Date 10th August 2022

Status Final

Geophysical Survey Nederwiek Wind Farm Zone
3D-UHRS survey

Annex 6 - Section IV

Scope of Work

Colophon

Project name	Geophysical Survey Nederwiek Wind Farm Zone
Project number	WOZ2220046
Version	Final
File name	NW_3D-UHRS_20220812_RVO_GP_Annex 6_Section IV_Scope of Work_D_F
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1 Introduction

1.1 Scope of this document

This document and its appendices detail the scope of the WORK as part of the CONTRACT that CLIENT has awarded to CONTRACTOR for carrying out a geophysical investigations at Nederwiek Wind Farm Zone (NWWFZ).

1.2 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.

1.3 Site description

The NWWFZ is split into two Wind Farm Sites (WFS), a north site called Nederwiek noord (NW noord) and a south site called Nederwiek zuid (NW zuid), which have been investigated for the offshore wind development of the Netherlands. Nederwiek is part of the roadmap 2030+ as presented in Figure 1. NWWFZ is planned for a total capacity of 2 GW.

The NWWFZ is indicated in Figure 1, taken from Annex [6] section VII of the Tender information pack, Starting Points and Assumptions, and Figure 2 illustrating the Investigation Areas (IA) area specific to the Geophysical Surveys of Nederwiek.

A Geological Desk Study (GDS) to be provided by RVO for the NWWFZ provides information on the expected stratigraphic units, geological structures and possible influence on the design and the construction of offshore wind farms in the IA. The GDS will be available February 2023.

1.4 Two tenders for Geophysical Survey Campaigns

The Contacting Authority has chosen to split the planned geophysical survey campaign for the NWWFZ into two Tenders.

Tender for 3D-UHRS survey (this tender), focusses on a full coverage 3D-UHRS survey for a 3D Investigation Area (IA) in NW zuid, including MBES and SBP, and additionally surveying a corridor 3D-UHRS survey for NW noord including MBES.

Tender for a Seabed Survey (SS) and 2D-UHRS survey (separate tender - WOZ2220040), focusses on a seabed survey for NW zuid and a seabed survey for NW noord, including 2D-UHRS and SBP.

With two tenders, the Contracting Authority aims to provide an opportunity for various contractors to bid for either tender, or both tenders, taking into account the overall planning of soil investigations in relation to the Roadmap 2030+ Offshore Wind development planning.

Figure 1. Newly announced Dutch Offshore Wind Farm Zones (Roadmap 2030+)

1.5 Investigation Areas

It is the intention to obtain a single set of geophysical data, reports and drawings for each investigation area. For NW zuid the IA covers the area to be occupied by part of the Wind Farm Zone (WFZ), whereas for NW noord the IA is a 110m corridor, located at 110 meter from the inner boundary of the WFZ. The corridor is only located at the East, South and West border of the WFZ, and not the North border. The IAs are shown in Figure 2, and the vertices are provided in Table 1.

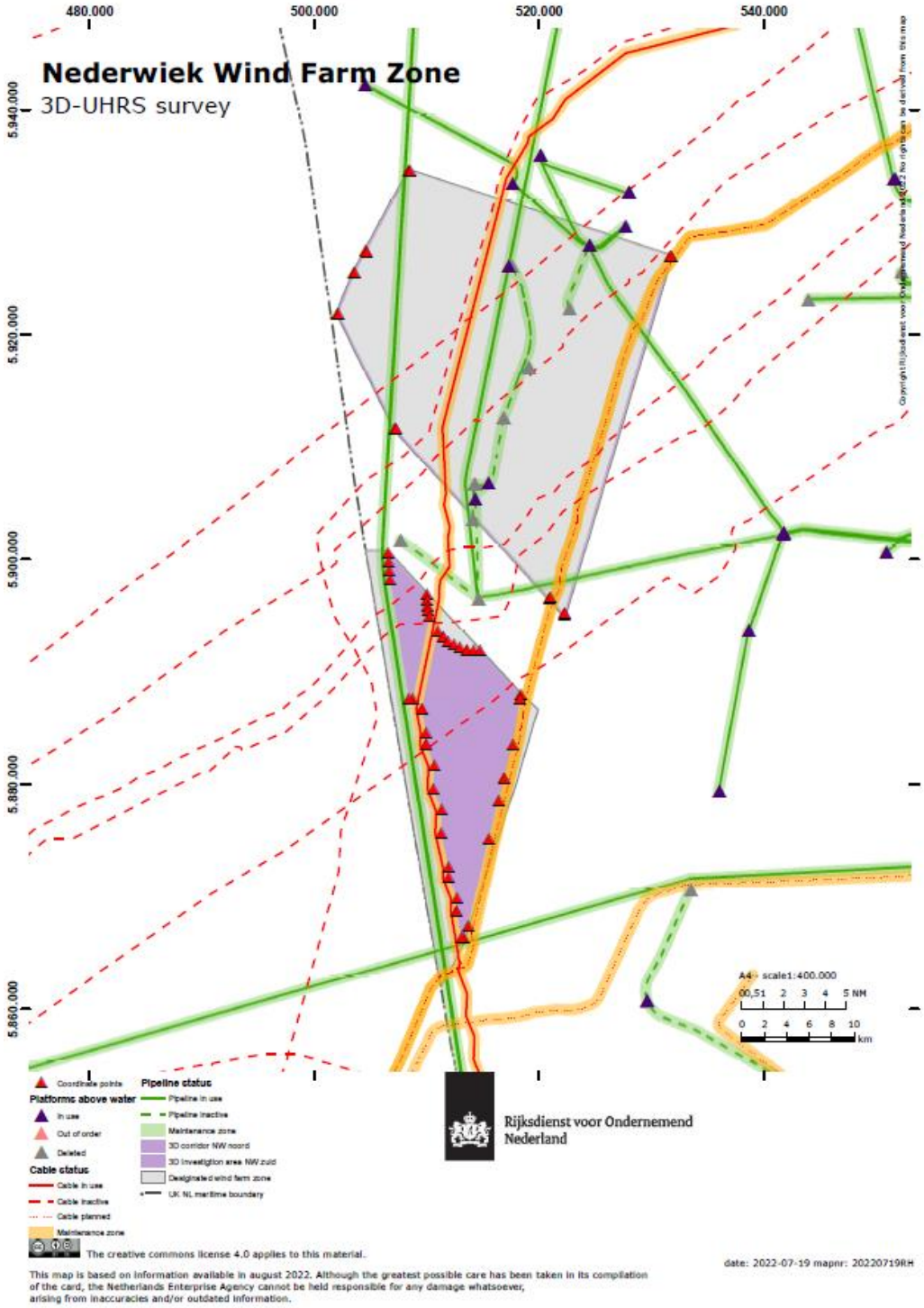

Figure 2. IAs to be surveyed during the geophysical campaigns at the NWWFZ. Please note that the seabed survey including 2D-UHRS seismic survey will be tendered separately.

