OPR-K362-KR

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: Hydrographic Multibeam & 200% Sidescan

Project Number: OPR-K362-KR

Time Frame: Beginning June 2006

LOCALITY

State: Louisiana

General Locality: Gulf of Mexico

2007

CHIEF OF PARTY
Joseph Burke

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DATE: September 2007, version 2

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A. EQUIPMENT

The major operational systems used to acquire hydrographic data include the Odom 200 kHz Hydrotrac single beam echosounder, a Simrad EM3002D multibeam echosounder, a Simrad EM 3002D single head transducer, and Klein 5000 and 3000 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.

A.1 SURVEY VESSEL

The survey vessel *Brooks McCall* was the survey vessel from which all hydrographic operations were conducted. The *S/V Brooks McCall* was leased from Cameron Offshore Boats of Cameron, Louisiana.

Vessel diagrams and specifications are included in Appendix A. The diagrams show all offsets from the vessel center reference point 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

Aboard the R/V *Brooks McCall,* a 200 kHz Hydrotrac single beam echosounder was installed on a retractable ram inside a moon pool configuration. Data from the Hydrotrac was continuously recorded and monitored in real-time as an independent check of the nadir beam (bottom-detect) of the multibeam sonar system.

A.3 MULTIBEAM SONAR OPERATIONS

Survey operations aboard the S/V Brooks McCall were conducted using a single head Simrad EM 3002. The transducer head was mounted on a retractable ram that was contained within 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 data collection, processing, quality assurance, and quality control. 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.

A.4 SIDE SCAN SONAR OPERATIONS

The Klein 5500 side scan sonar was operated in a towed configuration. During field operations on board the *S/V Brooks McCall*, the tow point was at the stern of the boat 28.4 meters astern of the vessel reference center.

Survey operations were conducted at speeds averaging 6.5 knots. With the Klein 5500's multibeam technology the requirement that a 1-meter target be ensonified a minimum of three times per pass was exceeded. The side scan sonar was operated at a 100-meter range scale with line spacing set at 90 meters for the majority of the survey, and was towed such that the fish remained between 8 and 10 meters off bottom. In shallower areas, such as subareas one and two of sheet A, and subarea one of sheet B, line spacing was reduced to 65 meters, but the range scale was kept at 100 meters. Confidence checks were performed a minimum of once a day.

Triton-Elics's Isis software was used for data collection and processing of the side scan sonar data.

B. QUALITY CONTROL

B.1 MULTIBEAM

B.1.1a PROCEDURES (Smooth Sheet production – Sheet A)

The first step in post-processing was to extract the generic vessel navigation data. The vessel position data (latitude, longitude, time) was extracted from the positioning systems' data files, discarding non-differential and high HDOP fixes. The appropriate UTM Zone projection (15N) was applied to the fixes to produce our standard x, y, time navigation files.

Next the data was time correlated and georeferenced. The transmit time of the ping was used to interpolate between the two nearest navigation fixes to determine the vessel position at the time of the ping. The position was compared to previous ping position and an alarm was generated if the distance exceeded a settable threshold.

The location of each sounding was calculated from the vessel position, the along-track and cross-track ranges and vessel heading given by the Simrad datagram, and the offset from the Navigation reference point to the transducer.

The vertical value for the sounding was calculated from the depth value from the Simrad datagram (which has draft, motion, and ray-tracing applied), a time interpolated tide level, and static z offset (to offset for the centroid of the squat range).

Soundings that were outside of a given sector were discarded. The outermost soundings that exceeded maximum allowed sounding spacing were discarded. A file containing georeferenced x, y, and z for each sounding was produced.

The soundings were then binned to reduce the data to one representative sounding per bin. Several algorithms were available for the binning process. A multi-shifted-median filter was developed to produce binned soundings for the smooth sheet. The median filter was set such that instead of selecting the 50th percentile sounding, it selected the sounding nearest the 60th percentile. This filter ran repeated shoal-biased median filters over the bins, shifting the x and y bin borders by a small fraction of the bin size each time. The resulting median values from all of the passes were run through a shoal filter to select the shoalest sounding for the bin.

