RVO Hollandse Kust (west) Geophysical and Geotechnical Survey Q&A

Question 1

The bathymetry coverage appears not to be 100 %. What are the reasons for that?

Answer 1

There are buoyant waterway markers in the HKW area and during data acquisition these had to be avoided resulting in gaps in MBES data coverage. Further, around platforms P6-B, P6-D, and P9-Horizon 500 m exclusion zones were adopted. No data was acquired within these exclusion zones.

Question 2

Why do the geotechnical locations occasionally deviate from the 2D UHR seismic lines? It would make sense to have the geotechnical locations sited on the 2D UHR seismic lines to directly compare geophysics and geotechnics.

Answer 2

Ideally geotechnical locations are situated on the 2D UHR lines. The geotechnical locations however are located on the magnetometer lines for operational safety reasons. Magnetometer lines are offset from the 2D UHR lines as a result of the used acquisition spread (MCS: towed streamers at some distance behind the survey vessel; MAG: sensor towed from a beam on the side of the vessel). For a safe execution of geotechnical operations Fugro aimed to be positioned away from any ferrous objects (possible UXO) on the seafloor, i.e. with positioning geotechnical locations on the magnetometer lines. Care was taken to position the geotechnical locations at the crossing of a magnetometer and a 2D UHR line. This was however not always achieved as the objective for having a geotechnical location was not always exactly present at a line crossing.

Question 3

Why were no downhole seismic CPTs performed, and only in seafloor mode?

Answer 3

During the seafloor in situ testing campaign, 30 seafloor seismic CPTs were performed to depths exceeding 35 m below seafloor in all cases. This was deemed sufficient for a good site coverage of seismic data and seismic data acquisition during the downhole phase could therefore be omitted from the programme.

Question 4

To what extent did the COVID-19 pandemic have an impact on the project activities?

Answer 4

Fieldwork execution was finished before the pandemic hit. Laboratory testing programmes were impacted due to the lockdown, but with Fugro COVID-19 measures assuring the safe continuation of critical laboratory activities and various support functions working from home, laboratory test results have been issued within the agreed time frame for disclosure in Q4 2020.

Question 5

Which monopile design criteria have been considered when setting up the cyclic and dynamic laboratory testing programme?

Answer 5

The laboratory testing programme has been set up by Fugro together with RVO to cover a broad range of test types, soil types, and loading ranges in order to facilitate possible use in a variety of design models. This has been achieved by a serial testing approach whereby various test series were designed in which variations in test conditions were introduced (e.g. specimen dry density, consolidation stress, cyclic/average stress ratio, one-way loading/two-way loading, no. cycles, various cyclic stages, with/without cyclic pre-shear) to try and target low, typical, and high cyclic resistance.

Question 6

Units F and G make up a large part of the depth of the geological model. Can these units be sub-divided more?

Answer 6

An attempt to subdivide these units was made based on the available data, but this proved very difficult. Although there are internal channels visible in these units, they could not be correlated over long distances. No continuous reflectors are present within these units, and as such no further subdivision was made.

Question 7

Age dating: based on palynological assessment, Unit F also contains Eemian signatures, while the unit is assessed to be Yarmouth Roads Formation. What is the cause of this?

Answer 7

Geological age dating (e.g. palynology) can be tricky in coarse grained environments. These high energy depositional environment have a tendency of having a poor record of fossilized plant remains (pollen spores). If present they are often not well preserved making assessment difficult. Ideally clay samples are used for palynological assessment. On top of this, the high energy environments lead to reworking of older deposits in younger formations/strata. As a result, the palynological signal of older strata may be incorporated in younger strata. In top of this the seismostratigraphic boundaries are locally not clear and there are depth uncertainties in time depth conversion and sampling. Especially when taking samples near seismostratigraphic or soil unit boundaries misinterpretation may be the result.

Question 8

Boreholes and CPTs aim to identify the important geotechnical features present at the site. Do you believe that this has actually been achieved?

Answer 8

Site characterisation has been performed by Fugro following an integrated approach as recommended by ISO standards. Note that geophysics has been 2D and not 3D, and further note that boreholes and CPTs are 1D. Thus theoretically, as each model has limitations, a local geological feature outside the data coverage (e.g. between seismic lines) may have been missed. However, we are confident that the important geological features present at the site have been identified.

Question 9

The geological ground model report states that boulders and cobbles can be expected in the HKW area (based on geological setting). Some possible boulders have been identified in the unmigrated SCS data, but not on other data. Can you please elaborate on this? From a developer's point of view, you rather not have boulders at wind turbine locations. What were the criteria for picking boulders and what is in your judgment the chance of encountering boulders at the site?

