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Status Final

Geophysical Survey
Search Area 6/7
Lot2: 3D-UHRS survey

Annex 5 - Section IV

Scope of Work

Colophon

Project name	Geophysical Survey Search Area 6/7 – Lot2
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1 Introduction

1.1 Glossary

Item	Description
GDB	Geodatabase
MBES	Multibeam Echo Sounder
SVP	Sound Velocity Profiler
SSS	Sidescan Sonar
MAG	Magnetometer
SBP	Sub-bottom Profiler
UXO	Unexploded Ordnance
MRU	Motion Reference Unit
GNSS	Global Navigation Satellite System
SVS	Sound Velocity Sensor
USBL	Ultra-Short baseline
BS	Backscatter
WC	Water column Data
CTD	Conductivity – Temperature – Density
SAS	Synthetic Aperture Sonar
HF	High Frequency
LF	Low Frequency
QA	Quality Assurance
QC	Quality Control
PPP	Precise Point Positioning
DGNSS	Differential GNSS
CRP	Central Reference Point
C-O	Computed - Observed
CR/OCR/COR	(OFFSHORE) CLIENT (OFFSHORE) REPRESENTATIVE

1.2 Scope of this document

This document and its appendices detail the scope of WORK as part of the CONTRACT that CLIENT has awarded to CONTRACTOR for carrying out a geophysical investigation in Search Area 6/7 (Sa 6/7).

1.3 Background

The Ministry of Economic Affairs and Climate Policy is responsible for the legislative framework for the development of offshore wind farms in the Netherlands. Within this framework (a) (concession) tender(s) for permit for construction and operation of (a) wind farm(s) will be organized under the current regulation. As part of the tender documentation, the participants will receive an information package in which detailed information on the offshore site is included. Detailed information on the soil conditions at the site will be part of this information package.

Information on the soil conditions at the site is to be developed through a sequence of commissions for geological, geophysical, geotechnical and morphodynamical studies. Information will be presented as factual data, integrated and interpreted data (an Integrated Ground Model) and will be comprehensively reported.

The Geophysical Survey follows and receives information from the Geological, Archaeological and UXO Desk Studies, and it is expected to precede and supply information to a geotechnical investigation, an Integrated Ground Model (IGM, integrating the results of Geological, Geophysical and Geotechnical investigations) and a morphodynamical investigation. The Integrated Ground Model is to be of sufficient precision to allow Offshore wind farm developers who want to participate in upcoming tenders in the Netherlands to make initial plans and costings for foundation design and cable installation.

This assignment is concerned with the geophysical investigation component, contributing to the information package to be provided to participants.

1.4 Site description, investigation area and reference systems

Search area 6/7 (Sa 6/7) is being investigated for the offshore wind development of the Netherlands. The geophysical survey will focus on the West of Search area 6/7, hereafter often called the Investigation Area (IA). For this scope of work, it is the intention to obtain a single, comprehensive set of geophysical data, reports, drawings and a preliminary ground model (PGM) for the Investigation Area (IA).

Within the Dutch Shelf of the North Sea, several search areas have been selected with potential for the development of offshore wind. Search area 6/7 (Sa 6/7) is located approximately 94 km off the northwest coast of the Netherlands and covers an area of approximately 4639 km^2. At the time of writing this document, there are no designated wind farm zones in this area.

Search area 6/7 is located within the northern part of the Dutch North Sea. General characteristics of the investigation area are shown in the table below, alongside Figure 1. A GIS dataset of Sa 6/7 and the IA can be found in the GIS examples and project files attached in this tender package. **After contract award, CONTRACTOR must request cable and pipeline data themselves from Rijkswaterstaat, since this is not public information any longer.**

Table 2: Characteristics of the investigation area

Characteristics	
Water depth	Approximately 40-50 m ALAT
Distance from shore	Approximately 94-170 km

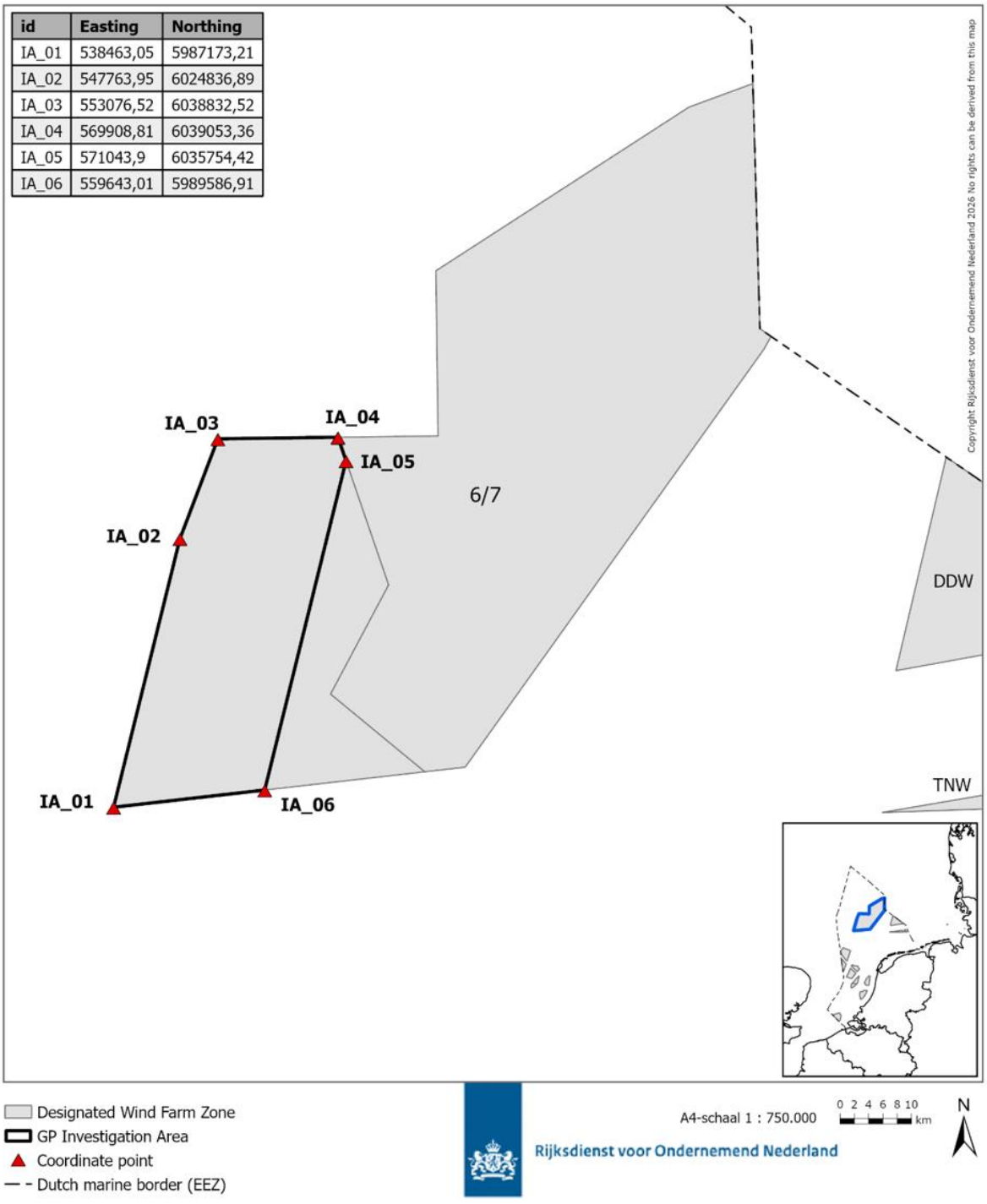

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Figure 1: Investigation area within windfarm zone Search area 6/7. The IA covers part of the Western part of Search area 6/7 (phase 1).

SI units (ISO/IEC 8000) are applicable for any activities carried out in the Search areas.

The chart datum is Approximate Lowest Astronomical Tide (ALAT). All positioning data shall be collected in the European Terrestrial Reference System 1989 (ETRS89) and projected using ETRS89 Transverse Mercator Coordinate Reference System (UTM Zone 31N) , with EPOCH 1 January 2027. The reference for this system is EPSG Projection code 25831 - ETRS89 / UTM zone 31N.

The requirements for GIS metadata which all Contractors shall comply with is shown in Appendix A. As RVO will make this data publicly available, the metadata needs to be in line with the General Data Protection Regulation (GDPR) (in Dutch: AVG) requirements.

1.5 Two Scopes of Work for geophysical survey campaigns

The Contacting Authority has chosen to split the planned geophysical survey campaign for the IA into two Scopes of Work (SoW).

1. Lot 1 (separate SoW): SoW for Seabed Survey (SS) focuses on a Seabed Survey in SA6/7 west (Sa 6/7-GP-Lot1).
2. Lot 2 (this SoW): for 3D-UHRS survey, including MBES, focuses on a full coverage 3D-UHRS survey in Sa 6/7 west (Sa 6/7-GP-Lot2).

With two scopes, the Contracting Authority aims to provide an opportunity for various contractors to bid for one or both of these SoWs, considering the overall planning of soil investigations in relation to the Dutch offshore wind RoadMap. More information on the current RoadMap can be found on *https://energietransitie.nl/soorten- energie/windenergie/windenergie-op-zee/doelstellingen-windenergie-op-zee.*

This SoW document covers Lot 1: Seabed Survey. Both lots cover the same IA, with different geophysical scopes, as summarised in the table below.

Table 3. Division over Lots of geophysical surveys.

Investigation Area + Tie Lines	Sa 6/7-GP-Lot1	Sa 6/7-GP-Lot2
Seabed survey (SSS, SBP, MBES, Backscatter, Magnetometer)	**All sensors**	**MBES only**
Seabed Grab Sampling	**200**	**-**
3D-UHRS	-	**Full Investigation Area**

Tie-Lines

Three tie-lines - to be obtained during vessel-call transits – are planned between the IA and Doordewind windfarm zone. The tie-lines have an estimated length of approximately 135km each.

1.6 Aims of the geophysical surveys

The aim of the geophysical soil investigations is to contribute to the geological understanding of Sa 6/7. The investigation is required to obtain seabed and sub-seabed information. This information is in turn expected to be suitable for the planning and preparation of geotechnical investigations for the subsequent integration into a ground model of sufficient quality to progress the basic/FEED design and installation requirements for offshore wind farms, including, but not limited to, foundations and cables.

The Lot 2 CONTRACTOR is expected to provide:

- An accurate bathymetric dataset;

- Sub-Seabed datasets of sufficient quality to support construction of a ground model to at least 100 m below seabed, with penetration, resolution and signal-to-noise ratio optimised for production of an Integrated Ground Model;
- 3D-UHRS interpretation as input to a Preliminary Ground Model (PGM) of the site, including as a minimum;
    - Estimated elevation (depth in meters below LAT) and depth below seabed for a set of interfaces between principal geological formations and other horizons of interest. The GDS report and data contain information on the known formations and units which can be expected across the site;
    - The locations of structural features or geohazards within the shallow geological succession including but not limited to faulting, accumulations of shallow gas, organic sediments/peat, buried/infilled channels, depth to hard ground/bedrock, soft sediments, salt diapir (deformation), structures associated with sub-glacial processes or glaciotectonism;
    - Integration of Lot 1 seabed survey results, including but not limited to the MBES and SBP, as interpreted by Lot 1 CONTRACTOR;
    - Correlation with existing geophysical and geotechnical interpretation as available.
- A comprehensive Final Interpretation Report on the survey results obtained, describing the Preliminary Ground Model (PGM);
- A preliminary zonation of the site for input into the specification and scope for a geotechnical sampling and testing program to follow the completion of the geophysical survey;
- Recommendations for a geotechnical location plan including 100 (deep) seabed CPT's, 100 Vibrocores, 100 x 60m boreholes, with reasoning.

The output of the investigation shall be delivered in formats defined in this scope of work and accompanying documents, including digital raw & processed data, metadata, Seismic Interpretation System Package, Geographic Information System project files, chart data, and reports.

The Geophysical Survey, and the resultant preliminary ground model, follows and receives information from the Geological, Archaeological and UXO Desk Studies, and it is expected to precede and supply information to a geotechnical investigation, an Integrated Ground Model (IGM, integrating the results of Geological, Geophysical and Geotechnical investigations) and a morphodynamical investigation.

It is expected that the IGM (to be developed under a separate, later commission following geotechnical data acquisition) will be a revision and significant enhancement of the PGM. It is expected to include a refinement of data processing of sub-seabed data, ground-truth calibration of geophysically estimated depths, rationalisation of geotechnical and geophysical observations, refinement of the preliminary litho-stratigraphic model to include geotechnically relevant structures and the development of a 3D distribution of geotechnical parameters.

