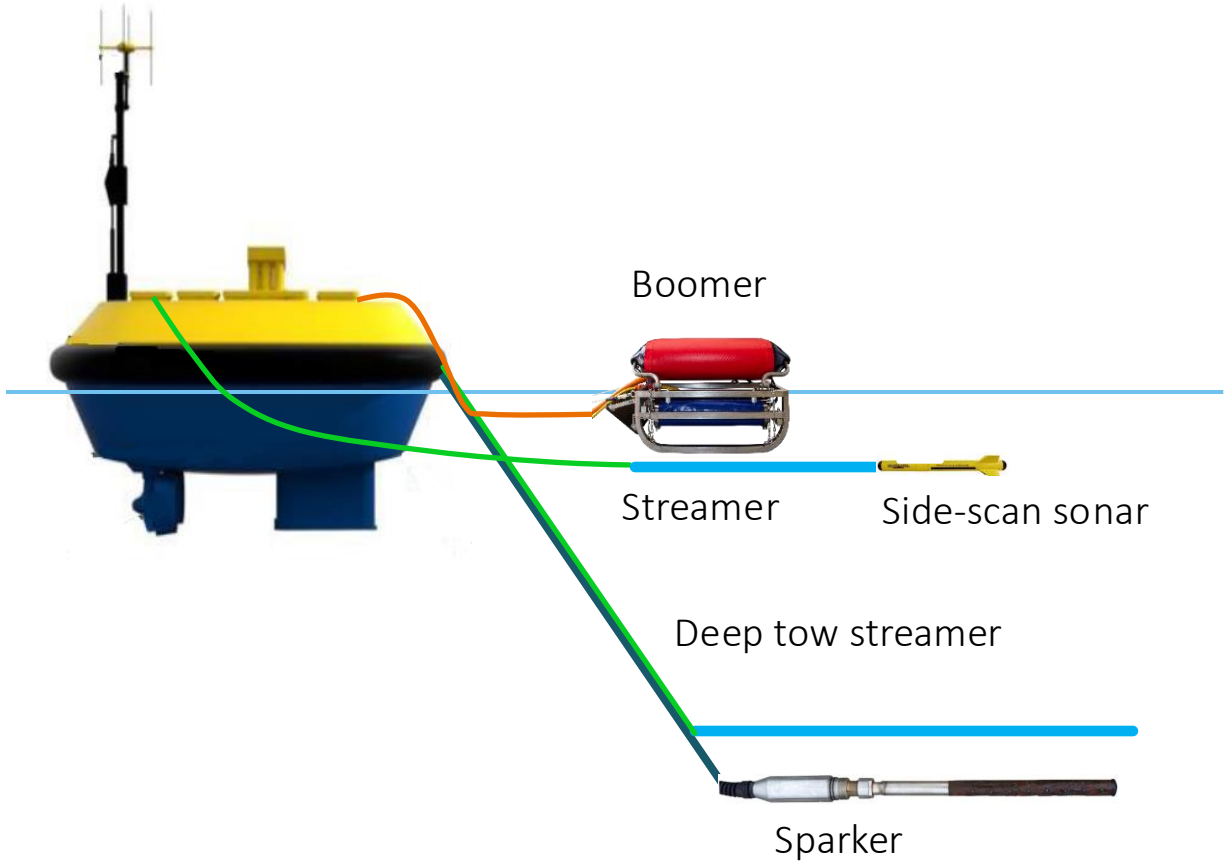
OBN acquisition in the same area



Source: First Break, volume 35, Nov. 2017

We can bring similar benefits to offshore windfarm markets

