NOAA FORM 76-35A

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SURVEY

Data Acquisition and Processing Report

Type of Survey **Hydrographic / SSS, SBES & MBES**

Registry No. **H11801**

Project No. **S-N915-KR-08**

Time frame **14 November 2008**
To
18 February 2009

LOCALITY

State **Washington**

General Locality **Whidbey Island**

Sub-locality **Oak Harbor to Saratoga Passage**

2008

CHIEF OF PARTY
Christopher S. Pinero
Williamson and Associates, Inc.

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DATE

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HYDROGRAPHIC TITLE SHEET

INSTRUCTIONS - The Hydrographic Sheet should be accompanied by this form, filled in as completely as possible, when the sheet is forwarded to the Office.

FIELD NO. **A**

State: Washington

General Locality: Whidbey Island

Locality: Oak Harbor to Saratoga Passage

Scale: 1:10,000 Date of Survey: 14 November 2008 – 26 January 2009

Instructions Dated: 1 April 2008 (H11801)
Project No. S-N915-KR-08

Vessels: Kvichak Defender IV (1154554); Nooit Volmaakt (WN 9180 NW); Storm (OR 574 ABU)

Chief of Party: Christopher S. Pinero

Surveyed by: *Brian Bunge, Bill Heather, Kyle Fankhauser, Chris Pinero, Donny Brouillette, John Tamplin*

Soundings taken by **echo sounder**, hand lead, pole: Multibeam Kongsberg EM3002, Singlebeam Odom HydroTrac

Graphic record scaled by:

Graphic record checked by:

Protracted by: Automated plot by:

Verification by: Colin Stewart

Digitally signed by Colin Stewart
DN: cn=Colin Stewart, o=Williamson & Associates, Inc., ou=Survey, email=cstewart@wassoc.com, c=US
Date: 2009.04.10 11:06:50 -07'00'

Soundings in **meters** at **MLLW**

REMARKS: **Contract #** DG133C-08-CQ-0001
Contractor: Williamson & Associates, Inc., 1124 NW 53rd St.; Seattle, WA 98107
Times: All times are recorded in UTC.
Purpose: To provide NOAA with modern, accurate hydrographic survey data for the purpose of updating the relevant nautical charts of the assigned areas: Sheet A (H11801) in Puget Sound, Whidbey Island, Washington.

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Table of Contents

Appendices

Appendix P. Valeport Mini SVP

Appendix Q. Seacat Profiler SBE19

Appendix R. Defender IV Vessel Survey

Appendix S. Nooit Volmaakt Vessel Survey

Appendix T. R/V Storm Vessel Survey

Appendix U. Defender IV Waterline Measurements

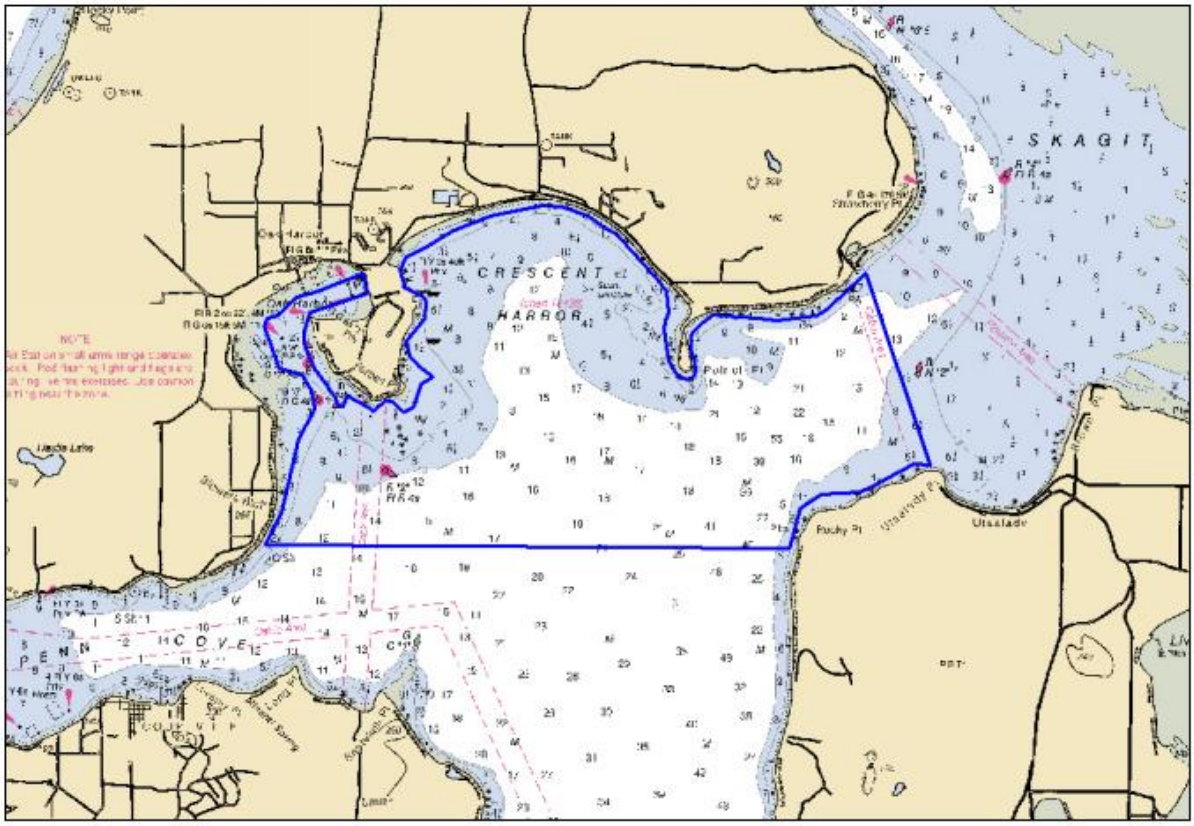
Appendix V. Multibeam Calibration and Patch Test Report

I. BACKGROUND

On 1 April 2008 NOAA contracted Williamson and Associates, Inc. to conduct a multibeam and sidescan survey of Oak and Crescent Harbor areas off Whidbey Island in Puget Sound under contract DG133C-08-CQ-0001. The objective of this project was to collect a multibeam bathymetry dataset with 100% seafloor ensonification in areas of greater than 4 meters water depth, along with 200% sidescan sonar coverage combined with single beam in areas between 2 and 4 meters water depth or where object detection is critical.

II. AREA

The area surveyed is Oak and Crescent Harbor between water depths of 6 and 360 feet. The survey area is mostly defined by the current NOAA BSB chart 18428 – Oak and Crescent Harbors with an extension to the west of approximately 8 nautical miles. The water depths are from 2 meters MLLW to about 110m MLLW in the southwest corner of the survey area. The chart below shows the survey area as outlined in the scope of work provided by NOAA.



III. EQUIPMENT

For a full equipment list with serial numbers see *(Appendix A)*

Vessels

Defender IV
The Defender IV is an aluminum catamaran built by Kvichak Marine Industries. It is 54 feet in length with a 20 foot beam. It has a large aft deck with an A-Frame and Davit. Defender IV can accommodate six crew members. *(Appendix B)*

(Defender IV)

Nooit Volmaakt

The Nooit Volmaakt is a Hewescraft 220 Ocean Pro. This is a 24 foot long aluminum boat with a 102 inch beam. The cabin can accommodate four people with two computers. The bow mounted sonar pole has been designed to rotate into and out of the water. The GPS antenna mount is directly over the sonar to minimize offsets. *(Appendix C)*

(Nooit Volmaakt)

R/V Storm

The research vessel Storm, owned by Tetra Tech, was contracted to run gap fill lines. R/V Storm is 21 feet long with an 8 foot beam. It has a winch assisted bow mounted sonar pole, to which is mounted a dual head Reson 7125. *(Appendix D)*

(R/V Storm)

Sonar Systems

EM 3002

High resolution multibeam imagery was acquired using a Simrad EM 3002. The EM 3002 has a frequency of 300 kHz and a maximum angular coverage of 130 degrees. There are 254 soundings possible from 160 beams. With a depth range of less than 1 meter to more than 200 meters, depth resolution is 1 cm and range resolution is 5 cm. The EM 3002 was mounted to a pole on the port side of the Defender IV just aft of the cabin. The multibeam pole has the ability to rotate out of the water. Multibeam data was acquired with SIS (Seafloor Information System), and imported into CARIS for processing. *(Appendix E)*

(Multibeam Pole on the Defender IV)

C3D

Sidescan imagery was acquired using a Teledyne Benthos C3D-LPM system which was pole mounted on the bow of the Nooit Volmaakt. The C3D system operates at 200 kHz, has a range of 25 to 300 meters, and an across track resolution of 4.5 cm. At the 50 meter range scale, the C3D has a pulse rate of 15 pings per second. Sidescan imagery was recorded in QINSy and later exported out of QINSy as an XTF for post processing. *(Appendix F)*

(C3D pole)

Odom Hydrotrac

The single beam echosounder used in conjunction with the C3D was an Odom Hydrotrac which operates at 200 kHz, has a depth range of 20cm to 600m, and has an accuracy of 1cm ± 0.1% of depth. A transducer with a 2.75° beam angle was mounted to a pole on the starboard side of the Nooit Volmaakt. Single beam data was plotted with a thermal printer as well as recorded in QINSy. *(Appendix G)*

Reson SeaBat 7125
On the R/V Storm Tetra-Tech ECI(TtEC) utilized dual Reson SeaBat 7125 multibeam echosounders (MBE). The two MBE were mounted with 30 degree outboard rolls to a single pole on the bow of the R/V Storm. The 400 kHz, 7125 MBE systems transmit and receive 256 equi-angle beams that are 1.0 x 0.5 degrees along track and across track (at nadir) respectively. *(Appendix H)*

Vessel Positioning & Orientation

Nooit Volmaakt
An IXSEA Octans surface gyrocompass and motion sensor was used on board the Nooit Volmaakt. The Octans has a heading accuracy of 0.1º secant latitude(0.1 x 1/COS Latitude), and a resolution of 0.01º. It has a 5 cm or 5% of heave, surge and sway accuracy. The dynamic roll and pitch accuracy is 0.01º with a resolution of 0.001º. The Octans was mounted on the floor of the cabin just to port of the vessel's center of gravity. *(Appendix I)*

Positioning of the Nooit Volmaakt was provided by a Trimble DSM232 DGPS receiver. The DSM232 has a horizontal RMS accuracy of less than one meter. The DSM232 receiver was mounted on the sonar pole directly above the C3D. *(Appendix J)*

On December 8th, the DSM232 and the Octans were replaced with a POS-MV Wave Master. *(Appendix K)*

Defender IV
The Defender IV used a Coda Octopus F180 for positioning and motion reference. The F180 has a pitch and roll accuracy of less than 0.025º. Using DGPS, there was a CEP positioning accuracy of 0.5 – 4.0 meters. The two GPS antennas were mounted on a T bar along the port side of the cabin with a 2 meter baseline, which gives a true heading accuracy of 0.05º. The F-180 has a heave accuracy of 5% of heave amplitude or 5 cm. *(Appendix L)*

R/V Storm
The positioning and motion reference for the R/V Storm is discussed in *(Appendix M)***.** The Trimble Ag132 DGPS is discussed in *(Appendix N)***.**

Sound Velocity
Defender IV employed two different Valeport sound velocity sensors. A miniSVS was used at the EM 3002 head for real time sound velocity sent directly into the Kongsberg SIS acquisition system. A miniSVP was used for full water depth sound velocity profiles. Sound velocity profiles were taken at the beginning and end of each survey day in addition to casts taken when moving to different survey areas or when sound speed errors were visible in the raw multibeam profile view. The miniSVP was set to measure the speed of sound at 1 meter depth intervals. After each cast was taken, the measured sound velocities were extracted using Valeport's Data Log Express (version 0400/7115/D2 01/08/2008), and imported into SIS and CARIS as sound velocity profiles.

Sound velocities were acquired aboard the Nooit Volmaakt with a Seabird SBE 19plus. The SBE 19plus is accurate to 0.005° C, 0.0005 S/m for conductivity, and 0.1% for depth. A sound velocity profile was created from the measured conductivity, temperature and depth, using Seabirds SEATERM software, version 1.59. Approximately once a week, simultaneous casts were taken with the SBE 19plus and the Valeport miniSVP to ensure the velocities were in agreement with each other. *(Appendices O, P & Q)*

Sound velocity profiles were acquired on the Storm using the same SBE 19plus as employed aboard Nooit Volmaakt.

Acquisition Systems

Defender IV

The navigation computer aboard Defender IV was built by Hard Drives Northwest. It is running Microsoft Windows Vista Ultimate with an Intel Core 2 Duo at 3.00GHz and 4.00 GB of RAM. There are two SLI paired NVIDIA GeForce 9600 GT video cards. This computer was running QINSy V.8

The computer running SIS version. 3.5.0 for multibeam acquisition was an Intel pentium D dual coremother board, 2GB memory DDR2 533mhz, 200 GB HD, Nvidia GeForce 8800GT video card, Windows XP SP2

Nooit Volmaakt

The computer on the Nooit Volmaakt was used for navigation, and to acquire sidescan and single beam data. The computer was built by Hard Drives Northwest. It is running Microsoft Windows Vista Ultimate with an Intel Core 2 Duo at 3.00GHz and 4.00 GB of RAM. There are two SLI paired NVIDIA GeForce 9600 GT video cards. This computer was running QINSy V.8

IV. QUALITY CONTROL

Multibeam

Table 1: BASE surface resolutions and depth ranges

Resolution	Depth Ranges
1m	0m to 30m
2m	29m to 60m
5m	59m to 150m

Sidescan

The sidescan sonar data was initially acquired and saved in QINSy. XTF files were exported from QINSy into a SonarWiz.MAP project. The first step in SonarWiz.MAP was to bottom track all the lines. Then an Empirical Gain Normalization (EGN) was applied to all the lines in the project. Next, each line was examined for contacts and quality. Vessel wakes, ping drop outs and other image quality factors were noted in the processing log.

Contacts were selected by carefully looking through each line in the waterfall view. Objects that cast a shadow were examined more closely by creating a target marker. Objects were designated as targets if the size of their shadow suggested the object's

height above the surrounding area to be one meter or greater. Because there was 200% coverage, duplicate targets were examined and deleted.

In order to ensure 1 meter objects are ensonified at least three times, the C3D sidescan sonar is limited to 9.719 knots on the 50m range scale. The Nooit Volmaakt never traveled faster than 6 knots during sidescan acquisition.

$$\text{Max Speed (meters/Second)} = \text{target size (1m)} * \text{pulse rate}/3(\text{sec}^{-1})$$
$$5 \text{ m/s} = 1\text{m} * 15 / 3(\text{sec}^{-1})$$
$$5 \text{ m/s} = 9.719 \text{ knots}$$

Proof of swath coverage was performed in SonarWiz. SonarWiz has an export function that generates a coverage report. The coverage report consists of a spread sheet that shows coverage information for each line, and a GeoTiff is created that shows areas of 100%, 200%, and 300% or more coverage with user defined colors. SonarWiz calculates coverage by building a grid under the sonar coverage map counting occurrences of data from each line. If a grid cell has a count of 1, it gets marked as 100%, if it has a count of 2, it gets marked as 200% and if it gets a count of 3, it gets marked as 300% or more.

V. CORRECTIONS TO ECHO SOUNDINGS

Sensor Offsets

On November 2008, Defender IV and the Nooit Volmaakt had their vessel shapes and sensor offsets surveyed by Bush, Roed & Hitchings, inc. Several locations around the vessels were marked using RTK GPS. From these locations a laser rangefinder was used to pinpoint on the vessel. These offsets were entered into the vessel configuration file in CARIS. The values obtained from the vessel survey are documented in *(Appendices R & S).*
The values for the R/V Storm are documented in *(Appendix T).*

Static and Dynamic Draft Corrections

Defender IV

Dynamic Draft measurements were entered into the CARIS Vessel File.
Static draft measurements were taken at the beginning and end of each survey day. In the calm waters of the marina, a tape measure with a weight attached to it was lowered down the side of the Defender IV to the water. A measurement was recorded from the waterline to the top of the railing. This measurement was entered into a calculation in Excel which calculated the draft of the transducer head. The daily draft measurements were entered into CARIS. *(Appendix U)*

Nooit Volmaakt

Static draft was measured twice daily using a weighted measuring tape that was

lowered to the water on the port and starboard side of the vessel. The variations in these measurements were determined to be insignificant for survey purposes.

Dynamic draft was not monitored for Nooit Volmaakt as this vessel was not acquiring multibeam data.

System Alignment and Calibrations

System Alignment and calibration procedures are fully documented in Appendix V, the Multibeam Calibration Procedures & Patch Test Report. There are two reports, one for each Multibeam sonar system used for this cruise. The calculated patch test values for latency, roll, pitch and yaw were entered into the vessel configuration files.

Tide Corrections

Tide correctors came from observed tides at NOAA's Seattle tide station 9447130. There are two tidal zoning areas within the survey area. Tidal zoning area PS 146 is referenced to the Seattle tide station with a time corrector of +6 minutes and a range corrector of X 1.01. Tidal zoning area PS 147 is also referenced to the Seattle tide station with time corrector of +6 minutes and a range corrector of X 1.03. The time and range correctors were entered into CARIS along with the verified tides from the Seattle tide station.

Software	Version Number
SonarWiz.MAP	V4.04.0015
QINSy	8.00.2008.11.21.1
CARIS	Service Pack 2
SIS	3.5.0
Valeport Data Log Express	0400/7115/D2
SEATERM	1.59
Hypack	2008 SP1
Hysweep	2008 SP1

KMI Leasing Co., LLC

Defender Class

KMI Leasing offers four state-of-the-art,
all-aluminum catamarans for *Lease* or *Charter*

469 NW Bowdoin Place • Seattle, WA 98107
Phone: (206) 353-7441 • E-mail: garyb@kvichak.com

KMI LEASING CO., LLC ● 469 NW BOWDOIN PLACE ● SEATTLE, WA 98107

DEFENDER CLASS

Fast-response, versatile catamarans for a wide range of applications

▪ Research ▪ Security
▪ Dive ▪ Crew Assist
▪ ROV & AUV
▪ Sonar
(side-scan, towed, pole-mounted)

SPECIFICATIONS

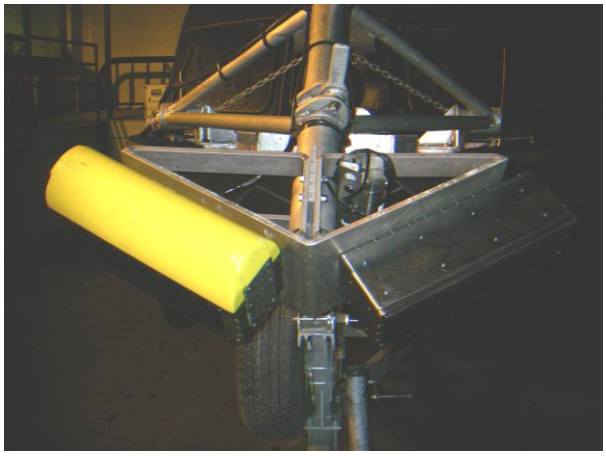
54' Length x 20' Beam	***Twin Caterpillar 3196 engines***
300 gal. fresh water capacity	***Crew accommodations for six***
1200 gallon fuel capacity	***Top speed ~30 knots***
A-Frame & Davit	***Full Galley***

For additional information & rates contact:
Gary Buholm
Phone: (206) 353-7441
garyb@kvichak.com

Manufacturer:	Hewescraft
Model:	220OP HT
Length:	24’3”
Beam:	102”
Side Height:	35”
Person/Weight Capacity:	10/1425 lbs
Max Weight Capacity:	2476
Fuel Capacity:	52 Gallons
Year:	2008
Motor:	Yamaha Outboard F200TXR
Motor:	Yamaha Outboard 8hp High Thrust
Batteries:	Dual 12vdc
Inverter:	12vdc to 120vac 800 Watts
Electro Mechanical Trim Tabs:	
GPS/Echosounder/Chartplotter:	Humminbird 997c SI Combo (sidescan)
Radar:	Furuno
Radio:	Marine VHF

Appendix D
Survey Vessels

Survey Vessel # 1 – Tetra Tech R/V Storm



Dual SeaBat MBE installed on TtEC Jet Boat

Laser Scanner installed on TtEC Jet Boat

Vessel Specifications

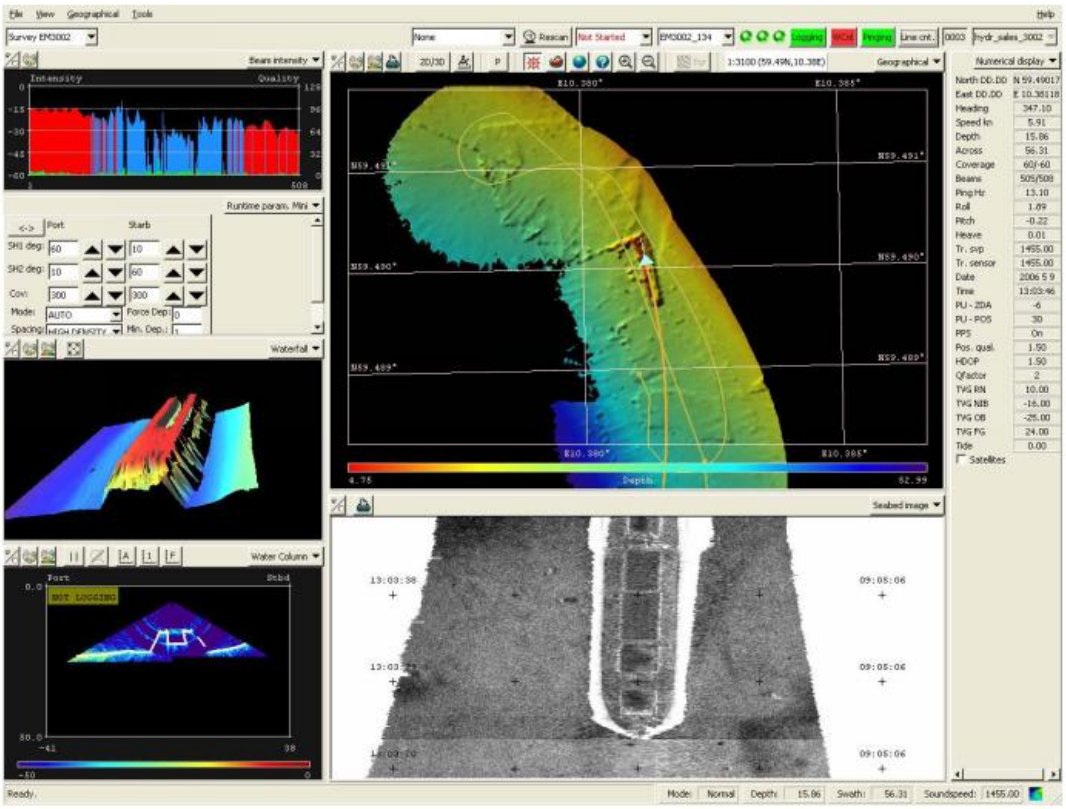
Hull Construction: Welded Aluminum
Overall Length: 21 ft.
Beam: 8.0 ft.
Draft: ~1.5 ft.
Gross Tons: 1.5
Electrical Generation: Honda 3000 Watt, 2000 watt Trace Inverter
Safety Equipment: All required U.S. Coast Guard equipment.
Bridge Equipment: DGPS, RTK GPS, Ross Hypack Control, VHF, kicker TR-1 autopilot
Survey Facilities: Equipment rack with operator stations
Transducer Mounts: RESON 8101/8125/7125/C3D, customized as needed
Hull Mounted Transducers: As required

EM 3002

KONGSBERG

Multibeam echo sounder

The new generation high performance shallow water multibeam



System description

Key facts

The **EM 3002** is a new advanced multibeam echo sounder with extremely high resolution and dynamically focused beams. It is very well suited for detailed seafloor mapping and inspection with water depths from less than 1 meter up to typically 200 meters in cold oceanic conditions. Maximum depth capability is strongly dependant on water temperature and salinity - up to 300 meters is possible under favorable conditions. Due to its electronic pitch compensation system and roll stabilized beams, the system performance is stable also in foul weather conditions.

