

H11829

NOAA FORM 76-35A U.S. DEPARTMENT OF COMMERCE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION NATIONAL OCEAN SERVICE
DATA ACQUISITION AND PROCESSING REPORT
Type of Survey: <u>Hydrographic Multibeam & 200% Sidescan</u>
Project Number: <u>OPR-K977-CC-08</u>
Time Frame: <u>July 2008 - October 2009</u>
LOCALITY
State: <u>Louisiana</u>
General Locality: <u>Gulf of Mexico</u>
<u>2009</u>
CHIEFS OF PARTY <u>Scott Croft, John Baker</u>
LIBRARY & ARCHIVES
DATE: _____

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A. EQUIPMENT

The major operational systems used to acquire hydrographic data include Odom 200 kHz Hydrotrac single beam echosounders, Simrad EM3002 multibeam echo sounders, Klein 5000 side scan sonars, and GeoAcustics side scan sonars. A combination of PCs and Sun Workstations were used to collect and process the data. All computers were networked to allow for precise time tagging and georeferencing of the data, and for efficient data transfer.

System	Manufacturer	Model
Multibeam Sonar	Simrad	EM3002
Side Scan Sonar (Inez McCall)	Klein	5000
Side Scan Sonar (C-Wolf & High Roller)	GeoAcoustics	159D
Side Scan Sonar (C-Ghost)	Edgetech	4200
Single Beam Sonar (Inez McCall)	ODOM	Echotrac DF3200 MK II
Single Beam Sonar (Small Vessels)	ODOM	Hydrotrac
Motion Sensor (Inez McCall)	Applanix	POS MV
Motion Sensor (C-Ghost & C-Wolf)	CODA	F180
Motion Sensor (High Roller)	TSS	335B
Primary Positioning System	CNAV	2050
Secondary Positioning System	CNAV	2050
Tertiary Positioning System (C-Ghost & C-Wolf)	CODA	F180
Tertiary Positioning System (Inez McCall)	Applanix	POS MV
Sound Speed at Transducer	Endeco	YSI
Sound Velocity Profiler	Seabird	SBE19 Plus

A.1 SURVEY VESSELS

Survey operations were conducted aboard the *Inez McCall*, *High Roller*, *C-Ghost*, and *C-Wolf*. The *Inez McCall* was leased from Cameron Offshore Boats of Cameron, Louisiana, the *High Roller* was leased from Arcement Marine of Breau Bridge Louisiana, and the *C-Ghost*, and *C-Wolf* are owned and operated by C&C Technologies.

Vessel diagrams and specifications are included in Appendix A. The diagrams show all offsets from the vessel center reference points to the antennas and to all survey equipment. The details of the vessels include registration numbers, capacity, and equipment.

A.2 SINGLE BEAM SONAR OPERATIONS

An Odom Hydrotrac was used to collect single beam data on board all of the small vessels, and an Odom Echotrac was used on the *Inez McCall*. Data from the single beam was continuously recorded and monitored in real-time as an independent check of the nadir beam (bottom-detect) of the multibeam sonar systems aboard the *C-Wolf* and the *Inez McCall*. The *C-Ghost* and the *High Roller* collected single beam data only.

A.3 MULTIBEAM SONAR OPERATIONS

Survey operations were conducted using a single head Simrad EM 3002 on board the *Inez McCall* and the *C-Wolf*. The *Inez McCall's* transducer head was mounted at the base of a pole attached to the bow of the vessel. The transducer on board the *C-Wolf* was mounted in a moon pool configuration. Multibeam sonar operations were conducted in a manner such that the accuracy and resolution standards set forth in Section 5.2 of the Specifications and Deliverables document were met. The swath was reduced to an angular sector of 45° to 60°, which provided over 2 times water depth of coverage and ensured that the detection criteria of being able to detect a 2 x 2 x 1 meter object was met. The survey speed was generally held to under 8 knots, and with a ping rate of 6 to 8 pings per second the criterion of 3.2 beam footprints per 3 meter along track distance was met.

C&C Technologies' proprietary Hydromap software was used for multibeam data collection, processing, quality assurance, and quality control aboard the *Inez McCall* and the *C-Wolf*. During data collection, the quality of the data was monitored in real

time. The display included a coverage map, several ping display waterfalls, and other parameter displays. These tools allowed the operator to monitor coverage, compare between single beam and multibeam depths, compare between the different positioning systems, and identify any ray-bending effects in real time. Corrective measures were made whenever necessary, ensuring that only quality data was collected. In cases where reruns were necessary due to degraded quality of data or due to lack of coverage, this was recorded and the data later rerun.

Winfrog, from Thales GeoSolutions was used aboard the *C-Ghost* and the *High Roller* to collect the single beam data.

A.4 SIDE SCAN SONAR OPERATIONS

On board the *Inez McCall*, the Klein 5500 side scan sonar was operated in a towed configuration. The tow point was at the stern of the boat, 17.97 meters astern of the vessel reference center.

GeoAcustics side scan sonars were towed from the bow of the *C-Wolf* and the *High Roller*, while an Edgetech 3200 was towed from the bow of the *C-Ghost*. Survey operations were conducted at speeds averaging 5 knots, exceeding the requirement that a 1-meter target be ensonified a minimum of three times per pass. The side scan sonar was operated at range scales of 50 or 100 meters, depending upon the depth. Line spacing was set at various ranges, from as little as 40 meters in shallow areas, up to 90 meters in deeper water. Due to the shallowness of the water, the side scan sonar was frequently towed at heights of less than the required 8 to 20 percent of the range scale. Confidence checks were performed a minimum of once a day.

Chesapeake Technologies SonarWiz software was used for data collection and processing of the side scan sonar data.

B. QUALITY CONTROL

B.1 MULTIBEAM

All multibeam and single beam data collected for OPR-K977-CC-08 was processed using Caris Hips and Sips 6.1. Prior to importing any sounding data into Caris, a Hips vessel file (.hvf) was created. This vessel file includes significant physical dimensions of the vessel, as well as error estimate values for all major equipment integral in the collection of the data. Error estimates assigned to the survey equipment utilized in determining the ships dimensions and physical offsets between equipment were based upon the manufacturers specifications. Error estimates assigned to major survey equipment used in determining water depths and horizontal positions were based upon manufacturers specifications as listed within the TPE resource link provided on the Caris web page. The vessel file used for this project is included in the Caris project submitted in conjunction with this report.

In order to allow for more efficient processing of the data, subareas were treated as independent surveys. Following the completion of processing of all subareas within a survey, the areas were combined into a single project on an external USB hard drive for submission to the Atlantic Hydrographic Branch for review.

Caris project directory structures were created according to the format required by Caris. All lines converted were assigned a project, vessel, and day.

Multibeam data collected was reviewed in the swath editor, and erroneous bathymetry was rejected from the project.

Separate BASE surfaces were created for each subarea. BASE surfaces were named as recommended by the NOAA Specs and Deliverables. All BASE

surfaces were created as uncertainty surfaces with a single resolution of 2 meters. All BASE surfaces were created based upon the IHO Order 1 standards.

The standard deviation layers of the BASE surfaces were used as a basis for data cleaning. Areas of high standard deviation were investigated by all means appropriate, including the subset editor, swath editor, and comparison to side scan sonar data. If data was found to misrepresent the seafloor, it was rejected.

All contact investigation data was cleaned in the swath editor before being incorporated into a BASE surface. After data was cleaned in swath editor, the data was reviewed in the subset editor and, if needed, a designated sounding was assigned to the least depth sounding of an identified contact.

After all data had been cleaned, and all least depths on contacts had been designated, all five BASE surfaces were finalized for submission.

B.1.2 PARAMETERS

During collection the swath width was restricted to between 45° and 60°. The parameters used for processing the data for the smooth sheet are listed in the following table.

Maximum Beam Spacing:	1.2 meters
Maximum RMS Difference	0.25 meters
Maximum Raw Standard Deviation	0.40 meters
Elevation Offset	0.18 meters
Bin Size	3 meters
Minimum Points Per Bin	8
Median Percentage	60
Multi-Median Bin Size	3 meters
Multi-Median Shift Size	1 meter

B.2 SIDE SCAN

B.2.1 REVIEW PROCESS

All sidescan data was reviewed at least twice. The side scan operator reviewed all data during collection and noted in the survey logs any significant features or surface/water column effects. The data was then reviewed for a second time by a geoscientist.

The reviewer first decided the order in which to view the lines. Since we were producing mosaics as proof of coverage it was best to view all lines in the first 100% first and then the remaining lines second. This way the coverage map that was generated during the review process contained only the data for the lines that were to be used for that particular mosaic (first or second 100% coverage).

B.2.2 CONTACT SELECTION

As each line was reviewed sonar contacts were tagged and recorded. All contacts with shadows were recorded. All existing infrastructure, such as pipelines, wells, platforms, and buoys was tagged, as were other features. Many of the targets that were tagged were described as insignificant debris that is associated with shipping and/or oil and gas field activities in the area.

All contacts which displayed a height of 1 meter or greater, calculated from shadow length, were deemed to be significant within water depths of 20 meters or less, per Attachment #1 of the Statement of Work; Specifications and Deliverables. Other contacts may have been deemed significant based on their characteristics (dimensions, strength of return, etc.). Contacts were tagged, recorded and plotted in AutoCAD. Sonar contacts from adjacent lines were correlated and noted in the sonar contact table.

B.2.3 PROOF OF COVERAGE

As the geoscientist reviewed the data a coverage map was produced. Any gaps in coverage were noted, logged in the rerun log, and brought to the attention of the party chief and the operators on shift.

For the coverage map requirement of the interim and final deliverables we submitted side scan sonar mosaics. A mosaic for each 100% of coverage was submitted. These mosaics served as another quality control tool. The mosaics were not only used for coverage but could be used to correlate contacts seen on adjacent lines. The mosaic images were also overlain with the nautical charts, sonar contact plot and bathymetry data to give a full picture of the survey area.

C. CORRECTIONS TO ECHO SOUNDINGS

C.1 INSTRUMENT CORRECTIONS

No instrument corrections were necessary.

C.2 VESSEL CONFIGURATION CORRECTIONS

Prior to survey operations, offsets to the antennas and other survey equipment were measured. Offsets were measured from the Central Reference Point (CRP) to all relevant points on the survey vessel (bow, stern, antennas, transducers, etc.) using traditional survey techniques incorporating plumb bobs, tape measures, and digital levels. CRPs were established as an arbitrary point on the central along track axis of the vessel within one meter of the multibeam, and single beam echo sounders.

The results of the vessel survey are shown in diagram form in Appendix A.

C.3 STATIC AND DYNAMIC DRAFT CORRECTIONS

Settlement and squat tests was performed for all vessels except the *High Roller*. The vertical corrections applied to the data, described in the following chart, varied with speed. All values were post applied in Caris.

Inez McCall (01/22/2008)

Vertical Correction (m)	Speed (m/s)
0.03	1.54
0.07	2.57
0.11	3.60
0.23	4.63

C-Ghost (06/06/2008)

Vertical Correction (m)	Speed (m/s)
0.0	1.29
0.01	2.06
0.06	3.60
0.05	5.14
-0.06	9.00

C-Wolf (06/06/2008)

Vertical Correction (m)	Speed (m/s)
0.01	1.18
0.02	1.95
0.06	3.08
0.02	5.92
-0.10	9.26

The *Inez McCall* is equipped with a draft tube, which was read at least once daily while at sea, and the water level/draft entries were updated in each system as required. Draft values were checked on board the *C-Wolf* by directly measuring the depth of water above the transducer in the moon pool. A lead line was used to verify draft on board the *C-Ghost* and the *High Roller*.

Lead lines were performed on a daily basis on board the *High Roller*, *C-Wolf*, and *C-Ghost*. Due to its larger size, the *Inez McCall* was able to work in much larger sea conditions than the small vessels. Lead lines aboard the *Inez* were generally not performed in seas greater than 1 to 1.5 ft, to avoid misreadings.

C.4 VESSEL MOTION CORRECTIONS

A Coda Octopus F180 was integrated with the multibeam and navigation software as the primary positioning and motion sensor aboard the *C-Ghost*, and *C-Wolf*. The F180 provided real-time heave, pitch, and roll corrections, as well as tertiary navigation.

A POS/MV motion sensor was integrated with the multibeam echosounder aboard both the *Inez McCall* to provide real-time heave, pitch, and roll corrections. The POS MV also provided Tertiary navigation.

