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

Field No. OPR-A366-KR-10

Registry No. H12256

LOCALITY

State Maine

General Locality Southern Penobscot Bay

Sublocality Southern Penobscot Bay

Defiance and Caledonia Beach

2010

CHIEF OF PARTY

Donald L. Brouillette

LIBRARY & ARCHIVES

DATE

NOAA FORM 77-28
(11-72)

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

REGISTRY No H12256

HYDROGRAPHIC TITLE SHEET

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

FIELD No.

State Maine

General Locality Southern Penebscot Bay

Sub-Locality Southern Penobscot Bay

Scale 10,000 **Date of Survey** 8-26-2010 - 9-28-2010

Instructions dated 05-20-2010 **Project No.** OPR-A366-KR-10

Vessel M/V Defender IV (1154554) M/V Beaver (1054456)

Chief of party Donald L. Brouillette

Surveyed by Brian Bunge, Jacob Deming, Ransom White

Soundings by echo sounder, hand lead, pole Kongsberg EM3002 MBES

Graphic record scaled by N/A

Graphic record checked by N/A **Automated Plot** N/A

Verification by Atlantic Hydrographic Branch

Soundings in fathoms feet at MLW MLLW Meters at MLLW

REMARKS: The purpose of this work is to provide NOAA with modern and accurate hydrographic survey data for the area in Southern Penobscot Bay.

All times are in UTC.

Projection is UTM (NAD83) Zone 19 N.

NOAA FORM 77-28 SUPERSEDES FORM C&GS-537

U.S GOVERNMENT PRINTING OFFICE: 1976-665-661/1222 REGION NO.6

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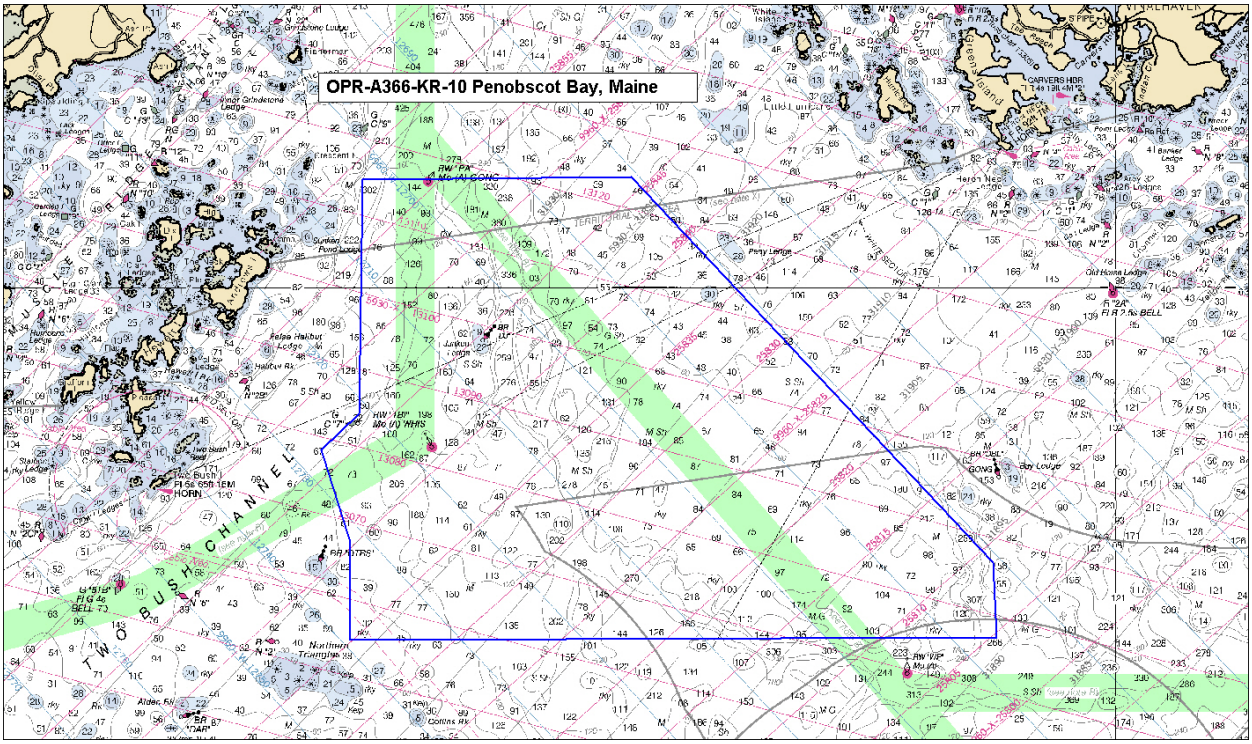


Figure 1: OPR-A366-KR-10

A. EQUIPMENT

A.1 Vessel – M/V R&R

The Ryan Marine's R&R is a custom built fiberglass Chesapeake that is 48 feet in length with an 18 foot beam. More vessel information is available in *Appendix A.*

A.2 Sounding Equipment

The M/V R&R was equipped with a pole mounted 300 kHz EM3002 multibeam system for the duration of the OPR-A366-KR-10 project. The EM3002 has 254 horizontal beams centered 1.5º apart and an along-track beam width of 1.5º with a maximum swath width of 130º or 200m (*Appendix C*).

A.3 Positioning and Orientation Equipment

The M/V R&R was equipped with an IXSEA OCTANS surface gyrocompass and motion sensor. The OCTANS has a heading accuracy of 0.1º times the secant of the latitude (0.1 x 1/COS latitude), and a resolution of 0.01º. Heave, surge and sway measurements are accurate to 5 cm or 5% of the measured amplitude. The dynamic roll and pitch accuracy is 0.01º with a resolution of 0.001º (*Appendix G)*. Position was determined in real time using a Trimble Zephyr Model 2 GPS antenna connected to a Trimble SPS 851 DGPS System (*Appendix B*). Coast Guard differential corrections were received by a Hemisphere MBX-4 DGPS beacon receiver. More information on the MBX-4 beacon receiver can be found in *Appendix D.*

The R&R survey crew monitored real-time QC displays in QINSy throughout the survey to ensure that the positional accuracies specified in the NOS Hydrographic Surveys Specifications and Deliverables were achieved.

A.4 Software

A.4.a Acquisition

Two computers were used during acquisition aboard the M/V R&R, one acting as an acquisition machine (SIS), the other as a navigation computer (QINSy). The data were collected and stored using SIS. The QINSY navigation computer also logged data as a backup. The QINSy computer operated on a 2.86 GHz Intel core 2 Quad processor PC running Windows 7. The Kongsberg SIS acquisition PC operated on a 2.86 GHz Intel dual core 2 processor PC running Windows XP service pack 3. Multibeam data were stored in their native SIS .all format and the native QINSy .db format. The recorded .all files contain bathymetry data corrected for horizontal position offsets, static draft, vessel attitude, heading and ZDA/1pps time stamp data.

Two log files were maintained daily aboard the R&R. The SVP and WL log, maintained by the sonar operator, contains daily water line measurement values and sound speed probe deployment operations. The Acquisition log, maintained by the navigator, was used to record relevant information such as the line number that was run, navigation information concerning time and location of the R&R and status updates about the daily operations and weather.