The Dataview editor was run on the binned data for each of the survey lines to flag transient water column reflectors and other noisy or errant soundings, determined at the discretion of the Hydrographer. For any questionable soundings in the binned data, the processor looked at the raw data at the same time using Coverage before flagging any points. Cull files were generated to list the stray soundings. The binning process was repeated with the new cull files.

Once all data for each tide zone was processed and merged, the survey lines were merged together using a shoal filter to select the shoalest co-located binned sounding. The merged data were sorted by depth with the shoalest soundings first. The data was cropped such that only soundings within the tidal zone remained.

To produce the final selected soundings for the smooth sheet, each sounding was examined in ascending order and selected if it could be placed on the plot without overlapping other soundings. An AutoCAD DXF file was generated with the 3D points associated with the selected soundings.

Once all of the soundings had been selected, back-trace files were generated. The trace data table entries corresponding to smooth sheet soundings were used to generate AutoCAD block attribute data for each sounding. This information was imported into the AutoCAD smooth sheet drawings.

B.1.1b PROCEDURES (BASE Surface – Sheet B)

All multibeam data collected for H11537 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.

This survey was broken into 5 separate survey areas, named subareas 1 – 5. In order to allow for more efficient processing of the data, these 5 subareas were treated as independent surveys. Following the completion of processing of all 5 areas, they were all 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. Tides were applied to all multibeam data in Caris using tidal data downloaded form the NOAA CO-OPS website, and corrected using a tidal zone definition file (.zdf) supplied by NOAA. After reviewing the processed data along the edges of the tidal zones, it was determined that no alterations to the .zdf file were required. Both the tide (.tid) and .zdf are included in the Caris project submitted in conjunction with this report. An angle from nadir filter that rejected all data outside of a 52-degree angle on both sides of the swath was applied to all data.

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 5 meters. All BASE surfaces were created based upon the IHO special order 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.1.3 SPECIAL CASES

The above-described procedure was for all the data however there were special cases when the automated processing did not choose the appropriate representative or least depth. This was often the case for obstructions and significant contacts. For each of these items a special procedure was followed whereby the least depth was hand picked by the hydrographer. The data in a small area surrounding the center of the target was processed at a very small bin size – approaching raw data density. The data was then viewed in conjunction with the side scan data in the same area. The shoalest point on the target was chosen by the hydrographer/processor and was inserted manually into the selected soundings file. All back-trace information was included with the sounding as it was for all other automatically chosen soundings that made it to the preliminary smooth sheet.

B.2 SIDE SCAN

B.2.1 REVIEW PROCESS

All data was reviewed at least twice in the field. The side scan operator reviewed all data during collection and noted in the survey logs any significant features or surface/water column effects. Within hours of collection the data was 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 were generated in the field and 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

C.2.1 S/V *BROOKS MCCALL*

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. The CRP was established as an arbitrary point along the central along track axis of the ship within one meter of the multibeam mounting pole.

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

C.3 STATIC AND DYNAMIC DRAFT CORRECTIONS

A settlement and squat test was performed on the Brooks McCall on June 15, 2006. The vertical corrections applied to the data, described in the following chart, varied with speed.

Vertical Correction	Speed (Knts)
-0.00225	0
0.007768421	2.9
-0.060370677	5.6
-0.172038879	7.8
-0.333587141	9.8

A draft tube was installed on the vessel prior to the survey. The draft tube was read once daily while at sea and the water level/draft entries were updated in each system as required. In addition to the daily readings, readings were also taken prior to each departure from the dock.

