Statkraft Ireland Ltd.

NISA Project: Foreshore Licence Application for Marine Survey Work – Schedule of Works

17th December 2019

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1 Introduction

Renewables developer North Irish Sea Array Windfarm Limited, which is a wholly owned subsidiary of Statkraft Ireland Ltd, are currently investigating the feasibility of developing an offshore wind farm located in the Irish Sea, 7km to 17km off the coast of Dublin, Meath and Louth. An export cable would connect the offshore wind farm to a landfall site, the location of which is yet to be decided. This application is for a foreshore licence to conduct marine site investigation surveys.

Statkraft Ireland Ltd. is part of the Statkraft group. The Group produces hydropower, wind power, solar power, gas-fired power and supplies district heating. Statkraft is a global company in energy market operations. Statkraft group have previous experience in offshore on the following projects in UK, Dogger Bank projects (4 x 1200MW), Triton Knoll (860MW), Dudgeon (402MW), Sheringham Shoal (317 MW).

Statkraft Ireland Ltd. (Statkraft) develops, owns and operates renewable production facilities and is also involved in the trading and origination of power from their own projects and those of third parties. Ireland is one the selected growth markets in Statkraft for wind and solar power, given its significant renewable energy resources, particularly in terms of wind energy. Statkraft is already playing a leading role in the transition to a low carbon future and believe that the company's experience and capabilities will be of service to Ireland in this transition over the coming years.

Statkraft intend to undertake marine surveys at the proposed site in order to inform the location and design of the proposed offshore wind farm. The marine surveys will include geophysical, geotechnical, metocean marine, ecological and archaeological surveys. These surveys are described in detail in this section of the report.

A foreshore licence is required for the proposed marine surveys. This document forms part of the Foreshore Licence Application to the Marine Planning and Foreshore Section of the Department of Housing, Planning and Local Government seeking permission to undertake the proposed marine surveys.

1.1 Description of the Project

Element Power acquired the North Irish Sea Array (NISA) project from previous developer Gaelectric in early 2018. In late 2018, Statkraft purchased the Element Power Group's Irish and UK operations that also included the NISA project.

Gaelectric had agreed a memorandum of understanding (MoU) to develop NISA with Oriel — the developer behind the proposed 330MW Oriel site in the Irish Sea — as well as a 15MW demonstration project. Gaelectric had originally prepared a high-level EIA from a desktop study. Additional to this, two different surveys were conducted on the site:

1. In September 2009 a survey was carried out in conjunction with University College Cork and INFOMAR where geophysical (MBES and shallow seismic) data as well as groundtruthing

(surface grabs and shallow cores) sampling were obtained. This was called the Irish Sea Marine Assessment (ISMA) and the survey code was CV09_UCC_GAEL.

2. In 2014 a cone penetration testing (CPT) campaign was carried out, again with UCC and INFOMAR, using the MARUM/University of Bremen Geotechnical Offshore Seabed Tool (GOST). Survey code is CE14_01.

The 2009 survey was conducted in conjunction with a desktop study of the site including preparing various constraints maps. This, along with the desktop EIA mentioned previously, was part of a licence application in December 2009 to carry out full EIA work towards a Lease Application. However, because the Foreshore Act was to be amended, the process was closed to such applications and the application paused.

In December 2009, Gaelectric applied to have the licence amended to carry out further SI work (namely boreholes) which was granted in February 2012.

1.2 Marine Survey

The proposed area for the marine survey is located in the north-west Irish sea approximately 7 to 17km off the coast of counties Louth, Meath and north county Dublin. The project location plan is shown in Figure 1-1. The total area of the proposed survey site is approx. 226.9km^2.

This Foreshore Licence application is requesting permission to undertake survey works on the proposed development site. This site investigation licence application refers to the site investigation works required to inform the engineering and detailed design of the offshore wind farm to a sufficient level to allow detailed engagement with the supply chain so as to enable participation in a RESS auction. This foreshore licence does not consider the completion campaign which will involve the securing of geotechnical data (a borehole and CPT) at every turbine location which will be required prior to the construction phase of the project, to inform final engineering designs.

- The objectives of these works are: to use the results to minimise uncertainty and to build upon the information already gathered on the site from the previous surveys in ground and metocean conditions at an early stage and optimise any future development proposal
- to confirm the suitability of the site for the installation of an offshore wind farm;
- to update existing seabed assessments to establish the optimum design parameters for the wind farm site;
- to update the baseline environmental data of the site;
- to enable the preparation of an EIAR and NIS.

Table 1-1: Summary of proposed survey methodologies

Survey	Purpose
Geophysical	
Multibeam echo sounder	Collect topographical data of the seabed
Side scan sonar	Develop an image of the seafloor
Magnetometer	Identify magnetic anomalies and hazard mapping for metal obstructions, ship wrecks and

	unexploded ordnance on the surface and in the sub-surface
Sub-bottom Profiling	Develop an image of the subsurface, identifying different strata encountered
Ultra-high resolution seismic	To identify and characterise the deeper layers of sediment/bedrock underneath the seafloor.
Geotechnical	
Boreholes	Sample and test soil and rock material, typically to depth up to 70m below the seafloor (bsf).
CPTs	Method for testing the soils strength parameters, typically to depth of 25 – 40mbsf
Vibrocore	Sample seafloor sediments (shallow depths)
Grab Samples	Sample seafloor sediments (shallow depths)
Metocean	
Floating LiDAR	Wind resource measurements.
Acoustic Doppler Current Profiler (ADCP)	Examine wave and current conditions in the survey area.
Ecology	
Fishing Survey	A fisheries survey will be carried out to ascertain the species and their distribution within the survey area.
Benthic Ecology	Identify the expected benthic communities and habitats on the site by grab samples and drop down video surveys.
Archaeological Survey	Identification and assessment of metallic and other targets recorded during marine magnetometer survey. Assessment of the archaeological significance of identified targets to include side scan sonar data analysis and diving as required.

The co-ordinates of the site extents are shown (in WG84 and Degrees, seconds, minutes) in Table 1-2.

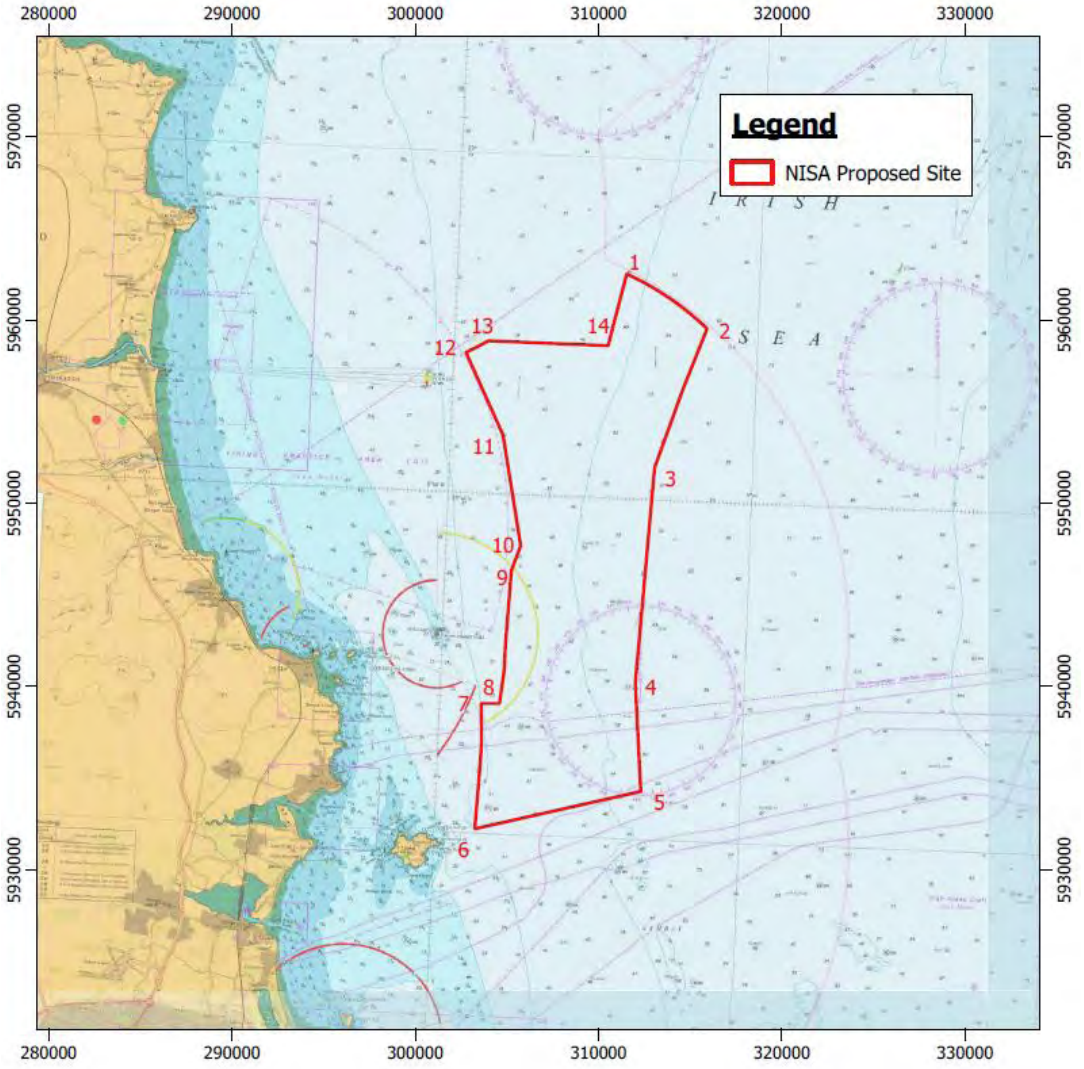


Figure 1-1: Proposed survey site location plan

Table 1-2: Proposed survey area co-ordinates

System: WGS 84 / UTM zone 30N				
ID	**Easting**	**Northing**	**Latitude (N)**	**Longitude (W)**
1	311536	5962508	53° 46' 37.2"	5° 51' 36.8"
2	315919	5959518	53° 45' 6.2"	5° 47' 31.3"
3	313059	5951942	53° 40' 57.7"	5° 49' 50.7"
4	312006	5940181	53° 34' 36.3"	5° 50' 22.5"
5	312304	5934277	53° 31' 25.8"	5° 49' 53.5"
6	303246	5932239	53° 30' 8.1"	5° 58' 0.2"
7	303600	5939081	53° 33' 49.6"	5° 57' 56.4"
8	304594	5939077	53° 33' 50.8"	5° 57' 2.4"
9	305247	5946340	53° 37' 46.5"	5° 56' 43.4"
10	305753	5947679	53° 38' 30.4"	5° 56' 18.8"
11	304785	5953731	53° 41' 44.7"	5° 57' 25.2"
12	302768	5958224	53° 44' 7.1"	5° 59' 25.3"
13	303975	5958865	53° 44' 29.4"	5° 58' 2"
14	310520	5958598	53° 44' 29.5"	5° 52' 23.6"

1.3 Survey Schedule

To minimise the risk associated with poor winter weather conditions, Statkraft would seek to carry out most of the proposed site investigation works between March and October within the five years following award of a Foreshore Licence. The intention is to begin survey activities in Summer of 2020 with a staged series of investigations over the subsequent five years as the project reaches the construction stage.

