PROJECT EXECUTION PLAN

ATLANTIS (EMERALD NETWORKS) CABLE SYSTEM

PREPARED FOR

TE SUBSEA COMMUNICATIONS LLC

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Appendix A – Scope of work

GLOSSARY OF TERMS AND ABBREVIATIONS

A list of abbreviations that may have been used within the main body of this document

ATT	Admiralty Tide Table
BSB	Below Sea Bed
C-O	Computed - Observed
CAD	Computer Aided Design
CM	Central Meridian
CPT	Cone Penetrometer Testing
DF	Dual Frequency
DGPS	Differential Global Positioning System
GSL	GEMS Survey Ltd
GPS	Global Positioning System
HF	High Frequency
HSE	Health Safety and Environment
KHz	Kilohertz
km	Kilometer
LAT	Lowest Astronomical Tides
LF	Low Frequency
m	Meter
MBES	Multibeam Echo Sounder
MRU	Motion Reference Unit
MSL	Mean Sea Level
MV	Motor Vessel
OPM	Offshore Project Manager
OTS	Over the Side
QA/QC	Quality Assurance / Quality Control
QINSy	Quality Integrated Navigation System
SBP	Sub Bottom Profiler
SSS	Side Scan Sonar
SVP	Sound Velocity Profile
UK	United Kingdom
UTC	Universal Time Co-ordinated
UTM	Universal Transverse Mercator
WGS84	World Geodetic System 1984

1. PROJECT OVERVIEW

GEMS Survey Ltd have been contracted by TE SubCom of Morristown, USA to perform analogue geophysical and geotechnical survey along a proposed cable route from the beach landing site at Southport, UK via a branching unit (BU) to the 1500m contour offshore St Johns, Canada and from the BU to the beach landing site at Reykjanesta, Iceland.

The project will be divided into deepwater (>1500m), shallow water (20-1500m), nearshore (3-20m), diver swim and beach landing surveys. The Kommandor Jack will undertake the deep and shallow water surveys with the Navigator or suitable locally chartered vessel undertaking the nearshore work. Divers will survey from the beach landing to 3m and land surveyors will survey the beach.

The Atlantis cable system is a planned fibre optic network intended to connect data centres in Iceland to Europe and North America. TE Subcom will use the data collected on this survey to design, manufacture and install the subea cable.

The project is scheduled to mobilise on 31 July 2011.

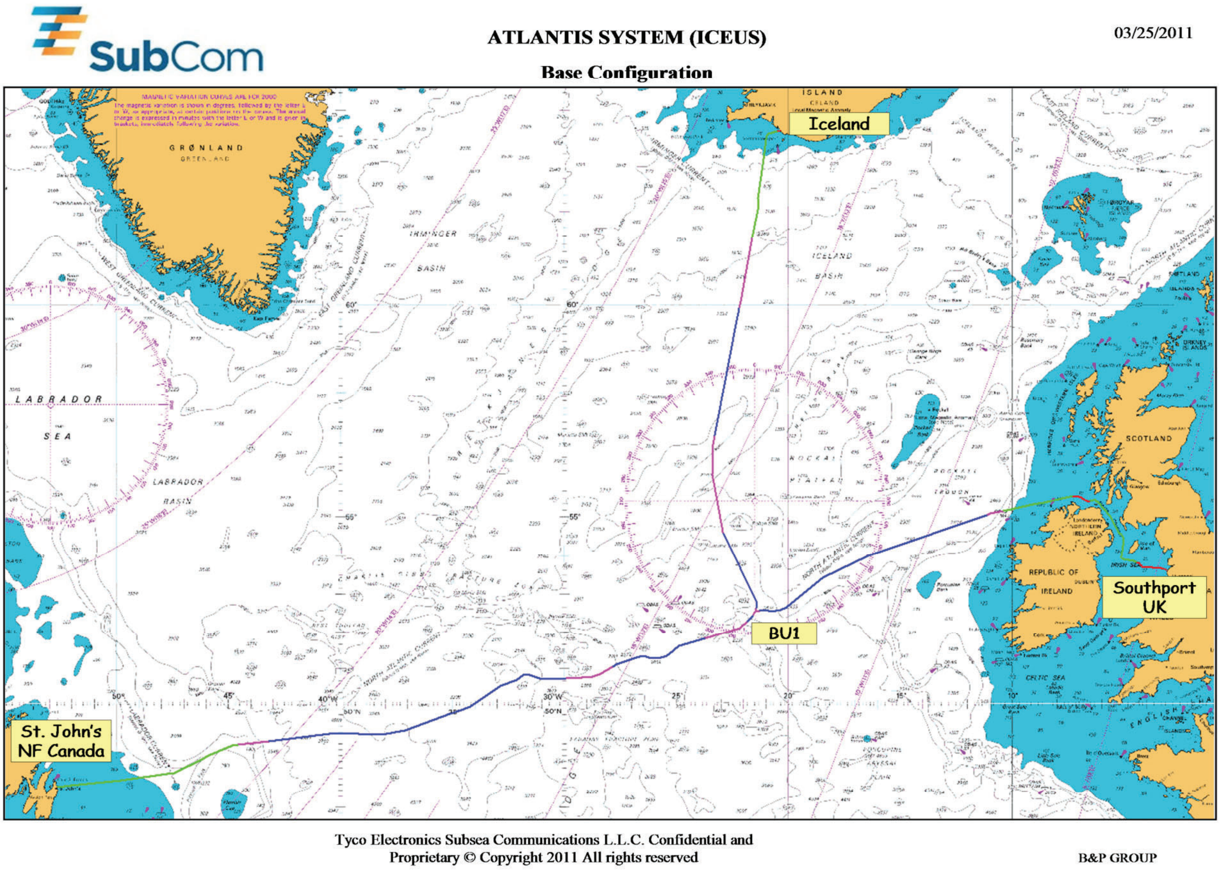


Figure 1: Project Area Chart

1.1 Document Overview

The objective of this Project Execution Plan is to detail the following aspects of the project:

- Project management structure
- Personnel / responsibilities
- Scope of work including processing and reporting deliverables
- Plan of work
- Location and geodesy
- Vessel and survey equipment

Further documents that would apply to this project include:

- Contract between GEMS and TE Subsea Communications LLC
- GEMS Group Integrated Management System
- GEMS Health Safety and Environment Management System
- GEMS Quality Management System
- GEMS Bridging Document for MV Kommandor Jack
- GEMS Project Safety Plan
- GEMS Travel Management Plan

2. PROJECT MANAGEMENT

2.1 Project Structure

The project will be organised by GEMS Survey Ltd (GSL) on a day to day basis where the project manager will be based. During the field operations, an offshore Party Chief (PC) will lead the fieldwork and report on a daily basis to the project manager in writing to update on project progress, weather conditions and expected completion date.

The project consists of pre-mobilisation activities, fieldwork operations, demobilisation, onshore and offshore data analysis and reporting.

2.2 Project Team

Immediately upon contract award a project manager was assigned who in turn appoints an offshore project manager to lead the fieldwork phase of the project. These personnel form the nucleus of the project and in turn select the remainder of the offshore team.