The spacing between soundings as well as the acoustic footprints can be set nearly constant over the swath in order to provide a uniform and high detection and mapping performance. Dynamic focusing of all receive beams optimizes the system performance and resolution for short range applications such as underwater inspections.

Typical applications

- Mapping of harbours, inland waterways and shipping channels with critical keel clearance
- Inspection of underwater infrastructure
- Detection and mapping of debris and other underwater objects
- Detailed surveys related to underwater construction work or dredging
- Environmental seabed and habitat mapping
- Mapping of biomass in the water column

Features

The EM 3002 system uses frequencies in the 300 kHz band. This is an ideal frequency for shallow water applications, as the high frequency ensures narrow beams with small physical dimensions. At the same time, 300 kHz secures a high maximum range capability and robustness under conditions with high contents of particles in the water.

EM 3002 uses a powerful sonar processor unit in combination with 1 or 2 compact sonar heads. The high computing power of the EM 3002 sonar processor makes it possible to apply sophisticated and exact signal processing algorithms for beamforming, beam stabilisation, and bottom detection. In High Density processing mode the system has close to uniform acoustic footprints and resolution over the whole swath width, and therefore a much improved capability to detect objects and other details on the bottom.

EM 3002 will in addition to bathymetric soundings, produce an acoustic image of the seabed. The image is obtained by combining the acoustic return signals inside each beam, thus improving signal to noise ratio considerably, as well as eliminating several artifacts related to conventional sidescan sonars. The acoustic image is compensated for the transmission source level, receiver sensitivity and signal attenuation in the water column, so that reliable bottom backscatter levels in dB are obtained. The image is also compensated for acoustic ray bending, and thus completely geo-referenced, so that preparation of a sonar mosaic for a survey area based upon data from several survey lines is easy. Objects observed on the seabed image are correctly located and their positions can be readily derived.

List of options

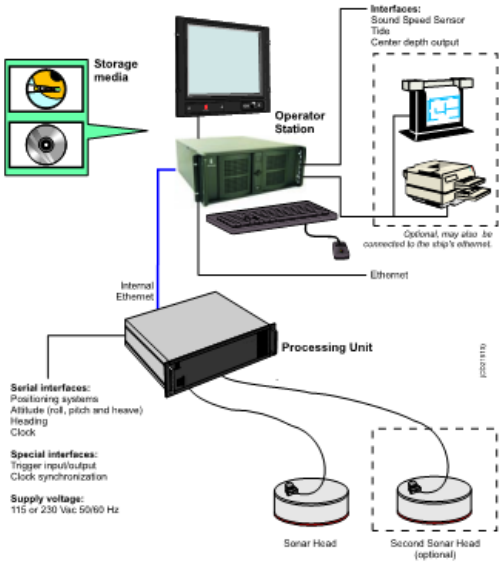
- Dual sonar heads - EM 3002D
- Logging of water column data
- Software for Automatic Calibration
- CUBE terrain modeling SW
- Extended depth raiting for transducer(s): 1500 m
- Extended length of transducer cable: 30 or 45 m
- Bracket for portable mounting of sonar head(s)
- Flight case for safe transportation of 1 sonar head w/cable
- Flight case for processing unit and operators workstation

- Full swath width accuracy to the latest IHO standard
- Swath width up to 10 x water depth (EM 3002D) or 200 m (cold oceanic water)
- Depth range from < 1 meter to > 200 meters
- Bottom detection by phase or amplitude
- 100% bottom coverage even at more than 10 knots vessel speed
- Real-time ray bending and attitude compensation
- Seabed image (sidescan) data output
- Sonar heads for 500 or 1500 meters depth rating
- Water column data display window + logging (optional)

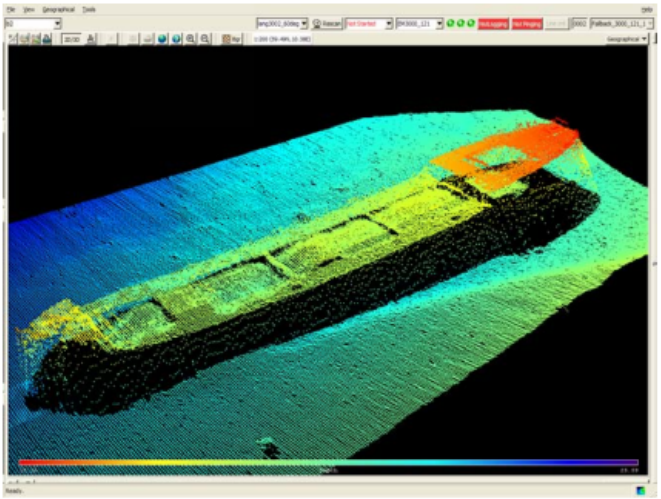
Operator Station

The Operator Station is a rugged zed PC workstation running on either Linux® or Microsoft Windows XP®. The Operator Station software, SIS, has extensive functionality such as 3D graphics, real-time data cleaning and electronic map background.

The EM 3002 can be set up to use other operational software than SIS, for example "QINCy®" or Costal Oceanographics "HYPACK® Max", and is also supported by software from Triton Elics International, EIVA and others.



Typical system configuration with desktop Operator Station, Processing Unit and one or two Sonar Heads.



The image of a sunken wreck at 20 m depth.

Note that Kongsberg Maritime AS does not take any responsibility for system malfunction caused by third-party software.

Advanced functions

- Bottom detection uses a combination of amplitude and phase processing in order to provide a high sounding accuracy over the whole swath width.
- All beams are stabilized for pitch and roll movements of the survey vessel, by electronically steering the transmit beam as well as the receive beams.
- Dynamic focusing of the receive beams is applied in order to obtain improved resolution inside the acoustic near-field of the transducer.
- Swath coverage with one sonar head reaches 130 degrees, but can be manually limited while still maintaining all beams inside the active swath. For deeper waters the swath width will be reduced due to reduced signal-to-noise margin. The system will automatically re-locate all beams to be within the active swath.
- With two sonar heads the swath width will reach 200 degrees to allow for inspection of constructions up to the water surface, as well as for efficient mapping of beaches, rivers and canals. On a flat shallow seabed the swath-width can be about 10 x depth.
- Operator controlled equidistant or equiangular beam spacing.

Technical specifications

Operational specifications

Frequencies ..... 293, 300, 307 kHz
Number of soundings per ping:
- Single sonar head ..... Max 254
- Dual sonar heads ..... Max 508

Maximum ping rate ..... 40 Hz
Maximum angular coverage:
- Single sonar head ..... 130 degrees
- Dual sonar heads ..... 200 degrees

Pitch stabilisation ..... Yes
Roll stabilisation ..... Yes
Heave compensation ..... Yes
Pulse length ..... 150 µs
Range sampling rate ..... 14, 14.3, 14.6 kHz
Depth resolution ..... 1 cm
Transducer geometry ..... Mills cross
Beam spacing ..... Equidistant or equiangular
Beamforming:
- Time delay with shading
- Dynamically focused receive beams

Seabed image data

- Composed from beamformed signal amplitudes
- Range resolution 5 cm.
- Compensated for source level and receiver sensitivity, as well as attenuation and spherical spreading in the water column.
- Amplitude resolution: 0.5 dB.

External sensors

- Position
- Heading
- Motion sensor (Pitch, roll and heave)
- Sound velocity profile
- Sound velocity at transducer.
- Clock synchronisation (1 PPS)

Environmental and EMC specifications

The system meets all requirements of the IACS E10 specification.The Operator Station, LCD monitor and Processing Unit are all IP22 rated.

Dimensions and weights

Sonar head:
- Shape ..... Cylindrical
- Housing material ..... Titanium
- Diameter ..... 332 mm
- Height ..... 119 mm
- Weight ..... 25 kg in air, 15 kg in water
- Pressure rating ..... 500 m (1500 m option)
- transducer cable length ..... 15 m

Sonar Processing Unit:
- Width ..... 427 mm
- Depth ..... 392 mm
- Height ..... 177 mm
- Weight ..... 14.5 kg

Operator Station:
- Width ..... 427 mm
- Depth ..... 480 mm
- Height ..... 127 mm
- Weight ..... 20 kg

19" industrial LCD monitor:
- Width 483mm
- Depth ..... 68 mm
- Height ..... 444 mm
- Weight ..... 12 kg
- Resolution ..... 1280 x 1024 pixels

All surface units are rack mountable. Dimensions exclude handles and brackets.

Kongsberg Maritime AS
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P.O.Box 111
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Norway

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Telefax: +47 33 04 47 53
www.kongsberg.com
E-mail: subsea@kongsberg.com

KONGSBERG

TELEDYNE BENTHOS GEOPHYSICAL

C3D-LPM
SONAR IMAGING SYSTEM

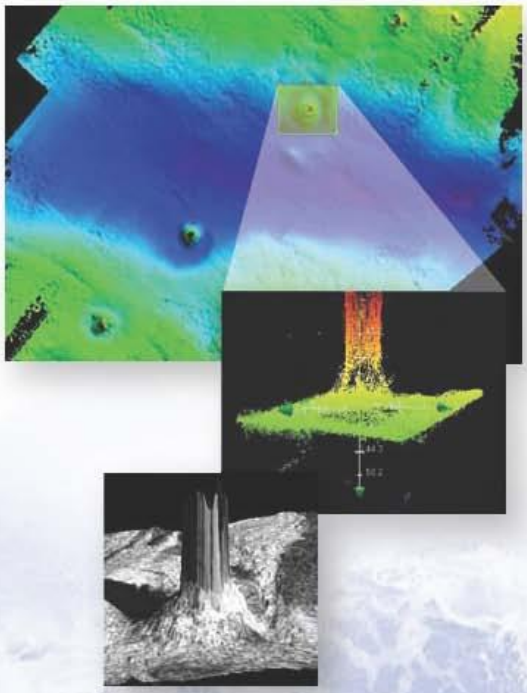
Lightweight pole mount for small vessel, shallow water applications

C3D-LPM Transceiver

The C3D-LPM transceiver houses the DSP, power supply and all the circuitry necessary for signal processing. The transceiver module interfaces to a standard PC (either supplied by Teledyne Benthos or customer supplied) via Ethernet. The DSP runs on 110/220 VAC power auto sensing.

C3D-PC All-in-One Computer

The C3D-PC is an all-in-one computer installed with third party acquisition software to display and store C3D data. The small footprint allows for easy installation on most small vessels. The PC operates on 110/220 VAC auto sensing.



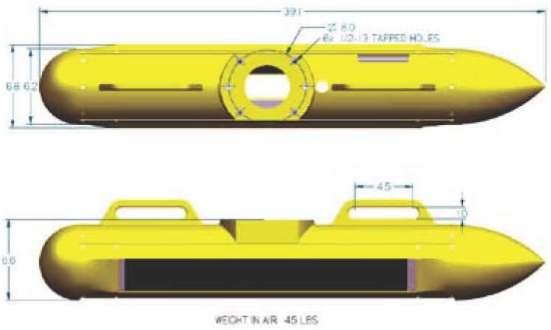
INNOVATIVE UNDERSEA SYSTEMS TECHNOLOGY

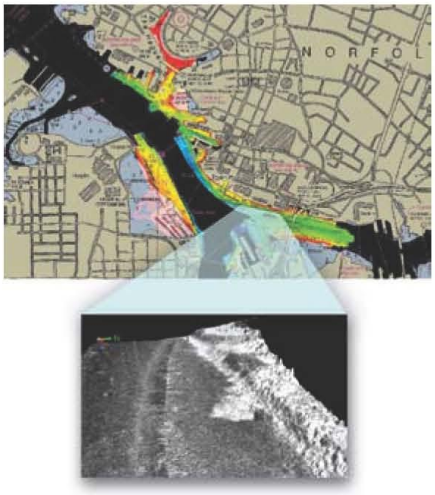
TELEDYNE BENTHOS
A Teledyne Technologies Company

C3D-LPM Sonar Imaging System

System Specifications

C3D System	
Sonar Frequency:	*200 kHz*
Side Scan Range:	*25 to 300 meters per side*
Bathymetric Range:	*10 to 12 times water depth*
Resolution (across track)	
Side Scan Sonar:	*4.5 cm*
Bathymetry:	*5.5 cm*
Beam Width:	*1 degree (one-way)*
Pulse Length:	*25 usec to 1 msec (depending on range)*
Repetition Rate:	*Up to 30 pings/sec*
Depression Angle:	*20, 30, 40 degrees*
Transmit Source Level:	*Max. 224dB re: 1uPa@1M*
C3D-LPM	
Construction:	*Stainless steel imbedded in glass filled polyurethane*
Length:	*99.3 cm (39.1 inches)*
Diameter:	*17.3 cm (6.8 inches)*
Weight (in air):	*20.4 kg (45 lbs)*
C3D-LPM Transceiver	
Topside Interface	
Power Supply:	*Input 110/220 VAC auto sensing*
Network interface:	*Ethernet*
Dimensions:	*2U Rack mount 48.3 cm (19 inches)*
Weight:	*9.5 kg (21 lbs)*
Transducer Cables:	*10 meters standard*
C3D-PC	
Operating System:	*Windows XP*
Processor:	*Pentium processor*
Storage:	*Large capacity hard drive, writable CD/DVD*
Network Interface:	*100base T Ethernet (compatible with ADSL high-speed communications interface)*
Serial:	*RS232*
Display Monitor:	*17" flat panel (built into processor)*





TELEDYNE BENTHOS
A Teledyne Technologies Company
www.benthos.com

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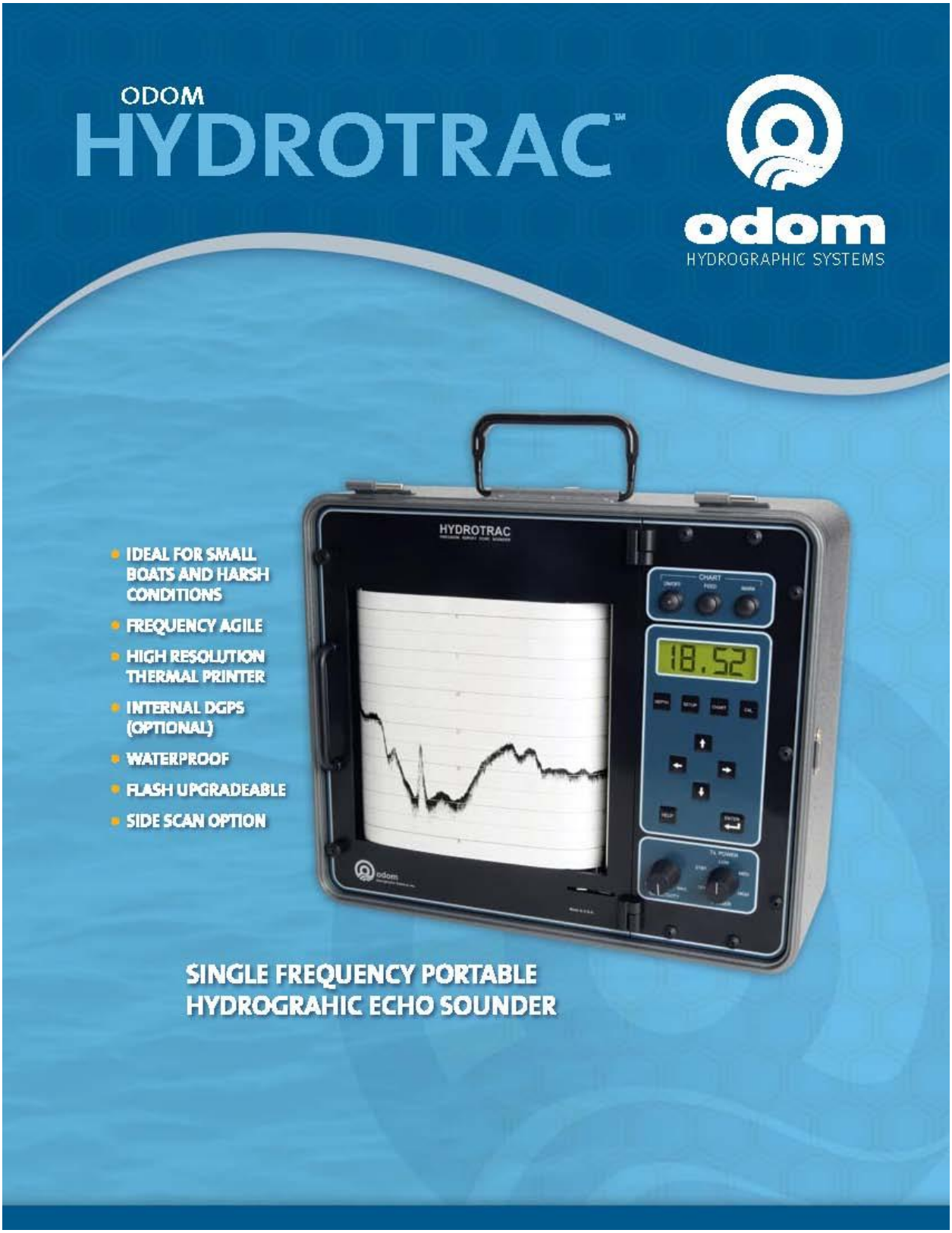
49 Edgerton Drive, North Falmouth, MA 02556 USA
Tel 508-563-1000 • Fax 508-563-6444 • E-mail: benthos@teledyne.com


ODOM
HYDROTRAC™
odom
HYDROGRAPHIC SYSTEMS
IDEAL FOR SMALL BOATS AND HARSH CONDITIONS
FREQUENCY AGILE
HIGH RESOLUTION THERMAL PRINTER
INTERNAL DGPS (OPTIONAL)
WATERPROOF
FLASH UPGRADEABLE
SIDE SCAN OPTION
HYDROTRAC
18.52
SINGLE FREQUENCY PORTABLE
HYDROGRAHIC ECHO SOUNDER

ODOM HYDROTRAC™

Specifically designed for work in less-than-ideal circumstances on small survey boats and inflatable watercraft, the **Hydrotrac**™ offers compact portability and the confidence of knowing you're using an Odom product. It is completely waterproof and comes equipped with the same advanced features you've come to trust and depend on in Odom echo sounders.

Buy Odom – invest in your peace of mind.

SPECIFICATIONS

Environmental Operating Conditions:
- 0 – 50 C

Frequency Agile
- Operator selectable – 24, 33, 40, 200, 210 and 340 kHz

Output Power
- 600 watts

Power Requirement
- 11-28 V DC (standard)
- 110/220 V AC (optional)

Communication
- 2 RS232 or RS422 ports

Depth Range
- MAX = 600 m/1968 ft

Resolution
- 0.1 ft/0.01 m

Accuracy
- 8.5 in/216 mm thermal printer (fax paper)
- LCD display (1 in high)
- Sealed keypad controls

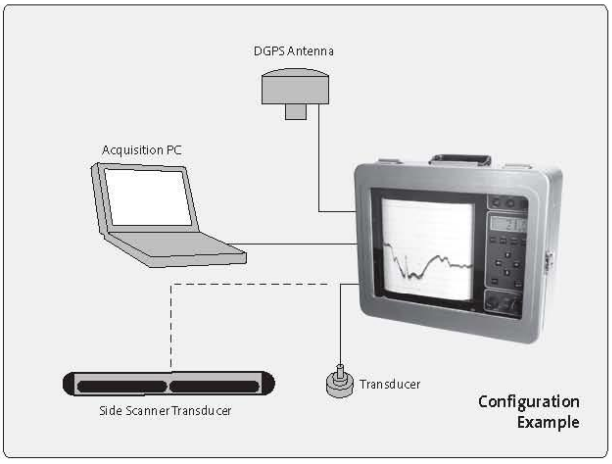
Weight
- (24.8 lbs/11.25 kg)

Dimensions
- (14.5 h x 16.5 w x 8 d in or 36.83 h x 41.91 w x 20.32 d cm)

Controls
- Sensitivity
- Chart on/off and advance
- Event mark (internal selectable timer)
- Transmit power (high/med/low)

Touch Pad Settings
- Draft, velocity and tide inputs
- Time and date
- Scale width and center
- Blanking
- Calibration gate
- Alarm filter
- Fix interval
- Chart speed
- HELP function (prints on chart)
- Current parameters (prints on chart)

Features
- Manual/remote mark command
- Auto scale change (phasing)
- GPS input
- Heave input from motion sensor
- Annotation printed on chart
- Auto pulse length, TVG
- Output: NMEA, ECHOTRAC, DESO 25, etc.
- Waterproof (with cover in place)
- Accuracy: 200 kHz – 1 cm 0.1% of depth value (corrected for sound velocity); 33 kHz – 10 cm 0.1% of depth value (corrected for sound velocity)
- Fix mark annotation: date, time, fix no., depth (and GPS if input)
- Optional 200 kHz or 340 kHz side scan transducer
- Optional built-in DGPS
- Optional remote display
- Flash memory upgradeable
- Built-in simulator
- Software included: Comlog
- Operation and installation manuals provided on CD



Configuration Example

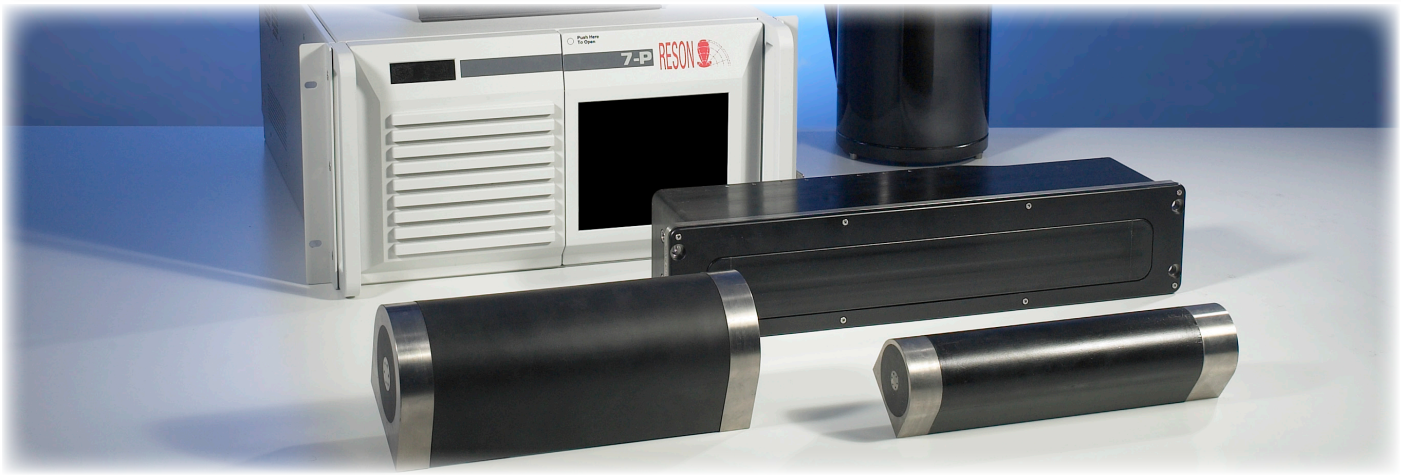
odom
HYDROGRAPHIC SYSTEMS

1450 Seaboard Avenue
Baton Rouge, Louisiana 70810-6261 USA
E-mail: email@odomhydrographic.com
www.odomhydrographic.com

ODOM HYDROGRAPHIC SYSTEMS, INC. (225) 769-3051 · (225) 766-5122 FAX

SeaBat 7125

HIGH-RESOLUTION MULTIBEAM ECHOSOUNDER SYSTEM



SeaBat 7125

- 512 beams and equi-distant footprints providing extremely high density and maximizing swath width
- Real-time roll stabilisation maximizing usable swath
- Dual frequency provides seamless coverage from 0.5 to 500m depth
- Compliance with IHO SP44Ed5 over entire depth range
- Advanced diagnostics
- High ping rate allows high-speed operations without compromising data density

The new generation SeaBat 7125 builds on the field experience and feedback from many users around the world and brings unparalleled resolution and installation flexibility. The system is available in three separate configurations; one designed specifically for installation on small survey vessels and a 6000m depth rated system for either ROV or AUV use.

