Erebus Floating Offshore Wind Farm
Geotechnical Survey
UPDATED OFFER

Title	**Technical Method Statement**
GEOxyz Report No.	4150-LU-TMS-01
Revision	3.0

Revision	Date	Description of Revision	Author	Checked	Approved
1.0	04-12-2020	First Revision to Client	GT	MS	DF
2.0	16-12-20	Updated post-clarifications	GT	DF	PR
3.0	17-12-20	Minor revisions following 2nd meeting	GT	DF	PR

REVISION HISTORY

The screen version of this document is always the controlled copy. When printed it is considered for information only, and it is the holder's responsibility that they hold the latest valid version.

Rev.	Date	Reason for revision	Changes from previous version
0.1	30-11-2020	First issue – internal review	N/A
1.0	04-12-2020	Round 1 proposal to Client	N/A
2.0	16-12-20	Dual vessel (survey / Geotech) revision	Highlighted
3.0	17-12-202-	More detail on subcontractor	CVs, work history

TABLE OF CONTENTS

REFERENCE DOCUMENTATION

Client Documents

Key documentation from the Client in relation to the ITT is listed.

Client reference documents

Ref.	Document Number	Title	Owner
1.	ERE-ENG-OWC-IT-GET-0001	Instructions to Tenderers	OWC
2.	ERE-ENG-OWC-IT-GET-0001	Section I&II BGW Contract Form	OWC
3.	ERE-ENG-OWC-IT-GET-0001	Section IV – Geotechnical Survey SoW B01	OWC
4.	ERE-ENG-OWC-IT-GET-0001	Section IV – B Technical Specification Geophysical B01	OWC
5.	ERE-ENG-OWC-IT-GET-0001	Section IV – B Technical Specification Geotechnical B01	OWC
6.	ERE-ENG-OWC-IT-GET-0001	Section V – BGW 1 Health and Safety Management Plan	OWC
7.	ERE-ENG-OWC-IT-GET-0001	Section III – BGW Remuneration Payment and Programme	OWC
8.	ERE-ENG-OWC-IT-GET-0001	Section V – BGW HS&E Competence Assessment for Suppliers	OWC
9.	ERE-ENG-OWC-IT-GET-0001	Section V – BGW Minimum HSEQ Requirements for Suppliers	OWC

GEOxyz Company Documents and Project Procedures

Standard procedures relative to this proposal and key company documents are listed. A project management plan and detailed risk assessments and execution plans will be provided as part of the project documentation following contract award and before the start of operations. A detailed list of all project-relevant documentation and deliverables will be held and maintained in a project document register. Personnel should always ensure they hold the latest revision of documents by checking with documentcontrol@geoxyz.eu or the project manager.

GEOxyz reference documents

Ref.	Document Number	Title
10.	GEO-OPP-6028	Positioning Systems Operation Procedure
11.	GEO-OPP-6029	Heading Sensor Operation Procedure
12.	GEO-OPP-6030	MRU Operation Procedure
13.	GEO-OPP-6031	SVP Operation Procedure
14.	GEO-OPP-6032	USBL Operation Procedure
15.	GEO-OPP-6033	MBES Operation Procedure
16.	GEO-OPP-6038	Side-scan Sonar Operation Procedure
17.	GEO-OPP-6039	Sub-bottom profiler Operation Procedure
18.	GEO-OPP-6040	Magnetometer & Gradiometer Operation Procedure
19.	GEO-OPP-6052	MBES Data Processing Procedure
20.	GEO-OPP-6053	Magnetometer Data Processing Procedure
21.	GEO-OPP-6054	SSS Data Processing Procedure
22.	GEO-OPP-6055	SBP Data Processing Procedure
23.	GEO-OPP-6057	Gradiometer Data Processing Procedure
24.	GEO-OPP-BE4059H-01-01	CPT Launch and Recovery Procedure
25.	GEO-OPP-BE4059H-02-01	Vibrocore Launch and Recovery Procedure
26.	GEO-MSM-2082	QHSE System Manual
27.	GEO.QF.13.03.E.00	Change Notification Form

Ref.	Document Number	Title
28.	GEO.HSP.21.01.E.01	Incident reporting and investigation procedure
29.	GEO.HSF.21.05.E.01	Incident Investigation Form
30.	GEO.HSF.21.04.E.00	Incident Report Form

DEFINITIONS AND ABBREVIATIONS

Throughout this document the following terminology is used:

- OWC Offshore Wind Consultants (Client)
- GEOxyz GEOxyz Offshore (Contractor)

The abbreviations and units listed are used within this report. Where abbreviations used in this document are not included in this table, it may be assumed that they are either equipment brand names or company names.

Abbreviations list

Acronym	Description	Acronym	Description
ALARP	As Low as Reasonably Practicable	S/N	Signal/Noise (ratio)
cm	centimetre	SBP	Sub-bottom Profiler
DGNSS	Differential Global Navigation Satellite System	SHEQ	Safety, Health, Environment and Quality
DPR	Daily Progress Report	SIMOPS	Simultaneous Operations
EOD	Explosive Ordnance Disposal	SIT	Surrogate Item Trial
GPS	Global Positioning System	SOW	Scope of Work
HIRA	Hazard Identification and Risk Assessment	SSS	Sidescan Sonar
ITT	Invitation to Tender	SVS	Sound Velocity Sensor
kHz	kilohertz	SWL	Safe Working Limit
km	kilometre	t	tonnes
LAT	Lowest Astronomical Tide	TBC	To be confirmed
m	metre	TBT	Toolbox Talk
MAG	Magnetometer	TIR	Target Investigation Report
MBES	Multibeam Echosounder	TVG	Transverse Gradient
MRU	Motion Reference Unit	USBL	Ultra-Short Baseline
MTL	Master Target List	UTM	Universal Transverse Mercator
PTW	Permit to Work	UXO	Unexploded Ordnance
pUXO	Potential Unexploded Ordnance	WROW	Work-class Remotely Operated Vehicle
RPL	Route Position List	WGS84	World Geodetic System 1984
RTK	Real-Time Kinematic		

