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

Data Acquisition & Processing Report

Type of Survey HYDROGRAPHIC

Project Number OPR-A375-NRT5-10

Time Frame JUNE – NOVEMBER

LOCALITY

State: MAINE

General Locality EASTPORT

2010

CHIEF OF PARTY
LTJG MATTHEW NARDI, NOAA

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DATE

NOAA FORM 77-28 U.S. DEPARTMENT OF COMMERCE
(11-72) NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

HYDROGRAPHIC TITLE SHEET

PROJECT NUMBER:

OPR-A375-NRT5-10

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

State: **Maine**

General Locality: **Eastport**

Sub-Locality:

Scale: **1:10,000**

Date of Survey: **June to November, 2010**

Instructions Dated: **5/27/10**

Project Number: **OPR-A375-NRT5-10**

Vessel: **NOAA NRT5, S3002**

Chief of Party : **LTJG Matthew Nardi, NOAA**

Surveyed by: **NOAA Navigation Response Team 5 Personnel**

Soundings by: **Kongsberg Simrad EM 3002 Multibeam Echosounder**

Verification by: **Atlantic Hydrographic Branch Personnel**

Soundings in: **Meters at MLLW**

Remarks:
1) All Times are UTC.
2) Projection is UTM Zone 19.

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APPENDICES

DATA ACQUISITION & PROCESSING REPORT

OPR-A375-NRT-10
NOAA Navigation Response Team 5
LTJG Matthew Nardi, Team Lead, Processing and Submittal
PS Nicholas Forfinski, Planning and Acquisition

A. EQUIPMENT

A.1. Vessels

A.1.1. <u>S3002</u>
NRT5 operated a single vessel, S3002 (see Fig. 1), a 30-foot (overall), gray, aluminum-hull SeaArk Commander. NOAA Survey Vessel S3002 was powered by dual 130-horse power Honda outboards. A Kohler 7.5e generator supplied AC power. A rack-mount APC Smart-UPS (uninterruptable power supply) provided battery backup for the survey-system electronics.

Figure 1: NOAA S3002 (NRT5)

A.1.1.1. Calibration & Configuration
See section C.1.1 for a description of the full vessel survey.

A.2. Depth Measurement Equipment

A.2.1. <u>Kongsberg Simrad EM3002 Multibeam Echosounder</u>
S3002 is equipped with a hull-mounted Kongsberg EM3002 multibeam, which is located directly beneath the IMU. The EM3002 is a 300 kHz (nominal) system with a characteristic operating depth range of 1 to 150 meters water depth. Under ideal, cold water conditions, the range may extend to 200 meters. The swath width is 130°, and the nadir beam is 1.5° x 1.5°. The system has a maximum ping rate of 40 Hz. The processing unit (PU) performs beam forming and bottom detection and automatically controls transmit power, gain, and ping rate. The sonar processor incorporates real time surface sound speed measurements for initial beam forming and steering. SVP correction is also performed in real time. The Seafloor Information System (SIS) application, designed to run under Microsoft Windows, provides control and monitoring of the EM3002.

A.2.1.1. Calibration & Configuration

The installation and runtime parameter configuration files are included in Appendix IV (Electronic Appendix). See section C.1.3 for a description of the calibration patch test.

A.3. Vessel Position and Orientation Equipment

A.3.1. TSS POS/MV Position & Orientation Sensor

S3002 is equipped with an Applanix POS/MV 320 version 4. The POS/MV consists of dual Trimble BD950 GPS receivers (with corresponding Zephyr antennas), an inertial motion unit (IMU), and a POS computer system (PCS). The two antennas are mounted approximately 1.5 meters apart atop the launch cabin (see Fig. 2). The primary receiver (on the port side) is used for position and velocity, and the secondary receiver is used to provide heading information as part of the GPS azimuthal measurement sub-system (GAMS).

Figure 2: POS/MV Antenna Installation

The IMU contains three solid-state linear accelerometers and three solid state gyros, which together provide a full position and orientation solution. The IMU is mounted on the top of the sonar housing, beneath a removable deck plate (see Fig. 3).

Figure 3: IMU Installation

A.3.1.1. Calibration & Configuration

A GAMS calibration was not performed specifically for OPR-A375-NRT5-10. No changes had been made to the POS/MV system which necessitated a GAMS calibration after the previous GAMS calibration in 2009. The 2009 GAMS calibration report is included in Appendix II.

The POS/MV is configured, operated, and monitored via the POS/MV controller software, which is installed on the S3002 acquisition computer. The primary GPS-to-reference point lever arm was accounted for in the POS/MV controller. A POS/MV configuration file detailing lever arms, input/output settings, and operational settings is contained in Appendix IV (Electronic Appendix).

The controller software was also used to initiate Ethernet logging of the POSPac datagram bundle, which was used in post-processed kinematic (PPK) processing (See ERS SOP in Appendix IV - Electronic Appendix).

A.3.2. Trimble DSM212L DGPS Receiver

The POS/MV receives differential (RTCM) correctors from a Trimble DSM212L GPS receiver that includes a dual-channel low-noise MSK beacon receiver, capable of receiving U.S. Coast Guard (USCG) differential correctors. The DSM212L can also accept RTCM messages from an external source such as a user-established DGPS reference station, however, no such stations were established for OPR-A375-NRT5-10.

A.3.2.1. Calibration & Configuration

Trimble's TSIP Talker was used to configure the GPS antenna supplying Coast Guard differential correctors to the POS/MV. Due to COM port limitations, TSIP Talker was not installed on the main acquisition computer, but a separate laptop.

There are three modes of DPGS operation; Auto-Range, which locks onto the beacon nearest the vessel, Auto-Power, which locks onto the beacon with the greatest signal strength, and Manual, which allows the user to select the desired beacon. NRT5 operated in the manual mode, with the beacon set to Penobscot, ME (290 kHz). The following parameters are periodically monitored in real-time through Trimble's TSIP Talker software to ensure position data quality: 1) number of satellites used in the solution, 2) horizontal dilution of precision (HDOP), 3) latency of correctors, and 4) beacon signal strength. The DSM212L is configured to go off-line if the age of DGPS correctors exceeds 20 seconds, and to exclude satellites with an altitude below eight degrees.

A.3.3. Trimble GeoXH GPS Receiver

Geospatial data for shoreline features were collected with a Trimble GeoExplorer 2008 series GeoXH handheld outfitted with a Trimble Zephyr antenna mounted on a 2-meter, bipod-equipped range pole. The Trimble GeoXH combines a Trimble L1/L2 GPS receiver with a field computer powered by Microsoft Windows Mobile version 6 operating system. The GPS field software utilized by the GeoXH to acquire data for this project was Trimble TerraSync version 4.1 while the Trimble GPS Pathfinder version 4.20 was used to post process data, and apply differential correction.

A.4. Sound Speed Equipment

S3002 is equipped with an Odom Digibar Pro surface sound speed sensor to measure sound speed at the flat-face multibeam transducer head. For water column sound speed profiles NRT5 used an Odom Digibar Pro sound speed sensor and a Seabird SBE19+ CTD profiler. Speed of sound through water is determined by a minimum of one cast every four hours, in accordance with the NOS Specifications and Deliverables for Hydrographic Surveys. Daily Quality Assurance tests (DQA) between the surface and profile sound speed probes were performed using Velociwin. Full cast comparisons were also performed periodically.

A.4.1. Odom Digibar Pro – Surface Sound Speed

Odom Digibar Pro serial# 98214 provided surface sound speed data to the flat-face EM3002 for beam steering and beam forming. The unit is mounted in a removable pole that is inserted into a bracket mounted on the transom between the two motors (see Fig. 4). The unit is configured to output an AML datagram to SIS, which is installed on the acquisition computer (see wiring diagram in Appendix II).

Figure 4: Surface Sound Speed Digibar Installation

A.4.2. Odom Digibar Pro – Profile Sound speed

Odom Digibar Pro serial #98212, which has 25 meters of cable, is used to obtain sound speed profiles in water depths up to 25 meters, or deeper if the water column is known to be well mixed beyond 25 meters. First, the Digibar profile data file is uploaded to the acquisition computer using Digibar software and processed using NOAA Velociwin software. The processing creates a series of files, including an *.asvp file, which is loaded into SIS for real-time sound speed ray tracing.

A.4.3. Seabird SBE19+ CTD Profiler

Seabird SBE19+ serial #4835 is used to obtain sound speed profiles in waters deeper than 25 meters. The raw profile data file is uploaded and processed with the acquisition computer using the NOAA Velociwin software. Velociwin generates an *.asvp file, which is loaded into SIS for real-time ray tracing.

A.4.4. Calibration & Configuration

Calibration reports for all three sound speed sensors are included in Appendix III.

A.5. Data Acquisition Software

A complete list of software and versions is included in Appendix I.

A.5.1. Hypack Hysweep

Hypack Hysweep was used for all data logging, real-time data display, and navigation. Hypack and Hysweep hardware configuration files are included in Appendix IV (Electronic Appendix).

A.5.2. Applanix PosView

The Applanix POSView software was used to configure and monitor the Applanix PosMV, and to log PosPac files for post processing. The PosMV configuration file, which is created using POSView, is located in Appendix IV (Electronic Appendix).

A.5.3. Kongsberg SIS-Seafloor Information System
SIS was used to control the EM3002 MBES, which performed real-time motion and SVP correction.

A.5.4. Trimble TerraSync
TerraSync software was used to collect GPS data with the GeoXH handheld receiver.

A.6. Data Processing Software

A.6.1. Applanix POSPac MMS and POSGNSS
The Applanix POSPac software was used for post processing position and ellipsoidal height using the single base station PPK method.

A.6.2. Caris HIPS
Caris HIPS was used to process all MBES data including tide correction, merging with navigation data, TPU calculation, data cleaning, and CUBE BASE surface creation. The Caris HVF file, which contains offsets and correctors applied in Caris, is located in Appendix IV (Electronic Appendix).

A.6.3. Caris Bathy Database
Caris Bathy Database was used for feature management and quality assurance.

A.6.4. Velociwin
Velociwin was used to process SVP casts, and for DQA tests. The .asvp files created by Velociwin were applied to the MBES data in real-time using SIS software.

A.6.5. Pydro
Pydro was used for feature management, DTON report generation, and tides requests.

A.6.6. Trimble Pathfinder Office
Pathfinder Office was used to post process GPS data collected with GeoXH hand held receiver.

B. QUALITY CONTROL

B.1. Multibeam Echosounder Data

B.1.1. Acquisition Operations
Mainscheme multibeam data were acquired using a “paint-the-bottom,” or adaptive-line-steering approach, whereby the coxswain viewed a real-time coverage map in Hysweep and accordingly adjusted line steering to ensure adequate overlap. The coxswain strove to avoid abrupt changes in direction and speed, but abrupt changes in direction and speed were unavoidable in certain areas due to current and confined areas. In areas where abrupt changes in direction were unavoidable, speed was reduced to minimize motion-related artifacts. When gaps in coverage were found, holiday line plans were created using Mapinfo and exported as Hypack line files.

The dynamic draft for a vessel of this size is typically quite small (0.5-2cm). Nonetheless, when sea conditions allow, NRT5 follows HSTP suggestions to maintain a consistent engine trim during survey operations. The trim indicator has been marked to insure the trim is set correctly for operations.

Sound speed casts were acquired as per HSSD section 5.2.3.3. The EM3002 system is designed to apply sound speed and attitude data in real-time. Because sound speed is applied real-time, a sound speed profile must be loaded into SIS before data acquisition. Currently, post-processing sound speed data in Caris is not possible.

B.1.2. Processing Workflow

Multibeam processing for OPR-A375-NRT5-10 was based on the BASE surface/directed-editing paradigm described in FPM section 5.2, Bathymetry Processing. The multibeam processing workflow had four main components: conversion, preliminary processing, surface generation, and surface review/data cleaning (see Fig. 5). Note that the surface generation and surface review/data cleaning steps are iterative.

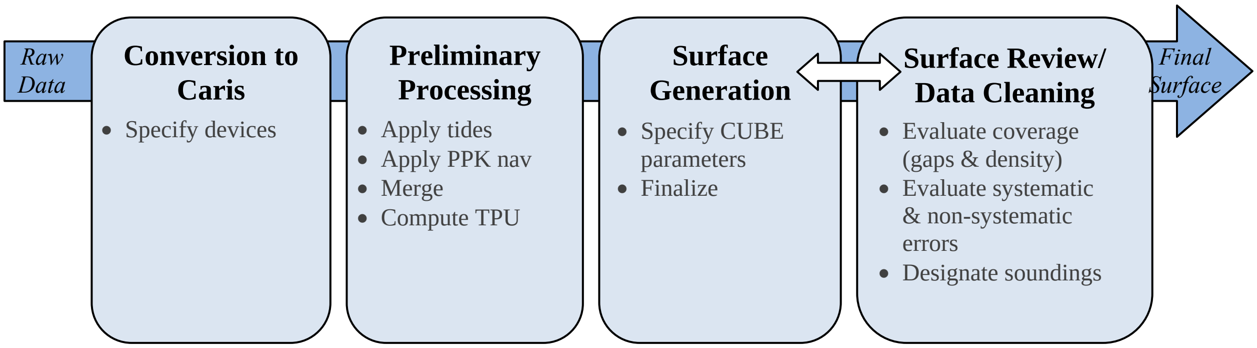


Figure 5: Multibeam Processing Workflow

B.1.2.1. Conversion

Raw multibeam .HSX data were converted to HDCS format in Caris HIPS. Device conversion parameters are shown in Figure 6.

Figure 6: Device Conversion Parameters

B.1.2.2. Preliminary Processing

After conversion, preliminary processing consisted of applying tide corrections and PPK navigation data, merging, and computing total propagated uncertainty (TPU). Unlike with traditional NOAA hydrographic processing schemes, the converted data for OPR-A375-NRT5-10 were corrected for sound speed in real time, and not in Caris post processing. The only correctors that were applied in Caris were PPK navigation, dynamic draft, patch test biases, and tide.

Applying Tides

Tide correctors were applied using a zone definition file (zdf) in Caris. See section C.3 for a detailed description of the tide correctors for OPR-A375-NRT5-10.

Applying PPK SBET

Post-processed kinematic (PPK) navigation data were applied to the HDCS data using the "Load Attitude/Navigation Data" function in HIPS, as per HSD's (Hydrographic Surveys Division) Ellipsoidally Referenced Survey (ERS) SOP contained in Appendix IV (Electronic Appendix).

Merging

The merge process in Caris combines the observed depths (created during conversion) with the loaded tide file, the navigation data, the HVF draft sensor (containing dynamic draft values), and the HVF swath1 sensor (containing patch test biases) to compute the final processed depths. The "Apply refraction coefficients" and "Apply GPS tide" options were not checked, and no smoothed sensors were applied during the merge process.

Computing TPU

The TPU computation process assigns each sounding a horizontal and vertical uncertainty, or estimate of error, based on the uncertainties of the various data components, such as position, sound speed, and loading conditions. Table 1 lists the HVF TPU values used for OPR-A375-

NRT5-10.