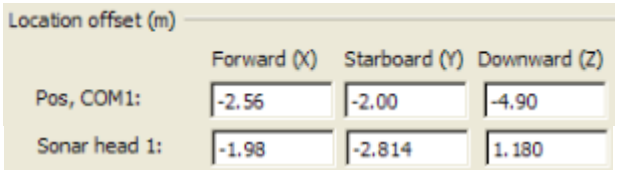
A.4.b Processing

All Soundings were processed using CARIS (Computer Aided Resource Information System) HIPS (Hydrographic Information Processing System) v6.1 SP2 hotfix 8

IVS Fledermaus 6.7 was used to generate CUBE surfaces for data cleaning and filtering.

A complete list of software and Hardware used on this project is included in *Appendix E and F*.

GPS and MBES offsets from the vessel were accounted for in SIS during acquisition while the patch test calibration values, TPU values, dynamic draft, and waterline measurements were entered into the HVF and applied during the merge process in CARIS HIPS. The physical offsets for the GPS and MBE were as follows:



B. QUALITY CONTROL

B.1 Processing Routine

In the CARIS Vessel Configuration File (HVF) for the M/V R&R, error estimates for all survey sensors were entered. These error estimates were used in CARIS to calculate the Total Propagated Uncertainty (TPU) at the 95% confidence interval for the horizontal and vertical components for each individual sounding. The values that were input in the CARIS HVF file for the survey sensors are the specified manufacturer accuracy values and were downloaded from the CARIS website http://www.caris.com/tpu/ in August 2010.

The calculated vertical and horizontal uncertainty or TPU values were then used to:

- Build and edit CUBE surfaces in IVS Fledermaus
- Filter the data to IHO order 1 specifications.
- Create finalized BASE surfaces that used only soundings meeting or exceeding IHO Order 1 standards and have been CUBE filtered in Fledermaus.

An overview of the data processing flow follows:

In order for the SIMRAD files to be used by CARIS, they must be converted to HDCS format using the CARIS conversion wizard. Horizontal and vertical sensor offsets were accounted for in SIS prior to the conversion while the patch test calibration values, TPU values, dynamic draft and waterline measurements were entered into the HVF.

Once converted, the tide data was loaded into each line and then the line was SVP corrected and merged in CARIS HIPS. The TPU was then computed for each sounding and the attitude, navigation and bathymetry data for each individual line were examined for noise, as well as to ensure the completeness and correctness of the data set.

After each individual line was examined and cleaned in CARIS HIPS, the HDCS files were then used to build Combined Uncertainty Bathymetry Estimator (CUBE) surfaces in IVS Fledermaus using PFM Direct. The CUBE surfaces were created at the finest resolution possible. The following depth thresholds were used on this project for cleaning purposes.

- Depth Threshold: 0 to 22 meters, resolution = 1 m
- Depth Threshold: 20 + meters, resolution = 2 m

Other CUBE options and configurations are as follows:

- Bin Size: 1-2 meters dependant on depth
- Vertical Resolution: 1cm
- CUBE Capture Distance: 5% of depth
- CUBE Hypothesis Resolution Algorithm: Number of Samples for depths <30m and Predicted Surface for depths >30m (this was done to obtain the best portrayal of possible DTON areas)

The data was then cleaned in Fledermaus by flagging and rejecting individual soundings or correcting the CUBE surface. The soundings were then filtered to IHO Order 1 standards off the CUBE surface; in some specific cases user defined filters were used near steeply sloping bathymetry to avoid filtering out valid data or possible DTONs.

Sounding data that were CUBE filtered and passed the required quality assurance checks were used in the final BASE uncertainty surfaces.

Deviations from these thresholds, if any, are detailed in the appropriate DR.

B.2 Uncertainty Values

Uncertainty is generally lowest near the sonar nadir beams and increases toward the outside of each swath. This is expected and primarily a result of sound speed error uncertainty.

Higher uncertainty is apparent in areas of steep or rapidly changing bottom topography, areas of variable sound speed through the water column, and areas where outer beams were left to contribute to the surface. However, despite high uncertainty in these areas, data matchup is good and acceptable for nautical charting purposes.

Uncertainty values for computation in CARIS are as follows:

Tide values:	Measured	0.1	m	Zoning	0.2	m
Sound Speed values:	Measured	0.2	m/s	Surface	0.2	m/s

These values were obtained from the HSSD 2010 as the least amount of expected uncertainty. The sound speed values also correlate with the comparison sound speed casts conducted.

The resulting uncertainty for this survey is described in detail in OPR-A366-KR-10 DR submitted under a separate cover.

B.3 Designated Soundings

While examining the data in subset mode, soundings were designated wherever the CUBE surface did not adequately depict the shoalest point of a feature. Designations were initially assigned to soundings in IVS Fledermaus, then were double checked and added to CARIS. Soundings were designated when they met or exceeded the criteria for designation set forth in the HSSD (April 2010) to ensure they were carried through to the finalized BASE surfaces.

C. CORRECTIONS TO SOUNDINGS

C.1 Sound Speed data

Sound speed profile casts were taken approximately every three hours, or when the sound speed at the head shifted by more than 2 m/s. Two Seabird CTDs were used aboard the R&R, each having been calibrated at the Sea Bird headquarters on August 4th, 2010. The CTD used for daily operations was a SBE 19+, while a SBE 19 was used for comparisons and, if needed, for backup. For each cast, the probes were held at the surface for 1-2 minutes to allow time for the unit to turn on and reach temperature and pressure equilibrium. The probes were then lowered and raised at an approximate rate of 1 m/s. The SBE 19+ was set to sample the water at a rate of 2Hz while the SBE 19 was set to sample at 1Hz. Only the downcasts were used for post processing. After each cast, the Sea Bird probes were rinsed out with freshwater to minimize salt-corrosion and in some cases to rinse out sediment.

The R&R used an OSIL Environmental and Marine Instruments' Smart AML SV&P for sound speed at the head of the EM3002, calibrated March 6th, 2010. Comparison casts (confidence checks) were completed every week between each probe and sensor in compliance with the HSSD (April 2010), section 5.1.3.3.

C.2 Squat and Settlement

The squat and settlement test for the M/V R&R was conducted on a due west heading on the leeward side of the Rockland Harbor jetty, on September 15th, 2010 (Julian Day 258).

The squat/settlement test was performed by first establishing a 1000 meter line up a shallow slope. Three reference areas were then logged at 250m, 500m and 750m with the engines out of gear coasting at 1-2 knots. These reference areas were run using the same methodology after the full line collection was completed. The full line was then run 5 times with the same heading, North, at incrementing vessel speeds (4, 5, 6, 7 and 8 knots). These data were then compared at each reference point (see squat and settlement spread sheets) by sampling soundings in the subset editor in CARIS. Median depth and average speed were computed for each line at each reference point. The difference in median depth were computed and correlated with the appropriate average speeds to plot overall Squat and Settlement.