Prior to the survey, standard patch test were performed on the *C-Wolf* and the *Inez McCall* to determine correctors for latency, pitch, roll, and heave. Patch tests were performed in the following manor. A patch test was not performed on both the *C-Ghost* and the *High Roller* because no multibeam echo sounders were used for data collection aboard these vessels.

Latency:

Two lines were run directly over the same target. The line was run once at a slow speed (<4 knots) and again at a fast speed (>8 knots). The location of the target was inspected and had there been a difference in its location on each of the passes, latency would have been calculated. No timing error was detected.

Pitch:

A set of reciprocal lines was run over the target at a low speed.

Heading:

Two sets of collinear reciprocal lines were run

Roll:

A set of collinear, reciprocal lines were run with each head in single head mode.

Patch tests were performed on board all vessels prior to the commencement of survey operations. The results of those tests are shown below.

Inez McCall (Sept.26, 2007 – South of Cameron, La.):

Roll	Pitch	Heading
-4.5°	9.3°	0.0°

C-Wolf (March 21, 2009 – Lake Duplecine):

Roll	Pitch	Heading
1.03°	-5.0°	0.0°

C.5 SOUND VELOCITY CORRECTIONS

Seabird sound velocity profilers were used on board all four survey vessels. The *Inez McCall* used Seabirds S/N 5221, 5222 and 2645.

The *C-Ghost* used Seabird S/N 5214. The *High Roller* used Seabird S/N 2645, and the *C-Wolf* used Seabirds S/N 1174 and 5214. Seabirds were replaced as calibration certificates expired, and individual units experienced malfunctions. On board the *Inez McCall*, casts were performed at least once daily and more often as needed. On board the three smaller vessels, casts were typically taken only once a day because of the limited amount of time available for working during daylight only operation, and because of the shallowness and relative homogeneity of the water column within the survey area. The multibeam data was corrected for the water column sound velocity in real-time. The mean water column sound velocity was applied to the single beam echosounder data. Endeco YSI sound speed profiles were used to determine sound speed at the transducers.

C.6 TIDE AND WATER LEVEL CORRECTIONS

Tide and water level corrections were applied as set forth in the Statement of Work.

Tides were applied to all data in Caris using tidal data downloaded from the NOAA CO-OPS website, and corrected using tidal zone definition files (.zdf) supplied by NOAA.

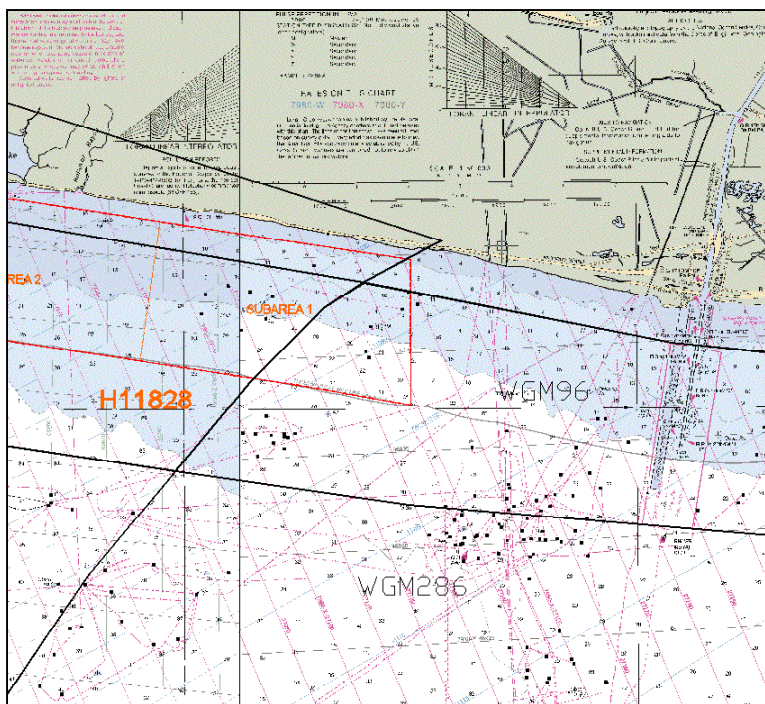
Two unique tide .zdf files were created for this project, one for sheets A-E, and another for sheets F and G, called K977KR2008CORP.zdf, and K977KR2008CORP_Rev.zdf respectively.

The file for sheets A-E incorporated gauge 8766072 (Freshwater Canal Locks, LA) and gauge 8768094 (Calcasieu Pass, LA). Due to outages in October 2008, a new zone definition file was provided by CO-OPS, which incorporated gauge number 8771510 (Galveston Pleasure Pier, TX). This file is called K977KR2008_March09RevCORP.zdf and had to be further modified by C&C to

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incorporate the north west corner of subarea 1 in sheet A. This file was named K977KR2008_March09RevCORP_C&C.zdf. Below is an image showing the zoning gap in sheet A. The tide zone WGM 96 was extended north to cover the gap.

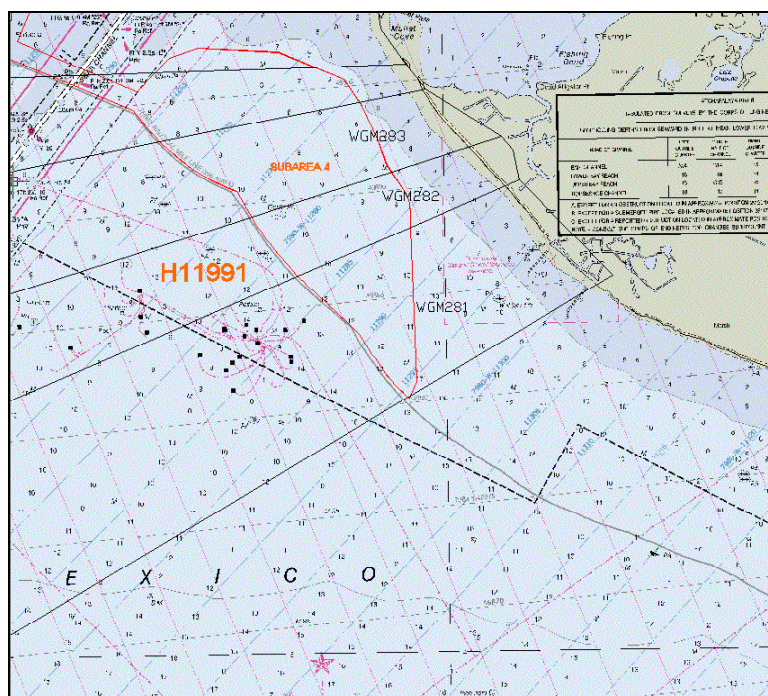


Tide zoning for Sheets F and G used gauge number 876227 (Amerada Pass, LA) for tidal corrections. This file had to be further modified by C&C to incorporate the southeast corner of subarea 4 in sheet G. Zone WGM 281 was extended to the south by approximately 1300 meters, and the new file was named K977KR2008CORP_Rev_C&Crev.zdf. The image below shows the small zoning gap. Due to a 13-day outage in July of 2009, a new zoning file was

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provided by CO-OPS which incorporated gauge 8771510 (Galveston Pleasure Pier, TX). This zone was called K977KR2008_Rev_CORP_July2009.zdf.



All of the tide (.tid) and .zdf files are included in the Caris projects submitted in conjunction with this report.

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APPENDIX A - VESSEL DESCRIPTIONS

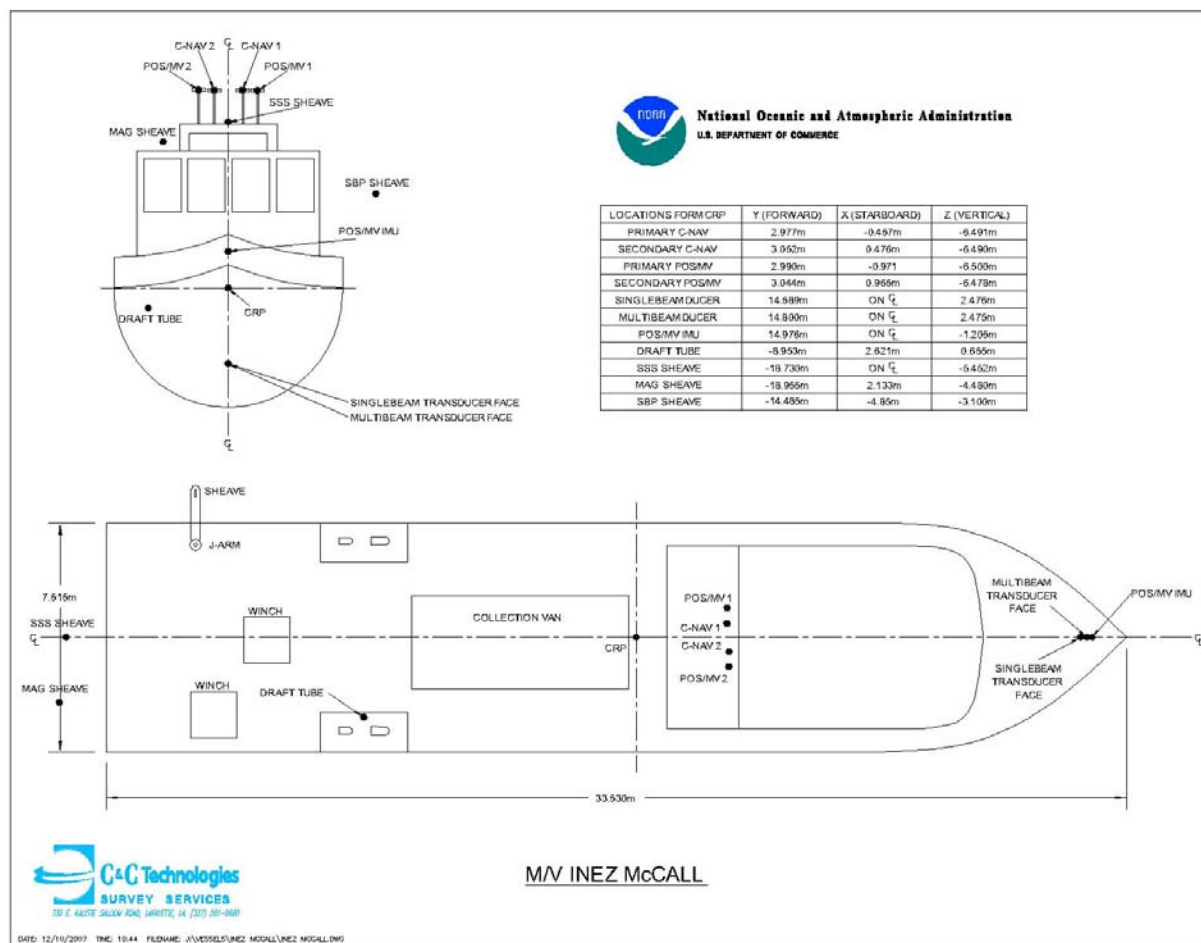
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INEZ McCALL





VESSEL PROFILE

Vessel Name	INEZ McCALL
Owner/Operator	Cameron Offshore Vessels
Flag/Home Port	USA/Cameron, La
US Coast Guard Official Number	648625
Year Built	1982
Place Built	Biloxi, MS
Hull Material	Steel
Official Number	648625
Intended Service	Supply Vessel
Operational Area	Gulf of Mexico
Tonnage Certificate	Issued by ABS
Loadline Certificate	Issued by ABS
Certificate of Classification	Issued by ABS full hull & machinery

SPECIFICATIONS

Length	108 ft. LOA
Breadth	24 ft
Depth	11.5 ft
Draft (summer load)	8 ft
Gross Tonnage	92 US regulation tons
Net Tonnage	63 US regulation tons