Configuration to image 0-100m area

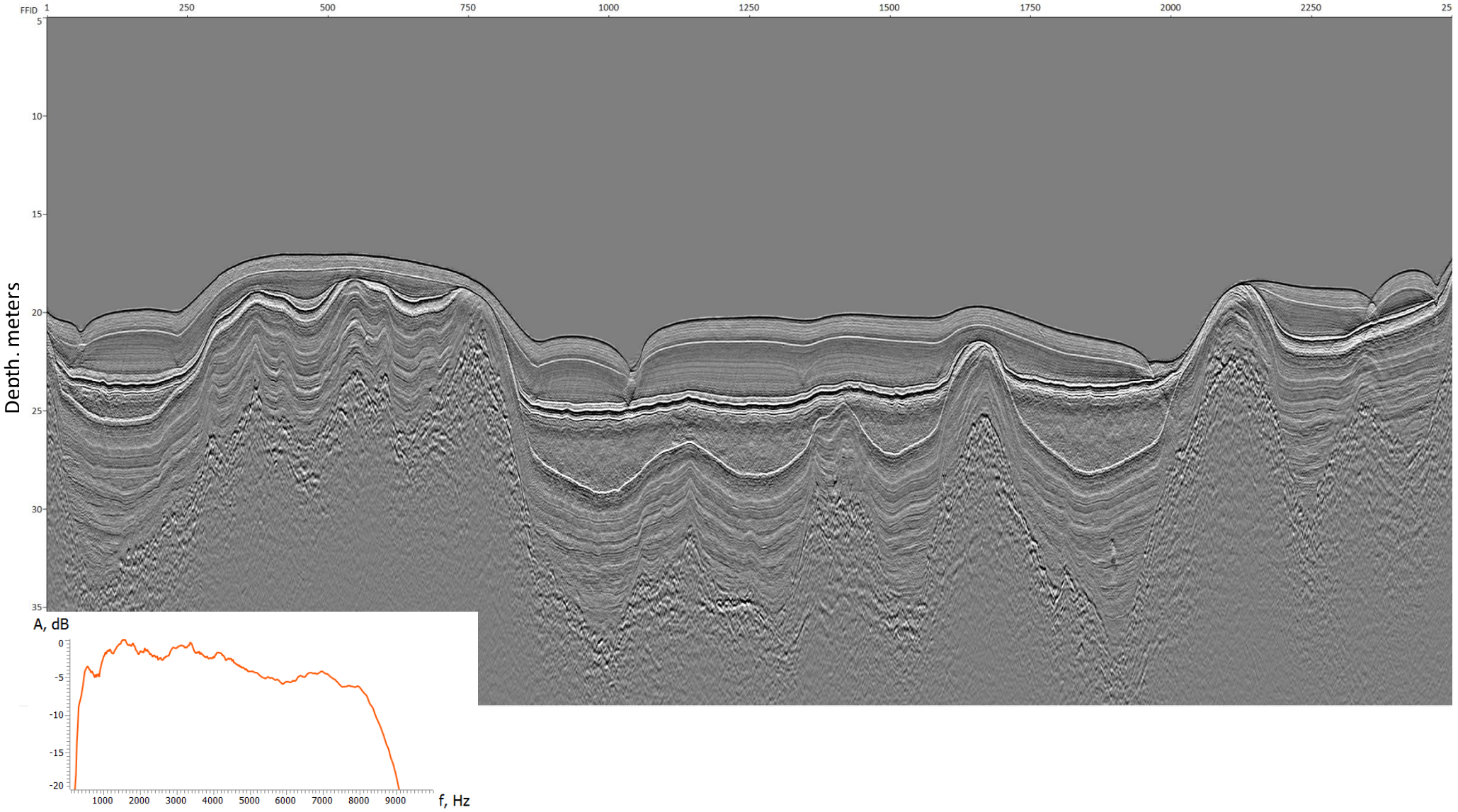


Example of configuration with:

- Very high-resolution seismic equipment
- Seabed mapping (SSS)

