UK Offshore Operators Association

GUIDELINES FOR THE CONDUCT OF MOBILE DRILLING RIG SITE INVESTIGATIONS IN DEEP WATER

(ADDENDUM TO GUIDELINES FOR THE CONDUCT OF MOBILE DRILLING RIG SITE SURVEYS)

Version 1.0

CONTENTS

1. Introduction

The Offshore Installations (Safety Case) Regulations 1992 require owners of mobile installations in the UKCS to submit a Safety Case for each installation. The Case must include particulars of (a) the limits of the environmental conditions beyond which the installation cannot be safely stationed or operated and (b) the properties of the seabed and subsoil which are necessary for the safe stationing and operation of the installation. The Offshore Installations and Wells (Design and Construction, etc.) Regulations 1996 require well operators to assess (a) the geological strata and any fluids within them and (b) any hazards that the strata may contain. A rig site investigation is required by the well operator to adequately assess the hazards of shallow formations and for the rig owner to demonstrate that the environment and seabed conditions are suitable for the rig. In *many* cases, this investigation will require a dedicated rig site survey. However, if adequate data already exist covering the location, a detailed desk study may suffice.

In 1996 and 1997, UKOOA prepared Guidelines for the Conduct of Mobile Drilling Rig Site Surveys in the UKCS. These guidelines aim to clarify current regulatory requirements and describe what is regarded as "good industry practice" for the conduct of rig site surveys in support of mobile drilling rig operations. Although these guideline included information on deep water surveys, with the increased activity in deeper water in the UKCS, UKOOA members requested an update of the existing guidelines to reflect the important different aspects of deep water operations. The following text is an addendum to the guidelines in support of deep water operations. The addendum should be read in conjunction with the Guidelines for the Conduct of Mobile Drilling Rig Site Surveys in the UKCS. When these Guidelines are next re-issued this addendum will be incorporated.

Deep water rig site surveys can be very expensive operations. They are undertaken in a difficult environment with extreme weather conditions and water currents. The area to be surveyed can be much larger than conventional water depth surveys due to the larger spread of anchors. Specialist survey equipment may be required which may be costly and not readily available. As with conventional water depth surveys, environmental constraints include minimisation of disturbance to marine life and the seabed. The appropriate selection of tools and techniques is therefore of great importance. To minimise costs associated with these surveys, all available relevant data should be carefully studied and integrated prior to designing the survey. In this way, dedicated site specific survey acquisition will be minimised or, in some cases, may not be required.

There has been some debate within the industry as to whether rig site surveys are required at all in deep water. Although there are some differences in deep water operations, the HSE and commercial impact of not undertaking appropriate rig site investigations in deep water may be considerable. This is discussed in the following text.

Environmental Impact Assessments are often required for drilling locations, particularly in deep water locations where there is no or little existing infrastructure. The original intention was to include in these guidelines, acquisition of some survey data in support of these assessments, whilst a survey vessel was on location. However, such data is beyond the scope of these guidelines.

It is not intended that these Guidelines are a text book on geophysics or geodetic positioning. Literature on these subjects is abundant and a selection is given in the References and Bibliography Section of Volume 2 of the Guidelines for the Conduct of Mobile Drilling Rig Site Surveys in the UKCS.

While regulations clearly establish a requirement for rig site investigations to be undertaken, the survey methods described in these guidelines are not mandatory. Operators may adopt different methods in particular situations where to do so would maintain an equivalent standard of quality and of Health, Safety and Environmental protection.

It is stressed that it is the responsibility of Operators themselves to keep abreast of Legislation, Regulations, Statutory Instruments and Departmental Notices, as well as local government laws and bye-laws.

2. Definitions

For the purposes of this Guideline, the following terms and meanings apply:

Deep Water – greater than 350 metres. This is the water depth at which conventional rig site survey equipment may be unable to deliver adequate data.

Operator - is the person or company having a valid UK Government Licence to explore for and/or produce hydrocarbons in a defined area of the UKCS and who is responsible for specifying the drilling requirements. Current legislation defines this person or company as the 'Concession Holder'.

Rig Owner or **Owner** - is the person or company who controls the operation of the rig.

Survey Contractor or **Contractor -** is the company contracted by the Operator or the Rig Owner to conduct geophysical, hydrographic and/or geotechnical investigations at a proposed drilling location.

Specialist Advisor or **Specialist** - is a qualified and experienced geophysicist, hydrographic surveyor or geotechnical engineer, as appropriate to the technical context of the subject in question.

3. Existing Regulations and Guidelines

3.1 Acts of Parliament and Regulations

The requirement to undertake rig site investigations prior to offshore drilling is established on the basis of (amongst others) the following Acts and associated Regulations. The text of relevant sections can be found in Volume 2 of the Guidelines for the Conduct of Mobile Drilling Rig Site Surveys in the UKCS.

- Coast Protection Act, 1949
- Continental Shelf Act, 1964
- Minerals Workings (Offshore Installation) Act, 1971
- Petroleum and Submarine Pipelines Act, 1975
- The Health and Safety at Work Act, 1974 (HSWA).
- Offshore Safety Act, 1992
- Petroleum Act (Production) (Seaward Areas) Regulations, SI 1988, No.1213
- The Offshore Installations (Construction and Survey) Regulations, SI 1974, No 289
- The Offshore Installations (Safety Case) Regulations, SI 1992, No 2885, and HSE Guidance
- The Offshore Installations and Wells (Design and Construction, etc.) Regulations, SI 1996, No 913
- Application for Consent to Drill an Exploration or Appraisal Well, DTI PON 4, May 1996
- Notification of Geophysical Surveys, DTI PON 14, May 1996
- Record and Sample Requirements for Surveys and Wells, DTI PON 9, May 1996
- Liaison with other bodies, HSE Offshore Operations Division. Operations Notice 3, February 1995
- Regulations to Implement the Environmental Impact Assessment Directive (85/337/EC) as it applies to Offshore Oil and Gas Activity

3.2 Other Relevant Notes for Guidance

The scope of investigations and the methods employed depend partly upon the type of rig concerned (e.g., anchored or dynamically positioned). Other formally issued guidance notes (listed below) have been used as a source in formulating good industry practice.