Each of these configurations utilise the same transducer set and provide identical high performance, superlative data quality, features and ease of use over depths from 0.5m to 500m.

Special emphasis has been put on maximizing operational efficiency and features such as variable swath width and roll stabilisation combined with a high ping rate and excellent data quality .

Surface Vessel installation

The new SeaBat 7125-SV is a highly integrated single or dual frequency system designed with ease of installation and operation as a high priority. The system consists of a surface transceiver with integrated multiport card and a standard 25m cable run to the transducers. The transceiver hardware is suitable for running data acquisition software and is available with RESON PDS2000 software pre-installed and configured.

ROV

For deep-water use the ROV version of the SeaBat 7125 has a 6000m depth rating and includes a 6000m rated titanium interface bottle. The system performance and feature set is identical to the other members of the 7125 family thus providing commonality and ease of use.

AUV

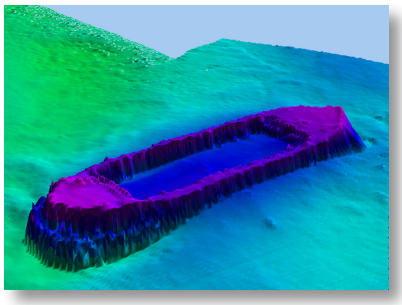
The AUV version of the 7125 provides on-board data processing and logging as well as interface to third party sensors. The electronics are supplied mounted on an aluminium frame for ease of integration and an optional 6000m depth-rated titanium electronics housing is available. The 7125-AUV provides high quality data and performance commensurate with the other versions of the 7125.

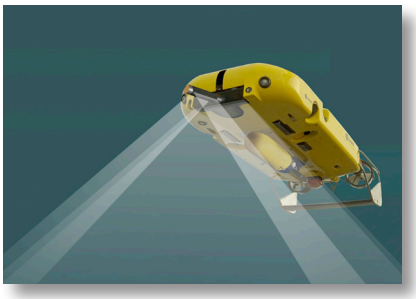
SeaBat 7125

HIGH-RESOLUTION MULTIBEAM ECHOSOUNDER SYSTEM

OPTIONS

- Mounting Bracket with Faring
- SVP-70 sound velocity Profiler with 25m Cable
- Extended Warranty / Support & Maintenance Contracts
- Fiber-Optic Conversion for ROV Installations
- Full Calibration (calibrated backscatter) (includes 1 TB external RAID)
- System Integration & Training





SYSTEM CHARACTERISTICS

* EA= Equi-angle / ED= Equi-distant	7125 SV	7125 ROV	7125 AUV
Frequency	200 or 400 kHz (dual freq. available)		
Along-track transmit beamwidth	2.2° (± 0.5°) at 200 kHz / 1° (± 0.2°) at 400 kHz		
Across-track receive beamwidth	1.1° (± 0.05°) at 200 kHz / 0.54° (± 0.03°) at 400 kHz		
Max ping rate	50 Hz (± 1 Hz)		
Puls length	50 µsec to 300 µsec		
Number of beams	256EA*/256ED* at 200kHz 256EA*, 512EA*, 512ED* at 400kHz		
Max Swath angle	128°		
Depth resolution	6mm		
Data output	Bathymetry, sidescan & snippets 7K data format Gbit Ethernet		
Power requirement	110/220 VAC 50/60 Hz 1700W max	48V DC(±10%) 110W max	48V DC (±10%) 200W max
Transducer cable length	25m standard 50m optional 10m optional	3m standard 10m optional	3m standard 10m optional
LCU to processor cable length	N/A	25m standard 6m optional 5m pigtail	N/A
System depth rating	50m	6000m	6000m optional
Temperature operating	0° to +40° C		
Temperature storage	-30° to +55° C		

COMPONENT

	7125 SV	7125 ROV	7125 AUV
EM 7200 Receiver	✓	✓	✓
TC2160 400kHz Projector	✓	✓	✓
TC2163 200 kHz projector (optional)	✓	✓	✓
7-L Link Control Unit	×	✓	×
7-P sonar Processor Unit with monitor, Keyboard and Pointer Device	×	✓	×
SV Transceiver with monitor, Keyboard and Pointer Device	✓	×	×
7-I Integrated Control & Processor Unit	×	×	✓
Standard Cable Set	✓	✓	✓
Shipping cases, manuals & accessories	✓	✓	✓

WEIGHT & DIMENSIONS

Component	TC2160 400 kHz projector	TC2163 200 kHz projector	EM7200 200/400 kHz-receiver	Surface transceiver	LCU bottle	ICPU frame	7-P processor
Height (mm)	77	115	102	5U	530	172	5U
Width (mm)	62	100	495	19”	Ø174	166	19”
Depth (mm)	285	280	131	557	N/A	497	630
Weight-kg/air	2.75	7.5	10.6	20	15.7	10	30
Weight-kg/water	1.75	5	5.5	N/A	5.2	N/A	N/A

For Acoustical Measurement Accuracy please refer to www.reson.com or contact sales.

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E-mail: info@reson.nl

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Tel: +65 6725 9851
E-mail: sales@reson.com

www.reson.com

Version: B066 090121 / A4

Ethernet
Bluetooth
Wi-Fi

OCTANS

SURFACE GYROCOMPASS AND MOTION SENSOR

OCTANS, with Ethernet output, is an IMO certified survey grade gyrocompass and complete motion sensor. It is based on IXSEA's FOG technology, which outputs true heading, roll, pitch, surge, sway, heave, speed, acceleration and rate of turn.

FEATURES

- Complete gyrocompass and motion sensor
- Fiber Optic Gyroscope (FOG), unique strap-down technology
- Ethernet, Bluetooth, Wi-Fi
- IMO Certification
- Small, portable plug and play system

BENEFITS

- High-performance real-time outputs of true heading, roll, pitch SAFE HEAVE™, surge, sway as well as acceleration and rate of turn
- No spinning element hence maintenance free
- Wireless network ready
- Pre-approved international quality and safety standard
- Saves valuable time

APPLICATIONS • Multibeam hydrographic survey • AUV • DP vessels • Dredging • Emergency gyro for submarines • Main AHRS for navigation and dynamic monitoring

OCTANS

TECHNICAL SPECIFICATIONS

IMO Certified
N° 09807/B0 EC

PERFORMANCE

Heading	
Accuracy	0.1 deg secant latitude [1] [2]
Resolution	0.01 deg
Settling time (static conditions)	< 1 min
Full accuracy settling time (all conditions)	< 5 min
Heave / Surge / Sway	
Accuracy	5 cm or 5% (whichever is highest) Set-up free (SAFE-HEAVE ™)
Roll / Pitch	
Dynamic accuracy	0.01 deg (for ±90 deg amplitude)[2]
Range	No limitation (-180 deg to 180 deg)
Resolution	0.001 deg

OPERATING RANGE / ENVIRONMENT

Vibrations	1 g sine (5 to 50 Hz)
Follow-up speed	Up to 750 deg/s
Shocks Operating / Survival	30 g 6 ms / 50 g 11 ms
MTBF	30,000 hours
Operating / Storage Temperature	-40 °C to +60 °C / +80 °C
No warm-up effects	
No latitude or speed limitation	

PHYSICAL CHARACTERISTICS

Dimensions (L x W x H)	280 x 136 x 150 mm
Weight in air	4.6 Kg
Water proof	IP66
Material	Aluminium
Mounting / Connectors	3 off M6 Holes / Souriau military
Inputs	Ethernet / 2 serial / 4 pulses
Outputs	Ethernet / 3 serial / 2 pulses Wi-Fi / Bluetooth

INTERFACES

Output protocols	Industry standards: NMEA 0183, binary
Serial I/O	RS232 or RS422 (user specific)
Baud rates	600 bauds to 115 kbauds
Output frequency	0.1 Hz to 200 Hz
Ethernet	UDP / TCP Client / TCP serveur
Data time stamping accuracy	< 100 microseconds
Power supply / consumption	24 VDC / 18 W

(1) Secant latitude = 1 / cosine latitude
(2) RMS value

Specifications subject to change without notice

IXSEA : • EMEA : +33 (0)1 30 08 98 88 • AMERICAS : +1 (781) 937 8800 • ASIA : +65 6747 4912 • www.ixsea.com

2006-05-PS-OCTSUR

Trimble DSM132 DGPS Receiver

Combined MSK, WAAS/EGNOS, and satellite L-band DGPS receiver for ports, harbors, and inland waterways

The Trimble® DSM™132 DGPS receiver is an ideal solution for surveying and dredging in ports, harbors and inland waterways.

The DSM132 is a high-performance submeter GPS receiver that houses an MSK beacon and satellite differential correction receiver. It uses free public differential corrections from sources such as MSK beacons or WAAS/EGNOS. Alternatively the DSM132 can use subscription-based private differential correction services. Using these corrections, the DSM132 calculates submeter positions in real time.

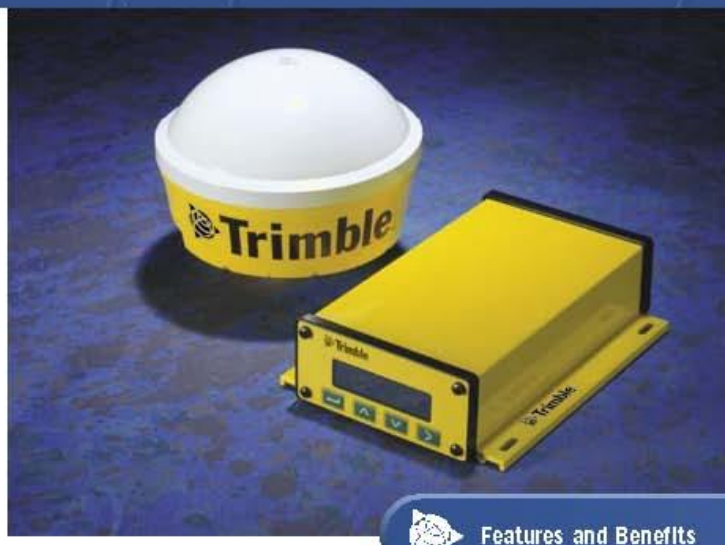
Wide area coverage

The MSK beacon receiver provides superior weak-signal performance, allowing differential corrections to be received at long distances from the reference station and during challenging weather conditions. The dual-channel capability allows for intelligent and seamless switching between beacons.

The L-band satellite differential correction receiver requires a subscription to a differential correction service and provides multiple vendor support. The receiver ensures the satellite corrections to be uniformly accurate over the entire satellite coverage area without the degradation in accuracy associated with increasing distance from fixed reference stations.

The DSM132 accepts RTCM SC-104 differential corrections from an external source through a serial interface.

The Trimble EVEREST™ technology improves results in high multipath environments and locations where other radio frequencies could jam the GPS signals such as harbors and construction sites.



Features and Benefits

- Easy to set up and install
- Beacon, L-band, WAAS/ EGNOS or external corrections
- Built-in display and keyboard
- High position output rate with low latency
- Optional reference station output

Superior Integration

The DSM132 receiver is designed for easy setup and installation with a built-in display and keyboard. The source and status of DGPS corrections can easily be determined from the built-in differential correction receivers, or from an external differential correction source.

The DSM132 is easy to connect with other onboard equipment such as integrated navigation systems, radars, autopilots, and plotters. Through one of the two serial ports, these receivers output standard NMEA-0183 messages, including position, velocity, and status information. The DSM132 receiver outputs position reports at up to 10 Hz. The second serial port is for setup, control, and data output using Trimble Standard Interface Protocol (TSIP). For easy setup, the Windows based Trimble TSIP Talker™ software is included with the DSM132. The receivers also feature a 1 PPS output available on either serial port and offer a differential speed accuracy of better than 0.1 Knot.

Reference Station

The DSM132RS is a cost effective solution for providing high quality DGPS corrections. The corrections are generated in the standard RTCM SC-104 format for broadcast in situations where there is no MSK beacon signals, or L-band corrections are not suitable.

The DSM132 receiver is a high-quality solution for applications that require submeter positioning in demanding environments.

Trimble.

Trimble DSM132 DGPS Receiver

Combined MSK, WAAS/EGNOS, and satellite L-band DGPS receiver for ports, harbors, and inland waterways

Standard Features

- 12-channel GPS receiver
- L-Band satellite differential correction receiver[1]
- Dual-channel digital medium frequency beacon reciever
- WAAS (U.S.A.) and EGNOS (Europe) capable[2]
- Sub-meter differential accuracy
- EVEREST Multipath Rejection (standard in receivers with version 1.73 firmware or greater)
- 2 line, 16 character liquid crystal display
- 4 button keyboard
- Combined L1 GPS, Satellite differential, and beacon antenna
- Two programmable RS-232 serial ports:
  - NMEA-0183 output/RTCM SC-104 input
  - TSIP I/O
- 1, 2, 5, and 10 Hz output messages
- Operation manual and utilities on CD
- 15 m antenna cable
- GPS reciever to PC cable
- Magnetic mount for antenna
- 1 PPS output

Physical Characteristics

DSM132

Size	14.5 cm wide × 5.1 cm high × 19.5 cm deep (5.7 in × 2.0 in × 7.7 in)
Weight	0.76 kg (1.68 lb)
Power	7 W (max.), 10 to 32 VDC
Operating temperature	-20 °C to +65 °C (-4 °F to +149 °F)
Storage temperature	-30 °C to +85 °C (-22 °F to +185 °F)
Humidity	100% condensing, unit fully sealed

Combined Antenna

Size	15.5 cm deep × 14 cm high (6.1 in × 5.5 in)
Weight	0.55 kg (1.2 lb)
Operating temperature	-30 °C to +65 °C (-22 °F to +149 °F)
Humidity	100% condensing, unit fully sealed
Casing	Dust proof, waterproof, shock resistant

Options

- Reference station (RTCM output)
- DSM132RS-DSM132RS receiver with 30 m antenna cable, L1 Geodetic antenna
- Trimble offers a range of radio options for users who do not wish to use MSK beacon or L band corrections

Performance Characteristics

GPS Receiver

General	12-channel, parallel tracking, L1 C/A code with carrier phase filtered measurements and multi-bit digitizer
Update rate	1, 2, 5 and 10 Hz
Differential speed	0.1 kn (0.1 MPH, 0.16 km/h, 5.6 cm/sec) accuracy
Differential position	Less than 1 m horizontal RMS accuracy (At least 5 satellites, PDOP <4 and RTCM SC-104 standard format broadcast from a Trimble reference station or equivalent reference station.)
Time to first fix	<30 sec, typical
NMEA messages	GGA, GLL, GRS, GSA, GST, GSV, MSS, RMC, VTG, XTE, ZDA and Trimble proprietary messages

MSK Beacon Dual-Channel Receiver

Frequency range	283.5 KHz to 325.0 KHz
Channel spacing	500 Hz
MSK modulation	50, 100 and 200 bits/sec
Signal strength	10 µV/meter minimum @ 100 BPS
Dynamic range	100 dB
Beacon acquisition	<5 sec, typical time
Operating modes	Auto Power, Auto Distance, and Manual modes

L-band Satellite Differential Correction Receiver with Multiple Vendor Support

Bit error band	10^{-5} for Eb/N of >5.5 dB
Acquisition and re-acquisition time	<2 sec, typical
Frequency band	1525-1560 MHz
Channel spacing	5 kHz

Ordering Information

For further information please contact your local Trimble office or representative. You may also visit our website at http://www.trimble.com.

1 For the DSM132 to operate with the L-band corrections the client must subscribe to a satellite differential service. Contact L band suppliers such as Omnistar or Thales to check L band availability in your area.

2 Contact your local Trimble office or representative to check for 'free to air' Satellite Based Augmentation Service (SBAS) availability in your area.

YOUR LOCAL TRIMBLE OFFICE OR REPRESENTATIVE

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+65-6348-2212 Phone • +65-6348-2232 Fax

www.trimble.com

Trimble.

POS MV™ WaveMaster

Providing the Marine Industry with robust, reliable, and repeatable position and orientation solutions in all dynamics

POSMV WaveMaster

POSMV WaveMaster RM

SYSTEM COMPONENTS

POS Computer System (PCS)
A rugged, compact computer system contains the core POS processor and IMU interface electronics, plus two GPS receivers. The PCS provides all motion variables and timing data at high rate and/or provides motion compensation and georeferenceing data to all multibeam systems.

POS Inertial Measurement Unit
The system's primary sensor is a Ring Laser Gyro (RLG) manufactured by one of the world's experts in inertial technology. This high performance, low drift rate gyro ensures that the attitude data remains robust as the dynamics increase.

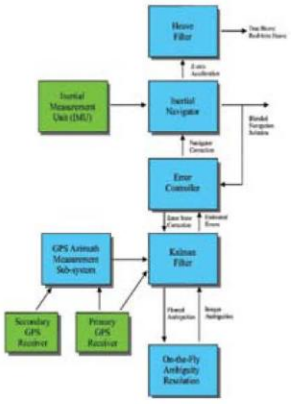
Primary and Secondary GPS Antennas
Dual frequency antennas for use with GAMS and RTK.

APPLANIX
A TRIMBLE COMPANY

Accurate Position and Orientation Solution
POS MV™ WaveMaster maintains positoning accuracy under the most demanding conditions. With its high data update rate, the system delivers a full six degree-of-freedom position and orientation solution to provide the following:

- Position (latitude, longitude and elevation)
- Velocity (north, east and vertical)
- Attitude (roll, pitch and true heading)
- Heave (real-time & delayed)
- Acceleration Vectors
- Angular Rate Vectors

The new POS MV™ WaveMaster generates a tightly-integrated solution for survey vessels, which means the system's Inertial Navigator will provide continuous positioning information while surveying in areas where GPS reception is compromised by multipath and signal loss. Raw GPS data from as few as one satellite can now be processed directly within the WaveMaster.



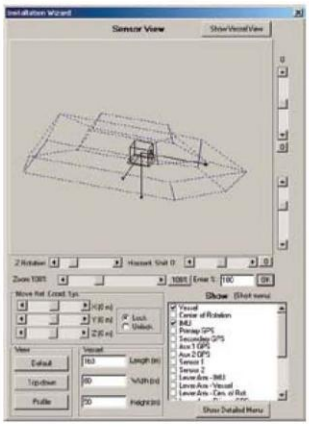
Tightly Coupled POS MV™ WaveMaster

Tightly-coupled integration offers the following advantages:

Advantage – Strengthens the system's ability to provide continuous, accurate data in areas with intermittent GPS reception
Advantage – Reduces position drift
Advantage – Enables almost instantaneous RTK re-acquisition (with internal RTK option)

WaveMaster Features and Benefits:

- Uses the latest GPS receiver technology from Trimble:
  - Maxwell™ chip technology
  - Everest™ multipath elimination technology
  - 10Hz raw observables for post-processing
  - Outstanding positioning performance and low elevation satellite tracking accuracy
- TrueHeave - Applanix's ground breaking delayed time heave processor
  - Removes processing artifacts but not real motion
  - Provides online quality measurement
- Faster CPU (700Mhz)
  - Low system loading allows for enhanced capabilities in the future
  - Runs at less than 10% of its total capacity to allow for upgrades and additional features
- TCP/IP protocol for raw data logging
  - Reliable logging of all raw data with microsecond-accurate time stamping
  - POSPac ready (for post-mission analysis)
- Firmware migration path
  - Access to new releases with new features as they become available
- New DC powered compact form-factor available
- New Graphical User Interface
  - Makes installation and setup intuitive
  - Reduces operator error



POS MV WaveMaster Graphical User Interface

POS MV™ WaveMaster

POS MV WAVEMASTER MAIN SPECIFICATIONS (with Differential Corrections)

Roll, Pitch accuracy:	0.03° (1 sigma with GPS or DGPS) 0.02° (1 sigma with RTK)
Heave Accuracy:	5 cm or 5% (whichever is greater) for periods of 20 seconds or less
Heading Accuracy:	0.06° (1 sigma) with 1 m antenna baseline, 0.03 (1 sigma) with 2 m baseline, 0.015 (1 sigma) with 4 m baseline
Position Accuracy:	0.5 - 2 m (1 sigma) depending on quality of differential corrections 0.02 - 0.10 m (RTK) with input from auxiliary RTK or optional internal RTK receiver
Velocity Accuracy:	0.05 m/s horizontal

POS MV WAVEMASTER DURING GPS OUTAGES

Roll, Pitch accuracy:	0.04° (1 sigma)
Heave accuracy:	5 cm or 5% (whichever is greater) for wave periods of 18s or less
Heading accuracy:	Drift less than 2° per hour
Position accuracy degradation:	3 m (1 sigma) for 30 s outages <10 m (1 sigma) for 60 s outages

PHYSICAL CHARACTERISTICS

Size POS MV WaveMaster

IMU	160mm x 160mm x 102mm
PCS	281mm x 165mm x 90mm
GPS Antenna (2)	187mm x 53mm

Size POS MV WaveMaster RM

IMU	160mm x 160mm x 102mm
PCS	432mm x 89mm x 356mm
GPS Antenna (2)	187mm x 53mm

Weight

	POS MV WaveMaster	POS MV WaveMaster RM
IMU	3.6kg	3.6kg
PCS	3.0kg	5.0kg
GPS Antenna	<0.5kg	<0.5kg

Power POS MV WaveMaster

IMU	Power provided by PCS
PCS	24vdc, 50 W (peak)
GPS Antenna	Power provided by PCS

Power POS MV WaveMaster RM

IMU	Power provided by PCS
PCS	110/230 Vac, 50/60 Hz, auto-switching 80 Watt
GPS Antenna	Power provided by PCS

ENVIRONMENTAL

Temperature Range (Operating)

IMU	-40 °C to +60 °C
PCS	-20 °C to +60 °C
GPS Antenna	-40 °C to +70 °C

Temperature Range (Storage)

IMU	-40 °C to +60 °C
PCS	-20 °C to +60 °C
GPS Antenna	-40 °C to +70 °C

Humidity

IMU	0-100% RH, Ingress Protection of 66
PCS	5-90% RH, non-condensing
GPS Antenna	0-100% RH

Ethernet (100 base-T)

Parameters	Time tag, status, position, attitude, heave, velocity, track and speed, dynamics, performance metrics, raw IMU data, raw GPS data
Display Port	Low rate (1 Hz) UDP protocol output
Control Port	TCP/IP input for system commands
Data Port 1	Real-time (up to 200 Hz) UDP protocol output
Data Port 2	Buffered TCP/IP protocol output for data logging to external device

Serial RS232 I/O

5 COM Ports	User assignable to: NMEA output (0-5), Binary output (0-5), Auxiliary GPS input (0-2), Base GPS correction input (0-2)

NMEA ASCII Output

Parameters	NMEA Standard ASCII messages: Position ($INGGA, $INGGK), Heading ($INHDT), Track and Speed ($INVTG), Statistics ($INGST), Attitude ($PASHR, $PRDID), Time and Date ($INZDA, $UTC).
Rate	Up to 50 Hz (user selectable)
Configuration	Output selections and rate individually configurable on each assigned com port.