RV HIGH ROLLER



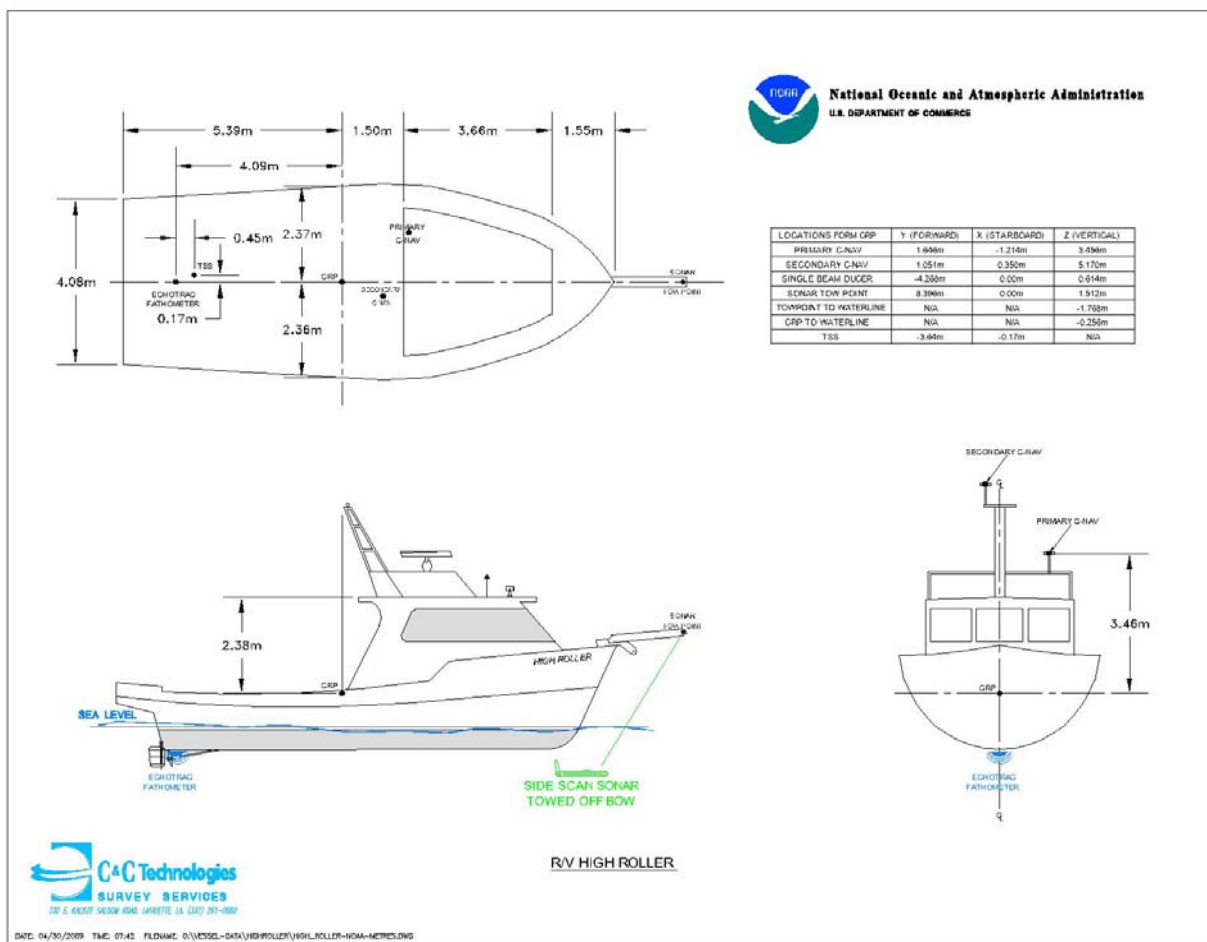
Vessel Particulars

- Official # LA 1954 EU
- Dimensions:
 - Length: 42 ft
 - Beam: 16 ft
 - Draft: 3 ft
- Construction: Fiberglass (built in 1996)
- Propulsion
 - Twin Caterpillar Diesel Engines (900 HP)
- Electronics
 - Radar: Furuno
 - VHF: Raytheon
 - Chart Plotter / Depth Finder
 - 9 kw Generator with Sound Enclosure
 - Twin A/C and Heat System

Positioning & Geophysical Equipment

- (2) C-Nav Satellite Based Differential GPS System
- Odom Hydrotrac 200 khz Single Beam Echo-Sounder
- TSS 335B Motion Sensor
- GeoAcoustics Side Scan Sonar model number ss982 (114/410 kHz)

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RV C-Ghost



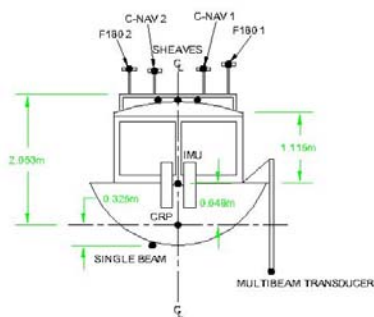
Vessel Particulars

- Official # LA 4402 FR
- Dimensions:
 - Length: 30 ft
 - Beam: 8.5 ft
 - Draft: 2 ft
- Construction: Aluminum – Built 2007
- Propulsion
 - (2) Honda 150 HP (4 stroke)
- Electronics
 - Radar: Furuno
 - VHF: Raytheon
 - Chart Plotter / Depth Finder
 - 7.1 KW water cooled genset 110 volts
 - (2) 1400 btu AC units
 - Phone: 337-504-0888

Positioning & Geophysical Equipment

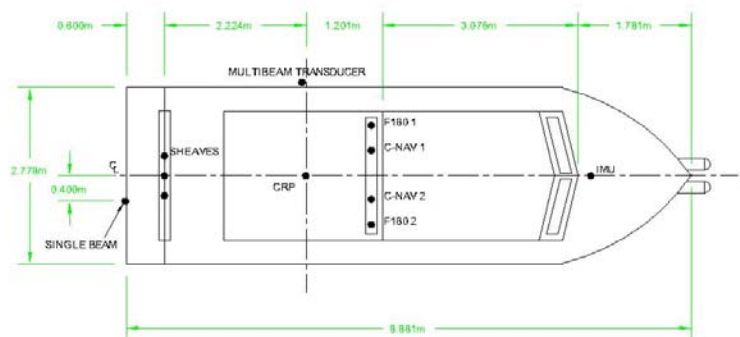
- (2) C-Nav Satellite Based Differential GPS System
- Coda F180 Inertial Attitude and Positioning System
- Edgetech 4200 Side Scan Sonar (100/400 Khz)
- Odom 200 Khz single beam echo sounder

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National Oceanic and Atmospheric Administration
U.S. DEPARTMENT OF COMMERCE

LOCATIONS FROM CRP	Y (FORWARD)	X (STARBOARD)	Z (VERTICAL)
C-NAV 1	1.027m	-0.400m	2.453m
C-NAV 2	1.027m	0.367m	2.420m
F180 1	1.027m	-0.792m	2.619m
F180 2	1.027m	0.769m	2.451m
MULTIBEAM TRANSDUCER	-0.060m	-1.470m	-0.730m
IMU	4.478m	ON CL	0.648m
SHEAVE	-2.224m	-0.311m	1.963m
SHEAVE	-2.224m	ON CL	1.963m
SHEAVE	-2.224m	0.311m	1.963m
SINGLE BEAM	-2.839m	-0.400m	-0.325m



R/V C-GHOST

DATE: 12/08/2008 TIME: 14:20 FILENAME: d:\VESSELS\G-GHOST\G-GHOST-NEW.DWG

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RV C-Wolf



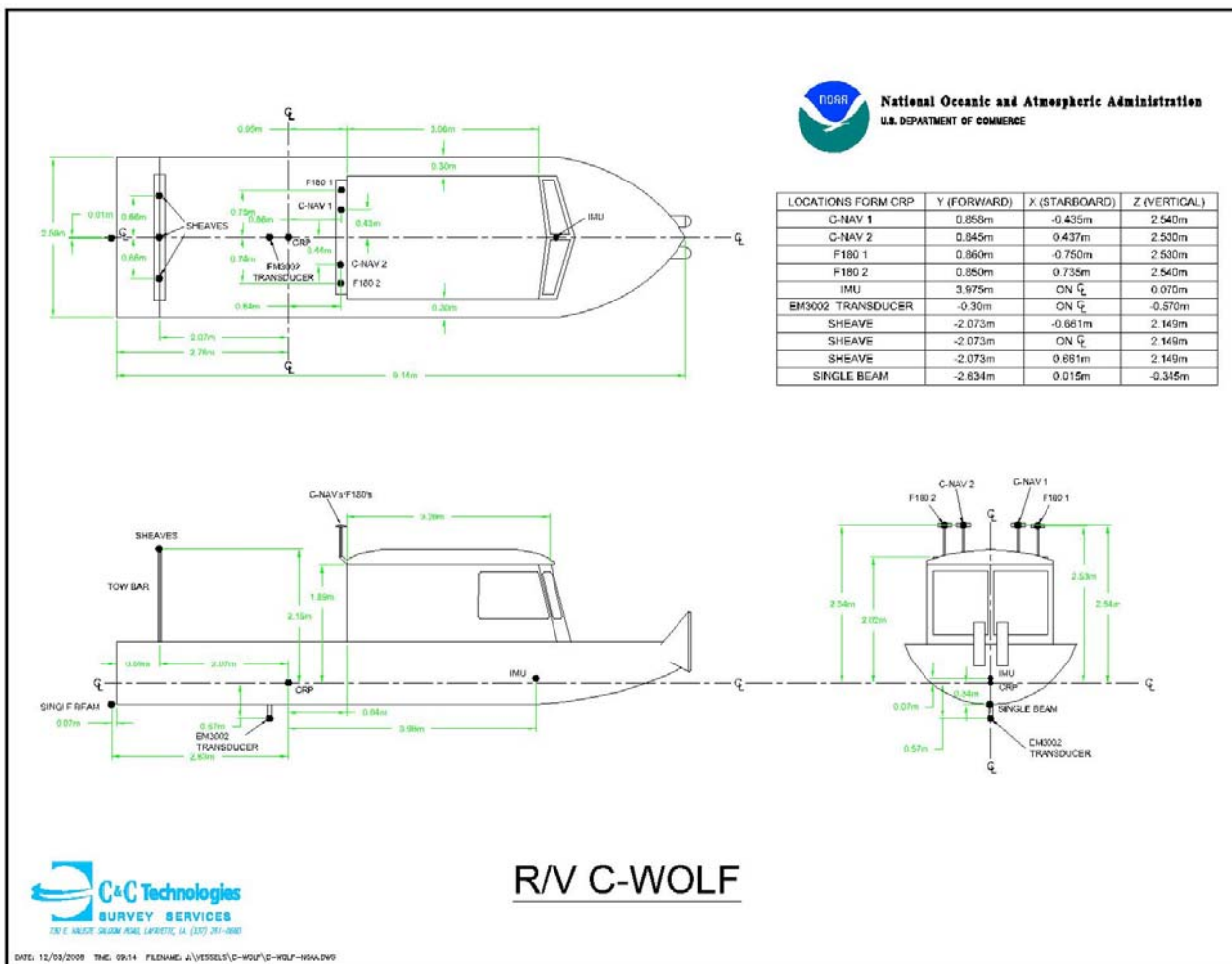
Vessel Particulars

- Official # LA 2935 FS
- Dimensions:
 - Length: 30 ft
 - Beam: 8.5 ft
 - Draft: 2 ft
- Construction: Aluminum – Built 2007
- Propulsion
 - (2) Yamaha 150 HP (4 stroke)
- Electronics
 - Radar: Furuno
 - VHF: Raytheon
 - Chart Plotter / Depth Finder
 - 7.1 KW water cooled genset 110 volts
 - (2) 1400 btu AC units
 - Phone: 337-504-0889

Positioning & Geophysical Equipment

- (2) C-Nav Satellite Based Differential GPS System
- Kongsberg EM3002 Multibeam Sonar (threw hull moon pool)
- Coda F180 Internal Attitude and Positioning System
- GeoAcoustics Side Scan Sonar model number ss982 (114/410 kHz)
- Odem 200 KHz single beam echo sounder

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APPENDIX B – EQUIPMENT DESCRIPTIONS

ODOM HYDROTRAC SINGLE BEAM ECHOSOUNDER

The HYDROTRAC echo sounder by ODOM Hydrographic Systems, Inc. can collect analog paper records as well as digitized depth information for output to a data logger. Digital depth data can be logged directly to the navigation computer along with date, time, and position for later post processing and mapping. The system includes a recording unit with built in digitizer and transceiver, and a side mountable transducer. The unit utilizes a combination of dynamic gating and velocity fit to track the true bottom through advanced microprocessor technology, solving the normal problems associated with conventional depth sounders. For example, if the "fixed gate" mode is activated, signal digitizing can be restricted to a user-defined range, rejecting unwanted returns during bar-check calibrations.

The acoustic pulse is generated with the Model OHS 200/9 transducer, which operates at single frequency of 200 kHz with a beam width of 9°. This system is very much similar to ODOM ECHOTRAC SF3200, except that ECHOTRAC has capabilities of operating on dual frequencies of 24 and 200 kHz. The shipboard transceiver automatically adjusts power output in proportion to the return signal yielding a clear, unambiguous record in shallow as well as deep water. The self-adjusting power varies from 1 to 225 watts at 200 kHz. Return signals are optimized by Time Varied Gain (TVG) and Automatic Gain Control.

