SEABED LOGGING

MOBILISATION REPORT

M/V ATLANTIC GUARDIAN

VERSION 01
REVISION 11

AUGUST 2007

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VESSEL **M/V Atlantic Guardian**	AREA **Sorell Basin** COUNTRY **Australia**
SURVEY PERIOD **August 2007**	EDITOR/AUTHOR **Greg Bass**
CONFIDENTIAL	CLIENT **Santos Limited**

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Summary:

The Atlantic Guardian was chartered by EMGS from the 25th of April 2005. The vessel was mobilised for SBL survey in Ulsteinvik/Norway and started production at the 01st of May 2005. The vessel carried out a DP test at the 24th of April. After the mobilisation of SBL equipment the survey instrumentation was calibrated at the quayside of Myklebust Shipyard in Gursken (DGPS), Aalesund (Attitude Sensors) and during transit to the first survey area (USBL system). The calibration, verification and offset measurement was carried out by Fugro Survey AS.
In June a new Octans FO-Gyro and attitude sensor has been installed and the USBL system was re-calibrated in the field.
In November a new calibration of the Ship gyro (Yokogawa) and the Octans gyro was performed, together with a DGPS verification at Bintulu Port, Sarawak, Malaysia
The gyro and a DGPS antenna survey was performed in Loyang Wharf in Singapore, October 2006. The USBL system was recalibrated before the start of survey in Egypt.
A gyro calibration and dGPS verification survey was carried out at Broome Australia, followed by a USBL calibration on prospect. The last Octans gyro calibration was performed in May, alongside Fremantle, Australia, followed by a USBL calibration on prospect area for the ongoing survey.

Revision History

Version (Date)	*Initials*	*Description*
V01R01 25-APR-2005	OW	Initial Document
V01R02 30-JUN-2005	OW	Recalibration of new Octans FOG
V01R03 27-SEP-2005	OW	Review and insert chapter 3.1
V01R04 26-JAN-2006	ERS	Recalibration of Gyros, and verification of DGPS
V01R05 26-JAN-2006	LF	Review
V01R06 02-NOV-2006	CW/OW	Update with Gyro calibration and USBL calibration
V01R07 02-DEC-2006	OW	Update with USBL calibration in Egypt and review of chapter 3.5 regarding new timing and synchronisation system
V01R08 26-DEC-2006	OW	Update with USBL calibration in Egypt after exchange of USBL transducer head
V01R09 14-MAR-2007	CA	Update with installation of Gator navigation system and 2 new dGPS systems (C-Nav & Veripos). Gyro calibration and USBL calibration offshore NWS Australia
V01R10 02-JUNE-2007	CA	Gyro calibration alongside Fremantle, Australia. USBL calibration performed offshore SE Australia.

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Acronyms and Abbreviations

CM	Central Meridian
CRP	Central Reference Point
CTD	Conductivity, Temperature, Density
CTL	Compact Transponder and Link unit
DFT	Discrete Fourier Transform
DGPS	Differential Global Positioning System
DP	Dynamic positioning
ECDIS	Electronic Chart and Display Information System
ED50	European Datum 1950
ES	Echosounder
GPS	Global Positioning System
HiPAP	High Precision Acoustic Positioning System
HDOP	Horizontal Dilution Of Precision
HSE	Health, Safety and Environment
LAT	Lowest Astronomical Tide
LTI/Ds	Lost Time Incident/Diseases
MBE	Multi Beam Echo Sounder
MRU	Motion Reference Unit
MSL	Mean Sea Level
PDOP	Position Dilution Of Precision
PGT	Programmable Generic Transponder
QA	Quality Assurance
QC	Quality Control
SBAS	Satellite Based Augmentation System
SSBL	Super Short Base Line
SV	Survey Vessel
SVP	Sound Velocity Probe/Profile
SSM	Super Sub-Mini Transponder
TSIP	Trimble Standard Interface Protocol
USBL	Ultra Short Base Line
UTM	Universal Transverse Mercator Projection
VRU	Vertical Reference Unit
WGS84	World Geodetic System of 1984

SBL related Acronyms and Abbreviations

DQC	Data Quality Control
EOL	End Of Line
EM	ElectroMagnetic
HED	Horizontal Electrical Dipole
MT	Magneto Telluric
MVO	Magnitude Versus Offset
OM	Offshore Manager (SBL survey manager)
PVO	Phase Versus Offset
Rx	Receiver
SBL	SeaBed Logging
SOL	Start Of Line
Tx	Transmitter

1. Vessel Specification

The Atlantic Guardian is a dynamically positioned vessel designed for stern working cable maintenance. The vessel was built at the van der Giessen-de-Noord Shipyard in Holland and delivered in December 2001.

Table 1: Atlantic Guardian - Vessel Specification

DIMENSIONS
Length Overall 103.49m
Breadth moulded 18.0m
Depth moulded 8.3m
Max Draught 5.75m
Gross Tonnage 7172
Port of registry ..... London
Call sign VNSF9

CLASSIFICATION
ABS A1, AMS, ACCU, DPS-2

DYNAMIC POSITIONING
DP Class 2
Alstom ADP 21
HPR/DGPS/Tautwire.

CABLE TANKS
2 main cable tanks below deck
Internal Diameter 12.0m
Tank Capacity 848m³
Max. Load ..... 850 Tonnes

CRANES/LIFTING CAPACITIES
Main cranes
1 x Hydralift Crane 3t at 22m/10t at 11m
1 x Hydralift Crane 2t at 12m

Auxiliary Cranes
2 x 2t SWL stores crane

Lifting Gantries
2 x 2.5t SWL covering center castle cable deck

A-Frame
1 x Hydralift 10t SWL

WINCHES
2 x 10t deck tugger winches

POWER AND PROPULSION
3 x Wartsila 9L26A each 2790kW at 900rpm
Alternators: Type ABB – AMG 0701LT08LSEA
Rating – 2970kW at 900rpm

Forward Thrusters
3 x Tunnel – Lips type 900kW each

Stern Thrusters
2 x 360º Azimuth – Lips type 2200kW each

Switch boards
1 x ship service
1x main switchboard

Emergency Alternators
1 x Caterpillar 190kW-440v – 1800RPM

Speed/Endurance
Service Speed ..... 13.5 Knots at 25 tonnes/day
Endurance ..... 40 Days incl. 10 days cable work

Bollard pull
60 tonnes with main engines developing 100% MCR.

ACCOMODATION
Captain Class 4
Single officers cabins 20
Single crew cabins 5
Double Crew Cabins 8
Hospital ..... 1 bed
Total berths 45

1.1. Vessel Navigation

1.1.1. Positioning Systems

The Vessel is equipped with two Leica Navigation systems (GPS/DGPS) with interfaces vessels navigation and control systems. The DGPS Navigator is using SBAS corrections (WAAS/EGNOS) or coast guard beacon stations. The vessel's DP-System is associated to the survey positioning setup with two redundant DGPS systems. 1 C-Nav and 1 Veripos dGPS system. Both systems use GPS corrections based on a global model generated from a network of Reference Stations, providing decimetre level accuracy. The positioning system is described in detail in chapter "3. Survey Navigation".

1.1.2. Vessel Navigation

Vessel's navigation is aided by a Kelvin Hughes X- and S band radar system (nucleus 2) and a Kelvin Hughes electronic chart system (ECDIS).

1.1.3. Vessel Control

For vessel control an Alstom duplex dynamic positioning system is installed to be certified to Lloyds AA (regarding DNV AUTR/IMO Class2). The DP operator can control the vessel from two identically consoles. All positioning systems, sensors and thrusters can be monitored from either console. Each DP console is powered by a separate un-interruptible power supply.
The following redundant positioning systems and sensors are interfaced to the DP system:

Position measurement equipment

- Two Differential GPS
- One USBL-system

Sensor Equipment

- Three Gyrocompasses
- Two Vertical Reference Units
- Three Anemometers

The DP system allows different control modes including the SBL relevant modes:

- Auto Positioning (DP)
  - Full automatic control of the vessel in all three axes (Surge/Sway/Yaw)
  - The vessel's position and heading at the instant DP is selected become those which the DP system attempts to maintain
  - Thrusters can be selected as long a the vessel is able to thrust fore/aft, port/stbd and produce a turning moment
- Auto Track
  - Auto Track controls the vessel between two or more operator defined points, on a set heading at a slow speed (SBL-Source towing modus)
- Auto Pilot
  - For a simple fast sailing transit mode to move the vessel on a constant set heading (Echosounder lines)
- Auto Sail
  - Auto Sail controls the vessel along a track between two or more operator defined points at speeds of (typically) over two knots.

  - Full automatic control of the vessel in all three axes (Surge/Sway/Yaw)

- The vessel's position and heading at the instant DP is selected become those which the DP system attempts to maintain
- Thrusters can be selected as long a the vessel is able to thrust fore/aft, port/stbd and produce a turning moment

Additionally a Robertson Autopilot system is interfaced to vessel's positioning and heading reference systems (Leica / mech. Gyro).

1.1.4. Auxiliary sensors

Echosounder

A Kongsberg-Simrad Echosounder with 12 kHz transducer is installed for seabed profiling down to 3000m water-depths.

Speed log

Additionally to speed over ground information from the GPS system, the speed through water is measured by a JRC Doppler log.

1.1.5. Equipment Summary

Table 2: Vessel Navigation and Control Equipment

Positioning		
System	***Manufacturer***	***Type***
DGPS	Leica	LMX 400 DGPSNavigator
GPS	Leica	LMX 420 Navigation System
Navigation		
Radar / ARPA	Kelvin Hughes	Nucleus2 6000A X/S-Band Radar
ECDIS	Kelvin Hughes	Nucleus2 5000 Electronic chart and display system
C-MAP	Furuno	TELchart V3
Vessel Control		
Dynamic Positioning	Alston	Duplex Dynamic Positioning
Autopilot	Robertson	AP9 Mk3Autopilot
Vessel Sensors		
Gyro (mechanical) 1/2/3	Yokogawa –	CMZ-700
Vertical Reference Unit 1/2	TSS –	CMS RP-25 Roll-Pitch Sensor
Echosounder	Kongsberg-Simrad	EA 500 12 kHz
Speed Log	JRC	NJC-18 Doppler Log

2. SBL-Equipment

2.1. Source

2.1.1. System Description

The source system is designed to meet state of the art SBL techniques with reasonable equipment specification regarding physical dimensions and practicability to handle the equipment safe and effectively.

The SBL source system consists of a
- power supply and control unit at the topside, a
- transmitter mounted on towed subsea-frame (towfish) and a
- horizontal electric dipole connected to the towfish.

The topside unit is controlling the power to generate the predefined EM pulse at the electric dipole. The power is transformed to high voltage/ low current and transferred via umbilical to the subsea system. At the subsea system the power is transformed back to low voltage / high current. A trailing electric dipole (antenna) is connected to the subsea signal source. This antenna is fed with a periodic current. The waveform, amplitude and periodic time can be defined and changed at the topside operator station.
A separate power supply feeds the instrumentation on the towfish.

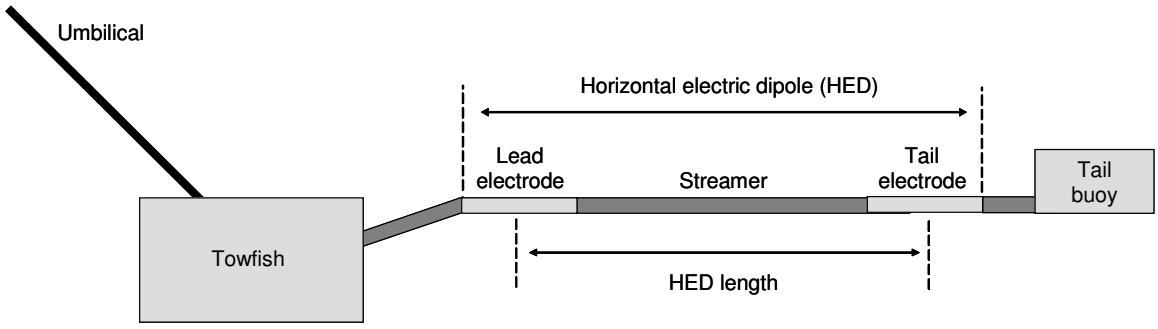


Figure 1: Schematic drawing of the source

Figure 1 shows the general schematic of the subsea configuration. The electric dipole (antenna) is neutral balanced for in-line towing operation. A tail buoy (tailfish) is designed to stretch the antenna system. Towfish (figure 2) and tailfish (figure 3) are carrying additional survey and navigation equipment.

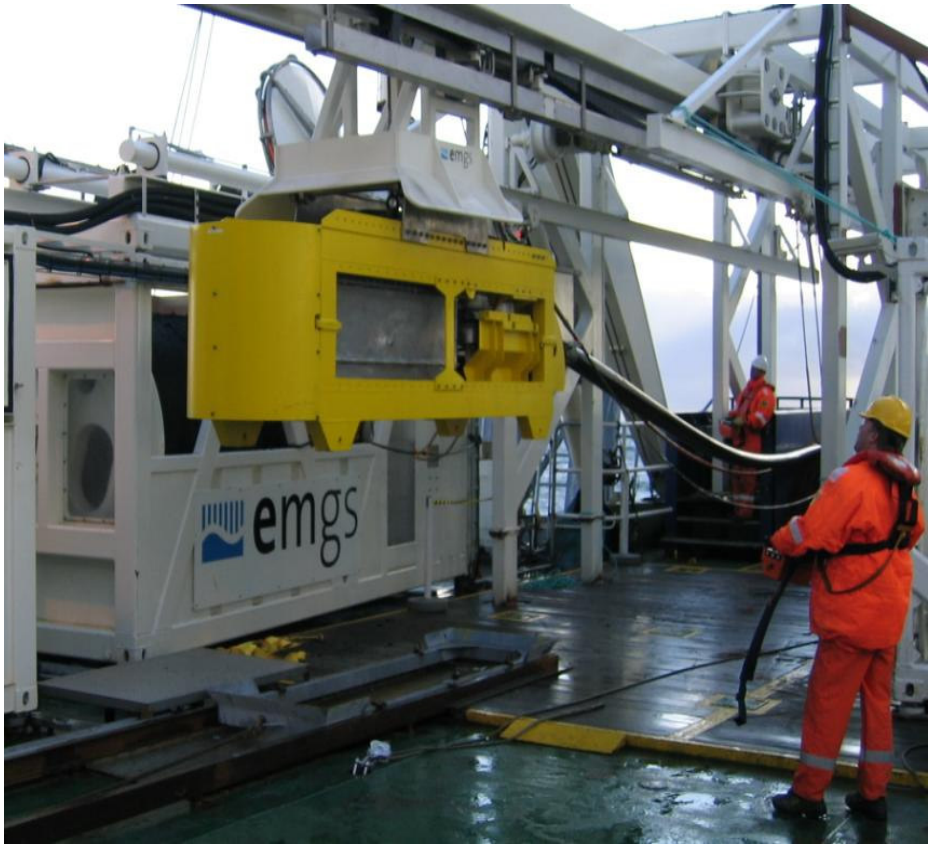


Figure 2: Towfish during deployment

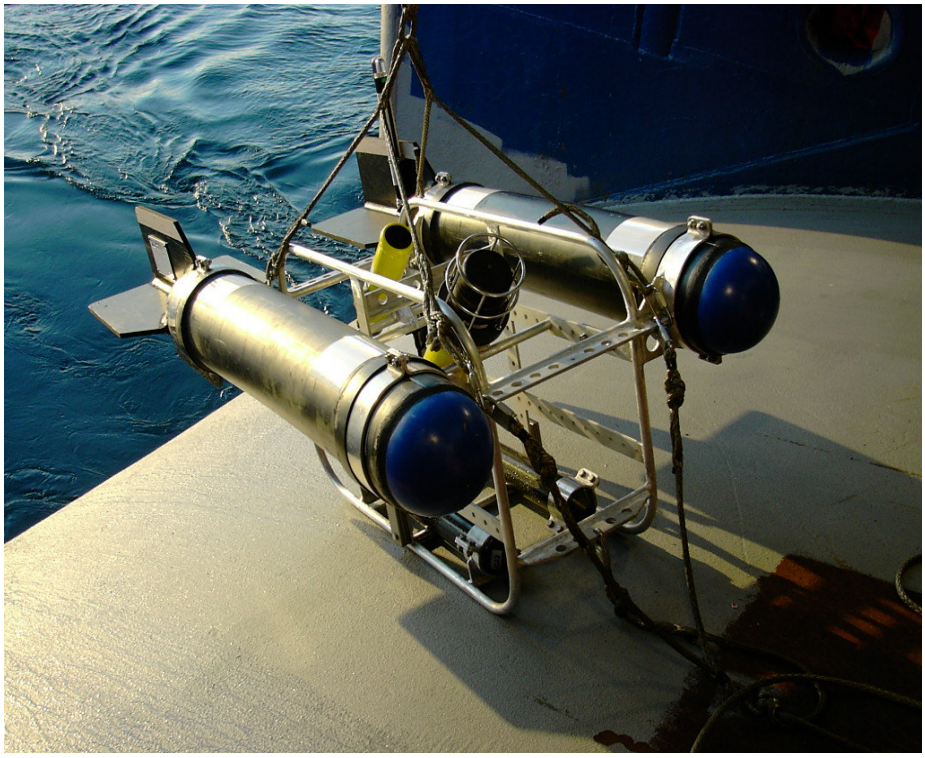


Figure 3: Tail buoy during deployment

Figure 4: HED-Electrode during deployment

2.1.2. Source Specification

The specifications of the main parameters of the source system are given in table 3 for the topside and table 4 for the subsea component.

Table 3: Source – Topside Specification

Topside	
Supply from vessels mains supply	440V / 400A Fuse / Three phase 47-63 Hz (EM-Source)
	230V / 10A Fuse / Single phase 47-63 Hz (Instrumentation)
Output to winch	3kV / 31A / Three phase, frequency 200-300 Hz (EM-Source)
	990V / 1A / Single phase auxiliary voltage to single source
Communication Interface	Ethernet connection for control PC and PLC (Simatic)
	Optical Fibre for communication to the subsea unit
Degree of protection	IP21
	The power unit is placed in an air conditioned and ventilated 10 foot container.

Table 4: Source – Subsea Specification

Subsea	
Current, Subsea	1250 A (peak)
Repeatability for current	+/- 2%
Peak Power	100kW (peak)
Voltage	75V peak
Frequency	0.05-10Hz
Time accuracy	+/- 1ms (Synchronised with GPS Clock)

2.2. Winch and Deck Handling System

A special winch and deck handling system was designed to for deployment, towing and recovering of the subsea system. The system consists of

- Umbilical winch with spooling device and overboard sheave
- Antenna winch
- Deployment and retrieval boom
- Hydraulic power unit (HPU)

Umbilical Winch

The umbilical winch is designed for towing operation in deep water down to 3000m water depth. A spooling device controls the correct spooling of the umbilical on the winch. The winch is compensated for heave by a stand alone motion reference unit (MRU).

Table 5: Umbilical Winch Specification

Physical Characteristics	
Type of winch	Heave compensated umbilical winch with spooling device
Drum core diameter / drum flange diameter	1570/2200 mm
Winch total dimensions	20 feet container
Total weight of winch without cable	Approx. 17300kg
Total weight of spooling device	Approx. 6300kg
Pulling force outer layer	220 kN
Pulling force inner layer	145 kN
Max pulling speed	120m/min
Motor type	Radial piston motor
Brake type	Single band break
Wire capacity	5500m
Classification	
Design base	DNV
Approval/certification	Works certificate

The umbilical layout encompasses power conductors for high voltage for the signal source, low voltage for instrument supply and fibre optical leads for instrument communication. The cable length and armouring is designed for deep tow operations. The following tables are containing the main parameters of the umbilical, the antenna winch system, the towfish handling boom and the hydraulic power unit.

Table 6: Umbilical Specification

Physical Characteristics	
Length	5500 m
Outer Diameter [mm]	28.2 mm
Weight in air	3.2 kgf/m
Weight in seawater (1.025kgf/dm)	2.2 kgf/m
Minimum bending diameter @ SWL	1400mm
Armouring breaking strength	400kN
Safe working load (max repeated)	110kN
Electrical Characteristics	
Power Conducters	3x 16mm2 / 3.5 kV
Fiber optic element	12x Single mode
Power Conducters	6x 0.5mm2 / 1 kV

Table 7: Antenna Winch Specification

Physical Characteristics	
Type of winch	Antenna spooling winch
Drum diameter	1600 / 2200 mm
Winch total dimensions	20 feet container
Total weight of winch without cable	Approx. 6400kg
Pulling force outer layer	220 kN
Pulling force inner layer	145 kN
Max pulling speed	0-30 m/min
Brake type	Automatic disc brake
Cable/Wire diameter / capacity	108mm / 550m (28mm / 5500m)
Classification	
Design base	DNV
Approval/certification	Works certificate

Table 8: Tow Fish Handling Boom Specification

Physical Characteristics	
Total boom length	15.m
Total boom width	2214 mm
Total concept height	1618 mm
Linear movement boom	5450 mm
Linear force boom carriage - stat	7500 Lb
Classification	
Design base	DNV's rules for certification of lifting appliances, 1994
Approval/certification	Hydrakraft works certificate

Table 9: Hydraulic Power Unit Specification

Physical Characteristics	
Max oil flow	3 x 450 Liters/min
El power supply	3 phase 440V/ 60Hz / 3 phase 380 50Hz
El power	3 x 240 kW / 3 x 200 kW
Oil tank capacity	2400 liters net
Design base oil type	ISO VG 46

2.3. Receiver

2.3.1. RxII System Description

Each receiver consists of a buoyancy system (One large main float shaped like a square halo, and a smaller tubical top float). The system includes two pairs of electric sensors (orthogonal to each other) and two magnetic sensors (parallel to the electric sensors and orthogonal to each other). In addition the receivers have full redundancy on the electric sensors with separate channels being recorded simultaneously.

