



Exploration & Production

GENERAL SPECIFICATION

SURVEYS

GS GEO 201

Offshore geophysical surveys

02	10/04	General review
01	10/03	General review - Change of Group name and logo
00	10/00	First issue
Rev.	Date	Notes

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1. Scope

The contents of these General Technical Specifications indicate the minimum standards required by COMPANY. However, should COMPANY consider that any aspects of the work requires more detailed investigation, COMPANY reserves the right to apply further Particular Technical Specifications.

All Equipment and Materials necessary to complete the survey in accordance with this Contract shall be supplied by CONTRACTOR. Such Equipment and Materials shall include all spare parts and spare Equipment units as may be necessary to provide normal and continuous operations, and shall be in good operating condition prior to the award of Contract.

Such Equipment shall be properly maintained in such a way as to assure accuracy within the tolerances set by the MANUFACTURERS for such Equipment. CONTRACTOR undertakes to provide a statement of the surveying accuracy of this Equipment.

The Work defined in these Specifications shall be performed in accordance with the Agreement.

The Work shall include the following phases:

- **Data acquisition phase:** Survey implementing multibeam echo-sounder system, side scan sonar, sub bottom profiling (pinger, boomer/sparker), digital multi-channel seismic, and piston-coring.
- **Data processing phase:** This phase is to be carried out while data acquisition in order to be sure that surveyed area is acceptable and concerns:
 - final navigation data for all sensors,
 - offshore acquisition of multi-beam echo-sounding, side scan sonar, analogue seismic and soil samples; onshore: laboratory tests on soil samples if any,
 - high-resolution digital multi-channel processing, to be carried out on-board seismic vessel while data acquisition is underway or further onshore.
- **Interpretation phase:** Preparation of comprehensive Reports in English language integrating all above data and all previous available data (previous site survey results as well as geotechnical data if available and required).

Reports shall include bathymetric, seabed feature, lithological, geophysical charts and interpreted cross-sections, as well as hazard chart(s) in order to recommend:

- Suitable drilling location(s) - sites surveys
- Suitable re-routing of the pipeline - pipeline route surveys
- As per objectives of the Particular Specification

The final product shall be an expert report.

The programme of the Work shall be described in the "Particular Technical Specifications".

2. Reference documents

In addition, applicable codes and Standards which are to be used in conjunction with this specification will be listed in the Particular Specification.

The order of precedence of the applicable documents shall be:

- i) The Particular Specification
- ii) The present General Specification
- iii) The Codes and Standards in reference.

Where this specification states no overriding requirements, the referenced Codes and Standards shall apply in full. Standards equivalent to those referenced herein shall not be substituted without written approval from the COMPANY.

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

Standards

Reference	Title
ISO 9000	Quality Management and Quality Assurance Standards
ISO 13623	Petroleum and Natural Gas Industries - Pipeline Transportation Systems
BS 8010, Part 3	Pipelines Subsea: Design, Construction and Installation
UKOOA guidelines	Guidelines for the Conduct of site Surveys for Mobile Drilling Rigs - 1995 and subsequent updates
	Guidelines on the use of differential global systems in offshore surveying, 1994
IAGC	Marine Geophysical Operations Safety Manual 7 th edition, 1991
OGP	Service Vessel Marine Safety Guidelines, Report No. 6.38/213 - December 1994
	Health, Safety and Environmental Schedules for Marine Geophysical Operations, July 1995
	Guidelines on the use of Small Boats in Marine Geophysical Operations, July 1995
DNV	Rules for Submarine Pipeline Systems, December 1996
IMCA	International Marine CONTRACTOR's Association, Guidelines for the use of multibeam echo-sounders for offshore survey, 2000

Professional Documents

Reference	Title
Not applicable	

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
Not applicable	

Other documents

Reference	Title
Not applicable	

Total General Specifications

Reference	Title
GS GEO 101	Offshore geotechnical soil survey
GS GEO 110	Requirements for Offshore Survey Vessels
GS GEO 202	Geophysical Survey for Offshore Pipelines Installation
GS GEO 203	Geophysical Survey for Offshore Pipelines Inspection
GS GEO 204	Geophysical Debris survey
GS GEO 301	Offshore surface positioning works
GS GEO 302	Subsea positioning works
GS GEO 304	RTK positioning

3. Survey objectives and methodology

3.1 Survey objectives

The object of this General Specification is to define the Work concerning:

- **Site surveys** at the locations specified in the Particular Technical Specifications
- **Pipeline corridor surveys**, on a route specified in the Particular Technical Specifications.

If the pipeline is planned to reach an onshore landing, the survey shall be divided into two specific operations:

- An **offshore pipe route survey**, that is from the offshore location(s) towards the coast until a water depth of 6 m (or safe manoeuvring depth based on proposed vessel draft)
- A **shore approach** survey, from nominal 6 m water depth as above, to the landfall (defined as 0.0-m depth contour after reduction to LAT).

3.2 Survey purpose

Interpretation of the data shall enable CONTRACTOR to report results of the **site surveys**, in order to:

- Chart water depths (bathymetric map)
- Delineate the steep and potentially unstable slopes of 5 degrees and more, if any
- Delineate irregular topography showing features and local relief (seabed feature map)
- Assess any obstacles to structure emplacement on the sea floor
- Define the nature of the soils (lithological map of surficial and mid-depth sediments, to nominal **75-m depth** sub seabed)
- Delineate active faults, modern and ancient landslides
- Map **shallow gas** or gas hydrate **occurrences**, and their horizontal extent as well as vertical height (structure and fluid column height)
- Recommend the safest drilling locations, with regard to drilling units; or sub-sea emplacements, development structures, relating to purposes of the Particular Specification
- Prepare comprehensive reports and charts, written in English language.

The results of **pipeline route surveys** shall enable CONTRACTOR to:

- Chart water depths (bathymetric map)
- Assess any obstacles to pipelay on or below the sea floor
- Define the nature of the soils (lithological map of surficial sediments) with regard to pipeline lay
- Recommend pipeline route alternative(s), to avoid pipelay obstacles at or below seabed, identified by interpretation of survey data. This shall be done offshore, in consultation with COMPANY, before de-mobilisation, to ensure sufficient coverage acquisition by survey
- Prepare comprehensive report written in English language, including maps and profiles presented on "**Alignment Sheets**".

3.3 Survey methods according to water depth

The location of survey will entail operation in a particular water depth range, which this general specification addresses by differentiating three types of survey.

- **Shore approaches** refer to the zone between 6-m (shallowest approach of a survey vessel) and the surf zone, calling for the use of shallow-draft vessel, maybe in conjunction with the survey vessel
- **Conventional survey** typically takes place on the continental shelf, between 6-m near-shore depths, and 400-600-m offshore depths. This normally carried out by a single survey vessel
- **Deep-water survey** presents challenges due to sensor positioning, and the choice of method follows from COMPANY's project-specific purposes, and the desired resolution and mapping accuracy. Deep-water is defined, for this purpose, as depths exceeding 400-600 metres for site or pipeline surveys.

For deep-water work, CONTRACTOR shall propose one or more of the below deployments, according to COMPANY's call for tender. The final choice of method will rest with COMPANY. The different methods vary by the deployments of sensors (relative resolutions/positioning accuracies), and are listed below in general order of preference.

- a) Autonomous Underwater Vehicle
- b) Deep-tow specification, 2 vessels
- c) Deep-tow specification, 1 vessel
- d) Hull-mounted vessel deployment.

Projects are awarded on the basis of one of these methods, or a combination in case of wide depth variations over the survey area. Any departures from these requirements need to be agreed by COMPANY.

Survey operations will follow the deployment-specific requirements of below section, particular to the method:

- 8.1. Deployment specifications

Geophysical/geotechnical aspects of the project will comply with the general specification, in below sections.

- 8.2 Data acquisition
- 8.3 Data processing
- 8.4 Data interpretation and reporting

4. Units and abbreviations

4.1 Units

Measurement system: The SI International System of Units shall be used in all relevant measurements, processing and reporting.

4.2 Abbreviations

AUV/UUV	Autonomous Underwater Vehicle/Unmanned Underwater Vehicle
AVO	Amplitude Versus Offset
BRS	Bottom Simulating Reflector
CD	Chart Datum
CDP/CMP	Common Depth Point/Common Mid-Point
DAC/DCC	Distance ACross Course
DTM	Digital Terrain Model (multi-beam data)
DGPS	Differential Global Positioning System
FPSO	Floating Production Storage Offloading
FRC	Fast Rescue Craft
HPR	Hydro-acoustic Positioning System

HR	High-resolution
LAT	Lowest Astronomical Tide
LBL	Long Base Line System
LCT	Landing craft (type of inshore vessel)
MBES	Multi-beam (or swathe) echo-sounder
MSL	Mean Sea Level
NMO	Normal Move Out
QC	Quality Control
ROV	Remote Operated Vehicle
SEGD	Society Exploration Geophysicists format D
SEGY	Society Exploration Geophysicists format Y
TDS	Temperature Depth Salinity
TEI	Triton Elics Int. (maker of processing software)
TLP	Tension Leg Platform
TVG	Time Variant Gain
USBL	Ultra Short Baseline System
VHF	Very High Frequency
VHR	Very High-resolution
WGS 84	World Geodetic System 1984

5. Vessel(s) used by CONTRACTOR

The vessel(s) to be used by CONTRACTOR will conform to TOTAL's General Specification **GS GEO 110**. In addition CONTRACTOR shall comply with the following points:

5.1 COMPANY reserves the right to not accept any vessel older than **twenty-five (25) years**, from new-built date; in any case, such vessels would be subjected to stringent audit from TOTAL's authorised personnel.

5.2 The vessel(s) to be used by CONTRACTOR will consist of one or more of the following:

- A **SURVEY VESSEL** for work to be performed in open sea where water depth is usually greater than 6 metres and can exceed 1500 m. The minimum length acceptable to COMPANY for such a vessel is 50-m
- Optionally, an additional **tracking vessel** to position deep-towed sensors deployed by SURVEY VESSEL
- Optionally for shore approach survey, an **inshore vessel** (shallow draft boat, which may be of LCT type). This shall operate from the main survey vessel, or independently from a shore base, nominated by CONTRACTOR and subject to COMPANY approval. The minimum length acceptable to COMPANY for such a vessel is 6-m, and an air-conditioned cabin is mandatory for work in tropical climates.

5.3 CONTRACTOR shall ensure that any vessel(s) used or chartered for the performance of the work hereunder shall be free from any legal, Contractual or other restriction preventing it from operation in those areas required under the terms of this Contract.

5.4 The SURVEY VESSEL used by CONTRACTOR for the performance of the work shall conform to the following requirements:

- For work in open waters: twin-engine, single or dual screw, and bow thruster
- For work within 500-m of coastline, or offshore installations (rig or platform): twin-engine, dual screw, and bow thruster.

The vessel shall be capable of good manoeuvrability as well as constant speed while surveying, namely cruising speed of (10 knots), and slow for survey purposes: down to 2 knots (4 m/s) and/or vessel speed compatible with 6.25-metres shot interval, when HR seismic is performed.

5.5 SURVEY VESSEL shall be manned with three bridge officers (Master, First and Second) and every watch shall keep a second vessel crew stationed on the bridge at all times, to act as look-out and general safety measure.

5.6 Master and First Officer of SURVEY VESSEL shall be specifically trained or experienced with survey work at sea. They **shall be fluent in English** language and shall have proper **acknowledged diploma** for safely operating survey vessels. Master shall be experienced for staying alongside petroleum offshore facilities. C.V. of Master, Mate together with other key personnel shall be attached by CONTRACTOR in Appendix 6.

5.7 The SURVEY VESSEL shall be equipped with **auto pilot**, one radar (ARPA type) and one spare radar, and gyro-compass (with digital output if interfaced with survey computer).

5.8 On Inshore vessel or SURVEY VESSEL, fully operative radio Equipment including HF and VHF radio telephone shall be provided by CONTRACTOR to allow uninterrupted contact with the shore network and other vessels. The radio shall be equipped with frequencies used in the country of Work.

In addition, on SURVEY VESSEL, **SATCOM facilities (phone/fax and e-mail)** shall be installed on-board, **as well as a weather fax**. The SATCOM transceivers shall be linked to the gyro-compass.

5.9 The autonomy of the SURVEY VESSEL (fuel, lubricants, food, fresh water and all consumables) shall be sufficient to assure the complete performance of the campaign without call in a port, taking into account the maximum authorised loading capacity of the vessel.