All measurements were corrected for pitch, roll, and reduced to the vessel's common reference point (CRP) in the CARIS vessel configuration file, HVF. It should be noted that a pitch offset of 5.850 deg was entered due to the MBE pole mount being cranked too far aft-ward, since any vertical shift in this behavior is negligible this had no affect on the validity of the test. Heave was removed so that the long-period heave would not produce bias in the dynamic draft calculations. A tide file was created using the average difference in depth between each pre and post corresponding reference point. Procedures were taken from Settlement and Squat Procedures Using the Multibeam Echo Sounder Method (see below for charted and table results).

Figure 2 - M/V R&R Settlement Curve

The results of the squat settlement test for the EM 3002 are shown below.

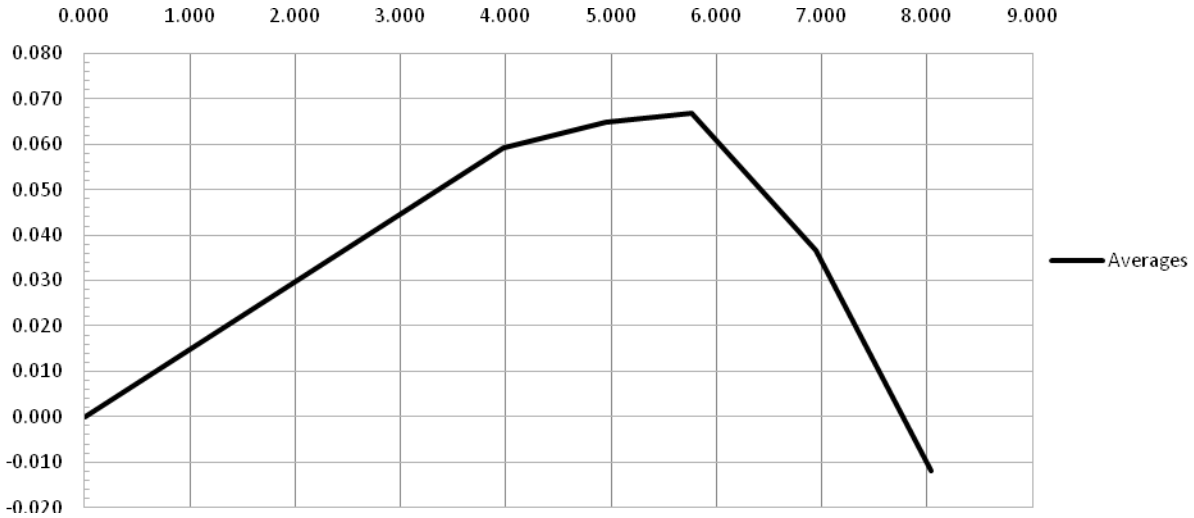


Table 1

M/V R&R EM3002 CALCULATED SETTLEMENT	
Speed (kts)	Settlement
0.000	0.000
3.973	0.059
4.947	0.065
5.765	0.067
6.945	0.037
8.034	-0.012

Note: Vessel speed was noted on the survey line logs, and the settlement values were entered into the CARIS HVF so HIPS could perform the correction automatically during merge.

C.3 Static Draft

Static draft was measured immediately before and after daily survey operations. These were measured on the pole mount on the port side. The MRU draft (vessel reference point Z value) was marked as 0 on the pole; 30 cm were then notched along the pole in each z direction (up and down) in 1 cm increments. Over the span of the entire survey the average draft was -0.166m with a standard deviation of 0.007m. Refer to table 2 below for draft values.

Table 2: M/V R&R Static Draft Measurements

Date	Time	Draft (m)
2010-238	12:30	-0.17
2010-239	5:00	-0.16
2010-242	5:00	-0.17
2010-244	22:30	-0.16
2010-250	11:45	-0.17
2010-251	12:30	-0.18
2010-252	12:30	-0.17
2010-253	12:00	-0.17
2010-253	21:30	-0.16
2010-254	12:30	-0.17
2010-256	11:00	-0.16
2010-259	22:00	-0.15
2010-261	14:30	-0.17
2010-264	12:00	-0.16
2010-267	12:30	-0.17
2010-270	22:15	-0.16

C.4 Tides

All sounding data were initially adjusted to MLLW using observed tidal data and tide zoning corrections (supplied by CO-OPS) from the Bar Harbor tide station (8413320). Observed tides were used for preliminary processing only. Verified tides were downloaded from the NOAA database for the Bar Harbor tidal gauge on October 07th, 2010. Verified tidal data were used for all final base surfaces.

C.5 Vessel Attitude

The M/V R&R's heading and dynamic motion were measured by the IXSEA OCTANS III (IMU). The system calculated heading and motion using its fiber optic gyroscope and motion sensor. The OCTANS was mounted just aft of the forward cabin/pilot house on the R&R at the vessels center of gravity. The operational accuracy specifications for this system can be found in *Appendix G.*

C.6 Calibrations

Multibeam patch tests were conducted on site each day of MB operations.

Pitch and roll offsets for the M/V R&R proved to be an issue due to the configuration of the EM3002 transducer mounting pole (which was re-fabricated and modified over the course of the first week of survey operations). Each day the mounting pole was winched tightly into the waterline bracing arm. Even though no visible difference between days could be observed on deck it became apparent in the data that we were getting a fraction of a degree in pitch and roll offset variation, the standard deviation of which was 1.175 degrees for pitch and 0.153 degrees for roll over the course of the entire survey (these values are also highly affected by the pole refabrication). These variations were accounted for by running 3 patch test lines each day for calibration purposes. The end result shows no significant errors in pitch, roll or yaw.

All calibration lines and vessel files (HVF) are included in the digital data deliverables. Please see *Appendix H* for the calibration report and procedures.

The Seabird CTDs used aboard the R&R (SBE-19 and SBE-19+) were each calibrated at the Sea Bird headquarters in August 4th, 2010.

D – APPROVAL SHEET

REGISTRY NUMBER H12256

This report and the accompanying digital data are respectfully submitted.

Field operations contributing to the accomplishment of project H12256 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.

WILLIAMSON AND ASSOCIATES, INCORPORATED

Digitally signed by Donald L. Brouillette
DN: cn=Donald L. Brouillette, o=WASSOC, ou=Survey, email=dbrouillette@wassoc.com, c=US
Date: 2010.10.12 17:30:47 -07'00'

Donald L. Brouillette

Hydrographer

Williamson & Associates, Incorporated

12 October 2010

M/V R&R

MV R&R is a custom built 48' Chesapeake and is well equipped for coastal research along with personnel movement ranging from day trips to extended cruises up and down the eastern seaboard.

The MV R&R is well equipped to support research, dive tending, and deployment of ROV's, bottom sensors, and Helix moorings. Currently outfitted davits capable of a 1500 lb. lifting capacity, open deck and open deck space of 17' x 25'.

Specification

Deck Space

- Main Deck: 17'x25' (425 sq. ft.)
- Fly Bridge: 16'x16' (256 sq. ft.)

Mid Transom Davit

- Power In & Out Winch: 1500 lb. capacity
- Free Spool & Planetary Clutch Brakes

Side Mount Davit

- Hand Crank Winch 350 lb. CapacityDive Ladder
- Fresh & Saltwater Wash Down
- Chain Hoist
- Block & Tackles
- 3 Point Anchor Capability
- (3) Steering Stations Main Cabin/Aft Deck/Fly Bridge
- 11' Inflatable 8 HP OB
- Main Deck Payload Capacity: 7840 lbs.