Table 1-3: Summary of geotechnical and metocean survey locations

Geotechnical Survey Method	Anticipated number of locations
Boreholes	12
Seabed CPTs	40
Vibrocore/ gravity sampling	40
Grab samples	40
Metocean Survey Method	
Floating LiDAR	1
Acoustic Doppler Current Profiler	3

The various staged timelines are outlined below:

1. Geophysical Survey – Start in Summer 2020 (approx. 3 months);
2. Geotechnical campaigns will then be staggered between 2020 and 2024 as the ground model is developed and the final engineering is completed;
3. The preliminary geotechnical campaign will be in Summer 2020 and will be approximately 3 months' duration;
4. MetOcean (current and wave) data will be collected in early 2020 (3-12 months);
5. LiDAR deployment – Start in Summer 2020 (which will remain in the sea for 2 years);
6. Ecology Survey - Start in Summer 2020/2021;
7. Archaeological data will be collected in Summer 2020.

The timing and coordination of the proposed site investigation works will be carried out in a way to minimise the potential disruption to existing fishing practices in the area. Statkraft, and in particular our FLO are working to form lines of communications with all the relevant stakeholders to ensure that adequate advance notice is given to the fisheries operating in the area to ensure the optimum coordination of the surveys with all stakeholders.

2 Description of proposed survey works

2.1 Foreshore application area

The proposed survey area forms an irregular, approximately rectangular shape, spanning 31km north-south and 14km east-west at its widest point. At its closest location, near Rush in Co. Dublin, the survey site is 7.4km from land (see Figure 1-1).

The total proposed survey area is approximately 226.9km^2 (22689ha); all of which lies entirely within the foreshore area limit. The north-east corner of the survey site lies directly on the 12nm foreshore area limit.

2.2 Marine Survey Vessels

A number of different marine vessels will be required for the deployment, execution and recovery of the various proposed survey methodologies. It is envisaged that different vessels will be required for the geotechnical, geophysical and metocean stages of the survey.

Geophysical survey vessels are typically between 15m and 60m in length and have an endurance of up to 14 days. These vessels are likely to use a local port for mobilisation and replenishment.

Geotechnical survey vessels are typically 55-90m in length and have an endurance of up to 28 days. Their port of mobilisation will depend on previous work but may be Irish, UK, or another European location. Should mobilisation from a local port be required, Dublin Port and Warren Point will be suitable options depending on requirement.

The exact vessels to be used will be confirmed following a tender process to procure the survey contractor.

All vessels will be fit for purpose, certified, and capable of safely undertaking all required survey work. The vessels will conform to the following minimum requirements as appropriate:

- Station-keeping and sea keeping capabilities required by the specified work at the proposed time of year; the appointed contractor may provide supplemental tug assistance if such assistance benefits the operation;
- Endurance (e.g. fuel, water, stores, etc.) to undertake the required survey works;
- Staffing to allow all planned work to be carried out as a continuous operation (on a 24 hour per day basis for the offshore activities and on a 12 hour per day basis for the inshore activities);
- Equipment and spares with necessary tools for all specified works;
- Appropriate accommodation and messing facilities on board;
- Adequate soil laboratory testing facility.

The survey contractor and vessels will comply with international and national statute as appropriate. A non-exhaustive list of examples includes:

- S.I. No. 507/2012 - Merchant Shipping (Collision Regulations) (Ships and Water Craft on the Water) Order 2012.
- Sea Pollution Act 1991 which transposes into Irish statute the requirements of the International Convention for the Prevention of Marine Pollution from Ships (MARPOL 73/78)
- Sea Pollution (Amendment) Act, 1999 - which gives effect to the International Convention on Oil Pollution Preparedness, Response and Co-operation, 1990 (OPRC).
- S.I. No. 372/2012 - Sea Pollution (Prevention of Pollution by Garbage from Ships) Regulations 2012.
- S.I. No. 492/2012 - Sea Pollution (Prevention of Pollution by Sewage from Ships) (Amendment) Regulations 2012

Figure 2-1: MV Gardline Ocean Vantage; an example of a DP2 geotechnical drillship

2.3 Geophysical Survey

Statkraft intend to carry out a number of geophysical surveys throughout the proposed marine survey area. Multiple survey methods will be used including multibeam echosounder, magnetometer, sub-bottom profiler , side scan sonar and ultra-high resolution seismic. This survey data will build on the existing data collected from previous surveys. The collected data will be used to better understand the water depths, topography and relief structure of the seabed and the subsurface structure, in particular the sub-surface stratigraphy, confirming the bedrock elevation. The process is non-intrusive and at no point will the equipment used make contact with the seafloor.

The objectives of the geophysical survey shall be:

- To attain up to date high-resolution water depth measurements across the site;

- To attain information on the seabed surface (type, texture, variability, *etc.*) and in particular identify any seabed features that may be of interest to the overall project;
- Identify any shallow geohazards (including but not limited to outcropping, boulders, shallow gas, wrecks, etc.);
- Determine the stratigraphy across the site and quantify the variability in the lateral and vertical extents to a depth of at least 70m below seabed;
- Identify the presence of bedrock should it exist within the top 70m;
- Identify any magnetic anomalies

The exact equipment to be used will be confirmed following a tender process to procure the site investigation contractor.

The proposed non-intrusive geophysical survey techniques include:

- Multibeam echosounder (MBES) system for detailed bathymetric mapping and seabed features;
- Side scan sonar (SSS) to characterise the seabed features and sediment characteristics;
- Magnetometer, to detect geomorphological anomalies and ferrous obstructions;
- Single channel sub-bottom profiling (SBP), to identify and characterise the shallower layers of sediment/bedrock underneath the seafloor;
- Ultra-high resolution seismics (UHRS); to identify and characterise the deeper layers of sediment/bedrock underneath the seafloor.

In line with best practice guidelines 'Guidance to manage the risk to marine mammals from man-made sound sources in Irish waters' from DAHG, 2014 and Irish Whale and Dolphin Group guidelines which are now being incorporated into the standard operating procedures of all geophysical surveys in Irish waters, an experienced Marine Mammals Observer (MMO) will be employed during all multibeam, single beam, side-scan sonar and sub-bottom profiling. Appendix 2 of the 'Appropriate Assessment Screening' document contains details on the MMO Monitoring protocols relevant to these surveys.

2.3.1 Bathymetric Surveying

A multibeam echosounder (MBES) system will be used to provide detailed bathymetric mapping throughout the survey area.

The R2Sonic 2024 may be taken as an indicative example of a MBES system to be used in the completion of these works. The equipment will operate within a frequency range of 400-700kHz (400,000-700,000Hz) with sound pressure levels in the range of 200-228dB re1µPa at 1 metre range.

2.3.2 Side Scan Sonar (SSS)

Side scan sonar is a towed sensor which is typically towed behind the vessel on an armoured tow cable, although some models can be pole mounted on the side of the vessel. SSS will be a dual frequency hydrographic sonar used to produce seabed imagery. The Seatronics Edgetech 4200 may be taken as an indicate example of an SSS device and will have a potential operating frequency range

of approximately 300 to 900 kHz (300,000 – 900,000 Hz) with sound pressure levels of 228dB re1µPa at 1 metre range. The frequency range used will be determined by the survey objectives.

Figure 2-2: Example of a towable side scan sonar data device

2.3.3 Magnetometer

The magnetometer is a passive towed device used to detect ferrous objects on the surface or in the subsurface. Magnetometer surveys are widely used prior to intrusive works such as geotechnical surveying and construction works to highlight any obstruction or potential risk such as unexploded ordnance. The magnetometer will be a cesium marine magnetometer such as the Geometrics G-882 and capable of recording variations in magnetic field strength during survey to an accuracy of ±0.5nT.

Figure 2-3: Magnetometer

2.3.4 Sub-bottom Profiling (SBP)

Shallow sub-bottom profiling surveying aims to create a 2-D or 3-D image of the subsurface up to potential depths of approximately 50m below seabed, depending on the geological conditions encountered and the choice of system used. Different types of SBP are available including chirp, pinger, boomer, sparker and parametric chirp systems. The most appropriate system will be decided depending on the seabed, anticipated geological environment and the objectives of the survey. The Seatronics Edgetech 3300 may be taken as an indicative example of a hull-mounted pinger system and will have an expected operating frequency range of approximately 2-16 kHz with sound pressure levels of 200dB re1µPa at 1 metre range. The Applied Acoustics may be taken as an indicative example of a boomer source and will have an expected operating frequency of approximately 2.5 kHz with sound pressure levels in the range of 208-211dB re1µPa at 1 metre range.

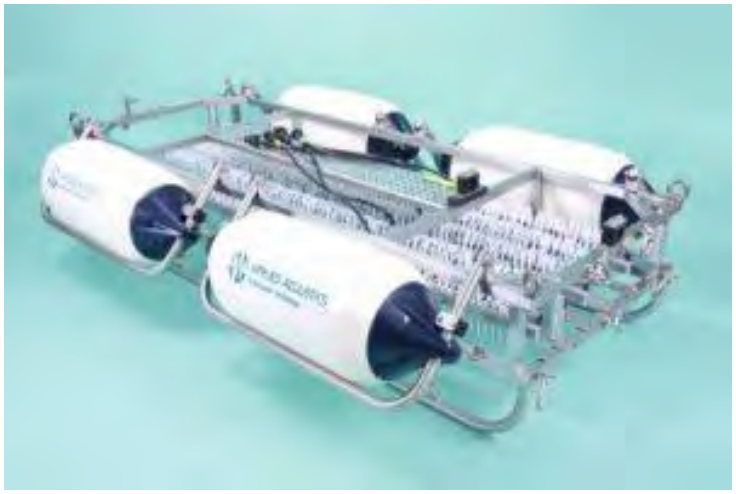


Figure 2-4: Example of sub-bottom profiler Boomer source

Figure 2-5: Towed Sub bottom profiler

2.3.5 Ultra-high resolution seismic (UHRS)

Ultra-high resolution seismic survey will be used to gain a 2D or 3D interpretation of the deeper strata. Depending on the water depth and the geological conditions, typical systems have the potential to penetrate down to approximately 200 m below seabed. The type of system used would ultimately depend on the objectives of the survey and the known geological conditions. The Geo Marine Geo-source 200 with a Geo Spark 1000 source is a typical example of the type of system that may be proposed; with a central operating frequency of 1.4 kHz and a source power in the range of 400-1000

joules; again depending on the geology and the survey objectives. This is considered low power in comparison to the oil and gas equivalent.

2.4 Geotechnical Survey

The purpose of the geotechnical survey is to evaluate the nature and mechanical properties of the superficial seabed sediments and/or bedrock formations to a depth below which possible existence of weak formations will not influence the safety or performance of the wind turbine and its support structure.

The location, quantity, target depths and type of scheduled preliminary geotechnical sampling will be determined following the interpretation of the geophysical survey but indicatively will comprise of:

- 12 no. boreholes
- 40 no. seabed CPTs
- 40 no. core samples acquired by vibrocore or gravity corer
- 40 no. grab samples

See 'Foreshore Licence Map' for the proposed investigative locations. The exact locations of the geotechnical testing/ sampling locations will be based on a combination of the results of the geophysical survey. Typically, stations are positioned at key structure locations and to confirm the geophysical interpretation and sample each change in geological unit. However, the positioning of stations also needs to take into consideration environmental constraints such as the position of sensitive habitats or archaeological features.

2.4.1 Boreholes

The quantity and scheduled penetration depth of boreholes will be largely dependent on the interpretation of geophysical data. The chosen borehole method will enable sample recovery and down-borehole in-situ geotechnical testing. It is anticipated that all borehole locations at the windfarm array site will be carried out using a Dynamic Positioning (DP) controlled drillship.