1 EXECUTIVE SUMMARY

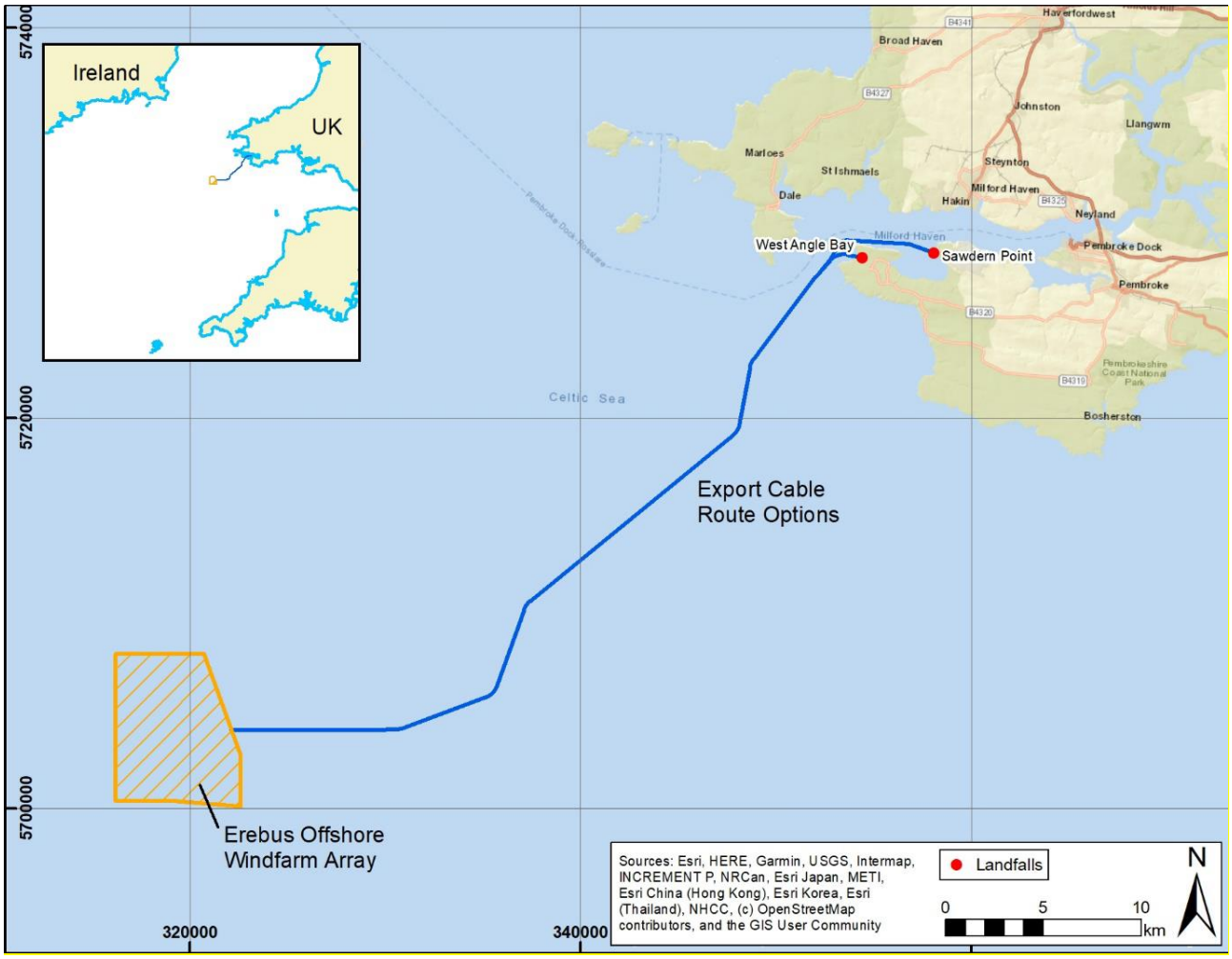
2 PROJECT SUMMARY

2.1 INTRODUCTION

Simply Blue Energy 1 (SBE1) is the developer and seabed leaseholder for Project Erebus, a proposed floating offshore wind (FLOW) development in the Celtic Sea region. The project is located approximately 44 km southwest of the Pembrokeshire coastline, in an outline area of interest of approximately 43.5 km$_2$ – see Figure 1.1.

The key Project components are:

- Between 7 and 10 floating Wind Turbine Generators (WTGs), of total capacity up to 96 MW, as well as the associated semi-submersible platforms and mooring infrastructure;
- Inter-array cables and a single offshore export cable to landfall;
- Onshore cabling between landfall and the grid connection; and
- Onshore substation at the grid connection point.



Erebus FOWF area and Export cable route

The primary potential landfall under consideration is West Angle Bay, considered in the firm survey scope although Sawdern Point is also a potential landfall option and is considered as optional survey scope. Currently the approximate route lengths are as follows:

- West Angle – 44.5 km (Firm scope);
- Sawdern Point – 48.7 km (Optional scope);

2.2 GEOPHYSICAL SCOPE OF WORK

The geophysical survey area comprises the following section:

- Windfarm Array Area: Extent of Area 2 windfarm boundary (43.5 km2) and 1 km buffer.

The Geophysical work involves the acquisition of multibeam echosounder (MBES), side scan sonar (SSS), magnetometer (MAG) and dual sub-bottom profiler (SBP) data within the Windfarm Array Area.

The survey must map the bathymetry, the static and dynamic bedforms and habitats of the seabed surface and the sub-surface geological soil layers, up to a depth of 20 m below seafloor

An appropriate line spacing (including tie lines) will be chosen to achieve the geophysical technical specification (e.g. sounding density, sidescan sonar coverage) and with a crossline spacing of no greater than 250 m. The sub-bottom profiler Common Mid Point (CMP) is to be the positioning datum for line keeping.

Where any wrecks or obstructions are identified, boxing of these sites will be discussed with the OCR, and an order of priority confirmed.

2.2.1 MBES

A 200/400kHz dual-head MBES shall be capable of an absolute gridded surface accuracy of +/- 0.25 m at 2 standard deviations and of producing a 0.5 m DTM cell size at 0.5 m resolution with a minimum of 10 soundings in each cell and with a minimum of 10% swathe overlap between lines. Seabed backscatter and water column imaging shall be recorded and nadir data must be acquired.

2.2.2 SSS

The SSS system shall be simultaneous dual frequency of 300/600 kHz to allow object detection of 0.5 m in any direction. The SSS shall have a horizontal beam width of <0.5° and shall be towed at a height above seabed of between 10-15% of the slant range. The SSS shall be towed at a speed to ensure that a minimum of 3 pings per 1 m object are achieved and the horizontal positional accuracy shall be +/- 2.5 m (mid-range). At least 200% coverage and a minimum of 100% overlap (including full 200% covering of the nadir) shall be achieved for all survey areas.

2.2.3 MAG

The magnetometer system shall consist of dual Caesium Vapour magnetometers (e.g. Geometrics G-882 or similar) with sensitivity of 0.02 nT or better and a maximum level of background noise of 2 nT (i.e. 1 nT peak to peak), allowing detection of anomalies of 5 nT or better. The dual magnetometers shall be towed in a fixed frame of Transverse Gradiometer (TVG) type or similar to allow a continuous swath of coverage on each run line (i.e. no gaps between the magnetometers in the frame). Magnetometers shall be equipped with altimeter and depth sensors and the horizontal positional accuracy shall be +/- 2.5 m and tow height of between 1 – 4 m above seabed. Data shall be recorded at a sample rate of not lower than 10 Hz.

2.2.4 SBP

Two SBP systems shall be provided and operated simultaneously:

- A High Frequency (HF) system, either hull mounted (preferable) or towed with minimum penetration below seabed of 5 m and vertical resolution of 0.2 m. The system shall be of Chirp type and/or parametric (pinger is not acceptable) with an operational frequency band of at least 3-15 kHz.
- A Low Frequency (LF) system, comprising a towed single channel sparker of negative discharge type (e.g. Geo-spark) with minimum penetration of 20 m below seabed and a vertical resolution of at least 0.5 m.

2.3 GEOTECHNICAL SCOPE OF WORK

The geotechnical survey area comprises the following sections:

- Windfarm Array Area: Extent of Area 2 windfarm boundary (43.5 km2) and 1 km buffer
- Offshore section of the export cable route: defined as >15 m water depth (WD) contour seaward to Windfarm Array Area with a corridor width of 500 m
- Nearshore section of the export cable route: defined as <15 m WD landward to the Intertidal area with a corridor width of 500 m

A maximum depth of PCPT equal to 20 m below mudline (mbml) is planned in the WTG array area while 6 mbml is planned along the Export Cable Corridor (ECC). Vibrocore and/or piston sampling to 6 mbml is planned for the WTG array and to 6 mbml for the ECC areas. Actual depth may vary depending on ground conditions encountered.
The following categorization of sample types is supplied:

2.3.1 Type A (seabed PCPT):

Continuous seabed 10cm^2 PCPT to a minimum target depth of 20 m, with the objective of acquiring a continuous soil profile in the WTG array area. If this depth cannot be achieved a maximum of three (3) bump overs should be undertaken. Additional bump overs can be undertaken at the discretion of the OCR.

2.3.2 Type B (seabed PCPT):

Continuous seabed 10cm^2 PCPT to a minimum target depth of 6 m, with the objective of acquiring a continuous soil profile along the export cable corridor.

2.3.3 Type C (vibrocore sampling):

Continuous soil sampling using a vibrocore equipment to a minimum target depth of 6 m or the maximum core length that can be acquired with the proposed equipment, whichever is higher.

2.3.4 Type D (piston sampling):

Continuous soil sampling using a piston corer sampler equipment to a minimum target depth of 6 m or the maximum core length that can be acquired with the proposed equipment, whichever is higher.

2.3.5 Type E (vibrocore sampling):

Continuous soil sampling using a vibrocore equipment to a target depth of 6 m.

2.3.6 Type F (piston sampling):

Continuous soil sampling using a piston corer sampler equipment to a target depth of 6 m.

2.3.7 Sampling Quantity

Sample Type	Area	Quantity
Type A	WTG array	10
Type C-Type D*	WTG array	10
Type B	ECC - Offshore	10
Type E-Type F*	ECC - Offshore	10
Type B	ECC - Nearshore	5
Type E-Type F*	ECC - Nearshore	5

3 RESOURCES

3.1 OFFSHORE –GEOTECHNICAL VESSEL

For water depths down to 10m the 24/24 hour GeoOcean III will be utilised as the geotechnical vessel. The GeoOcean III has a large, central moonpool which is used for CPT deployment, giving excellent weather tolerance and safe deployment/recovery methods. The vessel is DP2 classified, which gives her excellent station-keeping abilities, even in adverse currents.

Vessel and equipment summary Geo Ocean IV

Feature/Equipment	Geo Ocean III (or equivalent)
	
Length:	77 m
Width:	18 m
Draught:	3.8-6.1 m
Speed:	10 knots
Endurance:	14 days (24 hrs)
Accommodation:	56
Control:	DPII
A-Frame:	54 Tonnes @ 8 m AHC
Additional Info:	Deck crane 40 tonnes @ 9 m and 6 x 6 m moonpool with 30t A-frame and AHC winch
Positioning:	Fugro Seastar 9205 and POS-MV 320
USBL:	Sonardyne Ranger 2
Heading and MRU:	2 xPOS-MV 320s and Octans 3000

3.1.1 Seabed CPT

The AP van den Berg ROSON R100 Seabed CPT and operating crew will be provided by GeoForce Technical Services, of Beccles, UK. The Roson 100 can be operated in water depths up to 1500m, in standard form 3m - 15m penetration is easily achieved, and the system can be configured for up to 20m penetration. The Icone is driven into the seabed at a constant rate of 2cm/s with a max push and pull force of 100kN.