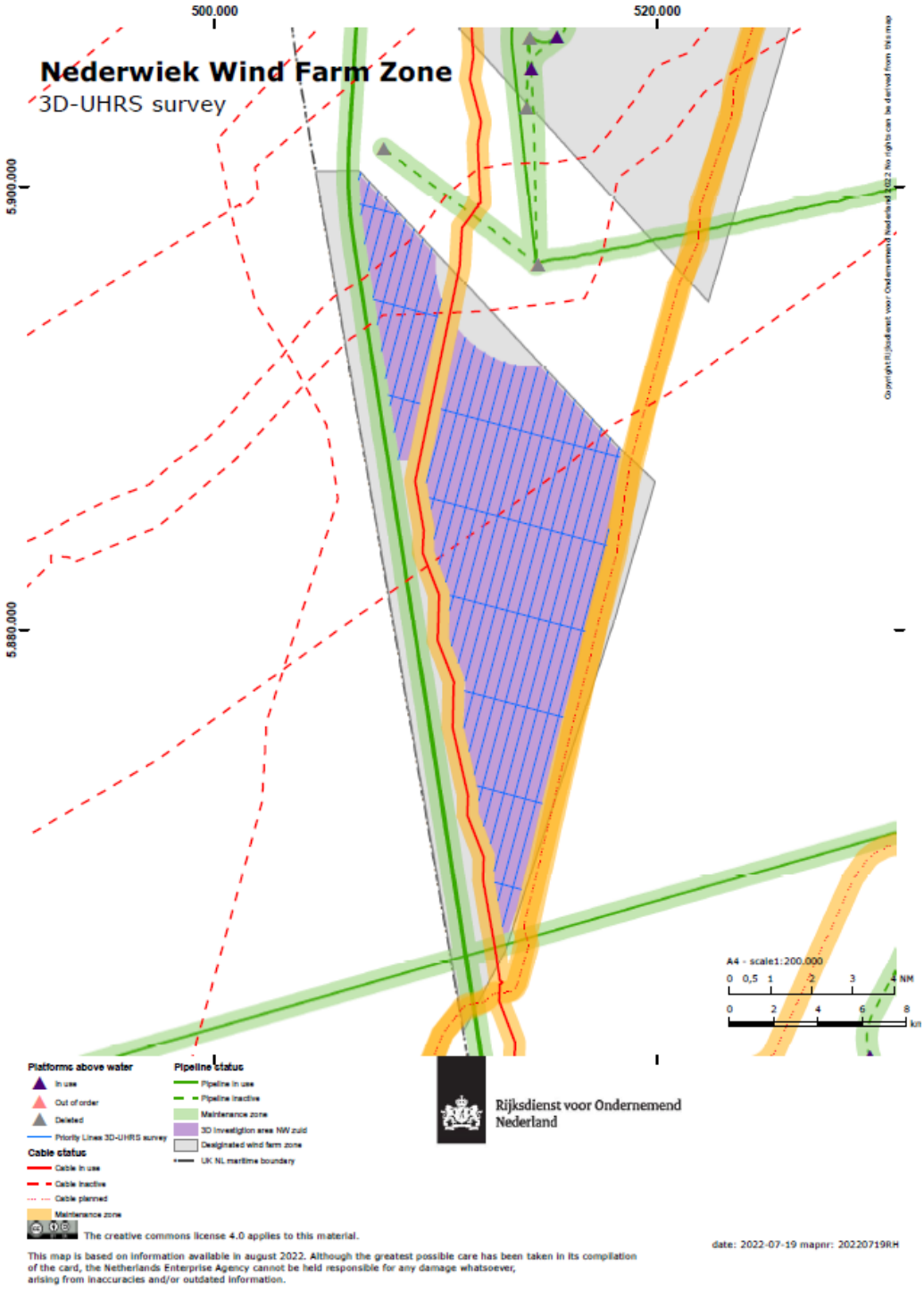

Figure 3. Priority line plan to be surveyed during the 3D-UHRS survey at NW zuid. Please note that the seabed survey including 2D-UHRS seismic survey will be tendered separately.

The coordinate points defining the IAs are provided in Table 1 in this document.

General information on the Wind Farm Sites is provided in Annex [6] - section VII: Starting Points and Assumptions.

Table 1. Coordinates of the vertices of the Investigation Areas for the Geophysical Surveys for Nederwiek WFZ

Coordinate system: ETRS_1989_UTM_Zone_31N		
EPSG 25831		
3D corridor Nederwiek noord		
Point No.	**Easting**	**Northing**
3D_01	531761,7	5926950,4
3D_02	522263,6	5894995,8
3D_03	520889,8	5896499,3
3D_04	507130,8	5911557,1
3D_05	502013,2	5921842,7
3D_06	503452,2	5925476,8
3D_07	504502,3	5927409,9
3D_08	508390,0	5934566,6
3D_09	508496,4	5934531,9
3D_10	504599,0	5927357,4
3D_11	503552,0	5925430,1
3D_12	502133,6	5921847,8
3D_13	507222,4	5911619,9
3D_14	520971,0	5896573,5
3D_15	522213,6	5895213,6
3D_16	531657,1	5926984,5
3D IA Nederwiek zuid		
Point No.	**Easting**	**Northing**
3D_17	506557.6	5900521.1
3D_18	510006.3	5896861.8
3D_19	509989.4	5896366.9
3D_20	510025.5	5895872.9
3D_21	510114.0	5895385.7
3D_22	510254.0	5894910.6
3D_23	508739.5	5887602.1
3D_24	508371.8	5887602.1
3D_25	506711.5	5898197.2
3D_26	506629.1	5898937.5
3D_27	506577.0	5899751.6
3D_28	510997.5	5893570.2
3D_29	511410.2	5893117.1
3D_30	511879.0	5892722.5
3D_31	512395.8	5892393.2
3D_32	512951.6	5892135.0
3D_33	513536.6	5891952.5
3D_34	514140.5	5891848.6
3D_35	514752.9	5891825.5
3D_36	518379.4	5887977.6
3D_37	518271.8	5887581.1
3D_38	517664.2	5883520.6
3D_39	516865.5	5880525.6
3D_40	516393.0	5878533.4
3D_41	515499.3	5875072.2
3D_42	513643.2	5867374.2