Table 1: TPU Values

Data Component	*TPU Value*	*Data Component*	*TPU Values*
Motion Gyro	0.02°	X, Y, & Z Offsets	0.001 m
Heave % Amplitude	5%	Vessel Speed	0.03 m/s
Heave	0.05 m	Loading	0.01 m
Roll	0.02°	Draft	0.03 m
Pitch	0.02°	Delta Draft	0.03 m
Position Nav	1 m*	MRU Align StdDev gryo	0.2°
Timing Transducer	0.01 s	MRU Align StdDev Roll/Pitch	0.2°
Nav Timing	0.01 s	Sound Speed Surface	0.5 m/s
Gyro Timing	0.01 s	Sound Speed Profile	0.5 m/s
Heave Timing	0.01 s	Tide measured	0.01 m
Pitch Timing	0.01 s	Tide zoning	0.11 m
Roll Timing	0.01 s		

B.1.2.3. Surface Generation

The multibeam sounding data were modeled using the CUBE BASE surface algorithm implemented in Caris HIPS. CUBE BASE surfaces were generated using the parameters outlined in Hydrographic Surveys Technical Directive 2009-02 (CUBE Parameters). The resolutions of the finalized surfaces were based on the complete MBES coverage resolution requirements specified in the Specs and Deliverables (5.2.2.2). The deeper limit of certain ranges was extended to avoid gaps between surfaces on particularly steep slopes.

B.1.2.4. Surface Review/Data Cleaning

Rather than a traditional line-by-line review and a full subset-cleaning, the data cleaning/quality review process for OPR-A375-NRT5-10 consisted of a combination of the directed-editing approach described in FPM section 5.2 and a full subset-review (not full subset-cleaning). All the sounding data were viewed in subset, but unlike in the traditional workflow, where every sounding deemed to be "noise" is rejected, only the soundings that negatively impacted the CUBE surface were rejected. Surface review also consisted of evaluating achieved coverage and sounding density, checking for systematic errors, and designating soundings. Sounding designation was in accordance with Specs and Deliverable section 5.2.1.2.

B.2. Feature Data

Feature management consisted of two main workflows (see Fig. 7): hydrography features and shoreline features. The distinction between the hydrography and shoreline workflow is due to (1) the acquisition method and (2) the inability to edit/export S-57 line features in/from Pydro. Whereas the hydrography features were derived from the bathymetry data or vessel navigation data, the shoreline features were acquired using a Trimble GeoXH GPS, digitized from an orthophoto, or acquired as a DP in Hypack, and processed using Caris BDB.

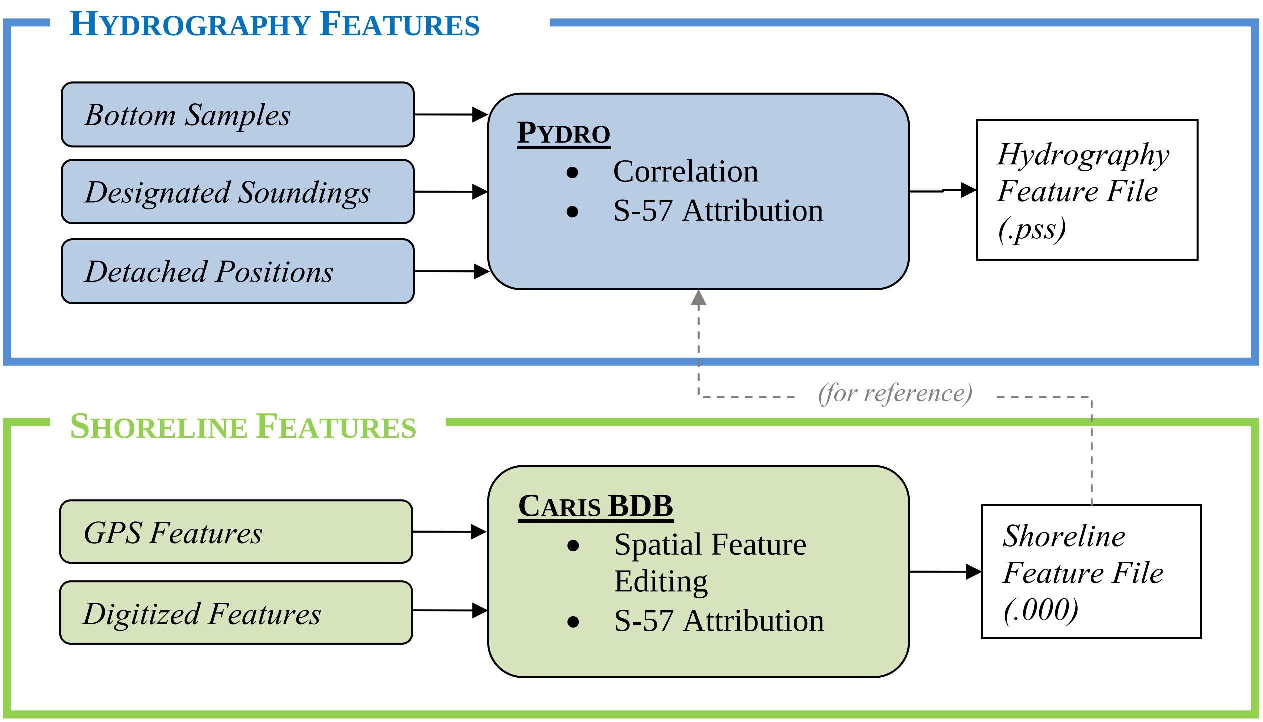


Figure 7: Feature Management Workflow

B.2.1. <u>Hydrography Features</u>

B.2.1.1. Bottom Samples

Bottom sample features were created in Caris Bathy Database. SBDARE point features were created at the position of each bottom sample and then attributed with the appropriate NATSUR/NATQUA attributes. The SBDARE features were then exported to a .000 file and imported into PYDRO for inclusion in the survey area feature file deliverable.

B.2.1.2. Designated Soundings

The least depth of charted features and significant uncharted features were flagged "designated" in Caris HIPS to ensure that the depth was portrayed in the final BASE surface. Soundings that were flagged designated were then imported into PYDRO as bathymetric features. Once in PYDRO, these bathymetric features were correlated with ENC GPs, and given the appropriate S-57 attribution.

B.2.1.3. Detached Positions (DPs)

Features for which the least depth or position could not be derived from the bathymetry data were defined based on a range and bearing, or detached position (DP), relative to the vessel position. DPs were created as Hypack targets and then imported into Pydro.

B.2.2. Shoreline Features

B.2.2.1. GPS Features

Acquisition: All GPS shoreline features were collected using an S-57 data dictionary installed on the GeoXH handheld. The data were acquired using the appropriate feature categories, which were primarily "shoreline construction" and "mooring facility". At the beginning of each feature survey, the GPS unit was allowed to acquire a minimum of 10 minutes of carrier-phase lock on the initial point, followed by a minimum 2-minute observation on each subsequent vertex of the structure while maintaining the initial lock. A GPS position was collected once every 5 seconds throughout each observation.

Processing: Data were held for a minimum 24-hour period before post-processing, to allow adequate time for the National Geodetic Survey (NGS) website to contain the necessary data. Data were processed using the recommended Automatic Carrier and Code Processing, with the H-Star Processing routine set to use the Eastport CORS station (EPRT) as the single base provider. Once the GPS shoreline feature data were post-processed, the feature data were exported from Pathfinder as a shapefile and then imported into the Pydro PSS as a reference layer.

Uncertainties: Raw data, as acquired, generally fell within a 1-meter accuracy range at a 68% confidence level. The GeoXH used H-Star technology to provide sub-foot (30cm) accuracy after post processing for the vast majority of positions acquired. A total of 4774 positions were collected over the course of shoreline feature geospatial data acquisition. The H-Star processing routine first attempts to process each position with code and carrier corrections, and then chooses the highest-quality solution. Table 2 summarizes the percentage of code- and carrier-corrected positions, and Table 3 summarizes the estimated accuracies for all positions collected.

Table 2: Code versus Carrier Corrections

Code Corrected	*Carrier Corrected*	*Code-Corrected Chosen Over Carrier-Corrected*
4774 (100%)	4722 (98.9%)	24 (0.5%)

Table 3: Shoreline-Features Position Uncertainty

Range (1-σ)	*Percentage*
0-15 cm	98.4%
15-30cm	0.0%
30-50cm	1.0%
0.5-1m	0.6%
1-2m	-
2-5m	-
>5m	-

B.2.2.2. Digitized Features

In three (3) special instances in H11257, shoreline features were digitized in Caris Bathy Database from orthophotos downloaded from the U.S. Geological Survey (USGS) Seamless Data website.

Refer to section D.1.4 of the H12257 descriptive report (DR) for a detailed discussion of these special instances.

C. CORRECTIONS TO ECHO SOUNDINGS

The following section describes the determination and evaluation of the three main categories of corrections to echosoundings: vessel, sound speed, and water level correctors.

C.1. Vessel Correctors

Vessel correctors include static offsets, dynamic offsets, and patch test biases. The various correctors are applied to echo soundings at different points throughout the data pipeline, which is detailed in the sections below.

C.1.1. Static Offsets

C.1.1.1. Vessel Lever-Arms

The National Geodetic Survey conducted a full vessel survey on 8/4-8/5/09 in Newport, RI (see Appendix II for the NGS report). The primary-GPS-to-Reference-Point lever arm is accounted for in the POS/MV controller. The Reference-Point-to-Multibeam-Transducer lever arm is accounted for in SIS.

C.1.1.2. Static Draft

A static draft measurement was performed in May 2010 in Newport, RI. To determine the static draft (i.e., the height of the waterline above/below the reference point), two new reference marks and an easily repeatable method were established. A reference mark was established on the port and starboard gunwales, closely aligned with the RP (the middle of the top surface of the IMU), in the along-ship dimension (see Figs. 8 & 9). The static draft was calculated by subtracting the waterline-to-gunwale vertical distance (0.658 m) from the RP-to-gunwale vertical distance (0.680 m) for each benchmark and then taking the average.

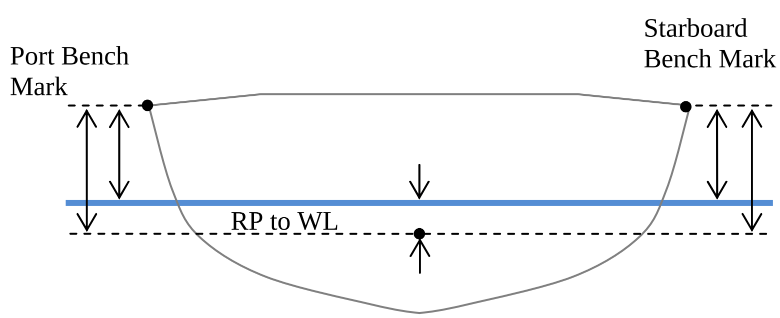


Figure 8: Waterline Offset

The vertical positions of the newly established reference marks were tied into the vessel coordinate frame by running a string taut athwartship over the RP (top mark on IMU). This athwartship string, orthogonal to the z-axis of the vessel coordinate frame, provided a convenient point, nearly directly over the IMU, at which to indirectly measure the RP-to-gunwale vertical distance. To account for the slight slope of the gunwale, a wedge was placed over both reference marks (see Fig 5).

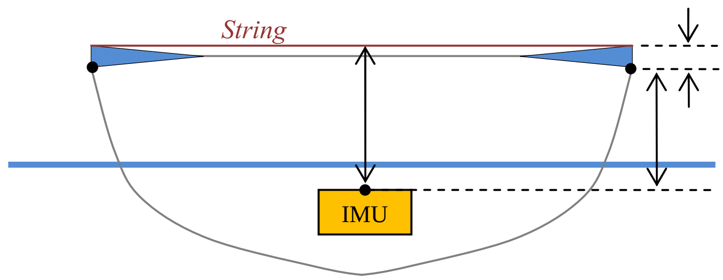


Figure 9: Waterline Reference Marks

C.1.2. Dynamic Offsets

Dynamic draft measurements were not performed specifically for OPR-A375-NRT5-10; however, no significant changes had been made to the vessel since the previous dynamic draft calculation in 2009. The 2009 dynamic correctors are summarized in Table 5. A negative draft corrector implies that the boat moved down.

Table 4: 2010 Dynamic Draft Values

Speed (kts)	Draft Correction (m)
2.07	-0.05
3.40	-0.04
6.50	-0.04
6.55	-0.03

C.1.3. Patch Test Biases

A patch test was performed on 8/30/10 (DN 242), in Friar Roads, just offshore of Eastport, ME (see Fig. 10). Distinct sandwaves were used as the calibration target. The timing offset was determined using the conventional method, rather than the “precise timing” method. The derived biases (summarized in Table 5), were entered into the Swath1 sensor of the Caris HVF and therefore were applied to the data during the merge step of post-processing.

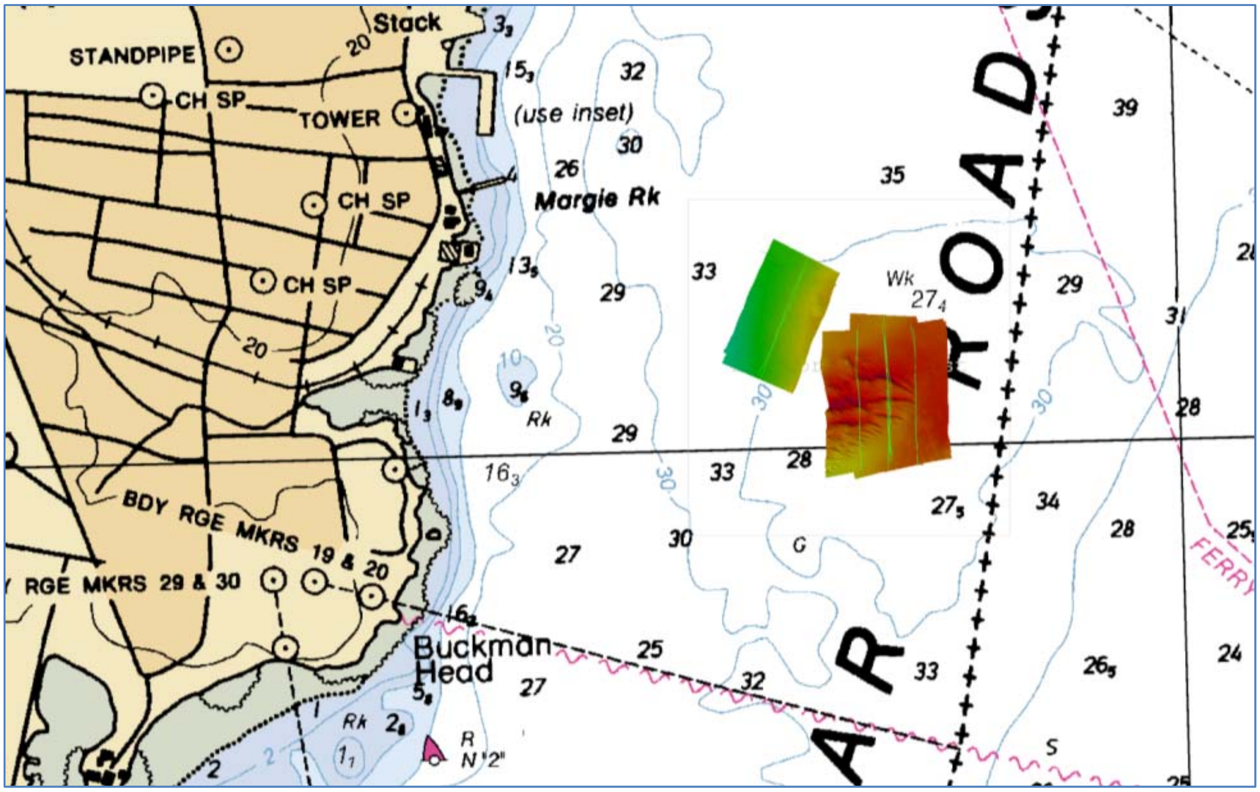


Figure 10: Patch Test Location (Charted depths are in meters)

Table 5: Patch Test Values

Bias	Estimate
Navigation Timing	0.15
Pitch	-1.30
Roll	0.03
Heading (Yaw)	0.86

C.2. Sound Speed

Sound speed corrections were performed in real-time by the EM3002 controller software, SIS. Casts were taken, at a minimum, every four hours as per NOS Specifications and Deliverables for Hydrographic Surveys.