1.7 Special Considerations

CONTRACTOR shall consider that time-sharing arrangements on the survey plans (timing and location at the site where the survey is carried out) shall be made with other contractors working in the vicinity of/ at the site and/or third parties using the space if required. It is expected that simultaneous operations (SIMOPS) might occur within the Investigation Area. This includes Notice to Mariners 7 day look ahead, as well as all shipping traffic through IMO and all other third party operations. SIMOPS and all relevant stakeholder communications are expected to be managed by the CONTRACTOR.

CONTRACTOR shall consider arrangements for permits to use the survey equipment within the investigation area and shall adhere to requirements of environmental and other required permits.

CONTRACTOR shall consider the close vicinity of the NL/DE maritime boundary and the shipping lanes as well as the active cables crossing the site.

1.8 Co-creation

The CLIENT wishes to collaborate with the CONTRACTOR as one team for the duration of the project. This does not mean an adaptation of responsibilities by the CONTRACTOR. In this context, the following opportunities are anticipated:

- Teamwork between RVO, RVO experts and CONTRACTOR to achieve optimum results;
- Acquisition of geophysical data to support and provide clearance for a geotechnical campaign;
- Development of a Preliminary Ground Model;
- Open and transparent correspondence during SIMOPS and data integration including but not limited to other parties contracted by the CLIENT (e.g. GP Lot 1 CONTRACTOR);
- Dissemination activities such as webinars and answering questions from the market;
- Development of use of 3D geophysical surveys for offshore wind farm planning, ideally followed by publication(s); and
- Reduction of environmental impact for survey operations.

1.9 Timing of the investigations

- The geophysical survey for Sa6/7-GP-Lot2 is expected to be conducted from Q1 2027 onwards. The key desired/ultimate dates are indicated in Annex [4]:
    - Issue Final Interpretation Report:
        - Desired date set by client (incl WoW) = 31-10-2028
        - Ultimate date set by client (incl WoW) = 31-12-2028
- The 3D-UHRS (including MBES), together with the data integration into the PGM from Sa 6/7-GP-Lot 1 is required for the preparation of the geotechnical borehole campaign within the IA. The PGM is also the foundation of subsequent GGM and IGM.
- CONTRACTOR shall provide a project plan over time in the Project Execution Plan, in which the survey area is fully covered and the survey time (as indicated by the CONTRACTOR in Annex [4]) is justified based on the speed of the surveying (km^2/day), expected weather downtime, crew change duration, technical maintenance, etc.

1.10 Available information

CONTRACTOR will thoroughly scrutinise the complete Tender package. Tenderer will get the opportunity to ask questions during the time set aside for the Memorandum of Information (MOI) as described in the Tender Document.

1.10.1 *WFZ specific information*

CLIENT has performed and will perform other studies on Sa 6/7. The following relevant desk studies are available on https://offshorewind.rvo.nl

- The CLIENT has performed and published a Geological Desk Study (GDS) containing information on the expected stratigraphic units, geological structures and possible influence on the design and the construction of offshore wind farms in the IA.
- Alongside the GDS, a UXO Desk Study has been published as well.

Both and future reports can be found on the offshore wind RVO website *https://offshorewind.rvo.nl/page/view/cbc43dd1-913d-4478-b284-f210753bcdcc/soil-search-area-6Z*.

The CLIENT will endeavour to give results of other studies earlier to the winning CONTRACTOR.

1.10.2 *Other information*

Further, for information, the results of the geophysical and geotechnical surveys carried out for all other Dutch WFZ's are available at https://offshorewind.rvo.nl/. It should be noted that this scope of work deviates from those of previous investigations *and may introduce additional requirements.*

2 Scope of Work

2.1 Survey requirements area Lot 2

This scope of work for Sa 6/7 GP Lot 2 covers the aforementioned Investigation Area (IA) and two Tie-lines. These tie-lines can be sailed during transit to and from site at the CONTRACTORS discretion with CLIENT approval. One tie line must fully cross Doordewind WFZ, crossing the IA in a E-W direction. The second tie line must fully cross Nederwiek WFZ and the IA in a N-S direction. Both tie lines will be sailed across relevant geotechnical boreholes. Geotechnical BH information will be supplied by the Client. Up to a maximum of 5 horizons will be interpreted and followed from the WFZ to the IA to aid the interpretation process. The X and Y coordinates are to be exactly determined at a later stage.

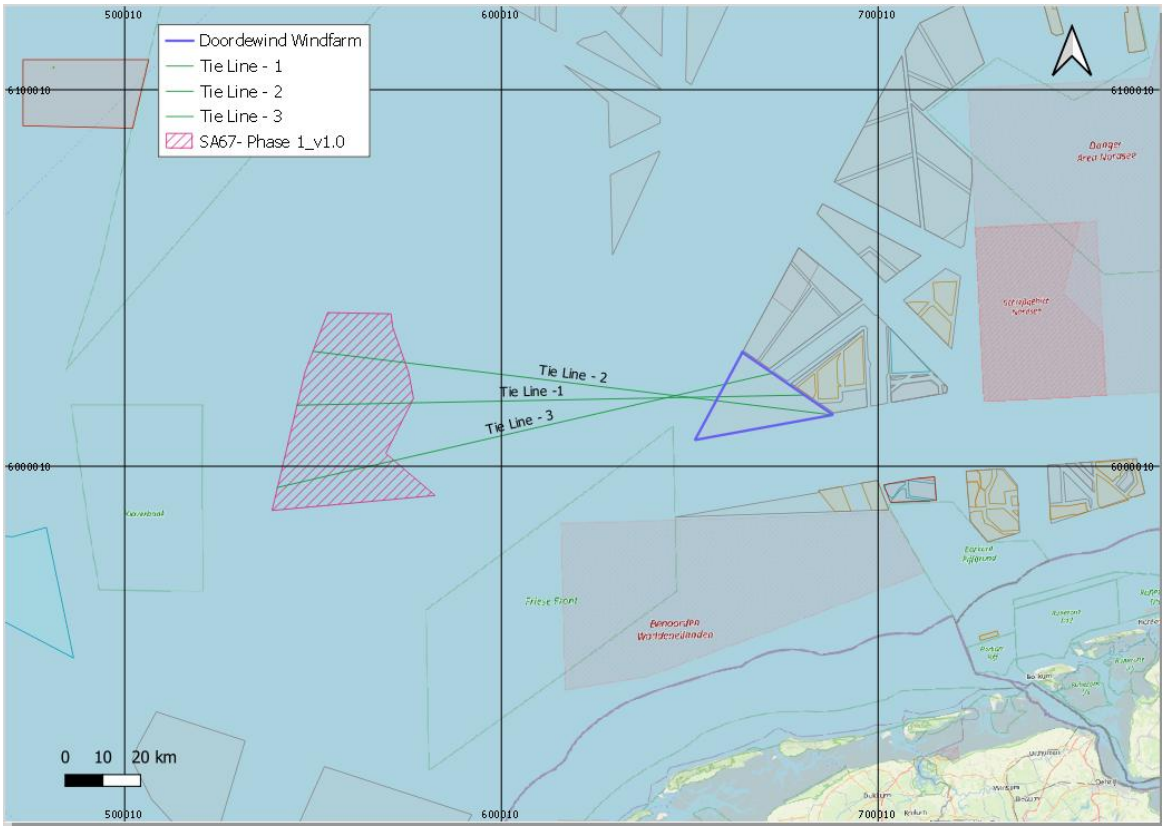

Figure 2: Example tie Lines from SA6/7 to Doordewind. Coordinates of both tie lines and Nederwiek tie line to be determined at a later stage.

2.2 General scope of work

2.2.1 *Activities*

The below text contains a summary of the activities the CONTRACTOR will carry out under the CONTRACT Scope of Work.

- **Preparation**:
  - All preparatory works required for the 3D-UHRS and a HRB (MBES) survey, including preparation of all documentation and plans that need to be provided and approved by CLIENT before the works can start, without which, the vessel cannot complete mobilization and leave port.
  - Permits to perform survey works with the proposed equipment.
- **Data Acquisition & Processing.**
  - High resolution bathymetric survey
  - 3D Multi-Channel Ultra High-Resolution Seismic (3D-UHRS) survey
  - Preliminary processing (e.g. coverage improvements like flex binning, signal to noise improvements, etc.) of the 3D-UHRS including first pass imaging; fast track 48 hour deliverables for quality checks performed on coverage.
- **Data Interpretation:**
  - Produce derived interpretation products for the creation of a PGM including but not limited to:
  - Tracing and mapping of the key subsurface interfaces representing boundaries of distinct geological units. The number of interfaces (horizons) should be proportional to what is observable within the resolution and quality of the data. Currently the CLIENT estimates 7-12 geological horizons (including seafloor) to be traced and mapped across the IA (refer to the geological desktop study found on the offshore wind RVO website here);
  - Tracing and mapping of all features/geohazards observed (including but not limited to channels, tunnel valleys, faults, shallow gas, gravel/till layers, prevalence of boulders in certain (till) layers, etc) observed in 3D-UHRS data and resultant surfaces.
  - Integrate Lot 1 survey elements into a complete and coherent Preliminary Ground Model of the IA (e.g. integration of Lot 1 SBP and MBES surfaces (previously interpreted by Lot 1 contractor) into this SoW Lot 2 data to produce final depth converted product.
- **Quality Assurance and Quality Control**
  - CONTRACTOR shall deliver a Quality Management Plan with requirements as described in Annex 5 Section VI and the Tender Document. The QMP and subsequent revisions will be adhered to throughout the WORK.
  - CONTRACTOR maintains an updated Project Execution Plan with requirements as described in the Tender Document and this SoW. The PEP and subsequent revisions will be adhered to throughout the WORK.
- **Reporting:**
  - Create final data package with QA and metadata elements.
  - Present the results in clear reports maps and drawings, detailed in '*Delivery*' while adhering to the Quality Requirements
  - Provide zonation and extents of sub-seabed geological units as guidance for design of a geotechnical investigation campaign.
  - Provide input for subsequent geotechnical studies, and an archaeological study (e.g. paleo landforms and incised channels etc.).
- **Delivery**
  - Products of the survey are to be delivered as a coherent and integrated data package with complete descriptive documentation.

This scope of work is designed to provide a minimum acceptable specification and contains important requirements throughout the document. Key requirements for survey layout are provided in sections 1.4 and 2.3.2, and for resolution of positioning and individual measurements in sections 2.5 and 2.6.

The description of the survey aims should inform the CONTRACTOR in preparing their proposal which should clearly describe their suggested specifications, including the survey geometry, in order to achieve the survey aims as well as their planned survey setup including communication protocols, back-up systems, and power supply.

It should be recognised that the results of the survey are to be integrated with other geophysical investigations and made available to multiple parties as part of the information package associated with the tender process described in section 1.5. The deliverable products of the survey must allow third parties receiving the data package to evaluate, reprocess, reinterpret, or otherwise rework the data to fit the needs of their processes. To this end, it is emphasised that raw data, positioning information, reporting and metadata are essential elements of the deliverable package.

2.2.2 *Deliverables*

The survey data together represent a significant array of elements which are required to be arranged in a coherent format. Details are found in sections 2.6, 2.7 & 2.7.6 of this document. The specifications of raw, processed, and interpreted deliverables from individual survey elements are described within their respective sections.

Three integrated deliverables are required for both the main survey and the tie lines:

1. a GIS project (*ESRI ArcGIS geodatabase is preferred)* containing *all* processed and integrated elements that may be represented in GIS;
2. a single Seismic Interpretation System project (e.g., IHS Kingdom, or a comparable system, after consultation with and approval from the CLIENT) containing *all* the subsurface data elements, and
3. reports describing the vessel operations and acquisition/ processing, as well as an integrated Final Interpretation Report which can be used as input to the PGM.

The contents of these integrated deliverables are to be supplemented by raw data suitable to allow reprocessing, intermediate processed data as specified for each data element, final data, interpreted data, metadata, and reporting.

2.3 Preparation

2.3.1 *Scrutiny of available information*

CONTRACTOR shall scrutinise the information that has been made available by CLIENT. The CONTRACTOR will warrant that it is not aware of any error, fault, inconsistency, or other defect in the data, unless specified in the Memorandum of Information (MOI). Information that is relevant for carrying out the WORK shall be considered while preparing the WORK. The CONTRACTOR will satisfy itself based on the provided information, public domain information, and experience as state of the art service provider as to the extent and nature of the work including, but not limited to, the services, personnel, materials, equipment, vessels, consumables, spare parts and facilities required for to execute the work. The CONTRACTOR assures the correctness and the completeness of its rates and prices taking into account the climate, sea & weather conditions, seafloor and subsoil conditions, and all matters which can be reasonably foreseen to impact the progress and performance of the work.

2.3.2 *Design Requirements of the Survey Layout and Configuration*

The CONTRACTOR shall select their optimum survey layout and acquisition configuration across the IA. (*e.g.* single- or multi-vessel solution, single or multiple passes) to achieve the survey objectives and data quality requirements.

CONTRACTOR is required to determine an effective logistical solution with regards to the requirements of each measurement type within the IA boundary.

The chosen survey geometry should be dutifully documented and included into the package of deliverables for CLIENT.