- Guidelines for the Anchoring of vessels in the Vicinity of UKCS installations and Pipelines and their Subsea Equipment. UKOOA, December 1994;
- Guidelines for the Use of Differential GPS in Offshore Surveying. UKOOA, September 1994.
- Environmental Guidelines for Exploration Operations in Near-shore and Sensitive Areas. UKOOA, September 1995.
- Guidelines for Minimising Acoustic Disturbance to Small Cetaceans, Department of the Environment, April 1998.
- Offshore Installations: Guidance on Design, Construction and Certification. Section 14, Site Investigations. Section 20, Foundations. Dept of Energy. Fourth Edition, June 1990.
- A guide to the Offshore Installations (Safety Case) Regulations 1992. Guidance on Regulations. Health and Safety Executive, L30, 1992.
- New Guidance on Coast Protection Act - Consent to Locate and the Marking of Offshore Installations. HSE Offshore Safety Division, operations Notice No. 14, February 1995.
- Environmental Guidelines for Worldwide Geophysical Operations. IAGC, January 1994
- Health, Safety and Environmental Schedules for Marine Geophysical Operations. E&P Forum. Report No. 6.34/206, July, 1994.
- Procedures Relating to the Notification of Vessels Intending to Anchor in the Vicinity of Pipelines or Other Subsea Installations. UKOOA Procedures Guide, agreed August 1986
- UKOOA Guidelines for the Conduct of Mobile Drilling Rig Site Surveys, Volumes 1 and 2, March 1997
- Guidance Notes on the Offshore Petroleum Production and Pipe-Line (Assessment of Environmental Effects) Regulations 1998. Oil and Gas Directorate, Department of Trade and Industry, February 1998.
- Guidance Note on the Implementation of the Guidelines for minimising Acoustic Disturbance to Marine Mammals from Seismic Surveys, JNCC, March 2000.

4. Objectives and Limitations of the Guidelines

The guidelines provide information for a standard approach to deep water rig site investigations, with the emphasis on good oil field practice. Accepted industry practice is to consider each and every drilling location on its own merits and to design any necessary surveys accordingly. This is particularly true of deep water surveys, which need to be carefully designed for the type of drilling rig and the local seabed and sub-seabed conditions.

It may be necessary to undertake more than one type of survey to acquire all the information needed to plan a drilling location. To assess the suitability of a drilling location and drilling impact, the following survey types may be required in deep water: -

1. High resolution seismic (multi-channel or single channel) and hydrographic survey (bathymetry and seabed features) with limited seabed sampling.
2. Geotechnical borehole coring and testing.
3. Current measurements (essential for UKCS deepwater operations).
4. Environmental baseline measurements.
5. Shipping movement studies, where required by the Consent to Locate requirements in the specific area.
6. Post drilling impact or 'debris' surveys.

Current industry practice is to undertake these survey types separately. These guidelines cover the first category of study, commonly known as 'Rig Site Surveys' and, to a limited extent, categories 2, 3, 4 and 6. Rig site surveys are acquired with several objectives, including shallow gas detection, other shallow drilling hazards, prediction of soil lithologies, identification of seabed hazards and measurement of water depth. They involve the application of 'state of the art' survey acquisition techniques.

It is important to recognise that, even with good data acquired to the limits of available technology and with careful analysis of the data, the geophysical survey results are still an interpretation.

In the case of shallow gas surveys, due to limitations of the data and interpretation, the results should be viewed as a preventative measure, reducing the risk of encountering shallow gas rather than eliminating it.

Lithology predictions should not be considered definitive. They are improved by correlation of seismic data with borehole or well data. The need to acquire site specific geotechnical data for mobile drilling rigs should therefore also be consciously addressed when planning rig site survey requirements. However, deep water geotechnical borehole data is extremely expensive and rarely acquired for mobile floating rigs unless there is already a defined need for field development studies. Acquisition of these data should only be considered if there are specific local problems identified by the geophysical data, or if there is a need for data for field development.

Acquisition of good quality rig site survey data is only possible in weather conditions suitable for the type of work being conducted. It is not possible to be prescriptive regarding acceptable sea conditions, as vessel and equipment capabilities are also significant factors. Operators are advised to take Specialist Advice on this aspect of planning and execution of the survey.

Sub-standard data and inadequate or improper use of survey results may jeopardise safety and have considerable financial implications. Specifying surveys in accordance with the guidelines will not alone guarantee the quality of the survey. Careful Quality Control by Specialists of the data acquisition, processing and interpretation is also required.

5. Responsibility for Compliance and Quality Assurance

It is the Rig Owners who are required to submit safety cases. However, due to the comparatively long lead times in planning drilling locations, and the often uncertain situation with regard to drilling rig availability, the Operator generally contracts services for undertaking rig site surveys. The Operator therefore should provide the Rig Owner with a comprehensive rig site assessment report, which is in compliance with good oil industry practice and on which he can base the safe planning of his operation.

To ensure the timely acquisition and quality of the great variety of rig site survey data, operations should be controlled in accordance with well established Quality Management Systems. It is beyond the scope of this guideline to fully describe appropriate Quality Control procedures, which are the Survey contractor's responsibility to operate. However a summary of those aspects of quality which are essential for the Operator to manage, can be found in the UKOOA Guidelines for the Conduct of Mobile Drilling Rig Site Surveys, Volume 2.