A thermal paper recording is printed in real-time where automated scale changes prevent the bottom from "running" off the chart. Scale widths are selectable in meters, 2 to 1,000, or feet, 10 to 3,000; however, routine operating scales are 10 to 100 feet. Key system parameters, i.e. velocity of sound, draft, and time, are input from the recorder's front panel. A tide correction may be introduced without altering the analog record in any way. A line is added to the chart to indicate where the bottom would be if corrected for water level.



Recording resolutions of the HYDROTRAC, ranging from 8 mm to 4 meters dependent upon the selected scale width, permit detailed assessments of local water depths. Reference to a tidal datum permits the evaluation of navigable waterways, subsidence and scour features around seafloor based structures, and pre/post dredging or construction water bottom conditions.

Specifications:

Frequency	200 kHz
Output Power	500 Watts
Power Requirement	11-28 VDC
	110/220 VAC (Optional)
Ports	RS 232

ODOM ECHOTRAC DF3200 MK II SINGLE BEAM ECHOSOUNDER



This dual frequency survey echo sounder employs a high-resolution thermal printer, microprocessor, DSP techniques, and flat screen displays. The sonar transceiver, echo processor, graphical operator interface and hardcopy recorder are all housed in one portable, splash-proof case. The unit is suited to table top, bulkhead, or rack mounting and is equally for small survey launches as it is on large ships. Well suited for use in the shallows of rivers and harbors, the mission variable unit is also capable of working to depths of over 2,000 meters.

Features

FREQUENCIES: Either single or dual frequency configurations of the unit are available: Standard frequencies are 200 and 24kHz or 210 and 33kHz.

Optional frequencies:

High - 100kHz to 1MHz

Low - 10kHz to 60 kHz

PRINTER: The high-resolution thin-film thermal print head measures 216mm. (8.5") wide. Resolution is 8 dots/mm. (023/in) along the print axis and 8 lines/mm along the paper axis. The unit is capable of printing up to 16 shades of gray.

DISPLAY: The Graphical LCD module (320 x 200 pixels) measures six inches diagonally (156.4mm). Fluorescent Back Lighting (CFL) of the paper white display provides excellent visibility in all light conditions. In dual frequency operation, both high and low frequency depth values are displayed continuously.

KEYPAD: a 16 NEMA 12 sealed unit with tactile feedback is used by the operator for parameter selection and numerical value entry. Ten digits, Up,



Down, Left, and Right arrow keys, Decimal Point/Help and Enter keys are provided.

DIGITIZER: The bottom tracking capabilities of the unit are enhanced by utilizing the DSP capabilities of the digitizer processor. These DSP algorithms yield reliable bottom detection even in the presence of high ambient noise and multiple returns.

Communications

INTERFACING & ANNOTATION: Four bi-directional RS-232 serial ports are standard. Depth information is output after each sounding cycle with the standard string including values for both the high and low channels in dual frequency operation. Output strings conforming to other major echo sounder formats are available. In addition, system parameters can be configured via comm1. The ECHOTRAC accepts annotation of up to 80 characters (printed on the Fix Mark Line). Standard NMEA formats from GPS receivers as well as proprietary strings from positioning and navigation systems can also be annotated on the chart. Interfacing to data acquisition systems is asynchronous and does not require handshaking.

Controls

ANALOG CONTROLS: Immediate access to critical analog controls is via front panel potentiometers and switches. They include: Receive Sensitivity, AGC (Automatic Gain Control) Transmit Power, and Threshold (digitizer level). Also mounted on the front panel are controls for the printer including: Chart ON/OFF, Paper advance, Paper Take-up, and Mark.

Specifications:

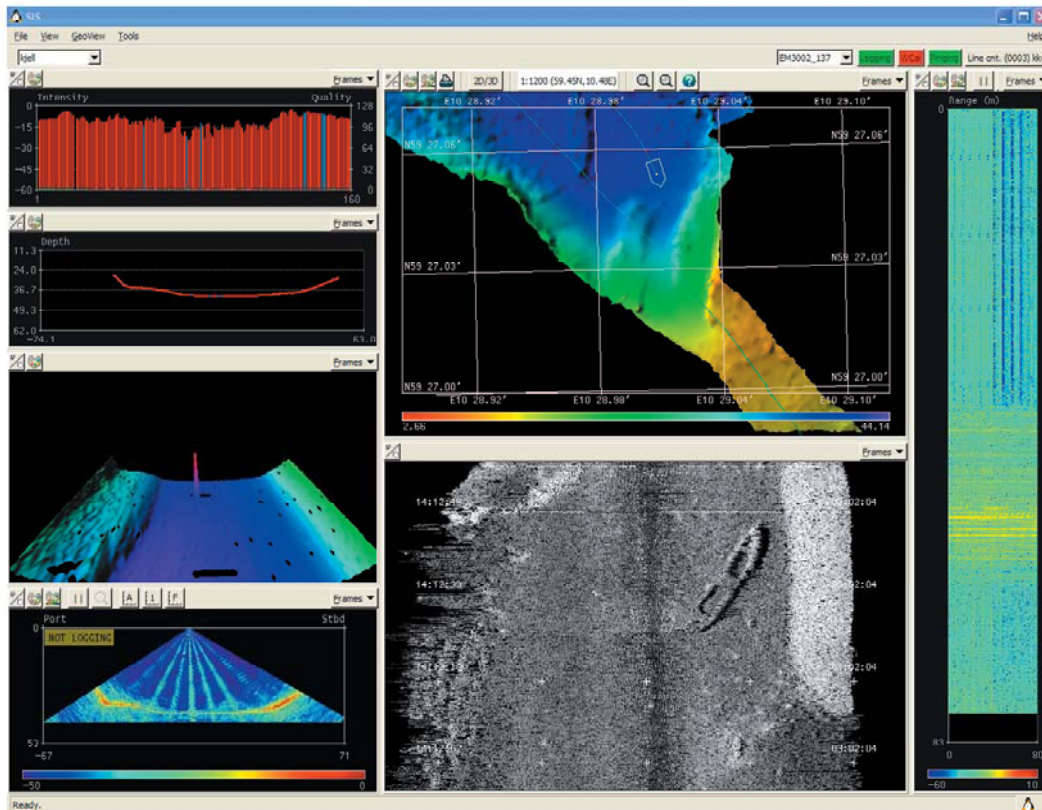
Frequency	200 kHz
Output Power	500 Watts
Power Requirement	18-32 VDC
	110/220 VAC (50/60 Hz.)
Ports	RS 232

EM 3002



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 150 meters in the ocean. 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 under-water 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 one of three available 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 new and very powerful sonar processor in combination with the same sonar head used with the popular and highly acclaimed EM 3000

system. The increase in processing power makes it possible to apply sophisticated and exact signal processing algorithms for beamforming, beam stabilisation, and bottom detection. The bottom detection algorithm is capable of extracting and processing the signals from only a part of each beam, thus making it possible to obtain independent soundings even when beams are overlapping.

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 acoustic seabed image is compensated for acoustic raybending 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.

Operator Station

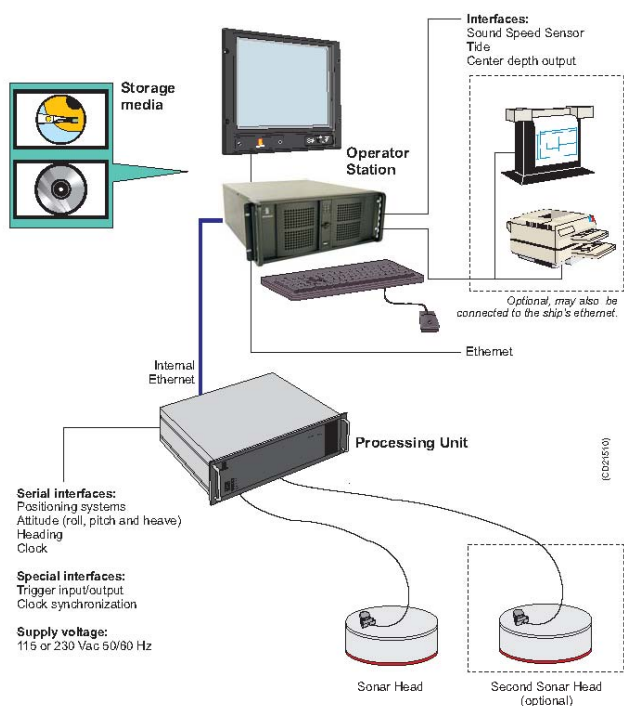
The Operator Station is a ruggedized PC workstation running on either Linux® or Microsoft Windows XP®. The Operator Station software, SIS, has been completely redesigned and expanded compared to the EM 3000 software, adding 3D graphics, real-time data cleaning and electronic map background.

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

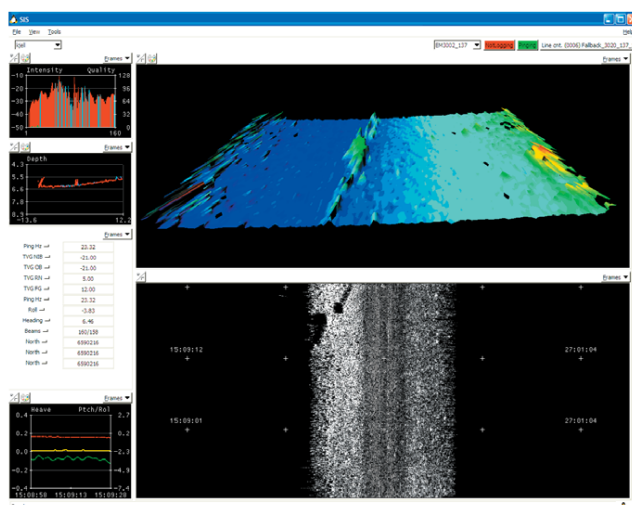
Note that Kongsberg Maritime AS does not take any responsibility for system malfunction caused by third-party software.

- Full swath width accuracy to the latest IHO standard
- Swath width up to 10 x water depth or 200 m
- Depth range from < 1 meter to > 150 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

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



This is an example on how the SIS software can be used.

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 all 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.
- Operator controlled equidistant or equiangular beam spacing.
- Real time compensation for acoustic raybending is applied.
- Imaging of objects in the water column is offered as an option.

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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 pattern	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)

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

17.4" industrial LCD monitor:

Width	460 mm
Depth	71 mm
Height	400 mm
Weight	9.2 kg
Resolution	1280 x 1024 pixels

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

Kongsberg Maritime is engaged in continuous development of its products, and reserves the right to alter the specifications without further notice. "HYPACK Max" is a trademark of Coastal Oceanographics Inc. "QINSy" is a trademark of QPS.

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KONGSBERG



KLEIN 5500 SIDE SCAN SONAR

Conventional side scan sonar systems use a single sonar beam per side to generate an image of the seafloor. The physics of this type of sonar results in degradation of image resolution with range and requires speeds of 5 knots or less to insure 100 percent bottom coverage. From a design perspective, both of these shortcomings can be eliminated by designing a side scan sonar that, through beam steering and focusing techniques, simultaneously generates several adjacent, parallel beams per side. This design approach, principally employed by military side scan sonar systems designed for high-speed mine hunting applications, has been prohibitively expensive for commercial operations. Klein Associates is the first commercial company to offer a multi-beam side scan sonar using similar design techniques to military sonars, but at a fraction of the cost.

The two main benefits of the high-speed, high-resolution 5500 systems are: higher towing speeds with no loss of bottom coverage and range independent high-resolution imagery capability. Since operation costs are dependent on the amount of at-sea time required to complete a survey, the new Klein 5500 Multi-Beam Side Scan Sonar Systems with survey speeds more than twice that of conventional side scan sonars, minimize at-sea time, thus greatly reducing survey costs.

The sonar system consists of a towfish, tow cable, transceiver/processor unit (TPU), and a PC display and control unit for viewing data. The stainless steel towfish incorporates two multi-channel acoustic arrays and a pressure bottle that houses all of the electronics and sensors necessary for sonar data acquisition, attitude sensing, system control and telemetry. The sonar and sensor data is transmitted up the tow cable via a high-speed digital telemetry link, requiring only a single coaxial or fiber-optic cable. The surface mounted TPU receives this data, performs all necessary digital processing functions on the acoustic data, and relays control command to the towfish. Processed data is then distributed to one or multiple PC Display and Control Units (DCU) via a 100 Base T Ethernet LAN Network where the tasks of data viewing, storage and analysis can be accomplished.