The following criteria represent layout requirements for the Lot 2 Technical proposal*,* covering the entire IA according to section 1.5.

2.3.2.1 Sa 6/7-GP-Lot2

- It is required that High-Resolution Bathymetry (MBES) data are acquired, processed, and delivered with 3D-UHRS survey to support source and receiver height compensation in 3D-UHRS (re)processing. High-Resolution Bathymetry data by Multi-Beam Echo Sounder (MBES) are to be acquired with isotropic parallel primary lines at not greater than 100 m line spacing. A line spacing should be chosen by the CONTRACTOR to achieve the required data quality and sufficient coverage on all sensors without relying on infill. The CONTRACTOR shall propose a MBES beam width/ head type for the average 40m water depth across the site also considering seabed type, vessel speed, line spacing and object detection required for 120% coverage.
- 3D Multi-Channel Ultra High Resolution Seismic (3D-UHRS) data are to be acquired for full 24 fold nominal coverage for the IA. CONTRACTOR shall provide coverage plots for the number of hits expected per bin (acquisition and final binning) for the purpose of soil unitization across the site at the required resolution as specified in section 2.5.5.
- Inline spacing and vessel sensor geometry configuration to be proposed by CONTRACTOR to ensure optimal 3D-UHRS coverage across the site. Proposals will be assessed on previous fold achieved on past surveys by the CONTRACTOR with the resultant resolution and interpretation demonstrated by way of hits per bin schematics, fold plots and target/unit identification and interpretation.

2.3.2.2 Tie-lines

For the tie-lines the MBES, SSS, MAG, and SBP systems must be active and interpreted. The tie-lines are expected to be ~135km each. The goal is to align the geophysical data between the surveys within the IA (West side of Sa 6/7) and possible future Seabed surveys within Sa 6/7, and between the IA and Doordewind Wind Farm Zone. Lot 1 and Lot 2 CONTRACTOR will sail the same traces. The Lot 2 tie-lines are leading, but will be discussed between all parties.

2.3.2.3 Vessel specifications, multiple sources and streamers

The streamer number and streamer separation and survey line spacing is to be proposed by the CONTRACTOR to achieve the desired vertical and horizontal resolution and survey project objectives. All geometries shall be clearly indicated on deck layout diagrams in the mobilisation plan.

Vessel specification sheets including instrumentation certificates, towing diagram, instrument settings and appropriate procedures are required to be produced, maintained, and followed. Annex 3b/c shall be filled in, and vessel and equipment spec sheets, certificates etc. shall be included in an appendix of the PEP for reference.

Equipment interference must be minimised in all cases, shall be proactively monitored, reported, and shall not impact the data quality. The mitigation measures for potential sources of interference should be described in the proposal as part of the risk assessment in the PEP. Passive Acoustic Monitoring equipment is for noise trials which shall be conducted and reviewed by onboard RVO client representative.

CONTRACTOR shall provide vessel assurance documentation in the form of:

- Filled in Annex 3 (b & c in separate tabs of Annex 3);
- A track record including the vessels previous project history (to be included in the PEP);
- Record of vessel service history;
- Sensor performance i.e. sensor interference from vessel noise;
- Standard of Vessel: Year, Fuel type, Dynamic positioning details, Weather tolerance;
- Other standard vessel paperwork to be expected for a geophysical survey vessel;
- HSE documents (detailed in separate HSE scope).

2.3.3 *Permits and notifications*

CONTRACTOR shall obtain and manage all necessary permissions other than the environmental exemption (underwater noise in Dutch waters), and/or notifications, to perform the survey (including

all permissions and fees necessary for access and safety arrangements to harbours and offshore positions). CLIENT shall arrange for environmental permit, on the basis of the documentation provided by the tenderers, and CONTRACTOR shall work within the requirements of this permit throughout survey activity. In this aspect attention is drawn to the vicinity of the shipping lanes. The latter may warrant different permits which are under the responsibility of the CONTRACTOR.

Operation of an Acoustic Deterrent Device (ADD) "Pinger" during all offshore works is mandatory to CONTRACTOR. Specifications of the active seismic sources (all sources for 3D-UHRS) shall not vary during the project from those supplied to the CLIENT for application of the ecological exemption (underwater noise). Furthermore, a soft start procedure for all sources should be in place before the start of the survey.

2.3.4 *UXO-assessment and measures*

The general risk regarding the presence of UXO (unexploded ordnance) will be assessed and reported in a separate desk study. The report will be published in January 2026 prior to any intrusive geotechnical sampling.

2.3.5 *Project Plans*

CONTRACTOR shall prepare all project plans as required by the CONTRACT. The Technical Proposal includes a Project Execution Plan, HSE management plan and Quality Management Plan. Along with the filled in annexes, these plans will form the first version of the Project Documentation. The Project Documentation shall include planning for the execution of operations, quality management and safety management. The organisation of these elements shall follow the requirements set in the tender document and scope of work. Elements can be according to the CONTRACTOR's normal working practice, but the planning material must include (but not be limited to) the following for every data type to be acquired:

- Project Execution Plan (PEP):
    - Line plans, method statements and safe systems of work;
    - Company standard operating procedures, including but not limited to: lifting plans, crew changes, personnel transfer, deck arrangements, towing configuration, UHRS launch and recovery, UHRS kit maintenance; i.e. battery change out, performing surveys with all sensors, processing data from all sensors, positioning, etc.
    - Mobilisation, equipment verification tests, parameter optimization;
    - Operational QAQC procedures (can reference to QMP, QAQC workflow in PEP)
    - Data acceptance criteria per sensor;
    - Data processing sequences;
    - Spares inventory management;
    - Preliminary project schedule;
    - The PEP must include the split of data into blocks suitable for data management and quality review (expected between 4-20 blocks). CONTRACTOR will make sure there is seamless overlap between the blocks and subsequent integration. For intermediate transfer purposes, the maximum file size shall not exceed 150 GB. Vessel specifications, instrumentation certificates, etc.;
    - Project & task specific risk assessment including mitigating measures
- HSE management plan, compliant with Annex [5], Section V HSE Requirements including but not limited to:
    - A comprehensive HSE and Emergency Response Procedure;
- Quality Management Plan, compliant with Annex [5] Section VI, including but not limited to:
    - Management systems
    - Meetings
    - Data management and transfer overview and workflow (see also delivery section and Quality Management Requirements);
    - Plans to interface between CONTRACTOR's offshore team, CONTRACTOR's onshore management, offshore CLIENT representative and CLIENT's onshore team, e.g. document and data sharing platforms.

The Tender Document describes the expected delivery format.

CONTRACTOR shall only commence the WORK when all project plans have been reviewed by CLIENT and all comments made by the CLIENT are resolved and approved. For all revisions a document version with track changes on, a document review form (DRF) and a final version are expected to be provided for ease of reviewing changes. The following review schedule is to be adhered to:

- The CLIENT will strive to complete its review of the first version within three weeks;
- The CONTRACTOR will implement changes and answer comments in the DRF within 2 weeks;
- The CLIENT will strive to complete its review of the 2nd version, within 2 weeks;
- The CONTRACTOR will implement changes and answer comments in the DRF within 1week.

The cycle described by the last two points will continue until the document is accepted.

Generic descriptions in the project plans which will be updated upon /after award of the contract shall be highlighted and provided with an (explicit) time bound plan providing insight when generic information will be replaced. Project specific information will be of added value.

The preparation of Project Documentation is expected to include an onshore based Technical Kick-Off Meeting (TKOM) and Hazard Identification and Risk Assessment meeting (HIRA, refer to Annex [5] - section V HSE Requirements) as well as physical meetings prior to a Vessel Kick-Off Meeting (VKOM) to be held as mobilisation starts.

The Technical kick-off meeting is held at least 3 weeks prior to the planned mobilisation date. The TKOM is minimal a 2 day in person meeting at either CLIENT's or CONTRACTOR's office.

The TKOM shall at least address following topics (with the final agenda being agreed between CLIENT and CONTRACTOR before the TKOM):

- Project Execution Plan; to include
  - Crew changes planned
  - Mobilization and demobilization ports agreed
  - Port agency, harbour master, customs control, fire brigade details confirmed (clearance for hot works) and arrival plans communicated
- Project schedule/planning
- Initial sensor/survey configuration
- Line plan
- Offshore data QC
- Data acceptance criteria per sensor
- Offshore testing phase/survey parameter optimisation
- De- and Mobilisation acceptance
- Technical mitigation plan (equipment breakdown/ positioning loss/ data quality degradation)/ etc.

Offshore equipment verification and parameter testing shall be required and agreed with onboard client representative and used as input to finalised production procedures, to be completed after the offshore testing phase. It is a requirement that all parameter/filter testing carried out is delivered as a field report to the client for data quality approval with data examples shown off before and after settings & filters applied.

2.4 Quality Assurance and Quality Control

Annex [5] - section VI Quality Requirements and Administrative Instructions contains a brief description of the quality management requirements to be implemented during the survey work. However, this section describes specific operational and technical QA requirements to be implemented in the PEP, in support of those described in Annex [5] - section VI.

During data acquisition, 3D-UHRS datasets shall be monitored continuously to ensure both coverage and quality (including signal stability and resolution) are maintained. The survey *speed over ground* shall be no more than 3.8 knots, vessel speed will be subject to weather and current conditions encountered and may impact on data quality (particularly for the 3D-UHRS data) so shall be monitored and reported. Throughout the offshore survey activity, data quality checks shall be carried out on board by a suitably qualified and experienced. Any omissions, inconsistencies or other issues that may impair the quality, quantity or interpretation of the final data shall be immediately discussed

with the offshore CLIENT representative and suitable actions agreed to rectify any dataset deficiencies. The "live" generation of a near-trace cube is helpful in these matters.
During data acquisition, specialised industry standard survey/navigation software (online and offline) will be used which:

- Is capable of the full range of standard survey operations, geodetics, offsets, and survey sensor interface (data acquisition, computation, calibration, display and logging of data);
- Allows to perform basis QC (including observation of data coverage in near real time);
- Allows for data management;
- Allows for an aid for navigation for the skipper by way of a helmsman display, live positioning of the vessel, and display of the planned survey lines and positions.

The CONTRACTOR will include it's planned survey system setup in their proposal, indicating:

- All survey systems which will be installed on-board and their location;
- How the communication and interfacing between each system will be performed;
- And how all systems will be powered.

A print-out of the final on-board survey system database will be delivered in the contractor's Mobilisation and Calibration report. The system consists of all necessary IT software, hardware, and associated interface cabling and equipment. All recorded data shall be backed-up at least once a day. A suitable back-up system will be provided by the CONTRACTOR and presented in the CONTRACTOR's proposal.

Suitable field data processing shall be undertaken on board by suitably qualified and experienced personnel to identify any anomalous or specific field data of interest, so that further investigation can be made while the offshore work is ongoing as appropriate. Any specific data processing operations required as a result of the data acquisition configuration shall be associated with a QA operation onboard to assure that collected data are acceptable. The CONTRACTOR shall implement and perform suitable quality control procedures to ensure that data of appropriate quality are being collected. The CONTRACTOR shall ensure that the offshore CLIENT representative is sufficiently aware of any obligatory data processing operations that the offshore CLIENT representative can effectively perform QA role.

All offshore data processing is to be considered preliminary and subject to rework should it be found deficient. The onboard QA activities are specifically defined to assure that data acquired are fit-for-purpose. Any attempt at onboard *final* processing is to be secondary to the task of quality management of the acquired data.

Navigational accuracy, tidal height accuracy, frequency and method of navigation checks and positioning specifications shall be stated. Navigation and datum checks shall be completed prior to leaving harbour. The procedures to be followed in event of navigational non-compliance shall be logged and the offshore CLIENT representative advised at the Worksite.

Accurate positioning is essential, and in the discussion of interpreted Contact locations, interface depths *etc*. in reports and other documentation the chain of positioning errors (Contact to instrument package to vessel to GPS network) must be considered in order to provide quantified uncertainty values. The derivation of these uncertainty values must be explicitly described.

During UHRS acquisition, daily data quality assessment shall be performed by generation of stacks with the minimum feasible data processing operations to enable evaluation of quality. The shot quality shall be continuously monitored. The PEP must include, prior to the start of production data acquisition, a set of criteria for acceptable quality. For example a shot may be deemed 'bad' if navigation is lost, feathering angle threshold of 12 degrees is exceeded, streamer balancing is compromised, signal-to-noise ratio is compromised, source signature is poor/not constant, shot point distance is not constant and at required intervals or shots are missing/misfired, *etc*.

End-of-line quality assessment shall comprise of an end-of-line report summarising such pertinent QA monitors for all datasets being acquired. The content of the EOL QA shall be suggested within the CONTRACTOR's proposal as part of the PEP and finalised before production data acquisition begins.

The following must be agreed with the CLIENT before UHRS surveying commences:

• A Quality Assurance monitoring programme for the data acquisition (and updated in the project documentation).

