Date June 12, 2018

Status Final

Soil Investigations Wind Farm Zones

Annex 5 - Section IV

Scope of Work Geophysical Survey

Hollandse Kust (west) Wind Farm Zone

Colophon

Project name	Site Studies Hollandse Kust (noord) Wind Farm Zone
Project number	
Version	
File name	HKW_20180612_Geophys_ANNEX 5-IV SoW_MTi_F
Projectmanager	M. Brijder
Contact	
Annex(es)	
Author	Reynolds International
Reviewed	M. Timmerman, B. de Sonneville
Approved	M. Brijder

Contents

1. Introduction

1.1. Scope document

This document and its appendixes detail the scope of the WORK as part of the CONTRACT that CLIENT has awarded to CONTRACTOR for carrying out geophysical investigations at Hollandse Kust (west) Wind Farm Zone (HKW WFZ).

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 subsidy 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 geological, geophysical, geotechnical and morphodynamic studies. Information will be presented as factual data, integrated and interpreted data (a Ground Model) and will be comprehensively reported.

1.3. Objective of the geophysical survey

The objective of the geophysical soil investigation is to contribute to the bathymetrical, morphological and geological understanding of the Hollandse Kust (west) (HKW) Wind Farm Zone (WFZ). The investigation is required to obtain seabed and sub-seabed information on this location. The information is required to be suitable for the 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 should provide:

- An accurate bathymetric chart
- Information on the presence of all seabed features of significance to the construction of wind farm facilities including but not limited to:
    - any natural features such as boulders, scour hollows, pock-marks;
    - any non-natural features such as wrecks and debris (both known and previously unmapped), pipelines, cables and infrastructure;
- A geological model of the site, including as a minimum;
    - Elevation and depth below seabed charts for the main geological formation interfaces including any mobile sediments, layers of potential archaeological significance, and any other significant interfaces that might impact on the engineering design;
    - Locations of any structural complexities or geohazards within the shallow geological succession such as faulting, accumulations of shallow gas, peat, buried channels etc.;
    - Detailed geological interpretation to show facies variations and structural feature changes via appropriate maps and sections;
- The exact, current position of existing (in service & out of service) cables and pipelines.

- Input into the specification and scope for a geotechnical sampling and testing programme following the completion of the geophysical survey;
- A comprehensive interpretative report on the survey results obtained to assist design of the offshore foundations / structures and cable burial.

The Hydrographic and Geophysical survey follows and receives information from the Geological, Archaeological and UXO Desk Studies, and it precedes and supplies information to the Geotechnical and Morphodynamic investigations.

1.4. Site description

The HKW WFZ site is indicated in Figure 1 as the blue zone annotated 2020. The HKW WFZ is the fourth WFZ after the Borssele WFZ, for which site investigations shall be executed.

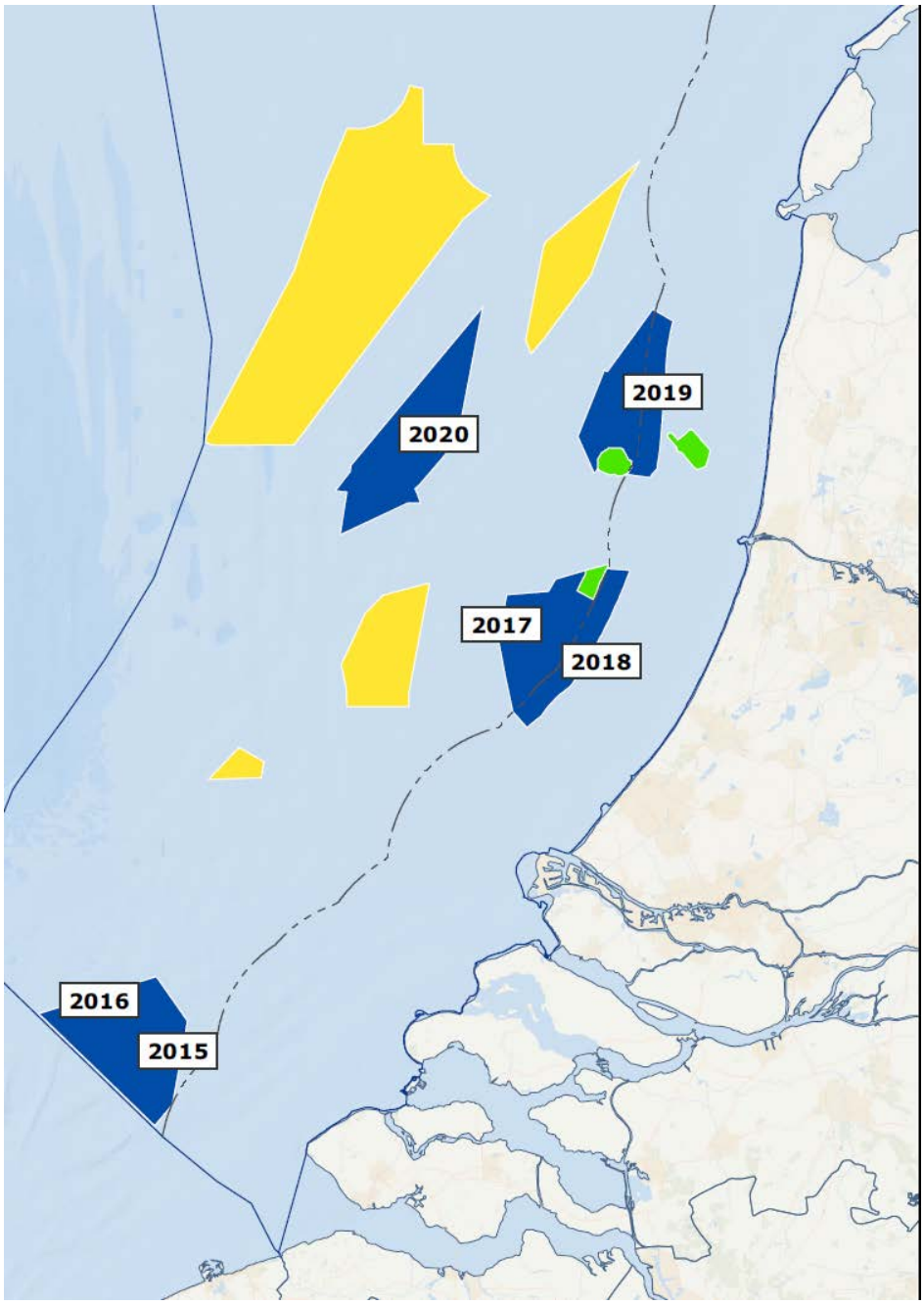

Figure 1 Designated Wind Farm Zones in the Netherlands

At present the HKW WFZ has not yet been subdivided into individual wind farm sites. The wind farm sites will be defined in at a later stage.

1.5. Investigation Area (IA)

It is the intention to obtain a single set of data, reports and drawings for the HKW WFZ, including an additional buffer zone (0.5km) around the zone. The WFZ including this additional buffer zone is defined as the Investigation Area (IA). The IA is shown in Figure 2 (see black line).

