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

# Data Acquisition & Processing Report

*Type of Survey* **Hydrographic**

*Project No.* **2009 Field Season**

*Registry No.*

## LOCALITY

*State* **Alaska**

*General Locality*

**CAPT Douglas D. Baird**

CHIEF OF PARTY

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**APPENDICES**

# INTRODUCTION

This Data Acquisition and Processing Report outlines the acquisition and processing procedures used for Hydrographic projects surveyed in 2009 by the NOAA Ship *Fairweather*.

Survey specific details will be listed in Descriptive Reports as needed. Unless otherwise noted, the acquisition and processing procedures used and deliverables produced are in accordance with the NOAA *Hydrographic Survey Specifications and Deliverables Manual (HSSD) April 2009*, the *Field Procedures Manual (FPM), May 2009*, and all active Hydrographic Surveys Technical Directives (HTD).

Any additions and changes to the following will be included with the individual Descriptive Reports.

# A EQUIPMENT

Detailed descriptions of the equipment and systems, including hardware and software, used for bathymetric data acquisition, horizontal and vertical control operations, shoreline acquisition, and processing are listed below.

## 1.0 Hardware

The hardware listed in this section was used throughout the 2009 field season.

### 1.1 Hardware Systems Inventory

Detailed hardware information, including installation dates and serial numbers, is included in Appendix I of this report. Manufacturer's product specifications are included in Appendix II.

### 1.2 Echo Sounding Equipment

#### 1.2.1 RESON 8111ER Multibeam Echosounder (MBES)

*Fairweather* is equipped with a RESON SeaBat 8111 MBES with the Extended Range (ER) and snippet options. The 8111ER is a 100 kHz multibeam system with swath coverage of 150°. The swath is made up of 101 discrete beams with an along-track and across-track beamwidth of 1.5°. It has a specified depth range of 3 to 1200 meters, though the typical operational depth range of the 8111ER on the *Fairweather* is 20 to 300 meters. No calibration information was provided by the manufacturer for the system.

The 8111ER is hull-mounted within a reinforced projection that extends 27 inches below the keel. It is located 39.5" starboard of the centerline at approximately frame 29 (see Figures 1 & 2).

#### 1.2.2 RESON 8160 Multibeam Echosounder (MBES)

*Fairweather* is equipped with a RESON SeaBat 8160 MBES with the snippet option. The 8160 is a 50 kHz multibeam system with a swath coverage of greater than 4x water depth. Each swath is made up of 126 discrete beams with an along-track and across-track beamwidth of 1.5°. It has a specified depth range of 10 to 3000 meters, though the typical operational depth range of the RESON 8160 on *Fairweather* is 300 to 1000 meters. No calibration information was provided by the manufacturer of the system.

The 8160 is hull-mounted within a reinforced projection that extends 13.6 inches below the keel. It is located 54 inches port of the centerline at approximately frame 29 (see Figures 3 & 4).

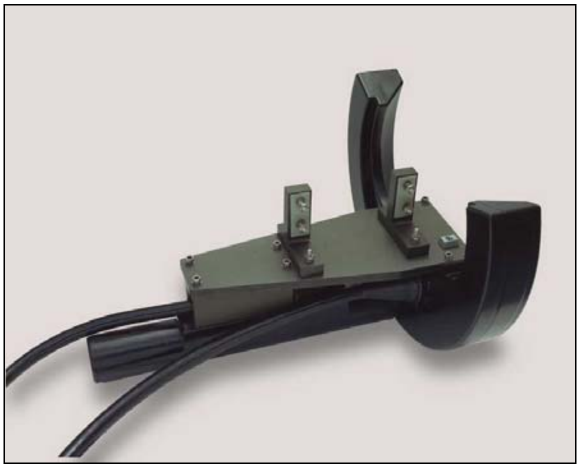

**Figure 1: RESON SeaBat 8111ER MBES**


**Figure 2: RESON SeaBat 8111ER MBES on *Fairweather***

**Figure 3: RESON SeaBat 8160**


**Figure 4: RESON SeaBat 8160 on *Fairweather***

### 1.2.3 RESON 8101ER Multibeam Echosounder (MBES)

Survey Launches 1010 and 1018 are each equipped with a RESON SeaBat 8101 MBES with the Extended Range and snippet option. The 8101ER is a 240 kHz multibeam system with a swath coverage of 150°. The swath is made up of 101 discrete beams with an along-track and across-track beamwidth of 1.5°. It has a specified depth range of up to 500 meters. The typical operational depth range of the RESON 8101 on launches 1010 and 1018 is 3 to 100 meters. Under optimal conditions with a hard bottom, high power and high gain, the depth range of the 8101 ER was observed to be as deep as 350 m producing a swath of ±45º from nadir. No calibration information was provided by the manufacturer for the system.

Each system is attached to a launch using a swing mount which is starboard of the keel and approximately centered fore and aft (see Figures 5 & 6).

Figure 5: Launch 1010 with 8101 extended

Figure 6: Launch 1010 with 8101 retracted

### 1.2.4 RESON 8125 Multibeam Echosounder (MBES)

Survey Launch 1018 can be equipped with a RESON SeaBat 8125 MBES with snippet option. The 8125 is a 455 kHz multibeam system with swath coverage of 120°. The swath is made up of 240 discrete beams with an along-track beamwidth of 1° and an across-track beam spacing of 0.5°. It has a maximum range scale of 120 meters for surveying depths less than 60 meters with a complete swath. The typical operational depth range of the 8125 on launch 1018 is 3 to 50 meters. No calibration information was provided by the manufacturer for the system.

The system is attached to the launch using a bolted-on sled mount which is on the port side of the keel and approximately centered fore and aft (see Figure 7).

Figure 7: Launch 1018 with 8125

### 1.2.5 Odom Echotrac CVM (VBES)

The Odom Echotrac CVM Vertical Beam Echo Sounder (VBES) is portable (Figure 8), and is intended for use during shoreline acquisition or as necessary with vessels 2302 and 1706. The CVM vertical beam system can utilize either a 4 degree or a smaller 9 degree 200 kHz side mounted transducer and has a depth range up to 180 meters (Figure 9). The CVM links directly into one Trimble Pathfinder® Pro XRS unit for positioning and provides a real-time bottom profile. Files are logged in Hypack as BIN files to obtain accurate depth records for the Shoreline NALL Buffer, VBES mainscheme, and/or VBES crosslines.

**Figure 8: Odom Echotrac CVM**

**Figure 9: Four degree (left) & nine degree transducers**

### 1.2.6 Klein Series 5000 Side Scan Sonar

The Klein Series 5000 Sonar System consists of a side scan sonar instrument-mounted towfish (Figure 10), a Transceiver and Processing Unit (TPU), and Windows-based computer for display and control, along with a tow cable and various interconnect cables. The 5000 series operates at a nominal frequency of 500 kHz (455 kHz actual) and has a depth rating to 200 meters. It is software driven on a PC platform employing Klein's SonarPro$^{tm}$ software. Files are logged in SDF format and converted into Caris HIPS and SIPS using the Conversion Wizard.

Preliminary testing of the Klein 5000 occurred in May 2009. Full testing and documentation will be conducted prior to data collection and system utilization.

The towfish can be used in one of two configurations, hull-mounted on launch 1018 or towed from *Fairweather.* In the hull-mounted configuration the towfish is bolted to a sled on the bottom of the launch. The sled is situated to port of the keel and is approximately centered fore and aft. In the towed configuration the towfish is fitted with a K-wing depressor and affixed to armored coaxial cable for deployment from *Fairweather's* A-frame. The amount of tow cable being used is manually entered into SonarPro$^{tm}$ for towfish layback calculation.

**Figure 10: Klein 5000 Side Scan Sonar**

## 1.3 Manual Sounding Equipment

### 1.3.1 Diver's Least Depth Gauge

The diver's least depth gauge (DLDG) is a hand-held device that uses pressure to determine depth of water over a discrete point (e.g. mast of a shipwreck). A raw sounding obtained during a dive is corrected with verified tides and Conductivity/Temperature/Depth (CTD) information acquired in the vicinity of the object.

The divers least depth gauge (see Figure 11) was calibrated by PTC Electronics Incorporated on April 2, 2008, documentation is included in Appendix V. Prior to field season use on April 22, 2009, raw DLDG sounding with simultaneous lead line readings allowed for comparison measurements for check purposes to ensure appropriate readings, the associated Divers Least Depth Gauge Report is include in Appendix V. Depths acquired with the DLDG are processed using the same procedures as other shoreline features that require tide correction as described in section B.2.2 of this report.

During projects that required DLDG use, periodic quality assurance checks are conducted as outlined in section 1.5.6 of the *FPM*. Daily DQA checks and pre and post dive DQAs are performed. Documentation and DQA files are included with the individual descriptive reports with the Sound Speed DQA data for the particular surveys that required the use of the DLDG.

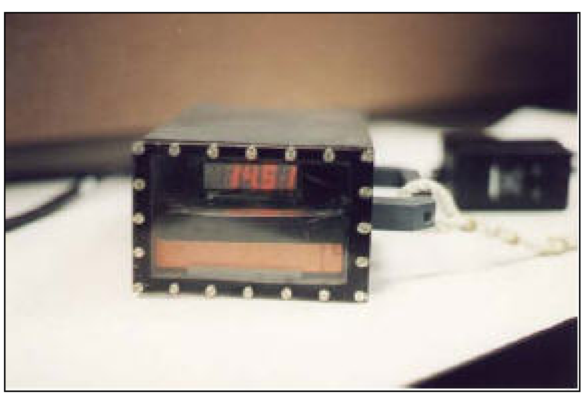

**Figure 11: Diver's least depth gauge**

### 1.3.2 Lead Lines

Vessels 1010, 1018, 1706, and 2302 are each equipped with a lead line. Lead lines are used for depth measurements near shore over submerged shoals and for echosounder depth comparisons.

Leadlines were created, measured and calibrated according to Section 1.5.3 of the *FPM* with the exception that the lines were calibrated to the meter instead of decimeter. Calibration was performed during April 2009. Calibration reports for the leadlines are included in Appendix V.

## 1.4 Positioning, Heading, and Attitude Equipment

### 1.4.1 TSS Positioning and Orientation System for Marine Vehicles (POS/MV)

*Fairweather* and her launches are each equipped with a TSS POS/MV 320 V4, configured with TrueHeave™. The POS/MV calculates position, heading, attitude, and vertical displacement (heave) of a vessel. It consists of a rack mountedPOS Computer System (PCS) (Hardware Version 2.9-7 on *Fairweather* and version 2.6-7 on both Launches), a strap down IMU-200 Inertial Measurement Unit (IMU), and two GPS antennas corresponding to GPS receivers in the PCS. The port side antenna is designated as the primary receiver, and the starboard side antenna is the secondary receiver (see Figures 12 & 13). Differential correctors are supplied to the POS MV by a CSI wireless MBX-3S Automatic Differential GPS receiver. The POS MV firmware version 3.42 and the controller software version 4.0.2.0 are currently the installed versions utilized.

For all multibeam systems aboard *Fairweather* and her launches, timing between the sonar swath, position, heading and attitude information was synchronized by utilizing the proprietary UTC string from POS/MV 320 v.4's. A timing string is sent from the POS/MV to the RESON topside unit via serial connection and to the Hypack acquisition computer via ethernet. Vessel wiring diagrams are included in Appendix III.

POS/MV controller software was used to monitor position accuracy and quality during data acquisition. This ensured that positioning accuracy requirements are met, as outlined in section 3.2.1 of the *HSSD*. The POS/MV controller software provides clear visual indications whenever accuracy thresholds are exceeded.

### 1.4.2 POS/MV GAMS Calibration

GAMS (GPS Azimuth Measurement Sub-system) calibrations were performed on each of the three POS/MV units. The GAMS calibration procedure was conducted in accordance with instructions in chapter 4 of the *POSMV V4 Installation and Operation Guide,* 2005. Results are included in the individual vessel reports and spreadsheets, with calibration details located in Appendix III.

**Figure 12: POS/MV antennas on 1018**

**Figure 13: POS/MV antennas on 1010**

### 1.4.3 CSI Wireless MBX-3S DGPS Receiver

*Fairweather* is equipped with commercial grade CSI Wireless MBX-3S DGPS Receivers that are used in conjunction with TSS POS/MV to provide vessel positioning during data acquisition. The DGPS receivers are configured in manual mode to allow reception of only one U.S. Coast Guard (USCG) differential GPS beacon station. Vessel wiring diagrams are in Appendix III-*vssl*-5.

Differential GPS (DGPS) is the primary method of real-time positioning. The individual descriptive reports list the U.S. Coast Guard beacon sites and frequencies used for differential corrections utilized during hydrographic surveying.

### 1.4.4 Trimble Backpack

*Fairweather* uses two GPS Pathfinder® Pro XRS receivers in conjunction with a field computer to acquire detached positions during shoreline verification in the field. Data can also be collected with a handheld TSCe data collector. *Fairweather*'s field computers are Panasonic Toughbooks. Currently in use are two CF-30's, one CF-29, one CF-19, and one CF-18. The receivers have integrated beacon/satellite differential antennas which allow access to digital real-time sub-meter accuracy solutions. Data quality assurance testing was conducted by *Fairweather* personnel in April 2009. Trimble units were tested over a published benchmark. Trimble positions matched the published benchmark position within 0.6m. Test results are located in Appendix V.

**Figure 14: Trimble Backpack Unit**

#### 1.4.5 Impulse LR Hand-held Laser

The Impulse Laser Rangefinder and TruPulse 200 Laser Rangefinder are used in conjunction with the Trimble Backpack GPS unit to acquire distances and heights during shoreline verification. These data are entered directly into the shoreline acquisition software and annotated on the detached position forms. The Impulse LR and TruPulse 200 Laser Rangefinder do not function properly in low light or in choppy seas when a feature is not distinguishable from surroundings.


**Figure 15: IMPULSE LR laser**


**Figure 16: TruPulse 200 Laser Rangefinder**

Data quality assurance testing was conducted in April 2009 by *Fairweather* personnel. Vertical and horizontal readings were taken with the laser rangefinders and compared to measurements taken with a steel tape. The laser rangefinder was set up on a tripod and a staff of known height was measured at distances of 10, 20, 50, and 100 meters. Three horizontal and three vertical readings were taken at each interval. The results of the laser rangefinder accuracy testing are located in Appendix V.

### 1.5 Sound Velocity Equipment

#### 1.5.1 SBE 19*plus* SEACAT Profiler

*Fairweather* is equipped with three SBE 19*plus* and two SBE 19*plusV2* SEACAT sound velocity profilers used to acquire conductivity, temperature, and depth (CTD) data in the water column to determine the speed of sound through water. Two of the SBE 19*plus* profilers have pressure sensors rated to 1000 meters. The third SBE 19*plus* profiler has a pressure sensor rated to 3,500 meters. The two SBE 19*plusV2* profilers have pressure sensors and units rated to 600 meters.

The SBE 19*plus* and SBE 19*plusV2* SEACAT sound velocity profilers were calibrated by the manufacturer and current calibration files were returned with the units. Calibration files are located in Appendix V.

Periodic quality assurance checks include comparison casts between CTD instruments. Data quality assurance (DQA) checks include comparison casts between two instruments as per section 1.5.2.2.2 of the *FPM* for each survey. Records of the DQA tests performed are kept aboard the ship and are included with the digital Separates II – Sound Speed Data for each survey.

To ensure that the CTDs continue to function properly a stringent maintenance schedule is followed using guidelines from the manufacturer's recommendations. This includes a thorough rinsing of the instrument with distilled water after each cast and periodically each CTD is flushed with a Triton X-100 solution.

### 1.5.2 Moving Vessel Profiler 200

A Brooke Ocean Technology, Ltd. (BOT) Moving Vessel Profiler 200 (MVP200) is mounted in the aft starboard corner of the fantail (see Figure 15). The MVP200 system is a self contained sound velocity profiling system capable of sampling water column profiles to 200m depth from a vessel moving up to 12 knots. The system is configured with a Single Sensor Free Fall Fish (SSFFF) outfitted with an Applied Microsystems Ltd. Sound Velocity and Pressure Smart Sensor. Deeper profiles can be obtained by reducing the vessel speed. When the vessel is holding station, the system is capable of recording casts over 400m in depth.

The MVP system consists of a winch, cable, fish (the towed unit with the sound velocity sensor), support assembly, and controlling hardware and software. During ship acquisition, the fish is deployed using the on-deck controller and towed with enough cable out to keep the fish 3-5 m below the water surface. A “messenger” (a short cable-thickening sleeve) is set to allow the system to keep the appropriate amount of cable out and is reset as needed when the ship acquisition speed is altered.

During SVP acquisition, the controlling computer application, BOT MVP version 2.4 is used to control the MVP system and to acquire SVP data. MVP allows for three acquisition modes: 1) automatic continuous multiple cast freefall casting while at speed, 2) single cast freefall casting while at speed, and 3) single cast winch speed casting while stationary. The user limits the depth to which the fish will fall by setting 1) the depth-off-bottom and 2) the maximum depth. Either single, individually initiated casts can be performed at the discretion of the Hydrographer or the auto deploy function can be enabled and set with varying intervals (every 10 minutes, for example) for deployment.

On 19 August 2009 the MVP Controller software was updated to version 2.401.

*Fairweather* has three Applied Microsystems Ltd. Sound Velocity and Pressure Smart Sensors. All of the sensors were calibrated by the manufacturer and current calibration files were returned with the units. Calibration files are located in Appendix V.

Periodic quality assurance checks include comparison casts between the MVP and one of the SBE 19*plus* or SBE 19*plusV2* SEACATs. Data quality assurance (DQA) checks include comparison casts among the instruments as per section 1.5.2.2.2 of the *FPM* for each survey. Records of the DQA tests performed are kept aboard the ship and are included with the digital Separates II – Sound Speed Data for each survey.

**Figure 17: *Fairweather*'s MVP200 sound velocity system**

### 1.5.3 RESON Sound Velocity Probe (SVP 70)

*Fairweather* is equipped with one RESON SVP 70. The SVP 70 measures the speed of sound near the ship's hull mounted transducers to provide real time surface sound speed values. The unit is mounted adjacent to the RESON 8160 as shown in Figure 18.

**Figure 18: *Fairweather*'s SVP 70 sound speed unit (left) and the 8160**

The sound speed is output to the RESON 8160's processing unit. The 8160 - a flat faced transducer - requires sound velocity information for beam forming. The 8160 cannot be used to acquire data without real time sound velocity information.

The unit was installed during the winter drydock period in Seattle at Lake Union Drydock Company. The current calibration report is included in Appendix V.

#### 1.5.4 Odom Digibar Pro

*Fairweather* is equipped with one Odom Digibar Pro. The Digibar measures the speed of sound near the RESON 8125 on the sled attached to Launch 1018 to provide real-time surface sound speed values. The unit is mounted vertically just aft of the RESON 8125 on the sled as shown in Figure 19.

**Figure 19: *Fairweather*'s Odom Digibar Pro mounted on Launch 1018.**

The sound speed is output to the RESON 8125 processing unit. The 8125 requires surface sound speed information for beam forming due to the flat faced transducer.

The unit was calibrated on April 16, 2009 and the current calibration report is included in Appendix V.

### 1.6 Vertical Control Equipment

#### 1.6.1 Water Level Gauges

Five Sutron 8210 tide gauges were provided to *Fairweather* by the Center for Operational Oceanographic Products and Services (CO-OPS) at the start of the 2009 field season. These gauges are equipped with Paros Scientific Sensors for pressure measurements. The tide gauges are checked annually by CO-OPS Field Operations Division personnel to ensure that their accuracy standards are being met.

CO-OPS does not provide calibration or quality assurance documentation to the *Fairweather*. Installation and removal of the water level gauges is the responsibility of *Fairweather* personnel. To ensure full functionality of the vertical control equipment prior to deployment for field operations, new gauges undergo testing by *Fairweather* personnel. Five gauges underwent testing in April 2009 and results are included in Appendix V.

#### 1.6.2 Leveling Equipment

*Fairweather* is equipped with four universal automatic levels (two Zeiss NI2 333 and two Leica NA2 100) and graduated metric staffs to assist in leveling tide gauges.

A Kukkamaki procedure is performed prior to leveling in order to verify the collimation error. Procedures used followed those described in the *User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations,* October 1987. Kukkamaki results for 2009 are located in the Tides section of Appendix V.

### 1.7 Horizontal Control Equipment

*Fairweather* is equipped with two Trimble NetR5 receivers and one Ashtech Z-Xtreme dual-frequency GPS base stations used for the positioning of horizontal control marks, tidal benchmarks and aids to navigation. These base stations can be configured for use as a portable DGPS or RTK reference station, or as a static receiver to record observations for use with PPK.

When deployed for PPK the base stations log data locally, either to internal memory or external memory, and the data is downloaded periodically. The data is downloaded either by visiting the site or remotely via Freewave 900 MHz spread spectrum Ethernet radios. Station power needs are supported by batteries and solar panels.

The Ashtech antenna can be equipped with an optional ground plane and all receiver antennas are used with a Seco fixed height GPS tripod.

Data quality assurance (DQA) testing of the Ashtech receiver was performed April 30th, 2009 by *Fairweather* personnel. The receiver was installed over control mark “VIXEN HBR 2009” (NGS PID: BBBK46) in Ernest Sound, AK using a Seco fixed height tripod. The receiver acquired data for 8 hours. The recorded observations were submitted to OPUS. The OPUS position of the receiver was half a centimeter from the published position. The OPUS solution is included in Appendix V.

Data quality assurance testing of all three GPS units was performed May 1st, 2009 by *Fairweather* personnel. The receivers were set up over Benchmark No. 37 (NGS PID: AI4914) in Ketchikan, AK using a Seco fixed height tripod. Each receiver acquired data for 2 hours. The recorded observations were submitted to OPUS. The OPUS position of each of the two Trimble receivers was within three centimeters of the published position for the mark. The Ashtech receiver had a position over a decimeter from the published position; this is likely due to fewer satellites observed during the recording period as compared with the two Trimble receivers and the significantly shorter observation period as compared to the previous DQA testing. The OPUS solutions are included in Appendix V.

Horizontal control equipment serial numbers and installation dates are located in the hardware section of Appendix I, System Tracking.

## 2.0 Software

### 2.1 Software Systems Inventory

An extensive software inventory with documentation, of the software systems used by NOAA ship *Fairweather*, is maintained as a *Survey Software* spreadsheet and is included with the Supplemental Survey Records for the individual Descriptive Reports. This spreadsheet includes specifics such as software applications, versions, and hot fixes, in addition to dates loaded on specific computers within the survey department.

### 2.2 Data Acquisition Software

#### 2.2.1 HYPACK® HYSWEEP

*Fairweather* uses the Hypack® software package to acquire multibeam echo sounder and backscatter data on all of its multibeam platforms. Hypack is used to log VBES data, which is acquired in two formats: .BIN and .RAW (used for processing).

Hysweep is a module of the Hypack software suite that allows for real-time data planning and acquisition. Hysweep combines geo-referenced bathymetric digital terrain models and reference files such as raster charts and vector shoreline files to display real-time bathymetric bottom coverage. Data is acquired in three formats: .RAW, .HSX (containing bathymetry), and .81X (containing snippets data). All three file types are logged but only the .HSX and .81X files are utilized, stored, and submitted.

#### 2.2.2 CARIS Notebook

CARIS Notebook™ can be used to directly collect detached shoreline positions and verify shoreline. The software is run on a field computer and receives the Trimble GPS data output from the GPS Pathfinder® Pro XRS receivers.

GPS settings in CARIS Notebook are as follows:

- Maximum Horizontal Dilution of Precision (HDOP) = 3
- Maximum Positional Dilution of Precision (PDOP) = 6
- Minimum Signal-to-Noise Ratio (SNR) = 12
- Minimum Elevation Mask = 8°
- Minimum # of Satellites = 4

Real-Time settings in CARIS Notebook are as follows:

- Source Type: Integrated Beacon – Manual Mode
- Position Mode: Corrected Only
- Age Limit: 20 seconds

Differential GPS correction is applied in real-time, using the unit's integrated beacon as the primary corrector. The unit can be setup to run without using DGPS with position mode set to "Autonomous Only" or with values different than those listed above. These special circumstances of acquisition with altered parameters are recorded and documented in the individual Descriptive Report as appropriate.

### 2.3 Data Processing Software

#### 2.3.1 NOAA Hydrographic Systems and Technology Programs (HSTP) Software

Sound speed data is processed with Velocwin, in-house software produced and maintained by NOAA's Hydrographic Systems and Technology Programs (HSTP) division. Velocwin creates and archives water column profiles, performs quality assurance, and processes pressure based depth data. Velocwin creates a standard file format across NOAA's hydrographic fleet for sound speed profiles applied to shallow water multibeam and single beam data.

Pydro, another NOAA program produced and maintained by HSTP, is used to produce Smooth Tides Requests along with DTON and AWOIS Reports. In addition, PYDRO is used for Tidal Constituent and Residual Interpolation (TCARI) tide application in conjunction with CARIS HIPS.

#### 2.3.2 CARIS

CARIS HIPS™ (Hydrographic Information Processing System) is used to process all multibeam data including data conversion, filtering, sound velocity, tide correcting, merging and cleaning. Vertical beam data is also processed using CARIS HIPS, where .RAW data is converted, filtered, tide corrected, merged, and displayed in Fieldsheets. CARIS HIPS also calculates the Total Propagated Error (TPE) used to produce Bathymetry Associated with Statistical Error (BASE) surfaces which assist the Hydrographer in data cleaning, analysis, and to produce BASE surface deliverables.

CARIS SIPS™ (Sonar Information Processing System) is used to process all side scan imagery data including data conversion, slant-range correction, beam pattern correction, and despeckling, if appropriate. CARIS SIPS is also used to inspect the imagery for contacts and to produce side-scan imagery mosaics.

CARIS Notebook™ is used to compile and display source shoreline, shoreline updates and S-57 features that are collected directly in the field, digitized, or imported from Pydro. The .hob files created in Notebook are the current shoreline deliverables.
CARIS BaseEditor™ will be used for data quality assurance checks on the BASE surface deliverables. At the time of writing the software was not available to *Fairweather* personnel.

#### 2.3.3 Fledermaus™

Fledermaus ™, an Interactive Visualization Systems 3D™ (IVS 3D) program, is used for data visualizations and creation of data quality control products, public relations material and reference surface comparisons.

As an additional data quality assurance check, Fledermaus ™ is used to examine the CARIS surfaces prior to submission. The combined BASE surface is exported from CARIS and then converted to a Fledermaus .sd file via the Avggrid and Dmagic modules.

#### 2.3.4 Geocoder

The Geocoder program is provided by University of New Hampshire CCOM and another implementation is provided by Hypack. Our primary use of these programs is to produce imagery of gathered snippets and bathymetry data. Hypack's .81X and .HSX files are used to assemble snippets data and along with CARIS HIPS processed depths as xyz grids for digital terrain model production.

## 3.0 Vessels

### 3.1 Vessel Inventory

The NOAA Ship *Fairweather* (S220) and her survey launches 1010 and 1018 are equipped to acquire multibeam echosounder (MBES) and sound velocity profile (SVP) data. Launch 1018 is also the primary vessel for dive operations. The AMBAR (2302) and Monark (1706) are used during shoreline verification, bottom sampling, and horizontal and vertical control operations. All vessels may be used in support of tide gauge operations. See Appendix I for the complete vessel inventory.

### 3.2 Noise Analysis

The *Fairweather* sonar systems, RESON 8160 and RESON 8111ER, underwent noise analysis testing on October 10 and 11, 2004 respectively. The results are used during acquisition to enhance data quality and are included in Appendix III-S220-7. Standard operating procedures utilizing the RESON 8160 and RESON 8111ER aboard the *Fairweather* have survey speeds set to minimize noise based on these noise analyses.

## 4.0 Data Acquisition

### 4.1 Horizontal Control

A complete description of horizontal control will be included in the project's *Horizontal and Vertical Control Report (HVCR)*, submitted for each project under separate cover when necessary as outlined in the *HSSD* and section 5.2.3.2.3 of the *FPM*.

The horizontal datum for all projects is the North American Datum of 1983 (NAD83) unless otherwise noted in the individual descriptive reports.

Multibeam and shoreline data are differentially corrected in real time using correctors provided by Coast Guard beacons. The specific beacons used for a given survey will be included in the Horizontal Control section of the survey's descriptive report. If loss of the differential beacon resulted in any data being recorded with C/A GPS positions it will be noted in the Descriptive Report for the specific survey.

If DGPS is commonly lost during the survey, the original navigation of the survey vessel can be replaced with a post processed kinematic (PPK) single best estimate of trajectory (SBET). The PPK solution is dependent on a local base station supported by the ship and processed in Applanix POSPac software using Single Base mode. The resulting navigation from PPK is an improvement over C/A and DGPS navigation. The use of PPK for a given survey will be included in the Horizontal Control section of the survey's descriptive report.

## 4.2 Multibeam Echosounder Acquisition and Monitoring Procedures

Methods of acquisition took into consideration system performance limitations, the bottom topography, water depth, and the ability of the vessel to safely navigate the area.

All multibeam data are acquired in Hypack's HYSWEEP® SURVEY extension (HSX) format and monitored in real-time using the 2-D and 3-D data display windows and the on-screen displays for the RESON SeaBat 8101ER, 8111ER, and 8160. Adjustable parameters that are used to control the RESON either directly or from the Hypack software include range scale, power, gain, and pulse width. These parameters are adjusted as necessary to ensure best data quality. Vessel speed was predominantly between 6-6.5 knots and reduced as needed to eliminate noise from the data and to ensure the required along-track coverage for object detection in accordance with the *HSSD*. Survey personnel follow standard operating procedures documented aboard the *Fairweather* while setting and utilizing the RESON systems and Hypack for acquisition of data.

Mainscheme multibeam sounding acquisition lines using the RESON SeaBat 8101ER, 8111ER, and 8160 are generally run parallel to the contours and spaced no greater than three to four times the water depth and in most cases at a tighter line spacing to ensure the appropriate data density for a given resolutions at a given depth range. For discrete item developments, line separation was reduced to 2 times water depth to ensure least-depth determination by multibeam near-nadir beams. Hypack Hysweep was used in lieu of planned line files. Hysweep displays the acquired multibeam swath during acquisition and was monitored to ensure overlap and full bottom coverage. If coverage was not adequate, additional lines are run while still in the area.

## 4.3 Shoreline Verification

*Fairweather* personnel conduct field shoreline verification at times near predicted low water, in accordance with the Project Instructions and section 3.5 of the *FPM*.

The composite source file (CSF) provided with the project instructions is the primary source for shoreline features to be verified. Additionally, AWOIS items and other features to be investigated are provided for a given survey and are included in the files utilized during shoreline verification. Specific details regarding the composite source and investigation features are included in the individual descriptive reports.

A Mean High Water (MHW) Buffer line, offset 0.8 mm at the scale of the largest chart in the area, is provided with the project instructions or created from the composite source MHW line. This MHW Buffer line is used in the shoreline acquisition software and on the boat sheet as a reference, and to determine the Navigable Area Limit Line (NALL). The NALL is determined in the field as the farthest off-shore of either the MHW buffer specified above, the 4-meter depth contour, or the inshore limit of safe navigation. All shoreline features from the composite source seaward of the Navigable Area Limit Line (NALL) are verified (including an update to depth and/or position as necessary) or disproved during shoreline operations. Features off-shore of the NALL and not addressed or features of an ambiguous nature are flagged with a marker note for further clarification.

Detached positions (DPs) acquired during shoreline verification indicate new features, revisions to source features, or source features not found in the field. They are recorded in the shoreline acquisition software and on DP forms.

## 5.0 Bottom Sample Acquisition

Bottom samples are acquired according to section 7.1 of the *HSSD*. Samples are acquired using the current shoreline acquisition system and processed similarly to other shoreline features as outlined in the Descriptive Report for the specific survey. Bottom sample results are included in the Notebook .hob deliverable layer, HXXXXX_ Final_Feature_File.

# B QUALITY CONTROL

The *Fairweather* has numerous standard operating procedures (SOPs) that are followed by personnel throughout the survey to ensure consistent high quality data and products.

## 1.0 Uncertainty Modeling

Error values for the multibeam and positioning systems on *Fairweather* and her survey launches were compiled from manufacturer specification sheets for each sensor (Heave, Pitch, Roll, Position, and Heading) and from values set forth in section 4.2.3.6 and Appendix 4 – CARIS HVF Uncertainty Values of the *FPM*.

Estimates for the Motion Reference Unit ( MRU) alignment errors are the standard deviations of the values determined by multiple personnel processing the patch test data (see section C 4.0). Initial MRU values were significantly large and impacted the Total Propagated Uncertainty/Error (TPU/TPE) values in CARIS inappropriately. Final MRU values used did not include the outlier patch test values to allow for more reasonable MRU uncertainty and CARIS TPE values.

The *Fairweather* TPU Values spreadsheet located in Appendix IV, lists the final uncertainty values for *Fairweather* and her launches, including the default tides and sound velocity values. Uncertainty values relating to vessels and survey systems are entered into the HIPS Vessel File (HVF) for each platform. The tidal errors for the gauge and for zoning are determined on a project by project basis. Sound speed uncertainties for a given survey are based upon either the defaults listed in the TPU value spreadsheet or based on utilization of NOAA sound speed uncertainty estimation software. Survey specific uncertainty values for tides and sound speed that are entered during the Compute TPE step in CARIS HIPS and how they were determined will be included in the individual Descriptive Report.

## 2.0 Data Processing

### 2.1 Multibeam Echosounder Data Processing

Bathymetry processing followed section 4.2 of the *FPM* unless otherwise noted.

Raw HSX multibeam data are converted to Caris HDCS format using established and internally documented settings. True heave, sound velocity and water level data are then applied to all lines and the lines merged. Once lines are merged Total Propagated Error (TPE) was computed.

The data acquired by the systems aboard *Fairweather* and her launches do not provide adequate densities to allow for representation at the resolutions and depth ranges specified in Hydrorgaphic Technical Directive (HTD) 2009-2. A waiver from this specification was obtained from Jeffrey Ferguson, Chief, Hydrographic Surveys Division to

*Fairweather* on May 19, 2009 and is included in Appendix VI. The general resolution, depth ranges, and CUBE parameter settings outlined in the waiver and used for processing are listed in Table 1. These values may also require adjustment by sheet managers for individual surveys to address visualization gaps between finalized surfaces in areas of greater slope. The lesser depth range value of a coarser grid will be adjusted shoaler if adjustment is necessary (ie 35-80m for an 8m resolution adjusted to 30-80m). Adjustments to the depth ranges will be communicated to and agreed upon with the appropriate processing branch prior to data submission. A detailed listing of the actual depth ranges used during the processing of each survey, along with the corresponding fieldsheet(s), will be provided in the Descriptive Report of each survey.

BASE surfaces are created using the Combined Uncertainty and Bathymetric Estimator (CUBE) algorithm and parameters contained in the NOAA Cubeparams.xml file as provided with (HTD) 2009-2. The Cubeparams.xml will be included with the HIPS Vessel Files with the individual survey data. The NOAA parameter configurations for resolutions 1-16 meters are used as listed in Table 1.

| **Surface Resolutions** | | **CUBE Parameters** |
|---|---|---|
| **Depth Range** | **Grid Resolution** | **Configuration Name** |
| 0 to 23 meters | 1 meter | NOAA_1m |
| 18 to 40 meters | 2 meter | NOAA_2m |
| 35 to 80 meters | 4 meter | NOAA_4m |
| 75 to 160 meters | 8 meter | NOAA_8m |
| 155+ meters | 16 meter | NOAA_16m |

**Table 1: Resolutions and Depth Ranges**

Multibeam data are reviewed and edited in HIPS swath editor and in subset mode as necessary. The finalized BASE surfaces and CUBE hypotheses are used for directed data editing at the appropriate depth range in subset editor. The surfaces and subset editor viewing are also used to demonstrate coverage and to check for errors resulting from tide, sound velocity, attitude and timing.

Vessel heading, attitude, and navigation data are reviewed in HIPS navigation editor and attitude editor if deemed necessary upon review of surfaces. Where necessary, fliers or gaps in heading, attitude, or navigation data are manually rejected or interpolated for small periods of time. Any editing of this nature will outlined in the Descriptive Report for the particular survey.

The Surface Filtering functionality in HIPS may be used in the processing of survey data to reject errant soundings. If utilized, the individual Descriptive Report shall list the confidence level settings for standard deviation used and discuss the particular way the surface filter was applied.

In areas of navigational significance, depths less than 30 meters, where the BASE surface did not depict the desired depth for the given area, a designated sounding was selected. Designated soundings are selected as outlined in section 5.1.1.3 of the *HSSD*.

Layers determining "IHOness" are added to the CUBE surfaces allowing the Hydrographer to see where and if the surfaces meet IHO Order. The process is easily performed in HIPS and allows the Hydrographer to identify problem areas and determine the severity of the situation. This is a spatial quality control check rather than just a statistical list of nodes and allows for specific areas with problems to be isolated and addressed.

IHO surfaces are utilized during data collection as an additional child layer of the finalized surfaces to indicate problem areas that need attention. Additionally, IHO child layer(s) are included with the submitted surface(s).

The combined surface's IHO layer exported from CARIS is examined to allow the Hydrographer to see the full data distribution rather than just the minimum and maximum values in the surface. This data distribution is used to assess the quality of the survey. Ninety-five percent of the data is highlighted in the histogram which allows the Hydrographer to show whether the data for a given survey meets the appropriate IHO order as specified in section 5.1.1.1 of the *HSSD.* An image of the histogram and/or its derived statistics will be included with the Descriptive Report for the specific survey.

Additionally, a combined surface is reviewed in Fledermaus or CARIS Base Editor to ensure that the data are sufficiently cleaned for submission.

## 2.2 Shoreline Data Processing

During shoreline verification, field detached positions (DP) are acquired with CARIS Notebook. Tide application for features requiring tide correction is applied in CARIS Notebook when using discrete zoning and via Pydro when TCARI is to be used.

An original composite source file (H#####_Original_Composite_Source.hob), clipped to the sheet limits for a particular survey, is saved prior to being edited and is submitted with the individual survey. New features and any updates to the composite source shoreline, such as ledges or reefs, are acquired or digitized with S57 attribution and reside in the H#####_Final_Feature_File.hob. Updates to a source shoreline feature primarily include a change in depth/height, position, or S57 classification. Notebook's editing tools are used to modify source feature extents or positions.

The SORIND and SORDAT S57 attribute fields for new features or modified source features are updated to reflect the information for the associated survey number and date. All new or modified features are S57 attributed as applicable. All unmodified source features retain their original SORIND and SORDAT values.

Short descriptive comments taken from the boat sheets or DP forms along with investigation or survey methods are listed under the Remarks field. For significant features that deserve additional discussion or disprovals, the Hydrographer included recommendations to the cartographer in the Recommendations field, along with the Hydrographer notes and investigation methods provided in the Remarks field.

Features that are disproved or that do not adequately portray the shoreline are moved to the H#####_Disprovals.hob layer from the H#####_Final_Feature_File.hob layer. Features in the disprovals layer retain their original SORIND and SORDAT values.

Photos labeled and associated with a DP number are included with the survey data and stored in the CARIS/Notebook photo folder with the deliverables.

AWOIS investigation items are received in the Project Reference File and investigated as necessary. Shoreline features correlated to the AWOIS item are included in either the H#####_Final_Feature_File.hob or H#####_Disprovals hob layers and labeled with the appropriate AWOIS number and include a remark and recommendation from the Hydrographer.

The CARIS Notebook files along with CARIS HIPS BASE surface(s) are viewed to compare soundings and features simultaneously. Standard operating procedures, for processing shoreline features in CARIS Notebook, are followed by survey personnel aboard NOAA Ship Fairweather as outlined in section 4.4 of the *FPM*. A detailed discussion of the procedures used and any deviations in shoreline processing from standard procedures or the *FPM* are documented in the individual Descriptive Reports.

Final Shoreline Deliverables may include a report in spreadsheet format of features named the H#####_Tabulated_Features_Listing included in Appendix II of the individual Descriptive Reports and up to three Notebook HOB files:

HXXXXX_Original_Composite_Source,
HXXXXX_Final_Feature_File,
HXXXXX_Disprovals.

## 3.0 Data Review

Specific procedures are used on *Fairweather* to ensure quality control of data throughout acquisition, processing, and submission. These procedures are documented and followed by the Hydrographer. A detailed Quality Control Check is performed by the survey manager. A detailed Review is conducted by qualified survey personnel (FOO, CST, SST, or PS) other than the survey manager as an outside review of the survey data and deliverables. Submission checklists are used to ensure that all data and deliverables are complete and included upon submission. Documentation of these tasks is completed for every survey but only the final processing log, HXXXXX_Data_Log, is submitted with the individual survey data.

# C Corrections to Echo Soundings

## 1.0 Vessel HVFs

CARIS HIPS Vessel Files (HVF) are created by *Fairweather* personnel and used to define a vessel's offsets and equipment uncertainty. The HVF is used for converting and processing data collected by each survey platform. The HVFs used for a given project are included with the digital data submitted with those surveys.

## 2.0 Vessel Offsets

Sensor offsets are measured with respect to each vessel's reference point. The reference point for *Fairweather* and survey launches 1010 and 1018 is the IMU. Specific offset values are input into the POS/MV and the CARIS HIPS Vessel File (HVF).

A ship survey was completed for the *Fairweather* by Westlake Consultants, Inc on September 23, 2003. A POS/MV components spatial relationship survey of the *Fairweather* was conducted by National Geodetic Survey (NGS) in February 2007. An additional POS/MV components spatial relationship survey was conducted by NGS on February 15, 2009 while the ship was at Lake Union Drydock in Seattle, WA. The results of these surveys were used to determine the offsets for the ship. The reports from each survey are located in Appendix III. The S220 *Offsets & Measurements* spreadsheet is also included in Appendix III, listing the final values for *Fairweather*'s offsets with explanations of how they were calculated.

Permanent control points were established on launches 1010 and 1018 in July of 2004. Sensor offsets were measured by *Fairweather* personnel according to documented procedures. Total stations were utilized for positioning the permanent control points (see Figure 20). The total station specifications are located in Appendix II, the calibration certificates for the *Nikon DTM 310* and the *Sokkia SET 5F* are included in Appendix V. A steel tape was used to verify and update specific vessel offsets in March 2009 and the results are located in the respective vessel's *Minimum Physical Measurements_2009* spreadsheet in Appendix III-101*X*-1. The final offsets for survey launches 1010 and 1018 are derived from a combination of values from the original full survey and the values updated in the verification surveys. The 2009 transducer measurement values indicated agreement with the 2008 values. Since the angle bias was not documented during 2009 measurement the 2008 offset values were used. Additionally, the values in the POSMV for the distances between the IMU to the Port Antenna and Heave point remained those used in 2008 and were not updated with the 2009 measurements for both launch 1010 and 1018. Though this creates a slight difference to the lever arm in the POSMV, no appreciable affects have been observed. The measurements, derivations, descriptions of methodology used, diagrams, and coordinate system references are included in the respective vessel's *Offsets & Measurements* spreadsheet in Appendix III-101*X*-1.

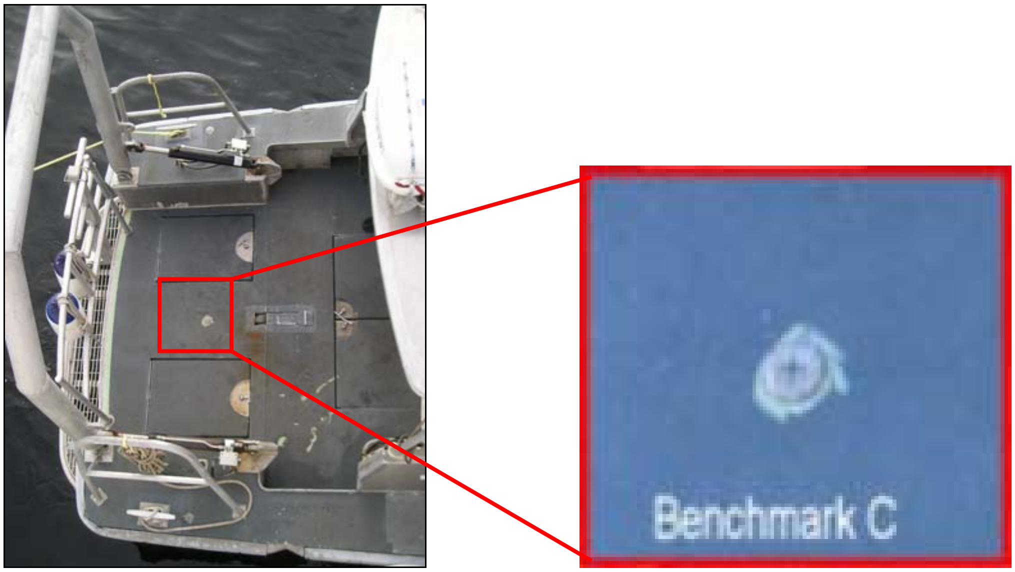


**Figure 20: Permanent Control Point "Benchmark C" on launch 1018**

## 3.0 Static and Dynamic Draft

The static drafts (*Waterline Height* in the HVF) for launch 1010 and 1018 were calculated based on steel tape measurements of the distance from benchmarks on the port and starboard quarter of the vessel to the waterline.

The bow and stern draft marks were used to perform a linear interpolation of the static draft at the *Fairweather*'s IMU. The static draft was measured under different loading conditions: with different amounts of fuel. The *Ship Draft 2009* spreadsheet records the static draft values and is included with the ship offset documentation in Appendix III-S220-1.

The values and calculations for static draft are listed in each vessel's *Minimum Physical Measurements and Offsets & Measurements* spreadsheets located in Appendix III-*vssl*-1.

Dynamic Draft measurements were conducted for *Fairweather* in February 2009, and for survey launches 1010 and 1018 in April of 2009. The measurements were made using the change in ellipsoid height while traveling at different speeds in Lake Washington. The ellipsoid heights were determined using Post Processed Kinematics (PPK) by recording POSPac on each vessel and then processing the data with local reference stations in Applanix POSPac software. The resulting Single Best Estimate of Trajectory (SBET) was exported from POSPac and the speed versus ellipsoid height was fit to a polynomial curve using a least squares fit method in a Python Script written by ship's personnel. The polynomial curve was used to derive the table used in the CARIS HVF's for the Reson 8101 multibeams that are swing-arm mounted to both launches 1010 and 1018, and the standard deviation of the residuals was used to determine the associated uncertainty in the measurement. A written report about the initial measurements carried out in February is provided for in *Fairweather's* 2009 HSRR along with spreadsheets containing applicable graphs and tables with comparison to previous years for launches 1010 and 1018. Documentation for the dynamic draft testing is located in the respective vessel's folder in Appendix III. Launch 1018 also completed a traditional bottom referenced dynamic draft measurement, and the results from this test are plotted in the ellipsoidally referenced graph.

The dynamic draft measurement for Launch 1018 taken in February 2009 was conducted without the mounting sled and Reson 8125 multibeam sonar head mounted to the hull of the vessel, which was mounted for the first time in May 2009. A new dynamic draft measurement specifically for the Reson 8125 and sled mount configuration was taken on August 7, 2009, in Dutch Harbor, AK, using the "Echosounder method" described on page 31 of the FPM. The applicable acquisition, processing, and analysis spreadsheet is contained in Appendix III. The dynamic draft values entered in the CARIS HVF for Launch 1018 are the derived values from this measurement. All data acquired during the 2009 field season to date with the Reson 8125 mounted to Launch 1018 has been corrected using these values.

## 4.0 Patch Tests

Patch tests were conducted in April 2009 on *Fairweather* for the RESON 8111 and 8160 multibeam acquisition systems. Survey launches 1010 and 1018 with RESON 8101 transducers were also tested in April 2009. Survey launch 1018 can be outfitted with an 8125 transducer attached via sled mount. Since this system is detachable a patch test is conducted after each reattachment. The 8125 has had a patch test conducted in May 2009 during the Ernest Sound (O119) project and in June 2009 during the Shumagin (P183) project. Additional patch tests will be conducted after remounting of the 8125 sled and as necessary for the other systems. The results of all patch tests to date, along with the acquisition and processing logs, are included in the individual MBES Calibration files in Appendix III-*vssl*-4. Also included in Appendix III is the Sounding System Comparison. This comparison includes leadline to MBES comparisons and surface differencing between MBES reference surfaces. Average differences between systems are less than one meter.

## 5.0 Attitude

All attitude corrections are generated by the POS/MV using data from the IMU-200 Inertial Measurement Unit (IMU). All attitude data are applied in post-processing in HIPS for systems acquiring data with the RESON 8101, 8111, and 8125. The RESON 8160 has real-time roll and pitch stabilization applied, thus these components of attitude were not applied in post-processing as to not double apply the correctors.

IMU values for uncertainty of heave, pitch and roll are included in the manufacturer specification in Appendix II and are included in the *Fairweather_TPE Values_2009* spreadsheet located in Appendix IV.

### 5.1 True Heave

*Fairweather* and her launches are equipped with the POS/MV TrueHeave™ (TH) option. True Heave™ is a ‘delayed’ heave corrector as opposed to ‘real time’ heave corrector and is fully described in Section 6 of the *POS/MV Version 4 Installation and Operation Manual*. TrueHeave is logged along with other POSPac data in the daily POS files (2009-ddd_vssl_.000) through the Ethernet Logging function in the POS/MV controller software. To ensure proper calculation of TH, files are logged for at least three minutes past the end of each day’s survey operations.

During daily processing the occurrence of “corrupted” TrueHeave files can occur. This is generally due to a formatting problem in the POS file. A fix has been provided by CARIS in a tool called “fixTrueHeave.exe.” In cases where this is necessary a new “fixed” file is created with the extension “.fixed” (2009-ddd_vssl_.000.fixed). The new fixed True Heave file is then applied to the data in the CARIS HIPS program. The original corrupted file is retained along with the fixed file with the raw data. Occurrences of this for specific surveys are noted in the individual Descriptive Reports.

In cases where TrueHeave™ could not be applied, real time heave correctors are used. Real time heave data are recorded in Hypack/Hysweep software and stored in the .HSX format and can be applied as the heave corrector for multibeam data. Data that does not have TrueHeave™ applied will be listed in the individual Descriptive Report for the survey.

## 6.0 Sound Velocity

SBE 19*plus* and SBE 19*plusV2* sound velocity profilers are used regularly to collect sound speed data for the RESON 8101 and RESON 8125 multibeam sonars on survey launches 1010 and 1018 and used on an as needed basis for the *Fairweather*’s RESON 8111 and 8160 multibeam systems. The Brooke Ocean Technology Moving Vessel Profiler (MVP) is primarily used to collect sound velocity data for sound speed correction of data acquired with *Fairweather*’s RESON 8111 and 8160 multibeam systems.

Daily sound speed profiles from the SBE 19*plus* and SBE 19*plusV2* profilers are processed with Velocwin and concatenated into single .svp files for each vessel per survey. Individual .svp files and the concatenated vessel files for the survey are submitted with each survey.

Sound speed profiles acquired using the Brooke Ocean Technology Moving Vessel Profiler 200 (MVP) are stored in files labeled .001, .001c, .001d, and .001e (collectively called BOT files) where the number increments by one with each subsequent cast. The .00#c file for each cast was opened with Velocwin and converted into CARIS .svp file format. The individual .svp profiles are concatenated into vessel specific .svp files for the entire survey. Individual sound velocity profile files taken by the MVP will not be submitted due to the large number of casts acquired; however, the daily concatenated files are submitted for backup purposes.

The concatenated sound velocity files are applied to multibeam data in CARIS HIPS during data processing. CARIS HIPS uses one of four different algorithms to automatically apply a sound velocity profile stored in a concatenated sound velocity file. They are: “previous in time,” “nearest in time,” “nearest in distance” and “nearest in distance within time.” In general, “previous in time” is the method used for applying sound velocity information in HIPS for launch data and “nearest in distance within time” is used for ship data, although the other methods may be used in certain situations. The method of applying sound velocity is included in the processing logs that are submitted with each survey.

## 7.0 Water Level

The vertical datum for projects conducted is Mean Lower Low Water (MLLW). Predicted, preliminary, and/or verified water level correctors from the primary tide station(s) listed in the project letter instructions may be downloaded from the CO-OPS website and used for water level corrections during the course of the project. These tide station files are collated to include the appropriate days of acquisition and then converted to CARIS .tid file format using FetchTides or HydroMI in MapInfo.

Water level data in the .tid files are applied to data in CARIS HIPS using the zone definition file (.zdf) or a Tidal Constituent and Residual Interpolation (TCARI) model supplied by CO-OPS. Upon receiving final approved water level data, all data are reduced to MLLW using the final approved water levels (smooth tides) as noted in the Descriptive Report included with the survey data.

A complete description of vertical control utilized for a given project can be found in the project specific *Horizontal and Vertical Control Report (HVCR)*, submitted for each project under separate cover when necessary as outlined in section 5.2.3.2.3 of the *FPM*.

