PROJECT SCOPE OF WORK

Macondo Well Location Seabed and Environmental Abandonment AUV Survey

M/V Miss Ginger

MC 252 and Surrounds

Mississippi Canyon Gulf of Mexico

Quality Control and MOC	
Issue Number and Date	**Issue Comments**
Version 1, 8th December 2010 Version 2, 28th February 2011	Includes Contractor Comments, Technical Specifications, and Final Photography locations Updated survey deliverables, SIMOPS
Author	**Approved**
Name: A. Hill Title: Marine Geohazards SeTA Name: J. Dingler Title: Site Investigation Specialist	Name: Title:

Introduction

Following the blowout of well MC252 #1BP and the sinking of the Deepwater Horizon, a large amount of response and intervention activity has taken place at, and surrounding, the well location.

An AUV based archaeological survey was undertaken of the full MC252 area, and some of its surrounding blocks, prior to drilling. Immediately following the blowout a limited area AUV seabed survey was undertaken to clear two relief well locations and to define the *broad* extent of the debris field from the sinking of the Deepwater Horizon. This survey however did not provide full coverage of the block or the area directly around the MC252 #1BP well due to vessel obstructions.

Since this survey a number of major operations have taken place at, and around, the well:

- A large flow of hydrocarbon has flowed from the well.
- Various engineering items have been wet stored on the seabed.
- A top-kill operation has taken place entailing installation of seabed manifolds and the flow of a substantial amount of mud into the water column.
- The well conductor has been severed and the well capped.
- Two free standing risers have been installed with associated suction can foundations and allied flow lines back to the original well location.
- The original Macondo well has been abandoned
- Two relief wells have been drilled and are in the process of being abandoned.
- A benthic seabed sampling campaign has been undertaken.

As operations and equipment demobilize from MC252, the site will clear to allow full access to AUV survey operations to be undertake a full re-survey of the block to:

- Redefine the baseline seabed conditions across the area.
- Define the as abandoned conditions at, and around, three well locations related to the blowout.
- Fully define by acoustic means the extent of the seabed wreckage field from the Deepwater Horizon.
- Confirm the location of any remaining major equipment left on the seafloor.
- Assist in definition of seabed benthic habitat conditions.
- Place seabed sample locations into a photographic framework to define conditions directly around sample locations that might impact on sample analysis results.
- Ensure that all the objectives are achieved without violating the defined Navy Exclusion Zone around the wreck of the Deepwater Horizon hull.

In addition to the acquisition of the standard suite of AUV acoustic survey data, the survey shall include the acquisition of a number of photo mosaic "patches" to be acquired by the AUV over sites where seabed samples or other environmental survey transects have been acquired.

Key aspects of this survey shall be:

1. Safety and coordination of infield marine operations with any vessels remaining in the field supporting completing the response.

- A SIMOPS meeting shall be held at BP's offices in Houston prior to mobilisation to site to define issues and agree how to manage the risks in the field.

2. Acquire data in a safe, consistent, and controlled manner to ensure avoidance of any interference with debris remaining on the seafloor – *in particular avoiding any entry within Navy Exclusion Zone around the hull of the Deepwater Horizon.*

3. Repeat the pre-drill line plan over the extent of the defined survey area that is coincident with the pre-spud survey to an extent of approximately 4 miles from the well location.

4. Repeat and Infill of the pre-spud line spacing over the central area at a low level with 410KHz sonar to provide high-resolution coverage of the well locations and debris field.

5. Extend the 2009 pre-drill survey area to map the extent of the plume of Top-Kill mud, junk-shot debris, or drill cutting splays that may extend out of the original 2009 pre-drill survey coverage.

6. Acquisition of seabed photo mosaic patches centred on pre-defined locations both in and outside of the main survey area that are coincident with the locations of previously taken locations of scientific sampling.

7. Fundamental technical standard for the works shall be BPXS standards (attached).

Technical and HSE issues raised by COMPANY will require resolution before operations can start.

Operations will otherwise be delivered in conformance with COMPANY and CONTRACTOR HSE policies and standards. Survey work will only commence after the Source area has been declared clear from competing vessel activity by the Incident Management Team in Houston.

All survey work will be completed in accordance with COMPANY BPXS Technical Specification.

General Operations

Operations are to be performed in the direct area over and around the Macondo Source Location. Operations shall not commence until the site is clear of vessel activity or a SIMOPs plan is in place with any vessel that remains in the area.

Prior to arrival into, upon arrival in the field, throughout the work, and upon completion and departing from the incident area, CONTRACTOR must coordinate operations and gain approval for work with the Houston IMT Source Control and SIMOPs coordinators in Houston.

The immediate point of contact for confirming arrival, incidents, actions in the field and approval for departure shall be:

IMT Source Controller:	Richard Harland (day) 281 844 6204
SIMOPs:	Geir Karlsen 713 855 7369

For technical issues the shoreside contact shall be:

Shoreside Survey SPA: Jeffrey Dingler
281-366-6471 office
619-852-5584 mobile

Survey Program

CONTRACTOR shall acquire a programme of AUV data acquisition in phases according to the survey plans attached, start and end coordinates, and numbering provided by COMPANY.

Lines shall be acquired in the manner detailed below.

Quality standards for the works shall be in accordance with BP BPXS Technical Specifications.

Survey Approach

The survey shall be completed in the following phase order.

I. Repeat of 2009 Pre-Drill Survey

An area of the 2009 Pre-Drill archaeological survey shall be repeated over the area defined in the attached chart. The bounds of this area are approximately 7.5 x 8 miles.

Line numbers acquired in 2009 will be repeated, however the line prefix shall be changed to:

BPAVMDO10

to differentiate the lines from the previous data. Line spacing shall be 200x900m to overlay the pre-existing grid.

Any lines that would have entered the Navy Exclusion Zone shall be cut off 50m from any point of entry.

Each line shall acquire multibeam bathymetry, 230KHz side-scan-sonar and sub-bottom profiler data.

Aims of this particular survey shall be to:

1. Provide an overview of the *as abandoned* seabed conditions directly around the three well sites.
2. Define the extent of the visible drill cuttings and top-kill drill mud splays on the seabed after the completion of drilling and intervention activities.
3. Define the general extent of the debris field relating to the sinking of the Deepwater Horizon rig and confirm the required extent of the high frequency sonar survey. Elevation of any piece of wreckage shall also be confirmed prior to acquisition of the High frequency survey.
4. Define the locations of any seabed seep sites and confirm the absence of seabed breakouts around, or close to, the Macondo well itself.

Some lines of the grid shall be extended to provide cover over photo mosaic sites out the immediate survey area to allow planning of seabed elevations during these surveys.

II. Westerly Extension of 2009 Pre-Drill Survey

The westerly extension is designed to map the extent of the plume of Top-Kill mud, junk-shot debris, or drill cutting splays that may extend out of the original 2009 pre-drill survey coverage in Phase I (above) of the project.

It is believed that the dominant deep current during the period up to the capping of the well close to seafloor was to the west and this is the direction that a suspended mud plume is most likely to have travelled.

Lines shall be acquired in the same style and on a continuation basis of the 200x900m grid acquired in Phase I.

III. High Resolution Sonar Definition of Main Debris Field

High frequency sonar shall be acquired over an area approximately 2x2 miles to more accurately define the extent of the wreckage field and the conditions immediately around the three abandoned well locations.

Lines shall be acquired on the same heading as the main grid and with a line spacing of 75m with an AUV acquisition altitude of 20m.

Line numbers shall be acquired with the line prefix:

BPAVMDO10HF

to differentiate the lines from data acquired earlier in 2010.

Any lines that would have entered the Navy Exclusion Zone shall be cut off 50m from any point of entry into the zone.

410KHz Side-Scan Sonar shall be operated on a 80m range, to ensure full isonification of the nadir zone beneath adjacent AUV tracks and to thus ensure greater than 200% cover of the survey area.

Sub-bottom profiler data need *not* be acquired on these lines to allow the ping rate for both side-scan and swath systems to be maximised and to thus ensure the highest possible in line data density and therefore sonar and swath data resolution.

Aims of this particular survey shall be to:

1. Accurately define the position of all pieces of wreckage related to the sinking of the Deepwater Horizon.
2. Define the final as abandoned locations of any equipment left on the seabed after the response.

IV. Isonification of the Navy Exclusion Zone

A single circular AUV line shall be acquired directly outside the Navy exclusion zone to allow isonification of the wreck and other debris lying within the zone.

The line shall be acquired 5m (five metres) outside the 750' radius exclusion zone.

The AUV shall fly at an altitude of 40m above seabed to allow isonification onto the top of the upturned hull of the Deepwater Horizon.

Side scan sonar shall be operated at 230KHz frequency and a range of 213m.

Swath bathymetry shall be acquired on this line but not sub-bottom profiler to allow ping rates to be maximised.

The objective of this line is to provide sonar coverage of as much of the Exclusion zone as possible without entry into it.

V. Photo Mosaics

A series of 100x100m high resolution photo mosaics shall be acquired centred on four different types of location:

- Abandoned Wellhead Locations (three)
  (Attachment 2)
- Sites of Seabed Samples (Mega-Core or Box-Core, total of six)
  (Attachment 3 & 4)
- Site of ROV Seabed Video Transects (two)
  (Attachment 5)
- Sites of Previous BOEM Photographic Sled Transects (three)
  (Attachment 6)

Each site shall be cleared by sonar and swath data first to identify the terrain and the safety of operations at a low AUV flight altitude. A site shall not be acquired if there is any doubt over vehicle safety.

Mosaics shall be acquired with a 3.5m line spacing and a 7m altitude above seabed.

Lines shall be acquired in a racetrack manner (all in one direction) to ensure vehicle along line yaw and thus photo frame alignment is consistent from one frame to frame and line to line.

Survey Planning

Operational Safety

A CMID of the Survey vessel Miss Ginger shall be undertaken prior to the start of the survey and all action points closed out prior to the start of operations.

A HAZid shall be carried out in the BP offices prior to the start up of the survey.

Two BP Representatives shall be aboard the vessel to monitor operations. Mr Richard Dailey shall be lead BP Representative and Technical Delivery Authority and Mr Larry Ward shall BP HSE representative responsible for monitoring onboard safety systems and safe operations.

Personnel

A list of personnel that shall be working on the project together with their roles, responsibilities and reporting lines, shall be submitted to COMPANY prior to start of this Scope of Work.