5.10 A **noise test** of the SURVEY VESSEL shall be provided to COMPANY prior the start of the operation.

5.11 The SURVEY VESSEL shall be equipped with a clean galley (sanitary standards) and **comfortable living quarters**. For surveys of duration greater than 1 week, SURVEY VESSEL is expected to be equipped with a dedicated recreation room, for use by survey crew and COMPANY REPRESENTATIVE.

5.12 Catering shall be of a good European/Asian standard. Soft drinks shall be available for the whole party. No alcohol is allowed on-board during operations. The fresh water on-board shall be filtered and drinkable. COMPANY reserves the right to request independent analysis of drinking water stored on-board for human consumption.

5.13 The SURVEY VESSEL shall have an independent **interpretation room** (at least 6 m²) where desk work and charting can be performed. A portable cabin installed on the deck is

acceptable. The interpretation room shall be fitted with a large table, a light table and a photocopier.

5.14 On SURVEY VESSEL, a **separate cabin** with a desk or working table shall be available for the COMPANY REPRESENTATIVE. A second, separate cabin shall be available for Liaison Officers or any additional COMPANY personnel.

5.15 Office equipments, such as **photocopier**, light table, **an extra computer** (PC), stationery and interpretation tools (compass, 10-point dividers, etc.) shall be available on-board the vessel.

5.16 Fuel, greases and lubricants of Total trade mark shall be used.

5.17 Specifications of the proposed vessel and its Equipment have to be attached below by CONTRACTOR.

6. Positioning

6.1 General

All raw data from the vessel(s) survey sensors shall be logged on magnetic tapes and made available to COMPANY REPRESENTATIVE in the UKOOA P2/91 format for the navigation.

UKOOA P1/90 data format will be used for processed data, and will be available to COMPANY REPRESENTATIVE in case of on-board processing. The logging procedure shall ensure that all survey sensor data are time-tagged to one common accurate clock reference.

6.2 Real-time DGPS

The use of differential GPS, as a stand-alone positioning system, is required for site investigation. An absolute accuracy of ± 5 m is required for survey operations.

Positioning data shall be finalised on-board, and output as hardcopy track plots to enable interpretation of data from all sensors.

Refer to **GS GEO 301** for technical details on Equipment and operational procedures.

6.3 RTK positioning

Refer to **GS GEO 304** for technical details on Equipment and operational procedures.

6.4 Ultra short base line acoustic positioning

This system shall be integrated in the primary positioning system in order to locate continuously the side scan sonar fish or a Remote Operated Vehicle (ROV) if requested.

Refer to **GS GEO 302** for technical details concerning Equipment and operational procedures.

7. Work specifications

7.1 Deployment specifications

The specification of deployments, or placement methods of sensors, aims at defining the context of different survey phases by water depth, with a view to proper planning such that low-mileage activities such as shore approaches are given due technical consideration and generate data of equal quality as the main survey campaign.

7.1.1 Shore approaches

This section of the pipeline corridor is located between a nominal 6-m water depth (minimum safe operation of the main survey vessel) and the landfall. It will be surveyed by the shallow-draft boat operating from the main survey vessel, as defined in above Section 5. Vessel.

This shallow-draft or inshore boat is expected to work 12 hours per day, for reasons of safety, including the time of transit to and from the main survey vessel or other berthing. Longer working hours if safely practicable, or shorter hours, if required by local conditions, will be at the discretion of COMPANY REPRESENTATIVE.

Data will be acquired by **simultaneous (1-pass) operation** of the sensors, and downloaded daily to the main survey vessel or shore base.

The inshore boat is expected to be sufficiently spacious for the above staff to work comfortably in a sheltered and air-conditioned cabin for the duration of daily operations. As per AGREEMENT, section "Access to WORK Locations", COMPANY REPRESENTATIVE will have full access to inshore vessel, during operations and any other time during the project.

The objective of inshore survey is to provide a dataset as compatible as possible with that of the main vessel, and acquire data from:

- Multi-beam and single-beam echo-sounders
- Side scan sonar
- Profiler (Pinger or Boomer or Sparker)
- Optional magnetometer
- Seabed sampling by piston-corer; grab-sampler as alternative is acceptable if sanctioned by COMPANY before mobilisation.

7.1.2 One-vessel operation, conventional or deep-towed surveys

The towed sensor approach to survey is conventional to continental shelf operations, and detailed in below specifications for various equipments. Data will be acquired by simultaneous (1-pass) operation of the sensors, on a 24-hour basis.

Particular demands are made of this specification in the case of deep-water operations, where actual vessel arrangements for sensor deployments make the difference between effective operations and operations constrained by equipment capability (accuracy, resolution) or logistics (weather operability, deployment speed).

In the case of deep-water spreads, CONTRACTOR is requested to detail, in his proposal, the specifics of the equipment for the depths of intervention, particularly:

- Effective capability of acoustic positioning for sensors: range, precision and the impact on the reliability and repeatability of acquisition
- Optimal configuration of ship-borne and over-the-side sensors, in order to effectively anticipate the achievable data quality, in terms of resolution and accuracy of final mapped results
- Actual performance of deployments (speed of all winches) for over-the-side sensors, such as of sonar and profiler cables, TDS probe and sampling devices; planned offset and depths, and estimates of deployment times for required water depth

- Planned acquisition grid to determine ability of the spread to deal with slopes, currents and other acquisition difficulties.

7.1.3 Two-vessel operation, Deep-towed surveys

This deployment calls for a second vessel, to track the position of sensors deployed by the main survey vessel. Data will be acquired by simultaneous (1-pass) operation of the sensors, on a 24-hour basis.

This tracking vessel shall be accepted by COMPANY before mobilisation, and be made available by CONTRACTOR for purposes of marine safety auditing on demand.

Survey operations making use of a tracking vessel will adhere to the following specifics.

The tracking vessel shall be positioned by GPS and carry out monitoring of the towfish position by means of acoustic positioning (USBL), fully motion-compensated, and suitably calibrated. Deployment of such acoustic systems may be over-the-side or permanent mounting (hull-mount or pole through gate valve). The directionality of the beacons, together with their effective range, shall be stated by CONTRACTOR prior to acceptance.

In the case of over-the-side deployments, CONTRACTOR shall submit to COMPANY's approval, at tender stage, its plans for the arrangement of the installation during mobilisation, including a technical case for the robustness of proposed mounts at survey speeds, and transit speed. Any deployment requiring to be recovered above water, for the vessel to transit at a nominal 10-knots, will need to be re-calibrated before the next period of acquisition.

The positioning solution is required to include real-time telemetry of the position data for sensor(s) obtained by positioning vessel, to the main survey vessel. Surveyors on-board the latter will process such absolute or relative positions, such that final track plots are obtained offshore in near real-time (hours), and used for interpretation of sonar/profiler data, and processing of multibeam data, where acquired.

Other duties may be carried out by this tracking vessel, as per CONTRACTOR's planning and subject to approval by COMPANY REPRESENTATIVE; these may include sounder calibrations (velocity profiling), seabed sampling or any task which may be effectively and safely carried out to support the main survey vessel.

As in the case of one-vessel operation, CONTRACTOR is requested to detail, in his proposal, the specifics of the equipment for the depths of intervention, particularly:

- Effective capability of acoustic positioning for sensors: range, precision and the impact on the reliability and repeatability of acquisition
- Optimal configuration of ship-borne and over-the-side sensors, in order to effectively anticipate the achievable data quality, in terms of resolution and accuracy of final mapped results
- Actual performance of deployments for over-the-side sensors, such as offset and depth of sonar and profiler cables, speed of winches for TDS probe and sampling devices, and estimates of deployment times for required water depth
- Planned acquisition grid to determine ability of the spread to deal with slopes, currents and other acquisition difficulties.

7.1.4 General specification for AUV

7.1.4.1 AUV Positioning and Acquisition

CONTRACTOR will specify the equipments deployed from the AUV, and the separate sensors if any planned for vessel deployment (e.g. deep profiler, sampling etc.). AUV data will be acquired by simultaneous (1-pass) operation of the vehicle, on a 24-hour basis.

The choice of system shall be explicit regarding:

- Vehicle endurance and deck turn-around times, empirical
- Effective multibeam footprint, for determination of line spacing
- Planned manning, for deck operation, acquisition monitoring, and processing
- Vehicle deployment/recovery method, and its weather constraints
- Horizontal and vertical accuracies for the combined sensor sequence, at the stated depths of operation and altitude, with nominal error cube.

The location of the AUV will be provided by acoustic positioning, optimised such that:

- Real-time positions can be tracked from survey vessel; final positions are generated on survey vessel within 12 hours of AUV recovery
- The range will be sufficient for operation at the water depths of survey, as advised by COMPANY before mobilisation
- The directionality of beacons shall be maximised, such that the vessel can track the vehicle anywhere within a 45° cone pointing upwards above the vehicle
- The power supply of beacons shall be sufficient as to not constrain vehicle endurance, e.g. beacon operation will out-last the power supply of the vehicle itself.

The AUV payload is expected to comprise side scan sonar, profiler and an appropriate multibeam sounder system, for which the proposal will detail acquisition parameters in the planned mode(s) of operation:

- Configuration and options of coverage
- Minimum and maximum operating depths, and operating AUV altitude (above seabed)
- Horizontal and vertical resolutions for stated configuration.

7.1.4.2 AUV deployments

CONTRACTOR will specify the systems pertaining to AUV deployments, control, and safety aspects:

- Launch procedure, including roles and responsibilities and liaison between bridge and back deck, from back deck to start of data logging
- Position control of AUV in-sea, and failsafe systems in case of control loss, for instrument location and tracking on the surface, such as lights, radar reflector, independent GPS/radio link
- Recovery procedure and fall-back measures in case of failure of primary procedure, including case of weather hampering recovery; emergency measures, safety issues of any workboat/Fast Rescue Craft involved in recovery

- Data downloading procedure, from AUV on deck to CONTRACTOR's survey computer on the survey vessel, by means of network connection.

7.2 Acquisition trials and confidence checks

7.2.1 Inshore surveys, trials

Pre-acquisition trials will maximise the line spacing, from the effective coverage provided by Multi-beam echo-sounders, and Side scan sonar, which ensures acquisition of:

- The required multi-beam overlap of 20%, and complete side scan sonar coverage
- Appropriate multibeam sampling for a grid size equal or smaller to that of the route acquired by the main vessel
- Centreline coverage to provide a sub-seabed profile.

Complete coverage may be achieved by infill lines in the shallower parts of the route, or by steering-by-coverage of the inshore boat, whichever is the most cost-effective means.

The choice of instruments deployed (particularly profiler), and that of acquisition grid (e.g. line spacing), will be determined by trials before acquisition, at the discretion of COMPANY REPRESENTATIVE.

COMPANY reserves the right to revise the programme or mode of operation if the effectiveness of the operation is significantly less productive than CONTRACTOR's estimation of the acquisition rate.

7.2.2 Multi-beam trials and Survey planning

Pre-acquisition Multi-beam activities

The first phase of multibeam operations shall consist of **calibrations**, as per below section **Corrections and Calibrations**.

Trials, before start of acquisition, will test the acquisition parameters of the multi-beam, in water depths similar to those of the survey. Tests of comparative parameters shall determine the optimal instrument settings: ping rate and range settings to produce a square ping footprint, power and gain settings most appropriate to the seabed under study.

The final **acceptance** of the multi-beam, before acquisition commences, will be run with acquisition parameters determined by trials, in water depths similar to those of the survey. This shall consist of two test lines, orthogonal and crossing in a distinctive location. The lines will be fully processed separately, and a difference map will be produced of the two resulting DTM's. The map will be plotted at high resolution, submitted to COMPANY REPRESENTATIVE for acceptance, and included in the final report.

Survey planning

COMPANY expects the multibeam system to have a real-time bathymetric display providing a **minimum** swathe width (seabed coverage) of **4 times the water depth**.

The survey programme, submitted by CONTRACTOR to COMPANY's approval, must specifically state the **planned line spacing**, MBES swath width, and overlap between MBES bathymetry and side-scan passes that will be achieved.

The effective multibeam swathe width achievable will be determined in the field by the pre-acquisition trials, to finalise the optimal **actual line spacing** used on the survey.

Any data set will be surveyed inclusive of cross-lines for quality control, at a nominal interval to be agreed with COMPANY REPRESENTATIVE. Additional sounding lines may be necessary to map out any significant feature/seabed obstacles identified.