C.3. Water Level Corrections

Tide corrections for OPR-A375-NRT5-10 were applied using the zone definition file A375NRT52010CORP.zdf.

Tide data were downloaded from the Center for Operational Oceanographic Products and Services (CO-OPS) website (http://tidesandcurrents.noaa.gov/olddata/) and applied using the zone definition file (*.zdf) provided by CO-OPS for this project. Approved final tides were applied by field personnel upon receipt.

APPROVAL SHEET

Data Acquisition & Processing Report
Navigation Response Team 5

As Chief of Party, I have ensured that surveying and processing procedures were conducted in accordance with the Field Procedures Manual and that the submitted data meet the standards contained in the 2010 Hydrographic Surveys Specifications and Deliverables.

I acknowledge that all of the information contained in this report is complete and accurate to the best of my knowledge.

Respectfully,

Matthew Nardi
I am approving this
document
2011.05.10 13:47:29 -04'00'

LTJG Matthew Nardi
Team Lead, NOAA NRT-5

Appendices

Appendix I – System Tracking

Hydrographic Vessel Inventory

Field Unit: NRT5

Effective Date: 15-April-2009

Updated Through: 1-June-2010

SURVEY VESSEL	
Vessel Name	NOAA NRT5
Hull Number	S3002
Call Letters	
Manufacturer	SeaArk Marine Inc., Portobello AK
Year of Construction	2003
Type of Construction	Welded Aluminum
Length Overall	9.65 m (31'8")
Beam	2.58 m (8'6")
Draft	
Date of Effective Full Vessel Static Offset Survey	1-Jan-09
Organization which Conducted the Effective Full Offset Survey	NGS
Date of Last Partial Survey or Offset Verification & Methods Used	
Date of Last Static Draft Determination & Method Used	May-2010 Tape Measure
Date of Last Settlement and Squat Measurements & Method Used	18-APR-2009 Base Surface
Additional Information	

Hydrographic Hardware Inventory

Field Unit: NRT5

Effective Date: 15-Apr-09

Updated Through: 1-Jun-10

Equipment Type	Manufacturer	Model	Serial Number	Firmware and/or Software Version	Version Install Date	Date of last Calibration	Date of last Service	Additional Information
SONAR & SOUNDING EQUIPMENT								
Multibeam Echosounder	Kongsberg Simrad	EM3002	563	SIS				256 Beams 1.5° x 1.5° Resolution
Side Scan Sonar	Klein	System 3000	TPU:348, Towfish: 457	SonarPro 11.3				
Verticalbeam Echosounder	Odom	Echotrac CV-200	23034	Odom Controller				
POSITIONING & ATTITUDE EQUIPMENT								
GPS Aided Inertial Naviation	Applanix	POS/MV 320 V4						
DGPS Reciever	Trimble	DSM212L	O220309909					
SOUND SPEED MEASUREMENT EQUIPMENT								
Sound Speed Profiler	Odom	Digibar Pro	98212					
Surface Sound Velocimeter	Odom	Digibar Pro	98214					
CTD								
TIDES & LEVELING EQUIPMENT								
HORIZONTAL AND VERTICAL CONTROL EQUIPMENT								
GPS Handheld	Trimble	GeoXH	4928419535	5.2.6 (Build 912)	5-Feb-09	n/a	n/a	CPU Type: Marvell, ARM920T-PXA27x; RAM:128MB; GPS
GPS External Antenna	Trimble	Zephyr	60269191	n/a	n/a	n/a	n/a	P/N: 39105-00 DC 4921
OTHER EQUIPMENT								

Hydrographic Software Inventory

Field Unit: **NRT5**
Effective Date: **15-Apr-09**
Updated Through: **10-Nov-10**

COMPUTERS						
Machine Name	NOAA-46BD3724C	OCS-W-NSD613020	OCS-W-NSD670262	OCS-S-NSD716664	CD0001755358	OCS-W-NSD716701
Location	Office Trailer	Office Trailer	Office Trailer	Office Trailer	Office Trailer	S3002
Make/Model	Dell Precision WorkStation T3400	Dell Precision WorkStation T3400	Dell XPS 630i	Dell PowerVault NF 100	Dell Latitude D820	Dell XPS 630i
Date Purchased	2008*	2008*	2010*	2009*	2006*	2010*
Processor, Speed	Intel®Core™2 Quad CPU, 2.66GHz	Intel®Core™2 Quad CPU, 2.66GHz	Intel®Core™2 Q9650, 3.00GHz	Intel®Celero®2 CPU, 1.66GHz	Intel®Core™2 CPU, 2.16GHz	Intel®Core™2 Q9650, 3.00GHz
RAM	3070MB	3070MB	3326MB	2048MB	2046MB	3326MB
Video Card	NVIDIA Quadro FX 1700	NVIDIA Quadro FX 1700	NVIDIA GeForce GTX 285	Standard VGA Graphics Adapter	NVIDIA GeForce Go 7300	NVIDIA GeForce GTX 285 & 8400 GS
Video RAM	512MB	512MB	1024MB	none	256MB	1024MB
Service Tag #	6F9YDG1	28PJ2H1	664MMK1	J6C1WK1	422MRB1	
Comments						
OPERATING SYSTEM:						
Windows XP	Version 2002, SP3	Version 2002, SP3	Version 2002, SP3		Version 2002, SP3	Version 2002, SP3
Windows Server				Version 2003		
ACQUISITION SOFTWARE:						
Hypack 2010	n/a	n/a	n/a	n/a	n/a	
Kongsberg SIS	n/a	n/a	n/a	n/a	n/a	
SonarPro	v11.2	v11.3	not installed	not installed	v9.6	
Odom Controller	n/a	n/a	n/a	n/a	n/a	
Velociwin						
PROCESSING SOFTWARE						
CARIS HIPS and SIPS	v7.0.2, SP2	v7.0.2, SP2	v7.0.2, SP2	not installed	v7.0.1, SP1	
MapInfo	v9.0.2	v10.0.1	v10.0.1	not installed	v10.0.1	
Pydro	v10.9 (r3020)	v10.9 (r3020)	v10.9 (r3020)	not installed	v10.9 (r3020)	
Applanix POSPac MMS	v5.3	v5.3	v5.3	not installed	not installed	
SUPPORT SOFTWARE						
Office Suite	Office 2007	Office 2007	Office 2007	not installed	Office 2000	Office 2007
Adobe Acrobat 8	installed	installed	installed	not installed	installed	not installed
SOFTWARE LICENSES						
Odom Digibar Pro Log	n/a	n/a	n/a	n/a	n/a	
SeaTerm	n/a	n/a	n/a	n/a	n/a	
Processing — Caris	Caris Key Serial Numbers: CW9604114, CW9604216, CW9605759 (HQ's key)					
Pydro	c240b6cdda43aaed64	c240b6cdd8d3193876	2129f804f649b10c74	not installed	b2c61c7b7de351f18b	not installed
GPS Pathfinder Office	Installation Code: 001615-00300-10258-E73100AD					
MapInfo	Serial Number: MINWEU0900013988					
Applanix POSPac MMS	Key Serial Number: 2797 (this is a 2-key set, with the other USB key numbered 7959)					

Hydrographic Personnel Roster

Field Unit: NRT5

Effective Date: 15-Apr-09

Updated Through: 1-Oct-10

Team Members

Name and Grade	Current Position	Years of Hydro Experience	Notes
Nicholas A. Forfinski	Team Lead	8.5	Honorary Son of Moose Island
Matt Andring	PST	3.0	Honorary Son of Moose Island
David McIntire	PST	1.0	Honorary Son of Moose Island

NOTES:

Appendix II - Vessel Reports, Offsets, and Diagrams

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Ocean Service
National Geodetic Survey
Field Operations Branch

NOAA Boat – S 3002
IMU and MULTI-BEAM Component Spatial Relationship Survey
Field Report

Kevin Jordan
August, 2009

NOAA Boat – S 3002
IMU and MULTI-BEAM Survey

PURPOSE

The intention of this survey was to accurately position the Inertial Measuring Unit (IMU) and MULTI-BEAM (MBES) components that have been installed onboard the NOAA Boat S 3002.

PROJECT DETAILS

This survey was conducted on August 4 & 5, 2009 near the Naval Education and Training Center in Middletown, RI. The Boat was on a trailer and attached to a towing vehicle. The weather was clear and sunny on the day of the survey. Reconnaissance was conducted, and control marks CL 1, BM 1, BM 2, and BM 3 were found as described. CL 2 and BM 4 were searched for, but were not recovered.

INSTRUMENTATION

The TOPCON GPT 3000 Series Total Station was used to make all measurements.

A SECO 25 mm Mini Prism System configured to have a zero mm offset was used as target sighting and distance measurements.

SOFTWARE AND DATA COLLECTION

ADL Ver. 2.0.11 was used for data collection

ForeSight DXM Ver. 3.2.2 was used for post processing.

PERSONNEL

Kevin Jordan NOAA/NOS/NGS/Field Operations Branch 757-441-3603

Steve Holdorff NOAA/NOS/NGS/Field Operations Branch 757-441-3603

NOAA Boat – S 3002
IMU and MULTI-BEAM Survey

SURVEY PROCEDURES

Establishing the Centerline

To conduct this survey a local coordinate reference frame was established, where the X axis runs along the centerline of the boat and is positive from the primary reference point towards the bow of the boat. The Y axis is perpendicular to the centerline of the boat (X axis), and is positive from the primary reference point towards the right, when looking at the boat from the stern. The Z axis is positive in an upward direction from the primary reference point.

A temporary centerline mark (TCL) was established to align horizontally with CL 1. This was performed by measuring between the two benchmarks at the stern (BM 2 and BM 3) and placing a single punch mark on the deck halfway between them. An assumed distance of 3 meters was entered into NGS Program FORWARD.exe to produce a coordinate along the X axis to enter into the data collector to start the survey (initial azimuth). The instrument was setup on TCL and an assumed elevation of 100 ft was entered into the data collector. A prism was set above CL 1 and an azimuth of 0° 00’ 00” was entered into the data collector while aimed at CL 1. From this station, temporary control points (TP 1 and TP 2) were set off the boat on steady ground.

Setup 1
TP 1 – While occupying TP 1 the instrument was set to initialize on TCL. After initialization was conducted, angular and distance measurements were taken to collect the following points: VBES (SINGLE-BEAM center point), GPS STAR (Starboard GPS Receiver), GPS PORT (Port GPS Receiver), DGPS (Differential GPS Receiver), BM 1, IMU, and BM 3.

Setup 2
TP 2 – Occupying TP 2 the instrument was set to initialize on TCL. After initialization was conducted, angular and distance measurements were taken to collect the following points: MBES (MULTI-BEAM center point), BM 2, and SSS TP (SIDE SCAN SONAR TOW POINT), and CL 1 OBS[*]. Coordinate checks were made to the following previously established points:

BM 3
X, Y = 0.008(m)
Z = 0.005(m)

IMU
X, Y = 0.020(m)
Z = 0.005(m)

DGPS
X, Y = 0.005(m)
Z = 0.005(m)

GPS PORT
X, Y = 0.010(m)
Z = 0.002(m)

GPS STAR
X, Y = 0.000(m)
Z = 0.002(m)

BM 1
X, Y = 0.027(m)
Z = 0.009(m)

* CL 1 OBS was positioned, but was determined later to have a bad elevation after review of field work later that day. Survey operations were conducted on the following day to correct this bad elevation.

Setup 3
Occupying TP 1 the instrument was set to initialize on TCL. After initialization was conducted, angular and distance measurements were taken to collect the following point: TP 4

During this observation, a coordinate check was made to:
BM 2
X, Y = 0.002(m)
Z = 0.002(m)

Setup 4
TP 4 – Occupying TP 1 the instrument was set to initialize on TCL. After initialization was conducted, angular and distance measurements were taken to collect the following point: CL 1 OBS

During this observation, a coordinate check was made to:
TP 1
X, Y = 0.001(m)
Z = 0.009(m)

POST PROCESSING

Since the project was initialized using assumed positions and elevations, the collected points needed to be translated to a referenced coordinate system. Using ForeSight DXM, our observed CL 1 OBS was translated N 0.000(m), E 0.000(m), and Elev 0.000(m). See table 1

The same adjustment was made for the IMU as the reference point of N 0.000(m), E 0.000(m), and Elev 0.000(m). See table 1

DISCUSSION

All sensor/benchmark coordinates are contained in spreadsheet "S3002 2009.xls."

The positions given for all GPS antenna are to the top center of the antenna. As stated from the previous 2005 survey by Kendall L. Fancher:

> "To correct the Z value contained in the spreadsheet for each antenna to the electronic phase center, I recommend the following steps be taken;
>
> 1) Measure the total height of each antenna type. This information is probably located on the antenna or with equipment documentation.
> 2) Investigate to find the electronic phase center offset of the antenna. This information is probably located on the antenna or with equipment documentation. This value may also be available at the NGS website for antenna modeling.

3) Subtract the total height of the antenna from the spreadsheet Z value for each antenna. This will give you a Z value for the ARP (antenna reference point)
4) Then add to this value the electronic phase center offset value."

NOAA BOAT S 3002							
		∆ Reference Point CL1			∆ Reference Point IMU		
POINT	Name	∆x (m)	∆y (m)	∆z (m)	∆x (m)	∆y (m)	∆z (m)
CL1 OBS	CENTERLINE POINT 1	0.000	0.000	0.000	2.070	0.001	-0.427
TCL	TEMPORARY CENTERLINE	-3.159	0.004	1.128	-1.089	0.004	0.701
BM1	BENCH MARK 1	4.477	0.022	1.497	6.547	0.022	1.070
BM2	BENCH MARK 2	-3.143	-1.129	1.256	-1.073	-1.128	0.829
BM3	BENCH MARK 3	-3.157	1.140	1.233	-1.087	1.141	0.806
IMU	IMU	-2.070	-0.001	0.427	0.000	0.000	0.000
DGPS	GPS NAVIGATION ANTENNA	-0.608	0.013	3.607	1.462	0.014	3.180
GPS PORT	IMU GPS PORT SIDE	1.125	-0.756	2.827	3.195	-0.755	2.400
GPS STAR	IMU GPS STARBOARD SIDE	1.137	0.782	2.825	3.207	0.783	2.398
MBES	MULTIBEAM REFERENCE POINT	-1.913	0.057	-0.112	0.158	0.058	-0.539
VBES	SINGLE BEAM REFERENCE POINT	0.179	-0.163	-0.026	2.249	-0.162	-0.453
SSS TP	SIDE SCAN SONAR TOW POINT	-2.826	1.646	2.915	-0.756	1.647	2.488

Table 1. - NRT S 3002 survey August 2009

CONTROL INVERSE COMPARISON (HORIZONTAL ONLY)			
	2005 SURVEY IN METERS	2009 SURVEY IN METERS	DIFFERENCE IN METERS
CL1 TO BM1	4.433	4.477	-0.044
CL1 TO BM2	3.371	3.399	-0.028
CL1 TO BM3	3.378	3.357	0.021
BM1 TO BM2	7.693	7.706	-0.013
BM1 TO BM3	7.699	7.719	-0.020
BM2 TO BM3	2.265	2.269	-0.004

Table 2. – NRT S 3002 Control network inverse comparison.