# Appendix I

## System Tracking

- **Vessel Inventory**
- **Hardware Inventory**
- **Computer Inventory**

## Hydrographic Vessel Inventory

**Field Unit:** FAIRWEATHER
**Effective Date:** April 20, 2009
**Updated Through:** July 18, 2009

| SURVEY VESSELS | | | | | | |
|---|---|---|---|---|---|---|
| **Vessel Name** | **FAIRWEATHER** | **Launch 1010** | **Launch 1018** | **Ambar 700** | **Skiff** | **FRB** |
| **Vessel Image** |  |  |  |  |  |  |
| **Hull Number** | S 220 | 1010 | 1018 | 2302 | 1706 | 2301 |
| **Call Letters** | WTEB | | | | | |
| **Manufacturer** | Aerojet-General Shipyards | The Boat Yard, Inc. | The Boat Yard, Inc. | Marine Silverships, Inc | MonArk | Zodiak of North America |
| **Year of Construction** | 1967 | 1973 | 1973 | 1998 | | 2004 |
| **Type of Construction** | Welded steel hull - ice strengthened | Aluminum hull | Aluminum Hull | RHIB | Aluminum Hull | RHIB |
| **Length Overall** | 70.4 m (231 ft) | 8.8 m (28ft 10in) | 8.8 m (28ft 10in) | 7.0 m (23 ft) | 5.2 m (17 ft) | 6.7 m (22 ft) |
| **Beam** | 12.8 m (42 ft) | 3.3 m (10ft 8in) | 3.3 m (10ft 8in) | 2.9 m (9ft 4in) | 2.3 m (7ft 2in) | 2.6 m (8ft 6in) |
| **Draft** | 4.7 m (15ft 6in) | 1.2 m (4 ft) | 1.2 m (4 ft) | 0.4 m (1ft 4in) | 0.4 m (1ft 3in) | 0.6 m (22 in) |
| **Cruising Speed** | 12.5 knots | 24 knots | 24 knots | 22 knots | 20 knots | 18 knots |
| **Max Survey Speed** | 6 knots | 6 knots | 6 knots | | | |
| **Date of Effective Full Vessel Static Offset Survey** | Origninal Survey 9/23/2003<br>POS/MV Offsets Surveyed 2/2007 and 2/15/2009 | 2004 | 2004 | | | |
| **Organization which Conducted the Effective Full Offset Survey** | Original Survey - Westlake Consultants<br>POS/MV Spatial Surveys - NGS | NOAA Personnel (Wetzler, Sampadian, Froelich) | NOAA Personnel (Wetzler, Sampadian, Froelich) | | | |
| **Date of Last Partial Survey or Offset Verification & Methods Used** | n/a | 3/20/2009<br>Steel Tape | 8101: 3/20/2009<br>8125: 4/29/2009<br>Steel Tape | | | |
| **Date of Last Static Draft Determination & Method Used** | April-2009<br>Draft Marks | 4/7/2009<br>Waterline to Benchmarks | 4/7/2009<br>Waterline to Benchmarks | | | |
| **Date of Last Settlement and Squat/Dynamic Draft Measurements & Method Used** | 2/23/2009<br>Post Processed Kinematic (Ellipsoidally referenced) | 4/17/2009<br>Post Processed Kinematic (Ellipsoidally referenced) | 4/16/2009<br>Post Processed Kinematic (Ellipsoidally referenced) | | | |

# Hydrographic Hardware Inventory

**Field Unit:** FAIRWEATHER

**Effective Date:** 4/20/2009

**Updated Through:** 7/21/2009

**SONAR & SOUNDING EQUIPMENT**

| Equipment Type | Manufacturer | Model | Serial Number | Firmware and/or Software Version | Version Install Date | Location | Date of last Field Cal/Testing | Date of last Manufacturer Cal/Service | Additional Information |
|---|---|---|---|---|---|---|---|---|---|
| Processor | RESON | 81-P (8111) | 35652 | Dry: 8111-E209-6114<br>Wet: 8111-E101-AFAA | Mar 2009 | S220 | N/A | | Bar Code : CD0001065312 |
| Transducer | RESON | 8111ER | unknown | N/A | Mar 2009 | S220 | 4/28/2009 | replaced transducer Mar-2009 | |
| Processor | RESON | 81-P (8160) | 35385 | Dry: 8160-2.09-7C6D<br>Wet: 8160-1.00-E9E1 | May-2004 | S220 | N/A | | Bar Code : CD0001065313 |
| Transducer | RESON | 8160 | unknown | N/A | Apr-2004 | S220 | 4/28/2009 | installed in hull, 2004 | |
| Processor | RESON | 81-P | 35737 | Dry: 8101-2.09-E34D<br>Wet: 8101-1.08-C215 | Jul-2004 | 1010 | N/A | | Bar Code : CD0001065349 |
| Transducer | RESON | 8101 ER | 2701011 | N/A | Jul-2004 | 1010 | 4/17/2009 | | |
| Processor | RESON | 81-P | 34497 | Dry: 8101-2.09-E34D<br>Wet: 8101-1.08-C215 | Jul-2004 | 1018 | N/A | | Bar Code : CD0001065351 |
| Transducer | RESON | 8101 ER | 3102026 | N/A | Jul-2004 | 1018 | 4/16/2009 | | |
| Processor | RESON | 81-P | 31562 | Dry: 8125-2.10-A50F<br>Wet: 8125-1.08-9E98 | Unknown | 1018 | N/A | | Bar Code: CD0000825308 |
| Transducer | RESON | 8125 | 4400007 | N/A | Unknown | 1018 | O119: 5/24/2009<br>P183: 6/27/2009 | Unknown | on loan from RUDE |
| Towfish | Klein | 5000 | 293 | N/A | | 1018 / S220 | preliminary testing 5/14/2009 | | Bar Code: CD0000825404 |
| Processor | Klein | Sonar Workstation | 23-326-2WS | Sonar Pro 11.3 | | 1018/S220 | preliminary testing 5/14/2010 | | Bar Code: CD0000825155 |
| Processor | Odom Hydrographic Systems | Echotrac CVM-A | 26034 | Version 4.01 | | 2302 / 1706 | | new unit, May-2007 | Bar Code: CD0001703210, ChartView Dongle (100.001.001.098) |
| Transducer (2) | Odom Hydrographic Systems | SMBB200-4A | TR5162/TR5159 | N/A | N/A | 2302 / 1706 | N/A | N/A | Two 4 degree (large) |
| Transducer (2) | Odom Hydrographic Systems | SMBB200_9 | TR5138/TR5139 | N/A | N/A | 2302 / 1706 | N/A | N/A | Two 9 degree (small) |
| Divers Least Depth Gaug | PTC | MODIII | 68377 | N/A | N/A | S220 | 4/22/2009 | 4/2/2008 | CD0001698256 |
| Lead Line | FA Personnel | Traditional | 10_01_05 | N/A | N/A | any | 4/20/2009 | | |
| Lead Line | FA Personnel | Traditional | 10_02_05 | N/A | N/A | any | 4/20/2009 | | |
| Lead Line | FA Personnel | Traditional | 20_01_05 | N/A | N/A | any | 4/28/2009 | | |
| Lead Line | FA Personnel | Traditional | 20_02_05 | N/A | N/A | any | 4/28/2009 | | |
| Lead Line | FA Personnel | Traditional | 20_03_05 | N/A | N/A | any | 4/28/2009 | | |
| Lead Line | FA Personnel | Traditional | 30_01_05 | N/A | N/A | any | 4/28/2009 | | |
| Lead Line | FA Personnel | V-100/Non-Traditional | 10_05_09 | N/A | N/A | any | 4/28/2009 | | |
| Lead Line | FA Personnel | V-100/Non-Traditional | 10_06_09 | N/A | N/A | any | | | work in progress |

**POSITIONING & ATTITUDE EQUIPMENT**

| Equipment Type | Manufacturer | Model | Serial Number | Firmware and/or Software Version | Version Install Date | Location | Date of last Field Cal/Testing | Date of last Manufacturer Cal/Service | Additional Information |
|---|---|---|---|---|---|---|---|---|---|
| POS/MV PCS | Applanix | 320 V.4 | 2411 | HW2.9-7, SW03.42 POS Cntrlr v. 4.0.2.0 | Jun-2008 | S220 IP:129.100.1.231 | 4/27/2009 | | Bar Code : CD0001697462 Auth. No. 811025-00534537 |
| POS/MV IMU | Applanix | LN200 | 292 | N/A | Apr-2004 | S220 | | | Bar Code : CD0001696450 |
| POS/MV Primary GPS Receiver | Applanix | | BD950 SN:4611A66708 | v.00211 | Feb-2007 | S220 | | | |
| POS/MV Secondary GPS Receiver | Applanix | | BD950 SN:4602A62806 | v.00211 | Feb-2007 | S220 | | | |
| POS/MV Port Antenna | Applanix | OEM2 3151R | S/N 60103854 | HW1 | Feb-2007 | S220 | | | P/N 39105-00 DC 4602 |
| POS/MV Stbd Antenna | Applanix | OEM2 3151R | S/N 60125191 | HW1 | Feb-2007 | S220 | | | P/N 39105-00 DC 4602 |
| DGPS Receiver | CSI Wireless | MBX-3S | 0324-11969-0002 | N/A | Jul-2004 | S220 | | | Bar Code: CD0001065375 |
| DGPS Antenna | CSI Wireless | MGL3 | 9824-1779-0002 | N/A | Apr-2004 | S220 | | | |
| POS/MV PCS | Applanix | 320 V.4 | 2564 | HW 2.6-7, SW 03.42 POS Cntrlr v. 3.4.0.0 | Jun-2008 | 1010 IP:129.100.1.231 | 4/15/2009 | 1/15/2008 | Bar Code : CD0001601275 |
| POS/MV IMU | Applanix | LN200 | 294 | N/A | Jul-2004 | 1010 | | | Bar Code : CD0001696449 |
| POS/MV Primary GPS Receiver | Applanix | | BD950 SN:4624A70264 | v.00211 | Mar-2007 | 1010 | | | |
| POS/MV Secondary GPS Receiver | Applanix | | BD950 SN:4624A68956 | v.00211 | Mar-2007 | 1010 | | | |
| POS/MV Port Antenna | Applanix | OEM2 3151R | S/N 60162863 | HW1 | Mar-2007 | 1010 | | | P/N 39105-00 DC 4626 |
| POS/MV Stbd Antenna | Applanix | OEM2 3151R | S/N 60145247 | HW1 | Mar-2007 | 1010 | | | P/N 39105-00 DC 4614 |
| DGPS Receiver | CSI Wireless | MBX-3S | 0331-12579-0008 | N/A | Jul-2004 | 1010 | | | Bar Code: CD0001065289 |
| DGPS Antenna | CSI Wireless | MGL3 | 0331-12579-0009 | N/A | Jul-2004 | 1010 | | | |
| POS/MV PCS | Applanix | 320 V.4 | 2560 | HW 2.6-7, SW 03.42 POS Cntrlr v. 3.4.0.0 | Jun-2008 | 1018 IP:129.100.1.231 | 4/15/2009 | 1/15/2008 | Bar Code : CD0001601274 |
| POS/MV IMU | Applanix | LN200 | 007 | N/A | Feb-2007 | 1018 | | | |
| POS/MV Primary GPS Receiver | Applanix | | BD950 SN:4624A70243 | v.00211 | Feb-2007 | 1018 | | | |
| POS/MV Secondary GPS Receiver | Applanix | | BD950 SN:4624A70263 | v.00211 | Feb-2007 | 1018 | | | |
| POS/MV Port Antenna | Trimble | OEM2 3151R | S/N 60145158 | N/A | Feb-2007 | 1018 | | | 39105-00 DC 4618 |
| POS/MV Stbd Antenna | Trimbe | OEM2 3151R | S/N 60130644 | N/A | Feb-2007 | 1018 | | | 39105-00 DC 4604 |
| DGPS Receiver | CSI Wireless | MBX-3S | 0328-12362-0001 | N/A | Jul-2004 | 1018 | | | Bar Code:00010652291 |
| DGPS Antenna | CSI Wireless | MGL3 | 0328-12352-0002 | N/A | Jul-2004 | 1018 | | | |
| Trimble Backpack 1 | Trimble | Pathfinder Pro XRS | 0224078543 | Firmware v1.96 RevA | Mar-2008 | S220 | | | Bar Code: CD0001269835 |
| Trimble Backpack 1: Antenna | Trimble | 33580-50 | 0220341062 | N/A | N/A | S220 | | | no Bar Code |
| Trimble Backpack 2 | Trimble | Pathfinder Pro XRS | 0224090101 | Firmware v1.96 RevA | Mar-2008 | S220 | | | Bar Code: CD0001269836 |
| Trimble Backpack 2: Antenna | Trimble | 33580-50 | 0220321059 | N/A | N/A | S220 | | | no Bar Code |
| Handheld data collector | Trimble | TSCe | 37318 | N/A | N/A | S220 | | | no Bar Code , PN 45268-50 |
| Antenna cable | Trimble | | P/N22628 | | | S220 | | | |
| Camcorder Batteries | Trimble | | P/N17466 | | | S220 | | | |
| NMEA/RTCM cable | Trimble | | P/N30232-00 | | | S220 | | | |
| data/power cable | Trimble | | P/N30231-00 | | | S220 | | | |
| dual battery cable | Trimble | | P/N24333 | | | S220 | | | |
| GPS Pathfinder field device cable | Trimble | | P/N45052 | | | S220 | | | |
| Laser | Laser Tech Inc. | Impulse Laser Rangefinder | i09290 | N/A | N/A | S220 | | | Bar Code: CD0001269812 |
| Laser | Laser Tech Inc. | TruPulse 200 Laser Rangefinder | 001481 | N/A | N/A | S220 | | | no Bar Code |
| Laser | Laser Tech Inc. | TruPulse 200 Laser Rangefinder | 000676 | N/A | N/A | S220 | | | no Bar Code |

| SOUND SPEED MEASUREMENT EQUIPMENT | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Equipment Type** | **Manufacturer** | **Model** | **Serial Number** | **Firmware and/or Software Version** | **Version Install Date** | **Location** | **Date of last Field Cal/Testing** | **Date of last Manufacturer Cal/Service** | **Additional Information** |
| Moving Vessel Profiler winch | Brooke Ocean Technology Inc. | MVP-200-5 | 10328 | | | S220 | N/A | Apr-2009 | Visit by BOT tech Darrell Groom |
| Moving Vessel Profiler fish | Brooke Ocean Technology Inc. | MVP-FFF-SS-32-1 | 10478 | | | S220 | N/A | Apr-2009 | Visit by BOT tech Darrell Groom, primary fish |
| Moving Vessel Profiler fish | Brooke Ocean Technology Inc. | MVP-FFF-SS-32-1 | 10329 | | | S220 | N/A | Apr-2009 | Visit by BOT tech Darrell Groom, spare fish |
| Moving Vessel Profiler sensor | Applied Micro Systems Ltd. | AML Smart SV +P | 4986 | | | S220 | DQAs weekly | 10/2/2009 | installed in primary fish |
| Moving Vessel Profiler sensor | Applied Micro Systems | AML Smart SV +P | 5229 | | | S220 | DQAs weekly if in service | | Returned to AML for service, April 2009 |
| Moving Vessel Profiler sensor | Applied Micro Systems Ltd. | AML Smart SV +P | 5466 | | | S220 | DQAs weekly if in service | 10/30/2009 | Purchased 2008, installed in spare fish |
| SEACAT Profiler | Sea-Bird | SBE 19plus | 19P36026-4585 | 1.4D | | S220 | DQAs weekly | 12/24/2008 | CON file: 4585.con |
| SEACAT Profiler | Sea-Bird | SBE 19plus | 19P36026-4616 | 1.4D | | 1010 or 1018 | DQAs weekly | 12/30/2008 | CON file: 4616.con |
| SEACAT Profiler | Sea-Bird | SBE 19plus | 19P36026-4617 | 1.4D | | 1010 or 1018 | DQAs weekly | 12/20/2008 | CON file: 4617.con |
| SEACAT Profiler | Sea-Bird | SBE 19plus V2 | 19P50959-6121 | 2.1 | | 1010 or 1018 | DQAs weekly | 8/28/2009 | CON file: 6121.con |
| SEACAT Profiler | Sea-Bird | SBE 19plus V2 | 19P50959-6122 | 2.1 | | 1010 or 1018 | DQAs weekly | 8/29/2009 | CON file: 6122.con |
| Real Time Sound Speed Profiler | RESON | SVP 70 | 4008077 | | | S220 | DQAs weekly | 1/4/2009 | |
| Real Time Sound Speed Profiler | Odom Hydrographic Systems | Digibar Pro | 98013-041609 | SW 1.11 | | 1018 | DQAs weekly | 4/16/2009 | |

| TIDES & LEVELING EQUIPMENT | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Equipment Type** | **Manufacturer** | **Model** | **Serial Number** | **Firmware and/or Software Version** | **Version Install Date** | **Location** | **Date of last Field Cal/Testing** | **Date of last Manufacturer Cal/Service** | **Additional Information** |
| Level | Carl Zeiss | N12 333 | 100056 | N/A | N/A | S220 | Mar-2009 | Mar-2008 | |
| Level | Carl Zeiss | N12 333 | 103267 | N/A | N/A | S220 | Mar-2009 | Mar-2008 | |
| Level | Leica | NA2 100 | 5332739 | N/A | N/A | S220 | | | Spare |
| Level | Lecia | NA2 100 | 5332747 | N/A | N/A | S220 | | | Spare |

| HORIZONTAL AND VERTICAL CONTROL EQUIPMENT | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Equipment Type** | **Manufacturer** | **Model** | **Serial Number** | **Firmware and/or Software Version** | **Version Install Date** | **Location** | **Date of last Field Cal/Testing** | **Date of last Manufacturer Cal/Service** | **Additional Information** |
| GPS Reciever | Trimble | NetR5 | 4910K61066 | 4.03 | Apr-2009 | S220 | Apr-2009 | obtained Apr-2009 | Bar Code: CD0001526972 |
| GPS Antenna | Trimble | Zephyr Geodetic 2 | | | | S220 | Apr-2009 | obtained Apr-2009 | no Bar Code |
| GPS Reciever | Trimble | NetR5 | 4910K61054 | 4.03 | Apr-2009 | S220 | Apr-2009 | obtained Apr-2009 | Bar Code: CD0001526973 |
| GPS Antenna | Trimble | Zephyr Geodetic 2 | 30767941 | | | S220 | Apr-2009 | obtained Apr-2009 | no Bar Code |
| GPS Receiver | Ashtech | Z-Xtreme | ZE1200339016 | ZE21 | Mar-2008 | S220 | Apr-2009 | obtained Apr-2004 | Bar Code: CD0001062363 |
| GPS Antenna | Ashtech | Geodetic 4 | 8365 | | | S220 | Apr-2009 | obtained Apr-2004 | No Barcode |
| UHF Radio | FreeWave | HTP-900RE | 884-8978 | 2.17 | Mar-2009 | S220 | | obtained Mar-2009 | Bar Code: CD0001526970 |
| UHF Radio | FreeWave | HTP-900RE | 884-9190 | 2.17 | Mar-2009 | S220 | | obtained Mar-2009 | Bar Code: CD0001526971 |
| UHF Radio | FreeWave | HTP-900RE | 8849511 | 2.17 | May-2009 | S220 | | obtained May-2009 | no Bar Code |
| UHF Radio | FreeWave | HTP-900RE | 8849301 | 2.17 | May-2009 | S220 | | obtained May-2009 | no Bar Code |
| UHF Antenna | PCTEL | MAX9053 | | | | S220 | | obtained May-2009 | no Bar Code |
| UHF Antenna | PCTEL | MAX9053 | | | | S220 | | obtained May-2009 | no Bar Code |
| UHF Antenna | PCTEL | MAX9053 | | | | S220 | | obtained May-2009 | no Bar Code |
| UHF Antenna | PCTEL | MAX9053 | | | | S220 | | obtained May-2009 | no Bar Code |
| Solar Charger | PWM | EPRC5 | | | | S220 | | obtained May-2009 | no Bar Code |
| Solar Charger | PWM | EPRC5 | | | | S220 | | obtained May-2009 | no Bar Code |
| Solar Charger | PWM | EPRC5 | | | | S220 | | obtained May-2009 | no Bar Code |
| Solar Panel | Uni-Solar | FLX-32 | USF-32-14639 | N/A | N/A | S220 | | | no Bar Code |
| Solar Panel | Uni-Solar | FLX-32 | USF-32-14634 | N/A | N/A | S220 | | | no Bar Code |
| Solar Panel | Uni-Solar | FLX-32 | USF-32-14633 | N/A | N/A | S220 | | | no Bar Code |
| Solar Panel | Uni-Solar | FLX-32 | USF-32-14529 | N/A | N/A | S220 | | | no Bar Code |
| Solar Panel | Uni-Solar | FLX-32 | USF-32-14631 | N/A | N/A | S220 | | | no Bar Code |
| Solar Panel | Uni-Solar | FLX-32 | USF-32-14625 | N/A | N/A | S220 | | | no Bar Code |
| Solar Panel | Uni-Solar | FLX-32 | USF-32-14645 | N/A | N/A | S220 | | | no Bar Code |
| Solar Panel | Uni-Solar | MBC-525 | 525-011590 | N/A | N/A | S220 | | | Bar Code: CD000684513 |
| Solar Panel | Uni-Solar | MBC-526 | 525-011093 | N/A | N/A | S220 | | | Bar Code: CD000684507 |
| Solar Panel | Uni-Solar | MBC-527 | 525-011589 | N/A | N/A | S220 | | | Bar Code: CD000684510 |
| Solar Panel | Uni-Solar | MBC-528 | 525-011607 | N/A | N/A | S220 | | | Bar Code: CD000684512 |
| Solar Panel | Uni-Solar | MBC-529 | 525-011587 | N/A | N/A | S220 | | | Bar Code: CD000684511 |
| Solutions Dongles | Ashtech | 600586 (A) | KEB2083 | N/A | N/A | S220 | | | no Bar Code |
| Solutions Dongles | Ashtech | 600586 (A) | KEB2077 | N/A | N/A | S220 | | | no Bar Code |

| ADDITIONAL POSITIONING EQUIPMENT | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Equipment Type** | **Manufacturer** | **Model** | **Serial Number** | **Firmware and/or Software Version** | **Version Install Date** | **Location** | **Date of last Field Cal/Testing** | **Date of last Manufacturer Cal/Service** | **Additional Information** |
| GPS RTK Receiver | Trimble | DSM-232 | 225111661 | 3.57 | Mar-2008 | S220 | | | Bar Code: CD0001697439 |
| GPS Receiver | Trimble | DSM-232RS | 225111655 | 3.57 | Mar-2008 | S220 | | | Bar Code: CDCD0001697422 |
| DGPS Antenna | Trimble | 33580-00 | 220395038 | N/A | N/A | S220 | | | |
| GPS Antenna | Trimble | Zephyr Geodetic Antenna | 30325441 | N/A | N/A | S220 | | | no Bar Code |
| GPS Antenna | Trimble | SPS MSK | 5876 | N/A | N/A | S220 | | | no Bar Code |
| GPS RTK Reciver | Trimble | MS 750 | 220339262 | | | | | | Bar Code: CD 0001478898 |
| GPS Antenna | Trimble | Trimble Micro Centered L1/L2 | 220298707 | N/A | N/A | S220 | | | NOAA Launch Barcode A2008 |
| Position Data Link High Powered Base Unit | Pacific Crest | PDL 4135 | 0424 0171 | 2.40 | Apr-2004 | S220 | 5/3/2007 | obtained Apr-2004 | Bar Code: CD0001269910 |
| Position Data Link Rover | Pacific Crest | PDL 4100 | 04240154 | 2.4 | Apr-2004 | S220 | 5/3/2007 | obtained Apr-2004 | |
| Position Data Link Rover | Pacific Crest | PDL 4100 | 03473047 | 2.32 | Apr-2004 | S220 | 5/3/2007 | obtained Apr-2004 | |
| Position Data Link Rover | Pacific Crest | PDL 4100 | 04240155 | 2.4 | Apr-2004 | S220 | 5/3/2007 | obtained Apr-2004 | |

## FAIRWEATHER Computers

| Machine Name | Location | Make/Model | Operationg System | Date Purchased | Date of Last Rebuild | Processor Speed | RAM (original) | RAM (checked March 2006) | Number of Video Outputs | Video RAM | Service Tag | Barcode | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **FA_Proc_1** | Plot Room | DELL Precision 490 | XP Pro 2002 SP3 | Nov-07 | | 2.66 GHz | 3GB | | 2 | 256 MB | 9MP1PD1 | CD0001615385 | New DELL deskptop installed week of 12/4/07 |
| **FA_Proc_2** | Plot Room | DELL Precision 490 | XP Pro 2002 SP3 | Nov-07 | | 2.66 GHz | 3GB | | 2 | 256 MB | 4NP1PD1 | CD0001615382 | New DELL deskptop installed week of 12/4/07 |
| **FA_Proc_3** | Plot Room | DELL Precision 490 | XP Pro 2002 SP3 | Nov-07 | | 2.66 GHz | 3GB | | 2 | 256 MB | 6MP1PD1 | CD0001615383 | New DELL deskptop installed week of 12/4/07 |
| **FA_Proc_4** | Plot Room | DELL Precision 490 | XP Pro 2002 SP3 | Nov-07 | | 2.66 GHz | 3GB | | 2 | 256 MB | 2NP1PD1 | CD0001615380 | New DELL deskptop installed week of 12/4/07 |
| **FA_Proc_5** | Plot Room | DELL Precision 490 | XP Pro 2002 SP3 | Nov-07 | | 2.66 GHz | 3GB | | 2 | 256 MB | 3MP1PD1 | CD0001615381 | New DELL deskptop installed week of 12/4/07 |
| **FA_Proc_6** | Plot Room | Dell Precision T3400 | XP Pro 2002 SP3 | Apr-08 | | 3.0GHz | 3GB | | 2 | 512MB | 1JKCZF1 | CD0001615471 | New DELL deskptop installed week of 04/06/08 |
| **FA_Proc_7*** | Plot Room | DELL Precision 490 | XP Pro 2002 SP3 | Nov-07 | | 2.66 GHz | 3GB | | 2 | 256 MB | 8MP1PD1 | CD0001615384 | New DELL deskptop installed week of 12/4/07 |
| **FA_Proc_8** | Plot Room | Dell Precision T3400 | XP Pro 2002 SP3 | Apr-08 | | 3.0GHz | 3GB | | 2 | 512MB | 5JKCZF1 | CD0001615467 | New DELL deskptop installed week of 04/14/08 |
| **FA_Proc_9** | Plot Room | Dell Precision T3400 | XP Pro 2002 SP3 | Apr-08 | | 3.0GHz | 3GB | | 2 | 512MB | 3JKCZF1 | CD0001615472 | New DELL deskptop installed week of 04/06/08 |
| **FA_Proc_10** | DP-2 | Dell Precision T3400 | XP Pro 2002 SP3 | Apr-08 | | 3.0GHz | 3GB | | 2 | 512MB | JHKCZF1 | CD0001615468 | New DELL deskptop installed week of 04/06/08 |
| **FA_CST** | Field Office | Dell Precision T3400 | XP Pro 2002 SP3 | Apr-08 | | 3.0GHz | 3GB | | 2 | 512MB | 4JKCZF1 | CD0001615469 | New DELL deskptop installed week of 04/06/08 |
| **FA_FOO** | Field Office | Dell Precision T3400 | XP Pro 2002 SP3 | Apr-08 | | 3.0GHz | 3GB | | 2 | 512MB | DHKCZF1 | CD0001615470 | New DELL deskptop installed week of 04/06/08 |
| **FA_O-LAB*** | O-LAB | Dell Prcision 360 | XP Pro 2002 SP3 | | | 3.0GHz | 3.5GB | | 2 | 128MB | GBBG451 | CD0001741480 | |
| **Toughbook 1** | Laptop | Panasonic CF-18 | XP Pro 2002 SP2 | ~ March 2004 | ~ July 2006 | 1.1 GHz | 2.5 GB | N/A | 1 | 64 MB | 4HKSA59499 | CD0001269860 | *rebuilt after crash July 2006 |
| **Toughbook 2** | Laptop | Panasonic CF-18 | XP Pro 2002 SP2 | ~ March 2004 | ~ September 2005 | 1.1 GHz | 2.5 GB | N/A | 1 | 64 MB | 4HKSA59560 | CD0001269858 | |
| **Toughtab 1** | Laptop | Panasonic CF-18 | XP Pro 2002 SP2 | ~ March 2004 | ~ September 2005 | 1.1 GHz | 2.5 GB | N/A | 1 | 64 MB | 4GKSA55049 | CD0001269859 | |
| **Toughbook 3** | Laptop | Panasonic CF-29 | XP Pro 2002 SP2 | March 2006 | N/A | 1.6 GHz | 2.5 GB | N/A | 1 | 128 MB | 6AKSB06863 | CD0001698251 | |
| **Toughbook 4** | Laptop | Panasonic CF-30 | XP Pro 2002 SP3 | March 2009 | | 1.7GHz | 1 Gb | | 0 | 384 MB | 8HKSB80630 | CD0001447100 | out for service |
| **Toughbook 6** | Laptop | Panasonic CF-30 | XP Pro 2002 SP3 | March 2009 | | 1.7GHz | 1 Gb | | 0 | 384 MB | | | out for service |
| **Toughbook 5** | Laptop | Panasonic CF-19 | XP Pro 2002 SP3 | March 2009 | | 1.1GHz | 1 Gb | | 1 | 384 MB | 9AKSB43281 | CD0001696424 | |
| **1010_ACQ** | Launch 1010 | ICI | XP Pro 2002 SP2 | Mar-08 | | 2.66GHz | 3GB | | 3 | 128MB | | CD0001615466 | |
| **1018_ACQ** | Launch 1018 | ICI | XP Pro 2002 SP2 | Mar-08 | | 2.66GHz | 3GB | | 3 | 128MB | | CD0001615463 | |
| **S220_ACQ** | Plot Room | Dell Precision T3400 | XP Pro 2002 SP2 | Mar-08 | | 3.0GHz | 3GB | | 3 | 512MB | CSH8NF1 | CD0001615444 | |
| **FA_MVP200** | Plot Room | MVP-C1-2001 | 2000 SP4 | ~ March 2004 | ~ September 2005 | 2.4 GHz | 230 MB | 230 MB | 1 | 64 MB | SN: 10330 | CD0001269854 | |

# Appendix II

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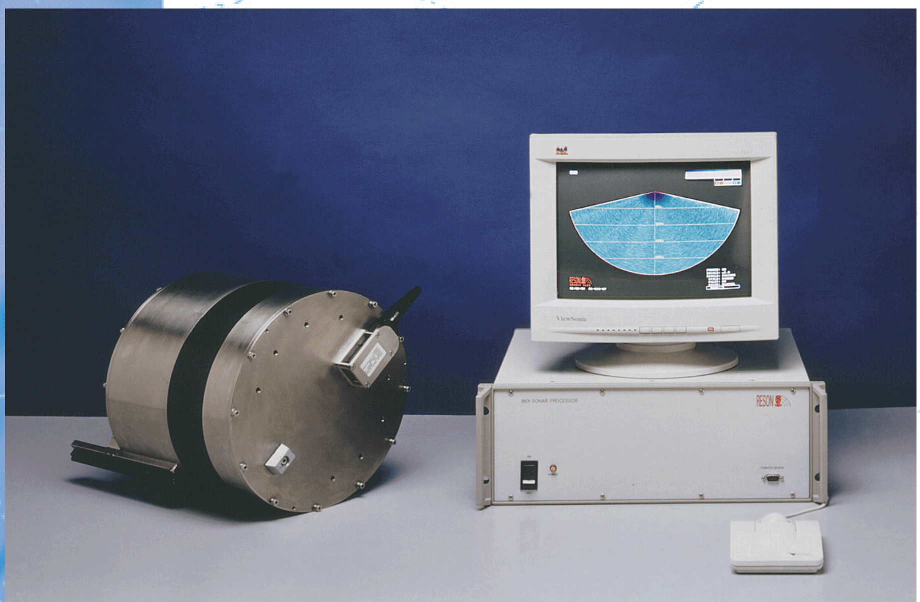
## Equipment Specifications

1. **Sonar Systems**
    a. RESON
        i. 8101 Equipment Specs
        ii. 8111 Equipment Specs
        iii. 8160 Equipment Specs
    b. VBES
        i. Odom Echotrac CVM
        ii. SMBB200-9 Transducer Information
        iii. SMSW200-4a Transducer Information
    c. SSS
        i. Klein 5000
2. **Positioning**
    a. POS MV
        i. v320
    b. DGPS
        i. MBX-3S
        ii. SF-2050
3. **Shoreline**
    a. Trimble
        i. Accuracy
        ii. Specs
        iii. TSCe
    b. Lasers
        i. TruPulse 200
        ii. Impulse 200 LR
4. **SV**
    a. MVP
        i. MVP 200
    b. SBE
        i. SBE 45
        ii. SVP 70
        iii. Specs-19p-4585
        iv. Specs-19p-4616
        v. Specs-19p-4617
        vi. Specs-19pV2-6121
        vii. Specs-19pV2-6122
5. **Control**
    a. Leveling
        i. Leica NA2 level
        ii. Zeiss NI2 level
    b. HorCon
        i. PDL
        ii. Z-Xtreme Ashtech GPS

6. **Total Stations**
    a. Nikon DTM310
    b. Sokkia SET5F

# SeaBat 8101
# PRODUCT SPECIFICATION
## 240kHz MULTIBEAM ECHO SOUNDER



- Phase and Amplitude Bottom Detection
- 150° Wide Swath Coverage
- 240 kHz Frequency
- Up to 500m Range Capability
- Portable Configuration
- Meets USACE Class 1 Standards
- Meets IHO Standards

The SeaBat 8101 Multibeam Echo Sounder measures discrete depths, enabling complex underwater features to be mapped with precision. Dense coverage is achieved utilizing up to 3,000 soundings per second for a swath that can be over 500 meters wide, even as the survey vessel travels at speeds of over 18 knots.

With high accuracy and a measurement rate up to 30 profiles per second, the SeaBat 8101 enables surveys to be completed faster and in greater detail than previously realized. The SeaBat is an integral part of the new, integrated bathymetry surveying systems.

The SeaBat transducer is available pressurized for depths from 100 to over 3,000 meters. Small and lightweight, it can be can be mounted on small un vehicles (ROV, AUV or towed) and taken to where accurate measure required.

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http://www.reson.com

*SeaBat 8101 Built-In Test Environment ("BITE") Screen*

## SYSTEM SPECIFICATIONS

***Operating Frequency:*** 240kHz
***Range Scales:*** 5, 10, 15, 20, 25, 35, 50, 75, 100, 125, 150, 175, 200, 250, 300, 350, 400, 450, 500m.
***Range Resolution:*** 1.25 cm
***Number of Beams:*** 101
***Horizontal Beamwidth:*** 1.5°
***Horizontal Coverage:*** 150°
***Vertical Beamwidth:*** 1.5°
***Update Rate:*** Range-variable up to 30 times per second

## SONAR HEAD SPECIFICATIONS

***Power Requirement:*** 24VDC, 2 Amps max. (Power available from surface processor.)
***Uplink:*** Digital, 76.8 Mbaud
***Down Link Control:*** RS-232 or RS-422, 19,200 baud
***Operating Depth:*** 100 meters (300m, 1500m, 3000m & 6000m avbl.)
***Dimensions:*** 266x320mm W/Diam (does not include projector)
***Temperature:*** Operating: -5° to +40°C
Storage: -30° to +55°C
***Weight (aluminum):*** Dry: 26.8 kg (59 lbs)
Wet: 4.8 kg (10.6 lbs)
***Weight (titanium):*** Dry: 40 kg (88 lbs)
Wet: 18 kg (39.6 lbs)

## DISPLAY SPECIFICATIONS

***Screen Size:*** 14 inch Diagonal
***Input:*** SVGA (800x600, 72 Hz)
***Display:*** High Resolution Color
***Power Consumption:*** 62 W

## PROCESSOR SPECIFICATIONS

***Power Requirements:*** 115/230VAC, 50/60Hz, 100W max.
***Data Output:*** Selectable, 300-155.2 Kbaud or Ethernet 10 base T or 10 base 2
***Video Output:*** SVGA (800x600, 72 Hz) or NTSC or PAL video.
***Graphics Colors:*** 256 colors (8-bit)
***Display Mode:*** Sector Format
***Display Arc:*** 150°
***Input Device:*** 3-Button Trackball
***Dimensions:*** 19" rack, 4U high (266x483x434mm HWD)
***Temperature:*** Operating: 0° to +40°C
Storage: -30° to +55°C
***Weight:*** 20 kg (44 lbs)

*SeaBat 8101 Head with Optional Fairings*

## OPTIONS

***Option 033:*** Side Scan Upgrade
***Option 034:*** Mounting Plate Assembly
***Option 035:*** Fairings (pictured above)
***Option 036:*** Spares Kit
***Option 037:*** Titanium Housing
***Option 038:*** 210° Swath
***Option 040:*** Extended-Range Projector
***Option 049:*** Increase Transducer Depth Rating

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032399

Due to our policy of continuous product improvement, specifications are subject to change without notice.

# SeaBat 8111
## PRODUCT SPECIFICATION
### MULTIBEAM ECHOSOUNDER

- **Phase and amplitude bottom detection**
- **100 kHz frequency**
- **150° swath coverage**
- **Real-time quality control**
- **Sidescan upgradeable**
- **Modular and portable**
- **Pitch stabilization**

The SeaBat 8111 is a modular multibeam echosounder system operating at 100 kHz. When installed on a vessel, it produces high-density, high-accuracy soundings on the seafloor over a 150° swath. Major system components include a transducer array, a transceiver unit, and a processor unit.

The SeaBat 8111 transducer array is comprised of a cylindrical receive array and a linear transmitter array, mounted together on a support cradle that provides mounting points to the vessel. Lightweight and portable, the array can be installed temporarily over the side of a vessel of opportunity—a first for a system in this frequency range.

The SeaBat 8111 transceiver features plug-in cards for easy maintenance and is controlled from the sonar processor.

The Seabat 8111 processor is compatible with other SeaBat sonar heads, can be updated in minutes to accommodate future requirements, and features a user-friendly point-and-click interface.

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# SeaBat 8111 SYSTEM SPECIFICATIONS

## SYSTEM PERFORMANCE

| | |
|---|---|
| ***Frequency:*** | 100 kHz |
| ***Range Resolution:*** | 3.7 cm |
| ***Swath Coverage:*** | 150º |
| ***Range:*** | 3m to 1200m (with Option 040) |
| ***Number of Beams:*** | 101 |
| ***Along-Track Beamwidth:*** | 1.5º 3.0º 4.5º 6.0º* |
| ***Across-Track Beamwidth:*** | 1.5º |
| ***Stabilization:*** | Pitch stabilization within +/-15º |
| ***Projector Beam Control:*** | External motion sensor required |
| ***Accuracy:*** | IHO Compliant |
| ***Operational Speed:*** | Up to 20 knots |
| ***Max. Update Rate:*** | 35 Hz |
| ***Transducer Pressure Rating:*** | 100m |

*operator selectable

## INTERFACE

| | |
|---|---|
| ***System Supply:*** | 90 to 260VAC, 50/60 Hz, 200W max. |
| ***Video Display:*** | SVGA, 800 x 600, 72 Hz |
| ***System Control:*** | Trackball or from Ethernet |
| ***Data Output:*** | 10 MB Ethernet or serial RS232C |
| ***Data Uplink:*** | High-speed digital coax with fiber-optic option |
| ***Temperature:*** | Operating: 0° to +40° C<br>Storage: -30° to +55° C |

## RELATED PRODUCTS

- Option 040 — Extended range capabilities
- Option 033 — Sidescan upgrade
- Option 051 — 24DC power supply for SeaBat 81-P Processor

## MECHANICAL INTERFACE

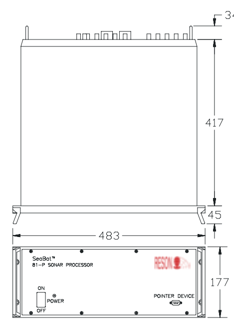
***Dimensions (in mm):***

| | |
|---|---|
| ***Transducer Array:*** | |
| ***Hydrophone:*** | 636 x 118 (Dia./Length) |
| ***Projector:*** | 113 x 650 (Dia./Length) |
| ***Processor:*** | 177 x 483 x 417 |
| ***Transceiver:*** | 267 x 483 x 489 |

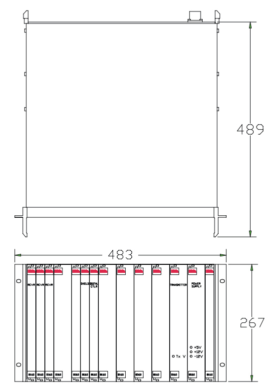
***Weight:***

| | |
|---|---|
| ***Transducer Array:*** | 72 kg (dry) / 59 kg (wet) with cables |
| ***Processor:*** | 20 kg |
| ***Transceiver:*** | 13.6 kg |

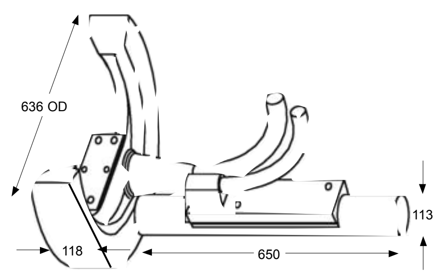
***Cable Length:*** 15m




**Processor**




**Transceiver**




**Transducer Array**

## SEAFLOOR COVERAGE

**(with Extended Range option)**

| Bottom Depth (meters) | Swath Width (meters) |
|---|---|
| 5 to 150 | Up to 1110 (7.4 x water depth) |
| 300 | 960 (3.2 x water depth) |
| 450 | 810 (1.8 x water depth) |
| 600 | 600 (1.0 x water depth) |
| 750 | 450 (0.6 x water depth) |
| 900 | 360 (0.4 x water depth) |

RESON

Version: B006 030205

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RESON reserves the right change specifications without notice.

# SeaBat 8160

## PRODUCT SPECIFICATION

### MULTIBEAM ECHOSOUNDER SYSTEM

- **Swath coverage greater than 4x water depth**
- **Operational depth: 10m to 3000m**
- **50 kHz frequency**
- **126 beams**
- **Hull-mount or portable**
- **Meets IHO accuracy**
- **Sidescan upgradable**

The SeaBat 8160 is a new addition to the 8100 series of multibeam echosounders. Operating at 50 kHz, the system ensonifies the whole swath in a single ping, generating 126 simultaneous high-resolution receive beams.

The SeaBat 8160 transducer array is comprised of a linear receive and transmit array mounted together on a support base. The T-shaped array geometry provides the basis for a compact, high-resolution sonar which is easily installed for portable or hull mounts—a first for a high-resolution system in this frequency range.

The system features a pitch-stabilized transmitter and an active roll-compensated receiver.

The SeaBat 8160 processor is compatible with other SeaBat sonar heads. It can be updated in minutes to accommodate future requirements, and features a user-friendly point-and-click interface.

RESON

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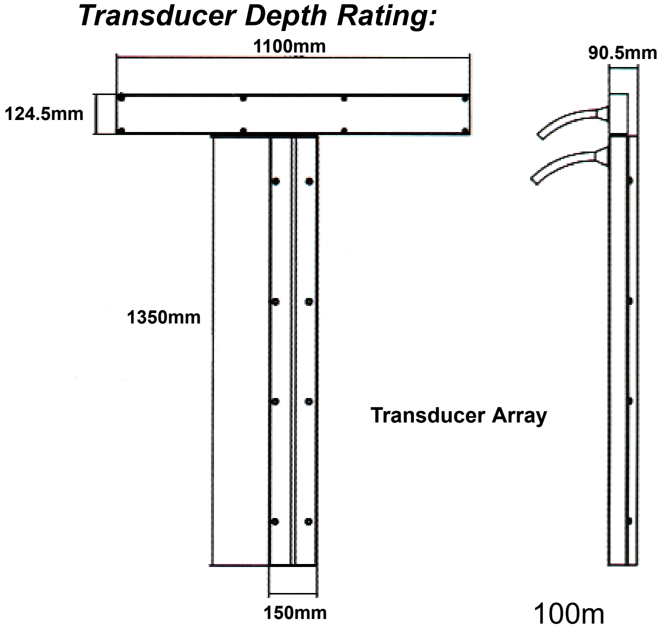
Email: reson@reson-gmbh.de

www.reson.com

# SeaBat 8160 SYSTEM SPECIFICATIONS

## SYSTEM PERFORMANCE

| | |
|---|---|
| ***Frequency:*** | 50 kHz |
| ***Depth Resolution:*** | 2.4 cm / 9.6 cm |
| ***Swath Coverage:*** | Greater than 4x water depth |
| ***Max Operational Depth:*** | 3000 m |
| ***Number of Beams:*** | 126 |
| ***Along-Track Beamwidth:*** | 1.5º |
| ***Across-Track Beamwidth:*** | 1.5º |
| ***Pitch Stabilization:*** | ±10º |
| ***Accuracy:*** | IHO Special Order |
| ***Operational Speed:*** | Up to 20 knots |
| ***Max. Update Rate:*** | 15 |
| ***Transducer Depth Rating:*** | 100m |




Mounting Frame
Option 034H

## INTERFACE

| | |
|---|---|
| ***System Supply:*** | 115V/230V 50/60 Hz, 350W |
| ***Video Display:*** | SVGA, 800 x 600, 72 Hz |
| ***System Control:*** | Trackball or from Ethernet |
| ***Data Output:*** | 10 MB Ethernet or serial RS232C |
| ***Data Uplink:*** | High-speed digital coax with fiber-optic option |
| ***Temperature:*** | Operating: 0° to +40° C<br>Storage: -30° to +55° C |

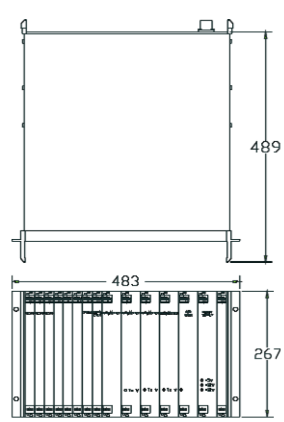
## MECHANICAL INTERFACE

***Dimensions (HWD in mm):***

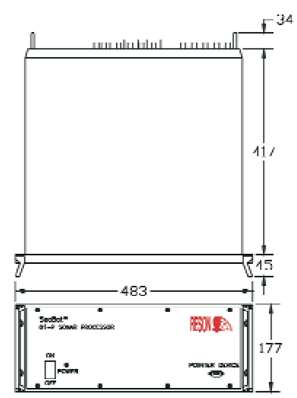
| | |
|---|---|
| ***Transducer Array:*** | 1474.5 x 1100 x 90.5 |
| ***Processor:*** | 177 x 483 x 417 |
| ***Transceiver:*** | 265 x 483 x 492 |

***Weight:***

| | |
|---|---|
| ***Transducer Array:*** | 50 kg (dry) / 30 kg (wet) |
| ***Processor:*** | 20 kg |
| ***Transceiver:*** | 13.6 kg |




Transceiver




Processor

RESON

Version: B34-PDF-011009
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RESON reserves the right change specifications without notice.

ODOM

# ECHOTRAC CVM™

odom
HYDROGRAPHIC SYSTEMS


## MOBILE HYDROGRAPHIC SYSTEM

- Portable carry-on case style includes a single or dual frequency echo sounder with optional DGPS receiver, notebook PC and bundled data acquisition software.
- Features include Ethernet LAN interface, frequency agile configurable transceivers, standard serial interfaces for data acquisition systems, motion sensors and DGPS receivers.

ODOM

# ECHOTRAC CVM™

The rugged and weatherproof **Echotrac CVM™** outperforms other echo sounders in its class, offering the utmost in portability without sacrificing Odom performance standards.

With dual or single frequency configurations, optional built-in DGPS and bundled notebook PC and your choice of data acquisition software, the **CVM™** has everything you need in an echo sounder – even when portability isn't an issue.

***Buy Odom – invest in your peace of mind.***

## SPECIFICATIONS

**Frequency**
- High band: 100 kHz – 340 kHz
- Low band: 24 kHz – 50 kHz

**Output Power**
- High: 200 kHz – 400 W RMS max
- Low: 33 kHz – 200 W RMS max

Input Power
- 12 to 24 V DC (nominal) 15 watts
- 110 or 220 V AC

**Resolution**
- 0.01 m/0.1 ft

**Accuracy**
- 0.01 m / 0.10 ft +/- 0.1% of depth @ 200 kHz
- 0.10 m / 0.30 ft +/- 0.1% of depth @ 33 kHz

**Depth Range**
- 0.2 – 200 m / 0.5 – 600 ft. @ 200 kHz
- 0.5 – 600 m / 1.5 – 1968 ft. @ 200 kHz

**Phasing**
- Automatic scale change, 10%, 20%, 30% overlap or manual

**Sound Velocity**
- 1370 – 1700 m/s
- Resolution 1 m/s

**Transducer Draft Setting**
- 0 – 15 m (0 – 50 ft)

**Depth Display**
- On control PC

**Clock**
- Internal battery backed time, elapsed time and date clock

**Annotation**
- Internal – date, time, GPS position
- External – from RS232 or Ethernet

**Interfaces**
- 2 x RS232
- Inputs from external computer, motion sensor, sound velocity
- Outputs to external computer
- Ethernet interface
- Heave – TSS and sounder sentence

**Blanking**
- 0 to full scale

**Software**
- Echotrac Control software
- ChartView display and logging software

**Help**
- The function of each parameter and its minimum and maximum values can be displayed.

**Environmental Operating Conditions**
- 0° – 50° C, 5 – 90% relative humidity, non-condensing

**Dimensions**
- 53 cm (20.75 in) W x 44 cm (17.25 in) D x 21.5 cm (8.5 in) H

**Weight**
- 13.8 kg (31 lbs)

**Options**
- One or two acoustic channels
- Side scan transducer – single or dual channel side looking 200 kHz or 340 kHz for search and reconnaissance
- Built-in DGPS
- Ruggedized notebook PC bundled with data aquisition software

odom
HYDROGRAPHIC SYSTEMS

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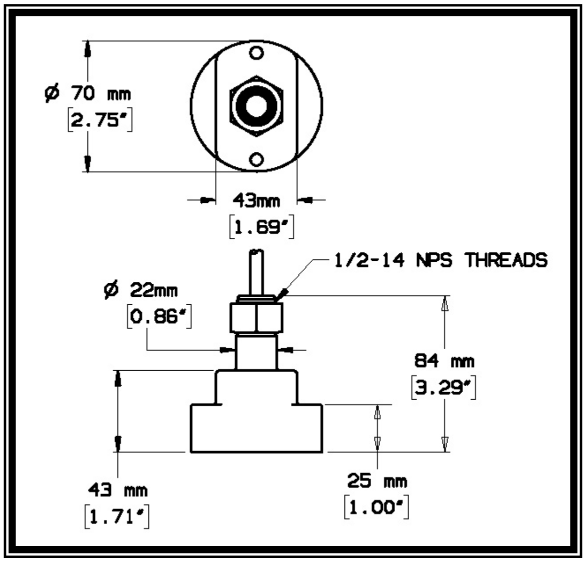
E-mail: email@odomhydrographic.com
www.odomhydrographic.com

odomhydrographic.com

Odom Hydrographic Systems, Inc.
1450 Seaboard Avenue
Baton Rouge, LA. 70810 –6261
225.769.3051, Facsimile 225.766.5122

# SMBB200-9




## Performance Data

| | |
|---|---|
| Frequency | 200kHz - BClq |
| Beam Width | 9° |
| Q (transmit) | 2.5 |
| Rated RMS Power | 500 W |
| Balanced Impedance | 60 ohms |
| Peak Figure of Merit | -16 |
| Bandwidth | |
| Acoustic Window Material | Urethane |
| Threads | ½" –14NPS |
| Cable Type | C33 (2-20 AWG) |
| Cable Size | 6mm |
| Weight | 1.3Kg. |

Broadband with superlow Q of 2.5. Small housing with short stem used primarily for navigation and survey applications. This model is usually mounted on an extension tube but is adaptable to portable survey and navigation systems. It contains a transformer which can be used to match the impedance of the echosounder or allow the use of longer cables. The transducer is available in either a bronze or stainless steel housing. Model SS510 provides good definition in hard bottoms with side lobes.

odomhydrographic.com

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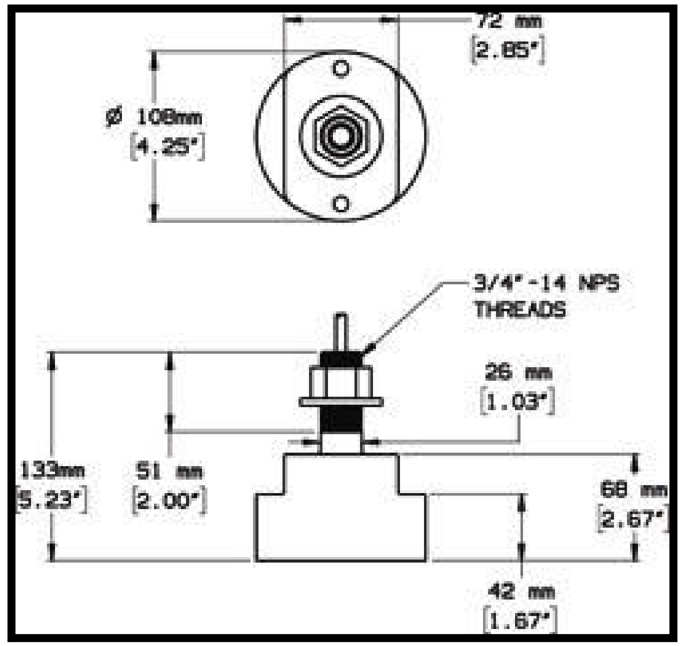
# SMSW200-4a




## Performance Data

| | |
|---|---|
| Frequency | 200kHz |
| Beam Width | 4° |
| Q (transmit) | |
| Rated RMS Power | |
| Balanced Impedance | 60 ohms |
| Peak Figure of Merit | |
| Bandwidth | |
| Acoustic Window Material | Urethane |
| Threads | ¾" –14NPS |
| Cable Type | C37 (2-20 AWG) |
| Cable Size | 6mm |
| Weight | 1.3Kg. |

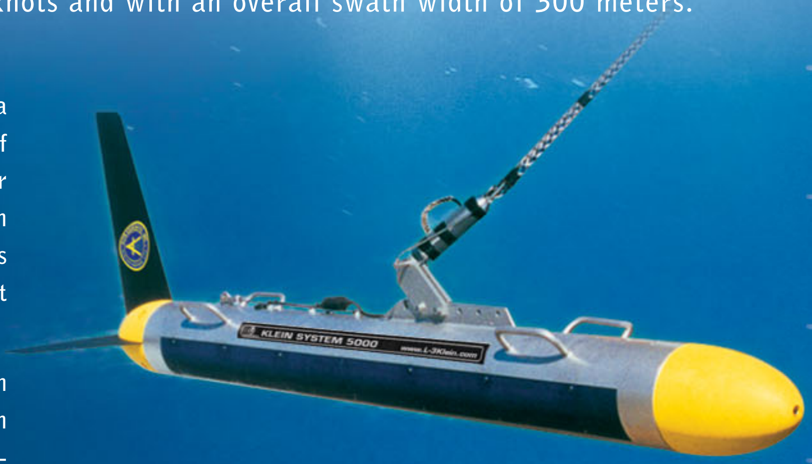
The compact stainless steel housing is easily adapted to portable or hull mounted applications.  This unit is primarily used for shallow and mid-depth survey applications where delineation of steep slopes and sounding in very shallow water are important features. It contains a transformer that matches the impedance of the transducer to that of the echo sounder and allows for the use of longer cables without affecting performance.

Klein Associates, Inc.

# KLEIN SYSTEM 5000

## HIGH-RESOLUTION, DYNAMICALLY FOCUSED, MULTI-BEAM SIDE SCAN SONAR

The System 5000 is a 5-beam side scan sonar designed for hydrographic, military and commercial applications requiring high-resolution images of the sea floor and bottom obstructions, while operating at tow speeds up to 10 knots and with an overall swath width of 300 meters.




Conventional side scan sonar systems use a single sonar beam per side to generate an image of the seafloor. The physics of this type of sonar results in degradation of image resolution with range poor along track resolution, and requires speeds of 5 knots or less to insure 100 percent bottom coverage.

From a design perspective, these shortcomings can be eliminated by designing a sonar that, through beam steering and focusing techniques, simultaneously generates several adjacent, parallel beams per side. Such a multi-beam design approach permits higher towing speeds with 100 percent bottom coverage, while providing high-resolution imaging to the maximum range of the sonar.

This design approach is principally employed by military side scan sonar systems designed for high speed mine hunting applications. L-3 Klein is the first commercial company to offer a multi-beam side scan sonar using similar design techniques to military sonars, but at a fraction of the cost.

The two main benefits of the high-speed, high- resolution System 5000 series are: higher towing speeds with no loss of bottom coverage, and range independent high-resolution image capability.

Since operation costs are dependent on the amount of at-sea time required to complete a survey, the Klein System 5000 Multi-Beam Side Scan Sonar with survey speeds more than twice that of conventional side scan sonars, minimize at-sea time, thus greatly reducing survey costs.

### KEY FEATURES

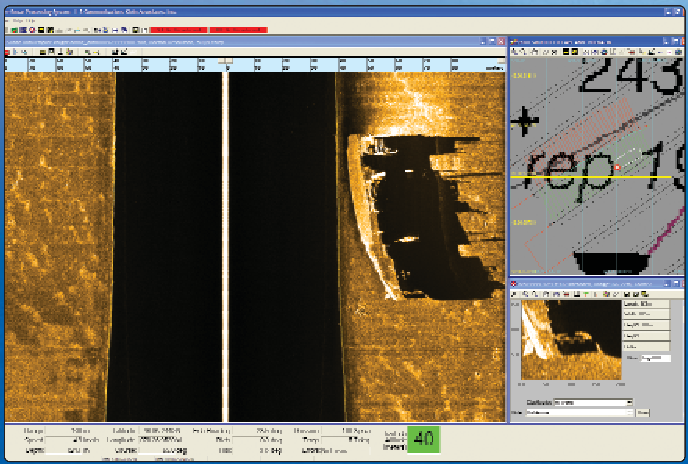
- Multiple simultaneous beams per side each ping
- High tow speed capability
- Dynamic digital auto-focusing
- Very high resolution and 100% coverage
- Sonar connected to PC display on Ethernet LAN

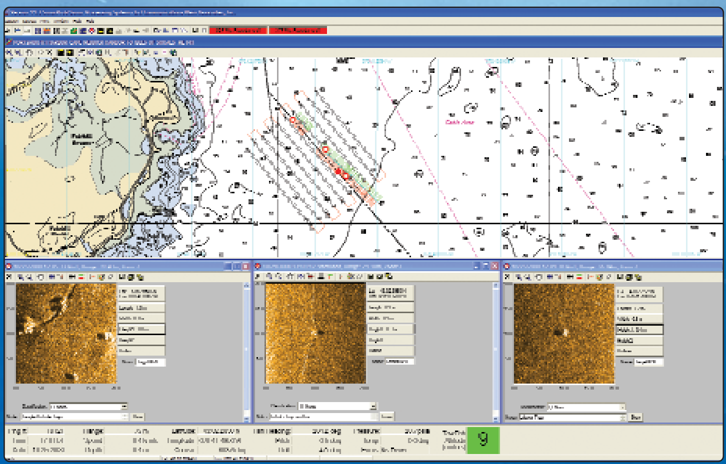
**THE DIFFERENCE IS IN THE IMAGE**

# Klein Associates, Inc.

# KLEIN SYSTEM 5000

## HIGH-RESOLUTION, DYNAMICALLY FOCUSED, MULTI-BEAM SIDE SCAN SONAR





| *Towfish Specifications* | |
|---|---|
| Number of beams | 5 port & 5 starboard |
| Frequency | 455 kHz ± 1% |
| Range scales | 50, 75, 100, 150 m |
| Pulse length | 50 to 200 μsec. |
| High-resolution mode (along track) | 10 cm to 38 m |
| Standard resolution mode (along track) | 20 cm to 75 m, thereafter increasing to maximum of 36 cm @ 150 m maximum range |
| Resolution (across track) | 7.5 to 30 cm |
| Operating speed envelope | 2-10 knots @ 150 m sonar range |
| Sonar digitization | 16 bit / channel |
| Maximum operating range | 150 m (300 m Swath) |
| Array length | 120 cm (47.2 in) |
| Body length | 194 cm (76.4 in) |
| Body diameter | 15.2 cm (6 in) |
| Weight (in air) | 70 kg (155 lbs) |
| Sensors:<br>Heading<br>Pitch & roll | <br>Standard<br>Standard |
| Pressure / altimeter | Standard |
| Depth rating* | 200 m standard |

| *Options* |
|---|
| Yaw rate and high-resolution roll sensors |
| Responder / transponder |
| Splash-proof TPU housing |
| Fiber optic interface |

* For deeper depth rated systems, please contact Klein

| *Transceiver Processor Unit (TPU) Specifications* | |
|---|---|
| Width | Standard 19-in rack-mount |
| Height | 13.2 cm (5.2 in) |
| Depth | 54.6 cm (21.5 in) |
| Weight | 12.7 kg (28 lbs) |
| Input voltage | 115/240 VAC, 50/60 Hz |
| Power | 120 W (includes towfish) |
| Navigation input | NMEA 0183 |
| Data output | 100 BaseT Ethernet LAN |

| *Tow Cable* | |
|---|---|
| Type: steel | Coaxial or fiber-optic double armored |

| *Workstation PC* | |
|---|---|
| Workstation PC<br>SonarPro® installed<br>Windows OS installed | Optional, with SonarPro software installed |

**Klein Associates, Inc.**

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Salem, NH 03079-1249 USA

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L-3 communications
Klein Associates, Inc.