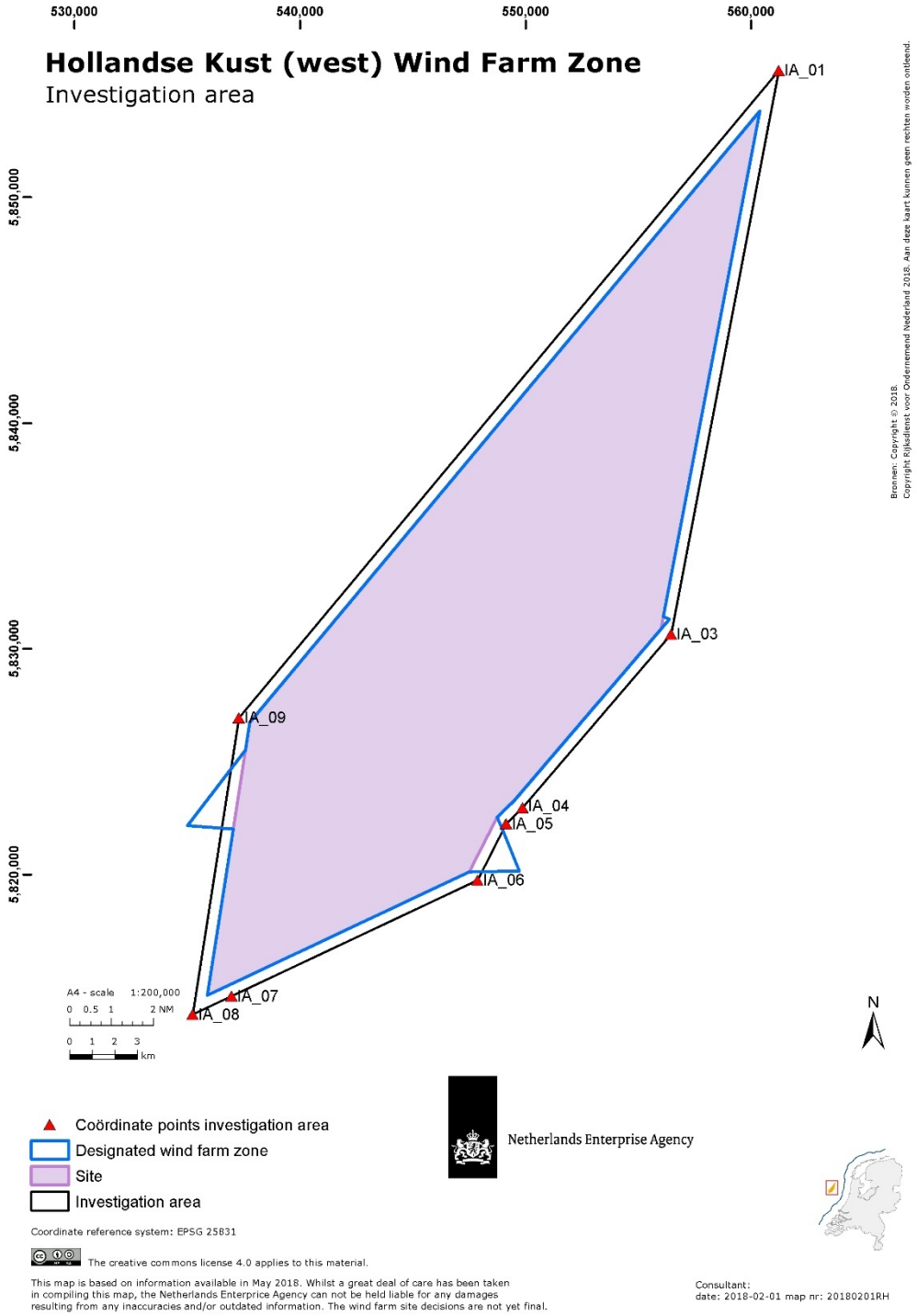

Figure 2 IA to be investigated during the geophysical campaign at the Hollandse Kust (west) WFZ (black line).

1.6. 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 if required.

1.7. Planning of the investigations

The survey shall be carried out in Q4 of 2018.

1.8. Available information

1.8.1. WFZ specific information

CLIENT is in the process of carrying out desk studies on the HKW WFZ. A geological desk study has been carried out and will be made available on https://offshorewind.rvo.nl/soilwh. The following studies will be provided separately to the CONTRACTOR if they become available before start of the works:

- Archaeological desk study;
- UXO desk study;

1.8.2. Other information

Further, for information, the results of the geophysical and geotechnical surveys carried out for Borssele, HKZ and HKN 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. General scope of work

2.1.1. Activities

The activities that need to be carried out to obtain the information detailed in section 1.3 are the following:

- **Preparation**:
  - all preparatory works required for the hydrographic and geophysical survey, including preparation of all plans that need to be provided (and approved) before the works can start.
- **Data Acquisition**:
  - High resolution bathymetric survey
  - High resolution side scan sonar Survey
  - Magnetometer survey
  - High resolution seismic profiling surveys (single and multi-channel)
- **Data processing and Interpretation:**
  - Process the data obtained through the geophysical survey
  - Produce derived products including interpretation
  - Integrate survey elements into a Preliminary Ground Model
- **Reporting:**
  - Create final data package with QA and metadata elements
  - present the results in clear reports and drawings.
  - Provide guidance for design of a geotechnical investigation campaign
  - Provide input for a morphodynamic study.
- **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 specification. The description of the survey targets should inform the contractors for preparing their proposal which should clearly describe their suggested specification suitable to achieve the survey objectives. Proposals of higher specification than the minimum may receive net higher scores if this is justified against a relevant performance improvement (*i.e.* a better chance of achieving the survey objectives to an appropriate quality level). A specification deemed to be of lower quality than the minimum will receive lower scores.

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 1.2. 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.

2.1.2. 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 and processed deliverables from individual survey elements are described within their respective sections. Two integrated deliverables are required: a GIS (*e.g. ESRI ArcGIS)* project containing *all* processed and integrated elements that may be

represented in GIS, and a seismic workstation (*e.g.* IHS Kingdom) project containing *all* of the subsurface data elements.

The contents of these integrated deliverables are to be supplemented by raw data, such processed data as are appropriate for each data element, final data as appropriate, interpretation data, metadata and reporting.

2.2. Preparation

2.2.1. Scrutinise available information

CONTRACTOR shall scrutinise the information that has been made available by CLIENT as specified in 1.8.1. Information that is relevant for carrying out the WORK shall be taken into account while preparing the WORK. The other information as specified in section 1.8.2 can be used as guidance while preparing the survey, however, the requirements as stated in this Scope of Work are leading and shall be adhered to at all times.