6. Rationale for Deep Water Rig Site Surveys

There has been some debate within the industry as to whether rig site surveys are required in deep water. In deep water, the rigs are more isolated from seabed and sub-seabed affects. However, encountering unexpected seabed and sub-seabed environments and/or hazards will still have considerable HSE and commercial impact. Deep water rigs are generally more expensive than conventional water depth rigs. In addition, working weather windows may be more restricted in the deep water environment of the UKCS. Anything, which delays deep water drilling operations, will have considerable financial impact. For example, in deep water, escaping shallow gas may not impact upon the rig due to the water depths and currents. However, escaping shallow gas will impact upon the environment. In addition, the well may be damaged and require costly remedial action or re-drilling.

Care of the Environment is a prime concern. Rig site investigations contribute to this by providing a ‘snapshot’ of seabed and sub-seabed conditions prior to rig installation. Rig site surveys may also be required in some instances post drilling to help demonstrate that operations have had minimal impact.

In deep water, understanding the regional setting is a key control for the local setting. For example, regional slope instability may not be obvious on a limited extent site specific study/survey. A good understanding of the regional setting, in particular regional geohazards will minimise the need for detailed dedicated surveys.

In deep water UKCS, all rigs will be of floating type and will be either moored (generally with anchors) or Dynamically Positioned (DP). As stated in the regulations, rig site survey data are required to *determine the physical environment in which a rig is to be located*. Survey objectives therefore include identification of safety and environmental hazards, features and conditions that may constrain the positioning of the well. The objectives will differ depending upon the rig type. However, for both rig types they can be divided into sub-seabed, seabed, and sea surface/water column.

In deep water, survey objectives include identification and mapping of: -

- **Sub-seabed**
  Drilling Hazards including Shallow Gas, Hydrates, unconsolidated sands, pressurised water bearing sands, boulders and faults
  Soils (conditions for anchoring, conductor/casing design and/or foundations)
  Slope stability (slumps, slides)
  Buried pipelines, cables, wrecks and well completions
  Tophole lithology

- **Seabed**
  Water depth, including definition of slopes, trenches

Slope stability (slumps, slides)
Seabed features such as bioherms (e.g. cold water coral (lophelia), current scour, boulders)
Seabed soils
Seabed installations, pipelines and cables
Wrecks and other non-oil industry related artefacts

- **Sea surface and water column**
  Offshore installations
  Anchor chains
  Navigation or obstruction warning buoys
  Areas restricted for navigation (Shipping routes, deep water and marine traffic separation schemes, military exercise areas etc.)
  Tidal streams and currents
  Waves

Some of the above features or hazards can be identified in the planning stage of a rig site survey, from existing information and publications such as Admiralty Charts and British Geological Survey (BGS) publications. In the case of restricted navigation areas, data can be obtained from the Department of Transport.

In addition exploration seismic data are very important for rig site investigations. In deep water, the near seabed data quality of these data are better than in shallow water. These data provide regional information that is essential to understand the local conditions. Careful examination of high quality 3D seismic data will provide extensive information on regional and local seabed and sub-seabed geology and. In addition 3D seismic data will provide an overview of regional trends in water depth. The resolution of good quality 3D seismic data is often similar to that of dedicated deep water bathymetry surveys. The seabed pick can also provide useful data on features such as steep slopes, slope instability, faults, canyons, mobile sediments. Careful use of these data by Specialists will minimise seabed survey requirements. In some cases where there is good control, these data may eradicate the need for a dedicated survey.

For the deep water UKCS there are several joint industry groups which have undertaken regional studies which provide extensive data for planning surveys. The Western Frontiers Association (WFA) has commissioned a series of studies, which identify shallow geological and seabed hazards. The Atlantic Frontiers Environmental Network (AFEN) has undertaken regional mapping of seabed sediments and features to establish an environmental baseline. *The North West Approaches Group (NWAG)* has undertaken metocean studies in the area, defining weather, wave and current conditions. The Rockall Consortia has undertaken detailed studies of the shallow geology.

Where possible Rig Owners and Survey Contractors should satisfy themselves that they have used all relevant data. Operators should assist in provision of relevant data, particularly in-house data, in order that the position of potential hazards and their relevance to drilling operations may be verified during the rig site survey process.

Having reviewed all available data, rig site surveys are then conducted to acquire any additional necessary information to complete the assessment of the physical environment of the site. The principal survey objectives in deep water are drilling hazard detection (particularly shallow gas), interpretation of soil lithology, water depth measurement, detection/identification of seabed or water column obstructions, and detection of bioherms.

The validity of rig site surveys is discussed in Volume 2 of the UKOOA Guidelines for the Conduct of Mobile Drilling Rig Site Surveys.

7. Planning Cycle for Deep Water Rig Site Surveys

Many items to be considered when planning deep water rig site surveys are similar to conventional water depth surveys. These are discussed in detail in the UKOOA Guidelines for the Conduct of Mobile Drilling Rig Site Surveys, Volume 2, Section B.

The planning cycle is summarised, in flowchart form, in Figure 1 of the UKOOA Guidelines for the Conduct of Mobile Drilling Rig Site Surveys, Volume 1 and 2. To meet regulatory requirements, the planning cycle for rig site surveys should preferably start 22 weeks before the planned spud date of a well. This time frame allows for all necessary statutory notifications to be exercised correctly and sufficient time for data acquisition, processing, interpretation and reporting. The planning cycle also allows time for geotechnical borehole work to be undertaken if required and for submission of the results to the relevant authorities.

For deep water surveys additional time may be required. The complexity of the seabed bathymetry and sub-seabed geology needs to be carefully assessed using all available data to ensure selection of appropriate survey techniques and tools. Weather conditions in the Atlantic dictate that surveys should, where possible, be undertaken in the summer months only. Specialist deep water survey systems may require long lead-in times to ensure availability and to cover mobilisation time. If precise positioning of deep tow sensors is required, Long Baseline (LBL) acoustic arrays may be required. Such arrays require significant detailed planning and testing well in advance of implementation.

