South Stream
Offshore Pipeline
ENERGISING EUROPE

Appendix 10.3: Marine Geophysical, Environmental, and Archaeological Survey Methods

The equipment used for geophysical and environmental surveys related to Project encompassed a broad spectrum of scientific and engineering applications. They can be primarily classified as acoustic instrumentation.

The acoustic instrumentation and methods included side-scan sonar, a seismic array, sub-bottom profilers, and multi-beam echo sounders. These instruments and their specifications are summarised below.

Side-scan sonar data was collected within the Survey Area (defined in **Chapter 10 Cultural Heritage**) to identify objects and features protruding up from the seafloor. Two primary side-scan sonar devices were used: a Benthos SIS 1624 multi-beam side-scan that operated in two frequency spreads of 110 to 130 kHz and 370 to 390 kHz; and a L3 Klein 3000 with dynamically steered beams operating at a chirped frequency spread of 100 to 500 kHz.

Sub-seafloor investigations were conducted within the Survey Area (defined in **Chapter 10 Cultural Heritage**) to locate geological features, such as faults, scarps, turbidites, and other geomorphic features commonly associated with geohazards for pipeline construction. For deep sediment penetration, a BOLT 2800LLX 2D seismic array using 193 channel streamers and 300 joule air guns producing an average frequency of 20 to 500 Hz was used. Higher resolution sub-bottom profiling data was collected by two additional systems, including: an Innomar SES2000 system with the primary frequency of 100 kHz and a secondary frequency of either 6 or 12 kH; and an Applied Acoustic AA200 boomer operating at 300 joule sound source (electric plate) and a central frequency spread of 360 to 550 Hz.

Echo sounders were employed to further record seafloor features along the proposed pipeline route. The multi-beam system consisted of a Reson Seabat 7111 with 101 beams operating at 100 kHz with a 150 degree beam angle. Single-beam systems consisted of a Simrad EK60 operating at 120 kHz with a ping rate of 20 Hz, and a SonarMite SM2HPR operating at 235 kHz with a ping rate of 6 Hz.

Vessel navigation was maintained and recorded through the use of satellite based global positioning system (GPS) using differential corrections from shore stations and satellite data (Trimble SPS 351 DGPS). Using a combination of fixed differential GPS receivers on the vessel and inertial guidance systems, vessel position was calculated and verified, maintaining sub meter accuracy for ship positions. This system enabled assigning all incoming data with highly accurate real time positioning. In addition to the above system, a Trimble SPS 751/551 was also used as a backup system. Navigation validation and integration was assessed with PDS2000 software during the survey.

During the geotechnical investigation carried out in 2012, remotely operated vehicles (ROV) were used to conduct visual inspections of potential geotechnical anomalies, some of these targets were then identified as cultural heritage objects. The ROV surveys were completed using a TAUZ ROV model Sub Fighter 7500 deployed off the RV Borey. This ROV used both sector scanning sonar and acoustic range and azimuth (USB) to navigate along the seafloor. The ROV used the USB navigation to move to the general position of the anomalies and the operator then used the sector scanning sonar to identify the specific target to be examined.

More detailed information on employed survey methods can be found in the original integrated survey report (Ref. 10.60). For information on third-party surveyors and survey dates, please refer to **Chapter 10 Cultural Heritage**.

Marine Data Interpretation Methods

Data collected from the geophysical and environmental surveys were initially processed by the third party surveyors. This included formatting raw, numerical data into more useable, interpretable data sets. More in-depth information on employed data processing methods can be found in the original integrated survey report (Ref. 10.60).

Post-processed marine data was reviewed and interpreted by cultural heritage experts to assess the potential for cultural heritage and archaeological material to exist within the Survey Area. Side-scan sonar imagery was primarily reviewed for this analysis and assessment, and all acoustic targets were entered into GIS along with proposed pipeline routing information. Objects that met certain criteria were flagged as potential cultural heritage objects (CHOs). These criteria included overall size (greater than 5 m in length), shape, height off the bottom, and acoustic reflectivity of the objects in the sonar images. Objects that met these criteria were selected for visual inspection and identification via ROV.

Geographic Information System Analysis Methods

In accordance with legislation and international agreements, and aligned with standards and guidelines for financing, avoidance is the preferred method of mitigation for CHOs. To ensure the protection of marine CHOs during all phases of the Project, an initial 150 m avoidance buffer was placed around all objects within the 150 m of the nearest pipeline. This avoidance buffer distance was chosen after careful consideration of engineering and design constraints and after a review of commonly-used avoidance buffer intervals for similar marine construction projects.

Generation of the 150 m avoidance buffer was completed using GIS mapping and analysis. Marine CHO distances were calculated using the four individual pipeline route centre-lines. A 150 m radius buffer was placed around each pipeline centre-line and if that buffer intersected the GPS coordinate of a CHO and then the CHO was flagged as 'within the pipeline corridor.' Marine CHOs located at a distance greater than 150 m from the nearest pipeline are at little to no risk of being adversely impacted by pipe-laying activities, while marine CHOs located within 150 m of the nearest pipeline are at a greater risk of being affected by these activities. The size of marine CHOs varies and ranges from 7 m long to 11 m long in the Zone of Influence. Given that a single GPS coordinate was recorded for each marine CHO and the size of marine CHOs can considerably vary, the chosen distance should provide adequate coverage and protection of archaeological sites and objects.