The following key personnel are assigned to this project:

Project Management

- Managing Director — Nigel Carey
- Project Manager — Ed Weare
- Operations Manager — Dave Stephens
- Chief Geophysicist — Phil Hayles
- HSE Advisor — Jon Maxwell
- QA / Reporting — Meg Gilliard

2.3 Project Organisation

The figure below outlines the project chain of command

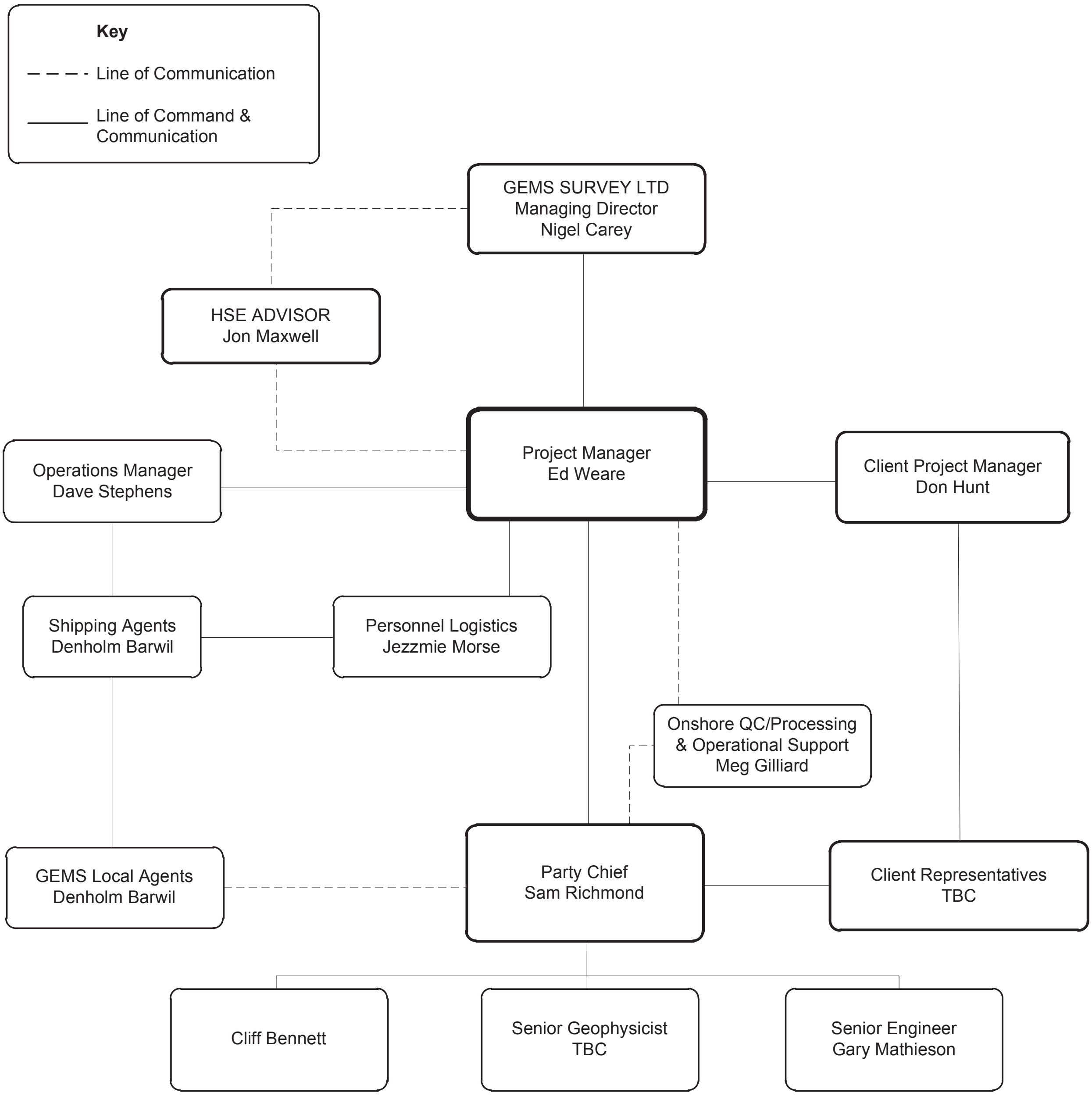


Figure 2: Personnel Management Chart

Table 1: Offshore Team

	Position	Phase 1 – Deep water	Phase 2 - Inshore
1	Party Chief	Darren Roberts	Sam Richmond
2	Lead Engineer	Gary Mathieson	TBA
3	Analogue Engineer		TBA
4	Analogue Engineer		TBA
5	Analogue Engineer		TBA
6	Analogue Engineer		TBA
7	Geotechnical Engineer		TBA
8	CPT Engineer		TBA
9	Online Surveyor	Cliff Bennett	Cliff Bennett
10	Online Surveyor	Rajeev Bakshi	TBA
11	Data Processor	Philmore Sydney	TBA
12	Data Processor	TBA	TBA
13	Geophysicist		Aaron Dent
14	Geophysicist		Joseph Morris
15	CAD	Illya Sparkes-Santos	Illya Sparkes-Santos
16	Client Rep	Jared Fedor	TBA
17	Client Rep	TBA	TBA

The CVs of the above key personnel can be supplied as required.

2.3.1 Daily Operations

On-board, the vessel the project team is divided into two shifts working back to back to provide 24 hour operations. Certain personnel such as the PC would be available 24 hours per day, as required, to oversee the operations of both shifts.

Shifts are run in 12 hour periods from 12:00 am to 12:00 pm and 12:00 pm to 12:00 am, personnel are divided into shifts as per PC preferences and is dependent upon the individuals experience and skills. There are four meal times on-board as follows:

Breakfast: 05:30-06:30

Lunch: 11:30-12:30

Dinner: 17:30-18:30

Midnight Meal: 23:30-00:30

2.4 Key Personnel Responsibilities

2.4.1 Project Manager

The project manager has ultimate responsibility for the project. The duties of the project manager include:

- Technical and logistic input into tender phase
- Selection of PC for offshore phases
- Briefing key personnel on project requirements
- Management of equipment and personnel mobilisation activities
- Maintenance of project schedule
- Approval of all project costs
- Principal point of contact for general client liaison
- To issue client weekly project progress reports as outlined in the project MDR
- To chair client kick off meeting

2.4.2 Party Chief

The Party Chief (PC) reports to the Project Manager. The PC is based on the vessel and is responsible for all the day-to-day operations on the project. Responsibilities include, but are not limited to the following:

Pre Fieldwork Activities

- To provide technical input to mobilisation activities
- To have input into selection and approval of project team
- To be available for technical liaison with clients
- Creation of project specific documentation

Fieldwork Operations

- To be the immediate point of contact for any onboard client representatives
- To implement the contract in consultation with the onshore Project Manager
- To be responsible for the mobilisation of the vessel in liaison with the vessel captain and client representative, and the correct checking of all the onboard systems
- To chair a project kick off meeting to detail the particular project specific requirements
- To ensure that all personnel have received a safety induction
- To organise the work program, in liaison with the onboard client representative and vessel captain, to ensure the execution of the required contractual tasks in a timely and professional manner
- To ensure that all contracted tasks are completed prior to departure from the job site
- To ensure that all operations are conducted in a safe and orderly manner, and conduct regular safety meetings with relevant personnel
- To ensure that the project QA procedures are adhered to during all offshore operations; this is to include mobilisation, harbour trials, field calibrations and calibration checks, project tasks, post project calibration checks and demobilisation
- To prepare detailed hand-over notes at any crew changes covering vessel status, equipment status, project progress, any ongoing problems and project plans and programs
- Production or approval of all necessary field reporting
- To be aware of the contents of the company's Quality and Safety Policy Manuals and to be ever mindful of one's responsibilities in the workplace which affect the health and safety of oneself and those of work colleagues.

Post Fieldwork Activities

- Confirming and supervising any onshore laboratory testing and data processing
- Management of production of operations report

2.4.3 Engineer in Charge (EIC)

The EIC is responsible for supervising the geophysical survey operations to ensure that the requirements of the project are met.

Responsibilities include, but are not limited to the following:

- Oversee shift engineers and back deck operations
- Ensure engineers logs are kept up to date and are accurate
- Ensure that all geophysical and geotechnical equipment is maintained in a working status
- Supervise the movement of geophysical and geotechnical equipment on/off the vessel and maintain an accurate equipment database
- Liaise with office freight logistics coordinator to ensure all necessary documentation is completed for freight leaving or entering the vessel
- Oversee acquisition and online QC of geophysical and bathymetric data offshore
- Planning and organising offshore procedures in respect of geophysical equipment.