C.4 VESSEL MOTION CORRECTIONS

A Coda Octopus F180 was integrated with the multibeam and navigation software as the primary positioning and motion sensor for the 2006 survey season aboard the *Brooks McCall*. The F180 provided real-time heave, pitch, and roll corrections, as well as primary navigation.

Prior to the survey, a standard patch test was performed at the work site (Sheet A) to determine correctors for latency, pitch, roll, and heave aboard the *S/V Brooks McCAll*. A charted obstruction was used as the target for the patch test. The patch test was performed in the following manner.

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 was run with each head in single head mode.

Two patch tests were performed on board the *Brooks McCall* during the 2006 survey season. The initial patch test was run on June 24, 2007 prior to the commencement of survey operations. The results of that test are shown below.

Roll	Pitch	Heading
-0.66°	0.00	-2.86°

A second patch test was performed on September 8, 2007 as a result of difficulties encountered raising and lowering the multibeam mounting ram. The results of the patch test are as follows:

Roll	Pitch	Heading
-0.51°	0.00	-2.86°

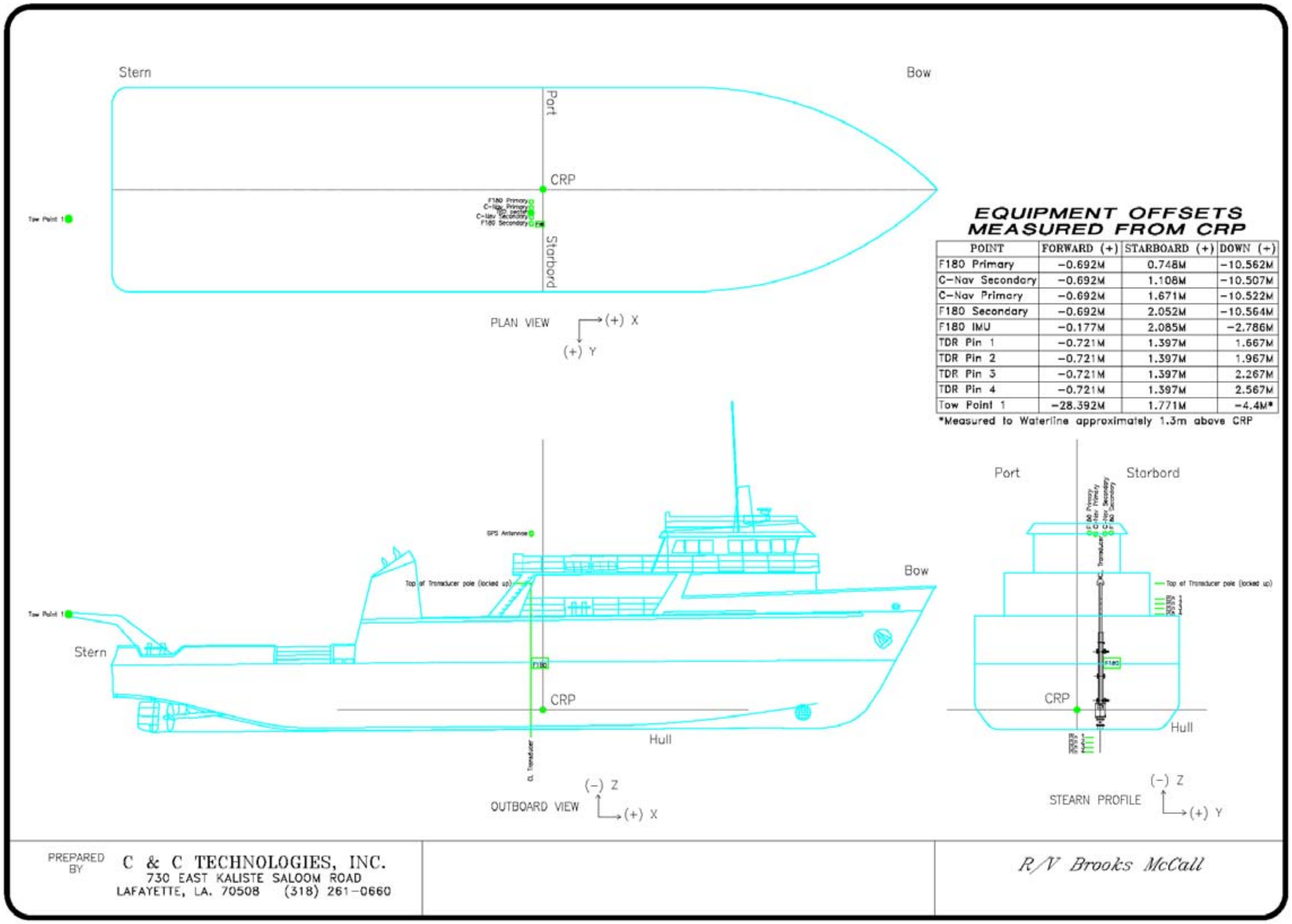
C.5 SOUND VELOCITY CORRECTIONS