A drilling head is lowered to the seabed via a drill string and stabilised using a seabed frame. The drill string is then rotated to commence boring. Tools are lowered into the drill string to recover samples or conduct in-situ soil testing. The drilling flush and drill cuttings are largely returned to the vessel and re-used and returned to shore for disposal, however some loss of flush and cutting should be expected.

All drilling equipment used will follow the ISO and API technical specifications for drilling equipment and at a minimum will have:

- Capability of completing in-situ down-borehole sampling and PCPT/SCPT testing
- A heave motion compensator system on board (seabed frame and/or drill string) with a minimum heave compensation of 1.5m;
- Capability of mud production to different densities (when mud production is required for the works). The mud shall be water or bio-degradable organic polymer

The boring log, a detailed description of the soil types, and the in-situ geotechnical properties determined for the boreholes will be documented to characterise the strata. An example borehole log is shown in Figure 2-6.

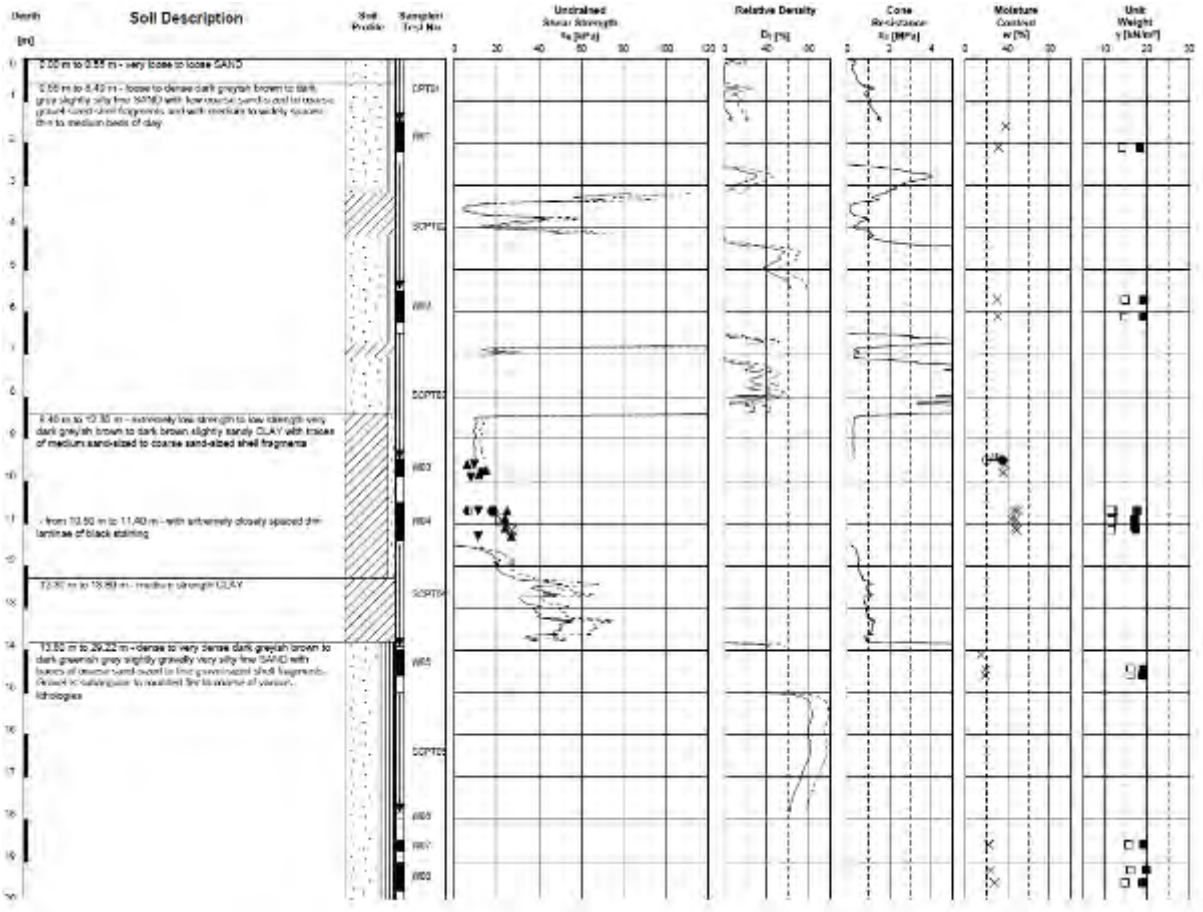


Figure 2-6: Typical borehole log

Figure 2-7: Example of drillship mast with heave motion compensation system

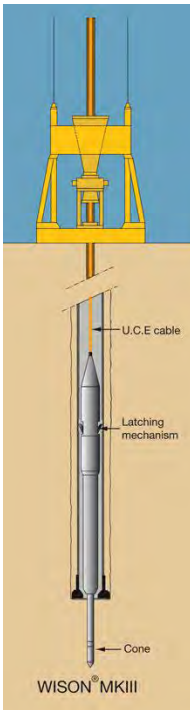


Figure 2-8: Schematic of down-borehole SCPT/PCPT system

2.4.2 Cone Penetrometer Testing (CPTs)

The Cone Penetration Test (CPT) is a type of geotechnical field test used to classify and quantify the sub-surface conditions for a given site. The CPT is one of the most commonly employed site investigation techniques for offshore projects worldwide.

The Cone Penetration Test involves pushing an instrumented and calibrated steel cone into the ground under a controlled test specification, while measuring the resistance to the penetration. The resulting resistance records are then used as a proxy for the soil strength and can therefore be used to classify the sub-surface conditions and inform the design of sub-surface foundations and infrastructure. For example, when the cone penetrates through one soil layer into an underlying layer, this would typically be accompanied by a change in resistance, by charting the resistance profile as a function of depth it allows the soil stratigraphy to be determined.

There are two separate ways of deploying CPTs offshore, which require different vessel types and equipment and therefore shall be considered separately below. The mode of deployment is either (a) Down-Borehole CPTs or (b) seabed CPTs.

a) Down-borehole CPTs

The down-the-hole CPT is undertaken in conjunction with a traditional drilling assembly. This allows the CPT to be pushed until such time as refusal is reached. A drill string is then used to core out the hole at the CPT location, this reduces the friction on the rods and allows the CPT to be pushed to greater depths. By contrast, the seabed CPT would have refused at shallower penetrations. The down-the-hole CPT takes longer and is more intrusive as it also involves drilling, however it allows deeper layers to be tested which cannot be reached with the seabed system.

b) Seabed CPTs

Seabed CPTs involve mobilizing a self-contained and automated CPT test unit housed within a seabed frame. This frame is typically kept on the deck of a dynamically positioned vessel. The vessel will typically locate at the required position and then use an on-board crane or winch system to lift the CPT frame into the water until it touches down on the seabed. The CPT is connected to the vessel via an umbilical. The cone is then automatically pushed into the seabed until it reaches refusal. Refusal is defined as the point where the resistance of the ground exceeds the weight of the reaction frame and as a result the cone cannot be pushed any further.

The seabed CPT unit, either continuous push or rod fed/ block push system, operated from the sea floor, lowered from the vessels crane, A-frame or through the moonpool, as shown in Figure 2-9. The seabed unit will be ballasted depending on the survey requirements, generally weighting 20 – 25 tonnes with a footprint of approx. 8 – 10 m^2. Seabed CPTs do not involve removing any material from the seabed or taking any samples. The test typically takes less than two hours, after which the seabed frame is lifted back on to the vessel and the vessel moves on to the next location.

Figure 2-9: Fugro Seacalf; example of a block push seabed CPT system

2.4.3 Vibrocore/ Gravity Sampling

The contractor will be required to carry out vibrocore sampling at the main array site, 40no. vibrocore sample locations at the main array site.

Vibrocoring is the state-of-the-art sediment sampling methodology for retrieving continuous, relatively undisturbed cores. The principal behind a vibrocore is the development of high frequency, low amplitude vibration that is transferred from the vibrocore head down through the attached barrel

or core tube. This vibrational energy allows the care barrel to penetrate the sediments. The core barrel will be fitted with a plastic liner, core catcher and cutting shoe. The vibrocore rig, similar to that seen in Figure 2-10, is lowered onto the seafloor on a wireline from the on-board vessel crane. Once coring is started, the drill rods will penetrate to the target depth or refusal. Samples will be recovered in the plastic liner, sealed appropriately and brought to shore or examined and tested in the vessels on-board lab. Vibrocore is best suited to non-cohesive soils.

Gravity core (self-weight penetration sampler) is performed where cohesive soil is expected. Similar to vibrocoring, it is equipped with a PVC liner. The gravity corer is lowered on the seabed and penetrates in the seabed under its own weight. Upon refusal or at target depth, the gravity core is recovered on deck where the recovery rate is measured.

The exact equipment to be used will be confirmed following a tender process to procure the site investigation contractor.

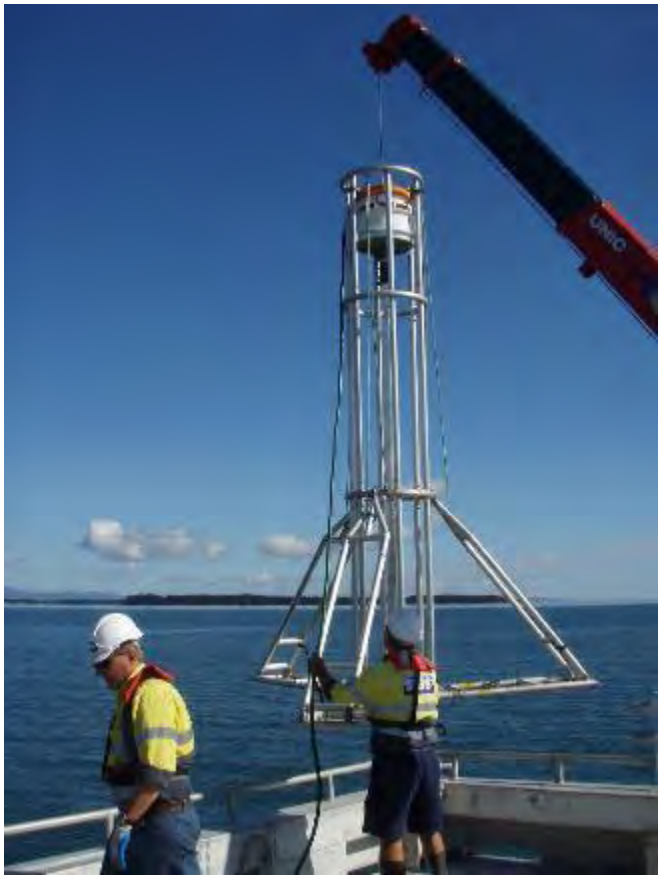


Figure 2-10: Example of a crane-deployed vibrocore system

2.4.4 Grab sampling

Grab sampling is required across the offshore survey area. 40 grab sampling locations are scheduled for the main array survey area.

Grab sampling will be carried out by lowering the sampling device from the vessel, either by crane or handheld device depending on requirements. The exact equipment to be used confirmed by the

contractor at the tendering stage; however, a Van Veen grab (Figure 2-11), box corer or similar device would most commonly be used. Material recovered by a grab sampler will be disturbed, so its strength properties will be compromised. Upon returning grab samples to the deck, material will be logged either onboard or onshore for various purposes, organic content, particle size and benthic infauna. The material will be preserved in 5% formalin and stored in a labelled sealed bag for transport to shore for later analysis in the laboratory.