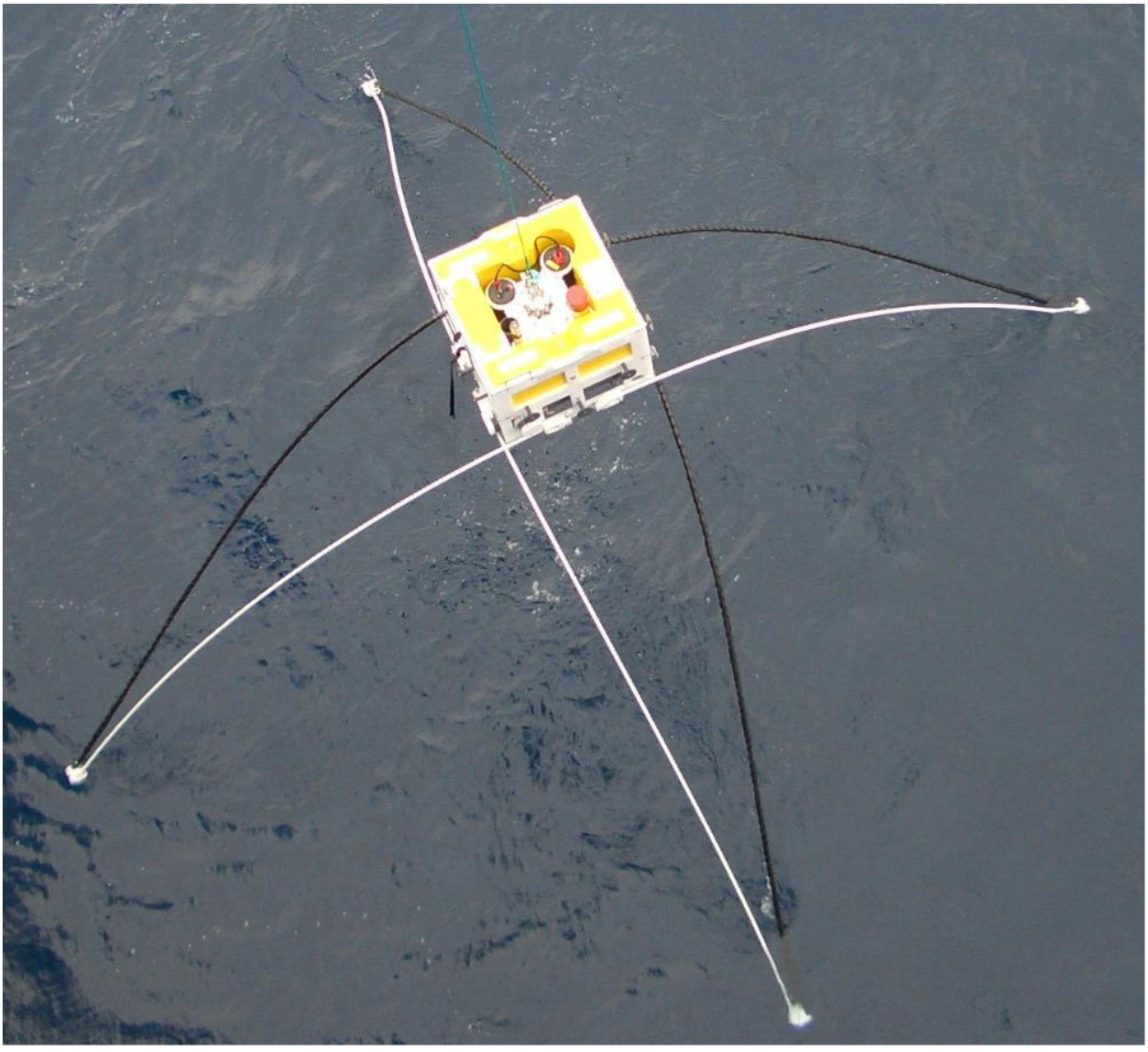


Figure 5: RxII Receiver during recovery

Electric sensors

The electric sensor consists of two pairs of flexible arms with two electrodes at the end of each pair. The arms are mounted in pairs and in opposite directions on the data acquisition unit. The acquisition unit is measuring the potential difference between the electrodes and is capable of recording voltage down to a few pico Volts. It can also change its amplifier gains to adapt it self to the different signal magnitudes as the source passes over head. Each sensor gives two independent registrations of the potential difference, since two electrodes are positioned at the end of each arm. Two electric sensors are standard in SBL, making it possible to record the electric field in two orthogonal directions (x and y).

Magnetic sensors

The magnetic sensors are induction coil magnetometers with a non-metal housing. The induced current (due to a time-varying magnetic field inside the coil) is measured and amplified before recorded by the data logger.

Recording unit / data logger

The data logger is the main electronic hardware in the RxII acquisition system. All electric and magnetic signals are registered and amplified before they get digitized and stored on the internal storage device (compact flash cards) in a 24 bit format. It is also possible to sample and store other values from sensors on the DAU, i.e. temperature, battery voltages, tilt and pitch etc. The data logger has six channels to store data of six sensors. A GPS synchronized internal clock time stamps the signals. The logger is configured via, and the data is downloaded through one joint connector. This makes it unnecessary to ever open the logger during normal operations, reducing the risks of water intrusion and general tear and wear.

Battery pack
The battery pack provides power for the data logger and is positioned inside the data acquisition frame in a separate and vacuumed pressure housing.

Acoustic positioning
An acoustic transponder (Kongsberg CTL) mounted on the data acquisition unit can communicate with the survey vessel while located on the seabed. The transponder gives the exact position of the receiver.

Release mechanism
The release mechanism consists of a primary release and a secondary release. They can both be triggered by an acoustic telemetry command from the vessel. It is possible to run the release procedure using both the acquisition unit and the transponder unit. These units can use their battery packs to run either of the release motors. The primary release retracts the claws used to attach the anchor to the receiver frame, while the secondary release ejects the claws leaving them on the sea bed together with the anchor.

GPS time synchronization system
The vessel mounted GPS receiver provides a GPS time stamp. This is used to synchronize the internal clock in the data logger before deployment. Following receiver recovery, the internal clock is compared to current GPS time to verify clock drift during the survey.

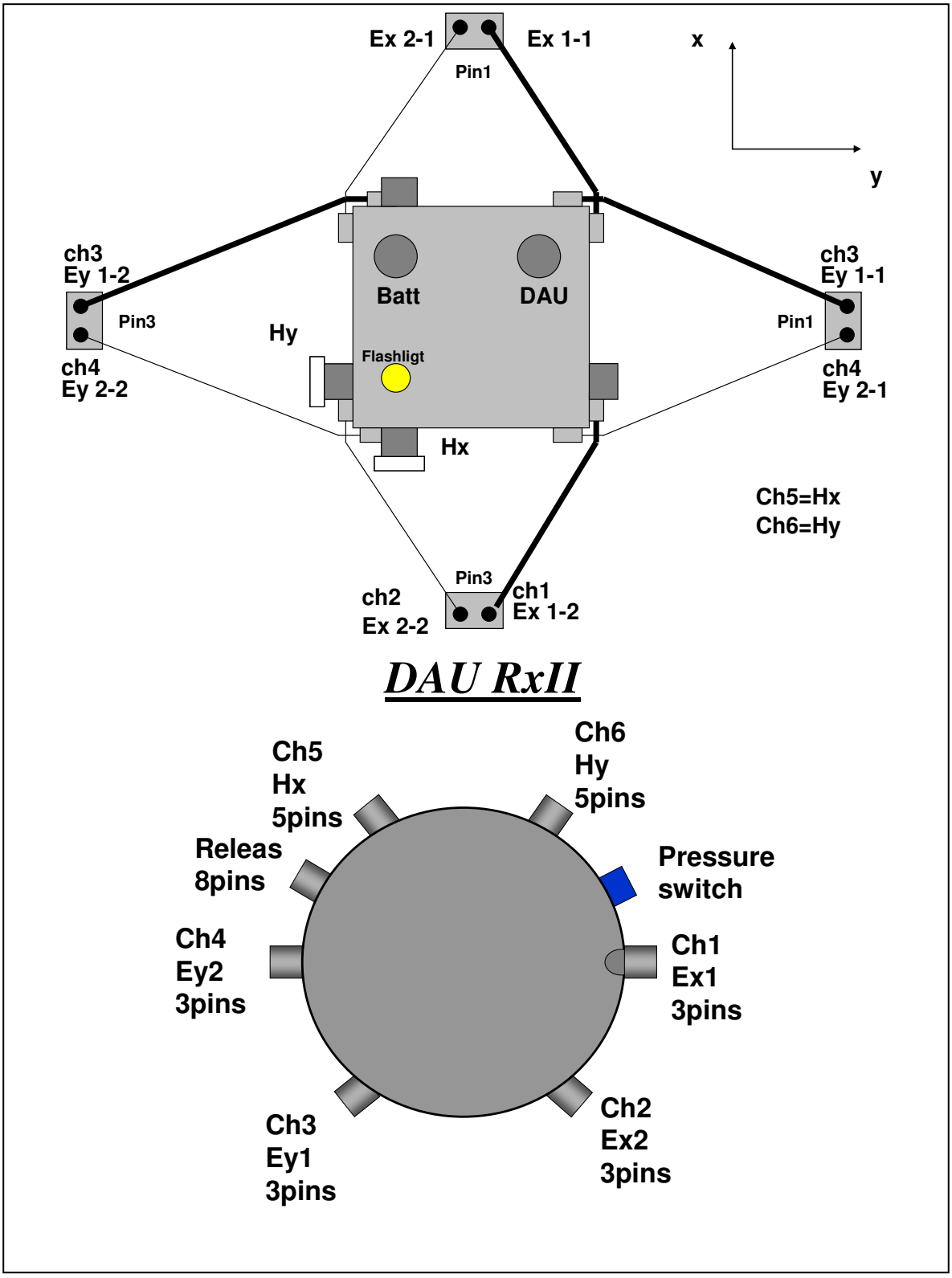
Software
The data acquisition unit contains software applications witch control the data acquisition parameters such as sampling frequency. Configuration before deployment is done via a PC terminal interface. After receiver recovery the data on the internal storage device is downloaded to a PC using an USB 2.0 cable through the one connector on the data logger unit. The data series from each sensor may be displayed on the PC for a qualitative quality check.

Anchor
Each receiver is mounted on a concrete anchor, in order to provide negative buoyancy during deployment, and to provide stability during seabed recording. The anchor remains at the seabed after release.

Buoyancy
Buoyancy is needed in order to bring the receivers back to the surface after the anchor release. The system consists of one large square halo shaped main float inside the frame, and a smaller tubical top float attached on the top of the frame. These are made of synthetic foam, giving the receivers positive buoyancy.

2.3.2. RxII Receiver Specification

Physical Characteristics	
Weight	In air : approx. 160kg ; Anchor in air: approx 180kg; Total system in water approx. 65kg
Depth Rating	4000m
Temperature Rating	40 deg. C
DAU Characteristics	
Analog to Digital	24 Bit
No of channels	6
Memory	4 GByte Compact Flash
Sampling Rate	50 Hz
Battery Type/Capacity	Alkaline/21 days (minimum)
Electric-Field Sensors	
Number	8 (Ex+1/2, Ex-1/2,Ey+1/2, Ey-1/2)
Type	Ag/AgCl
Dipole Length	8m
Magnetic Field Sensors	
Number	2 (Hx, Hy)
Type	MFS8U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Ch4
Ey2
3pins
Ch3
Ey1
3pins
Ch6
Hy
5pins
Pressure
switch
Ch1
Ex1
3pins
Ch2
Ex2
3pins

3. Survey Navigation

3.1. Integrated Navigation System

The SBL navigation system encompass a real-time data acquisition unit (RTNU) for all incoming positioning data, reference sensors and environmental sensors on the vessel and the subsea instrumentation, and the integrated navigation software package GATOR with SBL specific logging and display features.

Table 10: Integrated Navigation system

Navigation System		
System	***Manufacturer/Supplier***	***Type / Version***
Power RTNU	Concept Systems Ltd.	pRTNU
GPS Clock	Trimble	Thunderbold GPSClock
Online Navigation	Concept Systems Ltd.	GATOR V 9.1.11
OS for GATOR	Red Head Linux	Enterprise 4.0
Slave Node for Bridge	Concept Systems Ltd.	GATOR V 9.1.11
Slave Node for Winch Operator	Concept Systems Ltd.	GATOR V 9.1.11

3.2. Navigation Processing

Power RTNU

The PowerRTNU is a real time navigation unit from Concept Systems Ltd. with Real Time Operating System (RTOS) running on a VMEbus based architecture. The unit has the capability of 15 I/O channels and supports 100Mbit/sec Ethernet. The RTNU distributes time-synchronisation via NMEA+PPS and NTP. A built-in GPS clock is used to keep system time to better than 10us. The Trimble Thunderbolt GPS Clock uses an oven controlled oscillator to keep good system time in the event of a bad GPS signal. This is particularly important for the continuity of the synchronisation of the source during transmit lines.
Two slave nodes are installed to display online-source position and runline data on the Bridge (DP-operator) to the towing-winch operator.

Table 11: Navigation Data formats

Navigation Data Formats	
Dataformat Export data	EMGS Navigation Data format (.tx /.rx /)

3.3. Geodetic Parameter Conversion

All geodetical parameters are automatically converted in the Gator Navigation System. Test-coordinates to verify the correct setup at start of SBL operations are generated in the EMGS office by using “blue Marbles Geographic Calculation software.

Table 12: Geographic Calculator Software

Manufacturer	***Version***
Blue Marble Geographics	The Geographic Calculator 6.2

3.4. SBL-Source – Launch, Recovery and Towline Control

3.4.1. Horizontal Source Control

The towfish and tailfish positions and the calculated antenna-midpoint position are displayed on Gator Helmsman monitor to allow the navigator on the bridge the adjustment of the horizontal position of the SBL-source system to a runline according to the predefined runline corridor.

3.4.2. Vertical Source Control

For the vertical control of the SBL-source system the altitudes of towfish, tailfish and the antenna midpoint are displayed relatively to the (delayed) echosounder-depth below the vessel to the winch operator. The winch operator is monitoring and adjusting the height above the seabed of the SBL-source system to a decent altitude.
The towfish altitude is measured by a DVL (RDI-Navigator). Tailfish and antenna midpoint altitudes are calculated from the USBL positions (z-value) related to the towfish altitude by Gator

3.5. SBL-Receiver - Deployment and Recovery Control

The receiver positions during deployment and recovery are displayed on Gator Helmsman monitor to allow the navigator on the bridge the adjustment of the horizontal position. For the deployment the offset of the planned drop-position is set but the surveyor/navigator. During receiver recovery the bridge navigator move the vessel into the best position to pick up the receiver from the surface.

3.6. Water depth processing

The depths are compensated for a mean soundvelocity and directly logged as depths below surface.

3.7. Surface Positioning

3.7.1. System Description

For SBL survey positioining the Globally Corrected GPS (GcGPS) system “C-Nav” from C&C Technologies is used to meet high accurate horizontal and vertical accuracy. C-Nav is based on Real Time Gypsy (RTG) technology developed by NASA’s Jet Propulsion Laboratory to provide centimeter-level accuracy for space application. The RTG subscription service, combined with C-Nav GPS receivers provide worlwide positioning accuracy in the order of 0.1m.
A globlal network of reference stations is utilised to track the entire constellation of GPS satellites, which collect the raw GPS signal observations. These raw GPS ovbservations are then transmitted via the Internet back to the Network Control Centre (NCC). The NCC then calculates and models, in ‘real-time’ (RTG), all the GPS constellation satellite Orbital Corrections and also the individual delta Clock offset values. These Orbit and Clock correctors are then transmitted to the mobile user, via geostationary L-Band INMARSAT satellites.
Redundancy – C-Nav operates in a varity of redundant modes. If for some reasons the RTG signal subscription fails, C-Nav will automatically switch to each of these modes if available (WAAS, EGNOS).
As stand alone dual frequency GPS receiver, C-Nav provides a worldwide horizontal accuracy of 3-5m.
For tidal measurements the receivers can provide vertical accuracies of <0.5m.

3.7.2. Specifications

3.7.2.1. Primary Positioning System

C-Nav 1

C-Nav 2050 GPS Sensor / Controller

The 2050 Sensor consists of a 10-channel dual-frequency (L1/L29 precision GPS sensor with two additional channels for receiving Satellite Based Augmentation System (SBAS) signals and L-Band demodulator for reception of C-Nav StarFire Network correction service giving an immediate solution for the user utilising the global Real Time Gypsy (RTG) and regional Wide area Correction Transform (WCT) solutions. Additionally the unit can accept corrections for DGPS, WAAS/EGNOS, assuring seamless position output.

GPS Antenna and Inmarsat L-Band Antenna

The GPS antenna includes an antenna with a stable phase centre for GPS L1 and L2.
The combined GPS and Inmarsat antenna also receives L-Band signal from geostationary INMARSAT satellites.

Features

- Global decimetre-level accuracy using RTG corrections
- Automatic acquisition of satellite broadcast corrections
- Configurable for global L-Band satellite coverage – RTG, WAAS, EGNOS
- Accepts external GPS correction input in NCT, RTCM v2.2 or CMR format
- L1 & L2 full wavelength carrier tracking
- C/A, P1 & P2 code tracking
- 2 separate SBAS channels (WAAS/EGNOS)
- 1 PPS output

Performance

- Real-time Starfire DGPS Accuracy
  - Position (H): < 10cm
  - Position (V): < 30cm
  - Velocity: 0.01 m/s
- Time to first fix
  - Cold start, Satellite Acquisition: < 60 seconds (typical)
  - Reacquisition: < 1 second

- Data Latency
  - Raw data < 20ms
- 1pps Resolution
  - 12.5 ns

For the C-Nav 1 system a complete equipment back up is installed including GPS/Inmarsat Antenna and GPS receiver.

3.7.2.2. Secondary Positioning System

Veripos Ultra

As secondary system the output of the vessels DGPS (Veripos Ultra) is interfaced to the survey navigation computer. For Veripos Ultra the correction signals either from the Spot beam antenna or the Inmarsat antenna can be selected at the Veripos operation station on the bridge.

3.7.3. GNSS Quality Control

The QC parameters for the GNSS system are directly setup in the C-Nav GPS receivers.
Further GPS input quality control is continuously carried out in the navigation system (Gator).

Table 13: Key Parameters for GNSS QC

Navigation and Tracking Setup	
Elevation Mask	10 (degrees)
Navigation Rate	1Hz
Min SV's for Solution	4
Max PDOP for Solution	10
Differential Correction Service	RTG
Max dGPS age	300

3.7.4. Survey and Calibration

3.7.4.1. Survey

After changes of the arrangements in the antenna mast the new DGPS antennae were moved into new positions. The GPS antennae offsets from the VRP were calculated by measuring their offsets from the known positions of the previous antennae and adjusting this back to the VRP. The verification survey of the new dGPS systems GPS1 and GPS2 was undertaken between 05:20 and 05:49 (UTC) on 17th February 2007.

Two coordinated survey marks were already established on Broome Jetty: BR04 and BR05. In addition to this, two additional coordinated control points were established for use during the survey these being BR01a and BR23a.

A Total Station (Topcon GTS-220) was set up over BR01a, using BR05 as the reference object. A set of 60 range and bearing observations were made to a prism attached to the antennae mast at 30 second intervals during the observation period. These observations were synchronised with the Gator INS on the vessel.

The observations were used to compute the calculated positions of the dGPS antennae. WGS84 differentially corrected coordinates observed by the C-Nav and Veripos positioning systems were extracted from the Gator INS system and used as the onserved antennae positions. Offsets from the prism to both of the antennae were applied to the calculated positions and the observed positions were matched by time with the Total Station observations.

Preliminaries prior to the observations

Prior to the dGPS integrity check, the following were carried out:

- All mooring lines were tightened
- There was no heavy loading or unloading on the vessel
- The surveyor's time piece was synchronized with the vessel computer time
- All C-O were removed from the vessel computer system (i.e. logged raw data only)
- Navigators to monitor the stability of the DGPS and GYRO while calibration was ongoing.