• End of Line Acceptance criteria example:

  • Shots display

  • Near trace display for the entire time

  • Brute Stack for each volume

  • Navigation Merge Stacks

  • De-noise stacks

  • Amplitude spectrum measured from the near trace

  • RMS amplitude of the noise

  • RMS amplitude of the signal

  • Plot of source and receiver coordinates

  • Static correction QC

  • CDP binning/track plot QC

  • Penetration QC

2.4.1 *Offshore Representation*

Between 2 and 4 offshore CLIENT REPRESENTATIVES may be deployed offshore on each vessel during testing to facilitate optimisation and approval – suitable accommodation and messing shall be provided. If a port call is required to allow disembarkation of the CR, this shall be arranged to coincide with a planned port call at no charge, or a rate for a port call with no other purpose for CONTRACTOR shall be specified in the proposal. The CONTRACTOR will provide client representative free-of-charge with:

- Any PPE required to function on the vessel;
- Safety induction;
- Private cabin including office space with power supply;
- Access to communication systems;
- Access to messing facilities;
- Victuals;
- And an uninterrupted internet connection with a minimum speed of 512 kbit/sec upload/ download.

The CLIENT REPRESENTATIVES shall be allowed full access across the vessel as reasonably required to assess the qualitative execution of the service. CONTRACTOR will communicate the planned pick-up date at least 72 hours prior at a port agreed upon prior to the start of the works. The CONTRACTOR makes available to the offshore CLIENT Representatives capacity on the CONTRACTOR scheduled trips for its own personnel from land towards their survey or accompanying vessels.

2.4.2 *QAQC by CLIENT*

After demobilisation, CLIENT expects to be kept up to date of the processing of the data at a regular basis. A workshop (online or live) shall be organised by the CONTRACTOR two weeks after completion acquisition to discuss how the data will be processed and the structure and content of the Seismic processing report. CONTRACTOR shall send screenshots of processing output (before-after) of different areas upfront to be discussed during the workshop.

Follow up meetings shall be organised to regularly discuss the progress and until the final processing flow is agreed. The frequency is to be agreed between CONTRACTOR and CLIENT

(expected at least weekly at start). The progress review meeting will highlight any data challenges or problems encountered during processing.

The outcome of the processing workshops and iterations results in a draft Seismic processing report (see 2.7.4).

CLIENT also expects to be actively involved with work during the interpretation of individual survey elements and the integration stage (see also 2.6). A first workshop shall be held two weeks after the first processing workshop.
CLIENT-CONTRACTOR progress review meetings are to be held fortnightly with data examples shown and screen shares carried out with overview of data interpretation and delivery per block. The progress review meeting will highlight any data challenges or problems encountered during the interpretation. All interpretation preliminary (velocity) models across the site or per block and draft cross-sections will be shared at progress meetings with CLIENT prior to the assembly of the draft version of the Final Interpretation Reporting.

A workshop to finalize the interpretation shall be held prior to the assembly of the draft reporting at latest two (2) weeks before 1st revision Draft of the Interpretation Report.

2.5 Data Acquisition

2.5.1 *Mobilisation, testing, verification and calibration, demobilisation*

Mobilisation of the vessel(s) to the site will be considered completed when:

- All necessary survey and project documentation, equipment, spares, and personnel are accepted as operational, and all these aspects are optimised to the specification agreed and approved by the CLIENT.
- All equipment, including spares, has been validated;
- And alongside & offshore testing has been conducted to an agreed plan to demonstrate sensor settings are optimised to meet the survey requirements set out in this Scope of Work (SoW).

All required verifications, optimisations and calibrations of vessel and equipment (defined during TKOM) need to be documented, agreed, and signed off by both the RVO onshore Quality Expert Support, and offshore CLIENT Representative (CR).

Calibrations to be included at minimum:

- RTK/DGPS corrections (if not already done)
- Verify / Update geodetics in navigation software
- Dimensional Control Survey/Verification
- Establish (verify) vessel geometry
- DGNSS health check
- Direct comparison of primary and secondary DGNSS systems
- INS, Gyro and motion sensor calibrations
- Verification of entire setup
    - Wet test of MBES and SVP Absolute depth certification of the MBES system
    - Verification of both the SVP and the SVS;
- MBES patch test

For any equipment requiring factory calibration (e.g. SVP/ SVS) a calibration certificate will be provided proofing the equipment has been calibrated within the last 12 months at the time of mobilisation. At any point during the project execution, the calibration certificate shall not be older than 12 months.

The Contractor will propose descriptions of the following UHRS Acceptance Tests in the PEP. All resulting reports during execution are subject to Client and/or OCR approval, and combined in a MOB/MAC report.

- Through-test on all relevant cabling power cabling to ensure correct configuration.

- Datum transformation verification from ITRF(yy) to Project Datum of five (5) reference points (corners and centre).
- Head/Tail buoy GNSS Health Check
- Positioning test including positioning buoys
- Navigation recording test of beacons, with correct SEGY headers for every shot: FFID, Centre, receiver group
- ASCII format UHRS navigation file with sample log file and demonstration of import into UHRS processing software (e.g. RadExPro and ProMAX) and pairing with recorded seismic file.
- Source test at maximum energy expected for production for at least two (2) hours including reference (calibrated) hydrophone and pictures.
- Recording unit test (analogue system)
- Hydrophone tap test
- Integrated seismic spread test (during source test) with sparkers, streamers, auxiliaries, positioning, wifi and backup systems in place.

UHRS Test Requirements During Sea Trials

- Signature test: A calibrated reference hydrophone will be deployed 5 metres below each source. A file will be recorded at various energy levels.
- Streamer working noise limit, record the level of background noise, without firing the source, with a full spread deployed. with resulting noise mitigation action and determination of a level of acceptable streamer noise. Requirements for noise level and Signal-to-noise ratio are to be based on the tests performed at sea during mobilisation.
- Seismic source tow depth and monitor source ghost level to determine optimal tow depth.
- Streamer balancing.
- Positioning test comparing to MBES.
- Field verification test, running a full spread on a minimum of 3 swaths: 2 lines in opposite directions., and a third neighbouring line. Length of lines TBD, but as a minimum to satisfy the 1/4 size of a final cube. The 3D Volume must demonstrate the ITT requirements.
- Geological signal test: Record data over expected geology in survey area to ensure data quality meets all Contractual requirements – Can be combined with Field Verification Tests.

Where the final configuration of any survey equipment is not pre-defined in plans, (*e.g. where on-site configuration or optimisation is required)* ALL deployed options and spares are to be verified as operational during the mobilisation phase.

The harbour to be used for mobilisation of survey vessel(s), equipment and personnel is chosen by the CONTRACTOR with approval of the CLIENT. The harbour which will be used for subsequent port calls and crew changes is also to be chosen by the CONTRACTOR with approval of the CLIENT. Crew changes shall be organised at least every 28 days in a port within one day of sailing from the concession, or the closest suitable port.

Demobilisation of the vessel will be authorised when all the data required have been acquired and have passed field QA/QC criteria to the satisfaction of the offshore CLIENT representative and onshore QES.

Following equipment verification, a testing phase shall be implemented to establish the appropriate configuration and parameterisation of data acquisition equipment and finalisation of the survey QA parameters. A testing programme shall be agreed as part of the planning phase and should include the collection of data properly representative of the range of ground conditions at the site.

Provision shall be made for tests to be evaluated and signed off by both the RVO onshore QES, and onboard CR.

Acceptance by CLIENT of data acquisition configuration is expected to take place within 2 working days after mobilisation and testing. Production data acquired prior to acceptance of the data acquisition configuration is acquired at the CONTRACTOR'S risk.

Definitions of quality parameters are given in the document referenced below. CONTRACTOR is encouraged to apply assessment methodology as described in this document: Guidelines for the GNSS positioning in the oil & gas industry, International Marine Contractors Association, Report 373-19, June 2011

A draft mobilisation report (including calibration, verification, and testing phase results) is to be provided within one calendar week of acceptance of the data acquisition configuration to ensure smoother acceptance and set expectations for the final MOB report. This report is to be delivered both separately and included as an appendix to the Field (Operations) Report when this becomes available.

Examples of tests to conduct during testing phase (complete list shall be agreed on during TKOM):

- MBES –Perform an absolute depth check; the CONTRACTOR will propose a location and method to perform the depth check. Furthermore, patch and wet tests are required.

- Navigation – test correct navigation string is applied to each sensor, check measured layback where relevant[1]. Verify/ update geodetics in the navigation software.
- Positioning – verification of obtained x/y accuracy & absolute heights by all GNSS using an official datum point. The datum point to be proposed by the CONTRACTOR. Verification of the vessel's motion reference unit (sINS, Gyro, and motion sensor calibrations. Verification of the vessel's sound velocity profilers and sensors. Direct comparison of primary and secondary DGNSS systems.
- General – describe the timing/firing sequence, and steps taken to maximise lateral resolution and avoid interference between sensors. Establish/ verify the vessel geometry. Dimensional control survey/ verification.
- 3D-UHRS: Seismic source:
    - Test source energy level, frequency content and repeatability.
    - CONTRACTOR shall be encouraged to record far-field signatures of sources as being used in the survey or produce results from recent such recordings[2].
- 3D-UHRS: Hydrophone groups
    - Individual groups response shall not exceed more than 1% of specifications;
    - At least once every 500 m sailed a monitor record shall be made on which all streamer groups, including time break and near field hydrophone(s) are to be displayed.
- 3D-UHRS: Streamer
    - Before the start of the WORK, the streamer(s) shall be balanced and streamed at operational depth with minimal use of depth controllers.
- Polarity specification:
    - Recording polarity shall be in accordance with SEG specifications: a compression shall be recorded as negative number on file. Prior to the start of the survey, each hydrophone group shall be checked.

Noise tests to include RPM and speed tests:

- Deploy a calibrated reference hydrophone from the planned tow point for one of the central 3D-UHRS streamers, with a 40 m layback from the stern of the vessel.
- Test different combinations of propeller r.p.m and pitch settings around the desired survey speed of between 3-4.5 knots through water (STW) to identify the configuration with the least cavitation noise that will ensure most optimum settings to be used during all weather conditions without degrading data quality.

2.5.2 *Lost Equipment*

CONTRACTOR shall be responsible at his own cost for the marking the location and recovery of equipment dropped or lost during the execution of the project. CONTRACTOR shall mark the positions of equipment on or below the seabed with marker buoys if necessary and recover the equipment at the earliest possible opportunity.

CONTRACTOR is responsible for ensuring all necessary reporting to the relevant authorities is performed.

All reasonable possible attempts should be made to recover lost equipment.

For any non-electronic lost equipment not being recovered, a fee of €500 per piece is due to be paid by CONTRACTOR to an NGO selected by CLIENT for the purpose to support marine environmental protection.

[1] CONTRACTOR is encouraged to apply assessment methodology as described in this document: Guidelines for the GNSS positioning in the oil & gas industry, International Marine Contractors Association, Report 373-19, June 2011

[2] See SEG Standards for specifying marine seismic sources (1988).

For any other lost equipment not being recovered with circuit boards, hazardous fluids, or batteries inside, a fee of €5000 is due to be paid by CONTRACTOR to an NGO selected by CLIENT for the purpose to support marine environmental protection.

2.5.3 *Positioning*

Navigational accuracy, tidal height accuracy, frequency and method of navigation checks and positioning specifications shall be stated in project documentation. Navigation checks and positioning calibrations shall be completed prior to leaving harbour at mobilisation. The combined precision and accuracy of the navigational positioning capability and post-processing methods must be sufficient to allow horizontal positions of moving survey hardware to be determined to within ±1 m, with height values within ±0.1 m. Static measurements shall have DGPS positioning to ±0.1m in all 3 dimensions. Equipment must be positioned using DGPS systems...

Accurate positioning is essential. Coverage requirements dictate the 3D-UHRS data acquisition. Where seismic data are intended to be co-located an achievable positioning tolerance is to be agreed with the CLIENT, prior to the acquisition of production data. Co-location is defined as a common track of the reflection point at the seabed (near channel reflection point for UHRS).

The position of both the survey vessel and the equipment shall be monitored continuously during the execution of the works. Preferably RTK positioning is used for planimetric and altimetric positioning. In case this would not be available, DGNSS or PPP is to be used. All positioning should be tidal corrected.

An independent secondary and tertiary system will be provided, maintained, and operated during the survey. The secondary system is available as a backup to the primary system and can be used for online quality assurance of the primary system. When the primary and secondary system diverge, the survey shall be suspended. As a prudent practice, RINEX corrections will be recorded for the duration of the survey to allow for post-processing if required.

PPS timing will be supplied to all sensors requiring a timestamp. The pulses will be derived from the same single source.

The Gyro, INS, and motion reference units will provide the vessel's heading, heave, pitch and roll corrections. The sensors are to be aligned with the vessel's axes' and calibrated.

All sensors or to be positioned relative to the vessel's zero point (CRP).