**L-3.** Headquartered in New York City, L-3 Communications employs over 64,000 people worldwide and is a prime contractor in aircraft modernization and maintenance, $C^3$ISR (Command, Control, Communications, Intelligence, Surveillance and Reconnaissance) systems and government services. L-3 is also a leading provider of high technology products, subsystems and systems.

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POS MV™ marine vessels

# DATASHEET

## *The New POS MV - Providing the Marine Industry with robust, reliable, and repeatable position and orientation solutions*

**The new POS MV V4 - a tightly-coupled system utilizing advanced Inertially-Aided Real-Time Kinematic (IARTK) technology designed to increase your operational capability and reduce downtime.**

**Tightly integrated inertial navigation** – Continuous positioning data can be generated while surveying in areas where GPS reception is compromised by multipath effect and signal loss, such as close to offshore structures, or in ports, harbors, near-shore coastal waters and rivers. Raw GPS data from as few as one satellite can now be processed directly within the POS MV reducing position drift and RTK re-acquisition time.

## The V4 Advantage

**The Major Benefits**

- Faster, more robust heading aiding from GPS Azimuth Measurement Subsystem (GAMS) when compared to V3
- Proprietary Inertially Aided RTK providing almost instantaneous reacquisition of RTK following a GPS outage
- Superior low elevation tracking performance using lighter, smaller Trimble Zephyr ™ geodetic antenna technology
- Faster initial system calibration
- Maintains heading accuracy longer when in a high multipath environment
- Increased component reliability
- Automatic identification and error estimation for lever arm distances and angles

**The Latest Technology**

**V4 uses the latest Trimble BD950 receivers with the following attributes:**

- Extremely fast response time
- Latency of less than 20 milliseconds (at 20 times per second)
- Very low noise L1 and L2 carrier phase measurements
- Uses the Maxwell 4 Custom Survey GPS chip for enhanced tracking capability

**Straightforward Installation and Operation**

- All components mounted and installed using a straightforward, one-time-only, systematic procedure.

**Faster, More Reliable Networking Potential**

- An improved Ethernet raw data logging capability for streamlined data acquisition of all motion variables with microsecond-accurate time stamping

**Upgradeability***

- Convenient upgrade program for PCS and antennas, to allow for maximum interoperability when moving from L1 only to a full L1/L2 RTK unit

**The Most Accurate Position and Orientation Solution**

POS MV V4 maintains positioning accuracy under the most demanding conditions regardless of vessel dynamics. With its high data update rate, the system delivers a full six degree-of-freedom position and orientation solution to provide the following:

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

** For detailed upgrade information please call your Applanix Marine office*


## SYSTEM COMPONENTS

**POS Computer System (PCS)** – A rugged, compact computer system contains the core POS processor and IMU interface electronics, plus two GPS receivers and an optional removable PC-card disk drive. The PCS provides system timing, position and velocity aiding, together with GPS raw observables for use with GAMS.

**POS Inertial Measurement Unit** – The system's primary sensor allows for the continuous output of position and orientation data.

**Primary GPS Receiver Antenna** – A dual frequency antenna for use with GAMS.

**Secondary GPS Receiver Antenna** – A dual frequency antenna for use with GAMS.

APPLANIX™
A TRIMBLE COMPANY

**POS MV™ marine vessels**

# SPECIFICATIONS

## Accuracy

### POS MV 320 Main Specifications (with Differential Corrections)

| | |
|---|---|
| Roll, Pitch accuracy: | 0.02° (1 sigma with GPS or DGPS) |
| | 0.01° (1 sigma with RTK) |
| Heave Accuracy: | 5 cm or 5% (whichever is greater) for periods of 20 seconds or less |
| Heading Accuracy: | 0.02° (1 sigma) with 2 m antenna baseline, 0.01 (1 sigma) with 4 m baseline |
| Position Accuracy: | 0.5 - 2 m (1 sigma) depending on quality of differential corrections |
| | 0.02 - 0.10 m (RTK) with input from auxiliary RTK or optional internal RTK receiver |
| Velocity Accuracy: | 0.03 m/s horizontal |

### POS MV 320 during GPS Outages

| | |
|---|---|
| Roll, Pitch accuracy: | 0.02° (1 sigma) |
| Heave accuracy: | 5 cm or 5% (whichever is greater) for wave periods of 18s or less |
| Heading accuracy: | Drift less than 1° per hour (negligible for outages < 60s) |
| Position accuracy degradation: | 2.5 m (1 sigma) for 30 s outages<br><6 m (1 sigma) for 60 s outages |

### POS MV 220 Main Specifications (with Differential Corrections)

| | |
|---|---|
| Roll, Pitch accuracy: | 0.05° (1 sigma with GPS or DGPS) |
| | <0.05° (1 sigma with RTK) |
| Heave Accuracy: | 5 cm or 5% (whichever is greater) for periods of 20 seconds or less |
| Heading Accuracy: | 0.1° (1 sigma) with 2 m antenna baseline, 0.05° (1 sigma) with 4 m baseline |
| Position Accuracy: | 0.5 - 4 m (1 sigma) depending on quality of differential corrections |
| | 0.02 – 0.10 m (RTK) with input from auxiliary RTK or optional internal RTK receiver |
| Velocity Accuracy: | 0.05 m/s horizontal DPGS, .03 m/s horizontal RTK |

### POS MV 220 during GPS Outages

| | |
|---|---|
| Roll, Pitch accuracy: | 0.05° (1 sigma) |
| Heave accuracy: | 5 cm or 5% (whichever is greater) for wave periods of 18s or less |
| Heading accuracy: | Drift less than 3° per hour (negligible for outages < 60s) |
| Position accuracy degradation: | 2.5 m (1 sigma) for 30 s outages<br><6 m (1 sigma) for 60 s outages |

## Physical Characteristics

### Size

| | | |
|---|---|---|
| IMU: | 204 mm X 204 mm X 168 mm | 7.95 in X 7.95 in X 6.55 in |
| PCS: | 432 mm X 89 mm X 356 mm | 17.00 in X3.50 in X 14.05 in |
| | 2.0U 19 in rack mount | |
| GPS Antenna (x2): | 187 mm X 53 mm | 7.4 in X 2.1 in |

### Weight

| | | |
|---|---|---|
| IMU: | 3.5 kg | 7.7 lb (international) |
| Processor: | 5 kg | 11.0 lb (international) |
| GPS Antenna: | <0.5 kg | <1.1 lb (international) |

### Power

| | |
|---|---|
| Processor: | 110/230 Vac, 50/60 Hz, auto-switching 80 Watt |
| IMU: | Power provided by PCS |
| GPS Antennas: | Power provided by PCS |

## Environmental

### Temperature Range (Operating)

| | | |
|---|---|---|
| IMU: | -40 °C to +60 °C | -40 °F to +140 °F |
| Processor: | 0 °C to +55 °C | +32 °F to +131 °F |
| GPS Antenna: | -40 °C to +70 °C | -40 °F to +158 °F |

### Temperature Range (storage)

| | | |
|---|---|---|
| IMU: | -40 °C to +60 °C | -40 °F to +140 °F |
| Processor: | -25 °C to +85 °C | -13 °F to +185 °F |
| GPS Antenna: | -50 °C to +70 °C | -58 °F to +158 °F |

### Humidity

| | |
|---|---|
| IMU: | 10 - 80% RH, Ingress Protection of 65 |
| Processor: | 10 - 80% RH, non-condensing |
| GPS Antenna: | 0 - 100% RH |

### Shock & Vibration (IMU)

| | |
|---|---|
| Operating: | 90 g, 6 ms terminal saw tooth |
| Non-Operating: | 220 g, 5 ms half-sine |

## Applanix Marine Offices

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Canada L4B-3B3

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APPLANIX
A TRIMBLE COMPANY
17461 Village Green Drive, Houston TX 77040
Tel: 713-896-9900 Fax: 713-896-9919

# REPAIR REPORT

**TO:** NOAA- Ship Fairweather
1801 Fairview Ave E.
Seattle, WA 98102

**RMA #:** **L07-024**

**Date:** 15 January, 2008

**Repaired By:** Bruce A. Francis

**TEL:** 713-896-9900

**ATTN:** Larry Loewen
**TEL:**
**FAX:**

| PART NO. | DESCRIPTION | SERIAL NUMBER |
|---|---|---|
| PCS-29 | POSMV 320 V4 | 2560 |
| PCS-29 | POSMV 320 V4 | 2564 |

| ORIGINAL COMPLAINT / FAULT DESCRIPTION / VERIFICATION |
|---|
| IMU errors, GPS data gaps. |

| ITEM | REPAIR DETAILS |
|---|---|
| 1 | We were able to reproduce problems with both PCS units in the shop- intermittant IMU failures. |
| 2 | Found resistor R9 on the power supply board not soldered correctly. This has been identified as a fault in POS systems and have confirmed that these serial numbered units did received the faulty batch of power supplies with this problem. |
| 3 | Resoldered R9 and retested both systems on the bench for a number of days. No faults observed. |
| 4 | Installed latest firmware version 3.42 on both units whereas the previous version was 3.41. Version 3.42 adds ASCII IP address output to COM5 at bootup only to identify setting should it get changed by previous user. |
| 5 | |
| 6 | |
| 7 | |
| 8 | |
| 9 | |
| | Please verify all settings before use |

| ITEM | QTY | MATERIAL | |
|---|---|---|---|
| 1 | 16hrs | Labor | N/C |
| | | | |
| | | | |

| ADDITIONAL INFORMATION & COMMENTS |
|---|
| As this issue with R9 was of our own making, there is no charge for this repair. |


# MBX-3S

## The most popular commercial-grade Coast Guard Beacon Receiver

- Dual-channel Coast Guard beacon receiver
- Supplements GPS systems with free differential corrections, enhancing accuracy
- Fast signal acquisition
- Wide input voltage range for a variety of power sources
- Low power consumption extends battery life
- Automatic tuning mode for hands-free operation
- Integrated signal splitter outputs GPS signal from combined GPS /differential antennas
- Front-panel interface for easy configuration and status monitoring

ESRI Technology
AUTHORIZED BUSINESS PARTNER

csi wireless™
www.csi-wireless.com

# MBX-3S

The most popular commercial-grade DGPS Beacon Receiver

## Receiver Specifications

| | |
|---|---|
| **Channels:** | 2 independent channels |
| **Channel Spacing:** | 500 Hz |
| **Frequency Range:** | 283.5 to 325.0 Hz |
| **MSK Bit Rates:** | 50, 100, 200 bps |
| **Cold Start Time:** | <1 min |
| **Warm Start Time:** | <2 seconds |
| **Demodulation:** | Minimum shift keying |
| **Sensitivity:** | 2.5 µV/m for 6 dB SNR |
| **Dynamic Range:** | 100 dB |
| **Frequency Offset:** | ±8 Hz (27 ppm) |
| **Adjacent Channel Rejection:** | 61 dB $f_o$ ± 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 |
| **Storage Temperature:** | -40°C to +80°C |
| **Humidity:** | 95% non-condensing |
| **EMC:** | EN 60945<br>EN 50081-1<br>EN 50082-1<br>FCC: Part 15, sub-part J, class A digital device |

## Power Specifications

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

## Mechanical Specifications

| | |
|---|---|
| **Dimensions:** | 150 mm L x 125 mm W x 51 mm H<br>(5.9" L x 4.9" W x 2.0" H) |
| **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 |

## Operating Modes

| | |
|---|---|
| **MBX-3 Mode (Default):** | RTCM SC-104 correction and NMEA status message output (Default Mode) |
| **MBX-E Mode:** | RTCM SC-104 correction and NMEA status message output and GPS NMEA message input for position and satellite status display |

## NMEA 0183 I/O

- Receiver Automatic 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)

## Accessories

| | |
|---|---|
| **Antenna:** | Various |
| **Power Cables:** | Various |
| **Antenna Cables:** | Various |
| **Data Cables:** | Various |
| **CSI Beacon Command Center:** | MS Windows 95® beacon control software |

## Pin-out

**RS, 232C (DB9 PIN#)**

| | |
|---|---|
| Pin 2 | TXD, RTCM SC-104/Status Output |
| Pin 3 | RXD, configuration input |
| Pin 5 | Signal return |

**RS-422 (DB9 PIN#)**

| | |
|---|---|
| Pin 1 | TXD +, RTCM SC-104 / Status Output |
| Pin 2 | TXD -, RTCM SC-104 / Status Output |
| Pin 4 | RXD -, configuration input |
| Pin 5 | Signal return |
| Pin 7 | RXD +, configuration input |

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Warranty: Each CSI Wireless product is covered by a limited one-year warranty on parts and labor.

CSI Wireless Dealer

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# SF-2050G
# SF-2050M

gps products

NavCom's SF-2050G and SF-2050M modular StarFire™ receivers provide instant position information for decimeter-level position accuracy, anywhere in the world, anytime. Onboard memory, and a geodetic quality antenna enable millimeter level accuracy from post-processing.

## APPLICATIONS

The rugged and reliable SF-2050 series is designed for productivity with minimal setup time. The SF-2050G is designed for backpack GIS and mapping applications while the SF-2050M is ideal for vehicle mounting to suit a wide variety of machine guidance and control applications. The primary operating mode uses the StarFire™ service, and offers decimeter level accuracy for immediate results in the field; great for navigation and relocation of existing assets. The two onboard WAAS/EGNOS channels provide free GPS corrections, which coupled with dual frequency measurements and NavCom's enhanced SBAS algorithm typically provides half-meter real-time accuracy. Simply connect your controller solution to the serial port and receive NMEA format position information, or use a NavCom Partner controller solution for additional configuration and monitoring capabilities.

## BENEFITS

The SF-2050 receivers use our NCT-2100D GPS Engine, the fourth generation of the Touchstone™ ASIC family, of which more than 25,000 are in use worldwide. This incorporates our patented interference suppression and multi-path mitigation, up to 50Hz raw data rate, geodetic quality measurements, and up to 25Hz positioning.

The SF-2050 utilizes a compact tri-band antenna capable of receiving GPS and StarFire signals. This antenna provides excellent phase center stability in a small, robust, lightweight format.

Coupled with NavCom Technology's StarFire subscription service, the SF-2050 delivers 10 cm position fixes without the use of a second receiver serving as a base station. Add the RTK option to your SF-2050, and an external radio capable of receiving RTK corrections from a Base station, and now your SF-2050 is able to do RTK level surveys for unsurpassed accuracy.

## FLEXIBLE INTERFACE

The SF-2050 receivers are easily configured by the provided Windows®-based utility program. For system integrators needing maximum flexibility, the receivers offer a binary user interface that allows for complete command and control of the GPS and L-Band Module, thus enabling customization of the interface and receiver operation. The sensor can receive GPS corrections in NCT (NavCom's ultra compact binary format), RTCM and CMR thus permitting optimum correction source usage with seamless position output.

## FEATURES

- Fully integrated receiver in robust housing
- "All-in-view" tracking on 26 channels (12 L1/L2 GPS + 2 SBAS)
- Global decimeter level accuracy using StarFire™ corrections
- Fully automatic acquisition of StarFire broadcast corrections
- Two dedicated WAAS/EGNOS channels
- L1 & L2 full wavelength carrier phase tracking
- C/A, P1 & P2 code tracking
- 64MB internal memory for data recording
- User programmable measurement and navigation data rates
- Minimal data latency
- Superior interference suppression
- Patented multipath rejection
- Output format NMEA 0183 or NavCom binary format
- CAN bus interface (SF-2050M Only)
- 1PPS Output (SF-2050M Only)
- Event Marker (SF-2050M Only)
- TruBlu™ Wireless Connectivity, Bluetooth® compatible

## UPGRADES

- Raw measurement data rates up to 50Hz
- Positioning rates up to 25Hz
- RTK positioning rates up to 25Hz (external comm-link required)
- RTK Extend™ - RTK positioning during comm. outages

**Modular GPS and StarFire™ receiver provides worldwide decimeter level accuracy anywhere, anytime**

NAVCOM
A John Deere Company

www.navcomtech.com

**20780 Madrona Avenue, Torrance, CA 90503 • tel: + 1 310.381.2000 • fax: + 1 310.381.2001 • sales@navcomtech.com**

# SF-2050 Series
## TECHNICAL SPECS

### PHYSICAL/ENVIRONMENTAL

- Size (L x W x H): ..............................8.18in x 5.67in x 3.06in (208mm x 144mm x 78mm)
- Weight: ..........................................................4lbs (1.81 kg)
- External Power:
  Input Voltage: .......................................10 VDC to 30 VDC
  Consumption: ............................................................< 8 W
- Connectors:
  I/O: ..............................................................2 x 7 pin Lemo
  DC Power: ........................................................4 pin Lemo
  GPS Antenna: ..........................................................TNC-F
  CAN bus + Event: .................5 pin Lemo (SF-2050M Only)
  1PPS Output: ...................................BNC (SF-2050M Only)
- Temperature (ambient):
  Operating: ...........................-40° to +55°C (-40° to +131°F)
  Storage: ...............................-40° to +85°C (-40° to +185°F)
- Humidity: ............................................95% non-condensing
- Tested in accordance with MIL-STD-810F for: low pressure, solar radiation, rain, humidity, salt fog, sand & dust, and vibration

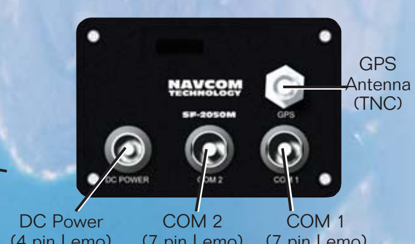
### PERFORMANCE [1]

- Measurement Precision (RMS):
  Raw C/A code: .....................................20 cm @ 42 dB-Hz
  Raw carrier phase noise: .............L1: 0.95 mm @ 42 dB-Hz
  L2: 0.85 mm @ 42 dB-Hz
- Velocity: ................................................................0.01 m/s
- Real-time StarFire Accuracy (RMS):
  Position (H): .........................................................<10 cm
  Position (V): ..........................................................<15cm
- Enhanced SBAS (WAAS/EGNOS) Positioning Accuracy:
  Horizontal: ..................................................................0.5m
  Vertical: ......................................................................0.7m
- Code Differential GPS Positioning <200kms (RMS):
  Horizontal: ....................................................12 cm + 2ppm
  Vertical: ........................................................25 cm + 2ppm
- RTK Positioning <10kms (Software option) (RMS):
  Horizontal: ....................................................1 cm + 1ppm
  Vertical: ........................................................2 cm + 1ppm
- RTK Extend (Software option) (RMS):
  Horizontal: ....................................................2 cm + 1ppm
  Vertical: ........................................................4 cm + 1ppm
- User programmable output rates:
  Position Velocity Time: .............5 Hz (10Hz, 25Hz Optional)
  Raw measurement data: ..5 Hz (10Hz, 25Hz, 50Hz Optional)
- Data Latency:
  Position Velocity Time: ..........................< 20 ms at all rates
  Raw measurement data: .......................< 20 ms at all rates
- Time-to-first-fix:
  Cold Start, Satellite Acquisition: ........< 60 seconds (typical)
  Satellite Reacquisition: ..................................... < 1 second
- Dynamics: (Speed & Altitude restricted by export laws)
  Acceleration: .........................................................up to 6g
  Speed: ..........................................< 1,000 knots (515 m/s)
  Altitude: ..............................................< 60,000 ft (18.3km)
- 1PPS Resolution: ...........................12.5ns relative accuracy (SF-2050M Only)

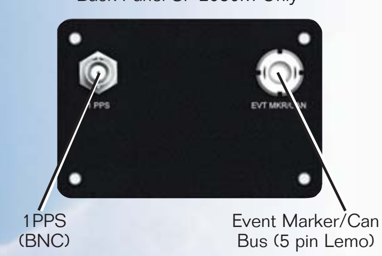
[1] *Performance dependent on location, satellite geometry, atmospheric conditions and GPS corrections.*

### COMMUNICATIONS

- Messages:
  Data/Control: ..................................NCT Binary Messages
  NMEA: .........................ALM, GGA, GLL, GSA, GST, GSV, RMC, VTG, ZDA
- Corrections: ............................RTCM Code (Msg. 1, 3 & 9)
  SBAS (WAAS/EGNOS)
  StarFire™
- RTK Corrections: .......................................NCT Proprietary
  (Optional) RTCM (Msg. 18/19 or 20/21)
  CMR (Msg. 0, 1, 2)
  CMR+

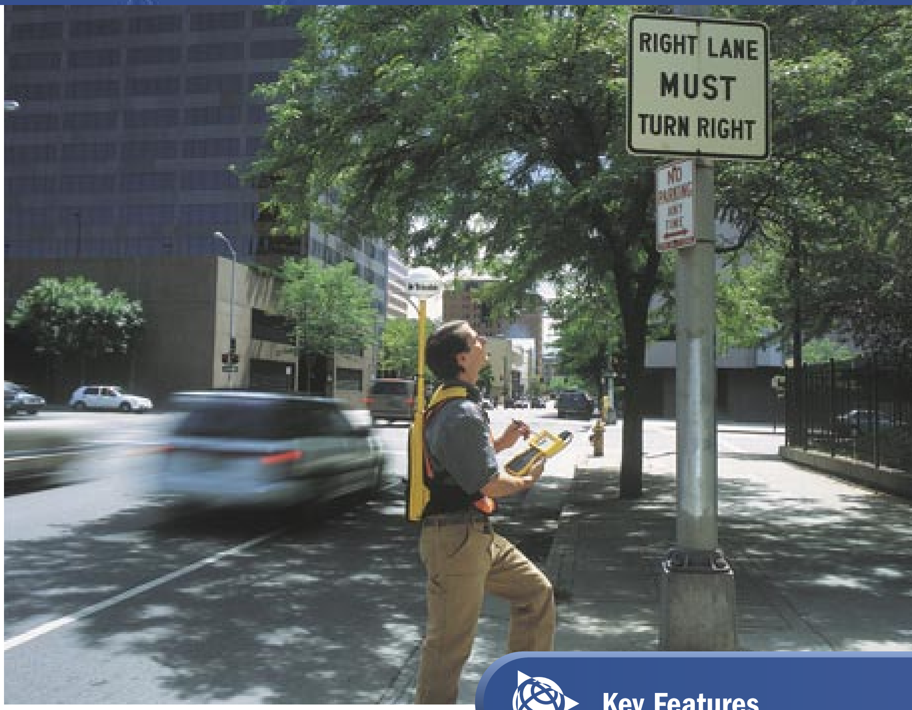




Back Panel SF-2050M Only




Technical specifications are subject to change at NavCom's discretion.
NCT-SF-2050/060119-6

# GPS Pathfinder Pro XRS




## High-performance GPS with a world of real-time options

The versatile GPS Pathfinder® Pro XRS receiver is the thoroughbred of GPS receivers. Offering a full range of accurate real-time correction sources, great performance in all GPS conditions, and rugged design for the toughest environments, the Pro XRS is an essential tool for collecting and maintaining GPS data.

### Built to meet your demands

With the Pro XRS, you don't have to worry whether your GPS receiver can stand up to harsh conditions. All its components are sealed in a robust casing. Waterproof, dustproof, and shock-resistant, the Pro XRS can work anywhere you can.

Just as tough is the custom-designed ergonomic backpack. But it's light and comfortable, so you can wear it all day.

### You're spoiled for real-time choice

If you're navigating in the field, or finding your way back to a previously recorded feature, you've got all the real-time options covered. Corrections from a radiobeacon, a satellite differential service such as OmniSTAR, or a satellite-based augmentation system (SBAS) like WAAS[1] or EGNOS[2] are not just built in, they're seamlessly integrated into the receiver. Want the freedom to connect to an external correction source like a virtual reference station (VRS)? You've got it. This array of real-time sources makes the Pro XRS the most adaptable real-time GPS receiver around.

### High quality, accurate data for your GIS

With the Pro XRS, you can be sure that the data you collect meets your high standards. Offering submeter accuracy in real time, and centimeter-level postprocessed accuracy, it's the obvious choice for collecting the high quality GPS data you need in your GIS. And it has advanced design features, like EVEREST™ multipath rejection technology, to ensure you get only the best positions.

### Get the results you want

The GPS Pathfinder Pro XRS's advanced design gives you complete control over GPS quality. You can focus on productivity, to keep working even in adverse GPS conditions. Or you can configure the receiver to deliver only the most precise positions. It's up to you.

### Flexible data collection options

Pick the field device and software that fits your workflow. The Pro XRS is ready to use with a variety of field computers, including Trimble's own range of handheld computers: the GIS TSCe™ field device, the Trimble® Recon™ handheld, and the GeoExplorer® series.

Choosing software? Try the TerraSync™ software, for a complete solution from the field to the office and back. Choose off-the-shelf GPS field software. Or use the GPS Pathfinder Tools SDK to build your own application that's totally customized to your needs.

### Key Features

- Real-time submeter accuracy
- Integrated satellite, beacon, and WAAS/EGNOS differential receiver
- EVEREST multipath rejection
- Rugged design
- Ergonomic, comfortable backpack system
- Choice of field device and field software

### All you need

You need equipment that's as adaptable and hard-working as you are. So when you're choosing GPS equipment, don't compromise. Get a GPS Pathfinder Pro XRS receiver and have it all.

Trimble®

# Introduction

The GPS Pathfinder Systems receivers calculate very accurate GPS positions on a second-by-second basis. After postprocessed differential correction, the horizontal accuracy of each position for the GPS Pathfinder Pro XR and Pro XRS receivers is better than 50 cm (RMS) + 1 part per million (ppm) times the distance between the base and the rover. For the GPS Pathfinder Power receiver, the horizontal accuracy is submeter (RMS) + 1 ppm. Using real-time corrections, each position can be as accurate as submeter with the GPS Pathfinder Systems, but is subject to a number of operational conditions.

***Note –** RMS means that approximately 63% of the positions are within the specified value.*

# Differential GPS Positioning Techniques

Differential GPS (DGPS) requires two or more receivers. One receiver, called the reference station, is located at a known point to determine the GPS measurement errors and compute corrections to these errors. An unlimited number of mobile GPS Pathfinder Systems receivers, commonly called *rovers*, collect GPS data at unknown locations within the vicinity of the reference station. Errors common at both the reference and rover receivers are corrected with DGPS either in real time or during postprocessing.

***Note –** For more information about GPS and DGPS, review the All About GPS tutorial on the Trimble website at www.trimble.com.*

The GPS Pathfinder Systems receivers, in combination with Trimble controlling software and the GPS Pathfinder Office software, provide three ways of obtaining submeter positions:

- Real-time DGPS
- Postprocessed DGPS
- Postprocessed real-time DGPS

The accuracy figures given in the sections below are obtained under the following conditions:

- Number of satellites used: ≥ 4
- PDOP: ≤ 6
- Signal-to-noise ratio: ≥ 4
- Satellite elevation mask: ≥ 15°
- Reference station receiver is a Trimble GPS Pathfinder Pro XL, Pro XR, Pro XRS, 4700, 4800, 5700, 5800, 4600 LS™, Series 4000 GPS receiver, DSM™, Reference Station, or equivalent.
- Synchronized measurements are logged at the reference station.
- The logging interval for the roving receiver is the same as, or a multiple of, the logging interval at the reference station.
- The reference station uses the correct antenna.

## Real-Time DGPS

When using real-time DGPS, the reference station broadcasts the correction values to the rovers within coverage range, through a transmitter such as a radiobeacon (beacon DGPS) or a satellite (satellite DGPS). The rover applies the corrections to its position in real time.

The positions calculated by the GPS Pathfinder Systems receivers using real-time DGPS are of submeter accuracy + 1 ppm. If you use a provider of real-time DGPS that uses VRS/VBS techniques, there is no degradation associated with distance from the reference station, and the accuracy always stays at the submeter level (RMS).

GPS Pathfinder Systems also supports corrections from satellite-based augmentation systems (SBAS) such as WAAS and EGNOS.

For information on postprocessing GPS data collected with real-time DGPS, see Postprocessed real-time DGPS, page 20.

## Postprocessed DGPS

When real-time DGPS is not available, or is available only part of the time, you have to postprocess the autonomous GPS data in your rover file to obtain the stated accuracy. When using postprocessed DGPS, the reference station stores the correction values in base data files on a computer.

Many reference station owners provide their base data to the community through the Internet or other means of communication. Often this means that you do not have to set up your own reference station for postprocessed DGPS, but can use an existing one. For a list of available reference stations, visit the Trimble website www.trimble.com/trs/findtrs.asp.

## Postprocessed real-time DGPS

Postprocessed DGPS positions are generally more accurate than DGPS positions obtained in real time. If you collect SuperCorrect records as well as GPS positions using Trimble TerraSync or GPScorrect™ software, or applications developed using the GPS Pathfinder Tools SDK, you can use the SuperCorrect option in the GPS Pathfinder Office software to process the data if the accuracy of the real-time DGPS positions is not sufficient, provided that you have access to suitable reference station base files.

The accuracy using postprocessed real-time DGPS is the same as for postprocessed DGPS (see the previous section).

# Factors Affecting Postprocessed DGPS Accuracy

The accuracy that you obtain after data collection depends on several factors, including:

- Number of visible satellites
- Multipath
- Distance between reference station and rover receivers

- Position Dilution of Precision (PDOP)
- Signal-to-noise ratio (SNR)
- Satellite elevations
- Occupation time at a point
- Receiver type at reference station
- Accuracy of the reference station position
- Synchronized measurements are logged at the reference station.
- The logging interval for the roving receiver is the same as, or a multiple of, the logging interval at the reference station.
- The reference station uses the correct antenna.

## Number of visible satellites

Generally, you need a minimum of four satellites to get a good position. If you have five or more satellites, accuracy increases by a small amount. You can obtain positions from only three satellites by supplying a height value manually. However, Trimble recommends that you do not use this method, as an inaccurate height can significantly reduce horizontal accuracy.

***Note –*** *The TerraSync software always uses a minimum of four satellites. You cannot configure this setting.*

When the number of visible satellites drops below the required number, the controlling software stops logging positions and displays the message Too few satellites.

## Multipath

GPS signals are sometimes reflected off nearby objects, particularly metallic objects, creating false or erroneous results. This phenomenon is known as *multipath*. Severe multipath may cause position errors of many meters, while mild multipath may cause small, undetectable errors. For optimal accuracy, collect data in an environment that is free of large reflective surfaces, such as buildings and trees. EVEREST multipath reduction technology in the receiver helps reduce the effects of multipath.

## Distance between reference station and rover

When you postprocess GPS Pathfinder Pro XR and Pro XRS data using the GPS Pathfinder Office software Differential Correction utility, the horizontal accuracy of the positions received is 50 cm (RMS) at a 1 km base line (distance from reference station). For the GPS Power receiver, the horizontal accuracy of the positions received is submeter (RMS) at a 1 km base line.

Accuracy degrades by 1 ppm as the distance between the reference station and the rover increases. This means that 1 mm of degradation occurs for every kilometer between the reference station and the rover. For example, you must collect data within 500 km (310 miles) of your reference station to obtain submeter accuracy for the GPS Pathfinder Pro XR and Pro XRS receiver.

## PDOP

PDOP (Position Dilution of Precision) is a unitless measure of the current satellite geometry. It indicates when the most accurate results are provided. When satellites are spread around the sky, the PDOP value is low, and the computed position is more accurate. When the satellites are grouped closely together, the PDOP value is high, and the computed position is less accurate. The lower the PDOP value, the more accurate the GPS positions.

You can configure the PDOP mask so that if the PDOP exceeds the mask value, the controlling software stops logging positions. A PDOP mask of 6 is required for submeter accuracy.

## SNR

SNR (signal-to-noise ratio) is a measure of the satellite signal strength relative to the background noise. A strong signal with low noise provides better accuracy. You can raise the SNR mask so that weak signals with an SNR below the mask are excluded from the position computation. In areas of dense canopy, the SNR mask can be lowered so that you can collect GPS positions, although you may not achieve submeter accuracy. For best results, the recommended setting for the SNR mask is 4.

## Elevation mask

When a satellite is low on the horizon, the GPS signals must travel further through the atmosphere, delaying reception by the receiver. To minimize noisy data, adjust the elevation mask. Satellites below the mask are excluded from the position computation. For best results, the recommended setting is 15°.

## Occupation period

The GPS Pathfinder Systems receivers achieve the specified horizontal accuracy with a one-second occupation time.

***Note** – To achieve higher levels of accuracy using a GPS Pathfinder Systems receiver, collect carrier-phase data and postprocess using the GPS Pathfinder Office software.*

## Receiver type

The following Trimble receiver models use Maxwell™ technology and, when used as the reference station, yield submeter accuracy with GPS Pathfinder Systems receivers:

- GPS Pathfinder Pro XRS
- GPS Pathfinder Pro XR
- GPS Pathfinder Pro XL

- 5800 GPS receiver
- 5700 GPS receiver
- 4800 GPS receiver
- 4700 GPS receiver
- 4600 LS Surveyor
- 4000 series receiver
- DSM Reference Station

**Warning –** If the GPS receiver at the reference station has fewer than 12 channels, you may be unable to differentially correct some of your data. If the reference station is not capable of logging data from all of the satellites the rover is using, the data collected by the rover cannot be differentially corrected using postprocessing.

## Accuracy of the reference station position

Any inaccuracy in the reference station position is reflected in your rover position accuracy. For information on the accuracy of your local DGPS reference station coordinates, contact the provider of that service, and check the Integrity Index in the GPS Pathfinder Office version 3.00 Differential Correction utility when selecting a new base station provider.

The Integrity Index provides you with an indication as to the quality of available base data in comparison to other available sources. Poor base data can result from a number of factors, such as an incorrect reference position, bad environmental location, or a large distance between the base and rover receivers. Base data downloaded from each station is analyzed to formulate the quality indicator values and three key measures are taken into account:

- Bias (the measure of distance between an averaged GPS position and a specified reference position)
- Precision (the measure of the spread of actual GPS positions)
- The distance between the base and rover receivers

Use the Integrity Index to avoid selecting base data that may provide an inferior differential correction result. The quality indicator has a range of 0 to 100, where 0 represents low quality base data and 100 represents high quality base data. For more information, refer to the GPS Pathfinder Office 3.00 Differential Correction Help.

## Synchronized measurements

To obtain optimal accuracy from differential correction, the reference station must record reference data (or output differential corrections) from synchronized measurements. Synchronized measurements occur when the reference station receiver and rover receivers simultaneously make measurements to all the satellites they are tracking.

When you use one of the receivers listed in Receiver type, page 23, as a reference station receiver, the data is always synchronized. When measurements are not synchronized, there is no equivalent reference station position measured at exactly the same time as the rover position. A simultaneous reference station position must be interpolated, which reduces accuracy.

## Logging intervals

Ideally, the logging interval at the reference station should be the same as the logging interval at the rover. For example, if the reference station is using a 5-second logging interval, the rover logging interval should be 5 seconds. The rover logging interval can also be a direct integer multiple of the interval at the reference station. For example, if the reference station is logging every 5 seconds, the rover can log every 10 seconds.

If the rover logging interval is not synchronized with the reference station, the accuracy of the GPS positions logged by the rover may not be submeter. This is because the reference station measurements must be interpolated to correct the roving receiver's measurements. For more information, see Synchronized measurements, page 25.

If the synchronized measurement logging interval at the reference is 1 second, you can use any logging interval at the rover. However, this generates a large file at the reference station. If the computer or data collector at the reference station runs out of space, you cannot differentially correct any rover data collected after the base file ends.

When disk space is at a premium, the best option is a 5-second logging interval for synchronized measurement data at the reference station and a 5-second logging interval for positions at the rover. This is frequent enough to be practical at the rover and uses the default reference station logging interval, which results in base files that are not too large.

Table 3.1 gives examples of various reference station and rover intervals and their effect on accuracy. They are valid for both postprocessed and real-time corrections.

**Table 3.1 Logging Interval Accuracy**

| Reference station interval (seconds) | Rover interval (seconds) | Base data interpolated? | Notes |
|---|---|---|---|
| 1 | 1 | No | Recommended for best accuracy. |
| 5 | 5 | No | Recommended if reference station disk space is at a premium. |
| 1 | 3, or 5, or 6, etc. | No | The rover interval is a direct integer multiple of the reference station interval. |
| 5 | 10 | No | The rover interval is a direct integer multiple of the reference station interval. |
| 5 | 1 | Yes | Base data is interpolated at seconds 1, 2, 3, and 4. A slight degradation of accuracy occurs with interpolation. One in five of the rover positions is not interpolated. |

# Factors Affecting Real-Time DGPS Accuracy

Real-time DGPS offers similar accuracies to postprocessed GPS. However, in addition to the factors discussed in Factors Affecting Postprocessed DGPS Accuracy, page 20, there are other factors that affect the accuracy of real-time DGPS positions. These factors include:

- Update rate of the corrections
- Corrections based on a different datum

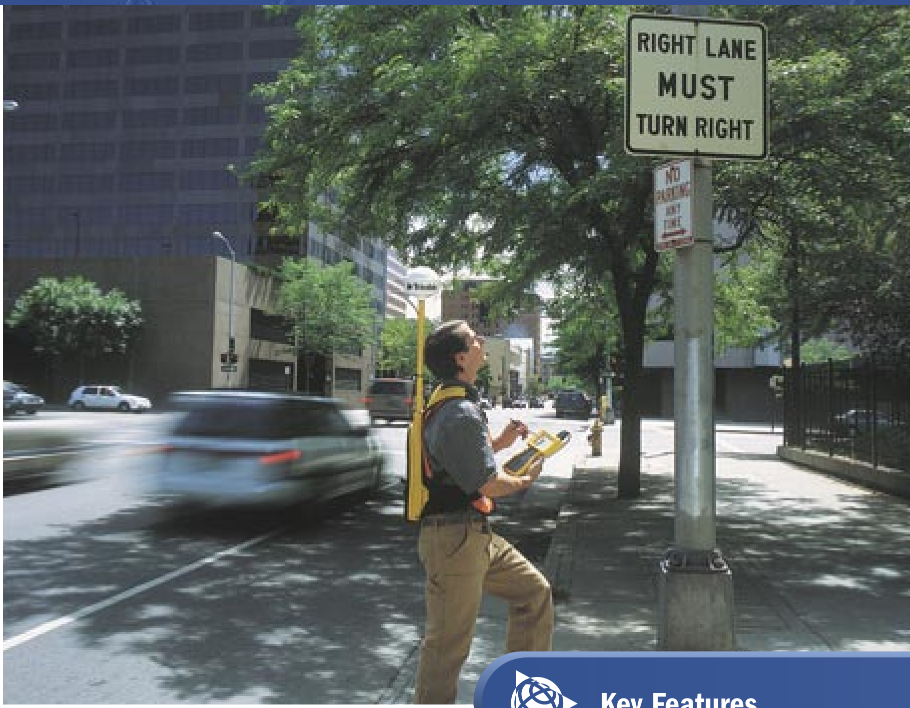
## Update rate of the corrections

The frequency, or rate, at which the RTCM differential correction messages are output from the reference station affects the accuracy of the GPS positions recorded by the roving receiver. The latency of the corrections (that is, the time it takes for up-to-date information to get from the reference station to the rover) also affects the rover position accuracy.

## Datum of corrections

Errors can occur if the reference stations use a datum other than WGS-84 as the basis for the DGPS corrections. The error introduced by using a reference station that transmits coordinates using a different datum is generally quite small. However, in some places the margin of error can be 5–10 meters. To avoid this type of error, set Trimble controlling software to collect SuperCorrect data. You can then postprocess the real-time DGPS positions if required.

# GPS Pathfinder Pro XRS




## High-performance GPS with a world of real-time options

The versatile GPS Pathfinder® Pro XRS receiver is the thoroughbred of GPS receivers. Offering a full range of accurate real-time correction sources, great performance in all GPS conditions, and rugged design for the toughest environments, the Pro XRS is an essential tool for collecting and maintaining GPS data.

**Built to meet your demands**
With the Pro XRS, you don't have to worry whether your GPS receiver can stand up to harsh conditions. All its components are sealed in a robust casing. Waterproof, dustproof, and shock-resistant, the Pro XRS can work anywhere you can.

Just as tough is the custom-designed ergonomic backpack. But it's light and comfortable, so you can wear it all day.

**You're spoiled for real-time choice**
If you're navigating in the field, or finding your way back to a previously recorded feature, you've got all the real-time options covered. Corrections from a radiobeacon, a satellite differential service such as OmniSTAR, or a satellite-based augmentation system (SBAS) like WAAS[1] or EGNOS[2] are not just built in, they're seamlessly integrated into the receiver. Want the freedom to connect to an external correction source like a virtual reference station (VRS)? You've got it. This array of real-time sources makes the Pro XRS the most adaptable real-time GPS receiver around.

**High quality, accurate data for your GIS**
With the Pro XRS, you can be sure that the data you collect meets your high standards. Offering submeter accuracy in real time, and centimeter-level postprocessed accuracy, it's the obvious choice for collecting the high quality GPS data you need in your GIS. And it has advanced design features, like EVEREST™ multipath rejection technology, to ensure you get only the best positions.

**Get the results you want**
The GPS Pathfinder Pro XRS's advanced design gives you complete control over GPS quality. You can focus on productivity, to keep working even in adverse GPS conditions. Or you can configure the receiver to deliver only the most precise positions. It's up to you.

**Flexible data collection options**
Pick the field device and software that fits your workflow. The Pro XRS is ready to use with a variety of field computers, including Trimble's own range of handheld computers: the GIS TSCe™ field device, the Trimble® Recon™ handheld, and the GeoExplorer® series.

Choosing software? Try the TerraSync™ software, for a complete solution from the field to the office and back. Choose off-the-shelf GPS field software. Or use the GPS Pathfinder Tools SDK to build your own application that's totally customized to your needs.

### Key Features

- Real-time submeter accuracy
- Integrated satellite, beacon, and WAAS/EGNOS differential receiver
- EVEREST multipath rejection
- Rugged design
- Ergonomic, comfortable backpack system
- Choice of field device and field software

**All you need**
You need equipment that's as adaptable and hard-working as you are. So when you're choosing GPS equipment, don't compromise. Get a GPS Pathfinder Pro XRS receiver and have it all.

Trimble®

# What Can the GPS Pathfinder Systems Receivers Do?

The GPS Pathfinder Systems receivers, with Trimble controlling software, make an ideal system for all GIS data collection and maintenance projects. The system allows you to collect precise data for utility, urban, and natural resource databases. As the demand for accurate and up-to-date position and attribute information increases, the system allows you to update existing GIS data, ensuring that decisions made with the GIS are based upon the most accurate, current, and reliable data available.

The foundation of the GPS Pathfinder Systems receivers is precise GPS positioning technology. The GPS receivers feature 12 parallel channels for continuous satellite tracking. Using differential GPS, the GPS Pathfinder Systems receivers deliver differentially corrected C/A code positions to submeter accuracy on a second-by-second basis under the most challenging operating conditions.

## Integrated Satellite Based Augmentation System (SBAS) receiver

Satellite Based Augmentation System (SBAS) support is integrated into the GPS Pathfinder Pro XR, Pro XRS, and Power receiver. It allows you free access to real-time solutions transmitted from geostationary SBAS satellites, such as the Wide Area Augmentation System (WAAS) in the United States and the European Geostationary Navigation Overlay Service (EGNOS) in Europe.

## Integrated beacon receiver

The MSK beacon receiver is included in the GPS Pathfinder Pro XR and Pro XRS receivers. It allows you free access to real-time solutions transmitted from DGPS radiobeacons operating in the MF (medium frequency) band from 283.5 kHz to 325 kHz. The integrated MSK beacon receiver is an advanced dual-channel radiobeacon receiver. It tracks broadcasts from DGPS radiobeacons conforming to the IALA Standard. The beacon receiver uses its *all-digital signal processing* techniques to track and demodulate signals from DGPS radiobeacons.

For an up-to-date list of beacon stations, visit the following Web page:

- www.trimble.com/findbeacon.asp

## Integrated satellite differential receiver

The integrated satellite differential capability of the GPS Pathfinder Pro XRS and Power receivers decodes and uses satellite differential corrections to provide submeter position accuracy. To receive and decode these satellite signals, you must subscribe to a satellite differential correction service. The GPS Pathfinder Pro XRS and Power receivers support the OmniSTAR satellite differential correction services. For information on obtaining a subscription, subscription rates, and satellite coverage maps, visit www.omnistar.com

Once you have a subscription, you activate the service through an on-the-air signal or an encrypted activation message entered into the controlling software.

Satellite differential signals provide valid corrections over a large area. Integrated virtual reference/base station (VRS/VBS) technology permits the satellite corrections to be uniformly accurate over the entire satellite coverage area, without the degradation in accuracy associated with increasing distance from fixed reference stations.

Satellite differential signals are line-of-sight and can be blocked by mountains, buildings, or tree canopy. Wet canopy, from a heavy rain, reduces the signals even more. The same environmental factors that affect the GPS signal, such as radar and microwave transmitters, can interfere with the satellite signal. Power lines usually have no effect.

### External differential correction receiver

The GPS Pathfinder Systems receivers can also receive differential corrections from any external differential correction receiver that communicates in the standard RTCM SC-104 data format.

## Standard GPS Pathfinder Pro XR and Pro XRS Features

The GPS Pathfinder Pro XR and Pro XRS receivers offer the following:

- 12-channel DGPS receiver with EVEREST™ multipath rejection technology, L1 C/A code tracking with carrier-phase smoothing, and instantaneous full-wavelength carrier-phase measurements.
- Submeter accuracy – Typically horizontal accuracy less than 50 cm RMS with GPS Pathfinder Office software postprocessing. This requires data to be collected with a minimum of 4 satellites, maximum PDOP of 6, minimum SNR of 4, minimum elevation of 15 degrees, and reasonable multipath conditions.
- Integrated WAAS/EGNOS differential corrections
- 1 Hz position and velocity update rate.
- Velocity computations incorporate carrier-phase data.
- Time to First Fix typically less than 30 seconds.
- Two RS-232 serial ports.
- NMEA-0183 output to external NMEA devices (supported messages are ALM, GGA, GLL, GSA, GSV, VTG, and ZDA).
- RTCM-SC 104 input from an external differential correction receiver.
- TSIP protocol to/from the field device.
- Fully automatic and manual beacon operating modes, fast acquisition of differential beacon signals.

- Immunity to MSK jamming signals, advanced techniques for combating atmospheric noise in the beacon receiver.
- Integrated GPS/MSK beacon antenna.
- User-upgradeable receiver firmware.
- Receiver manual.
- CE Mark compliance.

## Additional GPS Pathfinder Pro XRS receiver features

The GPS Pathfinder Pro XRS GPS/MSK/beacon/satellite differential receiver offers the items previously listed, and also:

- Integrated L-band satellite differential correction receiver
- Combined L1 GPS/beacon/satellite differential antenna

## Combined L1 GPS/beacon/satellite differential antenna

The GPS Pathfinder Pro XRS receiver integrated L1 GPS/beacon/satellite differential antenna (P/N 33580-50) features two antenna components:

- L1 GPS/satellite differential antenna

  This active antenna is designed to filter out unwanted signals and amplify the L1 GPS and satellite differential signals for transmission over the antenna cable to the receiver.

- MSK H-field loop beacon antenna

  This antenna features a pre-amplifier for filtering out signal interference such as AM radio broadcasts and noise from switching power supplies. After filtering, the pre-amplifier amplifies the MF signal for transmission over the same antenna cable to the beacon receiver.

The coaxial antenna cable also carries DC power to the pre-amplifier of both the L1 GPS/satellite differential and beacon antennas over the center conductor of the cable.

The antenna assembly integrates the L1 GPS/satellite differential antenna and a beacon antenna into a single antenna assembly, as shown in Figure 2.2. The antenna assembly is completely weatherproof and is designed to withstand harsh environmental conditions.


Figure 2.2 Combined L1 GPS/beacon/satellite differential antenna (for the GPS Pathfinder Pro XRS receiver)

# Introduction

This appendix lists specifications for GPS Pathfinder Systems receivers and antennas, and pinouts for cables that are supplied with the receivers.

# Specifications

Table B.1 lists specifications for the GPS Pathfinder Pro XR and Pro XRS receiver.

**Table B.1 GPS Pathfinder Pro XR and Pro XRS receiver specifications**

| Parameter | Specification |
|---|---|
| General | 12 channel, L1/CA code tracking with carrier phase filtered measurements and multibit digitizer |
| Update Rate | 1 Hz |
| Time to First Fix | < 30 seconds, typical |
| Size | 11.1 cm × 5.1 cm × 19.5 cm (4.4" × 2.0" × 7.7") |
| Weight | 0.76 kg (1.68 lb) |
| Power | XR 6 W (maximum)<br>XRS 7 W (maximum)<br>both 10 to 32 VDC |
| Temperature | –20 °C to 65 °C (–4 °F to 149 °F) operating<br>–30 °C to 85 °C (–22 °F to 185 °F) storage |
| Humidity | 100% non-condensing |
| Casing | Dustproof, splashproof, shock-resistant, sealed to 5psi |

Table B.3 lists specifications for the GPS Pathfinder Pro XRS antenna.

**Table B.3 Combined L1 GPS/beacon/satellite differential antenna specifications**

| Parameter | Specification |
|---|---|
| General | Right-hand, circular polarized; omnidirectional; hemispherical coverage |
| Size | 15.5 cm diameter × 14 cm high (6.1" × 5.5") |
| Weight | 0.55 kg (1.2 lb) |
| Temperature | –20 °C to 65 °C (–4 °F to 149 °F) operating<br>–40 °C to 85 °C (–40 °F to 185 °F) storage |
| Humidity | 100% fully sealed |
| Casing | Dustproof, waterproof, shock resistant |

# Pinouts

Table B.5 lists the pinouts for the GPS Pathfinder Pro XR and Pro XRS receiver's data/power cable.

**Table B.5 Data/power cable pinout (P/N 30231-00)**

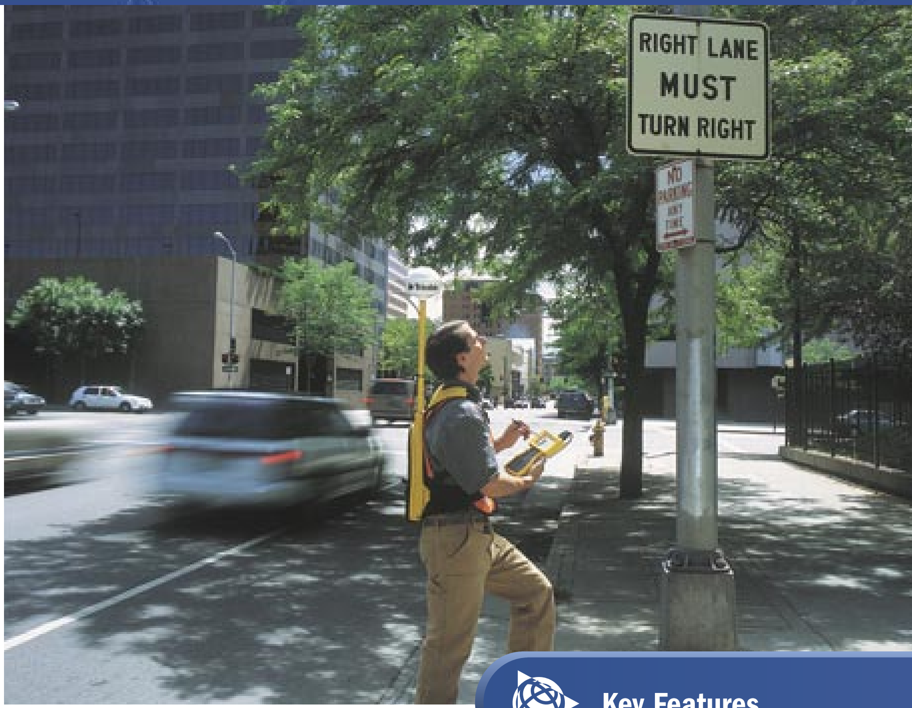
| To GPS Pathfinder Pro XR and Pro XRS receiver | | | | Field Device | | Input Power | | |
|---|---|---|---|---|---|---|---|---|
| **Conn P1** | | | **7 Cond Cbl #1** | **Conn P2 DE9-F** | | **2 Conn Cbl #2** | **Conn P3 TA3-M** | |
| Event In | 1 | in | — | — | | — | — | |
| TXD out | 2 | | Orange | 2 | RXD | — | — | |
| RXD | 3 | in | Red | 3 | TXD | — | — | |
| Chg Ctrl | 4 | in | Black | 4 | DTR | — | — | |
| Sig Gnd in/out | 5 | | Shield | 5 | Sig Gnd | — | — | |
| DSR out | 6 | | Yellow | 6 | DSR | — | — | |
| Pwr On | 7 | in | Brown | 7 | RTS | — | — | |
| CTS out | 8 | | Green | 8 | CTS | — | — | |
| Charge out | 9 | | Blue | 9 | RI | — | — | |
| V+ In | 10 | in | — | — | | White | 1 | V+ In |
| V– In | 11 | in | — | — | | Black | 2 | V– Out |
| PPS — | 12 | | — | — | | — | — | |

Table B.7 lists the pinouts for the GPS Pathfinder Pro XR and Pro XRS receiver's NMEA/RTCM cable.

**Table B.7 NMEA/RTCM cable pinout (P/N30232-00)**

| **To GPS Pathfinder Pro XR and Pro XRS receiver** | | | | **NMEA/RTCM output connectors** | | |
|---|---|---|---|---|---|---|
| **Conn P1** | | | **9 Cond Cbl #1** | **Conn P2 DE9-M** | **7 Conn Cbl #1** | **Conn P3 DE9-F** |
| Event In | 1 | in | — | — | — | — |
| TX– (232) | 2 | out | — | — | Orange | 2 TXD |
| RX– (232) | 3 | in | Red | 2 RXD | — | — |
| Chg Ctrl | 4 | in | — | — | Shield | |
| Sig Gnd | 5 | in/out | Shield | 5 Sig Gnd | — | 5 Sig Gnd |
| TX+ (422) | 6 | out | — | — | — | |
| Pwr On | 7 | in | — | — | — | — |
| RX+ (422) | 8 | out | — | — | — | — |
| Charge | 9 | out | Yellow | 9 Pwr | — | — |
| V+ In | 10 | in | — | — | — | — |
| V– In | 11 | in | — | — | — | — |
| PPS | 12 | — | — | — | Brown | 4 DTR |

# GPS Pathfinder Pro XRS




## High-performance GPS with a world of real-time options

The versatile GPS Pathfinder® Pro XRS receiver is the thoroughbred of GPS receivers. Offering a full range of accurate real-time correction sources, great performance in all GPS conditions, and rugged design for the toughest environments, the Pro XRS is an essential tool for collecting and maintaining GPS data.