3D_43	513301.4	5866341.1
3D_44	513064.3	5866273.3
3D_45	512631.5	5868756.5
3D_46	512662.9	5869827.5
3D_47	511922.0	5871722.3
3D_48	511947.1	5872551.7
3D_49	511253.1	5875628.0
3D_50	511323.5	5877691.3
3D_51	510581.1	5879593.2
3D_52	510642.6	5881646.2
3D_53	509910.4	5883553.0
3D_54	509944.5	5884511.0
3D_55	509572.7	5886694.5

1.5.1 *Coordinate reference system and datum, and project coordinates*

The project coordinate reference system, horizontal datum and vertical datum are defined in Annex [6] - section VII: Starting Points and Assumptions. The coordinate points defining the IA are provided in Table 1 in this document. Note that Table 1 represents the IA to be surveyed to specification by the geophysical survey and includes a buffer around the Wind Farm Sites.

Vertical datums for this project are Lowest Astronomical Tide (LAT) (primary, default) and mean Sea Level (MSL) (secondary). More detail is provided in section 2.3.4.

1.6 Aims of the geophysical surveys

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

The investigation 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
- A comprehensive interpretative report on the survey results obtained, describing the PGM (only NW zuid); and
- A preliminary zonation of the site (only NW zuid) for input into the specification and scope for a geotechnical sampling and testing programme to follow the completion of the geophysical survey.

The output of the investigation shall be delivered in formats defined in this scope of work including digital data, Seismic Workstation and Geographic Information System project filesystems, chart data and reports.

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.

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 refinement to 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 Execution of the investigation

CONTRACTOR shall take into account that arrangements on the survey plans (timing and location at the site where the survey is carried out) shall be made with other contractors working at the site and/or third parties using the space if required.

CONTRACTOR shall take into account arrangements for permits to use the survey equipment within the investigation area and shall adhere to requirements of environmental and other permits acquired by RVO.

CONTRACTOR shall take into account the close vicinity of the IAs to the UK/NL maritime boundary.

CONTRACTOR shall recognise that data acquisition will begin with thirty-seven (37) priority lines to be sailed within NW zuid. These lines will be required in order to provide clearance for a number of locations within a geotechnical survey (under separate tender).

The requirement for the priority lines in NW zuid is that the processed data for 2D stacks (including demultiple), extracted from acquisition of the 3D-UHRS dataset, to the full depth of interest, with preliminary processing applied is delivered, to the specifications for these datasets as described in Section 2.4, at the earliest possible opportunity.

The priority lines comprise main lines and cross lines. In the main line direction, twenty-nine line (29) lines will be acquired at a 500 line spacing, oriented 015°–195° (parallel with the current). In addition, eight (8) crosslines will be acquired within the priority line plan, at a 4000 m line spacing, oriented 105°–285° (perpendicular to the mainlines). The total length of the priority lines is 352.5 km. The priority lines should be part of the main line plan.

The priority lines will also be acquired as priority lines within the seabed survey of the first tender: Seabed Survey (see section 1.4) ender 1, meaning an element of co-creation between the two tenders.

The priority lines will also be acquired as priority lines within the Seabed survey and 2D-UHRS survey (separate tender), however the priority lines within the 2D-UHRS survey tender will extend over a larger survey area. Therefore acquisition of the priority lines across these two surveys will need to be aligned. This means an element of co-creation between the two tenders (seabed survey and 2D-UHRS survey tender, and 3D-UHRS survey tender – see section 1.4) is required, and potentially some CONTRACTOR flexibility with line planning on both tenders. The priority lineplan is shown within Figure 3, and provided as a shapefile within the SPA annex.

The requirement is to survey, process, and deliver the priority line data by, at the latest, 15/4/2023.

1.8 Co-creation

The CLIENT wishes to work with and encourages the concept of co-creation in the project. This means that new working forms between CONTRACTOR and CLIENT will be explored. In this context, the following co-creation opportunities are foreseen:

- Work together as a team between RVO, RVO experts and CONTRACTOR to come to the optimum result for all parties involved;
- Acquisition of priority geophysical data to support and provide clearance for a geotechnical campaign;
- Development of the Preliminary Ground Model;
- Dissemination activities such as webinar and answering questions from the market;
- Development of use of 3D site surveys for offshore wind farm planning; and
- Reduction of environmental impact for survey operations.

1.9 Timing of the investigations

3D UHRS Survey

- The 3D-UHRS Survey for NW zuid has priority over the 3D-UHRS survey at NW Noord. The 3D-UHRS survey for NW zuid is expected to be carried out from Q1 2023, beginning with the priority lines.
- The 3D-UHRS Survey for NW noord is expected to be carried out from Q1 2023.

1.10 Available information

1.10.1 *WFZ specific information*

CLIENT will carry out desk studies on NWWFZ. The following desk studies will become available on https://offshorewind.rvo.nl

- Geological desk study; (expected publication date: February 2023)
- Archaeological desk study; (expected publication date: February 2023)
- UXO desk study; (expected publication date: January 2023)

The CLIENT will endeavour to give results of these 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 Borssele, HKZ, HKN, HKW, TNW and IJV WFZ 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 per investigation area

This scope of work covers multiple geographic locations with different survey requirements per IA listed in Table 2.

Table 2. Geophysical survey requirements per IA

	Nederwiek noord	Nederwiek zuid
MBES	X	X
3D UHRS	X	X
SBP		X

2.2 General scope of work

2.2.1 *Activities*

The activities which are to be carried out to obtain the information detailed in section 1.6 are the following:

- **Preparation**:
  - all preparatory works required for the geophysical surveys, including preparation of all plans that need to be provided (and approved) before the works can start.
  - Permit to perform survey works with the proposed equipment within the IA.
- **Data Acquisition and processing**:
  - High resolution bathymetric survey
  - Shallow Penetration Sub-Bottom Profiler (SBP) survey (for Nederwiek zuid only)
  - 3D Multi-Channel Ultra High-Resolution Seismic (3D-UHRS) profiling survey
- **Data Integration:**
  - Load the data into a seismic workstation and ensure integration of the survey elements.
- **Quality Assurance and Quality Checking**
  - Apply a coherent Quality Management Plan throughout the work
- **Delivery**
  - Products of the survey are to be delivered as a coherent and integrated data package with clear 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 1.3 and 2.3.2, and for resolution of positioning and individual measurements in section 2.4.