Two-ton A-frame with winch & slip ring

Engines

- Main Engines: (2)3208 Cats - 435 HP each
- Gen-Set: Isuzu 6.3 KW
- Trolling Valve Port Engine

LOA: 48'

- Height: 25'
- Draft: 4' 6"
- Fuel Capacity: 400 Gallons
- Range @ Cruising Speed: 18 Knots 240 NM @ 30 GPH
- Beam: 18'
- Weight: 25 Gross Tons

Electronics

- 36 Mile Furuno Radar
- Furuno Chart Plotter
- Furuno Color Depth/Speed/H20/H20 Temp (50/200k)
- Hand Held GPS/VHF
- Standard Horizon VHF
- (2) Remote Spot Lights
- (2) Loud Hailer & Intercom Systems
- 110 Outlets throughout Vessel

DATASHEET

TRIMBLE SPS751 AND SPS851 MODULAR GPS RECEIVERS

KEY FEATURES

- Highly flexible base or rover receiver for construction site measurement applications and system integrators
- Separate antennas and receiver for maximum radio coverage and security on the job site
- Integrated license-free 900 MHz or 450 MHz UHF radio for base and rover tasks
- Rapid daily base station setup with a single button push using AutoBase™ technology
- Internet enabled base station via Ethernet or GSM/GPRS phone
- Supports GPS and L2C Modernized GPS signals
- Trimble SPS851 can be upgraded with GLONASS or L5 signals
- Integrated battery that also acts as a UPS power supply
- 1PPS output for time synchronization with other devices

FLEXIBLE GPS RECEIVER FOR PRECISE POSITIONING

Trimble® SPS751 and SPS851 Modular GPS Receivers are ideal for semi-permanent or permanent base station setups, construction rover applications as well as marine based applications.

Now heavy and highway contractors have the ideal base station to support grade checking, site measurement and stakeout. The receivers can be utilized as a rover with a controller in a site supervisors vehicle or on a pole.

Modular Design Means Flexible Set Up

The Trimble SPS751 and SPS851 receivers combine the radio and GPS receiver in a single housing. This allows contractors to secure the majority of their investment inside a site trailer or carrying case, protected from the elements and theft, leaving only the antennas outside. The antennas can now be located clear of obstructions and provide maximum radio coverage on site.

A future–proof investment

Available in a range of options to suit your construction application and performance requirements, versatile Trimble GPS receivers are a future-proof investment.

The SPS851 Modular GPS Receiver is designed to receive current and future satellite signals. This receiver supports GPS modernization through support of L2C code and can be upgraded to receive GLONASS or L5 GPS signals, protecting your investment well into the future.

The SPS751 is available in three models to suit specific budget and application requirements. All models support GPS modernization through support of L2C code. The SPS751 Basic Rover and Basic Base can be upgraded to the SPS751 Max giving you flexibility to swap between base and rover functionality as work demands.

Get Connected, Stay Connected

The SPS751 and SPS851 each contain a built-in powerful web server component that enables increased operational efficiency and flexibility. Using this internet-enabled base station allows for remote configuration and monitoring, eliminating the need for time-consuming and costly visits to the base station to set up each day or diagnose issues that may arise. Internet base stations can provide corrections to multiple jobsites in the same vicinity or provide corrections to cell phone enabled rovers in areas of radio blackout.

Larger site operations or system integrators can configure and monitor the quality of the system or utilize its multiple modes of operation by accessing the internal web server.

Improved GPS Performance

The new Trimble RTK engine improves performance under tree canopy and reduces initialization time after loss of lock, delivering high performance in a variety of measurement conditions. Combined with integrated 450 MHz UHF or license-free 900 MHz radio communications options these features make the receivers easier to use, faster to setup and more productive during measurement and stakeout.

Trimble

TRIMBLE SPS751 AND SPS851 MODULAR GPS RECEIVERS

UNIQUE PERFORMANCE SPECIFICATIONS

SPS751 Basic Modular GPS Receiver

Base and Rover interchangeability	No
Base only operation	SPS751 Basic Base
Rover only operation	SPS751 Basic Rover
Rover position update rate	1 Hz, 2 Hz
Rover maximum range from base	2.4 km (1.5 mile)
Rover operation within a VRS™ network	No

SPS751 Max Modular GPS Receiver

Base and Rover interchangeability	Yes
Rover position update rate	1 Hz, 2Hz, 5 Hz, 10 Hz
Rover maximum range from base	Unrestricted Typical range 2 – 5 km (1.2 – 3 miles) without radio repeater
Rover operation within a VRS network	Yes

SPS851 Modular GPS Receiver

Upgrade options	L5 GPS Full Cycle Carrier GLONASS L1/L2
Base and Rover interchangeability	Yes
Rover position update rate	1 Hz, 2Hz, 5 Hz, 10 Hz, 20 Hz
Rover maximum range from base	Unrestricted Typical range 2 – 5 km (1.2 – 3 miles) without radio repeater
Rover operation within a VRS network	Yes

COMMON PERFORMANCE SPECIFICATIONS

General

Keyboard and display	VFD display 16 characters by 2 rows On/Off key for one button start up Escape and Enter key for menu navigation 4 arrow keys (up, down, left, right) for option scrolls and data entry
Dimensions (L × W × D)	24 cm × 12 cm × 5 cm (9.4 in x 4.7 in x 1.9 in) including connectors
Weight	1.65 kg (3.64 lb) receiver with internal battery and radio 1.55 kg (3.42 lb) receiver with internal battery and no radio

Antenna options

L1/L2/L2C GPS, GLONASS and OmniSTAR operation	Zephyr™ Model 2
L1/L2/L2C GPS and GLONASS Base Station	Zephyr Geodetic™ Model 2
Supports legacy Trimble antennas	Zephyr, Zephyr Geodetic, Z+, Micro-Centered™, Choke ring, Rugged Micro-Centered GPS L1/L2

Temperature

Operating[1]	-40 °C to +65 °C (-40 °F to +149 °F)
Storage	-40 °C to +80 °C (-40 °F to +176 °F)
Humidity	MIL-STD 810F, Method 507.4
Waterproof	IP67 for submersion to depth of 1 m (3.3 ft), dustproof

Shock and vibration

Designed to survive a 1 m (3.3 ft) pole drop onto a hard surface

Shock: non-operating	To 75 g, 6 ms
Shock: operating	To 40 g, 10 ms, saw-tooth
Vibration	Tested to Trimble ATV profile (4.5 gRMS): 10 Hz–300 Hz: 0.04 g2/Hz; 300 Hz–1,000 Hz; –6 dB/octave

Measurements

- Advanced Trimble Maxwell™ 5 Custom GPS chip
- High-precision multiple correlator for L1/L2 pseudo-range measurements
- Unfiltered, unsmoothed pseudo-range measurements data for low noise, low multipath error, low time domain correlation, and high dynamic response
- Very low noise carrier phase measurements with <1 mm precision in a 1 Hz bandwidth
- L1/L2 signal-to-noise ratios reported in dB-Hz
- Proven Trimble low elevation tracking technology
- 72-channel L1 C/A code, L1/L2/L2C Full Cycle Carrier. Upgradable to GLONASS L1/L2 Full Cycle Carrier.
- Trimble EVEREST™ multipath signal rejection
- 4-channel SBAS (WAAS/EGNOS/MSAS)