Environmental Licence Restrictions may not permit survey operations at certain times of the year. Longer lead-in times may be required prior to drilling to ensure the data is available for Environmental Impact Assessment.

8. Shallow Gas and Other Drilling Hazards

8.1 Scope and Rationale

Shallow gas, when present, is a hazard when drilling from all types of rigs. In deep water, escaping shallow gas may not impact upon the rig due to the water depths and currents. However, escaping shallow gas will impact upon the environment. In addition, the well may be damaged and require costly remedial action or re-drilling.

The objective of a shallow gas survey is discussed in the UKOOA Guidelines for the Conduct of Mobile Drilling Rig Site Surveys. In summary, the objective of these surveys is to identify all gas accumulations within the interval drilled without a Blow-out Preventor (BOP). This may be greater than 1000 metres sub-seabed interval. Data to a resolution of better than 4 metres is required.

In deep water, gas hydrates are known to occur. Hydrates can act as a seal, accumulating shallow gas below. Hydrates will be a hazard to drilling due to the gas accumulated below. Detectable seismic response is typically a Bottom Simulating Reflector (BSR) which will generally depend upon free gas being trapped below the hydrate.

In addition, in some deep water areas of the UKCS, unconsolidated sands are a known drilling hazard (the Taylor Sands), resulting in stuck pipe and difficulty running casing. These sands need to be detected and the top and base defined. In deep water offshore Norway (and elsewhere in the world), high pressure water bearing sands have been encountered which have delayed drilling operations.

Successful imaging of the sub-seabed to depths in excess of 1000 metres depends upon the type and quality of equipment, equipment tuning, survey line planning, data processing and interpretation. Careful consideration should therefore be given to these items in designing the rig site survey. Imaging to 1000 metres may be easier in deep water than conventional water depths as the first seabed multiple may not occur within the zone of interest. This will impact upon selection of suitable survey equipment and parameters.

If exploration seismic data is available across the survey area, this should be used to interpret the shallow geology and to assist in the detection of shallow gas. Before the shallow gas hazard survey is undertaken, these data should be used to ensure that resources are targeted effectively by defining areas of likely hazard and, if necessary, moving the proposed location. In deep water, these data will be of higher resolution than in conventional water depths due to the shorter offset range. Reprocessing of these data utilising only the near offsets will provide a resolute data set from which a good interpretation of shallow geology and shallow gas may be possible. Due to bandwidth limitations these data (standard processing or short offset reprocessed) do not replace shallow gas surveys. However, careful use of high quality 3D exploration seismic data may allow a reduced, targeted grid of shallow gas survey lines. In some areas, with good knowledge of the local geology and if no gas indicators are observed, it may be possible to eliminate the need for any additional shallow gas survey lines. However, this should only be considered on a case by case basis after careful examination of all available data.

Post survey, the exploration seismic data can greatly assist in developing an understanding of the shallow geology and the extent of shallow gas accumulations.

An overview of the shallow gas and other drilling hazard element of deep water rig site surveys is given below. Detailed information on the selection of equipment, methods to be used, and recommended scope of work is provided in Volume 2 of the Guidelines for the Conduct of Mobile Drilling Rig Site Surveys in the UKCS. It is stressed however, that Specialist advice should be taken in defining the specific scope for each individual rig site survey, particularly if reduced, targeted survey grids are acquired.

8.2 Equipment

Equipment should be capable of imaging the sub-seabed to the nominal depths discussed above in Section 8.1. Seismic resolution should be sufficient to identify all significant lithology variations within the depth of interest. Resolution of the data will be a function of geology but also of equipment type and tuning which must therefore be optimally calibrated and operated.

The choice of the shallow gas seismic source, multi-channel hydrophone streamer length, streamer depth, hydrophone group length and interval, seismic recorder and sample rate should be determined by the key objective of shallow gas detection within the top 1000 metres subseabed. The system should be selected on the basis of providing maximum resolution within this zone (see UKOOA Guidelines for the Conduct of Mobile Drilling Rig Site Surveys, Volume 2, Section C).

In deep water, the recommended acquisition parameters for conventional water depths may not always be required as the first seabed multiple may occur at depths greater than 1000m sub-seabed. Only a few hydrophone channels or even single channel data may be acceptable. Lower seismic source outputs may also be acceptable. However, examination of available exploration seismic data should be used to support decisions to reduce the streamer length or number of channels or relax any acquisition parameters. In addition, reprocessing of short offset traces from existing exploration data or trial lines in the survey area should be considered, prior to acquisition of the final data, to ensure the shallow gas survey objectives can be achieved. If parameters are relaxed, some compromise may also be required on other aspects and attributes of the data (e.g. data for velocity analysis, AVO studies, etc). Decisions to relax these parameters should only be undertaken by Specialists with intimate knowledge of the geology of the survey area.

For most applications, high resolution 2D seismic data should be adequate for drilling hazard detection and mapping. However high resolution 3D seismic should be considered for mapping hazards such as high pressure water bearing sands or unconsolidated sands. As discussed above, short streamers may be acceptable for survey acquisition in deep water. 3D acquisition can then be undertaken relatively easily with multiple short streamers. This technique is regularly used in deep water Gulf of Mexico. However, decisions to employ such an acquisition technique should only be undertaken by Specialists, as some compromise may be required on other aspects of the data, as described above.

8.3 Survey Pattern and Line Orientation

As discussed in 8.1, careful use of existing high quality exploration 3D seismic data may allow a reduced, targeted grid of shallow gas survey lines. The survey pattern should consist of a number of lines (defined by Operator's Specialist Advisors) nominally shot at 100 metres separation. Denser (50 metre spaced) lines should be considered near the proposed location but in deep waters are of less value due to the Fresnel Zone (see UKOOA Guidelines for the Conduct of Mobile Drilling Rig Site Surveys, Volume 2, Section C.7). Some lines should be orthogonal to the main pattern. A recommended standard line plan is included in Volume 2 of the UKOOA Guidelines for the Conduct of Mobile Drilling Rig Site Surveys. However, the actual pattern selected is at Operator's discretion.