POS/MV Calibration Report

Field Unit: NRT-5

SYSTEM INFORMATION

Vessel: S3002

Date: 4/13/2009 **Dn:** 103

Personnel: Jaskoski, Ho, Doroba

PCS Serial # 2034

IP Address: 205.156.4.3

POS controller Version (Use Menu Help > About) 3.3

POS Version (Use Menu View > Statistics) MV320 Ver4

GPS Receivers

Primary Receiver SGN 99330009

Secondary Receiver SGN 98370085

CALIBRATION AREA

Location: Gravesend Bay, NY

Approximate Position:

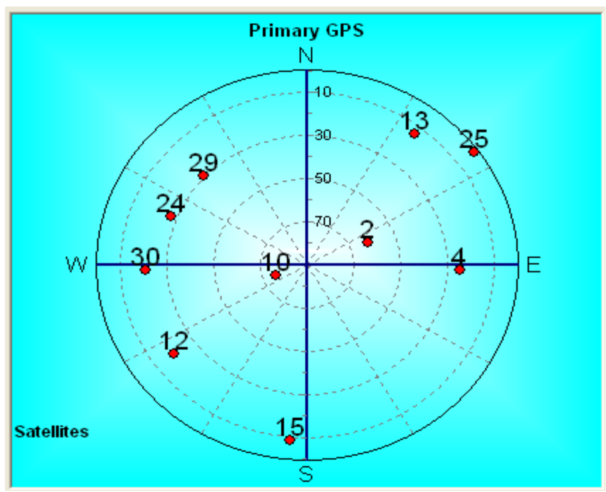
	D	M	S
Lat	40	35	51
Lon	74	1	51

DGPS Beacon Station: Sandy Hook

Frequency: 286 kHZ

Satellite Constellation

Primary GPS (Port Antenna)



HDOP: 0.856

VDOP: 1.317

Sattelites in Use: 12

2,4,7,8,10,15,21,24,26,27,29,30

PDOP 2.030 (Use View> GAMS Solution)

Note: Secondary GPS satellite constellation and number of satellites were exactly the same as the Primary GPS

SV	2	4	10	12	13	15	24	25	29	30
Status	L1 ph lc	L1 ph lc	L1 ph lc	L1 ph lc	L1 ph lc	L1 ph lc	L1 ph lc	L1 cd lc	L1 ph lc	L1 ph lc
Azimuth	68.0	92.0	249.0	234.0	37.0	185.0	291.0	54.0	313.0	268.0
Elevatior	62.0	25.0	76.0	20.0	14.0	9.0	28.0	2.0	30.0	21.0
L1 SNR	50.8	43.8	51.8	44.0	41.5	41.8	45.8	29.5	45.0	41.8
L2 SNR	42.8	29.5	42.8	30.8	21.8	23.0	30.8	0.0	33.3	30.5

POS/MV CONFIGURATION

Settings

Gams Parameter Setup (Use Settings > Installation > GAMS Intallation)

User Entries, Pre-Calibration		Baseline Vector	
1.542	Two Antenna Separation (m)	**-0.024**	X Component (m)
0.50	Heading Calibration Threshold	**1.542**	YComponent (m)
0	Heading Correction	**-0.006**	Z Component (m)

Configuration Notes:

POS/MV CALIBRATION

Calibration Procedure:

(Refer to POS MV V3 Installation and Operation Guide, 4-25)

Start time: 13:24 UTC

End time: 13:27 UTC

Heading accuracy achieved for calibration: 0.024

Calibration Results:

Gams Parameter Setup (Use Settings > Installation > GAMS Intallation)

POS/MV Post-Calibration Values		Baseline Vector	
1.543	Two Antenna Separation (m)	**-0.022**	X Component (m)
0.500	Heading Calibration Threshold	**1.543**	YComponent (m)
0	Heading Correction	**-0.007**	Z Component (m)

GAMS Status Online? Y

Save Settings? Y

Calibration Notes:

Save POS Settings on PC (Use File > Store POS Settings on PC)

File Name: 20090413

GENERAL GUIDANCE

The POS/MV uses a Right-Hand Orthogonal Reference System

The right-hand orthogonal system defines the following:

- The x-axis is in the fore-aft direction in the appropriate reference frame.
- The y-axis is perpendicular to the x-axis and points towards the right (starboard) side in the appropriate reference frame.
- The z-axis points downwards in the appropriate reference frame.

The POS/MV uses a Tate-Bryant Rotation Sequence

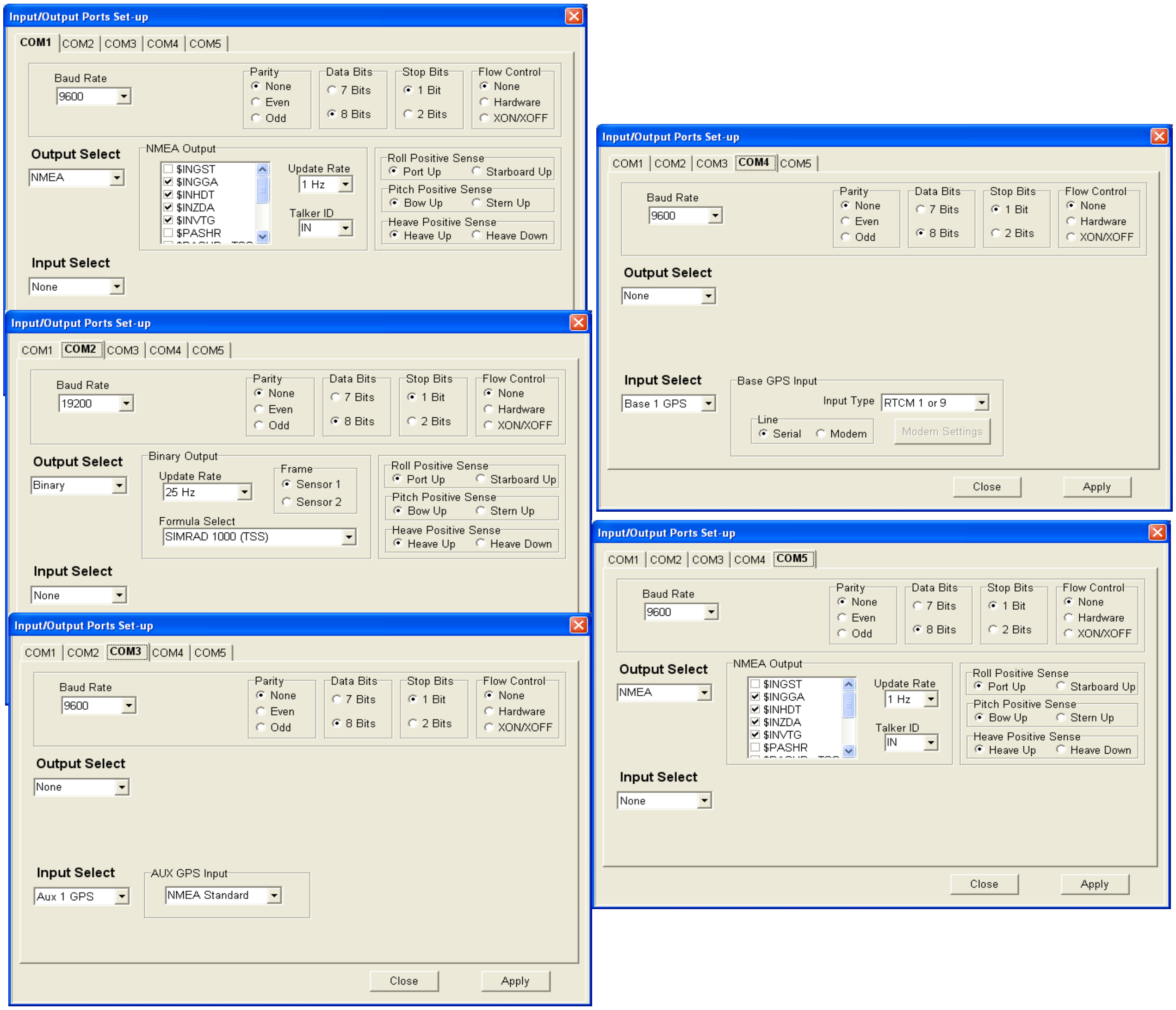
Apply the rotation in the following order to bring the two frames of reference into complete alignment:

a) Heading rotation - apply a right-hand screw rotation θz about the z-axis to align one frame with the other.

b) Pitch rotation - apply a right-hand screw rotation θy about the once-rotated y-axis to align one frame with the other.

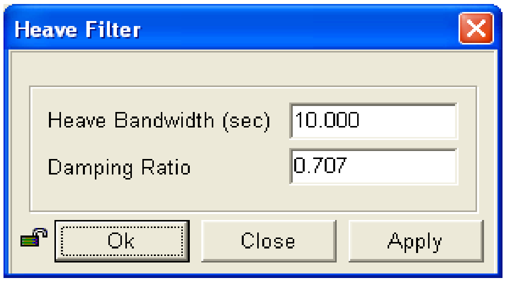
c) Roll rotation - apply a right-hand screw rotation θx about the twice-rotated x-axis to align one frame with the other.

SETTINGS (insert screen grabs)
Input/Output Ports (Use Settings > Input/Output Ports)

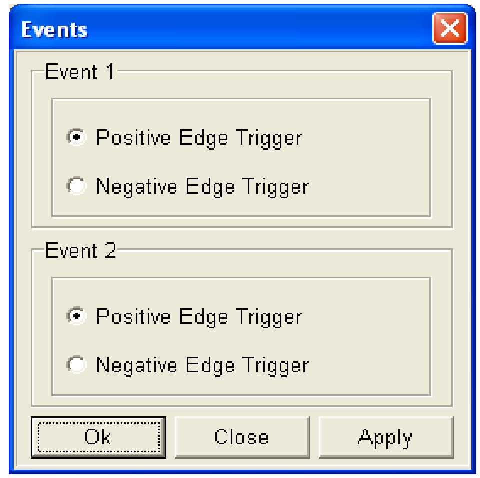


NOTE: COM3 and Analog are not used.

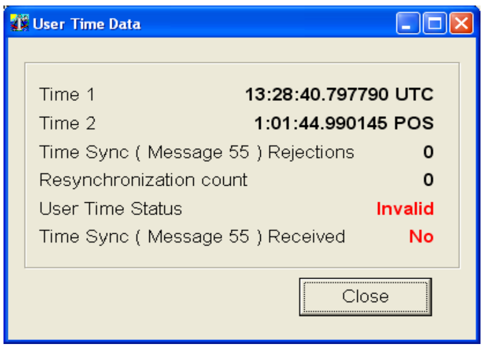
Heave Filter (Use Settings > Heave)



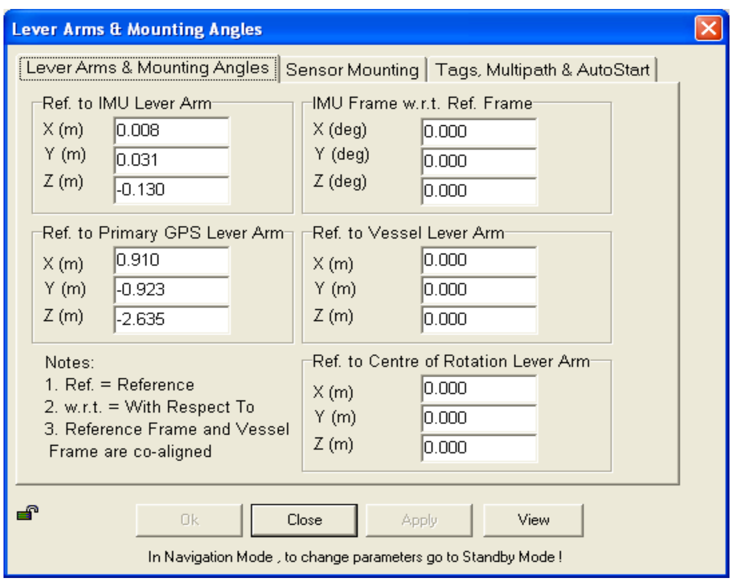
Events (Use Settings > Events)



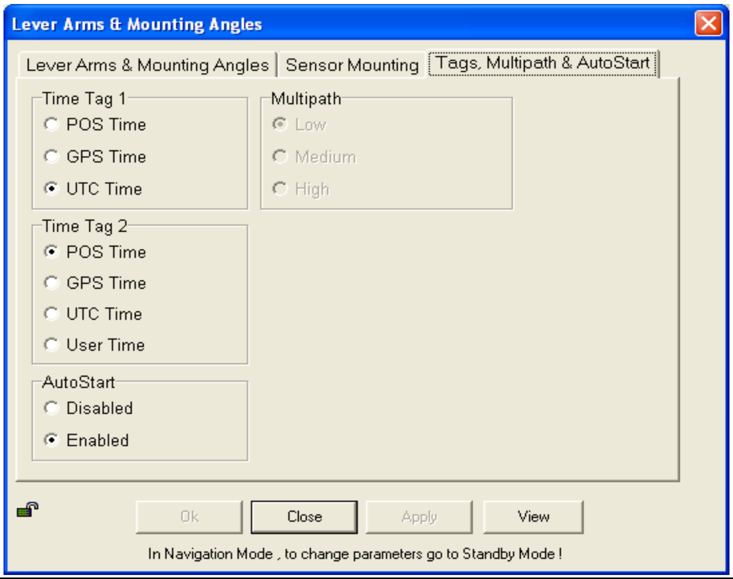
Time Sync (Use Settings > Time Sync)



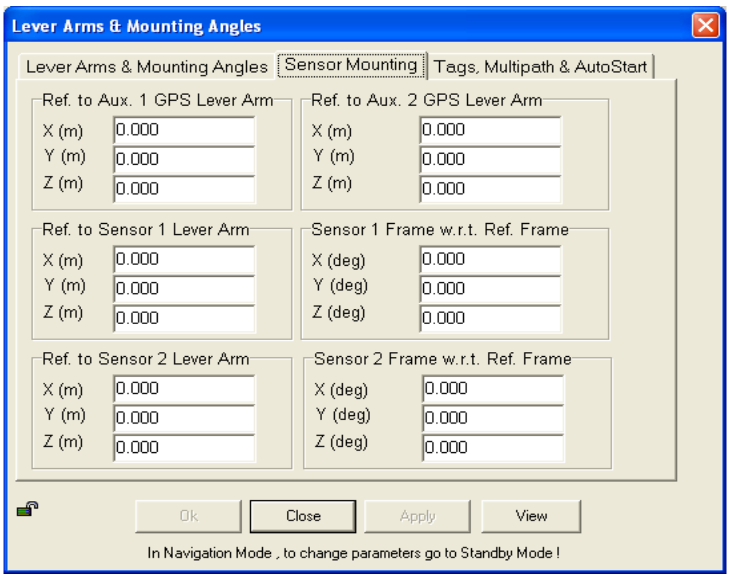
Installation (Use Settings > Installation)



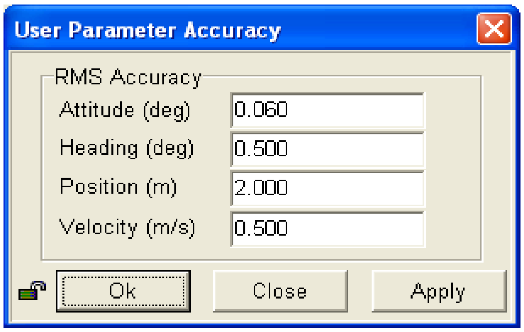
Tags, Multipath and Auto Start (Use Settings > Installation > Tags, Multipath and Auto Start)



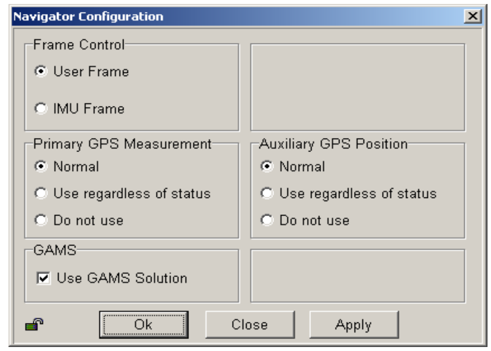
Sensor Mounting (Use Settings > Installation > Sensor Mounting)