- Work within a team of varying disciplines, and generate team spirit.
- Carry out administration tasks according to company's procedures
- Be conversant with all leading edge technology relating to geophysical engineering operations
- Undertake training on related disciplines as required
- Maintain and upgrade hardware of all geophysical systems as required
- Ensure operational capability of equipment is maintained.
- To be aware of the contents of the company's Quality and Safety Policy Manuals and to be ever mindful of one's responsibilities in the workplace which affect the health and safety of oneself and those of work colleagues.
- Any other duties deemed necessary, which are within the bounds of the incumbent's competence and function

2.4.4 QC Surveyor

Responsibilities include, but are not limited to the following:

- Senior surveyor, senior processing surveyor and/or party chief responsibilities
- Provide technical support for survey operations
- Provide training and mentoring of junior surveyors
- Operation of on-line navigation systems
- Operation of swath bathymetric systems
- Post Processing of navigation and swath data
- Report preparation
- Carry out administration tasks according to company's procedures
- Be conversant with all leading edge technology relating to navigation and swath bathymetric operations
- Assist in preparation of proposals
- Advise and instruct relevant managers on hydrographic matters during all operations
- To be aware of the contents of the company's quality and Safety Policy Manuals and to be ever mindful of one's responsibilities in the workplace that effect the health and safety of one self and those of work colleagues.
- Any other duties deemed necessary, which are within the bounds of the incumbent's competence and function

2.4.5 QC Geophysicist

Responsibilities include, but are not limited to the following:

- Process, interpret and report geophysical and hydrographic data.
- Prepare and assist in commercial tenders

- Prepare and deliver geophysical training for junior geophysicists
- Prepare and review marketing material
- Review and enhance Geophysical procedures
- Be conversant with all leading edge technology relating to geophysics operations
- Work within a team of varying disciplines, and generate team spirit
- Carry out administration tasks according to company's procedures
- Undertake training on related disciplines as required
- Assist in preparation of all Geophysics proposals as required
- To be aware of the contents of the company's Quality and Safety Policy Manuals and to be ever mindful of one's responsibilities in the workplace which effect the health and safety of oneself and those of work colleagues.
- Team leader on operations as required
- Acquisition of geophysical and hydrographic data offshore
- Online QC of geophysical and hydrographic data offshore
- Any other duties deemed necessary, which are within the bounds of the incumbent's competence and function

3. PROJECT SCOPE OF WORK

For further information please also see client supplied SOW in Appendix A

3.1 Survey Objectives

3.1.1 Deep Water Survey Objectives

The objective of the deep water survey is to provide the following information:

- Detailed route bathymetry within a corridor of 2.4 x water depth

3.1.2 Inshore and Shallow Water Survey Objectives

The objective of the inshore and shallow water survey is to provide the following information within a 500m wide corridor:

- Detailed route bathymetry
- Nature and position of any seabed obstructions.
- Sub-bottom shallow soil conditions.

3.1.3 Diver Swim Survey Objectives

The objective of the diver swim survey is to provide the following information within a 250m corridor:

- Bathymetry
- Sediment depth
- Video

3.1.4 Landing Site Survey Objectives

The objective of the landing site survey is to provide the following information within a 250m corridor:

- Topography
- Sediment depth
- Photos of all prominent features

4. PROJECT PLAN OF WORK

4.1 Schedule

Task Name	Duration	Start	Finish
UK and Iceland Deep Water Survey	**24.8 days**	**31 Jul 00:00**	**24 Aug 19:12**
Mob at Fairlie	1 day	31 Jul 00:00	01 Aug 00:00
Calibrate MBES	0.5 days	01 Aug 00:00	01 Aug 12:00
Vessel Transit to Deepwater Segment	1 day	01 Aug 12:00	02 Aug 12:00
Deep Water Survey UK to BU	2.52 days	02 Aug 12:00	05 Aug 00:29
BU1 Branching Unit Survey	0.08 days	05 Aug 00:29	05 Aug 02:24
Deep water survey BU to Canada	5.5 days	05 Aug 02:24	10 Aug 14:24
Vessel Transit back to BU	4.43 days	10 Aug 14:24	15 Aug 00:43
Deep water survey BU to Iceland	3.46 days	15 Aug 00:43	18 Aug 11:46
Weather Allowance	6.08 days	18 Aug 11:46	24 Aug 13:41
Transit to Iceland for Port Call	0.23 days	24 Aug 13:41	24 Aug 19:12

Figure 3: Deep Water Schedule

4.2 Equipment Inspection and Installation

Prior to sailing to site to commence survey the following actions will be undertaken:

- The equipment will be inspected to ensure that it is complete and undamaged.
- The DGPS surface positioning equipment will be installed.
- On-line computers will be interfaced to the survey sensors.
- Offsets will be measured from survey datum point to all other survey sensors.
- All clocks will be synchronised with the master clock designated to reference all survey time-keeping.
- Wet testing

4.3 Tests and Calibrations

At the Quayside

Whilst the vessel is alongside, the following checks and calibrations will be performed:

- The observed transducer depth will be recorded in the survey logs prior to the commencement of works.
- The DGPS will be checked against a known position on the quayside.
- The survey gyro will be calibrated against a known heading of the quayside.
- The echo sounder, multibeam systems and sub bottom profiler will be tested.
- The echo sounder will be calibrated
- A temperature and salinity profile will be conducted to check the velocity of propagation for the acoustic equipment.
- Confirmation that on-line computers and peripheral systems are operational and that all data is being interfaced, decoded, processed, presented and logged. This will be achieved by logging positioning data on the system and processing it to confirm its validity.

On Arrival at Calibration Site

On arrival at the calibration site, the following checks and calibrations will be performed:

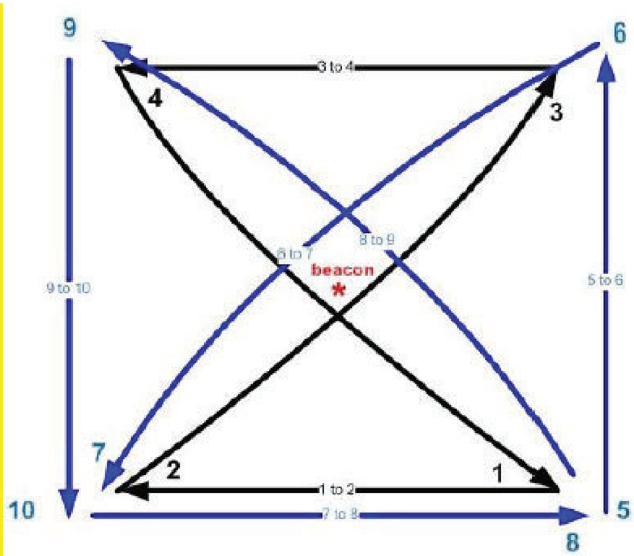
- Confirmation that the DGPS mobiles are receiving data from the satellite and that the fixes derived are consistent and within the positioning specification.
- Confirmation that on-line computers and peripheral systems are operational and that all system & sensor data is being interfaced, decoded, presented, logged and processed as appropriate.
- A temperature and salinity profile will be conducted to check the velocity of propagation for the acoustic equipment.
- Where appropriate all towed sensors will be deployed, tested and adjusted to achieve optimum data quality.

4.3.1 USBL Calibration

Prior to the start of the shallow water survey a USBL calibration will be done either on route to site or on site as per survey team discretion. The calibration procedure for the ultrashort baseline acoustic positioning system (USBL) is summarised as follows. The USBL system comprises an acoustic vessel-born localization system and sensors measuring vessel position, heading and attitude. The latter are used to transform the 'acoustic' UV position into Earth related coordinates. Misalignments between the different sensors lead to important positioning errors.

Quick calibration of the USBL system at sea without additional hardware is therefore an important operational feature. The procedure presented here uses position measurements obtained with the uncalibrated system for a fixed-point moored transponder beacon. The absolute beacon coordinates are not known initially; they are identified, together with angular misalignments of the USBL sensors, by an iterative adaptive estimator.

The vessel track during the recording of measurements is arbitrary and calibration is accomplished in less than one hour. The pattern below will be sailed at 2kts and the files will be recorded.



Calibration Pattern

4.3.2 SWATH Bathymetry Calibration

Of key importance to the accuracy of any swath survey is the calibration. To eliminate errors caused by slight misalignment of the sonar transducers during the mounting, a calibration has to be performed every time any equipment is changed. This calibration is required to resolve the effects of heave, roll, pitch and yaw. System latency is also checked.

The calibration process is as follows:

A suitable seabed site is selected, such as a dredged channel which includes a flat seabed and a slope or bathymetric feature, and CTD (SVP) probe is taken throughout the water column and the resulting velocity of sound results are recorded. Four survey lines are then run, two perpendicular to the slope, and two perpendicular to the first two survey lines. Each parallel line is run along the same survey line but from opposite directions. The survey lines are then compared and the amount of correction required to make them coincide is calculated (for latency, roll, pitch &yaw).