For reliable interpretation of geophysical data, tie lines should always be acquired to nearby wells, boreholes or other data calibration points. Such tie lines should allow sufficient overlap for differences in positioning accuracy's and, in the case of multi-channel seismic data, comprise full fold stacked data (and, if necessary, a migration aperture).

Line orientation should be defined to optimise subsurface imaging, based on pre-existing knowledge of the geology and local environmental conditions. However, orientation to suit weather conditions should also be considered to minimise costs. In general, lines should be acquired parallel to the predominant dip direction. However, Specialist advice should be taken on optimum line orientation if there is dipping or complex geology.

8.4 Extent of the Survey Area

The survey extent depends upon the degree to which the Operator has scope to move the location in the event of shallow gas being detected. It is advisable to maintain a lateral distance of at least 100 metres between the limit of a suspected shallow gas accumulation and the drilling location. As a minimum, the surveyed area of the 100 metres spaced lines should extend 200 metres radius from the notional rig location to allow for lateral uncertainties in interpretation. To allow a move of the proposed location due to unsuitable site conditions, the survey area should be increased to an area of approximately 1 km x 1 km. In addition, a minimum of two orthogonal lines should be surveyed to a distance of approximately 1 km from the notional location in order to provide a reliable local/regional setting for the interpretation.

8.5 Data Processing and Interpretation

See UKOOA Guidelines for the Conduct of Mobile Drilling Rig Site Surveys.

9. Seabed and near Seabed Soil Conditions

9.1 Scope and Rationale

Data will be required for the prediction of soil variations, which potentially affect drilling operations (e.g. guidebase support, conductor/casing setting studies, anchoring). In addition, the data may be useful at a later stage for foundation studies for installation of fixed structures (e.g. platforms, subs completions) during field development.

Reconnaissance of soil conditions is required in order to begin to establish design criteria for the following types of mobile rig and drilling operations:

- Anchoring of semi-submersible drilling rigs (fluke angle, piggy-back anchors).
- Surface casing stability.
- Conductor/casing setting for any rig type.
- Initial spudding of drilling equipment, including guidebase stability, from any rig type.
- Top-hole drilling.

Seismic data should only be used for the prognosis of general soil lithology and geotechnical conditions. On its own, the survey data will not provide quantitative data for well conductor/casing design and a geotechnical site investigation may additionally be required if Specialist Advisors consider that there is insufficient pre-existing, quantitative information. If anchor holding is critical, consideration should be given to obtaining and testing soil samples at specific anchor locations. Deep water geotechnical borehole data is extremely expensive and rarely acquired for mobile floating rigs unless there is already a defined need for field development studies. Acquisition of these data should only be considered if there are specific local problems identified by the geophysical data, or if there is a need for data for field development.

The usefulness of the data for soil predictions will depend upon the sub-seabed penetration and the resolution of the seismic data. All significant soil variations should be identified within the depth of interest. Acquisition and processing of the seismic data should therefore aim at providing optimum vertical and lateral resolution to the objective depth. An overview of the objective depths is provided below: -

Anchor holding prediction
In very soft sediments, anchors may penetrate to in excess of 15 metres. To support anchor holding predictions, the survey should be designed to acquire optimal data to a minimum of 15 metres sub-seabed.

Guidebase support and Wellhead competence studies
To support these studies seabed and near seabed data (10 metres sub-seabed) should be acquired.

Conductor/Casing setting and top hole drilling studies
To support these studies interpretation of the seismic data throughout the complete data length may be required.

Accepted industry practice is to consider each and every drilling location on its own merits and to design the survey accordingly. An overview of the shallow soils element of the survey is given below. Detailed information on the selection of equipment, methods to be used, and recommended scope of work is provided in the UKOOA Guidelines for the Conduct of Mobile Drilling Rig Site Surveys, Volume 2. It is stressed however, that Specialist advice should be taken in defining the specific scope of work for each individual rig site survey.

9.2 Equipment

Equipment should be capable of imaging the sub-seabed to the nominal depths discussed above in Section 9.1. Seismic resolution should be sufficient to identify all significant lithology variations within the depth of interest. Resolution of the data will be a function of geology but also of equipment type and tuning which must therefore be optimally calibrated and operated.

In deep water, unless the seismic source or receiver is towed near the seabed, imaging of shallow soils reflections may be difficult due source beam widths and to the Fresnel Zone (see UKOOA Guidelines for the Conduct of Mobile Drilling Rig Site Surveys, Volume 2, Section C.7). Deep tow sensors should always be utilised in areas of complex seabed bathymetry and sub-seabed geology.

Positioning of deep tow sensors can be difficult. Accuracy can be guaranteed by using Long Baseline (LBL) acoustic arrays. However the costs associated with such arrays can be high. Ultra Short Baseline positioning is much cheaper but ranges may not be adequate and some compromise may be required on position quality. Positioning accuracy required will depend upon the type of rig and associated seabed installations, and also the variability of the seabed bathymetry and sub-seabed geology. Operators should clearly define the accuracy required for positioning of the deep tow sensor and specify the appropriate system.

9.3 Survey Pattern and Line Orientation

Survey pattern should consist of a number of lines (defined by Operator's Specialist Advisors) nominally shot at 50 - 100 metres separation, some of which should be orthogonal to the main pattern. Recommended standard line plans are included in the UKOOA Guidelines for the Conduct of Mobile Drilling Rig Site Surveys, Volume 2. However, the actual pattern selected is at Operator's discretion.

For reliable interpretation of geophysical data, tie lines should always be acquired to nearby wells, boreholes or other data calibration points. Such tie lines should allow sufficient overlap for differences in positioning accuracies and, in the case of multi-channel seismic data, comprise full fold stacked data.