Permitting

BOEMRE approvals for the survey have been applied for by Operator.

Previous Reports

A copy of the 2009 and 2010 AUV survey reports and final data deliverables (DTM, Sonar Data, Mosaic, etc) of MC252 performed by C&C Technologies should be carried aboard the vessel to allow direct analysis of seafloor conditions for survey planning purposes.

Survey Deliverables

Contractor is expected to produce the following interpretation and charting deliverables within 28 days of vessel demobilisation.

Swathe Bathymetry:

- Detailed bathymetric model with appropriate bin-sizes relative to AUV operational height delivered in XYZ Ascii format.
- Bin hit chart with same bin size as Ascii XYZ bathymetric model.
- .GSF (Generic Sensor Format) files of processed bathymetry lines (multibeam bathymetry and multibeam backscatter). Cleaned data should be flagged, not deleted. This data must be compatible with Fledermaus, specifically the PFM class tools and FMgeocoder.
- .ALL (Kongsberg format) files of original multibeam data prior to processing.
- Fledermaus scene file of final processed dataset. Switchable format between colour water depth and/or seafloor gradient overlays.
- Area wide chart.
- Suite of detail charts as appropriate.
- Area wide and Detail Seafloor Gradient Maps with background sun relief shading of terrain.
- Difference map between the 2009 DTM and the new coverage.
- Difference map between the 2010 DTM and the new coverage.

Side Scan Sonar

- Side Scan Sonar lines in .XTF format (compatible with Fledermaus FMgeocoder).
- Individual lines in GeoPDF format. (Grid, chart included)
- Individual lines in Geotiff format. (No grid, chart or annotation data)
- Side Scan Sonar Mosaic in Geotiff format. (No grid, chart or annotation data)
- Side Scan Sonar Mosaic in GeoPDF format. (Grid, chart included)
- Detailed list of all defined debris and seabed features in Microsoft Excel format. The File name shall clearly emphasise version number and date in the case that survey work is ongoing. File shall include the following details:
    - Contact ID number,
    - Line number(s) – for events identified on multiple passes,
    - Time Event number,
    - X/Y position
    - estimated size (H,W, and L)
    - Water depth of feature
    - Height of highest point of feature above surrounding seafloor for man-made objects.

- Location of any suspected/confirmed plumes from the seabed

Any spreadsheet sent ashore from the field shall be clearly labelled to emphasise that it is a "Preliminary Real Time Contact Listing".

- Seafloor features map in GeoPDF format. (Grid, chart, annotation included)
- Depending on interpreted complexity, bathymetric contours may be required as a half-tone background on these charts.
- Annotated data examples of features of interest: debris, possible plumes etc.
- Outlines of all sonar data examples to be shown on seabed maps with cross reference to figure.

Sub-bottom Profiler

- All data shall be delivered in SEG-Y rev 1 format and shall be capable of being loaded and displayed in a Landmark Openworks R5000 environment (This may require that the sample data be shifted by the microsecond delay time).
- Updated shallow soils map to show sub-bottom features that were not identified on the 2009 or 2010 surveys (plumes, pock marks, shallow gas, dispersion features, drill cuttings, drill mud, etc.)
- Map any evidence of gas fronts, at or close to seabed, identified on profiler records.
- Map any evidence of seabed build-ups, or hollows that may be indicative of seabed breakout.
- Map any indication of *active* fluid seepage at seabed.
- Annotated data examples of features of interest: possible plumes, dispersion features etc.
- Outlines of all sub-bottom profiler data examples to be shown on seabed maps with cross reference to figure.

Photography

- For each Photo mosaic location a high resolution mosaic shall be delivered in geo-referenced geotiff format on a suitable digital medium.
- A geo-referenced geotiff of each individual photo frame at full acquired resolution shall be included in the report on a suitable digital medium.
- A paper plot of each mosaic shall be enclosed in the report at a suitable scale to fill a chart page (10 feet per inch or better) with full coordinate overlay. A specimen mosaic shall be delivered to the Shoreside SPA for approval prior to issue of all draft results.
- A GeoPDF and DWG version of each mosaic, overlayed with chart, interpretation, and annotation information, at a suitable resolution shall be enclosed in the report.

Charting

Shot point and Bathymetry Charts shall be output in a series of charts at a map scale of 1":500' or greater depending on mapped detail.

Final Chart formats to be submitted to BP Shoreside Survey SPA for prior approval.

Electronic copies will be supplied in DWG and GeoPDF format, along with .mxd Arc Mapping files. The .mxd files should link to data in the SDDM geodatabase using relative links.

Digital Data

All electronic data shall be input into the OGP Seabed Survey Data Model (SSDM) geodatabase provided by the Operator. All applicable pre and post survey data, and interpretation should be loaded into the SSDM.

Bathymetry, side scan, sub-bottom, and photography electronic files shall be hyperlinked to the appropriate data in the SDDM geodatabase.

Swathe Bathymetry DTM in XYZ ASCII and Fledermaus Scene files

Swathe Bathymetry and Swathe Bathymetry Backscatter lines in .GSF format (cleaned) and .ALL (raw data).

Side Scan Sonar lines in .XTF format (compatible with Fledermaus FMgeocoder).

Sub bottom profiler in SEG-Y format (Rev 1, microsecond delay time applied)

Navigation data in UKOOA P1/90 and P2/86 formats.

GeoPDF's should have layers enabled and should include attribute data when possible.

Reporting

A combined Field Operations and Interpretation Report shall include:

- All equipment specifications together with calibration details.
- Equipment layout and offset diagrams.
- Copies of all observation logs from the acquisition.
- A full description of operational progress to include a copy of all signed DPRs.
- CONTRACTOR's lessons learnt and constructive comments for future operational improvements.

All reports to comply with requirements of BP Technical Specification BPX 7010.

Location, Equipment and Acquisition Overview

1. Location Details	
Mississippi Canyon Protraction Area	MC 252 #1BP and surrounding blocks
2. Summary of Acquisition Methods	
Contractor:	C&C Technologies
Vessel:	Miss Ginger
Surface Navigation:	C-Nav
USBL:	Kongsberg Simrad HiPAP
AUV:	C-Surveyor III, Hugin 3000
Multibeam Echo sounder:	EM 2000
Side Scan Sonar:	Edgetech 230KHz and 410KHz
Analogue Profilers:	Edgetech chirp, 1.5-4.5KHz
3. AUV Survey	
Line Prefix:	BPAVMDO10 Standard Grid BPAVMDO10HF High Frequency Sonar Grid BPAVMDO10PH Photography Grids
Line Numbers:	To replicate, extend and infill the 2009 grid. Additional line numbers to be added in appropriate order. Reshoots: first reshoot add A, second Add B, Repeat for time lapse issues: add 1 before line number e.g. 1001, for first reshoot.
Acquisition Height:	Standard Grid 40m High Frequency Sonar Grid 20m Circle Line 40m Photography 7m

Equipment Calibrations

Calibrations of all systems (HiPAP, Swath etc.) shall be undertaken prior to the start of the first survey line.

Deviation to BPXS Specifications

All deviations from specification are to be immediately drawn to the attention of the BP COMPANY Representative or pre-agreed prior to the start of the works.

Work shall not continue if agreement has not been reached on the acceptability or non-acceptability of the deviation to specification.

Attachments

Attachment 1:	**Geodesy**
Attachment 2:	**Well Location Details**
Attachment 3:	**Mega-Corer Locations for Photo Mosaics**
Attachment 4:	**Box Core Location for Photo Mosaic**
Attachment 5:	**ROV Transect Site Centres for Photo Mosaics**
Attachment 6:	**BOEM Sled Sites for Photo Mosaics**
Attachment 7:	**BPXS AUV Specifications**
Attachment 8:	**SIMOPS**
Attachment 9:	**Survey Corner Points**

Attachment 1

Geodesy

The survey is based on NAD27/UTM Zone 16/US Survey Feet and the following related grid projection, spheroid and geodetic parameters :

Project Geodetic Parameters		
Coordinate Reference System (CRS, a.k.a., Projected CRS or simply Grid System)	Common Coordinate Reference System Name	Universal Transverse Mercator (UTM) Zone 16 North as defined for use in conjunction with the North American Datum of 1927 in U.S. Survey Feet (a.k.a. NAD27 / BLM 16N / ftUS)
	EPSG Code	32066
	CRS or Grid System Units	U.S. Survey Feet
	Projection Function Employed	Transverse Mercator (Gauss Kruger)
	Central Meridian (CM)	87° W
	Latitude of Origin	0° N
	False Easting [1]	1640416.667 U.S. Survey Feet
	False Northing	0.000 U.S. Survey Feet
	Scale Factor on CM	0.9996
Horizontal Datum	Local Datum Name	North American Datum 1927
	Ellipsoid Employed	Clarke 1866
	Semi-Major Axis (a) [2]	6,378,206.4 meters
	Semi-Minor Axis (b) [2]	6,356,583.8 meters
	Eccentricity Squared (e^2) [3]	0.006768657997
	Inverse Flattening (1/f) [4]	294.9786982139
	NAD27 <-> NAD83 Datum Transformation [5]	NADCON 2.1

Important Notes:
1. Equivalent to 500,000.0 meters where 1 U.S. Survey Foot = 1200/3937 SI Meters exactly
2. Taken as exact values
3. Derived from a and b where e^2 = 1-b^2/a^2
4. Derived from a and b where f = 1-b/a
5. The transform between NAD27 and NAD83 should be done through NADCON 2.1 (where NAD83 is considered to be functionally equivalent to WGS84/ITRF for GoM operations)