High Rate Attitude Output

Parameters	User selectable binary messages: attitude, heading, speed
Rate	Up to 100 Hz (user selectable)
Configuration	Output selections and rate individually configurable on each assigned com port.

Auxiliary GPS Inputs

Parameter	NMEA Standard ASCII messages: $GPGGA, $GPGST, $GPGSA, $GPGSV. Uses Aux input with best quality.
Rate	1 Hz

Base GPS Correction Inputs

Parameter	RTCM 1, 9, 18, 19, CMR and CMR+ input formats accepted. Combined with raw GPS observables in tightly-coupled navigation solution.
Rate	1 Hz

Digital I/O

1PPS Output	1 pulse-per-second Time Sync output, normally high, active low pulse
Event Input (2)	Time mark of external events. TTL pulses > 1 msec width, rising or falling edge, max rate 200 Hz.

Applanix Marine Offices

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APPLANIX
A TRIMBLE COMPANY

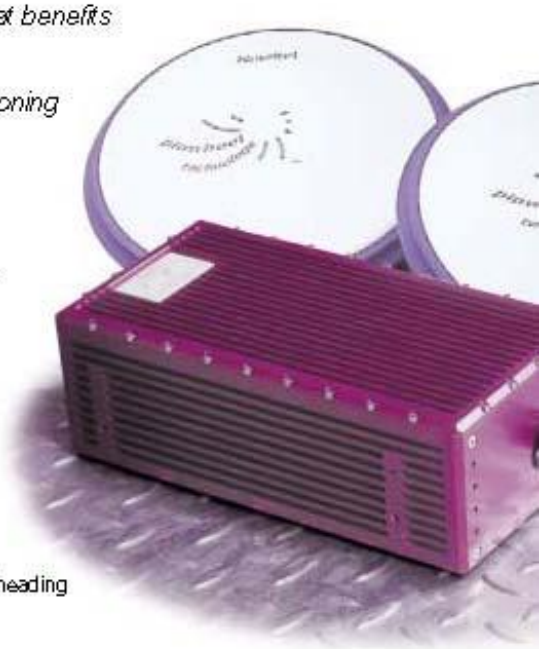

KEY APPLICATIONS:
Multibeam / Geophysical / single beam survey
Dynamic positioning
Platform stabilisation and motion measurement
F180
Attitude and Positioning System
Precise, reliable, dynamic attitude and positioning for the marine environment
• exportable
• affordable
• compatible
• available
• compact
• tried and tested
• supported
OCTOPUS
Leading GeoSurvey Solutions

F180 Attitude and

The Octopus F180 provides the user with highly accurate and reliable motion and position data, in a cost-effective solution that benefits from minimal export restrictions worldwide.

Delivering precise heave, roll, pitch, heading and positioning information in real time, it is a simple, easy-to-use 'plug and play' package.

The F180 is available in flexible 'wet pod', 'one box' or OEM configurations, depending upon your application.



'One box' 2.5kg dry-mounted Inertial Measurement Unit with Pinwheel Technology GPS antenn

FEATURES

- High accuracy GPS aided inertial navigation system
- Compatible with all leading multibeam sonars
- Plug and play with automatic alignment routine
- Sub 5 minute initialisation
- Zero data degradation and zero drift in all survey dynamics
- Available as one-box 2.5kg, wet pod or OEM package
- Remote location (lever-arm) output of heave, attitude, position and heading
- Optional processed heave output for long swell periods
- Unique WGS84 intelligent strapdown navigation module
- Accepts RTK and differential corrections as standard
- Standard data o/p formats
- Flexible ownership plans

'Wet pod' Inertial Measurement Unit with 19" rack interface for mounting with transducers.

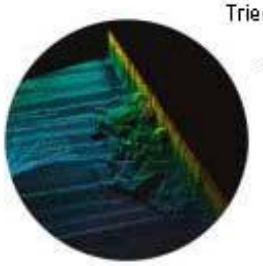
BENEFITS

- Easy to export worldwide – minimal restrictions
- Precise and reliable dynamic, attitude, heading and position
- Replaces standalone motion sensor, marine gyrocompass and GPS
- Lower cost of ownership
- Simple to operate – no precision alignment necessary
- Less weather down-time
- Greater survey productivity
- Premier 24/7 worldwide technical support

Positioning System

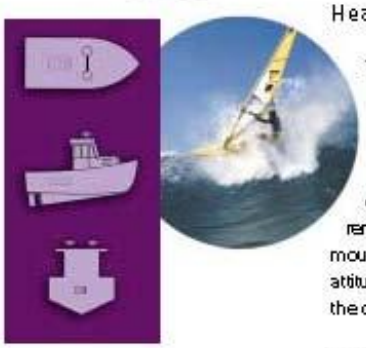
Originally developed for the high-speed world of motor racing, the proven technology in the F180 has been modified and enhanced to produce a commercial-off-the-shelf product that is designed for the most dynamic offshore conditions and any precision marine survey application.

Tried and tested performance



The F180's performance has been documented and the system tried and tested by leading multibeam manufacturers and survey contractors who require reliable and accurate measurements for their marine survey requirements. The F180 is designed to meet and exceed the demands of IHO (International Hydrographic Organisation) Special Order requirements.

Heave error reduction

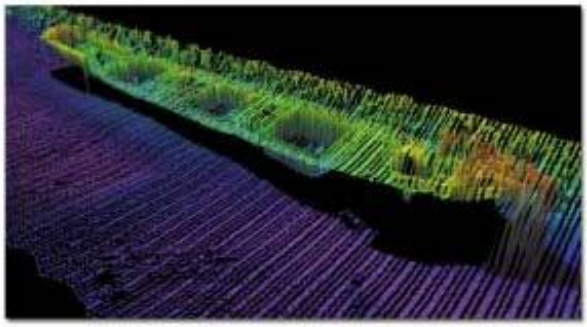


The F180 has the optional ability to output processed heave in near real-time allowing compensation of heave errors from very long swell periods.

To allow easy installation, the outputs of the F180 can be mapped to a remote position (e.g. transducer mounting) to give accurate heave, attitude, position and heading at the critical location.

Technical support

Survey vessels and offshore platforms operate worldwide, often in remote locations and in all time zones, which is why the F180 is available off the shelf, is exportable, easy to install and operate – and is supported around the clock by renowned CodaOctopus 24/7 support service.



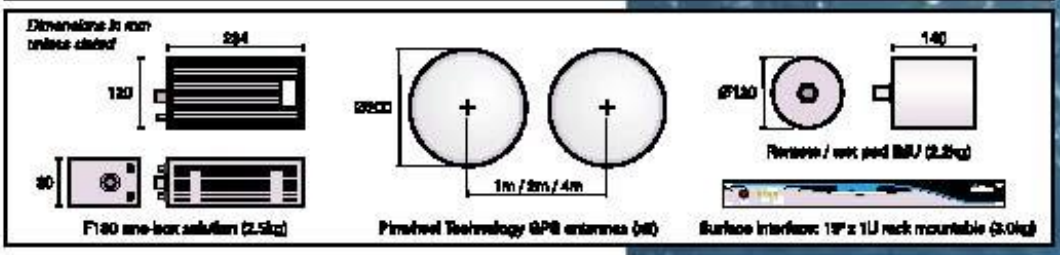
▲ *Countess of Erne*, Portland UK
Data collected with Reson 8125 multibeam system and F180.

Noise free, accurate and reliable

The F180 uses an advanced 23-state Kalman filter to combine the best qualities of Inertial Navigation Systems (INS) with those of GPS to give noise free, accurate and reliable measurements even during short GPS dropouts. This is very important in high multipath conditions or in survey areas such as ports and harbours, riverbanks, near-shore coastal waters and around offshore structures.

Technical Specification

PERFORMANCE	RTK	DGPS
Position (m CEP)	0.02	0.5 - 4.0
Velocity (minus 1)	0.03	0.03
Roll and pitch	<0.025°	<0.025°
True heading	1m baseline - 0.1° 2m baseline - 0.05° 4m baseline - 0.025°	1m baseline - 0.1° 2m baseline - 0.05° 4m baseline - 0.025°
Heave	5% of heave amplitude or 5 cm	5% of heave amplitude or 5 cm
PHYSICAL		
Weight	F180 one-box solution Remote / wet pod IMU Surface interface	2.5kg 2.2kg 3.0kg
Power	F180 one-box solution Remote / wet pod IMU Surface interface	9 - 18Vdc. 25 Watts 110 - 240 Vac. 60 Watts max
Temperature	IMU Antennae Surface rack	-10 to 60°C -40 to 60°C 0 to 60°C
Humidity	IMU (single box and wet pod) Antennae Surface rack	100% 100% 5 to 95% RH none condensing
Vibration	F180 one-box solution and remote / wet pod IMU	0.1g²/Hz 5-500 Hz
Cables	F180 one-box solution Remote / wet pod IMU to surface Antenna	5m standard power, serial and ethernet ethernet combined 25m standard, others to order 15m / 30m standard, others to order
INTERFACES	Function	Output
Ethernet Interface (100base-T)	Control, set-up and diagnosis of F180 using F180 windows application software.	High data rate output packet (100 Hz) for high speed interfacing. Outputs include, position, attitude, heading, velocity, track, speed, acceleration, status performance and raw data.
Serial 1	Attitude data	TSS1, Simrad BM3000 and other standard attitude strings. RS232 (DB9) up to 100Hz at 115k baud.
Serial 2	NMEA position data	GGA position, HDT heading. RS232 (DB9) up to 115k baud
Serial 3	RTK/Differential correction input	RS232 (DB9) up to 115k baud
Other	1PPS	
Optional	Up to 4 additional serial outputs and format types analogue heave pitch and roll outputs	
Software	Windows application allowing real time display of all output parameters and status messages. Allows reconfiguration of key variables including o/p formats and antenna baselines etc.	



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OCTOPUS
LeadingGeoSurveySolutions

Multibeam Survey Data Flow Report

Oak and Crescent Harbors

12 March 2009

Tetra Tech EC

19803 North Creek Parkway

Bothell, WA 98115

Data Flow

For the NOAA Oak & Crescent Harbor multibeam surveys Tetra-Tech ECI (TtEC) utilized dual Reson SeaBat 7125 multibeam echosounders (MBE). The two MBE were mounted with 30 degree outboard rolls to a single pole on the bow of the R/V Storm. The 400 kHz, 7125 MBE systems transmit and receive 256 equi-angle beams that are 1.0 x 0.5 degrees along track and across track (at nadir) respectively. =

During collection of the MBE data, two ancillary system configurations were utilized for horizontal positioning. This occurred due to issues associated with unreliable local Global Positioning System (GPS) signals and the solution required changing the primary positioning system from a Trimble AG 132 (AG132) to an Applanix POS MV 320 (POS/MV).

Initially the POS/MV was utilized for the collection of attitude data only and a United States Coast Guard (USCG) differentially corrected AG132 was used for primary horizontal positioning. The POS/MV is a high accuracy inertial measurement system which is coupled with two GPS receivers. This GPS aided inertial platform provides data for correcting MBE for vessel roll, pitch, heave, and heading.

Local interference, which could not be isolated, caused repeated problems with GPS signal retention for the AG132 and on January 26th 2009 (Julian Day 26) the POS/MV system was reconfigured (with approval from Williamson & Associates) to collect both vessel attitude and primary horizontal position. TtEC elected to make this change because the POS/MV provided more reliable GPS signal retention characteristics than the AG132. USCG differential beacon corrections were found to be unaffected by the local interference and were there for reliably provided by the AG132 to the POS/MV via a Radio Technical Transmission Committee for Marine Services (RTCM) string.

All ancillary system and multibeam data were logged in Hypack 2008 SP1. One or more Hypack projects were created for each Julian day and each survey line was logged as an individual file (generating .HSX and .RAW files for each survey line). All .HSX and .RAW files were then uploaded from the survey boat via wireless broadband connection to the Williamson FTP server.

A daily log sheet was created each day to track survey events such as conductivity, temperature and depth (CTD) casts, draft measurements, and the time at which each survey line was started. Vessel draft measurements were recorded at the start and end of each day on this daily log. The log sheet(s) was included with each Hypack Project FTP uploaded.

CTD data were collected with a SeaBird SBE 19 plus (provided by Williamson and Associates). Profile data were verified, processed and converted to sound velocities using SeaBird processing software. All sound velocity files were saved in the appropriate Hypack project and then uploaded to the Williamson FTP site under the associated Hypack project directory.

POSPac data for use in POSPac post processing software or for application of true heave in Caris was recorded using Applanix POS-View software. These data were saved in the appropriate Hypack project and then uploaded to the Williamson FTP site under the associated Hypack project directory.

Quality Control

A calibration test was conducted at the start and end of survey operation to confirm that the previously calculated calibration values had not changed. Bar checks were conducted periodically to confirm accurate depth readings from the sonar. Multiple GPS systems were utilized to confirm accurate positional information was being recorded. A Leica 1230 real-time kinematic (RTK) GPS system provided a secondary and backup source of elevation data. These data was logged into the Hypack .HSX and .raw files in the event that this information was needed for quality control or evaluation of RTK GPS tidal correction purposes.

Trimble AgGPS 132

AgGPS 124, AgGPS 132 and AgGPS 132 Air Receiver

Table F.1 ***Ag*GPS 124 / 132 / 132 Air Receiver Characteristics**

Size	14.5 cm W x 5.1 cm H x 19.5 cm D (5.7 in. W x 2.0 in. H x 7.7 in. D)
Weight	0.76 Kg (1.68 lb.)
Power	7 Watts (max), 10–32 VDC
Operating Temperature	–20°C to +65°C
Storage Temperature	–30°C to +80°C
Humidity	100% condensing, unit fully sealed
Casing	Dust-proof, waterproof, shock resistant

Combined Antenna

Table F.2 **Combined Antenna Characteristics**

	124	**132**
Size	15.5 cm D x 10.8 cm H (6.1 in. D x 4.3 in. H)	15.5 cm D x 14.0 cm H (6.1 in. D x 5.5 in. H)
Weight	0.49 kg (1.08 lb.)	0.55 Kg (1.2 lb.)
Operating Temperature	–30°C to +65°C	–30°C to +65°C
Storage Temperature	–40°C to +80°C	–40°C to +80°C
Humidity	100% condensing, unit fully sealed	100% condensing, unit fully sealed
Casing	Dust-proof, waterproof, shock resistant	Dust-proof, waterproof, shock resistant

GPS Channels

Table F.3 GPS Channels Performance Characteristics

General	12-channel, parallel tracking L1 C/A code and carrier phase filtered measurements and multi-bit digitizer
Update Rate	1 Hz standard; 10 Hz optional
Differential Speed Accuracy	0.1 MPH (0.16 KPH)
Differential Position Accuracy	Less than 1 meter horizontal RMS At least 5 satellites PDOP < 4 RTCM SC-104 standard format broadcast from Trimble 4000RSi or equivalent reference station
Time to First Fix	< 30 seconds, typical
NMEA Messages	GGA,† GLL, GSA,† GSV, GST, MSS, RMC,† VTG,† ZDA

† By default, the AgGPS 124/132 receiver is configured to output GGA, GSA, VTG, and RMC messages.

Beacon Channels

Table F.4 Beacon Channels

Frequency Range	283.5 kHz to 325.0 kHz
Channel Spacing	500 Hz
Beacon Modulation	50, 100, and 200 bits/second
Signal Strength	10 µV/meter minimum
Dynamic Range	100 dB
Channel Selectivity	70 dB @ > 500 Hz offset
Frequency Offset	17 ppm maximum
3rd Order Intercept	+15 dBm @ RF input (min. AGC setting)
Beacon Acquisition Time	<5 seconds, typical
Operating Modes	Auto Power, Auto Range, and Manual

L-Band Satellite Differential Correction Receiver

Table F.5 L-Band Satellite Differential Correction Receiver with Multiple Vendor Support (*Ag*GPS 132/132 Air only) Characteristics

Bit Error Rate	10^{-5} for Eb/N of >5.5 dB
Acquisition and Re-acquisition Time	<2 seconds, typical
Frequency Band	1525–1560 MHz
Channel Spacing	.5 kHz

Receiver Defaults

Table F.6 lists the default settings for the *Ag*GPS 124/132 receiver.

Table F.6 Receiver Defaults

DGPS Source	Satellite
Dynamics	Land
Elevation Mask	8°
SNR Mask	6
PDOP Mask	12
PDOP Switch	8
DGPS Mode	Auto On/Off
DGPS Age Limit	30 sec
Pos Fix Rate	1 Hz

VALEPORT

miniSVS

Our unique digital time of flight technology gives unmatched performance figures, with signal noise an order of magnitude better than any other sensor. The miniSVS is available in a selection of configurations and with optional pressure or temperature sensors. There is a variety of sizes to suit many applications.

miniSVS - the most accurate sound velocity sensor in the world. Why settle for less?

Sound Velocity Measurement

Each sound velocity measurement is made using a single pulse of sound traveling over a known distance, so is independent of the inherent calculation errors present in all CTDs. Our unique digital signal processing technique virtually eliminates signal noise, and gives almost instantaneous response; the digital measurement is also entirely linear, giving predictable performance under all conditions.

Range:	1400 - 1600m/s (extended range on request)	
Resolution:	0.001m/s	
Accuracy:	Dependent on sensor size	
100mm	Random noise (95%)	±0.002m/s
	Max systematic calibration error	±0.013m/s
	Max systematic clock error	±0.015m/s
	Total max theoretical error	**±0.03m/s**
50mm	Total max theoretical error	±0.06m/s
25mm	Total max theoretical error	±0.10m/s
Acoustic Frequency:	2.5MHz	
Sample Rate:	Selectable, dependent on sensor size.	

Rate	100mm	50mm	25mm
Single Sample	●	●	●
1Hz	●	●	●
2Hz	●	●	●
4Hz	●	●	●
8Hz	●	●	●
16Hz		●[1]	●

([1]Not possible with optional sensor fitted)

Optional Sensors

The miniSVS may be optionally supplied with either a pressure or temperature sensor (but not both). Data is sampled at the same rate as above.

Sensor	Pressure	Temperature
Type	Strain Gauge	PRT
Range	5, 10, 50, 100 or 600 Bar	-5°C to +35°C
Resolution	0.001% range	0.001°C
Accuracy	±0.1% range	±0.01°C

Data Output

Unit has RS232 & RS485 output, selected by command code. RS232 data may be taken directly into a PC over cables up to 200m long, whereas RS485 is suitable for longer cables (up to 1000m) and allows for multiple addressed units on a single cable. However, it also requires a suitable RS485 PC adaptor.

Baud Rate: 1200 - 38400

Protocol: 8 data bits, 1 stop bit, No parity, No flow control

Electrical

Voltage: 8 - 30vDC

Power: 0.25W (SV only)
0.35W (SV + Pressure)

Connector: Subconn Titanium MCBH6F (alternatives on request)

Data Format

<space>{sound_velocity}<cr><lf>
<space>{pressure}<space>{sound_velocity}<cr><lf>
<space>{temperature}<space>{sound_velocity}<cr><lf>

SV: Choose from mm/s (1510123), m/s to 3 decimal places (1510.123), or m/s to 2 decimal places (1510.12)

Pressure: If fitted, pressure is always output in dBar with 5 digits, with a decimal point, including leading zeroes if necessary. Position of the point is dependent on sensor range, e.g.

50dBar	47.123
100dBar	047.12
1000dBar	0047.1

Temperature: If fitted, temperature is output as a 5 digit number with 3 decimal places and leading zeroes, signed if negative, e.g.

21.456
02.298
-03.174

Physical

Please refer to drawing on reverse for detailed dimensions.

Depth Rating: 6000m

Weight: 1kg (housed type)

Housing & Bulkhead: Titanium

Transducer Window: Polycarbonate

Sensor Legs: Carbon Composite

Reflector Plate: Titanium

Ordering

All systems supplied with operating manual and carry case. OEM units come with a test lead, housed units with a 0.5m pigtail.

Configuration	100mm	50mm	25mm
Titanium Housed	0652004	0652005	0652006
Bulkhead OEM	0652001	0652002	0652003
Remote OEM	0652007	0652008	0652009

0652010	Spare 50cm Pigtail
0652013	Pressure sensor option (specify range)
0652028	Temperature sensor option

Datasheet Reference Number: miniSVS v1B

Valeport Limited, St. Peter's Quay, Totnes, Devon TQ9 5EW UK
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VALEPORT

miniSVP

The miniSVP has been developed to provide a cost effective tool for the collection of Sound Velocity Profiles, without compromising the quality of the data. Ideally suited to ROV, coastal, or small boat applications, the miniSVP will appeal to survey companies, the military and academia alike, being simple to use, easy to handle, and featuring of course the most accurate SV sensor in the world.

Sensors

The miniSVP is fitted with Valeport's digital time of flight sound velocity sensor, a PRT temperature sensor, and strain gauge pressure transducer.

Sound Velocity

Range:	1400 - 1600m/s (extended range on request)
Resolution:	0.001m/s
Accuracy:	±0.03m/s

Temperature

Range:	-5°C to +35°C
Resolution:	0.001°C
Accuracy:	±0.01°C

Pressure

Range:	10, 50, 100, 300 or 600 Bar
Resolution:	0.001% range
Accuracy:	±0.05% range

Data Acquisition

The miniSVP features a selection of pre-programmed sampling regimes, covering many standard applications. Data may be sampled from 1 to 8Hz, making it suitable for rapid profiling or for continuous measurement at a fixed point

Sampling Modes

Continuous:	Regular output from all sensors at 1, 2, 4 or 8Hz.
Profile:	Logs data as the device falls (or rises) by a defined amount through the water column.

Communications

The instrument will operate autonomously, with setup and data extraction performed by direct communications with PC before and after deployment. It also operates in real time, with a choice of communication protocols fitted as standard and selected by pin choice on the output connector.

RS232:	Up to 200m cable, direct to serial port
RS485:	Up to 1000m cable, addressable half duplex comms
Baud Rate:	4800 - 460800
Protocol:	8 data bits, 1 stop bit, No parity, No flow control
Bluetooth:	Optional Bluetooth adapter available for cable free data recovery (adapter not designed for immersion)

Memory

The miniSVP is fitted with a solid state non-volatile Flash memory, capable of storing over 10 million lines of data (equivalent to 10,000 profiles to 500m, at 1m profile resolution).

Electrical

Internal:	1 x C cell, 1.5v alkaline or 3.6v lithium
External:	9 - 28vDC
Power:	<250mW
Battery Life:	approx 30 hours operation (alkaline) approx 90 hours operation (lithium)
Connector:	Subconn MCBH10F

Physical

Materials:	Acetal or titanium housing (as ordered), polycarbonate & composite sensor components, stainless steel (316) deployment bracket
Depth Rating:	500m (acetal) 6000m (titanium) *NB: Maximum deployment depth may be limited by transducer range*
Instrument Size:	Main Housing 48mmØ Sensor Body 54mmØ Length 435mm (including connector)
Weight:	0.8kg (acetal) 1.6kg (titanium)
Shipping:	52 x 39 x 16cm, 6kg (acetal) / 7kg (titanium)

Software

System is supplied with DataLog Express Windows based PC software, for instrument setup, data extraction and display. DataLog Express is licence free.