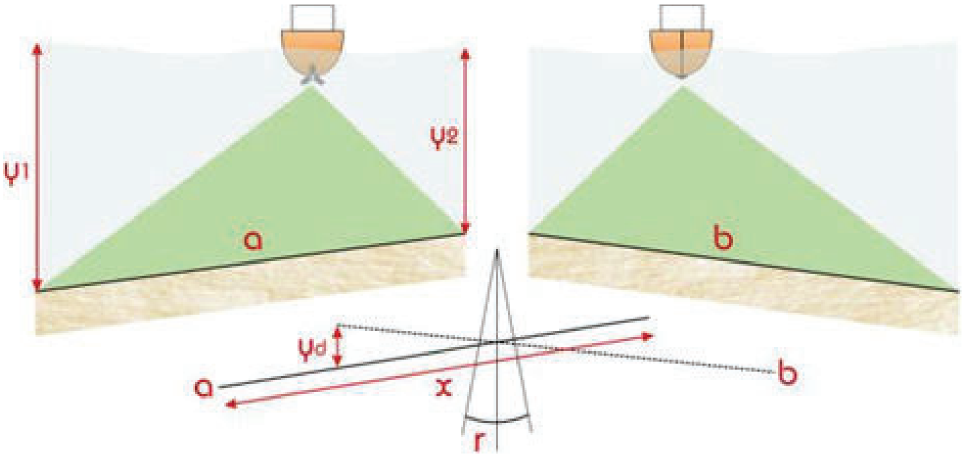


Figure 4: Roll error calibration

Roll error calibration - **a** is the across track profile of the sonar in one direction, **b** is the across track profile of the sonar in the opposite direction. **Yd** is the difference in depth across the profile, this can be expressed as **Y1–Y2=Yd**. **x** is the across track width of the profiles. The roll error (**r**) can be expressed as: tan-1 (**Yd** / **x**) / 2.

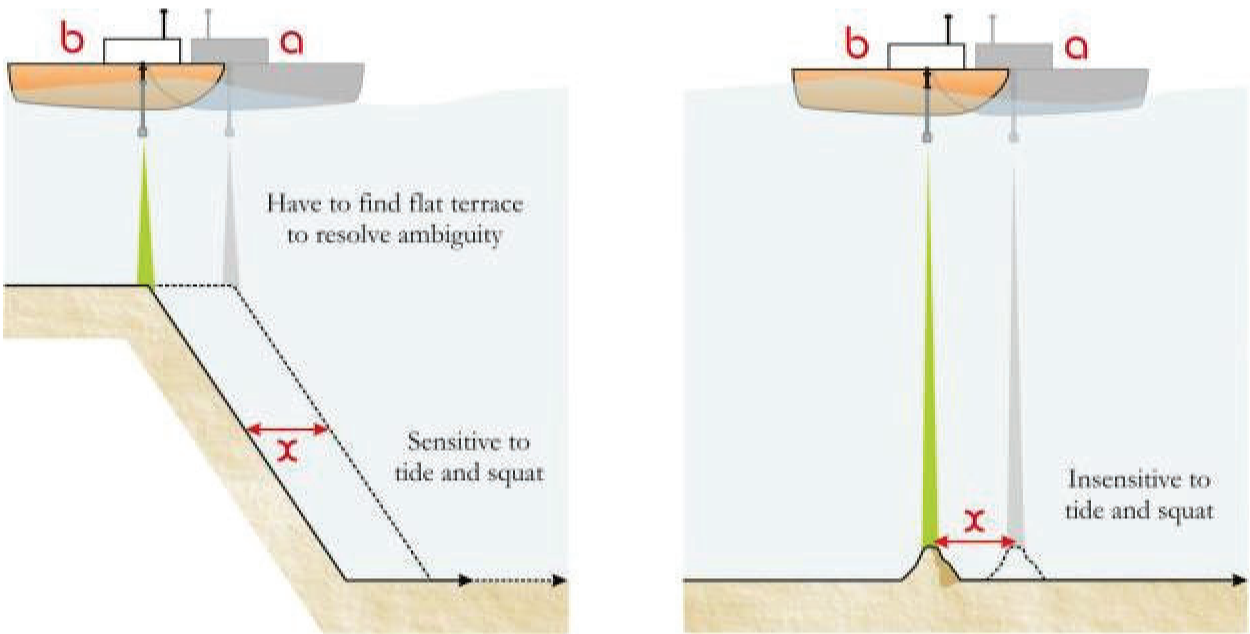


Figure 5: Pitch error calibration

Pitch error calibration - **a** is the right to left pass of the vessel, **b** is the left to right pass of the vessel; **x** is the difference along track between the two passes. The pitch error can be expressed as: tan-1 (**x** / 2) / depth

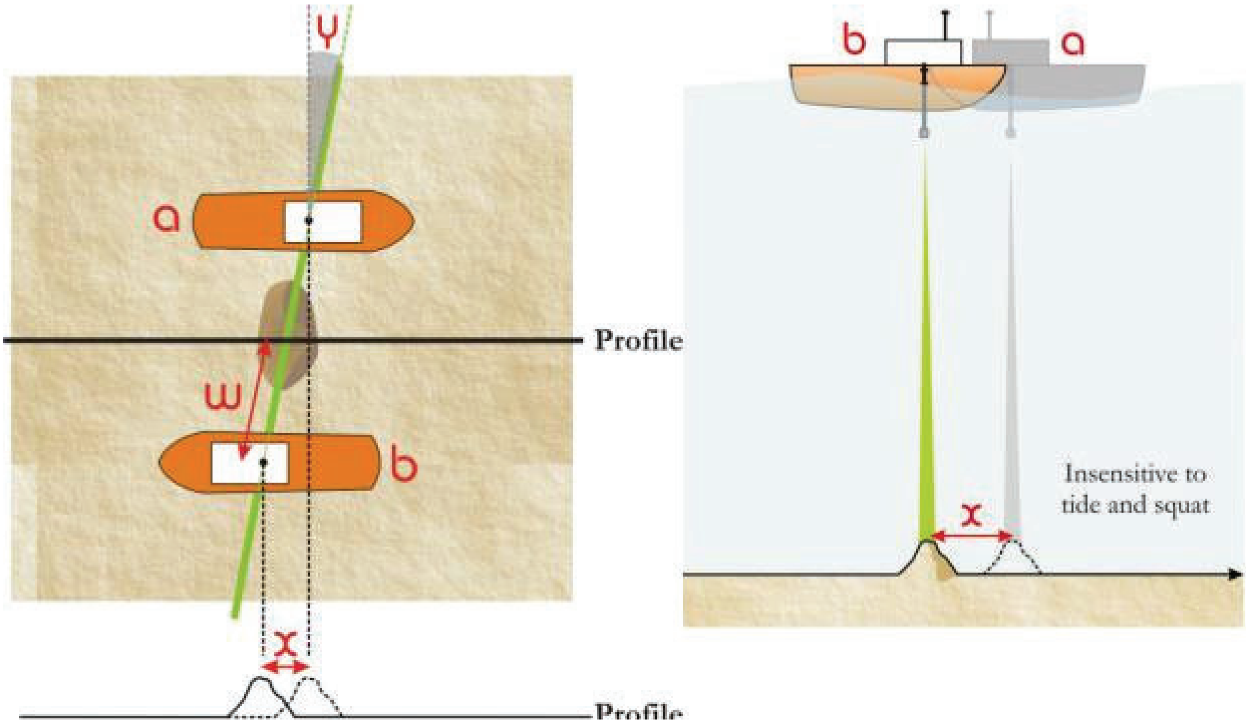


Figure 6: Yaw error calibration

Yaw error calibration - **a** is the pass to the North of the shoal, **b** is the pass to the South of the shoal, **x** is the along track difference in the position of the shoal from the two passes. **w** is the distance from the transducer to the shoal and **y** is the yaw error. The yaw error (**y**) can be expressed as: sin-1 (**x** / 2) / **w**

5. PROCESSING AND INTERPRETATION

5.1 Bathymetry

5.1.1 EM122

Swath bathymetry data will be acquired in QINSy and processed through QINSy and Fledermaus with a processing flow based on the relevant work instruction. A brief overview is presented below.