Attachment 2

Well Location Details

MC 252 #1 BP

28° 44' 17.304" N
88° 21' 57.403" W

1 202 798.33 ft E
10 431 619.79 ft N

UTM Zone 16N, NAD27, US Survey Feet

MC 252 #2

28° 43' 53.338" N
88° 22' 17.927" W

1 200 943.77 ft E
10 429 220.73 ft N

UTM Zone 16N, NAD27, US Survey Feet

MC 252 #3

28° 43 '51.564" N
88° 21' 45.616" W

1 203 817.67 ft E
10 429 008.64 ft N

UTM Zone 16N, NAD27, US Survey Feet

Attachment 3

Mega-Corer Locations for Photo Mosaics

1. SE-20100926-GY-NF011-HC-010_BDO (MC 208):

28° 45' 55.102" N
88° 22' 00.779" W

1 202 611.18 ft E
10 441 498.49 ft N

UTM Zone, NAD27, US Survey Feet

2. SE-20100928-OV01-0.00-BT-021_LLI (MC 252):

28° 44' 16.512" N
88° 23' 11.328" W

1 196 217.80 ft E
10 431 615.77 ft N

UTM Zone, NAD27, US Survey Feet

3. SE-20100928-OV01-1.01-BT-020_LLI (MC 250):

28° 44' 20.904" N
88° 28' 05.844" W

1 170 010.05 ft E
10 432 373.32 ft N

UTM Zone, NAD27, US Survey Feet

4. SE-20101018-GY-D012S-BT-059_LLI (MC 299):

28° 40' 20.860" N
88° 14' 02.753" W

1 244 795.91 ft E
10 407 284.21 ft N

UTM Zone, NAD27, US Survey Feet

5. SE-20101019-GY-LBNL14-BT-063_LLI (MC 251):

28° 43' 48.630" N
88° 25 '01.150" W

1 186 409.78 ft E
10 428 915.31 ft N

UTM Zone, NAD27, US Survey Feet

Attachment 4

Box Core Location for Photo Mosaic

1. BC 18-3 (MC 210):

28° 47' 02.09" N
88° 17' 00.65" W

1 229 389.3 ft E
10 447 965.9 ft N

UTM Zone, NAD27, US Survey Feet

Attachment 5

ROV Transect Site Centers for Photo Mosaics

Northern Station (MC 252):

28°45' 22.295" N
88°21' 58.520" W

1 202 774.15 ft E
10 438 183.47 ft N

UTM Zone, NAD27, US Survey Feet

Western Station (MC 252):

28°44' 16.360" N
88°23' 11.190" W

1 196 229.91 ft E
10 431 600.28 ft N

UTM Zone, NAD27, US Survey Feet

Attachment 6

BOEM Sled Sites for Photo Mosaics

Site 2 (MC 297):

28°40' 46.7" N
88°20' 31.6" W

1,210,196 ft E
10,410,271 ft N

UTM Zone, NAD27, US Survey Feet

Site 5 (MC 295):

28°42' 19.1" N
88°26' 21.8" W

1,179,125 ft E
10,419,962 ft N

UTM Zone, NAD27, US Survey Feet

Site 8 (MC 338):

28°39' 38.9" N
88°28' 09.3" W

1,169,349 ft E
10,403,902 ft N

UTM Zone, NAD27, US Survey Feet

Attachment 7

BPXS AUV Specifications

BPXS 4000AUV	TECHNICAL SPECIFICATION FOR AUV HYDROGRAPHIC AND SHALLOW GEOPHYSICAL SURVEYS
BPXS 3000AUV	TECHNICAL SPECIFICATION FOR AUV POSITIONING
BPXS 3150AUV	TECHNICAL SPECIFICATION FOR SWATHE BATHYMETRY (for AUV's)
BPXS 3301AUV	TECHNICAL SPECIFICATION FOR AUV SIDE SCAN SONAR PROFILING
BPXS 3302AUV	TECHNICAL SPECIFICATION FOR AUV SUB BOTTOM PROFILING SURVEYS
BPXS 3042AUV	TECHNICAL SPECIFICATION FOR AUV POSITIONING AND MBE QUALITY CONTROL OUTPUTS
BPXS 7001AUV	TECHNICAL SPECIFICATION FOR AUV ON BOARD DATA ORGANISATION

BP TECHNICAL SPECIFICATION 4000

TECHNICAL SPECIFICATION FOR AUV HYDROGRAPHIC AND SHALLOW GEOPHYSICAL SURVEYS

Revisions	Rev. 01	March 2007	AWH Change of name, various minor changes, and reformat.
	Original	December 2002	TPD Original Specification

1. GENERAL

An Autonomous Underwater Vehicle (AUV) equipped with hydrographic and geophysical survey equipment will be used to undertake seabed surveys.

The AUV will be used for surveys which would traditionally have been undertaken using conventional towed or deep towed sensors such as sidescan sonar, sub-bottom profiler and multibeam echosounder.

Navigation of the AUV will be achieved by integrating an inertial navigation system, fibre-optic gyrocompass, Doppler velocity log and USBL positioning systems. Some surveys may additionally require an LBL acoustic positioning system. A detailed navigation specification is described in BPXS 3000.

The AUV must be capable of operating at the maximum water depth expected within the survey area as indicated in the Scope of Work provided by COMPANY for the project concerned.

The surveys to be performed may cover areas within which installation of drilling or production facilities are planned such as subsea wells, platforms and manifolds, or the surveys may be linear such as along planned pipeline, umbilical or cable routes.

Surveying of existing production facilities may also be required, for example along flowlines or pipelines or to inspect areas around platforms and wellheads for debris or drill cuttings.

Occasionally there may be a requirement to inspect in detail seabed features which may be considered hazardous to or in some way constrain, limit or impact engineering or drilling operations. These features may be known pre-survey or may result from an interpretation of records acquired during the survey.

The AUV will be deployed from a Survey or Support Vessel. The Survey Vessel will provide support to the AUV during the AUV dive; however, fully autonomous AUV operations will be acceptable providing the positioning and survey requirements detailed herein are achieved.

Some nearshore operations may be run from the beach, or shoreline, with deployment and recovery from the shoreline.

CONTRACTOR shall conform at all times to COMPANY's AUV specifications for general operations, navigation and operation of individual payload sensors unless authorised in writing by the COMPANY Representative to deviate from specification. CONTRACTOR is required to demonstrate throughout the duration of a survey that all the specifications applicable to the survey are being fulfilled.

2. PERMITS

CONTRACTOR shall ensure that it is in possession of all necessary permits and approvals for the importation and use in the country of the AUV for the survey and, similarly, for all its onboard and ancillary equipment, components, and materials.

CONTRACTOR shall provide documentation to show that importation for use in the country of the AUV, or any of its components or ancillary equipment or materials, is not embargoed or restricted by any country from which the equipment, materials, or components, were developed or manufactured.

3. HSE REQUIREMENTS

Surveying with an AUV may have a potentially high HSE risk.

CONTRACTOR must provide to COMPANY written operational procedures upon award of a contract to describe how the AUV is to be used and maintained, to minimise, and actively manage, any HSE risk. The document shall contain detailed procedures about launch and recovery operations, on deck handling of the AUV, and battery maintenance. At all times the CONTRACTOR will operate and maintain the AUV and its battery according to these written procedures.

CONTRACTOR's procedures should state clearly the maximum sea state and weather conditions in which the AUV can be safely launched and recovered.

COMPANY does not support the use of small boat deployment to assist in either launch or recovery operations, but will permit the use of a small boat to assist such operations during an emergency, or malfunction of the launch or recovery system. Small boat deployment will only be allowed after a rigorous task risk assessment has been performed, detailed procedures have been developed, and it is shown that all personnel involved have been properly trained and equipped for the task.

CONTRACTOR's procedures should clearly describe battery maintenance practices including replacement, recharging, and, where necessary, refuelling of the battery. Storage, handling and disposal of battery materials should be in accordance with BP's HSE policy, the law of the country in which the survey is undertaken, and in accordance with international maritime regulations.

The CONTRACTOR's Party Chief will be responsible for the safety of the AUV and AUV crew. No AUV operation will commence unless the Party Chief, in consultation with the COMPANY Representative and Survey Vessel captain, is satisfied that the operation can be undertaken and completed safely. A toolbox talk shall always be performed before any recovery/deployment operation.

4. AUV OPERATIONS

All payload sensors on the AUV shall be capable of being operated simultaneously together with the navigation and, if present, acoustic communication systems.

If any part of a survey is resurveyed due to an inability to operate all the onboard AUV systems simultaneously then the resurvey will be at the CONTRACTOR's cost.

Sufficient time will be spent after diving the AUV, and before commencing survey data acquisition, to ensure each payload sensor and position measurement system is operating properly, for the computed position solution to stabilise, and for the propulsion and steering

control systems to stabilise. This period may require the AUV to undertake particular manoeuvres and for particular events to occur. This settling down period at the beginning of each dive after the AUV has arrived in the vicinity of the seabed and before data acquisition commences should not exceed 45 minutes.

The altitude of the AUV above the seabed for each phase of the survey will be defined in the Scope of Work. In an offshore setting, operational altitude is generally expected to be in the range 20-40 metres. In very rugged or steep seabed terrain or in areas where there are substantial features on the seabed the altitude of the AUV may be increased to ensure the safety of the AUV. In near shore environments, the operational height shall be set on a case by case basis in the COMPANY issued Scope of Work.

The minimum average speed of the AUV during survey operations will be 3.5 knots but it is anticipated that a typical average survey speed shall be approximately 4.0 knots.

A programme of survey lines to achieve the objectives of the survey will be agreed with the COMPANY Representative before commencing the survey. This programme may be modified based upon interpretation of results obtained during the survey. Any extension to the survey programme, for example to investigate features identified from the survey results, may be requested by the COMPANY Representative and such request must be in writing.

The programme of survey lines and associated altitudes will either be pre-loaded into the AUV's mission plan or the AUV will be actively controlled from the Survey Vessel. An ability to amend the survey programme during a dive is preferred.

Each mission plan must be thoroughly checked before diving.

5. TIME SYNCHRONISATION

All data logged onboard the AUV, including payload sensor data, navigation data, ancillary systems data together with vehicle, battery and propulsion data will be time tagged using an accurate onboard clock.

The AUV clock must be synchronised to the Surface Vessel's clock. All clocks shall be synchronised to GPS time.

During each dive the AUV clock will not drift by more than 0.1 second. A standard check to be undertaken at the end of each dive is to measure and record the drift in the AUV's onboard clock together with the duration, depth, and location of the dive to enable long term clock drift to be monitored.

Time tagging will be undertaken in a manner which will enable the merging of navigation and payload sensor data without loss of accuracy. When the AUV position is being measured using USBL on the Survey Vessel the USBL positions shall be merged with the AUV's onboard positioning systems without loss of accuracy.

6. PAYLOAD SENSORS

A multibeam echosounder, sub-bottom profiler and sidescan sonar capable of achieving the requirements detailed in the Scope of Work shall be installed on the AUV. These systems shall be operated in accordance with the COMPANY Technical Specifications provided for each sensor type.