Ordering

0660001	miniSVP Sound Velocity Profiler in acetal housing, supplied with deployment clamp, switch plug, 3m communications lead, DataLog Express software, manual and transit case. *Specify required pressure range*
0660002	miniSVP Sound Velocity Profiler in titanium housing, supplied with deployment clamp, switch plug, 3m communications lead, DataLog Express software, manual and transit case. *Specify required pressure range*
0400029	Optional RS485 communications adapter
04000536	Optional Bluetooth adapter

Datasheet Reference Number: MINISVP v1B

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SEACAT Profiler CTD

SBE 19*plus* V2

The SBE 19*plus* **V2** (Version 2) Seacat Profiler CTD measures conductivity, temperature, and pressure (depth) and provides high accuracy and resolution, reliability, and ease-of-use for a wide range of research, monitoring, and engineering applications. The pump-controlled, T-C ducted flow configuration minimizes salinity spiking caused by ship heave and allows for slow descent rates without slowing sensor responses, improving dynamic accuracy and resolving small scale structure in the water column. The V2 is the most versatile successor in the line of *Personal CTDs* begun with the original SBE 19 SEACAT in 1987.

Compared to the previous 19*plus*, the 19*plus* V2 incorporates an electronics upgrade and additional features. The V2 has two additional (6 total) auxiliary A/D input channels, FLASH memory is increased from 8 to 64 MB, and one RS-232 data input channel is added. An optional Digiquartz® pressure sensor provides highest-accuracy pressure measurement. Data can be output in XML as well as ASCII and HEX formats. Firmware upgrades can be downloaded through the communications port by the user, without opening the instrument.

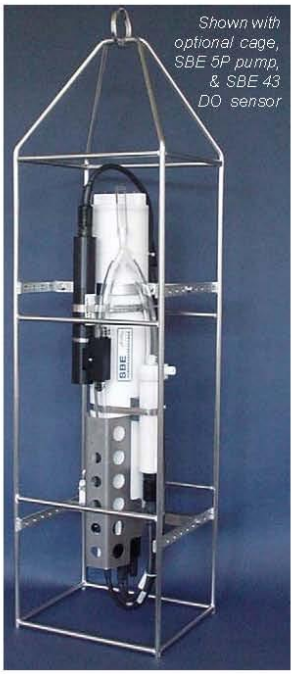
The 19*plus* V2 samples continuously at up to 4 scans per second (4 Hz) (2 Hz with Digiquartz®), is battery-powered and self-recording, and is commonly used in the field without a computer, recording up to 1000 individual profiles. Data can be uploaded to a PC and processed later, or can typically be transmitted in real time more than 100 meters to a PC for acquisition and display using SEASOFT software provided (maximum cable length is dependent on the number of auxiliary sensors, sampling rate, baud rate, and cable properties). The 19*plus* V2 can supply power to 7 external sensors and log their outputs with each CTD scan. Nine D-size alkaline batteries provide up to 60 hours of continuous operation when logging C, T, and P at 4 Hz (operation time is shorter if powering auxiliary sensors).

The 19*plus* V2 is easily integrated with an SBE 32 Carousel Water Sampler and is ideal for integration with the SBE 55 ECO Water Sampler. Both real-time and autonomous *auto-fire* operations are possible with any Sea-Bird CTD / Water Sampler system.

The 19*plus* V2 can operate in moored mode, recording time series measurements at user-programmable intervals. Moored mode is easily configured using setup commands and by removing the profiling T-C Duct and installing optional anti-fouling devices. (If profiling is not needed, the 16*plus* V2 Seacat Recorder offers greater moored-mode programming flexibility and a pressure sensor is optional.)

Accuracy, convenience, portability, software, and support: compelling reasons why the 19*plus* V2 is today's best low-cost CTD.

CONFIGURATION, OPTIONS, AND ACCESSORIES



A standard SBE 19*plus* V2 is supplied with:

- Plastic housing for depths to 600 meters
- Strain-gauge pressure sensor
- 64 Mbyte FLASH RAM memory
- 9 D-size alkaline batteries
- Glass-reinforced epoxy bulkhead connectors
- SBE 5M miniature pump with plastic housing for depths to 600 m, and T-C Duct

Options and accessories include:

- Titanium housing for depths to 7000 meters
- Wet-pluggable MCBH series connectors
- SBE 5M miniature pump with titanium housing for 7000 meters
- SBE 5P (plastic) or 5T (titanium) in place of SBE 5M for use with dissolved oxygen and/or other pumped sensors
- Digiquartz® pressure sensor
- Stainless steel protection cage
- Auxiliary sensors for Dissolved Oxygen, pH (Profiling mode only), fluorescence, radiance (PAR), light transmission, and optical backscatter (turbidity)
- Plastic shipping case
- Nickel Metal Hydride (NiMH) batteries and charger
- Moored mode conversion kit with anti-foulant device fittings
- Load-bearing underwater cables for hand-hauled, real-time profiling
- SBE 36 CTD Deck Unit and Power/Data Interface Module (PDIM) for real-time operation on single-core armored cable up to 10,000 meters

SOFTWARE

The SBE 19*plus* V2 is supplied with a powerful Windows 2000/XP software package, SEASOFT®-Win32, which includes programs for communication and data retrieval, real-time data acquisition and display, and data processing (filtering, aligning, averaging) and plotting.

SBE
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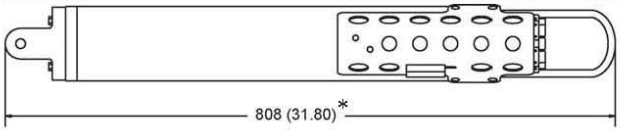
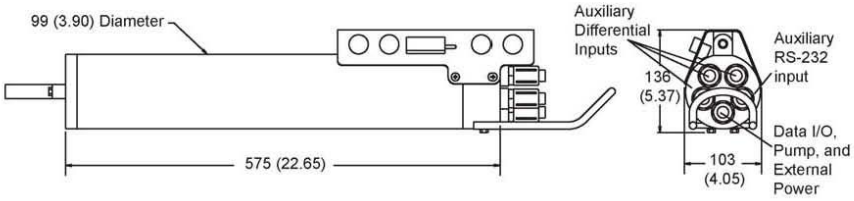
SEACAT Profiler CTD

SBE 19*plus* V2



*Note: 19*plus* V2 with optional Quartz pressure sensor is 190 mm (7.5 inches) longer than shown in drawing.



Dimensions in millimeters (inches)

	Measurement Range	Initial Accuracy	Typical Stability	Resolution
Conductivity (S/m)	0 to 9	0.0005	0.0003/month	0.00005 (most oceanic waters; resolves 0.4 ppm in salinity) 0.00007 S/m (high salinity waters; resolves 0.4 ppm in salinity) 0.00001 S/m (fresh waters; resolves 0.1 ppm in salinity)
Temperature (°C)	-5 to +35	0.005	0.0002/month	0.0001
Pressure - *Strain Gauge*	0 to 20/100/350/600/ 1000/2000/3500/ 7000 meters	0.1% of full scale range	0.1% of full scale range/year	0.002% of full scale range
Pressure - *Quartz*	0 to 20/60/130/200/ 270/680/1400/ 2000/4200/7000/ 10,500 meters	0.02% of full scale range	0.025% of full scale range/year	0.0025% of full scale range

Memory 64 Mbyte non-volatile FLASH memory

Data Storage

Recorded Parameter	Bytes/Sample
T + C	6
pressure - *strain gauge* or *Quartz*	5
each external voltage	2
auxiliary RS-232 sensor	sensor dependent

Real-Time Clock 32,768 Hz TCXO accurate to ±1 minute/year

Internal Batteries 9 alkaline D-cells (Duracell MN1300, LR20) provide 60 hours profiling; optional 9-cell NiMH battery pack provides 40 hours profiling per charge; optional 9-cell Ni-Cad battery pack provides 24 hours profiling per charge

External Power Supply 9 - 28 VDC; consult factory for required current

Power Requirements

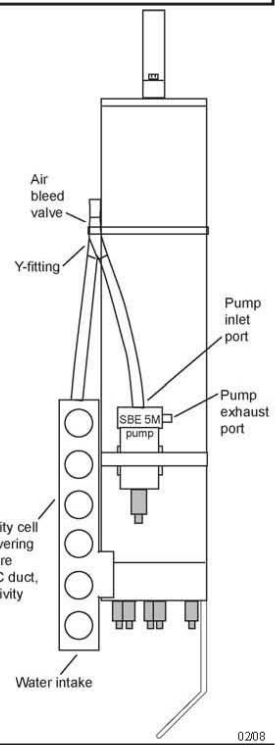
Sampling	70 mA	
Pump	SBE 5M: 100 mA	Optional SBE 5T or 5P: 150 mA
Communications	65 mA	
Quiescent	20 µA	

Auxiliary Sensors

Auxiliary power out	up to 500 mA at 10.5 - 11 VDC
Voltage sensor A/D resolution	14 bits
Voltage sensor input range	0 - 5 VDC

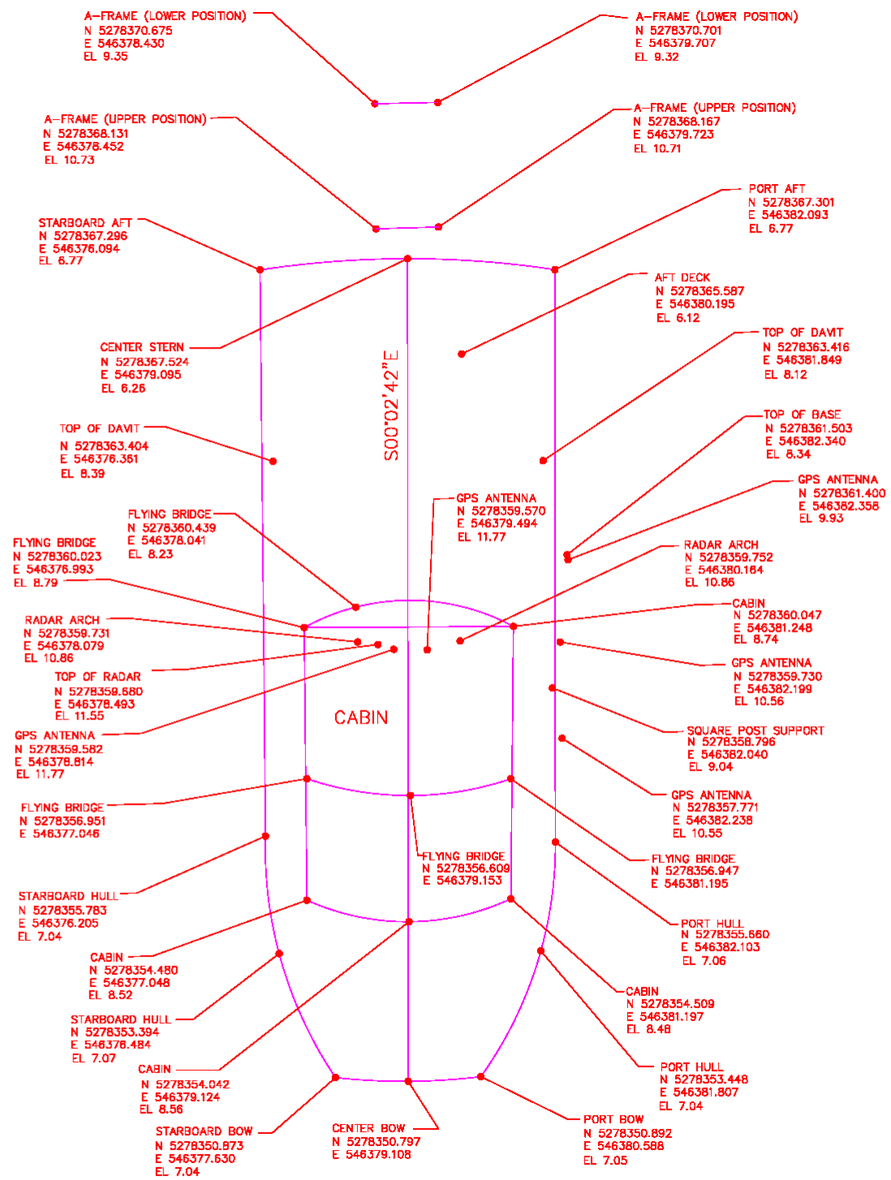
Housing Materials, Depth Rating, Weight in air*, Weight in water*
Acetal Copolymer *Plastic* housing, 600 m (1950 ft), 7.3 kg (16 lbs), 2.3 kg (5 lbs)
3AL-2.5V *Titanium* housing, 7000 m (22,900 ft), 13.7 kg (30 lbs), 8.6 kg (19 lbs)
*Weights listed are without pump; pump adds (in air) 0.3 to 0.7 kg (0.6 to 1.5 lbs), depending on pump model selected. See pump brochures for details.

Optional Cage
(for 19*plus* V2 with strain-gauge pressure) 1016 x 241 x 279 mm (40 x 9.5 x 11 in.), 6.3 kg (14 lbs)
(for 19*plus* V2 with Digiquartz pressure) 1219 x 241 x 279 mm (48 x 9.5 x 11 in.)



02/08

Sea-Bird Electronics, Inc.
1808 136th Place NE, Bellevue, Washington 98005 USA
Website: http://www.seabird.com
E-mail: seabird@seabird.com
Telephone: (425) 643-9866
Fax: (425) 643-9954



NOTES:
- EL INDICATES ELEVATION – NAVD88 DATUM
- COORDINATES ARE METRIC – UTM ZONE 10
- ELEVATIONS ARE METRIC
- DRAWING IS NOT TO SCALE

BOAT EXHIBIT

NAVIGATION CALIBRATION

WILLIAMSON AND ASSOCIATES

SEATTLE, KING COUNTY, WASHINGTON

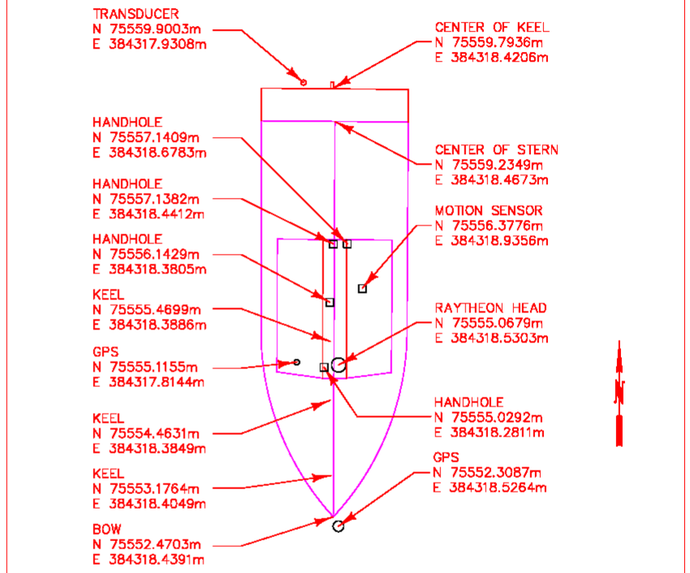
NO REVISION DATE

BUSH, ROED & HITCHINGS, INC.
CIVIL ENGINEERS & LAND SURVEYORS
2009 MINOR AVE. EAST
SEATTLE, Washington
98102-3513
(206) 323-4144
1-800-935-0606
FAX# (206) 323-7135
E-MAIL: INFO@BRHINC.COM

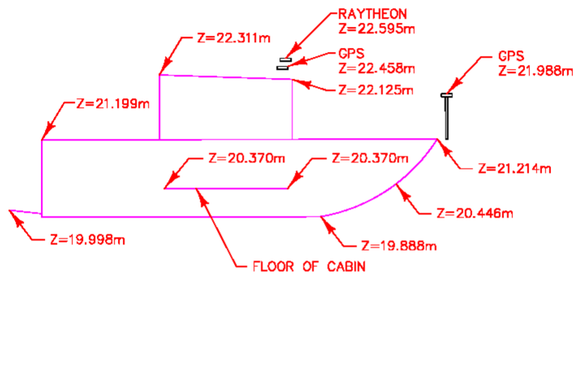
SEAL

drawn by JBK/JDC
checked by DCN/JDC
scale N.T.S.
date 11/08
job no. 2008171.01
sheet 1 of 1

LAYERSTATE:



PLAN VIEW



PROFILE VIEW

NOTES:
- Z INDICATES ELEVATION – NAVD88 DATUM
- COORDINATES ARE METRIC – WASHINGTON NORTH ZONE
- ELEVATIONS ARE METRIC
- DRAWING IS NOT TO SCALE

BOAT EXHIBIT
NAVIGATION CALIBRATION
WILLIAMSON AND ASSOCIATES
SEATTLE, KING COUNTY, WASHINGTON

NO. REVISION DATE

BUSH, ROED & HITCHINGS, INC.
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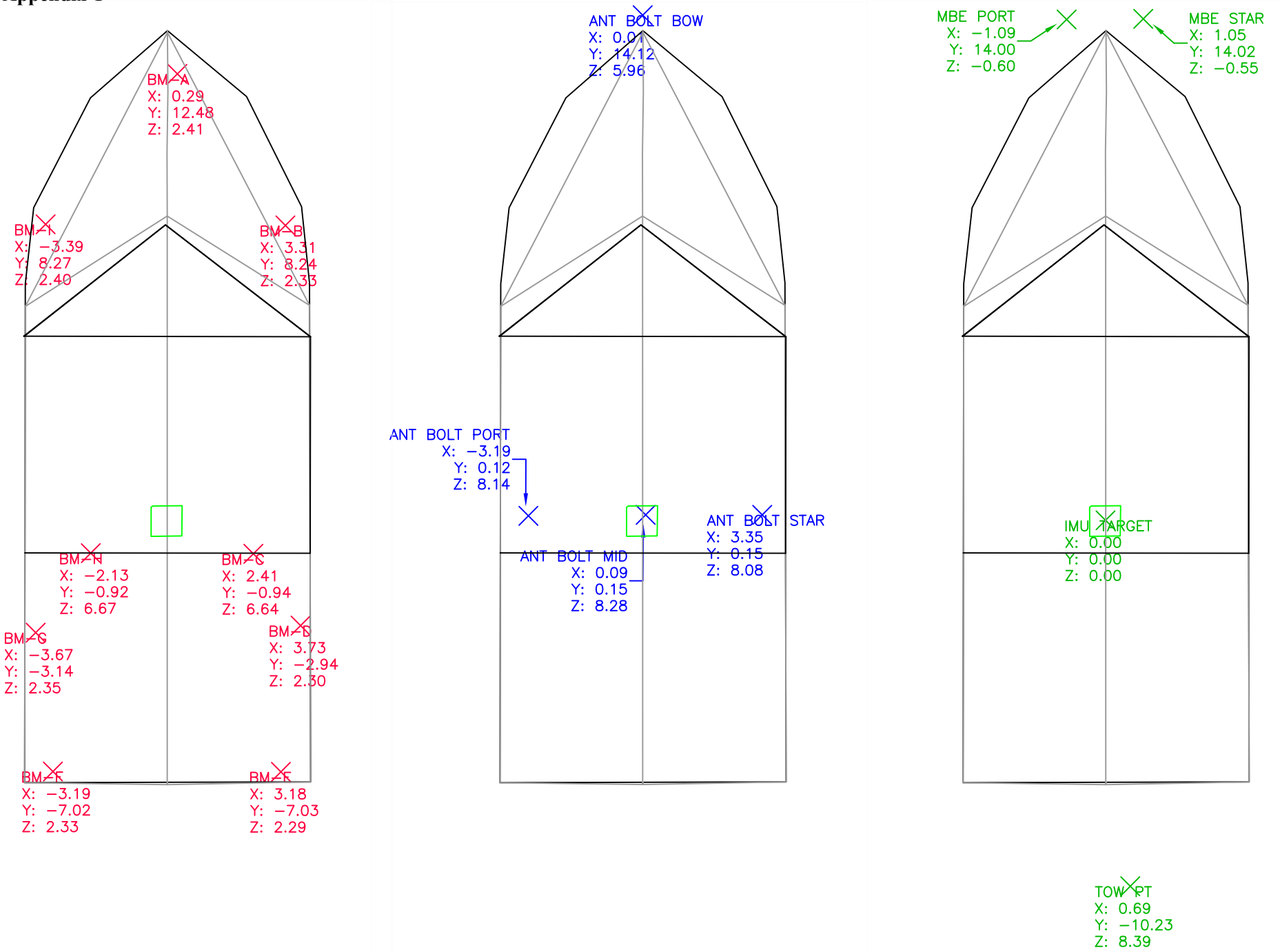
drawn by: DDR/JDC	checked by: DCN/JDC
scale: N.T.S.	date: 11/08
job no.: 2008171-00	
sheet 1 of 1	

LAYOUTSTATE:



TETRA TECH EC, INC.

LEGEND

- Benchmarks
- Antenna Points
- Equipment Points

Figure 1 - "Storm" Survey Vessel: Plan View

NOTES:

1. INCA survey from Leica Total Station on December 5th, 2008
2. Benchmarks placed for repeatability and new equipment reference
3. Survey taken with Dual Multibeam Echosounder (MBE) Bow Mount in collection position
4. Survey taken with davit in locked collection position

Geodetic Setting:

1. Datum: Inertial Measurement Unit (IMU) reference frame
2. Horizontal and Vertical Units: US Feet

INCA ENGINEERS INC.
A Tetra Tech Company

Static Vessel Survey of Tetra Tech EC's 21' launch.

Survey Narrative:

INCA Engineers Survey Department performed a static vessel survey for Tetra-tech EC. The vessel type is a 21' long Custom Weld, monohull aluminum boat, with jet drive. The vessel serial number is "WFE02280L304", the vessel registration number is "OR 574 ABU".

The survey was performed in the parking lot of INCA Engineers office at 400 112th Ave NE, Bellevue, WA 98004, on December 5th, 2008. The vessel was leveled (in both the transverse and longitudinal axis). Then supported by wood blocking, and jackstands for the duration of the survey. Note that no vessel motion was apparent during the survey.

Measurements were made using a Leica TCR-803 digital total station. The Leica TCR-803 measures both horizontal and vertical angles with a precision of plus or minus 3 arc seconds, and distances with a precision of 2 millimeters plus 2 parts per million. The measurement data was electronically stored in a Carlson Explorer II electronic field data collector. The use of an electronic field data collector virtually eliminates errors from miss-read measurements, transposition errors in data logging, and errors during data processing.

The field procedures included the establishment of three traverse control stations in the parking lot surrounding the vessel, to the stern, port side of the bow, and starboard side of the bow. From these locations, a full 360 degree view of the vessel is afforded. Measurements were taken to the GPS antennae mounting studs (four each), vessel benchmarks (several punch-marks with letter designations), IMU case (at the IMU target), IMU mounting plate (at the four corners), multi-beam transducer heads (two each), the towpoint (shackle at the end of the boom arm), various locations along the keel line, and the hull outline.

The field data was then processed in the office yielding final coordinates (on assumed datum). The field procedures include check shots (of two types). The first type is from the survey instrument control point position to one or more of the other control points. The second type is making a repeat shot on one or more vessel locations from a different survey control point. The results of these check shots exhibits an average radial (three dimensional) variance of 0.007 feet (or 0.002 meters).

Enclosures:

Coordinate Results (in feet).
Precision Analysis.
Field Note Copies.
Field Data Printout.

Survey Certification:

This survey was performed by me or under my direct supervision, at the request of Tetra-Tech EC, in December of 2008.