Table 14: GNSS Verification – Datum and Control Points

Geodetical Parameters	
Datum of Navigation System	WGS84
Projection	UTM Zone 51N , CM 123 deg. E
Observations	
No. of observations	60 for each GPS antenna

3.7.4.2. GNSS Antenna Offsets

Table 15: GNSS - Antenna Offsets

System	*Description*	*X [m]/Stbd*	*Y [m]/Fwd*	*Z [m]/Up*
VRP	Vessel Reference Point	0.00	0.00	0.00
GPS1	L1/L2 GPS Antenna (C-Nav 1 / Port)	-1.40	0.75	-37.10
GPS2	L1 (Veripos Ultra)	-2.64	1.14	37.10

3.7.4.3. Results of the DGPS Verification

Table 16: Results of the DGPS Verification

System	*Mean C-O Easting (m)*	*SD (m)*	*Mean C-O Easting (m)*	*SD (m)*
GPS1 (C-Nav)	-0.49	+/- 0.04	-0.67	+/- 0.04
GPS2 (Veripos)	-0.48	+/- 0.04	-0-84	+/- 0.05

3.8. Subsea Positioning

3.8.1. System Description

Subsea positions are calculated relatively to the vessel based on vessels surface position C-Nav 2050M and the input (x,y,z) of the vessel mounted USBL measurement system (Sonardyne Fusion & Sonardyne Ranger Pro).
The primary sensor for vessels heading, roll and pitch status is an iXSEA Octans system.
USBL-transponders are mounted on all receivers and the tailfish. The towfish is equipped with an USBL transponder in responder mode.
The receivers are directly positioned by the USBL-system (x,y,z) and calculated by Gator (Easting/Northing). The source position (antenna midpoint) is calculated from towfish and tailfish positions by Gator regarding antenna offsets (distances to HED electrodes).
Sound velocity profiles are logged during towfish deployments by using the towfish mounted CTD/SVP to improve the USBL positioning.
USBL verifications are carried out when necessary to confirm the correct USBL alignment and roll/pitch offsets.

3.8.1.1. USBL System

Sonardyne Fusion/Ranger pro

The Fusion & Ranger Pro system is comprised of hardware and software options to create a complete system. A typical system consists of a Data Fusion Engine (Processor/Hardware), USBL transceiver, Fusion USBL software, transponder(s) and various inputs from other sensor packages such as GPS and attitude sensors.
Fusion/Ranger Pro USBL is designed to accurately position multiple sub sea targets relative to a surface vessel. The system is particularly suited to tracking ROVs, AUVs and tow fish or as position reference input for vessels equipped with a Dynamic Positioning system.

In this application, a beacon is placed on a towfish or on the SBL receivers. The beacon on the towfish can be triggered alternatively acoustically from the USBL transducer (transponder mode) or electrically via multiplexer and umbilical (responder mode). The USBL system will track the position of the beacon

relative to the vessel (x,y,z). Multiple, mobile or stationary targets can be selected for tracking in USBL operation.

The Fusion/Ranger Pro system is designed to control Sonardyne channel frequencies as well as HPR300/400 (Simrad) channel frequencies.

USBL Transceiver – Standard Head

The USBL Transceiver is a complete microprocessor controlled interrogator/receiver operating on command from the navigation processor (Fusion Engine). The main functions of the transceiver are:

- Transmission of transponder interrogation signals on anyone of 29 frequencies between 19.2 and 36 kHz. The transmitted pulse can be variable in length between 1 and 8 ms. The output power can be adjusted in 3 steps of 6dB each.
- Reception of transponder reply signals can be on any one of the 29 frequency channels between 19.2 and 31.6 kHz.
- Decoding of Acoustic Telemetry
- Measurement of time and phase information in the received transponder reply.
- Transmission of measured (range and bearing) data to the navigation processor (Fusion Engine)

PGT (Programmable Generic Transponder/Responder)

PGTs are fitted on the tow and the tail fish of the source, providing their position relative to the towing vessel. In normal operation, the head transponder is externally powered and receives a trigger for use as a responder. The tail transponder is powered by an external battery pack and is interrogated acoustically. The “dual personality” design of the PGT allows for positioning the transponder with the Sonardyne Fusion as well as with Simrads HPR or HiPAP system. The PGT has a super-directional beam characteristic of 30deg.

SSM (Super Sub-Mini Transponder/Responder)

The SSM is designed for use with the Simrad HPR and Sonardyne LUSBL families of range-bearing acoustic navigation systems. By means of external rotary channel selection switches, it may be switched to any of the regular HPR 300 or HPR 400/HiPAP series channels. Forbidden HPR channels are corresponding to a list of SSM channels on sonardyne frequencies.
The SSM is of small size and weight compared to a PGT but is internally powered by a rechargeable battery while a PGT is powered by Lithium batteries with more capacity.

CTL (Compact Transponder and Link unit)

CTLs are fitted to each RxII SBL receiver to provide USBL positioning during deployment and recovery. It also has an acoustic telemetry link for command and data transfer. The CTL is connected to both the primary and secondary release motors, and can use it’s own battery pack to run these motors on command.
The CTL is compatible with the Kongsberg Maritime HiPAP and HPR systems as well as with the Sonardyne Fusion. It has a 40 degree cone transducer beamwidth.

3.8.1.2. Attitude Sensors

Gyro/VRU (Octans)

The Octans is a survey-grade fibre optic gyrocompass and a MRU providing true heading, roll pitch, yaw, heave, surge, sway, rates of turn and acceleration.
The Octans is used together with the DGPS-system and the Sonardyne Fusion system to find absolute positions of the SBL subsea equipment.
Three accelerometers, three fiberoptic gyrometers and a real time computer in the Octans make up an intertial measurement unit (IMU) in the instrument.

Specification

3.8.1.3. USBL System

Table 17: Fusion/Ranger Pro USBL Technical Specification

Fusion USBL	
Operating Range	1 to 5500m (Dependent on acoustically conditions and hardware performance)
Acoustic Coverage	+/-90 deg. or +/- 50deg. (Dependant upon USBL transceiver type)
Range Accuracy	<0.2m (Dependent on sound speed determination accuracy)
Directional Resolution	<0.1% of Slant Range
System Positional Stability	+/- 2m in 1000m (1Sigma)
Frequency Band	Sonardyne MF (19 kHz to 36 kHz)
Operating Temperature	0-40 deg. C

Table 18: USBL-Transceiver – Technical Specification (Acoustic)

USBLTransceiver – Standard Head	
Transmitting	
Directivity Index	8 dB approx.
Power	50 Watt acoustic
Source Level	195 DB / 1uPa*m (dB ref 1micro pascal @1m)
Receiving	
Operatingenvelope	+/- 80 deg. (160deg) min
Sensitivity Threshold	100 dB ref 1 micro pascal
Directivity Index	10 dB
Accuracy	Better than 1% of range

Table 19: PGT – Technical Specification (Acoustic)

PGT – Programmable GenericTransponder	
PGT – Type	7978
Super Directional	+/-15deg.
Frequency Range	MF 20-32 kHz
Acoustic Sensitivity	89 +/-4 dB re 1 uPa
Acoustic output at high power	210 +/- 3 dBre 1 uPa @ 1m
Channels available	HPR300: all 14 channels, 1-9, 11, 22, 33, 44, 55 HPR 400 + HiPAP: all 56 channels
Pulse length	10 ms
Turn around delay	30 ms
Maximum interrogation rate	750 ms
Operating Temperature Range	-5 to +30 deg. C
Storage Temperature Range	-10to +50 deg. C
Battery type	Lithium (7 D-Cells)
Depth rating, housing	3500m

Table 20: CTL – Technical Specification (Acoustic)

CTL – Compact Transponder and Link unit	
CTL – Type	342
Super Directional	+/-20deg.
Frequency Range	MF 20-32 kHz
Acoustic Sensitivity	95 dB
Acoustic output at high power	203 dB
Channels available	HPR 400 + HiPAP: all 56 channels
Pulse length	10 ms
Turn around delay	60 ms
Operating Temperature Range	-2 to +30 deg. C
Storage Temperature Range	-20to +30 deg. C (<50 % relative humidity)
Battery type	NiMH 3 strings of 12 cells serial
Depth rating, housing	4000m

Table 21: SSM – Technical Specification (Acoustic)

SSM – Super Sub-Mini Transponder	
SSM – Type	7970
Tx Beam Pattern	Low frequency channels +/-30 deg. conical High frequency channels +/-20 deg. conical
Acoustic Sensitivity	<100 dB re 1 uPa
Acoustic output at high power	199 +/- 3 dBre 1 uPa @ 1m
Channels available	HPR300: all 14 channels, 1-9, 11, 22, 33, 44, 55 HPR 400 + HiPAP: all 56 channels Sonardyne SSM Channels
Pulse length	10 ms
Turn around delay	30 ms
Maximum interrogation rate	750 ms
Battery type	Nickel Metal Hydride rechargeable
Depth rating, housing	4000m

3.8.1.4. Attitude Sensors

Table 22: Octans Gyro – Technical Specification

Octans Gyro		
Gyrocompass dynamic accuracy	+/-0.2 deg secant latitude, or 0.1 deg RMS	
Gyrocompass settle point error	+/-0.1 deg secant latitude, or 0.05 deg RMS	
Gyrocompass settling time (static)	1 minute	
Gyrocompass settling time (at sea)	3 minutes	
Gyrocompass repeatability	+/-0.025 deg secant latitude	
Gyrocompass resolution	0.01 deg	
Motion sensor heave, surge and sway accuracy	5cm or 5%, whatever is highest	
Motion sensor heave, surge and sway resolution	1 cm	
Motion sensor heave, surge and sway heave motion periods	0.003 to 100s (tunable)	
Motion sensor roll, pitch and yaw accuracy	0.01 deg	
Motion sensor roll, pitch and yaw range	No limitations	
Motion sensor roll, pitch and yaw follow-up speed	Up to 500 deg per second	
Sensor (IMU) intrinsic performances:	Accelerometers	Gyroscopes
In-room bias stability (rms)	20 micro-g	0.005 deg/hour
Bias stability over temperature range -40 deg to 80 deg	+/-500 micro-g	+/- 0.05 deg/hour
Resolution	10 micro-g	0.2 Arc-second

3.8.2. Survey and Calibration

The following surveys were carried out to calibrate the attitude sensors for use in the USBL system.

- Gyro calibration
  - Calibration of the USBL heading sensor (Octans/Vessel Gyro)
    The gyro calibration of the vessel was undertaken on the 17th and 18th February 2007 at Broome, Australia.

- MRU calibration
  - Calibration of the USBL motion reference unit (Octans)
    The survey was carried out in Ågotnes (Norway) the 3rd of November 2005.

- USBL calibration
  - Calibration of the USBL system
    Calibration for Transceiver misalignment was conducted on 22 February 2007 at location 19° 21.0' S, 114° 25.75' E.

3.8.2.1. Gyro Calibration

Method of Survey

The gyro compass calibration was conducted by time coordinated, simultaneous observations, using 2 Total Stations set over stations BR01a (referenced to BR05) and BR23a (referenced to BR04). Observations were made to reflecting prisms secured to the centre bow and stern of the vessel. The Gator INS was set to log raw, uncorrected gyro compass heading at 30 second intervals.

Synchronised observations to the bow and stern were taken between 04:52 and 05:10 and between 06:09 and 06:20 on the 17th of February. Readings were taken in 2 separate rounds of observations as the line of sight to the bow became obscured for approximately 1 hour. The second set of observations was taken between 06:46 and 07:16 on the 18th of February. During the first set of observations the vessel was on a heading of approximately 30° and the second set of observations was taken on the reciprocal heading of approximately 210°. The vessel had been tied up alongside the wharf for 2 hours prior to the second set of measurements allowing the gyro compass to settle.

Observations to the prisms located at the bow and stern were used to compute the calculated vessel heading (C). Raw values output from the gyro compass were used as the observed true heading (O). The calculated vessel heading (C) was compared to the observed true heading (O) to determine the calculated minus observed (C-O) value for the gyro compass. The results are shown in the table below.

Final Results of the Gyro Calibration

Table 23: Gyro Calibration – Final Results

Approximate Vessel Orientation	***Gyro Compass (Octans)***	
	Mean C-O	***SD***
Heading 030°	-1.91°	+/-0.02
Heading 210°	-1.98°	+/-0.03
Mean Correction	**-1.95°**	

3.8.2.2. Pitch Calibration

Method of Survey – Pitch Calibration

From a vessel drawing, or previous survey in a dry dock, heights at bow and stern are known relative to the keel or a parallel to the keel. From this information the heights of bow and stern prisms are derived in the vessel system. Corresponding survey heights are calculated using the average of the observations to each of the prisms. The height differences and the horizontal distance, derived from co-ordinates, are used for calculation of the pitch angle. This value is compared with average of the logged values (logged every 1-2 minute). The pitch is positive when the bow is up.

Observations and Final Results – Pitch Calibration

Table 24: Pitch Calibration – Final Results

Pitch Calibration			
System	***Computed***	***Observed***	***C-O***
Octans 3000	0.132 deg	0.020 deg	0.11 deg

3.8.2.3. Roll Calibration

Method of Survey – Roll Calibration

Co-ordinates and heights for every 5 or 10 minutes of port and starboard prisms are calculated and the average values are used for calculation of the roll angle. This value is compared with average of the logged values (logged every 1-2 minute). The roll angle is positive when the port side is up.

Observations and Final Results – Pitch Calibration

Table 25: Roll Calibration – Final Results

Roll Calibration			
System	***Computed***	***Observed***	***C-O***
Octans 3000	-0.50 deg	-0.39 deg	-0.11 deg

3.8.2.4. USBL calibration

Method of Survey

The calibration of the USBL transducer misalignment was performed on 22nd February 2007 in the waters off the North West coast of Australia in a water depth of around 1400m. After the acquiring of a local sound velocity profile, a 4-quadrant calibration method was chosen with 5 stationary vessel positions and opposite headings in each vessel position. The Figure below shows the vessel track starting from the centre at the top of the transponder.
The CASIUS calibration software (Sonardyne) has been used to calculate the alignment errors before and after the calibration process and the correction offsets for Heading, Roll and Pitch.

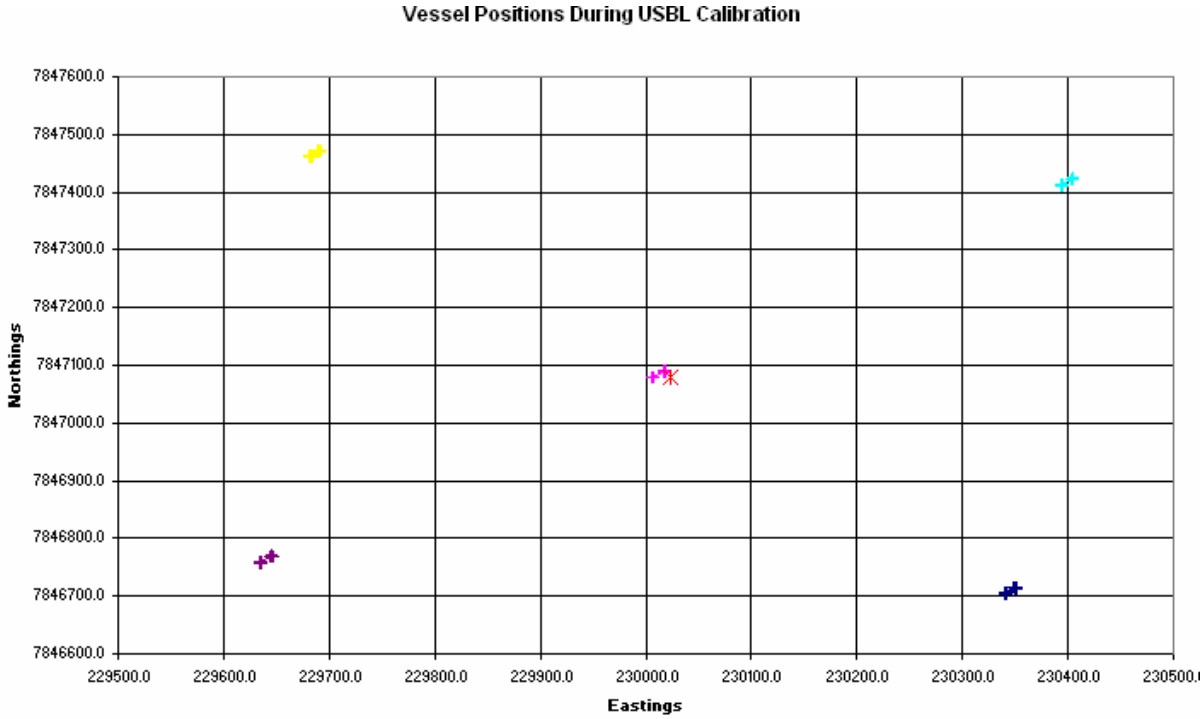


Figure 6: Vessel Track

The following figures are showing the transponder positions in 3D views before and after applying the calibration results. The Casius calibration report is followed by a scatter plot of the corrected transponder position.

Observations and Results

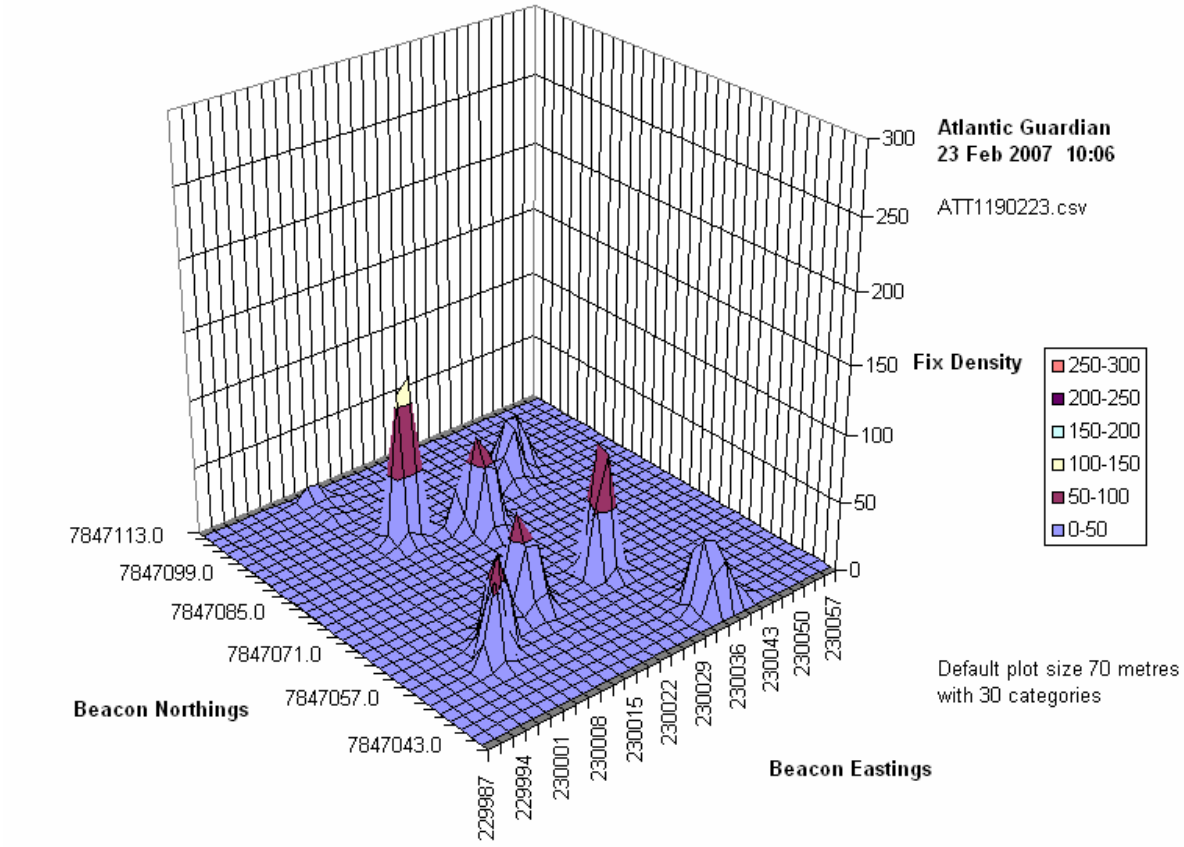


Figure 7: Uncorrected transponder position

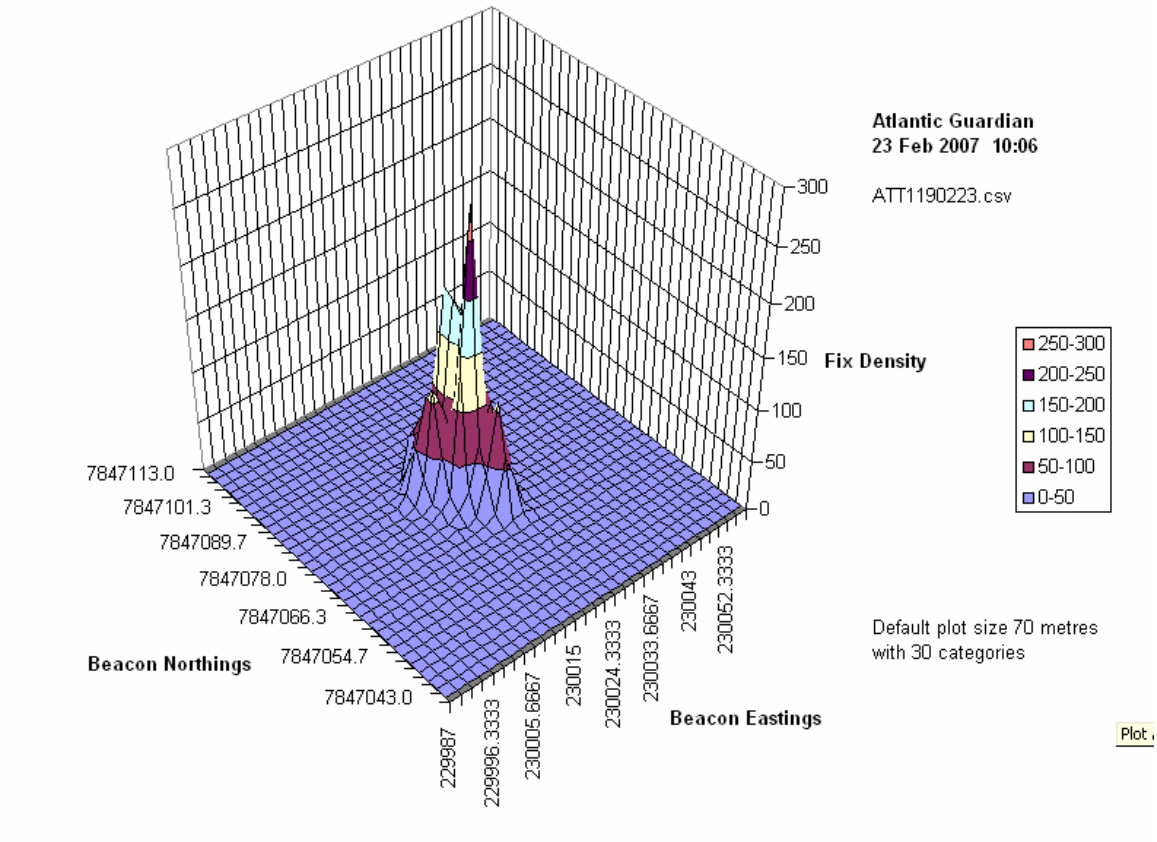


Figure 8: Corrected transponder position after the calibration

Calibration Report

Atlantic Guardian **CASIUS calibration report** Casius Version 4.7c Excel 11.0 LUSBL version 6