Line orientation should be defined to optimise subsurface imaging, based on pre-existing knowledge of the geology and local environmental conditions. However, orientation to suit weather conditions should also be considered to minimise costs. In general, lines should be acquired parallel to the predominant dip direction. However, Specialist advice should be taken on optimum line orientation if there is dipping or complex geology.

9.4 Extent of the Survey Area

Survey area depends upon the degree to which the Operator has scope to move the location in the event of unsuitable soil conditions being encountered.

For floating rigs, where anchors are to be deployed, the survey area should encompass the expected limit of any anchors plus 1 km (allowance for location moves). The anchor radius depends upon water depth, mooring design (all chain, all wire or a combination) and is therefore rig specific. In deep water, anchor radii may be very large. Anchor radii typically range from 2.5 to 4.5 times the water depth depending upon the weight of the mooring and the make-up (wire, chain or combination). Surveying such large areas will be very expensive so surveying only the proposed anchor corridors should be considered. If these are not precisely known at the time of the survey, then the area of uncertainty should be surveyed. In addition, in areas where adjacent slope instability may be of concern, some survey lines should be extended up slope to identify potential slip features.

9.5 Data Processing and Interpretation

See UKOOA Guidelines for the Conduct of Mobile Drilling Rig Site Surveys.

10. Bathymetry and Seabed Features

10.1 Rationale

Mapping of bathymetry and seabed features (particularly navigational obstructions) are required to ensure safe rig navigation, anchor pattern design, anchor position, and to define riser length and tension. DP rigs need to know the slope direction, as this will dictate the escape direction to move in case of emergency. For anchoring it is advisable to avoid, or at least be aware of, steep slopes and trenches. Water depth is also required as a drilling datum and to ensure adequate length of control lines on BOPs. If precise seabed positioning is required and Long Baseline (LBL) acoustic arrays are to be deployed, water depth mapping is also essential in areas of very variable bathymetry for ensuring LBL beacon intervisibility.

Mapping of seabed features, including the detailed shape of the seabed superimposed upon general bathymetry, is required as an aid to the design of anchor patterns and to the exact placement of guidebases. It is desirable to avoid, or at least to be aware of, features such as boulders, small sand waves or depressions in the seabed. To ensure that there is only minimal disturbance to the environment from drilling operations, identifying and mapping of bioherms such as cold water coral, Iophelia is required.

In addition to natural features there are occasional man-made artefacts on the seabed in parts of the UKCS. Some of these are connected with previous oil industry activity but there are many other obstructions such as telephone cables and wreckage. These may be wholly or partially buried in the seabed. Obstructions may also exist in mid water, such as mooring cable from metocean buoys. Planning of the drilling location should therefore first take account of all known features of this nature. The rig site survey should then find or relocate all potential obstructions so that they can be avoided when navigating and anchoring a rig on location.

Bathymetry and seabed feature information can be obtained from the seabed pick of 3D seismic data. The resolution of good quality 3D seismic data is often similar to that of dedicated deep water bathymetry surveys. The seabed pick can provide useful data on features such as steep slopes, slope instability, faults, canyons, mobile sediments. Careful use of these data by Specialists will minimise seabed survey requirements. In some cases where there is good control, these data may eradicate the need for a dedicated survey. In addition, in areas where environmental conditions are well established, multi-beam swathe bathymetry may provide adequate seabed feature information in frontier areas where petroleum infrastructure has not been established and the risk of significant seafloor obstructions is low.

If required, bathymetry and seabed features information can usually be acquired simultaneously with soil conditions seismic data (see Section 9).

An overview of the bathymetry/seabed features element of the rig site survey is given below. Detailed information on the selection of equipment, methods to be used, and recommended scope of work is provided in the UKOOA Guidelines for the Conduct of Mobile Drilling Rig Site Surveys, Volume 2. It is stressed however, that Specialist advice should be taken in defining the specific scope for each individual rig site survey.

10.2 Equipment

In general, echo sounders are used for bathymetry measurements and side scan sonars for seabed feature detection and identification. Visual techniques (stills cameras, video) may be considered for very small seabed feature to confirm the interpretation. These techniques will also provide information on seabed life (or lack of it) and seabed current activity and direction. There are other high resolution tools, such as laser line scan systems, being developed which should be considered for specific problems. A magnetometer should be considered for the detection of power and communication cables and any magnetic objects. However, in deep water it may be difficult to tow the sensor close enough to detect such objects.

Echo sounders (conventional or multi-beam systems) should be capable of sounding to the maximum expected depth in the survey area. Equipment should be correctly calibrated for vessel draft settings and for the velocity of sound in water. To achieve this, velocity profile measurements are required of the entire water column during the survey. A resolution of approximately 1% of the maximum water depth is the accepted system capability. However, this would represent only 10 metres resolution in 1000 metres of water. For some applications, Operators require a resolution of better than 0.5%. To achieve precise bathymetric data in deep water will require deep tow systems or Remotely Operated Vehicles (ROV) with very accurate positioning.

In addition, in deep water, unless the echo sounder is towed near the seabed, imaging complex seabed bathymetry may be difficult due to sensor beam width (see UKOOA Guidelines for the Conduct of Mobile Drilling Rig Site Surveys, Volume 2, Section E.5). Table 14 of Section E.5.1 has been modified below (Table 1 below) to include deep water.

	Water depth (m)					
Beam width	50	300	500	750	1000	2000
3°	2.6	15.7	26.2	39.3	52.4	104.7
8°	7.0	42.0	70.0	104.9	139.9	279.7
15°	13.2	0.25	3000	800	263.3	526.6

Table 1 : Diameter of the area insonified (in metres) by an echo sounder, for various beam widths and water depths.