Please note the CPT offered has maximum total thrust of 100kN 60Mpa Tip Pressure.

AP van den Berg ROSON CPT

The management of the power data umbilical is via fully automated constant tension winch, this ensures the cable is managed safely at all water depths, and improves the operational efficiency of the launch and recovery sequence.

The R100 is modular and the total reaction weight of the unit can be adjusted from 8.0t – 13.5t to ensure the unit can be deployed from smaller vessels, or have the ballast weight reduced should the seabed conditions dictate. A mud skirt can be added to reduce any sinkage and ensuring the cone remains unloaded before the start of the CPT test.

All CPTs are performed in compliance with ISO 22476-1 Geotechnical investigation and testing – Field testing-Part 1 and ISO 19901-8 Part 8 Marine Soil Investigations.

Specifications

- 100kN Max Push Force
- 10cm2 Icones - measuring Cone end resistance(qc), local friction (fs), pore water pressure(u)
- Weight = 8.0t – 13.5t
- Dedicated DNV Control Container
- Power Requirements = 3pH 63A 415V
- Dimensions = 2300 x 2300 x 2900mm

- Height with 6m Mast = 9.6m
- Quick to mobilise
- Robust Powerful and Reliable
- Add-on modules – Conductivity, Mag, Cone, Vane & Seismic, T-bar

An inventory of 10 calibrated cones and 80 rods will be supplied as standard. If required, additional spares can be taken on at port calls.

3.1.2 Vibrocorer

A Geoforce High Powered Vibrocore will be provided. The system is capable of obtaining continuous sediment cores, up to 6m below the seabed in most sediment types in water depths up to 400m. The system is offered as a complete vibrocoring solution and is supplied with:

- DNV rated control container with integrated core processing space
- Constant tension winch for safe management of the power umbilical
- Umbilical sheave
- Custom davit for safe positioning of umbilical sheave
- Core baskets (on request)

Geoforce's experience with this system allows us to adapt the configuration to suit a wide variety of vessels, by offering a bespoke solution which still ensures safe operations but at the same time reduces vessel space requirements.

Once the conditions and location are approved the High-Powered Vibrocorer motor is switched on and the corer penetrates either until reaching either the length of the core barrel or until refusal due to ground conditions has occurred. In the case of a piston gravity corer a trigger mechanism allows the corer to drop under gravity from a pre-set height above the seabed. On completion of each core attempt the machine is returned to the vessel where the sediment core, retained inside a semi-transparent tube is extracted and inspected.

Please note the Vibrocorer does not have a method for measuring penetration digitally during a test. Penetration is recorded via a spring ring measured on recovery.

Specifications

- Robust, reliable and powerful design
- 89kN High Power centrifugal force
- Quick to mobilise
- 3m/6m penetration options
- 85mm diameter core sample
- Dimensions = 7710*2500*2800 (l*w*h) 6m mode
- Lifting Requirements = 10t SWL (single fall mode)
- Power Requirements = 3 Phase 415V AC @ 50/60Hz
- Dedicated umbilical constant tension winch for safe operations
- Dedicated DNV container with comprehensive spares package
- Variable core catchers for optimised sediment recovery
- Integrated pull reduction sheave to reduce pullout & lifting requirements
- Integrated sensor for real time measurement during testing of penetration, base inclination and water temperature

3.1.3 Piston Corer

A six metre piston corer will be supplied as a backup sampling tool. The corer uses a trip mechanism to trigger the piston, which requires a minimum water depth of 20m to be effective.

3.2 OFFSHORE –GEOPHYSICAL VESSEL

Vessel and equipment summary Geo Ocean IV

Feature/Equipment	Geo Ocean IV (or equivalent)	
Length:	41.9 m	
Width:	9.1 m	
Draught:	5.2 m	
Speed:	11 knots	
Endurance:	14 days (24 hrs)	
Accommodation:	27	
Control:	Autopilot, joystick	
A-Frame:	5 t SWL	
Additional Info:	Crane 12 t/m	
Positioning:	Stema Systems Trimble OEM GNSS982 (G4+ or Marinestar), Plus C-NAV receiver	
USBL:	Kongsberg HiPap 351	
Heading & MRU:	Octans Surface IV	
MBES:	2x Kongsberg 2040 dual swath/receiver setup. 1x Mini SVS, Valeport	
SSS:	Edgetech 4200, 300/900 kHz	
HF SBP:	Innomar SES-medium	
LF SBP	GSO 360 Sparker	
Magnetometer/Gradiometer:	1 x TVG gradiometer containing 2 G882s	

3.2.1 MBES (Multi-Beam Echosounder)

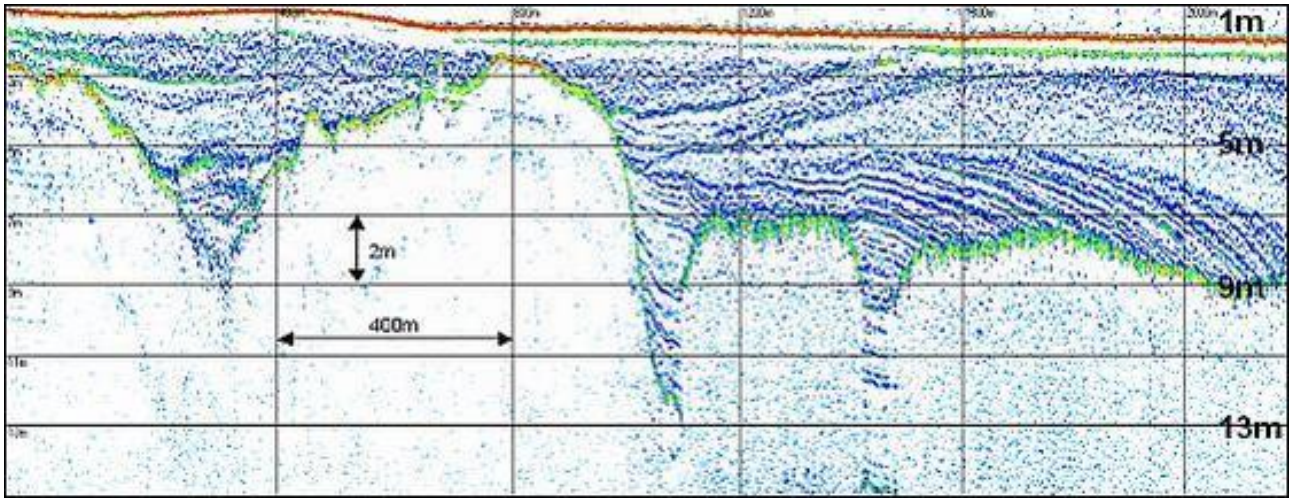
The EM2040 is a true wide band high resolution shallow water multibeam echo sounder and ideal for high resolution seabed mapping and inspection operations. The system operates in frequency ranges 200-400kHz. Due to the large operating bandwidth the MBES has a maximum ping-rate of 60kHz. The dual head configuration onboard the Geo Ocean IV allows higher data density (1600 soundings per swath) to meet survey coverage along track while allowing to maintain a high vessel survey speed. The EM2040 can also provide backscatter seabed imagery to complement MBES and SSS data.

3.2.2 Sidescan Sonar

The sidescan sonar that will be mobilized is the Edgetech 4200 series dual-frequency system (300/600kHz). The 4200 series system can be configured for almost any survey application from shallow to deep water and utilizes Edgetech's CHIRP technology to provide high resolution imagery at ranges up to 50% greater than non-CHIRP systems. Specifications of the system are supplied along with this proposal.

3.2.3 SBP Shallow

The Innomar SES-2000 compact model was designed for inshore surveys in shallow-water down to 400 metres water depth but can also be used in coastal areas. The system acquires full-waveform data that can be processed with any seismic software (SEG-Y format). Innomar also provides the ISE post-processing software specialized on the Innomar SES-2000 SBP data. The system has a penetration capability up to 40m depending on sediment type and noise with a vertical resolution of approx. 1cm up to 5cm.



Data example provided by Innomar

3.2.4 Deep SBP Sparker GSO 360

The GSO-360 consists of 4 x 90 tip electrode modules housed in a compact sparker frame. The electrode modules are evenly spaced in a planar array. This geometry along with design of the GSO electrode modules enhances the downward projection of the acoustic energy, and also reduces the primary pulse length since all tips fire perfectly in phase. Typical pulse length is 170µs.

The GSO-360 sparker provides very high resolution (<30 cm) seismic profiles of the "shallow" sub bottom strata in water depths up to approximately 1000m.

GSO 360 Sparker

Depending on the energy level, the geology and water depth, the effective penetration can exceed 200m below seabed.

3.2.5 Magnetometer

GEOxyz plans to mobilise a TVG which will be towed in Piggy Back fashion with the SSS.