For operations utilising a hull-mounted MBES, the "run-in" and "run-out" are to be such that the vessel is running along the projected survey line for a minimum of 300 metres before start and after end of lines. Where a towed system is used, the run-in and run-out lengths are to be agreed with COMPANY REPRESENTATIVE on-board the vessel, and will be dependent on offsets, water depth and ship's speed.

Pipeline surveys

The nominal corridor widths, for pipeline surveys, are at a **minimum**:

- Shoreline to 6 m depth 0.5 km
- 6 m to 400 m depth 0.9 km
- 400 m and deeper 0.5 km

The corridor width shall be centred on the proposed route, and each survey line shall provide a minimum of 20% overlap with adjacent survey lines in respect of multibeam data, i.e. 2 lines 100-m apart will have a common 20-m of coverage after nominal clipping of outer beams.

In the case of vessel-mounted MBES transducers, adjacent lines will be run in opposite directions, enabling CONTRACTOR to verify accuracy by means of matching features or contours between tracks.

Corridors will be surveyed with an odd number of lines, and the centreline is to be used for profile of the nominal route (depth and shallow geology). Where a corridor crosses existing coverage, a minimum of one centreline shall be acquired over the area, to ensure continuity of data with new coverage.

In all places where the line curvature exceeds 10° it will be necessary to run each line individually and not steer the vessel around the alter course. This procedure is to ensure complete and full data collection, and will mean that "loops" will have to be steered at the Turning Points.

7.2.3 Deep-water/AUV trials

The **VEHICLE** will be run on one or more sets of trial lines, to gain acceptance to the satisfaction of COMPANY REPRESENTATIVE, by demonstrating:

- Vehicle positioning accuracy, by comparative positions of a know feature such as a wellhead, imaged by at least 2 lines run in opposite directions; this verification is additional to lines of multibeam calibration
- Positioning reliability and line-keeping; the suggested procedure is to run the VEHICLE in a straight line at constant speed, and drive the vessel in a circle above the vehicle, to test the repeatability of directionality of acoustic positions
- Multibeam calibration, serving also as test of logging; the calibration report shall be given to COMPANY REPRESENTATIVE and included in the survey report Vol. 2
- Trial of acquisition parameters: effective range and resolution for a range of practical vehicle altitudes, and hence optimal line spacing for full coverage with reliable 20% multibeam overlap.

7.3 Data acquisition

7.3.1 Vessel speed

CONTRACTOR shall state the operating speeds of the proposed vessel, for all aspects of the operation, and the consequent resolution of the instruments at that that stated acquisition speed.

The ship's speed shall be reduced to a survey speed such that the quality of the data gathered is not affected by ship noise, and generates the same density of records for all the swaths or passes.

Survey records shall not be acquired at survey speeds (relative to seabed) exceeding five (5) knots for seabed survey (sounder/sonar/profilers), or three (3) knots for high-resolution 2D seismic.

Records shall be acquired continuously at constant speed, using acceptable chart advance rate, and depth or range scale, to be agreed with COMPANY REPRESENTATIVE.

7.3.2 Navigation and annotation of records

A dedicated computer shall be used for on-board navigation. It shall integrate navigation data, gyrocompass, echo-sounder input and logging functions. This computer shall drive trigger(s), annotator (fix-mark and its text label) and speed input to the side scan sonar recorder.

An annotator shall be interfaced with the navigation computer and shall automatically log fix marks and label all records.

A visual display unit and track plotter shall be used for navigation. The track plotter shall work in real-time in order to visualise immediately the quality of the navigation. An A0 track plotter is required.

At the beginning and end of all records along a line or portion of line, the following annotations shall be noted on the records (multi-beam echo-sounder, side scan sonar, pinger and/or other analogue seismic):

- Total affiliate and country
- Survey name
- Vessel name
- Location name or number
- Line number
- Date and times of recording
- First and last fix number
- Scale, range, significant parameters.

7.3.3 Multi-beam bathymetric survey

Multibeam echo-sounder, or swathe, technology is considered a standard survey tool, to be used on all projects, unless advised otherwise by COMPANY. This applies equally to:

- Shore approach survey (pipeline landing)

- Conventional survey
- Deep-water survey.

The vessel is to be fitted with a multi-beam echo-sounder surveying system capable of accurate depth measurement over the whole range of expected depths. This multi-beam echo-sounder can be hull-mounted, side-mounted or fitted in a towed fish or other deployment, providing the deployment's depth and position can be accurately determined.

A single-beam echo sounder shall be provided to generate a QC dataset, and operated on the most appropriate depth scale range for greatest accuracy in the depths being surveyed.

7.3.3.1 System considerations

CONTRACTOR needs to make the technical case, for any hull-mounted system, that it is appropriate to the task. System specifications from the MANUFACTURER will be respected, in terms of depth range, recommended attitude corrections, etc.

For non-permanent deployments, CONTRACTOR needs additionally to make a case for the robustness of the deployment. Pole-mounted systems need be sufficiently sturdy for sustained work, rapid recovery or transit at the ship's usual transit speed. Towfish based systems require a detailed technical case for accuracy and repeatability.

All soundings shall be motion-corrected, recorded in metres, corrected for draft and tides variation, and reduced to CD. Requirement is for a minimum depth resolution of 0.5%, and accuracy of 1%, both relative to water depth.

Amplitude data (backscatter) shall be made available by CONTRACTOR as a additional product in conjunction with other seabed imagery charting. Trials during mobilisation or calibrations will evaluate such displays, which will be incorporated in the products of the final report, at the discretion of COMPANY REPRESENTATIVE.

COMPANY may request colour and 3D visualisation displays to represent the totality of the survey, or a specified depth interval.

7.3.3.2 Corrections and Calibrations

Multi-beam data will be corrected, in real-time wherever possible, for draft and tide variation, as well as attitude input: roll, pitch, yaw, and latency.

Calibrations shall be carried out, during mobilisation, by the MANUFACTURER's recommended methodology. Any other practises should be justified in terms of industry references, guidelines or publications. Calibrations pre-dating the project will **not** be acceptable.

Any movement or re-deployment of the sensor head, mount or pole will require a re-calibration for confidence.

CONTRACTOR's nominated swathe specialist, offshore, will submit a calibration report to COMPANY REPRESENTATIVE, prior to start of operations.

COMPANY may require CONTRACTOR will prepare a test frame: pyramid shape, with one 2x2x1-m tier below a 1x1x1-m tier, with all outer surfaces filled with reflective surfaces. The device will be deployed in shallow water (20-30-m), for imaging by the system and evaluation of its resolution and acquisition/processing parameters.

Before the start of the survey, at regular interval, after any stand by or at the end of the survey, the following parameters and sensors shall be calibrated:

Draft

The draft of the multi-beam arrays shall be checked for accuracy before the beginning of the survey, on each day of survey and after any stand-by or instance of the vessel taking on water or fuel. Where applicable, the angle between the two arrays of the multi-beam echo sounder shall be properly maintained according to MANUFACTURERS specifications.

Sound velocity

The determination of averaged sound velocity throughout the vertical water column is mandatory at survey start and at regular intervals and/or locations during the survey operations. The interval of probe dips can be decreased at the discretion of COMPANY REPRESENTATIVE, if a time series of velocity results is assembled by CONTRACTOR to show low variability of the velocity profile at location.

This calibration shall be carried out with both of the following methods:

- Verification during mobilisation or case of doubt: direct depth readings with a steel plate, as far down as possible (Bar Check or Plate Check)
- Daily: speed of sound determination by TDS probe, recording 2-way profiles to seabed
- Probes measuring sound velocity directly, and mounted on the sounder transducer, shall not be used as velocity profile, for time to depth conversion.

The velocity data will be entered into the multibeam system and logged with the data files; it will be also be documented in a separate record, such as the hand-written online surveyor's log.

Heave compensator

A heave-compensator (motion sensor to generate attitude corrections) shall be used in order to obtain heave-corrected echo sounder and MBES records. It shall be securely placed at the nearest possible point to the acquisition sensor (head) and shall be interfaced with navigation computer and multi-beam echo sounder computer.

The offset geometry of the motion sensor will be documented on paper, verified at the request of COMPANY's REPRESENTATIVE, and explicit in CONTRACTOR's report.

Raw sensor data shall be time-flagged and archived on a dedicated storage, as well as sent to MBES files for processing.

The calibration of the heave compensator shall be carried out as per MANUFACTURER's instructions, including the following methods at a minimum:

- Roll offset: on a horizontally flat area, a sufficiently long line has to be surveyed twice in opposite direction. The calibration line should be placed orthogonally to the survey line. Depth difference will increase with cross-track distance from the survey line
- Pitch offset and lag (time delay): on a steep slope area, a sufficiently long line has to be surveyed twice in opposite direction. The calibration line should be placed parallel to the survey line and in the centre of the beam area. Any along-track depth difference shall be corrected
- Alignment (Gyrocalibration): after selection of a conspicuous feature on the sea-bed, two sufficiently long lines have to be surveyed twice (in opposite direction) to opposite sides of this target so that the target will be in the outer part of the echo-sounder swath. The

calibration line should be placed parallel to the survey lines and should intersect the target. The reference point should not have a different location along track and target contours shall overlap.

Tides

All recorded depths shall be reduced to Chart Datum (CD, or LAT, as defined in the Particular Specification) using **observed tides**. Tidal data shall be recorded with dedicated tide gauge(s), equipped with acoustic release, and deployed in the survey area during the time of the survey.

Observations shall be recorded by one of the following methods, to be agreed with COMPANY before the start of operations:

- a) Real-time tidal data, such as derived from RTK positioning, recorded on shore or on site, and transmitted to the vessel for use during fieldwork and final charting.
- b) Observed tides, recorded on site with a dedicated tide gauge. This will be equipped with acoustic releases, deployed by CONTRACTOR in the survey area during the survey duration, and recovered during fieldwork. Final tide corrections will be produced on-board.
- c) Observed tides, as per b) above. Actual tide reduction shall be performed onshore after recorded tides are processed.
- d) During the time of the survey, real-time displays shall be performed using predicted tides. For the final charts, all recorded depths shall be reduced to Chart Datum using same predicted tides.

During the time of the survey, corrections shall be applied using predicted tides, unless observed tidal data is available, as per paragraph a) above.

For the final charts, all recorded depths shall be reduced to Chart Datum using measurements of the tidal data recorded on-site. Such tidal measurements will be finalised on-board, and a comparison with predicted tides included in the survey report.

The requirement for observed tide corrections may be waived by COMPANY in deep-water (depths greater than 500-m), if CONTRACTOR can make a case that the tidal amplitude is significantly smaller than the accuracies of the sounding equipment for that water depth.

7.3.3.3 Recording and storage of MBES data

The MBES recording system shall be interfaced with outputs from the heave compensator, gyro and navigation computer (DGPS, speed). All the data coming from these devices should be time-flagged and synchronised with the MBES data.

The MBES system will log all inputs, including but not limited to: raw multibeam data and its navigation, calibration data, attitude sensor data, draft, velocity and tidal corrections applied, as well as processed data in XYZ format, as passed to the charting stage of the survey. The object is to enable re-processing after the event in case of revision of any of these inputs.

Sufficient data storage will be provided, in the form of easily transportable media such as optical disk or writable CD-ROM. The storage volume (Gigabytes) mobilised by CONTRACTOR for the work will be planned on the basis of best estimated data recorded per km, and workscope provided by COMPANY, and will include a minimum of 50% of spare capacity in relation the planned workscope.

Such storage will include the capacity for full back-ups on-board, such that raw, navigation and processed multibeam data are 100% backed-up by the time of demobilisation. The data volume

and its back-up shall be transported separately to the CONTRACTOR's nominated reporting centre.

7.3.4 Single-beam echo-sounder

For QC of the multi-beam data, soundings shall be acquired on all survey lines with a precision hydrographic echo-sounder, with dual-frequency transducers (33/210 kHz), and hull-mounted. The sounder accuracy shall be within 0.5% of the water depth. A heave-compensator shall be used, to obtain heave-corrected records.

The echo-sounder shall be equipped with a digitiser permitting a high digital sampling rate. An annotator shall be interfaced with the navigation computer, to automatically log fix marks and label all records. Data shall be logged directed to the navigation computer for QC, including on-board production of sounding charts if requested by COMPANY.

The calibration of the echo-sounder shall be carried out according to above section, **Multibeam Calibration**, particularly in respect of draft, sound velocity and tidal corrections. The accuracy of calibrations shall be within + 0.1 metre. The weather conditions during the calibrations shall not exceed four (4) on the Beaufort scale except otherwise agreed between COMPANY REPRESENTATIVE and CONTRACTOR REPRESENTATIVE.