- Gyro static accuracy: equal to or less than 0.5°
- Gyro repeatability: equal to or les then 0.25°
- Gyro resolution: equal to or less than 0.1°
- Surface X/Y positioning: equal to or less than 0.2 m accuracy
- Surface z positioning: equal to or less than 0.3 m accuracy

The CONTRACTOR must calibrate or verify the positioning system(s) in the work area or at similar water depth and demonstrate the validity of the calibration procedures prior to initiating survey work, synchronised using a Pulse Per Second signal (PPS).

2.5.4 *High Resolution Bathymetric Survey*

The objective of the High-Resolution Bathymetry (HRB) Survey is to contribute to the model of the seabed:

- Seabed elevations / depths relative to ALAT and MSL to support the calibration/reference of the 3D-UHRS survey;

Required elements

The HRB Survey must include:

- Area-wide bathymetric measurement;
- Repeat measurements on up to two transects, up to additional three passes;
- Sound velocity measurement (real time at receiver and min. 2 daily vertical profiling).

Specifications

Acquisition of high-resolution bathymetric data using a Multi-Beam Echo Sounder (MBES) with at least 120% coverage of the IA and the location of the Tie-lines.

The Contractor should strive to meet IHO Standard S-44 Edition 6[3] Special Order standard according to specifications issued by the International Hydrographic Association (IHO). The system shall be capable of providing a minimum of 6 soundings per 0.5x0.5 m cell when deployed on-site. The CONTRACTOR shall define the technology and line spacing employed to meet these requirements based on existing water depth information. Compliance with IHO Standard S-44 Edition 6 Special Order uncertainty thresholds must be demonstrated in the Field (Operations) report.

The following IHO S-44, ed-6 Matrix Code is to be used: Ba9, Bc10, Bd8, Be6, Bg9, Bh9 + 6 Pings/0.5x0.5m.

MBES data must be recorded with optimised settings for bathymetrical analyses of the seafloor.

Guidance

The system should incorporate a sound velocity probe to monitor the speed of sound in water in real time at the receiver to provide a constant comparison against a vertical Sound Velocity Profile (SVP) through the entire water column. The sound velocity sensor (SVS)incorporated into the MBES system should have an accuracy of better than ±0.05 m/s.

Vertical SVPs to measure the speed of sound in water should be obtained once per tide at a depth representative of the area being surveyed. SVP acquisition intervals may be increased with the agreement of the offshore CLIENT representative. Measurements should be made using a calibrated velocimeter or calculated using temperature, pressure, and salinity measurements, to create a static vertical SVP. Measurements should be taken continuously between the sea surface and the seabed in a vertical profile. The accuracy of the recorded depths should be within 0.5 m. The sound velocity measurements should have an accuracy of 0.05 m.

Reported water depths from MBES must be sound velocity corrected and reduced to ALAT by applying the latest ALAT model for the Dutch North Sea (NLLAT18[4]). Bathymetry relative to MSL shall be derived *from* the ALAT referenced data, for MSL reduction the latest DTU21[5] Mean Sea Level model shall be used. The methods for reduction shall be comprehensively explained in detail in the project plan and the final report.

Data Processing

Data shall be reduced to datum, then gridded to produce a raster Digital Terrain Model (DTM) of the seabed at 0.5 x 0.5 m resolution or better. Grids at 1.0 x 1.0 m and 0.5 x 0.5 m are required.

[3] https://iho.int/uploads/user/pubs/Drafts/S-44_Edition_6.0.0-Final.pdf

[4] https://english.defensie.nl/documents/2026/03/26/nllat2018

[5] https://ftp.space.dtu.dk/pub/DTU21/ Please note that DTU is in the TOPEX and mean tide system for use with satellites. DTU21 needs to be updated to ETRS89 ellipsoid and Tide Free system for consistency.

The reduction method and vertical and horizontal datums used must be compliant with Section 2.4, 2.5 and 2.6 and IHO standards and guidance (IHO, 2005[6]; IHO, 2020[7]). Details of the vertical reduction process (MSL and LAT) must be included in the Field (Operations) Report and demonstrated to meet or exceed the requirements of the specified standards and guidelines, using appropriate illustrations.

Full QA/QC must be carried out in order to generate statistical proof that the survey meets the requirements. A statistical description of Total Horizontal Uncertainty (THU) and Total Vertical Uncertainty (TVU) must be generated with the resulting values being demonstrated to meet or exceed the 'Special Order' minimum requirements described in the IHO Standard S-44 Edition 6 according to the matrix codes referenced above. A quantitative assessment of the feature detection thresholds for the survey must also be included and demonstrated to meet or exceed the Special-Order minimum requirements.

Offshore MBES Processing Requirements:

- Track processing/de-spiking & sound velocity corrections.
- Bathymetry data -xyz ASCII format, reduced to MSL.
- Bathymetric data cleaned on a line-by-line basis using area-based cleaning tools
- Manually delete largest residual outliers; line-by-line basis /using area-based cleaning tools which will also consider soundings/spikes/anomalies from adjacent lines
- Filters to be used to effectively removes spikes. The effectiveness /choice of the filters will be chosen dependent on geology/ environmental constraints
- Review the final soundings. Remove any residual noise
- Final deliverables to be in line with Table 4.

[6] IHO. 2005. Manual on Hydrography (C-13). International Hydrographic Bureau, Monaco, 1st ed. (corrections to February 2011), 36 pp.

[7] IHO. 2020. IHO Standards for hydrographic surveys (S-44). IHO Publications No. 44. International Hydrographic Bureau, Monaco, 6th ed., 49 pp

Deliverables

The following deliverables including their metadata are required at minimum:
Table 4: MBES deliverables

MBES deliverables						
Item ID	**Measurement**	**Module R = Raw P = Processing I = Interpretation**	**Description**	**Resolution**	**Format**	**Load into GIS-database**
a1	**MBES**	**R**	MBES output files	n/a	Native data format & .gsf	N
a2		**P**	Despiked, cleaned, positioning corrected soundings as x,y,z, per line, full density		Ascii+prj	N
a3						
a4			Subset of a2 for repeat lines		Ascii+prj	N
a5			Speed of sound in seawater vertical dip data profiles	n/a	.xlsx, PDF, Ascii+prj	N
a6			MBES tracks (navigation) data, Survey line ID and fix point index	n/a	.gdb, Ascii+prj	Y
a7			Gridded bathymetry, relative to LAT	0.5 m	Ascii+prj	N
a8			Gridded bathymetry, relative to MSL	0.5 m	Ascii+prj	N
a9			Gridded bathymetry, relative to LAT	0.5 m	Encoded Geotiff	Y
a10			Gridded bathymetry, relative to MSL	0.5 m	Encoded Geotiff	Y
a11			Gridded bathymetry, relative to LAT	1.0 m	Ascii+prj	N
a12			Gridded bathymetry, relative to MSL	1.0 m	Ascii+prj	N
a13			Gridded bathymetry, relative to LAT	1.0 m	Encoded Geotiff	Y
a14			Gridded bathymetry, relative to MSL	1.0 m	Encoded Geotiff	Y
a15			Height adjusted gridded bathymetry relative to LAT	1.0 m	.gdb	Y
a16			Height adjusted gridded bathymetry relative to LAT	0.5 m	netCDF*	Y
a17			Tile map index [polygon]	n/a	.gdb	Y
a18			Total Vertical Uncertainty (TVU) gridded XYZ	0.5 m	Ascii+prj	N
a19			Total Horizontal Uncertainty (THU) gridded XYZ	0.5 m	Ascii+prj	N
a20			Total Vertical Uncertainty (TVU) raster	0.5 m	Encoded Geotiff	Y
a21			Total Horizontal Uncertainty (THU) raster	0.5 m	Encoded Geotiff	Y
a22			Bathymetric contours, typically 1 m interval.	n/a	.gdb	Y
a23			Timestamp indexed text file of tidal correction	1 minute	.txt	N

Notes on MBES deliverables:

Raw:

- Raw output files from the MBES instrument are required as native data format of the used sensor/hydrographic survey software.

Processed:

- MBES trackplot (fix point and line).
- The bathymetry at a resolution of 0.5 x 0.5 m or better reduced to datums and produced by gridding the swath bathymetry data to a regular grid, as a single or tiled set of xyz text files (*.xyz/*.pts) without overlaps together with projection information saved in a .prj file; ***and*** a single or tiled raster/grid without overlaps.
- Bathymetry contours at an appropriate interval for the topographic complexity, the grid vertical accuracy/precision and the depth range (typically 1 m).
- Bathymetry Total Vertical Uncertainty (TVU) and Total Horizontal Uncertainty (THU) grids at an appropriate resolution, as: a single or tiled set of xyz text files (*.xyz/*.pts) without overlaps together with projection information saved in a .prj file; ***and*** a single or tiled raster/grid without overlaps.
- A timestamp indexed text file of the tidal correction.
- All raster deliverables for single-variable data should be supplied as single-band files with actual cell values (e.g. elevation). If provided in a non-ESRI GIS format (e.g. CAD, microstation), all processed deliverables listed above must be provided additionally in the project GIS archive.
- In case the above specified parameters cannot be met, the CLIENT should be notified and a motivation should be given. The CLIENT will decide if the provided motivation is acceptable to deviate from the specifications.
- All raster deliverables for single-variable data should be supplied as single-band files with actual cell values encoded (e.g. elevation, intensity).
- The processed data files should be of a maximum file size which can still be reasonably managed by a standard PC. The CONTRACTOR will propose a maximum file size in it's project documentation for acceptance by the CLIENT.

2.5.5 *3D Ultra High-Resolution Seismic Survey*

A 3D-UHRS data set will be acquired over the entire depth range of interest within the Sa 6/7-GP-Lot2.

The objective of the 3D- High-Resolution Seismic (3D-UHRS) is to contribute to the model of the sub-seabed including:

- Identification and mapping of potential hazards or influences on the development of offshore wind farm infrastructure at the site *e.g.,* faults, paleochannels, dipping structures, shallow gas, peat, interbedded soil units, gravel/till layers, outcropping/dipping bedrock, tunnel valleys, salt diapirs push-ups *etc.*;
- Identification and mapping of significant stratigraphic units and lithological horizons that characterise the site, the key geological units defined by the Geological Desk study and any other relevant literature or data; including soil types identified by seismic acoustic character
- Identification and mapping of subsurface structures that may represent changes in material properties relevant to the design, emplacement, and operation of Offshore Wind Farm infrastructure, i.e. paleochannels, paleo-valleys or enhanced porosity zones or dissolution pockets

The seismic image and interpreted preliminary velocity field are required. The depth range of interest is from seabed to a depth not less than 100 m below seabed for the 3D-UHRS survey.

Required Elements

- 3D-Multi-Channel Ultra High-Resolution Seismic (UHRS) surveying with a *high bandwidth* Sparker system suitable for the soil unitization across the site and a penetration of a minimum of 100m.

- Sound Exposure Level single strike (SELss) specifications are required in the tender in order to support CLIENT's application for an environmental exemption (underwater noise);
- Streamer number and length with cross cable and number of sources to be determined by CONTRACTOR;
- GPS positioning on source(s), and head and tail buoys of hydrophone cables;
- Delivery of the 3D-UHRS data as split blocks (expected # between 4 and 20) to be decided on award of contract between CLIENT and CONTRACTOR. This will be based on data volume and data handling efficiency.
- All recorded data should be delivered in one coherent and logically ordered dataset. All data must be referenced to a common vertical datum. Final time-domain seismic data must be corrected to a time-pseudo-datum corresponding to the vertical datum(s), all non-dipping water bottom reflections must tie within ≤0.1 ms.
- A low fold tolerance threshold for the near and far offsets acceptable criteria will be agreed between CLIENT and CONTRACTOR on award of the contract. This will be dependent on chosen CONTRACTOR's streamer length/number proposed and acquisition settings for sources.
- Use of 3D regularisation OR Flex Binning for final processing to enhance signal to noise ratio, preserve amplitudes and phase, and reconstruct any missing traces BUT CONTRACTOR must demonstrate how the lateral and vertical resolution of the data will be preserved. Previous project examples shall be included in the Project Implementation Plan and method statements.
- The Project Execution Plan, to be provided as part of the tender, shall demonstrate the CONTRACTOR's technical understanding of streamer length to the number of hits per bin relationship by way of acquisition set up diagrams and fold plots.

Required Specification

Data acquisition should be designed to optimise vertical and horizontal resolution (defined here as ¼ dominant wavelength), the signal-to-noise ratio and the recovery of coherent signal throughout the depth range of interest. Below contains the minimum resolution requirements. Better resolution means a better proposal as described by the Tender Document.