The description of the survey aims, should inform the CONTRACTOR in preparing their proposal which should clearly describe their suggested specification suitable to achieve the survey aims.

It should be recognised that the results of the survey are to be integrated with other products and made available to multiple parties as part of the information package associated with the tender process described in section 1.1. 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 important 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. The specifications of raw, processed, and interpreted deliverables from individual survey elements are described within their respective sections.

Three integrated deliverables are required: a GIS project (*ESRI ArcGIS is preferred)* containing *all* processed and integrated elements that may be represented in GIS; a single seismic workstation project (*IHS Kingdom is required*) containing *all* the subsurface data elements, and an report describing the data acquisition.

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 as specified in 1.9. Information that is relevant for carrying out the WORK shall be considered while preparing the WORK.

2.3.2 *Design Requirements of the Survey Layout and Configuration*

It is anticipated that the acquisition of geophysical and hydrographic datasets may involve one or more passes across the IA. The CONTRACTOR shall select their optimum survey layout and acquisition configuration (*e.g.* single or multiple passes, single- or multi-vessel solution) 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 as indicated in section 1.4.

The following criteria represent layout requirements for the proposal*,* covering the entire IAs where applicable according to section 1.5

2.3.2.1 Nederwiek noord

- Multi-Beam Echo Sounder (MBES) bathymetry
- 3D Multi-Channel Ultra High Resolution Seismic (3D-UHRS) data are to be acquired within a set of corridors supplied in table 2, nominally 110m wide, parallel to, and inboard of, the boundary of the WFS. 3D-UHRS data are to be acquired on sub-parallel sail lines to deliver a minimum of 12-fold data with a bin size of ≤1.0m (inline) and ≤2.0m (cross line). For the avoidance of doubt, a 30m halo of data is included in the 110m corridor boundary, this is to be acquired to provide a target 50m wide central corridor of fully migrated data to ~60m depth.
- Minimum length of any line or line segment shall be 500 m.

2.3.2.2 Nederwiek zuid

- Multi-Beam Echo Sounder (MBES) bathymetry

- Shallow penetration, high resolution Sub Bottom Profiler (SBP[1])
- 3D Multi-Channel Ultra High Resolution Seismic (3D-UHRS) data are to be acquired for full coverage for the IA defined by the coordinates supplied in Table 1. 3D-UHRS data are to be acquired on parallel sail lines to deliver a minimum of 12-fold data with a bin size of ≤1.0m (inline) and ≤2.0m (cross line)

2.3.2.3 Multiple vessels

Up to two (2) vessel(s) may be used by the CONTRACTOR to acquire the required datasets (MBES/SBP/3D-UHRS). Acceptable solutions include but are not limited to the use of the following configurations:

- One- or two-vessel solution each with a single pass to cover the MBES/SBP/3D-UHRS surveys concurrently.
- One- or multiple-vessel solution with multiple passes to cover the MBES/SBP/3D-UHRS surveys consecutively.

It is required that MBES data are acquired, processed and delivered with 3D-UHRS survey to support source and receiver height compensation in 3D-UHRS (re)processing.

Two pass or two vessel operations must deliver the results as a single, coherent body of data. 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 ≤0.2 ms. Vessel specification sheets including instrumentation and towing diagram, settings and appropriate procedures are required to be produced, maintained and followed where multiple vessels and/or multiple personnel rosters contribute to the same measurement type.

Equipment interference must be minimised in all cases, shall be proactively monitored and reported, and shall not impact the data quality. The mitigation measures for potential sources of interference should be described in the proposal.

2.3.3 *Permits and notifications*

CONTRACTOR shall obtain and manage all necessary permissions other than the environmental exemption (underwater noise), 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.

Operation of an Acoustic Deterrent Device (ADD) "Pinger" during all offshore works is mandatory to CONTRACTOR. Specifications of the active sources for sub-bottom profiler devices (all sources for SBP, 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 the sub bottom profiler devices should be in place before the start of the survey works.

NW zuid and NW noord will be split by a planned shipping lane (corridor separating on Figure 2). CONTRACTOR should be aware of planned activities in the area.

[1] Sub Bottom Profiler (SBP) refers in this document to systems with shallow penetration i.e. Pinger, Chirp or parametric or equivalent systems

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 2023. Draft results of the UXO desk study can be shared in 2022.

2.3.5 *Project Plans*

CONTRACTOR shall prepare all required project plans as required by the CONTRACT. These documents (the Project Documentation) shall include planning for the execution of operations, quality management and safety management. The organisation of these elements shall 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 implementation plan including method statements and safe systems of work
- Quality monitors
- Mobilisation, equipment verification, parameter optimisation
- Data acceptance criteria per sensor
- Spares inventory management
- If project plan is divided in multiple documents, a mapping document is required to provide an overview and latest versions for each document.

And for the general project management:

- Safety management and emergency response
- Quality management throughout the project
- Plans to interface between CONTRACTOR's offshore team, CONTRACTOR's onshore management, CLIENT's offshore representative and CLIENT's onshore team
- Interface between the project and any third parties requiring it

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.

Generic descriptions in the project plan which will be updated upon /after award of the contract shall be highlighted and provided with (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 (HIRA, refer to Annex [6] - section V HSE Requirements) as physical meetings prior to a Vessel Kick-Off Meeting (VKOM) to be held as mobilisation starts.

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

- Project Implementation Plan
- Project schedule/planning
- Initial sensor/survey configuration
- Line plan (incl. priority line plan NW zuid)
- Offshore data QC
- Data acceptance criteria per sensor
- Offshore testing phase/survey parameter optimisation
- Mobilisation acceptance

Offshore equipment verification and parameter testing shall be required input for finalised production procedures, to be completed after the offshore testing phase.

2.4 Data Acquisition

2.4.1 *Mobilisation and 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 optimised to the specification agreed by the CLIENT and approved by the CLIENT. Following equipment verification (including spares) an offshore testing phase shall be conducted to an agreed plan to demonstrate sensor settings are optimised to meet the survey requirements set out in this 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 QES, and onboard CR (this is regarded as part of the mobilisation).