The Klein 5500 is a 5-beam side scan sonar designed for hydrographic applications requiring high- resolution images of the seafloor and bottom obstructions while operating at tow speeds up to 10 knots and with an overall swath width of 300 meters. Applications of the side scan sonar include hydrographic surveys, mine hunting, pipeline surveys, debris searches, archaeological surveys, geologic surveys and autonomous underwater vehicle surveys. Specifications for the Klein 5000 are outlined below:

Towfish

Number of beams:	5 Port / 5 Starboard
Frequency:	455 kHz
Pulse Length:	50 to 200 usec. (operator selectable)

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Resolution Along Track: 20 cm @ 75 meter range, thereafter increasing to a maximum of 36 cm @ 150 meter maximum range
Resolution Across Track: Determined by selected pulse length
Operating Speed Envelope: 2 – 10 knots @ 150 meter maximum range
Sonar Digitization: 12 bit / channel
Maximum Operating Range: 150 meters (300-meter swath)
Array Length: 120 centimeters (47.2 inches)
Body Length: 194 centimeters (76.4 inches)
Body Diameter: 15.2 centimeters (6 inches)
Weight in air: 70 kg (155 lbs.)
Sensors: Heading, pitch, roll, temperature and pressure
Tow Cable: Coaxial or fiber

Transceiver Processor Unit

Width: 19-inch rack mount
Height: 13.2 centimeters (5.2 inches)
Depth: 54.6 centimeters (21.5 inches)
Weight: 12.7 kilograms (28 pounds)
Voltage: 115/240 VAC; 50/60 Hz
Power: 120 Watts
Navigation Input: NMEA 0183
Data Output: 100 Base-T Ethernet LAN
PC Display/Control Unit: Klein ruggedized or customer supplied PC



Dual Frequency Side Scan Sonar

Introduction

The GeoAcoustics Dual Frequency Side Scan Sonar system is the ideal tool for seabed feature mapping, offering flexibility and high quality results in a simple and reliable package. The system offers high resolution, switch selectable, dual frequency operation (114/410 kHz), which when combined with multiplexed data transmission enables a low drag co-axial tow cable to be used. The modular design of the system makes it ideal for combining with our GeoChirp and GeoPulse sub-bottom profilers.

The versatility, ease of operation and cost effectiveness of the system has made it a popular choice with commercial survey companies.

Transceiver

The transceiver unit allows the operator a simple means of controlling various Side Scan operating parameters. The unit includes standard controls such as: Gain, Time Varying Gain (TVG) and Automatic Gain Control (AGC), with duplicated controls for Port and Starboard channels. The operating frequency can also be switched from 114 kHz to 410 kHz directly from the Transceiver. The choice of frequencies means that long range scanning and short range high resolution investigations are both possible.

Multiplexer

The Multiplexer Unit (SS982) is the sub-sea processing section of the Side Scan Sonar system. The SS982 is mounted in the tail of the towfish, on the tail of a combined towfish or on a ROV, as required. The use of standard sub-sea connectors throughout allows easy installation in all situations. The SS982 includes all of the transmitter and multiplexing electronics, thereby ensuring that transmission power is not lost in the tow cable and also reducing the risk of high voltage defects.

The multiplexed data transmission technique employed allows the system to be used with a wide selection of towcables, including twisted pair and co-axial cables. Data from the Dual Frequency Side Scan Sonar can be input to a wide range of third party sonar processing systems, or it can be displayed on a wide variety of industry standard graphic recorders.



The multiplexed data offers a resolution equivalent to a 16 bit analogue to digital converter operating at 50k samples/sec per channel, when used with short towcables.

Standard System

The standard system employs a lightweight towfish, which is easily deployed by one person and can operate to a depth of 1000 metres. There are separate controls for each channel, which makes the system very easy to operate.

The basic system includes the following:

- Transceiver (model SS981)
- Towfish (model 159D), which houses the Multiplexer (model SS982) and Two Dual Frequency Transducers (model 196D/Port and Starboard).

Features

- 1000 metre depth rating (standard)
- Switch selectable dual frequencies
- Fully multiplexed signals
- Simple user controls
- Low cost
- High efficiency/low power
- Operates over long towcables
- Outputs to all standard recorders/processors
- High reliability (MTBF > 10,000 hours)
- Simple maintenance
- Low drag coaxial tow cable
- High system bandwidth and resolution

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Specifications

Transceiver Model SS981

General

Power requirements: 95/265VAC switchable, 40-60 Hz, 50W optional 24VDC
 Size: 43.2cm W x 45.7cm D x 18.7cm H
 Weight: 16kg
 Temperature: Storage: -20 to 75°C
 Operating: -5 to 50°C
 Humidity: 10% to 95% RH, non-condensing
 Mounting: The unit is suitable for either bench or rack mounting.

Operating Specification

Power output to tow vehicle: 150 VDC \pm 3 VDC, 100 mA average, 320 mA peak
 Key burst out: 455 kHz, pulse width selectable 16 Vpp, PRR determined by key source
 Key input: Positive CMOS to TTL, 10kW input impedance.

Receivers

Modulation freq.: Port 135 kHz, Starboard 65 kHz
 Bandwidth: 15 kHz
 Sensitivity: 6mV rms input produces 800 mV rms output with a 20dB signal-to-noise ratio (all gain maximum)

Input impedance:

5k Ω

Output impedance:

600 Ω on all outputs

Dynamic range:

Gain: adjustable over 60dB range

TVG: -20 to +20dB maximum

AGC: -34dB maximum

Output:

Selectable signal envelope or amplitude modulated 12 kHz

TVG delay: 3.3ms minimum, 330ms maximum

Event mark: 5Vpp, 12 kHz, front panel push button or BNC input requiring CMOS or TTL level pulse. Produces visual mark on recording media.

Key out: 0.6ms CMOS/TTL compatible

Modes: 100 kHz and 500 kHz operation

Raw signal and processed signal

Front Panel connectors

BNC: Seven each for signals & keys

Amphenol: MS3102A-22-34S for deck cable

Towfish Model 159D

Tow speed: 1 to 12 knots

Weight: 16 kg, 22 kg, or 38 kg depending on ballast used

Dimension: 11.4cm D by 128.5cm L, 3 fins on tail protrude 7.5cm

Frame: Cast aluminium with shear release carry handle/towpoint

Nose: Shock absorbing, abrasive resistant urethane. Cavity can carry small auxiliary transducer.

Multiplexer - Model SS982

Transmitter Section

Frequency: 114/410 kHz \pm 1%

Power output: 3 kW pulse \pm 20%

Pulse length: 167 μ sec/88 μ sec \pm 1%

Pulse repetition rate: 50 pulses per second maximum

Protection: Open and short circuit protected

Efficiency: Greater than 80%

Receiver Section

Port channel: 114/410 kHz, heterodyned to 135 kHz

Starboard channel: 114/410 kHz, heterodyned to 65 kHz

Bandwidth: 20 kHz

TVG: Transmission loss curve compensated at both frequencies. Approximately +40dB at 100m range

Keyburst:

Frequency: 455 kHz \pm 2%

Pulse length: 300 μ sec for 114 kHz operation

600 μ sec for 410 kHz operation

General:

Power requirements: 150 VDC at 100mA

Size: 10.2cm D x 34.5cm L

Weight: 3.2kg in air, 0.45kg in water

Transducers Model 196D

Source level: 223 \pm 3dB re 1 μ Pa@ 1m

Beamwidth: 114 kHz - 50° by 1°

410 kHz - 40° by 0.3°

Sensitivity: -190dB re 1V/ μ Pa

Depression angle: 10° \pm 1° down

Options

- Deeper rated towfish
- Stainless Steel towfish
- Lightweight Kevlar Towcable for shallow water use
- 60kHz operating frequency for increased range
- Towfish pitch, roll and heading sensors
- Towfish responder for acoustic tracking
- Towfish height off bottom measurement
- Towfish depth sensor

Specification sheet subject to change without notice (9-SS940-

69-A 05/2005)



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CODA OCTOPUS F180 INERTIAL ATTITUDE AND POSITIONING SYSTEM

The Coda Octopus F180 is a highly accurate inertial attitude, heading and positioning system that provides high-speed vessel motion data including heave, pitch, roll, heading and position in real time. The system uses the fastest Kalman filter on the market enabling it to track small and fast changes in orientation and calculate their overall error contribution and correct for them much faster. Mobilization is minimal due to the automatic self-alignment between the IMU and GPS antenna and automatic calculation of GPS lever arms and GAMS angles. The F180 uses velocity rather than acceleration to measure heave, thus reducing heave drift.

The technical specifications of the system are provided below.

PERFORMANCE*	RTK	DGPS
Position accuracy (CEP)	0.02 / 0.2**	0.5 – 4.0m
Velocity	0.03ms-1	0.03ms-1
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	Component	Specification
Weight	Splash-proof 'one-box' solution	2.5kg
Power	Splash-proof 'one-box' solution	9 – 18Vdc, 25 Watts
Antennas	Novatel Pinwheel Technology with integral choke rings to reduce multipath effects	

INTERFACES	Function	Output
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Ethernet Interface (100base-T)	Control, set-up and diagnosis of F180 using F180 windows application software.	High data rate comprehensive information output packet (100Hz) for high speed interfacing.
Serial 1	Attitude data	TSS1, Simrad EM3000 and other standard attitude strings.
Serial 2	NMEA position data	GGA position, HDT heading.
Serial 3	RTK / Differential correction input	RS232 (DB9) up to 115k baud

*All performance errors to within 1 sigma

**0.02m performance requires optional L1/L2 upgrade

C-NAV DIFFERENTIAL GPS

C-Nav is a globally corrected differential GPS system owned and operated by C & C Technologies, Inc. The C-Nav GPS Receiver combines a dual-frequency, geodetic grade, GPS Receiver with an integrated L-BAND communication RF detector and decoder all linked by an internal microprocessor. C-Nav uses monitoring stations strategically located around the globe to provide worldwide accuracies in the order of 0.25m (1 sigma)*.



The technique, developed by the Jet Propulsion Lab for the National Aeronautics Space Administration, uses a global network of reference stations to track the entire constellation of GPS satellites. The raw GPS observations are transmitted via the Internet back to the Network Control Center where the GPS constellation satellite orbital corrections and clock-offset values are calculated and modeled in real-time. These corrections are universally valid and can be applied to GPS measurements from any location on earth.

The multi-function antenna assembly is capable of receiving the L1 and L2 GPS frequencies as well as the Inmarsat L-BAND receive frequency band. The gain pattern of this antenna is designed to be relatively constant even at lower elevations. This allows for an efficient link budget when the unit is operated at higher latitudes where the elevation of the geo-stationary communication satellite is low and close to the horizon. Atmospheric delays are eliminated from local measurements by comparing the L1 and L2 frequencies in the internal GPS receiver.

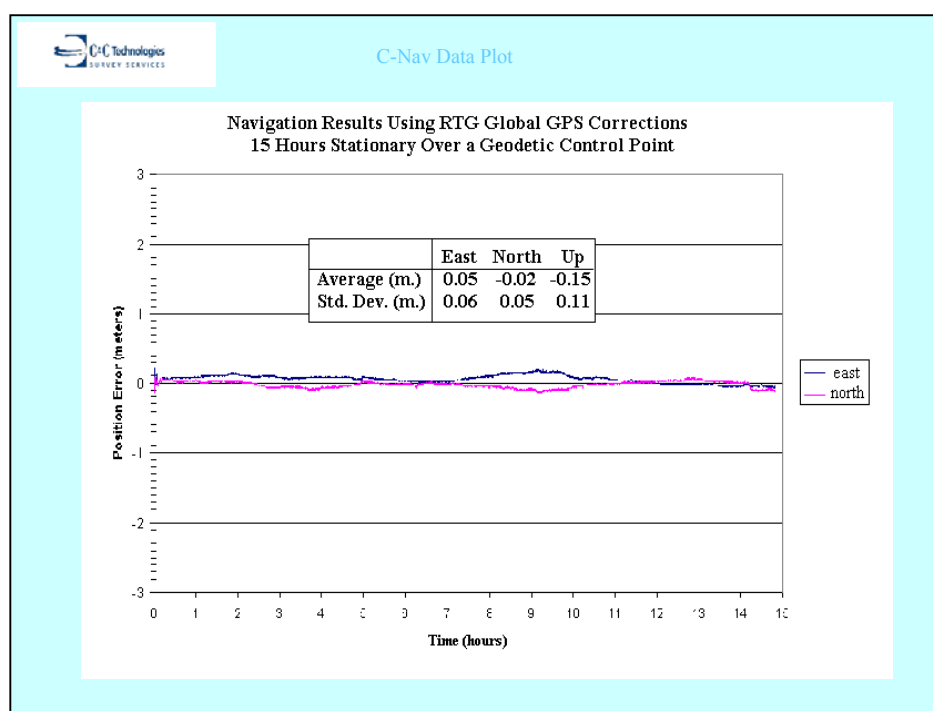
The C-Nav GPS System provides an output of RTCM (Type 1) pseudorange differential correction messages via a second RS232 interface. Raw GPS observation information can be collected from the C-Nav GPS Receiver system for recording and analysis. The

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raw GPS observation information can be converted to RINEX ASCII data (observation and navigation) file format as and when required.