Table 2: EM122 outputs

Software	Purpose	Outputs
QINSy Online	Acquisition, incorporating nav etc	.db .qpd
QINSy Offline	Tidal application, data QC	.gsf
Fledermaus	3D Area editing using CUBE	.asc raster data .tiff contours

Final results of the bathymetry will be provided to the other disciplines to allow the information to be included in their interpretation.

Slope information, gradients, directions etc will be produced from Fledermaus using the slope analysis feature.

5.1.2 Singlebeam Echosounder

Singlebeam echosounder data will be acquired concurrent to the swath data in QINSy, and processed in QINSy offline, with a .gsf or .xyz deliverable.

This will then be QC'd against the swath data surface within Fledermaus using the surface difference function.

5.1.3 Data QC and QA

Data will be statistically analysed within Fledermaus to ensure that mainlines, crosslines and singlebeam data agree to within survey tolerance. This is performed using the CrossCheck utility which compares discrete points from the crosslines against the surface created by the mainlines.

5.2 Side Scan Sonar

Side scan sonar data acquired with the Edgetech Discover software is processed using InfoX as outlined below.

Table 3: Edgetech outputs

Software	Purpose	Outputs	
Edgetech Discover	Online acquisition; XTF output (raw or online parameters applied).	.jsf .xtf	(for InfoX); (for Client)
InfoX Converter	Convert .JSF files to InfoX SSR; applies gains and bottom tracking	.ssr	(for NavClean)
InfoX Navclean	Layback, smooth navigation	.pro.ssr	(for SonarView)
InfoX SonarView	QC Data; pick/measure sonar contacts/targets; generate mosaic files	.sss, .raw .xls	(for NavClean/Mosaic); (Target database)
InfoX NavClean	Smooth navigation data (USBL data)	.new	(for Mosaic)
InfoX Mosaic	Interpret seabed features; generate mosaic tiles; export geotiff files	.dxf .tif. .tfw	(for CAD) (GeoTiff)

5.3 Sub-Bottom Profiler – Pinger Data

Pinger data is acquired and processed as outlined below:

Table 4: Pinger outputs

Software	Purpose	Outputs	
InfoX GAX Acquisition	Online acquisition, filtering, gain; Offline replay, hard-copy printing.	.wav .sgy	(for replay) (export for Kingdom Suite)
SMT Kingdom Suite	Interpret picked reflectors; grid interpreted surfaces; export isochrons/isopachs	.emf .dxf	Seismic images (for CAD) Isochron/isopach (for CAD)

5.4 Magnetometer

Magnetometer data will be imported into InfoX SonarView where it is empirically corrected for diurnal variations and displayed alongside the side scan sonar data to allow picking and measurement of magnetic anomalies. Anomaly locations will be passed to the on board cartographer for presentation within CAD.

5.5 Cartography

All data will be passed to the on board cartographer for conversion and presentation within CAD. AutoCAD Map 2010 will be available on the vessel, as well as WISH AutoCHART for chart layout.

Charted data will be passed back to the originating processor for QC once charted.

6. DATA INTERPRETATION, CHARTING AND REPORTING

Interpretation of analogue geophysical, hydrographic and geotechnical data shall be undertaken by a suitably qualified person onboard the vessel.

In addition to requirements specified in the SOW GEMS shall supply:

6.1 Daily Progress Reports

A Daily Operations Report (DPR) will be prepared by the Party Chief and provided to the onboard Client representative for approval. This report will contain the following information:

- Summary of previous 24 hours operations
- Time summary breakdown for previous 24 hours and to date
- Work completed in previous 24 hours and to date
- Observed weather conditions and weather forecast summary
- Work planned for the next 24 hours
- Lost and damaged equipment details
- Number of personnel onboard
- Health safety and environmental events

This report will be signed by the GEMS Party Chief and the onboard Client representative and distributed accordingly via email.

6.2 Weekly Customer Progress Reports

A Weekly Customer Progress Report (WCPR) will be produced by the GEMS Project Manager and issued to the Client Project Manager for distribution, this report will outline:

- Project Summary
- Project Schedule
- HSE Events and Activities
- Geophysical Fieldworks Scope of Work and Progress
- Environmental Fieldwork Scope of Work and Progress
- Finance
- Contract Variations
- Customer Meeting Schedule
- Actionable Items and Comments

6.3 Survey Reports

Reports for the surveys will be provided using the guide below:

Report Type	**Overview**
Mobilisation Report (MOB)	Details of mobilisation and calibrations, including equipment.
Operations Report (OPS)	Post-acquisition report detailing sequence of events (inc DPR), equipment used, processing sequences and parameters used, data user guide, personnel etc. Appendices will include all peripheral data to the survey.
Geophysics Report (GPH)	Post-acquisition report based on final data, detailing bathymetry, slope analysis, seabed features, geology, hazard assessments (if applicable) Appendices will include all charts, geotechnical information used within report, references.

7. VESSEL AND SURVEY EQUIPMENT

7.1 Vessel

GEMS will utilize the MV Kommandor Jack for the deep and shallow water surveys based on 24 hour operations and the MV Navigator or other suitable vessel for the inshore survey work based on 12 hour operations.

Figure 7 MV Kommandor Jack

7.2 Survey Positioning and Equipment

7.2.1 Navigation Software Suite

GEMS will utilise the QINSy Hydrographic Solution as the computing interface to receive, time stamp and log all positioning and peripheral data. QINSy's graphic user interface will also graphically present the survey vessel position relative to the project geodesy and worksite.

QINSy provides a user-friendly solution for all types of marine navigation, positioning and surveying activities. QINSy runs on a standard PC platform under the Windows operating system. QINSy uses WGS-84 for position calculation, with '*online*' transformation to the local project datum in real-time through geodetic datum shift parameters. Vessel and antenna offsets can also be entered into the system to allow specific positioning datum selection. Quality control of all positioning system components is continuous, with data logged to paper hard copy and magnetic or optical media as required.

The software allows the definition of a number of graphical navigation windows which are presented on an independent helmsman's screen. These windows include:

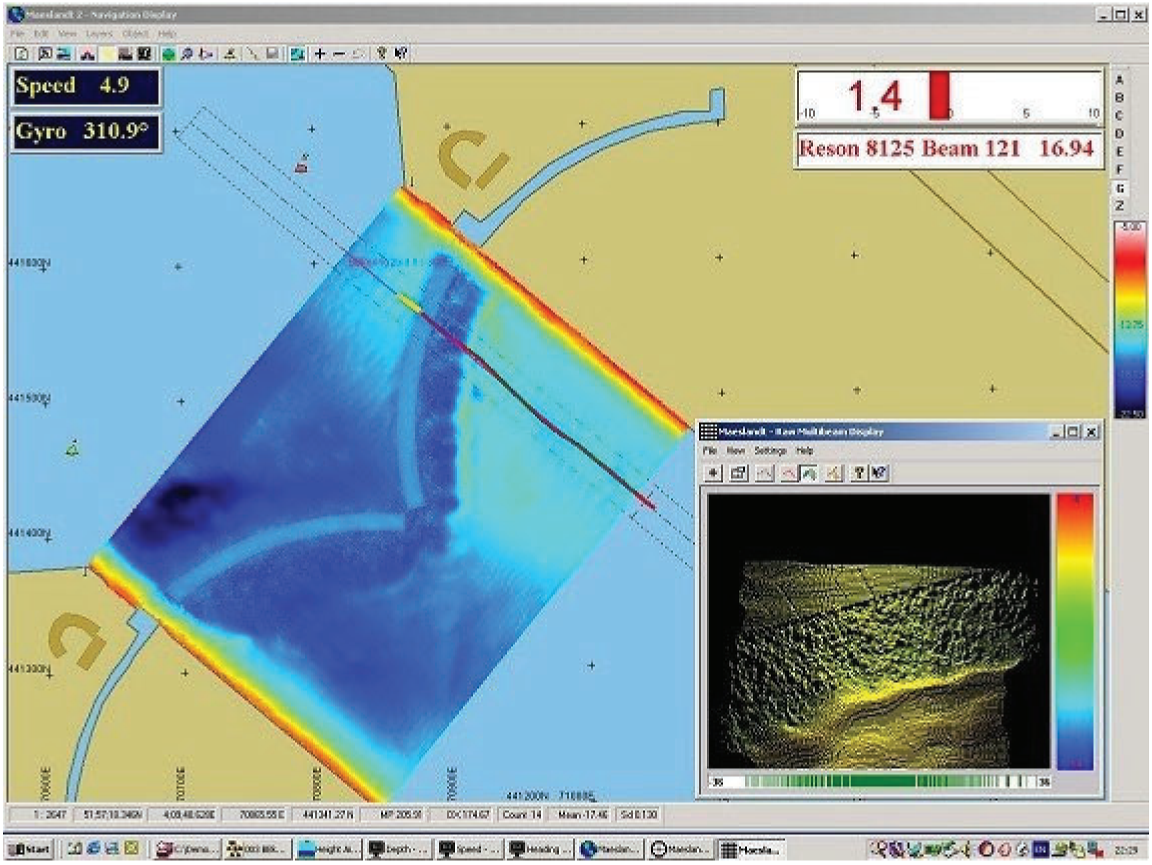


Figure 8: QINSy navigation display

- A navigation display: displays a plan view of the survey area with background charts as appropriate; the vessel and vessel track.
- A helmsman display: displays a left/right indicator which is used by the helmsman for line keeping during survey operations.

7.2.2 C-Nav DGPS positioning system

GEMS will utilise C-Nav**.** C-Nav provides worldwide horizontal accuracy in the order of 0.3m. The C-Nav RTG Network is a global system for the distribution of differential GPS corrections giving the user the ability to measure his position anywhere in the world with exceptional reliability and accuracy of better than 10 cm.

C-Nav is based upon Real Time Gypsy (RTG) technology, which utilises the global network of Inmarsat geostationary satellites. The NPH computes a refraction corrected orbit correction and a clock correction for each satellite. The data is then transmitted via dedicated land line to an earth station that beams them to an L-Band communications site. Onboard the vessel these corrections are received and applied to the local satellites.

If in the extremely unlikely event that the Inmarsat RTG service should fail, C-Nav will automatically default to dual-frequency stand-alone GPS which provides 3-5 metre horizontal accuracy.

The project area is covered by the C-Nav RTG network, which provides signals on a worldwide basis. This system has been used by GEMS (and other survey contractors) on a number of projects since its implementation and we can confirm signals are received in this area.

DGPS Verification

Verification of the DGPS system will be undertaken according to GEMS standard Work Instructions (WI211 – DGPS Static Check), using GEMS Field Form CAL02 – Positioning System Verification. If possible, a comparison check will be undertaken using a secondary DGPS system.

7.2.3 Sub-sea acoustic positioning

On the deep and shallow water surveys towed devices shall be dynamically located by an ultra short baseline acoustic positioning system. - the Sonardyne Ranger Pro.

Ranger USBL is the latest addition to the Sonardyne Ultra-Short Baseline product family and designed for survey and Dynamic Positioning (DP) reference operations. The system provides an operating range of up to 4,000 metres and is ideal for operators with limited experience or who are unlikely to ever undertake advanced USBL positioning and tracking tasks.

An important feature of Ranger USBL is the intuitive user interface means that the system is easy to learn, set-up and operate ensuring that any operator will achieve immediate success. Two versions of the system are available; Ranger and Ranger Pro.

Ranger Pro is designed for more advanced survey applications. Incorporating Sonardyne's unique 'ping stacking' technology, the system offers fast position update rates (1 second independent of water detph), tracking of up to 10 targets and full ocean depth operating range (4,000 metres). Range Pro also supports a wide range of industry standard (Sonardyne and non-Sonardyne) MF frequency transponders.

A feature available in both Ranger and Ranger Pro is the ability to undertake Inverted USBL (iUSBL) tracking of towfish over super-long laybacks. With this new method, the transceiver is not installed on the vessel but on the towed body itself which is often several kilometres behind and below the ship. Mounting the transceiver in this way eliminates the need for repeated system calibration, whilst the accuracy and repeatability of the acoustic signals are improved, as the transceiver is located in a low noise, dynamically stable environment.

Table 5: USBL System

Sonardyne Ranger USBL Acoustic Positioning System	
System Performance	
Operating Range	2,000 metres (Ranger) 4,000 metres (Ranger-Pro)
Acoustic Coverage	±90° or ±50° (Depending on transceiver type)
Accuracy (Typical)	0.27% 1 Drms Slant Range (63% of fixes within 2.7 metre radius in 1,000 metres water depth) r 0.20% 1 Sigma Slant Range (39.4% of fixes within 2 metre radius in 1,000 metres water depth) (Note: The absolute accuracy of the system is dependent upon the quality of attitude and heading ensors, beacon source level, vessel noise, water depth, the mechanical rigidity of the transceiver eployment machine, GPS and proper calibration of the total system using CASIUS)
Achievable (Lodestar Optimised USBL)	0.13% 1Drms
Tracking	Supports tracking of 1 surface vessel and 4 subsea targets (Ranger) Supports tracking of 1 surface vessel and 10 subsea targets (Ranger-Pro)
Maximum Update Rate	1 second, independent of water depth (Ranger-Pro only)

Ranger USBL Transceivers		
Type Numbers	**8021**	**8023**
Operating Frequency	MF (18-36kHz)	MF (18-36kHz)
Ranging Accuracy	Better than 0.2 metres (0.03 metres Wideband)	Better than 0.2 metres (0.03 metres Wideband)
Positioning Repeatability	Better than 0.1% of slant range 1 Drms	Better than 0.1% of slant range 1 Drms
Deployment Method	Through-hull or Over-the-Side	Through-hull or Over-the-Side
Dimensions (LxDia)	410mm (16.14”) x 225mm (8.86”)	487mm (19.16”) x 300mm (11.81”)
Weight in Air	28kg	41kg
Weight in Water	13.5kg	21kg

7.2.4 Attitude and Heading

GEMS will use a CodaOctopus F180 Attitude and Positioning System. The F180 Attitude & Positioning System applies technology originally developed for the high speed, mechanically extreme world of motor racing. Modifications and enhancements to this light yet robust equipment have resulted in a simple-to-use product that brings accurate positioning and motion data into the most dynamic offshore conditions for precision marine survey applications worldwide.

Delivering heave, roll, pitch, heading and positioning information in real time, it provides a highly accurate and reliable motion and position data. In addition, the outputs of the F180 can be mapped to a remote position – such as a swath transducer – to give accurate heave, attitude, position and heading at the critical location.

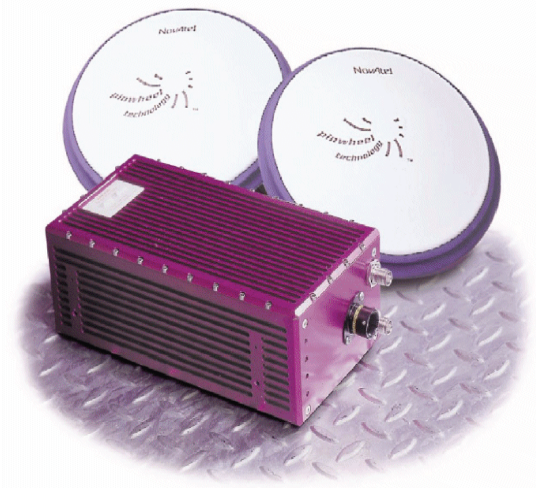


Figure 9 F180

7.3 Sound Velocity Measurements

GEMS will be using AML SV Plus sound velocity profiler which is a hull mounted SVP to give surface velocity and a suitable CTD to measure static velocity profiles.

Profiles will be obtained and presented to the Client once every 2 days or more regularly if the transducer head mounted velocity probe, or any other system, indicates an increased frequency of profiling is required in order to meet error budgets.

7.4 Bathymetry

The deep and shallow water bathymetry will be acquired with the Kongsberg EM122 multibeam echosounder and a Knudsen dual frequency singlebeam echosounder.