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.

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 CLIENTS offshore representative.

2.4.2 *Testing*

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. Where data processing operations are critical to either in-field QA/QC or evaluation of the suitability of the data acquisition configuration, design and parameterisation of these operations shall be part of the testing phase. 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 as soon as possible after mobilisation and testing. Production data acquired prior to acceptance of the data acquisition configuration is acquired at the CONTRACTOR'S risk.

Two (2) 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 specified in the proposal.

A draft mobilisation report (including calibration, verification, and testing phase results) is to be provided within two calendar weeks of acceptance of the data acquisition configuration. This report is to be included as an appendix to the Operations Report.

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

- Seismic source – test source energy level, polarity, and frequency content.
- MBES – test multiple pulse width and gain settings for backscatter (if applicable)

- SBP – test multiple pulse width and types, frequency selection.
- Navigation – test correct navigation string is applied to each sensor, check measured layback where relevant.
- General – describe the timing/firing sequence, and steps taken to maximise lateral resolution and avoid interference between sensors

2.4.3 *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. All equipment shall be removed to a reference level which is the trough of mobile sand waves in the area.

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

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

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.

2.4.4 *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 (or better) for surface and DGPS (or better) and USBL for subsurface gear.

Accurate positioning is essential. Coverage requirements dictate the 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).

2.4.5 *High Resolution Bathymetric Survey*

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

- seabed elevations / depths relative to LAT and MSL;
- identification and mapping of potential hazards to the development of offshore wind farm infrastructure at the site;
- identification and mapping of natural and anthropogenic seabed features and objects;
- classification and mapping of sea-bed sediments.

Required elements

The HRB Survey must include:

- Survey 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 100% coverage of the IA.

Data will be acquired to exceed IHO Standard S-44 Edition 6[2] 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 report.

Matrix Code: Ba9, Bc10, Bd8, Be6, Bg9, Bh9 + 6 Pings/0.5x0.5m.

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 probe incorporated into the MBES system should have an accuracy of better than ±0.15 m/s.

Vertical SVPs to measure the speed of sound in water should be obtained in the survey area at a minimum of twice per day. It is recommended that SVPs are obtained at the start and end of each day, and initially at low and high tides. SVP acquisition intervals may be increased with the agreement of the CLIENT's OFFSHORE REPRESENTATIVE. Measurements should be made using a calibrated velocimeter or calculated using temperature 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.

Reported water depths from MBES must be sound velocity corrected and reduced to LAT by applying the latest LAT model for the Dutch North Sea (NLLAT18[3]). Bathymetry relative to MSL shall be derived *from* the LAT referenced data, for MSL reduction the latest DTU21[4] 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.

Seabed sample acquisition is required during this survey campaign (section 2.3.7).

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.

The reduction method and vertical and horizontal datums used must be compliant with Section 2.4.5, **Fout! Verwijzingsbron niet gevonden.** and IHO standards and guidance (IHO, 2005[5]; IHO, 2020[6]). Details of the vertical reduction process (MSL and

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

[3] https://english.defensie.nl/downloads/applications/2020/06/12/nllat2018

[4] 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.

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

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

LAT) must be included in the 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. 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.

Deliverables

The following deliverables including their metadata are required at minimum:

Table 2: 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	N
a2		**P**	Despiked, cleaned, positioning corrected soundings as x,y,z, per line, full density		Ascii+prj	N
a3			Despiked, cleaned, positioning corrected MBES backscatter data as x,y,z, per line, full density		Ascii+prj	N
a6			Speed of sound in seawater vertical dip data profiles	n/a	.xlsx, PDF, Ascii+prj	N
a7			MBES tracks (navigation) data, Survey line ID and fix point index	n/a	.gdb, Ascii+prj	Y
a8			Gridded bathymetry, relative to LAT	0.5 m	Ascii+prj	N
a9			Gridded bathymetry, relative to MSL	0.5 m	Ascii+prj	N
a10			Gridded bathymetry, relative to LAT	0.5 m	Geotiff	Y
a11			Gridded bathymetry, relative to MSL	0.5 m	Geotiff	Y
a12			Gridded bathymetry, relative to LAT	1.0 m	Ascii+prj	N
a13			Gridded bathymetry, relative to MSL	1.0 m	Ascii+prj	N
a14			Gridded bathymetry, relative to LAT	1.0 m	Geotiff	Y
a15			Gridded bathymetry, relative to MSL	1.0 m	Geotiff	Y
a18			Tile map index [polygon]	n/a	.gdb	Y
a19			Total Vertical Uncertainty (TVU) gridded XYZ	0.5 m	Ascii+prj	N
a20			Total Horizontal Uncertainty (THU) gridded XYZ	0.5 m	Ascii+prj	N
a21			Total Vertical Uncertainty (TVU) raster	0.5 m	Geotiff	Y
a22			Total Horizontal Uncertainty (THU) raster	0.5 m	Geotiff	Y
a23			Bathymetric contours, typically 1 m interval.	n/a	.gdb	Y
a29			time-stamp 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 time-stamp 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.

2.4.6 *Sub-Seabed seismic investigations - general*

The objective of the 3D- High-Resolution Seismic (3D-UHRS) and Sub Bottom Profiling (SBP) Surveys is to contribute to the model of the seabed including:

- identification and mapping of static and potentially mobile bedforms such as megaripples and sand waves, including the thickness of potentially mobile sediments;
- identification and mapping of potential hazards or influences on the development of offshore wind farm infrastructure at the site *e.g.* faults, seabed or buried channels, shallow gas, peat, *etc.*;
- identification and mapping of significant stratigraphic and lithological horizons that characterise the site, the key geological units defined by the Geological Desk study and any other relevant literature or data;
- 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*;*
- Contribution of sub-surface data (SBP and 2D data extracted from the 3D-UHRS acquisition) to the priority lines in NW zuid, to provide clearance for a number of (sample) locations within a geotechnical survey (under separate tender). These priority datasets are required to be surveyed, processed, and delivered before 1/5/2023.

2.4.7 *Sub Bottom Profiling survey – 2D*

The SBP survey is required for sufficiently detailed imaging of the Holocene formations including the base of the mobile sediments. The primary purpose of the SBP survey is to provide information about the top 5 m as this depth range is important for cable design and installation.