Sounder records shall be continuous, using an acceptable paper advance setting and scale. At the beginning and end of all records, along a line or portion of a line, paper records shall be annotated as per above section **Navigation, annotation of records**.

The echo-sounder shall be checked for accuracy before the beginning of the survey, on each day of survey and after any stand-by, to ensure consistency of the dataset.

7.3.5 Side scan sonar

A dual-channel side scan sonar system, capable of ranges up to two hundred and fifty (250) meters either side, shall be used to obtain seabed data. This shall output all data digitally to a graphic recorder producing a permanent paper record.

Sonar with dual frequency of 100/500 kHz is required.

Acoustic positioning (USBL or equivalent) of the sonar towfish is required, and shall be integrated to the primary positioning system, in order to locate continuously the position of towfish and other deployed sub-tow devices.

Refer to **GS GEO 302** for technical details concerning Equipment and operational procedures.

Slant range correction: the equipment shall have an integrated system for the correction of longitudinal and lateral distortions in order to obtain true scale records (cross-line scale equals along-track scale) in real-time.

CONTRACTOR may be requested by COMPANY to build a mosaic (composite sonogram) of the whole or partial surveyed area.

The side scan sonar recorder shall be connected to the navigation computer, for vessel speed input.

Side scan sonar data shall be directly digitally recorded on **optical disk** or writable CD-ROM in XTF format and automatically referenced. Optical disks shall be not be used. In addition a thermal plotter is required, and shall be compatible with slant range correction display.

A fast winch (at least 1 m/s), remotely controlled, with slip rings and counting pulley, shall be used. The length of cable supplied must be sufficient to survey the water depths on site, as specified in the Particular Specification.

All necessary spare parts must be supplied, to remedy any breakdown during the survey. In particular, a spare tow fish is required.

7.3.6 Sub-bottom profiling

Analogue single-trace seismic shall be acquired with a package inclusive of **both** a mud penetrator (pinger), and a boomer or sparker (or equivalent).

7.3.6.1 Pinger (mud penetrator)

The pinger required shall be of **CHIRP** type (such as X-Star, Geochirp or equivalent).

The transducer may be part of a combined profiler/side scan sonar fish, as long as it complies with technical specifications for both side scan sonar and sub-bottom profiler.

The frequency of the source shall be in the range 2-7 kHz, preferably adjustable. The required power output is minimum 5 kW.

Data shall be tape recorded, automatically referenced, and displayed on a thermal plotter.

The penetration in soft sediments shall be at least 5 meters, and the resolution shall be 0.2 to 0.3 meter. It is understood that penetration may be less, in the event that the sea-bed is consolidated.

7.3.6.2 Boomer or Sparker (or equivalent)

A Boomer or Sparker (or equivalent) shall be deployed, to record deeper sub-seabed layering.

The Boomer will comprise a Uniboom source, and may be a "sub-tow" device (or equivalent) for shallow waters, or "deep-tow" type for deep waters (here meaning over 50-m). "Surface-tow" devices (catamaran mount) would be accepted by COMPANY only in the most sheltered and noise-free survey areas.

The Sparker shall be of SIG type, or equivalent subject to COMPANY approval.

The system shall be capable of delineating hard and soft layers in the first 75 metres with a definition of 0.50 metre near the sea-bed, and 1.5 metres at depth.

Spares (boomer or sparker towfish, hydrophones) shall be available on-board to ensure continuous acquisition.

7.3.6.3 Analogue seismic peripherals

Digital recorders/processing units with screen displays such as DELPH-SEISMIC of TEI or equivalent is required for each Pinger and Boomer. The data shall be tape recorded (writable CD ROM in SEG Y format or equivalent) and automatically annotated.

Reliable deployments for boomer/sparker array (booms and cables) shall be available, and tested during mobilisation to minimise in-sea noise, to COMPANY's satisfaction. Deployment can at the bow of the survey vessel, or other arrangement which minimises effects of the vessel or wake.

To power profilers, CONTRACTOR shall provide a dedicated independent generator, mounted on silent blocks, except if previous successful experience with the vessel's generator can be documented.

7.3.7 Refraction seismic (if required by Particular Specification)

High-resolution seismic refraction method shall be used to obtain a precise and continuous definition of the soil layering down to 5-7 metres. The required penetration and location of the profiles are described in the Particular Technical Specifications.

The equipment shall be of SHRIMP or GAMBAS type.

The streamer shall be composed of twenty four (24) sensors.

The seismic source shall be an air gun located very close to the seabed and the first sensor.

Accuracy on layer depth determination shall be better than 0.3 m for shallow objectives and 0.5 m for deep objectives.

Seismic velocity (V_p and V_s) analysis shall be better than 100 m/sec.

Digital (24 channels) recording EQUIPMENT shall be used. Geotechnical information shall be used by CONTRACTOR in order to calibrate seismic refraction results.

Geometry of source and receivers shall be adjusted on SITE depending on the required penetration.

7.3.8 High-resolution multi-channel seismic

7.3.8.1 Methodology

Survey design

The acquisition grid may one of two types, as required by COMPANY's Particular Specification:

i. 2D HR

Such conventional survey grids will consist of main lines (strike lines at nominal 100-m interval) and cross-lines (dip lines at nominal 100-m interval or more), acquired and processed as 2D project. Acquisition parameters shall be as per paragraph below.

ii. mini-3D

This acquisition grid will aim to simulate 3D acquisition, in places where COMPANY has no conventional 3D seismic volume available. Acquisition parameters shall be as per paragraph below, and additional requirements:

- Main lines at nominal 50-m interval, no cross-lines
- Acquired as 2D project, with a requirement for QC of bin fill
- Processed as 3D project, with interpolation of crosslines for a volume of 50x25-m bins.

Acquisition parameters

- | | |
|------------------------------|---|
| • Record length | 1.5 sec. (2.5 sec. for exploration lines) |
| • Sample rate | 1 millisecond |
| • Coverage | 48 |
| • Minimal number of channels | 48 (or 96 in deep water) |
| • Low-cut filter | Out |
| • High-cut filter | 320 Hz, 72 dB/Oct |

- Notch filter Out
- Gain constants Depending on Equipment, to be proposed by CONTRACTOR
- Polarity For minimum phase data, the convention "normal polarity" is compression-negative

7.3.8.2 Equipment

Source array

- Number of sources 1 for site surveys, 2 for explo lines
- Firing interval 6.25 m (or 12.5 m in deep water)
- Type of source Sleevegun cluster or GI gun
- Total volume minimum 160 cu.in. (320 for exploration lines)
- Operating pressure 2000 psi
- Total number of guns 1 to 4
- Depth of guns 2 to 3 m
- Energy release interval less than 2.5 sec.

Streamer

- Number of Streamers 1 + spares (50% of streamer length)
- Type of streamer preferably telemetric (digital)
- Groups per streamer 48 (6 for Mini 3D lines)
- Available Group intervals 12.5 m
- Active Group lengths Depending on Equipment, CONTRACTOR proposal
- Number of traces 48
- Nearest offset available minimal, in range 0 to 40 m
- Farthest offset available stretch + 600 m (+ 1500 m for exploration lines)
- Streamer depth 2 to 3 m max.
- CDP spacing 6.25 m

Recording unit

- **TTS2 or equivalent Data format shall be compatible with PROMAX system**
- Number of channels available 48 + auxiliaries (or 96 for exploration lines)
- Number of auxiliary channels 4
- Sampling rates available 0.5 ms, 1 ms or 2 ms
and method of switching software
- Record length as above
- Preamplifier gain as above



- Tape format S E G Y
- Tape density 6250 BPI

7.3.8.3 Test/Quality control

General

The work standards set forth herein intended to provide a reasonable minimum standard of reference for CONTRACTOR's work performance. Acquisition of data during times when one or more of these minimum work standards are not met may place burden of proof upon CONTRACTOR to justify charging for data so acquired, or CONTRACTOR shall re-shoot at no costs to COMPANY any and all lines whose data qualities and fold coverage falls outside the Quality Control Criteria specified hereinafter and/or other parts of Agreement.

a) Independent quality control of instrumentation

CONTRACTOR will provide all necessary assistance and information required to interface COMPANY REPRESENTATIVE's independent quality control instrumentation to their recording and positioning systems.

In case of particular conditions approved by COMPANY REPRESENTATIVE, the latter may waive certain of the following provisions at his discretion.

COMPANY REPRESENTATIVE may request recording operation to stop at any time if CONTRACTOR's work performance or data acquisition is sub-standard.

COMPANY REPRESENTATIVE will have at any time the right of access to all logs (technical and narrative) relating to the operations and their quality control and to all manuals and technical specifications of Equipment on-board vessel.

CONTRACTOR shall be responsible for bringing malfunctions of any Equipment to the attention of the COMPANY REPRESENTATIVE and shall inform him if the quality control criteria are not met and shall obtain his permission before changing any field parameters.

CONTRACTOR will continually check the cable feathering and depth and inform the COMPANY REPRESENTATIVE whenever the agreed limits are exceeded.

CONTRACTOR will ensure that **every** missed shot or misfire is properly reported on observer's and navigator's logs.

Any incident involving fishing or unidentified vessels will be reported immediately to the COMPANY REPRESENTATIVE.

b) System synchronisation

The electronic programmer of the seismic system (which is governed by the output of the navigation system) shall govern the synchronisation of all other systems such as heading, speed log, echo-sounder and so on, etc.

The gun signature shall be recorded.

c) Overlap

Required when joining or extending previous coverage. The objective is to repeat field recording such that subsequent data processing as independent data batches will yield duplicate subsurface fully-stacked coverage equivalent to one-half the effective length of streamer.

Quality control criteria

a) Cable noise

Fixed gain recording of cable towing at approximately operational recording speed will be made on the field tape and paper (RPM of propeller shaft and sea state shall be also annotated) during a straight line run of approximately one and one half cable length at the start and end of each line, or interrupted portion of line, and at any other time requested by COMPANY. The paper records will be identified as a "streamer noise recording" with fixed gain noted" it will be filed with the monitor records for that line.

Ambient noise will be measured using the recording filters for 5 seconds recording. A record will be made with all channels analysed by the seismic QC system (for reference purposes).

Cable noise is quoted in microbars RMS equivalent and is defined as the noise at the amplifier input in microvolts RMS equivalent divided by sensitivity of the detector group (when loaded with cable and amplifiers) in microvolts per microbar. The trace sensitivity is 5 microvolts per microbar.

b) Streamer Sensitivity

A streamer sensitivity test shall be required to be performed at the start of the survey. This will be performed by firing a small source a distance from the net holding a coiled streamer section and a calibrated reference hydrophone. At least two sections of the streamer shall be tested. A copy of all results and the test tapes will be forwarded to the COMPANY.

The maximum acceptable average noise is as follows:

- Coherent noise from ahead: $\leq 10 \mu$ bars
- Coherent noise from behind: $\leq 10 \mu$ bars
- Random noise, steady $\leq 5 \mu$ bars.

c) Defective traces

A seismic trace will be considered defective if:

- System noise including all wiring from hydrophones to tape recorders exceeds MANUFACTURER'S specifications when all normal shipboard machinery is operating
- It is dead, intermittent or more than 3 dB down relative to contiguous traces when noise levels on these traces meet the specifications of a) above
- It is distorted or has a phase shift of more than ± 1 millisecond
- Polarity is reversed
- It exhibits electrical leakage or the cable insulation pairs and from ground is less than **one mega ohm**
- Average ambient noise exceeds specifications in a) above or individual noise bursts exceed 25 microbars peak to peak in moderate sea conditions.

d) Cable depth

Cable depth will be recorded at least every 40th shotpoint at a minimum of three positions per 24 traces along the cable.

Cable depth is to be 2 to 3 metres. The optimum depth for cable streaming shall be considered to be 2.5 m.

Automatic depth control birds may be used where the safety of the cable is at risk, but are not to be used to change cable depth when on production shooting.

Cable depth transducers will be calibrated at the start of the survey and whenever the cable is subsequently repaired. They should be accurate to within ± 0.25 m.

Prior to production shooting and in the presence of COMPANY REPRESENTATIVE, the cable will be streamed with depth controllers in neutral position in order to ensure good cable balance in its neutrally buoyant state.

e) Cable drift

Cable feathering will not deviate by more than 5 degrees from prescribed bearing of the line unless COMPANY REPRESENTATIVE decides to waive the specification.