2.2.2. Preparation

Design

It is anticipated that the acquisition of geophysical and hydrographic datasets will require one or more passes across the IA. The CONTRACTOR shall select the most effective acquisition set-up (*e.g.* multiple passes, single- or multi-vessel solution) and the most cost effective and efficient survey layout to achieve the survey objectives and data quality requirements while adhering to the following criteria:

- Multi-Beam Echo Sounder (MBES) bathymetry, Side-Scan Sonar (SSS), magnetometry (MAGN) and Sub Bottom Profiler (SBP[1]) are to be acquired with survey lines at not greater than 100 m line spacing.
- Co-located SBP and Single-Channel Seismic (SCS[2]) survey lines are to be acquired with a maximum line spacing of 100 m.
- Multi-channel Seismic (MCS) survey lines to be acquired with a maximum line spacing of 400 m and to be co-incident (channel 1 mid-point) to within 20 m with the single-channel lines.
- Cross-lines are to be acquired at a maximum spacing of 2000 m for the MBES, SSS, MAGN and SBP/SCS surveys and 400 m for the MCS survey (MCS crosslines should be co-incident with SBP/SCS cross-lines).
- The inline orientation should be preferably approximately NNE-SSW, sub-parallel to the predominant sand ridge axis and perpendicular to the predominant sand wave crest orientation.

MCS data must be acquired in a separate pass from the MBES, SSS and MAGN datasets. Simultaneous acquisition of MCS and SBP/SCS data from the same vessel is highly discouraged.

It is anticipated that SBP and SCS data will be acquired simultaneously with the MBES/SSS data, but it is not required that SCS data are acquired along every MBES/SSS line in areas where the MBES/SSS survey line spacing is less than 100 m, as long as the ≤100-m single-channel seismic line spacing is achieved.

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

[2] Single Channel Seismic (SCS) refers to systems with medium penetration i.e. Boomer, high resolution Sparker or similar systems

One or more vessel(s) can be used by the CONTRACTOR to acquire the required datasets (MBES/SSS/MAGN/SBP/SCS/MCS). Acceptable solutions include the use of the following set-ups:

- One-vessel solution with two separated passes to cover the MBES/SSS/MAGN/SBP/SCS survey lines and the MCS lines consecutively.
- Two-vessel solution with vessel 1 acquiring MBES/SSS/MAGN/SBP/SCS data in one pass and vessel 2 acquiring MCS data at the same time.

It is also preferred that the MBES/SSS/MAGN data are collected from the same vessel rather from multiple vessels to avoid variable data quality/accuracy issues.

Equipment interference must be minimised in all cases and shall not impact the data quality.

Permits

CONTRACTOR shall obtain and arrange for all necessary permissions and/or notifications to perform the survey (including all permissions and fees necessary for access and safety arrangements to harbours and offshore positions).

Project Plans

CONTRACTOR shall prepare all required project plans as required by the CONTRACT. These documents include but are not limited to.

1. Project Execution Plan, including applicable Work Method Statements and Risk Assessments;
2. Project HSE Plan, including Emergency Response plan;
3. Project Quality Plan;

The specific acquisition method for each dataset must be detailed in the CONTRACTOR's Project Execution Plan (PEP). The CONTRACTOR's documentation (Project Execution and Quality Plans) should specify achievable in-field accuracies of obtained data for each survey method. The Project Quality Plan (PQP) should include a detailed data quality monitoring programme and methodology, including a summary of expected seabed and sub-seabed conditions to inform on-board data QC work. The PQP and PEP shall include mobilisation and testing plans including verification operations for all mission critical equipment.

PEP and PQP should include the data acquisition, data processing, interpretation, reporting, QAQC and delivery operations.

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.

2.3. Data acquisition

2.3.1. Mobilisation and demobilisation

Mobilisation of the vessel(s) to the site will be considered completed when all necessary geophysical survey equipment and personnel are accepted as operational to the specification agreed by the CLIENT and approved by the CLIENT. Verification of performance shall be made according to an agreed plan (section 2.2.2) with all required testing and calibration of vessel and equipment documented and signed off.

Where the final configuration of any hydrographic or geophysical equipment is not pre-defined in the PEP, ALL options 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 of the data required have been acquired and have passed field QAQC criteria.

2.3.2. Testing

Following mobilisation, 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 PEP and PQP, and should include the collection of data properly representative of the range of ground conditions at the site.

Production data acquired prior to acceptance of the data acquisition configuration is acquired at the CONTRACTORS risk, shall be subject to rigorous QC and may be rejected by the CLIENT OFFSHORE REPRESENTATIVE with no claim for compensation.

A draft mobilisation and testing report 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.

2.3.3. Positioning

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 at mobilisation. The combined precision and accuracy of the navigational positioning capability and post-processing methods must be sufficient to allow positions to be a quoted within +/-1 m, with height values within +/-0.1 m.

Accurate positioning is essential. Coverage requirements dictate the course of MBES and SSS data acquisition, while pre-plot line-plans are the primary target for positioning of MAGN, SBP/SCS and MCS 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 sea bed (near channel reflection point for MCS).

2.3.4. Coordinate reference system and datum

All positioning data shall be delivered in the ETRS89 Ellipsoidal Coordinate Reference System and projected using ETRS89 Transverse Mercator Coordinate Reference System (UTM Zone 31N).

The vertical datum for the survey is Lowest Astronomical Tide (LAT).

The method proposed for reduction of the survey height to LAT must be described and justified in the CONTRACTOR's PEP, Project Documentation and Final report. The reduction method/software and models used should be robust, well-established and documented fully in the final report.

2.3.5. *High resolution bathymetric survey*

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

- sea bed elevations / depths relative to LAT;
- identification and mapping of mobile bedforms;
- 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.

Specifications

Acquisition of high-resolution bathymetric data using a Multi-Beam Echo Sounder (MBES) with at least 100% coverage over the IA.

Data will be acquired to Dutch Standards for Hydrographic Surveys[3] Order 1a standard according to specifications issued by the Maritime and Coastguard Agency (MCA), which includes the identification of all objects greater than 2.0m x 2.0m dimensions. The system should be capable of providing a minimum of 9 soundings per 0.5x0.5 m cell at minimum. The CONTRACTOR shall define the technology and line spacing employed to meet these requirements based on existing water depth information. The system should be demonstrated to be capable of feature detection of the required dimensions as stated above. Compliance with Dutch Standards for Hydrographic Surveys Order 1a uncertainty thresholds must be demonstrated in the Field report.

Required elements

The HRB Survey must include:

- Bathymetric measurement
- Sound velocity measurement (real time at receiver and vertical profiling)
- Backscatter measurement for input to Acoustic Ground Definition (AGD) analysis.

Guidance

Evaluation of proposals will be made with reference to the following method preferences.

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 (through the entire water column). The sound velocity probe incorporated into the MBES system should have an accuracy of ±0.15 m/s.

Vertical Sound Velocity Profiles (SVPs) to measure the speed of sound in water should be obtained in the survey area at regular intervals. It is recommended that SVPs are obtained at the start and end of each day. Measurements should be made using a calibrated velocimeter or calculated using temperature and salinity measurements or a static vertical Sound Velocity Profile such as a Valeport Monitor Sound Velocity Probe or similar. Measurements should be taken continuously between the sea surface and the seabed in a vertical profile. A second set of readings should be taken from the seabed to the sea surface and the speed of sound computed from an average of all the derived values.