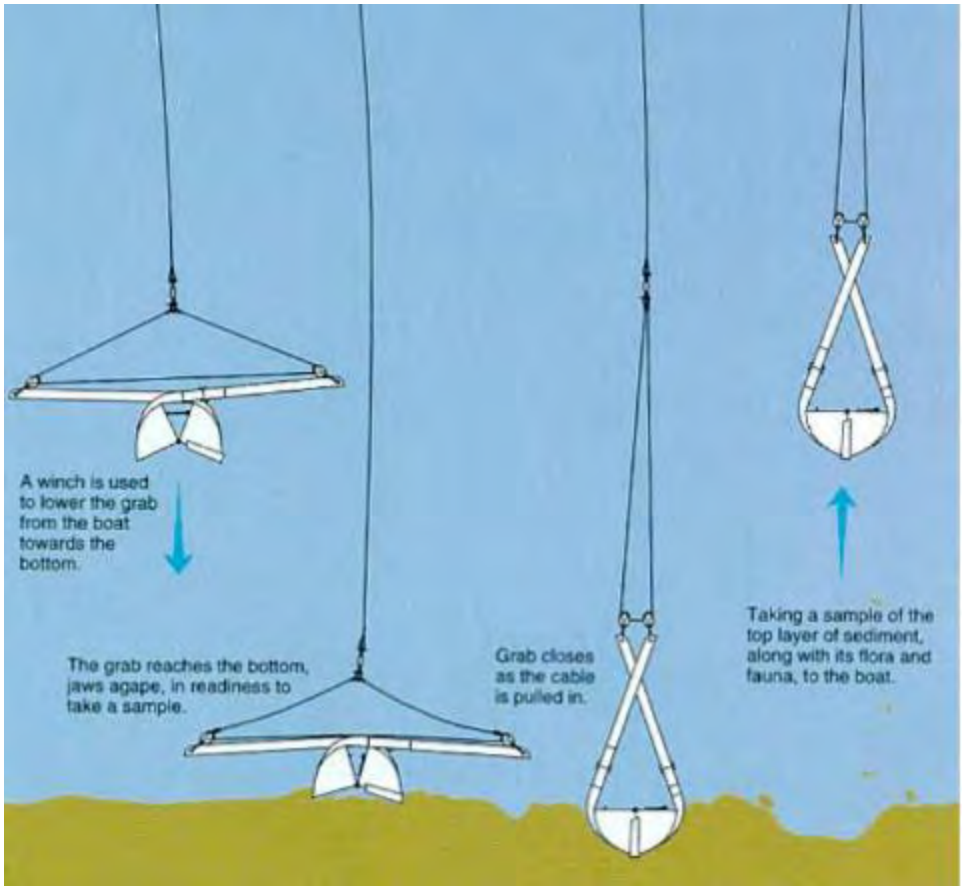


Figure 2-11: Van Veen sampler

To minimize repetition of survey work, it is proposed to split individual grab samples to facilitate a single sample serving multiple purposes (i.e. to inform our understanding of both geotechnical and benthic fauna).

2.5 Metocean Survey

The purpose of the proposed equipment outlined in this section is to evaluate the wind, wave and current conditions across the marine area of interest. These surveys will involve the mobilisation of various buoys and bottom profilers to collect *in-situ* data over periods varying between a number of hours up to 12 months. The suggested metocean survey methods include floating LiDAR, waverider buoys and an acoustic doppler current profiler (ADCP).

2.5.1 Floating LiDAR

A LiDAR buoy will be deployed to collect wind resource data within the prospect area. Exact details of the LiDAR buoy, deployment location within the prospect area, associated mooring arrangement and installation vessel will not be available until a contract has been awarded. An installation vessel will be required for the launch and recovery of this equipment, the details of which will become available on award of the tender contract. The same type of vessel used for the installation, will be required to service the floating liDAR.

The following provides an overview of a typical floating LiDAR (Seawatch) deployment. The LiDAR will be mounted on a buoy and will be moored using a mooring chain and concrete anchor. The device provides measurements across the entire rotor diameter and beyond and can be configured to measure up to 10 different heights from 12.5 to 300 metres above the sea surface.

The buoy will be moored to the seabed for a duration of 12 to 24 months and will be powered by solar panels, batteries and micro wind turbine generators.

Figure 2-12: Typical Floating LiDAR

2.5.2 Acoustic Doppler Current profiler (ADCP)

An acoustic doppler current profiler (ADCP) may also be deployed via a vessel's on-board crane and would rest on the seabed. The purpose of the ADCP is to determine the principal tidal current regime of the proposed survey area. Exact details of any ADCP and deployment location within the application area will not be available until a contract has been awarded; however, the following points provide a brief overview of an ADCP system, illustrated in Figure 2-13.

- The ADCP is expected to sit within a stainless-steel frame; dimensions of a typical ADCP, 1.8m base and 0.6m height off seabed.
- The total weight of the frame and ADCP will be in the order of 300kg.

- The ADCP and stainless-steel mooring frame will be attached to a ground line, a clump weight (approx. 150kg) and to an acoustic release system carrying a rope retrieval system. This will ensure that all equipment is recovered from the seabed after the monitoring period (minimum period of 30 days).

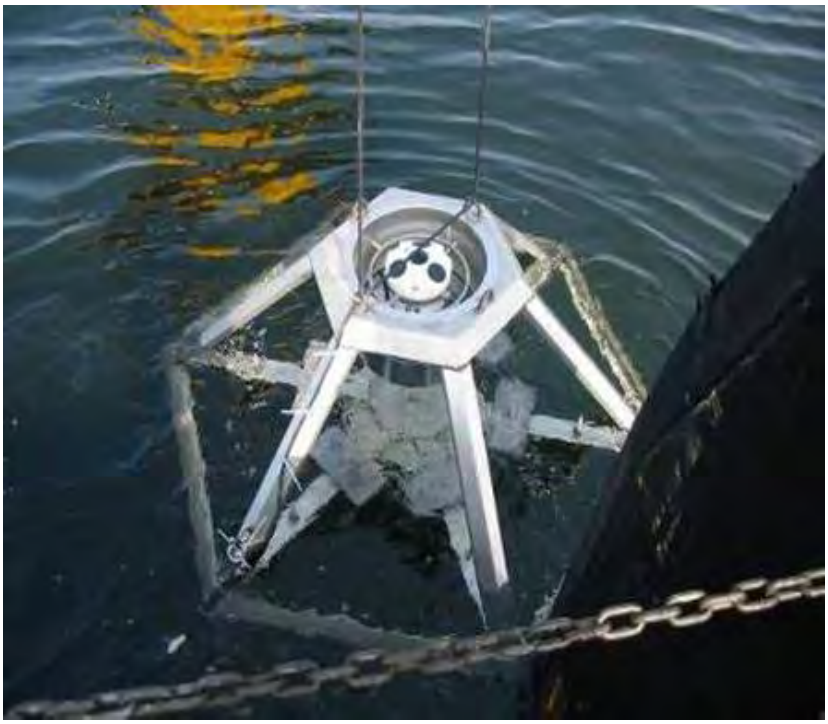


Figure 2-13: Acoustic Doppler Current Profiler (ADCP)

2.6 Ecology Survey

The purpose of the ecological survey is to update the baseline environmental data collected from previous ecological surveys. This data will primarily be used to inform the environmental impact assessment report (EIAR), by describing the environmental conditions within the site, and subsequently developing appropriate mitigation measures for any potential environmental impacts. The ecological scope of work will include a benthic survey.

2.6.1 Fisheries Survey

A fisheries survey will be carried out to ascertain the species and their distribution within the survey area. The Sea Fisheries Protection Authority will be consulted regarding the exact nature of the survey, a 3-day demersal survey is anticipated.

2.6.2 Benthic Survey

The aim of the proposed benthic survey is to map the distribution and extent of marine benthic biological communities and habitats in the application area. This will comprise a benthic sampling programme and video or still photographs. The sampling locations will be determined based upon interpretation of the geophysical data and will be selected in order to sample the full range of habitats and biological communities expected in the survey area.

As discussed in 2.4.4 a grab sampler, typically a Van Veen grab, will be used to retrieve a sediment sample of the seabed by the lowering of a mechanical grab from a vessel crane or A-frame. Each grab samples a volume of approximately 0.1m^3 of the seafloor. Grabs are required to obtain a sample greater than 5cm in depth, to try and achieve this, samples will be repeated for up to three attempts. It is currently estimated that 40 grab stations will be selected across the survey area. It is likely that three grab samples will be taken at each station;

- Two samples to be taken for faunal analysis; used for the identification and quantitative analysis of benthic fauna - colonial and epifaunal species will be recorded qualitatively.
- One sample for sediment and chemical analysis, such as;
    - Particle size analysis and distribution
    - Sediment organic matter and carbon analysis
    - Major trace element analysis
    - Hydrocarbon analysis

As mentioned in 2.4.4, to minimize repetition of survey work, it is proposed to split individual grab samples to facilitate a single sample serving multiple purposes (i.e. to inform our understanding of both geotechnical and benthic fauna).

2.7 Archaeological Survey

This can be done in conjunction with the geophysical survey as the item investigated will be based on results from the geophysical survey. The proposed archaeological survey will comprise of the following:

- A desk study;
- Identification and assessment of metallic and other targets recorded during marine magnetometer survey;

Assessment of the archaeological significance of identified targets to include sidescan analysis and diving as required.

All archaeological work will be carried out by a suitably qualified archaeologist to determine the location of all known archaeological features in advance of the intrusive geotechnical and environmental survey.

Appendix 1: Equipment Specification

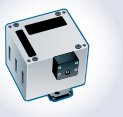
Multibeam Echosounder Specifications

R2 SONIC
OUR VISION IS SOUND™

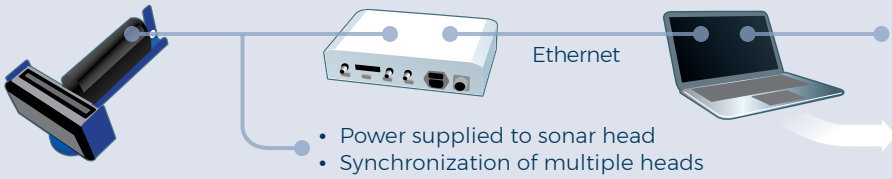
We apply our technical expertise and experience as surveyors to serve you: Our portfolio is elegantly simple while technologically advanced and user-friendly. **Beamwidth** and **depth range** are the 2 main characteristics that differentiate each of those MultiBeam EchoSounders (MBES). All options can be implemented on all products, except for the option to operate at 90kHz/100kHz that is exclusive to the Sonic 2026 (at the expense of the UHR option). This provides **high flexibility** to end-users to upgrade their equipment **remotely**. These options go beyond just opting for a longer cable; they all bring extra capabilities and functionalities, allowing even the entry level sonar to benefit from advanced operating modes. **Additionally, the firmware of all 4 MBES can be upgraded remotely.**

Standard Features for all R2Sonic MBES

SONIC 2020



Extra Light & Compact!



- Ultra High Density (UHD): 1024 soundings per ping
- Selectable operating frequencies 'on-the-fly' in steps of 1Hz
- Ability to rotate the swath sector 'on-the-fly'
- Free firmware updates can be done remotely by end users
- Low power consumption for the performance delivered
- Light & compact
- Training delivered by experts
- Options upgradable remotely
- Embedded processor / controller in the sonar head that enables fast and powerful computation at low power (no separate topside processor)
- 3-year warranty
- All R2Sonic MBES exceed IHO-S44 Special Order, when installed following the instructions from the Manual and used with the I2NS and the Sound Velocity Sensor offered by R2Sonic

Only R2Sonic does it...