The velocity of acoustic propagation through water will be measured and recorded continuously on the AUV throughout the duration of each dive using a calibrated device with ambient water flowing over its sensor. Direct measurement of velocity is preferred to temperature and salinity measurements.

Sufficient data storage capacity shall be provided onboard the AUV to store all the payload and navigation data at the highest possible data recording rate for each onboard system for the duration of the longest possible dive by the AUV.

7. AUV COMMUNICATIONS

7.1 Acoustic Communications

An acoustic communication link between the Survey Vessel and the AUV shall be provided in offshore environments. This shall be used to send commands, interrogations and USBL derived positions from the Survey Vessel to the AUV. It would also be used to reply to interrogations and to send vehicle and payload status information from the AUV to the Surface Vessel.

If an acoustic data link is used and the Survey Vessel continuously tracks the AUV then the acoustic data link could be used to send subsets of data from the payload systems on the AUV to enable quality and coverage of data to be assessed on the Survey Vessel in near real time.

7.2 Radio or Phone Communications

When on surface the AUV shall have the ability to be communicated with by either radio or phone link.

7.2.1 Radio Link

A radio link shall provide the ability to give commands direct to the AUV to assist in the recovery of the AUV, to abort dives, or to send surface position or range/bearing signals to the support vessel if missing.

7.2.2 Phone Link

A phone link shall provide the possibility for the AUV to transmit via satellite phone its position on surface if it has aborted a dive, reached surface and has not been found. The phone link may also allow the provision from the support vessel, or shore control point, of an updated command set or programme information.

8. AUV TESTS AND QUALITY CONTROL

8.1 Equipment Tests

Prior to mobilisation the AUV and all of its onboard systems including navigation and payload systems shall have undergone thorough testing by the CONTRACTOR.

8.2 Calibrations

Some sensors may require periodic calibration and certification. Such certification shall be kept up-to-date by CONTRACTOR and all associated documentation shall be available for inspection by the COMPANY Representative.

Prior to and immediately following completion of mobilisation on each cruise the following calibrations shall be carried out:

8.2.1 USBL calibration – achieved by boxing-in a seabed deployed transponder.

8.2.2 Multibeam bathymetry calibration – achieved by performing a patch test.

8.2.3 AUV position accuracy test – achieved by running a 12-point star pattern of reciprocal lines over a target of known coordinates in water depths typical for the survey area.

8.3 Faulty AUV Equipment

Under the following circumstances equipment shall be defined as being defective and must be replaced or repaired. Any time lost due to faulty equipment or taken to achieve the repairs shall be to the CONTRACTOR's account.

8.3.1 Failing to pass standard manufacturer calibration tests.

8.3.2 No response when powered up on deployment of AUV.

8.3.3 Absence of any indication that data is being recorded by the sensor on the onboard payload console.

8.3.4 Faulty or intermittent data returns from the system such that in excess of 15% of the data is being lost.

8.3.5 An amplitude change in excess of 6 db when compared to data on the previous line.

8.3.6 For multi-beam and sonar systems failure to achieve manufacturer range specification.

8.3.7 Exceeds instrument noise limit specifications or has intermittent noise bursts or spikes.

8.3.8 Causes interference on the records of other sensors

8.4 Recording Specifications

8.4.1 Work shall not start on any part of the survey until sufficient quality control data have been received to confirm all sensors are working and recording to the required specification.

8.4.2 Work shall not start on any part of the survey when any of the following conditions exist:

i. Any one of the recording sensors on the recording system is not working.

ii. Navigation quality is such that the positioning specifications will not be achieved.

8.4.3 When Work on a survey is interrupted, CONTRACTOR shall resume Work in such a way that subsequent data processing of the two parts of the survey as separate segments will yield an overlap of at least 1 (one) survey line kilometre.

8.4.4 When recording operations have been suspended for any reason that is attributable to CONTRACTOR's equipment not meeting its manufacturer's specifications, the affected portions of the survey shall be re-acquired at no cost to COMPANY.

9. MAINTENANCE AND SPARES

The AUV, its payload systems and all ancillary equipment shall be maintained according to the manufacturer's recommended procedures. Wherever possible, preventative maintenance shall be performed during transits between sites, and during other non operational periods.

Sufficient spare parts, components, replacements, and backup equipment shall be carried onboard the survey vessel. At the very least a full complement of manufacturers recommended spares shall be carried. Sufficient consumables, tools and support systems shall also be available to allow uninterrupted use of the AUV and thorough maintenance throughout the period of the survey contract.

BP TECHNICAL SPECIFICATION 3000

TECHNICAL SPECIFICATION FOR AUV POSITIONING

Revisions	Rev. 01	August 2006	TPD Accuracy & minor upgrade
	Original	November 2000	TPD

1. SCOPE OF SERVICE

The Survey Vessel and AUV shall be provided with positioning capabilities to meet the requirements below.

Horizontal coordinates, depths, heading and pitch & roll of the AUV along its track are to be determined in real time for vehicle navigation.

The accuracy (precision and reliability) of all position data shall be stated in the tender document, is required for all surveyed lines, and shall be proven in calibration trials at the start of any project.

A methodology shall be implemented during surveying operations to demonstrate that the computed position accuracies are actually being achieved and to also demonstrate repeatability of the AUV positioning method.

2. POSITIONING ACQUISITION REQUIREMENTS

2.1 Positioning of the Survey Vessel and AUV

Positioning of the Survey Vessel and AUV is to be undertaken continuously during AUV survey operations for each of the surveys to be performed and a log maintained of all positioning activities throughout the survey.

Where a "Master" Survey Vessel is operating the AUV, such as in a deepwater setting, absolute positions of the survey vessel are to be determined to the following accuracy:

Real time horizontal coordinates:	± 1 metre

AUV absolute positions in deepwater are to be determined to the following accuracies:

Real time horizontal coordinates:	± (10 meters + 0.005 * Water Depth)
Final processed horizontal coordinates:	± (3 meters + 0.003 * Water Depth)
Real time depth:	± (0.5 meters + 0.0005 * Water Depth)
Final processed depth:	± (0.3 meters + 0.0003 * Water Depth)
Real time heading:	± 0.4 degrees
Final processed heading:	± 0.2 degrees
Real time pitch & roll:	± 0.2 degrees
Final processed pitch & roll:	± 0.1 degrees

For nearshore, shallow water, operations absolute position accuracy standards for the AUV shall be stated in the tender document and confirmed in the COMPANY Scope of Work.

All accuracies are at the 2D RMS error value (approximating to 95% probability). CONTRACTOR shall demonstrate that these accuracies are being obtained during each AUV dive through appreciable redundancy of positioning measurements and appropriate analysis software.

2.2 AUV Track Keeping Tolerance

AUV track keeping shall be maintained within a horizontal position tolerance of ± (5m + 0.005 * Water Depth) relative to pre-programmed survey lines for 90% of position fixes recorded and within 25 metres for 100% of position fixes recorded. This tolerance is based upon final processed position data.

2.3 AUV Altitude Tolerance

When a survey plan is based upon AUV altitude above seabed, the AUV altitude will be maintained to within a tolerance of 5 metres vertical relative to the pre-programmed altitude for 90% of position fixes recorded and within 10 meters for 100% of position fixes recorded. In the event that surveys are being undertaken over a very rugged seabed, or where there are very steep seabed slopes, this tolerance may be relaxed by the onboard COMPANY representative. This tolerance is based upon final processed position data.

When a survey plan is based upon AUV depth below sea level, the AUV depth will be maintained to within a tolerance of 5 metres vertical relative to the pre-programmed depth for 90% of position fixes recorded, and within 10 meters for 100% of position fixes recorded. This tolerance is based upon final processed position data.

3. POSITIONING DATA PROCESSING REQUIREMENTS

Real time processing of position data shall permit full navigation of the AUV along pre-programmed survey lines and also enable provisional processing of data from payload sensors. Post-processing of positioning data, by means of forward and backward kalman filtering, will enable higher accuracy position determination, and improve position reliability for final payload data analysis by utilising all USBL measurements made during each AUV dive.

Within 12 hours of recovery of the AUV after completing a dive a full set of final post-processed position data shall be available. This will include AUV horizontal coordinates, depth, heading, pitch & roll, and speed values for the AUV track at suitable intervals along each survey line to allow data to be accurately merged with MBE swathe, side scan sonar and sub-bottom profiler data data. The post processed positioning data shall be available graphically and in numeric form.

A full error analysis of the AUV final processed position data shall also be produced. This shall include standard errors of the seven position parameters i.e. x, y, z, pitch, roll, heading, and velocity. Values indicating the internal quality (accuracy and reliability) of the Kalman filter solution shall also be produced to show how well positioning data has been integrated into the filter model. A time series plot showing the difference between the smoothed post-processed solution and the real time solution shall be provided.

Wherever applicable, residuals in positioning measurements shall be provided. In particular residuals for all USBL measurements relative to the final processed AUV horizontal positions will be provided graphically and in numeric form and resolved into along-track and cross-track components.

Sufficient data shall be provided to the COMPANY representative to demonstrate that AUV position data meets the requirements in sections 2.1, 2.2, and 2.3 for each AUV dive. Data provided will include derived accuracy values (standard errors) for each position parameter, values of biases for each measurement sensor and values for the statistical checks resulting from the forward and backward kalman filter analysis. The a priori standard errors for each position measurement sensor shall also be provided.

Final processed position data shall be produced in a format suitable for input to multibeam bathymetry data processing systems and also in a format suitable for input into any other payload data processing system.

The post processed data analysis shall be used to determine the presence of bias, fixed or any other type of systematic or predictable error in any of the positioning systems. Any such errors which are identified shall be logged, explained and a strategy implemented to deal with them. This may result in replacement, physical adjustment or recalibration of the affected positioning equipment.

4 POSITIONING DELIVERABLES

4.1 Co-ordinates

Coordinates of the track of the AUV reference point at regular intervals along each survey line in an agreed ASCII format (e.g. UKOOA P1/90 type) data file, each record will contain the following data:

4.1.1 Survey line name & event number
4.1.2 Date & time of event
4.1.3 Horizontal coordinates (eastings and northings)
4.1.4 AUV depth and altitude and total water depth
4.1.5 AUV heading and speed
4.1.6 Other pertinent data?