Comments: Enter specific information about this CASIUS calibration here.....

data file: ATT1190223.csv Path: H:\Data\D\FILES\USBLLOGS\Atlantic Guardian\Feb07\
report file: ATT1190223.xlr
log start: 23 Feb 2007 10:06 log end: 24 Feb 2007 09:47 duration: 23:40

INPUTS:	Tp East	Tp North	Tp Depth	Sound vel	Tcvr Stbd Offset	Tcvr Fwd Offset	Pitch Corr	Roll corr	Head corr
Used by USBL	-----	-----	-----	1,518.9	-----	-----	0.00	0.00	0.00
Initial Estimates	230,013.8	7,847,093.0	1,387.0	1,497.7	0.75	14.05	-----	-----	-----
Estimate accuracy	30.0	30.0	5.0	50.0	1.0	1.0	-----	-----	-----

Distance units are metres

Range gate	1.0	angle gate	2.0	% slant range			
Range accy	0.2			Ant Stbd Offset	1.1	Tcvr Index	15
Tcvr Depth Offset	9.35			Ant Fwd Offset	-2.6	Beacon Name	BEACON X
Tcvr depth	9.35	accuracy	0.5	Ant Height Offset	37.10	Turn Around Time	60 ms
Depth aid angle limit	22.0	depth limit	1.0			DGPS lags USBL by	0 seconds
DGPS protocol	NMEA 0183 GGA						

OUTPUTS:

	Tp East	Tp North	Tp Depth	Sound vel	Tcvr Stbd Offset	Tcvr Fwd Offset	Pitch Corr	Roll corr	Head corr
Calculated	230,022.9	7,847,078.4	1,389.8	1,502.5	0.76	14.12	**0.07**	**-0.60**	**1.25**
Calc accuracy	0.02	0.02	0.13	0.08	0.02	0.02	0.00	0.00	0.01

	Before CASIUS	After CASIUS		Box In	Tcvr Attitude
39.4% Tpdr posns. (1 sigma)	19.2	4.0	No. of iterations	2	2
50.0% Tpdr posns. (CEP)	24.9	4.7	No. Depth aided		0
63.2% Tpdr posns. (1 Drms)	32.9	5.8	No. of fixes used	3527	3527
86.5% Tpdr posns. (2 sigma)	41.5	8.5	Average weighted residuals	0.01	0.28
98.2% Tpdr posns. (2 Drms)	46.0	12.6			

N.B. The Pitch, Roll & Heading corrections are to be entered as the USBL tcvr/ship grid corrections.

Final Results

The calculated error radius (1 Drms) is 5.8m and is below the SBL-Standard criteria of 0.5% of the Slant Range (Water depth), it is therefore acceptable. The correction values for Heading, Roll and Pitch were setup in the USBL system (Fusion).

Table 26: USBLCalibration – Final Results

Criteria	***Result***	***SBL Standard***
1 Drms < 0.5% of Slant Range	5.8m = 0.42% of SR	6.9m =0.5% (1398.9m)
Heading corr.	***Roll corr.***	***Pitch corr.***
+0.1.25 deg.	-0.60	0.07

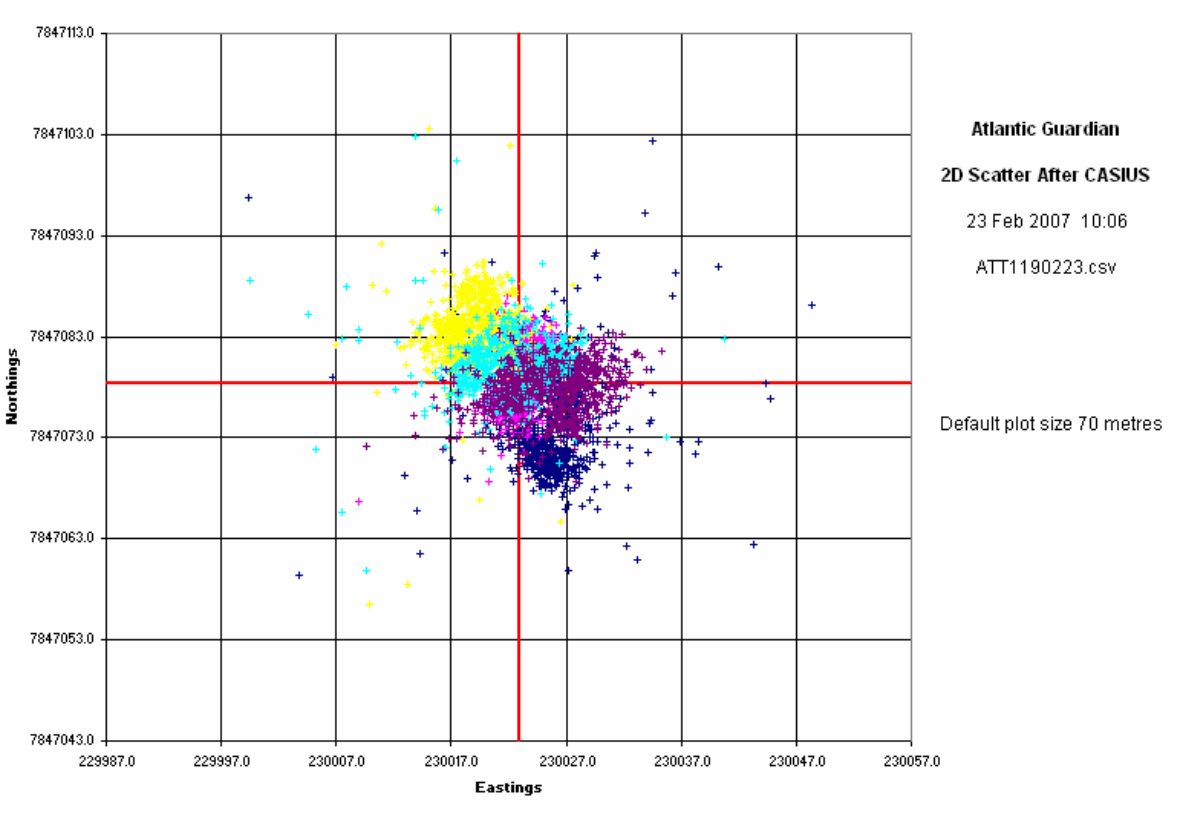


Figure 9: 2D scatter-plot of the calibrated transponder positions

3.9. Subsea Equipment

3.9.1. Instruments

DVL – Doppler Velocity Log

The RDI Workhorse Navigator is a Doppler velocity log (DVL) providing velocity and altitude updates.

Table 27: DVL- Technical Specification

Sound Velocity	
Frequency	300 kHz
Velocity range	+/- 10m/s
Velocity resolution	0.1 cm/s
Minimum Altitude	1m
Maximum Altitude	200m
Ping rate	7 Hz max
Depth rating	3000m

CTD/SVX – Oceanographic Sensor Package

The Valeport MIDAS SVX is a combined CTD & sound velocity profiler with internal logging capability. The unit is fitted with the following sensors:

Table 28: CTD/SVX- Technical Specification

Sound Velocity	
Type	Valeport “time of flight” sound velocity sensor
Range	1400 to 1600 m/s
Accuracy	+/- 0.03m/s (rms)
Resolution	0.001 m/s
Conductivity	
Type	Valeport inductive coil
Range	0.1 to 80mS/cm
Accuracy	+/- 0.01 mS/cm
Resolution	0.002mS/cm (up to 4Hz sampling, 0.006 mS/cm at 8 Hz)
Pressure	
Type	Strain Gauge
Range	500 Bar absolute (approx. 5000m water depth)
Accuracy	+/- 0.04% Full scale
Resolution	0.005% Full scale
Temperature	
Type	Fast response PRT
Range	-5 to +35 deg. C
Accuracy	+/- 0.01 deg. C
Resolution	0.002 deg. C
Mechanical Specifications	
Housing	Titanium
Weigth	15 kg (air), 8 kg (water)
Depth Rating	5000m
Sampling Rate	1,2,4 or 8 Hz

Offsets

3.9.1.1. Source – Antenna Arrangement

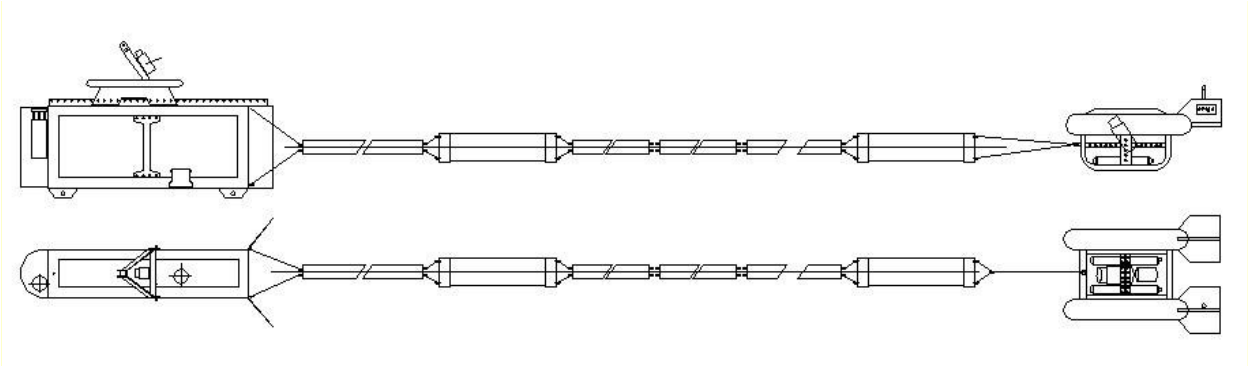


Figure 10: Source – Antenna Arrangement

3.9.1.2. Antenna Offsets

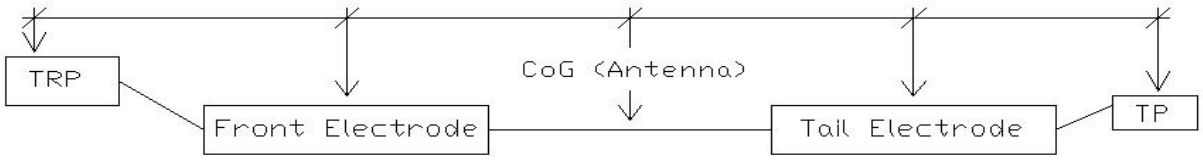


Figure 11: Antenna Offsets – Source/HED

Table 29: Antenna Offsets – Source/HED

Source / HED					
			x [m]	***y[m]***	***z [m]***
TRP to Front Electrode		TRP – FE	0.0	-24.00	0.0
Front Electrode to Tail Electrode		FE – TE	0.0	-275.50	0.0
Tail Electrode to TP		TE – TP	0.0	-7.7	0.0
TRP to CoG-Antenna (midpoint)		TRP - CoG	0.0	-161.75	0.0
TP to CoG-Antenna(midpoint)		TP - CoG	0.0	145.45	0.0

NB! The antenna offsets may be adjusted during a survey. The actual antenna offsets are updated in the headers of the .tx, .rx and .tl files.

3.9.1.3. Instrument Offsets Towfish

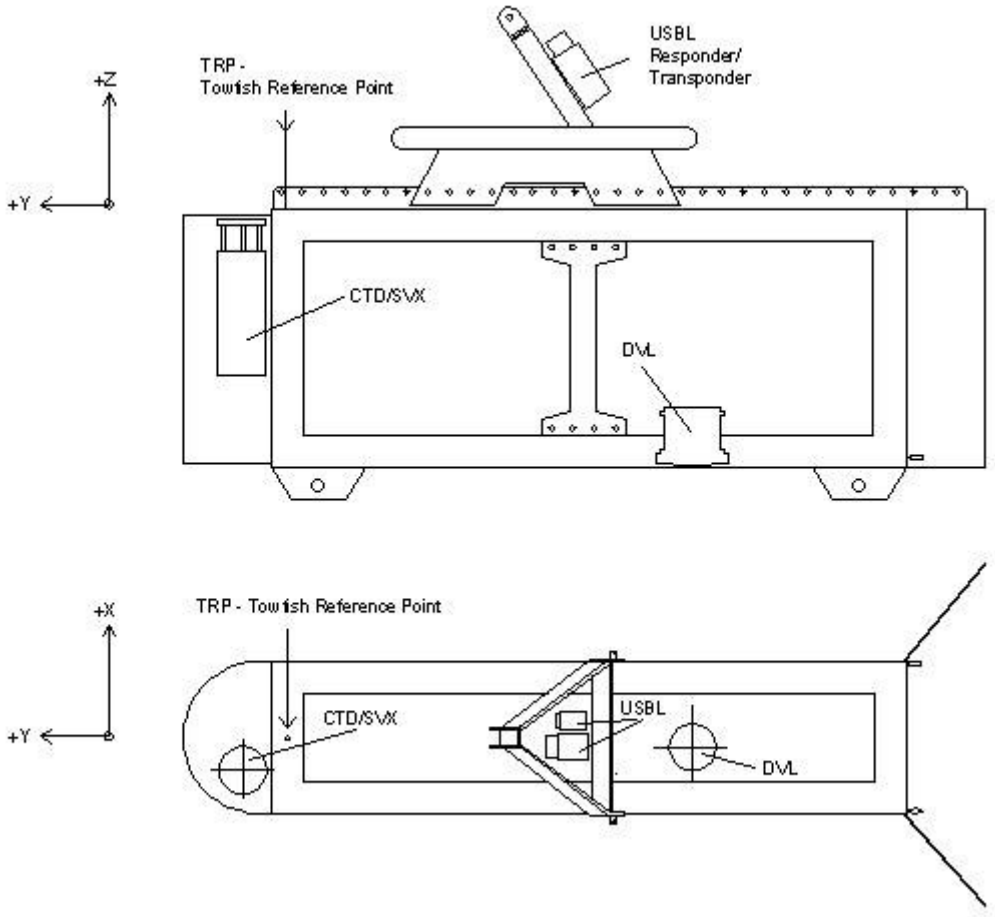


Figure 12: Instrument Offsets – Towfish

Table 30: Instrument Offsets - Towfish

Towfish					
Equipment	***Manufacturer***	***Type***	***x [m]***	***y[m]***	***z [m]***
TRP – Towfish Reference Point			0.0	0.00	0.00
USBL-Responder	Sonardyne	PGT	-0.1	0.3	+0.4
USBL Transponder	Sonardyne	SSM	0.1	0.3	+0.4
DVL-Doppler Velocity Log	RDI	Navigator 300 kHz	-0.0	-0.4	-1.0
CTD-Oceanographic Sensors	Valeport	MIDAS SVX	-0.1	1.2	-0.1

Instrument Offsets Tailfish

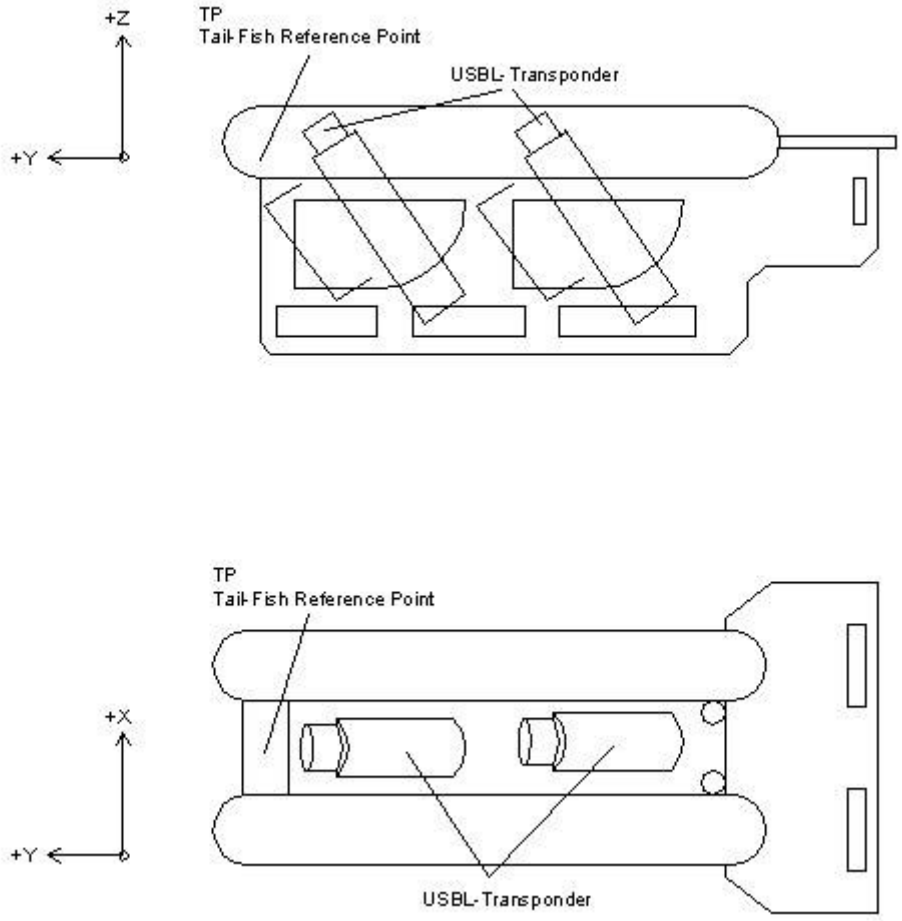


Figure 13: Instrument Offsets – Tailfish

Table 31: Instrument Offsets - Tailfish

Tailfish					
Equipment	***Manufacturer***	***Type***	***x [m]***	***y[m]***	***z [m]***
TP – Tailfish Reference Point			0.00	0.00	0.00
USBL-Transponder 1	Sonardyne	PGT	0.00	-0.35	+0.10
USBL Transponder 2	Sonardyne	SSM	0.00	-0.90	+0.10

3.10. Timing and Synchronisation

3.10.1. Source and Receiver Timing

The timing and synchronisation (timestamp) of the source (current-waveform) is based on the output of a Network Time Server of the Gator-Navigation System into the source control unit.
The GPS Network Time Server derives accurate time directly form the clocks aboard the GPS satellites.
The time is distributed by a 10/100Base-Ethernet interface.

3.10.2. Receiver Timing

To setup the time of a data acquisition system and to synchronise the internal clock before and at the end of a deployment, the output of the Gator Navigation System (NMEA string + PPS) is interfaced to the setup-computer.

The interface protocol design is based on theNMEA0183 ASCII interface specification (NMEA0183, Version 2.3). The 1PPS output is used to synchronise the datalogger with GPS time.

3.10.3. Navigation Timing

The Gator Navigation System is synchronised to it's PowerRTNU.and the incorporated Bullet III GPS system (Trimble) The PowerRTNU itself is time- stamping all incoming sensor data individually.
The USBL system is synchronised to the survey GNSS system (Veripos) and is capable to log WGS84 and local datum positions. Usually the time-stamped positions (range and bearing) are transferred to the Gator Navigation System.