Resolution to 50 m below seabed:	Offshore Acquisition Bin size: <6.25 m
	Vertical resolution <1 m
	Lateral resolution <10 m
Resolution from 50 m below seabed to at least 100 m below seabed:	Vertical resolution <2.5 m
	Lateral resolution <25 m

A time to depth data conversion is required. Horizons and units are to be reported on in the depth domain. The velocity field is to be assessed by CONTRACTOR to determine most suitable CDP interval for stacking velocities, based on the required resolution of the data to delineate/interpret units, features and structures to be able to assess presence of geohazards to a high degree of confidence. CONTRACTOR is to provide stacking (semblance gathers) and interval velocity displays and full processing flows. And finally, CONTRACTOR is to propose processing techniques and time estimates for delivery of the final depth converted product.

Note that the required bin should be square. Note that the specification is *outcome focussed* and required that the *delivered* (*i.e.* processed) data meet the resolution and signal penetration criteria.

Table 5: Other required 3D-UHRS survey parameters

Other required 3D-UHRS survey parameters	
Minimum offset	As close as feasible to the source, yielding processable traces, and not exceed 10 m
Maximum offset	Not less than 90 m and not greater than 150 m
Minimum Nominal (native/acquisition) CMP fold	Not less than 24
Minimum Effective fold	Not less than 12 everywhere
Offshore Acquisition Bin size	2-6.25 m. Positions of bin-centres shall be accurate to within 1.0 m in horizontal directions
Feathering	Not greater than 12 degrees, unless it can be compensated by shooting with the tides
Record length	Shall be minimally 0.250 s
Acquisition Time sample interval	0.5 ms at maximum. CONTRACTOR to define any processing changes at depth if data re-binned below 50 m.
Velocities	Stacked and Interval velocity volume SEGY deliverables. CDPs To be picked at minimum every 250 m

Anti-alias filter setting	Start at 60% of Nyquist frequency with an attenuation of at least 30dB cut off CONTRACTOR to determine filter type.
Misfires	No more than 5 consecutive misfires and no more than 5% on any line
Channels	No more than 2 dead channels in 1 line and no adjacent and none in first 6 channels

Various geometries of sources, receivers, and shot and receiver intervals will be assessed. Proposals for configurations meeting the minimum requirements need be discussed with and approved by CLIENT prior to commencing the WORK. Minimising the sailing effort is strongly encouraged.

Positioning of all components of the seismic instrumentation is to be accurately monitored using GPS antennae at key points, and supplemental positioning processes where applicable to improve accuracy. Depth control of seismic sources and streamers is to be maintained within defined tolerances and described in method statements within the project documentation.

Specification of acceptable fold shall be defined based on a maximum number of adjacent bins failing a minimum fold criterion (a gap) corresponding to a maximum acceptable size, with limitation on the number of smaller gaps per km^2. A working criterion for application shall be:

- Low fold criterion is defined as nominal CMP fold within a defined bin to be proposed by CONTRACTOR in relation to the objective of this survey for soil unitization across the site in order to achieve the stated vertical and horizontal resolution requirements.
- Maximum dimension of low fold zone (gap) to determine if infill shooting is necessary is to be determined by CLIENT on chosen CONTRACTOR's proposal
- Maximum percentage of low fold bins in an area is 4%, otherwise consultation with CLIENT is required to decide if infill shooting is needed;

Initial tolerances shall be agreed at TKOM and finalised after offshore testing in conditions representative of the site. The CLIENT objective is to limit the infill to a minimum. Continuous monitoring of CMP fold during the survey is mandatory. Required infill will be discussed onboard during acquisition.

All systems generating acoustic signal must conform to the sound pressure specifications described in the environmental permit. Acoustic deterrent systems and procedures are to be implemented and shall be described in the project documentation.

Guidance

A line-plan must be submitted with the CONTRACTOR's proposal as a properly referenced shapefile with description of line spacing and bearing of the primary direction.

Diagrams illustrating the source and receiver configuration leading to the desired Offshore Acquisition and Final Processed bin size and fold is required in the project documentation.

Vessel(s) or other platforms selected for data acquisition must be established as *low noise* relative to the type of seismic data acquisition proposed, with particular reference to the seismic source power and spectral characteristics in the context of the sea-bed conditions of the IA. Demonstration via representative data should be provided.

It is required that seismic sources and hydrophone cables are deployed by personnel demonstrably experienced in their back deck layout configuration and winch set ups, and all parameterisation, and optimisation from mobilisation and calibration phase to start of operation phase. Team composition and their project history and track record will be part of the evaluation of bids. Expert 3D-UHRS mobilisation engineer track records will be paramount to tender award.

Slant-cable is acceptable if the vessel operations and data processing teams are demonstrated to have had prior successful experience of the systems proposed. Positioning and depth control must

be monitored and documented. Any required data processing and QA schemes enabling the use of slant cables must be described and demonstrated to be established in production work.

Data Processing

3D-UHRS data processing is to be applied to ascertain adherence to stated requirements. Full reporting is required including a Field (Operations) Report and Seismic Processing Reports.

Offshore and onshore data processing will be monitored for quality, and CLIENT may require opportunity to inspect data, provide input and request modification at any point prior to delivery. Offshore QA data processing of 3D-UHRS data should be comprehensively tested, reported, and signed off by CLIENT on up to 3 sail-lines prior to production processing. Requirements for data delivery during survey with the purpose of QAQC by CR and/or CLIENT are listed in Table 6.

CONTRACTOR shall have the necessary hard drives available on board for the exchange of required data sets for QC at each crew change.

3D-UHRS data should have 'brute stacks' for a single inline generated for use in the QA operations on-board. Brute Stacks should contain the minimum processing required to evaluate the quality and penetration of the recorded data. A suggested 'Brute stack' processing sequence should be provided in the proposal in the PEP. Brute stacks form one element of the deliverables set.

The data are to be located using accurate positioning. Surveyed source and receiver positions should be verified prior to identing respective trace headers. Geometry assignment should be carried out such that each trace has its own unique co-ordinate pair associated with its common mid-point (CMP). A description of the geometry assignment procedure must be included in the Field (Operations) Report and the Seismic Processing Report raw shots with assigned geometry included in headers are a deliverable.

Full navigation editing must be carried out to ensure that erroneous, zero and duplicate co-ordinates have been removed and new values interpolated. Trace numbering must be sequential in increments of 1, with no duplicates. Navigation data must be included in header bytes 73-80 and 81-88 for pre-stack shot and receiver locations, and 181-188 for stacked CMP data.

3D-UHRS stack trace headers should conform to SEG Y Rev1 (2002)[8] in structure and should contain the appropriate information, including survey metadata in the text header.

Time correction for the source and receiver elevation to a single datum is required such that the 3D-UHRS data have their seabed signal aligned in the seismic interpretation project. Non-dipping seabed reflections should tie to ≤0.1 ms. Datum corrections should be written to the pre-stack header but *not* applied to the data.

[8] May be downloaded from http://www.seg.org/resources/publications/misc/technical-standards.

Table 6 Data delivery requirements for QAQC by CR and/or CLIENT

Frequency	Data	Description	File Type	Shared with:
Every 24 hrs	QA/QC	End of Line Acquisition checks (i.e. amprms QC, track plots, amplitude source spectra, streamer depth)	.SHP *** Fold plot to be included in all DPRs***	From Contractor RepCo to CR **ALSO** to QES during mobilisation & initial project phase
Every 48 hours	Fast-track processing	Accumulative outline of the 3D UHRS coverage (Fold check) & brute stack QC	.SHP *** Fold plot to be included in all DPRs***	From Contractor RepCo to CR & QES
48hrs *AFTER* completion of 800km or after 7 days (which ever comes first)	Navigation data	Test lines to be sent during Mobilisation & on request to OCR & QES: Line sections of Full Nav-merged SEG-Y	P1/90 .SHP	From Contractor RepCo to CR & QES
	QC Plots & Logs		.XLSX	
	UHRS raw data		Screen shot (SEG-Y on request)	
	UHRS Brutestack		Screen shot	
2 weeks after completion of each block at each crew change of approx 4 weeks	Block coverage	Merged seismic/navigation Shot gathers	.SHP	From Contractor RepCo to CR to QES

Some, or all operations of the final, production processing sequence 3D-UHRS data may be applied onboard or ashore (the preferred option). In either case the details of all processing undertaken must be explained and discussed in the Seismic Processing Report. At minimum, the processing operations applied to each dataset must be described and parameter tests presented. An outline prediction of the 3D-UHRS 'Final stack' processing sequence should be provided in the proposal in the PEP, with options presented as appropriate. The QC processing sequence should include at minimum:

- Positioning and Geometry assignment;
- Trace editing
- Static corrections
- Re-datuming to MBES Bathymetry
- Apply recording delay correction static: 0 ms
- Denoise: e.g. suppression of cable-, tow-, ship-noise;
    - Swell noise attenuation
    - Linear noise attenuation
    - Bubble pulse suppression
    - Source and receiver de-ghosting
- De-skew; Zero phasing
- Signal conditioning (e.g. signal deconvolution, de-ghosting);
- True Amplitude Recovery;
- Stacking velocity analysis at regular intervals of < 250 m;

    - Velocity analysis (TBD during processing tests. Highly dependent on geological complexity and site conditions)
- De-multiple: e.g. suppression of water bottom multiples with proposals for use of:
    - SRME
    - Hi-Res Radon
    - Parabolic hi-res Radon multiple attenuation, if required;
- NMO correction, mute and stack;
- Post-stack time imaging or better.
    - Kirchhoff Pre and Post-stack Time Migration
- Residual moveout correction (TBD during the onshore tests and agreed in the processing workshop)
- Final stack (Full offset and angle stacks)
- Amplitude inverse-Q filtering
- Post-stack processing including noise attenuation and gain.

Notes on data processing

- As a first (onboard) 3D-UHRS data QC step; make use of near trace cubes.
- Fully edited traces, including merging with navigational data, should be delivered. Export of acquisition data in SEG-D format, and of idented traces in SEG-Y format. Post plot navigation data to be exported in IOGP P1/11 format.
- Interpreted seismic velocity is required to be delivered with appropriate QA metrics. Stacking velocity interpretation is required to record length. Velocities are to be supplied as ASCII and a 3D velocity cube (SEGY format).
- The method by which depth values have been obtained from the seismic time picks, and the velocity used for converting seismic interpretation to depth must be described and provided as SEG-Y if appropriate.
- A Seismic Processing Report should be delivered with all QC processing parameters, such that the work eventually can be reproduced.
- CONTRACTOR to propose methods of noise reduction, signal preservation; detailed assessment of fold per bin (regularisation or flex binning) with spatial resampling strategy, demultiple techniques, and migration strategies.

Interpretation

The 3D-UHRS are to be interpreted using a seismic interpretation system. The 3D-UHRS data are to be loaded to the workstation project in the time domain. 3D-UHRS final interpretation is to be provided in the workstation project in the **DEPTH** domain, converted using a preliminary velocity field to be defined during the project and approved by CLIENT.

The definition of stratigraphic horizons to be interpreted shall be finalised by agreement between CLIENT and CONTRACTOR during the course of the project. The number of interfaces (horizons) should be proportional to what is observable within the resolution and quality of the data; sub-seabed horizons plus interpretation of buried channel-like features should be anticipated to a resolution of a few metres in thickness. (reference GDS). Interpretation of indication of geohazards relevant to windfarm planning shall be provided.

The integrated interpretation of 3D-UHRS data is discussed in section 2.6.

3D Multi-Channel Ultra High-Resolution Seismic survey deliverables

The following deliverables and their metadata are required at minimum:

Table 7: 3D Multi-Channel Ultra High-Resolution Seismic deliverables

3D Multi-Channel Ultra High-Resolution Seismic deliverables						
Item ID	**Measurement**	**Module R = Raw P = Processing**	**Description**	**Resolution**	**Format**	**Load into GIS-database**
g1	**UHRS Seismic**	**R**	Raw navigation merged shots * SEG-Y data need to have fully idented trace headers including navigational data	n/a	SEG-Y and SEG-D	N
g2			Multi-streamer sail line tracks (navigation) data, Survey line ID included as attribute [lin]	n/a	.gdb	Y
g3			Multi-streamer sail line (navigation) data, fix point included as attribute [ptn]	n/a	.gdb	Y
g4			EOL QC document (For every line provided every 24h)	n/a	.pdf	N
g5		**P**	QC log sheet (provided every 24h and final version at EOJ)	n/a	.xlsx	N
g6			Brute stack of priority lines as 2D SEGY (extracted from 3D acquisition)	n/a	SEG-Y	N
g7			Brute stack *	n/a	SEG-Y	N
g8			Pre-stack time migrated CMP Gathers	n/a	SEG-Y and SEG-D	N
g9			Demultiple stack (time domain)	n/a	SEG-Y	N
g10			Final Bin fold plot	Bin size 2-6.25x6.25 m	raster	Y
g11			Final stack (with post migration band pass filtering) (time domain)	n/a	SEG-Y	N
g12			Interval velocity file	n/a	SEG-Y	N
g13			RMS stacking velocity file	n/a	ascii	N
g14			3D-UHRS Navigation	n/a	Ascii (P1/90)	N

Milestone	**Data Description**	**File Type**
12 weeks after completion field works.	RAW field data	SEG-D
	Multi-streamer sail line tracks (navigation) data, Survey line ID included as attribute [lin]	.gdb
	Multi-streamer sail line (navigation) data, fix point included as attribute [ptn]	.gdb
	EOL QC document (For every line provided every 24h)	.pdf
	QC log sheet (provided every 24h and final version at EOL)	.xlsx
	Merged seismic/navigation Shot gathers	SEG-Y

Milestone	Data Description	File Type
	Fully Pre-Processed Input to Migration Gathers	SEG-Y
	Pre-stack time migrated CMP gathers	SEG-Y
	Raw Stack with Post-stack Migration; Full offsets	SEG-Y
	Final Stack with Post-stack Migration – Full offsets	SEG-Y
	Zero Phase Filter	SEG-Y/ASCII
	RMS Stacking Velocity	ESSOV2
	Migration Velocity	ESSOV2 & SEG-Y
	Observer Logs	PDF
	QC Logs	PDF
	Line Listing	PDF
	Raw Navigation	IOGP P2/11
	Navigation (with final migration CMP positions)	IOGP P2/11

Notes on 3D multi-channel UHRS deliverables:

Raw:

- Multi-channel raw seismic data with geometry and correct navigation applied (shot gathers) in SEG-Y and SEG-D format.