User Parameter Accuracy (Use Settings > Installation > User Accuracy)

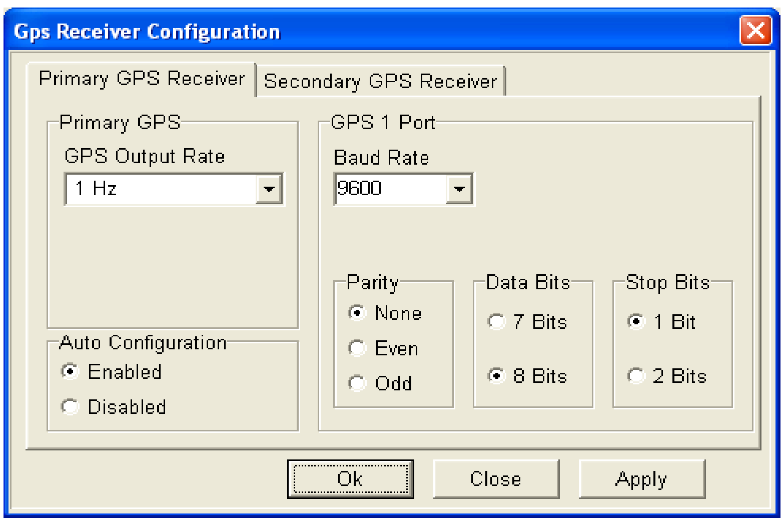


Frame Control (Use Tools > Config)

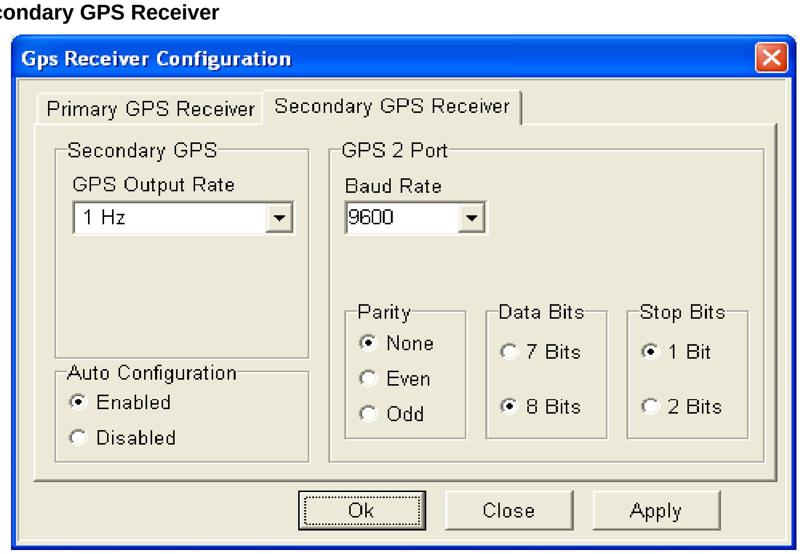


GPS Receiver Configuration (Use Settings> Installation> GPS Receiver Configuration)

Primary GPS Receiver



Secondary GPS Receiver

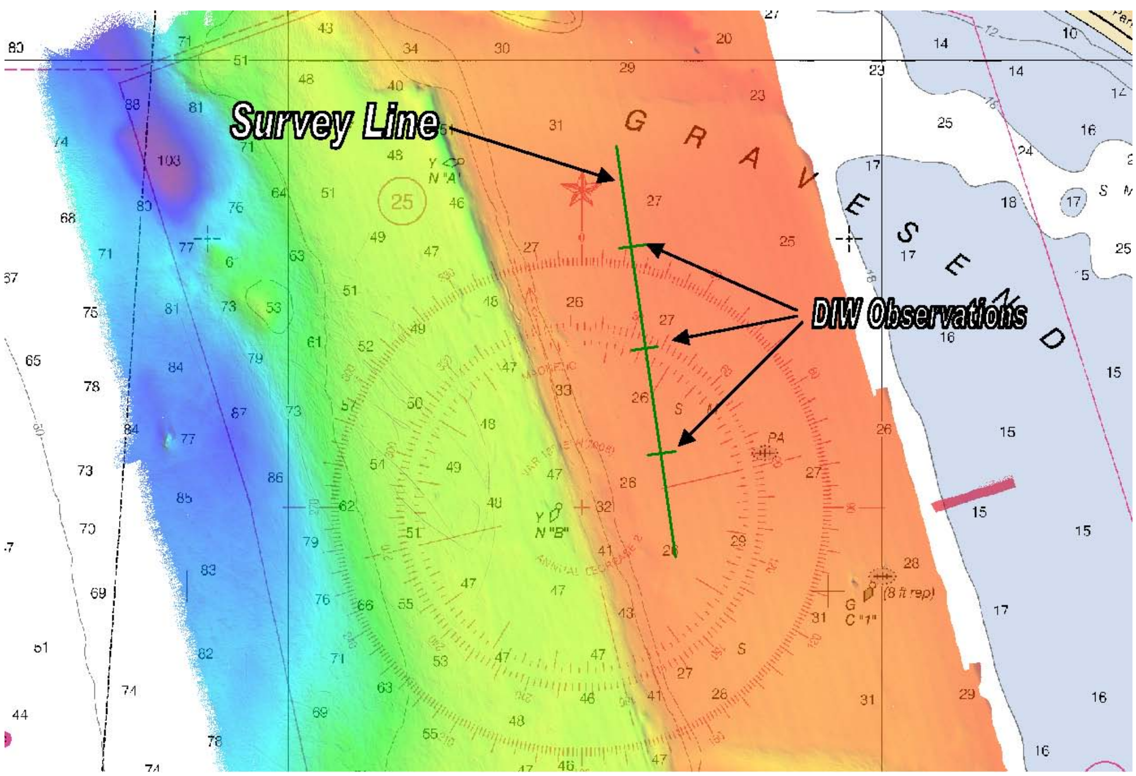


S3002 Dynamic Draft Test
13 April 2009
LT(jg) Matthew Jaskoski

Background:
NRT-5 is capable of acquiring both bathymetry data and side scan sonar imagery. Accuracy in data processing is in part dependent on the determination of the change in vessel draft in relation to vessel speed through the water. This test empirically determines the dynamic draft of S3002 using the multibeam echosounder method.

Location, Date, and Personnel:
Sonar data were acquired at Gravesend Bay, New York Harbor, NY (Figure 1) on April 13 2009 (DN 103) by LT(jg) Matthew Jaskoski (OIC), PST Bert Ho (data recorder), and PST John Doroba (launch coxswain).

Figure 1: Work Site



Equipment:

TSS POS/MV version 4 + Precise Timing Aero Antenna
DSM 212L DGPS receiver
Kongsberg Simrad EM 3002
Odom Digibar Pro Sound Velocimeter

Procedure:

Data Acquisition:

Data were acquired over a flat relatively shallow area (appx. 8m water depth) of the Gravesend Bay anchorage. The survey area is located as close as is practicable to the Battery Park Harmonic water level station. The survey time was planned to coincide as closely as practicable to slack water. To account for any current S3002 made repeated passes at various speed intervals over the survey line in both directions. The survey line was approximately 1000m in length, however due to a barge anchoring on the northern end of the survey line during data acquisition, dead in the water (DIW) data were acquired at positions 250m, 375m and 500m along the line instead of the usual 250m, 500m and 750m positions. A sound velocity cast was taken near the survey area and applied in SIS during data acquisition.

Data Processing:

Data were converted and processed in accordance with established protocols with the following exceptions; 1) True heave was not applied as long period heave may bias dynamic draft calculations – random short period heave will be canceled out by using the median reference surface depth, and 2) a dummy dynamic draft table was created in the HVF to ensure that historic dynamic draft measurements would not be applied to the dataset. Subsets were cleaned of fliers and Uncertainly weighted surfaces were generated at 0.50m resolution. Surfaces were queried for depth and standard deviation these values were entered into an Excel spreadsheet where the median was calculated for depth and the mean was calculated for standard deviation. Vessel speed was queried in the subsets, entered in the Excel spread sheet and averaged for all subsets. The dynamic draft offset was calculated for each reference area by subtracting the median reference surface depth from median depths for each RPM/speed interval. The mean dynamic draft was calculated by averaging the median values for the subsets at ¼ and ¾ the length of the line (subsets A and C).

These values are tabulated below.

Table 1: Dynamic Draft Offset Data

S3002 Dynamic Draft: 13 April 2009, DN 103						
RPM	Speed (kts)	Median A (m)	Median B (m)	Median C (m)	Std. Dev.	Mean (m)
Idle	0.00	0.00	0.00	0.00	0.05	0.00
900 (1 engine)	2.07	-0.06	-0.03	-0.04	0.04	-0.05
900 (both engines)	3.40	-0.06	-0.02	-0.02	0.04	-0.04
2000 (Both)	6.50	-0.05	-0.03	-0.03	0.04	-0.04
2200 (Both)	6.55	-0.04	-0.03	-0.01	0.04	-0.03

Figure 2: Dynamic Draft Offset Data

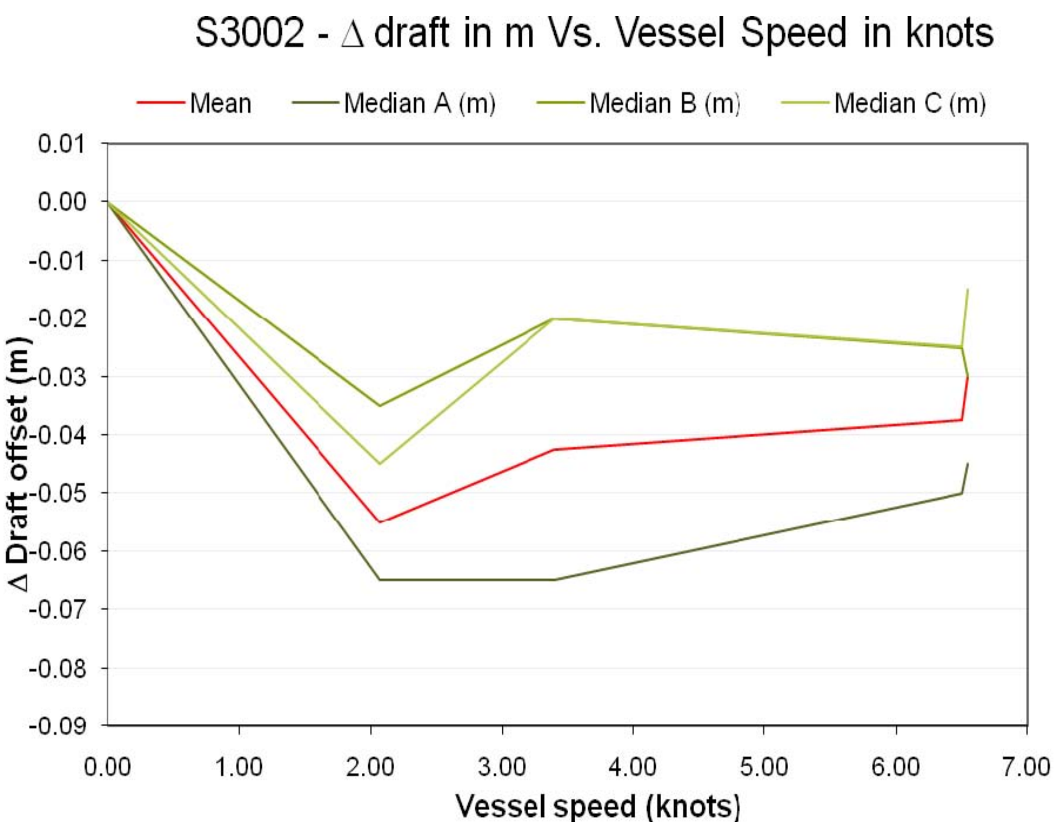
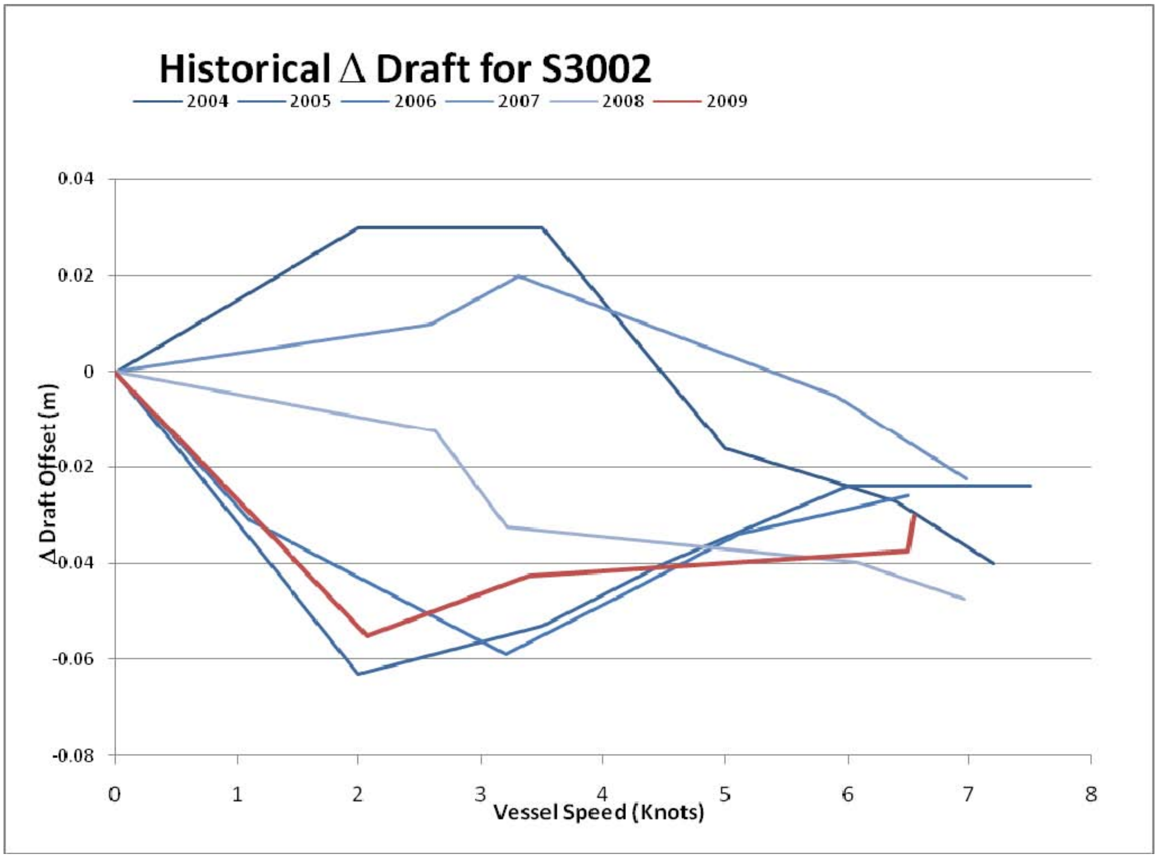
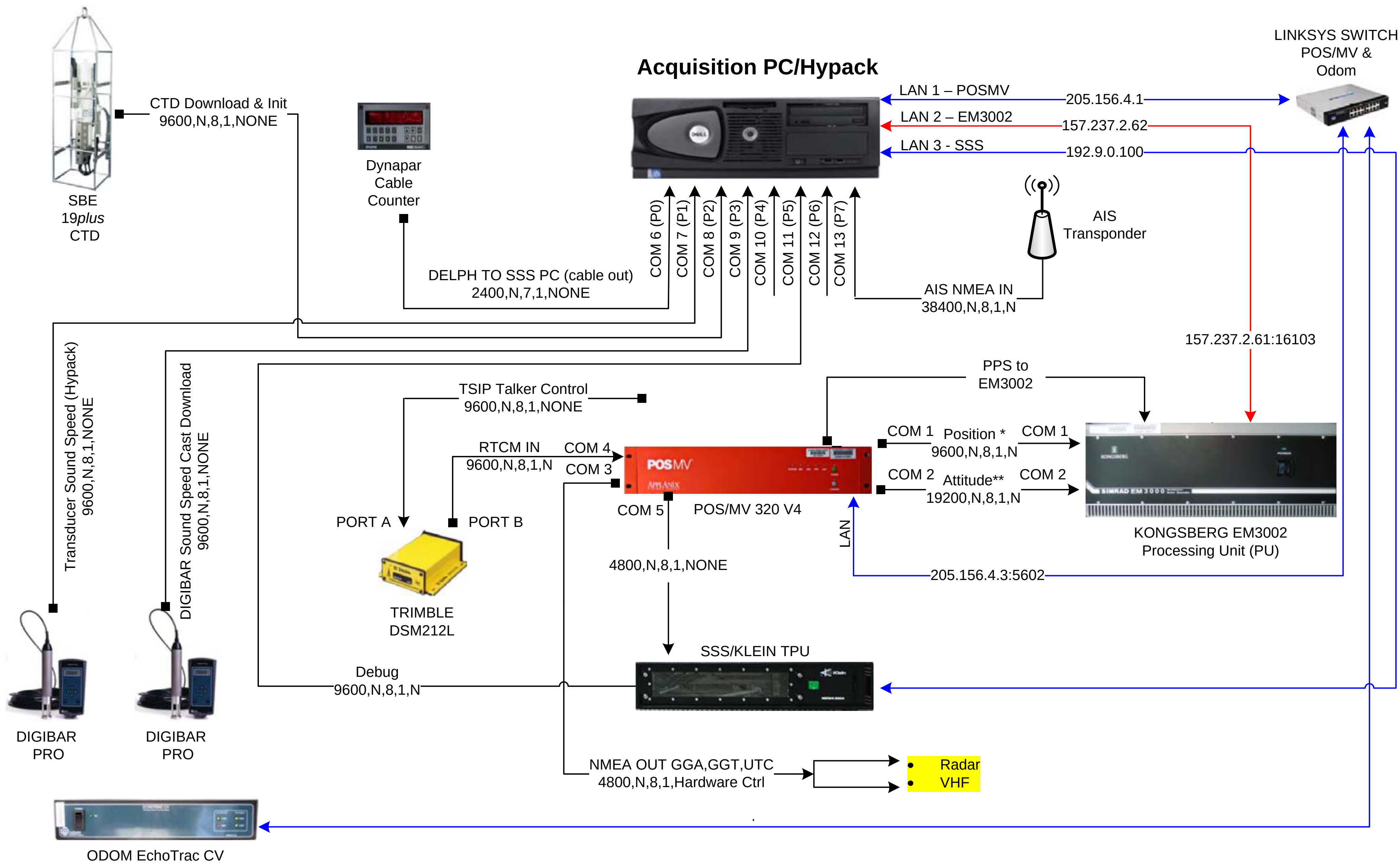