Required elements

- Single-channel, shallow penetration seismic surveying with a Sub-Bottom Profiler system (SBP), *i.e.* Pinger, Chirp, parametric or other system with equivalent performance. 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).

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.

Near surface resolution within 5 m of seabed:	Inline trace spacing <1 m
	Vertical resolution: 0.2 m
	Nominal penetration: ≥3 m

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

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 spacings, bearings of the primary and secondary line directions. The tracking point for line keeping shall be the CMP.

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.

SBP must be hull- or pole-mounted and provide effective heave and attitude compensation. An appropriate tidal correction should be applied to the SBP data. Parametric systems are preferred if CONTRACTOR can demonstrate track record of their successful use. Sufficient data processing is required to enable effective identification of the base of mobile sediments at the required resolution. Minimisation of ringing in the data is to be demonstrated during testing, and mitigation measures described in the proposal.

SBP and 3D-UHRS systems, if operated concurrently, must be arranged to minimise interference while optimising the horizontal resolution of each.

Data Processing

SBP data require data processing to be applied to optimise quality and resolution. Full reporting is required for each type of data collected. 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. Data processing of sub seabed data should be comprehensively tested, reported and signed off by CLIENT on up to 7 lines prior to production processing.

SBP trace headers should conform to SEG Y Rev1 (2002)[7] 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 SBP, and 3D-UHRS data have their seabed signal aligned in the processed final deliverables. Datum corrections should be written to pre-stack header words for deliverables but *not* applied to the data.

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

Some, or all operations of the final, production processing sequence for SBP and 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 Final Report. At minimum, the processing operations applied to each dataset must be described and parameter tests presented.

Interpreted seismic velocity is required to be delivered with appropriate QA metrics. Stacking velocity interpretation is required throughout the depth range of interest. Conversion to a coherent interval velocity model is required. Velocities are to be supplied as ASCII and as a 3D velocity cube (SEGY format).

Interpretation

There is no requirement for interpretation of SBP data, 3D-UHRS data, or MBES data, within the tender for the 3D-UHRS survey. Therefore, there is no requirement for production of a PGM (Preliminary Ground Model) within the 3D-UHRS survey.

Interpretation and integration within a ground model is planned to be carried out at a later date, by a contractor awarded production of the IGM (Integrated Ground Model).

Sub-Bottom Profiler deliverables

The following deliverables and their metadata are required at minimum:

Table 10: Sub-Bottom Profiler deliverables

Item ID	Measurement	Module R = Raw P = Processing I = Interpretation	Description	Resolution	Format	Load into GIS-database
f1	**SBP**	**R**	Raw data SBP with navigation applied	n/a	SEG-Y	N
f2		**P**	SBP tracks (navigation) data, Survey line ID as attribute [lin]	n/a	.gdb	Y
f3			SBP tracks (navigation) data, fix point included as attribute [ptn]	n/a	.gdb	Y
f4			Processed SBP data with navigation applied	n/a	SEG-Y	N
f5			SBP Navigation	n/a	P190	N

Notes on Sub-Bottom Profiler deliverables:

Raw:

- Raw SBP data with correct navigation applied in SEG-Y format (if applicable, heave information shall be provided separately and not applied to the raw data).

Processed:

- Trackplots for the SBP seismic survey.
- Processed SBP data where post-processing is required to deliver interpretable data at the resolution specified: interference is to be attenuated, and processes to achieve a compact wavelet with minimal ringing are to be applied

All raster deliverables for single-variable data should be supplied as encoded single-band files with actual 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.

2.4.8 *3D Ultra High Resolution Seismic Survey*

The 3D-UHRS area is required for the IA presented in Table 2. To be able to provide more detailed information in these areas a 3D-UHRS survey will be performed to enable the detection, interpretation and mapping of all significant subsurface horizons including formation interfaces, buried channel features and other relevant indicators of geohazards in high detail.

The seismic data and interpreted preliminary velocity field are required. The depth range of interest is from seabed to not less than 60 m below seabed for the 3D-UHRS survey.

Required Elements

- Survey data to be acquired providing at minimum complete coverage of the perimeter corridor defined in Table 1, at full target fold, plus additional area(s) to be defined. Maximum bin sizes are defined below.
- A minimum line spacing of 15 m to be used for the acquisition of the 3D UHRS data. Larger line spacings are accepted if all the other specification in this document are met.
- 3D-Multi-Channel Ultra High-Resolution Seismic (UHRS) surveying with a *high bandwidth* Sparker system(s), suitable for the resolution and penetration specifications for 3D imaging. 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).
- A multi-streamer hydrophone array and logging systems
- GPS positioning on source(s), and head and tail buoys of hydrophone cables
- The CMP fold of 3D-UHRS data is to be ≥ 12 traces
- The maximum offset is to be not less than 30 m and not greater than 90 m.
- 3D processing including deghosting, sufficient to deliver preliminary interpretation, including 3D migration, is required.

The configuration of sources, receiver cables and line spacing required to achieve the bin distribution and fold targets is not unique. For configurations that meet the minimum bin-size and fold requirements, evaluation of proposals will consider bin size (smaller and square is preferred, to a minimum of 0.5 x 0.5m) and the number of line km required to complete the perimeter (fewer preferred, with the balance to be assigned to additional area(s)).

Delivery of the 3D data in a single data volume or multiple linear sections is to be decided. Neither option shall incur additional cost.

<u>Required Specification</u>

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.

Resolution to 40 m below sea bed:	Inline bin spacing ≤ 1.0 m Xline bin spacing ≤ 2.0 m
	Vertical resolution ≤ 0.5 m
	Nominal penetration: ≥40 m

Resolution from 40 m below sea bed to >60 m below sea bed:	Inline bin spacing ≤ 1.0 m Xline bin spacing ≤ 2.0 m Vertical resolution ≤ 1.5 m Nominal penetration: ≥100 m

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

The CMP fold of 3D-UHRS data is to be ≥ 12 traces and the maximum offset is to be not less than 30 m and not greater than 90 m.

Bin sizes specified are *maximum values* – smaller bin sizes, maintaining the minimum fold of coverage, are considered additional value if acquired within the maximum sail-line km specified.

Specification of acceptable fold shall be finalised on the basis of 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 corridor km. A working criterion for application only to the proposal shall be:

- Maximum dimension of low fold zone (gap) ≤20m.
- Total number of 'gaps' between 10 m and 20 m dimension per corridor-km shall be limited to 3
- Total number of gaps between 2 m and 10 m dimension per corridor-km shall be limited to 10.