### Built to meet your demands

With the Pro XRS, you don't have to worry whether your GPS receiver can stand up to harsh conditions. All its components are sealed in a robust casing. Waterproof, dustproof, and shock-resistant, the Pro XRS can work anywhere you can.

Just as tough is the custom-designed ergonomic backpack. But it's light and comfortable, so you can wear it all day.

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### High quality, accurate data for your GIS

With the Pro XRS, you can be sure that the data you collect meets your high standards. Offering submeter accuracy in real time, and centimeter-level postprocessed accuracy, it's the obvious choice for collecting the high quality GPS data you need in your GIS. And it has advanced design features, like EVEREST™ multipath rejection technology, to ensure you get only the best positions.

### Get the results you want

The GPS Pathfinder Pro XRS's advanced design gives you complete control over GPS quality. You can focus on productivity, to keep working even in adverse GPS conditions. Or you can configure the receiver to deliver only the most precise positions. It's up to you.

### Flexible data collection options

Pick the field device and software that fits your workflow. The Pro XRS is ready to use with a variety of field computers, including Trimble's own range of handheld computers: the GIS TSCe™ field device, the Trimble® Recon™ handheld, and the GeoExplorer® series.

Choosing software? Try the TerraSync™ software, for a complete solution from the field to the office and back. Choose off-the-shelf GPS field software. Or use the GPS Pathfinder Tools SDK to build your own application that's totally customized to your needs.

### Key Features

- Real-time submeter accuracy
- Integrated satellite, beacon, and WAAS/EGNOS differential receiver
- EVEREST multipath rejection
- Rugged design
- Ergonomic, comfortable backpack system
- Choice of field device and field software

### All you need

You need equipment that's as adaptable and hard-working as you are. So when you're choosing GPS equipment, don't compromise. Get a GPS Pathfinder Pro XRS receiver and have it all.

Trimble®

# Reference Materials

If you have a problem and cannot find the information you need in the product documentation, *contact your local Distributor*. Alternatively, go to the Trimble Support page at www.trimble.com/support.html, and then do one of the following:

- Browse the available online support resources.
- Request technical assistance from Trimble Support, click the submit an inquiry link, fill in the form, and then click **Send.**

Trimble: www.trimble.com/support.html

Survey Controller: www.trimble.com/tsce.html

Survey Pro: www.tdsway.com

GIS TSCe: www.trimble.com/gistsce.html

ActiveSync™: www.microsoft.com/windowsmobile/resources/downloads/pocketpc/default.mspx

Windows CE: www.microsoft.com/windows/embedded/ce.net

# Hardware Specifications

| Feature | TSCe |
|---|---|
| *Processor* | Intel StrongARM SA-1110, 206 MHz |
| *Memory* | 64 MB low-power SDRAM |
| *Storage* | 512 MB non-volatile flash disk |
| *Screen* | 1/4 VGA transflective color LCD |
| *Touch Screen* | Passive - 87% transmissivity |
| *Keyboard* | 57 key tactile action |
| *9-Pin serial port* | RS232 COM1 |
| *26-Pin MultiPort* | RS232 COM2, Ethernet 10BaseT, USB client, power in/out and audio in/out |
| *Infrared* | IrDA Type1 COM3 |
| *Audio* | Integrated speaker and microphone |
| *Batteries* | NiMH rechargeable pack, 3800 mAH, 18.5 W-h, 4.8 V |
| *AC Adaptor* | Line voltage: 100 - 240 V AC 47-63 Hz |

## Specifications for Laser Tech TruPulse 200 Laser Rangefinder

| | |
|---|---|
| **Dimensions** | 5" x 2" x 3.5" (12cm x 5cm x 9cm) |
| **Weight** | 8 ounces (220 g) |
| **Data Communication** | Serial, via wired RS232 (standard) |
| **Power** | 3.0 volts DC nominal |
| Battery Type | (2) AA or (1) CRV3 |
| Battery Duration | AA: Approximately 7,500 measurements<br>CRV3: Approximately 15,000 measurements |
| **Eye Safety** | FDA Class 1 (CFR 21) |
| **Environmental** | Impact, Water & Dust Resistant. NEMA 3, IP 64 |
| **Temperature** | -4°F to +140°F (-20°C to +60°C) |
| **Optics** | 7X Magnification (Field-of-view; 330 ft @ 1000 yards) |
| **Display** | In-scope LCD |
| **Units** | Feet, Yards, Meters, and Degrees |
| **Monopod/tripod mount** | ¼ " - 20 female thread |
| **Measurement Range** | |
| Distance | 0 to 3280 ft (1000 m) typical, 6560 ft (2000m) max to reflective target |
| Inclination | ± 90 degrees |
| **Accuracy** | |
| Distance | ±1 ft (± 30 cm) to high quality targets, ±1 yd (±1 m) to low quality targets |
| Inclination | ±0.25 degrees |
| **Measurement Modes** | Horizontal Distance, Vertical Distance, Slope Distance and Inclination, and 3-point flexible height routine with auto sequencing |
| **Target Modes** | Standard, Closest, Farthest, Continuous, and Filter (requires reflector and foliage filter) |

# Impulse 200 LR Laser

Our Impulse lasers are specifically designed for optimal performance under whatever conditions you might encounter in the field. They are lightweight, extremely rugged, completely waterproof and versatile. Use them as a handheld unit or mount them on a tripod for added stability.

## Hardware Specifications:

| Typical Target Accuracy & Range | IMPULSE 200 LR | |
|---|---|---|
| | (Imperial) | (Metric) |
| Accuracy (Typical) | 0.1 - 0.2 ft | 3 - 5 cm |
| Accuracy (Max) | 0.5 ft | 15 cm |
| Overhead cable / Stake | 330 ft | 100 m |
| Phone pole / Stockpile | 655 ft | 200 m |
| Tree / Tower | 985 ft | 300 m |
| Rock Face / Building | 1640 ft | 500 m |
| Max Distance | 1885 ft | 575 m |
| Range Resolution | .01 ft | 0.01 m |
| Inclination Limits | +/- 90 deg | +/- 90 deg |
| Inclination Accuracy | +/- 0.1 deg | +/- 0.1 deg |
| Weight | 2.2 lbs. | 1 kg |
| Size | 6 x 2.5 x 5 in. | 15.2 x 6.4 x 12.7 cm |
| Power Supply | (2) AA batteries (20 hours of use) | |
| Environment | Waterproof to IP 67 and NEMA 6 | |
| Temperature | - 22 to + 140 F | -30 to + 60 C |

(Max distances are approximate)

Impulse Laser w/ 1.5 to 4 X Zoom Scope and Mounting Bracket


For 3-D data collection, integrate the Impulse with a MapStar System.

MapStar Angle Encoder

MapStar Compass Module

## Key Features:

- Custom backlit LCD display
- Audible and visual indicators
- RS232 serial output for electronic data storage
- Selective range gating for positive target acquisition
- Built-in tilt sensor
- Filter system to discriminate reflective targets
- Cumulative distance capability
- Determines the distance between two in-line objects
- Integrates with GPS

## Package Includes:

- Impulse laser
- Red-dot scope
- Hand strap
- Tripod / monopod mounting bracket
- (2) AA batteries
- Operator's manual
- Padded carrying case

## Optional Accessories:

- 1.5 to 4 X zoom scope
- Yoke and staff
- Remote trigger data cable


Impulse Laser w/ Red-dot Scope and Hand Strap

LASER TECHNOLOGY INC
Redefining Measurement

7070 S. Tucson Way, Centennial, CO 80112 USA
Toll Free: 1 (800) 280-6113 | Local: 1 (303) 649-1000
Web Page: www.lasertech.com | E-mail: info@lasertech.com

* All specifications are subject to change without notice.
(Rev. 11/15/03)

# MVP200
# OPERATION AND MAINTENANCE
# MANUAL

**BROOKE OCEAN TECHNOLOGY LIMITED**
50 Thornhill Drive
Dartmouth, Nova Scotia
Canada B3B 1S1

Phone: (902) 468-2928
Fax: (902) 468-1388
e-mail: sales@brooke-ocean.com
**www.brooke-ocean.com**

**[OM-0449-04-010]** **December 15, 2004**

# 1 SYSTEM DESCRIPTION

The MVP200 system is a self-contained profiling system capable of sampling water column profiles to 200m depth from a vessel moving at up to 12 knots, and deeper depths at slower speeds. The system provides vertical profiles of oceanographic data such as Sound Velocity, CTD, particle counts, etc. for various operations including the calibration of multi-beam sounder systems for hydrographic operations. The MVP200 is completely autonomous and can be controlled by computer without the requirement for personnel on deck. The system consists of a single or multi-sensor free-fall fish (fish), an integrated winch and hydraulic power unit, towing boom and a remotely located user interface controller. The MVP200 system is shown in Figure 1. The system block diagram is shown in Figure 2.

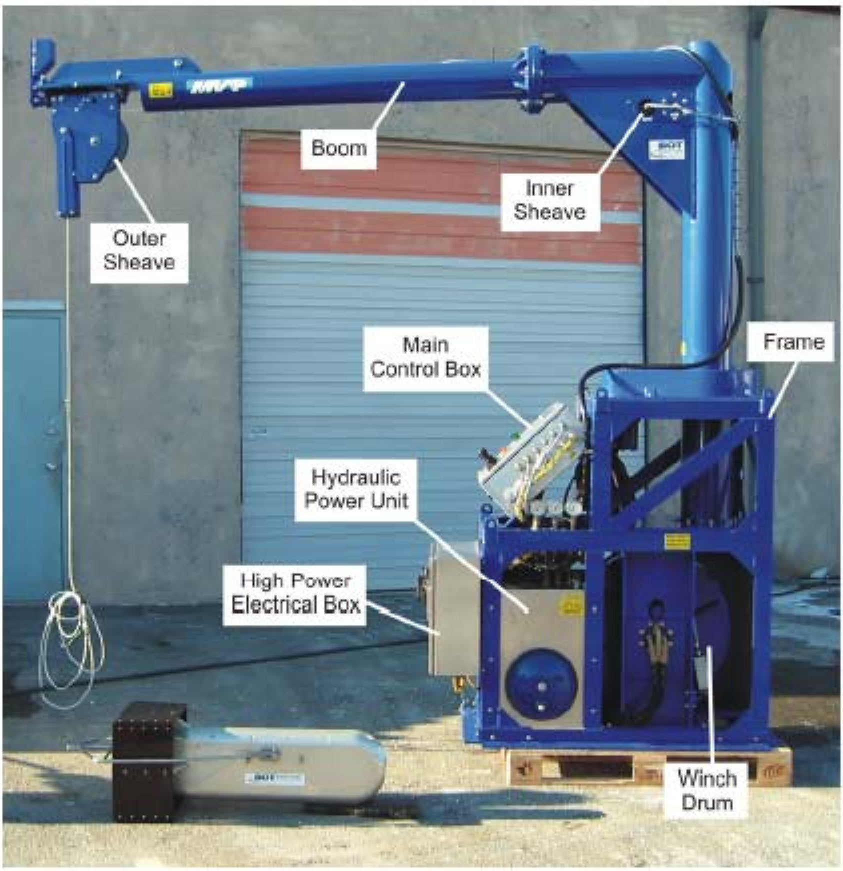



Figure 1: MVP200

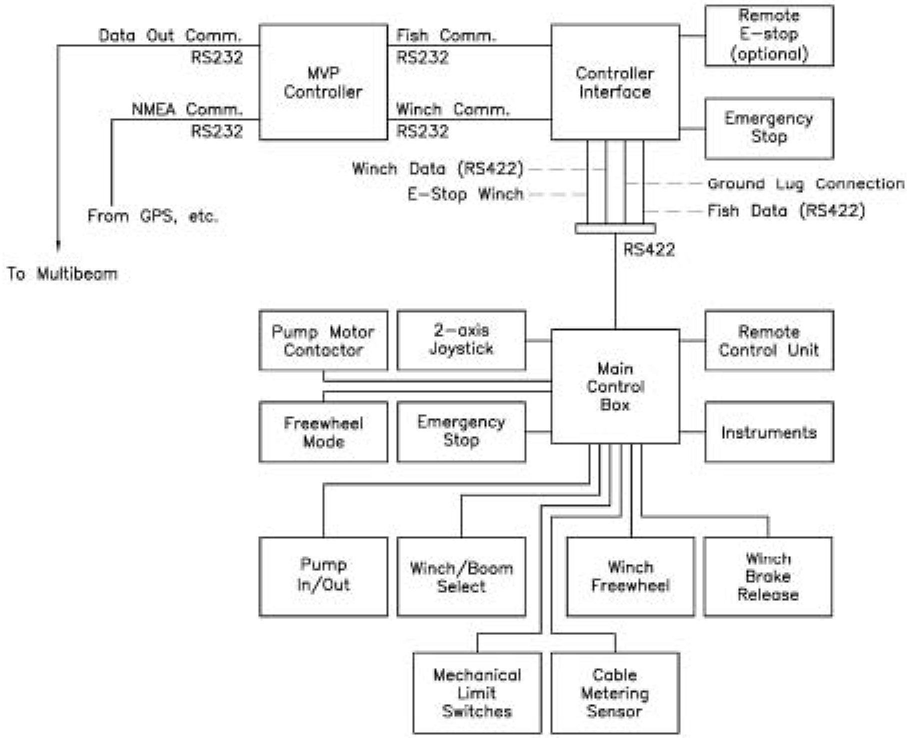



Figure 2: System Block Diagram

Upon actuation, the system deploys the fish from a towed position by setting the winch in 'freewheel' mode and releasing the brake. This allows the fish to free-fall almost straight down through the water at its terminal velocity of approximately 3 m/s. Once the (pre-set) depth limit is reached, the brake is applied to stop the cable pay-out. When the winch drum has stopped, the motor is engaged to haul in the cable until the fish is towed at the surface. Subsequent deployments occur from this position, either actuated by the operator or timed automatically with the automatic deployment setting.

The system operates in the automatic mode described above or in manual mode operated from controls at the winch. Manual mode is used as a convenient method to launch and recover the fish, but is not intended for moving vessel profiling.

## 1.1 FREE-FALL FISH

The free-fall fish can be either a single sensor or a multi sensor fish. The fish houses the main instrument, either a CTD or SV&P sensor. The instrument is normally configured for RS-485 serial communications.

The multi-sensor fish can support auxiliary sensors in addition to the main CTD/SV&P instrument. If auxiliary sensors are used, a DTM/Mux is required in the fish. The DTM/Mux is a data telemetry module with additional digitization and multiplexing circuitry. This allows data from various analog and digital sensors to be added to the main instrument's serial output stream, which is transmitted to the surface.

### 1.1.1 Single-Sensor Free-Fall Fish

The Single Sensor Free-Fall Fish (SSFFF) (see Figure 3) is machined from brass with a stainless steel towing bridle. The sensor guard at the tail of the fish is made from stainless steel. The shape of the fish allows minimal resistance while providing stability during free-fall and retrieval. The fish can be fitted with an Applied Microsystems Ltd. (AML) Sound Velocity and Pressure (SV&P) Smart Sensor or an AML CTD Micro Sensor. (A small plastic support is built into the sensor guard for use with the sound velocity sensor). An Impulse underwater connector allows the fish to be removed easily from the electromechanical cable.

The AML CTD Micro Sensor measures conductivity, temperature and pressure. The AML SV&P Smart Sensor measures sound velocity and pressure. The information is sent through the Electro-Mechanical cable to the main control box, through the deck cable to the Instrument Interface box where it then connects to the MVP Controller. If the sensor is a CTD, software in MVP Controller then computes sound velocity and salinity from the measured parameters using the UNESCO equations of state.

Figure 3: Single Sensor Free-Fall Fish

# 3 SPECIFICATIONS

## 3.1 OPERATING DEPTH

- 600 m @ 0 knots*
- 350 m @ 5 knots
- 200 m @ 12 knots

*** Ensure sensor(s) are rated for this depth before operations**

## 3.2 WINCH AND HYDRAULIC POWER UNIT

- Drum dimensions: 324 mm (12.7") barrel diameter
  99 mm (3.9") wide
  711 mm (28.0") flange OD
- Line Pull: Bare Drum - 410 kg (900 lbs.)
- Capacity: 660 m (2132 ft) of 6.0 mm (0.24") cable
- Cable: Jacketed Electro-Mechanical , 4 conductor,
  1089 kg (2400 lbs.) maximum break strength
- Hydraulic Winch Motor: Valmet Black Bruin # 403 040 2120
- Rotator Motor: White # 700540C8540ALAAA
- Slip Ring: Focal Technologies Model 180 ESR
- Hydraulic Pump: Rexroth #AA10VG18EP21/10R-NSC66-F004S
- Reservoir: 40 litre Stainless Steel Reservoir
- Maximum operating pressure: 3000 psi (207 Bar)
- Electric motor: 15 hp TEFC 230/460VAC 60 Hz, 208/416VAC 50 Hz, 3-phase
- Suction line filter: LHA Element #SPE-15-BTA-10
- Footprint: 1.22m x 0.71m (48" x 28") excluding boom
- Height: 3.18m (125")
- Approximate Weight: 680 kg (1500 lbs.)

## 3.3 FREE-FALL FISH

### 3.3.1 Single Sensor Free-Fall Fish

- Weight: 32 kg (72 lbs.) with sensor, in air
- Body Length: 673 mm (26.5") excluding bridle
- Body Diameter: 114 mm (4.5")
- Sensors: - AML Sound Velocity and Pressure (SV&P) "Smart Sensor", or
  - AML SVP&T Micro Sensor
  - AML CTD Micro Sensor

### 3.3.2 Multi-Sensor Free-Fall Fish

- Weight: 88.5 kg (195 lbs.) with sensor, in air
- Body Length: 1041 mm (41") excluding bridle
- Body Section: 147 mm x 279 mm (5.8" x 11.0")

Sensors: - AML Sound Velocity and pressure (SV&P) "Smart Sensor"
- AML CTD Micro Sensor
- AML Dissolved Oxygen (DO) Sensor
- Wet Labs fluorometers (Wet star, FLF300, and ECO)
- Satlantic OCR-500 series digital optical sensors
- Brooke Ocean Technology Ltd. - Laser Optical Plankton Counter (LOPC)

## 3.4 MVP CONTROLLER

***Minimum requirements (refer to system factory configuration for details)***

- Operating system: Windows 2000 Professional
- Processor: Pentium 600 or higher
- Ram: 128 Mb
- Hard Disk: 5 GB Hard drive
- Video: 1024x768 SVGA with 64 thousand colors
- Pointing Device: Microsoft Wheel Mouse
- Serial ports: 4 serial (RS232) ports
- Drive: CD-ROM drive and a 1.44 Mb Floppy drive
- Monitor: 15" Video Monitor
- Keyboard: PS/2 Keyboard
- Hardware: Network Card

## 3.5 POWER REQUIREMENTS

***Winch Power Ratings:***

- Vessel circuit breaker value 90A at 230v and 45A at 460v, maximum setting
- Voltage: 3-phase, 4-wire
  - 230/460V ±10%, 34/17A at 60 Hz or
  - 208/416V ±10%, 42/21A at 50 Hz

(Note that system supply voltage must be selected at time of order. It is not a field configurable item)

- 50A main disconnect, circuit breaker
- 15 HP Motor, dual frequency rating with 110V anti-condensation heater
- Motor contactor with thermal overload.
- Includes internal 110V auxiliary distribution: 7A/120V/840W

***MVP Controller (Lab Computer) Power Ratings:***

- Voltage: 1-phase, 100-230 VAC
- Current: 5-8A
- Frequency: 50 or 60 Hz

# MicroTSG (Thermosalinograph)

SBE 45

The SBE 45 MicroTSG Thermosalinograph is an externally powered, high-accuracy instrument, designed for shipboard determination of sea surface (pumped-water) conductivity and temperature. Salinity and sound velocity can also be computed. The MicroTSG is constructed of plastic and titanium to ensure long life with minimum maintenance.

## OPERATION OVERVIEW

Communication with the MicroTSG is over an internal, 3-wire, RS-232C link, providing real-time data transmission. Commands can be sent to the MicroTSG to provide status display, data acquisition setup, data display and capture, and diagnostic tests. User-selectable operating modes include:

- **Polled sampling** – On command, the MicroTSG takes one sample and sends the data to the computer.
- **Autonomous sampling** – At pre-programmed intervals, the MicroTSG samples and sends the data to the computer. The MicroTSG does not enter quiescent (sleep) state between samples.
- **Serial Line Sync** – A pulse on the serial line causes the MicroTSG to wake up, sample, and enter quiescent state automatically.

Calibration coefficients stored in EEPROM allow the MicroTSG to transmit data in engineering units.

## SENSORS

The MicroTSG retains the temperature and conductivity sensors used in the SBE 21 Thermosalinograph, but has improved acquisition electronics that increase accuracy and resolution, and lower power consumption. The MicroTSG's aged and pressure-protected thermistor has a long history of exceptional accuracy and stability (typical drift is less than 0.002 °C per year). Electrical isolation of the conductivity electronics eliminates any possibility of ground-loop noise.

The MicroTSG's internal-field conductivity cell is unaffected by external fouling, and uses expendable anti-foulant devices.

## OPTIONAL PN90402 - SBE 45 POWER, NAVIGATION, and REMOTE TEMPERATURE INTERFACE BOX

An optional AC- or DC-powered Interface Box:

- Provides isolated DC power and an optically isolated RS-232 data interface.
- Contains a NMEA 0183 port for appending navigation information from a NMEA navigation device to the data stream.
- Contains an RS-232 port for appending the output of an optional remote temperature sensor (SBE 38), allowing for measurement of sea surface temperature with minimal thermal contamination from the ship's hull.
- Outputs the data stream (MicroTSG, NMEA navigation device, and SBE 38 data) to the computer over an RS-232 interface.

## SOFTWARE

The MicroTSG is supplied with a powerful Win 95/98/NT/2000/XP software package, SEASOFT©-Win32. SEASOFT's modular programs include:

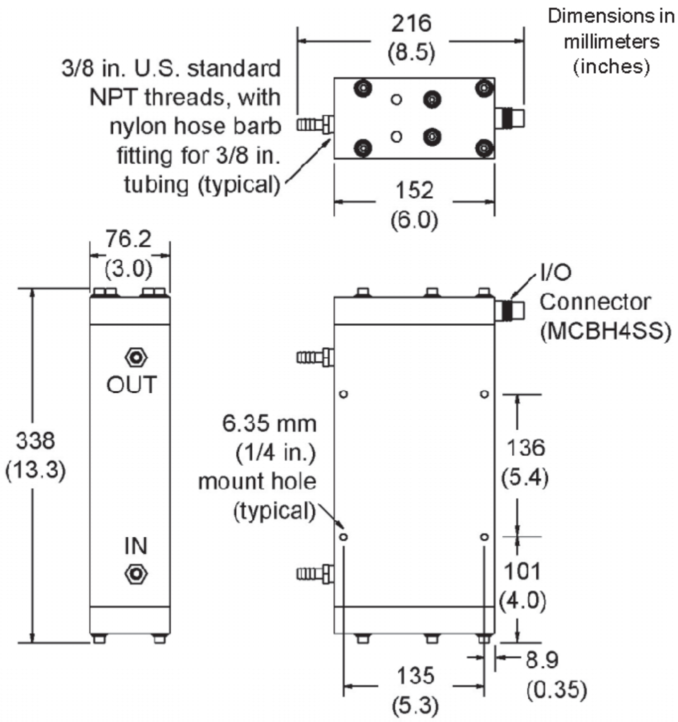
- SEATERM — terminal program for instrument setup and data display.
- SEASAVE — real-time data acquisition and display
- SBE Data Processing — filtering, aligning, averaging, and plotting of data and derived variables.

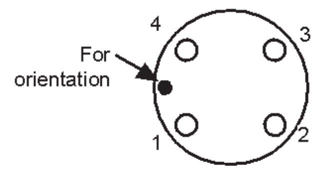
# MicroTSG (Thermosalinograph) SBE 45

## SPECIFICATIONS

| | |
|---|---|
| **Measurement Range** | |
| *Conductivity:* | 0-7 S/m (0-70 mS/cm) |
| *Temperature *:* | -5 to 35 °C |
| **Initial Accuracy** | |
| *Conductivity:* | 0.0003 S/m (0.003 mS/cm) |
| *Temperature *:* | 0.002 °C |
| *Salinity:* | 0.005 PSU, typical |
| **Typical Stability** ***(per month)*** | |
| *Conductivity:* | 0.0003 S/m (0.003 mS/cm) |
| *Temperature *:* | 0.0002 °C |
| *Salinity:* | 0.003 PSU, typical |
| **Resolution** | |
| *Conductivity:* | 0.00001 S/m (0.0001 mS/cm) |
| *Temperature *:* | 0.0001 °C |
| *Salinity:* | 0.0002 PSU, typical |
| **Calibration Range** | |
| *Conductivity:* | 0-6 S/m (60 mS/cm); physical calibration 2.6-6 S/m (26-60 mS/cm), plus zero conductivity (air) |
| *Temperature *:* | +1 to +32 °C |
| **Time Resolution** | 1 second |
| **Clock Stability** | 13 seconds/month |
| **Input Power** | 8-30 VDC |
| **Acquisition Current** | 34 mA at 8 VDC; 30 mA at 12-30 VDC |
| **Quiescent Current** | 10 microamps |
| **Acquisition Rate** | 1 Hz maximum |
| **Operating Pressure** | 34.5 decibars (50 psi) maximum |
| **Flow Rate** | 10 to 30 ml/sec (0.16 to 0.48 gal/min) |
| **Materials** | PVC housing |
| **Weight** | 4.6 kg (10.2 lbs) |

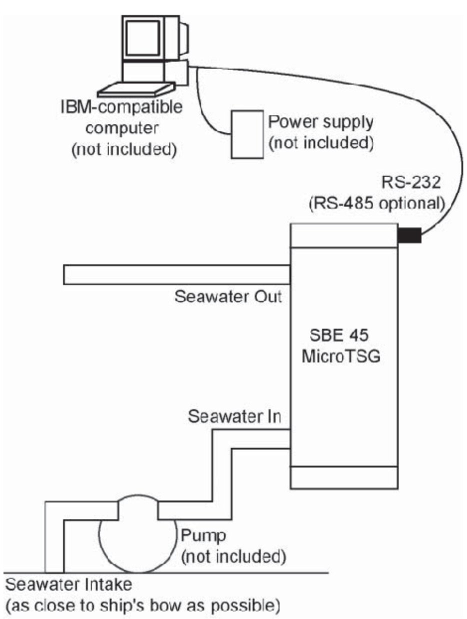
* For specifications for optional SBE 38 remote temperature sensor, see SBE 38 datasheet.



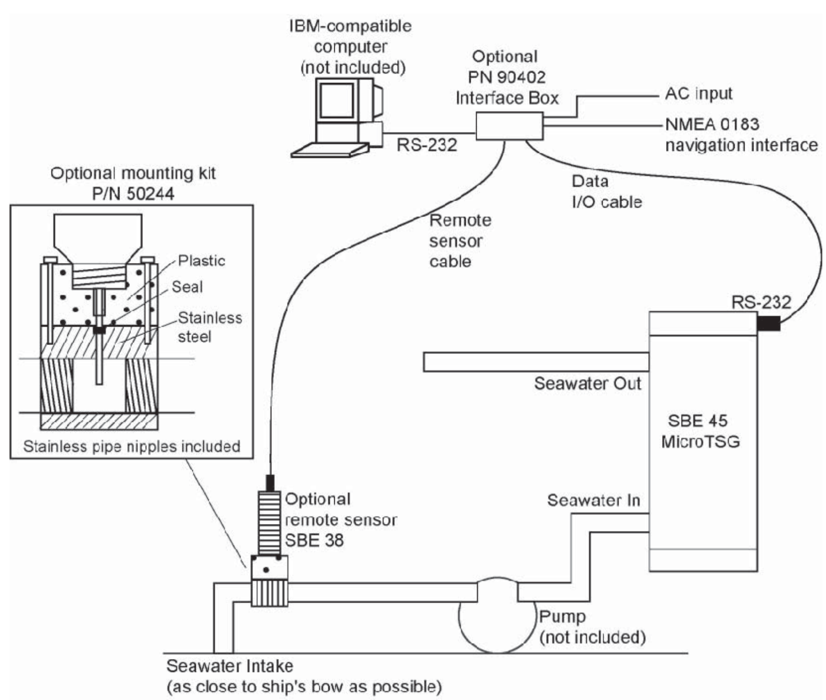




| Pin | Signal |
|---|---|
| 1 | Common |
| 2 | RS-232 RX from computer |
| 3 | RS-232 TX to computer |
| 4 | External power in (8 - 30 VDC) |

**System Schematic: SBE 45**




**System Schematic: SBE 45 with Optional PN 90402 Interface Box and Remote Temperature Sensor**




03/04


SBE
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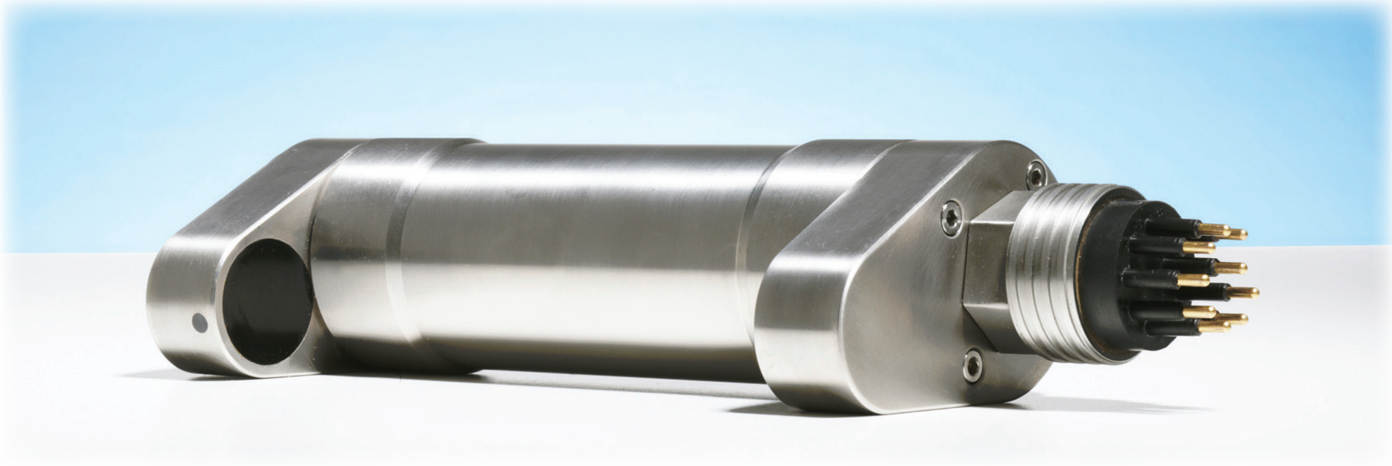
# SVP 70

A new generation of fixed-mount sound velocity probes



## SVP 70

- Accurate & reliable sound velocity measurement in seawater
- Compact housing in titanium for corrosion immunity and high strength
- Mechanical design for easy cleaning, optimal flow and flexible integration
- Galvanically isolated multiple communication interfaces as standard
- Direct path ultrasonic echo-sounding with 2MHz trans-ducer element
- Instant electronic temperature and pressure compensation via internal sensors
- Integrated electronics and up to 6000m depth rating

The RESON SVP 70 sound velocity probe is developed for fixed-mount installation on surface ships, outboard rigs, submarines, AUVs, ROVs and other self-propelled platforms. The SVP 70 uses the latest electronic technology combined with an innovative mechanical design to yield a compact, robust, yet very flexible product.

The SVP 70 uses a direct path echosounding technique that instantly compensates for temperature and pressure with internal sensors.

The SVP 70 comes in a water resistant case including brackets for mounting, a 3m accessory cable, bolts, and a user manual with system description. Additional adaptor kits and fairing accessories are available.

# SVP 70

## A new generation of fixed-mount sound velocity probes

## PRODUCT SPECIFICATION

| | |
|---|---|
| Sound velocity | |
| Range: | 1350 -1800m/s |
| Resolution: | 0.01m/s |
| Accuracy: | (0-50m ±0.05m/s |
| Accuracy: | (6000m) ±0.25m/s |
| Sampling Rate: | 20Hz and lower, programmable |
| Sampling Mode: | On request, continuous |

| | |
|---|---|
| I/O Interfaces | |
| Connector: | Birns MCBH9MTT* (Titanium) |
| Output: | (MCBH9M) True RS-232 and True RS-422 |
| Baud Rate: | 2400-115200 |
| Galvanic Insulation: | Yes |
| Output Options: | Direct, filtered, validity |
| Output Formats: | Universal Programmable ASCII, Valeport, AML, SVP24, NMEA, and others |

| | |
|---|---|
| Electrical | |
| Supply: | 8-55VDC |
| Current: | 150mA @ 12V |

| | |
|---|---|
| Physical | |
| Diameter: | 44mm (maximum) |
| Length: | 165mm (excl. connector) |
| End-Cap Height: | 69mm (maximum) |
| Connector (MCBH9M): | 52.5mm x Ø23mm |
| Weight: | approximately 1.0kg (excl. cable) |

| | |
|---|---|
| Environmental | |
| Pressure: | 0-630bar |
| Temperature: | -20 to +55°C |

Sales Package

- 900-63-0000-00 - SVP 70
- 904-63-0800-00 - Accessories Kit (5 pcs. DIN912 M6*10, 5 pcs. DIN933 M6*10, 4 x Mounting O-rings, 7.5ml Silicon oil for connectors, Microfibre cloth
- 7211C03 - 2 x Mounting Brackets with rubber membrane
- 904-63-0801-00 - Plastic Transport Case
- 904-63-0802-00 - Operators Manual
- 904-63-0803-00 - Quick Reference Manual
- 904-63-0804-00 - Test Cable 1.5m long terminated with RS232 and RS232 D-sub connections
- 904-63-0808-00 - 25m Wet Cable with connector
- 906-63-0800-00 - MCA Female locking sleeve

Optional Cables (All wet cable pigtails with connectors)

904-63-0805-00 - 1.5m • 904-63-0806-00 - 5m • 904-63-0807-00 - 10m •
904-63-0808-00 - 25m • 904-63-0809-00 - 60m

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Version: B178 090304/ A4

# SBE 19plus SEACAT PROFILER

*Conductivity, Temperature, and Pressure Recorder with RS-232 Interface*

## Serial Number: 19P36026-4585

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, Washington 98005 USA
Tel: 425/643-9866
Fax:425/643-9954

# L I M I T E D   L I A B I L I T Y   S T A T E M E N T

Extreme care should be exercised when using or servicing this equipment. It should be used or serviced only by personnel with knowledge of and training in the use and maintenance of oceanographic electronic equipment.

SEA-BIRD ELECTRONICS, INC. disclaims all product liability risks arising from the use or servicing of this system. SEA-BIRD ELECTRONICS, INC. has no way of controlling the use of this equipment or of choosing the personnel to operate it, and therefore cannot take steps to comply with laws pertaining to product liability, including laws which impose a duty to warn the user of any dangers involved in operating this equipment. Therefore, acceptance of this system by the customer shall be conclusively deemed to include a covenant by the customer to defend, indemnify, and hold SEA-BIRD ELECTRONICS, INC. harmless from all product liability claims arising from the use of servicing of this system.

# WARNING !!

**Do not submerge this instrument (S/N 19P36026-4585)**
**beyond the depth rating of the lowest rated component listed below!**

| | |
|---|---|
| Main Housing (Titanium) | 7000 meters |
| **Pressure Sensor (3500 dBar) Druck** | **3500 meters** |
| Pump (SBE 5M) | 10500 meters |

# SYSTEM CONFIGURATION 14 June 2004

| | |
|---|---|
| Model SBE 19plus | **S/N 19P36026-4585** |
| Instrument Type | **SBE 19plus SeaCaT Profiler** |
| Firmware Version | **1.4D** |
| Communications | **9600 baud, 8 data bits, no parity, one stop bit** |
| Memory | **8192K** |
| Housing | **7000 meter (3AL-4V Titanium)** |
| 0 Conductivity Raw Frequency | **2630.97 Hz** |
| Pressure Sensor | **Strain Gauge: 3500 dBar, S/N 5433** |
| Number of Voltages Sampled: | **0** |
| Serial RS-232C Sensor | **None** |

**Data Format:**

| | |
|---|---|
| Count | **Temperature** |
| Frequency | **Conductivity** |
| Count | **Pressure, Strain gauge** |

| | |
|---|---|
| Pump (SBE 5M) | **050647** |
| Voltage Delay Setting (standard) | **(standard) 0 seconds** |

## IMPORTANT SOFTWARE & HARDWARE CONFIGURATION INFORMATION

Sea-Bird supplies two versions of our software package for communication, real-time data acquisition, and data analysis and display:

- SEASOFT-Win32 - Windows software for PC running Win 95/98/NT/2000/XP
- SEASOFT-DOS - DOS software for IBM-PC/AT/386/486 or compatible computer with a hard drive

Detailed information on the use of the **Windows** software follows:

**SEASOFT-Win32**

SEASOFT-Win32 software was supplied on a CD-ROM with your CTD. This software package is designed to run on a PC running Win 95/98/NT/2000/XP. The CD-ROM also contains software manuals that describe the appropriate applications for the various programs, the procedure for installing the software, and instructions on using the programs. There are three primary programs used with the CTD for setup, data collection and retrieval, data display, and data processing:

- SEATERM - terminal program for setup of the CTD and uploading of data from the CTD memory (**Note**: If using the CTD with the 90208 Auto Fire Module or SBE 17*plus* V2 SEARAM, use SeatermAF instead of SEATERM)
- SEASAVE - real-time data acquisition program
- SBE Data Processing - data processing program

Instructions for using the software are found in their Help files.

To communicate with the CTD to set it up or to upload data from the CTD memory to the computer hard drive, **SEATERM** must have information about the CTD hardware configuration (communication parameters, internal firmware, etc.) and about the computer. To communicate with the CTD, double click on Seaterm.exe:

1. In the Configure menu, select the CTD. The Configuration Options dialog box appears.
   A. On the COM Settings tab, select the firmware version (if applicable), baud rate, data bits, and parity to match the CTD's configuration sheet. If necessary, change the com port to match the computer you are using.
   B. On the Upload Settings tab, enter upload type (all as a single file, etc.) as desired.
   *For the SBE 17 and 25 only*: enter the serial number for the SBE 3 (temperature) and SBE 4 (conductivity) modular sensors, exactly as they appear in the configuration (.con) file.
   C. On the Header Information tab, change the settings as desired.
   Click OK when done. SEATERM saves the settings in a SEATERM.ini file.
2. On the Toolbar, click Connect to communicate with the CTD.
3. To set up the CTD prior to deployment:
   On the Toolbar, click Status. SEATERM sends the Status command and displays the response. Verify that the CTD setup matches your desired deployment. If not, send commands to modify the setup.
4. To upload data from the CTD:
   On the Toolbar, click Upload to upload data from the CTD memory to the computer.

Sea-Bird CTDs store and/or transmit data from their primary and auxiliary sensors in the form of binary or hexadecimal number equivalents of the sensors' frequency or voltage outputs. This is referred to as the *raw* data. The calculations required to convert from *raw* data to *engineering* units of the measured parameters (temperature, conductivity, pressure, dissolved oxygen, pH, etc.) are performed using the software, either in real time, or after the data has been stored in a file. SEASAVE creates the file in real time. As noted above, SEATERM uploads the recorded data and creates the file on the computer hard drive.

To successfully store data to a file on the computer and subsequently convert it to engineering units, the software must know the CTD type, CTD configuration, and calibration coefficients for the sensors installed on the CTD. This information is unique to each CTD, and is contained in a *configuration* file. The configuration file, which has a .con extension, was written onto a floppy disk and the CD-ROM shipped with the CTD. The .con file for a given CTD is named with the last four digits of the serial number for that CTD (e.g., 1234.con). The configuration file is created or modified (e.g., changing coefficients after recalibration, or adding another sensor) by using the Configure menu in **SEASAVE** or
**SBE Data Processing**. The configuration file is used by SEASAVE to convert raw data to engineering units when it acquires, stores, and displays real-time data. The configuration file is also used by some modules in SBE Data Processing (Data Conversion and Derive) that convert raw data to engineering units during data processing.

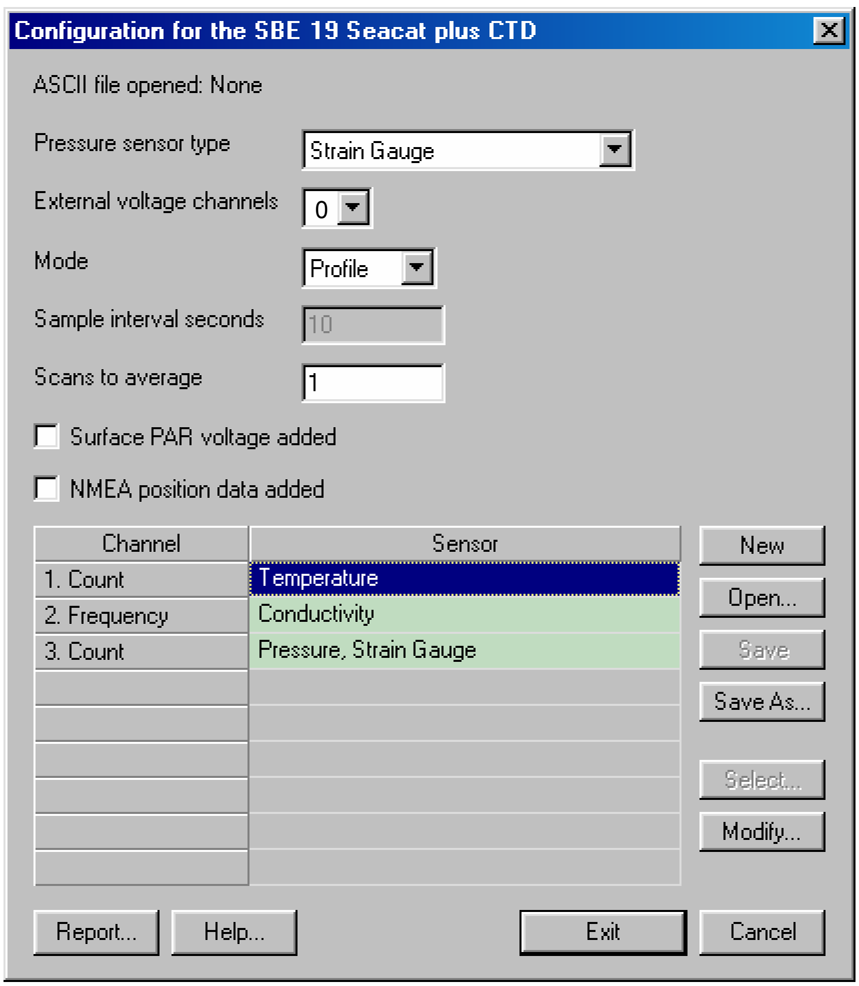
The instrument type and instrument configuration settings of the .con file and the required setup for the SEATERM.ini file for the CTD *as delivered* are documented below. The calibration coefficients for the CTD's sensors are contained in the calibration coefficient section of the CTD manual.

**NOTE:**

SEATERM will not upload data correctly without a properly configured SEATERM.ini file. SEASAVE and SBE Data Processing will not interpret the data correctly without the correct .con file.

## SEASOFT CONFIGURATION:

The correct instrument type for your instrument is SBE 19plus SEACAT Profiler. The correct settings for the configuration of your instrument as delivered are documented below:



# SPECIFICATIONS

# SEACAT Profiler

## SBE 19*plus*

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

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

The 19*plus* uses the same temperature and conductivity sensors proven in 5000 SEACAT and MicroCAT instruments, and a superior new micro-machined silicon strain gauge pressure sensor developed by Druck, Inc. Improvements in design, materials, and signal acquisition techniques yield a low-cost instrument with superior performance that is also easy to use. Calibration coefficients, obtained in our computer-controlled high-accuracy calibration baths, are stored in EEPROM memory. They permit data output in ASCII engineering units (degrees C, Siemens/m, decibars, Salinity [PSU], sound velocity [m/sec], etc.). The 19*plus* can be factory-configured to emulate the .hex output format and 2 Hz data rate of old SEACATs for compatibility with existing software or instrument fleets.

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

### CONFIGURATION AND OPTIONS

A standard SBE 19*plus* is supplied with:
- Plastic housing for depths to 600 meters
- Strain-gauge pressure sensor
- 8 Mbyte FLASH RAM memory
- 9 D-size alkaline batteries
- Impulse glass-reinforced epoxy bulkhead connectors: 4-pin I/O, 2-pin pump, and two 6-pin (two differential auxiliary A/D inputs each)
- SBE 5M miniature pump and T-C Duct

Options include:
- Titanium housing for depths to 7000 meters
- Sensors for oxygen, pH, fluorescence, light (PAR), light transmission, and turbidity
- SBE 5T pump in place of SBE 5M for use with dissolved oxygen and/or other pumped sensors
- Stainless steel cage
- MCBH *Micro* connectors
- Ni-Cad batteries and charger

*Shown with optional cage, SBE 5T pump, & SBE 43 DO sensor*

### SOFTWARE

SEASOFT©-Win32, our complete Windows 95/98/NT/2000/XP software package, is included at no extra charge. Its modular programs include:
- SEATERM© — communication and data retrieval
- SEASAVE© — real-time data acquisition and display
- SBE Data Processing© — filtering, aligning, averaging, and plotting of CTD and auxiliary sensor data and derived variables

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Website: http://www.seabird.com

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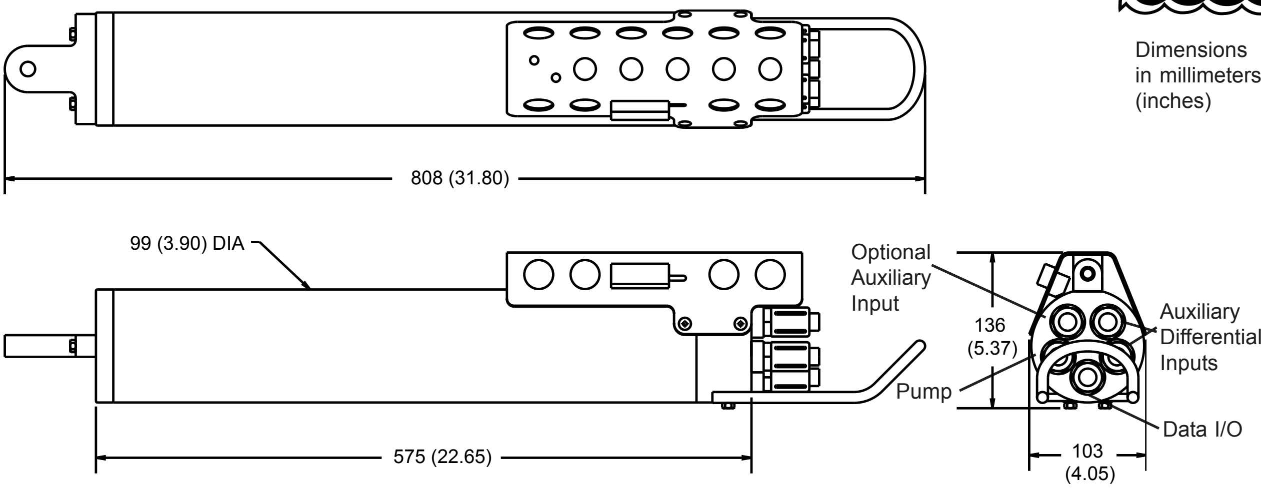
Telephone: (425) 643-9866
Fax: (425) 643-9954

# SEACAT Profiler

## SBE 19*plus*

Dimensions in millimeters (inches)




## SPECIFICATIONS

**Measurement Range**

| | |
|---|---|
| *Temperature* | -5 to +35 °C |
| *Conductivity* | 0 to 9 S/m |
| *Pressure* | 0 to 20 / 100 / 350 / 1000 / 2000 / 3500 / 7000 meters |

**Initial Accuracy**

| | |
|---|---|
| *Temperature* | 0.005 °C |
| *Conductivity* | 0.0005 S/m |
| *Pressure* | 0.1% of full scale range |

**Typical Stability (*per month*)**

| | |
|---|---|
| *Temperature* | 0.0002 °C |
| *Conductivity* | 0.0003 S/m |
| *Pressure* | 0.004% of full scale range |

**Resolution**

| | |
|---|---|
| *Temperature* | 0.0001 °C |
| *Conductivity* | 0.00005 S/m (most oceanic waters; resolves 0.4 ppm in salinity)<br>0.00007 S/m (high salinity waters; resolves 0.4 ppm in salinity)<br>0.00001 S/m (fresh waters; resolves 0.1 ppm in salinity) |
| *Pressure* | 0.002% of full scale range |

**Memory** 8 Mbyte non-volatile FLASH memory

**Data Storage**

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

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

**Internal Batteries** 9 alkaline D-cells provide 60 hours continuous CTD operation; optional 9-cell rechargeable nickel-cadmium battery pack provides approximately 24 hours operation per charge

**External Power Supply** 9 - 28 VDC

**Power Requirements**

| | |
|---|---|
| *Sampling* | 65 mA |
| *SBE 5M pump* | 95 mA |
| *Quiescent* | 30 µA |

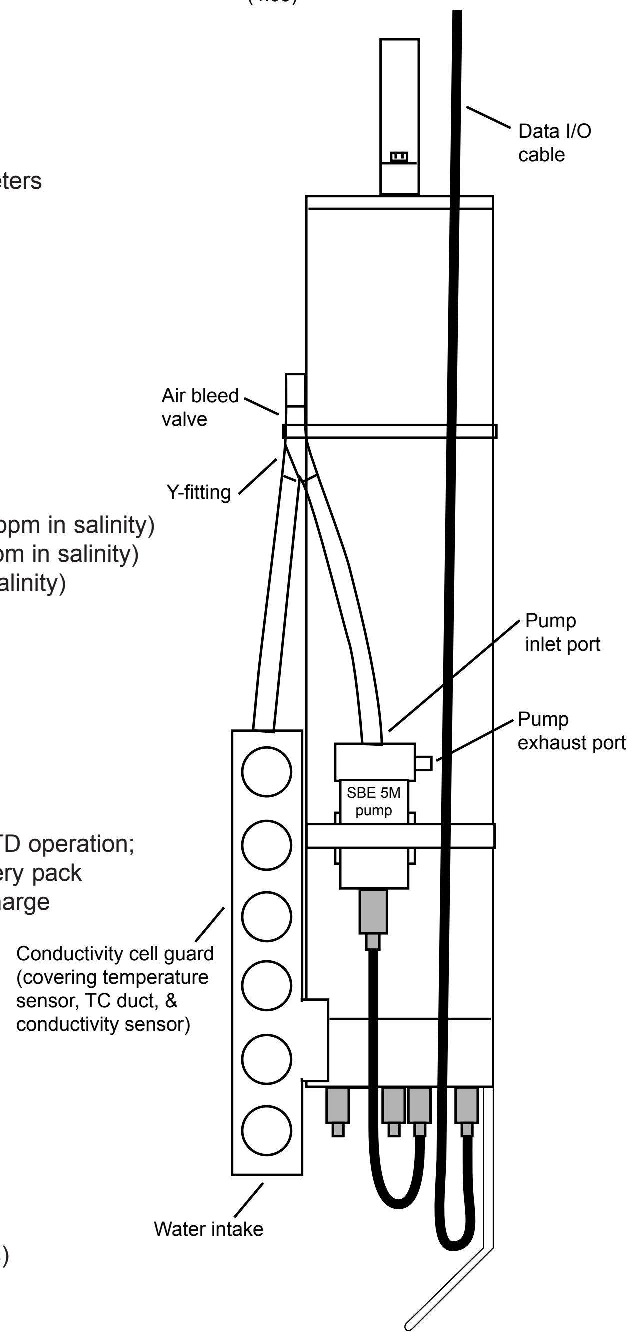
**Auxiliary Voltage Sensors**

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

**Housing Materials — Depth Rating — Weight**

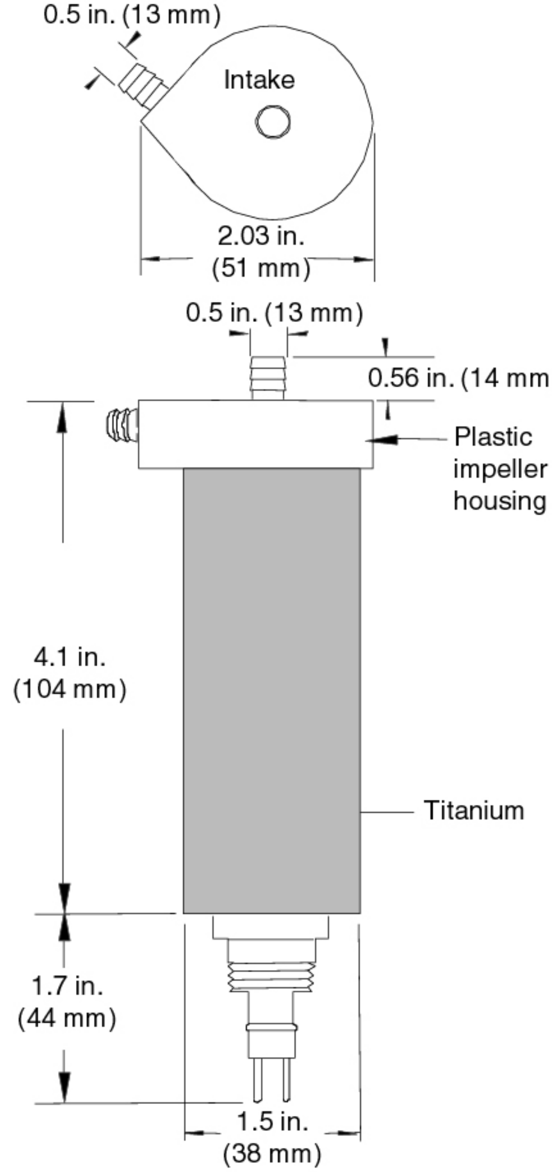
Acetal Copolymer *Plastic* housing — 600 meter (1950 feet) — 7.3 kg (16 lbs)

3AL-2.5V *Titanium* housing — 7000 meter (22,900 feet) — 13.7 kg (30 lbs)



# Mini Submersible Pump SBE 5M

The SBE 5M pump module consists of a centrifugal pump head and a long-life, DC ball bearing motor contained in a compact, titanium, pressure housing usable to 10,500 meters deep. The pump impeller and electric drive motor are coupled magnetically through the housing, providing high reliability by eliminating moving seals. Motor speed and pumping rate remain constant over the entire input voltage range. The motor drive electronics is intrinsically protected against accidental reversed polarity.




## APPLICATIONS

The SBE 5M is standard on the SBE 19 and 19*plus* SEACAT Profiler CTD. It is optional on the SBE 16, 16*plus*, and 16*plus*-IM SEACAT C-T Recorder. The pump flushes water through the conductivity cell at a constant rate, independent of the CTD's motion, improving dynamic performance. For applications requiring pumping through additional sensors (for example, a dissolved oxygen sensor), use the SBE 5T pump instead.

Specify:

- Option 5M-1 for profiling (continuous duty) applications such as the SBE 19*plus*.
- Option 5M-2 for moored (pulsed duty) applications such as the SBE 16*plus* or 16*plus*-IM.

Contact Sea-Bird for use in other applications.

## SPECIFICATIONS

**Option 5M-1 (continuous duty):**
**Input voltage range 9 - 18 VDC**

Flow Rate 25 ml/s supply current 95 ma

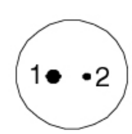
Note: Supply current is independent of operating voltage.