Code differential GPS positioning[2]

Horizontal accuracy	0.25 m + 1 ppm RMS (0.8 ft + 1 ppm RMS)
Vertical accuracy	0.50 m + 1 ppm RMS (1.6 ft + 1 ppm RMS)

SBAS (WAAS/EGNOS/MSAS) positioning[3]

Horizontal accuracy	Typically <1 m (3.3 ft)
Vertical accuracy	Typically <5 m (16.4 ft)

OmniSTAR positioning

VBS service accuracy	Horizontal <1 m (3.3 ft)
XP service accuracy	Horizontal 0.2 m (0.66 ft), Vertical 0.3 m (1.0 ft)
HP service accuracy	Horizontal 0.1 m (0.33 ft), Vertical 0.15 m (0.5 ft)

Real-Time Kinematic (RTK) positioning

Horizontal accuracy	10 mm + 1 ppm RMS (0.032 ft +1 ppm RMS)
Vertical accuracy	20 mm + 1 ppm RMS (0.065 ft +1 ppm RMS)

Initialization time

Regular RTK operation with base station	Single/Multi-base minimum 10 seconds + 0.5 times baseline length in km, up to 30 km
RTK operation with Scalable GPS infrastructure	Typically <30 seconds anywhere within coverage area (SPS751 Max and SPS851 only)
Initialization reliability[4]	>99.9%

TRIMBLE SPS751 AND SPS851 MODULAR GPS RECEIVERS

Power

Internal

- Integrated internal battery 7.2 V, 7800 mA-hr, Lithium-ion
- Internal battery operates as a UPS in the event of external power source failure
- Internal battery will charge from external power source when input voltage is >15 V
- Integrated charging circuitry

External

- Power input on 7-pin 0-shell Lemo connector is optimized for lead acid batteries with a cut-off threshold of 10.5 V
- Power input on the 26-pin D-sub connector is optimized for Trimble Lithium-ion battery input with a cut-off threshold of 9.5 V
- Power source supply (Internal/External) is hot-swap capable in the event of power source removal or cut off
- 9.5 V to 28 V DC external power input with over-voltage protection
- Receiver will automatically turn on when connected to external power

Power consumption .... 6.0 W in rover mode with internal receive radio; 8.0 W in base mode with internal transmit radio

Operation time on internal battery

Rover .... 13 hours; varies with temperature

Base station (SPS851 with GPS and GLONASS):
- 450 MHz systems[5] .... Approximately 11 hours; varies with temperature
- 900 MHz systems ...... Approximately 9 hours; varies with temperature

Regulatory approvals

- FCC: Part 15 Subpart B (Class B Device) and Subpart C, Part 90
- Industry Canada: ICES-003 (Class B Device), RSS-210, RSS-Gen, RSS-310, RSS-119
- R&TTE Directive: EN 301 489-1/-5/-17, EN 300 440, EN 300 328, EN 300 113, EN 60950, EN 50371
- ACMA: AS/NZS 4295 approval
- CE mark compliance
- C-tick mark compliance
- UN ST/SG/AC.10.11/Rev. 3, Amend. 1 (Lithium-Ion Battery)
- UN ST/SG/AC. 10/27/Add. 2 (Lithium-Ion Battery)
- RoHS compliant (excludes those with an internal 900 MHz radio)
- WEEE compliant

Communications

Port 1 (7 pin 0S Lemo)
- Serial 1 .... 3 wire RS-232

Port 2 (26 pin D-sub)
- Serial 2 .... Full 9 wire RS-232
- Serial 3 .... 3 wire RS-232
- 1PPS (pulse per second) .... via adapter cable
- USB (On the Go) .... via multi-port adapter
- Ethernet .... via multi-port adapter

Bluetooth .... Fully-integrated, fully-sealed 2.4 GHz Bluetooth[6] module

Integrated radios (optional) .... Fully integrated, fully sealed internal 450 MHz (UHF) Tx/Rx; internal 900 MHz Tx/Rx
- Channel spacing (450 MHz) .... 12.5 KHz or 25 KHz spacing available
- 450 MHz output power .... 0.5 W, 2.0 W (2.0 W available only in certain countries)
- 900 MHz output power .... 1.0 W (2.0 W available only in certain countries)
- Frequency approvals (900 MHz) .... USA/Canada (-10), New Zealand/Australia (-20), Australia (-30)

External GSM/GPRS, cell phone support ..... Supported for direct dial and internet-based correction streams; Cellular phone or GMS/GPRS modem inside TSC2 controller

Receiver position update rate .... 1 Hz, 2 Hz, 5 Hz, 10 and 20 Hz positioning

Correction data input .... CMR™, CMR+™, RTCM 3, RTCM 2.x

Correction data output .... CMR/CMR+, RTCM 2.x

Data outputs .... NMEA, GSOF, 1PPS Time Tags

Receiver options and upgrades

SPS751 Basic to SPS751 Max .... Adds Base/Rover and VRS capability, high update rate and unrestricted range

SPS851 GLONASS upgrade .... Uses GLONASS L1/L2 satellite signals

SPS851 L5 upgrade ..... Capable of tracking GPS modernization L5 signals

Internal Data Logging .... 2 MB for SPS751 Max; 28 MB for SPS851

1 Receiver will operate normally to -40°C. Internal batteries are rated to -20°C.
2 Accuracy and reliability may be subject to anomalies such as multipath, obstructions, satellite geometry, and atmospheric conditions. Always follow recommended practices.
3 Depends on SBAS system performance.
4 May be affected by atmospheric conditions, signal multipath, and satellite geometry. Initialization reliability is continuously monitored to ensure highest quality.
5 If your receiver has the 2.0 W upgrade, you will experience reduced battery performance compared to the 0.5 W solution.
6 Bluetooth type approvals are country-specific. For more information, contact your local Trimble office or representative.

Specifications subject to change without notice.