The gradiometer to be used will be the Geomatrix Transverse Gradiometer Frames with Geometrics G-882 caesium vapour magnetometers. The TVG frame exploits the innate hydrodynamic properties of the G-882 tow fish to minimise the inline drag enabling a 1:6 layback to depth ratio.

Geometrix TVG frame

The in-line drag force of the TVG frame is less than 50Kg at typical survey speeds (4 knots) and therefore can be deployed with up to a 100m soft tow cable and 30V top end power supply or with up to a 6km wire line when deployed with a Geometrics telemetry system.

The G-882 is the industry standard marine magnetometer. Very high resolution Caesium Vapour performance has been incorporated onto a low cost, small size, system for professional surveys in shallow water. High sensitivity at fast sample rates of total field measurements are maintained for all applications.

3.3 NEARSHORE GEOTECHNICAL SURVEY (OPTION)

3.3.1 Deployment Vessel

For nearshore scopes, GEOxyz will utilise the 12/24 hour DP1 Multicat vessel Coastal Endeavour (or equivalent vessel, subject to availability). Acta Marine crews have extensive experience of similar geotechnical operations, making for a safe and efficient operation.

Nearshore geotechnical scopes will be undertaken after completion of the offshore scopes.

Parameter	Specification
	
Type:	DP-1 Shallow Draft Multicat 3512
Classification	Bureau Veritas I 3/3 Special Service / Multi
LOA (m)	37
Beam (m)	11.84
Max Speed	11kts
Propulsion	Twin fixed pitch propellors in nozzles, 2 x 360 deg bow thruster, 360 stern thruster

Proposed Nearshore Geotechnical Vessel

4 PERSONNEL

4.1 OFFSHORE PERSONNEL

The anticipated personnel required for each vessel are provided below. Exact levels of manning will depend on the work phase of each project and the workload and are indicative only. Vessel manning may be adjusted accordingly at port calls.

All personnel involved in the project will be suitably trained an experienced. Personnel will carry copies of their medical and offshore training/survival certification.

4.1.1 GEO Ocean III – Offshore Geotechnical Survey

The *Geo Ocean III* will be manned with the personnel listed.

Geo Ocean III personnel list – offshore geotechnical survey

Position	No.		Position	No.
Party Chief	1		Geotechnical Crew	4
Senior Surveyor	1			
Surveyor	1			
MBES/Data Processors	2			
Total			**9**	

4.1.2 GEO Ocean IV – Geophysical Survey

The *Geo Ocean IV* will be manned with the personnel listed.

Geo Ocean IV personnel list – geophysical survey

Position	No.		Position	No.
Party Chief	1		Survey Technicians	4
Senior Surveyor	1		Geophysicist	2
Surveyor	1			
MBES/Data Processors	2			
Total			**11**	

4.1.3 Coastal Chariot – Nearshore Geotechnical Survey

The *Coastal Chariot* will be manned with the personnel listed.

Coastal Chariot personnel list – nearshore geotechnical survey

Position	No.		No.
Party Chief/Surveyor	1	Surveyor	1
Survey Tech	1	Geotechnical Crew	4
Total	**7**		

4.2 ROLES & RESPONSIBILITIES

Description of the roles and responsibilities of key positions within the offshore project teams are provided below.

4.2.1 Party Chief

The Party Chief will have responsibility for the execution of the project scope offshore. He will act as the primary point of contact for all offshore survey crew, as well as for the Project Manager, the offshore Client Representative and the vessel Master. The Party Chief will take responsibility for the quality of data collected offshore and will liaise with the Senior Geotechnical and Geophysical Lead in this regard. He will track offshore project performance and ensure that the Scope of Work, HSE Plan and Project Execution Plan are adhered to.

4.2.2 Reports Coordinator

The Reports Coordinator will work back-to-back with the Party Chief to ensure a management presence 24hrs per day. They will assume the Party Chief responsibilities through the night and will be responsible for producing the offshore reports, including the Mobilisation, Preliminary Field and Operations Reports. They will also liaise with the surveyors and data processors to ensure the objectives of the survey are being met.

4.2.3 Senior Surveyors

The Senior Surveyors are responsible for ensuring procedures are followed correctly and for the documentation of the operations. They are also responsible for data security and quality control and are required to report any operational issues to the Party Chief/Reports Coordinator.

4.2.4 Lead Geophysicists

The Lead Geophysicists are responsible for the overall quality and coverage of the data, as well as processing and interpretation of the geophysical data sets acquired during the survey. They will ensure the objectives of the survey can be met with the acquired data and will liaise with all processors and reporting personnel to coordinate the results. They will report directly to the Party Chief/Reports Coordinator.

4.2.5 Lead Geotechnical Engineer

The lead geotechnical engineer is responsible for the timely and safe conduct of all geotechnical survey operations conducted in both the coastal and offshore zones in line with project requirements. As such, it is envisaged that he or she will work closely with the field team to provide invaluable experience during the field survey itself.

4.3 ONSHORE PERSONNEL

A dedicated Project Manager will be appointed to the Project and supported by a Project Surveyor or Works Manager to assist in administration and logistical matters. The Project Manager will also receive contractual and management support from the Commercial Manager, QHSE Manager and the Survey Manager respectively. During the execution of the project, communication lines must be very clear. The Project Manager will be supported with a project team as shown in **Error! Reference source not found.**.

Project key personnel contact details

Project Key Personnel/Contacts	
Project Manager	
QHSE Manager	

Project Key Personnel/Contacts	
Survey Manager	
Document Control	
Data Coordinator	
Crewing & Logistics	
GEOxyz Office Belgium	
GEOxyz Duty Phone	

CVs of key members of the proposed team are provided along with this proposal.

4.3.1 Project Manager

The Project Manager will be responsible for the execution of the project in terms of scope, health and safety, and project quality management. The Project Manager will be the primary point of contact for all onshore communication between OWC and GEOxyz, as well as between the offshore teams and onshore project support team. The Project Manager will oversee and take responsibility for all project planning, scheduling and financial tracking, as well as data quality and project deliveries.

4.3.2 Project Surveyor / Works Manager

The Project Surveyor / Works Manager will work closely with the Project Manager, providing support on all technical matters relating to the project. They will be responsible for producing the project documentation and assist the vessel directly with operational support. They will liaise with the data processing and reporting teams to ensure the objectives of the survey, and requirements of the contract, are met from a technical perspective.

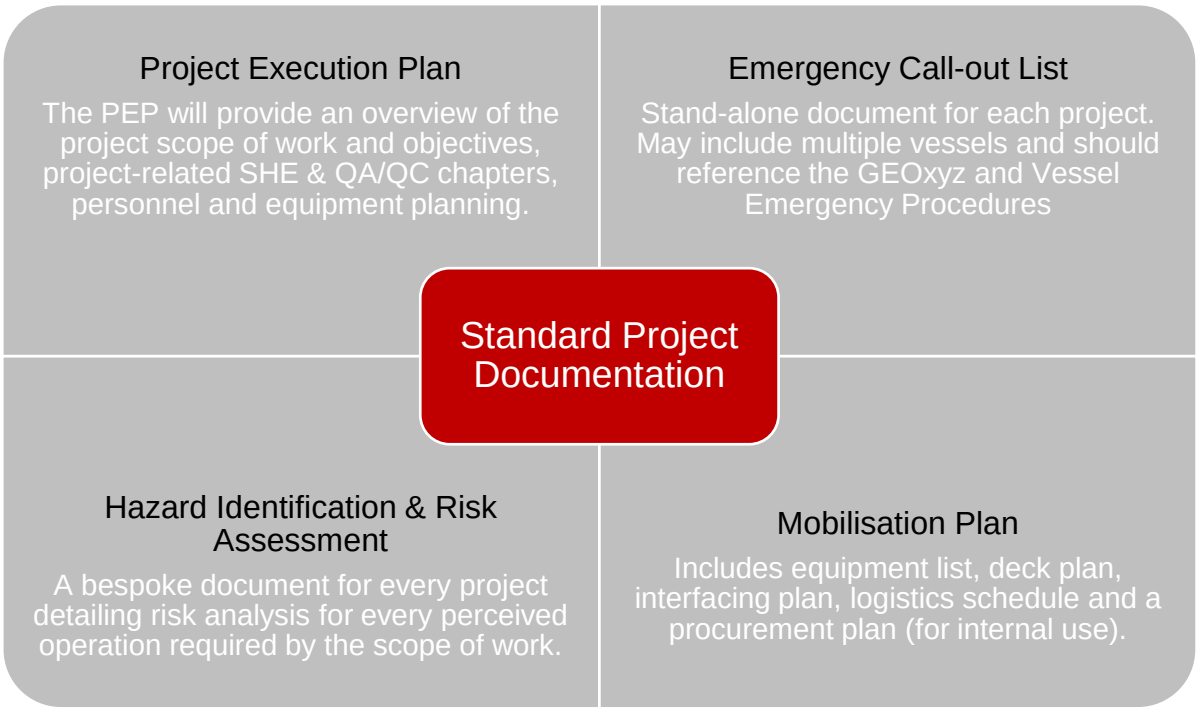
4.3.3 QHSE Manager

The HSE Manager is responsible for, in liaison with the Project Manager, all QHSE aspects of the project. They will ensure that HSE and Emergency Response documentation is in place, and that it is fit for purpose on the project. The HSE Manager will provide assistance and direction to the Party Chief during project operations where HSE matters are concerned. The HSE Manager will nominate an onshore HSE advisor to manage the day-to-day activities of the project team from an HSE standpoint and will always remain available to the project.