[3] http://publicaties.minienm.nl/download-bijlage/92306/dutch-standards-for-hydrographic-surveys.pdf & http://publicaties.minienm.nl/download-bijlage/92302/erratum-bij-tabel-1-english.pdf

Reported water depths must be sound velocity corrected and related to LAT (tidal correction).

Backscatter/snippets data from seabed returns should be logged and processed for use in seabed characterisation using an Acoustic Ground Definition System (AGDS). AGDS classification work should be carried out by an experienced AGDS analyst who is familiar with the specific AGDS package used.

Substantial seabed and shallow borehole data are available with sources described in the geological desk study. An appropriate subset of the data available may be used to support the AGD analysis, however new grab sample acquisition is not required in this survey campaign.

Deliverables

Deliverables are specified in section 2.7

2.3.6. High resolution side scan sonar survey

The objective of the Side Scan Sonar Survey is to contribute to the model of the sea-bed including:

- identification and mapping of mobile bedforms;
- 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 seabed sediments.

The Side Scan Sonar survey should, ideally, be run simultaneously with MBES acquisition.

Specifications

The SSS survey should be carried out using simultaneous multiple channel, multiple frequency side scan sonar with frequencies of ≥100 kHz and ≥ 600 kHz.

The line spacing should be defined to ensure that the SSS survey shall provide at least 100% coverage of the IA with frequency sufficient to resolve all objects of 0.5 x 0.5 x 0.5 m or larger, including sufficient overlap to obtain data at the nadir (the acoustically blank area directly under the SSS fish).

Required elements

The SSS Survey must include:

- Side Scan Sonar

Guidance

Evaluation of proposals will be made with reference to the following method preferences. The side-scan sonar tow fish should be towed at the optimum altitude for the water depth encountered. The towing altitude is normally expected to be between 8% and 15% of the selected sonar range. The slant range used should be set to yield 100% coverage of the survey area and with adjacent line spacings sufficient to provide enough lateral image overlap that the nadir of each line is covered by the range of at least one adjacent line, so that the nadir gap does not appear in the final mosaic.

Scale ranges, depth of tow and tow speed should be determined on site to attain optimum resolution and area coverage.

Interference in the SSS data from other equipment (*e.g*. seismic or magnetometer altimeter) should be minimised and should not impact on the SSS data quality and interpretability. Seabed features should be correlated with seabed samples and any other visual observations where provided by the Client.

Specific care should be taken during SSS data acquisition and processing to provide high quality side-scan sonar mosaics at 0.5 m resolution.

Deliverables

Deliverables are specified in section 2.7

2.3.7. Magnetometer survey

The objective of the Magnetometer (MAGN) Survey is to contribute to the model of the sea-bed including:

- identification and mapping of natural and anthropogenic seabed features and objects;

The primary purpose of this survey will be the identification/confirmation of the positions of all pipelines and possibly electrical and communications cables. The MAGN survey line spacing should as a minimum be equal to the line spacing for the SSS survey. It is acknowledged that a magnetometer survey along widely spaced lines will not be suitable for a UXO survey

The magnetometer shall be deployed in the same survey pass as the MBES and SSS surveying.

Specification

The magnetometer survey line spacing should as a minimum be equal to the line spacing for the SSS survey

Nominal altitude of Magnetometer from seabed: ≤ 7 m

magnetometer sensitivity: 0.01 nT/√Hz or better

magnetometer sample rate: 10 Hz or greater

Required elements

The MAGN survey must include:

- Total Magnetic Intensity at measurement altitude

Guidance

Evaluation of proposals will be made with reference to the following method preferences.

The magnetometer survey line spacing should as a minimum be equal to the line spacing for the SSS survey.

The magnetometer shall be deployed in the same survey pass as the MBES and SSS surveying. The magnetometer should be towed at sufficient distance from the survey vessel to minimize magnetic interference from the vessel. This distance is normally expected to be at least three times the length of the vessel. Where the magnetometer is piggy-backed to other equipment such as a Side-Scan Sonar towfish, sufficient distance to prevent interference from the towfish and other

instruments (*e.g.* seismic) should be ensured. The mounting of any position-tracking equipment on magnetometer tow cables must also be such that interference is minimized. Deck cabling should be arranged to minimize noise.

The magnetometer should be towed as close to seabed as practicable during surveying to ensure that even small magnetic fields such as those produced by thin submarine cables can be easily detected. In all cases it is recommended that the distance between the magnetometer sensor and the seabed should not exceed 7 m. Exceptions will be allowed in areas where the presence of bedforms may incur risk of damage to the equipment, in which case the increased tow height should be approved by the CLIENT OFFSHORE REPRESENTATIVE.

Deliverables

Deliverables are specified in section 2.7

2.3.8. High resolution seismic profiling survey

The objective of the High-Resolution Seismic (HRS) profiling Survey is to contribute to the model of the sea-bed including:

- sea bed elevations / depths relative to LAT;
- identification and mapping of mobile bedforms such as megaripples and sand waves, including the lowest depth of mobile sediments.
- identification and mapping of potential hazards to the development of offshore wind farm infrastructure at the site;
- identification and mapping of significant stratigraphic and lithological horizons that characterise the site;
- 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.

A HRS data set will be acquired (over the entire depth range of interest) over the IA to enable the detection and mapping of any significant subsurface horizons including formation interfaces and buried channel features. The depth range of interest is from sea bed to a depth of approximately 100 m below seabed. Multiple seismic measurements are required to recover information at the range of depths and resolutions of interest.

The HRS data set acquired should at a minimum allow the interpretation of:

- The key geological units defined by the Geological Desk study and any other relevant literature or data;
- The potential geohazards (faults, channels, shallow gas, peat, etc.).

In order to identify any other significant reflector levels that might impact on the engineering design (as per the survey objectives) the following work may be required:

- Interpretation of a subset of intra-formational interfaces (depending on clarity of the reflection, continuity over a significant distance if they represent key markers of the geological model; and
- Interpretation of ‘structural complexities’ such as buried channels within a formation if they extend over a significant area and/or represent major features.

Specification

Data acquisition should be designed to optimise vertical and horizontal resolution, the signal-to-noise ratio and the recovery of coherent signal throughout the depth of interest.

Near surface resolution:	Inline trace spacing <1 m Line spacing ≤200 m Vertical resolution: 0.2 m Nominal penetration: ≥3 m
Resolution to (deepest) first water layer multiple:	Inline trace spacing ≤ 1 m Line spacing ≤ 200 m Vertical resolution ≤ 0.5 m Nominal penetration: ≥40 m
Resolution below (deepest) first water layer multiple:	Inline (stack) trace spacing ≤ 1.57 m Line spacing ≤ 400 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.

ALL sub-seabed data are to be acquired on co-located lines with minimised offset between reflection point tracks. A track separation threshold shall be set during the testing phase but shall not be greater than 20 m.