Table 32: GPS Disciplined Clock Technical Specification

Thunderbolt GPS Disciplined Clock	
General	L1 frequency CA/code (SPS), 8 Channel continuous tracking
Update Rate	1Hz
PPS Accuracy	UTC 20 nanoseconds (1 Sigma)
Holdover	1 microsecond over 2 hours (max 15deg C temperature change)
1PPS	TTL level, 10 microseconds-wide pulse with the leading edge synchronised to UTC within 20 ns (1 Sigma).

Appendices

Appendix I - Raw Observations and Calibration Results of Gyro Calibration 17th -18th Feb 2007

Fugro Survey Pty Ltd
FSHY31-4
Gyrocompass Calibration - Dual Total Station Method

Fugro Job Number:	P0623	**Wharf:**	Broome
Job Description:	Seismic Cals	**Vessel:**	Atlantic Guardian
Client:	EMGS	**Observation Date :**	17 February 2007
Surveyor:	L. Arrowsmith & J. Richards	**Gyro Type:**	
Time Zone :	UTC + 9.0	**Serial No.:**	

Geodesy

Spheroid	GRS80	**Projection**	Transverse Mercator (UTM)
Semi Major Axis	6378137	Central Meridian	123
Inverse Flattening	298.2572221	False Easting	500000
Datum	GDA94-ITRF2007.50	False Northing	10000000
		Central Scale Factor	0.9996

Station Details

	ID	Easting	Northing	AHD Height		
Bow						
Instrument Station	BR01a	417 318.02	8 009 648.15	0.00	Instrument Type	TOPCON
Backsight Station	BR05	417 265.12	8 009 585.04	0.00	Instrument Serial No. :	
Stern						
Instrument Station	BR23a	417 244.16	8 009 496.95	0.00	Instrument Type	TOPCON
Backsight Station	BR04	417 218.95	8 009 502.62	0.00	Instrument Serial No. :	

Calculated Grid Bearing (Bow RO):	219	58	13
Calculated Grid Bearing (Stern RO) :	282	40	32
Calculated Grid Convergence :	000	14	29

Gyrocompass Observations

Bow Backsight Observation:	0	00	00
Stern Backsight Observation :	0	00	00

Obs	Time	Observation Point	Observed Direction (DMS)			Observed Distance (m)	Observed Heading
1	04:52:30	Bow	271	22	57	21.808	30.0
2	04:52:30	Stern	119	59	51	61.909	30.0
3	04:53:00	Bow	271	21	18	21.822	30.0
4	04:53:00	Stern	120	01	40	61.906	30.0
5	04:53:30	Bow	271	21	54	21.810	30.1
6	04:53:30	Stern	120	01	18	61.923	30.1
7	04:54:00	Bow	271	21	28	21.833	30.0
8	04:54:00	Stern	120	01	24	61.916	30.0
9	04:54:30	Bow	271	22	45	21.789	30.1
10	04:54:30	Stern	119	56	16	61.899	30.1
11	04:55:00	Bow	271	21	24	21.818	30.0
12	04:55:00	Stern	120	01	33	61.914	30.0
13	04:55:30	Bow	271	21	43	21.794	30.1
14	04:55:30	Stern	119	56	30	61.892	30.1
15	04:56:00	Bow	271	21	39	21.799	30.0
16	04:56:00	Stern	120	0	37	61.919	30.0
17	04:56:30	Bow	271	22	18	21.784	30.0
18	04:56:30	Stern	119	59	4	61.896	30.0
19	04:57:00	Bow	271	20	52	21.858	30.0
20	04:57:00	Stern	120	7	42	61.949	30.0
21	04:57:30	Bow	271	21	36	21.835	30.0
22	04:57:30	Stern	120	07	41	61.948	30.0
23	04:58:00	Bow	271	23	03	21.823	30.0
24	04:58:00	Stern	120	05	10	61.927	30.0
25	04:58:30	Bow	271	20	39	21.813	30.0
26	04:58:30	Stern	120	02	16	61.918	30.0

Obs	Time	Observation Point	Observed Direction (DMS)			Observed Distance (m)	Observed Heading
27	04:59:00	Bow	271	20	26	21.829	30.0
28	04:59:00	Stern	120	04	48	61.936	30.0
29	04:59:30	Bow	271	20	34	21.852	29.9
30	04:59:30	Stern	120	07	56	61.932	29.9
31	05:00:00	Bow	271	23	50	21.809	30.0
32	05:00:00	Stern	120	01	01	61.909	30.0
33	05:00:30	Bow	271	21	45	21.824	30.0
34	05:00:30	Stern	120	4	22	61.924	30.0
35	05:01:00	Bow	271	19	41	21.871	30.0
36	05:01:00	Stern	120	9	12	61.949	30.0
37	05:01:30	Bow	271	21	28	21.819	30.0
38	05:01:30	Stern	120	3	34	61.921	30.0
39	05:02:00	Bow	271	19	17	21.872	30.0
40	05:02:00	Stern	120	7	26	61.951	30.0
41	05:02:30	Bow	271	23	51	21.825	30.0
42	05:02:30	Stern	120	03	50	61.920	30.0
43	05:03:00	Bow	271	21	38	21.835	30.0
44	05:03:00	Stern	120	05	06	61.928	30.0
45	05:03:30	Bow	271	21	15	21.856	30.0
46	05:03:30	Stern	120	07	02	61.938	30.0
47	05:04:00	Bow	271	20	53	21.848	30.0
48	05:04:00	Stern	120	04	18	61.923	30.0
49	05:04:30	Bow	271	20	42	21.855	30.0
50	05:04:30	Stern	120	02	05	61.907	30.0
51	05:05:00	Bow	271	21	23	21.837	30.0
52	05:05:00	Stern	120	01	20	61.909	30.0
53	05:05:30	Bow	271	21	48	21.856	30.0
54	05:05:30	Stern	120	4	40	61.926	30.0
55	05:06:00	Bow	271	21	17	21.862	30.0
56	05:06:00	Stern	120	4	40	61.920	30.0
57	05:06:30	Bow	271	20	6	21.869	30.0
58	05:06:30	Stern	120	3	31	61.930	30.0
59	05:07:00	Bow	271	19	22	21.864	30.0
60	05:07:00	Stern	120	5	12	61.938	30.0
61	05:07:30	Bow	271	20	40	21.851	30.0
62	05:07:30	Stern	120	03	56	61.923	30.0
63	05:08:00	Bow	271	19	52	21.836	30.0
64	05:08:00	Stern	120	05	12	61.924	30.0
65	05:08:30	Bow	271	21	02	21.853	30.0
66	05:08:30	Stern	120	04	54	61.935	30.0
67	05:09:00	Bow	271	21	31	21.822	30.0
68	05:09:00	Stern	120	01	25	61.906	30.0
69	05:09:30	Bow	271	20	02	21.849	30.0
70	05:09:30	Stern	120	04	42	61.926	30.0
71	05:10:00	Bow	271	21	16	21.825	30.0
72	05:10:00	Stern	120	01	58	61.922	30.0
73	05:10:30	Bow	271	20	21	21.884	30.0
74	05:10:30	Stern	120	3	17	61.923	30.0
75	06:09:00	Bow	271	30	10	21.680	30.0
76	06:09:00	Stern	119	55	23	61.874	30.0
77	06:09:30	Bow	271	29	15	21.695	30.0
78	06:09:30	Stern	119	53	46	61.873	30.0
79	06:10:00	Bow	271	31	24	21.656	30.0
80	06:10:00	Stern	119	52	29	61.863	30.0
81	06:10:30	Bow	271	30	29	21.701	30.0
82	06:10:30	Stern	119	58	36	61.887	30.0
83	06:11:00	Bow	271	30	28	21.668	30.0
84	06:11:00	Stern	119	57	32	61.887	30.0
85	06:11:30	Bow	271	29	23	21.706	30.0
86	06:11:30	Stern	119	56	19	61.884	30.0
87	06:12:00	Bow	271	29	22	21.715	30.0

Obs	Time	Observation Point	Observed Direction (DMS)			Observed Distance (m)	Observed Heading
87	06:12:00	Bow	271	29	22	21.715	29.980
88	06:12:00	Stern	119	57	26	61.885	29.980
89	06:12:30	Bow	271	28	06	21.708	30.010
90	06:12:30	Stern	119	55	50	61.880	30.010
91	06:13:00	Bow	271	27	27	21.733	29.980
92	06:13:00	Stern	120	00	12	61.894	29.980
93	06:13:30	Bow	271	29	21	21.703	29.970
94	06:13:30	Stern	119	56	45	61.883	29.970
95	06:14:00	Bow	271	26	26	21.751	30.000
96	06:14:00	Stern	120	0	30	61.905	30.000
97	06:14:30	Bow	271	26	35	21.745	29.980
98	06:14:30	Stern	119	59	17	61.891	29.980
99	06:15:00	Bow	271	27	53	21.707	30.010
100	06:15:00	Stern	119	57	11	61.880	30.010
101	06:15:30	Bow	271	25	27	21.737	29.990
102	06:15:30	Stern	119	58	03	61.892	29.990
103	06:16:00	Bow	271	26	55	21.717	30.000
104	06:16:00	Stern	119	55	36	61.886	30.000
105	06:16:30	Bow	271	27	34	21.703	30.020
106	06:16:30	Stern	119	52	17	61.870	30.020
107	06:17:00	Bow	271	24	17	21.781	30.010
108	06:17:00	Stern	120	02	00	61.921	30.010
109	06:17:30	Bow	271	26	41	21.723	29.990
110	06:17:30	Stern	119	55	40	61.886	29.990
111	06:18:00	Bow	271	25	13	21.782	30.000
112	06:18:00	Stern	120	02	01	61.914	30.000
113	06:18:30	Bow	271	25	52	21.753	29.990
114	06:18:30	Stern	119	59	6	61.902	29.990
115	06:19:00	Bow	271	25	0	21.756	30.000
116	06:19:00	Stern	119	59	16	61.905	30.000
117	06:19:30	Bow	271	25	44	21.723	30.000
118	06:19:30	Stern	119	54	45	61.883	30.000
119	06:20:00	Bow	271	25	54	21.719	30.020
120	06:20:00	Stern	119	57	35	61.897	30.020

Signature

SURVEYOR/PARTY CHIEF

Date 19 Feb 07

Fugro Survey Pty Ltd

FSHY31-4

GYROCOMPASS CALIBRATION - DUAL TOTAL STATION METHOD

Fugro Job Number:	P0623	**Wharf:**	Broome
Job Description:	Seismic Cals	**Vessel:**	Atlantic Guardian
Client:	EMGS	**Observation Date:**	17 February 2007
Surveyor:	L. Arrowsmith & J. Richards	**Gyro :**	Octans
Time Zone :	UTC + 9.0	**Serial No.:**	

Geodesy

Spheroid	GRS80	**Projection**	Transverse Mercator (UTM)	**Zone**	51
Datum	GDA94-ITRF2007.50	**Central Meridian**	123		

Results

Obs	Time UTC (hh:mm:ss)	Obs Point	Observed Direction (DMS)			Observed Distance (m)	Plane Bearing			Plane Distance (m)	Calculated Coordinates Easting	Northing	Calc True	Obs True Heading	C-O
1	04:52:30	Bow	271	22	57	21.808	131	21	10	21.801	417334.39	8009633.75	28.11	30.01	-1.90
2	04:52:30	Stern	119	59	51	61.909	042	40	23	61.889	417286.11	8009542.45			
3	04:53:00	Bow	271	21	18	21.822	131	19	31	21.815	417334.40	8009633.74	28.10	30.01	-1.91
4	04:53:00	Stern	120	01	40	61.906	042	42	12	61.896	417286.13	8009542.43			
5	04:53:30	Bow	271	21	54	21.810	131	20	07	21.803	417334.39	8009633.75	28.10	30.05	-1.95
6	04:53:30	Stern	120	01	18	61.923	042	41	50	61.903	417286.14	8009542.45			
7	04:54:00	Bow	271	21	28	21.833	131	19	41	21.826	417334.41	8009633.74	28.11	30.02	-1.91
8	04:54:00	Stern	120	01	24	61.916	042	41	56	61.896	417286.13	8009542.44			
9	04:54:30	Bow	271	22	45	21.789	131	20	58	21.782	417334.37	8009633.76	28.14	30.05	-1.91
10	04:54:30	Stern	119	56	16	61.899	042	36	48	61.879	417286.06	8009542.49			
11	04:55:00	Bow	271	21	24	21.818	131	19	37	21.811	417334.40	8009633.75	28.10	30.03	-1.93
12	04:55:00	Stern	120	01	33	61.914	042	42	05	61.894	417286.14	8009542.44			
13	04:55:30	Bow	271	21	43	21.794	131	19	56	21.787	417334.38	8009633.76	28.14	30.05	-1.91
14	04:55:30	Stern	119	56	30	61.892	042	37	02	61.872	417286.05	8009542.48			
15	04:56:00	Bow	271	21	39	21.799	131	19	52	21.792	417334.38	8009633.76	28.10	30.02	-1.92
16	04:56:00	Stern	120	00	37	61.919	042	41	09	61.899	417286.13	8009542.45			
17	04:56:30	Bow	271	22	18	21.784	131	20	31	21.777	417334.37	8009633.77	28.11	30.02	-1.91
18	04:56:30	Stern	119	59	04	61.896	042	39	36	61.876	417286.09	8009542.45			
19	04:57:00	Bow	271	20	52	21.858	131	19	05	21.851	417334.43	8009633.72	28.06	30.01	-1.95
20	04:57:00	Stern	120	07	42	61.949	042	48	14	61.929	417286.24	8009542.39			
21	04:57:30	Bow	271	21	36	21.835	131	19	49	21.828	417334.41	8009633.73	28.05	29.97	-1.92
22	04:57:30	Stern	120	07	41	61.948	042	48	13	61.928	417286.24	8009542.39			
23	04:58:00	Bow	271	23	03	21.823	131	21	16	21.816	417334.40	8009633.74	28.07	29.99	-1.92
24	04:58:00	Stern	120	05	10	61.927	042	45	42	61.907	417286.19	8009542.40			
25	04:58:30	Bow	271	20	39	21.813	131	18	52	21.806	417334.40	8009633.75	28.09	29.98	-1.89
26	04:58:30	Stern	120	02	16	61.918	042	42	48	61.898	417286.15	8009542.43			
27	04:59:00	Bow	271	20	26	21.829	131	18	39	21.822	417334.41	8009633.74	28.07	30.00	-1.93
28	04:59:00	Stern	120	04	48	61.936	042	45	20	61.916	417286.19	8009542.41			
29	04:59:30	Bow	271	20	34	21.852	131	18	47	21.845	417334.43	8009633.73	28.06	29.94	-1.88
30	04:59:30	Stern	120	07	56	61.932	042	48	28	61.912	417286.23	8009542.37			

31	05:00:00	Bow	271	23	50	21.809	131	22	03	21.802	417334.38	8009633.74	28.10	30.01	-1.91
32	05:00:00	Stern	120	01	01	61.909	042	41	33	61.889	417286.12	8009542.44			
33	05:00:30	Bow	271	21	45	21.824	131	19	58	21.817	417334.40	8009633.74	28.08	30.01	-1.93
34	05:00:30	Stern	120	04	22	61.924	042	44	54	61.904	417286.18	8009542.41			
35	05:01:00	Bow	271	19	41	21.871	131	17	54	21.864	417334.45	8009633.72	28.05	29.98	-1.93
36	05:01:00	Stern	120	09	12	61.949	042	49	44	61.929	417286.26	8009542.37			
37	05:01:30	Bow	271	21	28	21.819	131	19	41	21.812	417334.40	8009633.75	28.08	29.99	-1.91
38	05:01:30	Stern	120	03	34	61.921	042	44	06	61.901	417286.17	8009542.42			
39	05:02:00	Bow	271	19	17	21.872	131	17	30	21.865	417334.45	8009633.72	28.07	29.97	-1.90
40	05:02:00	Stern	120	07	26	61.951	042	47	58	61.931	417286.24	8009542.39			
41	05:02:30	Bow	271	23	51	21.825	131	22	04	21.818	417334.39	8009633.73	28.08	29.99	-1.91
42	05:02:30	Stern	120	03	50	61.920	042	44	22	61.900	417286.17	8009542.41			
43	05:03:00	Bow	271	21	38	21.835	131	19	51	21.828	417334.41	8009633.73	28.07	29.98	-1.91
44	05:03:00	Stern	120	05	06	61.928	042	45	38	61.908	417286.19	8009542.40			
45	05:03:30	Bow	271	21	15	21.856	131	19	28	21.849	417334.43	8009633.72	28.07	30.00	-1.93
46	05:03:30	Stern	120	07	02	61.938	042	47	34	61.918	417286.22	8009542.39			
47	05:04:00	Bow	271	20	53	21.848	131	19	06	21.841	417334.42	8009633.73	28.09	30.00	-1.91
48	05:04:00	Stern	120	04	18	61.923	042	44	50	61.903	417286.18	8009542.41			
49	05:04:30	Bow	271	20	42	21.855	131	18	55	21.848	417334.43	8009633.73	28.12	30.01	-1.89
50	05:04:30	Stern	120	02	05	61.907	042	42	37	61.887	417286.14	8009542.42			
51	05:05:00	Bow	271	21	23	21.837	131	19	36	21.830	417334.41	8009633.73	28.11	30.05	-1.94
52	05:05:00	Stern	120	01	20	61.909	042	41	52	61.889	417286.13	8009542.44			
53	05:05:30	Bow	271	21	48	21.856	131	20	01	21.849	417334.43	8009633.72	28.09	30.03	-1.94
54	05:05:30	Stern	120	04	40	61.926	042	45	12	61.906	417286.18	8009542.41			
55	05:06:00	Bow	271	21	17	21.862	131	19	30	21.855	417334.43	8009633.72	28.09	30.01	-1.92
56	05:06:00	Stern	120	04	40	61.920	042	45	12	61.900	417286.18	8009542.40			
57	05:06:30	Bow	271	20	06	21.869	131	18	19	21.862	417334.44	8009633.72	28.11	30.03	-1.92
58	05:06:30	Stern	120	03	31	61.930	042	44	03	61.910	417286.17	8009542.42			
59	05:07:00	Bow	271	19	22	21.864	131	17	35	21.857	417334.44	8009633.73	28.09	30.01	-1.92
60	05:07:00	Stern	120	05	12	61.938	042	45	44	61.918	417286.20	8009542.41			
61	05:07:30	Bow	271	20	40	21.851	131	18	53	21.844	417334.43	8009633.73	28.09	30.01	-1.92
62	05:07:30	Stern	120	03	56	61.923	042	44	28	61.903	417286.17	8009542.41			
63	05:08:00	Bow	271	19	52	21.836	131	18	05	21.829	417334.42	8009633.74	28.08	29.99	-1.91
64	05:08:00	Stern	120	05	12	61.924	042	45	44	61.904	417286.19	8009542.40			
65	05:08:30	Bow	271	21	02	21.853	131	19	15	21.846	417334.43	8009633.73	28.08	30.01	-1.93
66	05:08:30	Stern	120	04	54	61.935	042	45	26	61.915	417286.19	8009542.41			
67	05:09:00	Bow	271	21	31	21.822	131	19	44	21.815	417334.40	8009633.74	28.11	30.02	-1.91
68	05:09:00	Stern	120	01	25	61.906	042	41	57	61.886	417286.13	8009542.43			
69	05:09:30	Bow	271	20	02	21.849	131	18	15	21.842	417334.43	8009633.73	28.09	30.01	-1.92
70	05:09:30	Stern	120	04	42	61.926	042	45	14	61.906	417286.19	8009542.41			
71	05:10:00	Bow	271	21	16	21.825	131	19	29	21.818	417334.40	8009633.74	28.10	30.02	-1.92
72	05:10:00	Stern	120	01	58	61.922	042	42	30	61.902	417286.15	8009542.44			
73	05:10:30	Bow	271	20	21	21.884	131	18	34	21.877	417334.45	8009633.71	28.12	30.06	-1.94
74	05:10:30	Stern	120	03	17	61.923	042	43	49	61.903	417286.16	8009542.42			
75	06:09:00	Bow	271	30	10	21.680	131	28	23	21.673	417334.26	8009633.80	28.08	30.00	-1.92
76	06:09:00	Stern	119	55	23	61.874	042	35	55	61.854	417286.03	8009542.48			
77	06:09:30	Bow	271	29	15	21.695	131	27	28	21.688	417334.27	8009633.79	28.11	29.98	-1.87
78	06:09:30	Stern	119	53	46	61.873	042	34	18	61.853	417286.00	8009542.50			
79	06:10:00	Bow	271	31	24	21.656	131	29	37	21.649	417334.24	8009633.81	28.10	30.00	-1.90