Repetition rate will depend upon the water depth, since there must be sufficient time between pulses to display the seabed return. Table 14 of Section E.5.1 has been modified below (Table 2) to include deep water. Table 2 below tabulates the along track sampling interval in metres for various repetition rates, assuming a vessel speed of 2 metres per second (industry standard of 4 knots).

Repetition Rate (Hz)	Range	Along track Sampling Interval (m)
10	75	0.2
2.5	300	0.8
1	750	2
0.5	1500	4
0.25	3000	8

Table 2 : Along track echo sounder sampling interval for various repetition rates and ranges (vessel speed of 2 ms^{-1}).

Due to beam width effects, even with low repetition rates it is very unlikely that the seabed will be undersampled unless the vessel is surveying at high speed.

It can be clearly seen from Tables 1 and 2 that deep tow echo sounders should always be utilised in areas of complex seabed bathymetry.

Side scan sonars should be capable of providing minimum coverage of 100% of the specified survey area. For moored and DP rigs in the deep water UKCS, most Operators require detection of objects in the size range 1-3 metres. Conventional 100kHz systems should be capable of detecting objects 0.5-1 metre cube (nominal) or linear features 0.2 metres in diameter (nominal). These sonar systems should easily satisfy Operator requirements.

To achieve resolute data side scan sonars must be towed near the seabed. Deep tow fish are therefore required for deep water. Fast side scan sonar winches are required with deep tow fish to minimise line time taken on line turns.

For the detection of very small obstructions, higher frequency (500kHz) side scan sonar should be considered which can detect linear features 0.1 metres in diameter (nominal). To achieve this resolution, favourable operating conditions are required and the equipment must be carefully selected, optimally tuned, calibrated and operated.

Positioning of deep tow sensors can be difficult. Accuracy can be guaranteed by using Long Baseline acoustic arrays. However the costs associated with such arrays can be high. Ultra Short Baseline positioning is much cheaper but ranges may not be adequate and some compromise may be required on position quality. Positioning accuracy required will depend upon the type of rig and associated seabed installations, and also the variability of the seabed bathymetry and sub-seabed geology. Operators should clearly define the accuracy required for positioning of the deep tow sensor and specify the appropriate system.

10.3 Survey Pattern and Line Orientation

Survey pattern will normally be determined by the soil conditions seismic survey requirements (see Section 9) which are generally more critical. Echo sounding and side scan sonar imaging should be conducted on all survey lines, including orthogonal lines, in order to provide multiple observations for checking data integrity.

Use of multi-beam swathe echo sounders will mean that wider line spacing is acceptable in deep water. However, as discussed in Section 10.2 above, resolution will be limited unless these sounders are towed near the seabed.

Side scan sonar line spacing is dependent upon water depth, instrument tow depth and range capability of the sonar in use. Minimum coverage should be 100% over the specified survey area from lines in the principle pattern direction. Currents are usually strong in the deep water UKCS. This will make regular grids of side scan sonar lines very difficult to acquire. Considerable infill may be required to ensure adequate coverage. Some orthogonal lines (25-50% of main pattern) should also be run. Where there are linear features, lines parallel to these should be run to obtain optimal images. Any significant features should be 'boxed in' by means of running closely spaced lines to ensure the object is viewed from all sides and that its position can be plotted.

For bathymetric surveying, line orientation is generally not critical in UKCS operating areas. The line orientation of the soil conditions seismic survey should be acceptable. Line orientation to suit weather conditions should also be considered to minimise cost. However, if the seabed is expected to be steeply dipping (> 10 degrees), or there are significant seabed features in the area (e.g. sand waves), consideration should be given to optimising the line orientation. In general, lines should be acquired parallel to the predominant dip direction. However, Specialist advice should be taken on optimum line orientation if there is dipping or complex seabed morphology.

10.4 Extent of Survey

Survey extent will also normally be determined by the soil conditions seismic survey. For an anchored rig, the area should extend to a minimum radius equal to the anchor pattern plus a nominal 1 km to allow for a possible move in location. In deep water, surveying such large areas will be very expensive so surveying only the proposed anchor corridors should be considered. If these are not precisely known at the time of the survey, then the area of uncertainty should be surveyed. Specialist advice should be taken before reducing the size of a survey area.

In addition, in areas where adjacent slope instability may be of concern, some survey lines should be extended up slope to identify potential slip features.

10.5 Data Processing and interpretation

See UKOOA Guidelines for the Conduct of Mobile Drilling Rig Site Surveys.

11. Seabed Sampling and In Situ Measurements

11.1 Rationale

These guidelines cover geophysical and hydrographic aspects of rig site surveys. Discussions on seabed sampling are therefore confined to systems, which can be deployed from the vessels undertaking these surveys. Seabed sampling in this context is usually only undertaken for calibration of the seabed and shallow geophysical data to improve the reliability of the interpretation. In addition the data are useful for Environmental Impact Studies and geochemical studies. However, samples acquired for these environmental or geochemical purposes may require specialised storage and handling equipment.

Sample and test data is generally limited to a maximum of 6 metre sub-seabed penetration. If data are required to sub-seabed depths greater than this, specialist equipment will be required which may dictate the use of a specialist vessel. Deep water sampling tools with greater penetration capability have been, and are being developed (RGD corer, Selcorer) which can be deployed from conventional rig site survey vessels. However, a dedicated geotechnical site investigation may additionally be required if Specialist Advisors consider that there is insufficient pre-existing, quantitative information to depths of greater than 6 metres sub-seabed. Deep water geotechnical borehole data is extremely expensive and rarely acquired for mobile floating rigs unless there is already a defined need for field development studies. Acquisition of these data should only be considered if there are specific local problems identified by the geophysical data, or if there is a need for data for field development.