Cable drift shall be continuously monitored and recorded during the 3D data acquisition phase.

f) Seismic source

Visual display of individual gun acoustic impulses will be shown as a fixed image on memory oscilloscope or any similar Equipment.

Individual firing times from all guns will be synchronised within ± 1 millisecond. A screen monitor will provide a display with 0.25 millisecond resolution of gun firing times.

Compressed air system shall enable to provide 2000 psi $\pm$ 200 psi or 90% of normal pressure.

Specified source depth is 2-3 metres. Maximum deviation from specified source depth will be $\pm 10\%$.

The drop-out specifications for the gun/array shall be:

- No more than one gun in any sub-array shall be malfunctioning before beginning a new line; (e.g.) If during the acquisition of one line, a two gun-association is malfunctioning the line will be aborted and re-shoot
- Each gun string or sub-array shall be equipped with remote reading depth sensors such that the depth of any gun can be determined with an accuracy superior to ± 0.25 m
- Actual shot interval shall differ less than 10% from theoretical distance, on a line basis.

g) Offset

The offset to the beginning of the streamer measured will be checked with water break data.

Cable towing point on ship is to be as low as operationally possible and towing link should be elastic to transmit minimum vibration from ship.

h) Monitor records

Multichannel paper monitors to be made every 40th shotpoint whenever deemed necessary and systematically annotated as produced.

Camera shall have a plotter display system.

Shot instant, timing signal, gun phone signatures, etc., Hz timing line display, water-break phones and the seismic detector groups will all be displayed.

Timing reference and timing line signal will coincide within 1 millisecond.

Single channel section monitors will be recorded on a **Delph-seismic** or equivalent system, continuously and systematically annotated.

i) Tapes

All seismic and navigation data will be recorded on new certified magnetic tapes (IBM 3090 or equivalent) of a MANUFACTURER and brand acceptable to the COMPANY.

Proper precautions will be observed in recording, sealing, storing and transporting both new and recorded tapes.

CONTRACTOR will warrant that all tapes prepared by CONTRACTOR in performance of the work and/or services under this Contract shall be of such quality that, on the basis of normal wear and tear, COMPANY is able to use such tapes for a period of at least ten (10) years calculated from the date of recording and/or use of the tapes by CONTRACTOR for the work and/or services.

No tape reel shall contain data for more than one survey line.

Tape labels will be annotated with CONTRACTOR, COMPANY, vessel name, prospect area, tape number, Julian and calendar date, time, line number, file number, shotpoint numbers, sample rate and record length.

Tape reels will be numbered consecutively.

Tape skew standards are as follows:

- Throughout the survey static skew will not exceed 5% and dynamic skew 10% of byte time
- Tape speed will be maintained within 1% of MANUFACTURER's specifications.

j) Polarity

SEG convention will be used i.e. a compressional wave will be recorded as a negative number on tape and as a downward deflection on the monitor record.

Magnetic tape recording, read-after-write, or play-back and monitors polarity will be identical.

Polarity will be checked prior to start of survey and whenever sections of the streamer cable are replaced or where there is a change in signal routing.

k) Misfires

The following conditions constitute a misfire:

- Loss of magnetic recording
- Loss of time break
- More than seven consecutive parity errors
- Array not within the drop-out specifications as defined in f).
- Failure of compressors to supply continuously a minimum of 90% of normal pressure or pressure variations leading to mistuning of the array
- Distorted airgun pulses or a spread of more than 1 millisecond among individual gun acoustic pulses
- Autofiring of guns
- Variation of depth along streamer and/or of the airgun array exceeding ± 0.5 m of its specified depth
- Less than three operative depth transducers

- More than three defective traces on a record
- The A/D converter overdrives, i.e. 32 counts or more per record on seismic data channels (for shallow water only)
- When the firing time of any one gun in any array differs by more than 1 ms from its specified time
- Airgun controlling system malfunctions or is inoperative
- Loss of recording of positioning data
- Shut-off of positioning specifications (10%).

I) Work not to commence

Recording will not commence on any line at any time of the following conditions occur:

- Airgun array not within the drop-out specifications as mentioned in f) above, except if spare guns can be substituted for malfunctioning guns
- Whenever the output signal is not properly tuned according to CONTRACTOR's specifications attached to this Agreement
- Firing time of guns varying by more than ± 1 milliseconds
- One of the streamer depth detectors faulty
- Polarity is not in accordance with specifications
- Multi-channel monitor malfunction unless normal operation is achieved within first kilometre of line. However, recording may continue beyond the first kilometre if CONTRACTOR can at a later stage play-back the missed monitor records and demonstrate acceptable data quality. Any reshoots for unacceptable data under these circumstances would be at CONTRACTOR's expense
- Echo-sounder not functioning
- Cable noise recording has not been made
- Cable or/and source depth exceeds allowable range
- Energy source generation Equipment operating below 90% of operational pressure
- Cable noise specifications as defined in a) are not met
- Minimum of two tape transports are not operational
- Single channel section monitor inoperable. However, CONTRACTOR shall be allowed to start recording if it plays back the profile at a later stage and demonstrates acceptable data quality.

Any reshoots for unacceptable data quality under these circumstances would be at CONTRACTOR's expense.

- The positioning or/and CLS systems not functioning in accordance with minimum standards set forth for shore based radio-positioning and MANUFACTURER standards
- Three or more traces defective on the cable or two more adjacent traces
- Feathering not within the specifications as from d).
- Individual gun pulses cannot be displayed.

At start of each new 24 hours period, or at the first new line standard in a new 24 hours period, there will be:

- A daily set of instrument test records approved by COMPANY on-board REPRESENTATIVE
- No defective traces when the cable is deployed after each withdrawal.

m) Work to be interrupted

Recording will not continue when any of the following conditions occur:

- Cable noise exceeds specifications
- Four successive misfires or more than four misfires during any 12 seismic impulses
- Misfire rate exceeding 5% on any line or 3% on average for any portion of survey completed
- Airgun array not within the drop-out specifications as in f).
- More than 4% of traces defective or otherwise unusable (i.e. not meeting noise, leakage, polarity and normal sensitivity specifications). More than one trace in 12 consecutive traces defective or unusable. More than two adjacent traces are defective
- Less than 90% of cable depth transducers are operational
- Cable and/or source depth exceeds allowable range
- Equipment to measure streamer drift (feathering angle) is not operational
- Feathering not within specifications as from "Cable drift"
- Energy source generating Equipment operating below 90% of operational pressure
- Multi-channel monitor recorder inoperable such that five (5) successive monitor seismograms have been missed. However, recording may continue, if CONTRACTOR can a later stage play-back the missed monitor records and demonstrate acceptable data quality. Any reshoots for unacceptable data under these circumstances would be at CONTRACTOR's expense
- Single channel section monitor inoperable for one-half hour. However, recording shall continue if CONTRACTOR plays back the profile at a later stage and demonstrate acceptable data quality. Any reshoots for unacceptable data quality under these circumstances would be at CONTRACTOR's expense
- Inoperative echo-sounder for more than 30 minutes or 50% of the time required to acquire the line, whichever is the shortest
- The positioning system not functioning in accordance with minimum standards set forth for this Equipment.

n) Reshooting

No more than four consecutive misfires will be lost or below standard without reshooting. Lost or substandard portion will be reshoot at CONTRACTOR's expense.

Should line be interrupted for any acceptable reason or reshot, overlap of duplicate subsurface fully stacked coverage equivalent to one-half the effective length of cable when reshooting in the same direction or one cable length when reshooting in the opposite direction must be obtained.

If the interruption or reshoot is for reasons whereby the CONTRACTOR is accountable, the reshoot is for CONTRACTOR's account.

o) Ship speed

Average sea bottom speed during seismic recording (run-in and run-out) will be maintained as closely as possible to **3 knots**. Speed at any given time will not exceed that necessary to obtain a full record plus recorder cycle time; average speed will be logged continuously, calculated on a line-by-line basis, and will not exceed 4 knots.

p) Observer's report

With the magnetic tapes of each recorded seismic line, will be furnished complete information required to process the data, including such data as streamer diagram or other description of streamer configuration, source position, nearest group position, tailbuoy position and geometry with respect to streamer, bathymetry, etc.

q) Instrument test schedule

Before start

CONTRACTOR will have all MANUFACTURERS instrument test and procedures manuals on-board the vessel and available for inspection by the COMPANY REPRESENTATIVE.

Instrument tests shall be carried out prior to the commencement of the survey at each area and at least every month and at the end of survey thereafter by CONTRACTOR according to the instrument MANUFACTURER's manuals. Tests will be made using filter, setting, and sample rates used in production. The survey will not continue if MANUFACTURER's specifications are not met. CONTRACTOR shall describe the envisaged receiver sensitivity testing procedure.

CONTRACTOR will send the instrument test tape to a processing centre for computer evaluation as rapidly as possible or it will be evaluated on-board the vessel. The computer centre evaluation will be made available to COMPANY.

These instrument tests shall include daily and monthly instrument tests as described below:

Daily instrument tests

Daily instrument test as recommended by the MANUFACTURER will be carried out to ensure the instruments remain correctly calibrated. These tests consist of:

- Dynamic Range (e.g.): -3 dB - 9 dB, -15 dB and -21 dB
- 10 microbar Reference Signal (e.g.)
- Cable Noise Test
- Step Response
- Harmonic Distortion analysis.

Monthly instrument tests

A comprehensive of tests will be run prior to the commencement and at the end of the survey, repeated monthly and when the system suffers a serious breakdown. These tests will include the Daily Instrument Tests and the tests below:

- Header Check
- Digital Pattern Tests
- Polarity test

- Production Shot Record
- All ones on each tape transport.

Results of these tests will be submitted to the COMPANY.

7.3.9 Sampling and soil testing

7.3.9.1 Sampling

Samples shall be recovered using a gravity piston corer (Kullenberg type) or a vibro-corer in conjunction with piston (if possible) with surface control of the barrel penetration.

A grab-sampler (Shipek grab or equivalent) shall be available to allow the recovery of sea-bed samples if soils are too stiff for gravity corer operation.

For surveys of continental shelf and top slope (water depth from 0 to ≈ 400 m), the barrel length shall be at least 3 metres. Nevertheless, in the case of soft sediments, the length of the barrel shall be extended to a minimum of at least 6 m, or up to 12 metres if possible.

For deep water surveys, over 400 m water depth, where soft sediments are expected, the barrel length shall be at least 6 m, or up to 12 metres if possible.

The internal diameter of the PVC liners shall never be less than 80 mm. Transparent liners are required. Sufficient core catchers and PVC liners must be supplied to cope with any additional coring program.

The soil sample locations, selected on the vessel by agreement between CONTRACTOR and COMPANY REPRESENTATIVES. Under normal conditions, the coring program shall be performed when seismic/acquisition has been completed, on the basis of the preliminary interpretation.

CONTRACTOR shall provide positioning of the coring device by acoustic means (USBL), at seabed locations, for deep-water locations (over 500-m depths).

At each core location, the water depth shall be measured, and a profiler (pinger) record shall be obtained for correlation purposes.

The cores shall be identified on-board the ship and the soil description immediately correlated with other survey results (sonar/profiler records). The soil shall be described according to the International standards defined in **GS GEO 101**.

Torvane and pocket penetrometer tests shall be performed on-board.

Samples shall be kept sealed by waxing and properly labelled. They may be divided in 1-m lengths for shipping providing the segments are all identified in order, and by sample number.

7.3.9.2 Soil testing on samples

CONTRACTOR shall provide, at tender stage, the option of providing advanced soil testing by means of mobilising an on-board laboratory, with dedicated geotechnical engineer. This additional manning will perform offshore analysis of samples to provide:

- Water content
- Dry density, wet density
- Relative density on sands

- Shear strength measurements on clays
- Grain size distribution, if applicable.

COMPANY may request the option to forward samples to a laboratory onshore, to perform tests including, but not limited to:

- Classification, description
- Water content
- Dry density, wet density
- Atterberg limits, if applicable
- Relative density on sands
- Shear strength measurements on clays
- Grain size distribution, if applicable.

In this case, CONTRACTOR shall propose his choice of analysis laboratory, and the appropriate series of tests to be performed on the samples, together with schedule of reporting for such tests.

The proposal shall be submitted for COMPANY's approval. Testing of samples shall not start without COMPANY's written consent.

Soil testing shall conform to COMPANY specification **GS GEO 101**.