The interval between position records may be an event interval of one of the payload sensors or it may be based on time or distance intervals along the survey line tracks.

Each data file will contain a header detailing the name and location of the survey, contractor, client, purpose of the survey, vessel, payload systems used, geodetic and map projection parameters

4.2 Charts

Charts at an agreed scale (e.g. 1:5,000 or 1:10,000) showing the horizontal track of the AUV and the program of survey lines at each site and route to be surveyed, fully annotated with line and event numbers, map grid and scale bar.

4.3 Quality Control Data

Data describing the derived position parameters, their accuracy and the quality of position post processing as described in section 2 and section 3 shall be provided. This data shall be used to assess the actual quality of AUV positioning being achieved in relation to required accuracies and tolerances. This data shall initially be made available to the onboard COMPANY representative and then delivered to COMPANY for ongoing review on a regular basis during the survey.

5. POSITIONING TECHNICAL SPECIFICATIONS

Positioning of the Survey Vessel and AUV shall be conducted through integrated surface and sub-surface positioning systems. It is expected that these will include systems as detailed in the following sections:

5.1 Survey Vessel Positioning Systems

Surface positioning shall be available 24 hours per day throughout the survey area. It is expected that this will generally be by means of a high accuracy differential GPS system or a globally corrected GPS system which can achieve the position accuracy specified in Section 2.1. There shall be redundancy in the differential data links, preferably through the use of dual systems.

The positioning system must be capable of performing quality control functions as described in the UKOOA *Guidelines on the use of Differential GPS in Offshore Surveying*.

A vessel heading sensor with precision of 0.1 degrees and an accuracy of 0.5 degree or better shall be provided, monitored continuously by comparison with a back-up system.

A USBL system used to track the AUV at regular and frequent intervals throughout a dive.

All observed raw data including DGPS, gyrocompass, USBL and attitude data shall be logged in a format to enable vessel position and USBL positions to be reprocessed. All vessel and USBL positions derived in real-time shall be logged. USBL positions of the AUV shall be measured and logged at the fastest rate possible for the water depth in which the AUV is operating. These USBL derived positions shall be used in post processing the AUV position data.

5.2 Positioning of the AUV

Positioning of the AUV is expected to comprise:

5.2.1 An aided inertial positioning system (INS) integrated with seabed tracking Doppler velocity log (DVL) and a three axes fibre optic gyroscope.

5.2.2 Accurate depth measurement using a Digiquartz (or similar) pressure sensor.

5.2.3 A USBL transponder for which horizontal coordinates determined by the surface vessel will be telemetered to the AUV at regular intervals.

5.3 Instrument Calibration and Use

The CONTRACTOR shall ensure that all positioning equipment on the Survey Vessel and the AUV is calibrated and used correctly. It is expected that the CONTRACTOR will have a set of technical specifications covering calibration and use of all positioning equipment. These specifications will be made available to Client for examination on request.

Survey Vessel positioning equipment calibrations shall consist where applicable of gyrocompass, magnetic compass, DGPS verification, USBL acoustic system and associated motion attitude sensors, verification of positioning system offsets, reference directions, etc., and verification of coordinate system transformations. Calibration shall be repeated in the event of any malfunction of the equipment which may nullify earlier calibrations.

Prior to commencing survey data acquisition at the start of a survey The CONTRACTOR shall undertake an AUV sub sea accuracy test. A wellhead of known coordinates or a boxed-in

transponder shall be used as a target for running reciprocal lines in a 12 point star pattern (lines at 30° separation centered on the target). Positions for the wellhead or transponder derived from the AUV pre and post processed AUV navigation, swathe bathymetry and/or side scan sonar data shall be analyzed and presented as a scatter plots and compared with the known coordinates of the target to demonstrate the required accuracies are being achieved for real-time and post processed AUV positioning.

All calibration values and any systematic errors determined by position data analysis will be recorded for each of the navigation systems. This calibration log will be maintained and updated for all successive surveys for each AUV deployed.

5.4 Acoustic Velocity, Water Density and Atmospheric Pressure Determination

Measurement of acoustic velocity profiles shall be regularly undertaken throughout AUV survey operations to ensure optimal performance of USBL and DVL and of acoustic payload systems. A velocity profile shall be determined in the deepest part of each site to be surveyed. Formulae for computing acoustic velocity of propagation in sea water from CTD measurements and average velocity shall be agreed with COMPANY before mobilisation.

Measurement of water density profiles through the water column shall be undertaken regularly throughout AUV survey operations to ensure optimal performance of the pressure sensor for determining AUV depth. Formulae for computing water density from CTD measurements and average density shall be agreed with COMPANY before mobilisation.

Atmospheric pressure shall be recorded at regular intervals during the survey using a calibrated barometer and used to correct water pressure measurements from which AUV depth is determined.

The results of the acoustic velocity and water density profiles shall be delivered to COMPANY.

5.5 Survey Vessel Position Processing System

An integrated positioning computer system shall be supplied which can (by combination of on-line and off-line processing):

5.5.1 be simultaneously interfaced to at least two differential GPS satellite positioning systems and survey gyrocompasses.

5.5.2 monitor DGPS system performance in real time and provide facility to select reference stations and GPS satellites to be used in the final fix calculations.

5.5.3 compute a fully integrated solution using data from all available DGPS systems to derive the vessel's GPS antenna position. Computations will conform to the methods described in UKOOA *Guidelines on the use of Differential GPS in Offshore Surveying*.

5.5.4 provide the helmsman with sufficient information to enable him to maintain Survey Vessel or other steering point on the desired track.

5.5.5 compute and display the position of the AUV relative to the vessel.

5.5.6 log all time-tagged DGPS and USBL data for use in AUV post-processing.

5.5.7 provide on request hard copy track plots of the Survey Vessel and AUV during dive operations.

5.6 AUV Position Processing System

5.6.1 Onboard data processing capability to integrate all positioning measurement data to provide an optimal position solution for the AUV throughout the entire duration of a dive. Full error analysis and quality control of the positioning solution will be undertaken continuously throughout a dive.

5.6.2 All raw and processed positioning data will be recorded to permit reprocessing after completion of a dive.

5.7 AUV Position Post-Processing Capabilities

AUV Position Post-Processing Capabilities should include:

5.8.1 filtering, interpolation, rejection of raw observations, where necessary.

5.8.2 network analysis and testing, and output of quality statistics such as misclosures, error ellipses, standard deviations, residuals, normalised residuals, unit variance, minimum detectable errors, external reliability.

5.8.3 comparison between real time and final processed position data. For a given AUV mission all pre and post plot position differences plotted in the form of a magnitude and frequency graph. A time series plot showing the difference between the smoothed post-processed solution and the real time solution.

5.8.4 kalman filter analysis and testing, and output of quality statistics such as misclosures, error ellipses, standard errors, residuals, normalised residuals, unit variance, minimum detectable errors, external reliability and other standard quality parameters derived by the Kalman filter.

5.8.5 ability to include data which was not used during real time processing including USBL derived positions.

5.9 Positioning Log

A written log shall be maintained throughout the project, recording all positioning activities. Details of equipment calibrations, acoustic velocity determinations, equipment reconfigurations and any other event or issue that may impact AUV or vessel positioning will be recorded.

BP TECHNICAL SPECIFICATION 3150(AUV)

TECHNICAL SPECIFICATION FOR SWATHE BATHYMETRY (for AUV's)

Revisions	Rev. 05	March 2007	AWH Common Format, sub-metre cell sizes
	Rev. 04	August 2005	TPD Calibration & procedures
	Rev. 03	14 August 2000	AWH for AUVs

1. GENERAL

A swathe or multibeam bathymetry system capable of acquiring data in water depths across the survey area to the accuracy given in the scope of work shall be supplied as an integral part of the AUV system supplied.

1.1 System Provision

The system should include provision for UPS facilities for each sub system and have full onboard processing and colour A0 plotting facilities. The processing system and acquisition system computer hardware should have full redundancy to ensure no hiatus in operations owing to hardware failure. This shall mean that there shall be at least one back up acquisition computer system and at least one back up processing computer system. Even if common hardware is used, there shall still be full redundancy to allow parallel processing of two sets of data. The back up plotter may be a black and white plotter.

1.3 Motion Sensor

A high quality attitude measuring system capable of roll accuracy measurement of at least $\pm 0.05^{\circ}$ and 100 Hz data output rates must be fitted as an integral part of the AUV system. The data shall be recorded in such a manner as to allow stabilization before data acquisition. In view of the importance of the motion sensor system a spare such motion sensor shall be carried.

1.4 Timing

Timing of all main and sub sensors associated with the acquisition of swathe bathymetric data shall be controlled by a 1pps output signal from the AUV's integrated navigation system and that has been synchronized to the surface Vessel's GPS receiver at the start of the dive.

1.5 Raypath Analysis

Raypath analysis shall be carried out based on acoustic velocity profiles measured in the working area before commencement of data acquisition to determine the effects of refraction on all of the beams of the swath.

2. SYSTEM REQUIREMENTS

The system employed shall be capable of the following.

2.1 Calibration

Calibration of the AUV mounted swathe bathymetry system shall be performed prior to the start of survey data acquisition by undertaking a patch test or similar procedure. The calibration procedure shall be submitted to COMPANY in writing for approval at least two weeks before mobilisation commences. The purpose of the calibration is to determine the values of all the systematic errors involved in using the AUV mounted swathe system to measure seabed bathymetry and to ascertain position accuracy of the AUV.

The systematic errors to be determined by the calibration include timing and offset errors between the various sensors, attitude sensing errors including pitch, roll and yaw, horizontal positioning, depth and heading errors. The choice of site and water depth for the initial swathe calibration is seen to be important as is the presence of a seabed feature to provide a target for the swathe system to detect and to assist in the calibration process. The best target is one whose position is accurately known such as a wellhead or a seabed transponder (such as the transponder used for USBL calibration). The procedure shall describe in detail criteria for selecting the calibration site and seabed target.

The written calibration procedure shall be comprehensive, detailed and rigorous and at the very least describe and quantify the following:

2.1.1 Equipment, devices and ancillary systems to be used.

2.1.2 Personnel and their functions involved in the calibration.

2.1.3 Environmental and operational criteria and selection of calibration site.

2.1.4 Limitations or constraints on the calibration operation or the quality of calibration results.

2.1.5 Calibration programme schedule including sequence of events and expected durations.

2.1.6 Offset measurements and requirements from navigation systems.

2.1.7 Determination of acoustic velocity and any other measurements required in support of the calibration.

2.1.8 Correct operation of each positioning, attitude sensing and depth measuring system.

2.1.9 Vessel operations for data gathering including a calibration line plan showing geometry of AUV path, height above seabed and heading in relation to the calibration site and seabed target.