Two Seabirds with the following S/Ns were used, 3278 and 3279. Casts were performed at least twice daily and more often as needed. 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. Two 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.

APPENDIX A - VESSEL DESCRIPTIONS



EQUIPMENT OFFSETS MEASURED FROM CRP

POINT	FORWARD (+)	STARBOARD (+)	DOWN (+)
F180 Primary	−0.692M	0.748M	−10.562M
C−Nav Secondary	−0.692M	1.108M	−10.507M
C−Nav Primary	−0.692M	1.671M	−10.522M
F180 Secondary	−0.692M	2.052M	−10.564M
F180 IMU	−0.177M	2.085M	−2.786M
TDR Pin 1	−0.721M	1.397M	1.667M
TDR Pin 2	−0.721M	1.397M	1.967M
TDR Pin 3	−0.721M	1.397M	2.267M
TDR Pin 4	−0.721M	1.397M	2.567M
Tow Point 1	−28.392M	1.771M	−4.4M*

*Measured to Waterline approximately 1.3m above CRP

VESSEL PROFILE

Vessel Name	BROOKS McCALL
Owner/Operator	Cameron Offshore Vessels
Flag/Home Port	USA/Cameron, La
US Coast Guard Official Number	1093280
Year Built	1999
Place Built	Mobile, Al
Builder	C&G Boat Works Inc.
Hull Number	44
Intended Service	Ocean Research
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	144 ft. LOA
Breadth	40 ft
Depth	13 ft
Draft (summer load)	13.3 ft
Gross Tonnage	182 US regulation tons
Net Tonnage	123 US regulation tons

APPENDIX B – EQUIPMENT DESCRIPTIONS

ODOM HYDROTRAC 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:

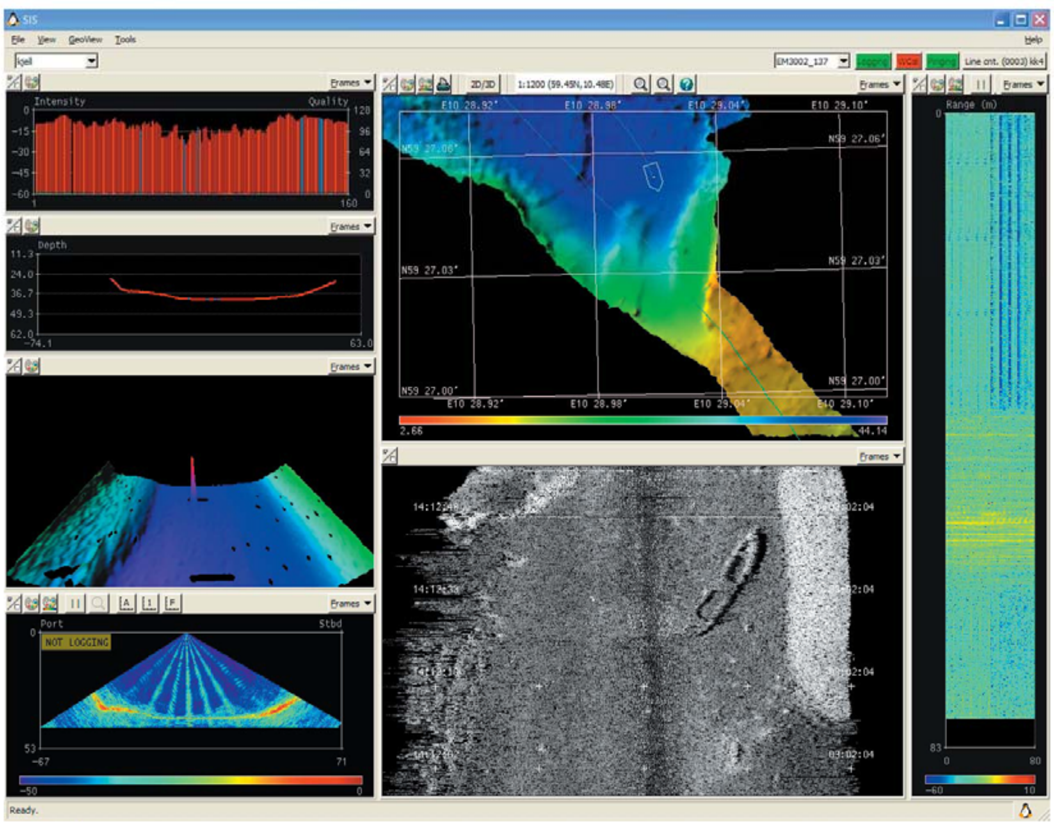
Frequency	200 kHz
Output Power	500 Watts
Power Requirement	11-28 VDC
	110/220 VAC (Optional)
Ports	RS 232

EM 3002

KONGSBERG

Multibeam echo sounder

The new generation high performance shallow water multibeam



(855-164771 / Rev.D / March 2004)

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 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 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.

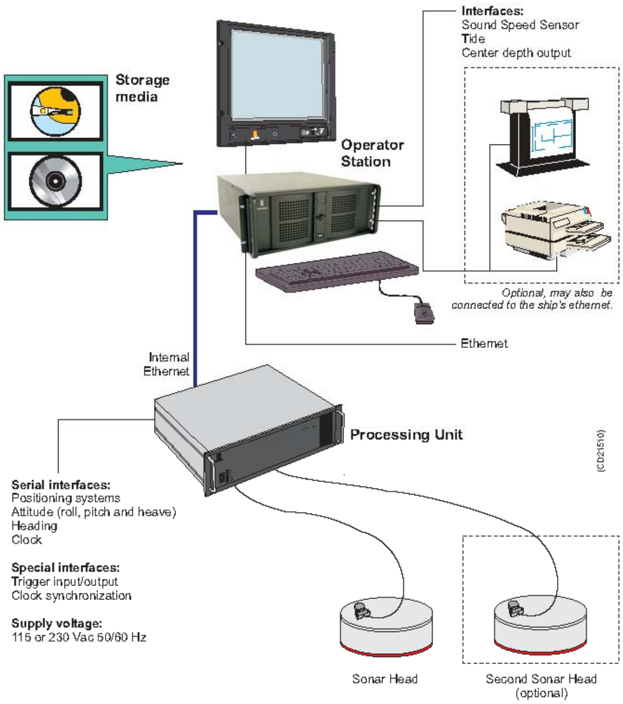
Operator Station

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.