Bluetooth® CE

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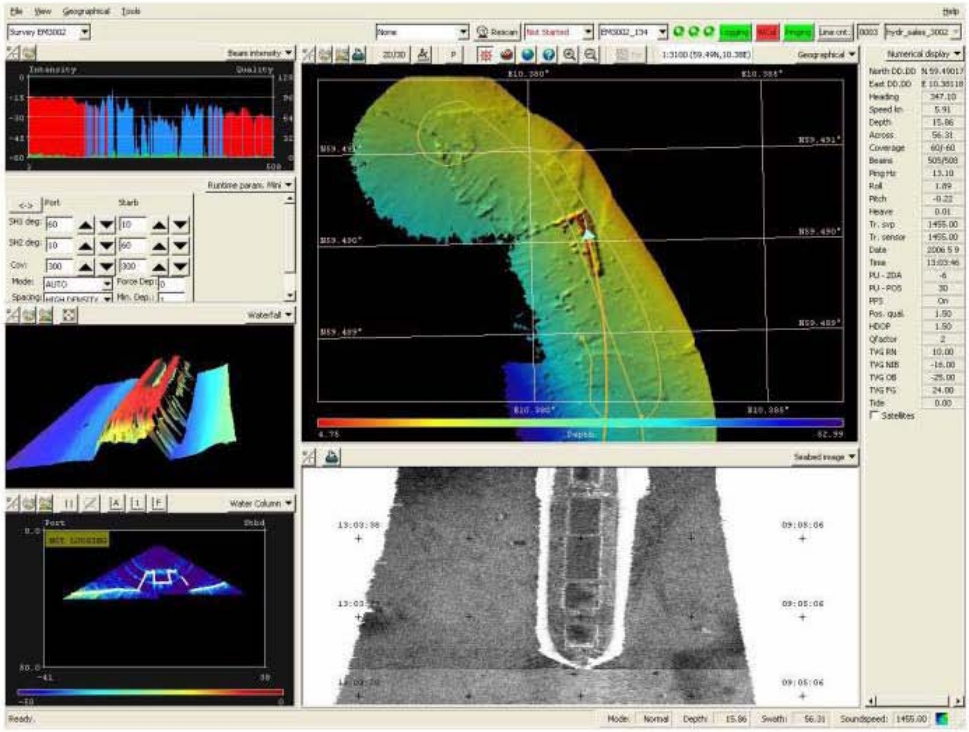
EM 3002

KONGSBERG

Multibeam echo sounder

The new generation high performance shallow water multibeam



(855-164771 / Rev.E / 20.06.2006)

System description

Key facts

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

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

Typical applications

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

Features

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

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

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

List of options

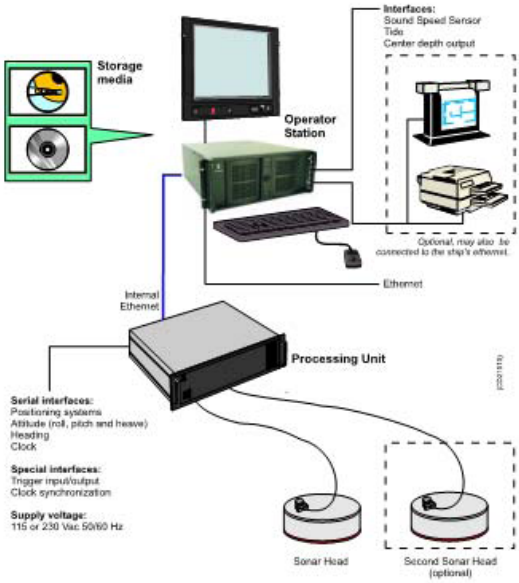
- Dual sonar heads - EM 3002D
- Logging of water column data
- Software for Automatic Calibration
- CUBE terrain modeling SW
- Extended depth raiting for transducer(s): 1500 m
- Extended length of transducer cable: 30 or 45 m
- Bracket for portable mounting of sonar head(s)
- Flight case for safe transportation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

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

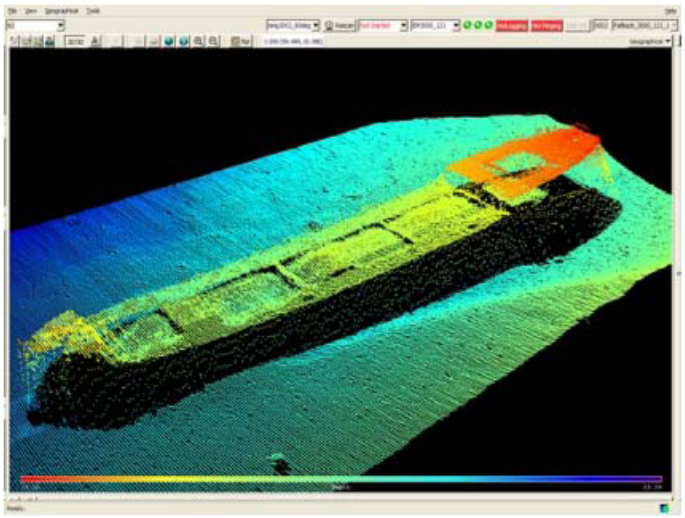
Operator Station

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

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



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



The image of a sunken wreck at 20 m depth.

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

Advanced functions

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

Technical specifications

Operational specifications

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

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

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

Seabed image data

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

External sensors

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

Environmental and EMC specifications

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

Dimensions and weights

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

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

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

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

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

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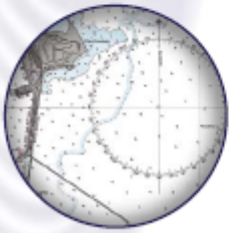
KONGSBERG

Hemisphere GPS

MBX-4

Reliable Auto-Tracking Differential Beacon Receiver



Provide a reliable source of free differential corrections with the MBX-4 Differential Beacon Receiver that augments a separate GPS receiver with free accuracy-improving correction data from networks of beacon stations located throughout the world. With automatic dual-channel tracking, the MBX-4 ensures the best beacon station is always being decoded. Beacon stations are automatically tracked based on signal strength or station distance and can also be manually selected.

Hemisphere GPS' MBX-4 has been optimized for high performance reception and proves reliable even in noisy environments. It outputs the industry standard RTCM SC-104 format accepted by differential-ready GPS receivers and can be configured and monitored with NMEA 0183 protocol. Hemisphere GPS' MBX-4 receiver kit includes an integrated GPS and beacon antenna.

Key MBX-4 Advantages

- Supplements GPS systems with free beacon differential corrections, capable of sub-meter accuracy (depending on GPS receiver quality)
- Dual-channel design allows strongest signal or closest station selection
- Integrated signal splitter outputs GPS signal from combined GPS / differential antenna
- Simple to monitor and configure through menu system and display
- Patented ceramic filter blocks out-of-band signals, optimizing reception

Hemisphere GPS

MBX-4 Beacon Receiver

Receiver Specifications

Channels:	2-channel, parallel tracking
Channel Spacing:	500 Hz
Frequency Range:	283.5 to 325.0 Hz
MSK Bit Rates:	50, 100, 200 bps
Operating Modes:	Manual, Automatic and Database
Cold Start Time:	<1 min
Warm Start Time:	<2 seconds
Demodulation:	Minimum Shift Keying (MSK)
Sensitivity:	2.5 µV/m for 6 dB SNR
Dynamic Range:	100 dB
Frequency Offset:	±8 Hz (27 ppm)
Adjacent Channel Rejection:	61 dB @ ± 400 Hz
Correction Output Protocol:	RTCM SC-104
Input Status Protocol:	NMEA 0183

Communications

Interface:	RS-232C or RS-422
Baud Rates:	2400, 4800, 9600

Environmental Specifications

Operating Temperature:	-30°C to +70°C (-22°F to 158°F)
Storage Temperature:	-40°C to +80°C (-40°F to 176°F)
Humidity:	95% non-condensing
EMC:	CISPR22 EN 61000-6-1 CE

Power Specifications

Input Voltage Range:	9 to 40 VDC
Nominal Power:	2.5 W
Nominal Current:	210 mA @ 12 VDC
Antenna Voltage Output:	10 VDC (5 VDC optional)
Antenna Input Impedance:	50