Michael A. Lee, PLS
Washington Registration No. 35143

12/10/2008

EXPIRES 6/5/2009

08-066 >><< Tt 21' Launch >><< USFt >><< Control Measures and Checks
COORDINATE FILE : 21CW.CRD

LIST COORDINATES
LIST POINT # [,THRU POINT #] : 100,1100

	PT#	NORTH	EAST	ELEV
CPSXCs to Stern	100	20000.000	50000.000	200.000
CPSXCs to Port	101	20049.984	50000.000	199.649
CPSXCs to Starboard	102	20049.588	50019.695	199.568
CPCT 101	103	20049.984	50000.000	199.649
CPCT 100	104	20000.000	50000.000	200.000
CPBS 101	1000	20049.985	50000.000	199.643
TOW PT	1001	20026.474	50004.098	210.385
KEEL STERN	1002	20029.405	50004.132	201.559
BM-E	1003	20028.964	50007.294	204.286
BM-D	1004	20032.793	50008.827	204.294
BM-C	1005	20035.061	50008.039	208.632
BM-H	1006	20036.190	50003.638	208.667
ANT BOLT PORT	1007	20037.460	50002.869	210.133
ANT BOLT MID	1008	20036.684	50006.052	210.274
ANT BOLT STAR	1009	20035.888	50009.212	210.080
IMU TARGET	1010	20036.559	50005.929	201.996
IMU PLATE	1011	20036.035	50006.221	201.447
IMU PLATE	1012	20036.851	50006.439	201.443
IMU PLATE	1013	20037.042	50005.641	201.457
IMU PLATE	1014	20037.024	50005.589	201.458
IMU PLATE	1015	20036.234	50005.389	201.460
CPBS 101	1016	20049.985	50000.000	199.643
CPBS 100	1017	20000.002	50000.000	199.997
BM-B	1018	20043.740	50011.153	204.325
ANT BOLT BOW	1019	20050.245	50009.390	207.953
BM-A	1020	20048.586	50009.263	204.406
CHK 1009	1021	20035.894	50009.210	210.080
KEEL BOW	1022	20049.843	50009.294	204.283
MBE STAR	1023	20049.890	50010.381	201.451
KEEL	1024	20049.778	50009.278	204.289
KEEL	1025	20048.155	50008.881	203.213
KEEL	1026	20046.533	50008.445	202.310
KEEL	1027	20044.802	50008.014	201.578
HULL STAR	1028	20049.824	50009.289	204.470
HULL STAR	1029	20047.500	50010.981	204.408
HULL STAR	1030	20044.139	50011.718	204.347
HULL STAR	1031	20042.016	50011.414	204.313
HULL STAR	1032	20028.489	50008.032	204.278
CPBS 100	1033	20000.001	50000.000	199.998
CPBS 102	1034	20049.588	50019.699	199.560
CHK 1007	1035	20037.466	50002.860	210.127
BM-I	1036	20045.411	50004.663	204.399
BM-G	1037	20034.414	50001.601	204.349
BM-F	1038	20030.533	50001.119	204.323
MBE PORT	1039	20050.398	50008.300	201.396
HULL PORT	1040	20048.531	50006.743	204.434
HULL PORT	1041	20045.942	50004.454	204.419
HULL PORT	1042	20043.941	50003.707	204.376
HULL PORT	1043	20030.424	50000.275	204.312
CPBS 102	1044	20049.588	50019.699	199.560
Port Hull 0.506' Above IMU	1045	20037.350	50002.809	202.502
CPBS 102	1046	20049.589	50019.699	199.560
Starboard Hull 0.506' Above IMU	1047	20035.770	50009.070	202.502
CPBS 103	1048	20049.984	49999.995	199.642

LIST POINT # [,THRU POINT #] :

Check Shot PID	Check Shot Type	delta northing feet	delta easting feet	delta elev feet	3D radial delta feet
1000	Check Survey Control Point	0.002	0.000	0.003	0.004
1016	Check Survey Control Point	0.001	0.000	0.006	0.006
1017	Check Survey Control Point	0.002	0.000	0.003	0.004
1021	Check GPS Ant. Stud	0.006	0.002	0.000	0.006
1033	Check Survey Control Point	0.001	0.000	0.002	0.002
1034	Check Survey Control Point	0.000	0.004	0.008	0.009
1035	Check GPS Ant. Stud	0.006	0.009	0.006	0.012
1044	Check Survey Control Point	0.000	0.004	0.008	0.009
1046	Check Survey Control Point	0.001	0.004	0.008	0.009
1048	Check Survey Control Point	0.000	0.005	0.007	0.009
	Average Radial Error				**0.007**

INCA

JOB NO. 08-066

DATE

BK. (OFFICE)

PG. 0

INST.

CREW

WEATHER

SURVEY:

TETRA TECH EC

21' LAUNCH STATIC SURVEY

VESSEL:

21' CUSTOM WELD 2004 MODEL YEAR

S/N WFE 02280L304

REG. OR 574 ABU

LOCATION:

INCA ENGINEERS

400-112TH AVE NE

BELLEVUE WA 98004

(AT EAST SIDE OF PARKING LOT)

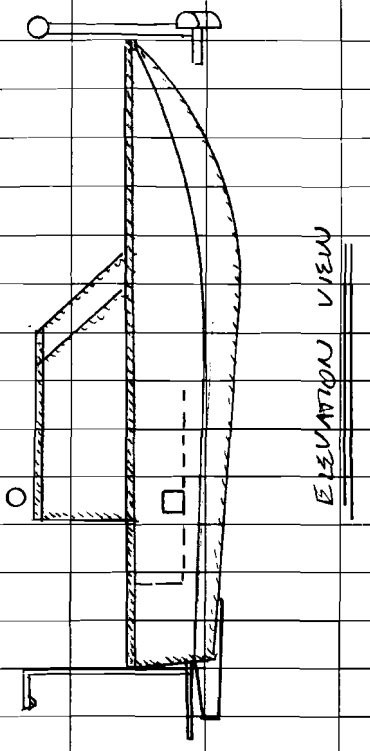
PG. (FIELD)

OF PG.

INCA

JOB NAME Tt 21' LAUNCH

TASK GENERAL LAYOUT



INCA

JOB NO.

DATE

BK. (OFFICE)

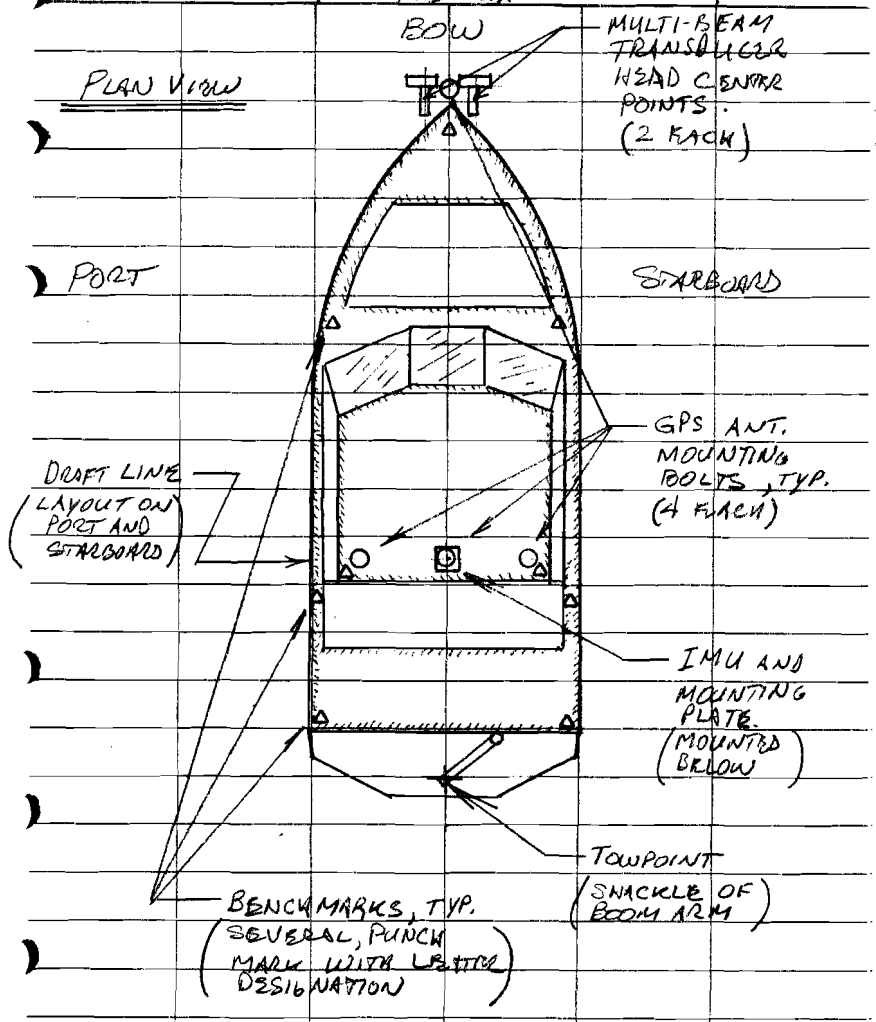
PG. 1

INST.

CREW MIKE LEE
JACK WARTFELT
CHRIS RUX

WEATHER

PLAN VIEW



PG. (FIELD)

OF PG.

INCA

JOB NAME

TASK

E-126

INCA

JOB NO. 08066

DATE 12/05/08

BK. (OFFICE)

PG. 2

INST.

CREW

WEATHER

JOB #08066
VESSEL SURVEY

VESSEL TYPE: 21' CUSTOM WELD (GOLDEN EDIT. STORM)

VESSEL REGISTRATION: OR 574 ABU

(LEICA)

INSTRUMENT TYPE: TCR803 ULTRA - R300

INSTRUMENT SERIAL #: 254316

VERSION #: 310.537

TEMP: 45°

PRESSURE: 30.4

PPM: -10

MODE - IR FINE // PRISM CONST - 4.4 mm

JACK H.

CHRIS R.

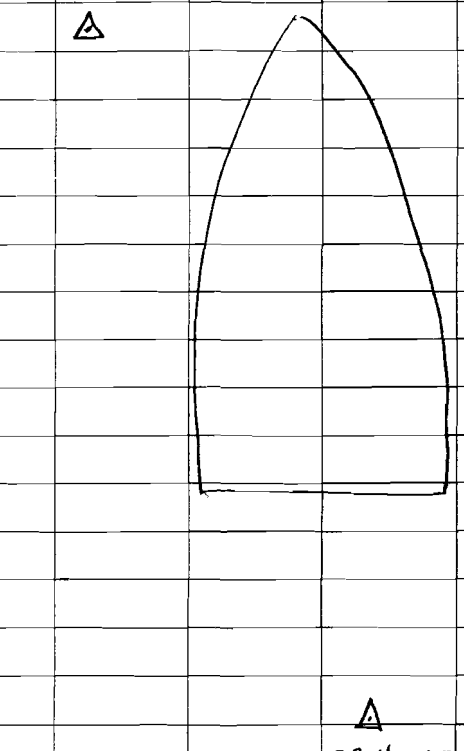
PG. (FIELD)

OF PG.

INCA

JOB NAME 21' CUSTOM WELD
TASK VESSEL SURVEY

ASSUMED CO-ORDS FOR CONTROL



E-126

INCA

JOB NO. 08066
DATE 12/05/08
BK. (OFFICE)
PG. 3

INST. LEICA 803 CARLSON EXII
CREW JH/CR
WEATHER

ASSUMED CONTROL CO-ORDS

#100	N-	10,000.00
	E-	20,000.00
	EL-	500.00
#101	N-	10049.9851
	E-	20000.00
	EL-	499.643
#102	N-	10049.5862
	E-	20019.698
	EL-	499.569

PG. (FIELD)
OF PG.

INCA

JOB NAME: 21' CUSTOM WELD
TASK: VESSEL SURVEY

SET COLLECTION:

T @ 100 = 5.61
BS @ 101 = 5.43
FS @ 102 = 5.52

TOPOGRAPHY:

T @ 100 = 5.61
BS @ 101 = 5.43

POINT #	DESCRIPTION:			
1000	CPBS	101		
1001	TOWPOINT	-0.32'		
1002	KEEL	STERN	"	
1003	BM	"E"	+0.32	
1004	BM	"D"	"	
1005	BM	"C"	"	
1006	BM	"H"	"	
1007	ANT BOLT	PORT ~~MID~~	SIDE	+0.32'
1008	"	"	MID	"
1009	"	"	STARBOARD	"
1010	IMU	TARGET		
1011	IMU	PLATE		
1012	"	"		
1013	"	"		

INCA

JOB NO. 08066
DATE 12/05/08
BK. (OFFICE)
PG. 4
INST. LEICA 803 CARLSON EX II
CREW JH/CR
WEATHER

1014		IMU	PLATE		
1015		"	"		
1016		CPBS	101		
	SET COLLECTION:				
	T @ 102 = 5.73				
	BS @ 100 = 5.40				
	FS @ 103 = 5.43	= CPCHK	101		
	TOPOGRAPHY:				
	T @ 102 = 5.73				
	BS @ 100 = 5.40				
POINT #	DESCRIPTION:				
1017	CPBS	100			
1018	BM	"B"			
1019	ANT BOLT	BOW			
1020	BM	"A"			
1021	CHK	1009	(INV. =	HD = 0.005 VD = 0.0009)	
1022	Keel	BOW			
1023	MBE	STAR			

PG. (FIELD)
OF PG.

INCA

JOB NAME: 21' CUSTOM WELD
TASK: VESSEL SURVEY

TOPO: CONTINUED

POINT #	DESCRIPTION:	
1024 - 1027	KEEL	
1028 - 1032	HULL	STARBOARD
1033	CPBS	100

SET COLLECTION:

↑ @ 103 = 5.63
BS @ 102 = 5.52
FS @ 104 = 5.40 = CPCT 100

TOPOGRAPHY:

↑ @ 103 = 5.63
BS @ 102 = 5.52

POINT #	DESCRIPTION:		
1034	CPBS	102	
1035	CLIK	1007	(HD - 0.013, VD - 0.011)
1036	BM "I"		
1037	BM "G"		
1038	BM "F"		
1039	MBE	PORT	
1040 - 1043	HULL	PORT	
1044	CPBS	102	

J.L. DARLING CORPORATION ALL-WEATHER WRITING PAPER (253) 922-5000 • FAX (253) 922-5300

E-126

INCA

JOB NO. 08066
DATE 12/05/08
BK. (OFFICE)
PG. 5

INST. LEICA 803 CARLSON EX II
CREW JH/CR
WEATHER

↑ @ 103 = 5.63
BS @ 102 = 5.52

<501.996> SET OUT LINE 1002 → 1022

STA.	O/S	ELEV.	DESCRIPTION:	STORE #
0+07.38	3 23 3 L	502.50	DRAFT LINE (PORT)	1045
			CPBS 102	1046

↑ @ 102 = 5.73
BS @ 103 = 5.43

SET OUT LINE

STA.	O/S	ELEV.	DESCRIPTION:	STORE #
0+07.38	3 23 R	502.50	DRAFT LINE (STAR)	1047
			CPBS 103	1048

PG. (FIELD)
OF PG

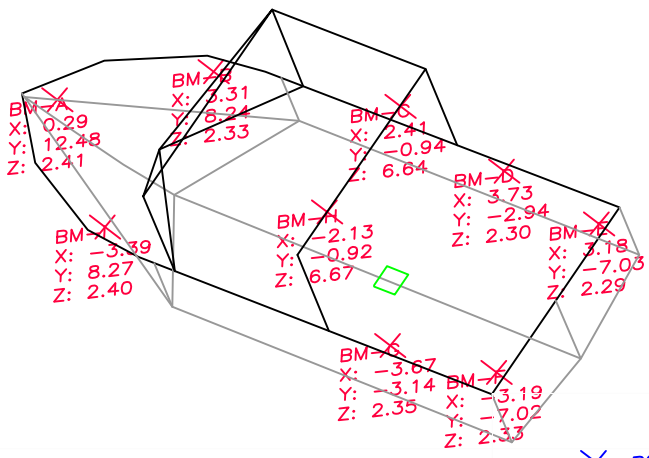
```
00NMSDR33     V04-01.00 Dec-05-08 08:58 122211
10NM08066-1205JH    12
13OOOBS
13NMSurvCE Version 2.02
13NMCRD: Alphanumeric
13NMAL East NAD83
13NMEquipment: Leica TPS Series (Direct)
06NM1.00000000
13NMEDM Mode: standard
21 FT CUSTOM WELD
13NMVESSEL SURVEY
13NMMIKE LEE
45DEG   31.4PRESSURE
08KI            10010000.00000000  20000.00000000  500.00000000    CP
13NMP.C. mm Applied: 4.4000
02TP            10010000.0000      20000.0000      500.0000        5.6100          CP

03NM5.43000000
11KI            100             1010.00000000
07TP            100             1010.00000000      0.00000000
13NMBacksight by Azimuth
09F1            100             10149.98800000     90.61555556     0.00000000      CP

13NMCalculated: AR
13NMMeasured: AR
13NMDelta: AR
13NMSet Collection with Obs Order 123...321...
02SC            10010000.0000      20000.0000      500.0000        5.6100          CP

03NM5.43000000
12SC            100001001111
03NM5.43000000
09F1            100             10149.98800000     90.61611111     0.00000000      CP

03NM5.52000000
09F1            100             10253.35800000     90.55972222     21.66416667     CP

09F2            100             10253.35800000     269.44166667    201.66416667    CP

03NM5.43000000
09F2            100             10149.98800000     269.38583333    179.99777778    CP

09MC            100             10149.98639201     90.40869048     0.00000000      CP

03NM5.52000000
09MC            100             10253.35719801     90.46225006     21.66527778     CP

07SC            100             1010.00000000      -0.00111111
03NM5.43000000
02TP            10010000.0000      20000.0000      500.0000        5.6100          CP

03NM5.43000000
07TP            100             1010.00000000      0.00000000
09F1            100             10149.98800000     90.61527778     0.00000000      CP

13NMCalculated: AR 0°00'00"HD49.985, Z499.643
13NMMeasured: AR 0°00'00"HD49.985, Z499.643
13NMDelta: AR 0°00'00"HD0.000, Z0.000
09F1            100             100049.98800000    90.61527778     0.00000000      CPBS 101

03NM-0.32000000
09F1            100             100127.15700000    80.55722222     8.80000000      TOE PT

13NMEDM Mode: Standard
09F1            100             100230.01400000    98.37305556     7.99972222      KEEL
```

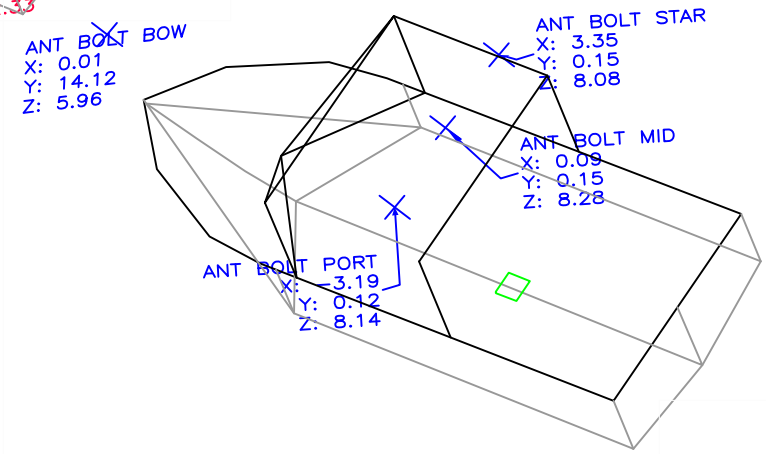
```
STERN
03NM0.32000000
09F1            100          100329.88500000    91.92500000     14.13583333     BM-E

09F1            100          100433.97500000    91.68000000     15.06527778     BM-D

09F1            100          100536.12600000    84.69166667     12.91333333     BM-C

09F1            100          100636.52900000    84.69638889     5.74000000      BM-H

09F1            100          100737.88100000    82.65500000     4.37944444      GPS ANT.
BOLT PO
09F1            100          100837.51200000    82.36444444     9.36805556      GPS ANT.
BOLT MI
09F1            100          100937.36000000    82.63361111     14.39666667     GPS ANT.
BOLT ST
03NM5.00000000
09F1            100          101037.06300000    87.85694444     9.21222222      IMU
TARGET
09F1            100          101136.57800000    88.68944444     9.79416667      IMU PLATE

09F1            100          101237.41900000    88.72444444     9.91111111      IMU PLATE

09F1            100          101337.47900000    88.70555556     8.65805556      IMU PLATE

09F1            100          101437.45300000    88.70333333     8.58444444      IMU PLATE

09F1            100          101536.64200000    88.67111111     8.45944444      IMU PLATE

03NM5.43000000
09F1            100          101649.98800000    90.61500000     0.00027778      CPBS 101

13NMSet Collection with Obs Order 123...321...
02SC            10210049.5862      20019.6980   499.5690        5.7300          CP

03NM5.40000000
12SC            102001001111
03NM5.40000000
09F1            102            10053.35500000   89.89333333     0.00000000      CP

03NM5.43000000
09F1            102            10319.70600000   90.65833333     69.48833333     CPCHK 101

09F2            102            10319.70600000   269.34388889    249.48944444    CPCHK 101

03NM5.40000000
09F2            102            10053.35400000   270.10972222    179.99611111    CP

13NMWarning: Horizontal Angles to foresight differ by 0°00'00"°00.0000
09MC            102            10053.35614286   89.53757673     201.66527778    CP

03NM5.43000000
09MC            102            10319.70484240   89.78493577     271.15611111    CPCHK 101

07SC            102            100201.66527778  -0.00194444
03NM5.40000000
02TP            10210049.5862      20019.6980   499.5690        5.7300          CP

03NM5.40000000
07TP            102            100201.66527778  0.00000000
09F1            102            10053.35400000   89.89416667     0.00000000      CP

13NMCalculated: AR 0°00'00"HD53.355, Z500.000
13NMMeasured: AR 0°00'00"HD53.354, Z499.998
13NMDelta: AR 0°00'00"HD-0.002, Z-0.002
```