The C-Nav GPS Receiver requires at least four (4) usable GPS satellites to compute a three dimensional (3D) solution. The C-Nav GPS Receiver will yield an autonomous horizontal position accuracy of 2 to 5 meters (1 sigma), depending on the GPS satellite geometry configuration and tracking (DOP index values).



Receiver Specifications:

Features

- Real-time sub meter accuracy
- Single integrated package – simple installation
- Rugged, waterproof housing
- Wide-range (10-40VDC) power supply
- RTCM and NMEA {GGA, GSA, RMC, VTG, ZDA) outputs
- Patented multipath mitigation significantly reduces noise
- Geodetic quality dual frequency GPS virtually eliminates ionospheric effects

Performance

- L-band receiver frequency
- Automatically selected 1525 to 1560 MHz

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GcGPS Accuracy:

Position (H): <30cm

Position (V): <70cm

{1-sigma and HDOP ≤ 1 }

Velocity <0.02m/s

Time to first fix: Cold Start: 90 sec(typical)

Reacquisition

Coast for 30 sec with GPS lock <2sec

L-band loss with less than 30 sec with GPS lock <30 sec

Physical/Environmental

Size: 9.2 in (H) x 7.2 in (D) (24.8 x 18.7 cm)

Weight: 5.5 lbs (2.4 kg)

Power: Input voltages: 10-40 VDC

Consumption: <10W average power

1.2 A max @12 VDC

I/O Connector 8 pin waterproof connector

Temperature: Operating: -20°C to +70°C

Storage: -40°C to 85°C

Humidity: 100% non-condensing

Display Unit Specifications:

Features

4 x 20 character LCD screen

12 key membrane button input pad

Rugged, stainless steel housing

Wide-range (20-40VDC) power supply

RTCM and NMEA and raw data outputs

Physical/Environmental

Size: 9.6 in (L) x 6.7 in (W) x 3.3 in (H) (24.4 x 17.0 x 3.3 cm)

Weight: 3.8 lbs (1.75 kg)

Power: Input voltages: 20-40 VDC

Consumption: <1W average power

100 mA max @28 VDC typical

I/O Connectors: 3 db-9, 1 cat-5 and 1 8 pin waterproof connector

Temperature: Operating: -20°C to +70°C

Storage: -40°C to 85°C

Humidity: 100% non-condensing

EDGETECH 4200 SIDESCAN SONAR



4200-MP SIDE SCAN SONAR SYSTEM

*Technologically
advanced digital
Dual Mode high-
resolution side scan
sonar system*



The **EdgeTech 4200-MP Side Scan Sonar System** provides a unique advantage over conventional dual frequency side scan systems by combining EdgeTech's Full Spectrum and Multi-Pulse technologies into one unit. The 4200-MP comes available with a choice of three dual simultaneous frequency sets; either 100/400 kHz, 300/600 kHz or 300/900 kHz, and offers two software selectable modes of operation:

- **High Definition Mode (HDM)** - conventional dual simultaneous frequency operation with extra long array for superior resolution; excellent tool for Mine Countermeasures (MCM).
- **High Speed Mode (HSM)** - Multi-Pulse operation on either selected frequency for speeds up to 10 knots, while meeting NOAA and IHO-44 requirements for Hydrographic Survey for "hits on target" compared to conventional systems at 4 knots. This is an additional feature for high-speed navy patrol vessels.

Features:

- Either 100/400, 300/600 or 300/900 kHz dual simultaneous frequencies
- Selectable dual mode of operation: High Definition Mode (HDM) or High Speed Mode (HSM)
- 2000 meter depth rating for stainless steel towfish
- 500 meter depth rating for lightweight aluminum towfish
- Data transmitted over long single coaxial cable lengths
- Integrated with other sensors
- Full Spectrum CHIRP processing
- Able to interface with customer supplied PC and 3rd party software

Applications:

- Mine Countermeasures (MCM)
- Hydrographic surveys
- Geo-hazard surveys
- Geological/geophysical surveys
- Route surveys
- Archeological surveys
- Search and recovery
- AUV/ROV adaptable

"The Sound Solution"



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The array configuration for these two modes of operation is dynamically reconfigured by the system to suit the user's immediate application. Real time selection of the 2 modes allows the user to choose the mode best suited to his task at hand.

The 4200-MP uses EdgeTech's Full-Spectrum CHIRP technology to deliver wide band, high energy transmit pulses, coupled with high-resolution and superb signal to noise ratio echo data. The system employs wide band, low noise front end electronics which reduce system induced phase errors and drift to negligible levels. The sonar data is also available as a complex, fully coherent data set suitable for advanced user applied post processing.

The 4200-MP offers dual simultaneous frequency operation in both HDM and HSM and is designed to allow efficient integration of other optional sensors.

The EdgeTech telemetry link allows the sonar signals that are digitized in the towfish to be transmitted over long coaxial cable lengths with no loss of signal quality.

The 4200-MP offers two towfish options based upon the user's desired applications; a stainless steel or lightweight aluminum version. The stainless steel towfish is heavier and ideal for deeper water operation of up to 2000 meters and the lightweight aluminum towfish for shallower water operation of depths up to 500 meters. Both towfish are available with any of the three frequency sets.

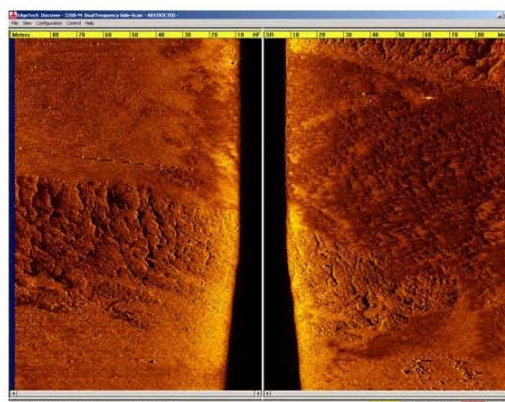
Along with the choice of towfish, the 4200-MP also offers three different topside processor options which again allows the user to customize the system to best suit his needs. All of the topside processors come installed with EdgeTech's DISCOVER software, which serves as the control and data acquisition sub-system for display, storage and printing of sonar data. You also have the option of configuring the system for third-party interface and or utilizing your own PC / laptop.

The EdgeTech Model 4200 Topside Processor is a standard 19" rack mountable topside that is ideal for use on larger vessels or when portability is not a main concern. In this configuration, all of the electronics are housed within a 19" rack mounted Windows® based PC System and the data is displayed on a high resolution flat screen color monitor.

The EdgeTech Model 4200-P Topside Processor is a portable unit that is ideal for smaller vessels or when operating outside of a protected area. All of the electronics are mounted within a waterproof "suitcase-style" housing and the data is displayed on a laptop computer via a wired or wireless Ethernet connection.

For customers who would prefer to use their own 3rd party topside processor, EdgeTech offers the 701-DL (Digital Link) which acts as the interface between the 4200-MP towfish and the display and acquisition software. With this option the user supplies the PC and runs the 4200-MP using EdgeTech's DISCOVER software.

The 4200-MP sets new standards in the industry for seafloor mapping by integrating key performance and safety features, the dual mode feature along with EdgeTech's Secondary Recovery System, Standard Heading, Pitch & Roll, optional Depth, Magnetometer interface and Acoustic responder for accurate towing positioning at a price which is commercially sensitive.



600 kHz data image of hydrophones



Data Acquisition and Processing Report

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The 4200-MP uses EdgeTech's Full-Spectrum CHIRP technology to deliver wide band, high energy transmit pulses, coupled with high-resolution and superb signal to noise ratio echo data. The system employs wide band, low noise front end electronics which reduce system induced phase errors and drift to negligible levels. The sonar data is also available as a complex, fully coherent data set suitable for advanced user applied post processing.

The 4200-MP offers dual simultaneous frequency operation in both HDM and HSM and is designed to allow efficient integration of other optional sensors.

The EdgeTech telemetry link allows the sonar signals that are digitized in the towfish to be transmitted over long coaxial cable lengths with no loss of signal quality.

The 4200-MP offers two towfish options based upon the user's desired applications; a stainless steel or lightweight aluminum version. The stainless steel towfish is heavier and ideal for deeper water operation of up to 2000 meters and the lightweight aluminum towfish for shallower water operation of depths up to 500 meters. Both towfish are available with any of the three frequency sets.

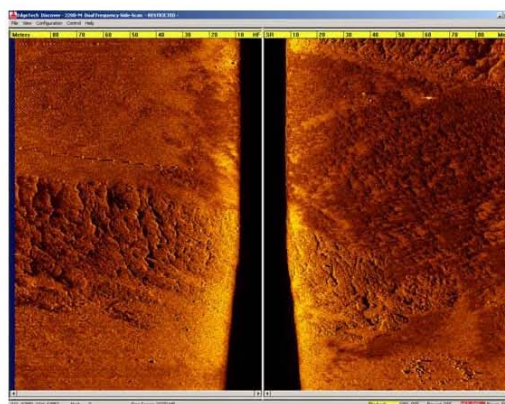
Along with the choice of towfish, the 4200-MP also offers three different topside processor options which again allows the user to customize the system to best suit his needs. All of the topside processors come installed with EdgeTech's DISCOVER software, which serves as the control and data acquisition sub-system for display, storage and printing of sonar data. You also have the option of configuring the system for third-party interface and or utilizing your own PC / laptop.

The EdgeTech Model 4200 Topside Processor is a standard 19" rack mountable topside that is ideal for use on larger vessels or when portability is not a main concern. In this configuration, all of the electronics are housed within a 19" rack mounted Windows® based PC System and the data is displayed on a high resolution flat screen color monitor.

The EdgeTech Model 4200-P Topside Processor is a portable unit that is ideal for smaller vessels or when operating outside of a protected area. All of the electronics are mounted within a waterproof "suitcase-style" housing and the data is displayed on a laptop computer via a wired or wireless Ethernet connection.

For customers who would prefer to use their own 3rd party topside processor, EdgeTech offers the 701-DL (Digital Link) which acts as the interface between the 4200-MP towfish and the display and acquisition software. With this option the user supplies the PC and runs the 4200-MP using EdgeTech's DISCOVER software.

The 4200-MP sets new standards in the industry for seafloor mapping by integrating key performance and safety features, the dual mode feature along with EdgeTech's Secondary Recovery System, Standard Heading, Pitch & Roll, optional Depth, Magnetometer interface and Acoustic responder for accurate towing positioning at a price which is commercially sensitive.