Mechanical Specifications

Dimensions:	150 mm L x 125 mm W x 51 mm H (5.9 L x 4.9 W x 2.0 H inches)
Weight:	0.64 kg (1.4 lb)
Display:	2-line x 16-character LCD
Keypad:	3-key switch membrane
Power Connector:	2-pin circular locking
Data Connector:	DB9-S
Antenna Connector:	BNC-S
Optional GPS Output Port:	TNC-S

NMEA 0183 I/O

- Receiver Automatic, Database and Manual tune command
- Frequency and data rate query
- Receiver performance and operating status queries
- Automatic search almanac queries (proprietary)
- Baud rate selection command
- Receiver tune command
- Force cold start command (proprietary)
- Software upgrade command (proprietary)
- Configuration up-load command (proprietary)

Back Panel Configuration

Nomenclature - Software	Model	Serial Number	Comments
QPS Navigation Software	QINSy		Version 8.0 Release 8.00.2010.03.01
Seabird Seaterm Software			Version 1.59
Kongsberg SIS Software	SIS	4F4B1DBF	Version 3.7
Microsoft Office 2007	Word, Excel		
OCTANS Software	Repeater	3453-470	FrmWOCTANS V10_88_36_96
AlwaySync			Version 10.5.1

Nomenclature - Equipment	Model	Serial Number	Comments
Furuno AIS/DGPS	FA-150	16764	Transponder FA1501 S/N 3552-7456
Hemisphere Beacon Receiver	MBX 4	0923-9416-0006	
IXSEA Gyro/MRU	OCTANS	3453-470	
Trimble DGPS	SPS-851	4822K56259	Zephyr Model 2 Antenna S/N 30941425
Trimble DGPS	SPS-851	4822K56260	Zephyr Model 2 Antenna S/N 1440912525
Navigation Computer	Windows 7	Survey 3	
Multibeam SIS computer	Windows XP SP3	HWS15	
Kongsberg MB processing unit	EM3002	1103	
Seabird CTD	SBE 19+	19P46434-5077	
Seabird CTD	SBE 19	1916199-1767	
AML Smart SVS	AML Smart SVS	4179	

Ethernet
Bluetooth
Wi-Fi

OCTANS

SURFACE GYROCOMPASS AND MOTION SENSOR

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

FEATURES

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

BENEFITS

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

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

OCTANS

TECHNICAL SPECIFICATIONS

IMO Certified
N° 09807/B0 EC

PERFORMANCE

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

OPERATING RANGE / ENVIRONMENT

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

PHYSICAL CHARACTERISTICS

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

INTERFACES

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

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

32

Specifications subject to change without notice

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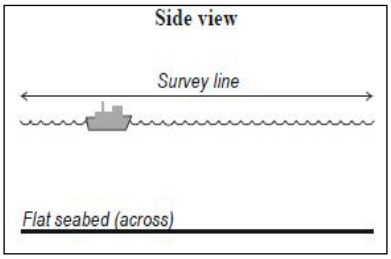
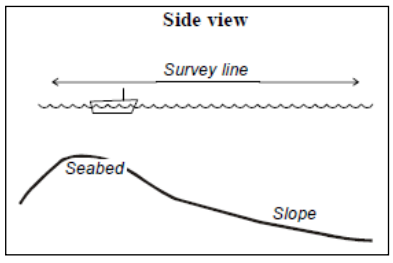
Calibration checks of the R/V R&R multibeam sonar system: EM 3002

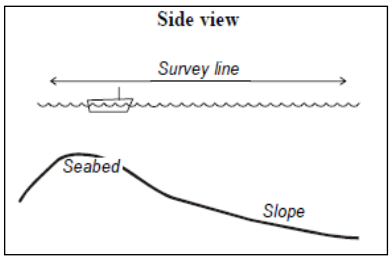
25th of September 2010

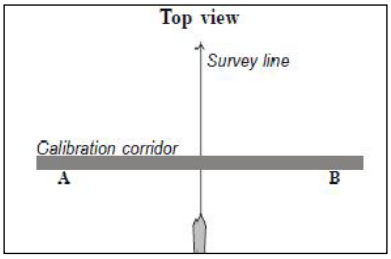
The multibeam sonar system used for this project was pole mounted on the port side. Installation offsets relative to the ship's reference point origin (POS/MV IMU in this case) were measured during the physical installation of the system and calibrated during acceptance testing. These offsets included pitch, roll and yaw.

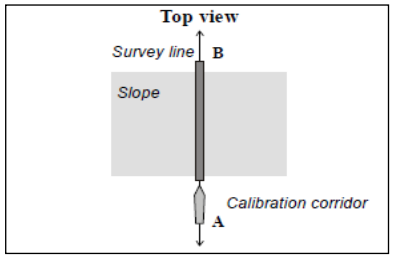
Lines were planned to test for offsets in latency (GPS <-> sonar), pitch, roll, and yaw. Latency, pitch, and yaw lines were run over a sloping seafloor and roll lines over a flat seafloor. Data from the EM3002 was acquired along calibration line segments. Latency lines consisted of two runs of the same line in the same direction, but different speeds. An along-track cross section of near-nadir beams of the overlapping lines were then inspected in CARIS HIPS Calibration Editor. Pitch lines were run over the same line in opposite direction. Similar to latency, near-nadir beams were inspected for any noticeable offset. Yaw lines consisted of two parallel lines run in the same direction over a slope, spaced at 30 meters distance in 10 meters water depth so the outer beams overlapped. The overlapping outer beams were then examined for offsets against the slope feature. Roll lines over a flat seafloor were run overlapping in opposite directions. A cross-track section was then examined for roll bias.