Required elements

- Single-channel seismic surveying with a Sub-Bottom Profiler system (SBP), *i.e.* Pinger, Chirp, parametric or equivalent system
- Single-channel seismic (SCS) with a medium penetration system , *i.e.* Boomer or high-bandwidth Sparker system,
- Multi-Channel Seismic (MCS) surveying with a high bandwidth Sparker system or alternative source with demonstrated similar spectral characteristics suitable for the resolution specifications. Nominal fold is to be ≥ 24 real traces (without interpolation) and the maximum offset is to be not less than 70 m and not greater than 150 m.

Guidance

Evaluation of proposals will be made with reference to the following method preferences.

Vessel(s) selected for seismic 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 may be required.

SBP must be hull- or pole-mounted and provide effective heave and attitude compensation. Sufficient data processing is required to enable effective identification of the base of mobile sediments at the required resolution.

The SBP 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 3 m in particular as this depth range is important for cable design and installation

SBP and SCS systems, if operated concurrently, must be arranged to minimise interference while maximising the horizontal resolution of each.

The MCS equipment should include a streamer with group spacing of preferably 2 m or less and certainly no more than 3.125 m to provide high horizontal resolution; an active streamer length of between ~70 m and 150 m is required. Shot interval shall be as small as practically possible and defined to maximise CMP fold.

It is preferred that seismic sources and hydrophone cables are deployed by personnel experienced in their configuration, parameterisation and optimisation. A consistent, broad band seismic pulse is required for both SCS and MCS surveys.

Slant-cable or hybrid-cable proposals are acceptable if the vessel operations team can be guaranteed to have had prior experience of the systems proposed and any required data processing schemes are proven to be established in production work. Slant-cable may only be proposed in conjunction with documented and proven mitigation for receiver ghost effects. Both slant-cable and hybrid cable proposals must be accompanied by specific descriptions of the methods of geometry assignment and QA metrics to ensure acceptable performance.

A line-plan must be submitted with the CONTRACTOR's proposal.

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. Trace headers should conform to SEG Y Rev1 (2002)[4] in structure and should contain the appropriate information.

The data are to be layback-corrected. Layback-correction should be carried out such that each trace has its own unique co-ordinate pair associated with its reflection point. Trace co-ordinates must be unique to each trace, appropriately interpolated between fix points, and consistent navigation data are to be provided in trace headers and track plot tables. A description of the layback procedure must be included in the Field report.

Data processing is described in section 2.4.

Deliverables

Deliverables are specified in section 2.7.

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

2.3.9. Quality Control

General

Focus shall be on obtaining high quality results and meeting the programme requirements.

During data acquisition, bathymetry, magnetometer, side scan and sub-bottom profiling (SBP, SCS and MCS) datasets shall be monitored continuously to ensure both coverage and quality (including resolution) are maintained. The target survey speed shall be no more than 4 knots, however actual survey speed will be subject to weather conditions encountered and impact on data quality (particularly for the MCS data). Throughout the offshore survey activity, data quality checks shall be carried out on board by a qualified 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 an experienced geophysicist 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 suitable. 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 target locations, interface depths *etc*. in reports and other documentation the chain of positioning errors (target 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.

High-resolution seismic surveying

Regular (but not daily) seismic Data Quality Reports (“DQR”) may be requested by the CLIENT during the course of the offshore work. The DQR should summarise the quality monitoring work and contain screenshots of both the raw and preliminary processed data at sufficient scale and resolution to allow the data quality and interpretability to be assessed.

During MCS acquisition, daily data quality assessment shall be performed by generation of stacks with the minimum feasible data processing operations to enable evaluation of fitness-for-purpose. The shot quality shall be continuously monitored. A shot is deemed 'bad' if *e.g.* navigation is lost, feathering angle threshold is exceeded, streamer balancing is compromised due to poor navigation, signal-to-noise ratio is compromised due to ambient or artificial noise, 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 at least feathering angle, nominal fold, and bad shots.

The following must be agreed with the CLIENT before (SCS and MCS) surveying commences:

- A Quality Assurance monitoring programme for the seismic acquisition.
- Acceptance criteria for completion of acquisition for a seismic line.

2.4. Data processing

2.4.1. Bathymetry

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.

The reduction method and vertical and horizontal datums used must be compliant with Section 2.3.4, 2.3.5 and IHO standards and guidance (IHO, 2005*; IHO, 2008^). Details of the vertical reduction process must be included in the Operations Report and demonstrated to meet or exceed the requirements of the specified standards and guidelines, using appropriate illustrations.

Regardless of the theoretical capability of the hydrographic and navigational systems deployed, full QA/QC must be carried out in order to generate statistical proof that the survey meets the requirements of Order 1a. A statistical description of Total Horizontal Uncertainty (THU) and Total Vertical Uncertainty (TVU) must be generated with the resulting errors being demonstrated to meet or exceed Order 1a minimum requirements. A quantitative assessment of the feature detection thresholds for the survey must also be included and demonstrated to meet or exceed the Order 1a minimum requirements."

*IHO. 2005. *Manual on Hydrography (C-13).* International Hydrographic Bureau, Monaco, 1st ed. (corrections to February 2011), 36 pp.
^IHO. 2008. *IHO Standards for hydrographic surveys (S-44).* Special Publications No. 44. International Hydrographic Bureau, Monaco, 5th ed., 36 pp

2.4.2. Side-Scan Sonar

Data shall be corrected for slant range, towfish skew, absorption of sound by seawater, geometric spreading and ship speed to produce the SSS mosaic. The bathymetry elevation data should be used for topographic corrections such that the corrections are carried out based on 3D positioning. The data should be mosaicked to 0.5 x 0.5 m or better and the nadir gap should not appear in the final mosaic.

2.4.3. Magnetometer

During processing, the CONTRACTOR is to edit the magnetometer data to remove obvious spikes and to de-trend the raw data to extract residual magnetic anomalies. The de-trending and reduction to residual magnetic anomaly procedures must be described in detail in the Final report.

Magnetic anomaly data must not be interpolated between adjacent lines and magnetometer data must under no circumstances be gridded: generation of an Analytic Signal Chart series is not required for coarsely-spaced, non-UXO survey data. Should it be required to plot the magnetometer data in plan view in addition to plotting of the targets, ribbon plots should be used.

2.4.4. Seismic

SBP, SCS and MCS data require data processing to be applied to optimise quality. Full reporting is required for each type of data collected.

MCS data may have 'brute stacks' generated for use in the QA operations on-board. Brute Stacks should contain the minimum processing required to evaluate the quality 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.

Final processing of MCS data may be applied onboard or ashore, in either case the details of any 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 test panels presented. A tentative prediction of the 'Final stack' processing sequence should be provided in the proposal, with options presented as appropriate. It is expected that all necessary processing will be undertaken to all SCS and MCS data to maximise the data interpretability. Data processing will be monitored for quality, and CLIENT may require opportunity to inspect data and provide input at any point prior to delivery. Data processing of MCS data should be comprehensively tested, reported and signed off by CLIENT on up to 7 lines – three NNE-SSW lines and four WNW-ESE lines - prior to production processing.