- Multispectral mode: survey with up to 5 frequencies in 1 pass and with 1 MBES. **Saves Time & Money!**
- Increased true sounding density with UHD → **It Provides Accurate and Truthful Resolution***
- **Smallest Beamwidth Available!** Down to **0.3° x 0.6°**
- Clean and small data files which reduces processing time and **Saves Time & Money!**
- Ability to upgrade options remotely
- Free firmware updates
- Optional 6-year warranty, which **minimizes risk** on investment
- 24/7 technical support via email and phone wherever you are in the world
- Express and high quality repairs, performed by the team that engineered the systems

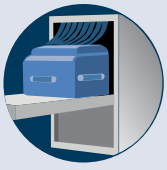
Options

- Ultra High Resolution (UHR): beamwidth down to 0.3° x 0.6°
- Multimode
  - o Pipeline mode: 2 frequencies, requiring UHR (700kHz)
  - o Multispectral mode: ability to survey with up to 5 different frequencies in one pass and with one system
- TruePix™: provides highly compact water column imagery and backscatter
- Raw water column data output
- Robo™: automated operation
- On-site training (theory class & hands-on demo)
- 6-year warranty
- 4000m and 6000m immersion depth rating
- Mounting hardware & assemblies, including Dual Head for Sonic 2020
- Antifouling coating protection
- Switchable Forward Looking Sonar Imagery
- I2NS™ (Integrated Inertial Navigation System): 3 types available that provide different accuracy for roll / pitch and heading
  Please consult specification sheet for more information on the I2NS™
- Software available: HYPACK®, QINSy™, SonarWiz 7, Fledermaus GeoCoder
- Sound Velocity Sensors available

Quick Mobilization

Easy to Pack

Easy to Maneuver



Easy to Check-In

Sonic Series store easily in Peli™ Case, for increased mobility

US Patent 10,132,924

*Please consult the "Making Concepts Simple" booklet for clarification on technical terms / concepts.

MADE IN USA

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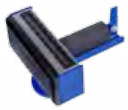
Technical Specifications

Multibeam Echosounders






	Sonic 2020	Sonic 2022	Sonic 2024	Sonic 2026
Applications	Entry level hydrography Very small vessels Small ASV and AUV	Construction Dredging Autonomous Surface Vehicle (ASV) Offshore O&G (pipeline)	Autonomous Surface Vehicle (ASV) Construction Dredging Offshore O&G (pipeline) Offshore WindFarm (cable, towers)	Advanced hydrography Research Seafloor characterization Autonomous Underwater Vehicle (AUV) Remote Operated underwater Vehicle (ROV)
Selectable Frequencies	200kHz - 400kHz. Optional 700kHz	170 - 450kHz. Optional 700kHz		170 - 450kHz. Optional 90kHz and 100kHz
Minimum frequency increase	1Hz			
Beamwidth, across track and along track	1° x 1° at 700kHz (optional) 2° x 2° at 400kHz 4° x 4° at 200kHz	0.6° x 0.6° at 700kHz (optional) 0.9° x 0.9° at 450kHz 2° x 2° at 200kHz	0.3° x 0.6° at 700kHz (optional) 0.45° x 0.9° at 450kHz 1° x 2° at 200kHz	0.45° x 0.45° at 450kHz 1° x 1° at 200kHz 2° x 2° at 90kHz & 100kHz (optional)
Number of soundings	Up to 1024 soundings per ping			
Max speed (vessel)	11.1 knots for full coverage (*)			
Near-field focusing*	Yes			
Roll stabilized beams	Yes			
Pitch stabilized beams	Yes	No		Yes
ROBO™ Automated Operation	Yes Auto Power, pulse width, rangeTrac™, GateTrac™, SlopeTrac™			
Saturation monitor	Yes			
Selectable Swath Sector *(also referred as Max Coverage)*	10° to 130° User selectable in real-time	10° to 160° User selectable in real-time		
Sounding Patterns	Equiangular Equidistant single / double / quad modes Ultra High Density (UHD)			
Sounding Depth	up to 200m+	up to 400m+		up to 800m+
Pulse Length	15µs - 1ms			15µs - 2ms
Pulse Type	Shaped CW			
Ping rate	up to 60Hz			
Bandwidth	up to 60kHz			
Immersion Depth	100m Optional 4000m		100m Optional 4000m & 6000m	100m Optional 4000m
	FLS projectors are rated 4000m	FLS projectors are rated 3000m		FLS projectors are rated 4000m
Bottom Detect Resolution	3mm			
Operating Temperature	-10°C to 40°C	-10°C to 50°C		
Storage Temperature	-30°C to 55°C			

Electrical Interface

Mains	90-260VAC, 45-65Hz			
Power consumption	20W avg	35W avg	50W avg	100W avg
Uplink/downlink	10/100/1000Base-T Ethernet			
Sync in, Sync out	TTL			
Deck cable length	15m, optional 25m and 50m			

Mechanical

Sonar Dimension (Sonic 2020)	140 x 161 x 133.5 mm			
Sonar Mass (Sonic 2020)	4.4kg			
Receiver Dim (LWD)		276 x 109 x 190 mm	480 x 109 x 190 mm	
Receiver Mass		7.7kg	12.9kg	
Projector Dim (LWD)		273 x 108 x 86 mm		480 x 109 x 196 mm
Projector Mass		3.3kg		13.4kg
Sonar Interface Module Dim (LWH)	280 x 170 x 60 mm			
Sonar Interface Module Mass	2.4kg			

(*) The speed of the survey is primarily limited by the installation of the MBES.

Specification Sheet 2019 version 1.3 subject to change without notice

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4200 SERIES

SIDE SCAN SONAR SYSTEM

FEATURES

- Optional Multi-Pulse (MP) technology for high speed surveys
- Crisp, high resolution CHIRP images
- Multiple dual simultaneous frequency sets to choose from
- Stainless steel towfish
- Easily integrates to other 3rd party sensors
- Meets IHO & NOAA Survey Specifications

APPLICATIONS

- Cable & Pipeline Surveys
- Geological/Geophysical Surveys
- Mine Countermeasures (MCM)
- Geohazard Surveys
- Channel Clearance
- Search and Recovery
- Archeological Surveys

The 4200 Series is a versatile side scan sonar system that can be configured for almost any survey application from shallow to deep water operations. The 4200 utilizes EdgeTech's Full Spectrum® CHIRP technology to provide crisp, high resolution imagery at ranges up to 50% greater than non-CHIRP systems; thus allowing customers to cover larger areas and save money spent on costly surveys.

One of the unique features of the 4200 is the optional Multi-Pulse (MP) technology, which places two sound pulses in the water rather than one pulse like conventional side scan sonar systems. This allows the 4200 to be towed at speeds of up to 10 knots while still maintaining 100% bottom coverage. In addition, the MP technology will provide twice the resolution when operating at normal tow speeds, thus allowing for better target detection and classification ability. The addition of the optional MP technology provides the operator with two modes of operation; either High Definition Mode (HDM) or High Speed Mode (HSM). This software-selectable mode of operation provides the operator the ability to select the best configuration for the specific job type.

All EdgeTech 4200 systems are comprised of a topside system and a reliable stainless steel towfish. A choice of dual simultaneous frequency sets are available to the user and topside processors come in a choice of configurations from portable to rack mounted units. In addition, an easy-to-use GUI software is supplied with every unit.

info@EdgeTech.com | USA 1.508.291.0057

4200 SERIES

SIDE SCAN SONAR SYSTEM

KEY SPECIFICATIONS

SONAR SPECIFICATIONS	STANDARD	WITH OPTIONAL MP TECHNOLOGY	
Frequency	Choice of either 100/400, 300/600 or 300/900 kHz dual simultaneous		
Operating Range (meters/side)	100 kHz: 500m, 300 kHz: 230m, 400 kHz: 150m, 600 kHz: 120m, 900 kHz: 75m		
Horizontal Beam Width:	100 kHz: 1.5°, 300 kHz: 0.5°, 400 kHz: 0.4°, 600 kHz: 0.26°, 900 kHz: 0.2°	In High Speed Mode: 100 kHz: 1.26°, 300 kHz: 0.54°, 400 kHz: 0.4°, 600 kHz: 0.34°, 900 kHz: 0.3° In High Definition Mode: 100 kHz: 0.64°, 300 kHz: 0.28°, 400 kHz: 0.3°, 600 kHz: 0.26°, 900 kHz: 0.2°	
Resolution Along Track	100 kHz: 5 m @ 200 m 300 kHz: 1.3 m @ 150 m 400 kHz: 0.6 m @ 100 m 600 kHz: 0.45 m @ 100 m 900 kHz: 18 cm @ 50 m	High Definition Mode: 100 kHz: 2.5m @ 200m 300 kHz: 1.0m @ 200m 400 kHz: 0.5m @ 100m 600 kHz: 0.45m @ 100m 900 kHz: 18 cm @ 50m	HIgh Speed Mode: 100 kHz: 4.4m @ 200m 300 kHz: 1.9m @ 200m 400 kHz: 0.7m @ 100m 600 kHz: 0.6m @ 100m 900 kHz: 26 cm @ 50m
Resolution Across Track	100 kHz: 8 cm, 300 kHz: 3 cm, 400 kHz: 2 cm, 600 kHz: 1.5 cm, 900 kHz: 1 cm		
Vertical Beam Width	50°		
Depression Angle	Tilted down 20°		
TOWFISH	**STAINLESS STEEL**		
Diameter	11.4 cm (4.5 inches)		
Length	125.6 cm (49.5 inches)		
Weight in Air/Saltwater	48 / 36 kg (105 / 80 pounds)		
Depth Rating (Max)	2,000m		
Standard Sensors	Heading, pitch & roll		
Optional Sensor Port	(1) Serial – RS 232C, 9600 Baud, Bi-directional & 27 VDC		
Options	Pressure Sensor, Magnetometer, Integrated USBL Acoustic Tracking System, Built-in Responder Nose, Depressor, Power Loss Pinger and Custom Sensors		
TOPSIDE PROCESSOR	**4200-P**	**4200**	**701-DL INTERFACE**
Hardware	Portable splash-proof case	19" rack mount computer	19" rack mount interface
Display & Interface	Splash-proof laptop	21" flat panel monitor, keyboard & trackball	Customer-supplied
Power Input	20-36 VDC or 115/230 VAC	115/230 VAC	115/230 VAC
Operating System	Windows© XP Pro		
File Format	Native JSF or XTF		
Output	Ethernet		
TOW CABLE			
	Coaxial Kevlar or double-armored up to 6,000m, winches available		

G-882
Cesium Marine Magnetometer

GEOMETRICS
Innovation • Experience • Results

Geometrics' G-882 Marine Magnetometer is the leading marine system in the industry with over 1,000 systems sold! The G-882 is the only system that meets the standards for UXO clearance in the North Sea.

This very high-resolution Cesium vapor marine magnetometer is low in cost, small in size, and offers flexibility for professional surveys in shallow or deep water. Use your personal computer with our MagLog™ software to log, display and print GPS position and magnetic field data.

The system directly interfaces to all major side-scan manufacturers for tandem tow configurations. Being small and lightweight, it is easily deployed and operated by one person. But add several streamlined weight collars and the system can quickly weigh more than 100 lbs for deep-tow applications.