Processed:

- Trackplot for sail lines of the 3D-UHRS survey (point and line);
- Raw, nav merged shot gathers and a full set of CMP gathers without NMO correction are required to facilitate reprocessing, in SEG-Y format;
- Stacked, imaged seismic data with correct navigation and tidal correction applied in SEG-Y format;
- Velocity model to be provided for time depth conversion across entire site

2.6 Data Integration

Lot 2 CONTRACTOR shall integrate the Lot 1 and Lot 2 datasets into one coherent Preliminary Ground Model (PGM). The purpose of this PGM is to deliver the aggregation of the data associated with the seabed itself (MBES, SBP, SSS, MAG; SoWs Annex [5]-Section IV Lot1) and the

aggregation of the data associated with the sub-seabed (SBP; SoW Lot 1 and this SoW Lot 2) to inform the design of the anticipated Geotechnical Investigation.

The integration operations required of the PGM are principally the aggregation of the seabed data (MBES, SSS, MAG), the aggregation of the sub-seabed data (UHRS, SBP) to deliver a sub-seabed workstation project, a set of interpreted datasets, and the integration of all suitable data elements into a GIS project, and the Final Interpretation Report.

The integration will be performed by the Lot 2 CONTRACTOR**. The Lot 1 CONTRACTOR is expected to reasonably assist the Lot 2 CONTRACTOR** by providing information on the datasets, the processing steps taken, and the conclusions drawn within one week (5 working days) of the Lot 2 contractor request. The Lot 2 CONTRACTOR will reprocess the SBP data by performing a time to depth conversion of the dataset, using the velocity model applied to the UHRS data.

The PGM is expected to be updated, incorporating the output of the Geotechnical Investigation to form an Integrated Ground Model (IGM) which is expected to develop the subsurface geological model extensively. The construction of the IGM is outside the scope of the Geophysical Investigations.

As mentioned in section 2.4.2, CLIENT expects to be actively involved with work during the interpretation of individual survey elements and the integration stage. **A workshop to finalise the interpretation shall be held prior to the assembly of the draft reporting** at latest two (2) weeks before 1st revision Draft of the Interpretation Report.

The 3D-UHRS data interpretation should result in a sub-seabed seismic interpretation project, the integration of all suitable data elements into a GIS project, and the Final Interpretation Report.

SBP and 3D-UHRS subsurface data are to be loaded into a seismic interpretation system at least capable of representation of all subsurface data elements in a common system.

3D-UHRS acquired within this Lot 2 survey, are required to be compatible and referenced to the same vertical datum as SBP data acquired within the Lot 1 survey.

2.6.1 *Outputs – sub-seabed data integration*

The output of the subsurface data integration shall be:

- Seismic workstation project incorporating SBP data of Lot 1 and 3D-UHRS data of Lot 2, horizon picks, grid, and other information used in the interpretation.
- 75 x Geological cross-sections (50 x 'inlines' and 25 x 'crosslines') identifying all significant features and DEPTH converted horizons (superimposed on the processed seismic data) to a depth of 100m on one or more A0 charts at an appropriate scale. The cross-sections shall at least include the lines corresponding with the Lot 1 output.
- Gridded elevation surface and contours (isolines) for each interface showing depth to top of formation/formation member/unit below datum (LAT), provided electronically as ascii data and ArcGIS geodatabase elements.
- Gridded depth below seabed and depth below seabed contours of each formation/formation member/unit provided electronically as ascii data and ArcGIS geodatabase elements.
- Gridded thickness of each formation/formation member/unit provided electronically as ascii data and ArcGIS geodatabase elements.
- Mapped extents (lateral and thickness) for each formation/formation member/unit and laterally extensive geohazard (*e.g*. shallow gas, peat, or buried channels) electronically as ascii data and ArcGIS geodatabase elements and as one or more A0 charts at an appropriate scale.
- Preliminary zonation of the site into zones of common geological sequence as ESRI shapefile, for input to geotechnical campaign planning.

The following output deliverables are required at minimum:

Table 8: Sub-Seabed integrated interpretative deliverables.

Sub-Seabed integrated interpretative deliverables						
Item ID	**Measurement**	**Module I = Interpretation D = Database**	**Description**	**Resolution**	**Format**	**Load into GIS-database**
i1	**Integrated SBP UHRS**	**I**	Horizon files for each interpreted stratigraphic or other horizon or interface, XYZ (**in meters below LAT**) and XYT	n/a	Ascii+prj	N
i2			Gridded elevation surface for each horizon or interface, reduced to ALAT and MSL datums, XYZ	tbc	Ascii+prj	N
i3			Gridded elevation surface for each horizon or interface, reduced to ALAT and MSL datums, raster	tbc	Geotiff	Y
i4			Gridded elevation surface for each horizon or interface, below seabed, XYZ	tbc	Ascii+prj	N
i5			Gridded elevation surface for each horizon or interface, below seabed, raster	tbc	Geotiff	Y
i6			Gridded thickness map for each unit, XYZ	tbc	Ascii + prj	N
i7			Gridded thickness map for each unit, raster	tbc	Geotiff	Y
i8			Elevation Contours for all gridded surfaces, reduced to ALAT and MSL datums [line]	tbc	.shp, .gdb	Y
i9			Elevation Contours for all gridded surfaces, below seabed [line]	tbc	.shp, .gdb	Y
i10			Extent polygons for sub-seabed geology [polygon]	n/a	.shp .gdb	Y
i11			Processed SBP data with navigation and heave correction applied in depth domain, ALAT and MSL, time-depth converted using UHRS velocity model	n/a	SEG-Y	N
i12			SBP Horizon interpretation for all tracks, provided by Lot 1: xyz file per horizon (in ALAT and MSL). Time-Depth converted using UHRS velocity model.	For all horizons identified within the top 10 m and 0.1-0.2m vertical resolution	Ascii	N
i13			Laterally extensive geohazard (such as shallow gas, boulder field or peat) [line, polygon]	n/a	.shp .gdb	Y
i14			Faults [line]	n/a	.shp .gdb	Y
i15			Area of faulting [polygon]	n/a	.shp .gdb	Y
i16			Preliminary zonation	n/a	.shp, .gdb	Y
i17		**D**	Kingdom / Comparable Seismic project including all SBP and 3D-UHRS data in the time domain. Interpreted horizons to be included in TWTT, and grids to be provided in depth below ALAT.	n/a	.tks or comparable	N

Notes on sub-seabed integrated interpretation deliverables:

- Text (or csv) horizon files for each interpreted geological surface (including seabed and interfaces/features that were of too small extent or too sparse to be gridded) to be provided in an exchangeable format with at minimum fields for XY coordinates, survey line name, shot point/trace number, two-way time, and elevation relative to ALAT and MSL

- Elevation surfaces for all interpreted horizons at an appropriate resolution (~0.25-1 x line spacing, to be agreed with CLIENT), reduced to datum, and produced by gridding the horizon data to a regular grid, as an xyz text file (*.xyz/*.pts) ***and*** a raster/grid. Products to be delivered relative to both ALAT and MSL datums.
- Elevation contours relative to ALAT and MSL for all interpreted horizons at an appropriate depth.
- Thickness maps for all interpreted units as an xyz text file (*.xyz/*.pts) ***and*** a raster/grid. Limited to the lateral extent of the unit. Products to be delivered in meter.
- Depth below seabed information for all interpreted horizons at the same resolution as the elevation grids, as an xyz text file (*.xyz/*.pts) ***and*** a raster/grid.
- Depth below seabed contours at an appropriate interval.
-
- Formation/formation member/unit and laterally extensive geohazard (such as shallow gas, boulder fields or peat) extents as polygons in ArcGIS, AutoCAD or Microstation format or similar. Extent polygons should:
    - include and clearly indicate areas where the unit/feature is thought to be present, but the base/top cannot be interpreted; and
    - exclude areas where the unit/feature is absent.
- Faulting as linear features (individual faults) and/or polygons (areas of faulting).

All raster deliverables for single-variable data should be supplied as single-band files with actual encoded cell values (*e.g.* elevation, intensity), not as multi-band RGB images. If provided in a non-ESRI GIS format (*e.g.* CAD, microstation), all processed deliverables listed above must be provided additionally in the project GIS archive.

2.6.2 *Geographic Information Systems*

A project Geographic Information System (GIS) archive is to be delivered in a single GIS deliverables folder with metadata in accordance with requirements as specified Appendix A. Accompanying map document(s) (*.mxd), containing data as specified throughout this Scope of Work should be provided.

Data should ideally be provided in a geodatabase file, but shapefile data would be acceptable with appropriate handling of 'null' values.

The GIS data must be consistent with all other data deliverables (*e.g.* Kingdom-generated elevation grids and GIS elevation rasters should match, *etc.*).

The GIS data archive must include *at minimum*:

Table 9: GIS deliverables

GIS deliverables						
Item ID	**Measurement**	**Module M = Map D = Database Meta = Metadata**	**Description**	**Resolution**	**Format**	**Load into GIS-database**
k1	**all**	**M**	Master Map document	n/a	.mxd	Y
k2	**all**	**D**	ArcGIS geodatabase	n/a	.gdb	Y
k3	**Survey**	**D**	Project area, wind farm and survey boundaries (polygons).	n/a	.gdb: polygon	Y
k4	**Tracks**	**D**	Vessel trackplot(s) and fix points.	n/a	.gdb: line, point	Y
k5	**Tracks**	**D**	Sensor trackplots and fix points	n/a	.gdb: line, point	Y
k6	**Seabed**	**D**	Bathymetry grid and contours.	Full	.gdb: raster, line	Y
k7	**Seabed**	**D**	TVU and TVH uncertainty grids.	Full	.gdb: raster	Y
k8	**Geology**	**D**	Elevation grids and contours for all interpreted interfaces	Full	.gdb: raster	Y
K9	**Geology**	**D**	Thickness grids for all interpreted units	Full	.gdb: raster	Y
k10	**Geology**	**D**	depth below seabed grids and contours for all interpreted interfaces	Full	.gdb: raster	Y
k11	**Geology**	**D**	Polygon extents for each identified geological unit, Formation, and features (e.g. boulder fields, gas, channels, areas of faulting, etc.)	n/a	.gdb: polygon	Y
k12	**Geohazards**	**D**	Point and polyline geohazards (e.g. channels, areas, etc.)	n/a	.gdb: point, line	Y
k13	**all**	**Meta**	Metadata to specifications provided in scope and appendix A	n/a	.gdb	Y

Notes on GIS deliverables:

- Sensor trackplots and fix points (transmitter/receiver midpoint where transmitter and receiver are not co-located; CDP-based for the 3D-UHRS trackplots).
- Elevation and depth below seabed grids and contours for all interpreted interfaces (including gridded geohazards, *e.g.* top shallow gas). Grid and contour coverage must be consistent with the associated extent polygons.
- Polygon extents for each identified geological unit and Formation and all spatially extensive geohazards (gas, significant channels, areas of faulting *etc.*). Areas where an interface or geohazard is thought to be present but is not interpretable must be differentiated from areas where it is thought to be absent.
- Point and polyline geohazards (shallow gas, boulder fields, isolated peat occurrences of too small an extent to be gridded, *etc.*).
- The master map (*.mxd document) should include a layout containing at minimum a map window (with appropriate graticule), scale bar and legend. All data should be symbolised using similar schemes as per the report charts for ease of cross-referencing.
- Layers should be grouped into meaningful categories (background mapping, geohazards, seabed features, *etc.*) and layer and group names should be used that can be easily cross-

referenced to the report text and charts (rather than simply using the feature class/grid names).