600 kHz data image of hydrophones



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4200-MP SIDE SCAN SONAR SYSTEM

Key Specifications

Sonar Specifications	
Frequency	Choice of either 100/400, 300/600 or 300/900 kHz dual simultaneous
Modulation	Full Spectrum CHIRP frequency modulated pulse with amplitude and phase weighting
Operating Range (meters/side)	100 kHz: 500m, 300 kHz: 230m, 400 kHz: 150m, 600 kHz: 120m, 900 kHz: 75m
Towing Speed (max safe)	12 knots
Towing Speed *	4.8 knots in HDM, 9.6 knots in HSM while maintaining 100% coverage
Output Power	100 kHz: 4 j, 300 kHz: 3 j, 400 kHz: 2 j, 600 kHz: 1 j, 900 kHz: 1 j
Pulse Length	100 kHz: up to 20 ms, 300 kHz: up to 12 ms, 400 kHz: up to 10 ms, 600 kHz up to 5 ms, 900 kHz: up to 3 ms
Resolution Across Track	100 kHz: 8 cm, 300 kHz: 3 cm, 400 kHz: 2 cm, 600 kHz: 1.5 cm, 900 kHz: 1 cm
Resolution Along Track	100 kHz: 2.5m @ 200m, 300 kHz: 1.0m @ 200m, 400 kHz: 0.5m @ 100m, 600 kHz: 0.45m @ 100m, 900 kHz: 18 cm @ 50m
Horizontal Beam Width (HDM)	100 kHz: 0.64°, 300 kHz: 0.28°, 400 kHz: 0.3°, 600 kHz: 0.26°, 900 kHz: 0.2°
Horizontal Beam Width (HSM)	100 kHz: 1.26°, 300 kHz: 0.54°, 400 kHz: 0.4°, 600 kHz: 0.34°, 900 kHz: 0.3°
Optional CW Pulse Short Range	Yes
Digital Link	4 Mbits/sec (typical), 4 channels of side scan data + sensor data
Dynamic Range	24 Bits
Depression Angle	Tilted down 20°
Vertical Beam Width	50°
Operating Temperature	0°C to 45°C
Power In (4200-P portable topside processor)	18-36 VDC or 110/240 VAC (auto-ranging); 300 Watts maximum
Power In (4200 rack mount topside processor)	80-140 VAC or 175-265 VAC (auto switching); 300 Watts maximum
Optional Sensor Port	(1) Serial - RS 232C, 9600 Baud, Bi-directional & 27 Vdc
Heading/Pitch/Roll	Heading Accuracy: < 1.5° RMS Heading Resolution: 0.1° Roll, Pitch Angle Accuracy: ± 0.4° Roll, Pitch Angle Repeatability: 0.2° Roll, Pitch Angle Resolution: 0.1°
Towfish Specifications	
Diameter	11.4 cm (4.5 inches)
Length	125.6 cm (49.5 inches)
Weight in Air/Saltwater	Stainless Steel: 48 / 36 kg (105 / 80 pounds) Aluminum: 30 / 18 kg (66 / 40 pounds)
Tow Cable Length	6,000 meters typical
Tow Cable Type	Co-axial
Operating Depth (maximum)	Stainless Steel Towfish: 2,000m, Aluminum Towfish: 500m
Options	Pressure, Temperature, Magnetometer, USBL Acoustic Tracking System, Depressor, Power Loss Pinger and Custom Sensors

* Meets NOAA Shallow Water Survey Specification - Min 3 pings on a 1 meter target

Other EdgeTech Products

✓ Side Scan, Sub-bottom, Integrated and Modular Imaging Systems for Deep Towed, AUV, ROV and Other Applications utilizing Full Spectrum, MultiPing or Synthetic Aperture Acquisition and Processing Techniques.



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APPLANIX POS MV ATTITUDE AND POSITIONING SYSTEM

APPLANIX - THE PREFERRED CHOICE OF MARINE SURVEY

Applanix is transforming the world of marine mobile mapping. As pioneers of the first commercial position and orientation systems for marine survey vessels, and now with over 10 years of established market leadership, we supply superior technology, expertise, and support to customers, partners, and equipment manufacturers around the world. With over 500 systems in use worldwide, the Applanix POS MV is the "industry standard" in positioning and orientation systems for hydrographic vessels.

The APPLANIX Marine Team

We have the industry's most experienced team of marine survey engineers, geospatial experts, and quality assurance personnel – all here to guarantee you the highest quality solution and the highest level of performance. Every Applanix product comes with our company-wide commitment to world-class customer care, so whether you're looking for information on using your system with a new sensor, or just need some expert advice, Applanix is here to serve you in any way.

POS MV™

The Applanix POS MV system is a GPS-aided inertial navigation system which provides a complete set of position and orientation measurements, including exceptional estimates of heave and ellipsoidal altitude. POS MV was launched onto the world market in 1996 and since that time has been the industry leader for users who are serious about making the most of their investment in multibeam technology.

The POS MV 320, POS MV Elite and the POS MV WaveMaster (for smaller survey launches) are tightly-coupled systems which use Applanix' unique approach to Inertially-Aided Real-Time Kinematic (IARTK) technology. They are user-friendly, turnkey systems which maintain positioning accuracy under the most demanding conditions, regardless of vessel dynamics.

With its high data update rate, POS MV delivers a full six degrees-of-freedom position and orientation solution. The POS MV is designed for use with multibeam sonar systems, enabling adherence to IHO (International Hydrographic Survey) standards on sonar swath widths of greater than ± 75 degrees under all dynamic conditions.

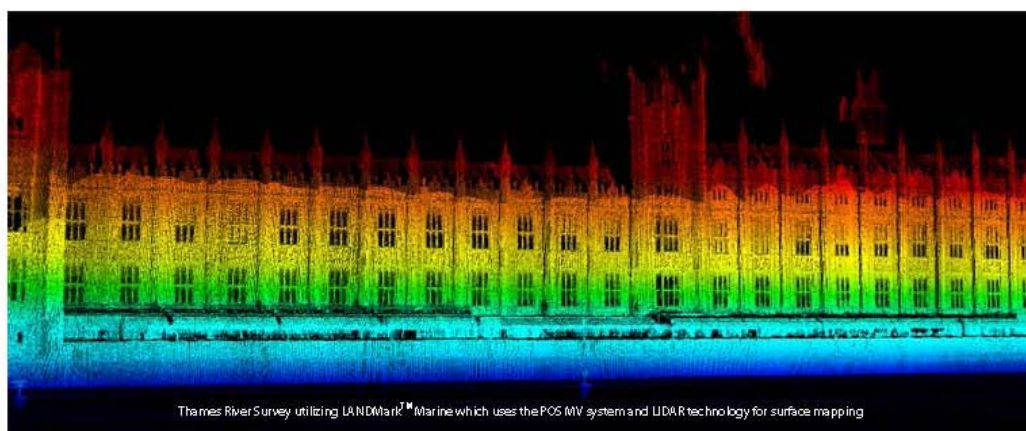
The POS MV Elite offers true heading accuracy without the need for dual GPS installation and offers users the highest degree of accuracy in motion measurement for their marine applications.

TrueHeave Technology

Applanix has redefined accuracy and reliability of heave data with TrueHeave. Based on advanced two-sided filtering techniques, TrueHeave uses both past and present vertical motion to compute a highly accurate heave estimate.

Hydrographic Mapping on the Ellipsoid

Unmeasured changes in the water level mean difficult challenges for hydrographers. Applanix has paved the way in providing centimetric level accuracy of the ellipsoidal altitude, allowing for coherent sea floor images to be obtained in even the most difficult tidal regimes.



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POS MV BENEFITS

Applanix' POS™ technology was originally developed as part of an extensive military project. This proven technology was enhanced, customized and packaged to yield an off-the-shelf commercial product, uniquely suited to the requirements of precision marine motion sensing, hydrographic surveying and charting. It has been rigorously tested and proven in trials with numerous national hydrographic offices and commercial survey organizations. POS MV delivers:

- **Reliable and repeatable performance under all dynamic conditions**
 - Very low noise L1 and L2 carrier phase measurements
 - Superior low-elevation tracking performance regardless of latitude
 - Continuous sensor monitoring to compute a robust navigation solution. Continuity of all data is thereby assured when GPS reception is compromised
- **Improved accuracy and productivity with "TrueHeave"**
 - TrueHeave software enables heave data to meet and exceed the highest marine industry standards. TrueHeave users reap the double benefits of significant improvements in accuracy and productivity.
- **Immunity to GPS outages**
 - Provides almost instantaneous reacquisition of RTK following GPS signal loss. The system uses accurate inertial data aided by GPS observables from as few as one satellite to compute a robust navigation solution, thereby assuring continuity of all data including position and heading when GPS reception is compromised. Short-term loss of GPS does not significantly degrade the POS MV roll, pitch or heading solution.
- **Robust centimetric positioning with Inertially Aided RTK**
 - Applanix' proprietary Inertially Aided RTK (IARTK) algorithms enable the rapid re-acquisition of fixed integer RTK positioning. In difficult GPS environments POS MV with IARTK affords a significantly more robust and accurate position solution than can be achieved with stand-alone RTK.
- **Operation in a high multipath environment**
 - POS MV uses high performance GPS components that enable excellent carrier phase tracking capability even in a high multipath environment. The result is robust, dynamically accurate true heading data to accuracy better than 0.02°.
- **Post-Processing Capabilities**
 - POS MV is the only marine POS solution with post-processing capabilities.
- **Self-Calibration**
 - POS MV continually monitors the status of its sensors and if required, automatically reconfigures itself to provide the best navigation solution.

- **Upgradeability**

- POS MV uses the latest Trimble BD960 24-channel GNSS receivers with Trimble Zephyr L1/L2 antennas. POS MV offers a low cost upgrade path from DGPS to L1/L2 IARTK (Applanix' unique tightly coupled Inertially Aided RTK technology) without modifying the hardware.

THE COMPONENTS

POS MV provides the functionality of a GPS receiver, gyrocompass and conventional motion sensor in a single, user-friendly, turnkey solution:

POS Computer System (PCS):

The PCS contains firmware to perform all functions necessary to control the IMU and GPS receivers, outputting



data in the correct format to interface with other systems aboard the survey vessel. The processor software functions include the Strapdown Inertial Navigation Algorithm to compute velocity, roll, pitch and true heading from the accelerometer and gyro outputs, a Kalman filter that estimates long term drift in the inertial solution using GPS aiding measurements, and an error corrector that applies the Kalman Filter estimates to the strap-down navigator to continually calibrate the inertial sensor. The PCS also contains a GPS Azimuth Measurement Subsystem for computing true heading from carrier phase measurements output by the dual GPS receivers. The processor firmware and software provide sensor calibration, and also fault detection, isolation and automatic reconfiguration.

Inertial Measurement Unit (IMU):

The IMU contains 3 high quality gyroscopes and 3 high quality accelerometers. The IMU is entirely solid state for high reliability, and is housed in its own rugged, water and salt resistant case. Power for the IMU is provided by the PCS.

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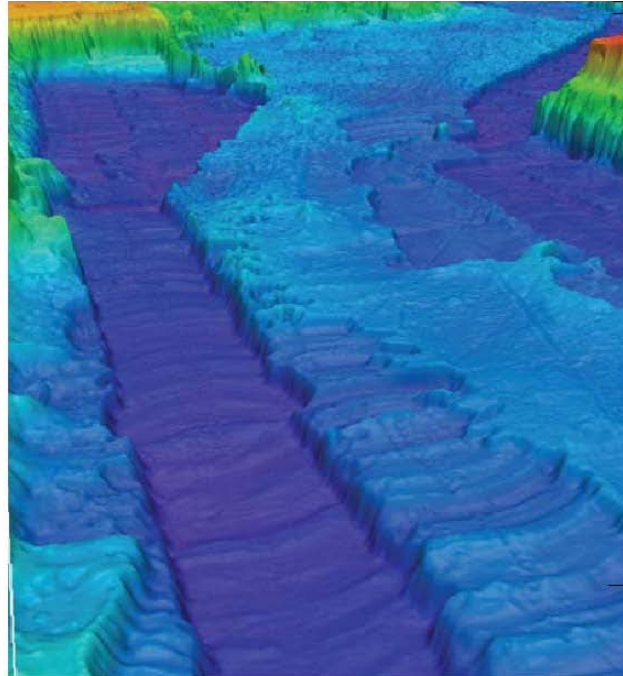
GPS Sub-system:

The GPS subsystem is comprised of two antennas and two low noise, survey grade twelve channel receiver cards embedded in the PCS. The GPS subsystem computes position to 0.02 m with optional RTK, or 1 m or better with standard differential corrections.

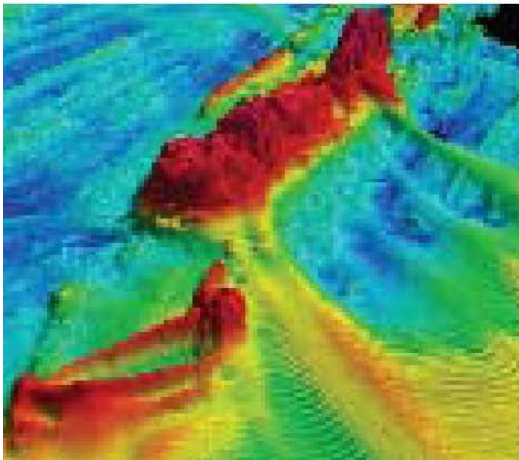
APPLICATIONS

Whether in shallow, narrow or rough waters where the GPS environment may be compromised by large vessels, cranes and other dock-side structures, or in calm and open seas, the POS MV system provides accurate, robust results in the following applications:

- Harbour Mapping
- Seafloor Mapping
- Dredging
- Wreck and Salvage Charting
- Surface Mapping with LIDAR



Above right: Multibeam image of dredged channel.
Bottom right: USCGC Healy in Northern latitudes.
Below left: Multibeam image.