The method by which depth values have been obtained from the single-channel seismic time picks must be clearly explained. The velocity used for converting all seismic interpretation to depth should be selected based on consideration of the MCS-based velocity model and the choice of velocity used should be described.

2.5. Interpretation

2.5.1. Target identification

Overview

Target picking must be carried out on SSS, magnetometer and MBES data. Targets should be reported as points, polygons and polylines. Linear targets of lengths on the order of the line-spacing or greater must be provided as polylines, not points.

Where linear features are identified (cables and/or pipelines), an interpretation should be made by linking the point targets to form linear targets. Where a linear target is identified based on a number of point targets from one or more of the MBES, SSS and magnetometer data, both the point and linear targets must be retained in the deliverables. Linear targets that are associated with known cables/pipelines must be mapped and included in the deliverables. The contractor to investigate before commencement of the survey if further in-service and out-of-service cables and pipelines can be found in the area, based on their own information and on the Geological Desk Study and associated GIS archive.

An overview of active cables and pipelines known to CLIENT is included in Annex 5-VII (the provided GIS-file). Contractor to investigate before commencement of the survey if further in-service and out-of-service cables and pipelines can be found in the area, based on own information.

Side-Scan Sonar

SSS target picking must be carried out. Identified features must include *at minimum*:

1. Wrecks;
2. Both linear and point debris ≥ 0.5 m;
3. Boulders ≥ 0.5 m;
4. Pock-marks/depressions
5. Cables;
6. Pipelines; and
7. Trawl scars and regions of trawl scars

Where a class of target feature is not detected within the IA, reporting of the search for and conclusions of absence of such features is required.

Additionally, the nadir must be checked for evidence of gas plumes.

The thresholds indicated are nominal, and a higher threshold and/or mapping of discrete areas of anomalously high target density may be appropriate if feature densities are high, subject to approval by the CLIENT. Proposed identification thresholds should be indicated within the CONTRACTOR's PEP for approval by the CLIENT.

MBES

MBES target picking should be carried out based on gridded data to support the interpretation of SSS targets.

MBES targets must be identified and should be listed separately in a spreadsheet, along with a description of the target length, width and depth/height.

Targets must be classified *at minimum* into the following categories:

- Wreck-associated, correlated to local wreck registers, if available, and associated magnetometer/SSS targets;
- Debris-associated, correlated to associated magnetometer/SSS targets;
- Possible pipeline (with appropriate ID to indicate where multiple targets are thought to be associated with the same pipeline);
- Possible cable (with appropriate ID to indicate where multiple targets are thought to be associated with the same cable);
- Mound.
- Depression.

Magnetometer

Magnetometer target picking must be carried out based on residualised profile data. Under no circumstances should gridded data be used for interpretation.

Magnetometer targets must be identified and listed separately in a spreadsheet, along with a description of the anomaly type (positive/negative monopole, dipole). The recommended picking threshold is a peak-to-trough amplitude of ≥5 nT. A higher threshold may be appropriate if noise levels are high, subject to approval by the CLIENT.

Targets must be classified *at minimum* into the following categories:

- Wreck-associated, correlated to local wreck registers, if available, and associated bathymetry/SSS targets;
- Debris-associated, correlated to associated bathymetry/SSS targets;

- Possible pipeline (with appropriate ID to indicate where multiple targets are thought to be associated with the same pipeline);
- Possible cable (with appropriate ID to indicate where multiple targets are thought to be associated with the same cable);
- Possible UXO;
- Undesignated.

Checks must be carried out on the magnetometer data to identify those magnetometer targets that are probably related to wrecks that are visible in the SSS/MBES data, and to identify additionally any magnetometer targets that may be indicative of buried wrecks (or potentially UXO). If possible UXO targets are identified, these must be indicated in the target table.

2.5.2. Sea bed classification

Sea bed classification shall be carried out based primarily on MBES backscatter/snippets data. AGDS classification work should be carried out by an experienced AGDS analyst who is familiar with the specific AGDS package used. AGDS processing parameters must be detailed within the Final report. Side-Scan Sonar (SSS) data should be used to check/refine the AGDS classification, as should ground-truthing data where available. The Final report must justify the use of default/'black box' classification parameters, if used.

If grab samples are available from another source then they should be incorporated into the seabed sediment characterisation analysis, however new grab sample acquisition is not required in this survey campaign.

2.5.3. Bedform classification

Bedform zonation, carried out according to a recognised classification scheme. It is suggested that nomenclature follows that used in the morphodynamic studies of other WFZ data packages of the Hollandse Kust series. The quantitative basis for the classification scheme selected must be described in the report and a table of parameters (bedform length, width, height and shape) for each selected class must be provided. At minimum, the following features shall be mapped:

- Megaripples
- Sandwaves
- Large sandwaves.
- Linear Tidal Sand Ridges.
- Anthropogenic features (*e.g.* dredging areas).

Where bedforms of different classes are co-located, this shall be indicated through the use of separate, overlapping class polygons (*i.e.* in an area where small dunes are superimposed on large dunes, the polygons for these two classes shall overlap).

The seabed slope (degrees) shall be calculated.

The position of the crests of Sandwaves and Large sandwaves shall be mapped.

2.5.4. Outputs

The result of the MBES, magnetometer and SSS survey shall be:

- Sea bed features as GIS layers and on one or more A0 charts at an appropriate scale showing both SSS Magnetic targets and MBES targets superimposed on the SSS mosaic. All pipelines/cables, both previously known and unknown, must be mapped both as linear and associated point targets.

- Sea bed features as GIS layers and on one or more A0 charts at an appropriate scale showing both SSS and Magnetic targets (and MBES targets, if picked) superimposed on a ribbon plot of the processed magnetometer data. All pipelines/cables, both previously known and unknown, must be mapped both as linear and associated point targets.
- In addition to a full target list (within the report or as an appendix), the report must contain a summary table indicating the number of magnetometer targets of each classification.
- In addition to a full target list (within the report or as an appendix), the report must contain a summary table indicating the number of SSS targets of each classification.
- The report must contain a table of the wrecks identified through all methods. If any known wreck is not identified then the possible reasons for this must be discussed.
- If an object is located offset from the location recorded in the relevant database, both the recorded and as-found locations and dimensions must be indicated on charts and target tables.
- The report must contain a table of cables and pipelines identified through all methods. The report must contain an evaluation comparing the expected and actual location for cables and pipelines in the IA. The evaluation should include a map and a discussion in the text. If identity/location of (part of) cables and pipelines cannot be confirmed the reason for this shall be clearly specified.

Deliverables are specified within section 2.7

2.5.5. Subsurface

Subsurface data are to be interpreted using a workstation package at least capable of representation of all subsurface data elements in a common system, capable of picking interfaces in the time domain and rationalising those picks between the data elements and at line intersections to ensure consistency. The Kingdom application from IHS Markit is preferred.