2.7 Reporting

The reporting requirements for the geophysical survey work are as follows:

2.7.1 *Mobilisation and Calibration Report*

A Mobilisation and Calibration Report shall be made available for Sa 6/7-Lot2 one (1) week after completion of mobilisation. This report shall include at a minimum the following sections:

- INTRODUCTION, including but not limited to:
  - Project Overview, Scope of Work, Survey Area, Reference documents
- SURVEY PARAMETERS, including but not limited to:
  - Horizontal Datum, Coordinate Transformations, Test Coordinate, Vertical Datum, Projected Coordinates, Geodetic Coordinates, Time and Log Keeping, Survey Units, Vessel Reference System And Rotation Convention
- RESOURCES, including but not limited to:
  - Vessel, Survey Equipment, Software, Personnel, Nearshore Personnel, Onshore Personnel
- QHSE, including but not limited to:
  - SOCs, Toolbox talks, Muster Drills
- MOBILISATION AND CALIBRATIONS, including but not limited to:
  - Activity Summary of field procedures, Vessel Calibrations, Navigation, Sub-sea positioning, Sound Velocity, MBES, UHRS verification and acceptance test results.
- APPENDIX A - CALIBRATION REPORTS
- APPENDIX B - SVP CALIBRATION CERTIFICATE
- APPENDIX C - VESSEL DIMENSIONAL CONTROL SURVEY REPORT

2.7.2 *Daily & Weekly reporting*

Besides the reports to be delivered as result of the surveys as specified in Annex [5] - Section IV (Scope of Work), CONTRACTOR shall issue daily, and weekly project progress reports as detailed below.

The purpose of this reporting is to inform CLIENT on all aspects of CONTRACTOR's performance over the period of reporting and to give an up-to-date and clear picture of the project progress such that CLIENT can directly establish whether the project is on schedule and within budget.

At the start of the project CLIENT and CONTRACTOR shall agree on the content and frequency of the reporting. CONTRACTOR shall provide accurate reports of the progress of the project and shall highlight all trends that have impact on the execution of the WORK.

During the offshore execution of the works CONTRACTOR shall issue to CLIENT **Daily Progress Reports (DPR)** to be submitted before 09:00h CET each day, providing full details of previous 24 hours' work and results.

The format and content of the daily report shall be submitted to the CLIENT for approval prior to implementation, but shall include as a minimum:

- Activities executed in the past 24 hours and cumulative to date described in all phases.
- Activities planned for the upcoming 24 hours.
- Any occurrence causing delay to the project with consistent abbreviations/codes, including but not limited to
  - Equipment downtime.
  - Scheduled maintenance.
  - Instrument calibrations.
  - WAITING ON WEATHER.
  - Weather standby below WORKABLE WEATHER LIMITS.
  - Other standby.
- Daily observation and registration of weather and sea state.

- HSE occurrences such as incidents, accidents, near misses, safety meetings, safety stand downs, number of HSE observations, together with measures taken and status
- Non-conformance reporting

The DPRs will be provided in a consistent PDF format and will preferably not be scanned. DPRs are to be signed by the CLIENT offshore representative before issuing to CLIENT, unless the contents are subject of dispute.

CONTRACTOR shall issue to CLIENT **weekly progress reports**. These weekly progress reports shall provide progress data on the progress achieved during the reporting period of critical phases. The weekly progress report of CONTRACTOR shall include - but not be limited to - the following subjects:

- Work in progress;
- Health Safety & Environment;
- Safety Statistics;
- Status summary work schedule, including weekly planning update.
- Forward looking information for the next two reporting periods.
- In case of deviations from the program: proposals for remedial action together with any revised plans and projections needed to substantiate or explain proposals.
- Status of queries / concession requests.
- Risk Log including areas of concern and actions taken to address them.
- Change control, including list of issued and Potential Variation Orders and their status.
- Updated document register.
- Photographs of relevant achievements.
- Areas of concern.
- Overview of the total time spend Waiting on Weather

The Weekly Progress Report shall be based on a week cut-off date being each Sunday at 24:00h. CONTRACTOR shall issue the reports before Tuesday 12:00h (midday), following the cut-off date, and at least 4 hours before the start of the weekly progress meeting.
The CONTRACTOR will arrange a weekly progress meeting with the CLIENT and QES of a minimum duration of 1 hour, including all key personnel (for meetings in referred to [Annex 5_Section VI]). During the meeting when the geophysical survey is ongoing, the Weekly Progress Report and progress of the work will be discussed as well as any technical or HSE issues which might have arisen.

2.7.3 *Field (Operations) Report - Geophysics*

A Field (Operations) Report shall be made available for the Sa 6/7- Lot2 within five (5) weeks of demobilisation. The Field (Operations) Report shall contain daily logs and summaries of the work completed, together with any preliminary results that can be provided.

The Field (Operations) Report should include as a minimum:

- Introduction
    - A statement of the purpose of the investigation and Scope of work
    - Executive summary including the end results and conclusions (in Dutch and English)
- Project Details
    - Dates, Times, and locations of the survey;
    - Project geodetic parameters;
    - Acquisition methodology for each dataset;
    - Quality Control procedures and reference to specifications and standards adopted and any deviations from them for each survey type;
- Field operations:
    - End-of-line reports;
    - Health & Safety records, Incident reports and safety meeting minutes as well as mitigative measures taken;
    - Any technical and qualitative incidents occurred, and the mitigative measures taken;
    - Environmental observations;
- Equipment used
    - Equipment list including their serial numbers

    - If instrument configurations were changed in the field, each instrument configuration
    - An overview of all vessels involved in the operations
    - Vessel Offset Diagrams for each vessel
- Personnel involved
    - An overview of all personnel which was involved on the project (name, vessel deployed on, function, and date present (GDPR compliant)
- A daily log summarizing the sequence of events
- Appendices
    - Copies of the daily reports
    - Copies of the incident reports
    - Survey logs
    - Any other relevant survey documentation
    - A copy of the final survey database (PDF and digital)
    - Raw data

It is the intention of the CLIENT to publish the operations report. Therefore, CONTRACTOR is encouraged to make sensitive information (e.g. personnel details in DPR's, safety observations, incident reports) easily redactable, at CONTRACTORS discretion.

The CONTRACTOR shall provide a Draft Field (Operations) Report, through ftp-site or other electronic means, which shall be made final after processing of comments and approval by the CLIENT. Two rounds of comments are envisioned, with review cycles equal to those described in 2.3.5.

For all revisions a document version with track changes on and a final version are expected to be provided for ease of reviewing changes.

2.7.4 *Seismic Processing Report*

A Processing Report shall be made available for Sa 6/7 GP Lot 2 following completion of the fieldwork in accordance with Annex 4. This Processing Report shall include the following sections:

- INTRODUCTION including purpose and objectives of the survey document
- SURVEY AREA including infrastructure
- DATA ACQUISITION including but not limited to acquisition parameters and line identification
- MBES data processing and positioning methodology
- SEISMIC DATA PROCESSING SEQUENCE including but not limited to swath domain processing flow and volume domain processing flow
- PROCESSING QUALITY CONTROL
    - Before and after data examples of de-noise / de-multiple / migration tests
    - Any concessions, limitations, deviation from specifications / standards
- DELIVERABLES: see table in section 2.5.5
- CONCLUSIONS

2.7.5 *Final Interpretation Report - Geophysics*

A Final Interpretation Report shall be made available, incorporating interpretational reporting, for Sa 6/7-GP-Lot2 and integration with Sa 6/7-GP-Lot1 outcome, the latest twenty (20) weeks following completion of the Lot 2 fieldwork. This Final Interpretation Report shall include:

- INTRODUCTION:
    - A statement of the purpose of the investigation
    - Background geology of site
    - Executive summary including the end results and conclusions (in Dutch and English)
- Methodology:
    - An operational overview of the work conducted
    - Description of methodology used for interpretation of each dataset and integration of the datasets of Lot 1 and Lot 2;
    - Exact locations of all survey lines;
    - Data Limitations; acquisition and processing
- RESULTS:
    - Data integration acquisition overview between data blocks **AND** between Lot 1 and Lot 2
    - Integration of Lot 1 results report for bathymetry overview across site with relevant findings correlated to Lot 2
    - Integration of Lot 1 results report for sub-surface sensor overview across site with relevant findings correlated to Lot 2
    - Description of all interpreted seismic units to depth of 0.125 s
    - Description of features found across the site, in separate report sections;
    - Description of preliminary zonation of the site into zones of common geological sequence, for input to geotechnical campaign planning.
    - Timeslices to show features of interest across the site (requirement of at least 5 per block at every 0.02 s)
    - Tabulated isopachs of each unit and their distribution vertically and laterally
    - Velocity analysis methodology and findings across the site with any integration of CPT/p-s logging if geotechnical survey data is available at time of interpretation report
    - Description of, and geological cross-sections identifying all significant features and horizons (superimposed on the processed seismic data) for a representative subset of lines on one or more A0 charts at an appropriate scale.
- CONCLUSION:

- Recommendations on a geotechnical location plan to support creation of a future ground model, including 100 (deep) seabed CPT's, 100 Vibrocores, 100 x 60m boreholes, with reasoning.
- Charts at an appropriate scale on A0 of all outputs defined by CLIENT as required.

All reports and data deliverables shall be accompanied by metadata that are compliant with RVO's metadata requirements specified in Appendix A.

The CONTRACTOR shall provide a Draft version of the Final Interpretation Report, which shall be made final after processing of comments and approval by the CLIENT.

For all revisions a document version with track changes on, a document review form (DRF) and a final version are expected to be provided for ease of reviewing changes.

It is anticipated that a physical meeting should be arranged after delivery of draft report and data, to facilitate the review and implementation of any corrections and changes required.

Deliverables

A complete data archive, as defined in the preceding sections, must be provided with each and all draft and final reports.

The following reporting and charting deliverables are required at minimum:

Table 10: Reporting and Chart deliverables

reporting and Chart deliverables						
Item ID	**Measurement**	**Module R = Reports C = Charts**	**Description**	**Resolution**	**Format**	**Load into GIS-database**
m1	**Report and Charts**	**R**	Mobilisation and Testing Report	n/a	.pdf	N
m2			Field (operations) Report	n/a	.pdf	N
m3			Seismic Processing Report (3D)	n/a	.pdf	N
m4			Final Interpretation Report	n/a	.pdf	N
m5		**C**	Bathymetry overview chart	n/a	.pdf	N
m6			Geohazards overview chart	n/a	.pdf	N
m7			Geological Cross Sections	n/a	.pdf	N
m8			Geological unit elevations, thickness and extents	n/a	.pdf	N
m9			Preliminary Zonation chart	n/a	.pdf	N

Notes on reporting and charting:

A table of file names against line names for all MBES and seismic data files as plain text file or spreadsheet is required. For lines associated with multiple line-part data files, each data file should have its own entry in the index table. The table should also contain the following information against each line name entry:

- Acquisition vessel;
- Acquisition date;
- Source type and ID;
- Receiver type and ID;
- Start and End fix points;
- Name of the relevant Vessel Offset Diagram;
- Indication of whether the file is a production file or has not been processed.

All raster deliverables for single-variable data should be supplied as single-band files with encoded actual cell values (e.g. elevation, intensity), not as multi-band RGB images., all processed

deliverables listed that can be included in a GIS archive must be provided additionally in the project GIS archive.

2.7.6 *Delivery*

Draft and Final deliveries should contain all reports, data, and charts. All Deliverables MUST be subject to rigorous QC by the CONTACTOR to ensure completeness and correctness of all components.

CONTRACTOR to propose in their Quality Management Plan how best to manage the large volume of data to be delivered., i.e. provide an estimation of volume of data (in TBs) to be expected and how best to deliver it per data block, which data transfer technique, and over what frequency throughout the operations. Individual file sizes should not exceed 150 GB. The proposal shall include a robust method of data handling and coordination of the data between all teams offshore and onshore and data/document sharing with CLIENT.

Draft versions of reports shall be provided via online transfer systems. The Draft (1st and 2nd version) and Final reports must each be accompanied by a complete set of data deliverables as defined in Section 2.7, including the project GIS archive.

Draft versions of reports shall be provided with two (2) hard drives. The same hard drives can be exchanged between CONTRACTOR and CLIENT until final version is accepted.

Final versions shall be provided via multiple portable hard drives (3) for all reports, AND through RVO's data uploading portal. Additional to the delivery of the final data on HDD, the final data shall be uploaded to the RVO dataportal with the use of a by RVO provided upload tool. Contractor shall install a uploading program (provided by RVO) and use the provided program to upload the data.

2.7.7 *Webinar and Project Site Description*

The CONTRACTOR is expected to prepare and host a webinar for potential developers which will outline the work performed and the main results of the study. The webinar should be at least 1 hour and no more than 1.5 hour, with 30 minutes considered for questions.

CONTRACTOR shall provide a short description for the CLIENT's PSD wind farm site. In general this will be a summary of the works performed and site specific findings. Examples can be found on offshorewind.rvo.nl.