Figure 3: Historical Dynamic Draft Offset Data for S3002



Conclusions:

The multibeam echosounder method of determining the dynamic draft has yielded acceptable results, current dynamic draft numbers fall within the range of previous years' results.



Key

- Serial
- Crossover
- Patch

* POS/MV COM 1 Position Data: 9600,N,8,1,NONE; GGA, HDT, ZDA, VTG; 1Hz
** POS/MV COM 2 Attitude Data: SIMRAD 1000 Tate-Bryant, 25Hz

Launch S3002 Wire Diagram

Rev 1.0	5/5/2011	Philip Sparr

Appendix III – Calibration

SEA-BIRD ELECTRONICS, INC.

13431 NE 20th Street, Bellevue, Washington, 98005-2010 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 4835
CALIBRATION DATE: 26-May-10

SBE19plus TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

a0 = 1.266560e-003
a1 = 2.595838e-004
a2 = 4.741769e-007
a3 = 1.352598e-007

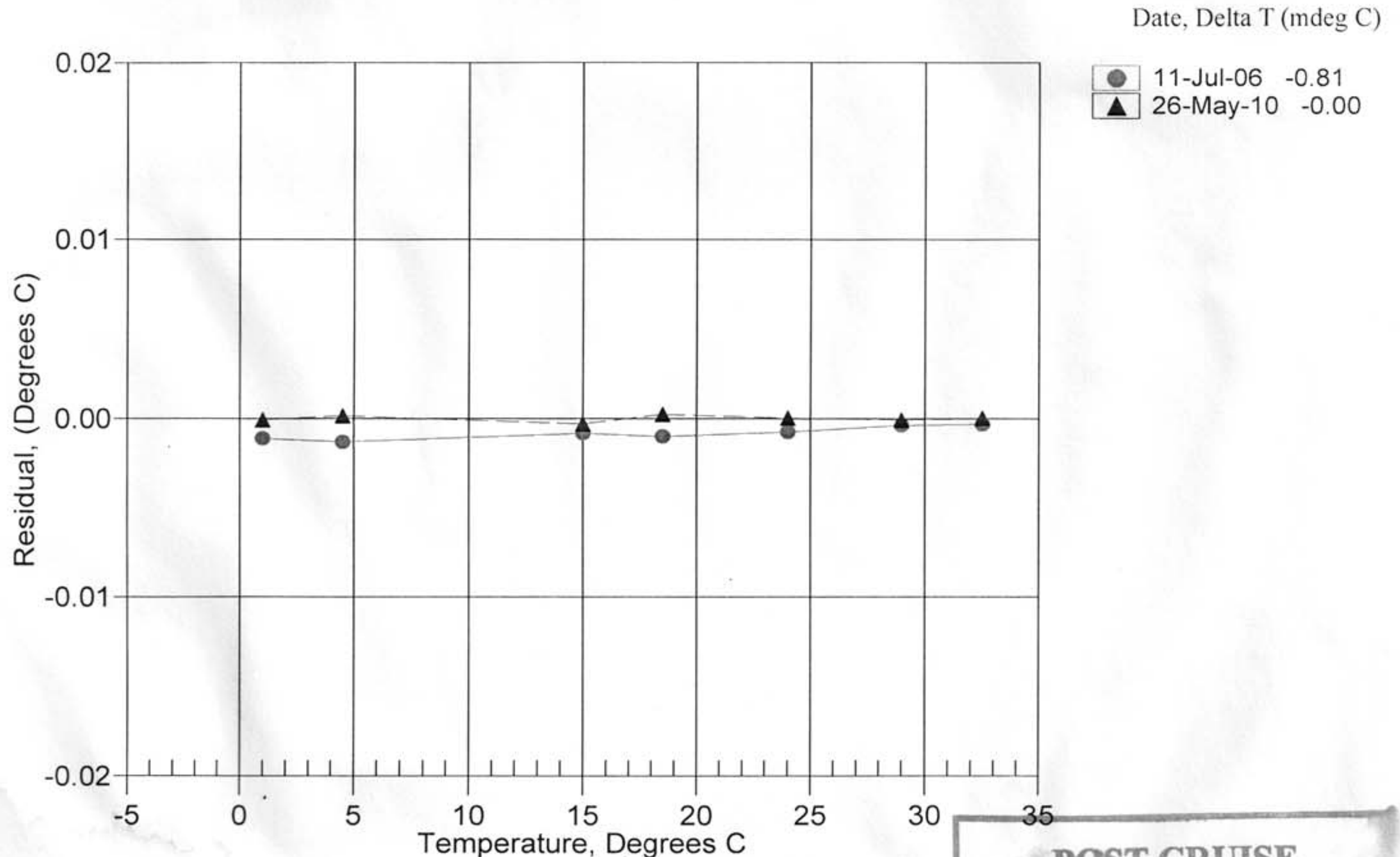
BATH TEMP (ITS-90)	INSTRUMENT OUTPUT(n)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	600983.339	0.9999	-0.0001
4.5000	533096.712	4.5001	0.0001
15.0000	365261.966	14.9997	-0.0003
18.5000	320325.322	18.5002	0.0002
24.0000	259409.288	24.0000	0.0000
29.0000	213091.203	28.9999	-0.0001
32.5001	185130.441	32.5001	0.0000

MV = (n - 524288) / 1.6e+007

R = (MV * 2.900e+009 + 1.024e+008) / (2.048e+004 - MV * 2.0e+005)

Temperature ITS-90 = $1/\{a0 + a1[ln(R)] + a2[ln^2(R)] + a3[ln^3(R)]\} - 273.15$ (°C)

Residual = instrument temperature - bath temperature



POST CRUISE
[illegible]BRATION

SBE SEA-BIRD ELECTRONICS, INC.
13431 NE 20th St. Bellevue, Washington 98005 USA
Phone: (425) 643-9866 Fax: (425) 643-9954 www.seabird.com

Temperature Calibration Report

Customer:	NOAA-NAVIGATION RESPONSE BRANCH		
Job Number:	59813	**Date of Report:**	5/26/2010
Model Number:	SBE 19Plus	**Serial Number:**	19P39974-4835

Temperature sensors are normally calibrated 'as received', without adjustments, allowing a determination sensor drift. If the calibration identifies a problem, then a second calibration is performed after work is completed. The 'as received' calibration is not performed if the sensor is damaged or non-functional, or by customer request.

An 'as received' calibration certificate is provided, listing coefficients to convert sensor frequency to temperature. Users must choose whether the 'as received' calibration or the previous calibration better represents the sensor condition during deployment. In SEASOFT enter the chosen coefficients using the program SEACON. The coefficient 'offset' allows a small correction for drift between calibrations (consult the SEASOFT manual). Calibration coefficients obtained after a repair apply only to subsequent data.

'AS RECEIVED CALIBRATION' ☑ Performed ☐ Not Performed

Date: 5/26/2010 Drift since last cal: +0.00021 Degrees Celsius/year

Comments:

'CALIBRATION AFTER REPAIR' ☐ Performed ☑ Not Performed

Date: Drift since Last cal: Degrees Celsius/year

Comments:

SEA-BIRD ELECTRONICS, INC.

13431 NE 20th Street, Bellevue, Washington, 98005-2010 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 4835
CALIBRATION DATE: 26-May-10

SBE19plus CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -1.018451e+000
h = 1.321073e-001
i = -2.285564e-004
j = 3.350235e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006

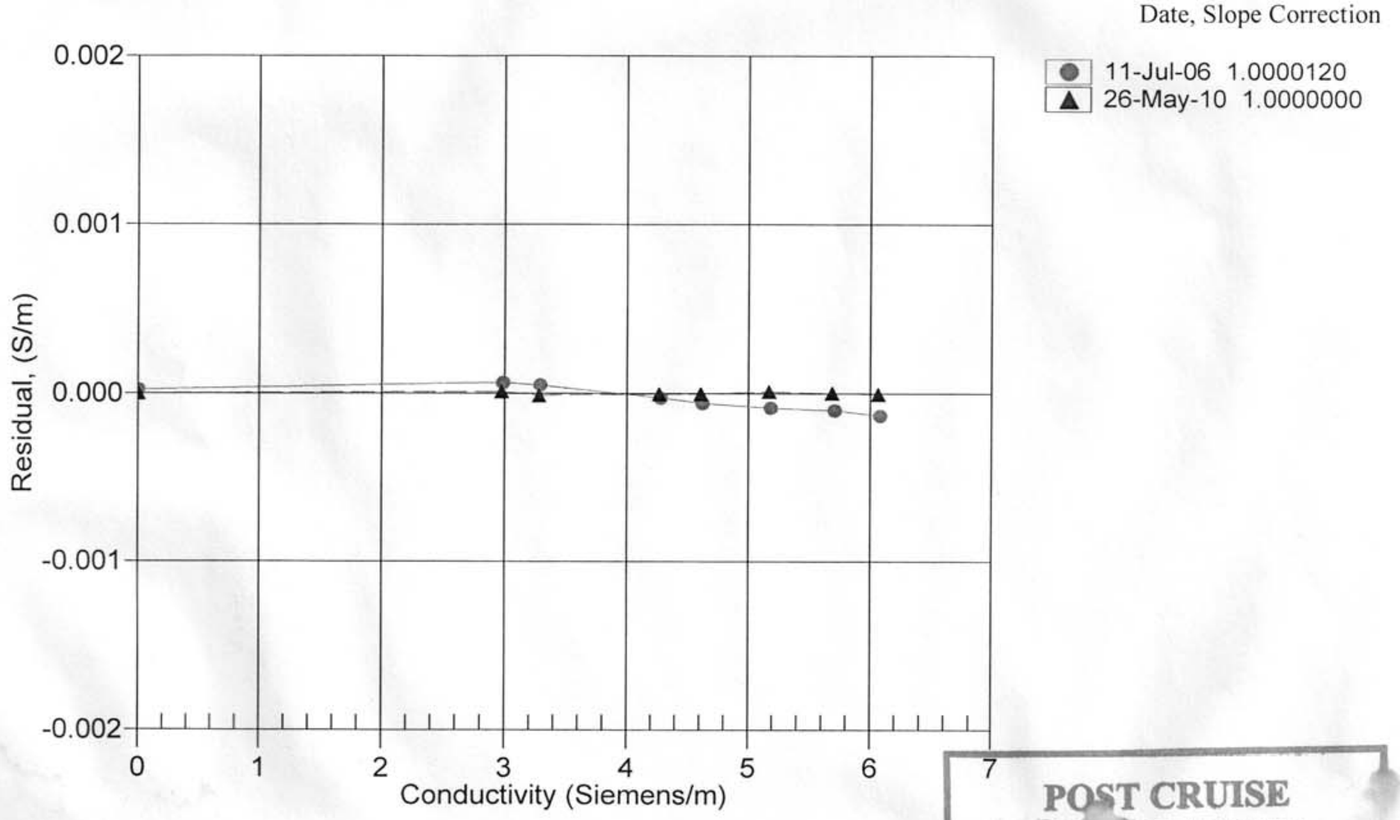
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2780.52	0.0000	0.00000
1.0000	34.8252	2.97665	5504.29	2.9767	0.00001
4.5000	34.8053	3.28379	5711.31	3.2838	-0.00001
15.0000	34.7620	4.26566	6327.08	4.2657	-0.00000
18.5000	34.7528	4.61085	6529.50	4.6108	-0.00000
24.0000	34.7426	5.16887	6843.76	5.1689	0.00001
29.0000	34.7366	5.69073	7124.76	5.6907	0.00000
32.5001	34.7320	6.06296	7318.40	6.0630	-0.00001

f = INST FREQ / 1000.0

Conductivity = $(g + hf^2 + if^3 + jf^4) / (1 + \delta t + \varepsilon p)$ Siemens/meter

t = temperature[°C)]; p = pressure[decibars]; δ = CTcor; ε = CPcor;

Residual = instrument conductivity - bath conductivity



POST CRUISE CALIBRATION

SBE SEA-BIRD ELECTRONICS, INC.
13431 NE 20th Street Bellevue, Washington 98005 USA
Phone: (425) 643-9866 Fax: (425) 643-9954 www.seabird.com

Conductivity Calibration Report

Customer:	NOAA-NAVIGATION RESPONSE BRANCH		
Job Number:	59813	Date of Report:	5/26/2010
Model Number:	SBE 19Plus	Serial Number:	19P39974-4835

Conductivity sensors are normally calibrated 'as received', without cleaning or adjustments, allowing a determination of sensor drift. If the calibration identifies a problem or indicates cell cleaning is necessary, then a second calibration is performed after work is completed. The 'as received' calibration is not performed if the sensor is damaged or non-functional, or by customer request.