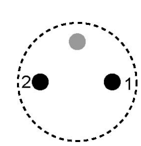
**Option 5M-2 (pulsed duty):**
**Input voltage range 6 - 18 VDC**

| *Pulse Duration* | *Flow Volume* | *Electrical Charge* |
|---|---|---|
| 0.5 seconds | 15 ml | 0.148 amp-seconds |
| 1.0 seconds | 21 ml | 0.283 amp-seconds |
| 1.5 seconds | 31 ml | 0.418 amp-seconds |
| 2.0 seconds | 40 ml | 0.553 amp-seconds |

XSG-2BCL-HP-SS

| Pin | Signal |
|---|---|
| (1) | Ground |
| (2) | + Power |




Optional wet-pluggable connector, MCBH-2MTI

**Weight**
In Air: 0.42 kg (0.91 lbs)
In Water: 0.28 kg (0.60 lbs)

06/03

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## SBE 5M MINI SUBMERSIBLE PUMP CONFIGURATION SHEET

Serial Number: 0647

Job Number: 36026

Customer: NOAA/PMC

Delivery Date: 6/14/2004

Single Connector Housing with Titanium screws

Pressure Case: 10,500 meters (titanium)

Maxon Motor Type:

P/N 90337, Motor PN 20130 (Low power 6 VDC, 2000 RPM MAX) ☐

P/N 90335, Motor PN 20130 (Low power 9 VDC, 2000 RPM MAX) ☑

| | | | | | |
|---|---|---|---|---|---|
| Vin 15V voltage across C2: | 8.015 | VDC | Current | 7.73 | mA |
| Vin 9V voltage across C2: | 8.014 | VDC | Current | 7.4 | mA |
| Vin 6V voltage across C2: | 5.888 | VDC | Current | 7.61 | mA |

Pump submerged test, no load, Vin 12VDC Average current draw in water: 121 mA

# SBE 19plus
# SEACAT PROFILER

*Conductivity, Temperature, and Pressure Recorder with RS-232 Interface*

## Serial Number: 19P36026-4616


Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, Washington 98005 USA
Tel: 425/643-9866
Fax:425/643-9954

# WARNING !!

**Do not submerge this instrument (S/N 19P36026-4616)**
**beyond the depth rating of the lowest rated component listed below!**

| | |
|---|---|
| **Main Housing (Plastic)** | **600 meters** |
| Pressure Sensor (1000 dBar) Druck | 1000 meters |
| Pump (SBE 5M) | 10500 meters |

# SYSTEM CONFIGURATION 14 June 2004

| | |
|---|---|
| Model SBE 19plus | **S/N 19P36026-4616** |
| Instrument Type | **SBE 19plus SeaCaT Profiler** |
| Firmware Version | **1.4D** |
| Communications | **9600 baud, 8 data bits, no parity, one stop bit** |
| Memory | **8192K** |
| Housing | **600 meter (Celcon plastic)** |
| 0 Conductivity Raw Frequency | **2686.52 Hz** |
| Pressure Sensor | **Strain Gauge: 1000 dBar, S/N 5512** |
| Number of Voltages Sampled: | **0** |
| Serial RS-232C Sensor | **None** |
| **Data Format:** | |
| Count | **Temperature** |
| Frequency | **Conductivity** |
| Count | **Pressure, Strain gauge** |
| Pump (SBE 5M) | **050651** |
| Voltage Delay Setting (standard) | **(standard) 0 seconds** |

## IMPORTANT SOFTWARE & HARDWARE CONFIGURATION INFORMATION

Sea-Bird supplies two versions of our software package for communication, real-time data acquisition, and data analysis and display:

- SEASOFT-Win32 - Windows software for PC running Win 95/98/NT/2000/XP
- SEASOFT-DOS - DOS software for IBM-PC/AT/386/486 or compatible computer with a hard drive

Detailed information on the use of the **Windows** software follows:

**SEASOFT-Win32**

SEASOFT-Win32 software was supplied on a CD-ROM with your CTD. This software package is designed to run on a PC running Win 95/98/NT/2000/XP. The CD-ROM also contains software manuals that describe the appropriate applications for the various programs, the procedure for installing the software, and instructions on using the programs. There are three primary programs used with the CTD for setup, data collection and retrieval, data display, and data processing:

- SEATERM - terminal program for setup of the CTD and uploading of data from the CTD memory (**Note**: If using the CTD with the 90208 Auto Fire Module or SBE 17*plus* V2 SEARAM, use SeatermAF instead of SEATERM)
- SEASAVE - real-time data acquisition program
- SBE Data Processing - data processing program

Instructions for using the software are found in their Help files.

To communicate with the CTD to set it up or to upload data from the CTD memory to the computer hard drive, **SEATERM** must have information about the CTD hardware configuration (communication parameters, internal firmware, etc.) and about the computer. To communicate with the CTD, double click on Seaterm.exe:

1. In the Configure menu, select the CTD. The Configuration Options dialog box appears.
   A. On the COM Settings tab, select the firmware version (if applicable), baud rate, data bits, and parity to match the CTD's configuration sheet. If necessary, change the com port to match the computer you are using.
   B. On the Upload Settings tab, enter upload type (all as a single file, etc.) as desired.
      *For the SBE 17 and 25 only*: enter the serial number for the SBE 3 (temperature) and SBE 4 (conductivity) modular sensors, exactly as they appear in the configuration (.con) file.
   C. On the Header Information tab, change the settings as desired.

   Click OK when done. SEATERM saves the settings in a SEATERM.ini file.
2. On the Toolbar, click Connect to communicate with the CTD.
3. To set up the CTD prior to deployment:
   On the Toolbar, click Status. SEATERM sends the Status command and displays the response. Verify that the CTD setup matches your desired deployment. If not, send commands to modify the setup.
4. To upload data from the CTD:
   On the Toolbar, click Upload to upload data from the CTD memory to the computer.

Sea-Bird CTDs store and/or transmit data from their primary and auxiliary sensors in the form of binary or hexadecimal number equivalents of the sensors' frequency or voltage outputs. This is referred to as the *raw* data. The calculations required to convert from *raw* data to *engineering* units of the measured parameters (temperature, conductivity, pressure, dissolved oxygen, pH, etc.) are performed using the software, either in real time, or after the data has been stored in a file. SEASAVE creates the file in real time. As noted above, SEATERM uploads the recorded data and creates the file on the computer hard drive.

To successfully store data to a file on the computer and subsequently convert it to engineering units, the software must know the CTD type, CTD configuration, and calibration coefficients for the sensors installed on the CTD. This information is unique to each CTD, and is contained in a *configuration* file. The configuration file, which has a .con extension, was written onto a floppy disk and the CD-ROM shipped with the CTD. The .con file for a given CTD is named with the last four digits of the serial number for that CTD (e.g., 1234.con). The configuration file is created or modified (e.g., changing coefficients after recalibration, or adding another sensor) by using the Configure menu in **SEASAVE** or
**SBE Data Processing**. The configuration file is used by SEASAVE to convert raw data to engineering units when it acquires, stores, and displays real-time data. The configuration file is also used by some modules in SBE Data Processing (Data Conversion and Derive) that convert raw data to engineering units during data processing.

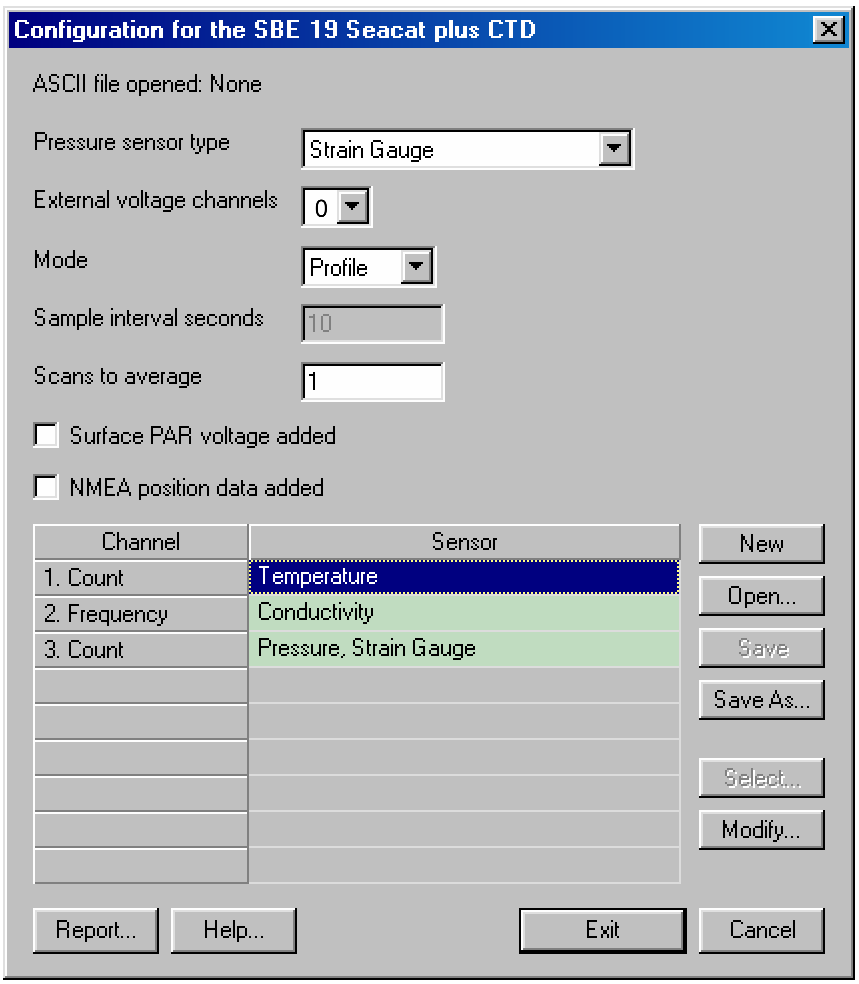
The instrument type and instrument configuration settings of the .con file and the required setup for the SEATERM.ini file for the CTD *as delivered* are documented below. The calibration coefficients for the CTD's sensors are contained in the calibration coefficient section of the CTD manual.

**NOTE:**

SEATERM will not upload data correctly without a properly configured SEATERM.ini file. SEASAVE and SBE Data Processing will not interpret the data correctly without the correct .con file.

**SEASOFT CONFIGURATION:**

The correct instrument type for your instrument is SBE 19plus SEACAT Profiler. The correct settings for the configuration of your instrument as delivered are documented below:



# SPECIFICATIONS

# SEACAT Profiler

## SBE 19*plus*

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

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

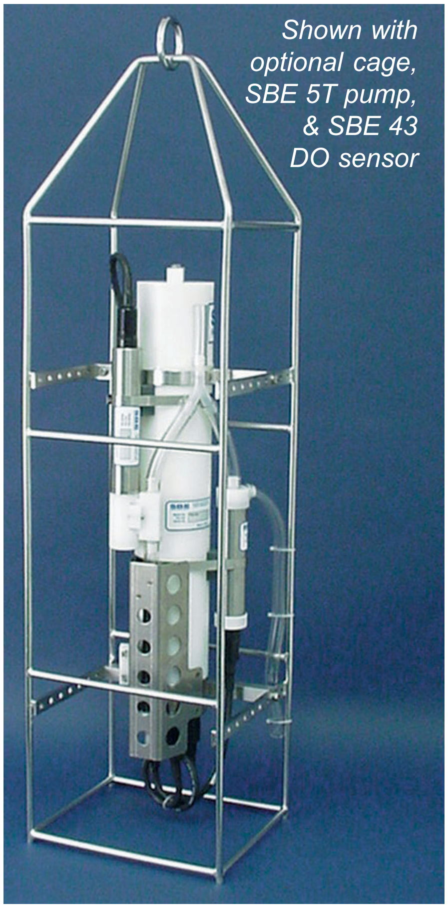
The 19*plus* uses the same temperature and conductivity sensors proven in 5000 SEACAT and MicroCAT instruments, and a superior new micro-machined silicon strain gauge pressure sensor developed by Druck, Inc. Improvements in design, materials, and signal acquisition techniques yield a low-cost instrument with superior performance that is also easy to use. Calibration coefficients, obtained in our computer-controlled high-accuracy calibration baths, are stored in EEPROM memory. They permit data output in ASCII engineering units (degrees C, Siemens/m, decibars, Salinity [PSU], sound velocity [m/sec], etc.). The 19*plus* can be factory-configured to emulate the .hex output format and 2 Hz data rate of old SEACATs for compatibility with existing software or instrument fleets.

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

### CONFIGURATION AND OPTIONS

A standard SBE 19*plus* is supplied with:
- Plastic housing for depths to 600 meters
- Strain-gauge pressure sensor
- 8 Mbyte FLASH RAM memory
- 9 D-size alkaline batteries
- Impulse glass-reinforced epoxy bulkhead connectors: 4-pin I/O, 2-pin pump, and two 6-pin (two differential auxiliary A/D inputs each)
- SBE 5M miniature pump and T-C Duct

Options include:
- Titanium housing for depths to 7000 meters
- Sensors for oxygen, pH, fluorescence, light (PAR), light transmission, and turbidity
- SBE 5T pump in place of SBE 5M for use with dissolved oxygen and/or other pumped sensors
- Stainless steel cage
- MCBH *Micro* connectors
- Ni-Cad batteries and charger


*Shown with optional cage, SBE 5T pump, & SBE 43 DO sensor*

### SOFTWARE

SEASOFT©-Win32, our complete Windows 95/98/NT/2000/XP software package, is included at no extra charge. Its modular programs include:
- SEATERM© — communication and data retrieval
- SEASAVE© — real-time data acquisition and display
- SBE Data Processing© — filtering, aligning, averaging, and plotting of CTD and auxiliary sensor data and derived variables

SBE
**Sea-Bird Electronics, Inc.**
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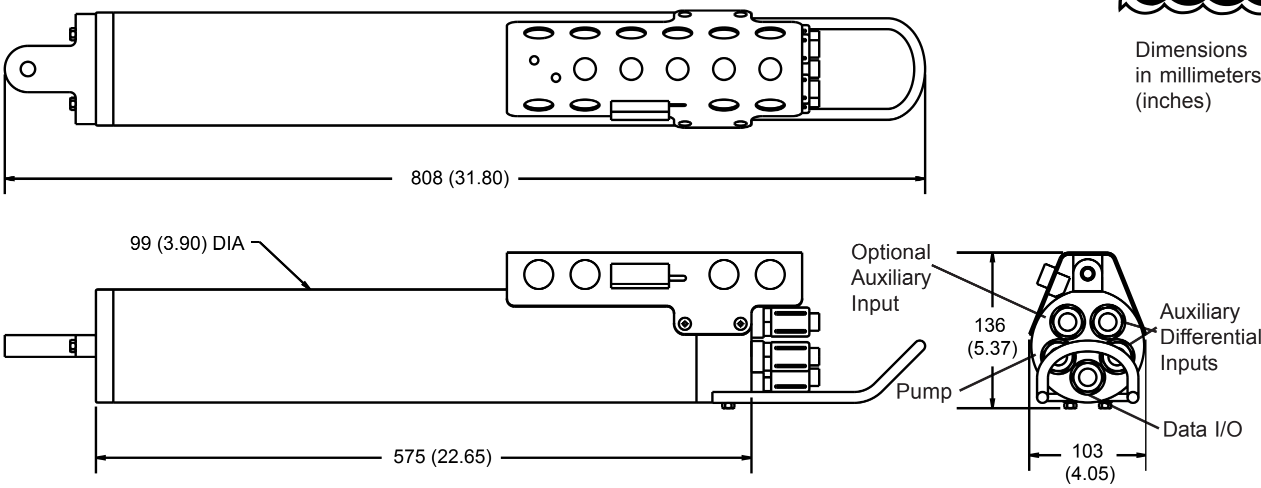
# SEACAT Profiler

# SBE 19*plus*




## SPECIFICATIONS

**Measurement Range**

| | |
|---|---|
| *Temperature* | -5 to +35 °C |
| *Conductivity* | 0 to 9 S/m |
| *Pressure* | 0 to 20 / 100 / 350 / 1000 / 2000 / 3500 / 7000 meters |

**Initial Accuracy**

| | |
|---|---|
| *Temperature* | 0.005 °C |
| *Conductivity* | 0.0005 S/m |
| *Pressure* | 0.1% of full scale range |

**Typical Stability (*per month*)**

| | |
|---|---|
| *Temperature* | 0.0002 °C |
| *Conductivity* | 0.0003 S/m |
| *Pressure* | 0.004% of full scale range |

**Resolution**

| | |
|---|---|
| *Temperature* | 0.0001 °C |
| *Conductivity* | 0.00005 S/m (most oceanic waters; resolves 0.4 ppm in salinity)<br>0.00007 S/m (high salinity waters; resolves 0.4 ppm in salinity)<br>0.00001 S/m (fresh waters; resolves 0.1 ppm in salinity) |
| *Pressure* | 0.002% of full scale range |

**Memory** — 8 Mbyte non-volatile FLASH memory

**Data Storage**

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

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

**Internal Batteries** — 9 alkaline D-cells provide 60 hours continuous CTD operation; optional 9-cell rechargeable nickel-cadmium battery pack provides approximately 24 hours operation per charge

**External Power Supply** — 9 - 28 VDC

**Power Requirements**

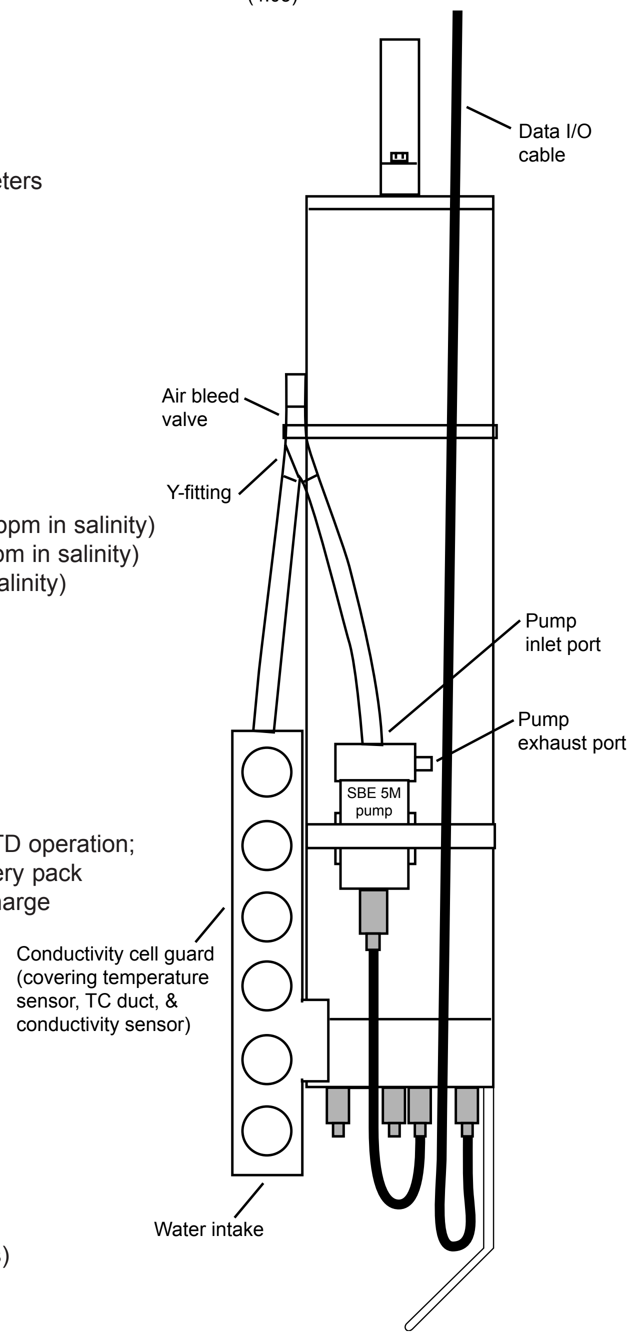
| | |
|---|---|
| *Sampling* | 65 mA |
| *SBE 5M pump* | 95 mA |
| *Quiescent* | 30 µA |

**Auxiliary Voltage Sensors**

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

**Housing Materials — Depth Rating — Weight**

Acetal Copolymer *Plastic* housing — 600 meter (1950 feet) — 7.3 kg (16 lbs)
3AL-2.5V *Titanium* housing — 7000 meter (22,900 feet) — 13.7 kg (30 lbs)

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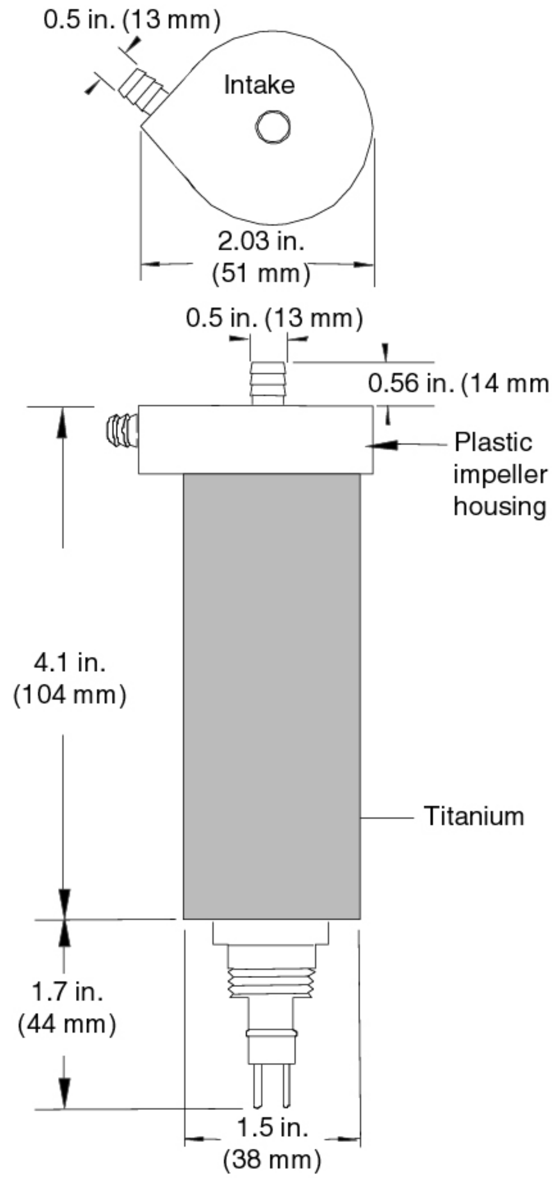
# Mini Submersible Pump SBE 5M

The SBE 5M pump module consists of a centrifugal pump head and a long-life, DC ball bearing motor contained in a compact, titanium, pressure housing usable to 10,500 meters deep. The pump impeller and electric drive motor are coupled magnetically through the housing, providing high reliability by eliminating moving seals. Motor speed and pumping rate remain constant over the entire input voltage range. The motor drive electronics is intrinsically protected against accidental reversed polarity.




## APPLICATIONS

The SBE 5M is standard on the SBE 19 and 19*plus* SEACAT Profiler CTD. It is optional on the SBE 16, 16*plus*, and 16*plus*-IM SEACAT C-T Recorder. The pump flushes water through the conductivity cell at a constant rate, independent of the CTD's motion, improving dynamic performance. For applications requiring pumping through additional sensors (for example, a dissolved oxygen sensor), use the SBE 5T pump instead.

Specify:
- Option 5M-1 for profiling (continuous duty) applications such as the SBE 19*plus*.
- Option 5M-2 for moored (pulsed duty) applications such as the SBE 16*plus* or 16*plus*-IM.

Contact Sea-Bird for use in other applications.

## SPECIFICATIONS

**Option 5M-1 (continuous duty):**
**Input voltage range 9 - 18 VDC**

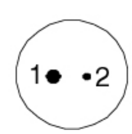
Flow Rate 25 ml/s    supply current 95 ma

Note: Supply current is independent of operating voltage.

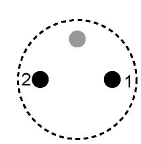
**Option 5M-2 (pulsed duty):**
**Input voltage range 6 - 18 VDC**

| *Pulse Duration* | *Flow Volume* | *Electrical Charge* |
|---|---|---|
| 0.5 seconds | 15 ml | 0.148 amp-seconds |
| 1.0 seconds | 21 ml | 0.283 amp-seconds |
| 1.5 seconds | 31 ml | 0.418 amp-seconds |
| 2.0 seconds | 40 ml | 0.553 amp-seconds |

XSG-2BCL-HP-SS




| Pin | Signal |
|---|---|
| (1) | Ground |
| (2) | + Power |




Optional wet-pluggable connector, MCBH-2MTI

**Weight**

| | |
|---|---|
| In Air: | 0.42 kg (0.91 lbs) |
| In Water: | 0.28 kg (0.60 lbs) |

06/03

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Website: http://www.seabird.com Email: seabird@seabird.com

## SBE 5M MINI SUBMERSIBLE PUMP CONFIGURATION SHEET

Serial Number: 0651

Job Number: 36026

Customer: NOAA/PMC

Delivery Date: 6/14/2004

Single Connector Housing with Titanium screws

Pressure Case: 10,500 meters (titanium)

Maxon Motor Type:

P/N 90337, Motor PN 20130 (Low power 6 VDC, 2000 RPM MAX) ☐

P/N 90335, Motor PN 20130 (Low power 9 VDC, 2000 RPM MAX) ☑

| | | | | | |
|---|---|---|---|---|---|
| Vin 15V voltage across C2: | 7.929 | VDC | Current | 9.29 | mA |
| Vin 9V voltage across C2: | 7.928 | VDC | Current | 8.8 | mA |
| Vin 6V voltage across C2: | 5.885 | VDC | Current | 7.99 | mA |

Pump submerged test, no load, Vin 12VDC Average current draw in water: 120 mA

# SBE 19plus
# SEACAT PROFILER

*Conductivity, Temperature, and Pressure Recorder with RS-232 Interface*

## Serial Number: 19P36026-4617

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, Washington 98005 USA
Tel: 425/643-9866
Fax:425/643-9954

# LIMITED LIABILITY STATEMENT

Extreme care should be exercised when using or servicing this equipment. It should be used or serviced only by personnel with knowledge of and training in the use and maintenance of oceanographic electronic equipment.

SEA-BIRD ELECTRONICS, INC. disclaims all product liability risks arising from the use or servicing of this system. SEA-BIRD ELECTRONICS, INC. has no way of controlling the use of this equipment or of choosing the personnel to operate it, and therefore cannot take steps to comply with laws pertaining to product liability, including laws which impose a duty to warn the user of any dangers involved in operating this equipment. Therefore, acceptance of this system by the customer shall be conclusively deemed to include a covenant by the customer to defend, indemnify, and hold SEA-BIRD ELECTRONICS, INC. harmless from all product liability claims arising from the use of servicing of this system.

# WARNING !!

**Do not submerge this instrument (S/N 19P36026-4617)**
**beyond the depth rating of the lowest rated component listed below!**

| | |
|---|---|
| **Main Housing (Plastic)** | **600 meters** |
| Pressure Sensor (1000 dBar) Druck | 1000 meters |
| Pump (SBE 5M) | 10500 meters |

# SYSTEM CONFIGURATION 14 June 2004

| | |
|---|---|
| Model SBE 19plus | **S/N 19P36026-4617** |
| Instrument Type | **SBE 19plus SeaCaT Profiler** |
| Firmware Version | **1.4D** |
| Communications | **9600 baud, 8 data bits, no parity, one stop bit** |
| Memory | **8192K** |
| Housing | **600 meter (Celcon plastic)** |
| 0 Conductivity Raw Frequency | **2801.47 Hz** |
| Pressure Sensor | **Strain Gauge: 1000 dBar, S/N 5513** |
| Number of Voltages Sampled: | **0** |
| Serial RS-232C Sensor | **None** |
| **Data Format:** | |
| Count | **Temperature** |
| Frequency | **Conductivity** |
| Count | **Pressure, Strain gauge** |
| Pump (SBE 5M) | **050649** |
| Voltage Delay Setting (standard) | **(standard) 0 seconds** |

## IMPORTANT SOFTWARE & HARDWARE CONFIGURATION INFORMATION

Sea-Bird supplies two versions of our software package for communication, real-time data acquisition, and data analysis and display:

- SEASOFT-Win32 - Windows software for PC running Win 95/98/NT/2000/XP
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Detailed information on the use of the **Windows** software follows:

**SEASOFT-Win32**

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- SEATERM - terminal program for setup of the CTD and uploading of data from the CTD memory (**Note**: If using the CTD with the 90208 Auto Fire Module or SBE 17*plus* V2 SEARAM, use SeatermAF instead of SEATERM)
- SEASAVE - real-time data acquisition program
- SBE Data Processing - data processing program

Instructions for using the software are found in their Help files.

To communicate with the CTD to set it up or to upload data from the CTD memory to the computer hard drive, **SEATERM** must have information about the CTD hardware configuration (communication parameters, internal firmware, etc.) and about the computer. To communicate with the CTD, double click on Seaterm.exe:

1. In the Configure menu, select the CTD. The Configuration Options dialog box appears.
   A. On the COM Settings tab, select the firmware version (if applicable), baud rate, data bits, and parity to match the CTD's configuration sheet. If necessary, change the com port to match the computer you are using.
   B. On the Upload Settings tab, enter upload type (all as a single file, etc.) as desired.
      *For the SBE 17 and 25 only*: enter the serial number for the SBE 3 (temperature) and SBE 4 (conductivity) modular sensors, exactly as they appear in the configuration (.con) file.
   C. On the Header Information tab, change the settings as desired.

   Click OK when done. SEATERM saves the settings in a SEATERM.ini file.
2. On the Toolbar, click Connect to communicate with the CTD.
3. To set up the CTD prior to deployment:
   On the Toolbar, click Status. SEATERM sends the Status command and displays the response. Verify that the CTD setup matches your desired deployment. If not, send commands to modify the setup.
4. To upload data from the CTD:
   On the Toolbar, click Upload to upload data from the CTD memory to the computer.

Sea-Bird CTDs store and/or transmit data from their primary and auxiliary sensors in the form of binary or hexadecimal number equivalents of the sensors' frequency or voltage outputs. This is referred to as the *raw* data. The calculations required to convert from *raw* data to *engineering* units of the measured parameters (temperature, conductivity, pressure, dissolved oxygen, pH, etc.) are performed using the software, either in real time, or after the data has been stored in a file. SEASAVE creates the file in real time. As noted above, SEATERM uploads the recorded data and creates the file on the computer hard drive.

To successfully store data to a file on the computer and subsequently convert it to engineering units, the software must know the CTD type, CTD configuration, and calibration coefficients for the sensors installed on the CTD. This information is unique to each CTD, and is contained in a *configuration* file. The configuration file, which has a .con extension, was written onto a floppy disk and the CD-ROM shipped with the CTD. The .con file for a given CTD is named with the last four digits of the serial number for that CTD (e.g., 1234.con). The configuration file is created or modified (e.g., changing coefficients after recalibration, or adding another sensor) by using the Configure menu in **SEASAVE** or **SBE Data Processing**. The configuration file is used by SEASAVE to convert raw data to engineering units when it acquires, stores, and displays real-time data. The configuration file is also used by some modules in SBE Data Processing (Data Conversion and Derive) that convert raw data to engineering units during data processing.

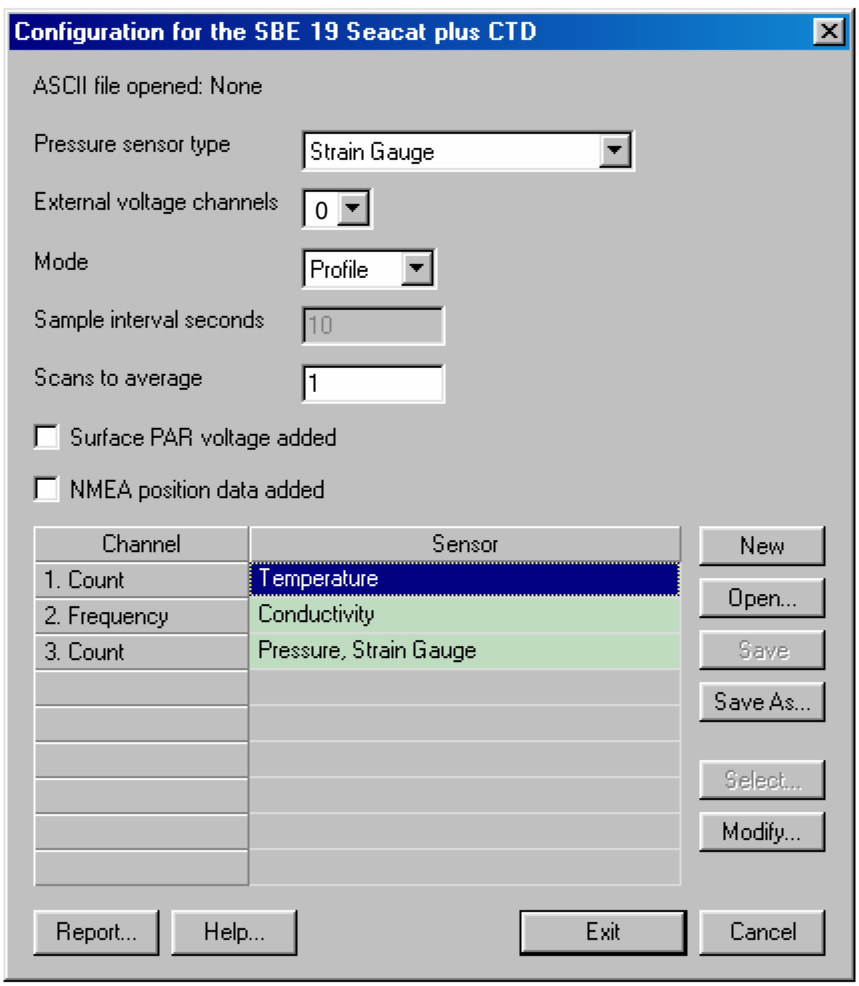
The instrument type and instrument configuration settings of the .con file and the required setup for the SEATERM.ini file for the CTD *as delivered* are documented below. The calibration coefficients for the CTD's sensors are contained in the calibration coefficient section of the CTD manual.

**NOTE:**

SEATERM will not upload data correctly without a properly configured SEATERM.ini file. SEASAVE and SBE Data Processing will not interpret the data correctly without the correct .con file.

## SEASOFT CONFIGURATION:

The correct instrument type for your instrument is SBE 19plus SEACAT Profiler. The correct settings for the configuration of your instrument as delivered are documented below:



# SPECIFICATIONS

# SEACAT Profiler

## SBE 19*plus*

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

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

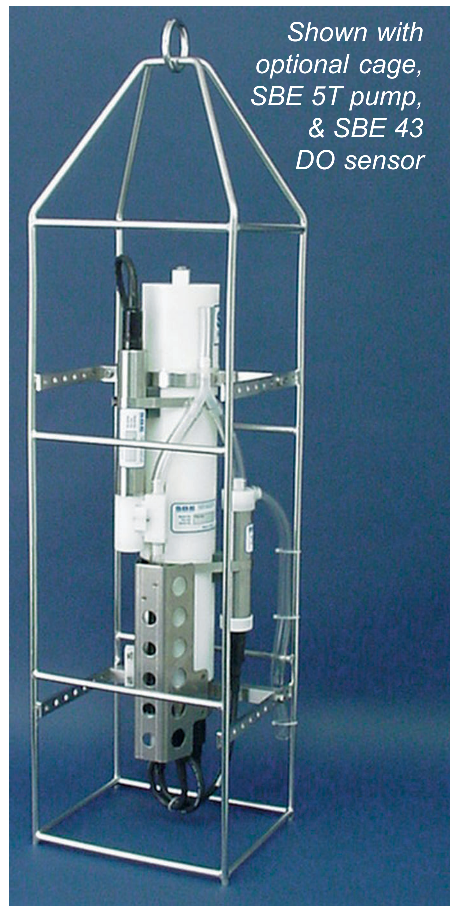
The 19*plus* uses the same temperature and conductivity sensors proven in 5000 SEACAT and MicroCAT instruments, and a superior new micro-machined silicon strain gauge pressure sensor developed by Druck, Inc. Improvements in design, materials, and signal acquisition techniques yield a low-cost instrument with superior performance that is also easy to use. Calibration coefficients, obtained in our computer-controlled high-accuracy calibration baths, are stored in EEPROM memory. They permit data output in ASCII engineering units (degrees C, Siemens/m, decibars, Salinity [PSU], sound velocity [m/sec], etc.). The 19*plus* can be factory-configured to emulate the .hex output format and 2 Hz data rate of old SEACATs for compatibility with existing software or instrument fleets.

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

### CONFIGURATION AND OPTIONS

A standard SBE 19*plus* is supplied with:
- Plastic housing for depths to 600 meters
- Strain-gauge pressure sensor
- 8 Mbyte FLASH RAM memory
- 9 D-size alkaline batteries
- Impulse glass-reinforced epoxy bulkhead connectors: 4-pin I/O, 2-pin pump, and two 6-pin (two differential auxiliary A/D inputs each)
- SBE 5M miniature pump and T-C Duct

Options include:
- Titanium housing for depths to 7000 meters
- Sensors for oxygen, pH, fluorescence, light (PAR), light transmission, and turbidity
- SBE 5T pump in place of SBE 5M for use with dissolved oxygen and/or other pumped sensors
- Stainless steel cage
- MCBH *Micro* connectors
- Ni-Cad batteries and charger


*Shown with optional cage, SBE 5T pump, & SBE 43 DO sensor*

### SOFTWARE

SEASOFT©-Win32, our complete Windows 95/98/NT/2000/XP software package, is included at no extra charge. Its modular programs include:
- SEATERM© — communication and data retrieval
- SEASAVE© — real-time data acquisition and display
- SBE Data Processing© — filtering, aligning, averaging, and plotting of CTD and auxiliary sensor data and derived variables

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

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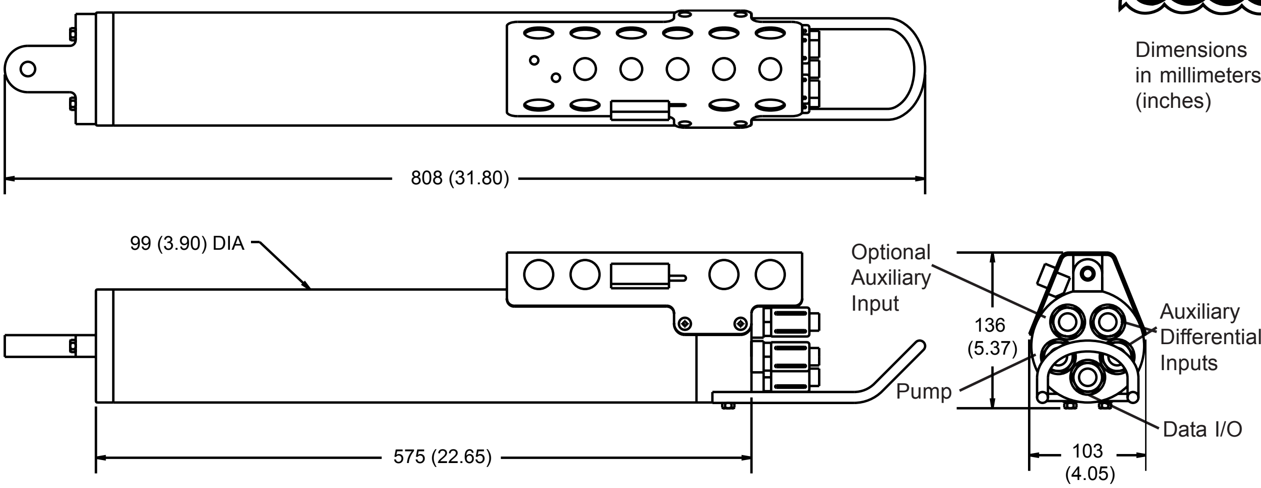
# SEACAT Profiler

**SBE 19*plus***




## SPECIFICATIONS

**Measurement Range**

| | |
|---|---|
| *Temperature* | -5 to +35 °C |
| *Conductivity* | 0 to 9 S/m |
| *Pressure* | 0 to 20 / 100 / 350 / 1000 / 2000 / 3500 / 7000 meters |

**Initial Accuracy**

| | |
|---|---|
| *Temperature* | 0.005 °C |
| *Conductivity* | 0.0005 S/m |
| *Pressure* | 0.1% of full scale range |

**Typical Stability (*per month*)**

| | |
|---|---|
| *Temperature* | 0.0002 °C |
| *Conductivity* | 0.0003 S/m |
| *Pressure* | 0.004% of full scale range |

**Resolution**

| | |
|---|---|
| *Temperature* | 0.0001 °C |
| *Conductivity* | 0.00005 S/m (most oceanic waters; resolves 0.4 ppm in salinity)<br>0.00007 S/m (high salinity waters; resolves 0.4 ppm in salinity)<br>0.00001 S/m (fresh waters; resolves 0.1 ppm in salinity) |
| *Pressure* | 0.002% of full scale range |

**Memory** 8 Mbyte non-volatile FLASH memory

**Data Storage**

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

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

**Internal Batteries** 9 alkaline D-cells provide 60 hours continuous CTD operation; optional 9-cell rechargeable nickel-cadmium battery pack provides approximately 24 hours operation per charge

**External Power Supply** 9 - 28 VDC

**Power Requirements**

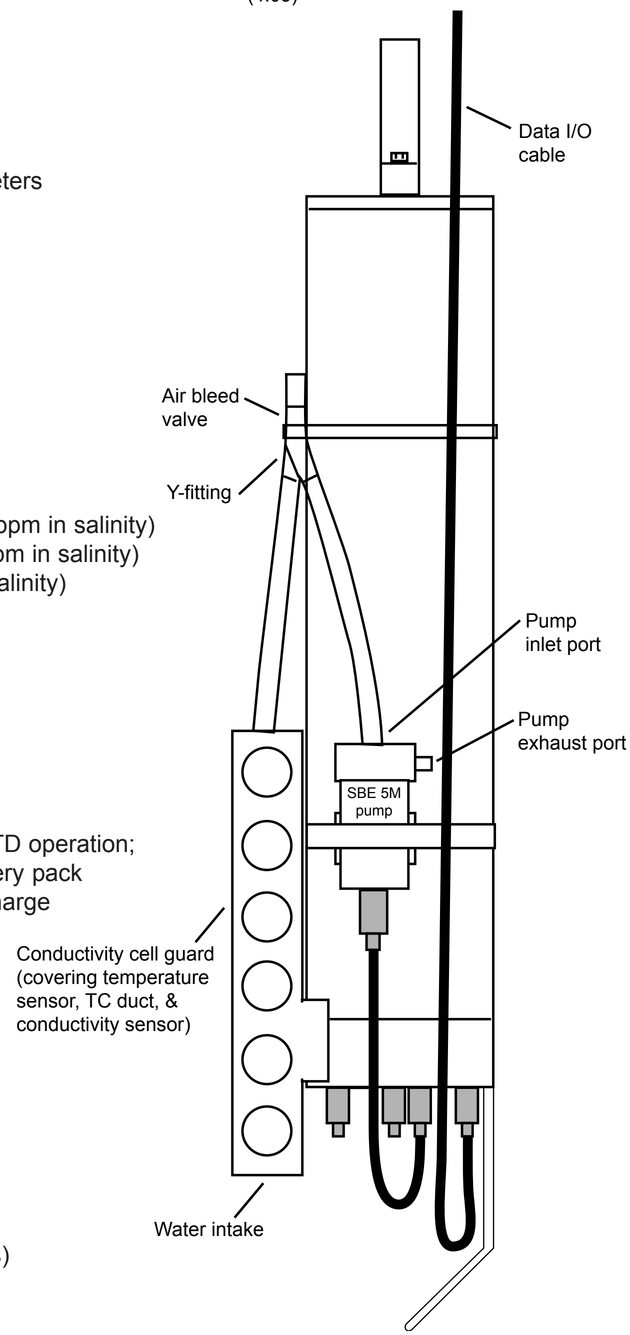
| | |
|---|---|
| *Sampling* | 65 mA |
| *SBE 5M pump* | 95 mA |
| *Quiescent* | 30 µA |

**Auxiliary Voltage Sensors**

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

**Housing Materials — Depth Rating — Weight**

Acetal Copolymer *Plastic* housing — 600 meter (1950 feet) — 7.3 kg (16 lbs)
3AL-2.5V *Titanium* housing — 7000 meter (22,900 feet) — 13.7 kg (30 lbs)

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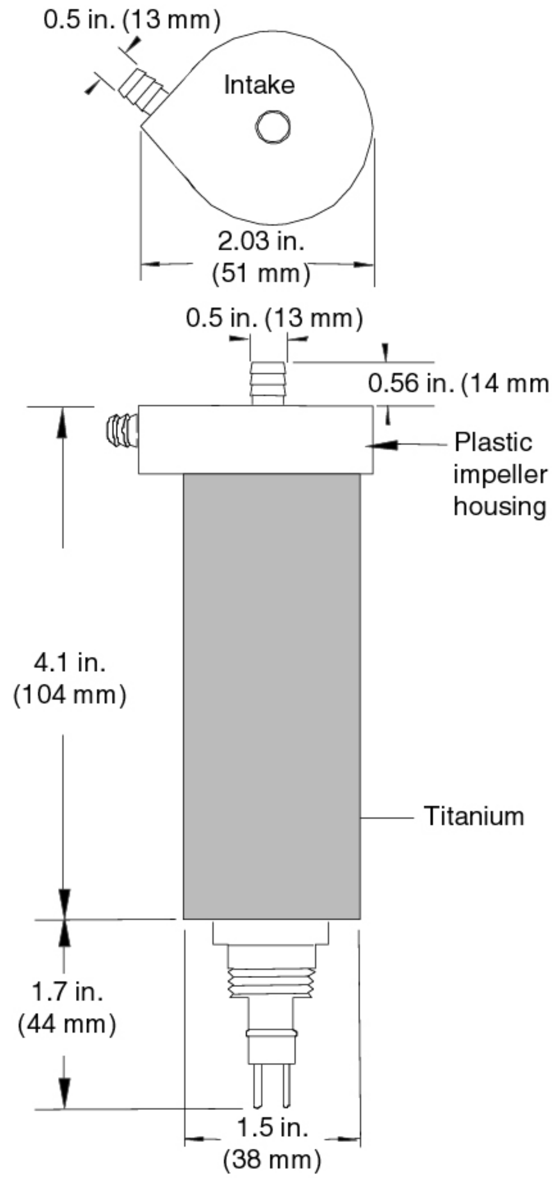
# Mini Submersible Pump SBE 5M

The SBE 5M pump module consists of a centrifugal pump head and a long-life, DC ball bearing motor contained in a compact, titanium, pressure housing usable to 10,500 meters deep. The pump impeller and electric drive motor are coupled magnetically through the housing, providing high reliability by eliminating moving seals. Motor speed and pumping rate remain constant over the entire input voltage range. The motor drive electronics is intrinsically protected against accidental reversed polarity.




## APPLICATIONS

The SBE 5M is standard on the SBE 19 and 19*plus* SEACAT Profiler CTD. It is optional on the SBE 16, 16*plus*, and 16*plus*-IM SEACAT C-T Recorder. The pump flushes water through the conductivity cell at a constant rate, independent of the CTD's motion, improving dynamic performance. For applications requiring pumping through additional sensors (for example, a dissolved oxygen sensor), use the SBE 5T pump instead.

Specify:

- Option 5M-1 for profiling (continuous duty) applications such as the SBE 19*plus*.
- Option 5M-2 for moored (pulsed duty) applications such as the SBE 16*plus* or 16*plus*-IM.

Contact Sea-Bird for use in other applications.

## SPECIFICATIONS

**Option 5M-1 (continuous duty):**
**Input voltage range 9 - 18 VDC**

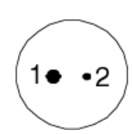
Flow Rate 25 ml/s supply current 95 ma

Note: Supply current is independent of operating voltage.

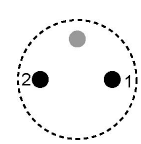
**Option 5M-2 (pulsed duty):**
**Input voltage range 6 - 18 VDC**

| *Pulse Duration* | *Flow Volume* | *Electrical Charge* |
|---|---|---|
| 0.5 seconds | 15 ml | 0.148 amp-seconds |
| 1.0 seconds | 21 ml | 0.283 amp-seconds |
| 1.5 seconds | 31 ml | 0.418 amp-seconds |
| 2.0 seconds | 40 ml | 0.553 amp-seconds |

XSG-2BCL-HP-SS




| Pin | Signal |
|---|---|
| (1) | Ground |
| (2) | + Power |




Optional wet-pluggable connector, MCBH-2MTI

**Weight**
In Air: 0.42 kg (0.91 lbs)
In Water: 0.28 kg (0.60 lbs)

06/03

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## SBE 5M MINI SUBMERSIBLE PUMP CONFIGURATION SHEET

Serial Number: 0649

Job Number: 36026

Customer: NOAA/PMC

Delivery Date: 6/14/2004

Single Connector Housing with Titanium screws

Pressure Case: 10,500 meters (titanium)

Maxon Motor Type:

P/N 90337, Motor PN 20130 (Low power 6 VDC, 2000 RPM MAX) ☐

P/N 90335, Motor PN 20130 (Low power 9 VDC, 2000 RPM MAX) ☑

| | | | | | |
|---|---|---|---|---|---|
| Vin 15V voltage across C2: | 7.947 | VDC | Current | 11.8 | mA |
| Vin 9V voltage across C2: | 7.948 | VDC | Current | 11.0 | mA |
| Vin 6V voltage across C2: | 5.868 | VDC | Current | 10.2 | mA |

Pump submerged test, no load, Vin 12VDC Average current draw in water: 124 mA

# SBE 19plusV2
# SEACAT PROFILER

*Conductivity, Temperature, and Pressure Recorder with RS-232 Interface*

## Serial Number: 19P50959-6121

## User Manual, Version 002

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, Washington 98005 USA
Tel: 425/643-9866
Fax:425/643-9954

# LIMITED LIABILITY STATEMENT

Extreme care should be exercised when using or servicing this equipment. It should be used or serviced only by personnel with knowledge of and training in the use and maintenance of oceanographic electronic equipment.

SEA-BIRD ELECTRONICS, INC. disclaims all product liability risks arising from the use or servicing of this system. SEA-BIRD ELECTRONICS, INC. has no way of controlling the use of this equipment or of choosing the personnel to operate it, and therefore cannot take steps to comply with laws pertaining to product liability, including laws which impose a duty to warn the user of any dangers involved in operating this equipment. Therefore, acceptance of this system by the customer shall be conclusively deemed to include a covenant by the customer to defend, indemnify, and hold SEA-BIRD ELECTRONICS, INC. harmless from all product liability claims arising from the use of servicing of this system.

# WARNING !!

**Do not submerge this instrument (S/N 19P50959-6121)**
**beyond the depth rating of the lowest rated component listed below!**

| | |
|---|---|
| **Main Housing (Plastic)** | **600 meters** |
| Pressure Sensor (600 dBar) Druck | 600 meters |
| Pump (SBE 5M) | 600 meters |

# SYSTEM CONFIGURATION 30 September 2008

| | |
|---|---|
| Model SBE 19plusV2 | **S/N 19P50959-6121** |
| Instrument Type | **SBE 19plusV2 SeaCaT Profiler** |
| Firmware Version | **2.1** |
| Communications | **9600 baud, 8 data bits, no parity, one stop bit** |
| Memory | **64MB** |
| Housing | **600 meter (Acetron Plastic)** |
| 0 Conductivity Raw Frequency | **3148.83 Hz** |
| Pressure Sensor | **Strain Gauge: 600 dBar, S/N 2752079** |
| Computer communications (Data I/O) connector | **Located on the P/N 17709 Y-Cable** |
| Number of Voltages Sampled: | **0** |
| Serial RS-232C Sensor | **None** |

**Data Format:**

| | |
|---|---|
| Count | **Temperature** |
| Frequency | **Conductivity** |
| Count | **Pressure, Strain Gauge** |

| | |
|---|---|
| **Pump (SBE 5M)** | **051056** |

## IMPORTANT SOFTWARE & HARDWARE CONFIGURATION INFORMATION

Sea-Bird supplies two versions of our software package for communication, real-time data acquisition, and data analysis and display:

- SEASOFT-Win32 - Windows software for PC running Win 95/98/NT/2000/XP
- SEASOFT-DOS - DOS software for IBM-PC/AT/386/486 or compatible computer with a hard drive

Detailed information on the use of the **Windows** software follows:

### SEASOFT-Win32

SEASOFT-Win32 software was supplied on a CD-ROM with your CTD. This software package is designed to run on a PC running Win 95/98/NT/2000/XP. The CD-ROM also contains software manuals that describe the appropriate applications for the various programs, the procedure for installing the software, and instructions on using the programs. There are three primary programs used with the CTD for setup, data collection and retrieval, data display, and data processing:

- SEATERM - terminal program for setup of the CTD and uploading of data from the CTD memory (**Note**: If using the CTD with the 90208 Auto Fire Module or SBE 17*plus* V2 SEARAM, use SeatermAF instead of SEATERM)
- SEASAVE - real-time data acquisition program
- SBE Data Processing - data processing program

Instructions for using the software are found in their Help files.

To communicate with the CTD to set it up or to upload data from the CTD memory to the computer hard drive, **SEATERM** must have information about the CTD hardware configuration (communication parameters, internal firmware, etc.) and about the computer. To communicate with the CTD, double click on Seaterm.exe:

1. In the Configure menu, select the CTD. The Configuration Options dialog box appears.
   A. On the COM Settings tab, select the firmware version (if applicable), baud rate, data bits, and parity to match the CTD's configuration sheet. If necessary, change the com port to match the computer you are using.
   B. On the Upload Settings tab, enter upload type (all as a single file, etc.) as desired.
   *For the SBE 17 and 25 only*: enter the serial number for the SBE 3 (temperature) and SBE 4 (conductivity) modular sensors, exactly as they appear in the configuration (.con) file.
   C. On the Header Information tab, change the settings as desired.

   Click OK when done. SEATERM saves the settings in a SEATERM.ini file.
2. On the Toolbar, click Connect to communicate with the CTD.
3. To set up the CTD prior to deployment:
   On the Toolbar, click Status. SEATERM sends the Status command and displays the response. Verify that the CTD setup matches your desired deployment. If not, send commands to modify the setup.
4. To upload data from the CTD:
   On the Toolbar, click Upload to upload data from the CTD memory to the computer.

Sea-Bird CTDs store and/or transmit data from their primary and auxiliary sensors in the form of binary or hexadecimal number equivalents of the sensors' frequency or voltage outputs. This is referred to as the *raw* data. The calculations required to convert from *raw* data to *engineering* units of the measured parameters (temperature, conductivity, pressure, dissolved oxygen, pH, etc.) are performed using the software, either in real time, or after the data has been stored in a file. SEASAVE creates the file in real time. As noted above, SEATERM uploads the recorded data and creates the file on the computer hard drive.

To successfully store data to a file on the computer and subsequently convert it to engineering units, the software must know the CTD type, CTD configuration, and calibration coefficients for the sensors installed on the CTD. This information is unique to each CTD, and is contained in a *configuration* file. The configuration file, which has a .con extension, was written onto a floppy disk and the CD-ROM shipped with the CTD. The .con file for a given CTD is named with the last four digits of the serial number for that CTD (e.g., 1234.con). The configuration file is created or modified (e.g., changing coefficients after recalibration, or adding another sensor) by using the Configure menu in **SEASAVE** or **SBE Data Processing**. The configuration file is used by SEASAVE to convert raw data to engineering units when it acquires, stores, and displays real-time data. The configuration file is also used by some modules in SBE Data Processing (Data Conversion and Derive) that convert raw data to engineering units during data processing.

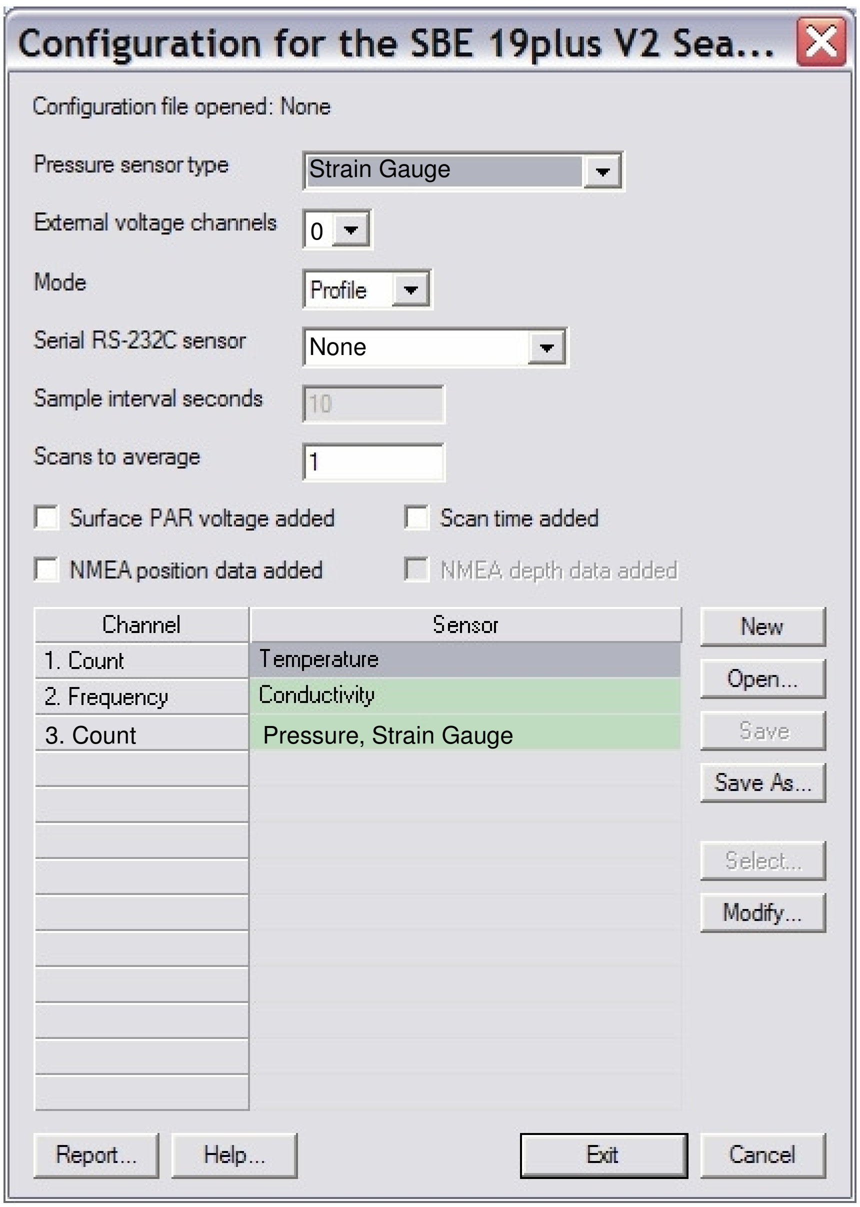
The instrument type and instrument configuration settings of the .con file and the required setup for the SEATERM.ini file for the CTD *as delivered* are documented below. The calibration coefficients for the CTD's sensors are contained in the calibration coefficient section of the CTD manual.