7.3.9.3 In situ soil testing

In situ penetrometer tests (CPT) may be required by COMPANY in addition to soil coring. Penetrometer testing shall be according to **GS GEO 101**.

7.4 Quality Control and Data Management

7.4.1 QC and monitoring, multi-beam sounder

MBES quality control will run in real-time and display the following at a minimum, though they may be combined:

- Horizontal coverage display of cumulative lines, with colour-coded depth banding
- Display of any on-line filtering or rejection of the data
- Latest motion-corrected data profile, as conditioned by attitude sensors.

In the case of vehicles, such as AUV or deep-towfish, acquiring depth data by MBES, in conjunction with vehicle depth by pressure measurements (such as Digiquartz): the time series of barometric pressure measurements and/or gravity factor utilised shall be logged, available for inspection by COMPANY, and documented in report.

Near real-time bathymetric plots must be available for inspection as the survey proceeds: it is expected that draft plots can routinely be produced within 12-hours of acquisition.

The single-beam echo-sounder will output data for logging to file, and be operated over all MBES lines, with full calibrations and corrections. This will provide a back-up data set (paper and file) in case of doubts on the integrity of the MBES data.

A data QC comparison of sounding values obtained from MBES and single beam (cf. 7.3.4) shall be performed at intervals, or at the request of COMPANY REPRESENTATIVE. QC cross-lines shall also be run for that purpose. This spot check will be logged.

For the system used, an error budget shall be developed, using MANUFACTURER's specification and CONTRACTOR's experience, to compare the expected and actual accuracies in terms of error cube: acquisition footprints of a typical ping across-track, along-track and depth. This should take into account the motion sensor(s) (frequency of sampling and output), sampling geometry (vessel speed and ping rate), and various corrections applied (tides, vessel squat, draft measurement and its drift).

7.4.2 QC and monitoring, Deep-water/AUV VEHICLE

CONTRACTOR will specify the real-time Monitoring and Quality Control system proposed for the VEHICLE operation, e.g. acoustic link(s) to enable:

- Monitoring of vehicle attitude, battery status and other relevant indicators to provide sufficient control for effective operations
- Quality Control to track a sub-set of the data transmitted by acoustics from VEHICLE to the vessel, to verify actual logging of the data, and extent of line coverage on a grid basis (multi-line).

These display(s) will be maintained on the survey vessel, logged throughout the VEHICLE in-sea period, and made available to COMPANY REPRESENTATIVE at all times.

7.4.3 Data logging and management, Deep-water/AUV VEHICLE

CONTRACTOR will plan the line grid for the survey according the Particular Specification of App.B, and anticipate mass storage requirements for a commensurate volume of data, including a contingency of 50% extra.

Processor(s) on the survey vessel will be equipped with state of the art computer(s), with sufficient live memory, speed and connectivity to carry out the processing effectively, i.e. keep up without difficulty with the pace of optimal acquisition.

CONTRACTOR's proposal will specify the data transfer rates between VEHICLE and main survey vessel, in terms of hours of VEHICLE on-deck time required to download a given data volume, namely that of the anticipated VEHICLE dive mission time.

Storage will be such as to provide for the entire raw and processed datasets for all deployed sensors. The raw multibeam data for the entire survey shall be:

- Accessible on-line to processors
- Backed-up as the survey progresses, to secure medium specified by CONTRACTOR, and accessible on-board.

7.5 Data processing

Data processing shall be performed on-board on a 24-hour basis, according to the specifications given in this Appendix, for:

- Navigation for all sensors - to production of track plots for all sensors
- Multi-beam bathymetry - to gridded data on chart(s), by predicted tides or observed tides where available

- Side scan sonar and single-trace seismic profilers - to interpretation, and field report
- High-resolution multi-channel seismic - to preliminary sections.

As raw data is recorded, COMPANY may request CONTRACTOR to carry-out further post-processing or re-processing of partial or whole dataset, offshore, for the benefit of the interpretation.

However, means of data processing/re-processing shall be available onshore at CONTRACTOR's interpretation centre, if required by COMPANY.

7.5.1 Multi-beam and seabed imaging data

Processing system

COMPANY requires all acquired bathymetry data to be processed and charted offshore, to monitor coverage, consistency and allow the development of any additional coverage areas.

CONTRACTOR shall provide an MBES system comprising on-line QC, and an offline processing system (multi-beam data, on-line and off-line processing system, plotter) capable of producing final results on-board. The system will be set-up with connectivity and storage capacity sufficient to perform real-time QC on-line, near real-time draft charts (within 12 hours).

Processing will be carried out by dedicated offline processor(s) with a track record of work on the system used for the project. It will be carried out on a dedicated processing computer receiving data from the acquisition system, and outputting to an A1 or A0 colour plotter.

Storage capacity shall be sufficient for on-line acquisition of the entire survey, plus 50% contingency, and off-line processing.

The on-line computer shall be able to log to data files and any step of the data processing it performs, in order to perform Quality Control analysis. The depth data reaching the processing system shall be fully interfaced and time-correlated with position and correction data from navigation and heave-compensator systems.

During the off-line processing, it shall be possible to log and/or to modify all processing parameters used, depending on the results, to enable testing and re-processing.

The processing system shall be fully interfaced and time-correlated with navigation and heave compensator systems.

Vessel shall have capability to read and validate the acquired tidal records, if needed for one phase of the survey, or for quality control purposes.

Method

Data shall be processed, with predicted tides on-board the survey vessel, or if indicated in the particular Specification, from tides observed in a place as near as practical, and of similar water depth. Refer details in above section **Calibrations and corrections**.

Actual tide reduction of the data shall be performed onshore after recorded tides are processed, unless real-time data is available.

The processing system shall be able to display on screen, and send to plotter back-scatter (pseudo sonar) images and colour bathymetric maps with contours, spot depths or slope values. Analysis of raw data, gridded data and statistics (standard deviation) should be displayed on screen. Standard deviation shall be less than 0.5% of water depth.

The parameters of the **processing flow** will be tested before the production processing begins, or else the processing updates will involve re-processing the data run to date, to a uniform sequence.

The main tests expected to justify the choice of parameters will produce:

- Comparative displays of rejected data and edge clipping to show the signal-to-noise ratio
- Detailed representative QC displays such as SD (standard deviation) or cell fill, to document the actual data quality and density, particularly in overlaps between lines
- Comparative grid cell displays to support the choice of grid size for the specific area, centred on the smallest significant result (seabed feature of interest).

The requirement for **gridding interval** of multibeam data is 1-m in shallow water, or 2-m in deep water (over 500-m), unless otherwise agreed by COMPANY.

Bathymetric charts shall be displayed with the smallest **contour interval** representative of the morphology, as can be produced on a legible chart of the specified scale; 1-m interval is considered the norm.

Smoothing will be kept to a minimum: sufficient for reduction of the dataset to a consistent and readable set of contours at the scale of charting, but not excessive (e.g. all traces of artefacts of acquisition or merging are absent from final surface imagery). Any bulk shifts utilised in the process of merging lines for gridding will be documented in graphical map form. The amplitude of such shifts will not exceed the expected accuracy of the swathe system as quoted by MANUFACTURERS, or a nominal $\pm 0.25\%$ of the water depth.

Offline **quality control** will be provided in the form of seabed map displays, or Digital Terrain Models, and plotted on A0 paper or examined on screen (with un-decimated files) to allow maximum magnification. This QC output will be checked by CONTRACTOR and COMPANY REPRESENTATIVE for integrity (as representative of seabed features) and coherence (artefacts).

Processing report

A processing report will be prepared on the vessel by CONTRACTOR's nominated processing specialist, submitted to the COMPANY REPRESENTATIVE, and included in the final survey report.

This will include, for representative areas or entire survey if the size of the dataset allows, the following:

- All parameter tests, such as clipping and data rejection criteria, gridding cell size, etc.
- Detailed processing sequence, with screen dump displays of typical displays
- Quality checks such as cell fill displays, profiles to show accuracy of tide corrections, line ties, etc.
- Difference plots of major steps in the processing, i.e. pre- and post- transformations such as de-smiling, merge, smoothing.

Products of Multibeam, required

The final products of MBES processing are:

- Bathymetric chart (spot depths and contours)
- DTMs (seabed imagery charts), to display geomorphology

- Pseudo-sonar imagery (back-scattering), if requested by COMPANY
- 3D perspective views of significant findings or seabed features.

These products will be included in CONTRACTOR's final survey report.

Products of Multibeam, optional

In addition to above, COMPANY may request 3D visualisations of bathymetry, "fly-by" video imagery or other types of displays.

Such requests are expected to be carried out onshore by CONTRACTOR or his SUB-CONTRACTORS, during final reporting, unless explicitly called for by App.B, Particular Specification.

7.5.2 Echo-sounder data

Data processing in respect of tides: as per section above, Multi-beam Data.

7.5.3 Side scan sonar mosaicing

Side scan sonar mosaicing may be required, at COMPANY's option. Subsequent data post-processing shall be performed offshore, and onshore after field operations, subject to COMPANY approval.

If during acquisition phase, side scan sonar data are displayed without the slant range correction, they shall be post-processed with such correction at optimal range scale.

7.5.4 Single-trace seismic data

Means of post-processing or re-processing lines shall be available offshore, off-line, for the acceptance of lines or benefit of interpretation, if required by COMPANY.

Means of post-processing or re-processing shall be available onshore at the interpretation center, in case post-processing and/or re-processing is to be carried out during or after the data interpretation phase, for the finalisation of reporting, if required by COMPANY.

7.5.5 Laboratory tests of soil samples

Refer to **GS GEO 101** for technical details concerning laboratory tests.

7.5.6 Seismic refraction data (if required by Particular Specification)

Data processing shall be performed on site.

However, further post-processing may be carried-out onshore CONTRACTOR facilities at interpreter's request.

The processing shall be performed in four (4) main steps:

- Record quality control
- First break picking
- Dromochronic computation
- Output of velocity-depth information and plot of interpreted profiles.

7.5.7 High-resolution multi-channel seismic processing

7.5.7.1 On-board 2D processing

An on-board processing system shall be added to the data acquisition package.

A PROMAX or equivalent is required. Specific software to carry out all processing sequences below, including attribute analysis is mandatory.

The objective of on-board processing are seismic quality control and final processing.

The final processing sequence shall be as follows unless otherwise agreed by COMPANY REPRESENTATIVE:

- Reformatting (or Demux)
- Resampling to 2 ms (**if required**)
- Spherical divergence (in tv^2) correction and/or exponential gain recovery
- F/K Filtering (in shot domain)
- F/K Filtering (in receiver domain with AGC, AGC^{-1}) (**optional**)
- Signature Deconvolution
- Predictive Deconvolution (DBS) surface consistent
- CDP Gather
- Velocity Analysis
- Multiple elimination
- DMO, **if required**
- Velocity Analysis
- NMO corrections and Mute
- AVO processing and displays
- Stack
- Predictive Deconvolution (DAS) **if required**
- Time migration, after velocity smoothing
- Time variant filter
- Equalisation/preserved amplitude
- Displays.

All scaling should be reversed after the processing sequence step requiring such scaling.

The final length of sections shall be a minimum of 1000 ms below the seabed.

Three (3) velocity analysis per kilometre shall be performed, unless otherwise agreed by COMPANY REPRESENTATIVE.

AVO processing:

- No AGC should be applied to the data. Geometric spreading compensation of the type TV should be applied instead in two steps, the T compensation at the start of processing and the V with the NMO correction. Pattern effects can be removed deterministically
- Spiking deconvolution is to be avoided
- Multiple elimination: FK or Tau-p. In case scaling is applied prior to filtering, it should be reversed after filtering. Mild and well tapered filters should be selected, allowing for uncertainties in primary velocities
- Re NMO mute a stretch factor of 10% should be considered as a limit, as stretching the wavelet in time is equivalent to compressing it in frequency and one wish to keep the wavelet shape the same at all offsets
- Gathers shall be displayed on a number of AVO anomalies as required by the COMPANY REPRESENTATIVE.

Prior determining the processing parameters (and the final processing sequence) tests shall be performed for filtering and deconvolution. Deconvolution before and/or after stack may be skipped if proven unnecessary. The final parameters and sequence shall be selected with the COMPANY REPRESENTATIVE's approval.

Final display required: preserved amplitude and equalised migrated sections, AVO displays (near mid and far CDP gathers and RO, G and RO*G).

Final AVO and stack tapes shall be in SEG Y format in order to be replayed on a work-station. They shall be delivered to COMPANY with the Final Reports.