An 'as received' calibration certificate is provided, listing the coefficients used to convert sensor frequency to conductivity. Users must choose whether the 'as received' calibration or the previous calibration better represents the sensor condition during deployment. In SEASOFT enter the chosen coefficients using the program SEACON. The coefficient 'slope' allows small corrections for drift between calibrations (consult the SEASOFT manual). Calibration coefficients obtained after a repair or cleaning apply only to subsequent data.

'AS RECEIVED CALIBRATION' ☑ Performed ☐ Not Performed

Date: 5/26/2010 Drift since last cal: 0.0000 PSU/month*

Comments:

'CALIBRATION AFTER CLEANING & REPLATINIZING' ☐ Performed ☑ Not Performed

Date: Drift since Last cal: PSU/month*

Comments:

**Measured at 3.0 S/m*

Cell cleaning and electrode replatinizing tend to 'reset' the conductivity sensor to its original condition. Lack of drift in post-cleaning-calibration indicates geometric stability of the cell and electrical stability of the sensor circuit.

SEA-BIRD ELECTRONICS, INC.

13431 NE 20th Street, Bellevue, Washington, 98005-2010 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 4835
CALIBRATION DATE: 25-May-10

SBE19plus PRESSURE CALIBRATION DATA
160 psia S/N 7813

COEFFICIENTS:

PA0 = 7.421843e-003
PA1 = 4.872009e-004
PA2 = -3.870473e-012
PTEMPA0 = -6.105904e+001
PTEMPA1 = 5.376443e+001
PTEMPA2 = -1.768733e-001

PTCA0 = 5.240121e+005
PTCA1 = -1.119879e+000
PTCA2 = 5.730617e-002
PTCB0 = 2.512200e+001
PTCB1 = -2.000000e-003
PTCB2 = 0.000000e+000

PRESSURE SPAN CALIBRATION

PRESSURE PSIA	INST OUTPUT	THERMISTOR OUTPUT	COMPUTED PRESSURE	ERROR %FSR
14.54	553779.0	1.6	14.53	-0.01
59.87	646775.0	1.6	59.86	-0.00
94.81	718512.0	1.6	94.79	-0.01
124.80	780206.0	1.6	124.79	-0.00
159.80	852280.0	1.6	159.81	0.00
124.81	780242.0	1.6	124.81	0.00
94.81	718569.0	1.6	94.82	0.01
59.82	646696.0	1.6	59.83	0.01
29.83	585205.0	1.6	29.86	0.02
14.54	553788.0	1.6	14.54	-0.00

THERMAL CORRECTION

TEMP ITS90	THERMISTOR OUTPUT	INST OUTPUT
32.50	1.75	554455.25
29.00	1.69	554385.15
24.00	1.59	554399.91
18.50	1.49	554427.08
15.00	1.42	554430.69
4.50	1.22	554421.67
1.00	1.16	554413.36

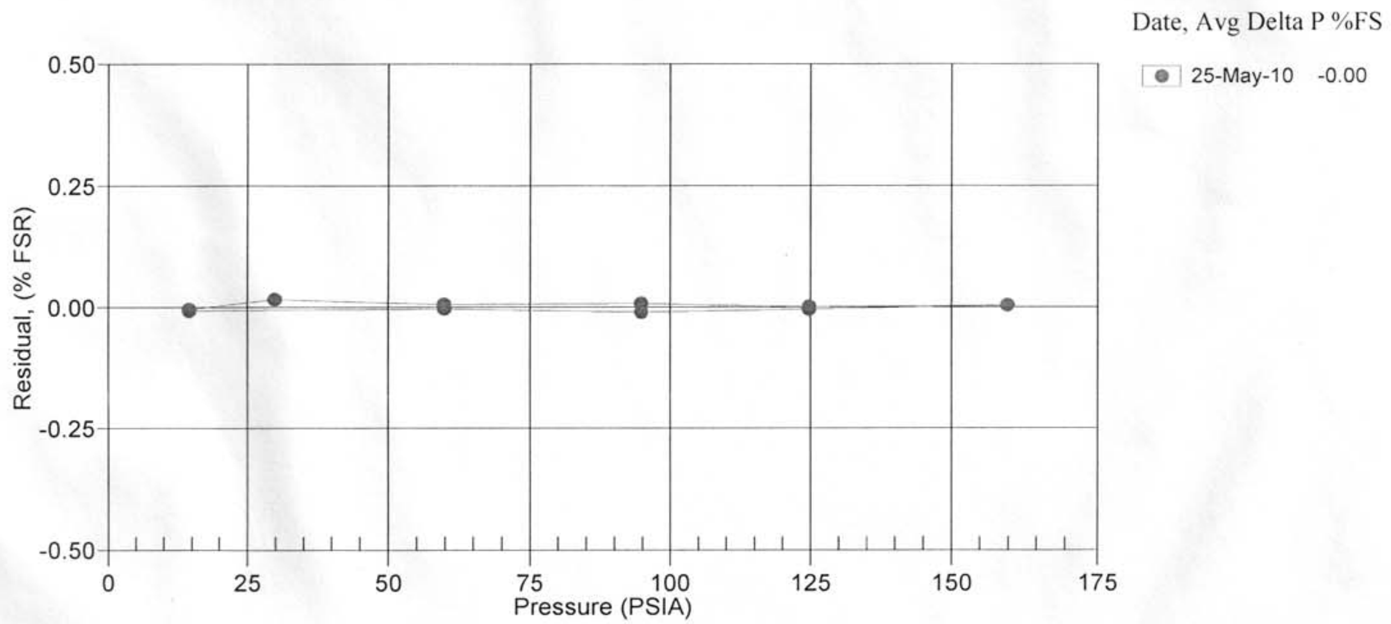
TEMP(ITS90)	SPAN(mV)
-5.00	25.13
35.00	25.05

y = thermistor output; $t = PTEMPA0 + PTEMPA1 * y + PTEMPA2 * y^2$

x = pressure output - $PTCA0 - PTCA1 * t - PTCA2 * t^2$

$n = x * PTCB0 / (PTCB0 + PTCB1 * t + PTCB2 * t^2)$

pressure (psia) = $PA0 + PA1 * n + PA2 * n^2$



Date:
Sep 25, 2009

Serial #:
98214-092509

DIGIBAR CALIBRATION REPORT

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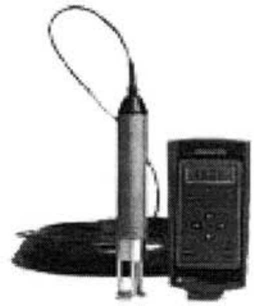
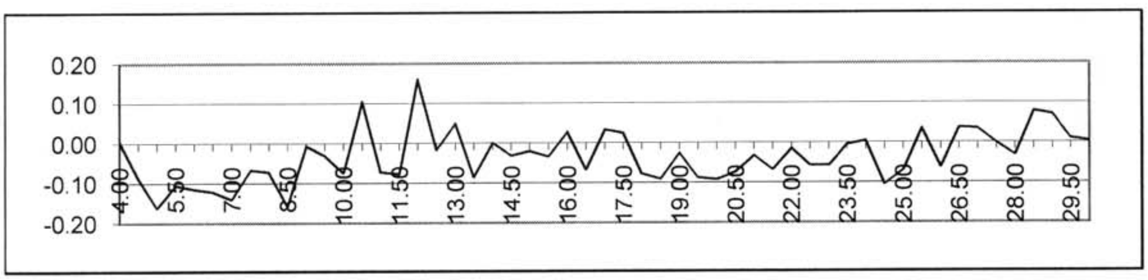


STANDARD DEL GROSSO H^2O

TEMP	VELOCITY	MEASURED FREQUENCY	RES_VEL	OBS-CAL
4.00	1421.62	5531.97	1421.63	0.01
4.50	1423.90	5540.35	1423.81	-0.09
5.00	1426.15	5548.69	1425.99	-0.16
5.50	1428.38	5557.43	1428.27	-0.11
6.00	1430.58	5565.82	1430.46	-0.11
6.50	1432.75	5574.12	1432.63	-0.12
7.00	1434.90	5582.27	1434.76	-0.14
7.50	1437.02	5590.68	1436.95	-0.07
8.00	1439.12	5598.69	1439.05	-0.07
8.50	1441.19	5606.29	1441.03	-0.16
9.00	1443.23	5614.71	1443.23	-0.01
9.50	1445.25	5622.36	1445.22	-0.03
10.00	1447.25	5629.84	1447.18	-0.07
10.50	1449.22	5638.08	1449.33	0.11
11.00	1451.17	5644.86	1451.10	-0.07
11.50	1453.09	5652.21	1453.02	-0.08
12.00	1454.99	5660.40	1455.16	0.16
12.50	1456.87	5666.91	1456.86	-0.02
13.00	1458.72	5674.26	1458.77	0.05
13.50	1460.55	5680.75	1460.47	-0.09
14.00	1462.36	5688.00	1462.36	0.00
14.50	1464.14	5694.71	1464.11	-0.03
15.00	1465.91	5701.50	1465.89	-0.02
15.50	1467.65	5708.11	1467.61	-0.03
16.00	1469.36	5714.92	1469.39	0.03
16.50	1471.06	5721.05	1470.99	-0.07
17.00	1472.73	5727.84	1472.76	0.03
17.50	1474.38	5734.13	1474.41	0.03
18.00	1476.01	5739.98	1475.93	-0.08
18.50	1477.62	5746.09	1477.53	-0.09
19.00	1479.21	5752.42	1479.18	-0.02
19.50	1480.77	5758.18	1480.68	-0.09
20.00	1482.32	5764.08	1482.22	-0.09
20.50	1483.84	5769.99	1483.77	-0.07
21.00	1485.35	5775.91	1485.31	-0.03
21.50	1486.83	5781.46	1486.76	-0.07
22.00	1488.29	5787.27	1488.28	-0.01
22.50	1489.74	5792.64	1489.68	-0.06
23.00	1491.16	5798.09	1491.10	-0.06
23.50	1492.56	5803.67	1492.56	0.00
24.00	1493.95	5809.01	1493.95	0.01
24.50	1495.32	5813.82	1495.21	-0.10
25.00	1496.66	5819.11	1496.59	-0.07
25.50	1497.99	5824.60	1498.02	0.04
26.00	1499.30	5829.24	1499.24	-0.06
26.50	1500.59	5834.56	1500.63	0.04
27.00	1501.86	5839.42	1501.89	0.04
27.50	1503.11	5844.08	1503.11	0.00
28.00	1504.35	5848.69	1504.31	-0.03
28.50	1505.56	5853.77	1505.64	0.08
29.00	1506.76	5858.33	1506.83	0.07
29.50	1507.94	5862.62	1507.95	0.01
30.00	1509.10	5867.05	1509.11	0.00



Odom Hydrographic Systems, Inc.

1450 SeaBoard Avenue, Baton Rouge, Louisiana 70810-6261, USA
Telephone: (225)-769-3051, Facsimile: (225)-766-5122
E-mail: email@odomhydrographic.com, HTTP: www.odomhydrographic.com

Date:
Sep 25, 2009

Serial #:
98214-092509

DIGIBAR CALIBRATION REPORT

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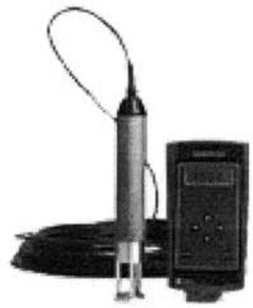
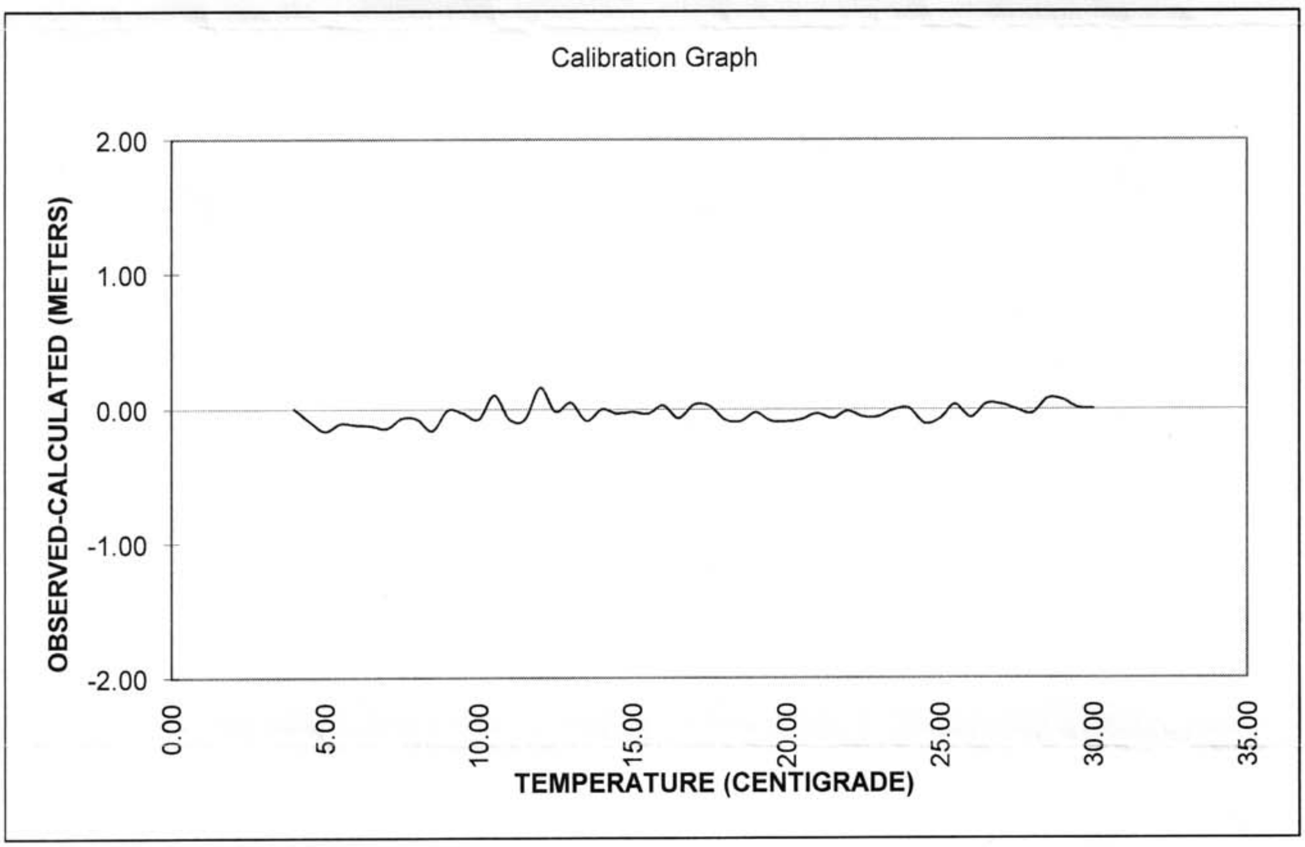


Burn these numbers to EPROM: Gradient **3342**; Intercept **227**



The instruments used in this calibration have been calibrated to the published manufacturer specifications using standards traceable to NIST, to consensus standards, to ratio methods, or to acceptable values of natural physical constants that meets the requirements of ANSI/NCSL Z540-1, ISO 9001, ISO 10012 and ISO 17025. Certificate/traceability numbers: 0002-2655.00-23491-001, 0002-2655.00-23491-002. ID#'s:294,295,762,172,56

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A Teledyne Technologies Company