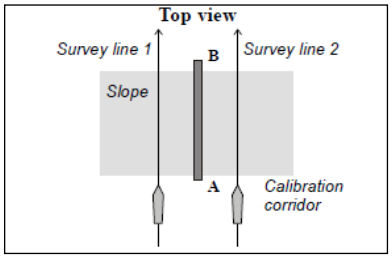










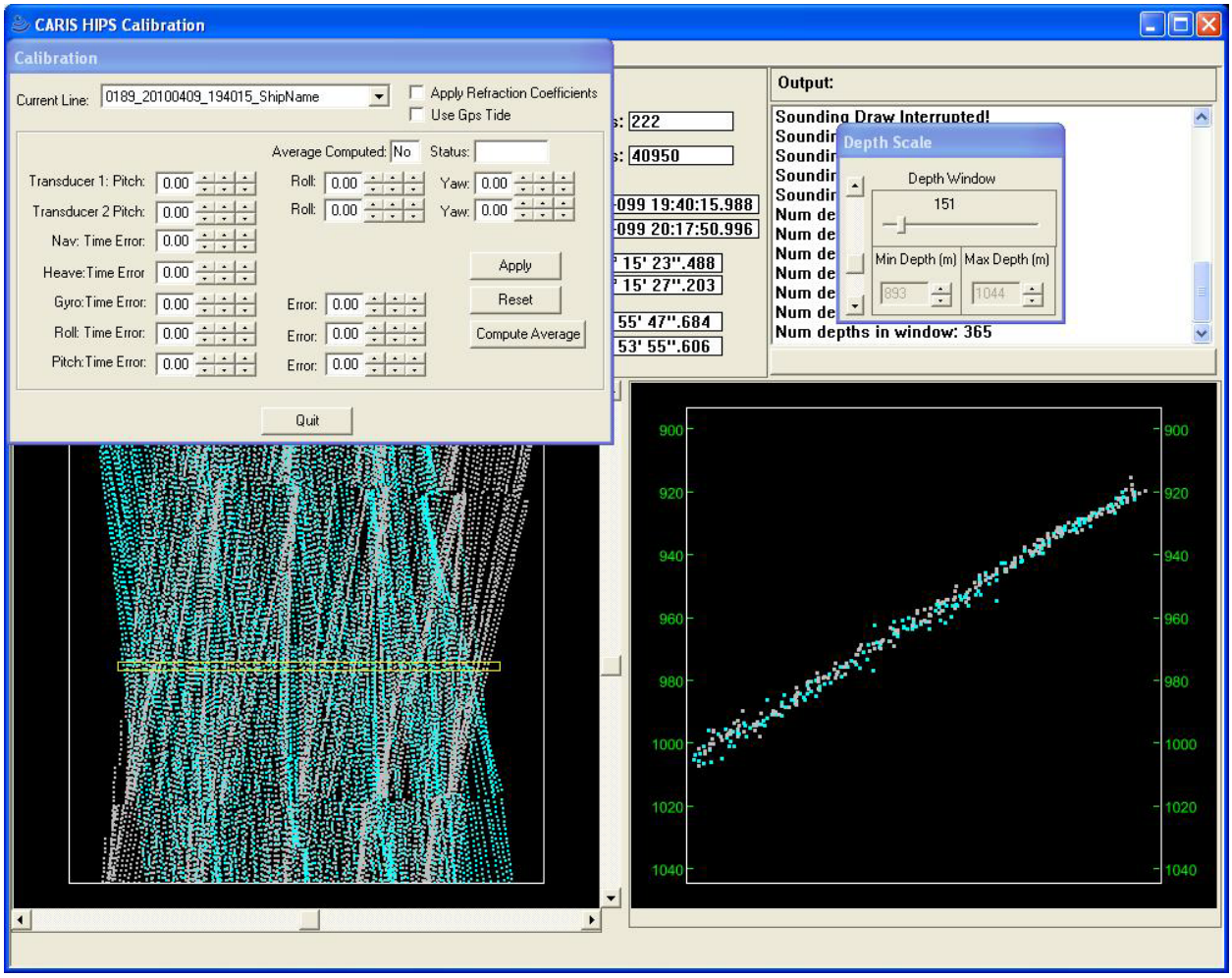


EM 3002 Multibeam Echo Sounder

Calibration analysis: The measured and installed offset for pitch angles input by the Kongsberg install team has been validated by this calibration routine. Due to the pole mount configuration and deployment daily offsets were tested for and input into CARIS.

Standard Dev: 1.175

Average Pitch Value: 2.116

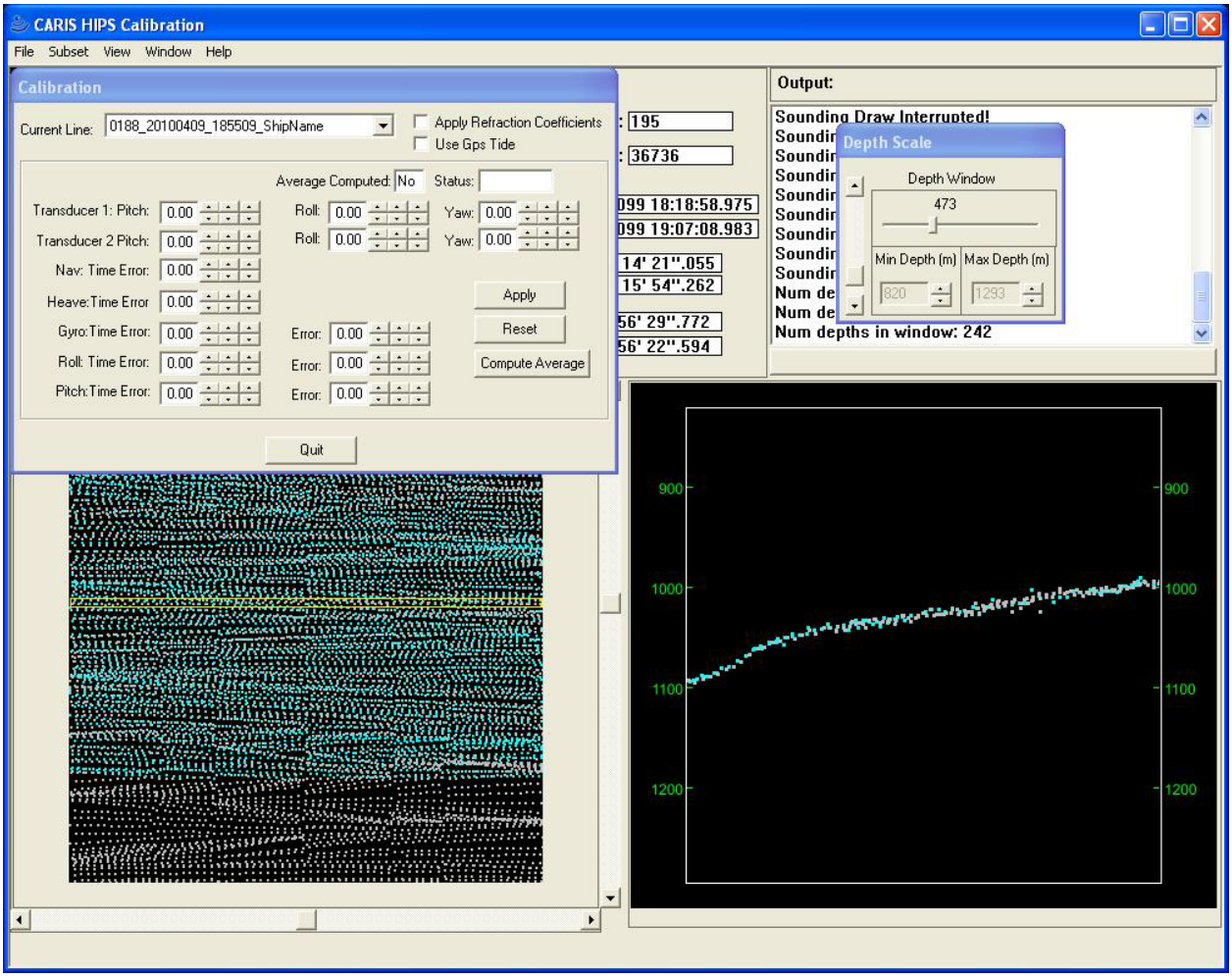


EM 3002 Multibeam Echo Sounder

Calibration analysis: The measured and installed offset for roll angles input by the Kongsberg install team has been validated by this calibration routine. Due to the pole mount configuration and deployment daily offsets were tested for and input into CARIS.

Standard Dev: 0.153

Average Roll Value: -2.91



EM 3002 Multibeam Echo Sounder

Calibration analysis: The measured and installed offset for yaw angles input by the Kongsberg install team has been validated by this calibration routine. Due to the pole mount configuration and deployment daily offsets were tested for and input into CARIS.

Standard Dev: 0.804

Average Yaw Value: -2.372