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 reasonable amount of lines, and the required infill will be discussed onboard during acquisition.

A diagram of the proposed source and cable specification to illustrate the binning strategy is required in the proposal.

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 spacings, bearings of the primary and secondary line directions.

Diagrams illustrating the source and receiver configuration leading to the desired 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.

The 3D-UHRS equipment should include a streamer with group spacing of preferably 2 m or less and no more than 3.125 m to provide the required horizontal resolution; an active streamer length of between 90 m and 150m is preferred. Shot interval

should be defined to deliver the required CMP fold and bin size. A consistent, broad band seismic pulse is required and QA metrics demonstrating this should be provided.

It is required that seismic sources and hydrophone cables are deployed by personnel demonstrably experienced in their configuration, parameterisation and optimisation. Team composition and their project history and track record will be part of the evaluation of bids.

Slant-cable or hybrid-cable proposals are 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 require extensive data processing to be applied to optimise quality and resolution. It is anticipated that a significant proportion of processing will be performed onshore, with offshore processing focussed on data acquisition QA. Full reporting is required including operations and 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.

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. Brute stacks form one element of the deliverables set.

The data are to be located using accurate source and receiver positions. Geometry assignment should be carried out such that each stacked 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 Operations and Processing Reports. 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 SBP and 3D-UHRS data have their seabed signal aligned in the seismic workstation project. Non-dipping seabed reflections should tie to ≤0.2 ms.

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 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'

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

processing sequence should be provided in the proposal, with options presented as appropriate. The Final stack processing sequence should include at minimum:

- Positioning and Geometry assignment
- Denoise
- Signal conditioning (e.g. deconvolution, deghosting)
- Amplitude correction
- Stacking Velocity analysis at < 1000 m interval
- Demultiple
- NMO correction, mute and stack
- Migration (post stack)

The actual processing sequence may be more complex than the list provided and may not be in the same order.

Interpreted seismic velocity is required to be delivered with appropriate QA metrics. Stacking velocity interpretation is required throughout the depth range of interest, and should be coherent with the horizons picked on the 2D-UHRS data within the SS and 2D-UHRS tender (separate tender). Conversion to an interval velocity model is required. Velocities are to be supplied as ASCII and a 3D velocity cube (SEGY format).

Interpretation

Interpretation of 3D-UHRS data is not required within Tender 2 beyond that implicit in velocity analysis.

3D Multi-Channel Ultra High Resolution Seismic survey deliverables

The following deliverables and their metadata are required at minimum:

Table 11: 3D Multi-Channel Ultra High-Resolution Seismic deliverables

Item ID	Measurement	Module R = Raw P = Processing I = Interpretation	Description	Resolution	Format	Load into GIS-database
g1	**UHRS Seismic**	**R**	Raw navigation merged shots *	n/a	SEG-Y or SEG-D	N
g2			Multichannel sail line tracks (navigation) data, Survey line ID included as attribute [lin]	n/a	.gdb	Y
g3			Multichannel 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			Demultiple CMP gathers	n/a	SEG-Y or SEG-D	N
g9			Demultiple stack (time domain)	n/a	SEG-Y	N
g10			Final Bin fold plot	Bin size	raster	Y
g10			Final stack (with post migration processing) (time domain)	n/a	SEG-Y	N

Table 11: 3D Multi-Channel Ultra High-Resolution Seismic deliverables						
Item ID	**Measurement**	**Module R = Raw P = Processing I = Interpretation**	**Description**	**Resolution**	**Format**	**Load into GIS-database**
g11			Interval velocity vs time	n/a	SEG-Y	N
g12			RMS stacking velocity file	n/a	ascii	N
g13			3D-UHRS Navigation	n/a	Ascii (P190)	N

Notes on 3D multi-channel UHRS deliverables:

Raw:

- Multi-channel raw seismic data with geometry and correct navigation applied (shot gathers) in SEG-Y or 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 after multiple attenuation is applied (without NMO correction) are required to facilitate reprocessing;
- Stacked, migrated seismic data with correct navigation and tidal correction applied in SEG-Y format; including the entire corridor specified in table 1.
- Interval velocity vs TWTT at all CDP locations in the corridor as SEGY; and
- Stacking velocity vs TWTT pairs at analysis locations.

2.5 Data Integration

There is no requirement for interpretation of SBP data, 3D-UHRS data, or MBES data, within this 3D-UHRS survey tender. Therefore, there is no requirement for production of a PGM (Preliminary Ground Model) within this tender.

Interpretation and integration within a ground model is planned to be carried out at a later date, by a contractor awarded production of the IGM (Integrated Ground Model).

The Integrated Ground Model (IGM) is expected to develop the subsurface geological model extensively. The construction of the IGM is outside the scope of the Geophysical (and Geotechnical) Investigations described within the Scope of Work for the SS and 2D-UHRS survey tender (separate tender), and the 3D-UHRS survey tender (this document).

3D-UHRS and SBP data acquired within 3D-UHRS survey tender, are required to be compatible and referenced to the same vertical datum as 2D-UHRS and SBP data acquired within the SS and 2D-UHRS survey tender (separate tender), and the Preliminary Ground Model (PGM) constructed within the SS and 2D-UHRS survey tender (see section 1.4).

2.5.1 *Sub-seabed data integration*

Subsurface data are to be loaded into a workstation package at least capable of representation of all subsurface data elements in a common system. Although interpretation is not required within the 3D-UHRS survey tender (this tender), this integration step will ensure data is able to be loaded, and will allow data to be

compared for consistency between datasets. The Kingdom application from IHS Markit is required, but if an argument is present to use alternative software, then the software version can be discussed at TKOM.

2.5.2 *Outputs – sub-seabed data integration*

The output of the subsurface data integration shall be:

- Seismic workstation project incorporating 3D-UHRS and SBP data,

The following output deliverables are required at minimum:

Table 13: Sub-Seabed integrated interpretative deliverables

Item ID	Measurement	Module I = Interpretation D = Database	Description	Resolution	Format	Load into GIS-database
i1	**Integrated SBP and UHRS**	**D**	Kingdom Seismic Direct project including all SBP and 3D-UHRS (navigation-applied) data in the time domain.	n/a	.tks	N

All raster deliverables for single-variable data should be supplied as single-band files with actual 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.