2.1.10 Position and attitude data to be gathered and logged including formats.

2.1.11 Minimum quantity and quality of data to be gathered.

2.1.12 Data processing software including techniques and user options.

2.1.13 Parameters to be determined by the calibration and their accuracy.

2.1.14 Results of the error analysis and how this information is to be used.

2.1.15 Acceptance criteria definitions for assessing calibration results.

2.1.16 Details about how are the calibration parameters are to be used.

2.1.17 Verification methods to demonstrate that the calibration results are within the

acceptance criteria and that they have been implemented correctly into the AUV mounted swathe data acquisition and processing system.

2.1.18 Acceptance criteria definitions for assessing verification results.

2.1.19 Assess impact of water depth and seabed target availability at the calibration site on:

i. data gathering and processing methods
ii. calibration quality including accuracy of derived parameters
iii. acceptance criteria for calibration and verification results

2.1.20 Sign conventions used for geometrical parameters (e.g. offsets, pitch, roll & heading) for the positioning and attitude sensing systems.

2.1.21 Comparison with results of previous swathe calibrations and explanation of trends and anomalies in the results.

2.1.22 Contents of calibration report to be submitted to COMPANY.

2.1.23 How is ongoing performance of swathe bathymetry system in terms of accuracy and reliability to be assessed during survey operations.

2.1.24 Criteria for undertaking repeat calibrations or accuracy verifications of the AUV mounted swathe system.

2.1.25 QC/QA of swathe system calibration.

2.1.26 It is expected that the procedure will include a detailed description of all HSE aspects of undertaking the calibration including results of a risk assessment.

In addition to the calibration report all data gathered during the swathe calibration and verification operations shall be made available to COMPANY in a standard industry format to permit calibration data to be independently processed by a third party.

2.2 Quality Control

Demonstrating that it is functioning correctly and acquiring acceptable data during data acquisition. Quality control functions should include:-

2.2.1 Real Time Coverage Display

A display indicating the AUV position with corrected heading input and the actual swathe coverage achieved, as the AUV progresses shall be visible in real time. It is permissible, although not preferred, to use an agreed, theoretical, value of swathe coverage with which to display achieved track and overlap, but there must be an independent display of actual profile achieved on a separate page of the system. It shall be made clear whether the coverage display is derived from all beams or only a specific swath of beams. The actual survey line shall be depicted using a separate color.

2.2.2 Vessel Attitude

A real time graphical display of scaled, continuous values of the pitch, roll, and heave of the vessel shall be shown.

2.2.3 Error Calculation

Establishing roll, pitch, heave, heading, timing and velocity and tide reduction errors.

2.2.4 Intersection Mis-ties
A real time capability shall exist to extract the center beams and analyze intersections mis-ties.

2.2.5 Altimeter or Sub-bottom Profiler Comparison
A capability in real time to extract the center beam profile and comparing with the simultaneously recorded altimeter, and, or, sub-bottom profiler data from the seabed return.

2.2.6 Ray Bending Error Calculation
A capability to compare outer, mid and center beams to assess quality of data and ray bending errors.

2.2.7 Adjacent Line Comparison
Extracting and comparing depths in the same horizontal profile acquired from adjacent lines.

2.2.8 Error Correction
The system shall be fully capable of correcting errors calculated as detailed above.

2.3 Data manipulation

The system should be able to:

2.3.1 Test Area Extraction
use a test area to determine the most suitable cell size, data rejection criteria and gridding approach to be used in processing the entire dataset.

2.3.2 Data Weighting and Rejection
Weight or reject data based on offset from the vertical/central beam.

2.3.3 Variable Cell Size
Have a selectable processing cell size including 0.25, 0.5, 1, 2, 3, 5, and 10m.

2.3.4 Data Density
Have a method for determining data density and standard deviation of data in any cell.

2.3.5 Difference Plots
Be capable of producing raw vs. processed data difference plots.

2.3.6 Datum Correction
Be able to correct depths to the specified sounding datum.

2.4 Products

The system should be used to produce swathe bathymetry acquisition and processing products for delivery to the COMPANY that portray the seafloor in a variety of ways. Each product shall be delivered in an industry standard format for use by third party software systems. It is envisaged that data sets will be used as input files to IVS Fledermaus.

The following products are required:

2.4.1 Raw Multibeam Echosounder Measurement Data

Raw data shall be supplied as Generic Sensor Format (GSF) data files which shall incorporate AUV position, depth, heading and attitude such that the swathe bathymetry data can be rigorously and fully processed by a third party. All data shall be accurately time tagged with AUV system time. Acoustic velocity profiles recorded during the survey shall also be provided.

2.4.2 Processed Multibeam Echosounder Data

Processed swathe bathymetry data shall be supplied as XYZ ASCII data files with one data record for each swathe bathymetry spot depth. Data shall be arranged such that depths from adjacent or overlapping survey lines can be easily distinguished.

2.4.3 Digital Terrain Models (DTM)

A regular gridded DTM with grid interval or cell size agreed with COMPANY shall be supplied as XYZ ASCII data files. COMPANY may request a triangulated DTM in addition to or instead of a regular gridded DTM.

2.4.4 Contour Maps

Appropriately smoothed water depth contour maps in digital form at various contour intervals as requested by COMPANY.

2.4.5 Colour Coded Maps

Colour-banded maps of water depth, in digital and hard copy form, with color scale clearly displayed in the map legend.

2.4.6 Backscatter Imagery

Logged backscatter data shall be processed to produce and plot properly scaled and georeferenced pseudo-sonar mosaics of the seafloor in GeoTIFF format.

2.4.7 Perspective Displays

Isometric perspectives or false relief displays with selectable view and illumination parameters shall be available and used to produce overview images of the survey area and to illustrate seabed features and areas of interest.

2.4.8 Seabed Profile

Seabed profiles generated from the DTM along random lines between a series of chosen points. This information shall be available as XYZ ASCII data files for use by other data processing systems or as a line section on a chart.

2.4.9 Seabed Gradient Displays

Colour coded displays showing the seabed gradient as calculated direct from the raw swathe bathymetry data, the processed swathe bathymetry data or the final seabed DTM.

2.4.10 Attribute Data

Attribute data files in ASCII format in the form XYA (where XY is horizontal position and A is a recorded attribute) shall be produced for swathe bathymetry backscatter and other recorded attributes. A sample tape of data in the proposed format shall be submitted to COMPANY by CONTRACTOR for approval prior to submission of the final data set(s).

All digital data shall include, where appropriate, comprehensive header records and/or comprehensive metadata files.

3. DELIVERY

Unless specified otherwise in the Scope of Work all swathe bathymetry products shall be delivered to COMPANY with the final written report for the survey.

BP TECHNICAL SPECIFICATION 3301(AUV)

TECHNICAL SPECIFICATION FOR AUV SIDE SCAN SONAR PROFILING

Revisions	Rev. 07	October 2009	AWH/MF Mosaic and field data delivery formats defined.
	Rev. 06	March 2007	AWH Format and added detail to Mosaic chart and GeoTIFF requirements.
	Rev. 05	August 2000	AWH For AUV Operations
	Rev. 04	February 1997	AWH Layout, content and arrangement.

1. GENERAL

A dual frequency side scan sonar system shall be provided that is an integral part of the AUV system. The system shall be capable of ranges to in excess of 250 metres on each channel to obtain seabed imagery data in a digital and permanent graphic form.

1.1 Operation

The transducers used shall be rated as being capable of deployment to a depth in excess of the maximum water depth expected in the area of Work. The equipment shall be used to obtain optimum resolution data across the site of Work. To achieve this aim the equipment shall be operated to the manufacturer's specifications. The transducers shall be washed with soap and water before deployment to ensure that they are free of grease or oily deposits.

1.2 Coverage

Complete coverage of the survey area should be achieved with a range per channel that should provides 100% overlap of data if the Company specified line spacing allows, and with a definition that allows clear identification of seabed features.

1.4 Additional Coverage

Where possible seabed hazards are identified, further side scan sonar cover from a different direction and at different range and frequency setting may be required by Company.

1.5 Quality Control

A properly annotated (range ticks, fix marks etc) continuous waterfall record of the acquired data, or sub-sample thereof received via the AUV Acoustic Data Link, shall be visible on the Payload Console throughout the AUV's dive.

1.6 Spares

A spare sonar system and a complete manufacturer's spares kit shall be provided. Adequate hardware and consumables for the duration of the envisaged operations shall be carried.

2. DATA RECORDING

The side scan sonar data shall be digitally recorded with fix marks, fix annotation data, AUV heading, and all other data necessary to accurately reproduce the field records. The data shall be post processed to allow signal conditioning and mosaicing, to be performed.

Processing shall be performed aboard the vessel as the survey proceeds using hardware installed aboard the vessel.

2.1 Computer Generated Sonar Mosaics

A seabed image covering 100% of the survey area shall be produced as a sonar mosaic as well as individual mosaics of single lines. To this end the CONTRACTOR shall have the facilities available to process the recorded side scan data aboard the vessel.

Processing shall include:

2.1.1 Slant range correction.

2.1.2 AUV heading correction (if available).

2.1.3 Beam forming of individual scans in the cross line direction to correct for:

i) Side lobe amplitude effects
ii) Outer range amplitude decay

2.1.4 Balancing of along track amplitude variations.

2.1.5 Plotting of the true recorded position and direction of each scan to take account of the heading yaw of the AUV.

2.1.6 Preference is for the final mosaic to be built interactively, in the presence of a COMPANY representative, to verify that the choice of overlap preferences of adjacent lines is not obscuring important interpretive detail.

2.1.7 Processed Data Format Requirements

2.1.7.1 Sonar Mosaics shall be delivered as geotiff files with all the correct geo-referencing metadata embedded within the .tif files. Where mosaics are large, they shall be broken up into sections so that .tif file sizes are no more than 200 megabytes. The sub-sections of the mosaic shall be designed so that adjacent panels abutt each other and there are no white background areas obscuring mosaic data when all the .tif files for a survey area are displayed at the same time.