Other configurations are possible depending on customer requirements

Data example



MultiJack 2500HP3.0

FWS-250

HRStreamer 1-ch data

Geodevice

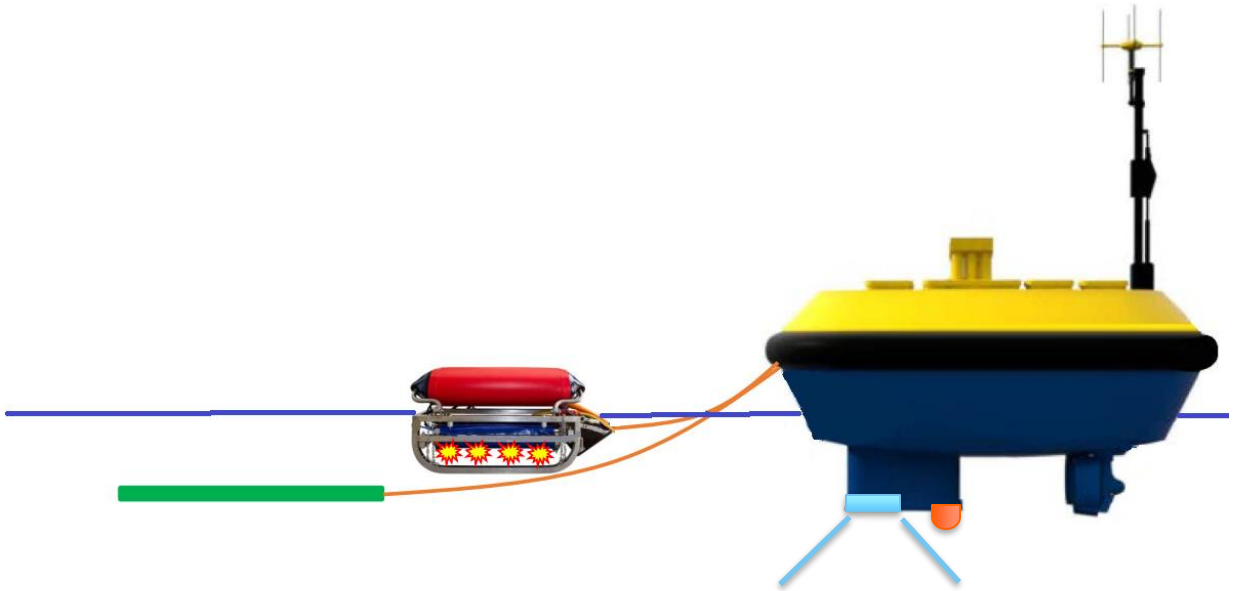
17-23 m

Lake Ladoga

Integration of multi-physics measurements

Multiple equipment can be mounted or towed:

- High resolution seismic (source and streamer)
- Electromagnetic
- Magnetometer
- Sonar (SSS, multi-beam)
- Echosounder
- Bathymetry
- Current profiler



UHRS streamer

Electrodynamic boomer

Sparker

A unique Unmanned Vessel: endurance, robust, high sea state, powerful

Overall size: L x l x H	8.20 x 5.5 x 4 m (bottom keel to deck)
Mast height	5.8 m
Draft	2.4 m
Weight	21 tons
Autonomy	41 days (subject to use and sea conditions)
Power	2 x 100 kW diesel electric generators
Propulsion	2 x azimuthal thrusters
Bollard pull	3 tons
Winch (pulling capacity)	Up to 4.5 tons
Sailing speed	Up to 5 knots
Compartment	3 (electronic room, engine room and thruster room)
Current profiler	300 kHz Workhorse Sentinel ADCP
Positioning	GNSS (PPP) with INS
Radio links	Iridium, UHF, 2.4 and 5 GHz
Others	Anemometer, NTP server, deck camera