2.5.3 *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 in Annex [6] - Section VII Annex 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.* Contact feature classes in the GIS archive must contain the same attribute columns and values as in the Excel/text file Contact tables and report appendices, Kingdom-generated elevation grids and GIS elevation rasters should match, *etc.*).

Further specifications for GIS can be found in the RVO starting points and assumption document (Annex [6] - Section VII).

The GIS data archive must include *at minimum*:

Table 14: 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
147	**all**	**Meta**	Metadata to specification provided in Annex A06 s VII 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 (including bathymetry surface). Grid and contour coverage must be consistent with the associated extent polygons.
- 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, *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.

2.6 Quality Assurance and Quality Control

Annex [6] - section VI Quality Requirements and Administrative Instructions contains a brief description of the operational quality management requirements to be implemented during the survey work. A Quality Management Plan (QMP) is required, this section describes specific operational QA requirements in support of those described in Annex [6] - section VI section 1.2.5.

During data acquisition, MBES, and sub-bottom (SBP and 2D UHRS) datasets shall be monitored continuously to ensure both coverage and quality (including resolution) are maintained. The survey *speed over ground* shall be no more than 4.5 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. Throughout the offshore survey activity, data quality checks shall be carried out on board by a suitably qualified and experienced geophysicist including comparison of data collected on adjacent and perpendicular survey lines to ensure continuity. Any omissions, inconsistencies or other issues that may impair the quality, quantity or interpretation of the final data shall be immediately discussed with the CLIENT offshore representative and suitable actions agreed to rectify any dataset deficiencies.

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 CLIENT offshore representative is sufficiently aware of any obligatory data processing operations that the CLIENT offshore 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 on-board *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 checks shall be completed prior to leaving harbour. The procedures to be followed in event of navigational non-compliance shall be logged and the CLIENT offshore 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 QMP 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 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 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).
- Acceptance criteria for completion of acquisition for a seismic line.

2.6.1 *Offshore Representation*

The CLIENT may require up to two (2) CLIENT offshore representative per vessel to witness the offshore phase of the surveys.

The CONTRACTOR is to be responsible for providing safety induction training for the CLIENT offshore representative who are to work on or visit any vessel in connection with the execution of the work.

The CONTRACTOR shall provide adequate facilities for the CLIENT offshore representative on any vessels to include a private cabin, office space, PC of sufficient power and with applications loaded suitable for QA operations, communication systems including satellite phone and appropriate internet connection and messing facilities. The CLIENT cabin needs to have an internet connection with a minimum speed of 512 kbits/sec upload / download.

CONTRACTOR shall provide Personal Protective Equipment (PPE), life jackets and any special offshore PPE for the CLIENT offshore representative for the duration of the project.

2.7 Reporting

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

2.7.1 *Daily & Weekly reporting*

The CONTRACTOR is to submit daily reports throughout the period of the fieldwork, providing full details of previous 24 hours' work and results. Further CONTRACTOR shall issue a weekly report providing insight in the progress of the WORK on a weekly basis. The minimum content of the daily and weekly reports is specified in Annex [6] - section VI of this CONTRACT.

The CONTRACTOR may be requested by the CLIENT to provide Data Quality Reports ("DQR") when appropriate. The DQR will not have to be provided on a daily basis but the CONTRACTOR must be prepared to compile and provide these reports under the supervision of the CLIENT offshore representative. Content of standardised elements of DQRs is to be established at the TKOM.

Upon request from the CLIENT, the CONTRACTOR shall provide a portion of raw or processed data by email or web transfer for the purpose of monitoring Quality Control. The CONTRACTOR shall provide the CLIENT such data within 24 hours of the request.

2.7.2 *Field report - Geophysics*

A Field Report shall be made available for the IA within three (3) weeks of demobilisation. The Field Report shall contain daily logs and summaries of the work completed, together with any preliminary results that can be provided.

The Field Report should include as a minimum:

- A statement of the purpose of the investigation and Scope of Work;
- A description of the work carried out, including:
    - Project personnel (GDPR compliant); vessels; equipment list;
    - Vessel Offset Diagrams for each vessel and, if instrument configurations were changed in the field, each instrument configuration;
    - Mobilisation, Testing and Calibration operations
    - Exact positions of all survey data and details of survey positioning control (positioning calibrations, geodetic data, *etc.*), with accompanying calibration records; field procedures, including methodology,
    - Acquisition methodology for each dataset.
    - Quality Control procedures and reference to specifications and standards adopted and any deviations from them for each survey type;
    - End-of-line reports.
    - Environmental observations;
    - Health & Safety records, Incident reports and safety meeting minutes.
    - Copies of daily reports,
    - Relevant signed calibration sheets

The CONTRACTOR shall provide a Draft Field Report, through ftp site or other electronic means, which shall be made final after processing of comments and approval by the CLIENT.

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

2.7.3 *Final report - Geophysics*

A Final Report shall be made available, incorporating interpretational reporting, for the NW zuid IA within thirteen (13) weeks and for the NW Noord IA ten (10) weeks following completion of the fieldwork. These Final Report shall include:

- A statement of the purpose of the investigation;
- A description of the work carried out, including methodology used for the processing of each dataset and the positioning data plus reference to specification and standards adopted and any deviations from them;
- Exact locations of all survey lines;
- Electronic copies of all raw and processed data from the survey;
- 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 Annex [6]-Section VII Appendix A.

The CONTRACTOR shall provide a Draft Final 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 11: 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 Reports, (3D) - as appendix to Operations Report	n/a	.pdf	N
m4		**C**	Bathymetry overview 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 actual cell values (e.g. elevation, intensity), not as multi-band RGB images, with the exception of the SSS mosaic. If provided in a non-ESRI GIS format (*e.g.* CAD, microstation), all processed deliverables listed that can be included in a GIS archive must be provided additionally in the project GIS archive.

2.8 Delivery

Draft and Final deliveries should contain all reports, data and charts. Partial or interim deliveries are not encouraged. All Deliverables MUST be subject to rigorous QC by the CONTACTOR to ensure completeness and correctness of all components.

The Draft (1st and 2nd version) and Final Reports must each be accompanied by a complete set of data deliverables as defined in Section 0, including the project GIS archive. Data shall be provided via multiple portable hard drives (5) for all reports, electronic delivery may be accepted with prior agreement of CLIENT, though agreement to delivery in this way is not guaranteed.

CONTRACTOR shall present the Final Reports in two webinars to be organised by CLIENT.