As well as the fully geo-referenced geotiff files, a separate set of .tfw world files shall be provided. Each .tif file shall have an accompanying .tfw file.

2.1.7.2 Individual Processed Lines used to build a mosaic shall be saved as standalone .tif files with accompanying .tfw file and delivered to COMPANY to allow the reconstruction of a mosaic as required.

2.2 Deliverables

2.2.1 Charts

Final side scan mosaic charts shall either be produced at a scale of 1:5000, or at scales requested in the Scope of Work, unless otherwise advised by COMPANY, and shall include annotation as detailed in BPXS Reporting Specification 7010.

Charts shall be output at an adequate pixel size, or plotted on a plotter of adequate resolution, to not lose relevant interpretive detail of the mosaiced data.

2.2.2 Digital Data

CONTRACTOR shall produce and deliver to COMPANY on an agreed medium each individual sonar line saved as an .xtf file.

These .xtf files shall contain the raw (i.e. not slant range corrected) side scan sonar data with fully processed (final position) navigation data embedded.

The complete set of .xtf files for the survey shall be delivered to BP within 30 days of completion of the survey.

All digital data delivered to COMPANY shall include, where appropriate, comprehensive header records and/or comprehensive metadata files.

BP TECHNICAL SPECIFICATION 3302(AUV)

TECHNICAL SPECIFICATION FOR AUV SUB BOTTOM PROFILING SURVEYS

Revisions	Rev. 06	March 2007	AWH Common Format
	Rev. 05	August 2000	AWH for AUVs
	Rev. 04	February 1997	AWH Major update

1. GENERAL

A sub bottom profiler shall be operated simultaneously with the multi-beam bathymetry system and side-scan sonar and be an integral part of the AUV.

Equipment shall be provided to support the simultaneous operation of multiple profiling systems without evidence of interference between these and other survey systems.

1.1 Chirp Systems

In areas where the technology has been shown to provide good results a Chirp system of suitable bandwidth and power (whether integrated with side scan sonar or not) may be considered for use by COMPANY. If CONTRACTOR wishes to propose use of such a system, CONTRACTOR must submit sample data records from a comparable operational area to prove the applicability of the system.

1.2 Equipment Operation

The sub bottom profiler shall be set up to obtain maximum penetration and resolution across the site. To achieve this aim, the equipment shall be operated to the manufacturers' specifications and set up to produce optimum records in terms of pulse length, signal to noise ratio etc.

1.3 Spares

A complete manufacturer's spares kit and other ancillary supplies shall be provided for each sub bottom profiling system carried, including consumables appropriate for the anticipated duration of operations.

1.4 Mobilization Tests and Calibrations

1.4.1 Mobilization Tests

During mobilization the system shall be wet tested in harbor and proven to be operable at maximum power level and firing rates for a period of one hour.

1.4.2 Acceptance Trials

During acceptance trials the profiler system shall be tested in accordance with the appropriate manufacturer's test procedure to prove that the source output meets the manufacturer's specifications and those quoted by CONTRACTOR in their tender documents. For this purpose a storage oscilloscope and a calibrated hydrophone, with a suitable frequency response for the system being tested, should be provided. Details of the hydrophone calibration shall be available on board.

2. DATA RECORDING AND PROCESSING

2.1 Quality Control Display

A properly annotated (timing lines, fix marks etc) continuous waterfall record of the acquired data, or sub-sample thereof, received via the AUV's Acoustic Data Link, shall be visible on the Payload Operator's Console throughout the dive.

2.2 Online Signal Processing

The field acquisition system shall include a band pass filter and a TVG amplifier for data enhancement, as a minimum, either in the form of individual filters or a combined processing system such as the TSS360. The system should also be capable of displaying the data relative to the true seabed profile, in real time, through use of the AUV's altimeter and depth sensor data.

2.3 Recording

All data shall be recorded digitally. The chosen sample rate must be adequate to record and preserve the full signal bandwidth of the profiling system in use. Data shall be recorded with fix marks, fix annotation data, time, and all other data necessary to accurately reproduce the field records. The purpose of recording the data is to enable post acquisition processing to be performed. The chosen recording format should be accessible to any post processing software provided by CONTRACTOR.

2.4 Post Processing and Output

Profiler data, recorded in 2.3 above, is required to undergo full post acquisition processing to the point of producing full workstation compatible SEG-Y tapes.

Such processing shall undergo rigorous quality control, all test panels and parameter selections shall be presented to COMPANY or COMPANY's onboard representative for approval. A full set of SEG-Y format data files shall be delivered to COMPANY with no more than one survey line per data file. If a modified SEG-Y format is used then a full description of the modified format shall be provided.

Where appropriate the delivered data file shall include comprehensive header records and/or comprehensive metadata files.

BP TECHNICAL SPECIFICATION 3042

TECHNICAL SPECIFICATION FOR AUV POSITIONING AND MBE QUALITY CONTROL OUTPUTS

Revisions	Original	October 2007	TPD / AWH

1. GENERAL

AUVs, by their very nature, are complex systems requiring careful quality control. The quality of the imagery that AUV sensors can now deliver in turn requires the most accurate navigational control to ensure that positioning artifacts are not imprinted onto the imagery that detract from the overall survey data quality and interpretability.

The specification is not, nor is it intended to be, comprehensive. It is intended to address aspects of AUV survey data processing that require careful attention during a survey to ensure problems are not spotted in the field. There will be other parameters that data processors may find useful to assess, or monitor, when working with GPS / USBL / AUV / MBE data and these should also become part of a data QC package at the Contractor's discretion.

The time-plots, maps, charts, and statistics described are only useful if they are routinely produced in a convenient format and readily available onboard the survey vessel to survey staff and the Company Onboard Representative(s) to evaluate the quality of positioning and sensor quality as a survey proceeds and are retained fro reference by personnel working with the survey data after the survey has been completed.

The prime users of QC data should be the survey contractor to satisfy themselves that data quality is of the required standard. Some of the QC requirements suggested will be meaningful only to surveyors, or those specialising in some aspect of survey data processing. Suitably educated, trained, and experienced personnel will be required to make full use of the QC data.

Making QC data available to Onboard Company Representatives, and including them as part of the final package of Operations Report deliverables, to Company is imperative.

2. START-UP AND MANAGEMENT OF CHANGE

At the start of each survey, or whenever any equipment is replaced, or maintained, and at regular intervals through a survey, a list of all offsets between all positioning sensors is to be generated, including GPS antennae, USBL transducer, attitude sensor, etc.

A similar list shall be recorded for all in AUV sensor offsets.

The offsets should be the values actually being used in online data processing. A check list shall be recorded at the start of AUV sensor processing to record all sensor and antenna offsets input to the processing of navigation or sensor data. The check-list will be cross checked and signed off for correct application: values used, correct sign convention etc., by the Senior onboard Surveyor, or Party Chief. The cross checked log shall be incorporated in the Operations or Processing Report.

3. GPS POSITIONING

For surface positioning by GPS of the AUV control, or mother, vessel the following displays shall be available on a per line and, or, per dive basis:

3.1 PDOP and HDOP

Time-plot of GPS PDOP and HDOP of constellation actually observed - for primary and secondary systems. Displays should highlight periods of low values, e.g. below 5.

3.2 Number of Satellites

Time-plot of GPS number of satellites actually observed - for primary and secondary systems. Displays should highlight high values, e.g. 5 or more.

3.3 GPS Antenna Height

Time-plot of GPS measured antenna height (if tide and geoid variations removed this should be almost constant, but will show system noise and un-removed heave. Any drift, steps or trends may indicate horizontal position problems)

3.4 3D Position

Time-plot of 3D position differences between primary and all secondary GPS systems - corrected for offsets and pitch, roll and heave (differences should be small and within expected limit - exceeding the limit indicative of positioning problems)

3.5 Attitude Sensor Data

Time-plots of attitude sensor data (pitch, roll & heave) might be useful to investigate positioning problems.

3.6 Time Series Statistical Parameters

Statistical parameters for all time series should be evaluated: maximum, minimum, average and standard deviation values. Also time intervals between consecutive data measurements should be statistically summarised - especially maximum interval between measurements and, perhaps, number of occasions a pre-specified interval is exceeded. This would help identify the nature and severity of data outages.

3.7 Display Periods

The period for which time-plots and statistics can be presented should be interactive such that the entire duration of each dive can be seen overview, while review of shorter durations, to investigate positioning problems, can be immediately facilitated.

4. USBL/AUV POSITIONING

4.1 Raw to Final Position Differences

Time and map plot showing position difference between final post processed AUV position and raw USBL position at the time each USBL position is recorded.

This data should be resolved into range & bearing, along-track & cross-track and dE & dN position differences.

Position difference values should be small with zero mean. Any trends, jumps, or omissions would be indicative of problems, especially if they occur at survey line SOL or EOL.

This is seen to be a necessary QC requirement as it will reveal the magnitude of noise in USBL measurements, and help to identify the presence of systematic errors in USBL data.

4.2 AUV vs. Vessel Track

A time-plot shall be produced showing location of AUV relative to the survey vessel.

This data shall be resolved into range & bearing, along-track & cross-track and dE & dN position differences.

Some systematic errors affecting USBL positioning may be a function of relative position and these plots may assist in identifying if such effects are occurring.

4.3 Real-Time vs. Final Processed AUV Position

A time-plot and map plot showing differences between real-time and final post processed AUV positions shall be available post-dive.

Time series data should be resolved into range & bearing, along-track & cross-track and dE and dN position differences.

These plots will show impact of post processing. Any unusual differences, trends, or anomalies, that may be indicative of positioning problems, shall be resolved.

4.4 USBL Position Update Interval (On-line)

A time-plot showing time interval between consecutive USBL position updates telemetered to the AUV shall be produced.

It is expected that the update interval should be no greater than 30 seconds.

Larger values may point to AUV tracking problems and or poor data quality.

Data shall be summarised statistically and shall highlight maximum data outages (Ref: Section 3.6 in GPS Positioning, above).

4.5 USBL Position Update Interval (Post-Processed)

Similar to 4.4 above, a time-plot showing time interval between consecutive USBL updates used for AUV final post processing shall be produced.

It is expected that the update interval should be about 5seconds, larger values will indicate loss of USBL tracking and hence lower reliability/accuracy in AUV position.

Data shall be summarised statistically and shall highlight maximum update intervals (Ref: Section 3.6 in GPS Positioning, above).