80	06:10:00	Stern	119	52	29	61.863	042	33	01	61.843	417285.98	8009542.51			
81	06:10:30	Bow	271	30	29	21.701	131	28	42	21.694	417334.27	8009633.78	28.06	30.00	-1.94
82	06:10:30	Stern	119	58	36	61.887	042	39	08	61.867	417286.08	8009542.45			
83	06:11:00	Bow	271	30	28	21.668	131	28	41	21.661	417334.25	8009633.80	28.06	29.98	-1.92
84	06:11:00	Stern	119	57	32	61.887	042	38	04	61.867	417286.06	8009542.47			
85	06:11:30	Bow	271	29	23	21.706	131	27	36	21.699	417334.28	8009633.78	28.09	30.01	-1.92
86	06:11:30	Stern	119	56	19	61.884	042	36	51	61.864	417286.05	8009542.48			
87	06:12:00	Bow	271	29	22	21.715	131	27	35	21.708	417334.29	8009633.78	28.08	29.98	-1.90
88	06:12:00	Stern	119	57	26	61.885	042	37	58	61.865	417286.06	8009542.47			
89	06:12:30	Bow	271	28	06	21.708	131	26	19	21.701	417334.29	8009633.79	28.10	30.01	-1.91
90	06:12:30	Stern	119	55	50	61.880	042	36	22	61.860	417286.04	8009542.48			
91	06:13:00	Bow	271	27	27	21.733	131	25	40	21.726	417334.31	8009633.77	28.07	29.98	-1.91
92	06:13:00	Stern	120	00	12	61.894	042	40	44	61.874	417286.10	8009542.44			
93	06:13:30	Bow	271	29	21	21.703	131	27	34	21.696	417334.28	8009633.79	28.08	29.97	-1.89
94	06:13:30	Stern	119	56	45	61.883	042	37	17	61.863	417286.05	8009542.47			
95	06:14:00	Bow	271	26	26	21.751	131	24	39	21.744	417334.33	8009633.77	28.07	30.00	-1.93
96	06:14:00	Stern	120	00	30	61.905	042	41	02	61.885	417286.12	8009542.44			
97	06:14:30	Bow	271	26	35	21.745	131	24	48	21.738	417334.32	8009633.77	28.08	29.98	-1.90
98	06:14:30	Stern	119	59	17	61.891	042	39	49	61.871	417286.09	8009542.45			
99	06:15:00	Bow	271	27	53	21.707	131	26	06	21.700	417334.29	8009633.79	28.08	30.01	-1.93
100	06:15:00	Stern	119	57	11	61.880	042	37	43	61.860	417286.05	8009542.46			
101	06:15:30	Bow	271	25	27	21.737	131	23	40	21.730	417334.32	8009633.78	28.09	29.99	-1.90
102	06:15:30	Stern	119	58	03	61.892	042	38	35	61.872	417286.07	8009542.46			
103	06:16:00	Bow	271	26	55	21.717	131	25	08	21.710	417334.30	8009633.79	28.10	30.00	-1.90
104	06:16:00	Stern	119	55	36	61.886	042	36	08	61.866	417286.04	8009542.49			
105	06:16:30	Bow	271	27	34	21.703	131	25	47	21.696	417334.29	8009633.79	28.13	30.02	-1.89
106	06:16:30	Stern	119	52	17	61.870	042	32	49	61.850	417285.98	8009542.52			
107	06:17:00	Bow	271	24	17	21.781	131	22	30	21.774	417334.36	8009633.76	28.07	30.01	-1.94
108	06:17:00	Stern	120	02	00	61.921	042	42	32	61.901	417286.15	8009542.44			
109	06:17:30	Bow	271	26	41	21.723	131	24	54	21.716	417334.31	8009633.78	28.11	29.99	-1.88
110	06:17:30	Stern	119	55	40	61.886	042	36	12	61.866	417286.04	8009542.49			
111	06:18:00	Bow	271	25	13	21.782	131	23	26	21.775	417334.36	8009633.75	28.07	30.00	-1.93
112	06:18:00	Stern	120	02	01	61.914	042	42	33	61.894	417286.14	8009542.43			
113	06:18:30	Bow	271	25	52	21.753	131	24	05	21.746	417334.33	8009633.77	28.09	29.99	-1.90
114	06:18:30	Stern	119	59	06	61.902	042	39	38	61.882	417286.09	8009542.46			
115	06:19:00	Bow	271	25	00	21.756	131	23	13	21.749	417334.34	8009633.77	28.09	30.00	-1.91
116	06:19:00	Stern	119	59	16	61.905	042	39	48	61.885	417286.10	8009542.46			
117	06:19:30	Bow	271	25	44	21.723	131	23	57	21.716	417334.31	8009633.79	28.12	30.00	-1.88
118	06:19:30	Stern	119	54	45	61.883	042	35	17	61.863	417286.02	8009542.50			
119	06:20:00	Bow	271	25	54	21.719	131	24	07	21.712	417334.31	8009633.79	28.08	30.02	-1.94
120	06:20:00	Stern	119	57	35	61.897	000	00	00	61.877	417286.07	8009542.47			
													Mean C-O		-1.91
													SD		0.02

Signature Klaus Arnt SURVEYOR/PARTY CHIEF

Date 19 Feb 07

Fugro Survey Pty Ltd
FSHY31-4

Gyrocompass Calibration - Dual Total Station Method

Fugro Job Number:	P0623	**Wharf:**	Broome
Job Description:	Seismic Cals	**Vessel:**	Atlantic Guardian
Client:	EMGS	**Observation Date :**	18 February 2007
Surveyor:	L. Arrowsmith & J. Richards	**Gyro Type:**	Octans
Time Zone :	UTC + 9.0	**Serial No.:**	

Geodesy

Spheroid	GRS80	**Projection**	Transverse Mercator (UTM)
Semi Major Axis	6378137	Central Meridian	123
Inverse Flattening	298.2572221	False Easting	500000
Datum	GDA94-ITRF2007.50	False Northing	10000000
		Central Scale Factor	0.9996

Station Details

Bow	ID	Easting	Northing	AHD Height		
Instrument Station	BR23a	417 244.16	8 009 496.95	0.00	Instrument Type	TOPCON
Backsight Station	BR04	417 218.95	8 009 502.62	0.00	Instrument Serial No. :	
Stern						
Instrument Station	BR01a	417 318.02	8 009 648.15	0.00	Instrument Type	TOPCON
Backsight Station	BR05	417 265.12	8 009 585.04	0.00	Instrument Serial No. :	

Calculated Grid Bearing (Bow RO):	282	40	32
Calculated Grid Bearing (Stern RO) :	219	58	13
Calculated Grid Convergence :	000	14	30

Gyrocompass Observations

Bow Backsight Observation:	0	00	00
Stern Backsight Observation :	0	00	00

Obs	Time	Observation Point	Observed Direction (DMS)			Observed Distance (m)	Observed Heading
1	06:46:30	Bow	119	47	35	61.341	210.600
2	06:46:30	Stern	279	21	50	23.346	210.600
3	06:47:00	Bow	119	48	11	61.341	210.600
4	06:47:00	Stern	279	21	38	23.356	210.600
5	06:47:30	Bow	119	46	17	61.316	210.600
6	06:47:30	Stern	279	24	14	23.336	210.600
7	06:48:00	Bow	119	46	41	61.324	210.600
8	06:48:00	Stern	279	23	38	23.341	210.600
9	06:48:30	Bow	119	46	25	61.335	210.600
10	06:48:30	Stern	279	24	43	23.321	210.600
11	06:49:00	Bow	119	45	34	61.318	210.600
12	06:49:00	Stern	279	24	39	23.331	210.600
13	06:49:30	Bow	119	48	26	61.353	210.600
14	06:49:30	Stern	279	20	58	23.363	210.600
15	06:50:00	Bow	119	48	6	61.348	210.600
16	06:50:00	Stern	279	20	0	23.341	210.600
17	06:50:30	Bow	119	47	9	61.335	210.600
18	06:50:30	Stern	279	19	4	23.333	210.600
19	06:51:00	Bow	119	48	7	61.365	210.600
20	06:51:00	Stern	279	19	50	23.349	210.600
21	06:51:30	Bow	119	46	09	61.330	210.600
22	06:51:30	Stern	279	26	35	23.301	210.600
23	06:52:00	Bow	119	46	08	61.337	210.600
24	06:52:00	Stern	279	23	10	23.328	210.600
25	06:52:30	Bow	119	46	45	61.338	210.600
26	06:52:30	Stern	279	20	20	23.309	210.600

Obs	Time	Observation Point	Observed Direction (DMS)			Observed Distance (m)	Observed Heading
27	06:53:00	Bow	119	49	16	61.380	210.600
28	06:53:00	Stern	279	19	29	23.327	210.600
29	06:53:30	Bow	119	47	16	61.375	210.600
30	06:53:30	Stern	279	21	30	23.322	210.600
31	06:54:00	Bow	119	44	25	61.311	210.600
32	06:54:00	Stern	279	26	22	23.285	210.600
33	06:54:30	Bow	119	45	16	61.331	210.600
34	06:54:30	Stern	279	20	19	23.296	210.600
35	06:55:00	Bow	119	48	5	61.393	210.600
36	06:55:00	Stern	279	16	17	23.313	210.600
37	06:55:30	Bow	119	47	21	61.379	210.600
38	06:55:30	Stern	279	18	2	23.309	210.600
39	06:56:00	Bow	119	47	9	61.365	210.600
40	06:56:00	Stern	279	17	39	23.321	210.600
41	06:56:30	Bow	119	46	31	61.381	210.600
42	06:56:30	Stern	279	17	20	23.308	210.600
43	06:57:00	Bow	119	45	55	61.360	210.600
44	06:57:00	Stern	279	18	26	23.286	210.600
45	06:57:30	Bow	119	45	25	61.361	210.600
46	06:57:30	Stern	279	18	00	23.270	210.600
47	06:58:00	Bow	119	44	48	61.364	210.600
48	06:58:00	Stern	279	19	11	23.269	210.600
49	06:58:30	Bow	119	45	24	61.371	210.600
50	06:58:30	Stern	279	18	17	23.293	210.600
51	06:59:00	Bow	119	46	47	61.392	210.600
52	06:59:00	Stern	279	15	50	23.293	210.600
53	06:59:30	Bow	119	45	3	61.374	210.600
54	06:59:30	Stern	279	20	13	23.261	210.600
55	07:00:00	Bow	119	44	22	61.361	210.600
56	07:00:00	Stern	279	19	48	23.243	210.600
57	07:00:30	Bow	119	43	30	61.346	210.600
58	07:00:30	Stern	279	21	22	23.249	210.600
59	07:01:00	Bow	119	44	25	61.375	210.600
60	07:01:00	Stern	279	16	59	23.243	210.600
61	07:01:30	Bow	119	43	35	61.374	210.600
62	07:01:30	Stern	279	21	11	23.227	210.600
63	07:02:00	Bow	119	43	42	61.359	210.600
64	07:02:00	Stern	279	19	54	23.239	210.600
65	07:02:30	Bow	119	42	52	61.352	210.600
66	07:02:30	Stern	279	22	04	23.217	210.600
67	07:03:00	Bow	119	43	25	61.364	210.600
68	07:03:00	Stern	279	20	25	23.220	210.600
69	07:03:30	Bow	119	42	47	61.356	210.600
70	07:03:30	Stern	279	20	30	23.222	210.600
71	07:04:00	Bow	119	41	39	61.344	210.600
72	07:04:00	Stern	279	22	47	23.198	210.600
73	07:04:30	Bow	119	43	0	61.363	210.500
74	07:04:30	Stern	279	20	44	23.189	210.500
75	07:05:00	Bow	119	41	53	61.356	210.500
76	07:05:00	Stern	279	21	42	23.177	210.500
77	07:05:30	Bow	119	43	46	61.377	210.500
78	07:05:30	Stern	279	22	30	23.208	210.500
79	07:06:00	Bow	119	40	11	61.336	210.500
80	07:06:00	Stern	279	24	4	23.159	210.500
81	07:06:30	Bow	119	41	50	61.353	210.500
82	07:06:30	Stern	279	19	25	23.161	210.500
83	07:07:00	Bow	119	42	40	61.370	210.500
84	07:07:00	Stern	279	21	40	23.168	210.500
85	07:07:30	Bow	119	41	59	61.379	210.500
86	07:07:30	Stern	279	19	00	23.183	210.500
87	07:08:00	Bow	119	41	49	61.377	210.500

Obs	Time	Observation Point	Observed Direction (DMS)			Observed Distance (m)	Observed Heading
87	07:08:00	Bow	119	41	49	61.377	210.500
88	07:08:00	Stern	279	18	44	23.166	210.500
89	07:08:30	Bow	119	41	23	61.361	210.500
90	07:08:30	Stern	279	20	08	23.162	210.500
91	07:09:00	Bow	119	42	00	61.394	210.500
92	07:09:00	Stern	279	17	34	23.174	210.500
93	07:09:30	Bow	119	40	26	61.358	210.600
94	07:09:30	Stern	279	21	1	23.158	210.600
95	07:10:00	Bow	119	41	0	61.366	210.500
96	07:10:00	Stern	279	19	35	23.160	210.500
97	07:10:30	Bow	119	41	39	61.374	210.500
98	07:10:30	Stern	279	19	25	23.149	210.500
99	07:11:00	Bow	119	40	45	61.378	210.500
100	07:11:00	Stern	279	20	57	23.122	210.500
101	07:11:30	Bow	119	40	34	61.381	210.500
102	07:11:30	Stern	279	18	52	23.123	210.500
103	07:12:00	Bow	119	40	14	61.378	210.500
104	07:12:00	Stern	279	19	22	23.135	210.500
105	07:12:30	Bow	119	39	04	61.369	210.500
106	07:12:30	Stern	279	19	58	23.106	210.500
107	07:13:00	Bow	119	38	50	61.364	210.500
108	07:13:00	Stern	279	21	53	23.098	210.500
109	07:13:30	Bow	119	39	07	61.361	210.500
110	07:13:30	Stern	279	22	48	23.080	210.500
111	07:14:00	Bow	119	37	23	61.342	210.500
112	07:14:00	Stern	279	24	38	23.046	210.500
113	07:14:30	Bow	119	39	37	61.384	210.500
114	07:14:30	Stern	279	20	4	23.094	210.500
115	07:15:00	Bow	119	40	28	61.399	210.500
116	07:15:00	Stern	279	17	41	23.099	210.500
117	07:15:30	Bow	119	39	29	61.382	210.500
118	07:15:30	Stern	279	19	58	23.090	210.500
119	07:16:00	Bow	119	37	10	61.357	210.500
120	07:16:00	Stern	279	23	0	23.031	210.500

Signature _____ Date 19 Feb 07

SURVEYOR/PARTY CHIEF

Fugro Survey Pty Ltd

FSHY31-4

GYROCOMPASS CALIBRATION - DUAL TOTAL STATION METHOD

Fugro Job Number:	P0623	**Wharf:**	Broome
Job Description:	Seismic Cals	**Vessel:**	Atlantic Guardian
Client:	EMGS	**Observation Date:**	18 February 2007
Surveyor:	L. Arrowsmith & J. Richards	**Gyro :**	Octans
Time Zone :	UTC + 9.0	**Serial No.:**	

Geodesy

Spheroid	GRS80	**Projection**	Transverse Mercator (UTM)	**Zone**	51
Datum	GDA94-ITRF2007.50	**Central Meridian**	123		

Results

Obs	Time UTC (hh:mm:ss)	Obs Point	Observed Direction (DMS)			Observed Distance (m)	Plane Bearing			Plane Distance (m)	Calculated Coordinates		Calc True	Obs True Heading	C-O
											Easting	Northing			
1	06:46:30	Bow	119	47	35	61.341	042	28	07	61.322	417285.56	8009542.18	208.61	210.60	-1.99
2	06:46:30	Stern	279	21	50	23.346	139	20	03	23.339	417333.23	8009630.45			
3	06:47:00	Bow	119	48	11	61.341	042	28	43	61.322	417285.57	8009542.18	208.61	210.60	-1.99
4	06:47:00	Stern	279	21	38	23.356	139	19	51	23.349	417333.24	8009630.44			
5	06:47:30	Bow	119	46	17	61.316	042	26	49	61.297	417285.53	8009542.18	208.62	210.60	-1.98
6	06:47:30	Stern	279	24	14	23.336	139	22	27	23.329	417333.21	8009630.44			
7	06:48:00	Bow	119	46	41	61.324	042	27	13	61.305	417285.54	8009542.18	208.62	210.60	-1.98
8	06:48:00	Stern	279	23	38	23.341	139	21	51	23.334	417333.22	8009630.44			
9	06:48:30	Bow	119	46	25	61.335	042	26	57	61.316	417285.54	8009542.19	208.61	210.60	-1.99
10	06:48:30	Stern	279	24	43	23.321	139	22	56	23.314	417333.20	8009630.45			
11	06:49:00	Bow	119	45	34	61.318	042	26	06	61.299	417285.52	8009542.19	208.62	210.60	-1.98
12	06:49:00	Stern	279	24	39	23.331	139	22	52	23.324	417333.20	8009630.45			
13	06:49:30	Bow	119	48	26	61.353	042	28	58	61.334	417285.58	8009542.18	208.61	210.60	-1.99
14	06:49:30	Stern	279	20	58	23.363	139	19	11	23.356	417333.24	8009630.44			
15	06:50:00	Bow	119	48	06	61.348	042	28	38	61.329	417285.58	8009542.18	208.61	210.60	-1.99
16	06:50:00	Stern	279	20	00	23.341	139	18	13	23.334	417333.23	8009630.46			
17	06:50:30	Bow	119	47	09	61.335	042	27	41	61.316	417285.55	8009542.18	208.61	210.60	-1.99
18	06:50:30	Stern	279	19	04	23.333	139	17	17	23.326	417333.23	8009630.47			
19	06:51:00	Bow	119	48	07	61.365	042	28	39	61.346	417285.59	8009542.20	208.61	210.60	-1.99
20	06:51:00	Stern	279	19	50	23.349	139	18	03	23.342	417333.24	8009630.45			
21	06:51:30	Bow	119	46	09	61.330	042	26	41	61.311	417285.54	8009542.19	208.60	210.60	-2.00
22	06:51:30	Stern	279	26	35	23.301	139	24	48	23.294	417333.17	8009630.46			
23	06:52:00	Bow	119	46	08	61.337	042	26	40	61.318	417285.54	8009542.20	208.62	210.60	-1.98
24	06:52:00	Stern	279	23	10	23.328	139	21	23	23.321	417333.21	8009630.45			
25	06:52:30	Bow	119	46	45	61.338	042	27	17	61.319	417285.55	8009542.19	208.60	210.60	-2.00
26	06:52:30	Stern	279	20	20	23.309	139	18	33	23.302	417333.21	8009630.48			
27	06:53:00	Bow	119	49	16	61.380	042	29	48	61.361	417285.61	8009542.19	208.58	210.60	-2.02
28	06:53:00	Stern	279	19	29	23.327	139	17	42	23.320	417333.23	8009630.47			
29	06:53:30	Bow	119	47	16	61.375	042	27	48	61.356	417285.58	8009542.21	208.60	210.60	-2.00
30	06:53:30	Stern	279	21	30	23.322	139	19	43	23.315	417333.21	8009630.47			