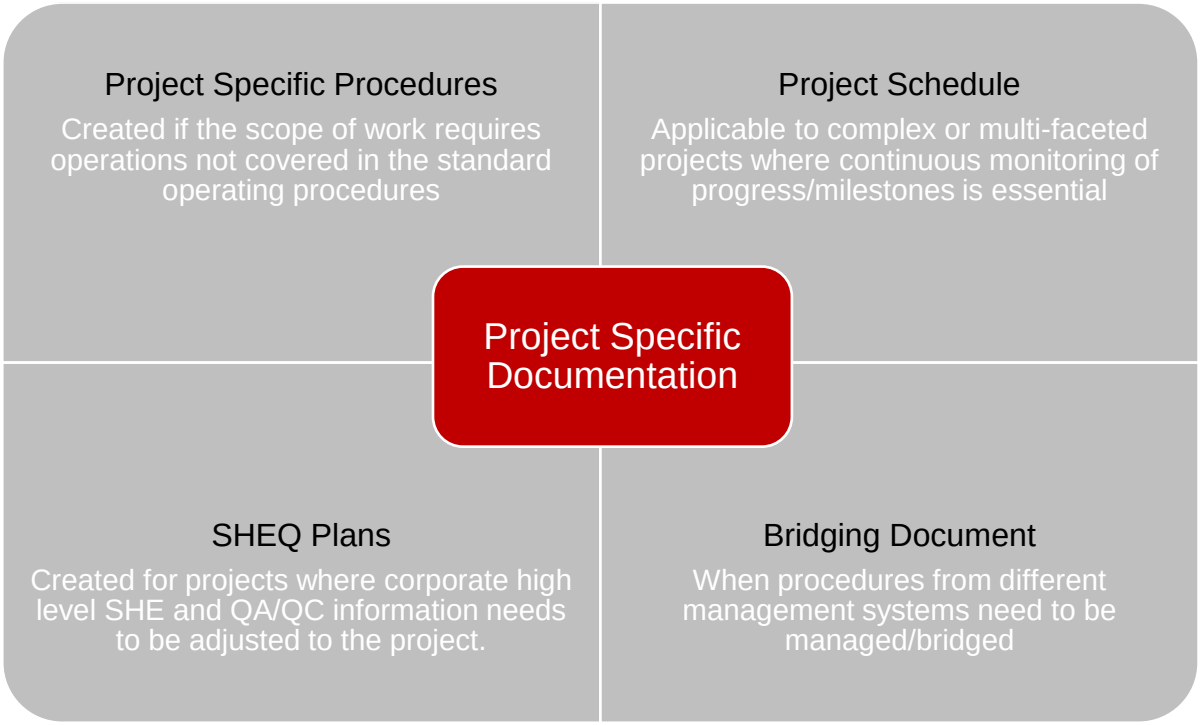
5 PLANNING & PREPARATION

5.1 PROJECT DOCUMENTATION

As standard the below documentation will be produced.



The above are all standard documentation but in many cases the project requires additional documentation tailored to the project:



5.2 PROJECT MANAGEMENT

To complete projects in time and within the budget, but above all within the SHEQ indicators, a solid project management approach is key. GEOxyz therefore uses for each project an experienced and dedicated project team where a Project Manager will be appointed upon contract award and will be the focal point for all operational communications between OWC and GEOxyz. He will be supported by a Project Surveyor, to assist in technical survey and operational matters.

The project management team will be supported by the SHEQ manager, Logistics, Crewing and Survey Manager for technical survey support. Contractual support will be provided by the Commercial Manager

5.3 OPERATIONAL CONSIDERATIONS

5.3.1 Crew Changes

Crew changes for each vessel are planned to take place every 14 days in either Pembroke or Milford Haven. It is planned that in the early hours of the morning of the planned crew change, the vessel will break from site to be alongside in port by 6 or 7am. Personnel changeover, handovers and vessel provisioning are all expected to take place within a 12-hour period with the vessel sailing again for site by the evening.

Timing of any such port calls will be planned according to crew rotation such that not all project crew members are changed-out at the same time.

The port calls for each vessel involved in the survey phase will be staggered so that there is one port call each week.

5.3.2 Metocean Conditions

Water depth, tides and currents on location will guide equipment selection and be used during project planning to efficiently complete the operation. An analysis of **predicted currents** was undertaken at the OWF location using the Metocean Analytics tool, and also at nodal points of the UKHO Total Tides database, at points SN050A, SN050Q and SN050G.Utilising a 0.8m/s (1.6kt) threshold, models predict surface current exceedance of 3.5% at the array area, and 18% at location SN050A.

UHO Total Tides Analysis Point SN050A

	Mag_bin [m.s-1]	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	
Theta_bin [degrees]		0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	**Total**
348.75	11.25	0.13	0.74	1.44	1.88	2.11	2.31	1.65	0.82	0.03	11.12
11.25	33.75	0.24	0.59	0.91	1.16	0.85	0.46	0.08	0.00	0.00	4.29
33.75	56.25	0.16	0.52	0.77	0.75	0.20	0.00	0.00	0.00	0.00	2.41
56.25	78.75	0.23	0.44	0.75	0.54	0.00	0.00	0.00	0.00	0.00	1.96
78.75	101.25	0.15	0.40	0.66	0.63	0.04	0.00	0.00	0.00	0.00	1.88
101.25	123.75	0.22	0.56	0.73	0.91	0.60	0.07	0.00	0.00	0.00	3.09
123.75	146.25	0.19	0.60	0.78	1.10	1.48	1.28	0.78	0.22	0.00	6.42
146.25	168.75	0.09	0.63	1.14	2.22	2.34	3.01	3.45	3.08	2.11	18.08
168.75	191.25	0.11	0.67	1.26	1.96	2.47	2.27	2.02	1.37	0.91	13.05
191.25	213.75	0.15	0.43	1.09	0.93	0.62	0.16	0.00	0.00	0.00	3.37
213.75	236.25	0.27	0.67	0.60	0.40	0.03	0.00	0.00	0.00	0.00	1.98
236.25	258.75	0.22	0.48	0.65	0.16	0.00	0.00	0.00	0.00	0.00	1.51
258.75	281.25	0.12	0.54	0.69	0.40	0.00	0.00	0.00	0.00	0.00	1.75
281.25	303.75	0.23	0.58	1.02	0.85	0.46	0.03	0.00	0.00	0.00	3.16
303.75	326.25	0.13	0.55	1.03	1.42	1.60	1.80	0.97	0.16	0.00	7.67
326.25	348.75	0.09	0.59	1.40	2.57	3.13	3.52	4.15	2.37	0.44	18.27
Total		2.73	9.02	14.92	17.89	15.93	14.91	13.10	8.01	3.49	100.00

Metocean Analytics Modelled Tidal Currents (Array Area)

An analysis of predicted **weather windows** at the OWF array area yielded the following results:

T=6h, hs<1.5, tp<14.0	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max.	2.16	0.00	7.57	22.77	32.16	33.80	27.03	29.32	17.46	13.11	5.03	0.00
Paverage	15.45	18.73	32.41	46.33	55.48	58.97	63.52	60.55	49.42	31.59	25.83	18.05
P50	11.89	17.37	32.84	48.60	55.54	59.22	65.54	61.89	50.28	31.35	25.42	15.00
P80	5.95	4.19	18.57	35.03	35.89	49.33	54.05	51.70	32.43	19.11	15.47	9.14
P90	3.57	2.23	16.38	27.32	34.76	45.36	48.35	41.65	25.84	17.76	8.55	3.24
Min.	44.73	50.15	70.27	73.60	81.62	76.40	83.78	87.43	85.20	58.65	52.65	55.27

The results indicate that for 1.5mHs exceedance, 6 hour windows, P50 statistics show 67.3% and 51.47% standby in March and April, respectively.