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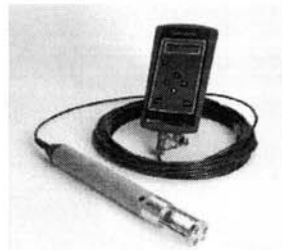
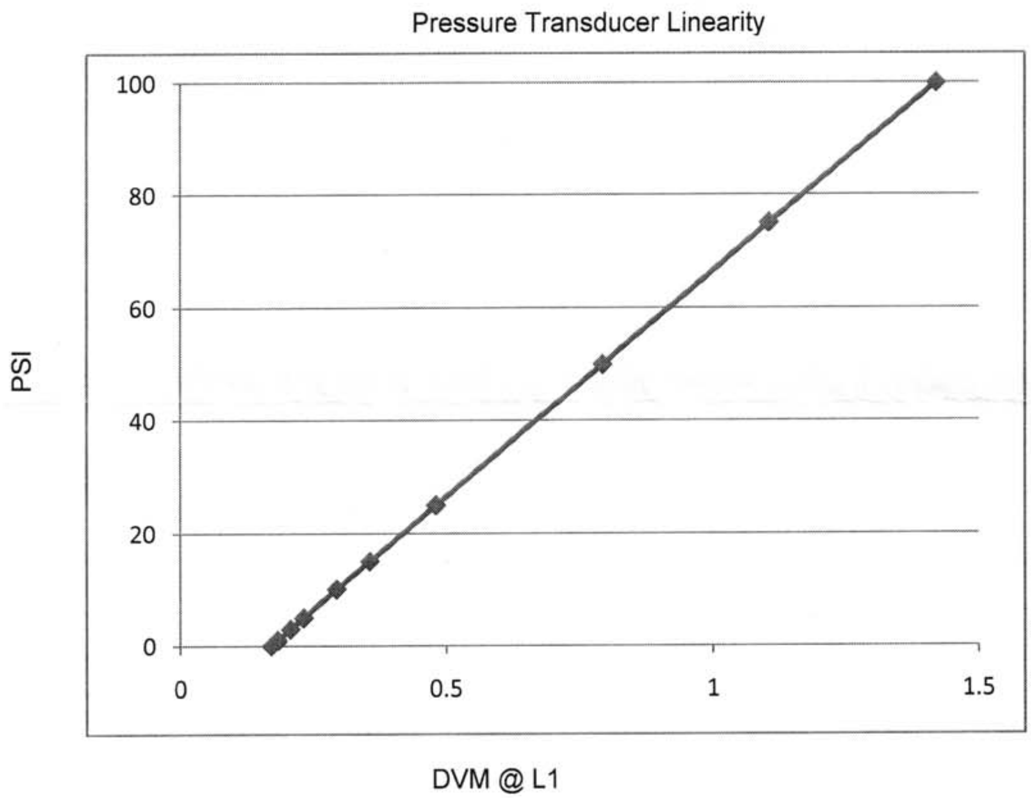


Date	9/28/2009
Serial #	98214
SW Version	1.08
Cable Length	100m

Press Transducer	58649
Zero Voltage	.17
Span Volage	2.67
Mid-Scale Voltage	1.42
R5	3.9K
R9	10K
Gradient	3342
Intercept	227

Max psi:	200psi
Velocity Check:	√
Depth Check:	√
Communications:	√
External Power:	NA

Board Identification	Serial #
Power Supply	
Control PCB	
LCD	
Probe Sensor	
Probe Controller	
Airmar Transducer	1811906



Transducer Linearity	
PSI	DVM@L1
0	0.17
1	0.182
3	0.207
5	0.232
10	0.294
15	0.356
25	0.481
50	0.793
75	1.106
100	1.42

Date:
May 13, 2010

Serial #:
98212-051310

DIGIBAR CALIBRATION REPORT

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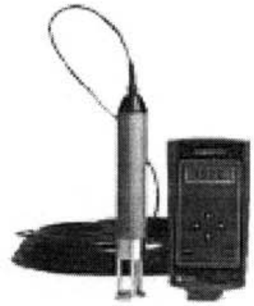
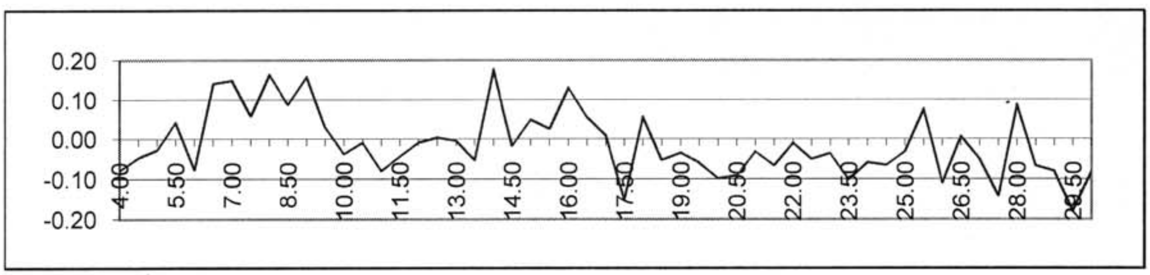


STANDARD DEL GROSSO H^2O

TEMP	VELOCITY	MEASURED FREQUENCY	RES_VEL	OBS-CAL
4.00	1421.62	5539.87	1421.54	-0.08
4.50	1423.90	5548.63	1423.85	-0.05
5.00	1426.15	5557.24	1426.13	-0.03
5.50	1428.38	5565.94	1428.42	0.04
6.00	1430.58	5573.82	1430.50	-0.08
6.50	1432.75	5582.88	1432.89	0.14
7.00	1434.90	5591.05	1435.05	0.15
7.50	1437.02	5598.75	1437.08	0.06
8.00	1439.12	5607.09	1439.28	0.16
8.50	1441.19	5614.65	1441.28	0.09
9.00	1443.23	5622.67	1443.39	0.16
9.50	1445.25	5629.84	1445.29	0.03
10.00	1447.25	5637.15	1447.21	-0.04
10.50	1449.22	5644.73	1449.21	-0.01
11.00	1451.17	5651.84	1451.09	-0.08
11.50	1453.09	5659.27	1453.05	-0.04
12.00	1454.99	5666.60	1454.99	-0.01
12.50	1456.87	5673.76	1456.88	0.00
13.00	1458.72	5680.75	1458.72	0.00
13.50	1460.55	5687.50	1460.50	-0.05
14.00	1462.36	5695.22	1462.54	0.18
14.50	1464.14	5701.24	1464.13	-0.02
15.00	1465.91	5708.17	1465.96	0.05
15.50	1467.65	5714.67	1467.67	0.03
16.00	1469.36	5721.57	1469.49	0.13
16.50	1471.06	5727.71	1471.11	0.06
17.00	1472.73	5733.87	1472.74	0.01
17.50	1474.38	5739.52	1474.23	-0.15
18.00	1476.01	5746.48	1476.07	0.06
18.50	1477.62	5752.16	1477.57	-0.05
19.00	1479.21	5758.24	1479.17	-0.03
19.50	1480.77	5764.08	1480.71	-0.06
20.00	1482.32	5769.79	1482.22	-0.10
20.50	1483.84	5775.59	1483.75	-0.09
21.00	1485.35	5781.52	1485.31	-0.03
21.50	1486.83	5787.01	1486.76	-0.07
22.00	1488.29	5792.77	1488.28	-0.01
22.50	1489.74	5798.09	1489.69	-0.05
23.00	1491.16	5803.54	1491.13	-0.03
23.50	1492.56	5808.61	1492.46	-0.10
24.00	1493.95	5814.02	1493.89	-0.06
24.50	1495.32	5819.17	1495.25	-0.06
25.00	1496.66	5824.40	1496.63	-0.03
25.50	1497.99	5829.84	1498.07	0.08
26.00	1499.30	5834.09	1499.19	-0.11
26.50	1500.59	5839.42	1500.59	0.01
27.00	1501.86	5844.02	1501.81	-0.05
27.50	1503.11	5848.42	1502.97	-0.14
28.00	1504.35	5853.97	1504.43	0.09
28.50	1505.56	5857.99	1505.50	-0.07
29.00	1506.76	5862.48	1506.68	-0.08
29.50	1507.94	5866.58	1507.76	-0.18
30.00	1509.10	5871.36	1509.02	-0.08



Odom Hydrographic Systems, Inc.
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Telephone: (225)-769-3051, Facsimile: (225)-766-5122
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Date:
May 13, 2010

Serial #:
98212-051310

DIGIBAR CALIBRATION REPORT

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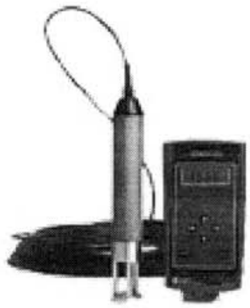
ODOM HYDROGRAPHIC SYSTEMS, Inc.



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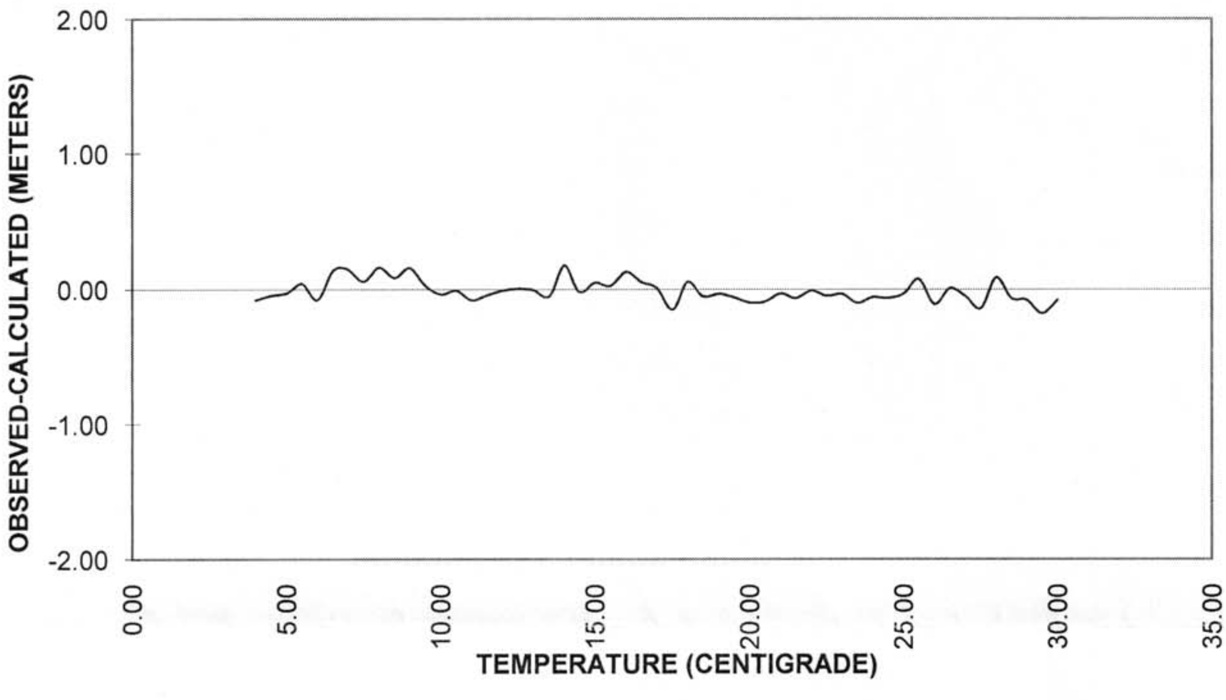
Intercept **405**



The instruments used in this calibration have been calibrated to the published manufacturer specifications using standards traceable to NIST, to consensus standards, to ratio methods, or to acceptable values of natural physical constants that meets the requirements of ANSI/NCSL Z540-1, ISO 9001, ISO 10012 and ISO 17025. Certificate/traceability numbers: 0002-2655.00-23491-001, 0002-2655.00-23491-002. ID#'s:294,295,762,172,56

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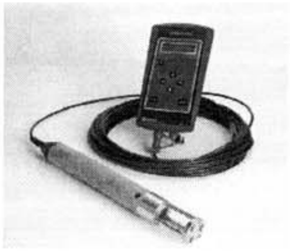
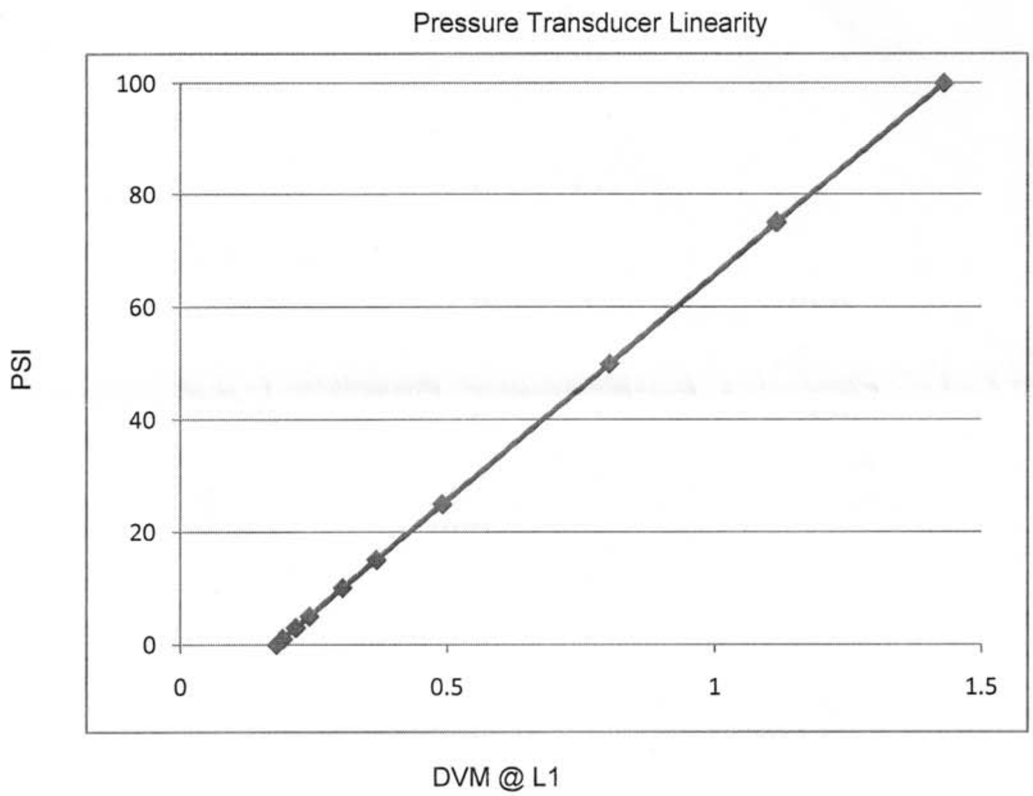


Date	5/20/2010
Serial #	98212
SW Version	1.11
Cable Length	20 meter

Press Transducer	58649
Zero Voltage	.18
Span Volage	2.68
Mid-Scale Voltage	1.43
R5	3.9K
R9	10K
Gradient	3378
Intercept	405

Max psi:	200 psi
Velocity Check:	√
Depth Check:	√
Communications:	√
External Power:	NA

Board Identification	Serial #
Power Supply	
Control PCB	
LCD	
Probe Sensor	
Probe Controller	
Airmar Transducer	1753326



Transducer Linearity	
PSI	DVM@L1
0	0.18
1	0.192
3	0.217
5	0.242
10	0.304
15	0.367
25	0.491
50	0.804
75	1.116
100	1.43

Appendix IV – Electronic Appendix

The Electronic Appendix contains digital files meant to accompany the report body. It is submitted as a .zip file located in the *Appendix4-ElectronicAppendix* folder.