The interfaces to be mapped are to be identified and agreed between CLIENT and CONTRACTOR but shall include the sea-bed, the base of mobile sediment and up to 5 additional stratigraphic, lithological or other interfaces. The interpretational framework shall be initiated using a subset of not less than 7 lines – three NNE-SSW lines and four WNW-ESE lines; these lines shall be interpreted first, in close collaboration with CLIENT and the framework and strategy agreed with CLIENT prior to further interpretation. All sub-bottom data are to be interpreted.

The interpretation must include consistency/line-tie checks between the single- and multi-channel seismic datasets within the same interpretation environment, and these checks must be described in the interpretative reporting.

Formation boundaries and selected intraformational interfaces as required must be gridded and contoured. A single grid should be provided for each interface. The gridding methods and parameters used to generate interface grids from the original pick files must be described in full. Where a single interface has been picked from more than one seismic dataset (*e.g.* Pinger and Boomer) then a single interface grid must be generated and the reporting must describe how the final grid for that interface was derived from the picks of each seismic dataset. A quantitative discussion of the elevation uncertainty of all interfaces must be included in the report.

Geohazard and intra-formational interfaces may be gridded or presented as pick plots depending on their extent and continuity. The spatial extent of interfaces and geohazards is to be mapped and delivered within both seismic workstation and GIS deliverables.

If a significant portion of the subsurface is characterised by intense faulting, the characterisation of the faulting pattern (mean fault throw and density) can replace the picking of each individual fault.

2.5.6. Outputs

The output of the subsurface interpretation shall be:

- Seismic workstation project incorporating all subsurface datasets, horizon picks, grids, culture and other information used in interpretation.
- Geological cross-sections identifying all significant features and horizons (superimposed on the processed seismic data) for a representative subset of lines from each dataset (SCS and MCS) on one or more A0 charts at an appropriate scale.
- Gridded elevation surface and contours (isolines) for each interface showing depth to Base of formation/formation member/unit) below datum (LAT), electronically and as one or more A0 charts at an appropriate scale.
- Gridded depth below seabed and depth below seabed contours of each formation/formation member/unit) electronically and as one or more A0 charts at an appropriate scale.
- Mapped extents for each formation/formation member/unit) and laterally extensive geohazard (*e.g*. shallow gas or peat), electronically and as one or more A0 charts at an appropriate scale.

Deliverables are specified within section 2.7

2.6. Reporting

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

2.6.1. 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 contents of the daily and weekly reports is specified in Section VII of this CONTRACT.

As indicated in Section 2.3.8, the CONTRACTOR may be requested by the CLIENT to provide seismic 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 OFFSHORE CLIENT REPRESENTATIVE.

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.

2.6.2. Field report

A Field Report shall be made available for the IA within two (2) weeks of completion of the fieldwork. 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; vessels; equipment list;
    - Vessel Offset Diagrams for each vessel and, if instrument configurations were changed in the field, each instrument configuration;
    - Exact positions of all survey works 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 report for the MCS survey.
    - 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.

2.6.3. Final report

An Final Report shall be made available , incorporating interpretational reporting, for the IA within nine (9) weeks following completion of the fieldwork. This Final Report shall include:

1. A statement of the purpose of the investigation;
2. 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;
3. Exact locations of all survey lines;
4. Geophysical data interpretation and conclusions drawn. This includes all results deliverables specified in Section 2.3, 2.4 and 2.5;
5. Electronic copies of all raw and processed data from the survey;
6. Charts at an appropriate scale on A0 of all outputs defined by CLIENT as required.
7. Recommendations for geotechnical investigation locations to qualify the seismic interpretation for stratigraphy, lithology, geohazards and representative geotechnical parameters, including sufficient ‘typical’ and ‘anomalous’ locations to characterise the variation across the IA. These may number up to 40-80 locations, depending on geological complexity of the site. Include for each location:
    a. Justification for choosing the location.
    b. Recommendation if a CPT or borehole should be executed and to what depth.
    c. Chart and description of predicted geological sequence.
8. A proposed CPT and borehole plan. This plan should be derived based on recommendations of point 7 with the aim to select suitable locations for in situ investigations in the subsequent geotechnical campaign. The plan is to

be issued as a separate memo with the proposed CPT / borehole locations, their coordinates, a concise motivation per selected location and a shape file with the proposed locations.

All reports and data deliverables shall be accompanied by metadata that are compliant with RVO's metadata requirements specified in Annex 5- Section VII.

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

The Draft 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. Data shall be provided via multiple portable hard drives (8).

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

2.7. Data deliverables

2.7.1. Overview

A complete data archive as defined in the following sections must be provided with both the draft and final interpretative reports.

All data shall be provided with appropriate metadata using the Dutch metadata profile as defined in Annex 5 – Section VII.

A table of file names against line names for all MBES, Side-Scan Sonar, magnetometer and seismic data files as plain text file or spreadsheet. 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;

2.7.2. Raw

The following raw data deliverables are required *at minimum*.

- Swath bathymetry data per line/file (full density), in the form of cleaned, de-spiked text (x,y,z) files, after application of positioning QA/QC.
- MBES backscatter data, in standard format such as Generic Sensor Format (GSF).
- Speed of sound in seawater vertical dip data profiles as Excel spreadsheets containing graphs, and as plain text files stripped of trailing values. Data columns must include, at minimum, depth of sounding, recorded speed and corrected speed. Correction parameters should also be included as headers or data columns. Data from both down- and up-going casts must be included.
- Side-Scan Sonar data in the form of raw, un-mosaiced data files (*e.g.* *.xtf files)
- Cleaned, de-spiked magnetometer data as text (x,y,z) files per line/file, after application of positioning QC and layback

- Raw SCS (SBP and SCS) data with correct navigation applied in SEG-Y format (if applicable, heave information shall be provided separately and not applied to the raw data).
- Multi-channel raw seismic data with geometry and correct navigation applied (shot gathers) in SEG-Y or SEG-D format.

2.7.3. Processed

The following processed data deliverables are required *at minimum*.

- MBES trackplot (fix point and line).
- The bathymetry at a resolution of 0.5 x 0.5 m or better reduced to datum 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; ***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).
- MBES backscatter image at an appropriate resolution, produced by gridding the swath bathymetry backscatter data to a regular grid, as: a single or tiled set of xyz text files (*.xyz/*.pts) without overlaps; ***and*** a single or tiled raster/grid without overlaps.
- 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; ***and*** a single or tiled raster/grid without overlaps.
- The bathymetry slope in degrees calculated from the bathymetry grid as a single or tiled set of xyz text files (*.xyz/*.pts) without overlaps; ***and*** a single or tiled raster/grid without overlaps.
- A time-stamp indexed text file of the tidal correction.
- SSS trackplot (fix point and line).
- Magnetometer trackplot (fix point and line).
- Single or tiled Side-Scan Sonar mosaic at 0.5 m resolution without overlaps in raster format (*e.g.* *.tif).
- Cleaned, de-spiked magnetometer data as text (x,y,z) files per line/file, including layback, detrended to residual anomaly
- Trackplots for the SCS seismic survey (based on the source-receiver mid-point) (point and line).
- Trackplot for the multi-channel survey (based on the CDPs) (point and line).
- Processed SCS data with correct navigation and tidal correction applied in SEG-Y format (if applicable, the processed data shall be heave corrected) in time.
- Multi-channel processed seismic data with correct navigation and tidal correction applied in SEG-Y format (including processed data at major interim stages of the processing, *e.g*. brute stack, after multiple attenuation and before and after migration) in time and depth.