5.3.3 Existing Infrastructure and Known Hazards

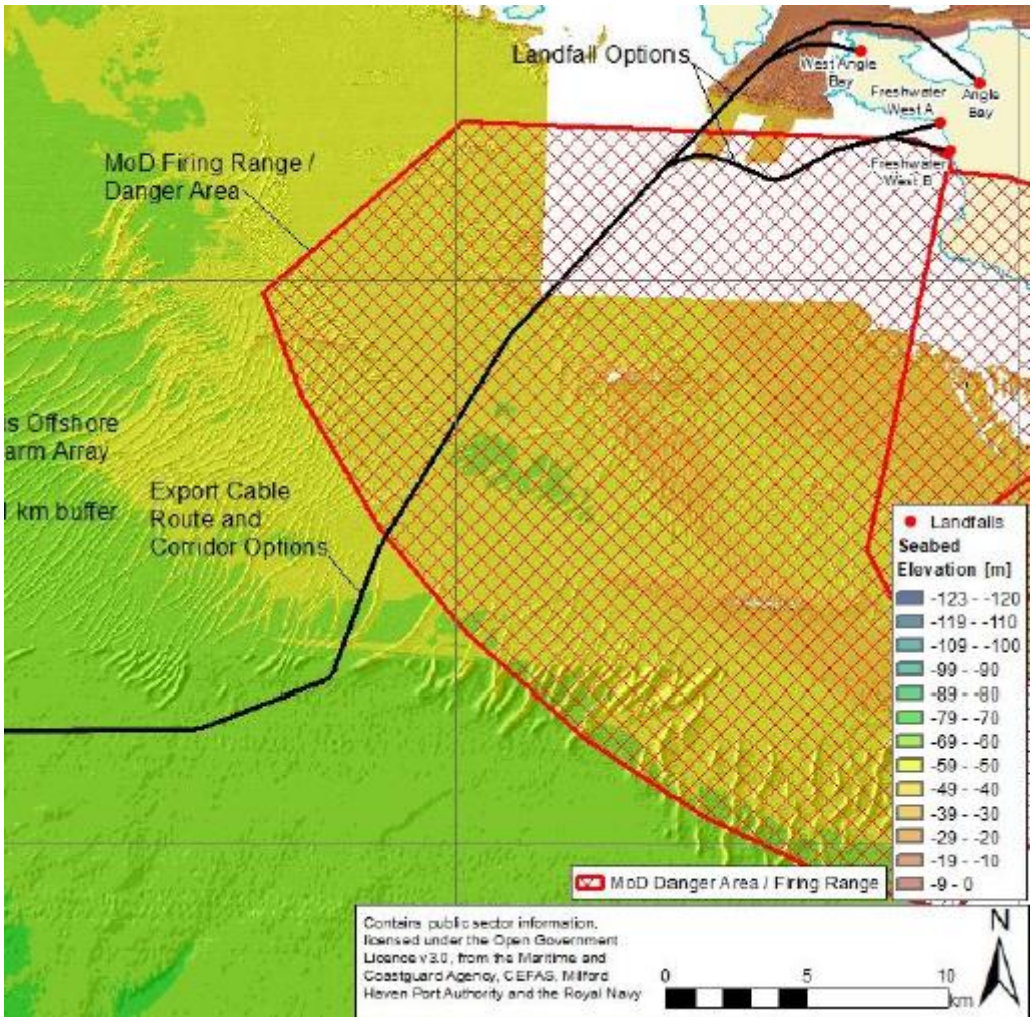
Client-supplied information relating to the existing infrastructure will be geo-referenced and displayed in the navigation software as background information for use by the project team during planning and operations.

Identified hazards from any previous surveys will also be highlighted during planning. Specific Risk Assessments will be undertaken to minimise potential problems whilst the vessel is in the vicinity of any infrastructure or hazard.

5.3.4 Restricted Areas

SBE1 has undertaken early consultation with the Ministry of Defence (MoD) in relation to survey activity in proximity to MoD activities in the area, with the most recent meeting held on 16/12/19.

The survey corridor will pass through the Castlemartin Sea Danger Area for approximately 20km. The appointed Contractor will be required to design survey operations to minimise disruption to Castlemartin Firing Range.



Castlemartin Sea Danger rea relative to the export cable (source: OWC)

5.3.5 Environmentally Sensitive Areas

Should any of the work sites lie within the nature reserves or environmentally sensitive areas, GEOxyz work closely with OWC and their chosen environmental consults to ensure all the required mitigating actions are in place and that any required permitting associated within working in such areas are obtained in a timely fashion and the conditions attached thereto stringently adhered to. Such considerations will be, but not necessarily limited to, the use of bio-oil, breeding grounds, nesting season, sound emission levels on marine mammals, waste disposal/discharge etc.

Zotera and Saltmarsh Habitats

It is noted that a known seagrass bed (*Zostera noltii*) and potential saltmarsh habitat is present within the intertidal area of West Angle Bay. These habitats will be mapped using during the UAV flight to be conducted at this landfall location in line with NRW Guidance note GN030f. It is not anticipated that sampling of these

habitats will be required however if deemed a requirement OEL propose to access the lower shore via its intertidal hovercraft.

5.3.6 Simultaneous Operation (SIMOPS)

GEOxyz is not planning to carry out SIMOPS, with geophysical, offshore geotechnical and nearshore geotechnical scopes undertaken as separate campaigns with different vessels.

GEOxyz will coordinate with OWC's Marine Coordinator as required. Other Operator's may be required to liaise with GEOxyz for radio and acoustics/frequencies management planning in order to avoid interference on location.

5.3.7 Marine Coordination

Details of any marine coordination provided by OWC for any of the work location is not known at this time. GEOxyz has experience of dealing with Marine Coordinator's in the past and we will provide and communicate the planned works daily in whatever format is required, subject to instruction by the Client.

5.3.8 Radio & Acoustics Management

Should any other parties be working in the field/proximity to GEOxyz during the operations, using equipment which may be operating on similar acoustic frequencies, GEOxyz will liaise accordingly to develop and agree an acoustics management plan to avoid interference and disruption to operations.

5.3.9 Weather Forecasts

Weather forecasts specific to the work area will be obtained daily. During operations the weather conditions will be continually monitored by the bridge crew and the Party Chief. Prior to the onset of bad weather, operations will cease in time to allow a safe recovery of all equipment and if necessary, seek shelter.

5.3.10 Operating Limits

Details of the hypothetical limiting conditions for launch, recovery and safe operation of equipment through all phases of the project are provided. It should be noted that the parameters specified therein are only estimations, and any one stand-alone factor will not necessarily dictate whether the vessel or survey spread is capable of safely operating. In practice, several localised met-ocean parameters can interact and combine to generate conditions that are un-workable. It is GEOxyz policy that the ability of the vessel or survey spread to work at any given time will be down to the discretion of the vessel Master or Party Chief respectively.

Hypothetical operating limits

Activity	Comments	Wave Height Hs [m]	Current [kt]
Geophysical – GO4	Masters discretion	1.5	1.6
Geotechnical Survey – GO3	Masters discretion	1.5	1.6
Nearshore Geotechnical	Masters discretion	1.0	1.6

5.3.11 Spare Parts & Breakdown

GeoXYZ will ensure that spares of all key survey sensors are carried onboard the offshore survey vessels such that any lost time associated with equipment breakdown or failure is minimized. It is generally expected that any repairs or replacement of equipment will take place at sea. If required, in unforeseen circumstances, a port call may have to be made.

It's worth noting that GEOxyz are aware of the impact that lost time due to equipment failure can have on a project schedules. However, with our large pool of in-house, well-maintained equipment we are confident any such issues will be minimal.

We will also ensure that the works are started as early in the season each year as practicable, in order to allow us to coordinate all the routine and optional works in a timely and efficient fashion. As such, any time associated with equipment breakdown or replacement will not have an adverse effect on the overall schedule for delivery.

5.3.12 Shoreside Accommodation

For nearshore operations on a 12 hour basis, the crew will utilize local accommodation while off-shift.

5.4 PERMITS

GEOxyz will work with OWC to ensure all relevant permitting is in place before operations commence.

5.5 VESSEL AUDITS

GEOxyz will supply all vessel certification to OWC during the project planning phase. Any required audits will be conducted in advance and findings rectified before mobilisation commences.

5.6 VESSEL KICK-OFF MEETING

A kick-off meeting will be held on contract award to finalise the contract and start initial planning. Additionally, as part of the vessel mobilisation, a further kick-off meeting with all project personnel will be conducted on the vessel. This meeting will capture the full onboard project teams, senior onshore staff and OWC personnel providing an overview of upcoming operations and safety matters.

5.7 COMMUNICATIONS

Email will be the primary communication tool between GEOxyz, OWC and the vessel. Satellite telephone and VHF radio will also be available for communications should they be required. Vessel to vessel communication will be by VHF radio.

5.8 SURVEY CONTROL

5.8.1 Datum & Projection

The applicable geographical datum and projection parameters are listed in **Error! Reference source not found.**.