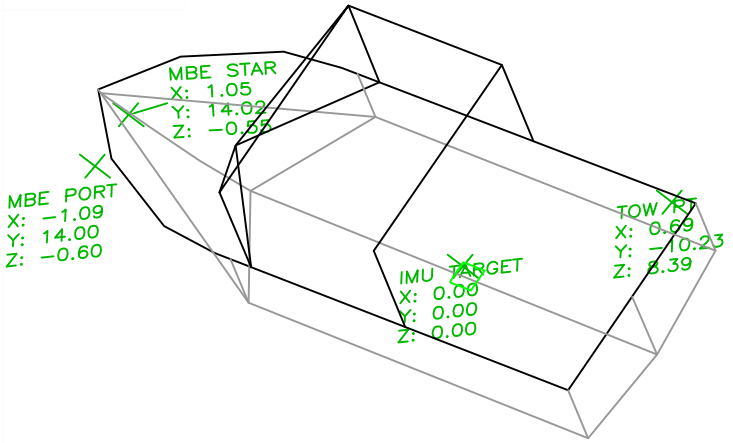
```
09F1            102          101753.35400000     89.89416667     0.00055556      CPBS 100

03NM0.32000000
09F1            102          101810.37300000     93.60972222     33.94722222     BM-B

09F1            102          101910.74600000     73.93055556     71.98666667     GPS ANT.
BOLT BO
03NM5.00000000
09F1            102          102011.25700000     68.59583333     62.85250000     BM-A

03NM0.32000000
09F1            102          102117.98600000     73.52222222     15.78000000     CHK 1009

03NM-0.32000000
09F1            102          102210.49000000     97.31361111     69.74166667     KEEL BOW

03NM-0.42000000
09F1            102          102310.25000000     114.60222222    70.19583333     MBE STAR

03NM-0.32000000
09F1            102          102410.50400000     97.26944444     69.38250000     KEEL

09F1            102          102511.17100000     102.43111111    60.79138889     KEEL

09F1            102          102612.11800000     105.84361111    53.14583333     KEEL

09F1            102          102713.25500000     107.74638889    46.05777778     KEEL

03NM0.10000000
09F1            102          102810.43500000     94.00166667     69.63944444     HULL STA.

03NM0.32000000
09F1            102          10298.97900000      93.63750000     54.86472222     HULL STA.

09F1            102          10309.68100000      93.73555556     34.00611111     HULL STA.

09F1            102          103111.24100000     93.39361111     25.90388889     HULL STA.

09F1            102          103224.11800000     91.66388889     7.27194444      HULL STA.

03NM5.40000000
09F1            102          103353.35500000     89.89277778     0.00000000      CPBS 100

13NMSet Collection with Obs Order 123...321...
02SC            10310049.9838     19999.9973     499.6430        5.6300          CPCHK 101

03NM5.52000000
12SC            103001001111
03NM5.52000000
09F1            103           10219.70400000     90.57972222     0.00000000      CP

03NM5.40000000
09F1            103           10449.98400000     89.86777778     88.84194444     CPCT 100

09F2            103           10449.98400000     270.13194444    268.84027778    CPCT 100

03NM5.52000000
09F2            103           10219.70400000     269.42111111    179.99777778    CP

09MC            103           10219.70319513     90.25930755     91.15611111     CP

03NM5.40000000
09MC            103           10449.98505993     89.60413819     179.99833333    CPCT 100

07SC            103           10291.15611111     -0.00111111
```

```
03NM5.52000000
02TP            10310049.9838      19999.9973      499.6430        5.6300          CPCHK 101

03NM5.52000000
07TP            103              10291.15611111    0.00000000
09F1            103              10219.70400000    90.58000000     0.00000000      CP

13NMCalculated: AR 0°00'00"HD19.705, Z499.569
13NMMeasured: AR 0°00'00"HD19.703, Z499.554
13NMDelta: AR 0°00'00"HD-0.002, Z-0.015
09F1            103              103419.70400000   90.58000000     0.00000000      CPBS 102

03NM0.32000000
09F1            103              103513.84200000   68.07527778     75.97861111     CHK 1007

09F1            103              10366.55500000    94.90111111     43.29000000     BM-I

09F1            103              103715.66400000   92.23083333     82.97666667     BM-G

09F1            103              103819.49400000   91.86861111     85.55500000     BM-F

03NM-0.42000000
09F1            103              10399.35800000    117.37833333    355.99694444    MBE PORT

03NM0.32000000
09F1            103              10406.91800000    94.35194444     11.00833333     HULL PORT

09F1            103              10416.03900000    95.12666667     41.07000000     HULL PORT

09F1            103              10427.11400000    94.70416667     57.31888889     HULL PORT

09F1            103              104319.57300000   91.89333333     88.04111111     HULL PORT

03NM5.52000000
09F1            103              104419.70400000   90.57916667     359.99972222    CPBS 102

02TP            10310049.9838      19999.9973      499.6430        5.6300          CPCHK 101

03NM5.52000000
07TP            103              10291.15611111    0.00000000
09F1            103              10219.70400000    90.57916667     0.00000000      CP

13NMCalculated: AR 0°00'03"HD19.705, Z499.569
13NMMeasured: AR 0°00'00"HD19.703, Z499.554
13NMDelta: AR 0°00'00"HD-0.002, Z-0.015
13NMEDM Mode: Reflectorless
13NMP.C. mm Applied: 34.4000
13NMEDM Mode: Standard
13NMP.C. mm Applied: 4.4000
13NMEDM Mode: Reflectorless
13NMP.C. mm Applied: 34.4000
03NM0.00000000
09F1            103              104513.23700000   102.10861111    76.31305556     .0+07.38
Lt3.2
13SOCut 0.000       DNorth 0.789        DEast 3.135
13NMEDM Mode: Standard
13NMP.C. mm Applied: 4.4000
03NM5.52000000
09F1            103              104619.70400000   90.57888889     359.99750000    .CPBS 102

13SOCut 0.000       DNorth 13.027       DEast 13.756
02TP            10210049.5862      20019.6980      499.5690        5.7300          CP

03NM5.43000000
07TP            102              103271.15611111   0.00000000
```

```
09F1            102             10319.70600000      90.65694444     0.00000000      CPCHK 101

13NMCalculated: AR 0°00'00"HD19.705, Z499.643
13NMMeasured: AR 0°00'00"HD19.705, Z499.643
13NMDelta: AR 0°00'00"HD0.000, Z0.000
13NMEDM Mode: Reflectorless
13NMP.C. mm Applied: 34.4000
03NM0.00000000
09F1            102            104717.65300000      99.11166667     306.40500000    .0+07.38
Rt3.2
13SOCut 0.004       DNorth 0.791        DEast 3.132
13NMEDM Mode: Standard
13NMP.C. mm Applied: 4.4000
03NM5.43000000
09F1            102            104819.70600000      90.65611111     359.99944444    .CPBS 103

13SOCut 0.000       DNorth 13.423       DEast 5.943
```







TETRA TECH EC, INC.

LEGEND

- Benchmarks
- Antenna Points
- Equipment Points

Figure 2 - "Storm" Survey Vessel: Isometric View

NOTES:

1. INCA survey from Leica Total Station on December 5th, 2008
2. Benchmarks placed for repeatability and new equipment reference
3. Survey taken with Dual Multibeam Echosounder (MBE) Bow Mount in collection position
4. Survey taken with davit in locked collection position

Geodetic Setting:

1. Datum: Inertial Measurement Unit (IMU) reference frame
2. Horizontal and Vertical Units: US Feet

Start of survey	**Port**	**Starboard**	**Draft**
Tuesday 18th Nov.			
Morning	1.634		0.896
	1.634		
	1.636		
Wednesday 19th Nov.	1.644		0.905
	1.644		
	1.644		
Thursday 20th Nov.			
Morning	1.625		0.889
	1.625		
	1.63		
Night	1.65		0.908
	1.64		
	1.65		
Friday 21st Nov.			
morning	No Survey		
Saturday 22nd Nov.			
Morning	1.64		0.897
	1.635		
	1.633		
JD 328_0100			
	164.5		0.906
	164.5		
	164.5		
JD 329_1556	1.645		0.909
	1.648		
	1.65		
JD 330_0050	1.65		0.911
	1.652		
	1.648		
JD 330_1538	1.62		0.917
	1.5		
	1.55		
JD330_2239	1.65		0.911
	1.65		
	1.65		
JD343_1700	1.6		0.861
	1.6		
	1.6		

Draft calculator	
1	1.63
2	1.63
3	1.635
xducer draft =	=(G3+G4+G5)/3-0.739

JD344_0040	1.605	0.863
	1.6	
	1.6	
JD344_1600	1.605	0.869
	1.61	
	1.61	
JD345_0030	1.615	0.878
	1.62	
	1.617	
JD345_1530	1.61	0.868
	1.605	
	1.605	
JD346_0100	1.61	0.871
	1.61	
	1.61	
JD346_1540	1.61	0.87
	1.608	
	1.61	
JD347_0020	1.62	0.881
	1.62	
	1.62	
JD347_1530	1.62	0.881
	1.62	
	1.62	
JD348_1830	1.63	0.889
	1.63	
	1.625	
JD349_0015	1.64	0.901
	1.64	
	1.64	
JD349_1555	1.64	0.898
	1.64	
	1.63	
JD350_0015	1.64	0.897
	1.63	
	1.637	
JD350_1550	1.645	0.908
	1.65	
	1.645	

JD351_0030	1.65 1.645 1.65	0.909
JD351_1620	1.65 1.655 1.655	0.914
JD352_0030	1.645 1.645 1.65	0.908
JD352_1614	1.635 1.64 1.638	0.899
JD352_2008	1.65 1.65 1.645	0.909
JD_353_1551	1.65 1.65 1.65	0.911
JD_354_0020	1.65 1.645 1.645	0.908
JD_354_1550	1.65 1.65 1.648	0.91
JD_354_2323	1.66 1.658 1.66	0.92
JD_355_1555	1.63 1.63 1.635	0.893

EM3002 CALIBRATION (PATCH TEST)

Multibeam Calibration

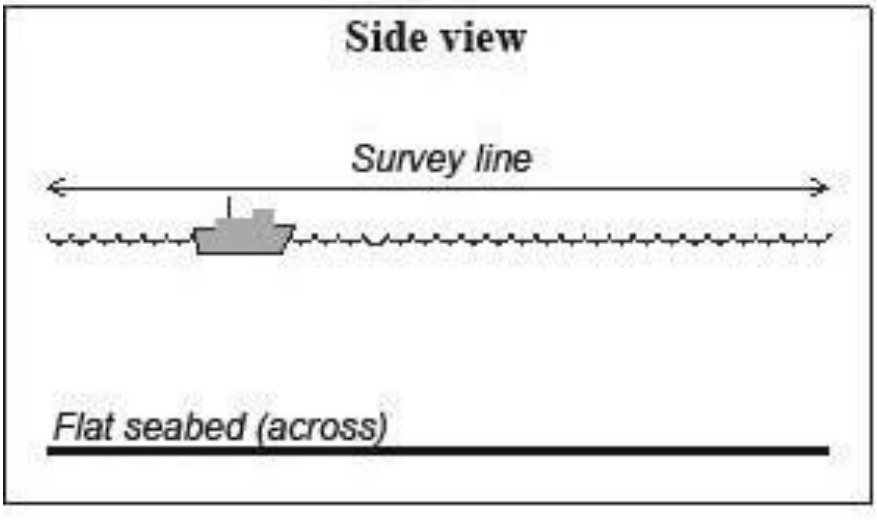
On a flat area only roll error will cause significant depth errors. (Sound speed and echo sounder errors are not considered in this discussion.) Thus if the survey is to be run in a reasonably flat area, it may be sufficient to perform roll calibration only. Usually, however, a full calibration is required, and the calibration should then be done so that different sensor errors have no influence on the echo sounder data, except for the one which is to be determined. Note that the positioning accuracy is vital for good calibration results, except for the roll error calibration on a flat bottom.

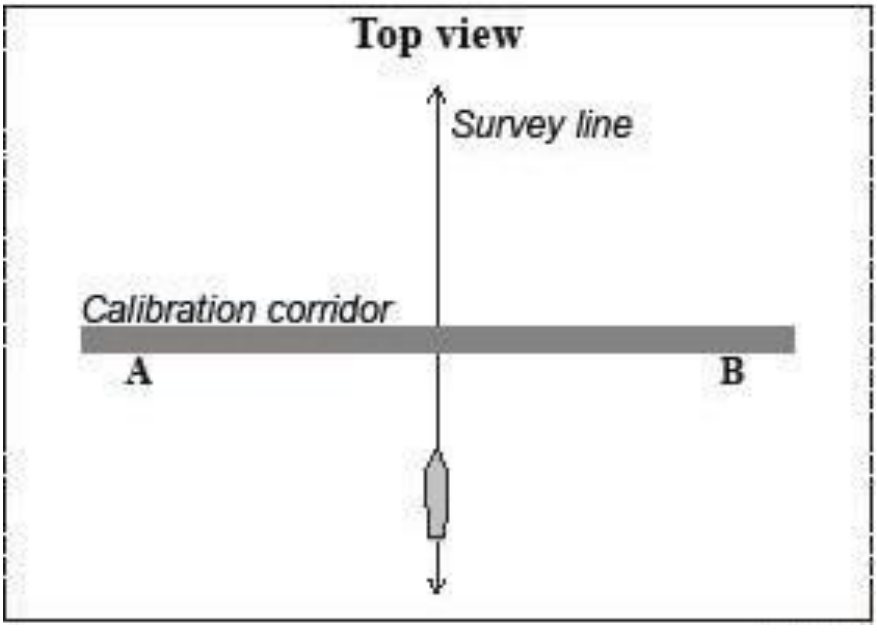
The ideal calibration area is partly flat and partly a fairly steep slope with little change in depth acrosstrack, and with a distinct feature such as a peak or hollow in the flat area. If the heading and positioning errors are negligible, the flat area is not required if the slope has a reasonably constant depth acrosstrack. The slope used for pitch and time delay calibration should have an appreciable relative change in depth from top to bottom, say 30%, if pitch offset and time delay are to be resolved accurately. Note that the slope should not be too steep, say not more than 20%, otherwise the echo sounder could have problems in maintaining good data quality.

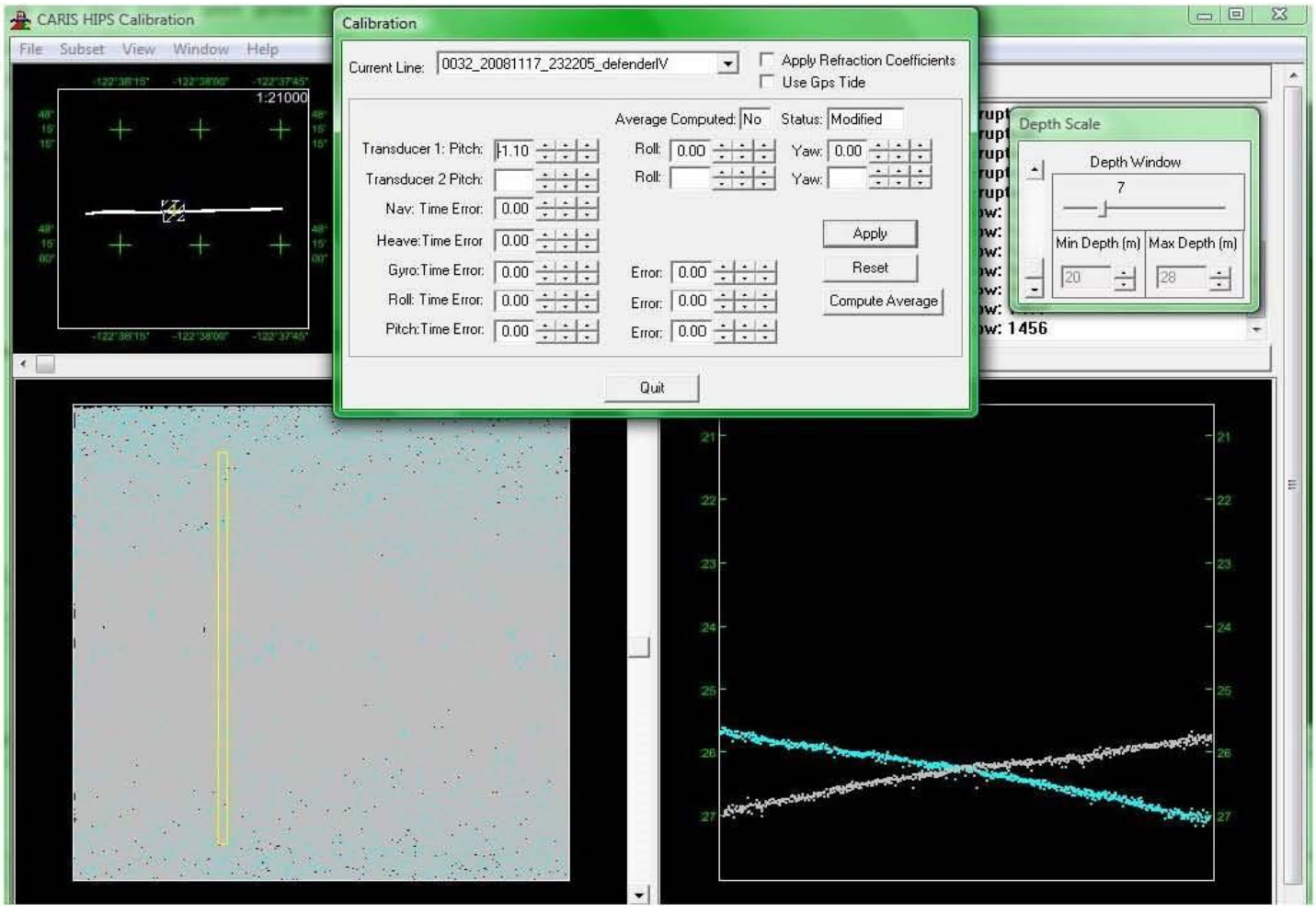
Procedures for running a MBES calibration (patch test)

Roll offset in the acrosstrack direction

Choose a horizontally flat area (at least acrosstrack). Survey a sufficiently long line twice in opposite directions. Ensure that a sufficient lead-in time to the line is used for the roll sensor to stabilize. The corridor used to compare data from the two survey data sets should be placed orthogonally to the survey lines. If there is a roll offset, there will be a depth difference between the two data sets, increasing with acrosstrack distance from the centre where it is zero.



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File Subset View Window Help
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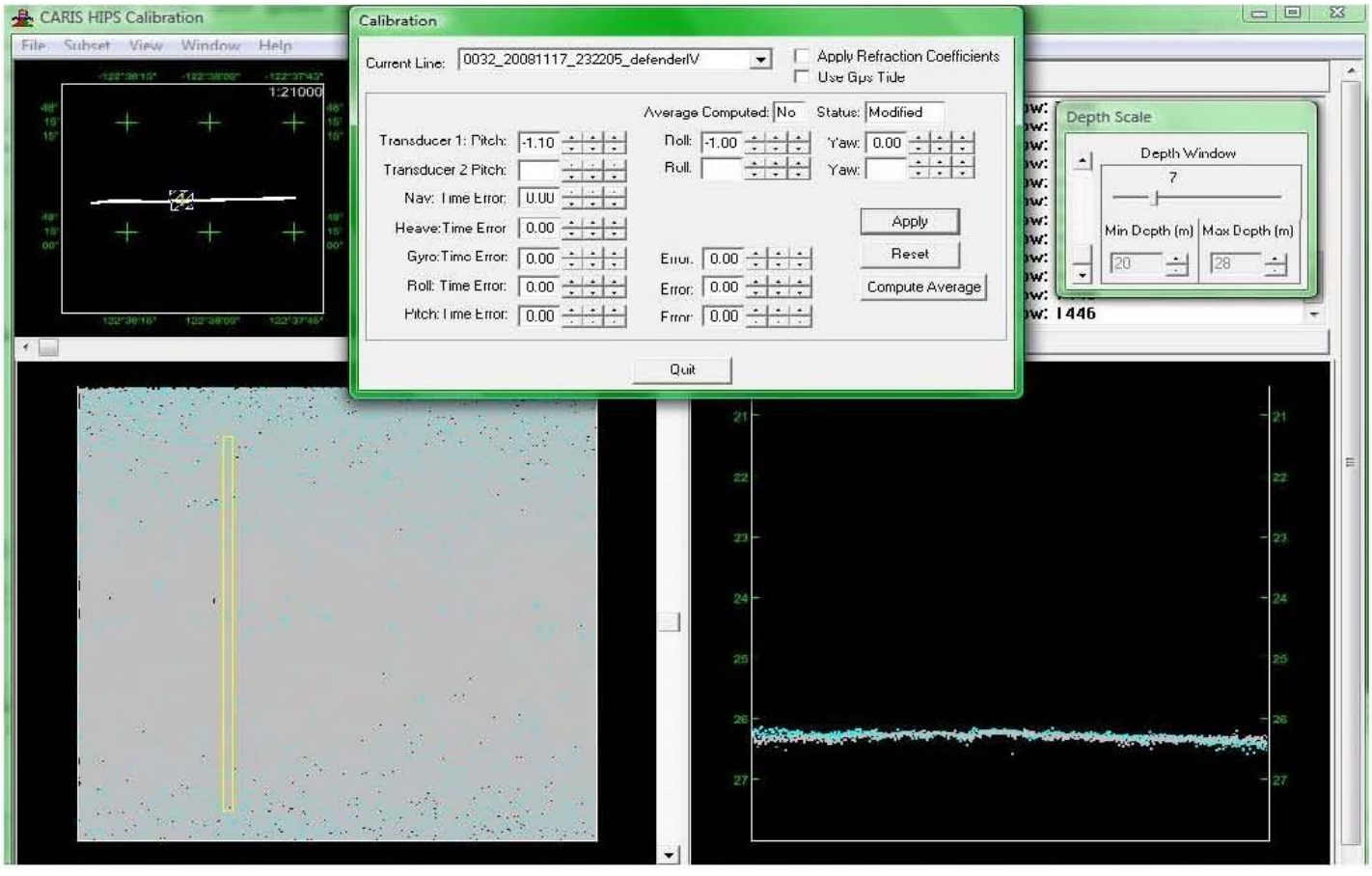
Calibration
Current Line: 0032_20081117_232205_defenderIV
Apply Refraction Coefficients
Use Gps Tide
Average Computed: No
Status: Modified
Transducer 1: Pitch: -1.10
Roll: 0.00
Yaw: 0.00
Transducer 2 Pitch:
Roll:
Yaw:
Nav: Time Error: 0.00
Heave: Time Error 0.00
Gyro: Time Error: 0.00
Roll: Time Error: 0.00
Pitch: Time Error: 0.00
Error: 0.00
Error: 0.00
Error: 0.00
Apply
Reset
Compute Average
Quit
Depth Scale
Depth Window
7
Min Depth (m)
Max Depth (m)
20
28
w: 1456


CARIS HIPS Calibration
File Subset View Window Help
1:21000
Calibration
Current Line: 0032_20081117_232205_defenderIV
Apply Refraction Coefficients
Use Gps Tide
Average Computed: No
Status: Modified
Transducer 1: Pitch: -1.10
Roll: -1.00
Yaw: 0.00
Transducer 2 Pitch:
Roll:
Yaw:
Nav: Time Error: 0.00
Heave: Time Error 0.00
Gyro: Time Error: 0.00
Roll: Time Error: 0.00
Pitch: Time Error: 0.00
Error: 0.00
Error: 0.00
Error: 0.00
Apply
Reset
Compute Average
Quit
Depth Scale
Depth Window
7
Min Depth (m)
Max Depth (m)
20
28
w: 1446

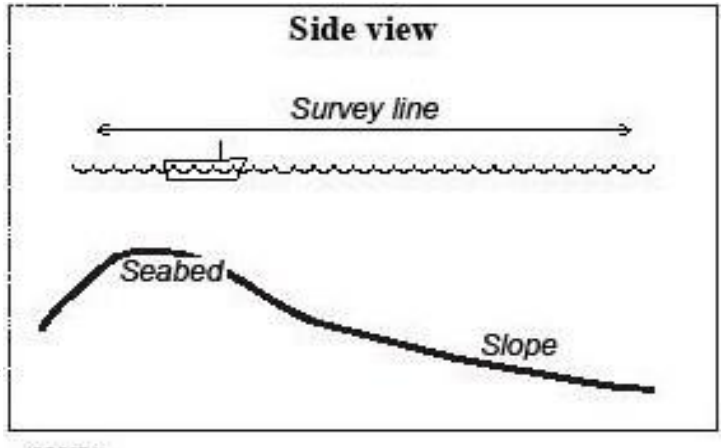
Pitch offset and time delay

Choose an area with a continuous but not too steep slope alongtrack. Survey a sufficiently long line twice in opposite directions with the same vessel speed, and once with a significantly lower speed. The direction is not important in the last survey. Ensure that a sufficient lead-in time to the line is used for the pitch sensor to stabilize.