With the objective of shallow gas determination, the following trace attributes shall be worked out on the two cross lines going through the selected locations and where required by COMPANY:

- Amplitude
- Energy (power spectrum)
- Instantaneous phase
- Instantaneous frequency.

7.5.7.2 Onshore 2D processing (Optional)

If necessary, a part of the data may be processed or re-processed onshore after the field operations.

Data processing shall be performed in specialised High-Resolution Processing Centre, which shall be agreed by the COMPANY.

7.5.7.3 Special 2D processing (Optional, onshore)

Special processing shall be done with COMPANY REPRESENTATIVE Approval:

- Synthetic seismogram may be performed in order to calibrate the seismic data. Well information (sonic logs) shall then be given by COMPANY to CONTRACTOR after the field operations
- Large scale displays

- Very detailed velocity analysis (including geo-statistics if required by COMPANY)
- Acoustic impedance inversion
- Pseudo velocity logs (acoustic impedance) with colour code display. Calibration may be done with well data provided by COMPANY.

7.5.7.4 3D processing (onshore)

3D processing of the data is the expected outcome of the seismic acquisition.

The processing shall be carried out on the first 300 m of the streamer, 1 s record length and with 2 ms sampling rate.

The processing sequence shall be as follows:

- Reformatting
- Static corrections
- Seismic/Navigation data merging
- Amplitude recovery
- FK filtering (if needed)
- Designature or deconvolution in narrow band (sparker only)
- Predictive deconvolution
- Binning
- Velocity analysis
- Elastic binning
- Tide corrections
- 3D Stack and control display
- Time Migration
- **Option of output:** near-, mids, and far-trace cubes for elastic acoustic impedance inversion
- Stacked and migrated data to be provided on SEG-Y format on cartridge 8 mm tape support
- Report.

Additionally, if required by COMPANY, the following processing shall be carried out:

- Acoustic impedance inversion
- Elastic acoustic impedance inversion
- Geo-statistical analysis of the velocity field
- Very detailed velocity analysis.

7.6 Data interpretation

7.6.1 On-board interpretation

Interpretation shall be carried out on-board, in order to assure that all data necessary to the objectives of the survey are acquired correctly, and coverage is sufficient.

Location maps and track plots shall be made on-board using suitable automatic AO plotter. A colour printer is also required for screen dumps.

In the case of pipeline surveys, production of field charts, showing track plots and bathymetry, shall be carried out within 12 hours of data acquisition in order to facilitate selection of route and coverage.

On the basis of this interpretation, an additional programme may be worked out and implemented with COMPANY REPRESENTATIVE Approval. This can nominally represent up to 50% of the workscope.

Data from the different sensors shall be integrated in order to produce the following charts, required from the preliminary on-board interpretation:

- Bathymetry (single and multibeam data, corrected with the recorded tide)
- Seabed features (morphology and man-made features)
- Surficial lithology and the thickness of the recent soft surficial sediments, to include isopach chart of the first reflector; this is to address anchoring conditions
- Geology down to 800-1000 metres, including at least one chart and one vertical profile representative of the site
- Shallow gas risk, and any other geohazard.

Initial interpretation of processed HR multi-channel seismic data shall be carried out on-board, using paper sections or screen displays.

7.6.2 Final interpretation onshore

Unless otherwise mentioned in the Particular Specifications, final interpretation of HR multi-channel seismic data shall be completed onshore at CONTRACTOR facilities. Interpretation will be carried out on seismic workstation, and representative colour displays will be included in the final report.

HR interpretation shall consist in the determination of the amplitude anomalies, velocity anomalies, and fault pattern in the upper 800-1000 metres; also, when required: AVO variations, and trace attribute mapping. The objective is to assess, within the geological context, the **shallow gas risk or any other geohazard**, for drilling or field development purposes. Final product shall be one or more geo hazard maps.

COMPANY reserves the right to request CONTRACTOR to integrate the interpretation with related datasets, HR or 3D seismic data, as supplied by COMPANY.

7.7 Reporting

The schedule of delivery for all reports shall be as per the Particular Specifications.

7.7.1 Field Report

This Report shall include but not limited to:

- Log of daily events
- Navigation parameters
- Track plot of surveyed lines
- Bathymetric preliminary maps with predicted tides (observed tides if available)
- Representative side scan and single trace sections (Delph Seismic)
- Geophysical profiles (reflection and refraction where applicable)
- Observer's reports, including:
 - Test records
 - Monitor displays
 - PROMAX tests and stacks
- Typical interpretative geological profiles on single-trace sections with superficial formations, significant main reflectors, bed rock and all complementary information
- Preliminary conclusions
- Description of samples and list of the samples sent ashore to the laboratory.

The COMPANY REPRESENTATIVE shall define on-board the exact content of the Operation Report.

7.7.2 Final Report, general

The Report shall be prepared in conformity with instructions that will be given by COMPANY in the Particular Specifications.

The Report shall be an Expert Report assessing soil conditions with the objective of the project. It shall be structured and concise, and include clear and practical conclusions in regard of the survey objectives.

In case the proposed pipeline route and/or site survey locations identify geohazards, recommended locations shall be proposed by CONTRACTOR's interpreters, taking into account pipeline engineering and/or exploration criteria as given by COMPANY.

The final Report shall be presented in two (2) volumes:

- Volume 1: Survey Results including data examples, track plots and charts.
- Volume 2: Technical appendices including Equipment description, logs and other technical documents as required by COMPANY REPRESENTATIVE.

Title: the final report shall be entitled:

- Name of recipient - COMPANY affiliate/subsidiary/project
- Block reference and location name, Country
- "Survey Report for:"
- Title Survey (e.g. Geophysical investigation for Jacket, pipeline, semi-sub rig, etc.)

- Name of the structure(s), field(s), or Start of pipe - End of pipe
- Survey COMPANY's name
- Start/end dates of offshore work, and vessel.

Certification: the first page of the report shall show certification, and shall specify:

- Name of Party Chief in charge of the field work
- Name of person responsible for checking Navigation/Bathymetry
- Name of person responsible for Analogue Interpretation
- Name of person responsible for Refraction interpretation (if applicable)
- Name of person responsible for Digital Interpretation (if applicable)
- Name and signature of QA/QC issuing Authority
- Date of issue.

7.7.3 Draft of Final Report

One draft copy of final report, with all relevant maps and illustrations, shall be submitted to COMPANY, for review and approval.

CONTRACTOR shall issue the final report after incorporation of COMPANY's amendments or addenda, if any, into the said report.

7.7.4 Final Report, Content

The Final Report, or Survey Report, shall comprise:

Volume 1, "Survey results", to include (when applicable):

Section 1: "Abstract" giving a brief description of the operations:

- Date of survey
- Location surveyed with key co-ordinates and situation plan
- Type of vessel and Equipment used, positioning, acquisition procedures and operation parameters
- The number of line kilometres recorded
- Summary of the main survey results (water depths, observed tidal range, sonar features or obstructions, nature of soils and structure/thickness of the different units)
- Evaluation of potential risks regarding the installation of the structure, or pipeline
- Conclusion and recommendations summarising the main results with respect to the planned activities.

Section 2: "Results"

This part, dealing with the description of sea-floor features (bathymetry, morphology, obstructions, nature of soils, structures, etc.), shall include, but not be limited to:

- Location map with limits of the survey area and existing structures, and geological setting of the area including the previous investigations

- Bathymetric data and average, maximum and minimum slopes
- Seabed feature/clearance charts from side scan sonar interpretation; assessment of soil conditions clearly pointing out hazardous geological/morphological events for the structure (anchoring and platform stability)
- Seismic reflection report and geological interpretation with comments of the records
- Seismic refraction report and geological interpretation with comments of the records, if applicable
- Predictive geological columns at proposed and recommended locations
- Data examples showing typical bottom and sub-bottom features, and interpreted records, in particular at proposed and recommended locations
- Core descriptions, and results of analysis and soil testing (on-board and laboratory tests on samples if such tests are required by COMPANY)
- Recommendation for changing the initial proposed well location(s), if necessary, and proposal(s) for acceptable new location(s)
- Selection of relief well area(s) according to the following criteria:
 - clear of identified geohazards,
 - In the predominantly up-wind quadrant within a radius ranging from 300 m to 1000 m from actual drilling location; if two predominant wind seasons occur, two relief well areas shall be selected.

On the copies of analogue seismic profiles (centreline) and of digital HR sections, prominent reflectors shall be colour-coded to illustrate the stratigraphy. They must be referred to accordingly in the text.

Interpretation, lithological sequences, plotted reflectors, etc. shall also take into account the numbering used in previous reports.

Interpretation will make use of multibeam data, to provide data examples as illustrations of characteristic or exceptional features, where significant to interpretation. These displays will be at a scale appropriate to the feature of interest, and where possible be displayed alongside with imagery of other sensors (side scan sonar or profiler) to support interpretation statements.

Section 3: "Maps"

Because of the reduction of all charts to A3 standard size, special attention must be paid to the printing quality.

All maps shall show the geographical and grid co-ordinates, as well as the survey grid (in filigree) and a North arrow.

All maps shall show the proposed, and when applicable, recommended locations, as well as the relief well locations.

All symbols used must be explained in a key.

Certification: the personnel in charge, date of issue and revision number must be indicated on each map.

Map scales: the scale of all maps and the horizontal scale of the cross-sections shall be 1/5 000, unless otherwise mentioned by COMPANY in the Particular Specification.

Units: the International Unit System shall be used.

Multibeam data: will feature on maps in two forms:

- Charts of numerical data, spot depths and contours at the smallest readable or meaningful contour interval suited to the dataset
- Charts of seabed imagery data (digital terrain model), if practical or not entirely featureless, as sun-illuminated grayscale or colour according to the best representation of the seabed features
- Or combination charts: black-line major contours, with gradational colour-banded depth fill, and overlaid or draped shaded relief for visualisation.

a) Maps for platform or drilling site surveys

- General location map showing the intended structure location, the existing platforms, cables, pipelines and, in general, all place names used in the report. This map must also appear in the text

In the case of multiple charts, their numbered outlines must appear in an index map repeating on each of the charts.

- Track charts, showing the tracks, intended and existing structure locations, block and survey boundaries, etc.:
 - Analogue seismic track chart (sensor position)
 - Side scan sonar towfish track chart (sensor position)
 - Seabed sample locations
 - Digital seismic track chart (CDP points), showing the deep seismic lines passing through the drilling location (for drilling structures only), if available.
- Sounding chart, displaying colour-banded spot depths (soundings reduced to LAT, MSL or Chart Datum level, showing shifts between vertical datums)
- Bathymetric map representing depths by gradational colour banding, with sun illumination at the angle best suited to visualisation of relief features. Colours should be chosen such that warm colours represent shallower depths, colder colours represent deeper areas
- 3D perspective view(s) of bathymetry, representing depths by gradational colour banding, and rotated such that the relief or features are visualised in the most representative way
- Seabed features/morphology obtained from side scan sonar data, overlain with bathymetric contour map (contour interval: 0.5 m for continental shelf surveys, 1 to 5 m for deep-water site surveys). If a large number of features are mapped, a separate morphological map shall be drawn
- Isopach map of the superficial sediments, showing the core locations with a brief description of all samples
- Structural isopachs, or isobath map of stratigraphic horizon(s) representing the mappable tops of all geohazard intervals. This map should indicate faults and crests of folds and other features that may act as traps for potentially hazardous shallow gas
- Geological feature map(s) or hazard/anomaly map(s) showing all features that could affect exploration drilling, site selection or foundation design. Features commonly shown include

gas seeps, shallow gas pockets, faulting, buried channels, hardground areas, mud lumps and flows, slopes, reefs, etc.

- Geological cross-sections, from shallow profiler data, along each line going through (or close to) all proposed and recommended locations. Vertical scale to be defined according to investigation depth, showing the main lithological units
- Cross-sections from digital multi-channel seismic along each line going through (or close to) all proposed and recommended locations.

b) Charts for pipelines

The following charts are required.

- **General location** map showing the intended structure location, the existing platforms, cables, pipelines and, in general, all place names used in the report. This map must also appear in the text.

In the case of multiple alignment sheets, their numbered outlines must appear in an index map repeating on each of the charts.

The general location map shall also act as summary of findings, by showing outlines of major features such as high slope areas, extents of hardground or disturbed seabed, or other significant areas identified by interpretation.