31	06:54:00	Bow	119	44	25	61.311	042	24	57	61.292	417285.50	8009542.20	208.61	210.60	-1.99
32	06:54:00	Stern	279	26	22	23.285	139	24	35	23.278	417333.17	8009630.47			
33	06:54:30	Bow	119	45	16	61.331	042	25	48	61.312	417285.53	8009542.20	208.61	210.60	-1.99
34	06:54:30	Stern	279	20	19	23.296	139	18	32	23.289	417333.20	8009630.49			
35	06:55:00	Bow	119	48	05	61.393	042	28	37	61.374	417285.61	8009542.22	208.59	210.60	-2.01
36	06:55:00	Stern	279	16	17	23.313	139	14	30	23.306	417333.24	8009630.50			
37	06:55:30	Bow	119	47	21	61.379	042	27	53	61.360	417285.59	8009542.21	208.59	210.60	-2.01
38	06:55:30	Stern	279	18	02	23.309	139	16	15	23.302	417333.22	8009630.49			
39	06:56:00	Bow	119	47	09	61.365	042	27	41	61.346	417285.57	8009542.21	208.61	210.60	-1.99
40	06:56:00	Stern	279	17	39	23.321	139	15	52	23.314	417333.23	8009630.48			
41	06:56:30	Bow	119	46	31	61.381	042	27	03	61.362	417285.58	8009542.23	208.60	210.60	-2.00
42	06:56:30	Stern	279	17	20	23.308	139	15	33	23.301	417333.23	8009630.50			
43	06:57:00	Bow	119	45	55	61.360	042	26	27	61.341	417285.55	8009542.22	208.60	210.60	-2.00
44	06:57:00	Stern	279	18	26	23.286	139	16	39	23.279	417333.21	8009630.51			
45	06:57:30	Bow	119	45	25	61.361	042	25	57	61.342	417285.55	8009542.22	208.60	210.60	-2.00
46	06:57:30	Stern	279	18	00	23.270	139	16	13	23.263	417333.20	8009630.52			
47	06:58:00	Bow	119	44	48	61.364	042	25	20	61.345	417285.54	8009542.23	208.60	210.60	-2.00
48	06:58:00	Stern	279	19	11	23.269	139	17	24	23.262	417333.19	8009630.52			
49	06:58:30	Bow	119	45	24	61.371	042	25	56	61.352	417285.56	8009542.23	208.61	210.60	-1.99
50	06:58:30	Stern	279	18	17	23.293	139	16	30	23.286	417333.21	8009630.50			
51	06:59:00	Bow	119	46	47	61.392	042	27	19	61.373	417285.59	8009542.23	208.59	210.60	-2.01
52	06:59:00	Stern	279	15	50	23.293	139	14	03	23.286	417333.22	8009630.51			
53	06:59:30	Bow	119	45	03	61.374	042	25	35	61.355	417285.55	8009542.24	208.59	210.60	-2.01
54	06:59:30	Stern	279	20	13	23.261	139	18	26	23.254	417333.18	8009630.52			
55	07:00:00	Bow	119	44	22	61.361	042	24	54	61.342	417285.53	8009542.24	208.59	210.60	-2.01
56	07:00:00	Stern	279	19	48	23.243	139	18	01	23.236	417333.17	8009630.53			
57	07:00:30	Bow	119	43	30	61.346	042	24	02	61.327	417285.51	8009542.24	208.60	210.60	-2.00
58	07:00:30	Stern	279	21	22	23.249	139	19	35	23.242	417333.17	8009630.52			
59	07:01:00	Bow	119	44	25	61.375	042	24	57	61.356	417285.54	8009542.25	208.59	210.60	-2.01
60	07:01:00	Stern	279	16	59	23.243	139	15	12	23.236	417333.19	8009630.55			
61	07:01:30	Bow	119	43	35	61.374	042	24	07	61.355	417285.53	8009542.26	208.58	210.60	-2.02
62	07:01:30	Stern	279	21	11	23.227	139	19	24	23.220	417333.15	8009630.54			
63	07:02:00	Bow	119	43	42	61.359	042	24	14	61.340	417285.52	8009542.24	208.59	210.60	-2.01
64	07:02:00	Stern	279	19	54	23.239	139	18	07	23.232	417333.17	8009630.54			
65	07:02:30	Bow	119	42	52	61.352	042	23	24	61.333	417285.51	8009542.25	208.59	210.60	-2.01
66	07:02:30	Stern	279	22	04	23.217	139	20	17	23.210	417333.14	8009630.54			
67	07:03:00	Bow	119	43	25	61.364	042	23	57	61.345	417285.52	8009542.25	208.58	210.60	-2.02
68	07:03:00	Stern	279	20	25	23.220	139	18	38	23.213	417333.15	8009630.55			
69	07:03:30	Bow	119	42	47	61.356	042	23	19	61.337	417285.51	8009542.25	208.59	210.60	-2.01
70	07:03:30	Stern	279	20	30	23.222	139	18	43	23.215	417333.15	8009630.55			
71	07:04:00	Bow	119	41	39	61.344	042	22	11	61.325	417285.49	8009542.26	208.59	210.60	-2.01
72	07:04:00	Stern	279	22	47	23.198	139	21	00	23.191	417333.13	8009630.56			
73	07:04:30	Bow	119	43	00	61.363	042	23	32	61.344	417285.52	8009542.26	208.57	210.50	-1.93
74	07:04:30	Stern	279	20	44	23.189	139	18	57	23.182	417333.13	8009630.57			
75	07:05:00	Bow	119	41	53	61.356	042	22	25	61.337	417285.50	8009542.26	208.58	210.50	-1.92
76	07:05:00	Stern	279	21	42	23.177	139	19	55	23.170	417333.12	8009630.58			
77	07:05:30	Bow	119	43	46	61.377	042	24	18	61.358	417285.54	8009542.26	208.57	210.50	-1.93
78	07:05:30	Stern	279	22	30	23.208	139	20	43	23.201	417333.14	8009630.55			
79	07:06:00	Bow	119	40	11	61.336	042	20	43	61.317	417285.46	8009542.27	208.58	210.50	-1.92

80	07:06:00	Stern	279	24	04	23.159	139	22	17	23.152	417333.10	8009630.58			
81	07:06:30	Bow	119	41	50	61.353	042	22	22	61.334	417285.50	8009542.26	208.57	210.50	-1.93
82	07:06:30	Stern	279	19	25	23.161	139	17	38	23.154	417333.12	8009630.60			
83	07:07:00	Bow	119	42	40	61.370	042	23	12	61.351	417285.52	8009542.26	208.56	210.50	-1.94
84	07:07:00	Stern	279	21	40	23.168	139	19	53	23.161	417333.11	8009630.58			
85	07:07:30	Bow	119	41	59	61.379	042	22	31	61.360	417285.52	8009542.28	208.58	210.50	-1.92
86	07:07:30	Stern	279	19	00	23.183	139	17	13	23.176	417333.14	8009630.58			
87	07:08:00	Bow	119	41	49	61.377	042	22	21	61.358	417285.51	8009542.28	208.57	210.50	-1.93
88	07:08:00	Stern	279	18	44	23.166	139	16	57	23.159	417333.13	8009630.60			
89	07:08:30	Bow	119	41	23	61.361	042	21	55	61.342	417285.50	8009542.27	208.57	210.50	-1.93
90	07:08:30	Stern	279	20	08	23.162	139	18	21	23.155	417333.12	8009630.59			
91	07:09:00	Bow	119	42	00	61.394	042	22	32	61.375	417285.53	8009542.29	208.57	210.50	-1.93
92	07:09:00	Stern	279	17	34	23.174	139	15	47	23.167	417333.14	8009630.60			
93	07:09:30	Bow	119	40	26	61.358	042	20	58	61.339	417285.48	8009542.28	208.58	210.60	-2.02
94	07:09:30	Stern	279	21	01	23.158	139	19	14	23.151	417333.11	8009630.59			
95	07:10:00	Bow	119	41	00	61.366	042	21	32	61.347	417285.49	8009542.28	208.58	210.50	-1.92
96	07:10:00	Stern	279	19	35	23.160	139	17	48	23.153	417333.12	8009630.60			
97	07:10:30	Bow	119	41	39	61.374	042	22	11	61.355	417285.51	8009542.28	208.56	210.50	-1.94
98	07:10:30	Stern	279	19	25	23.149	139	17	38	23.142	417333.11	8009630.61			
99	07:11:00	Bow	119	40	45	61.378	042	21	17	61.359	417285.50	8009542.29	208.56	210.50	-1.94
100	07:11:00	Stern	279	20	57	23.122	139	19	10	23.115	417333.09	8009630.62			
101	07:11:30	Bow	119	40	34	61.381	042	21	06	61.362	417285.50	8009542.30	208.56	210.50	-1.94
102	07:11:30	Stern	279	18	52	23.123	139	17	05	23.116	417333.10	8009630.63			
103	07:12:00	Bow	119	40	14	61.378	042	20	46	61.359	417285.49	8009542.30	208.57	210.50	-1.93
104	07:12:00	Stern	279	19	22	23.135	139	17	35	23.128	417333.10	8009630.62			
105	07:12:30	Bow	119	39	04	61.369	042	19	36	61.350	417285.47	8009542.31	208.57	210.50	-1.93
106	07:12:30	Stern	279	19	58	23.106	139	18	11	23.099	417333.08	8009630.64			
107	07:13:00	Bow	119	38	50	61.364	042	19	22	61.345	417285.46	8009542.31	208.56	210.50	-1.94
108	07:13:00	Stern	279	21	53	23.098	139	20	06	23.091	417333.07	8009630.63			
109	07:13:30	Bow	119	39	07	61.361	042	19	39	61.342	417285.47	8009542.30	208.55	210.50	-1.95
110	07:13:30	Stern	279	22	48	23.080	139	21	01	23.073	417333.05	8009630.64			
111	07:14:00	Bow	119	37	23	61.342	042	17	55	61.323	417285.43	8009542.31	208.55	210.50	-1.95
112	07:14:00	Stern	279	24	38	23.046	139	22	51	23.039	417333.02	8009630.66			
113	07:14:30	Bow	119	39	37	61.384	042	20	09	61.365	417285.49	8009542.31	208.55	210.50	-1.95
114	07:14:30	Stern	279	20	04	23.094	139	18	17	23.087	417333.07	8009630.65			
115	07:15:00	Bow	119	40	28	61.399	042	20	60	61.380	417285.51	8009542.31	208.55	210.50	-1.95
116	07:15:00	Stern	279	17	41	23.099	139	15	54	23.092	417333.09	8009630.65			
117	07:15:30	Bow	119	39	29	61.382	042	20	01	61.363	417285.48	8009542.31	208.55	210.50	-1.95
118	07:15:30	Stern	279	19	58	23.090	139	18	11	23.083	417333.07	8009630.65			
119	07:16:00	Bow	119	37	10	61.357	042	17	42	61.338	417285.44	8009542.32	208.54	210.50	-1.96
120	07:16:00	Stern	279	23	00	23.031	000	00	00	23.024	417333.02	8009630.68			
													Mean C-O		-1.98
													SD		0.03

Signature

SURVEYOR/PARTY CHIEF

Date 19 Feb 04

Appendix II - Raw Observations and Calibration Results for Pitch and Roll

ROLL AND PITCH

Octans 3000

Roll

Port Target Height: 1.280 m
Starboard Target Height: 1.280 m

TIME UTC Start	TIME UTC Stop	PORT Direction grads	PORT Vert Angle grads	PORT Distance m	STARBOARD Direction grads	STARBOARD Vert Angle grads	STARBOARD Distance m	PORT => STBD Dist m	PORT => STBD DH m	ROLL Calc deg	ROLL Obs deg	ROLL C-O deg
17:22	17:52	308.4399	105.0823	283.888	306.9147	105.3454	268.161	17.09	0.149	-0.50	-0.39	**-0.11**

Positive Roll = Starboard side down

Pitch

Height of Fore Point: 11.800 m Target Height: 1.280 m Offset from C/L: 8.545 m (Positive to Starboard)
Height of Aft Point: 11.800 m Target Height: 1.285 m Offset from C/L: 8.865 m (Positive to Starboard)

Height reference: Vessel drawing

TIME UTC Start	TIME UTC Stop	AFT Direction grads	AFT Vert Angle grads	AFT Distance m	FORE Direction grads	FORE Vert Angle grads	FORE Distance m	AFT => FORE Dist m	AFT => FORE DH m	PITCH Calc deg	PITCH Obs deg	PITCH C-O deg
17:22	17:52	291.9587	104.6294	306.998	306.9147	105.3454	268.161	77.55	-0.182	0.132	0.02	**0.11**

Positive Pitch = Bow down

Appendix III - Raw Observations and DGPS verification results

Fugro Survey Pty Ltd

FUGRO

Static DGPS Verification - Single Total Station Method

Fugro Job Number:	P0623	**Wharf:**	Broome
Job Description:	Calibration	**Vessel:**	Atlantic Guardian
Client:	EMGS	**Date:**	17 Feb 2007
Surveyor:	L. Arrowsmith & J. Richards	**Antenna**	V1_GPS1
Time Zone :	UTC + 9.0		

Geodesy

Spheroid	GRS80	**Projection**	Transverse Mercator (UTM)
Semi Major Axis	6378137	Central Meridian	123
Inverse Flattening	298.25722	False Easting	500000
Datum	WGS 84	False Northing	10000000
		Central Scale Factor	0.9996

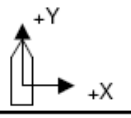
Station Details

Instrument Station:	B01a	Easting (m):	417318.02
Instrument Type :	TopCon	Northing (m):	8009648.15
Instrument Serial No. :		AHD Height (m):	0.00
Backsight Station (RO) :	BR05	Easting (m):	417265.12
		Northing (m):	8009585.04
		AHD Height (m):	0.00

Prism Offsets to DGPS System

Y: 0.10
X: 0.05

Offset Convention



Calculated Grid Bearing to RO :	219° 58' 13.36"
Calculated Convergence :	-000° 14' 28.89"

Correction to Gyro from Cal.

Corrn. : -1.95°

Observations To:	V1_GPS1		*CHECK Backsight Station (RO)*	Easting (m):	417265.12
Backsight Observation (Set to) :	0°	0 '	0 '	:	Northing (m):	8009585.04
Check Backsight:	180°	0 '	00		AHD Height (m):	0.00

Obs	Time (hh:mm:ss)	Observed Distance (m)	Observed Direction (DMS)			Positioning System DGPS Co-ordinates		Vessel Heading
						Latitude	Longitude	
1	05:20:00	67.853	329	07	45	-18.0005280	122.2188900	30.1
2	05:20:30	67.834	329	10	50	-18.0005270	122.2188900	30.0
3	05:21:00	67.825	329	10	10	-18.0005270	122.2188900	30.0
4	05:21:30	67.851	329	06	41	-18.0005270	122.2188900	30.0
5	05:22:00	67.848	329	07	21	-18.0005280	122.2188910	30.0
6	05:22:30	67.844	329	07	36	-18.0005280	122.2188910	30.1
7	05:23:00	67.844	329	08	31	-18.0005270	122.2188910	30.0
8	05:23:30	67.845	329	08	16	-18.0005270	122.2188910	30.1
9	05:24:00	67.860	329	06	17	-18.0005280	122.2188920	30.0
10	05:24:30	67.863	329	04	11	-18.0005280	122.2188910	30.0
11	05:25:00	67.864	329	04	30	-18.0005280	122.2188910	30.0
12	05:25:30	67.869	329	04	56	-18.0005280	122.2188910	30.0
13	05:26:00	67.846	329	07	59	-18.0005270	122.2188910	30.0
14	05:26:30	67.852	329	06	43	-18.0005280	122.2188910	30.0
15	05:27:00	67.856	329	07	53	-18.0005270	122.2188910	30.1
16	05:27:30	67.847	329	08	17	-18.0005280	122.2188910	30.1
17	05:28:00	67.849	329	07	10	-18.0005280	122.2188910	30.0
18	05:28:30	67.840	329	08	06	-18.0005270	122.2188910	30.1
19	05:29:00	67.832	329	08	00	-18.0005270	122.2188910	30.0
20	05:29:30	67.848	329	08	22	-18.0005270	122.2188910	30.1
21	05:30:00	67.845	329	08	21	-18.0005280	122.2188910	30.0
22	05:30:30	67.854	329	06	10	-18.0005280	122.2188910	30.0
23	05:31:00	67.829	329	10	15	-18.0005270	122.2188900	30.1
24	05:31:30	67.834	329	08	11	-18.0005280	122.2188910	30.0
25	05:32:00	67.833	329	10	20	-18.0005270	122.2188900	30.0
26	05:32:30	67.847	329	07	42	-18.0005270	122.2188910	30.0
27	05:33:00	67.832	329	08	24	-18.0005270	122.2188900	30.0
28	05:33:30	67.850	329	06	39	-18.0005270	122.2188900	30.0
29	05:34:00	67.835	329	10	57	-18.0005270	122.2188900	30.1

Obs	Time (hh:mm:ss)	Observed Distance (m)	Observed Direction (DMS)			Positioning System DGPS Co-ordinates		Vessel Heading
						Latitude	Longitude	
30	05:34:30	67.835	329	08	45	-18.0005270	122.2188900	30.0
31	05:35:00	67.826	329	10	58	-18.0005270	122.2188900	30.1
32	05:35:30	67.812	329	10	57	-18.0005270	122.2188900	30.0
33	05:36:00	67.836	329	09	37	-18.0005270	122.2188900	30.0
34	05:36:30	67.823	329	10	47	-18.0005270	122.2188900	30.0
35	05:37:00	67.830	329	07	48	-18.0005270	122.2188900	30.0
36	05:37:30	67.819	329	11	32	-18.0005270	122.2188900	30.1
37	05:38:00	67.839	329	08	15	-18.0005280	122.2188910	30.0
38	05:38:30	67.839	329	08	16	-18.0005270	122.2188900	30.0
39	05:39:00	67.828	329	11	00	-18.0005270	122.2188900	30.0
40	05:39:30	67.818	329	11	44	-18.0005270	122.2188900	30.1
41	05:40:00	67.807	329	12	45	-18.0005270	122.2188900	30.0
42	05:40:30	67.812	329	12	16	-18.0005270	122.2188900	30.0
43	05:41:00	67.808	329	12	25	-18.0005270	122.2188910	30.0
44	05:41:30	67.834	329	09	36	-18.0005270	122.2188900	30.0
45	05:42:00	67.819	329	11	10	-18.0005270	122.2188900	30.1
46	05:42:30	67.804	329	14	52	-18.0005270	122.2188890	30.1
47	05:43:00	67.811	329	13	22	-18.0005270	122.2188900	30.0
48	05:43:30	67.822	329	11	53	-18.0005270	122.2188900	30.1
49	05:44:00	67.815	329	11	09	-18.0005270	122.2188900	30.1
50	05:44:30	67.809	329	12	58	-18.0005270	122.2188900	30.0
51	05:45:00	67.825	329	10	46	-18.0005270	122.2188900	30.0
52	05:45:30	67.827	329	10	55	-18.0005270	122.2188900	30.0
53	05:46:00	67.803	329	12	42	-18.0005270	122.2188890	30.0
54	05:46:30	67.810	329	13	30	-18.0005270	122.2188890	30.0
55	05:47:00	67.813	329	13	18	-18.0005270	122.2188900	30.1
56	05:47:30	67.833	329	11	59	-18.0005270	122.2188900	30.0
57	05:48:00	67.824	329	11	43	-18.0005270	122.2188900	30.0
58	05:48:30	67.815	329	12	52	-18.0005270	122.2188900	30.0
59	05:49:00	67.819	329	11	35	-18.0005270	122.2188900	30.0
60	05:49:30	67.813	329	12	53	-18.0005270	122.2188900	30.0

Signature Louise MacDonald Date: 19 Feb 2007

SURVEYOR/PARTY CHIEF

Fugro Survey Pty Ltd

Static DGPS Verification - Single Total Station Method

Fugro Job Number:	P0623	**Wharf:**	Broome
Job Description:	Calibration	**Vessel:**	Atlantic Guardian
Client:	EMGS	**Date:**	17 Feb 2007
Surveyor:	L. Arrowsmith & J. Richards	**DGPS :**	V1_GPS1
Time Zone :	UTC + 9.0	**Serial No.:**	0

Geodesy

Spheroid	GRS80
Datum	WGS 84
Projection	Transverse Mercator (UTM)
Central Meridian	123

Observations To: V1_GPS1

Signature _____
SURVEYOR/PARTY CHIEF

RESULTS :