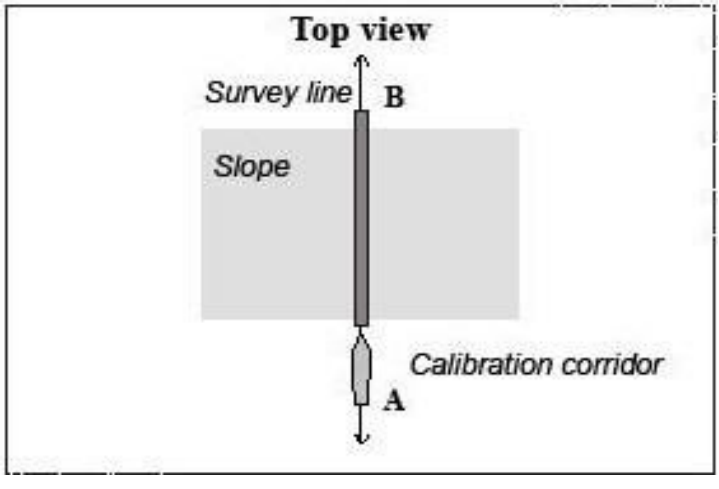
The corridor used to compare data from the survey data sets should be placed parallel to the survey line on the vessel track. Any alongtrack depth difference between the runs may be due to four different factors:

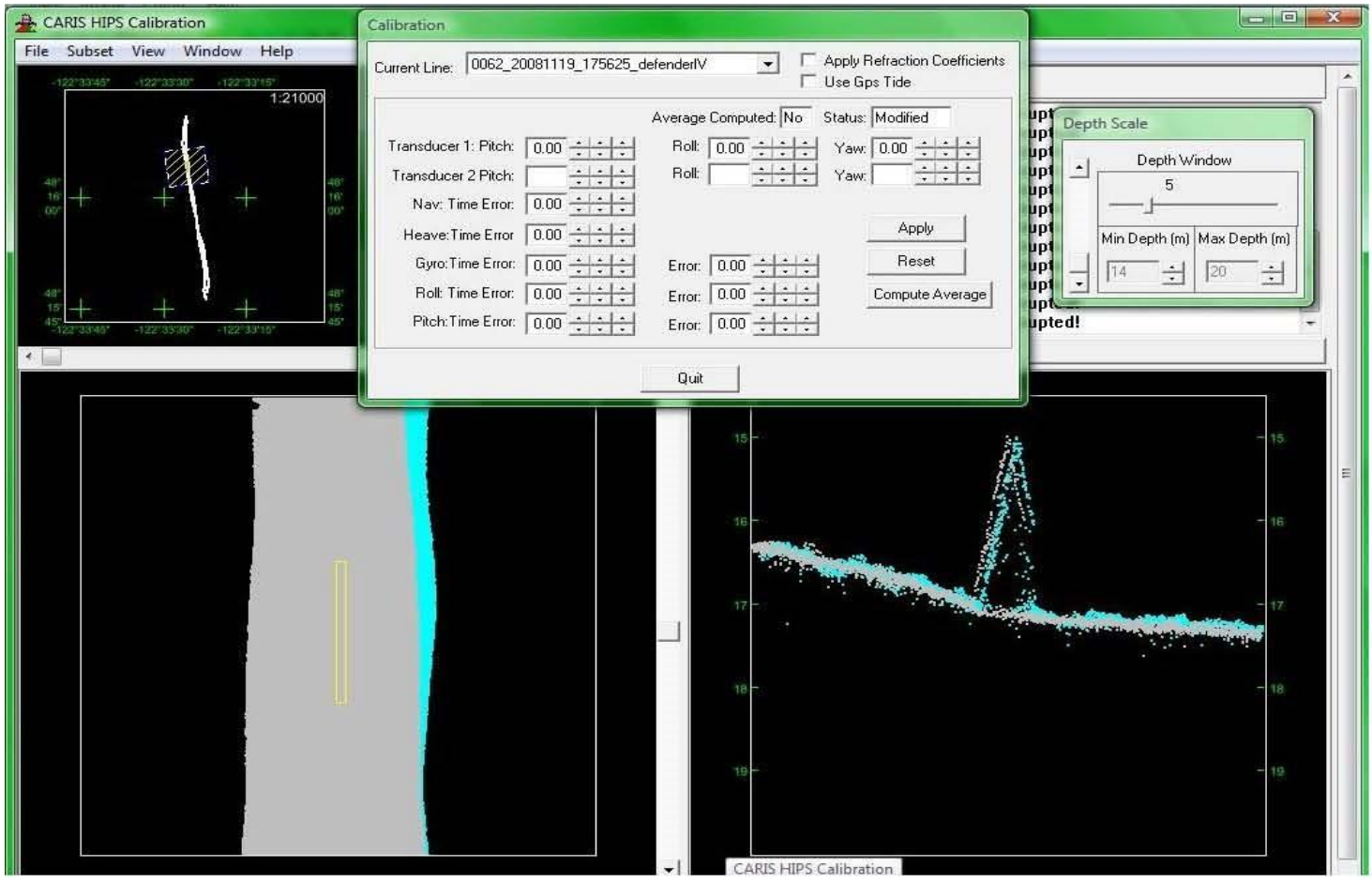
- Pitch offset.
- Time delay between actual position and position when position datagram is supposed to be valid.
- Multibeam echo sounders with transducers: Position distance offset (either due to an error in the positioning system or an error in entered locations).
- Tide difference.

Note that a depth error on a constant gradient slope, due to pitch offset, increases with increasing depths, while that due to position time delay increases with vessel speed, while that due to distance offset is independent of depth and speed. Comparing data from the two lines in the same direction, but with different vessel speed, will thus allow the time delay to be found. After the correction for any time delay error has been applied to the data, the pitch offset can be determined from the two lines run in opposite directions. Any distance offset must of course first be removed.



(CD3571)

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File Subset View Window Help
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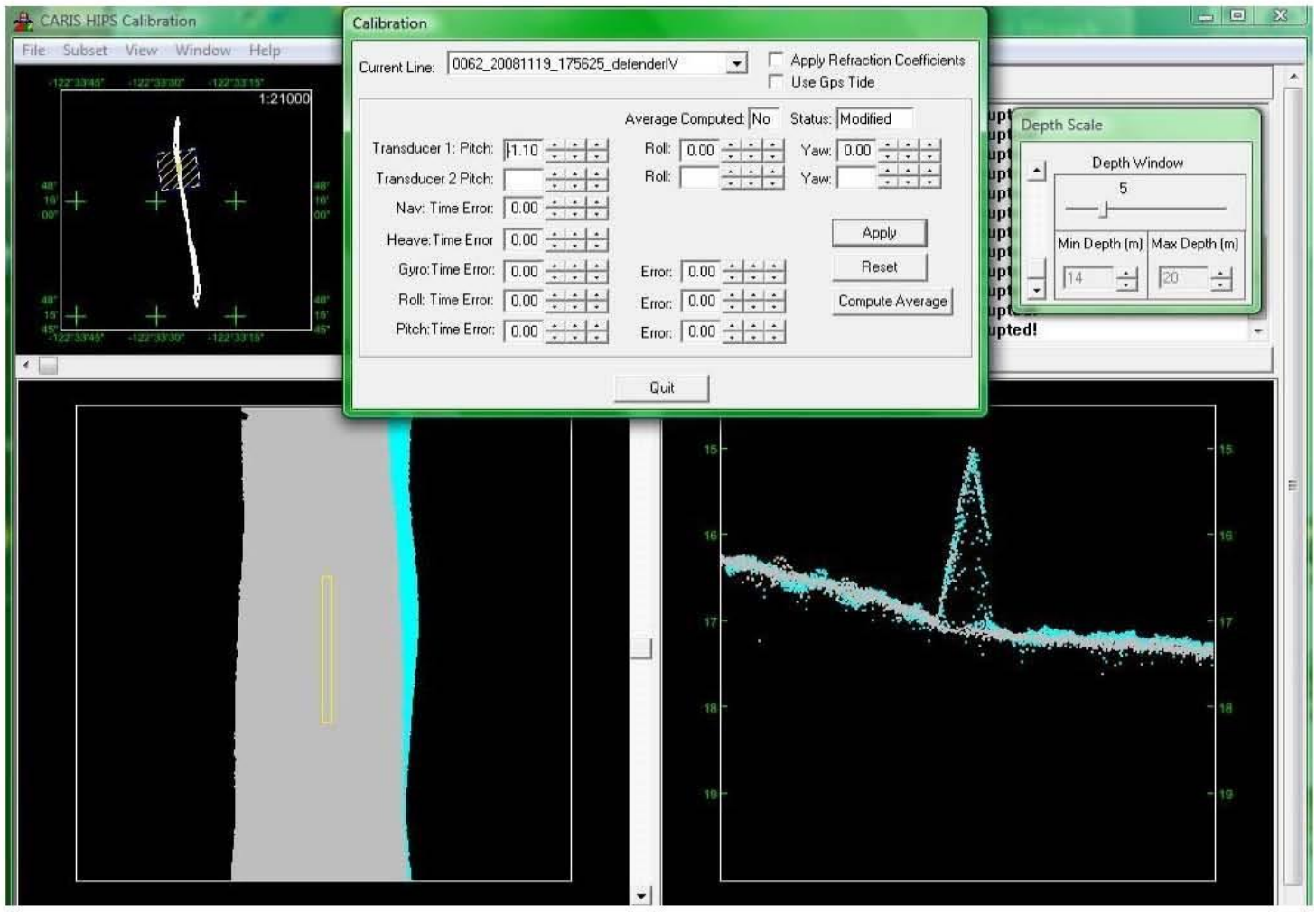
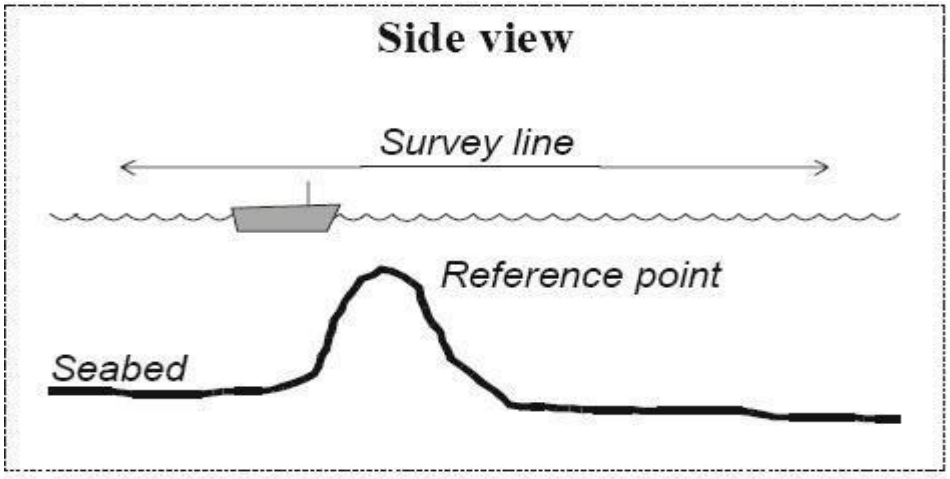
Calibration
Current Line: 0062_20081119_175625_defenderIV
Apply Refraction Coefficients
Use Gps Tide
Average Computed: No
Status: Modified
Transducer 1: Pitch: 0.00
Roll: 0.00
Yaw: 0.00
Transducer 2 Pitch:
Roll:
Yaw:
Nav: Time Error: 0.00
Heave: Time Error 0.00
Gyro: Time Error: 0.00
Roll: Time Error: 0.00
Pitch: Time Error: 0.00
Error: 0.00
Apply
Reset
Compute Average
Quit
Depth Scale
Depth Window
5
Min Depth (m)
Max Depth (m)
14
20
upted!
CARIS HIPS Calibration


CARIS HIPS Calibration
File Subset View Window Help
1:21000
Calibration
Current Line: 0062_20081119_175625_defenderIV
Apply Refraction Coefficients
Use Gps Tide
Average Computed: No
Status: Modified
Transducer 1: Pitch: -1.10
Roll: 0.00
Yaw: 0.00
Transducer 2 Pitch:
Roll:
Yaw:
Nav: Time Error: 0.00
Heave: Time Error 0.00
Gyro: Time Error: 0.00
Roll: Time Error: 0.00
Pitch: Time Error: 0.00
Error: 0.00
Apply
Reset
Compute Average
Quit
Depth Scale
Depth Window
5
Min Depth (m)
Max Depth (m)
14
20
upted!

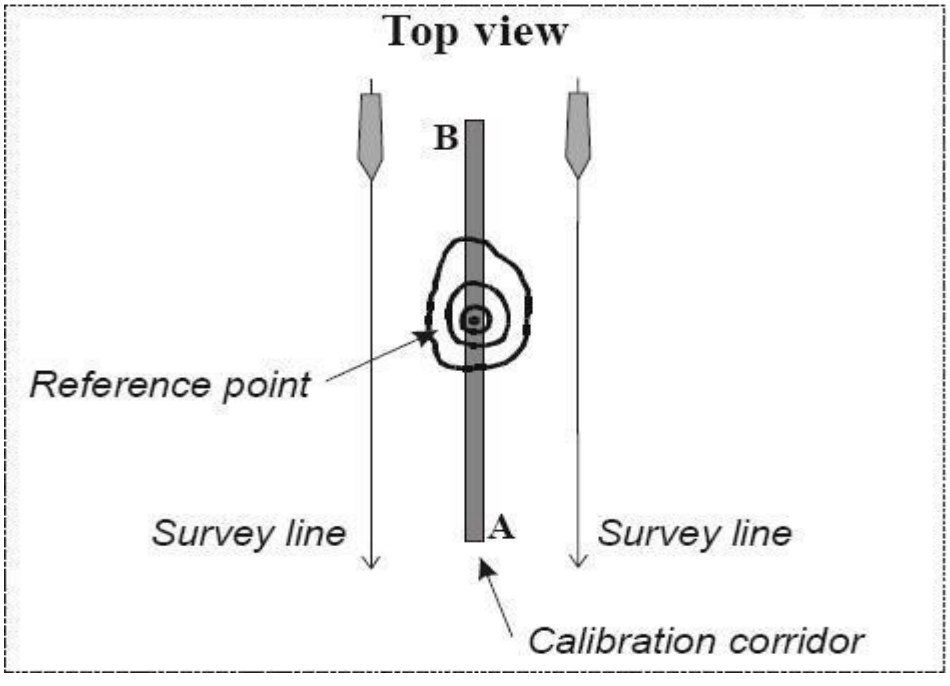
Heading offset

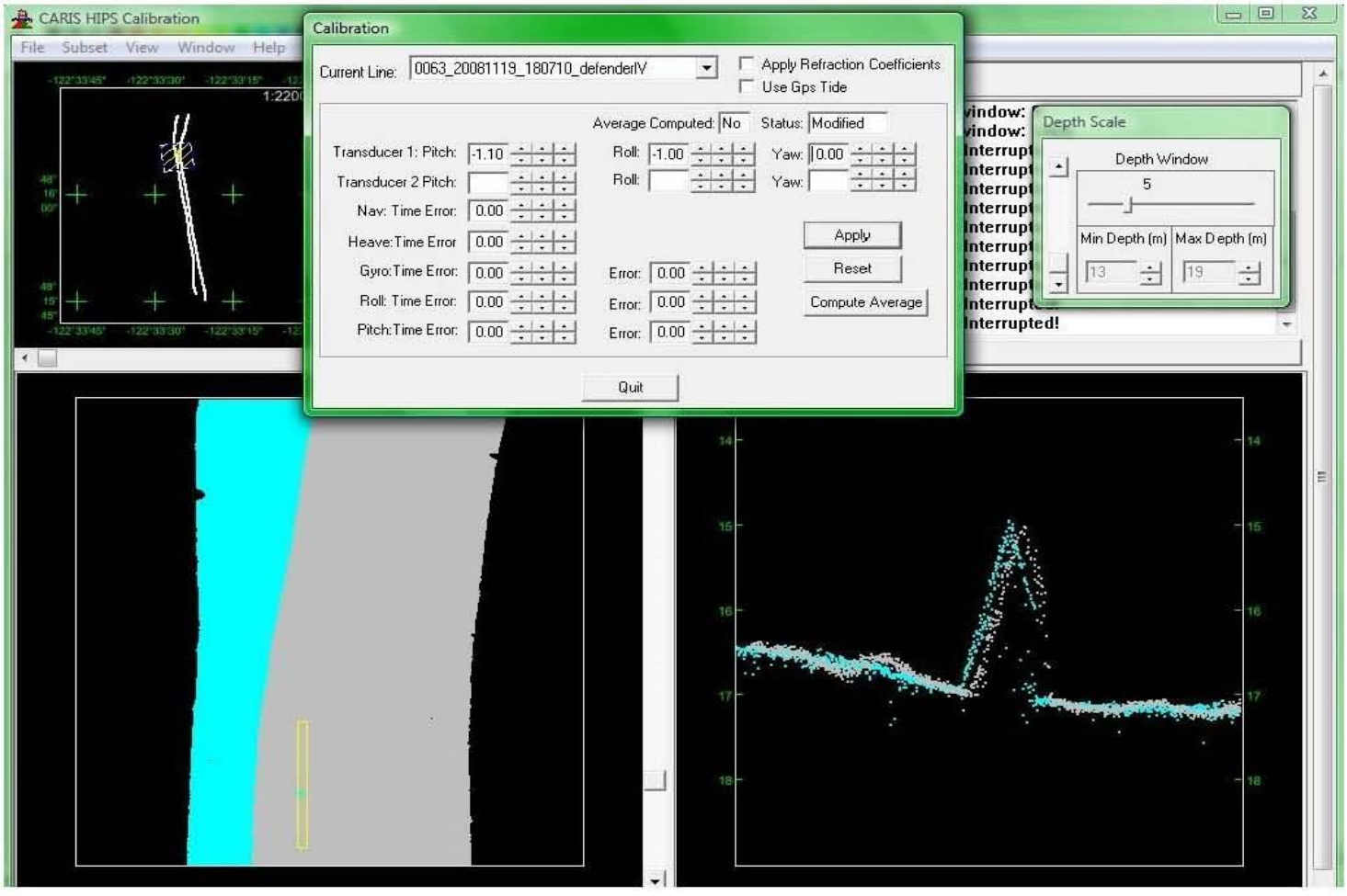
Find an easy recognizable point or feature on the bottom such as a peak or a depression. Set up **two** survey lines well to opposite sides of this feature so that the point will be in the outer part of the echo sounder swath. Survey these two lines in same direction.

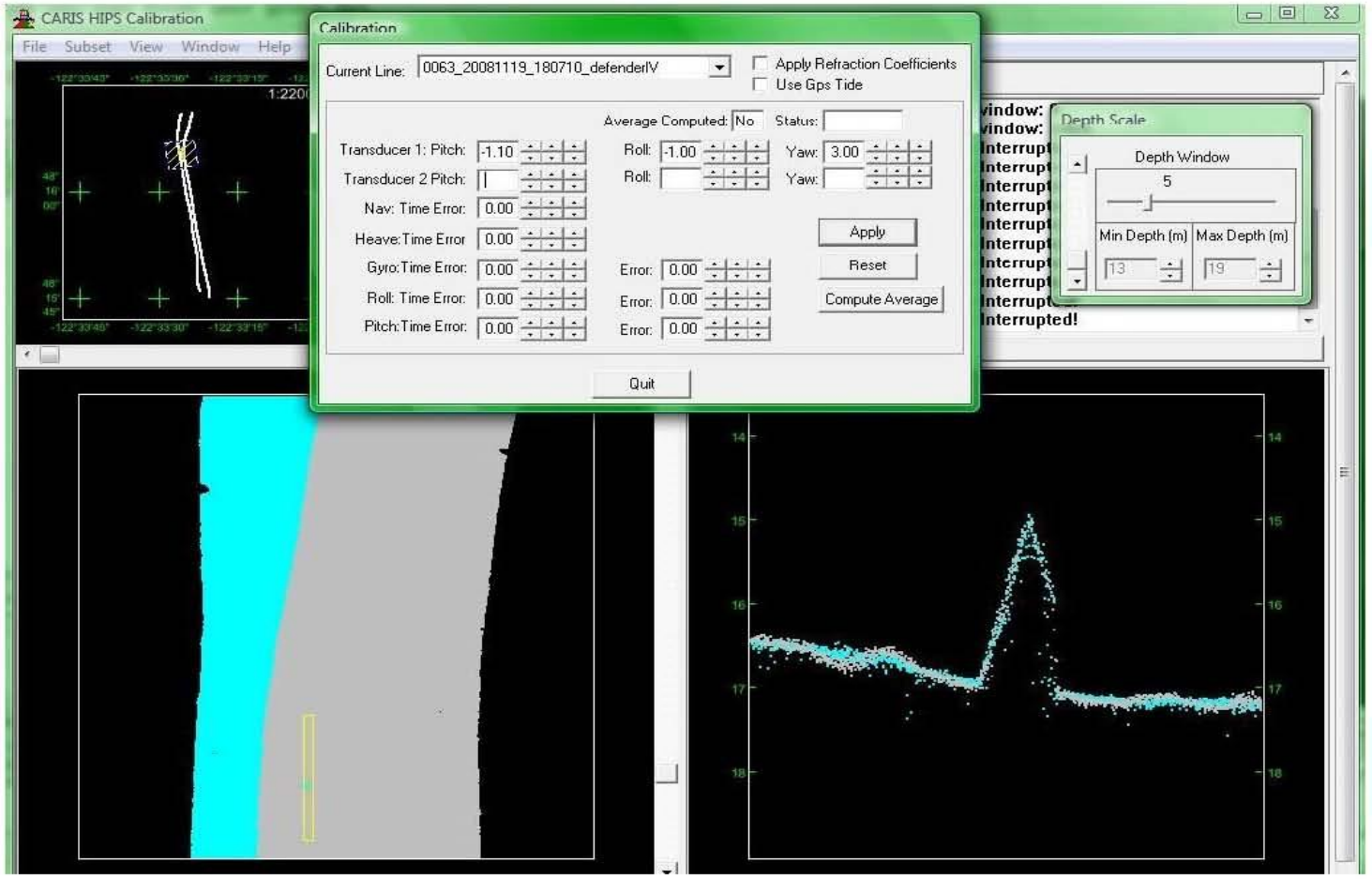
The corridor used to compare data from the two survey data sets should be placed so that it intersects the feature, and is parallel to the survey lines. If there is a heading offset, you will have a different location alongtrack in the two data sets.


Side view
Survey line
Reference point
Seabed

(CD3572)


Top view
B
Reference point
Survey line
A
Survey line
Calibration corridor


CARIS HIPS Calibration
File Subset View Window Help
Calibration
Current Line: 0063_20081119_180710_defenderIV
Apply Refraction Coefficients
Use Gps Tide
Average Computed: No
Status: Modified
Transducer 1: Pitch: -1.10
Roll: -1.00
Yaw: 0.00
Transducer 2 Pitch:
Roll:
Yaw:
Nav: Time Error: 0.00
Heave:Time Error 0.00
Gyro:Time Error: 0.00
Error: 0.00
Roll: Time Error: 0.00
Error: 0.00
Pitch:Time Error: 0.00
Error: 0.00
Apply
Reset
Compute Average
Quit
Depth Scale
Depth Window
5
Min Depth (m)
Max Depth (m)
13
19
Interrupted!


CARIS HIPS Calibration
File Subset View Window Help
Calibration
Current Line: 0063_20081119_180710_defenderIV
Apply Refraction Coefficients
Use Gps Tide
Average Computed: No
Status:
Transducer 1: Pitch: -1.10
Roll: -1.00
Yaw: 3.00
Transducer 2 Pitch:
Roll:
Yaw:
Nav: Time Error: 0.00
Heave:Time Error 0.00
Gyro:Time Error: 0.00
Error: 0.00
Roll: Time Error: 0.00
Error: 0.00
Pitch:Time Error: 0.00
Error: 0.00
Apply
Reset
Compute Average
Quit
Depth Scale
Depth Window
5
Min Depth (m)
Max Depth (m)
13
19
Interrupted!