Table 6: Kongsberg EM122 Multi Beam Echo Sounder

Kongsberg EM 122 Multibeam Echo Sounder	
Operating Frequency	12 kHz
Depth Range	20-11000 m
Swath Width	6 x Depth, to approx. 30 km
Pulse Forms	CW and FM chirp
Swath Profiles Per Ping	1 or 2
Motion Compensation: Yaw………………………………….. Pitch………………………………… Roll…………………………………..	 ....± 10 degrees ....± 10 degrees ....± 15 degrees
Focused Beams for Transmission and Reception	
High Density and Multiping Modes for increased Resolution	
Seabed Image (Sidescan) Data Display and Recording	
Water Column Data Display and Recording	
Modular Design, Beamwidths 0.5 to 4 degrees	
Mammal Protection	

For the inshore work GEMS will use the Sea SWATHplus (117 kHz) swath bathymetric system which has the advantage of wide range coverage especially in shallow water. This system has the major advantage in providing wide swath widths in shallow waters, and thus reducing the impact of infill lines to provide coverage. All data will be digitally recorded and integrated into the main survey processing systems.

Table 7 SWATHplus Specification Sheet

SWATHplus 117 kHz Sonar System		
Item	Notes	Value
Swath width	min (in 5m-30m water depth)	6-12x water depth
Max swath width	range limit	600m

Measurable depth	min.. max..	>1m <200m
Across track resolution	in 20m water depth, full swath	50cm
Along track resolution	in 20m water depth	50cm
Survey specifications to full swath width	in 30m water, given accurate position and heading inputs, (after gridding, better than)	XY: 0.5m Z: 0.2m
General survey specs	where applicable: (from IHO S44 4th edition, April 1998)	IHO S44 special order IHO S44 order 1 IHO S44 order 2
Coverage	in 30m water depth	full coverage at 4kts with 20% overlap full coverage at 10kts with 100% overlap
Sidescan data	-	Co-registered with bathymetry. Real time hardcopy output available
Data storage	Format:....................................... Media:	- raw data - processed data (if required) - Hard drive (removable optional) and DVD for archiving
Quality control display	Real Time	- bathymetry (ping by ping) - bathymetry (history) - sidescan - merged sidescan/bathymetry - heave/pitch/roll sensor monitor - ancillary input monitor (ASCII)
Data output	Gridded	XYZ suitable for export to standard GIS packages

Bathymetric data will be reduced to LAT by use of Admiralty Tide Tables, using standard ports and associated secondary ports, with a co-tidal model if required.

7.5 Side Scan Sonar

Deep and shallow water sidescan data will be acquired utilising the Edgetech 4200 Multi-pulse sonars. These side scans emit multiple pulses vastly increasing resolution and allowing for faster survey speeds. Main features are as indicated below:

- Either 100/400 or 300/600 kHz dual simultaneous frequencies
- Selectable dual mode of operation:
- High Definition Mode (HDM) or High Speed Mode (HSM)
- 2000 meter depth rating for stainless steel towfish
- Data transmitted over long single coaxial cable lengths
- Integrated with other sensors
- Full Spectrum CHIRP processing

Table 8: SSS System

Edgetech 4200 - MP Side Scan Sonar System	
Frequency (dual simultaneous)	Choice of either 100/400, 300/600 or 300/900 kHz
Horizontal Beam Width (HDM)	100 kHz: 0.64°, 300 kHz: 0.28°, 400 kHz: 0.3°, 600 kHz: 0.26°, 900 kHz: 0.2°
Horizontal Beam Width (HSM)	100 kHz: 1.26°, 300 kHz: 0.54°, 400 kHz: 0.4°, 600 kHz: 0.34°, 900 kHz: 0.3°
Optional CW Pulse Short Range	Yes
Operating Range (max)	100 kHz: 500m, 300 kHz: 230m, 400 kHz: 150m, 600 kHz: 120m, 900 kHz: 75m
Towing Speed (max safe)	12 knots
Towing Speed *	4.8 knots in HDM, 9.6 knots in HSM
Towfish Material	Stainless Steel, Aluminum
Towfish Diameter	11.4 cm. (4.5 inches)
Towfish Length	125.6 cm. (49.5 inches)
Weight (in air)	48 kg (105 lbs.), 30 kg (66 lbs.)
Weight (in sea water)	36 kg (80 lbs.), 18 kg (40 lbs.)
Operating Depth (max)	2000 meters, 500 meters
Tow Cable Type	Coaxial
Tow Cable Length	6000 meters typical
Options	Pressure, Temperature, Magnetometer, USBL Acoustic Tracking System, Depressor, Power Loss Pinger and Custom Sensors

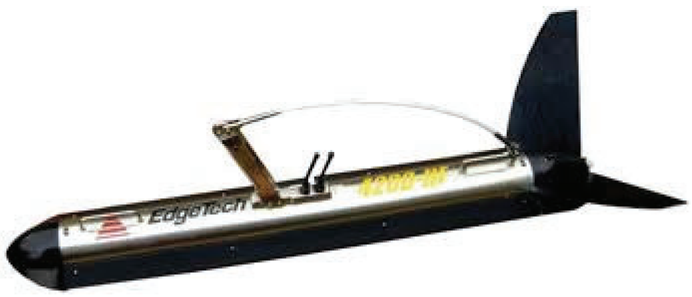


Figure 10 Edgetech 4200 hardware

For inshore survey operations, GEMS will use a CMAX CM2 system operating at 100/325 kHz, and is purpose designed for high-resolution shallow water imagery. The system will be deployed using the purpose designed lightweight portable winch to ensure that distance off the seafloor is maintained at the optimum height at all times. Key highlights of the C-max system are:

- New ultra-low noise towfish electronics
- Digital towfish and 2 wire cable telemetry, no cross talk or loss of quality in the cable.
- Lateral resolution of 78mm (325kHz)

- Range out to 500m (100kHz) or 150m (325kHz)
- Enhanced immunity to unwanted surface reflections

7.5.1 Sub-bottom Profiling

Sub-bottom profiling onboard will be achieved using a hull mounted 4 x 4 Pinger array (2x1 for inshore work) (GeoAcoustics model 5430A / 132B) 3.0-7.5 kHz to profile the shallow seabed geology. The GeoAcoustics Pinger system has excellent resolution of near surface sub-bottom events.

The sub bottom data will be logged on an InfoX GA-X acquisition system.

7.5.2 Magnetometer

A Marine Magnetics SeaSpy (Overhauser) Marine Magnetometer will be used as required for the detection of ferromagnetic objects. The magnetometer will be interfaced with the navigation computer. The data are stored on hard disk and CD-ROM.

7.5.3 Seabed Sampling

Sampling will be carried out in order to support and enhance the geophysical evaluations. GEMS will utilise a sampling system consisting of an up to 750kg weighted 3m barrel piston (gravity) corer and a grab sampler. Both devices will be deployed via an over-the-side A-frame. A core sample will be acquired on an average distance of 10 km during the shallow water surveys. The Purchaser Representative and the geophysicist will determine the sampling locations and decide on the most suitable sampling device. Clearly, in areas of bedrock with little sediment cover, it would not be feasible to employ the drop corer.