TSS 335B MOTION SENSOR



GENERAL DESCRIPTION

**"Precision Roll/Pitch/Heave measurement
for all marine and offshore applications"**

Following the introduction of the new generation of multibeam echosounders and sonars where roll/pitch and vertical displacement affect the accuracy of soundings, TSS has developed the 335B Roll/Pitch/Heave Motion Sensor. In addition to this new technology, advances have also been made in base line positioning systems which now require high accuracy attitude measurement.

With these needs in mind, TSS has designed the 335B to provide accurate real-time motion measurement, providing outputs in both digital and analogue formats for applications where precise measurement of vessel motion is critical.

Cost effective, lightweight and easy to install the TSS 335B is ideally suited for precise motion measurement in all marine and offshore applications.

Measuring dynamic roll and pitch to 0.1°, and heave to 5cm or 5%, the TSS 335B enables operators to achieve maximum efficiency from a wide range of technologies. Depth rated to 1000m as standard, the TSS 335B is the most versatile and accurate motion sensor available in the market place today.

- **Multibeam Echosounder Compensation**
- **Vessel Motion Analysis**
- **Navigation Antenna Correction**
- **Dynamic Positioning Systems**
- **Acoustic Correction**
- **Defence Applications**
- **Platform Stabilisation**

Features	Benefits
• High dynamic accuracy	• Enables multibeam echosounders to exceed Intl Hydrographic Office (IHO) standards
• Real-Time Operation together with high output data rates	• Eliminates time induced errors
• Depth rated to 1000m	• Suitable for all marine applications
• Optimum combination of sensor elements	• Allows rapid recovery from the effects of vessel turns



**Making
technology
work for you!**

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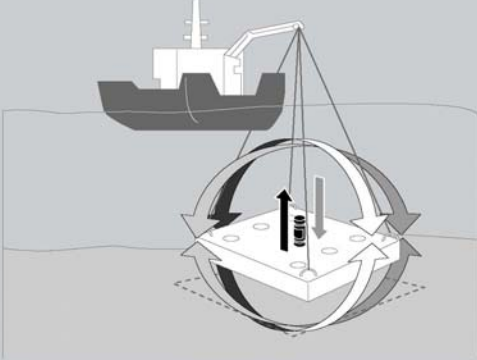


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TSS 335B MOTION SENSOR

TECHNICAL SPECIFICATIONS

Range:	335B Motion Sensor Heave: $\pm 10\text{m}$ Acceleration: $\pm 20\text{ m/s}^2$ Bandwidth: 0.1-20 secs
Accuracy:	Roll/Pitch: $\pm 50^\circ$ Roll/Pitch: $\pm 100^\circ/\text{s}$ Heave: 5cm or 5% (whichever is greater) Resolution: Digital: 1cm Analogue: 0.5cm (at $\pm 10\text{V}=\pm 10\text{m}$ [programmable]) Noise: $<0.01^\circ$ rms (*dynamic) Cross axis coupling: $<0.1\%$ (*Dynamic conditions: $\pm 30^\circ$ sinusoidal motion at 20s period)
Processing:	Analogue output update: 2730Hz Digital outputs (EIA RS232): 21Hz (free running) 0-100Hz (interrogate) Selectable output variables in various formats Settling time: <3 mins Deck cable: 30m standard (1km max) Parameter storage: E2PROM
Dimensions:	Sensor Pod: 160mm \varnothing x 370mm Mounting Plate: 270mm x 250mm x 20mm
Weight:	Sensor pod: 8.0kg Mounting plate: 1.5kg
Materials:	Sensor pod: Hard anodised aluminium Packaging: Rugged transit case
Shock (Survival):	30g peak, 40ms half-sine
Vibration (Operating):	30mm/s or 0.2mm, 7-300Hz
Acceleration/Yaw (Operating):	500mg peak, 0.1s sine/ $\pm 10^\circ/\text{s}^2$
Depth Rating:	1000m
Fixing:	3 point adjustable Trim Measurement: Automatic on command
Power:	18 - 36V d.c. 20W
Operating Temperature:	-5° to $+40^\circ\text{C}$
Connector:	Impulse MSSJ 10 pin
Options:	Field support kit Depth rating 10 1000m 90 - 260V a.c. power supply



Marketed By

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SEACAT Profiler

SBE 19plus

The SBE 19plus is the next generation *Personal CTD*, bringing numerous improvements in accuracy, resolution (in fresh as well as salt water), reliability, and ease-of-use to the wide range of research, monitoring, and engineering applications pioneered by its legendary SEACAT predecessor. The 19plus samples faster (4 Hz vs 2), is more accurate (0.005 vs 0.01 in T, 0.0005 vs 0.001 in C, and 0.1% vs 0.25% — with *seven* times the resolution — in D), and has more memory (8 Mbyte vs 1). There is more power for auxiliary sensors (500 ma vs 50), and they are acquired at higher resolution (14 bit vs 12). Cabling is simpler and more reliable because there are four differential auxiliary inputs on two separate connectors, and a dedicated connector for the pump. All exposed metal parts are titanium, instead of aluminum, for long life and minimum maintenance.

The 19plus can be operated without a computer from even the smallest boat, with data recorded in non-volatile FLASH memory and processed later on your PC. Simultaneous with recording, real-time data can be transmitted over single-core, armored cable directly to your PC's serial port (maximum transmission distance dependent on number of auxiliary sensors, baud rate, and cable properties). The 19plus' faster sampling and pump-controlled TC-ducted flow configuration significantly reduces salinity spiking caused by ship heave, and allows slower descent rates for improved resolution of water column features. Auxiliary sensors for dissolved oxygen, pH, turbidity, fluorescence, and PAR can be added. For moored deployments, the 19plus can be set to *time-series* mode using software commands. External power and two-way real-time communication over 10,000 meters of cable can be provided with the SBE 36 CTD Deck Unit and Power and Data Interface Module (PDIM).

The 19plus uses the same temperature and conductivity sensors proven in 5000 SEACAT and MicroCAT instruments, and a superior new micro-machined silicon strain gauge pressure sensor developed by Druck, Inc. Improvements in design, materials, and signal acquisition techniques yield a low-cost instrument with superior performance that is also easy to use. Calibration coefficients, obtained in our computer-controlled high-accuracy calibration baths, are stored in EEPROM memory. They permit data output in ASCII engineering units (degrees C, Siemens/m, decibars, Salinity [PSU], sound velocity [m/sec], etc.).

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

CONFIGURATION AND OPTIONS

A standard SBE 19plus is supplied with:

- Plastic housing for depths to 600 meters
- Strain-gauge pressure sensor
- 8 Mbyte FLASH RAM memory
- 9 D-size alkaline batteries
- Impulse glass-reinforced epoxy bulkhead connectors: 4-pin I/O, 2-pin pump, and two 6-pin (two differential auxiliary A/D inputs each)
- SBE 5M miniature pump with plastic housing for depths to 600 meters, and T-C Duct

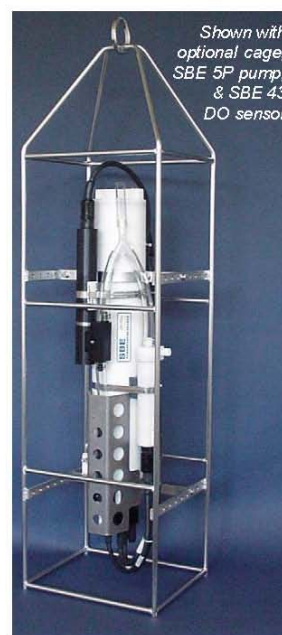
Options include:

- Titanium housing for depths to 7000 meters
- SBE 5M miniature pump with titanium housing in place of plastic housing
- SBE 5P (plastic) or 5T (titanium) pump in place of SBE 5M for use with dissolved oxygen and/or other pumped sensors
- Bulkhead connector for use with PAR sensor
- Sensors for oxygen, pH (for integration in Profiling mode only), fluorescence, light (PAR), light transmission, and turbidity
- Stainless steel cage
- MCBH *Micro* connectors in place of glass-reinforced epoxy connectors
- Nickel Metal Hydride (NiMH) or Nickel-Cadmium (Ni-Cad) batteries and charger
- Moored mode conversion kit with anti-foulant device fittings

SOFTWARE

The SBE 19plus is supplied with a powerful Windows 2000/XP software package, SEASOFT®-Win32, which includes:

- SEATERM® — communication and data retrieval
- SEASAVE® — real-time data acquisition and display
- SBE Data Processing® — filtering, aligning, averaging, and plotting of CTD and auxiliary sensor data and derived variables



Sea-Bird Electronics, Inc.
1808 136th Place NE, Bellevue, Washington 98005 USA
Website: <http://www.seabird.com>

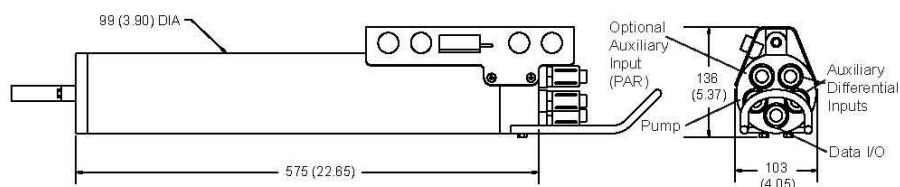
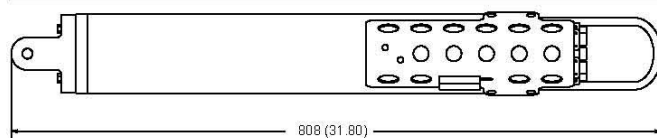
E-mail: seabird@seabird.com
Telephone: (425) 643-9866
Fax: (425) 643-9954

Data Acquisition and Processing Report

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SEACAT Profiler



SBE 19plus



Dimensions
in millimeters
(inches)

SPECIFICATIONS

	Measurement Range	Initial Accuracy	Typical Stability (per month)	Resolution
Conductivity (S/m)	0 to 9	0.0005	0.0003	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	0.0001
Pressure	0 to 20/100/350/600/ 1000/2000/3500/ 7000 meters	0.1% of full scale range	0.004% of full scale range	0.002% of full scale range

Memory 8 Mbyte non-volatile FLASH memory

Data Storage

Recorded Parameter	Bytes/Sample
T + C	6
pressure	5
each external voltage	2

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	65 mA	
Pump	SBE 5M: 100 mA	Optional SBE 5T or 5P: 150 mA
Communications	60 mA	
Quiescent	30 µA	

Auxiliary Voltage Sensors

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

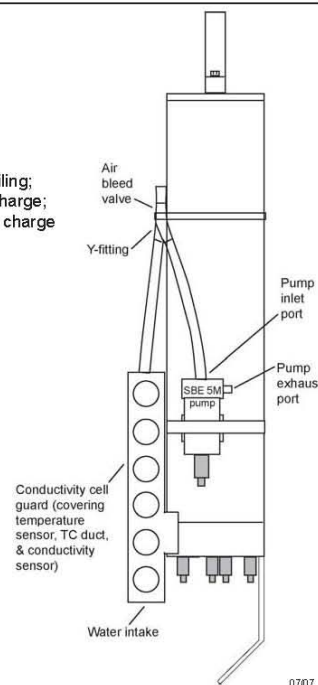
Housing Materials, Depth Rating, Weight in air*, Weight in water*

Acetal Copolymer Plastic housing, 600 meter (1950 feet), 7.3 kg (16 lbs), 2.3 kg (5 lbs)
3AL-2.5V Titanium housing, 7000 meter (22,900 feet), 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

1016 mm x 241 mm x 279 mm (40 in. x 9.5 in. x 11 in.), 6.3 kg (14 lbs)



0707



Sea-Bird Electronics, Inc.

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LETTER OF APPROVAL

Data Acquisition and Processing Report
H11829

This report is respectfully submitted.

Field operations contributing to the accomplishment of this survey were conducted under my direct supervision with frequent personal checks of progress and adequacy. This report has been closely reviewed and is considered complete and adequate as per the Statement of Work.

John Baker
Chief of Party
C&C Technologies
December 2009