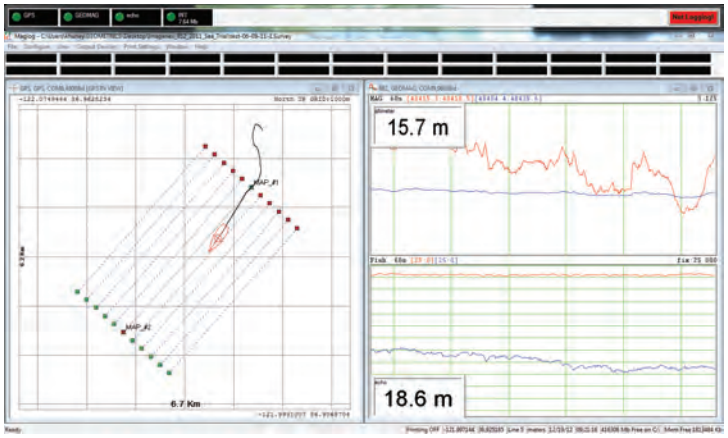
This marine magnetometer system is particularly well-suited for the detection and mapping of all sizes of ferrous objects. This includes anchors, chains, cables, pipelines, ballast stones and other scattered shipwreck debris, munitions of all sizes (UXO), aircraft, engines and any other object with a magnetic expression. The G-882 is also perfect for geological studies. Its high sensitivity and high sample rates are maintained for all applications.

Objects as small as a 5-inch screwdriver are readily detected provided that the sensor is close to the seafloor and within practical detection range (refer to table on back).

FEATURES & BENEFITS

- **Cesium Vapor High Performance** – Highest detection range and high probability of detecting all sized ferrous targets.
- **Streamlined Design for Tow Safety** – Low probability of fouling in fishing lines or rocks. Rugged fiber-wound fiberglass housing.
- **Sample at up to 20Hz** – Unparalleled data density while also covering larger areas per day.
- **Sensor can be Rotated for Optimal Signal** – Can be used worldwide.
- **Easy Portability and Handling** – No winch required. Built-in easy-carry handle. Operable by a single man; only 44 lb with 200 ft cable.
- **Combine Multiple Systems for Increased Coverage** – Internal CM-221 Mini-counter provides multi-sensor sync and data concatenation, allowing side-by-side coverage which maximizes detection of small targets and reduces noise.
- **Export Version Available** – Use anywhere in the world without need for an export license (except embargoed countries). See specifications.

SPECIFICATIONS | G-882 Cesium Marine Magnetometer



MagLogLite™ Data Logging software is included with each magnetometer and allows recording and display of data and position with automatic anomaly detection. Additional software options include: MagLog Pro™, advanced logging software; MagMap™, a plotting and contouring package; and MagPick™ post-acquisition processing software.

MAGNETOMETER / ELECTRONICS

Operating Principle: Self-oscillating split-beam Cesium vapor (non-radioactive).

Operating Range: 20,000 to 100,000 nT.

Operating Zones: The earth's field vector should be at an angle greater than 10° from the sensor's equator and greater than 6° away from the sensor's long axis. Automatic hemisphere switching.

Noise: <0.004 nT/$\sqrt{Hz}_{rms}$. (SX (export) version: <0.02 nT/$\sqrt{Hz}_{rms}$).

Max Sample Rate: 20 Hz.

Heading Error: < 1 nT (over entire 360° spin).

Output: RS-232 at 1,200 to 19,200 Baud.

Power: 24 to 32 VDC, 0.75 A at power-on and 0.5 A thereafter.

MECHANICAL

Sensor Fish

DIA: 7 cm; L: 137 cm (2.75x54 in) (with fin assembly).
Weight: 18 kg (40 lb).

Includes sensor and electronics and 1 main weight. Additional collar weights are 6.4 kg (14 lb) each; total of 5 capable.

Tow Cable

DIA: 12 mm; L: 800 m (0.47 in x 2,625 ft).
Weight: 7.7 kg (17 lb) with terminations.
Break strength: 1,630 kg (3,600 lb)
Bend diameter: 30 cm (12 in).

Typical Detection Range for Common Objects

1.	Ship: 1000 tons	0.5 to 1 nT at 800 ft (244 m)
2.	Anchor: 20 tons	0.8 to 1.25 nT at 400 ft (120 m)
3.	Automobile	1 to 2 nT at 100 ft (30 m)
4.	Light Aircraft	0.5 to 2 nT at 40 ft (12 m)
5.	Pipeline (12 inch)	1 to 2 nT at 200 ft (60 m)
6.	Pipeline (6 inch)	1 to 2 nT at 100 ft (30 m)
7.	Iron: 100 kg	1 to 2 nT at 50 ft (15 m)
8.	Iron: 100 lb	0.5 to 1 nT at 30 ft (9 m)
9.	Iron: 10 lb	0.5 to 1 nT at 20 ft (6 m)
10.	Iron: 1 lb	0.5 to 1 nT at 10 ft (3 m)
11.	Screwdriver: 5-inch	0.5 to 2 nT at 12 ft (4 m)
12.	Bomb: 1000 lb	1 to 5 nT at 100 ft (30 m)
13.	Bomb: 500 lb	0.5 to 5 nT at 50 ft (16 m)
14.	Grenade	0.5 to 2 nT at 10 ft (3 m)
15.	Shell: 20 mm	0.5 to 2 nT at 5 ft (1.8 m)

ENVIRONMENTAL

Operating Temperature: -35°C to +50°C (-30°F to +122°F).

Storage Temperature: -45°C to +70°C (-48°F to +158°F).

Altitude: 9,000 m (30,000 ft).

Depth: 4,000 psi (2,730 m; 8956 ft).

Water Tight: O-Ring sealed for up to 4,000 psi depth operation.

ACCESSORIES

Standard: Operation manual, shipping/storage container, ship kit with tools and hardware, power supply, MagLogLite™, MagMap™ and MagPick™ processing software, depth transducer, altimeter.

Optional: Steel tow cable to 6,000 m (19,600 ft) with telemetry, longitudinal or transverse gradiometer, plastic Pelican® case, MagLogPro™, collar weights.

GEOMETRICS
Innovation • Experience • Results

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3300

HULL MOUNT SUB-BOTTOM PROFILING SYSTEM

FEATURES

- Superior Sub-bottom images
- Wideband Full Spectrum CHIRP sub-bottom technology
- Multiple configuration options
- Full ocean depth capabilities
- Increased penetration and high resolution

APPLICATIONS

- EEZ coastal planning and resource development
- Geo-technical surveys
- Hazard surveys
- Geohazard Surveys
- Environmental site investigations
- Geological studies
- Sediment classification
- Geophysical surveys

The EdgeTech 3300 hull mount sub-bottom profiling system is a versatile wideband Frequency Modulated (FM) sonar that generates cross-sectional images of the seabed and collects digital normal incidence reflection data over many frequency ranges. EdgeTech's Full Spectrum® Technology has several distinct advantages over conventional sub-bottom systems, including increased penetration and higher resolution. The tapered waveform spectrum, results in images that have virtually constant resolution with depth. Another Full Spectrum advantage is the reduction of side lobes in the effective transducer aperture. The wide bandwidth of the sweep frequency has an effect of smearing the side lobes of the transducer. The result is a beam pattern with almost no side lobes.

Because the FM pulse is generated by a digital to analog converter with a wide dynamic range and a transmitter with linear components, the energy, amplitude and phase characteristics of the acoustic pulse can be precisely controlled. This precision produces high repeatability and signal definition required for sediment classification.

The frequency range of operation is determined by the acoustic characteristics of the transmitter and receiver mounted on the vessel. Depending on the array size the system can transmit acoustic pulses with different center frequencies and bandwidths. The selection of the pulse is made by the operator while profiling to achieve the best imagery.

3300

HULL MOUNT SUB-BOTTOM PROFILING SYSTEM

KEY SPECIFICATIONS

ARRAY SIZE	4.5 KHZ CENTER FREQUENCY	OPERATIONAL DEPTH
2 x 2	40 degrees	300 meters
3 x 3	30 degrees	1500 meters
4 x 4	24 degrees	3000 meters
5 x 5	20 degrees	5000 meters
2-16 kHz Penetration (typical)	6 meters in coarse sand or 80 meters in clay	
Resolution	6 to 10 cm	

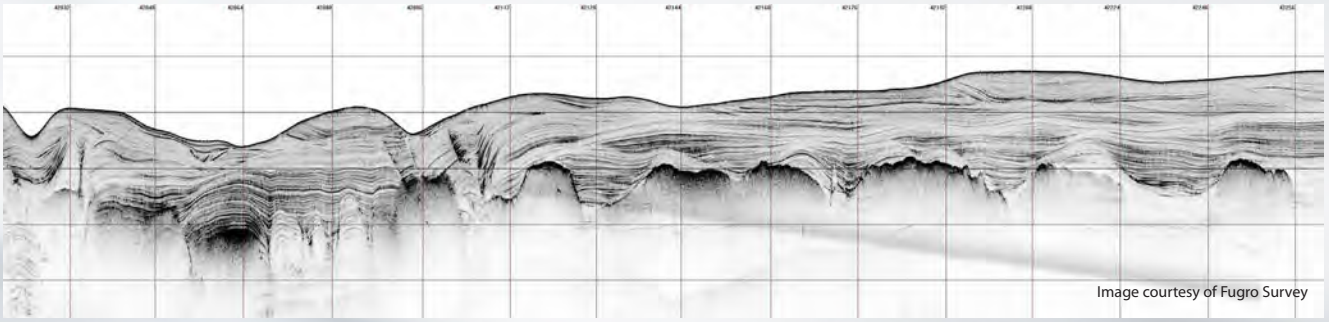

Image courtesy of Fugro Survey

For more information please visit EdgeTech.com

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APPLIED ACOUSTICS
Underwater Technology
An AAE Technologies Group Company

Applied Acoustic Engineering Ltd
Marine House, Marine Park, Gapton Hall Road,
Great Yarmouth, NR31 0NB
United Kingdom

AA251, AA301 Boomer Seismic Sound Source

The AA251 and AA301 boomer plates are seismic sound sources that produce a sharp repeatable pulse from a floating position on the sea surface.

The AA251, deployed on either a robust CAT100 or CAT200 catamaran, is ideal for inshore surveys from small craft.

The AA301 is designed for higher power applications and can also be used as a variable frequency boomer when combined with a CSP energy source.