**NOTE:**

SEATERM will not upload data correctly without a properly configured SEATERM.ini file. SEASAVE and SBE Data Processing will not interpret the data correctly without the correct .con file.

## SEASOFT CONFIGURATION:

The correct instrument type for your instrument is SBE 19plus V2 SEACAT Profiler. The correct settings for the configuration of your instrument as delivered are documented below:



# SPECIFICATIONS

# SEACAT Profiler CTD

## SBE 19*plus* V2

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

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

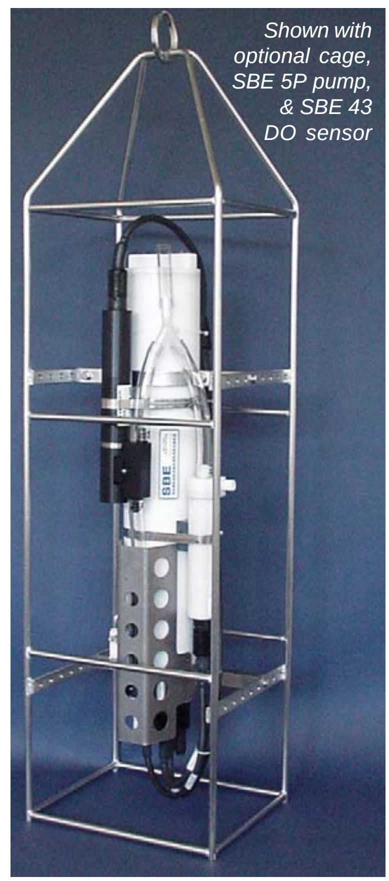
The 19*plus* V2 samples continuously at up to 4 scans per second (4 Hz) (2 Hz with Digiquartz®), is battery-powered and self-recording, and is commonly used in the field without a computer, recording up to 1000 individual profiles. Data can be uploaded to a PC and processed later, or can typically be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

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

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

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

### CONFIGURATION, OPTIONS, AND ACCESSORIES



Shown with optional cage, SBE 5P pump, & SBE 43 DO sensor

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

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

Options and accessories include:

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

### SOFTWARE

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

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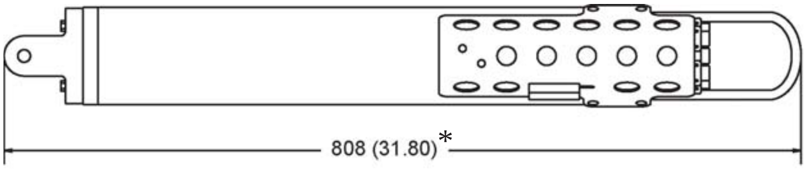
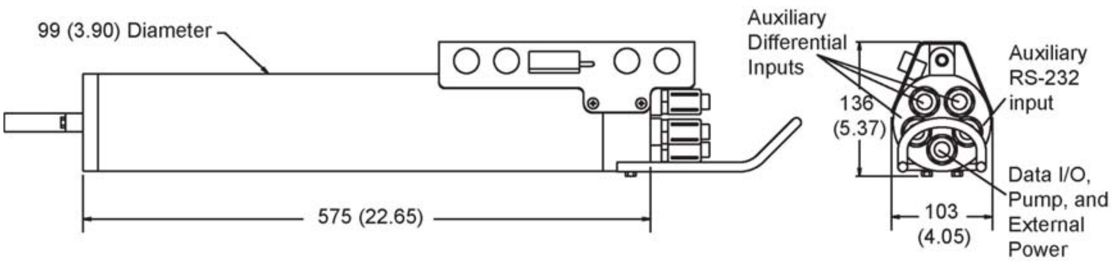
# SEACAT Profiler CTD

## SBE 19*plus* V2




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




Dimensions in millimeters (inches)

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

**Memory** 64 Mbyte non-volatile FLASH memory

**Data Storage**

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

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

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

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

**Power Requirements**

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

**Auxiliary Sensors**

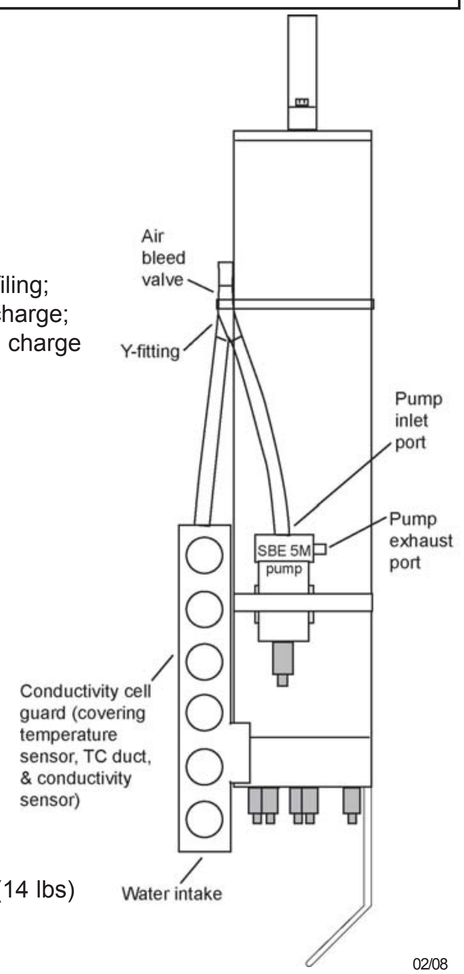
| | |
|---|---|
| *Auxiliary power out* | up to 500 mA at 10.5 - 11 VDC |
| *Voltage sensor A/D resolution* | 14 bits |
| *Voltage sensor input range* | 0 - 5 VDC |

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

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

**Optional Cage**

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

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Fax: (425) 643-9954

# Mini Submersible Pump

# SBE 5M

The SBE 5M pump module consists of a centrifugal pump head and a long-life, DC, ball-bearing motor contained in a compact, titanium pressure housing usable to 10,500 meters (34,400 ft) deep. A plastic housing for depths to 600 meters (1960 ft) is available as an option. The pump impeller and electric drive motor are coupled magnetically through the housing, providing high reliability by eliminating moving seals. Motor speed and pumping rate remain constant over the entire input voltage range. The motor drive electronics is intrinsically protected against accidental reversed polarity.



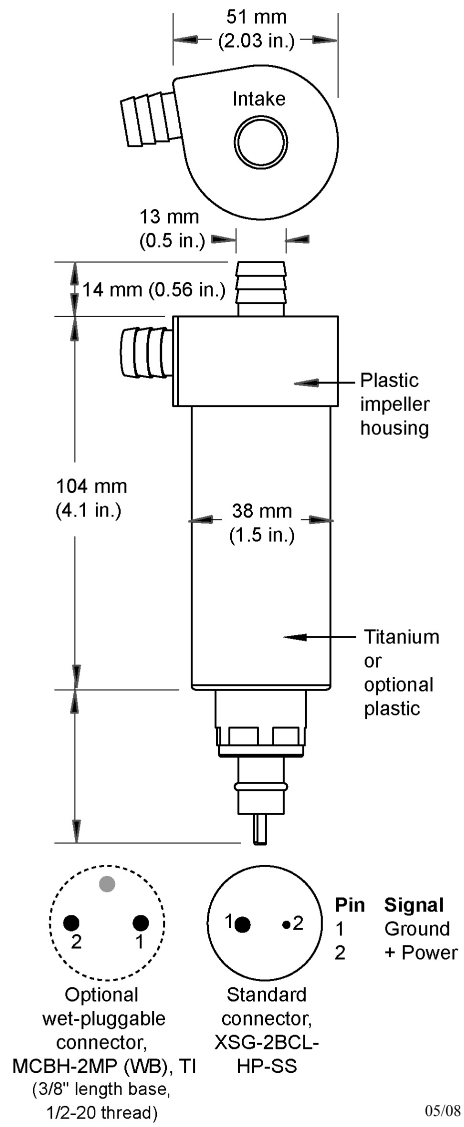
## APPLICATIONS

The SBE 5M is standard on the SBE 19*plus* V2 SEACAT Profiler CTD, and is optional on the SBE 16*plus* V2 and 16*plus*-IM V2 SEACAT C-T Recorders. The pump flushes water through the conductivity cell at a constant rate, independent of the CTD's motion, improving dynamic performance. For applications requiring pumping through additional sensors (for example, a dissolved oxygen sensor), use the SBE 5T or 5P pump instead.

Specify:

- Option **5M-1** for profiling (continuous duty) applications such as the SBE 19*plus* V2.
- Option **5M-2** for moored (pulsed duty) applications such as the SBE 16*plus* V2 or 16*plus*-IM V2.

Contact Sea-Bird for use in other applications.

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## SPECIFICATIONS

**Option 5M-1 (continuous duty):**
**Input voltage range 9 - 18 VDC**

Flow Rate 25 ml/s    Supply current 95 mA
*Note: Supply current is independent of operating voltage.*

**Option 5M-2 (pulsed duty):**
**Input voltage range 6 - 18 VDC**

| *Pulse Duration* | *Flow Volume* | *Electrical Charge* |
|---|---|---|
| 0.5 seconds | 15 ml | 0.148 Amp-seconds |
| 1.0 seconds | 21 ml | 0.283 Amp-seconds |
| 1.5 seconds | 31 ml | 0.418 Amp-seconds |
| 2.0 seconds | 40 ml | 0.553 Amp-seconds |

**Weight**
With standard ***titanium*** housing:
In Air - 0.42 kg (0.91 lbs); In Water - 0.28 kg (0.60 lbs)
With optional ***plastic*** housing:
In Air - 0.28 kg (0.60 lbs); In Water - 0.13 kg (0.29 lbs)

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SBE

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## SBE 5M MINI SUBMERSIBLE PUMP CONFIGURATION SHEET

Serial Number: 1056

Job Number: 50959

Customer: NOAA/PMC

Delivery Date: 10/3/2008

Single Bulkhead Connector.

Pressure Case: 10,500 meters (titanium)

Maxon Motor Type:

**P/N 801605, Motor PN 20130 (Pulsed Duty 6 VDC, 2000 RPM MAX)** ☐

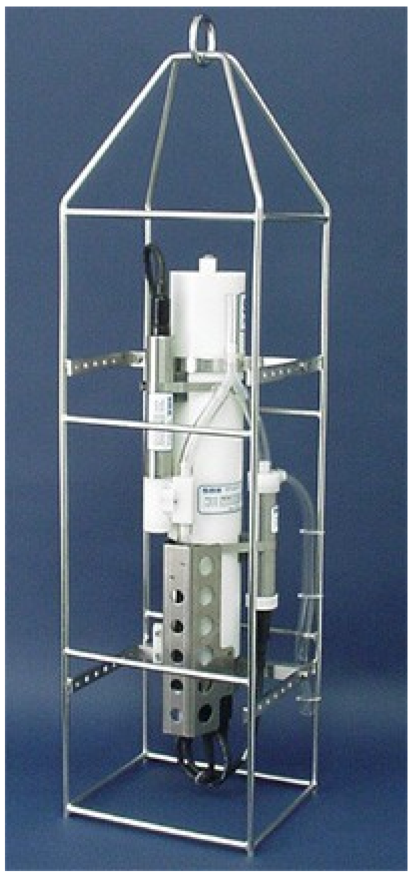
**P/N 801606, Motor PN 20127 (Continuous Duty 9 VDC, 2000 RPM MAX)** ☑

| | | | | | |
|---|---|---|---|---|---|
| Vin 15V voltage across C2: | ***7.96*** | VDC | Current | ***15.8*** | mA |
| Vin 9V voltage across C2: | ***7.96*** | VDC | Current | ***15.7*** | mA |
| Vin 6V voltage across C2: | ***5.9*** | VDC | Current | ***10.4*** | mA |

Pump submerged test, no load, Vin 12VDC  Average current draw in water: ***120*** mA

# SBE 19plusV2
# SEACAT PROFILER

*Conductivity, Temperature, and Pressure Recorder*
*with RS-232 Interface*



## Serial Number: 19P50959-6122

## User Manual, Version 002

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, Washington 98005 USA
Tel: 425/643-9866
Fax:425/643-9954

# LIMITED LIABILITY STATEMENT

Extreme care should be exercised when using or servicing this equipment. It should be used or serviced only by personnel with knowledge of and training in the use and maintenance of oceanographic electronic equipment.

SEA-BIRD ELECTRONICS, INC. disclaims all product liability risks arising from the use or servicing of this system. SEA-BIRD ELECTRONICS, INC. has no way of controlling the use of this equipment or of choosing the personnel to operate it, and therefore cannot take steps to comply with laws pertaining to product liability, including laws which impose a duty to warn the user of any dangers involved in operating this equipment. Therefore, acceptance of this system by the customer shall be conclusively deemed to include a covenant by the customer to defend, indemnify, and hold SEA-BIRD ELECTRONICS, INC. harmless from all product liability claims arising from the use of servicing of this system.

# WARNING !!

**Do not submerge this instrument (S/N 19P50959-6122)**
**beyond the depth rating of the lowest rated component listed below!**

| | |
|---|---|
| **Main Housing (Plastic)** | **600 meters** |
| Pressure Sensor (600 dBar) Druck | 600 meters |
| Pump (SBE 5M) | 600 meters |

# SYSTEM CONFIGURATION 1 October 2008

| | |
|---|---|
| Model SBE 19plusV2 | **S/N 19P50959-6122** |
| Instrument Type | **SBE 19plusV2 SeaCaT Profiler** |
| Firmware Version | **2.1** |
| Communications | **9600 baud, 8 data bits, no parity, one stop bit** |
| Memory | **64MB** |
| Housing | **600 meter (Acetron Plastic)** |
| 0 Conductivity Raw Frequency | **2523.44 Hz** |
| Pressure Sensor | **Strain Gauge: 600 dBar, S/N 2752080** |
| Computer communications (Data I/O) connector | **Located on the P/N 17709 Y-Cable** |
| Number of Voltages Sampled: | **0** |
| Serial RS-232C Sensor | **None** |

**Data Format:**

| | |
|---|---|
| Count | **Temperature** |
| Frequency | **Conductivity** |
| Count | **Pressure, Strain Gauge** |

**Pump (SBE 5M)** **051058**

## IMPORTANT SOFTWARE & HARDWARE CONFIGURATION INFORMATION

Sea-Bird supplies two versions of our software package for communication, real-time data acquisition, and data analysis and display:

- SEASOFT-Win32 - Windows software for PC running Win 95/98/NT/2000/XP
- SEASOFT-DOS - DOS software for IBM-PC/AT/386/486 or compatible computer with a hard drive

Detailed information on the use of the **Windows** software follows:

### SEASOFT-Win32

SEASOFT-Win32 software was supplied on a CD-ROM with your CTD. This software package is designed to run on a PC running Win 95/98/NT/2000/XP. The CD-ROM also contains software manuals that describe the appropriate applications for the various programs, the procedure for installing the software, and instructions on using the programs. There are three primary programs used with the CTD for setup, data collection and retrieval, data display, and data processing:

- SEATERM - terminal program for setup of the CTD and uploading of data from the CTD memory (**Note**: If using the CTD with the 90208 Auto Fire Module or SBE 17*plus* V2 SEARAM, use SeatermAF instead of SEATERM)
- SEASAVE - real-time data acquisition program
- SBE Data Processing - data processing program

Instructions for using the software are found in their Help files.

To communicate with the CTD to set it up or to upload data from the CTD memory to the computer hard drive, **SEATERM** must have information about the CTD hardware configuration (communication parameters, internal firmware, etc.) and about the computer. To communicate with the CTD, double click on Seaterm.exe:

1. In the Configure menu, select the CTD. The Configuration Options dialog box appears.
   A. On the COM Settings tab, select the firmware version (if applicable), baud rate, data bits, and parity to match the CTD's configuration sheet. If necessary, change the com port to match the computer you are using.
   B. On the Upload Settings tab, enter upload type (all as a single file, etc.) as desired.
   *For the SBE 17 and 25 only*: enter the serial number for the SBE 3 (temperature) and SBE 4 (conductivity) modular sensors, exactly as they appear in the configuration (.con) file.
   C. On the Header Information tab, change the settings as desired.
   Click OK when done. SEATERM saves the settings in a SEATERM.ini file.
2. On the Toolbar, click Connect to communicate with the CTD.
3. To set up the CTD prior to deployment:
   On the Toolbar, click Status. SEATERM sends the Status command and displays the response. Verify that the CTD setup matches your desired deployment. If not, send commands to modify the setup.
4. To upload data from the CTD:
   On the Toolbar, click Upload to upload data from the CTD memory to the computer.

Sea-Bird CTDs store and/or transmit data from their primary and auxiliary sensors in the form of binary or hexadecimal number equivalents of the sensors' frequency or voltage outputs. This is referred to as the *raw* data. The calculations required to convert from *raw* data to *engineering* units of the measured parameters (temperature, conductivity, pressure, dissolved oxygen, pH, etc.) are performed using the software, either in real time, or after the data has been stored in a file. SEASAVE creates the file in real time. As noted above, SEATERM uploads the recorded data and creates the file on the computer hard drive.

To successfully store data to a file on the computer and subsequently convert it to engineering units, the software must know the CTD type, CTD configuration, and calibration coefficients for the sensors installed on the CTD. This information is unique to each CTD, and is contained in a *configuration* file. The configuration file, which has a .con extension, was written onto a floppy disk and the CD-ROM shipped with the CTD. The .con file for a given CTD is named with the last four digits of the serial number for that CTD (e.g., 1234.con). The configuration file is created or modified (e.g., changing coefficients after recalibration, or adding another sensor) by using the Configure menu in **SEASAVE** or
**SBE Data Processing**. The configuration file is used by SEASAVE to convert raw data to engineering units when it acquires, stores, and displays real-time data. The configuration file is also used by some modules in SBE Data Processing (Data Conversion and Derive) that convert raw data to engineering units during data processing.

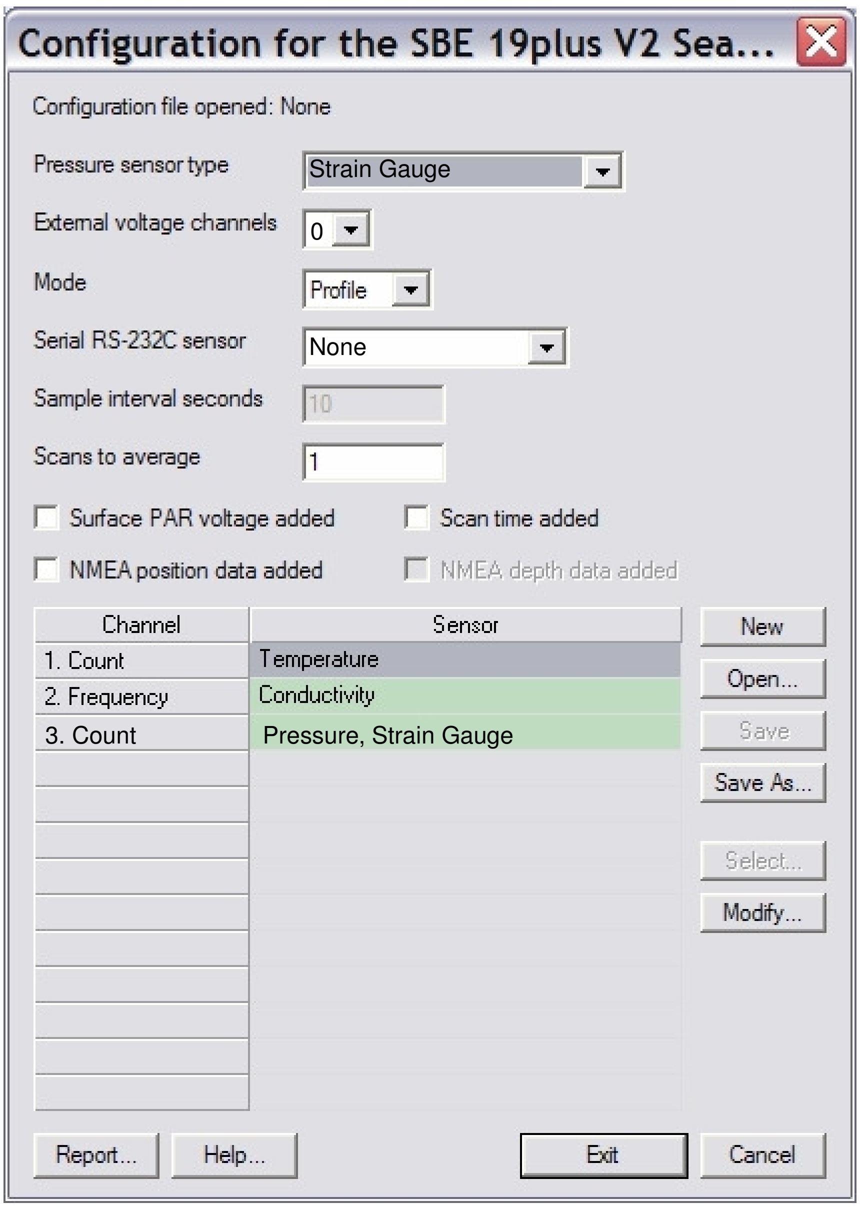
The instrument type and instrument configuration settings of the .con file and the required setup for the SEATERM.ini file for the CTD *as delivered* are documented below. The calibration coefficients for the CTD's sensors are contained in the calibration coefficient section of the CTD manual.

**NOTE:**

SEATERM will not upload data correctly without a properly configured SEATERM.ini file. SEASAVE and SBE Data Processing will not interpret the data correctly without the correct .con file.

**SEASOFT CONFIGURATION:**

The correct instrument type for your instrument is SBE 19plus V2 SEACAT Profiler. The correct settings for the configuration of your instrument as delivered are documented below:



# SPECIFICATIONS

# SEACAT Profiler CTD

## SBE 19*plus* V2

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

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

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

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

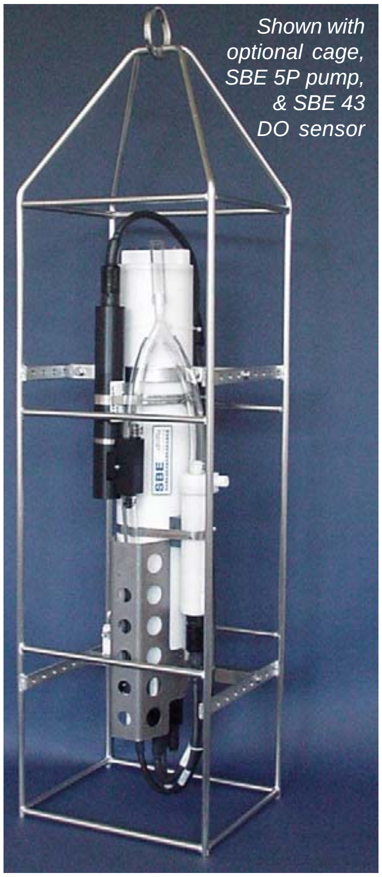
The 19*plus* V2 can operate in moored mode, recording time series measurements at user-programmable intervals. Moored mode is easily configured using setup commands and by removing the profiling T-C Duct and installing optional anti-fouling devices. (If profiling is not needed, the 16*plus* V2 Seacat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

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

### CONFIGURATION, OPTIONS, AND ACCESSORIES

A standard SBE 19*plus* V2 is supplied with:
- Plastic housing for depths to 600 meters
- Strain-gauge pressure sensor
- 64 Mbyte FLASH RAM memory
- 9 D-size alkaline batteries
- Glass-reinforced epoxy bulkhead connectors
- SBE 5M miniature pump with plastic housing for depths to 600 m, and T-C Duct

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


Shown with optional cage, SBE 5P pump, & SBE 43 DO sensor

### SOFTWARE

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

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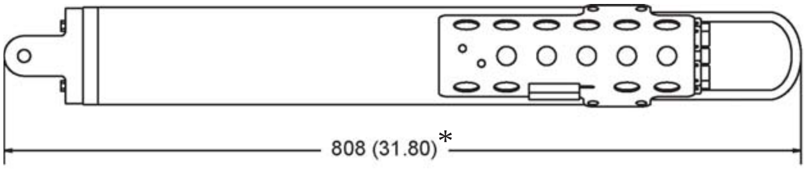
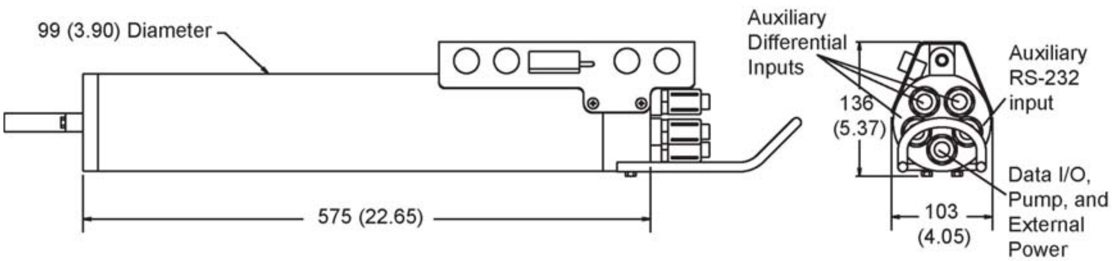
# SEACAT Profiler CTD

## SBE 19*plus* V2




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




Dimensions in millimeters (inches)

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

**Memory** 64 Mbyte non-volatile FLASH memory

**Data Storage**

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

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

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

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

**Power Requirements**

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

**Auxiliary Sensors**

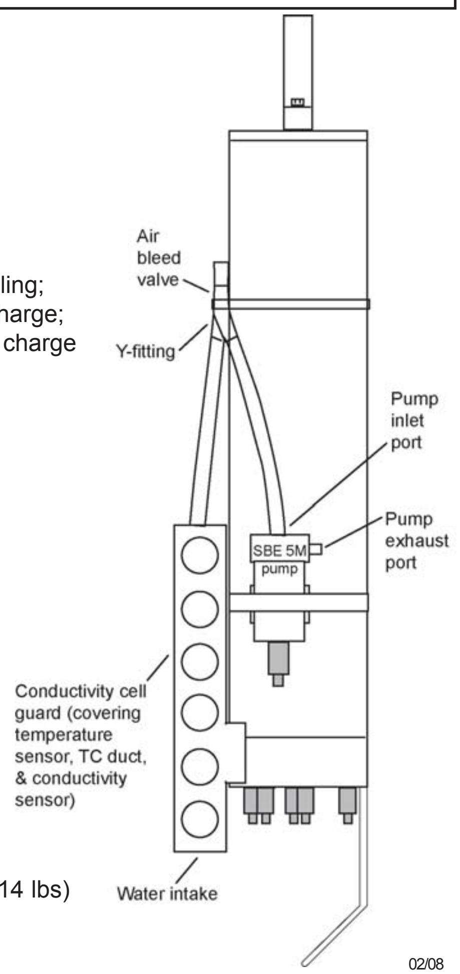
| | |
|---|---|
| *Auxiliary power out* | up to 500 mA at 10.5 - 11 VDC |
| *Voltage sensor A/D resolution* | 14 bits |
| *Voltage sensor input range* | 0 - 5 VDC |

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

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

**Optional Cage**

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




02/08

# Mini Submersible Pump

# SBE 5M

The SBE 5M pump module consists of a centrifugal pump head and a long-life, DC, ball-bearing motor contained in a compact, titanium pressure housing usable to 10,500 meters (34,400 ft) deep. A plastic housing for depths to 600 meters (1960 ft) is available as an option. The pump impeller and electric drive motor are coupled magnetically through the housing, providing high reliability by eliminating moving seals. Motor speed and pumping rate remain constant over the entire input voltage range. The motor drive electronics is intrinsically protected against accidental reversed polarity.



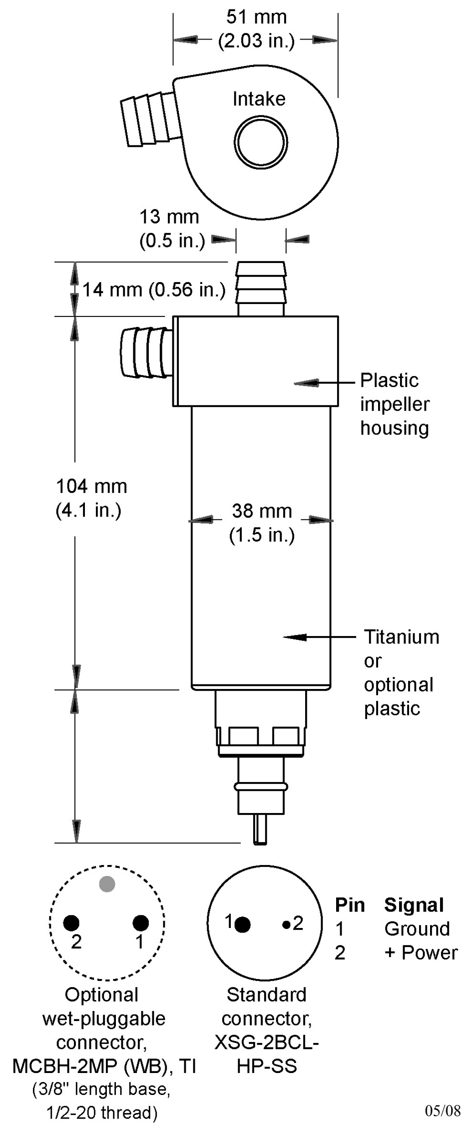
## APPLICATIONS

The SBE 5M is standard on the SBE 19*plus* V2 SEACAT Profiler CTD, and is optional on the SBE 16*plus* V2 and 16*plus*-IM V2 SEACAT C-T Recorders. The pump flushes water through the conductivity cell at a constant rate, independent of the CTD's motion, improving dynamic performance. For applications requiring pumping through additional sensors (for example, a dissolved oxygen sensor), use the SBE 5T or 5P pump instead.

Specify:

- Option **5M-1** for profiling (continuous duty) applications such as the SBE 19*plus* V2.
- Option **5M-2** for moored (pulsed duty) applications such as the SBE 16*plus* V2 or 16*plus*-IM V2.

Contact Sea-Bird for use in other applications.




## SPECIFICATIONS

**Option 5M-1 (continuous duty):**
**Input voltage range 9 - 18 VDC**

Flow Rate 25 ml/s Supply current 95 mA
*Note: Supply current is independent of operating voltage.*

**Option 5M-2 (pulsed duty):**
**Input voltage range 6 - 18 VDC**

| *Pulse Duration* | *Flow Volume* | *Electrical Charge* |
|---|---|---|
| 0.5 seconds | 15 ml | 0.148 Amp-seconds |
| 1.0 seconds | 21 ml | 0.283 Amp-seconds |
| 1.5 seconds | 31 ml | 0.418 Amp-seconds |
| 2.0 seconds | 40 ml | 0.553 Amp-seconds |

**Weight**
With standard ***titanium*** housing:
In Air - 0.42 kg (0.91 lbs); In Water - 0.28 kg (0.60 lbs)
With optional ***plastic*** housing:
In Air - 0.28 kg (0.60 lbs); In Water - 0.13 kg (0.29 lbs)

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Website: http://www.seabird.com Email: seabird@seabird.com

## SBE 5M MINI SUBMERSIBLE PUMP CONFIGURATION SHEET

Serial Number: 1058

Job Number: 50959

Customer: NOAA/PMC

Delivery Date: 10/3/2008

Single Bulkhead Connector.

Pressure Case: 10,500 meters (titanium)

Maxon Motor Type:

**P/N 801605, Motor PN 20130 (Pulsed Duty 6 VDC, 2000 RPM MAX)** ☐

**P/N 801606, Motor PN 20127 (Continuous Duty 9 VDC, 2000 RPM MAX)** ☑

| | | | | | |
|---|---|---|---|---|---|
| Vin 15V voltage across C2: | ***7.95*** | VDC | Current | ***13.2*** | mA |
| Vin 9V voltage across C2: | ***7.95*** | VDC | Current | ***13*** | mA |
| Vin 6V voltage across C2: | ***5.87*** | VDC | Current | ***9.96*** | mA |

Pump submerged test, no load, Vin 12VDC Average current draw in water: ***116*** mA

# LEICA NA2 · NAK2


***Universal automatic level***

Leica
Geosystems

# *LEICA NA2*
# *The classical level from Leica Geosystems*

The NA2 universal automatic level meets all requirements regarding precision, convenience and reliability.

It was designed by surveyors and development engineers with years of experience and who know what a field instrument has to be able to do.

The NA2 soon pays for itself, because it can be used for all types of surveying job; on building sites for routine levelling, in engineering projects, and for geodetic control at all levels of accuracy.

## *Universal application*

- Levelling of all types and all orders of accuracy
- Precise levelling and settlement determinations on buildings
- Routine heighting for the construction of roads, railways, pipelines, tunnels and so forth
- Setting-out work and control measurements on the construction site
- Area levelling of high accuracy
- Tacheometric levelling with the K-version on flat terrain by combining stadia and angular measurements with height readings
- Deformation measurement and monitoring of bridges

# Quickly set up, simple to use

### *Strong tripods*

In principle, the NA2 can be set up on any Leica Geosystems tripod. In practice, for all-round purposes, we recommend the heavy-duty GST20 telescopic-leg tripod. For precise levelling the GST40 fixed-leg tripod is suitable because of its extreme rigidity.

The modular relationship between instrument and tripod is an advantage when transport space is limited.

### *Centring is easy*

The circular level only needs to be centred approximately to bring the compensator well into its working range of ~30', and so setting-up goes quicker.

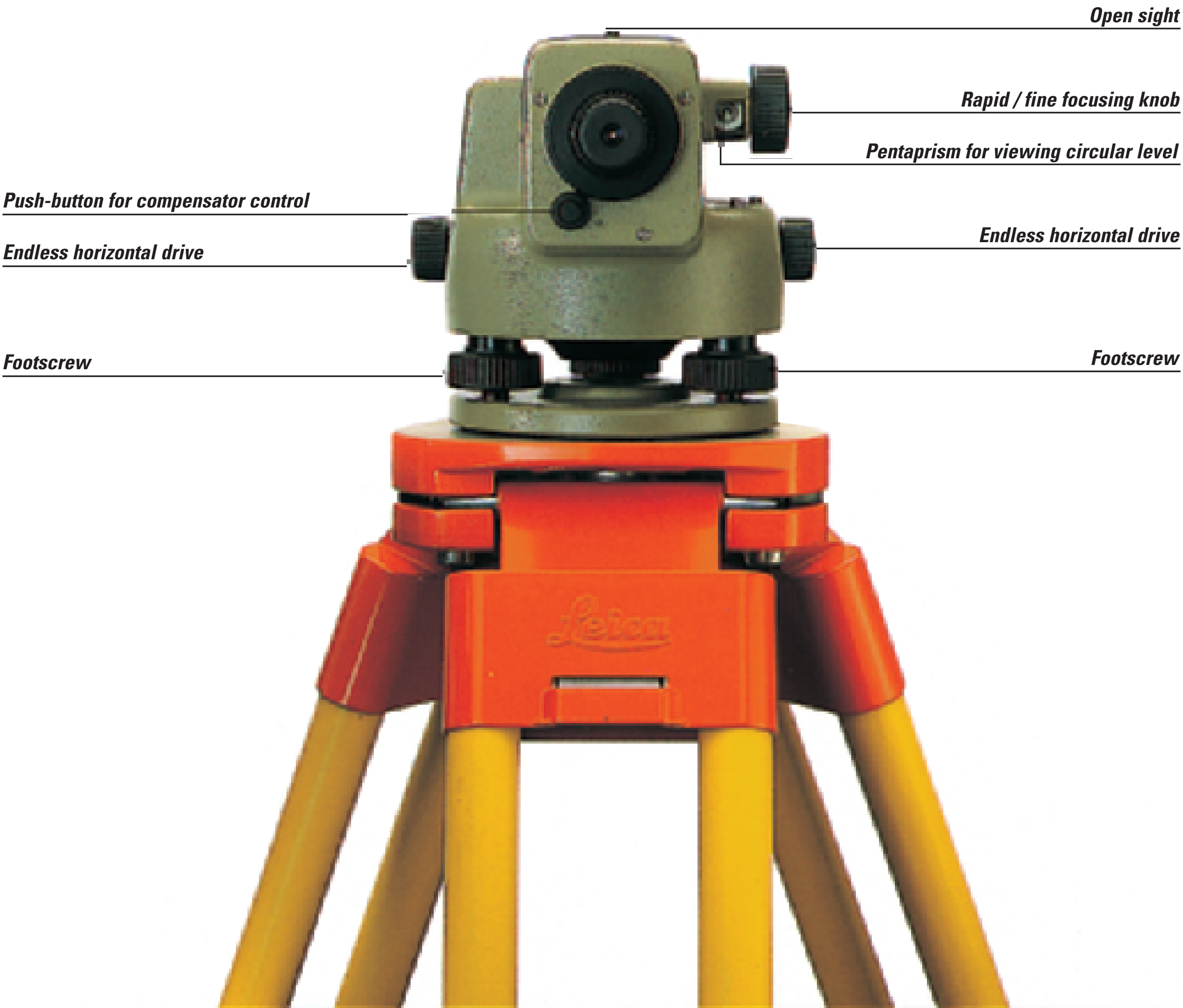
The bubble is viewed positively via a pentaprism and is monitored down the eyepiece.

### *Play-free footscrews*

The pitch of the smooth-running and backlash-free footscrews is such that the bubble can be centred in a very short time.

### *Independent of temperature*

Unlike the tubular level of a traditional instrument, the NA2 universal automatic level is relatively insensitive to direct solar radiation and an umbrella need only be considered for the most precise levelling.



# *Adjust the line of sight automatically*

### *Easy to level up*

The advantage of this instrument is that, as soon as the bubble is centred, the line of sight is horizontal for all pointings of the telescope. The observer is freed of the time-consuming centring procedure involved with the traditional tubular level, and can concentrate on the business of staff readings.

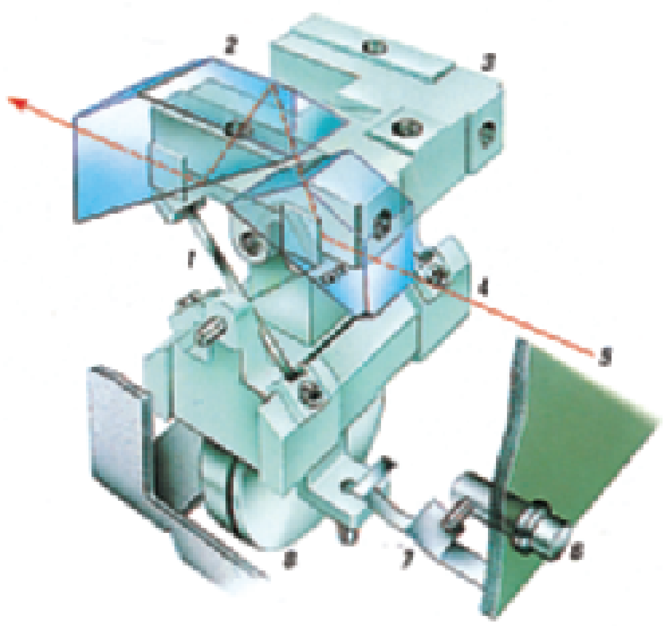
### *Robust and automatic*

The compensator is essentially a pendulum with a prism (4).

The suspension system comprises four flexed tapes (1) made of a special alloy to ensure faultless functioning even at extreme temperatures. The compensator, which is located between the focusing lens and the crosshair reticle, is pneumatically damped against mechanical vibration and is screened against magnetic fields.

### *Minimum maintenance*

In the unlikely event that the compensator is damaged (and this can only happen as a result of extremely harsh treatment) it is replaced easily, being held only by three screws.



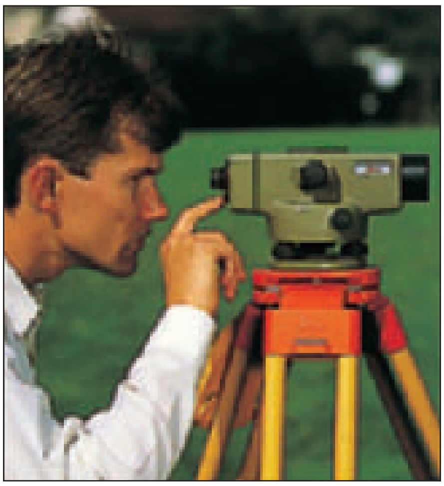
***2/NAK2 compensator***

*;uspension tapes*
*'rism (fixed)*
*:ompensator body*
*'endulum with prism*
*ine of sight*
*'ush-button*
*;pring which taps pendulum*
*'neumatic damping mechanism*

### *Push-button control – added security*

With most automatics one taps the tripod or instrument to check if the compensator is functioning. Leica Geosystems offers a far more sophisticated solution.

Pressing the button under the NA2 eyepiece gives the compensator a gentle tap, so that you see the staff image swing smoothly away and then float gently back to give the horizontal line of sight. This check, which takes less than a second, is technically perfect, as the pendulum itself is activated and swings through its full range. It is also immediately apparent if the bubble is not centred.



# Top-class optics

## Top-class optics

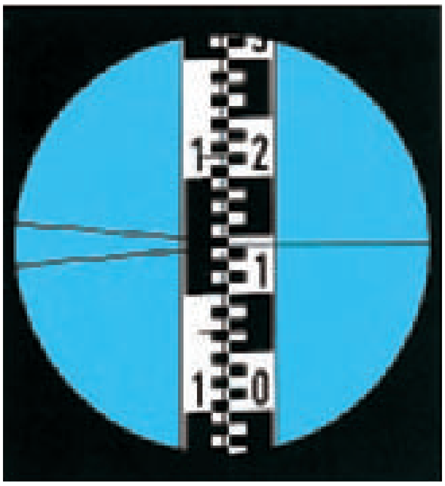
The telescope is of excellent quality and gives a bright, high-contrast, erect image, even in poor light – an essential for accurate levelling. With the standard eyepiece the magnification is 32×, the optimum for most applications of the instrument. Optional eyepieces are available; the 40× may be preferred for precise levelling, the 25× in hot, shimmer conditions. Eyepiece exchange takes only a second or so.

The focusing knob has a coarse/fine movement:
– coarse, for rapid setting with minimum turning
– fine, for the final delicate touch to give the perfect image.

## Fatigue-free viewing

The reticle has:
– a single horizontal hair for reading normal staffs
– a wedge-shaped hair for use with invar staffs
– stadia hairs for distance measurement and three-wire levelling.

The general layout of the controls, the smooth friction-braked rotation of the instrument, and the endless horizontal drive with bilateral knobs, all combine to make the instrument easy to use.




***NA2 field of view with metric levelling staff***
***Reading at horizontal hair: 1.143 m***

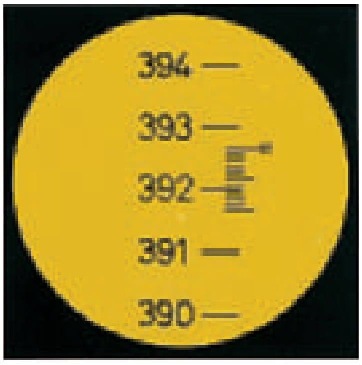
## At an advantage on unstable ground

If a tubular level is used on unstable ground it tilts out of range and has to be continuously reset. By contrast, the pendulum of the NA2 “compensates” and keeps the line of sight horizontal.

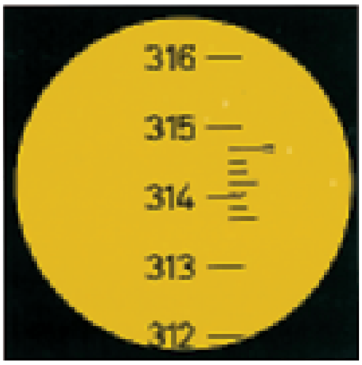
## Angle measurement with the NAK2

Civil engineers and contractors often require a circle for angle measurement and setting-out work. Even simple detail surveys, by taking angle, distance and height, and plotting with the polar method, can be done with a level.

The model NAK2 has an internal glass circle which is read via a scale microscope and which can be set to any value by turning the rim around the base of the instrument.




***NAK2***
***circle reading (400 gon)***
***392.66 gon***




***NAK2***
***circle reading (360°)***
***314°42'***

# High-performance accessories for precise levelling

## GPM3 parallel-plate micrometer

This optional accessory slips over the telescope objective and blends perfectly with the smooth lines of the NA2. With a compensator setting accuracy of ±0.3" (equivalent to 0.01 mm in 10 m) and a micrometer reading to 0.1 mm direct and 0.01 mm by estimation, the NA2 with GPM3 is an ideal combination for precise levelling, deformation studies, and even optical tooling. The micrometer drive for raising and lowering the line of sight is conveniently located and readings are taken on a glass scale viewed through an eyepiece just above the telescope eyepiece. This optical reading system, which is digital apart from the last and estimated figure in the metric and inch versions, is superior to the usual metal drum system.

## GPM6 parallel-plate micrometer

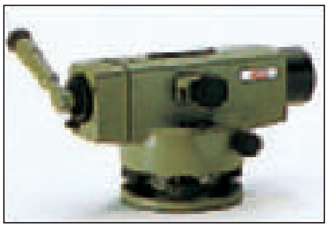
There are tasks for which a micrometer is needed, yet for which the very high accuracy of the GPM3 is not essential.

To meet this requirement, a simpler micrometer attachment, the GPM6 with drum reading, is available for the NA2.

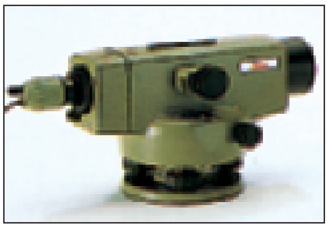
The GPM6 fits on to the telescope objective in the same manner as the GPM3, but the graduation is engraved on a metal drum.

## Eyepiece accessories for specialized tasks

Because of the bayonet fastening of the interchangeable eyepiece, all theodolite eyepiece accessories can be used with the NA2.



- Diagonal eyepiece for observing from above, below, and from the side; useful in cramped spaces



- Eyepiece lamp for converting the NA2 into a horizontal collimator for laboratory work

- Autocollimation eyepiece for setting machine parts and instrument components precisely vertical

***Compact***

The rugged NA2 is indifferent to weather conditions and is extremely reliable in the rough world of the building site. The pendulum compensator is protected against knocks and shocks. There is a highly-effective vibration-damping mechanism.

***Precise***

The high setting accuracy ensures that the line of sight stays put. The attachable parallel-plate micrometer renders the NA2 ideal for precise fine levelling.

***Reliable, automatic, maintenance-free***

The instantaneous check facility with the push-button control not only makes work easier; it also promotes confidence.

***Easy handling***

The convenient, well-arranged controls are designed for maximum convenience. The bilateral, endless horizontal drive promotes rapid fine-pointing.

***Quick levelling-up***

The instrument is quickly set up with the three rapid-action footscrews. Their self-adjusting threads make subsequent resetting unnecessary.

***Superb telescope***

Telescope with excellently-corrected optics for bright, high-contrast images. All optical components are coated on both sides.

***Effortless focusing***

The erect image seen down the telescope is quickly and accurately brought into focus with the convenient rapid and fine focusing knob.

***Abundant accessories; many applications***

Additional items such as the parallel-plate micrometer, the laser eyepiece, or theodolite eyepiece accessories, offer almost unlimited possibilities.

# LEICA NA2 · NAK2
# Proven reliability ensures precise results

## Versatile accessories for demonstrable success

A comprehensive program of accessories enables you to expand the performance and applications range of each instrument. This way, you can match your equipment exactly to requirements.

The possibilities are described in brochure "Survey accessories" 710 883en.

## Robust container for safe transport

The NA2 is supplied in a foam-padded container made of high performance synthetic material. The foam padding absorbs all jolts and shocks. The container provides perfect protection for the NA2.

## Technical data

| | |
|---|---|
| Standard deviation for 1 km double-run levelling, depending on type of staff and on procedure | up to 0.7 mm |
| With parallel-plate micrometer | 0.3 mm |
| Telescope | erect image |
| Standard eyepiece | 32× |
| FOK73 eyepiece (optional) | 40× |
| FOK117 (optional) | 25× |
| Clear objective aperture | 45 mm |
| Field of view at 100 m | 2.2 m |
| Shortest focusing distance | 1.6 m |
| Multiplication factor | 100 |
| Additive constant | 0 |
| Working range of compensator | ~30′ |
| Setting accuracy of compensator (stand. dev.) | 0.3“ |
| Sensitivity of circular level | 8′/2 mm |
| Glass circle (K version) | 400 gon (360°) |
| Graduation diameter | 70 mm |
| Graduation interval | 1 gon (1°) |
| Reading by estimation to | 10 mgon (1′) |
| Water- and dust resistance | IP53 |
| Temperature range: | |
| Operation | –20°C to +50°C (– 4°F to 122°F) |
| Storage | –40°C to +70°C (–40°F to 158°F) |

| **Parallel-plate micrometer** (optional accessory) | Range | Interval | Estimation |
|---|---|---|---|
| **GPM3,** with glass scale | 10 mm | 0.1 mm | 0.01 mm |
| **GPM6,** with metal drum | 10 mm | 0.2 mm | 0.05 mm |

TQM
ISO 9001 / ISO 14001

***Total Quality Management – Our commitment to total customer satisfaction***

Ask your local Leica Geosystems agent for more information about our TQM program.

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710 837en – V.03 – RDV

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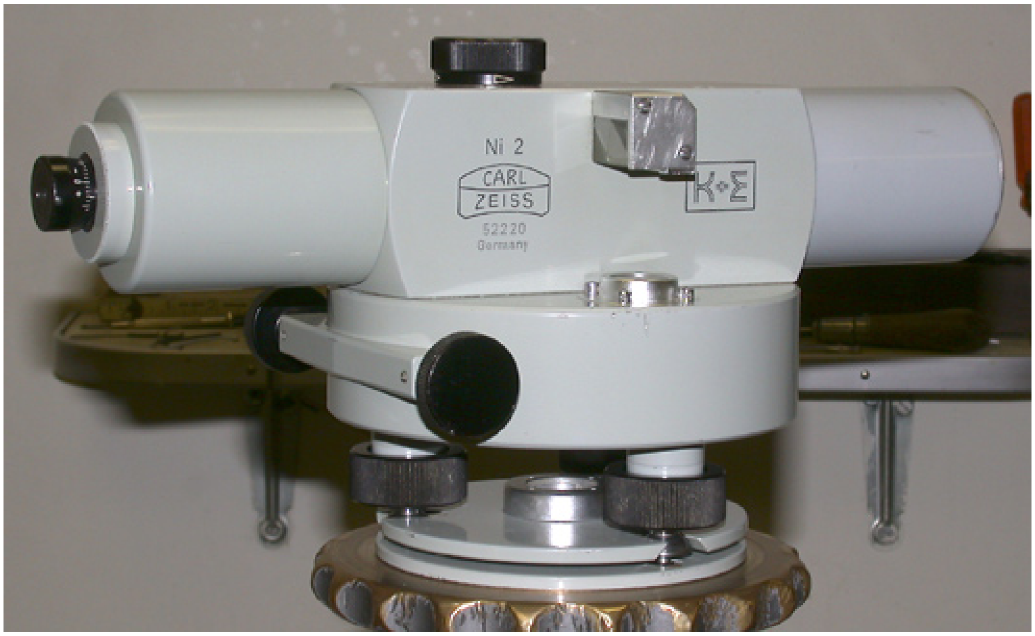
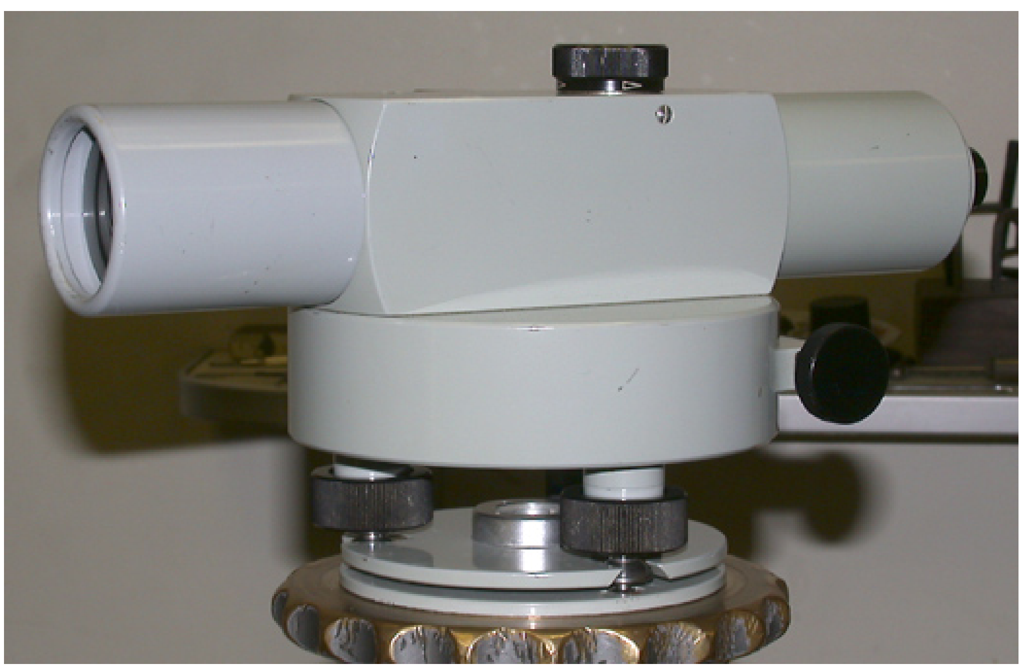
*Fax +41 71 727 46 73*
*www.leica-geosystems.com*

# Carl Zeiss  NI-2 Level



# Contents





# Optical Data

**Telescope** with Zeiss T-coating

| | |
|---|---|
| Magnification | 32 × |
| Aperture | 1 58 in (40 mm) |
| Shortest sighting distance | 11 ft (3 3 m) |
| Field of view | 23 ft at 1000 ft |

Estimation of $^1/_{1000}$ ft. on $^1/_{100}$ ft. graduation up to 120 ft (1 mm on a 1 cm graduation up to 120 m)

**Circular Level**

| | |
|---|---|
| Sensitivity | 15 per 2 mm |

**Circle** (on request)

| | |
|---|---|
| Material | Glass |
| Diameter | 2 95 in (75 mm) |
| Graduation | $360^\circ$ or $400^g$ |
| Graduation interval | $1^\circ$ or $1^g$ |

Readings through reading microscope

| | |
|---|---|
| Magnification | 17 × |
| Scale interval | 10 or 0 $1^g$ |
| Estimation to | 1 or 0 $01^g$ |

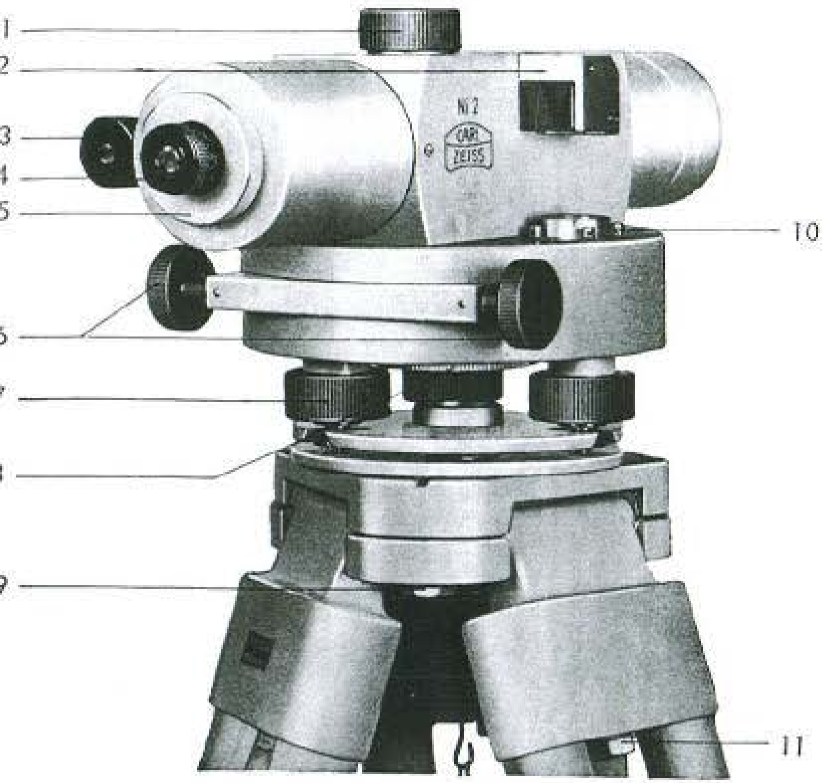


Fig. 1 Ni 2 with horizontal circle

(about 1/3 natural size)

1 Focus control with quick-fine movement
2 Viewing prism for circular level
3 Eyepiece of reading microscope for circle
4 Telescope eyepiece with dioptre scale
5 Screw cover over reticle adjusting screw
6 Lateral fine movement controls
7 Leveling screw
8 Knurled setting ring for circle orientation
9 Adjusting screw for tripod hinges
10 Adjusting screws for circular level
11 Clamping screw for tripod leg fitting



# Mechanical Data

| | |
|---|---|
| **Dimensions:** | |
| Length of telescope | 10.6 in. (27 cm.) |
| Height of instrument | 5.1 in. (13 cm.) |
| Diameter of base | 5.1 in. (13 cm.) |
| External dimensions of case | 13×6.9×6.1 in. (33×17.5×15.6 cm.) |
| S 3 tripod extending from | 3 ft. 5 in. to 5 ft. 7 in. (approx.) (102–170 cm.) |
| S 2 tripod extending from | 3 ft. 5 in. to 5 ft. 7 in. (approx.) (102–170 cm.) |
| **Weights:** | |
| Ni 2 without circle | 4.6 lbs. (2.1 kg.) |
| Ni 2 with circle | 5.3 lbs. (2.4 kg.) |
| Case for Ni 2 without circle | 6.4 lbs. (2.9 kg.) |
| Case for Ni 2 with circle, with plumb bob | 6.6 lbs. (3.0 kg.) |
| Parallel plate micrometer in leather case | 1.3 lbs. (0.6 kg.) |
| Torch with supports | 0.7 lbs. (0.3 kg.) |
| Leather case for torch | 1.7 lbs. (0.7 kg.) |
| S 3 tripod | 11.6 lbs. (5.3 kg.) |
| S 2 tripod | 13.6 lbs. (6.2 kg.) |
| Leveling staff (03) 4 m. folding to 2 m. | 12 lbs. (5.5 kg.) |
| Leveling staff (05) 3 m. folding to 1.5 m. | 6.4 lbs. (2.9 kg.) |
| Invar staff (06) 3 m., rigid | 9 lbs. (4.0 kg.) |
| "Scotch light" staves, additional weight | 0.45 lbs. (0.2 kg.) |



01 Tripod leg
only, not n
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(1 m.) apar
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02 Lift instrum
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03 Center circ
hairs on a
the eyepiec

**Caution:** D
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04 Aim telesc
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05 For fine se
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06 Focus for
focus cont
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07 Read staff
necessary
slightly tap
movement


ng for
or tripod
for circular
or tripod

## Mechanical Data

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| | |
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| Leveling staff (05) 3 m. folding to 1.5 m. . . . . . . . . | 6.4 lbs. (2.9 kg.) |
| Invar staff (06) 3 m., rigid . . | 9 lbs. (4.0 kg.) |
| "Scotch light" staves, additional weight . . . . . . . . | 0.45 lbs. (0.2 kg.) |



## Setting up, Reading

01 Tripod legs should be extended to a convenient height only, not necessarily to their maximum; observe correct stiffness of joints (see No. 43); spread legs about 3 ft. (1 m.) apart; level tripod head to eyesight; tread tripod tips moderately into ground.