Answer 9

Boulders/cobbles are generally represented by high amplitude point reflectors, which are sometimes associated with hyperbolae coming from these point reflections. It should be noted that these hyperbolae are removed during the processing phase of the multichannel data.

Based on the geological setting we cannot rule out the presence of boulders. At the seismic lines there was little evidence for boulders, however we only have lines at 100 m (SBP and SCS) and 400 m for MCS data. Boulders that are not directly 'below' seismic lines have not been detected.

Question 10

Will the webinar be recorded and available on the website?

Answer 10

Yes, the webinar will be recorded and become available on the website.

Question 11

Why did the 2D UHR survey take about 4 months? Because of the weather?

Answer 11

The survey took place over the winter months between October and February so there were weather downtimes when conditions were not suitable for survey activities.

Question 12

Was there a lot of weather downtime? If so, may we ask how much?

Answer 12

This information is not publicly available, however, metocean data from buoys deployed on the HKW site is available for individual assessment of the weather conditions that occurred during the survey.

Question 13

Can you comment on the multichannel UHR seismic processing? How was multichannel UHR seismic migrated etc.?

Answer 13

A 2D Kirchhoff post-stack time migration was applied to the UHR data (PoSTM). The processing report can be found on https://offshorewind.rvo.nl/soilw and then Appendices B-L of the geophysical results.

Question 14

Was there also backscatter data acquired during the geophysical campaign?

Answer 14

Yes, backscatter data was collected, processed and used for the interpretation of seabed features and sediment types.

Question 15

Were ferrous and non-ferrous UXOs investigated? Does that relate to the 0.3 m lower detection limit?

Answer 15

Ferrous UXO's were investigated by MAG, seafloor objects (including possible non-ferrous UXO) were investigated by MBES and SSS. Possible subsurface objects were investigated by SBP. Note the limitations due to detection limits and line spacing of each system.

Question 16

Do we know the date when the spudcan was installed to infer mobility within that vicinity?

Answer 16

It is not known to RVO or Fugro when the spudcan was installed.

Question 17

Can you comment on the shape of the sand waves, taken for the image presented the sand waves asymmetric with the peak relative short and high and the trough relative long, is this correct?

Answer 17

Sand waves typically have an asymmetric profile with a lower angle stoss side/slope and a steep lee side/slope facing the direction of propagation (sand waves migrate in the direction of the steepest slope). For more information on morphodynamics we refer to the morphodynamic assessment and the morphodynamic webinar.

Question 18

Were the deliverables and data model certified?

Answer 18

All project deliverables and data have been certified by DNV GL, with no outstanding issues. Certification reports are included in the deliverables available on RVO's website. Exemption is the Synthetic CPT profiles report, for which, due to absence of standards and norms, a review report is issued by DNVGL.

Question 19

What is the geometry range of subsurface boulders identified?

Answer 19

The minimum size of the potentially detected boulders is approximately 0.3 m, based on resolution of the unmigrated SCS-UHR dataset.

Question 20

Was there any inversion applied to the seismic data? And was there any demultiple scheme applied to the data as well?

Answer 20

Inversion was applied to gain synthetic CPT data (to be covered in a separate webinar). For demultiples, SRME was performed.

Question 21

Can you say something about the percentage of early termination versus achieved termination depth?

Answer 21

Plate 'Location Overview' in report P904711/01 provides an overview of penetration depths and test termination criteria for all test points. Of the 148 PCPT and SCPT tests, 79 % reached maximum push length of the test equipment.

Question 22

How has Fugro addressed the identification of true origin of waves due to uncertainty in contact between the seabed and SCPT frame? Due to the many contact points between the SBF and the seabed, there may be multiple waveforms and potential interference from the seismic source.

Answer 22

Due to the weight of the seabed frame, good contact was ensured between the source located on the seabed frame and the seabed. During a SCPT a very clear first arrival is visible after a shot has been fired, which is in most cases clearly distinguishable from background noise. A comparison of peak-to-peak arrival times to infer shear wave velocity is made for the interval between geophones, and hence the uncertainty of the 'true origin' is of limited importance.

Question 23

Are CPTu and PCPT the same?

Answer 23

Yes, these two identifiers are used for the same test type (CPTs using **p**iezocones, i.e. with a sensor measuring pore water pressure, **u**).