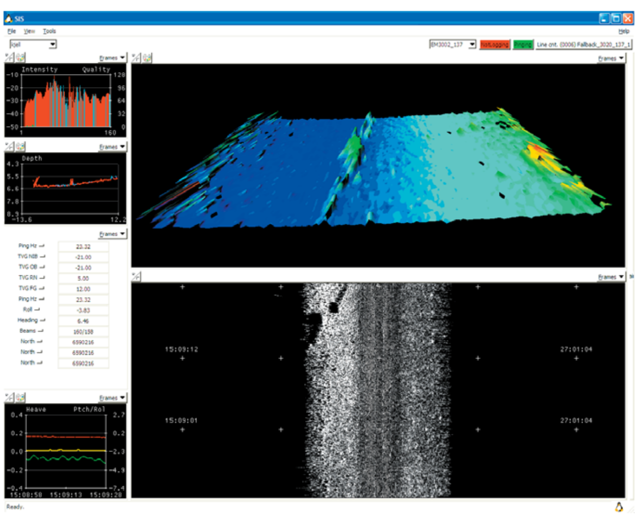
The EM 3002 can be set up to use other operational software than SIS, for example QPS "QINCy" or Coastal Oceanographics "HYPACK Max", and is also supported by software from Triton Elics International, EIVA and others.

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



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.

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 focussing 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)
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

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***
Ethernet Interface (I00base-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

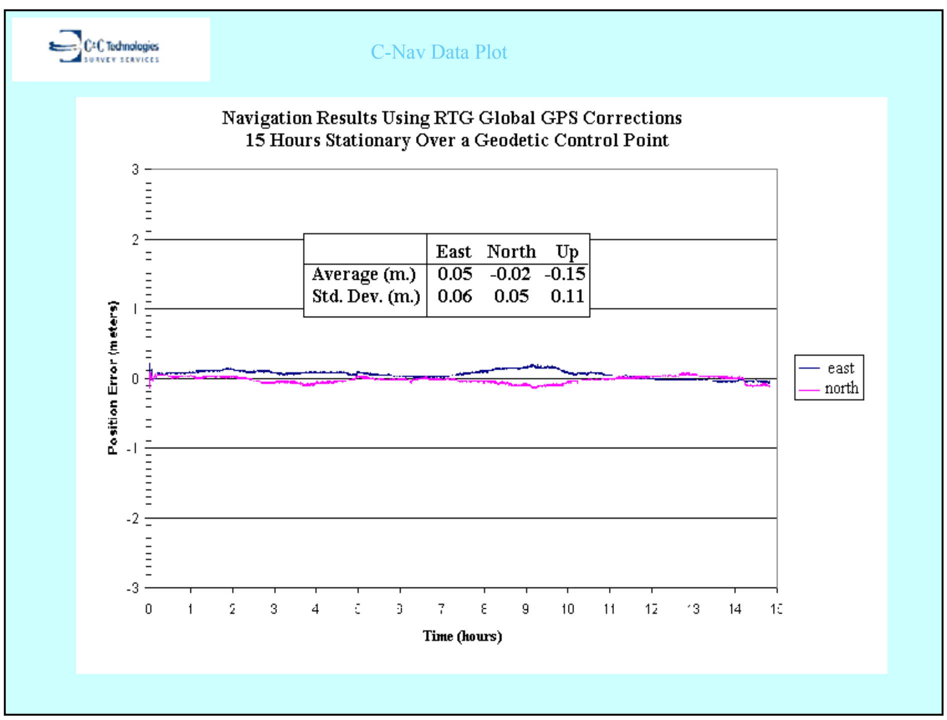
C-Nav is a globally corrected differential GPS system owned and operated by C & C Technologies, Inc. The C-Nav GPS Receiver combines a dual-frequency, geodetic grade, GPS Receiver with an integrated L-BAND communication RF detector and decoder all linked by an internal microprocessor. C-Nav uses monitoring 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 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
- 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

APPENDIX C – CALIBRATION RECORDS

LETTER OF APPROVAL

Data Acquisition and Processing Report

H11537

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.

Joseph Burke
Chief of Party
C&C Technologies
September 2007