02 Lift instrument slightly to find thread for center screw and secure tightly.

03 Center circular level with leveling screws. Focus cross-hairs on a bright background by turning the milled ring of the eyepiece (4, fig. 1).

**Caution:** Do not store wet instrument in the container over an extended period of time. Instrument should be dried with a cloth on the outside as soon as possible and allowed to get completely dry overnight (to be taken out of the container for that purpose).

04 Aim telescope roughly onto target by viewing along one edge of the telescope housing.

05 For fine setting observe through telescope and use one of the fine movement screws (6).

06 Focus for a parallax-free staff image with dual speed focus control (1). Reversing the sense of rotation automatically introduces a slow motion (range: ¼ turn).

07 Read staff graduation against horizontal crosshairs (if necessary also stadia lines, fig. 2). As a checking measure slightly tap the telescope with a pencil or operate the fine movement screw jerkily to and fro. After a small oscillat-

# Positioning Data Link™

# PDL™

## High Performance Data Link

**Designed for Survey Systems**

**19,200 Baud Rate**
Higher Over-the-Air Link Rate
Extends Your Battery Life

**Enhanced User Interface**
Change Channels in the Field
View Status Information

**Compatible with GPS RTK Equipment Worldwide**
Complete Kit Solutions Available
for Your Application

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Rugged, All Season Operation

**2 Year Warranty**
Lower Cost of Ownership


Surveyors utilizing Global Positioning Systems require a rugged radio modem data link for precise positioning information. The PDL is compact and lightweight and offers power efficient operation. It is easy to use, and provides high performance and rugged dependability for the toughest survey environments.

PDL Products are designed to easily mount on all standard tripods and range poles. Complete kit solutions are available.

PACIFIC CREST
CORPORATION

# Positioning Data Link™

| | High Power Base | Low Power Base | Rover |
|---|---|---|---|
| **General Specifications** | | | |
| DTE – DCE Interface | 3 Wire, RS-232, 38.4k Baud Maximum. | | |
| User Interface | On/Off Button.<br>Channel Button with AutoBase™ and AutoRover.™<br>Digital Display.<br>Modem/Power Status Indicators.<br>RF Power Select Toggle Switch. | On/Off Button.<br>Channel Button with AutoBase™ and AutoRover.™<br>Digital Display.<br>Modem/Power Status Indicators. | On/Off Button.<br>Channel Button with AutoBase™ and AutoRover.™<br>Digital Display.<br>Modem/Power Status Indicators. |
| **Power** | | | |
| External | 9 – 16 VDC. | | |
| Internal Battery | N/A | N/A. | Lithium Ion Battery Pack. |
| During TX (nominal) | 110 Watts. | 11 Watts. | N/A. |
| During RX (nominal) | 1.9 Watts. | 0.9 Watts. | 0.3 Watts. |
| **Antenna** | | | |
| External | 50 Ohm, BNC. | 50 Ohm, NMO. | 50 Ohm, NMO. |
| **Modem Specifications** | | | |
| Link Rate/Modulation | 19,200 bps/4 Level FSK.<br>9600 bps/4 Level FSK.<br>9600 bps/GMSK.<br>4800 bps/GMSK. | | |
| Link Protocols | Transparent, Packet Switched, Digipeater, TRIMTALK.™ | Transparent, Packet Switched, Digipeater, TRIMTALK.™ | Transparent, Packet Switched, TRIMTALK.™ |
| Forward Error Correction | Hamming Code (12, 8) with Data Interleaving. | | |
| **Radio Specifications** | | | |
| Frequency Bands | Refer to price list for available frequency bands. | | |
| Frequency Control | Synthesized 12.5k Hertz Resolution.<br>±2.5 ppm Stability. | | |
| RF Power Select | Low/High. Factory Programmable. | N/A. | |
| RF Transmitter Output | 3/35 Watts Maximum. | 0.5 – 2 Watts. | 0 Watt (Receive Only). |
| Sensitivity | -116 dBm (12 dB SINAD). | | |
| Adjacent Channel Selectivity | >-60 dB. | >-70 dB at 9600 bps/GMSK.<br>>-60 dB at 19,000 bps/4 Level FSK. | >-60 dB. |
| Type Certification | All models are type accepted and certified for operation in the U.S. and Canada.<br>For detailed information concerning your country's type certification, please contact your sales representative. | | |
| **Environmental Specifications** | | | |
| Operating Temperature | -22° to +140° F (-30° to +60° C). | | -4° to +140° F (-20° to +85° C). |
| Storage Temperature | -67° to +185° F (-55° to +85° C). | | -4° to +185° F (-20° to +85° C). |
| Vibration/Shock | ANSI/ASAE EP455. | | |
| Enclosure | IEC 60529 I.P. 66.<br>Water Tight and Dust Proof. | | |
| **Mechanical Specifications** | | | |
| Dimensions | 6.23" W x 2.77" H x 6.58" L. | 8.25" L x 2.40" Diameter. | 8.25" L x 2.40" Diameter. |
| | (15.8 cm W x 7.0 cm H x 16.7 cm L). | (21.0 cm L x 6.1 cm Diameter). | (21.0 cm L x 6.1 cm Diameter). |
| Weight | 2.96 lbs. (1.34 Kg). | 0.65 lbs. (0.30 Kg). | 0.75 lbs. (0.34 Kg). |
| Data/Power Connector | 5 Pin LEMO #1 Shell. | 5 Pin LEMO #0 Shell. | 5 Pin LEMO #0 Shell. |
| Mount | Tripod Bracket. | 5/8" – 11 Range Pole. | 5/8" – 11 Range Pole. |

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INSTANT-RTK TECHNOLOGY

# Z-Xtreme Survey System


## Z-Xtreme

The Ashtech® Z-Xtreme™ from Thales Navigation professional products is a rugged, weather-proof, dual-frequency GPS receiver designed to provide surveyors with cost-effective, centimeter-accurate positions in a variety of system configurations.

The Z-Xtreme receiver begins with state-of-the-art satellite electronics coupled with patented Z-Tracking™ to deliver the highest GPS signal reception level. A removable battery and flash memory card provide enough capacity to last all day for maximum utility. Components are completely integrated inside a weather-proof, high impact plastic housing, ensuring your investment is safe, rain or shine. Use the easy-to-operate interface on the front panel for important functions such as site information entry, survey status, and set-up of RTK base stations without the additional cost of a handheld controller. The result: Z-Xtreme with Instant-RTK® outperforms all other receivers in its class!

## ZX-Solutions

The Z-Xtreme survey system from Thales Navigation provides a range of solutions designed for the vast array of positioning needs – from entry level static or kinematic post-processed surveys, all the way up to real-time functions such as stake out. The entry level ZX-Solutions™ system dramatically increases your productivity for control surveys and other post-processed applications. Add an optional kinematic kit to make topographic feature collection more cost effective. Use Ashtech Solutions™ software to easily process the field data, export results and generate reports. Purchase only what you need for the job at hand because ZX-Solutions is fully upgradeable.

## ZX-SuperStation

Eclipse the productivity of optical instrument stake out with a ZX-SuperStation™. The ZX-SuperStation is a field-to-finish GPS surveying system that combines the Z-Xtreme receiver with a powerful data collector and wireless modems for centimeter accuracy in real-time. Instant-RTK gives you the ability to initialize the centimeter solution in a fraction of the time of conventional RTK systems. Powerful data collection software gives you the ability to efficiently perform GPS surveying techniques and to interface seamlessly with optical total stations.

# TECHNICAL SPECIFICATIONS

## Ashtech Technology

- 12 channel all-in-view operation
- Full-wavelength carrier on L1 and L2
- Z-Tracking
- Multipath mitigation
- Dual-frequency smoothing for improved code differential
- Instant-RTK

## Performance Figures[1]

**Static, Rapid Static**
- Horizontal: 0.005 m + 1 ppm (0.016ft+1ppm)
- Vertical: 0.010 m + 1 ppm (0.033ft + 1ppm)

**Post-Processed Kinematic**
- Horizontal: 0.010 m + 1 ppm (0.033ft + 1ppm)
- Vertical: 0.020 m + 1 ppm (0.065ft+1ppm)

**Real-Time Code Differential Position**
- <1 m (3.28 ft)

**Real-Time Z Kinematic Position (Fine Mode)**
- Horizontal: 0.010 m + 2 ppm (0.033ft + 2 ppm)
- Vertical: 0.020 m + 2 ppm (0.065ft + 2 ppm)
- Azimuth (arc sec): 0.4 + 2.0/baseline (km)

**RTK Occupation Time**
- 2 seconds (typical - sub-centimeter accuracy with longer occupation time)

**Instant-RTK Initialization**
- 99.9% reliability
- Typically <2 seconds with 6 or more satellites, PDOP <5, baseline length <7 km (4.35 mi), open sky and low multipath conditions

**RTK Operating Range**
- Recommended: 10 km (6.21 mi)
- Maximum: 40 km (24.85 mi)

## Standard Features

- 16 MB PCMCIA removable memory card
- NMEA 0183 output
- Selectable update rate from 999 sec to 10 Hz
- Event marker
- Point positioning
- 1 PPS timing signal
- Session programming
- Wide array of coordinate transformations
- Removable internal battery
- 8-character alphanumeric LED display with 4-button interface
- 3 function LED display - Radio,Memory, Satellites/Power
- Multi-function audible alarm
- Quick reference card holder
- External mount capabilities
- External power input
- 4 RS-232 ports (115200 baud max, 3 external, 1 internal)
- 1-year warranty
- Free factory technical support

## Standard Accessories

- Communications software
- Padded system bag and hard case
- RS-232 data cable
- Receiver operating manual
- Quick reference field card

## Technical Data

**Environmental**

Z-Xtreme Receiver
- Meets MIL-STD 810E for wind driven rain and dust
- Operating temperature: -30° to +55°C (-22° to 131°F)
- Storage temperature: -40° to +85°C (-40° to 185°F)

Geodetic 4 Antenna
- Meets IPX7 specifications for submersion
- Operating temperature: -55 to +75°C (-40° to 149°F)
- Storage temperature: -55° to +75°C (-67° to 167°F)

**Physical**

Weight
- Receiver: 1.59 kg (3.50 lb)
- Antenna: 0.82 kg (1.81 lb)
- Battery: 0.43 kg (0.95 lb)

Dimensions
- 76.2 H x 196.85 W x 222.25 D mm
- (0.25 H x 0.646 W x 0.729 D ft)

Power
- 10 - 28 VDC, 6.0 W

**Internal battery**
- Capacity: 6000 mAh
- >9 hours (typical) @ 25°C (77°F)
- Operating temperature: -30° to +55°C (-22° to 131°F)
- Storage temperature: -40 to +60°C (-40° to + 140°F)

**PC card**
- ATA Type II PCMCIA memory card (16 MB standard)
- Temperature range: -40° to +85°C (-40° to 185°F)
- Data capacity: 4500 epochs per 2 MB*

** Based on one session, eight satellites' data and full measurements. This number can vary significantly depending on the conditions of the session.*

## Optional Features

- Real-time kinematic (base and rover modes) for cm-accuracy
- RTCM 2.2 (Types 1, 2, 3, 9, 16, 18, 19, 20, 21, 22)
- Internal UHF or spread spectrum radio for RTK rover operations
- External UHF or spread spectrum radio for RTK base and rover operations
- Geodetic 4 antenna ground plane kit
- Kinematic antenna kit
- Aircraft antenna kit
- AC power cable
- Choke ring antenna
- Long haul backpack kit
- All-on-a-pole kit

## Optional Application Software

**GPS data processing**
- Ashtech Solutions

**Land Surveying and Construction**
- TDS Survey Pro
- Carlson SurvCE
- Ashtech Survey Control II
- Ashtech GPS Fieldmate

**Mining and Land Seismic**
- Ashtech Mine Surveyor II
- Ashtech Seismark II

*1 Specifications assume operation follows all the procedures recommended in the product manual utilizing Instant-RTK, post processing with Ashtech Solutions or Ashtech Office Suite for Survey. High-multipath areas, high PDOP values, low satellite visibility, and periods of adverse atmospheric conditions and/or other adverse circumstances will degrade system performance. All accuracy specifications are RMS values.*

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**Thales Navigation follows a policy of continuous product improvement; specifications and descriptions are thus subject to change without notice. Please contact Thales Navigation for the latest product information.**

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THALES NAVIGATION

Nikon

# TOP GUN®
# DTM-310
## ELECTRONIC TOTAL STATION

# Valuable functions, superior cost-performance, longer battery life and enhanced software


*Nikon has just taken the world-renowned Top Gun® DTM-300 total station to a whole new level. The new Top Gun® DTM-310's enhanced keyboard and on-board software enable easy code input in both alphabet and numbers, the way you've always wanted. It builds on existing features — such as the large four-line LCD and full numeric key pad — to improve overall convenience. And software upgrades make it easier to search and display data. In fact, the Top Gun® DTM-310 provides customers in any field — from civil construction to cadastral surveying and mapping — with greater ease of operation.*

### ENHANCED BASIC FUNCTIONS

- Large four-line display with full alphanumeric input on both faces
- Meets basic requirements for distance and angle measurement
- Resume function for quick startup and power management
- Enhanced, powerful built-in programs
- 500-point on-board data storage function
- 7.3 hours continuous measuring with one on-board battery
- Compact and lightweight
- Quick access to the 20 most recently stored codes


## Convenient Alphanumeric Input

*The inclusion of alphabetic input enables you to store codes in a combination of letters and numerals. Codes, target heights (HT) and point numbers are easily input for each new measurement. And codes can also be selected from the most recent 20 codes stored in the memory, eliminating the need to repeatedly input the same codes.*

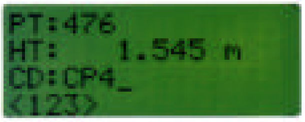

### ■ KEY DESCRIPTIONS

**MSR:** Distance measurement in normal measurement mode
**DSP:** Selects display item by scrolling display
**TRK:** Distance measurement in high-speed measurement mode
**ANG:** Horizontal angle zero-set, user-defined angle input or hold
**XYZ:** Coordinate measurement
**RDM:** Remote distance measurement (continuous or radial)
**REM:** Remote elevation measurement
**STN:** Station setup (known point, 2-point resection or 3-point resection)
**S-O:** Stakeout by inputting angle distance or coordinates
**Illumination:** Display illumination
**REC:** Data record to internal memory
**ENT:** Data entry or sending observation data to communication port in normal observation mode
**FNC:** Input of temperature and barometric pressure, prism constant, and height of target; simple COGO calculation; settings; view/edit stored data; communication (internal memory); vertical collimation correction

# Enhanced, Powerful Built-in Programs

### On-board data storage function

The DTM-310 memory stores up to 500 raw or coordinate records. Coordinate data can be manually input, measured or




uploaded from a PC. (Contact your Nikon distributor for download/upload and format conversion software.) Data can be instantly recalled and reviewed for station setup, stakeout and COGO.

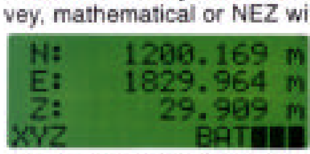
### Station setup

For station setups, in addition to the known station setup obtained by inputting the coordinate of backsight or direction angles, a more simplified default station setup is also possible. This can be obtained by setting the station point coordinates at zero


while maintaining the prior orientation intact. Two- and three-point resections are also available. In the case of a three-point resection, it is possible to transfer the elevation from a bench mark.

### XYZ coordinate measurement

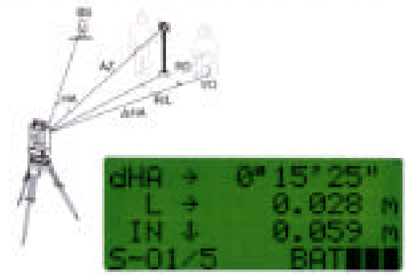
The coordinate system can be set to survey, mathematical or NEZ with indepen-




dent coordinate order settings. Azimuth zero-direction can be set to either north or south. Coordinate calculations are based on these settings. Point name, number, code and coordinate data can be stored in the data file. The target height can be changed at any time by pressing the FNC key.

### Stakeout

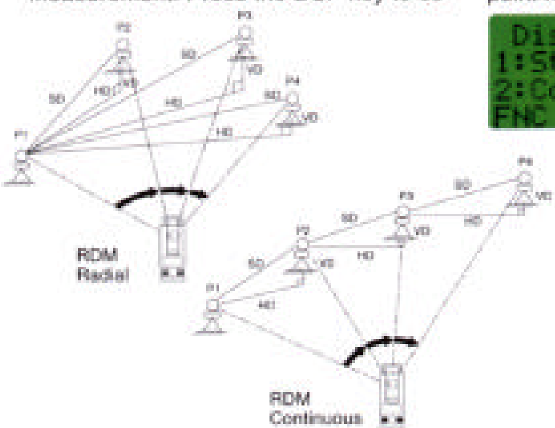
Lets you perform stakeouts by inputting angle and distances, or coordinates. Co-




ordinates can be searched and retrieved from the built-in memory. Zero-direction countdown and delta displays (Left/Right, In/Out, Cut/Fill) make for fast and simple stakeouts. Stakeout data can be also recorded in the internal memory.

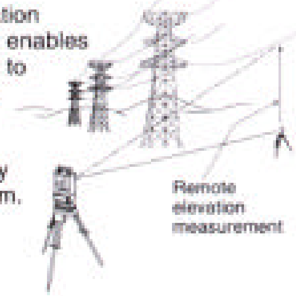
### RDM

For continuous or radial remote distance measurement. Press the DSP key to select slope distance, elevation difference, horizontal distance, grade, legal grade ratio between two points, or azimuth from first to second points.




### REM

Remote elevation measurement enables measurement to points (e.g., a power pole) where you cannot directly place the prism.

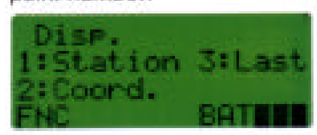



### COGO calculation

Enables point-to-point inverse calculations, plus azimuth and distance calculations. Coordinates can be searched and retrieved from the on-board memory, and calculated coordinates can be saved.

### Data display

The DTM-310 enables you to search data by tracing back from the most recent record, from specific station points, or from a simple point number.




# 7.3 Hours Continuous Operating Time

Internal battery BC-60 provides about 7.3 hours (with full charge, at 20°C, for distance/angle measurements) of continuous operation. The remaining battery power is indicated by the LCD. As Ni-MH battery BC-60 contains no harmful substance, recycling is not necessary. Quick recharge can be performed in about 2 hours with standard battery charger Q-70U/Q-70E. The Q-70U/Q-70E's discharging function preserves the batteries' minimum power and protects against deterioration.

# Resume Function

This resume function can automatically revert to the orientation prior to power OFF, or automatically display the previous horizontal angle. It guarantees the safety of all previous data settings.

# Basic Measurement Functions

- Built-in Automatic Vertical Compensation
- Vertical Angle Zero-Degree Set Handled in Three Modes
- Grade Display
- With Triple Prism, to 1.2km or 3,900 feet (under good conditions)
- ±(5 + 3ppm x D)mm Precision
- Automatic Environmental Compensation
- Selectable Angle Reading of 5/10", 0.5/1mgon, 0.02/0.05MIL
- Angle Measurement Accuracy of 5"/1.6mgon/0.02MIL (standard deviation based on DIN18723)

## Standard Package

- DTM-310 main unit
- On-board battery BC-60
- Battery charger Q-70U/Q-70E
- Lens cap
- Plumb bob
- Tool set
- Plastic case
- Vinyl cover
- Instruction manual

On-board battery BC-60 and battery charger Q-70U/Q-70E

## Optional Accessories

- Diagonal eyepiece prism
- High-power (32x) and low-power (16x) eyepiece lenses
- Compass (tubular type) and compass adapter
- Zenith prism
- Solar filter
- Solar reticle
- External battery B4

## Specifications

| | |
|---|---|
| **Telescope** | |
| Tube length | 150mm/5.9 in. |
| Effective diameter of objective | 36mm/1.41 in. (EDM aperture 40mm/1.57 in.) |
| Magnification | 26x (standard) |
| Field of view | 1°30' |
| Resolving power | 3.5" |
| Minimum focusing distance | 1.0m/3.3 ft. |
| **Angle measurement** | |
| Reading system | Incremental encoder |
| Unit of reading | Degree/Gon/6400MIL |
| Least count (selectable) | |
| (360°) | 5" or 10" |
| (400G) | 0.5mgon or 1mgon |
| (6400MIL) | 0.02MIL or 0.05MIL |
| Accuracy (Standard deviation based on DIN 18723) | 5"/1.6mgon/0.02MIL |
| Tilt sensor (Automatic Vertical Compensator) | Liquid type |
| Working range | ±3' |
| **Distance measurement** | |
| Range (with Nikon prism) | |
| (Normal conditions: ordinary haze, visibility 20km/12.5 miles) | |
| with mini prism | 380m/1,300 ft. |
| with single prism | 800m/2,600 ft. |
| with triple prism | 1,100m/3,700 ft. |
| (Good conditions: no haze, visibility 40km/25 miles) | |
| with mini prism | 450m/1,500 ft. |
| with single prism | 1,000m/3,300 ft. |
| with triple prism | 1,200m/3,900 ft. |
| Accuracy | ±(5 + 3ppm x D)mm, –10°C to +40°C/+14°F to +104°F<br>±(5 + 5ppm x D)mm, –20°C to +50°C/–4°F to +122°F |
| Maximum measurement display | 1,230m/4,000 ft. |
| Least count | |
| Standard MSR mode | 1mm/0.005 ft. |
| Tracking mode | 10mm/0.05 ft. |
| Measuring intervals | |
| Standard MSR mode | 4 sec. |
| Tracking mode | 1.2 sec. |
| Measuring mode | Continuous/Single/Average (2 - 99) |
| Ambient temperature range | –20°C to +50°C (–4°F to +122°F) |
| Atmospheric correction range | |
| Temperature range | –40°C to +60°C (–40°F to +140°F) |
| Pressure range | 400 to 999mmHg (1mmHg step)<br>15.8 to 39.3 in.Hg (0.1 in.Hg step)<br>533 to 1,332hPa (1hPa step) |
| **Display** | Dot-matrix LCD<br>16 characters x 4 lines |
| **Level vial** | |
| Sensitivity of plate level vial | 30"/2mm |
| Sensitivity of circular level vial | 10'/2mm |
| **Leveling base** | |
| Tribrach | Detachable |
| **Optical plummet** | |
| Image | Erect |
| Magnification | 3x |
| Field of view | 5° |
| Focusing range | 0.5m/1.6 ft. to ∞ |
| **Power sources** | |
| Type | Ni-MH 7.2V DC |
| Continuous operating time | 7.3 hrs. or 8,760 measurements (for distance/angle measurement)<br>22 hrs. (for angle measurement only) |
| **Quick battery charger (Q-70U/Q-70E)** | |
| Input voltage | 115V for Q-70U, 220/240V for Q-70E |
| Recharging time | 1.5 hrs. |
| **Dimensions (W x D x H)** | |
| Main unit (with carrying handle) | 164 x 177 x 335mm/6.5 x 7.0 x 13.2 in. |
| **Weight** | |
| Main unit w/battery | 5.5kg/12.1 lbs. |
| Battery BC-60 | 0.5kg/1.1 lbs. |
| Carrying case | 2.5kg/5.5 lbs. |

These products (DTM-310 and battery charger Q-70U/E) are strategic products subject to Japanese/International export control regime. They should not be exported without authorization from the appropriate governmental authorities.

Specifications and equipment are subject to change without any notice or obligation on the part of the manufacturer. February 1997

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# V. SPECIFICATIONS

## 1. Main Unit

### ● Telescope

| | |
|---|---|
| Image | : Erect/unreversed |
| Magnification | : 26× |
| Effective diameter of objective | : 36mm |
| Field of view | : 1°30′ |
| Minimum focusing distance | : 1.0m |
| Resolving power | : 3.5″ |

### ● Distance Measurement

| | |
|---|---|
| Distance range of Nikon prisms | : 450m with mini prism<br>1000m with single prism<br>1200m or longer with triple prism<br>*With visibility 40km (25miles) |
| Precision | : ±(5mm+3ppm×D)<br>*With accurate measurement mode, at −10°C~+40°C/+14°F~+104°F<br>D is measuring distance, mm unit<br>±(5mm+5ppm×D) at −20°C≦t<−10°C/−4°F≦t<+14°F and +40°C<t≦50°C/+104°F<t≦+122°F |
| Measuring time response | : [MSR] mode: About 4sec. (initial: about 5sec.)<br>[TRK] mode (cm): About 1.2sec (initial: about 2.2sec.) |
| Least count | : 1mm |
| Display | : Up to 1230m |
| Display unit | : m/ft-INT/ft-US |

### ● Angle Measurement

| | |
|---|---|
| Accuracy | : 5″ (Standard deviation based on DIN 18723) |
| Reading system | : Photoelectric detection by incremental encoder single-sided reading |
| Display unit | : Degree/Gon/MIL |

## ● Automatic Vertical Compensator

| | |
|---|---|
| System | : Liquid-electric detection |
| Working range | : ±3′ |

## ● Optical plummet

| | |
|---|---|
| Image | : Erect |
| Magnification | : 3× |
| Field of view | : 5° |
| Focusing range | : 0.5m～∞ |

## ● Clamps/tangent screws : Coaxial dual speed tangents

## ● Sensitivity of level vials

| | |
|---|---|
| Plate level vial | : 30″/2mm |
| Circular level vial | : 10′/2mm |

## ● Tribrach : Detachable

## ● Dimensions and weight

| | |
|---|---|
| Main body | : 5.5kg (12lbs) including BC-6 battery pack |
| Case | : About 3.5kg (7.6lbs) |

## ● Operating temperature range:

−20°C～50°C/−4°F～+122°F

SOKKIA

# SET5F

Version 01-00

TOTAL STATION

## Enhanced software with 3,000-point data memory.

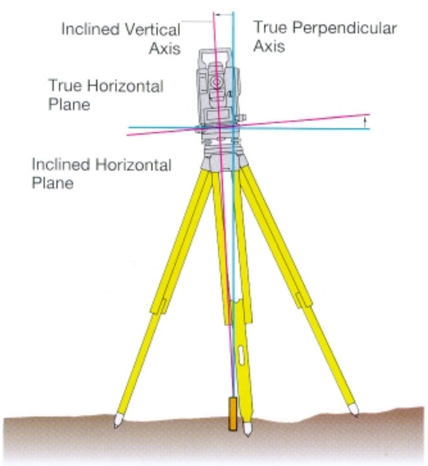
# *Flexible, Friendly and Featherweight*

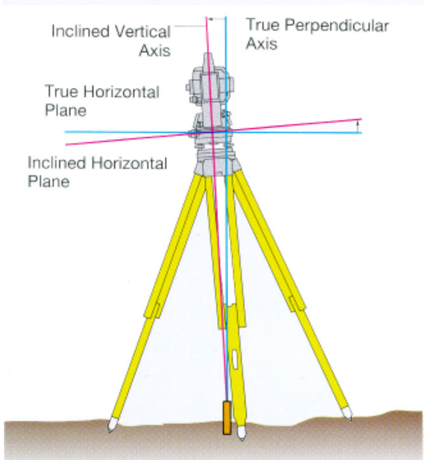
**The SET5F's powerful EDM, dependable dual-axis compensator and 3,000-point data memory are conveniently packaged in a compact, lightweight body. Software [Version 01-00) has been enhanced for more effective survey work, and "softkey" assignments can be freely customized to suit all user needs.**

## *Dependable Hardware*

### Proven Dual-axis Compensator

•Since its introduction with the Series C total station in 1989, Sokkia's dual-axis compensator has proven its reliability and accuracy at survey sites all over the world.
•The dual-axis tilt sensor monitors deviations of both the X and Y axes and the correct horizontal and vertical angle readings are automatically computed and applied. The result is easier and faster instrument leveling.




### The High-performing EDM

•1,500m/4,900ft range with a single prism under good ambient conditions (40km/25miles visibility, with no haze, overcast, no scintillation).
•Outstanding precision; ±(3+2ppmxD)mm. This corresponds to a deviation of a mere ±3.2mm at a distance of 100m and ±5mm at 1,000m.
•Supreme speed; only 1.7 seconds initial measuring time in the rapid measurement mode.

| | Average Conditions | Good Conditions |
|---|---|---|
| CP01 Compact Prism | 700 m/2,300 ft. | |
| One AP01 Prism | 1,200 m/3,900 ft. | 1,500 m 4,900 ft. |
| Three AP01 Prisms | 1,600 m/5,200 ft. | 2,000 m 6,500 ft. |

### Powerful Telescope

•Highest magnification in its class: 30x
•Easy, accurate sighting of prisms or targets

### Outstanding Mobility

•Total carrying weight (including instrument, tribrach, battery and hard case) is a mere 8 kg/18 lbs. The secret lies in the lightest and most compact carrying case of its kind (W390 x D255 x H220mm / W15.3 x D10.0 x H8.6in.), making the SET5F supremely portable.
•A convenient shoulder strap is provided as standard. An optional back pack (SC94) is ideal for longer day treks.


*Key assignment mode*

### Spacious 3,000-point Internal Memory

•The SET5F's internal memory is large—holding a full 3,000 data points—and secure. For optimum convenience, measurements can be performed and recorded at the touch of a key.
•Up to five (5) job files can be created to efficiently organize multiple survey tasks.
•Forty (40) feature codes (max.13 charac-ters each) can be kept in the memory for easy recall as needed.


## *Enhanced Software*

### The SET5F can be easily customized to your preferred key assignments.

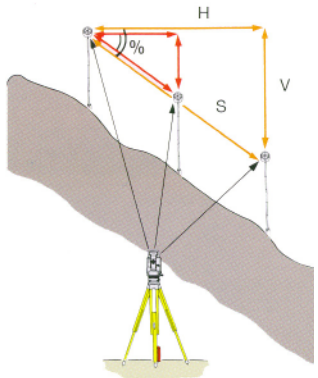
•The SET5F offers optimum keyboard flexibility. Any keyboard layout can be configured. For example, functions can be assigned to any key position on any page, and unused functions can be temporarily deleted.
•A powerful "softkey" feature facilitates input of coordinate values, feature codes, etc.

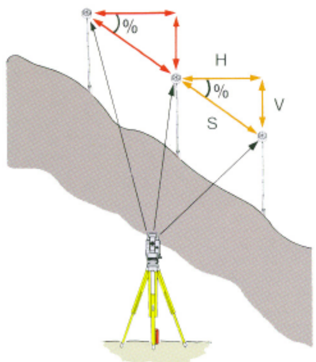
### Sophisticated Application Software

**Missing Line Measurement (MLM)**

•The SET5F measures horizontal distance, slope distance, height difference, and slope in percent (%) between two prisms, all at the touch of a key.

# The SET5F brings full freedom to survey work.

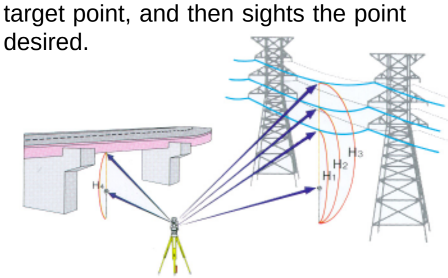




## Remote Elevation Measurement (REM)

•The SET5F can be used to easily determine the height of a point where a prism cannot be placed. The system sights a prism directly above or below the target point, and then sights the point desired.

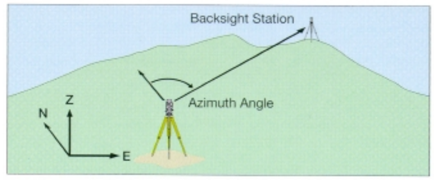


## Angle Repetition

•For enhanced accuracy in the horizontal angle measurement, the SET5F can measure in repetition. It then calculates and displays the average of the multiple angle measurements.

## Azimuth Angle Setting

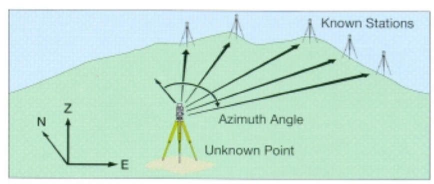
•Using the coordinates of the instrument station and a backlight point, the SET5F can automatically set the horizontal angle to the azimuth of the backlight.




## Resection

•With 2 to 5 known points, the SET5F can be used to determine the azimuth and coordinates of the unknown instrument station.

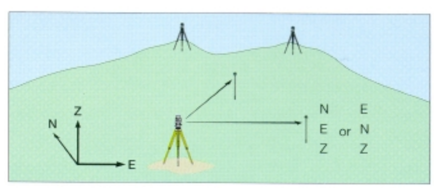
•When using 2 known points, both angles and distances are measured. When using 3 or more points, the distance does not always have to be measured.




## 3-D Coordinate Measurement

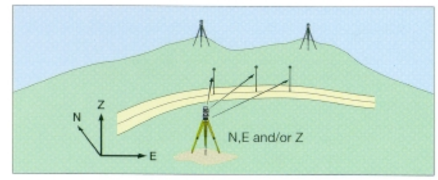
•The SET5F calculates 3-D coordinate values of measuring points.

•The operator may choose display settings either of "N, E, Z" or "E, N, Z."



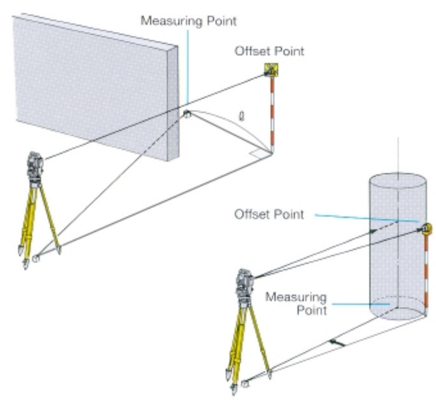

## 3-D Setting-out

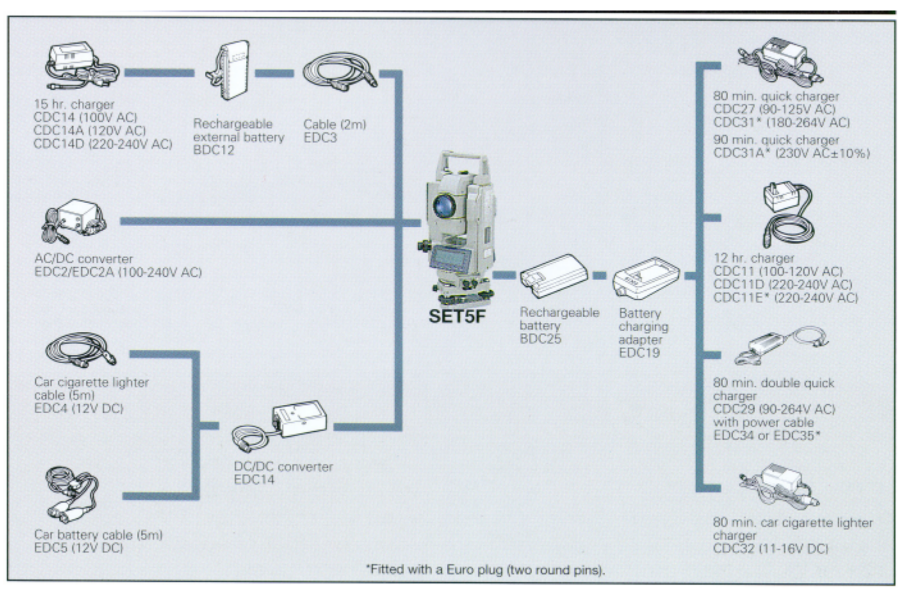
•The SET5F can be used to perform 3-dimensional setting-out with N, E and/or Z coordinates.




## Offset Measurements

Two basic offset measurement methods are provided to measure the hidden points. One calls for input of the offset distance and the direction between the measuring point and the prism. The other uses a prism set on the left or right side of the measuring point at the same distance from the SET5F; the angles and distance to the prism are measured, and the measuring point is sighted. In both cases, the SET5F calculates the horizontal and vertical angles and distance, or the N, E, Z coordinates.



## Standard Configuration

The SET5F comes with two (2) BDC25 rechargeable batteries EDC19 battery charging adapter CDC27, CDC31 or CDC31A quick charger, CP7 tubular compass, sunshade, lens cap, plumb bob, vinyl cover, tool kit, operator's manual, carrying case and shoulder strap.

## Electronic Field Books (SDR33/SDR31)

Thanks to its advanced two-way communications port, the SET5F's functions can all be accessed by external controller. For example, by connecting one of the Sokkia's acclaimed Electronic Field Books (SDR33 or SDR31), complex field operations such as traverse adjustment, intersection, area calculations and roading can be carried out with remarkable ease.

## Optional Accessories

| | |
|---|---|
| DE17A | Diagonal Eyepiece |
| OF1/OF1A | Solar Filters |
| SC94 | Back Pack |

## SET5F Specifications

| | | |
|---|---|---|
| **Telescope** | | **Fully transiting, coaxial EDM** |
| Length | | 165mm (6.5in) |
| Objective aperture | | 45mm (1.8in) |
| Magnification, image | | 30x, Erect |
| Resolving power | | 3.0" |
| Field of view | | 1°30'(26m/1,000m) |
| Minimum focus | | 1.3m (4.3ft.) |
| Reticle illumination | | Bright or Dim, selectable |
| **Angle measurement** | | **Incremental encoder, diametrical detection** |
| Display resolution | H&V | 1"/ 0.2 mgon/ 0.005 mil, 5"/1 mgon/ 0.02 mil |
| Angle unit | H&V | Degree/Gon/Mil |
| Accuracy | H&V | 5" (1.5 mgon/ 0.02 mil) according to DIN18723 |
| Dual-axis compensator | | Liquid dual-axis tilt sensor, range: ±3' (±55 mgon) |
| Display mode | H | Clockwise/ Counterclockwise, Repetition, Oset, Hold available |
| | V | Zenith 0°/ Horizontal 0°/ Horizontal 0°±90°/ Slope% |
| **Distance measurement** | | **Electro-optical with modulated infrared LED.** |
| Measuring range (slope distance) | | A: Average conditions; slight haze, visibility about 20km(12 miles), sunny periods, weak scintillation.<br>G: Good conditions; no haze, visibility about 40km (25 miles), overcast, no scintillation.<br>Maximum ranges are achieved with Sokkia CP/AP prisms. |
| With CP01 compact prism | | A: 1.3m (4.3ft.) to 700m (2,300ft.) |
| With one AP01 prism | | A: 1.3m (4.3ft.) to 1,200m (3,900ft.), G: 1,500m (4,900ft.) |
| With three AP01 prism | | A: 1.3m (4.3ft.) to 1,600m (5,200ft.), G: 2,000m (6,500ft.) |
| Distance unit | | Meters or feet, selectable |
| Accuracy (Fine measurement) | | ±(3+2ppmxD)mm D=measuring range, unit=mm |
| Measuring unit and time (slope distance) | Fine | 0.001 m Every 3.2 seconds (initial 4.7 seconds) |
| | Rapid | 0.001 m 1.7 seconds |
| | Tracking | 0.01 m Every 0.3 seconds (initial 1.4 seconds) |
| | Average | 0.0001 m (average of 2 to 9 times measurement) |
| Atmospheric correction | | Key-in the temperature and pressure, or -499 to +499ppm. |
| Prism constant | | -99 to 0mm (1 mm steps) |
| Refraction & Earth-curvature correction | | On/off selectable (K=0.142) |
| **General** | | |
| Display | | LCD dot matrix display (20 characters x 4 lines) on both faces with back light. |
| Keyboard | | 5 keys on both faces, free assignment of functions. |
| Resume function | | On/off selectable |
| Sensitivity of levels | | Plate level: 40"/2mm, Circular level: 10'/2mm (in tribrach) |
| Optical plummet | | Image: erect, Magnification: 3x, Minimum focus: 0.5m (1.6ft.) |
| Interface | | Asynchronous serial, RS-232C compatible, baud rate 1200/ 9600bps |
| 2-way communication | | Provided |
| Data storage | | 3,000-point data memory |
| Operating temperature | | -20°C to +50°C (-4°F to +122°F) |
| Tilting/Trunnion axis height | | 236mm (9.3in) from tribrach bottom, 193mm (7.6in) from tribrach dish. |
| Size with handle and battery | | W150 x D165 x H353mm, W5.9 x D6.5 x H13.9in. |
| Weight with handle and battery | | 5.4kg (11.9lbs) |
| Weight of parts | | BDC25 battery: 240g (8.5oz.), Handle: 100g (3.5oz.), Tribrach: 740g (1.6 lbs), Case:2.4kg (5.3lbs) |
| **Power supplies** | | |
| Battery level display | | 4 steps with warning message. |
| Automatic power cut-off | | On/off selectable (30 minutes after the last operation) |
| Power source | | BDC25 rechargeable battery, Ni-Cd 6V, 2 supplied as standard. |
| Working duration at 25°C (77°F) w/one BDC25 battery | | Distance & angle measurement: about 5 hours, about 600 points (Fine & single measurement with 30 seconds intervals).<br>Angle measurement only: about 9 hours. |
| Charging time | | CDC27/31: about 80 minutes, CDC31A: about 90 minutes |

Designs and specifications are subject to change without notice.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Sokkia is a sponsor of the International Federation of Surveyors.

ISO 9001 Certified
Certificate No. JQA-0557
ISO 9001/BS EN ISO 9001/EN 29001/JIS Z9901
SOKKIA CO.,LTD.

# Appendix III

## Vessel Reports, Offsets, and Diagrams

### Launch 1010

1. Offsets
2. Patch Test
3. DDSSM and Settlement & Squat
4. POS Gams Calibration
5. Wire Diagram

### Launch 1018

1. Offsets
2. Patch Test
3. DDSSM and Settlement & Squat
4. POS Gams Calibration
5. Wire Diagram

### S220

1. Offsets
2. Patch Test
3. DDSSM and Settlement & Squat
4. POS Gams Calibration
5. Wire Diagram
6. Correspondence

## Waterline Measurements

Measuring Party: Rice, Argento, Campbell, Beduhn

Waterline Measurements should be Negative!

**Fill in Yellow squares only!**

| | 1010 | |
|---|---|---|
| | Benchmark A to Waterline | Benchmark B to Waterline |
| Measure 1 | -86.2 | -88.5 |
| Measure 2 | -86.6 | -89.2 |
| Measure 3 | -87.6 | -96.0 |
| Avg (cm) | -86.80 | -91.23 |
| Avg (m) | -0.8680 | -0.9123 |
| Stdev | 0.00721 | 0.04143 |
| BM Z-value (m) | -0.02017 | -0.05283 |
| BM C to WL (m) | -0.888 | -0.965 |

Date: 4/7/2009 Dn 097

Fuel Level: .5+

Draft Tube:

Port-to-Stbd Z-difference

| Theoretical | Actual | Error |
|---|---|---|
| 0.0327 | -0.0443 | -0.0770 |

BM C to WL Average (m)

-0.927 (This value added to 1010_Offsets & Measurements_200X.xls)

| | | |
|---|---|---|
| Individual measurement | -0.88217 | -0.93783 |
| | -0.88617 | -0.94483 |
| StDev for TPU xls (of 6 #'s) 0.04986 | -0.89617 | -1.01283 |

utilized in Offsets and Measurements and TPU spreadsheet

This spreadsheet is designed to compute the z-values of the phase centers of the new POS M/V antenna.

**All offsets are in the Theodolite Coordinate System**

| | | | | | |
|---|---|---|---|---|---|
| BM E | x | 1.665536 | Port Ant | x | 2.316862 |
| | y | -0.892424 | | y | -0.886431 |
| | z | 1.612667 | | z | Unknown |
| BM F | x | 1.668082 | Stbd Ant | x | 2.324270 |
| | y | -0.001217 | | y | 0.952574 |
| | z | 1.649000 | | z | Unknown |
| BM G | x | 1.668115 | | | |
| | y | 0.957794 | | | |
| | z | 1.578000 | | | |

POS MV V4 Installation and Operation Guide

Drawings

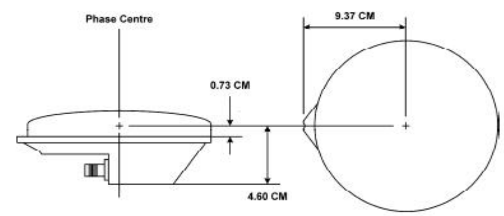



Figure 79: GPS Antenna Footprint

| **Measuring Party (fill in yellow spaces only):** | **Date:** | **Serial #- Port** | **Serial #- Stbd** |
|---|---|---|---|
| Rice, Argento, Campbell, Beduhn | 4/7/2009 | 60162863 | 60145247 |

| **Distances** | | | | | z-Values Ant. Base | Phase Center | |
|---|---|---|---|---|---|---|---|
| Port Ant to BM 'E' | 0.693 | 0.693 | 0.693 | 0.70575 | 1.884369 | 1.930369 | |
| Port Ant to BM 'F' | 1.11 | 1.11 | 1.112 | 1.1234167 | 1.888889 | 1.934889 | |
| Port Ant to BM 'G' | 1.967 | 1.97 | 1.97 | 1.98175 | 1.902489 | 1.948489 | |
| | | | | | 1.886629 | 1.932629 | AVERAGE |
| | | | | | | 0.0094 | STDEV |
| Stbd Ant to BM 'E' | 1.959 | 1.964 | 1.962 | 1.9744167 | 1.858381 | 1.904381 | |
| Stbd Ant to BM 'F' | 1.166 | 1.167 | 1.167 | 1.1794167 | 1.874221 | 1.920221 | |
| Stbd Ant to BM 'G' | 0.707 | 0.705 | 0.705 | 0.7184167 | 1.870499 | 1.916499 | |
| | | | | | 1.872360 | 1.918360 | AVERAGE |
| | | | | | | 0.0083 | STDEV |

| Antenna Post | Diameter | Radius |
|---|---|---|
| | 0.0255 | 0.01275 |

The distances from the antenna post to each benchmark was measured three times and averaged. The post offset to phase center (radius) was then added.

The distance is 0.046m (4.60cm) from the bottom of the antenna to the Phase center, obtained from the POSM/V v4 guide, see image above.

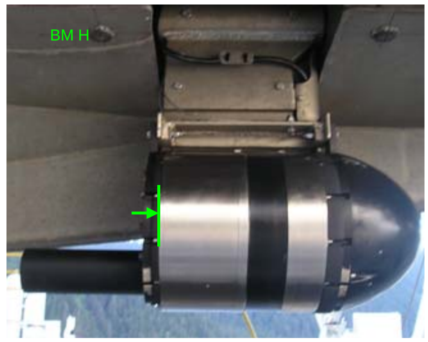
# Offsets from Aft Benchmark to Phase Center of Transducer

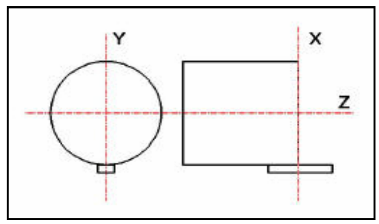
| 3/20/2009 | 79 | Launch 1010 | Campbell, Argento, Beduhn |
|---|---|---|---|
| Date | DN | Vessel | Personnel |

2701011
Serial Number of Transducer

**Instructions:** The purpose of this measurement is to check for gross movement of the tranducer. **Fill in yellow spaces only.**

While the boat is in the cradle, gently lower the transducer and lock it in place. Using a metric tape measure, plumb bob and carpenter's level, measure the horizontal and vertical offsets from the aft benchmark (BM H) to the phase center of the transducer. The phase center is measured at the forward edge of the black insulating layer, as shown in the photos. If you have trouble locating the center, borrow a compass from the navigation department.




Notwithstanding a major accident, BM H will be outboard, aft and higher than the phase center; as such, enter all offsets as positive numbers (in cm) and the proper signs will be applied.

Once offsets have been measured, apply a digital level to the IMU to determine any pitch or roll bias in the orientation of the launch. For the purposes of this spreadsheet, a positive angle (measured in degrees) will imply the bow is higher than the stern and the port side is higher than the starboard side.

All measurements should be done in triplicate to aid in the calculation of the uncertainty (needed in the HVF). The *IMU to Phase Center* values will be calculated automatically.

| Offset Measurements (positive cm): | | | | Average |
|---|---|---|---|---|
| Bow-Stern | 10.6 | 10.7 | 11.0 | 10.8 |
| Port-Stbd | 15.9 | 15.9 | 15.8 | 15.9 |
| Up-Down | 35.5 | 35.4 | 36.0 | 35.6 |

| Angle Bias (deg): | |
|---|---|
| Bow Up | |
| Port Up | |

The measuring crew should insure there will be no yaw bias.

| Std Dev: | |
|---|---|
| Bow-Stern | 0.16 |
| Port-Stbd | 0.05 |
| Up-Down | 0.30 |

**BM H to Phase Center**
(Theodolite Coordinate System)

x #REF! cm

y #REF! cm

z #REF! cm

Measured by NOAA Personnel
inserted into Offset Worksheet,
if to be used in IMU to 8101 calculation

**IMU to Phase Center**
(CARIS Coordinate System)

x #REF! m

y #REF! m

z #REF! m

Calculated Value for check purposes

These 2009 values were not used for the hvf offsets due to the angle bias not being entered. The 2008 values were used instead and the 2009 values were used as a check that the unit had not been displaced.