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 mosiac. If provided in a non-ESRI GIS format (*e.g.* CAD, microstation), all processed deliverables listed above except the cleaned, de-spiked magnetometer data must be provided additionally in the project GIS archive.

2.7.4. Interpretative

The following interpretative deliverables are required at minimum.

- Bedform classification polygon(s).
- Sandwave crests as polylines.
- Sediment distribution/seabed classification, depending on the classification method used to be provided as: either a single or tiled set of xyz text files (*.xyz/*.pts) without overlaps and a single or tiled raster/grid without overlaps; ***or*** a digital vector file/drawing (AutoCAD or Microstation format or similar).
- Full Side Scan Sonar contact report containing information and images for all identified SSS targets in Microsoft Word and Adobe pdf formats.
- Side-Scan Sonar target table and associated point, line and polygon spatial data files with columns for:
    - unique ID;
    - target classification (wreck, boulder, debris, *etc.*);
    - X co-ordinate (centre);
    - Y co-ordinate (centre);
    - dimension(s);
    - short description;
    - where relevant, associated wreck number or cable/pipeline ID; and
    - where relevant, associated magnetic anomaly ID(s).
- MBES target table and associated point, line and polygon spatial data files with columns for:
    - unique ID;
    - target classification (wreck, boulder, debris, *etc.*);
    - X co-ordinate (centre);
    - Y co-ordinate (centre);
    - dimension(s);
    - short description;
    - where relevant, associated wreck number or cable/pipeline ID; and
    - where relevant, associated magnetic anomaly ID(s).
- Magnetometer target table and associated point, line and polygon spatial data with columns for:
    - unique ID;
    - target classification (wreck, debris, cable, *etc.*);
    - X co-ordinate (centre);
    - Y co-ordinate (centre);
    - source line name;
    - source file name;
    - short description;
    - approximate total peak-to-trough magnitude;
    - approximate anomaly width;
    - anomaly shape, *e.g.* negative monopole, positive monopole or dipole;
    - where relevant, associated wreck number or cable/pipeline ID;
    - where relevant, associated Side-Scan Sonar anomaly ID(s).
- Separate table containing all vertex co-ordinates for each identified cable/pipeline, indexed by cable/pipeline ID.
- Text (or csv) pick files for each interpreted horizon (including seabed and interfaces/features that were of too small extent or too sparse to be gridded) in an exchangeable format with at minimum columns for XY coordinates, survey line name, shot point/trace number, time and elevation.

- 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 pick data to a regular grid, as an xyz text file (*.xyz/*.pts) ***and*** a raster/grid.
- Elevation contours for all interpreted horizons at an appropriate interval.
- 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.
- Sub-surface point geohazard (such as diffraction apices that may indicate the presence of boulders) table(s) and associated point spatial data with columns for X and Y co-ordinates at minimum and depth where appropriate
- Formation/formation member/unit and laterally extensive geohazard (such as shallow gas or peat) extents as polygons in 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 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.

2.7.5. GIS

A project GIS archive in a single GIS deliverables folder in accordance with requirements as specified in Annex 5-VI, and accompanying map document(s) (*.mxd), containing data as specified throughout this Scope of Work. Data should ideally be provided in a geodatabase, 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.* target feature classes in the GIS archive must contain the same attribute columns and values as in the Excel/text file target tables and report appendices, Kingdom-generated elevation grids and GIS elevation rasters should match, *etc.*). The GIS data archive must include *at minimum*:

1. Project area, wind farm and survey boundaries (polygons).
2. Vessel trackplot(s) and fix points.
3. Sensor trackplots and fix points (transmitter/receiver midpoint where transmitter and receiver are not co-located; CDP-based for the MCS trackplots).
4. Bathymetry grid (full resolution) and contours.
5. TVU and TVH uncertainty grids.
6. MBES backscatter grids.
7. SSS mosaic (full resolution).
8. MBES, SSS and magnetometer targets (point, linear and polygon targets to be symbolised appropriately; *e.g.* significant linear targets should be recorded as line features and not points), including as-found cables, pipelines, wrecks *etc.* MBES and SSS targets may be combined into a single Feature Class/shapefile but magnetometer targets must be kept separate.
9. 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.

10. 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.
11. Point and polyline geohazards (suspected boulders, isolated peat occurrences of too small an extent to be gridded, *etc.*).
12. Seabed sediment classification.
13. Bedform classification.
14. Geotiffs of all reported side scan sonar contacts.

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.

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).

2.8. Offshore Representation

The CLIENT may require up to two (2) CLIENT OFFSHORE REPRESENTATIVES per vessel to witness the offshore phase of the surveys, in addition to any other client representatives required under the contract.

The CONTRACTOR is to be responsible for providing safety induction training for the CLIENT OFFSHORE REPRESENTATIVES 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 REPRESENTATIVES on any vessels to include a private cabin, office space, 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 128 kbits/sec upload / download.

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

3. KEY DATES

The KEY DATES, excluding WAITING ON WEATHER are set out in the table below. It is anticipated that the acquisition of data is executed in two separate passes over the Wind Farm Zone (see section 2.2.2), these passes are indicated with Part A and Part B. [The tasks executed during part A and part B are indicated in Annex 4 (Cycle Times and prices/rates)][5].

No.	Description	Date
1	COMMENCEMENT DATE CONTRACT	
2e	Project documentation final	
Part A: MBES / SSS / Magnetometer / SCS / MCS[5]		
3a*	Start of Mobilisation	
3b	Mobilization finished	
3c	Testing and transit to site finished	
3d	Surveying	
3f	Offshore Completion Date Part A (excluding WAITING ON WEATHER)	
3g	Offshore Completion Date Part A (including WAITING ON WEATHER)	
Part B: MBES / SSS / Magnetometer / SCS / MCS[5]		
4a*	Start of Mobilisation	
4b	Mobilization finished	
3c	Testing and transit to site finished	
4d	Surveying	
4f	Offshore Completion Date Part B (excluding WAITING ON WEATHER)	
4g	Offshore Completion Date Part B (including WAITING ON WEATHER)	
Data processing and reporting		
5a*	Offshore Completion Date (latest date of 3f and 4f)	
5b	Field Report (days after offshore completion date)	
5c*	Issue 1st revision Draft Final Report ([●][5] days after offshore completion date)	
5f	Client Review of 1st revision Draft Final Report	
5g	Issue 2nd revision Draft Final Report	
5h	Client review of 2nd revision Draft Final Report	
5i*	Issue Final Report (time including any further revisions and consequential review time required)	

*Table 1 KEY DATES (*Contractor is liable for Liquidated Damages in case of failure to complete at these dates)*

[5] To be updated after award on the basis of the Annex 4 that was issued with the proposal of CONTRACTOR