4.6 AUV Pitch, Roll and Heading

A time-plot showing pitch, roll and heading values shall be produced.

Time series should be stable during a dive, along survey lines, and from dive to dive, unless otherwise indicative of control problems or response to rugged seabed.

4.7 Kalman Filter Displays

4.7.1 DVL "Bias"

A time-plot showing Kalman filter "bias" (or residual) in measured doppler velocity log values shall be produced.

It is expected that the value should be small and constant. A large value would indicate incorrect calibration/alignment and a variable bias would indicate either poor DVL tracking or another positioning problem.

4.7.2 Pitch / Roll "Bias"

Time-plot showing Kalman filter "bias" in pitch & roll measurements (these should be small and constant - large values indicates incorrect calibration/alignment and a variable bias may be indicative of positioning problems)

4.7.3 Derived Standard Errors

Derived standard error, or precision, of the computed final Kalman Filter derived position parameters including:

i) Easting
ii) Northing
iii) Depth
iv) Pitch
v) Roll
vi) Heading
vii) Velocity

shall be displayed in time-plots with the expected tolerances of the supplier of the integrated INS software shown as reference lines. Displays should highlight where tolerances have been exceeded.

Displayed values should be small and within the integrated INS supplier's prescribed tolerances.

4.10 As-Sailed vs. Planned AUV Position

A time-plot and map plot shall be produced showing the difference between post-processed AUV position and intended, or pre-plot, position. The displays will show AUV tracking error with respect to intended survey lines.

4.11 Statistical Representation

All the named parameters described for display in the time plots above shall be expressed statistically: maximum, minimum, average, and standard deviation values.

4.12 Problem Investigation

All time-plot data for GPS positioning and AUV positioning should be directly linked to AUV track data such that if an issue is identified, on any of the time-plots, then the location it occurred can be readily identified on a map showing the relevant part of the survey line.

Conversely, if a positioning problem is suspected on a survey line the appropriate section of time plot data should be readily found and displayed. A benefit of time-plots is that data outages are, usually, easy to identify.

QC display software should provide assistance in highlighting data outages and times when prescribed tolerances are exceeded.

Owing to the nature of AUV surveys, where each dive consists of many separate survey lines, it will be difficult to design map plots (ie charts) showing the parameters requested in a format that is readily understandable and usable. Some creativity will be required to output a readily interpretable series of displays.

5. MBE DATA PROCESSING

Onboard processing of MBE data is important not only for delivery of an early final data set upon project completion (in keeping with requirements of BPXS 3i50AUV) but also in terms of the capability to analyse immediately post-dive the performance of the MBE system and identify faults. As such the following displays are required to be produced onboard the vessel to gauge system performance.

5.1 Bin Charts

The following types of bin charts shall be produced as the survey proceeds:

5.1.1 Chart showing number of raw data hits for each data processing bin (cell).

5.1.2 Chart showing number of data hits per bin after editing and which are used in the final processed solution.

5.1.3 Chart showing number of hits per bin which have been edited out (i.e. removed) from the final processed solution.

5.1.4 Chart showing standard deviation of the data hits within each bin of the final processed solution.

5.1.5 Chart showing the maximum range of data values within each bin of the final processed solution.

5.1.6 Chart identifying bins with no, or insufficient, data to be reliably binned. Chart should indicate whether final processed solution treats the bins as empty (i.e. holes) or filled with "smoothed" or "interpolated" depth values from adjacent bins. If interpolation is used the maximum search radius that is used should be clearly stated.

5.1.7 Chart showing the depth difference per bin between overlapping swaths, including adjacent parallel swaths and tie lines.

All the MBE data processing QC charts should be suitably colour coded. Bins in which values exceed prescribed project tolerances should be readily identifiable.

QC charts should be available for onboard client review at all times and should be delivered with the final processed DTM.

BP TECHNICAL SPECIFICATION 7001(AUV)

TECHNICAL SPECIFICATION FOR AUV ON BOARD DATA ORGANISATION

Revisions	Rev. 05	March 2007	AWH minor additions and common format.
	Rev. 04	12 August 2000	AWH for AUVs
	Rev. 03	6 February 1997	AWH Structural and format changes

1. RECORD MANAGEMENT

1.1 Data Logs

An overall data log shall be kept which tabulates:

- Date,
- Dive Number
- Dive Time,
- Line Numbers,
- Start and End Times
- Start and End Fix numbers
- Equipment Used per Line.
- Recovery Time

To ensure close control on accumulated acceptable data coverage, a spreadsheet or database system shall be used to keep track of lines run/shot, required reruns and data holes, anomalies etc. A similar strategy shall be adopted for inspection of post-plotted sonar and profiler records.

1.2 Payload Operator's Logs

A detailed Observer's Log shall be completed for each survey line by the Payload Operator. It shall include remarks on record quality or important features along each line.

1.3 Changes in Set Up

Full details of any changes in payload sensor or control settings whilst running a line shall be marked in the records as an operator change and shall be written in the Observer's Log for that line.

1.4 File and Tape Annotation

All disk files names shall follow a standard nomenclature to differentiate project name, sensor type, dive number, etc.

Derived magnetic, or optical, data tapes will be carefully and consistently annotated for each survey line and sensor type with the following information:

- Client,
- Project name,
- Area of work,
- Data Type,
- Water Depth (approx.),
- Line Number,
- First and Last Fix Numbers,
- Recorder Scale / Range,
- Scale Line Interval,
- Equipment used.

Where appropriate the following information will also be included:

- Firing / Print Sequence,
- Time Delay,
- Power or Frequency of Operation,
- Band Pass Filter Settings.
- Processing details (Swath, Sonar or Profiler Data)
- Output Resolution (Cell size, pixel size, etc.)
- Output data format (XYZ Ascii, GeoTIFF, SEG-Y etc.)

1.5 Fix Annotation

On paper records fiducial fixes will be numbered at least every five fixes and cross checked between all data recorders every ten fixes and at the end of each line.

2. ON BOARD DATA COVERAGE DISPLAYS

A capability shall exist to produce the following types of coverage display aboard the survey vessel as the survey progresses either during a dive or immediately after completion.

2.1 Bathymetry

Charts shall be produced showing unreduced, but motion compensated, water depth data, preferably color coded by selectable depth range, in real time, or immediately post dive, to show that coverage has been achieved or where infill is required. Each chart shall show the applicable projected coordinate system grid, a scale fraction, and be clearly labeled to show whether depths are uncorrected or reduced to project vertical datum. Preference is for the chart to be shaded with an artificial sun illumination to highlight acquisition or processing artifacts. Charted depths shall include all high and low points along each profile. Final charts of this type, when required, are to be produced before the vessel leaves location to ensure 100% coverage of the survey area.

2.2 Side-Scan Sonar

Where side scan sonar is being used, a chart shall be produced depicting the area of insonified seabed thus highlighting any gaps in seabed coverage. For this purpose, a distance equal to 80% of the sonar operating range applied perpendicular to the fish track from the fish position shall be used as an assumed maximum coverage range.

2.3 Sub-Bottom Profiling

Charts showing source track shall be produced. Such charts shall be produced on a continual update basis whilst the dive/survey is in progress, and plotted at a scale suitable to show any irregularities.

Attachment 8

SIMOPS

BP SIMOPS
Once the DD III leaves the survey area in early March there are currently no plans for BP vessels to be working in the survey area. The BP SIMOPS coordinator is Geir Karlsen.

Geir Karlsen
Geir.karlsen@bp.com
281-366-4880 office
713-855-7369 mobile

NOAA-NRDA SIMOPS
The following vessels are scheduled to be in the survey area during March:

WHOI Oceanus (March 8th – 30th)
Towed video plankton imaging
WHOI Contact: Eric Benway 508-548-1400
NOAA Contact: Chad Smith 617-999-4163
Vessel Satcom:011-882-651-453-509
Vessel e-mail: master@oceanus.whoi.edu

NOAA Ship Oregon II
Towed nets and CTD casts
NOAA Contact: Chad Smith 617-999-4163
Vessel Satcom: 011-8816-7633-5993
vessel e-mail: Noaa.Ship.Oregon@noaa.gov

M/V Meg Skansi (In field till March 20th)
Mid water net tow
Dr Joni Harney (Entrix/BP) - 407-408-3154
e-mail: JHarney@entrix.com
Vessel e-mail: Nick.Bach@moellerinc.com
Sat Phone: 985-520-4398 or 4399

M/V Nick Skansi (In field until March 20th)
Mid water net tow
Dr Joni Harney (Entrix/BP) - 407-408-3154
e-mail: JHarney@entrix.com
Sat Phone: 985-241-4494 or 4495

The NOAA-NRDA Vessel Coordinator is Chad Smith.

Chad Smith
chad.smith@darkwatermarine.com
617-999-4163

Attachment 9

Survey Corner Points

Corner #1

28° 48' 05.982" N
88° 16' 42.995" W

1 231 029.32 ft E
10 454 400.00 ft N

UTM Zone 16N, NAD27, US Survey Feet

Corner #2

28° 48' 00.704" N
88° 25' 30.039" W

1 184 142.98 ft E
10 454 400.00 ft N

UTM Zone 16N, NAD27, US Survey Feet

Corner #3

28° 44' 13.929" N
88° 30' 36.861" W

1 156 559.93 ft E
10 431 837.02 ft N

UTM Zone 16N, NAD27, US Survey Feet

Corner #4

28° 37' 39.479" N
88° 28' 37.855" W

1 166 659.22 ft E
10 391 873.19 ft N

UTM Zone 16N, NAD27, US Survey Feet

Corner #5

28° 35' 51.850" N
88° 26' 09.708" W

1 179 728.42 ft E
10 380 844.43 ft N

UTM Zone 16N, NAD27, US Survey Feet

Corner #6

28° 37' 34.437" N
88° 23' 07.691" W

1 196 070.18 ft E
10 391 011.90 ft N

UTM Zone 16N, NAD27, US Survey Feet

Corner #7

28° 40' 12.537" N
88° 21' 42.528" W

1 203 840.00 ft E
10 406 888.92 ft N

UTM Zone 16N, NAD27, US Survey Feet

Corner #8

28° 40' 15.512" N
88° 16' 37.271" W

1 231 029.32 ft E
10 406 888.92 ft N

UTM Zone 16N, NAD27, US Survey Feet