Linear Misclose:	0.83

	C-O East(m)	C-O North(m)
MEAN	-0.49	-0.67
SD	0.04	0.04

Obs	Time (hh:mm:ss)	Observed Direction (DMS)			Observed Distance (m)	Calculated Co-ordinates of DGPS Antenna		Observed Position of DGPS Antenna		Positioning System DGPS Co-ordinates		C-O East	C-O North
						Easting (m)	Northing (m)	Latitude	Longitude	Easting (m)	Northing (m)		
1	05:20:00	329	07	45	67.853	417307.386	8009581.233	-18.000528	122.218890	417307.81	8009581.85	-0.42	-0.61
2	05:20:30	329	10	50	67.834	417307.329	8009581.262	-18.000527	122.218890	417307.81	8009581.96	-0.48	-0.70
3	05:21:00	329	10	10	67.825	417307.343	8009581.268	-18.000527	122.218890	417307.81	8009581.96	-0.46	-0.69
4	05:21:30	329	06	41	67.851	417307.407	8009581.232	-18.000527	122.218890	417307.81	8009581.96	-0.40	-0.72
5	05:22:00	329	07	21	67.848	417307.395	8009581.237	-18.000528	122.218891	417307.91	8009581.85	-0.52	-0.61
6	05:22:30	329	07	36	67.844	417307.390	8009581.242	-18.000528	122.218891	417307.91	8009581.85	-0.52	-0.60
7	05:23:00	329	08	31	67.844	417307.373	8009581.244	-18.000527	122.218891	417307.91	8009581.96	-0.54	-0.71
8	05:23:30	329	08	16	67.845	417307.377	8009581.243	-18.000527	122.218891	417307.91	8009581.96	-0.54	-0.71
9	05:24:00	329	06	17	67.860	417307.413	8009581.222	-18.000528	122.218892	417308.02	8009581.85	-0.61	-0.63
10	05:24:30	329	04	11	67.863	417307.454	8009581.212	-18.000528	122.218891	417307.91	8009581.85	-0.46	-0.63
11	05:25:00	329	04	30	67.864	417307.448	8009581.212	-18.000528	122.218891	417307.91	8009581.85	-0.47	-0.63
12	05:25:30	329	04	56	67.869	417307.438	8009581.209	-18.000528	122.218891	417307.91	8009581.85	-0.48	-0.64
13	05:26:00	329	07	59	67.846	417307.383	8009581.241	-18.000527	122.218891	417307.91	8009581.96	-0.53	-0.72
14	05:26:30	329	06	43	67.852	417307.406	8009581.231	-18.000528	122.218891	417307.91	8009581.85	-0.51	-0.62
15	05:27:00	329	07	53	67.856	417307.383	8009581.231	-18.000527	122.218891	417307.91	8009581.96	-0.53	-0.73
16	05:27:30	329	08	17	67.847	417307.377	8009581.241	-18.000528	122.218891	417307.91	8009581.85	-0.54	-0.61
17	05:28:00	329	07	10	67.849	417307.398	8009581.235	-18.000528	122.218891	417307.91	8009581.85	-0.52	-0.61
18	05:28:30	329	08	06	67.840	417307.381	8009581.247	-18.000527	122.218891	417307.91	8009581.96	-0.53	-0.71
19	05:29:00	329	08	00	67.832	417307.384	8009581.255	-18.000527	122.218891	417307.91	8009581.96	-0.53	-0.70
20	05:29:30	329	08	22	67.848	417307.375	8009581.240	-18.000527	122.218891	417307.91	8009581.96	-0.54	-0.72
21	05:30:00	329	08	21	67.845	417307.376	8009581.243	-18.000528	122.218891	417307.91	8009581.85	-0.54	-0.60
22	05:30:30	329	06	10	67.854	417307.417	8009581.227	-18.000528	122.218891	417307.91	8009581.85	-0.50	-0.62
23	05:31:00	329	10	15	67.829	417307.341	8009581.265	-18.000527	122.218890	417307.81	8009581.96	-0.47	-0.69
24	05:31:30	329	08	11	67.834	417307.381	8009581.253	-18.000528	122.218891	417307.91	8009581.85	-0.53	-0.59
25	05:32:00	329	10	20	67.833	417307.339	8009581.261	-18.000527	122.218890	417307.81	8009581.96	-0.47	-0.70
26	05:32:30	329	07	42	67.847	417307.388	8009581.239	-18.000527	122.218891	417307.91	8009581.96	-0.53	-0.72
27	05:33:00	329	08	24	67.832	417307.377	8009581.256	-18.000527	122.218890	417307.81	8009581.96	-0.43	-0.70
28	05:33:30	329	06	39	67.850	417307.408	8009581.233	-18.000527	122.218890	417307.81	8009581.96	-0.40	-0.72
29	05:34:00	329	10	57	67.835	417307.327	8009581.261	-18.000527	122.218890	417307.81	8009581.96	-0.48	-0.70
30	05:34:30	329	08	45	67.835	417307.369	8009581.254	-18.000527	122.218890	417307.81	8009581.96	-0.44	-0.70
31	05:35:00	329	10	58	67.826	417307.328	8009581.270	-18.000527	122.218890	417307.81	8009581.96	-0.48	-0.69
32	05:35:30	329	10	57	67.812	417307.330	8009581.284	-18.000527	122.218890	417307.81	8009581.96	-0.48	-0.67
33	05:36:00	329	09	37	67.836	417307.352	8009581.256	-18.000527	122.218890	417307.81	8009581.96	-0.46	-0.70
34	05:36:30	329	10	47	67.823	417307.332	8009581.272	-18.000527	122.218890	417307.81	8009581.96	-0.48	-0.68
35	05:37:00	329	07	48	67.830	417307.389	8009581.256	-18.000527	122.218890	417307.81	8009581.96	-0.42	-0.70
36	05:37:30	329	11	32	67.819	417307.318	8009581.279	-18.000527	122.218890	417307.81	8009581.96	-0.49	-0.68
37	05:38:00	329	08	15	67.839	417307.378	8009581.249	-18.000528	122.218891	417307.91	8009581.85	-0.54	-0.60
38	05:38:30	329	08	16	67.839	417307.378	8009581.249	-18.000527	122.218890	417307.81	8009581.96	-0.43	-0.71
39	05:39:00	329	11	00	67.828	417307.327	8009581.268	-18.000527	122.218890	417307.81	8009581.96	-0.48	-0.69
40	05:39:30	329	11	44	67.818	417307.314	8009581.280	-18.000527	122.218890	417307.81	8009581.96	-0.49	-0.68
41	05:40:00	329	12	45	67.807	417307.296	8009581.294	-18.000527	122.218890	417307.81	8009581.96	-0.51	-0.66
42	05:40:30	329	12	16	67.812	417307.305	8009581.288	-18.000527	122.218890	417307.81	8009581.96	-0.50	-0.67
43	05:41:00	329	12	25	67.808	417307.302	8009581.292	-18.000527	122.218891	417307.91	8009581.96	-0.61	-0.66
44	05:41:30	329	09	36	67.834	417307.353	8009581.258	-18.000527	122.218890	417307.81	8009581.96	-0.45	-0.70
45	05:42:00	329	11	10	67.819	417307.325	8009581.277	-18.000527	122.218890	417307.81	8009581.96	-0.48	-0.68
46	05:42:30	329	14	52	67.804	417307.255	8009581.304	-18.000527	122.218889	417307.70	8009581.96	-0.45	-0.65
47	05:43:00	329	13	22	67.811	417307.283	8009581.292	-18.000527	122.218890	417307.81	8009581.96	-0.52	-0.66
48	05:43:30	329	11	53	67.822	417307.310	8009581.277	-18.000527	122.218890	417307.81	8009581.96	-0.50	-0.68
49	05:44:00	329	11	09	67.815	417307.326	8009581.281	-18.000527	122.218890	417307.81	8009581.96	-0.48	-0.68
50	05:44:30	329	12	58	67.809	417307.291	8009581.293	-18.000527	122.218890	417307.81	8009581.96	-0.52	-0.66
51	05:45:00	329	10	46	67.825	417307.332	8009581.270	-18.000527	122.218890	417307.81	8009581.96	-0.48	-0.69
52	05:45:30	329	10	55	67.827	417307.328	8009581.269	-18.000527	122.218890	417307.81	8009581.96	-0.48	-0.69
53	05:46:00	329	12	42	67.803	417307.298	8009581.298	-18.000527	122.218889	417307.70	8009581.96	-0.40	-0.66
54	05:46:30	329	13	30	67.810	417307.261	8009581.294	-18.000527	122.218889	417307.70	8009581.96	-0.42	-0.66
55	05:47:00	329	13	18	67.813	417307.284	8009581.290	-18.000527	122.218890	417307.81	8009581.96	-0.52	-0.67
56	05:47:30	329	11	59	67.833	417307.307	8009581.266	-18.000527	122.218890	417307.81	8009581.96	-0.50	-0.69
57	05:48:00	329	11	43	67.824	417307.313	8009581.274	-18.000527	122.218890	417307.81	8009581.96	-0.49	-0.68
58	05:48:30	329	12	52	67.815	417307.292	8009581.287	-18.000527	122.218890	417307.81	8009581.96	-0.52	-0.67
59	05:49:00	329	11	35	67.819	417307.317	8009581.279	-18.000527	122.218890	417307.81	8009581.96	-0.49	-0.68
60	05:49:30	329	12	53	67.813	417307.292	8009581.289	-18.000527	122.218890	417307.81	8009581.96	-0.52	-0.67

Signature Louise Harrison
SURVEYOR/PARTY CHIEF

Date 19 Feb 2007

Fugro Survey Pty Ltd

FUGRO

Static DGPS Verification - Single Total Station Method

Fugro Job Number:	P0623	**Wharf:**	Broome
Job Description:	Calibration	**Vessel:**	Atlantic Guardian
Client:	EMGS	**Date:**	17 Feb 2007
Surveyor:	L. Arrowsmith & J. Richards	**Antenna**	V1_GPS2
Time Zone :	UTC + 9.0		

Geodesy

Spheroid	GRS80	**Projection**	Transverse Mercator (UTM)
Semi Major Axis	6378137	Central Meridian	123
Inverse Flattening	298.25722	False Easting	500000
Datum	WGS 84	False Northing	10000000
		Central Scale Factor	0.9996

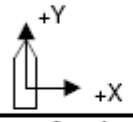
Station Details

Instrument Station:	B01a	Easting (m):	417318.02
Instrument Type :	TopCon	Northing (m):	8009648.15
Instrument Serial No. :		AHD Height (m):	0.00
Backsight Station (RO) :	BR05	Easting (m):	417265.12
		Northing (m):	8009585.04
		AHD Height (m):	0.00

Prism Offsets to DGPS System

Y: 0.10
X: 1.08

Offset Convention



Calculated Grid Bearing to RO : 219° 58' 13.36"
Calculated Convergence : -000° 14' 28.89"

Correction to Gyro from Cal.

Corm. : -1.95°

Observations To: V1_GPS2

Backsight Observation (Set to) : 0° 0' 0"
Check Backsight: 180° 0' 00"

CHECK Backsight Station (RO) :

Easting (m): 417265.12
Northing (m): 8009585.04
AHD Height (m): 0.00

Obs	Time (hh:mm:ss)	Observed Distance (m)	Observed Direction (DMS)			Positioning System DGPS Co-ordinates		Vessel Heading
						Latitude	Longitude	
1	05:20:00	67.853	329	07	45	-18.000531	122.218899	30.1
2	05:20:30	67.834	329	10	50	-18.000531	122.218898	30.0
3	05:21:00	67.825	329	10	10	-18.000531	122.218898	30.0
4	05:21:30	67.851	329	06	41	-18.000531	122.218899	30.0
5	05:22:00	67.848	329	07	21	-18.000531	122.218898	30.0
6	05:22:30	67.844	329	07	36	-18.000531	122.218899	30.1
7	05:23:00	67.844	329	08	31	-18.000531	122.218899	30.0
8	05:23:30	67.845	329	08	16	-18.000531	122.218899	30.1
9	05:24:00	67.860	329	06	17	-18.000530	122.218899	30.0
10	05:24:30	67.863	329	04	11	-18.000531	122.218899	30.0
11	05:25:00	67.864	329	04	30	-18.000531	122.218900	30.0
12	05:25:30	67.869	329	04	56	-18.000531	122.218900	30.0
13	05:26:00	67.846	329	07	59	-18.000531	122.218899	30.0
14	05:26:30	67.852	329	06	43	-18.000531	122.218899	30.0
15	05:27:00	67.856	329	07	53	-18.000531	122.218899	30.1
16	05:27:30	67.847	329	08	17	-18.000531	122.218899	30.1
17	05:28:00	67.849	329	07	10	-18.000530	122.218899	30.0
18	05:28:30	67.840	329	08	06	-18.000531	122.218899	30.1
19	05:29:00	67.832	329	08	00	-18.000531	122.218899	30.0
20	05:29:30	67.848	329	08	22	-18.000531	122.218899	30.1
21	05:30:00	67.845	329	08	21	-18.000531	122.218899	30.0
22	05:30:30	67.854	329	06	10	-18.000531	122.218899	30.0
23	05:31:00	67.829	329	10	15	-18.000531	122.218899	30.1
24	05:31:30	67.834	329	08	11	-18.000531	122.218899	30.0
25	05:32:00	67.833	329	10	20	-18.000531	122.218899	30.0
26	05:32:30	67.847	329	07	42	-18.000530	122.218899	30.0
27	05:33:00	67.832	329	08	24	-18.000531	122.218899	30.0
28	05:33:30	67.850	329	06	39	-18.000531	122.218899	30.0
29	05:34:00	67.835	329	10	57	-18.000530	122.218899	30.1

Fugro Survey Pty Ltd

Static DGPS Verification - Single Total Station Method

Fugro Job Number:	P0623	**Wharf:**	Broome
Job Description:	Calibration	**Vessel:**	Atlantic Guardian
Client:	EMGS	**Date:**	17 Feb 2007
Surveyor:	L. Arrowsmith & J. Richards	**DGPS :**	V1_GPS2
Time Zone :	UTC + 9.0	**Serial No.:**	0

Geodesy

Spheroid	GRS80
Datum	WGS 84
Projection	Transverse Mercator (UTM)
Central Meridian	123

Observations To: V1_GPS2

Signature _____
SURVEYOR/PARTY CHIEF

RESULTS :

Linear Misclose: 0.97

	C-O East(m)	C-O North(m)
MEAN	-0.48	-0.84
SD	0.04	0.05

Obs	Time (hh:mm:ss)	Observed Direction (DMS)			Observed Distance (m)	Calculated Co-ordinates of DGPS Antenna		Observed Position of DGPS Antenna		Positioning System DGPS Co-ordinates		C-O East	C-O North
						Easting (m)	Northing (m)	Latitude	Longitude	Easting (m)	Northing (m)		
1	05:20:00	329	07	45	67.853	417308.275	8009580.713	-18.000531	122.218899	417308.76	8009581.52	-0.49	-0.80
2	05:20:30	329	10	50	67.834	417308.218	8009580.742	-18.000531	122.218898	417308.66	8009581.52	-0.44	-0.78
3	05:21:00	329	10	10	67.825	417308.233	8009580.749	-18.000531	122.218898	417308.66	8009581.52	-0.42	-0.77
4	05:21:30	329	06	41	67.851	417308.297	8009580.713	-18.000531	122.218899	417308.76	8009581.52	-0.47	-0.81
5	05:22:00	329	07	21	67.848	417308.284	8009580.718	-18.000531	122.218898	417308.66	8009581.52	-0.37	-0.80
6	05:22:30	329	07	36	67.844	417308.280	8009580.722	-18.000531	122.218899	417308.76	8009581.52	-0.48	-0.80
7	05:23:00	329	08	31	67.844	417308.262	8009580.725	-18.000531	122.218899	417308.76	8009581.52	-0.50	-0.79
8	05:23:30	329	08	16	67.845	417308.267	8009580.723	-18.000531	122.218899	417308.76	8009581.52	-0.50	-0.80
9	05:24:00	329	06	17	67.860	417308.303	8009580.703	-18.000530	122.218899	417308.76	8009581.63	-0.46	-0.93
10	05:24:30	329	04	11	67.863	417308.344	8009580.693	-18.000531	122.218899	417308.76	8009581.52	-0.42	-0.83
11	05:25:00	329	04	30	67.864	417308.337	8009580.694	-18.000531	122.218900	417308.87	8009581.52	-0.53	-0.83
12	05:25:30	329	04	56	67.869	417308.328	8009580.690	-18.000531	122.218900	417308.87	8009581.52	-0.54	-0.83
13	05:26:00	329	07	59	67.846	417308.272	8009580.722	-18.000531	122.218899	417308.76	8009581.52	-0.49	-0.80
14	05:26:30	329	06	43	67.852	417308.296	8009580.712	-18.000531	122.218899	417308.76	8009581.52	-0.47	-0.81
15	05:27:00	329	07	53	67.856	417308.272	8009580.711	-18.000531	122.218899	417308.76	8009581.52	-0.49	-0.81
16	05:27:30	329	08	17	67.847	417308.266	8009580.721	-18.000531	122.218899	417308.76	8009581.52	-0.50	-0.80
17	05:28:00	329	07	10	67.849	417308.288	8009580.716	-18.000530	122.218899	417308.76	8009581.63	-0.47	-0.91
18	05:28:30	329	08	06	67.840	417308.271	8009580.727	-18.000531	122.218899	417308.76	8009581.52	-0.49	-0.79
19	05:29:00	329	08	00	67.832	417308.274	8009580.736	-18.000531	122.218899	417308.76	8009581.52	-0.49	-0.78
20	05:29:30	329	08	22	67.848	417308.264	8009580.721	-18.000531	122.218899	417308.76	8009581.52	-0.50	-0.80
21	05:30:00	329	08	21	67.845	417308.265	8009580.724	-18.000531	122.218899	417308.76	8009581.52	-0.50	-0.79
22	05:30:30	329	06	10	67.854	417308.306	8009580.708	-18.000531	122.218899	417308.76	8009581.52	-0.46	-0.81
23	05:31:00	329	10	15	67.829	417308.231	8009580.745	-18.000531	122.218899	417308.76	8009581.52	-0.53	-0.77
24	05:31:30	329	08	11	67.834	417308.270	8009580.734	-18.000531	122.218899	417308.76	8009581.52	-0.49	-0.78
25	05:32:00	329	10	20	67.833	417308.228	8009580.742	-18.000531	122.218899	417308.76	8009581.52	-0.53	-0.78
26	05:32:30	329	07	42	67.847	417308.278	8009580.720	-18.000530	122.218899	417308.76	8009581.63	-0.48	-0.91
27	05:33:00	329	08	24	67.832	417308.266	8009580.737	-18.000531	122.218899	417308.76	8009581.52	-0.50	-0.78
28	05:33:30	329	06	39	67.850	417308.298	8009580.714	-18.000531	122.218899	417308.76	8009581.52	-0.46	-0.80
29	05:34:00	329	10	57	67.835	417308.216	8009580.741	-18.000530	122.218899	417308.76	8009581.63	-0.55	-0.89
30	05:34:30	329	08	45	67.835	417308.259	8009580.735	-18.000530	122.218899	417308.76	8009581.63	-0.50	-0.89
31	05:35:00	329	10	58	67.826	417308.217	8009580.750	-18.000530	122.218899	417308.76	8009581.63	-0.54	-0.88
32	05:35:30	329	10	57	67.812	417308.220	8009580.764	-18.000530	122.218898	417308.66	8009581.63	-0.44	-0.86
33	05:36:00	329	09	37	67.836	417308.242	8009580.737	-18.000530	122.218899	417308.76	8009581.63	-0.52	-0.89
34	05:36:30	329	10	47	67.823	417308.221	8009580.753	-18.000530	122.218899	417308.76	8009581.63	-0.54	-0.88
35	05:37:00	329	07	48	67.830	417308.278	8009580.737	-18.000530	122.218898	417308.66	8009581.63	-0.38	-0.89
36	05:37:30	329	11	32	67.819	417308.207	8009580.759	-18.000530	122.218898	417308.66	8009581.63	-0.45	-0.87
37	05:38:00	329	08	15	67.839	417308.268	8009580.730	-18.000530	122.218899	417308.76	8009581.63	-0.49	-0.90
38	05:38:30	329	08	16	67.839	417308.268	8009580.729	-18.000531	122.218899	417308.76	8009581.52	-0.49	-0.79
39	05:39:00	329	11	00	67.828	417308.216	8009580.749	-18.000530	122.218898	417308.66	8009581.63	-0.44	-0.88
40	05:39:30	329	11	44	67.818	417308.203	8009580.760	-18.000530	122.218898	417308.66	8009581.63	-0.45	-0.87
41	05:40:00	329	12	45	67.807	417308.186	8009580.775	-18.000530	122.218898	417308.66	8009581.63	-0.47	-0.85
42	05:40:30	329	12	16	67.812	417308.194	8009580.769	-18.000530	122.218898	417308.66	8009581.63	-0.46	-0.86
43	05:41:00	329	12	25	67.808	417308.192	8009580.773	-18.000531	122.218899	417308.76	8009581.52	-0.57	-0.75
44	05:41:30	329	09	36	67.834	417308.242	8009580.738	-18.000531	122.218899	417308.76	8009581.52	-0.52	-0.78
45	05:42:00	329	11	10	67.819	417308.214	8009580.758	-18.000530	122.218899	417308.76	8009581.63	-0.55	-0.87
46	05:42:30	329	14	52	67.804	417308.144	8009580.784	-18.000530	122.218898	417308.66	8009581.63	-0.51	-0.84
47	05:43:00	329	13	22	67.811	417308.173	8009580.773	-18.000529	122.218897	417308.55	8009581.74	-0.38	-0.97
48	05:43:30	329	11	53	67.822	417308.200	8009580.757	-18.000530	122.218898	417308.66	8009581.63	-0.46	-0.87
49	05:44:00	329	11	09	67.815	417308.215	8009580.762	-18.000530	122.218898	417308.66	8009581.63	-0.44	-0.87
50	05:44:30	329	12	58	67.809	417308.181	8009580.774	-18.000530	122.218898	417308.66	8009581.63	-0.47	-0.85
51	05:45:00	329	10	46	67.825	417308.221	8009580.751	-18.000530	122.218899	417308.76	8009581.63	-0.54	-0.88
52	05:45:30	329	10	55	67.827	417308.218	8009580.750	-18.000530	122.218898	417308.66	8009581.63	-0.44	-0.86
53	05:46:00	329	12	42	67.803	417308.187	8009580.779	-18.000530	122.218899	417308.76	8009581.63	-0.57	-0.85
54	05:46:30	329	13	30	67.810	417308.171	8009580.775	-18.000530	122.218898	417308.66	8009581.63	-0.49	-0.85
55	05:47:00	329	13	18	67.813	417308.174	8009580.771	-18.000530	122.218898	417308.66	8009581.63	-0.48	-0.86
56	05:47:30	329	11	59	67.833	417308.196	8009580.747	-18.000530	122.218898	417308.66	8009581.63	-0.46	-0.88
57	05:48:00	329	11	43	67.824	417308.203	8009580.755	-18.000530	122.218898	417308.66	8009581.63	-0.45	-0.87
58	05:48:30	329	12	52	67.815	417308.182	8009580.768	-18.000530	122.218898	417308.66	8009581.63	-0.47	-0.86
59	05:49:00	329	11	35	67.819	417308.206	8009580.760	-18.000530	122.218898	417308.66	8009581.63	-0.45	-0.87
60	05:49:30	329	12	53	67.813	417308.182	8009580.770	-18.000530	122.218898	417308.66	8009581.63	-0.47	-0.86

Signature Louise Arrowsmith
SURVEYOR/PARTY CHIEF

Date 19 Feb 2007