- **Alignment sheets**

The results on the structure route survey shall be presented in the form of "Alignment sheets" having five thematic boxes or "windows" in the following order:

- **Upper window:** track chart of all profiles, core locations.
- **Second window:** bathymetry reduced to LAT, as contours plus spot depths where necessary, for clarity. The contour interval shall be defined in the Particular Specification.
- **Third window:** seabed features compilation chart including
 - . seabed features from side scan sonar, significant obstructions and targets, morphology such as hardgrounds, ripple marks, etc.),
 - . existing structure/pipeline positions,
 - . nature of soils from cores,
 - . isopach chart of the surface sediments over the first characteristic reflector (the contour interval shall be defined in the Particular Specification),
 - . morphologic features with quantitative indications (% slope, feature height, etc.).
- **Fourth window:** bathymetric profile and geological section along the proposed pipeline route including:
 - nature of the seabed with emphasis on areas of potential risk for laying and trenching (rocks outcrops, boulders, stiff clays etc.),
 - sub-soil structure interpretation down to 15 m,
 - coring locations, with schematic lithological log.
- **Fifth window:** blank for annotations for engineering purposes.

Specific requirements for these alignment sheets are:

- Map sheet assembly on front of folded sheet
- KP's with 100-metre ticks
- Overlapping sheets (by at least 10 cm) with match lines
- If applicable: longitudinal profile obtained from an ROV's highly accurate bathymetric suite indicating potential free span areas
- If available: photos of potential obstacles to laying or trenching.

The layout of these Alignment sheets may change according to project findings or requirements, if approved by COMPANY.

Section 4: "Digital sections" (for drilling structures only)

- Final sections of all lines shall include relative and equalised amplitude, displayed on two different sheets. The horizontal scale of the digital sections is 1/5000, the vertical scale is 30 cm/second
- Seismic digital data shall be delivered in SEG-Y format, with position in headers such that it can be loaded in a Charisma project for review. The medium of preference is Exabyte.

Volume 2, "Technical Appendices" (Operations report)

Section 1: "Technical report"

The following shall be included:

- The programme carried out and the number of line kilometres
- The percentage times of operation, transit, stand-by and breakdown
- Geodetic parameters; datum shift; vertical datums
- The results of the positioning system accuracy check and monitoring
- The results of all calibrations, trials and tests, including bar checks and CTD profiles
- The settings and all recording parameters used (vessel layout/equipment offsets, instrument settings, accuracies, etc.), and processing sequence(s) applied to all final data (navigation, multibeam, HR, etc.)
- The accuracy on the soundings (statistical analysis of observed discrepancies at line crossing, absolute error calculation)
- Tidal information and reference level calculation, showing both predicted and observed curves
- Typical examples of QC displays for all instruments; such as (case of HR acquisition): shot record, near-trace record, streamer and gun depth recording, shot interval statistics
- HR data: mean RMS and interval velocity curve, together with time-to-depth conversion curve.

Section 2 - "Appendices" will comprise:

- Appendix 1: Reduction of all charts to A3 standard size
- Appendix 2: Detailed lithological logs of the core samples and results of the soil mechanical analyses
- Appendix 3: Summarized tidal data and correlation to the Chart Datum
- Appendix 4: Personnel involved
- Appendix 5: Daily survey diary
- Appendix 6: Detailed description of the survey Equipment and VESSEL
- Appendix 7: Positioning system description. Shore station description and co-ordinates. Antenna offset on-board the vessel, diagram, etc.
- Appendix 8: Printout of a line listing of the entire grid, and list of data rolls/records.

Other items

CONTRACTOR to note also data forwarding requirements of the below section 9, Field data required - Care of samples and results, Data required.

8. Personnel

8.1 General

CONTRACTOR shall nominate an onshore **Project manager** who shall be in charge of whole project on both technical and administrative grounds, he shall be the CONTRACTOR REPRESENTATIVE.

The Project Manager shall nominate a **Chief Geophysicist** to be responsible for the whole acquisition and interpretation work, if he cannot himself be technically involved. Project Manager or Chief Geophysicist shall be fully experienced in seismic data processing including AVO and the use of a workstation if geohazard analysis and/or 3D interpretation is required.

The Party Chief shall be a qualified geophysicist/surveyor, specialised in shallow HR digital seismic and in single-trace seismic Work, and shall be present on-board during the whole duration of the offshore operations.

During this period and this period, he shall be acting as sole CONTRACTOR REPRESENTATIVE, and shall sign the Daily Work Sheets.

Project Manager and Chief Geophysicist shall remain assigned by CONTRACTOR to the project during the whole duration of the project.

Project Manager, Chief geophysicist and Party Chief shall be entirely familiar with the Contract.

The **geophysicist** mobilised on the vessel for on-board interpretation shall remain with the project in the interpretation team on shore, until issue of the final report. He shall be fully experienced with all processing systems used offshore.

8.2 CONTRACTOR's personnel, main survey vessel

For a survey consisting of seabed mapping and profiling ("analogue" survey), the survey crew shall consist nominally of a minimum of 13 core personnel, comprising the following roles and responsibilities:

- 1 x Party Chief, non watch-keeping
- 2 x surveyors (on-line), at least one per 12-hour shift
- 2 x senior geophysicists on board (interpretation), at least one per 12-hour shift
- 4 x senior engineers (sonar/profilers), at least two per 12-hour shift
- 2 x staff: 1 senior multi-beam specialist/processor, and 1 offline processing surveyor
- 2 x staff: 1 drafting personnel (CAD for on-board charting), and 1 personnel dedicated to report compilation.

In addition, projects mobilising for HR seismic acquisition will include specialist personnel:

- 2 x senior observer (2D HR seismic) [1]
- 2 x gun mechanic/digital seismic engineer [1]
- 2 x senior seismic processor (2D HR seismic)

[1] HR personnel may be same individuals as "4 x senior engineers" in above listing of core personnel, proving appropriate experience and qualifications

In addition, projects mobilising other instruments, will include dedicated specialist personnel:

- Magnetometer specialist(s)
- Geotechnical sample analysis engineer(s)
- AUV personnel, as per specification in Section below
- Tracking vessel personnel, as per specification in Section below
- Inshore vessel personnel, as per specification in Section below
- Any others as proposed by CONTRACTOR for COMPANY's approval.

The ratio of permanent CONTRACTOR in-house personnel, over total offshore personnel, shall be at least 75%.

Depending on project, CONTRACTOR shall maintain on-board the survey vessel during the data acquisition phase the following personnel:

- A qualified **senior Hydrographic Surveyor**, fully experienced with multi-beam echo-sounding systems, including calibration and processing
- Two qualified Senior Geophysicists (experts in pinger/other profilers; and acquisition, processing, interpretation of HR digital seismic). They shall be fully experienced with **CHIRP systems, HR workstation, and PROMAX** processing of HR data; as well as with AVO processing, if required
- A qualified TEI/DELPH system expert, if such system is required. He shall also be fully experienced with used side scan sonar interpretation.

8.3 CONTRACTOR's personnel, inshore work

In the case of shore approach surveys, the manning requirements for inshore boat(s) are for daylight work (nominal 12-hours), and are expected to comprise, as a minimum (above and beyond the crew on survey vessel if the latter is to work simultaneously):

- 1 experienced on-line surveyor
- 2 engineers to operate systems carried on-board.

8.4 CONTRACTOR's personnel, 2-vessel operations

The manning requirements for the second, or tracking vessel, are for 24-hour work, and are expected to comprise, above and beyond the crew on survey vessel:

- 2 experienced on-line surveyors
- 2 engineers to operate systems carried on-board.

8.5 Manning of AUV operation

CONTRACTOR will specify the manning planned for AUV deployments, indicating if such personnel overlaps with that otherwise planned for the operation of the geophysical spread on the survey vessel.

Manning of AUV work requires sufficient personnel for 24-hour operation and on-board processing, and is expected to comprise 7-9 dedicated staff:

- Party Chief (PC), non-watch keeping, separate from survey team's PC if the AUV is sub-contracted by CONTRACTOR
- Team of 3-4 surveyors, comprising a lead surveyor/off-line processor, and at least one surveyor per shift for on-line operation
- Team of 3-4 AUV engineers, comprising a chief engineer, and at least one engineer per shift for deck work.

9. Field data required - Care of samples and results

9.1 Report delivery

When the final version of the Survey Report, volumes 1 and 2, has been approved and edited accordingly, it shall be output and dispatched, in the following formats:

- Word for Windows 97 (.doc file)
- Adobe Acrobat (.pdf file).

In addition, a copy of the full report, with all geo-referenced charts, shall be stored on CD ROM in the following formats:

- AutoCAD 14 (.dwg/.dxf file)
- MicroStation ver.7 (.dgn file).

The distribution list of the survey report shall be as per in the Particular Specification.



9.2 Data required

With the Final Report CONTRACTOR shall forward to COMPANY:

- All drawings, illustrations and charts included in the report
- All raw data of analog seismic, (DELPH-2 or similar) **shall be provided on CD ROM**. Side scan data records shall be provided on the data acquisition CD ROM and shall be compatible with DELPH MAP system
- Final AVO and Stack tapes (HR digital seismic). **They shall be provided in SEG Y format.**

After issuance of the Final Acceptance Certificate, the following data shall be supplied to COMPANY:

- Navigation data records, track-plots of all surveyed lines (inc. rejected/un-processed)
- All multi-beam data, archived raw and processed
- Echo-sounder and side scan sonar records, analogue seismic records
- All HR data: multi-channel monitors, seismograms, single trace sections, magnetic tapes of seismic recordings, recording sheets, shot-point listing, tests records
- Oceanographic data, if applicable.

9.3 Care of samples and results

CONTRACTOR shall retain and file all tapes and results until their permanent forwarding to COMPANY, as per above paragraph, Data Required. COMPANY may advise of different disposal. During such period CONTRACTOR is fully liable for any loss or damage to the said documents.

Core samples shall be carefully retained by CONTRACTOR and delivered to COMPANY in such condition as defined in the Particular Specifications, and at all times shall be stored in conditions to be submitted to COMPANY REPRESENTATIVE's approval.

All original records must be sent within one month of final report delivery and must comply with the following requirements:

- Each tape, file and roll shall be labelled with a reference number and listed
- The detailed listing of original records, including the common reference numbers, shall be included the final report as per this General Specification
- Type of survey source, file or number, profile numbers with first and last fix numbers, date of the recording and location name shall be indicated
- Bathymetric data shall be delivered in AutoCad and MicroStation form
- Digital sonar data shall be delivered in XTF format
- Profiler data and HR seismic data shall be delivered in SEG Y format.

Data shall not be destroyed without written approval from COMPANY.

10. Health, Safety and Environment of marine operations

10.1 Safety standards

CONTRACTOR is required to adhere at all times to Health, Safety and Environment standards as set out in the safety manual for Marine geophysical field operations (IAGC 1991) and the E&P - Forum Health and Safety Schedule for Offshore Geophysical Operations.

10.2 Emergency planning

CONTRACTOR is required to submit their safety plan to COMPANY, for each project or different area within a project, before mobilisation, and including Emergency Preparedness and medical evacuation from the worksite. Such planning shall explicitly involve the structures and facilities of COMPANY where appropriate (vicinity of worksite).

CONTRACTOR shall submit to COMPANY a crew list of all persons actually on vessel, by the time of the initial sailing (during mobilisation), or any subsequent crew changes during the WORK.

10.3 Weather

CONTRACTOR shall be required to cease operations in adverse weather conditions only when it is considered that such adverse conditions may affect:

- The safety of personnel and of the vessel, in which case such adverse conditions shall be defined and documented on-board by the Captain of the VESSEL
- Or the quality of the work in which case such adverse conditions shall be defined on-board by the REPRESENTATIVES of CONTRACTOR and COMPANY.

10.4 Communications from vessel(s)

CONTRACTOR office and survey vessel are required to be connected to Internet e-mail system. CONTRACTOR's e-mail system on-board VESSEL will be such that:

- COMPANY REPRESENTATIVE has a private mail account, able to communicate securely with parties on-board, as well as with COMPANY onshore
- The allowable file size to be mailed from ship to shore is no smaller than 5 megabytes, in order to transmit records, charts and any other results at the discretion of COMPANY REPRESENTATIVE.

This and other ship-to-ship and ship-to-shore communications requirements are detailed in the above Section 5 - VESSELS.

10.5 Reporting of incidents/accidents

All accidents will be investigated, even if not resulting in lost time injury (near-misses). The accident reports would be forwarded to COMPANY's REPRESENTATIVE within 24 hours. An accident investigation form shall be included in an appendix to CONTRACTOR's safety plan.