Key Features

- Stable pulse shape clarity with minimum reverberation
- Rugged mechanical design with weight kept to a minimum
- Supplied as individual product, or with a catamaran
- Supplied with RMK connectors and locking collars as standard
- AA251 forms part of the Inshore Boomer System, ideal for coastal surveys
- AA301 ideal for nearshore and shallow water surveys (up to 120m) depending on geology

Technical Specification

PHYSICAL

	Size	Weight air/water	Fixing centres	Connector
AA251 Boomer plate	380 x 380mm	18kg/10kg	315mm^2	RMK 1/0
AA301 Boomer plate	620 x 520mm	25kg/14kg	485mm x 440mm	RMK 1/0

ELECTRICAL INPUT

Recommended energy	AA251	50 – 200J/shot
	AA301	100 – 300J/shot
Maximum energy	AA251	300J/shot
	AA301	350J/shot
Average energy	AA251	600J/second
	AA301	1000J/second
Operating voltage	3600 to 4000Vdc	

APPLIED ACOUSTICS
Underwater Technology
An AAE Technologies Group Company

AA251, AA301 Technical Specification

SOUND OUTPUT

Source level	AA251	Typically 212dB re 1µPa at 1 metre with 200J
	AA301	Typically 215dB re 1µPa at 1 metre with 300J
Pulse length	AA251	120/150/180µs at 50/100/200J
	AA301	200µs depending on energy setting of CSP
Reverberation	AA251	<10% of initial pulse
	AA301	<10% of initial pulse

COMPATIBLE ENERGY SOURCES

AA251	CSP-P, CSP-Dv, CSP-Nv, CSP-SNv1250
AA301	CSP-P, CSP-Dv, CSP-Nv, CSP-SNv1250

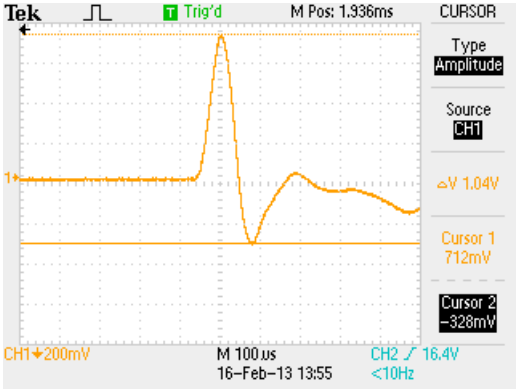
COMPATIBLE CATAMARAN

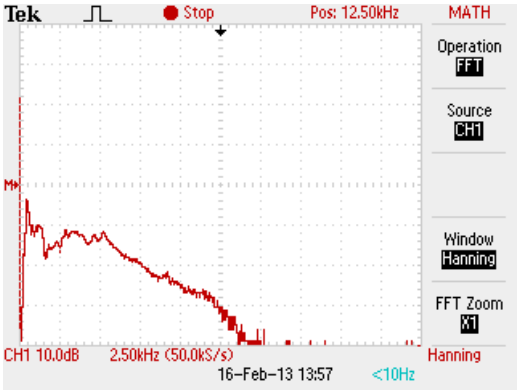
AA251	CAT 100:	940 (L) x 740 (W) x 500 (H) mm
	CAT 200:	1280 (L) x 915 (W) x 525 (H) mm
AA301	CAT 200:	1280 (L) x 915 (W) x 525 (H) mm
	CAT 300:	1700 (L) x 660 (W) 490 (H) mm

COMPATIBLE HV CABLE

AA251 and AA301	HVC 2000 Standard length 75m RMK 1/0 connectors complete with locking collars

AA301 TYPICAL PULSE SIGNATURE AT 300J





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Geo-Source 200 Light Weight

Marine Multi-Tip Sparker System

Operational Features

- Specially designed for small vessel surveys,
- Can be handled by one person
- Water depths from 2 to 500 m
- Penetration to 200 - 300 ms below seabed depending on geology
- Vertical resolution up to 10- 30 cm
- Overall performance depending on acoustic characteristics of vessel, geology and acquisition conditions

Applications

- Small vessel surveys
- Site & route surveys
- Offshore engineering
- Mineral exploration
- Sand searches
- Oceanographic research

Examples of Records

To see examples of our sparker records, please visit the 'Downloads' page on our website:
www.geo-spark.com

Efficient & Cost Effective

With the Geo-Spark HV power supplies you will save a lot of time and money, since the electrodes do NOT burn off like in all other systems.

You don't need to trim tips during the survey. There is no need to have any stock of consumables.

INNOVATIVE Preserving Electrode Mode

The Geo-Source 200 light weight is designed for operation with the Geo-Spark 1000 Pulsed Power Supply using the "Preserving Electrode Mode". This patented concept consists of using a NEGATIVE electric discharge pulse, instead of a positive electric discharge pulse.

Note that working with a negative pulse is NOT the same thing as reversing the polarity of an antique power supply, which is generating a positive pulse.

Maintenance free Electrodes

5 year guarantee

The Preserving Electrode Mode reduces the tip wear to practically **zero**. You can shoot day after day, week after week, month after month with practically **NO tip maintenance.**

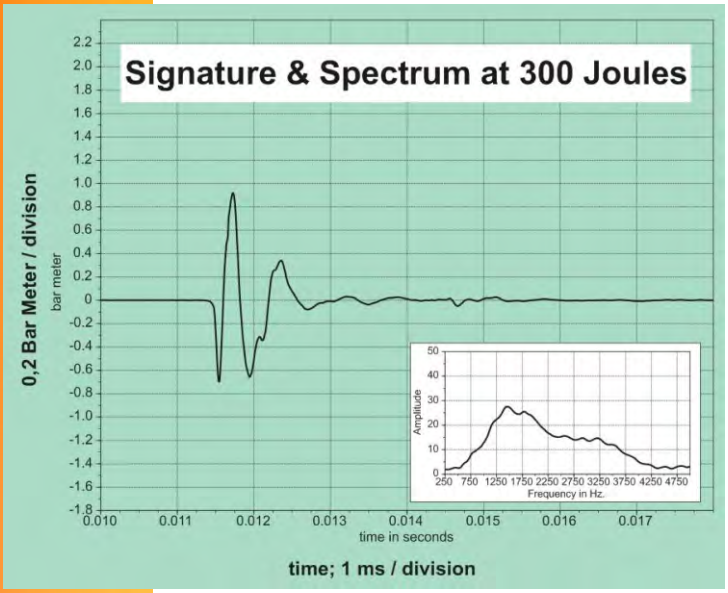
Optimum Acoustic Repeatability

Zero tip wear is essential for the repeatability of the acoustic pulse, which depends largely on a constant, unaltered electrode surface.

Electrode tip after three years of operation

Geo-Source 200 Light Weight

Technical Specifications



Flexible & floating HV tow cable

A flexible, floating power/tow cable with a standard length of 25 m plus 6 m jumpers to the PS is available for small vessel operations .

This dedicated coaxial HV cable contains 4 leads of 6 mm^2 plus outer braiding of 24 mm^2

It is designed to have a low self-inductance in order to preserve the high dI/dt pulse output of the Geo-Spark 1000.

The wet side of the cable is terminated with two special HV connectors to the electrode modules and a ground connector to the frame. Connecting or disconnecting the cable to the Geo-Source 200 L takes not more than ten minutes. The cable weights only 35 kg and is easy to handle by one person.

Control of All Sparker Parameters

The advanced Geo-Source 200 L design gives you full control of:

- **Source depth and geometry**
- **Joules per tip**
- **Number of tips actively in use**

- The effective source depth is set to 15 - 20 cm below the surface A constant source depth at 1/4 of the wavelength is essential in order to optimize the constructive interference between the primary pulse and surface ghost.
- The electrode modules are evenly spaced in a planar array of 0.50 m x 1.00 m. This geometry not only enhances the downward projection of the acoustic energy, it also reduces the primary pulse length, since all tips are perfectly in phase.
- Two electrode modules of 100 tips each allow the distribution of energy from the Geo-Spark 1000 PPS over 100 or 200 tips.
- Each tip has an exposed surface of 1.4 mm^2, suitable for maximum 10 Joules per tip.
- The standard electrode configuration with the Geo-Spark 1000 consists of 2 electrode modules of 100 tips each. This configuration gives an excellent pulse over the 100 - 1000 Joule power range.
- For the highest resolution it is recommended to set the energy output< 400 Joule. This power is usually sufficient in water depths to 300 m

Compatible with standard 50 m floating HV Power cable on reel with axial contacts

The Geo-Source 200 L is compatible with the standard cable for the Geo-Source 800 and 200, and can also be towed by the (4 x 10 mm^2) power cable on the dedicated cable reel with axial rotating contacts.

Cable Reel with axial contacts

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Fax: +31 10 41 55 351
info@geomarinesurveysystems.com
Website: www.geo-spark.com

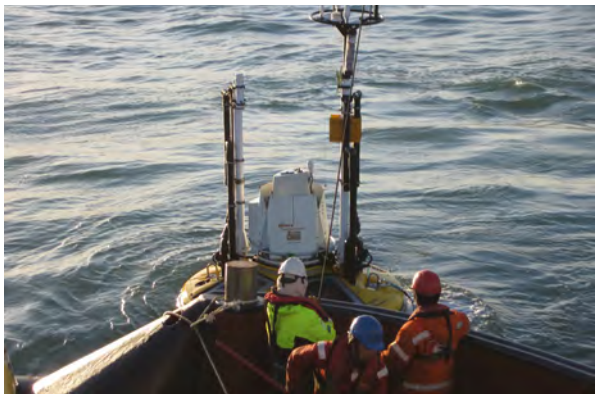
SEAWATCH Wind LiDAR Buoy

The Wind LiDAR buoy is a cost-effective and reliable solution for measuring wind profiles, waves and current profiles.

Wind Profile, Wave and Current Measurements

The SEAWATCH Wind LiDAR Buoy represents the next generation of multi-purpose buoys tailored for the renewable energy industry. The buoy accurately measures the speed and direction of wind across the diameter of wind turbine rotors, whilst sensors provide oceanographic parameters such as ocean waves and current profiles.

Accurate measurement of wind profile using SEAWATCH Wind LiDAR Buoy



Deployment of the SEAWATCH Wind LiDAR buoy

Features

- Collects data for wind resource assessments and/or for engineering design criteria
- Buoy mast wind profile measurements at 2.5 m, 4 m and 5 m
- Configurable LiDAR wind profile measurements at 10 levels from 12.5 m up to 300 m
- Configurable ocean wave measurements and sea current profiles
- Full on-board processing of all measured data
- Two-way communication link for data transfer and control
- Real-time data transfer and presentation
- Flexible configuration of sensors and data collection
- Modular hull for easy transport and local assembly
- Safe and easy handling and deployment
- Robust and reliable in all weather and temperature extremes
- Position tracker for increased safety
- The Wavescan buoy platform has a successful track record worldwide since 1985