Figure 11 Piston Corer

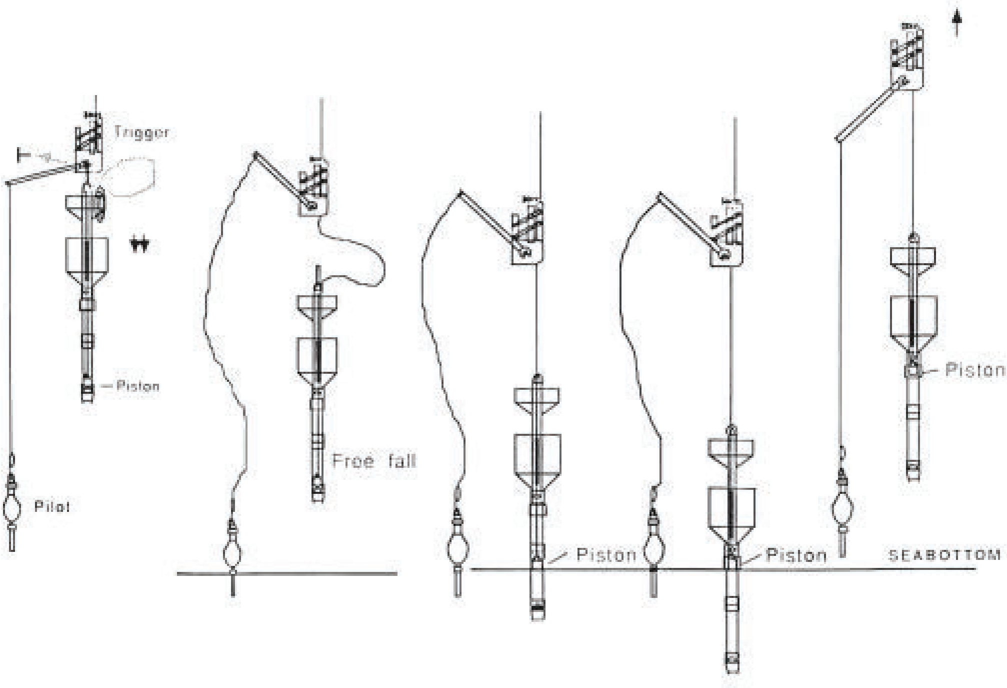


Figure 12 Piston Corer Operation

Simple onboard analysis of the samples will be carried out. This will include a visual inspection and description according to the Munsell soil colour chart as well as Torvane testing after successful core recovery in order to ascertain the shear strength of the sediment. In the case of no recovery from the piston corer the grab sampler will be used. On the nearshore survey only the grab sampler will be used.

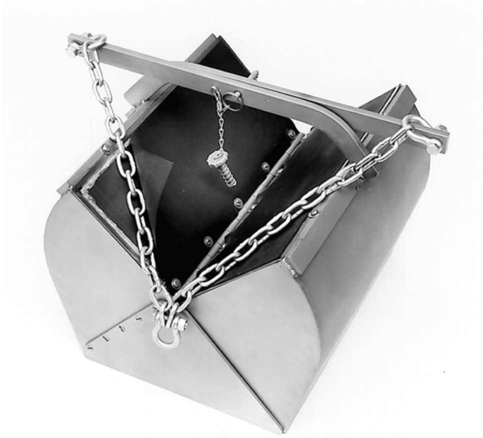


Figure 13 Van Veen type Grab Sampler

7.6 Mini CPT

GEMS will utilise their Neptune MCPT system which has been used extensively to successfully recover in situ soils data in water depths in excess of 2,000 metres from a variety of vessels.

The cone penetration test (CPT) has been commonly used for geotechnical engineering in preliminary and advanced phases of subsurface soil investigations. The simplicity and cost effectiveness of the test, the quality of the measured data and reliability of the interpretation procedures have made the CPT an outstanding test to determine soil conditions such as soil classification, stratification and a range of geotechnical parameters. The GEMS Miniature Cone Penetrometer is a light weight probe system capable of accurate soil characterisation. The system is designed to operate in water depths of up to 2000 m. The complete system can be and can be deployed from virtually any vessel with reasonable station keeping (+/- 20% water depth for the few minutes of the test) without the need for anchoring

At the heart of the system lies the miniature cone penetrometer. The cone tip area has been miniaturised from the standard 10 cm^2 to just 1.97 cm^2 thus reducing dramatically the required reaction force needed to drive the cone into the seabed. The cone is attached to a continuous stainless steel tube which forms the thrusting rod and through which signals from the cone's strain gauges are transmitted via the umbilical to the surface equipment. For convenience, the rod is coiled into a free coil of 1 m diameter, it is straightened as it is thrust into the ground and automatically recoils on retraction. The cone is advanced into the seabed using a hydraulic ram jacking system and a set of linear friction chucks. The electronic instrumentation housed in the cone provides data on tip resistance and sleeve friction and, as an option, pore pressure and cone inclination for every 0.5 cm over the full depth of penetration. The information in transferred digitally to the operator's PC on the deployment vessel and provides real time detailed geotechnical and stratigraphic information which can be immediately interpreted, allowing an experienced crew to modify the investigation programme as they proceed. The data can be checked and quickly processed into a report ready format.

Figure 14 Neptune MCPT System

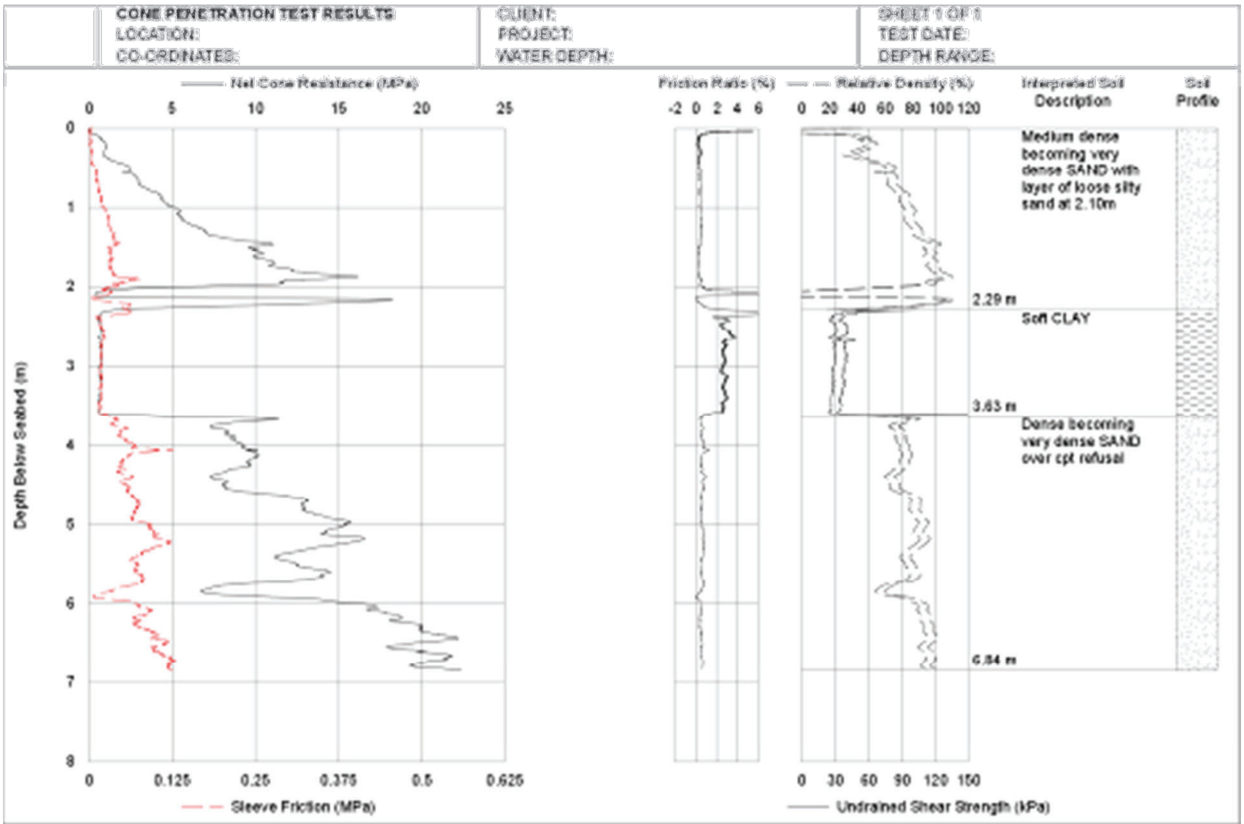


Figure 15 Example of an Interpreted MCPT Plot

8. HSE

Please see separate Project Safety Plan.

8.1 Safety Drills and Meetings

Safety meetings shall be carried out at regular intervals onboard. These shall involve the Master, Party Chief, Company's onboard representatives and representatives of the survey and marine crew. Minutes of the meeting, together with details of any further action to be taken will be provided to the company representative within 48 hours.

Toolbox talks shall be undertaken before all operations. Where this is the first operation of its kind during the survey the vessel specific procedures and risk assessment shall be reviewed. The tool box talk shall be minuted in the survey logbook.

APPENDIX A – SCOPE OF WORK

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