Project geodetic and projection parameters

Geodetic Parameters	
Ellipsoid	World Geodetic System 1984 (WGS84)
Semi-Major Axis (a)	6 378 137.000m
Flattening (1/f)	298.257 223 563
EPSG Code	4326
Project Projection Parameters	
Grid Projection	Universal Transverse Mercator
Zone	UTM Zone 30 N

Central Meridian (CM)	3° West
Latitude of Origin	0° North
False Easting	500 000 m
False Northing	0 m
Scale Factor on CM	0.9996
Units	Metre
EPSG Code	32630
Notes	
Rotation Convention	Coordinate Frame Rotation (right-handed convention)

5.8.2 Vertical Reference

Height data will be acquired in relation to the ellipsoid and translated to the project vertical datum (Lowest Astronomical Tide) using the United Kingdom Vertical Offshore Reference Framework (VORF) model at the project location.

5.8.3 Time Control

Local time will be used for record keeping during the project. The vessel will also maintain local time for operations. Data time-tagging and synchronization will use UTC (Universal Time Coordinated). All data recorded in the online navigation software will be time stamped using the time string and the pulse-per-second (PPS) from the GPS.

5.9 EXPECTED SURVEY PRODUCTIVITY

5.10 EXPECTED GEOTECHNICAL OFFSHORE PRODUCTIVITY

6 GEOPHYSICAL SURVEY OPERATIONS

6.1 MOBILISATION

For all work the port selected for mobilisation, crew changes and demobilisation will be either Milford Haven or Pembroke, UK.

All project-specific equipment will be mobilised as per GEOxyz standard procedures and the manufacturer's installation instructions. The equipment that will be used on the project is summarised in Section 3 of this document, and the planned calibrations and system verifications are summarised below. A full description of the mobilisation activities will be provided in the Mobilisation and Calibration reports for each vessel.

The mobilisations will be deemed complete when all the following have been completed to the satisfaction of the Client or Client representative.

- All systems, tests, trials, calibrations, equipment, personnel is/are in place and functioning correctly
- All documentation is in place, reviewed and approved by the Client representative
- All permits and consents are in place

6.2 CALIBRATIONS

The following verification and/or calibrations of the survey spread will take place during the mobilisation and prior to the commencement of operations.

- Geodetic computation verification
- Vessel geometry check
- DGNSS health check
- Comparison of primary and secondary DGNSS/RTK systems
- Vessel gyrocompass comparisons and/or calibrations
- Vessel MRU comparisons and/or calibrations
- Sound velocity profiler comparison
- USBL calibration/verification
- MBES calibration
- Wet tests of towed systems
- SBP and Sparker settings check

6.3 POSITIONING

6.3.1 Surface Positioning

Two independent, high-accuracy Differential GPS (DGPS) positioning systems will be provided. Correction services will be provided by Fugro Marinestar (G4+ or similar) which is able to provide XYZ accuracy up to 8cm. Back-up corrections can be received over the internet (Ntrip).

The independent secondary system (i.e. independent in all aspects including corrections except positioning satellites) shall be operated in parallel with the primary system, to provide full real-time redundancy. A continuous comparison between the position solutions derived from the primary and secondary systems will be made throughout the survey.

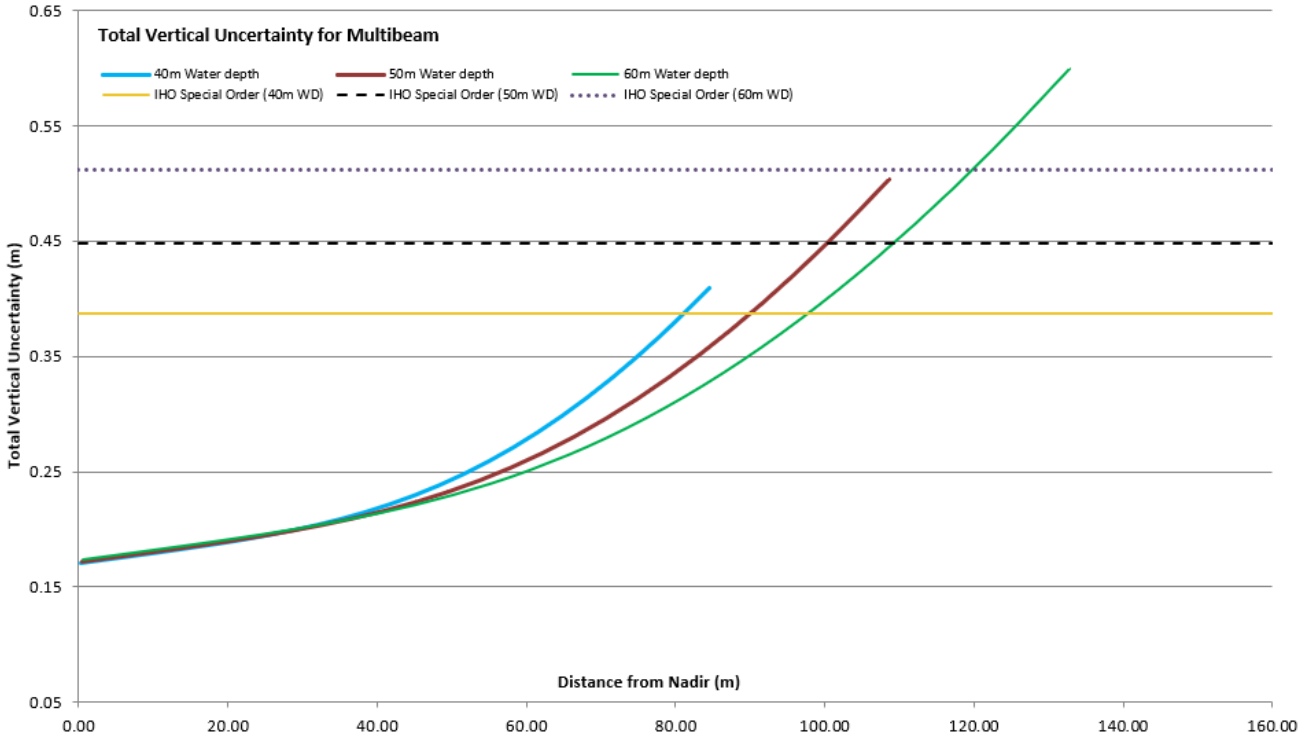
6.3.2 Subsea Positioning

The vessels will both be fitted with USBL systems which have a positional accuracy of 0.15% of slant range. Positioning of towed systems will be made using transponder beacons mounted ahead of the SSS and scanfish

systems. Offsets to the measuring centres of each sensor will be accurately made during mobilisation and entered/accounted for in the acquisition software. Acquisition software will therefore display data accuracy, position age and real-time relative and absolute position of the towed systems in real-time during operations.

6.4 ERROR BUDGETS

The Total Vertical Uncertainty (TVU) for MBES data has been calculated for a number of different water depths which are representative of the working depths expected to be encountered across the site. These are presented. It should be noted that we are most likely going to be operating with a narrow swath angle given the close line spacing (12m) in relation to the coverage requirements.



TVU error budget for MBES

Further details on the derivation of the TVU values in 60m water depths have been included by way of example.

TOTAL VERTICAL PROPAGATED ERROR (TVE) BUDGET R2SONIC MULTIBEAM ECHOSOUNDER SETUP VESSELMOUNTED													Water Depth: 60 m MBES altitude: 55 m
Beam Angle deg. from nadir		Offset from nadir [m.]	Slant Range [m.]	Dimension Control	Tides	Heave	Roll	Multibeam Installation roll angle	Soundvel. Sd	Soundvel. repeatability	R2Sonic Range Resolution	R2Sonic Bearing Accuracy	**Total** TPE
Beam nr	Angle			System	Random	Random	Random	System	System	Random	Random	Random	m.
1 = 256	67.50	132.78	143.72	0.01	0.080	0.050	0.046	0.116	0.009	0.435	0.005	0.002	**0.58**
10 = 247	65.81	122.45	134.23	0.01	0.080	0.050	0.043	0.107	0.007	0.370	0.005	0.002	**0.51**
20 = 237	63.87	112.12	124.88	0.01	0.080	0.050	0.039	0.098	0.006	0.311	0.005	0.002	**0.44**
30 = 227	61.61	101.78	115.69	0.01	0.080	0.050	0.036	0.089	0.005	0.257	0.006	0.002	**0.38**
40 = 217	58.98	91.45	106.71	0.01	0.080	0.050	0.032	0.080	0.004	0.209	0.006	0.002	**0.33**
50 = 207	55.86	81.12	98.00	0.01	0.080	0.050	0.028	0.071	0.003	0.166	0.007	0.001	**0.28**
60 = 197	52.15	70.78	89.64	0.01	0.080	0.050	0.025	0.062	0.003	0.129	0.008	0.001	**0.24**
70 = 187	47.70	60.45	81.73	0.01	0.080	0.050	0.021	0.053	0.002	0.097	0.008	0.001	**0.20**
80 = 177	42.34	50.12	74.41	0.01	0.080	0.050	0.017	0.044	0.001	0.072	0.009	0.001	**0.18**
90 = 167	35.88	39.78	67.88	0.01	0.080	0.050	0.014	0.035	0.001	0.054	0.010	0.001	**0.16**
100 = 157	28.17	29.45	62.39	0.01	0.080	0.050	0.010	0.026	0.001	0.043	0.011	0.001	**0.14**
110 = 147	19.17	19.12	58.23	0.01	0.080	0.050	0.007	0.017	0.001	0.038	0.012	0.000	**0.13**
120 = 137	9.07	8.78	55.70	0.01	0.080	0.050	0.003	0.008	0.001	0.037	0.012	0.000	**0.12**
128 = 129	0.54	0.52	55.00	0.01	0.080	0.050	0.000	0.000	0.001	0.037	0.012	0.000	**0.11**

TVU MBES tabular calculation

Further checks have been made to ensure we can meet the client-stipulated footprint sizes in the SOW

6.5 DATA ACQUISITION

6.5.1 Multibeam Echosounder Data

Multibeam Echosounder data will be collected at the same time as the gradiometer acquisition. The swath opening angle may therefore be maintained at a narrow angle such that we easily maintain enough coverage with adjacent lines. This will not only maintain the highest quality dataset, but also improve the along-track ping-rate and overall data density per square metre.