SEAWATCH Wind LiDAR Buoy

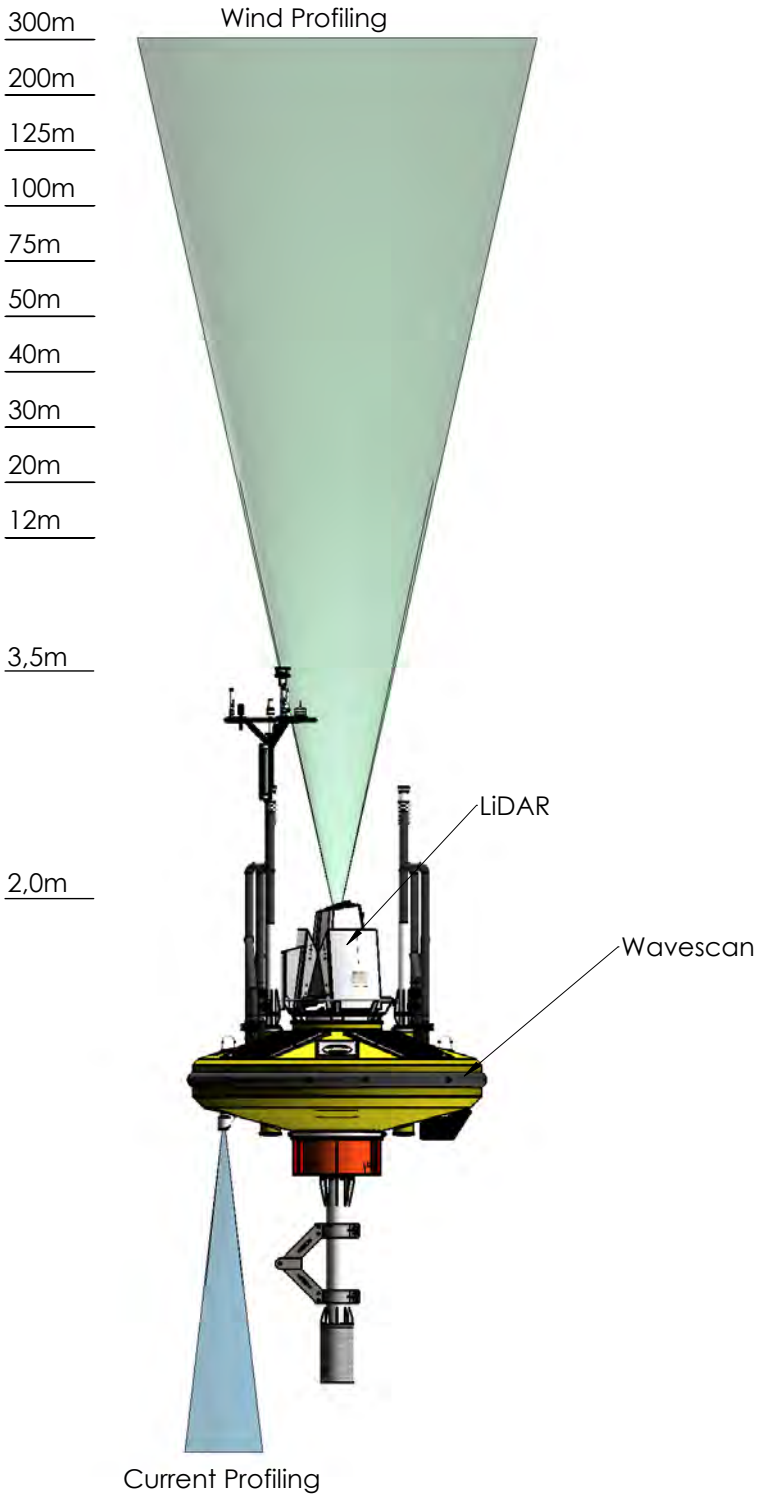
A Unique Cost-Efficient Solution

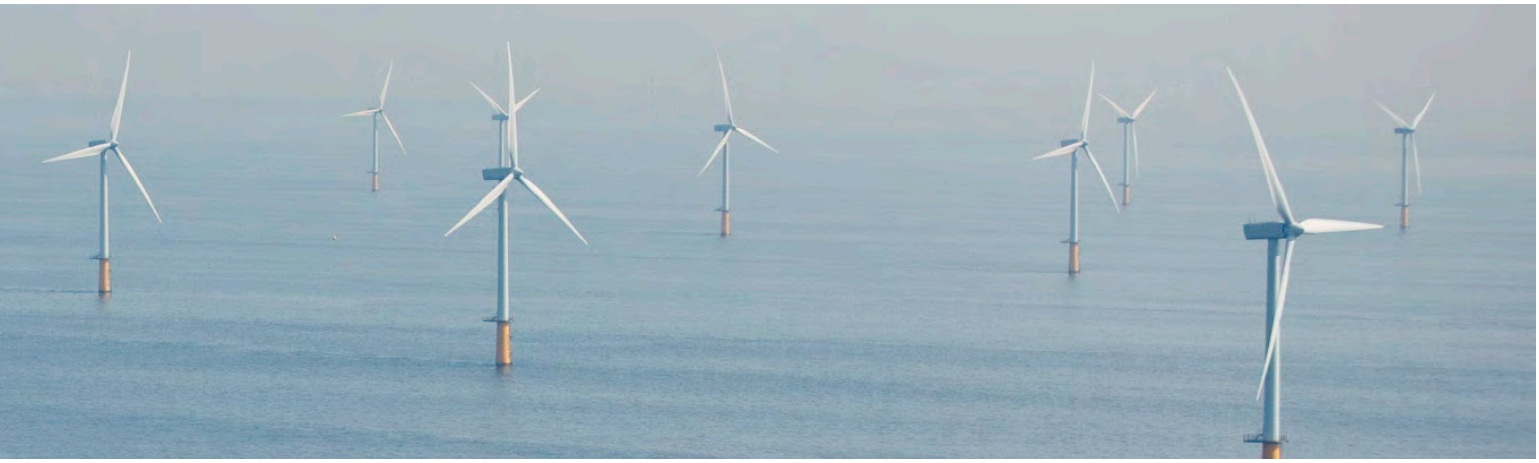
The SEAWATCH Wind LiDAR Buoy is a cost-efficient way to measure wind data at heights of conventional offshore wind turbines for wind resource assessments and engineering design criteria.

It is the first single compact buoy capable of measuring:

- Wind profiles across the blade span of the largest offshore wind turbines
- Ocean wave height and direction
- Ocean current profiles from the surface to the seabed
- Meteorological parameters
- Other oceanographic parameters as required

The smaller SEAWATCH Wind LiDAR Buoy is a proven ocean monitoring solution and is easily deployed and relocated (by towing or lifting onboard vessels) enabling data gathering across multiple locations. This is a more cost-effective alternative to existing wind profiling solutions such as fixed met masts or larger floating buoys.





Proven Platform and Technology

The SEAWATCH Wind LiDAR Buoy is built on the SEAWATCH Wavescan platform which has been deployed for a large number of satisfied clients in the most hostile oceanographic environments since 1985.

Its well proven SEAWATCH technology, includes the GENI™ controller, an intelligent power management unit and the ZephIR LiDAR.

ZephIR LiDAR

The ZephIR LiDAR was selected after years of testing and comparison of various concepts. The ZephIR 300 provides highly accurate measurements across the entire rotor diameter and beyond and can be configured to measure up to 10 different heights from 12.5 to 300 metres above the sea surface.

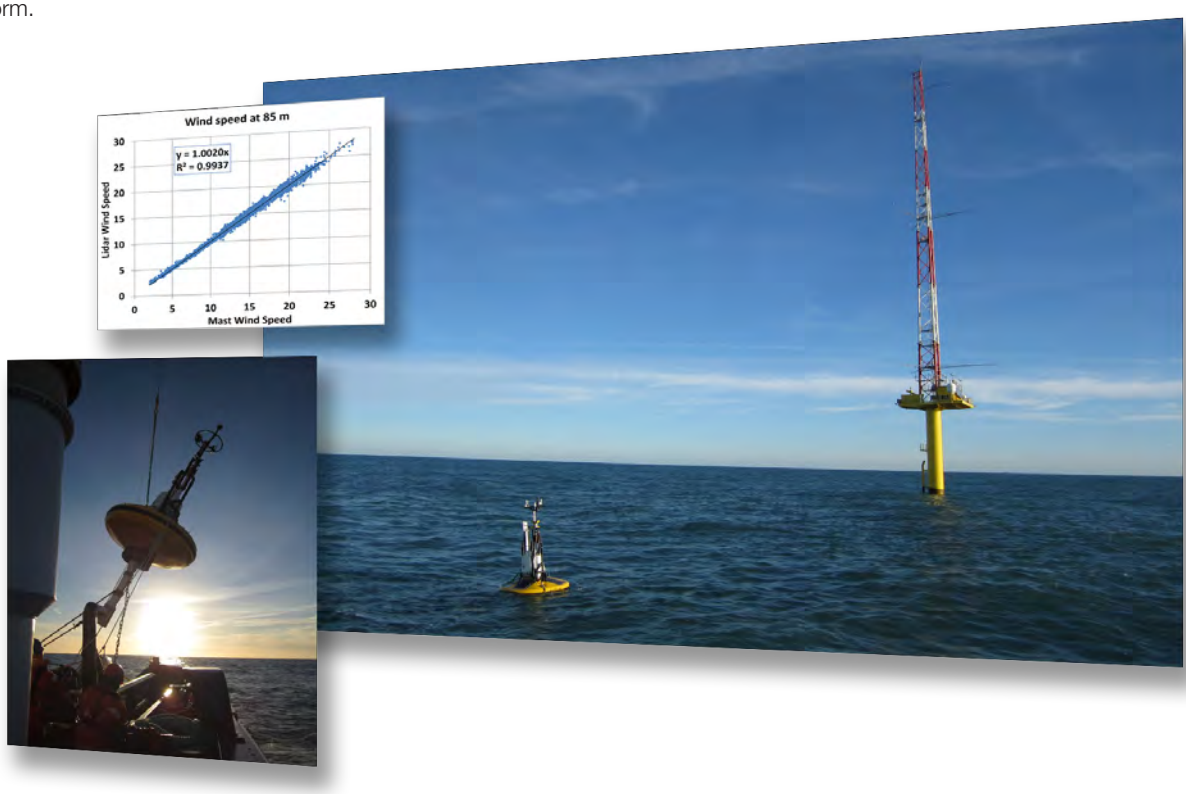
Low power consumption of the ZephIR 300 and intelligent power management are key to efficient operation when using a small low-cost platform.

Successful Collaboration

The SEAWATCH Wind LiDAR Buoy is the result of a successful joint industry R&D project, utilising offshore and wind technology expertise from Norwegian universities, research institutes and the energy company Statoil.

Offshore Testing / Validation

The SEAWATACH Wind LiDAR Buoy has been tested and validated at the Ijmuiden met mast in Dutch waters. The wind profile data measured by the SEAWATCH Wind LiDAR Buoy were compared with data from anemometers at 3 heights mounted on the met mast and a ZephIR LiDAR, measuring the wind profile above 90 m. An inter-comparison showed almost no bias and a squared correlation of more than 0.99. The validation test was performed in close cooperation with DNVGL



SEAWATCH Wind LiDAR Buoy

Technical Specifications

General

Material	Polyethylene, Aluminium, Stainless Steel
Flash light	LED based, 3-4 nautical miles range
	IALA recommended characteristic
Positioning	GPS (Inmarsat-C, Iridium, Standalone Receiver)

Buoy Dimensions

Weight (approx)[1]	1700 kg
Overall height	6.1 m
Diameter	2.8 m
Net buoyancy	2500 kg
Mast height (above water)	3.5 m

Power Supply [2, 3]

Solar panels (optional)	180 W
Lead-acid battery bank (optional)	Up to 248 Ah
Lithium battery bank	Up to 9792 Ah
Fuel cells	Up to 25926 Ah

Processing

4 GB data storage

Real-time operating system (Linux)

Large number of serial and analogue inputs

Flexible data acquisition software

Data Communication

Short range	GSM / GPRS
	UHF / VHF radio (two-way)
Long range	Inmarsat-C and Iridium (two-way)
	ARGOS (one-way)

1 - With fuel cells and methanol cartridges

2 - All values are nominal ratings

3 - The buoy consumes roughly 150 Ah per day. Exact power consumptions will be made for each case

Wind Profiler - ZephIR 300 CW LiDAR

Measurement height (configurable)	10 m – 300 m
Probe length at 10 m	0.07 m
Probe length at 100 m	7.7 m
Number of simultaneous heights measured	Up to 10
Sampling rate	50Hz
Average period (configurable)	1 second upwards
Scanning cone angle	30°
Wind speed accuracy	< 0.5%
Wind speed range	< 1 m/s to 70 m/s
Wind direction accuracy	< 0.5°

Various additional sensors are available on request, including but not limited to:

Oceanographic Sensors

Wave height and direction

Surface current velocity and direction

Water temperature

Conductivity / Salinity

Current profile

CTD profile

Meteorological Sensors

Wind speed/direction

Air pressure

Air temperature

Humidity

Precipitation

Solar radiation

Water Quality Sensors

Dissolved oxygen

Light attenuation

Chlorophyll-a

Hydrocarbon

Turbidity

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