Accepted industry practice is to consider each and every drilling location on its own merits and to design the survey accordingly. For example, if anchor holding is critical, consideration should be given to obtaining and testing soil samples at specific anchor locations. An overview of the deep water sampling element of the rig site survey is given below. Detailed information on the selection of equipment, methods to be used, and recommended scope of work is provided in the UKOOA Guidelines for the Conduct of Mobile Drilling Rig Site Surveys, Volume 2. It is stressed however, that Specialist advice should be taken in defining the specific scope for each survey.

As discussed in Section 9, reconnaissance of soil conditions is required in order to begin to establish design criteria for the following types of mobile rig and drilling operations:

- Anchoring of semi-submersible drilling rigs (or jack-ups for stand-off locations).
- Slope Stability studies.
- Conductor/casing setting for any rig type.
- Initial spudding of drilling equipment, including guidebase stability.
- Wellhead competence evaluations.
- Environmental Impact Studies.

11.2 Equipment

The systems used can be divided into four categories: -

(i) Grab samplers.
(ii) Gravity and piston corers.
(iii) Vibrocorers.
(iv) Cone Penetrometer Test (CPT) systems.

It is recommended that gravity core and/or grab sampling is undertaken as a minimum. It is possible to deploy Cone Penetrometer Test (CPT) systems and vibrocorers from some survey vessels. These systems provide suitable geotechnical data but have limited sub-seabed penetration. In deep water, considerable time will be required to lower equipment to the seabed and then recover it. Winches need to be fast to minimise equipment deployment time.

Positioning of sampling equipment in deep water can be difficult. For most applications, Ultra Short Baseline positioning should be appropriate. Positioning accuracy required will depend upon the type of rig and associated seabed installations, and also the variability of the seabed

bathymetry and sub-seabed geology. Operators should clearly define the accuracy required for positioning of the sampling equipment and specify the appropriate system.

11.3 Survey Pattern

The seabed and near seabed survey data should be used in identifying the number of coring locations and their desired position.

12. Reports and Survey Data

12.1 Recipients of the Report(s)

See UKOOA Guidelines for the Conduct of Mobile Drilling Rig Site Surveys, Volume 1, Section 11. An addition to Section 11.13 Operator Recipients should be: -

Environmental Department. Department responsible for preparing Environmental Impact Statements

12.2 Recommended Minimum Contents

Reports should be concise and relevant to the survey objectives which themselves should be clearly defined in the report. Consideration should be given to the information needs of all users of the report. As many users are not geoscientists, geological/geophysical descriptions and jargon should be avoided.

The reporting style should aim to provide brief and clear statements on the expected conditions at the proposed drilling location. These statements should not be confused by discussion of features in or around the survey area which have no relevance to either rig installation or subsequent drilling at the location.

It is common industry practice to present a one page report summary or Abstract at the front of the report for management overview purposes. Operators and Rig Owners should however be aware that Rig Site Survey reports address a wide variety of relevant issues and it is critical to the safety cases for rig moves and well operations that the full implications of the report be fully understood by all concerned.

The following further guidance is relevant to specific aspects of the report(s).

Drilling hazards
Drilling hazards in the deep water UKCS include shallow gas, hydrates, boulders and unconsolidated sands. For all of these, the objective is to identify and map possible hazards, which may impact upon the choice of location. The report should therefore clearly indicate the depth and lateral extent of any such hazards both at the location and nearby. Any information used in the interpretation of the data and assessment of the hazard potential should be included.
Whenever possible, top hole well data should be used to calibrate the shallow gas seismic data and to improve the interpretation. Speculative interpretations unless substantiated by published data (e.g. BGS publications, results of previous wells) should be avoided.

Sub-seabed Soils
For foundation/anchoring purposes, the report should clearly indicate the depth and map the lateral extent of any relevant soil units. Additional information such as sedimentary features, used to characterise soil units should be described. The depth and lateral extent of any relevant features, e.g. sub-seabed channels, slope failure such as slides, slumps, debris flows should be described and mapped. Whenever possible borehole or CPT data should be used to confirm the interpretation.

Interpretation of the shallow gas seismic data may also be useful for guide base foundation studies, conductor/casing setting studies and detection of potential zones of difficult drilling. The report should therefore clearly indicate the depth and map the lateral extent, within coverage, of any relevant features (e.g. sub-seabed channels, slope failure such as slides, slumps, debris flows). A prognosis of lithology throughout the objective depth interval should be included

Bathymetry
The report should clearly indicate water depths at the proposed location and within the survey area, reduced to LAT. Seabed gradients and irregularities (e.g. depressions, sandwaves) should be described, particularly in the areas of the drilling guidebase. Slope failure such as slides, slumps, debris flows should be described and mapped. Specific attention should be drawn to water depths that are significantly different from those previously charted.

Seabed Conditions and Obstructions
Seabed sediments and any natural features or obstructions within the survey area (e.g. wrecks, boulders, cables, other moorings, and bioherms such as lophelia coral) should be described in the text and mapped in their correct position. Any evidence of seabed current activity such as scour, current lineation should be described. Slope failure such as slides, slumps, debris flows should be described and mapped. This information should be derived from survey data and any other sources (e.g. Admiralty charts). Specific attention should be drawn to features and obstructions that have not been previously charted or are found to be in positions different from those previously charted. Obstructions previously charted but not found during the survey should be mapped but annotated as "not confirmed".

Current Measurements
Results of any measurements available in the area.

12.2 Data Retention

See UKOOA Guidelines for the Conduct of Mobile Drilling Rig Site Surveys.

13. References

UKOOA Guidelines for the Conduct of Mobile Drilling Rig Site Surveys, Volume 1, March 1997, Version 1.2

UKOOA Guidelines for the Conduct of Mobile Drilling Rig Site Surveys, Volume 2, March 1997, Version 1.0

Acknowledgement

A working group formed by the UKOOA Surveying and Positioning Committee compiled this guideline in 2000. Comments or questions arising from the guideline should, in the first instance, be directed to the Secretary of UKOOA for the attention of the Chairman of the Surveying and Positioning Committee. Working group members were as follows:

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