6.5.2 Sound Velocity Profiling

Sound velocity profiles shall be taken across the complete water column at least twice every 24 hours or at each significant bathymetry variation or location change.

6.5.3 Side Scan Sonar Data

Side Scan Survey data will be collected simultaneously with all other sensors. The SSS will be deployed in-line with the GEOxyz launch and recovery procedures. As data is acquired, the elevation and off-line position of the side scan sonar will be monitored to ensure the data being collected is within the required specification for tolerance and fit to meet the objectives of the survey.

Some SSS processing software has issues applying corrected navigation files if the start and end timestamps on the SSS record are outside the timestamps supplied in a corrected navigation file. It is therefore important that the following order is adhered to: Start logging in navigation software → start logging SSS → stop logging SSS → stop logging in navigation software.

These settings should not be changed without first consulting the party chief, who shall discuss with the Client representative as appropriate.

The primary parameter that should be monitored during data acquisition is the fish altitude, track position in relation to the survey corridor/adjacent dataset (i.e. coverage), and overall quality of the record in terms of noise, visibility of features etc.

During acquisition it may be necessary to adjust gain settings, and this should generally be done following consultation with the onboard geophysicist.

6.5.4 Magnetic Data

A single TVG comprised by two Geomatrix G882 magnetometers will be towed in a piggy back configuration behind the side scan sonar. The towed systems are operated using an electrical winch in order to maintain proximity with the seabed.

To check the altitude above the seabed both the magnetometers are fitted with a depth sensor and an altimeter. The altitude of the sensors above the seafloor can be actively controlled by adjusting the tow length of the tow cable (electrical winch) or by changing the speed of the survey vessel.

It is noted that the maximum acceptable height is 4m according to the specifications.

During the survey, several checks of the instruments are performed to ensure good data quality, positioning and navigational accuracy. Before launching the system, a notification is sent to all vessels in the vicinity to inform them of the survey activities. Navigation speed is held at a speed of ca. 3-4 knots to obtain full data coverage and optimal data quality.

Underwater positioning of the TVG is done using a USBL system. Where USBL positioning is not achievable due to distance and shallow depths, the system will be positioned using manual layback mode in QINSy.

Once all the required datasets are collected and following appropriate QC checks for quality, coverage and density etc., any outstanding infill or re-runs will be collected. It may be more operationally efficient to collect re-run and infill data as the acquisition progresses depending on the location and other operational variables. The planning for this is left up to the Party Chief onboard.

The online surveyor is responsible for the real time QC of all data gathered. The incoming data will be monitored continuously and that all sensors are operating within specification.

6.5.5 High Frequency SBP

The aim of the sub-bottom profiling survey is to provide preliminary information regarding the geological structures of the survey zone down to 5 m beneath the seabed. The system has a high-frequency band between 85 – 115 kHz and low frequency user selectable between 4 and 15 kHz. Under normal conditions penetration up to 10 m should not be a problem, however, the final achievable penetration will depend on the shallow geology of the survey area. Depending on the used frequency, resolution will be approximately 1 cm and up to 5 cm. Data is acquired using the Innomar ISE software whereas processing is completed using Silas processing software.

SBP frequency, pulse, power and gain settings will generally have been optimised during initial wet-testing and following first deployment. Optimal settings will enhance objects and geological structures in the sedimentary layers down to the required depth below seabed. As the geology can change within a work area, these settings will be constantly monitored by the geophysicist as data is acquired.

Once all the required datasets are collected and following appropriate QC checks for quality, coverage and density etc., any outstanding infill or re-runs will be collected. It may be more operationally efficient to collect re-run and infill data as the acquisition progresses depending on the location and other operational variables. The planning for this is left up to the Party Chief onboard.

The online surveyor is responsible for the real time QC of all data gathered. The incoming data will be monitored continuously to ensure that coverage is achieved, and that all sensors are operating within specification.

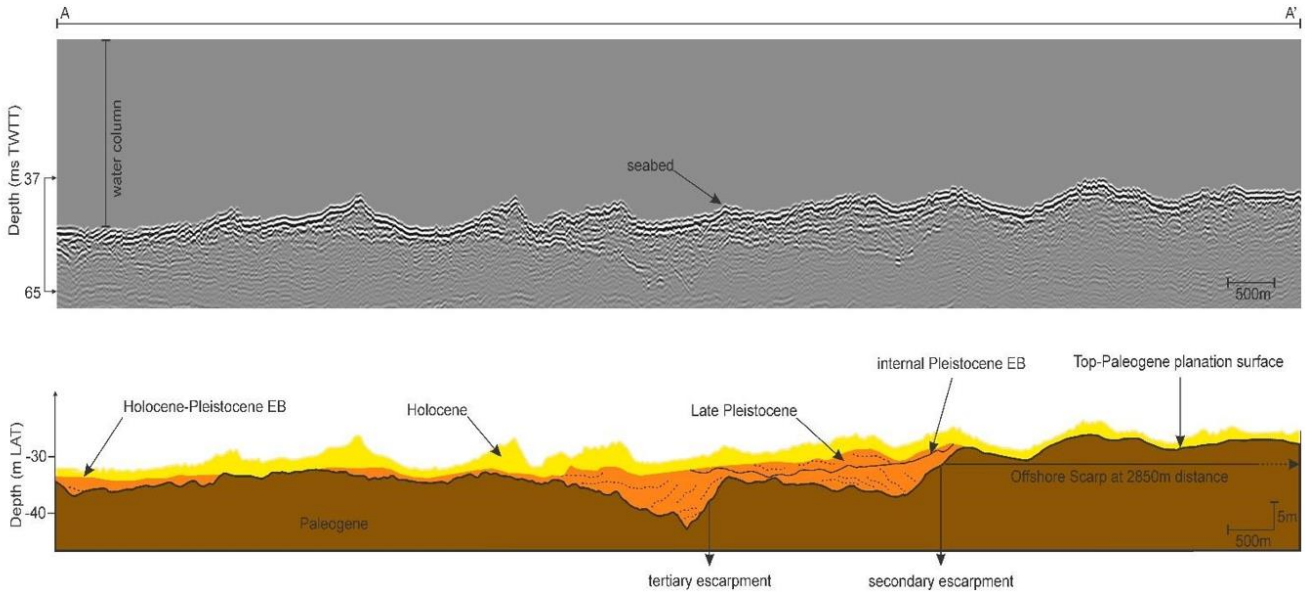
6.5.6 Low Frequency SBP

If optional seismic reflection profiling works are requested by the Client, SBP frequency, pulse, power and gain settings will generally have been optimised during initial wet-testing and following first deployment. Optimal settings will enhance objects and geological structures in the sedimentary layers down to the required depth below seabed. As the geology can change within a work area, these settings will be constantly monitored by the geophysicist as data is acquired.

Once all the required datasets are collected and following appropriate QC checks for quality, coverage and density etc., any outstanding infill or re-runs will be collected. It may be more operationally efficient to collect re-run and infill data as the acquisition progresses depending on the location and other operational variables. The planning for this is left up to the Party Chief onboard.

The online surveyor is responsible for the real time QC of all data gathered. The incoming data will be monitored continuously to ensure that coverage is achieved, and that all sensors are operating within specification.

When combined with the GSO 24 element single channel mini streamers, the GSO-540 can be used as a reliable and low maintenance source for single channel seismic profiling. The proven characteristics of the GSO-360 also allow it to be used as a very stable acoustic energy source for high-resolution multi-channel operations.



Example of a single-channel seismic profile from the GSO 360

Example of a multi-channel 2D UHR seismic profile from the GSO 360

7 DATA PROCESSING AND INTERPRETATION

8 SAMPLE HANDLING AND LABORATORY TESTING

9 HEALTH, SAFETY AND ENVIRONMENTAL

10 QUALITY MANAGEMENT AND ASSURANCE

APPENDIX A. ALARP SIGN-OFF CERTIFICATION