Question 24

What velocities are presented? Only geophone 1 to geophone 2 from a single test or pseudo results too (i.e. from geophone 1 to geophone 2 in two adjacent tests)?

Answer 24

Presented velocities are from a single seismic velocity test and represent shear wave velocity of the interval between both geophones. Pseudo velocities between seismic velocity depths have not been presented.

Question 25

For SPCT, do you provide shear wave velocity in both x and y directions or just one direction?

Answer 25

Presented shear wave velocities are presented for either x- or y-channel, depending on which of the two channels provided the best response. Stacked traces for both channels are presented.

Question 26

The green dashed line correlation method for G_{max}; is this a site-specific correlation of a standard published method, and was this checked against the lab test data?

Answer 26

Used correlations to derive G_{max} from CPT data are published correlations according to Mayne and Rix (1993) for cohesive soils and Rix and Stokoe (1991) for frictional soils. Refer to report P904711/01 for details. No specific comparison with G_{max} data from shear wave velocity tests (in situ or laboratory) was performed.

Question 27

I don't believe the lab tests and those done in the lab offshore - the in situ testing is preferred but has some challenges. Smart machine learning correlations with geophysics would be nice.
Clarification that followed later: *I don't believe the in lab / offshore in lab thermal tests in sand* drains too quickly.

Answer 27

This may be a misunderstanding. Thermal conductivity testing was performed in office, on saturated test specimens.

Question 28

Which soil classification?

Answer 28

Question not exactly clear, but in general: soil description and classification has been performed in accordance with BS 5930:2015, ISO 14688-1:2017, ISO 14688-2: 2017, with carbonate content classification based on Clark & Walker (1977). Refer to report P904711/03 for details.

Question 29

Needle probe too fragile.

Answer 29

The Fugro thermal needle probe is too fragile in general for use in (dense) sands (needle probes were onboard during the fieldwork however). Temperature cones were used instead, for in situ thermal testing.

Question 30

During the seafloor phase 1500 and 1000mm2 CPT cones were used, during the downhole phase 500 and 1000 mm2 CPT cone were used, what is the reason for this difference?

Answer 30

This is caused by differences in testing mode (seafloor vs downhole) and corresponding differences/limitations in equipment and configuration.

Question 31

Is the TCPT still reliant on the heat generated from friction, or has a heat source similar to the needle probe been added?

Answer 31

The principle of temperature equilibrium tests performed as part of TCPT's for this project is based on heat generation from friction between cone steel and surrounding soil during penetration.

Question 32

Are there plans to develop a TCPT with own heat source?

Answer 32

Fugro is continuously striving to innovate its equipment and test methods.

Question 34

Are the Nkt values assumed or were unit-specific correlations undertaken?

Answer 34

Default N_{kt} values of 15 and 20 have been used to derive undrained shear strength from CPT data, considering typical values for southern North Sea and used laboratory tests. A project-, site-, layer- or test-specific Nk assessment did not form part of the scope of work. Such assessment may be appropriate for specific use of CPT-derived undrained shear strength values. Report P904711/07 provides more details on N_{kt}.

Question 35

In your question, can you please define your interpretation of pre-shear, since I've seen this being misunderstood previously. CSS pre shear cycles were applied drained or undrained?

Answer 35

Cyclic pre-shear applied to CSS specimens was performed in constant stress ('drained') mode, using 400 cycles at a frequency of 0.1 Hz and using symmetric two-way loading applying a relatively low cyclic stress amplitude of 5 % consolidation stress.

Question 36

Has ever been considered a 3D seismic acquisition or accessing any 3D seismic vintage data may be available in the area?

Answer 36

3D seismics are costly to perform on such a large area, current acquisition of MCS and SCS data is deemed of sufficient quality for the current purpose. Fugro has performed 3D UHR for micrositing of wind turbines for a developer in 2017. Vintage data do not have the high frequencies required for the sub-meter resolution. RVO has executed a trial in the Ten noorden van de Waddeneilanden (TNW) WFZ covering an area of 6 km^2. The report on 3D seismic survey TNW is available on the RVO website.

Question 37

Through many innovations, the ground model has strongly evolved over the years since Borssele and is now of much higher value to the end user. Looking forward, where does Fugro see opportunities to innovate even further?

And where do end-users see opportunities or knowledge gaps, and how is this fed back RVO?

Answer 37

Innovating is a continuous process. Based on the HKW scope and budget as defined by RVO, the best quality has been achieved within the given time schedule. Feedback to RVO is provided by interviews with end users, and during evaluations of webinars. Suggestions for improvements are welcomed through woz@rvo.nl.