Client's payload options

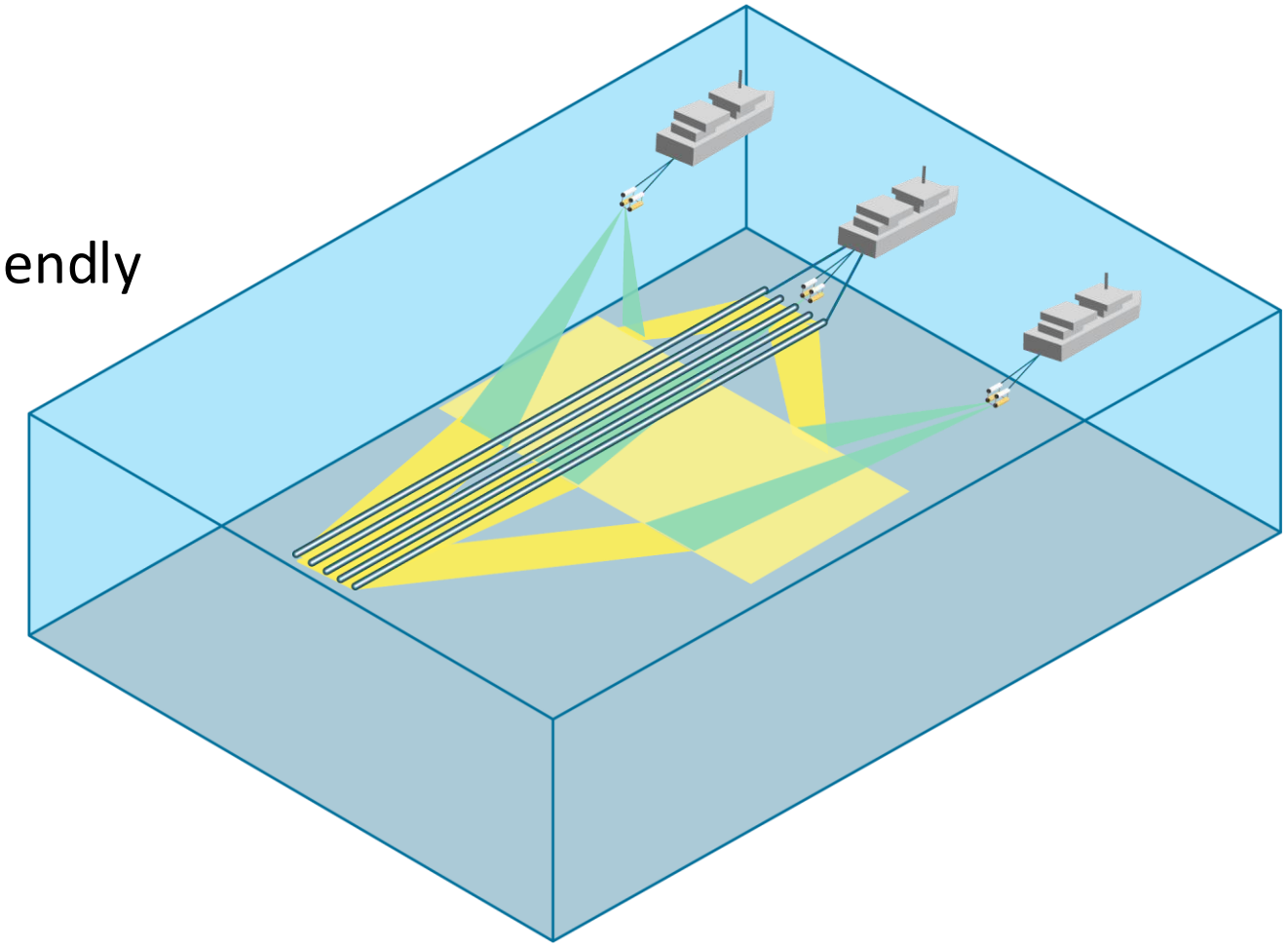
Umbilical	400 m armored cable with data fiber optic and power wire
Keel	Integrated compartment inside the keel.

Multiple vessel configuration

Optimize cost vs. performance trade-off

- Higher quality
- Higher productivity

Safer, faster, and environment friendly

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