## 1010 Offsets and Measurements - Summary

| Measurement aka Coord. Sys. | IMU to RP* | 8101 to RP* | IMU to 8101 (SWATH1 x,y,z & MRU to Trans) | Port Ant to 8101 (Nav to Trans x,y,z) | RP* to Waterline |
|---|---|---|---|---|---|
| | Caris | Caris | Caris | Caris | Caris |
| x | 0.000 | 0.250 | 0.250 | 1.147 | n/a |
| y | 0.000 | -0.133 | -0.133 | 1.066 | n/a |
| z | 0.000 | 0.549 | 0.549 | 3.665 | -0.256 |

*IMU is RP (Reference Pt)

Vessel Offsets for 1010_8101 are derived from the Horizontal, Vertical & XYZ worksheets in this spreadsheet. 2008 Measured Values

### Calculations

Coord. Sys. Theodolite

| 8101 to RP* | IMU to 8101 | | | Port Ant to 8101 | | | RP to Waterline | | |
|---|---|---|---|---|---|---|---|---|---|
| | IMU (m) | x | 3.516 | IMU (m) | x | 3.516 | IMU (m) | x | 3.516 |
| | | y | 0.011 | | y | 0.011 | | y | 0.011 |
| | | z | -1.183 | | z | -1.183 | | z | -1.183 |
| | BM H | x | 3.271447 | Port Antenna | x | 2.317 | BM C | x | 0.000 |
| | | y | 0.425598 | | y | -0.886 | | y | 0.000 |
| | | z | -1.37667 | | z | 1.933 | | z | 0.000 |
| | IMU to BM H | x | -0.244 | IMU to Port Antenna | x | -1.199 | BM C to IMU | | |
| | | y | 0.415 | | y | -0.897 | | x | n/a |
| | | z | -0.194 | | z | 3.116 | | y | n/a |
| | | | | | | | | z | -1.183 |
| | BM H to Phase Ctr (cm) measured | x | 11.10496 | IMU to Phase Ctr | x | -0.133 | | | |
| | | y | -16.466 | | y | 0.250 | BM C to Waterline | | |
| | | z | -35.540 | | z | -0.549 | measured | x | n/a |
| | | | | | | | | y | n/a |
| | | | | | | | | z | -0.927 |
| | BM H to Phase Ctr (m) | x | 0.11105 | | | | | | |
| | | y | -0.16466 | | | | | | |
| | | z | -0.3554 | | | | | | |

see

Coord. Sys. Theodolite

| IMU to 8101 | IMU to 8101 | | | Port Ant to 8101 | | RP to Waterline | |
|---|---|---|---|---|---|---|---|
| | IMU to Phase Ctr | x | -0.133 | x | 1.066 | x | n/a |
| | | y | 0.250 | y | 1.147 | y | n/a |
| | | z | -0.549 | z | -3.665 | z | 0.256 |
| | Coord. Sys. CARIS | | | Coord. Sys. CARIS | | Coord. Sys. CARIS | |
| | | x | 0.250 | x | 1.147 | x | n/a |
| | | y | -0.133 | y | 1.066 | y | n/a |
| | | z | 0.549 | z | 3.665 | z | -0.256 |

## 1010 Offsets and Measurements - Summary

| Port Ant to Stbd Ant | | IMU to Port Antenna | | IMU to Heave | |
|---|---|---|---|---|---|
| | | Caris | Pos/Mv | Caris | Pos/Mv |
| Scalar Distance | 1.839 | -0.897 | -1.199 | -0.011 | -1.176 |
| | | -1.199 | -0.897 | -1.176 | -0.011 |
| | | -3.117 | -3.117 | -0.243 | -0.243 |

**Values in the POSMV remained as entered in 2008.**

2009 Measured Values

2007 Measured Values

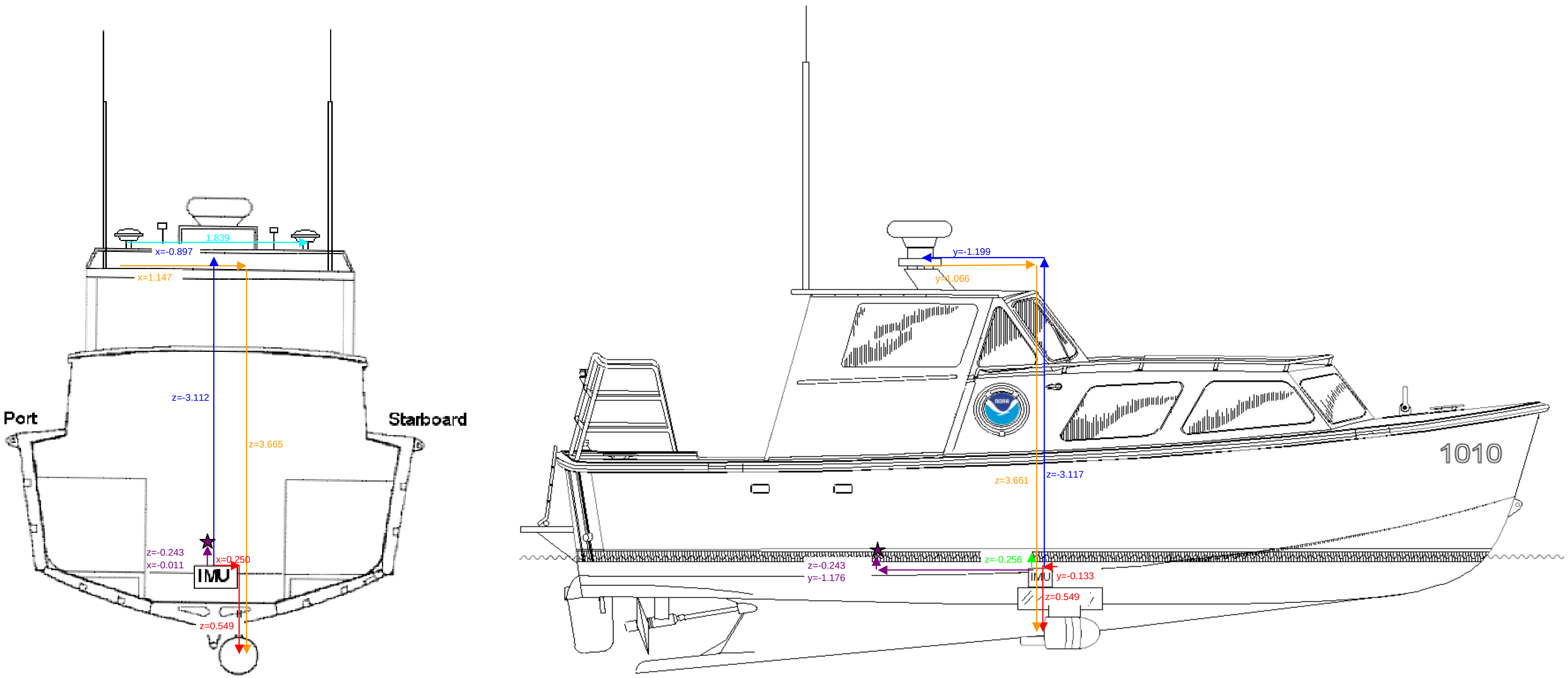
| Port Ant to Stbd Ant | | | IMU to Port Antenna | | | IMU to Heave | | |
|---|---|---|---|---|---|---|---|---|
| Port Ant (m) | x | 2.317 | IMU (m) | x | 3.516 | IMU (m) | y | 0.011 |
| | y | -0.886 | | y | 0.011 | x is n/a | z | -1.183 |
| | z | 1.933 | | z | -1.183 | | | |
| | | | | | | Heave Pt (m) | | |
| Stbd Ant (m) | x | 2.324 | Port Ant (m) | x | 2.317 | (centerline) | y | 0.000 |
| | y | 0.953 | | y | -0.886 | | | |
| | z | 1.918 | | z | 1.934 | BM C to Waterline (m) | | -0.940 |
| | | | | | | measured scalar dist | | |
| | | | | | | BM C | | |
| | | | | | | x&y are n/a | z | 0.000 |
| | | | | | | BM C to Waterline (m) | | |
| | | | | | | (Heave Pt) | z | -0.940 |
| | | | | | | IMU to LCG | x | -1.176 |
| | | | | | | See IMU to Heave tab | | |

| Port Ant to Stbd Ant | | IMU to Port Antenna | | | IMU to Heave | | |
|---|---|---|---|---|---|---|---|
| | | | x | -1.199 | | x | -1.176 |
| Scalar Distance | 1.839 | | y | -0.897 | | y | -0.011 |
| | | | z | 3.117 | | z | 0.243 |
| | | Coord. Sys. Pos/Mv | | | Coord. Sys. Pos/Mv | | |
| | | | x | -1.199 | | x | -1.176 |
| | | | y | -0.897 | | y | -0.011 |
| | | | z | -3.117 | | z | -0.243 |
| | | | | | See IMU to Heave tab | | |

# Description of Offsets for Launch 1010

All Values Shown are in CARIS Coordinates

The Ship Reference Frame (SRF) for Launch 1010 was based from benchmark (BM) C as the 0 point. Physical locations were measured with x,y,z offsets from this point. These locations were used to calculate offsets of items with respect to each other, as described for each offset.



| IMU to 8101 | | |
|---|---|---|
| x | y | z |
| 0.250 | -0.133 | 0.549 |

The physical positions of the IMU and the phase center of the 8101 with respect to the Ship Reference Frame were measured by NOAA personnel. These physical measurements were used to calculate the xyz offsets from the IMU to BM H. Measurements from BM H to the Phase Center of the 8101 were collected by NOAA personnel while the boat was secured on the pier and thought to be as level as possible. The measured offsets from BM H to the phase center were then added to the offset from the IMU to BM H. The result is the offset from the IMU to the phase center of the transducer. The values in the X and Y fields are transposed and the inverse of the Z value is used to give the offsets in CARIS coordinates.

| Port Ant to 8101 | | |
|---|---|---|
| x | y | z |
| 1.147 | 1.066 | 3.665 |

NOAA personnel calculated the distance between the port antenna and the phase center of the port antenna subtracting the IMU to Port Antenna value from the IMU to Phase Center value.

| RP to Waterline | | |
|---|---|---|
| x | y | z |
| N/A | N/A | -0.256 |

The average vertical distance from BM A and B to the waterline was measured by FAIRWEATHER personnel using a steel tape and bubble level. These values were used to calculate the BM C to the waterline value. With the knowledge of the BM C height above the IMU, the waterline height above the IMU could be calculated. On launch 1010, the IMU is used as the reference point.

| Port Ant to Stbd Ant |
|---|
| Scalar Distance |
| 1.839 |

The location of the phase center of the port and starboard POS/MV antennas were measured by NOAA personnel with respect to the SRF. The scalar distance between the phase centers was then calculated.

| IMU to Port Antenna | | |
|---|---|---|
| x | y | z |
| -0.897 | -1.199 | -3.117 |

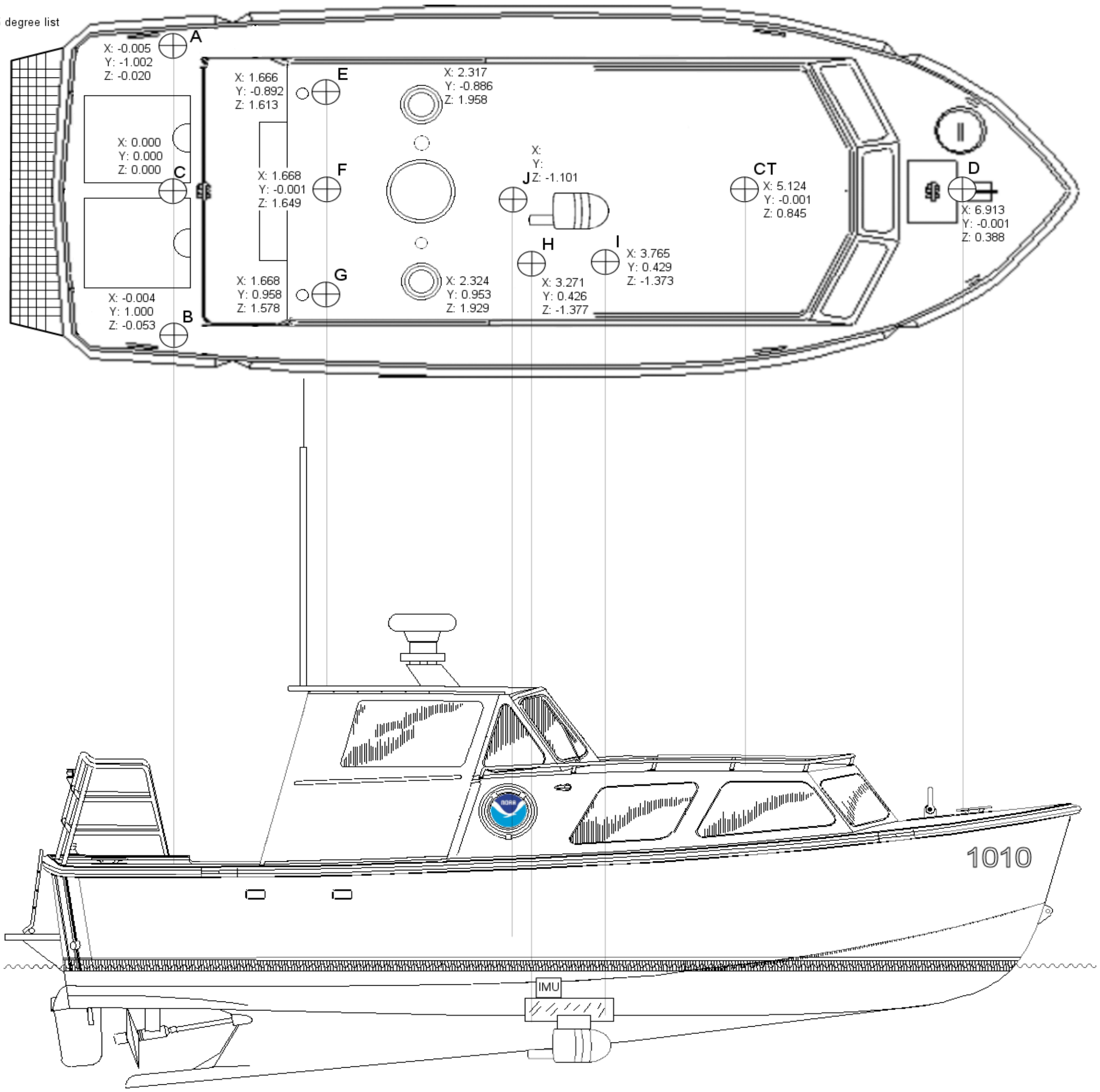
The location of the IMU and the location of the port antenna were measured by NOAA personnel with respect to the Ship Reference Frame (SRF). The xyz offsets from the IMU to the port antenna could be calculated from these physical locations.

| IMU to Heave | | |
|---|---|---|
| x | y | z |
| -0.011 | -1.176 | -0.243 |

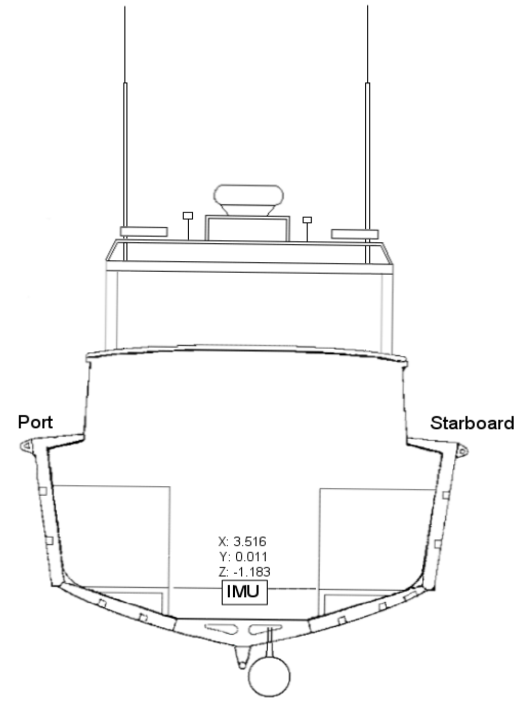
The heave point was positioned differently on each of the axes. The distance for the longitundinal axis was determined as described in the "IMU to Heave" tab in this workbook. The athwart ships axis was the vessel centerline. Lastly, the waterline was used as the height of the heave point, which was calculated earlier in 'RP to Waterline'.

# 1010 Vessel Diagram

All Values Shown are in Theodolite Coordinates




Note: Both antenna have been replaced for the POS V4. While their x-y values are not thought to have changed, the z-value has been remeasured.



**FAIRWEATHER**

**Multibeam Echosounder Calibration**

**Launch 1010**
Vessel

| | | |
|---|---|---|
| 4/17/2009 | 107 | Lake Washington, Seattle, Washington |
| Date | Dn | Local Area |

Rice, Beduhn, Forney, Marcum
Calibrating Hydrographer(s)

| | | |
|---|---|---|
| Reson 8101 | Swing Arm-Hull Mount | not available |
| MBES System | MBES System Location | Date of most recent EED/Factory Check |

| | |
|---|---|
| 2701011 | 35737 |
| Sonar Serial Number | Processing Unit Serial Number |

| | |
|---|---|
| Swing Arm | 3/20/2009 |
| Sonar Mounting Configuration | Date of current offset measurement/verification |

| | |
|---|---|
| DGPS - Woodby Island | 4/15/2009 |
| Description of Positioning System | Date of most recent positioning system calibration |

## Acquisition Log

| | | | |
|---|---|---|---|
| 4/17/2009 | 107 | Lake Washington | 5-10kt, >1ft |
| Date | Dn | Local Area | Wx |

| | |
|---|---|
| | 10m-80m |
| Bottom Type | Approximate Water Depth |

Marcum, Rice, Forney, Beduhn
Personnel on board

Beacon: 302 Hz Whidbey, MBES lines 2009__1071850_1 through 2009__1072047_5, 24 lines collected
Comments

TH_1010_107
TrueHeave filename

| | | | | | |
|---|---|---|---|---|---|
| 09107175_4616.5nv | 0:00 | 47/39/01.97 | 122/16/17.32 | 51 | |
| SV Cast #1 filename | UTC Time | Lat | Lon | Depth | Ext. Depth |
| 09107202.3nv | 0:00 | 47/39/15.82 | 122/15/31.53 | 51 | |
| SV Cast #2 filename | UTC Time | Lat | Lon | Depth | Ext. Depth |
| 09107210.0nv | 0:00 | 47/39/08.84 | 122/14/06.18 | 15 | 20 |
| SV Cast #3 filename | UTC Time | Lat | Lon | Depth | Ext. Depth |

**NAV TIME LATENCY** view parallel to track, one line with induced roll (outerbeam) or same lines bounded slope (nadir) [same direction, different speed]

| SV Cast # | XTF Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| 1 | 2009_1071923_1 | 271 | 5.4 | |
| 1 | 2009_1071925_1 | 093 | 5.1 | |
| 1 | 2009_1071927_1 | 272 | 5.0 | |
| 1 | 2009_1071929_1 | 091 | 5.0 | |
| 1 | 2009_1071914_1 | 272 | 2.9 | |
| 1 | 2009_1071917_1 | 090 | 2.7 | |
| 1 | 2009_1071931_1 | 272 | 2.5 | |
| | | | | |

**PITCH** view parallel to track, same line (at nadir) [opposite direction, same speed]

| SV Cast # | XTF Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| 1 | 2009__1071850_1 | 272 | 4 | |
| 1 | 2009__1071910_1 | 92 | 4 | |
| 1 | 2009__1071905_1 | 93 | 4 | |
| 1 | 2009__1071907_1 | 271 | 4 | |
| 1 | 2009__1071903_1 | 270 | 4 | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

**HEADING/YAW** view parallel to track, offset lines (outerbeams) [opposite direction, same speed]

| SV Cast # | XTF Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| 1 | 2009__1071945_4 | 272 | 4 | N |
| 1 | 2009__1071938_4 | 272 | 4 | N |
| 1 | 2009__1071935_4 | 94 | 4 | N |
| 1 | 2009__1071941_4 | 93 | 4 | N |
| 1 | 2009__1071955_2 | 092 | 4 | S |
| 1 | 2009__1071959_2 | 272 | 4 | S |
| 1 | 2009__1071949_2 | 092 | 4 | S |
| 1 | 2009__1071952_2 | 272 | 4 | S |

**ROLL** view across track, same line [opposite direction, same speed]

| SV Cast # | XTF Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| 2 | 2009__1072043_5 | 04 | 3.8 | |
| 2 | 2009__1072039_5 | 183 | 3.5 | |
| 2 | 2009__1072047_5 | 184 | 3.5 | |
| 2 | 2009__1072035_5 | 03 | 3.9 | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

## Processing Log

| 4/18/2009 | 108 | Welton |
|---|---|---|
| Date | Dn | Personnel |

☑ **Data converted --> HDCS_Data in CARIS**

☑ **TrueHeave applied**

☑ **SVP applied**

☑ **Tide applied**

**Zone file** na

**Lines merged** ☑

**Data cleaned to remove gross fliers** ☐

| Compute correctors in this order | | | |
|---|---|---|---|
| **1. Precise Timing** | **2. Pitch bias** | **3. Heading bias** | **4. Roll bias** |
| Do not enter/apply correctors until all evaluations are complete and analyzed. | | | |

### PATCH TEST RESULTS/CORRECTORS

| Evaluators | Latency (sec) | Pitch (deg) | | Roll (deg) | Yaw (deg) | |
|---|---|---|---|---|---|---|
| FOO Ringel | -0.05 | 0.20 | | 1.50 | 0.50 | |
| B. Welton | 0.02 | -0.35 | | 1.50 | 0.35 | |
| G. Rice | 0.01 | 0.43 | | 1.48 | 0.28 | |
| N.Morgan | 0.06 | | | 1.48 | | |
| A. Raymond | 0.02 | 0.00 | | 1.46 | 0.20 | |
| CST Morgan | 0.00 | -0.40 | | 1.48 | 0.60 | |
| | | | | | | |
| | | | | | | |
| **Averages** | 0.01 | -0.02 | | 1.48 | 0.39 | |
| **Standard Deviation** | 0.04 | 0.36 | 0.04 | 0.02 | 0.16 | 0.08 |
| **FINAL VALUES** | 0.00 | -0.02 | | 1.48 | 0.39 | |

**Final Values based on** averages with outliers removed

**Resulting HVF File Name** FA_1010_Reson8101_2009.hvf

**Actual values used**

**MRU Align StdDev gyro** ~~0.16~~ Value from standard deviation of Heading offset values — 0.075 **MRU Align StdDev gyro**

**MRU Align StdDev Roll/Pitch** ~~0.19~~ Value from averaged standard deviations of pitch and roll offset values — 0.025 **MRU Align StdDev Roll/Pitch**

**NARRATIVE**

Lines from Dn108 (2009_1081822_11 through 2009_1082211_2) were also utilized to assess patch test values.
Dn108 did not have True Heave applied as the Pos file was not logged, therefore a full patch write-up was not conducted.

Removed N. Morgan pitch (-1.6 deg) and yaw (1.62) values from the averages as outliers.

Initial MRU values were too high, TPU values reassessed with outliers removed.

☑ **HVF Hydrographic Vessel File created or updated with current offsets**

**Name:** CST/FOO/Welton **Date:** 04/24/09

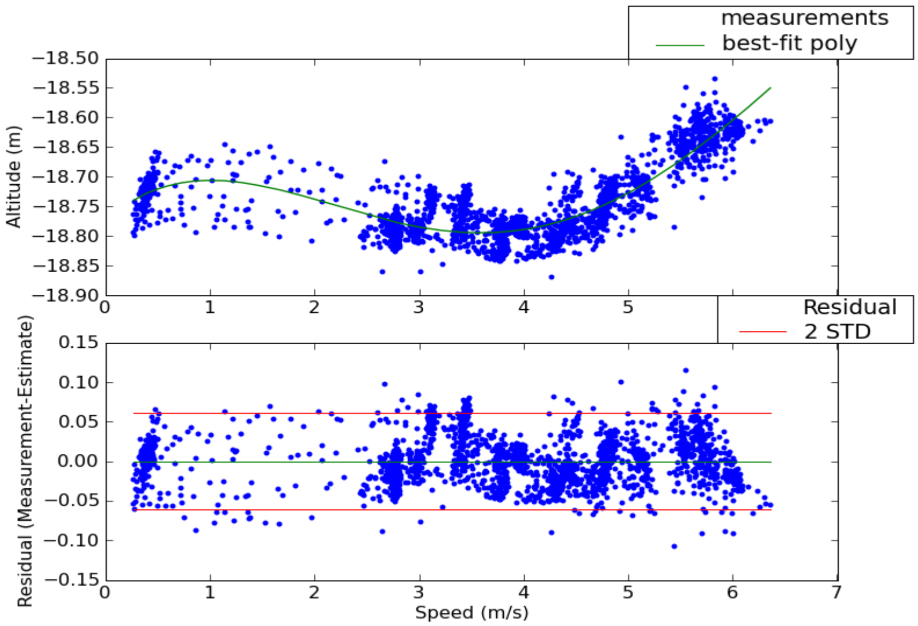
# Ellipsoid Referenced Dynamic Draft

Launch 1010

| Date | DN | Local Area | Processor |
|---|---|---|---|
| 4/17/2009 | 107 | Lake Washington | Rice |

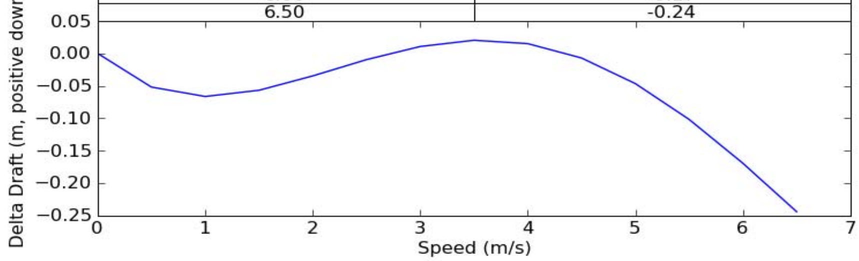
| Primary Station | POSPac File | SBET File |
|---|---|---|
| SEAI | TH_1010_107.000.002 | 1018_ERDDM.txt |

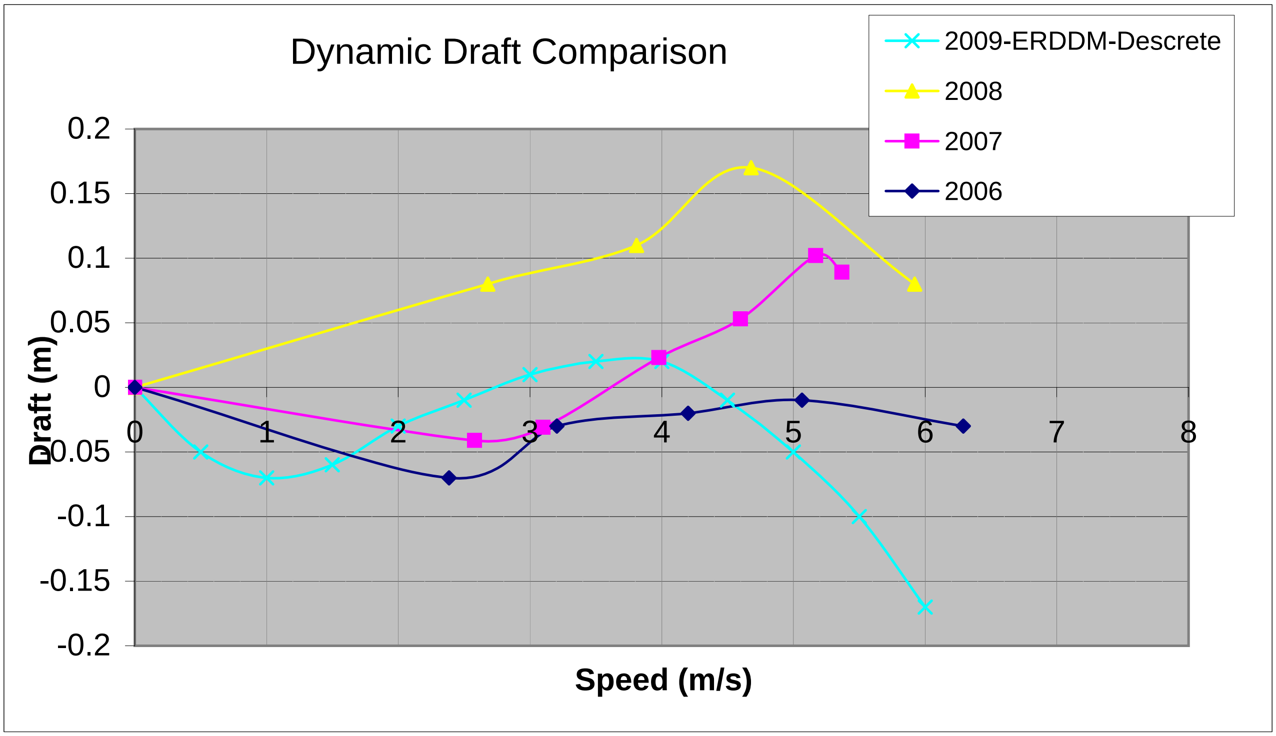
| Processing Method | Coefficients |
|---|---|
| proc_erddm.py, v0.12 | 4 |




$1.24e\text{-}003*X^3 + \text{-}2.15e\text{-}002*X^2 + 1.05e\text{-}001*X$

| Speed (m/s) | Delta Draft (m) |
|---|---|
| 0.00 | 0.00 |
| 0.50 | -0.05 |
| 1.00 | -0.07 |
| 1.50 | -0.06 |
| 2.00 | -0.03 |
| 2.50 | -0.01 |
| 3.00 | 0.01 |
| 3.50 | 0.02 |
| 4.00 | 0.02 |
| 4.50 | -0.01 |
| 5.00 | -0.05 |
| 5.50 | -0.10 |
| 6.00 | -0.17 |
| 6.50 | -0.24 |






**2009 HVF Values**

**2009-ERDDM-Descrete**

| speed (m/s) | draft (m) |
|---|---|
| 0 | 0 |
| 0.5 | -0.05 |
| 1 | -0.07 |
| 1.5 | -0.06 |
| 2 | -0.03 |
| 2.5 | -0.01 |
| 3 | 0.01 |
| 3.5 | 0.02 |
| 4 | 0.02 |
| 4.5 | -0.01 |
| 5 | -0.05 |
| 5.5 | -0.1 |
| 6 | -0.17 |

2008

| speed (m/s) | draft (m) |
|---|---|
| 0 | 0 |
| 2.68 | 0.08 |
| 3.81 | 0.11 |
| 4.68 | 0.17 |
| 5.92 | 0.08 |

2007

| speed (m/s) | draft |
|---|---|
| 0 | 0 |
| 2.58 | -0.041 |
| 3.1 | -0.031 |
| 3.98 | 0.023 |
| 4.6 | 0.053 |
| 5.17 | 0.102 |
| 5.37 | 0.089 |

2006

| speed (m/s) | draft |
|---|---|
| 0 | 0 |
| 2.385 | -0.07 |
| 3.205 | -0.03 |
| 4.2 | -0.02 |
| 5.065 | -0.01 |
| 6.29 | -0.03 |

# NOAA POS/MV Calibration Report

**Fill out all fields!** See previous years as an example.

**Yellow areas require screen grabs!**

**Ship:** FAIRWEATHER
**Vessel:** 1010
**Date:** 4/15/2009
**Dn:** 105

**Personnel:** W Renoud, L Morgan, T Beduhn

**PCS Serial #** 2564
**IMU Serial #** 294
**IP Address:** 129.100.1.231

**Port Antenna Serial #** 60162863
**Stbd Antenna Serial #** 60145247

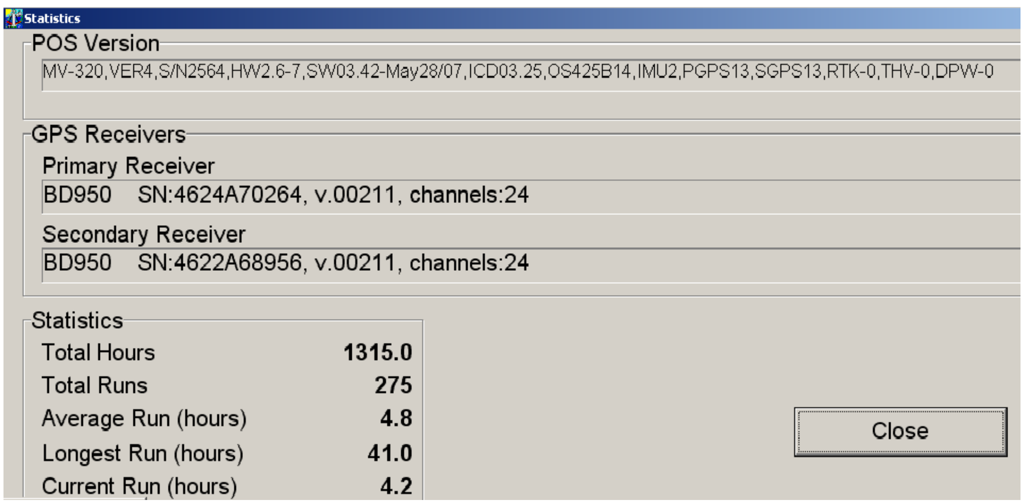
**POS controller Version (Use Menu Help > About)** 3.4.0.0

**POS Version (Use Menu View > Statistics)** MV-320,VER4,S/N2564,HW2.6-7,SW03.42-May28/07,ICD03.25, OS425B14,IMU2,PGPS13,SGPS13,RTK-0,THV-0,DPW-0

**GPS Receivers**

Primary Receiver Serial #: 4624A70264

Secondary Receiver Serial #: 4622A68956




## Calibration area

**Location:** Lake Washington, N of Sandpoint

**Approximate Position:**

| | | | |
|---|---|---|---|
| **Lat** | 47 | 43 | 41 |
| **Lon** | 122 | 16 | 30 |

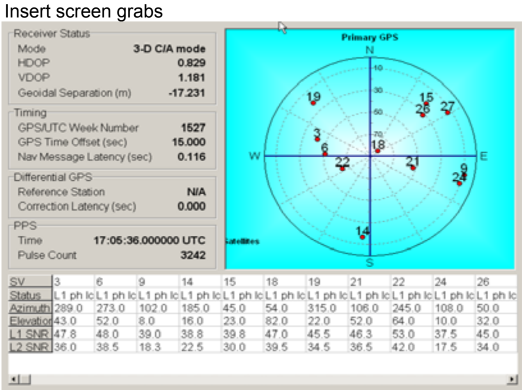
**DGPS Beacon Station:** Whidbey
**DGPS Receiver Serial#:** 0331-12579-0008
**Frequency:** 302HZ

## Satellite Constellation

(Use View> GPS Data)

### Primary GPS

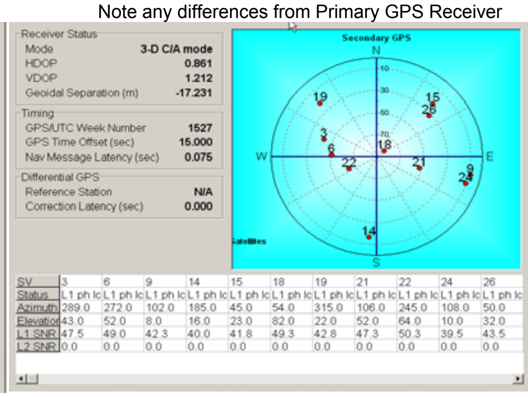
Insert screen grabs




| SV | 3 | 6 | 9 | 14 | 15 | 18 | 19 | 21 | 22 | 24 | 26 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Status | L1 ph lc | L1 ph lc | L1 ph lc | L1 ph lc | L1 ph lc | L1 ph lc | L1 ph lc | L1 ph lc | L1 ph lc | L1 ph lc | L1 ph lc |
| Azimuth | 289.0 | 273.0 | 102.0 | 185.0 | 45.0 | 54.0 | 315.0 | 106.0 | 245.0 | 108.0 | 50.0 |
| Elevation | 43.0 | 52.0 | 8.0 | 16.0 | 23.0 | 82.0 | 22.0 | 52.0 | 64.0 | 10.0 | 32.0 |
| L1 SNR | 47.8 | 48.0 | 39.0 | 38.8 | 39.8 | 47.0 | 45.5 | 46.3 | 53.0 | 37.5 | 45.0 |
| L2 SNR | 36.0 | 38.5 | 18.3 | 22.5 | 30.0 | 39.5 | 34.5 | 36.5 | 42.0 | 17.5 | 34.0 |

### Secondary GPS

Note any differences from Primary GPS Receiver



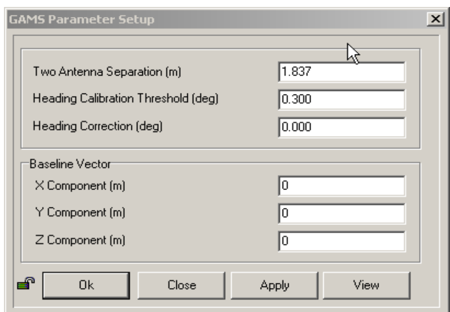

| SV | 3 | 6 | 9 | 14 | 15 | 18 | 19 | 21 | 22 | 24 | 26 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Status | L1 ph lc | L1 ph lc | L1 ph lc | L1 ph lc | L1 ph lc | L1 ph lc | L1 ph lc | L1 ph lc | L1 ph lc | L1 ph lc | L1 ph lc |
| Azimuth | 289.0 | 272.0 | 102.0 | 185.0 | 45.0 | 54.0 | 315.0 | 106.0 | 245.0 | 108.0 | 50.0 |
| Elevation | 43.0 | 52.0 | 8.0 | 16.0 | 23.0 | 82.0 | 22.0 | 52.0 | 64.0 | 10.0 | 32.0 |
| L1 SNR | 47.5 | 49.0 | 42.3 | 40.0 | 41.8 | 49.3 | 42.8 | 47.3 | 50.3 | 39.5 | 43.5 |
| L2 SNR | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

**PDOP** 1.736 (Use View> GAMS Solution)

## POS/MV Configuration

### Settings

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




**Configuration Notes:**

## POS/MV Calibration

### Calibration Procedure:

(Refer to POS MV V4 Installation and Operation Guide, 4-25)

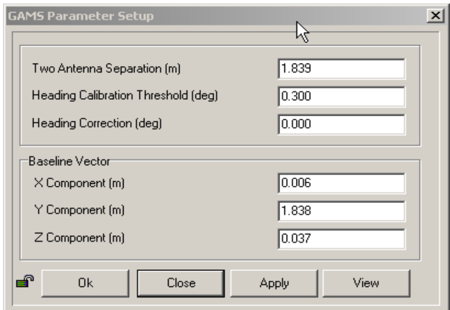
Start time: ____________________

End time: ____________________

Heading accuracy achieved for calibration: 0.091°

### Calibration Results:

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




GAMS Status Online X

Save Settings X

**Calibration Notes:**

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

File Name: 1010_Dn105_POS_Config_new.nvm

## General Notes:

**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.

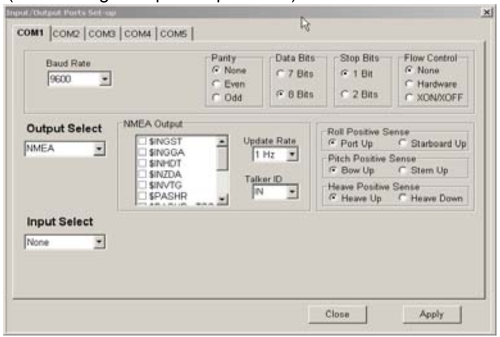
b) Pitch rotation - apply a right-hand screw rotation θy about the once-rotated y-axis to align one frame with the other.

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

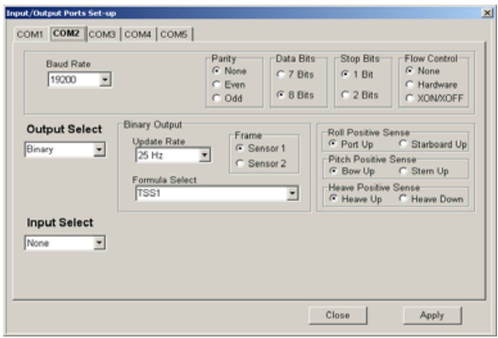
## SETTINGS

**Input/Output Ports** (Use Settings > Input/Output Ports)

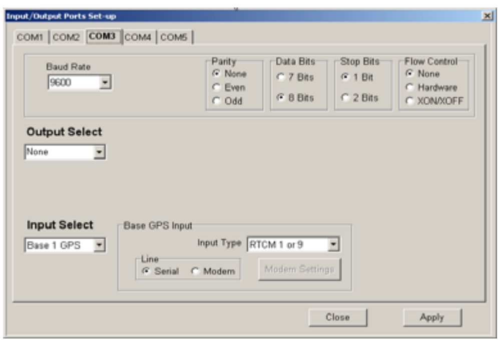
**COM1**



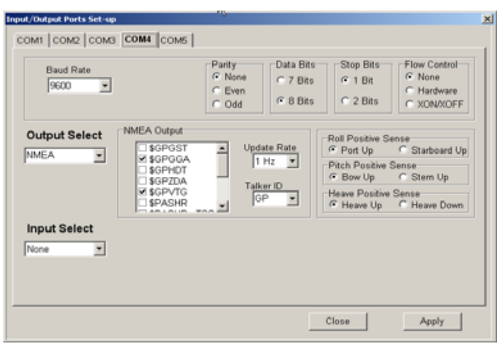

**COM2**



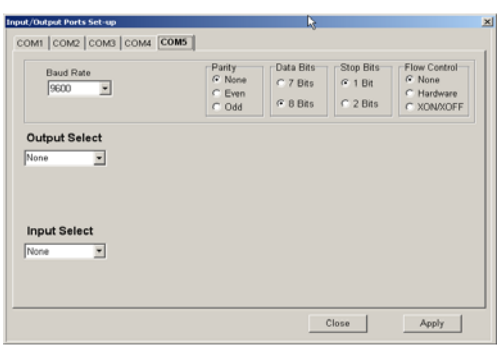

**COM3**




**COM4**

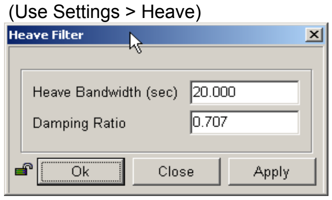



**COM5**

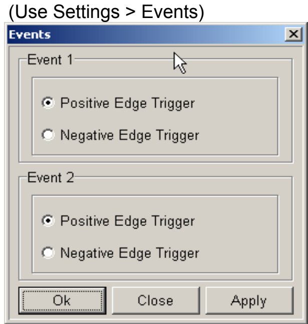


## SETTINGS Continued

**Heave Filter** (Use Settings > Heave)




**Events** (Use Settings > Events)



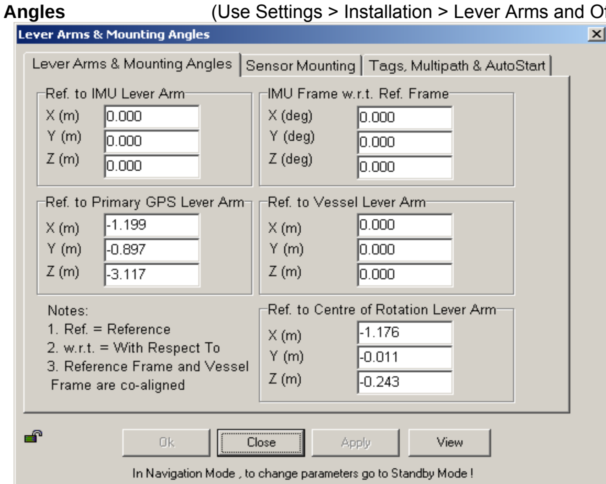

**Time Sync** (Use Settings > Time Sync)

User Time Conversion (Units/Sec.)

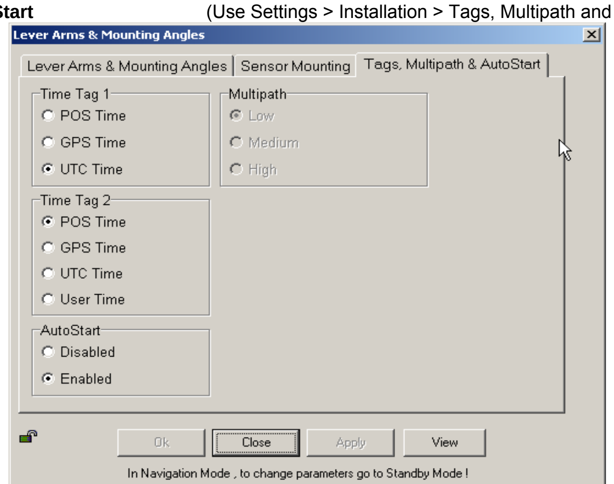
## INSTALLATION

(Use Settings > Installation)

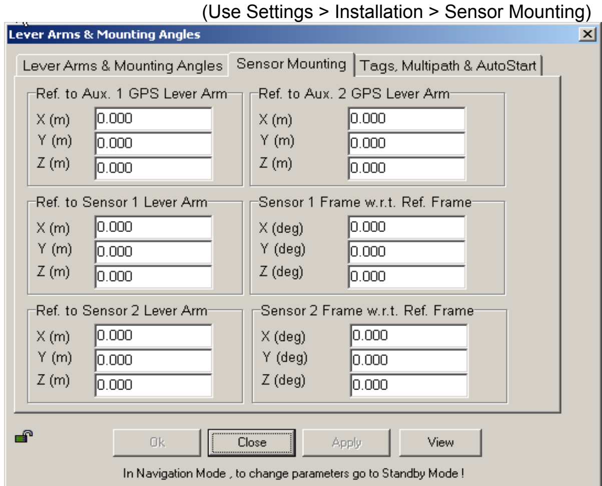
**Lever Arms and Mounting Angles** (Use Settings > Installation > Lever Arms and Offsets)



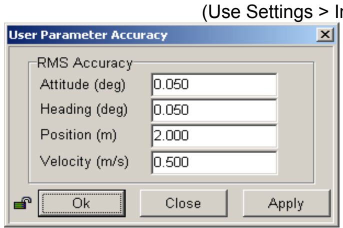

**Tags, Multipath and Auto Start** (Use Settings > Installation > Tags, Multipath and Auto Start)



**Sensor Mounting** (Use Settings > Installation > Sensor Mounting)




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




**Frame Control** (Use Tools > Config)

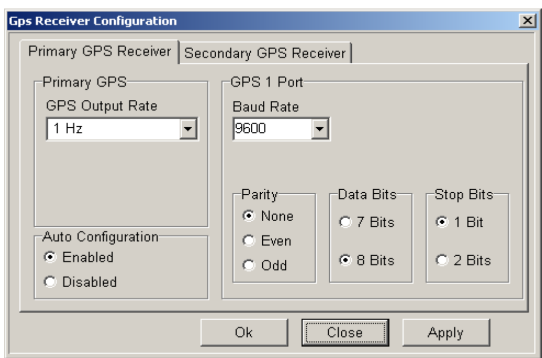
| | | | |
|---|---|---|---|
| | User Frame | Primary GPS Measurement | |
| | IMU Frame | Auxiliary GPS Measurement | |

| | **Use GAMS enabled** |
|---|---|

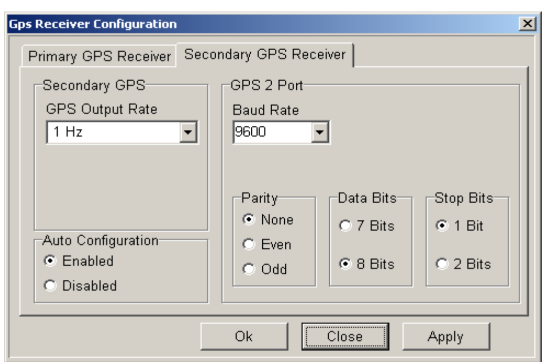
## GPS Receiver Configuration

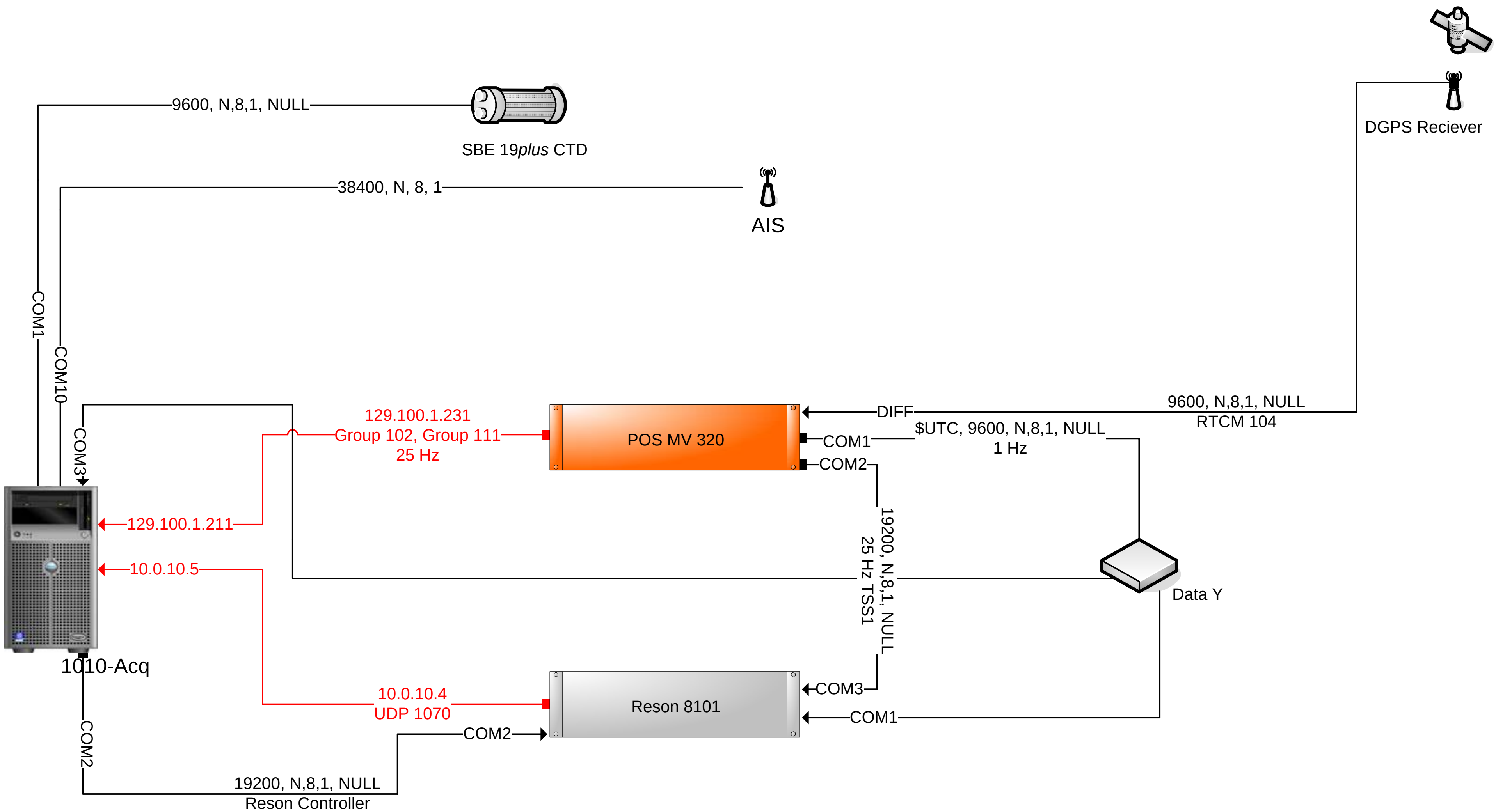
(Use Settings> Installation> GPS Receiver Configuration)

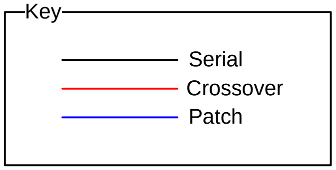
**Primary GPS Receiver**




**Secondary GPS Receiver**






# Launch 1010 Wire Diagram

| | | |
|---|---|---|
| Rev 3.0 | 12 July 2009 | LT Ringel |

## Waterline Measurements

**Fill in Yellow squares only!**

Measuring Party: Rice, Argento, Campbell, Beduhn

Waterline measurements should be negative!

| | 1018 | |
|---|---|---|
| | Benchmark A to Waterline | Benchmark B to Waterline |
| Measure 1 | -80.8 | -81.0 |
| Measure 2 | -81.3 | -82.1 |
| Measure 3 | -81.1 | -81.9 |
| Avg (cm) | -81.07 | -81.67 |
| Avg (m) | -0.8107 | -0.8167 |
| Stdev | 0.00252 | 0.00586 |
| BM Z-value (m) | 0.29933 | 0.27567 |
| BM C to WL (m) | -0.511 | -0.541 |

| | | | |
|---|---|---|---|
| Individual measurement | | -0.50867 | -0.53433 |
| | | -0.51367 | -0.54533 |
| StDev for TPU xls (of 6 #'s) | 0.016742 | -0.51167 | -0.54333 |

Date: 4/7/2009

Fuel Level: 0.75

Draft Tube:

Port-to-Stbd Z-difference

| Theoretical | Actual | Error |
|---|---|---|
| 0.0237 | -0.0060 | -0.0297 |

BM C to WL Average (m)

-0.526 (Add this value to 1018_Offsets & Measurements_200X.xls)

utilized in Offsets and Measurements and TPU spreadsheet

Measuring Party: Raymond, Welton

| | 1018 | |
|---|---|---|
| | Benchmark A to Waterline | Benchmark B to Waterline |
| Measure 1 | -82.4 | -82.2 |
| Measure 2 | -82.3 | -82.2 |
| Measure 3 | -82.0 | -81.1 |
| Avg (cm) | -82.23 | -81.83 |
| Avg (m) | -0.8223 | -0.8183 |
| Stdev | 0.00208 | 0.00635 |
| BM Z-value (m) | 0.29933 | 0.27567 |
| BM C to WL (m) | -0.523 | -0.543 |

| | | | |
|---|---|---|---|
| Individual measurement | | -0.52467 | -0.54633 |
| | | -0.52367 | -0.54633 |
| StDev for TPU xls (of 6 #'s) | 0.011572 | -0.52067 | -0.53533 |

Date: 4/16/2009

Fuel Level: half full

Draft Tube: na

Port-to-Stbd Z-difference

| Theoretical | Actual | Error |
|---|---|---|
| 0.0237 | 0.0040 | -0.0197 |

BM C to WL Average (m)

-0.533 (or add this value to 1018_Offsets & Measurements_2008)

This spreadsheet is designed to compute the z-values of the phase centers of the new POS M/V antenna.

**All offsets are in the Theodolite Coordinate System**

| | | | | | |
|---|---|---|---|---|---|
| BM E | x | 1.825761 | Port Ant | x | 2.445325 |
| | y | -0.861405 | | y | -0.913449 |
| | z | 2.018667 | | z | Unknown |
| BM F | x | 1.826865 | Stbd Ant | x | 2.444676 |
| | y | -0.002043 | | y | 0.920569 |
| | z | 2.054333 | | z | Unknown |
| BM G | x | 1.828354 | | | |
| | y | 0.918931 | | | |
| | z | 1.998333 | | | |

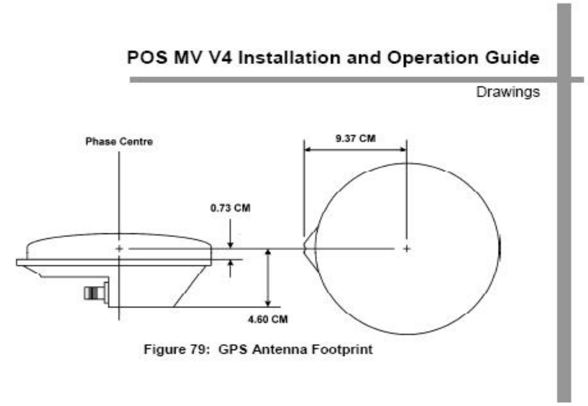


Figure 79: GPS Antenna Footprint

| **Measuring Party (fill in yellow spaces only):** | **Date:** | **Serial #- Port** | **Serial #- Stbd** |
|---|---|---|---|
| Rice, Argento, Campbell, Beduhn | 4/7/2009 | 60145158 | 60130644 |

| **Distances** | | | | | z-Values Ant. Base | Phase Center | |
|---|---|---|---|---|---|---|---|
| Port Ant to BM 'E' | 0.652 | 0.652 | 0.653 | 0.665083 | 2.254818 | 2.300818 | |
| Port Ant to BM 'F' | 1.109 | 1.11 | 1.111 | 1.12275 | 2.272081 | 2.318081 | |
| Port Ant to BM 'G' | 1.941 | 1.945 | 1.943 | 1.95575 | 2.292759 | 2.338759 | |
| | | | | | 2.263449 | 2.309449 | AVERAGE |
| | | | | | | 0.019 | STDEV |
| Stbd Ant to BM 'E' | 1.884 | 1.882 | 1.889 | 1.89775 | 2.225956 | 2.271956 | |
| Stbd Ant to BM 'F' | 1.111 | 1.112 | 1.113 | 1.12475 | 2.233664 | 2.279664 | |
| Stbd Ant to BM 'G' | 0.648 | 0.647 | 0.647 | 0.660083 | 2.234669 | 2.280669 | |
| | | | | | 2.234166 | 2.280166 | AVERAGE |
| | | | | | | 0.005 | STDEV |

| Antenna Post | Diameter | Radius |
|---|---|---|
| | 0.0255 | 0.01275 |

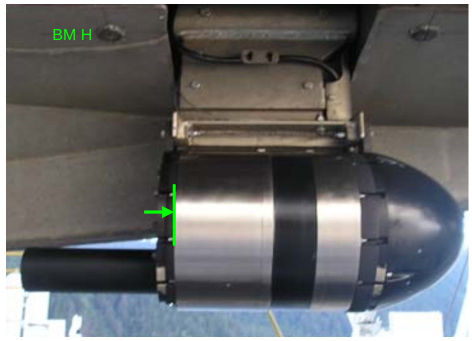
The distances from the antenna post to each benchmark was measured three times and averaged. The post offset to phase center (radius) was then added.

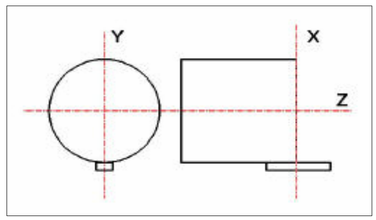
The distance is 0.046m (4.60cm) from the bottom of the antenna to the Phase center, obtained from the POSM/V v4 guide, see image above.

# Offsets from Aft Benchmark to Phase Center of Transducer

| | | | |
|---|---|---|---|
| 3/20/2009 | 79 | launch 1018 | Campbell, Argento, Rice, Beduhn |
| Date | DN | Vessel | Personnel |

3102026
Serial Number of Transducer




**Instructions:** The purpose of this measurement is to check for gross movement of the tranducer. **Fill in yellow spaces only.**

While the boat is in the cradle, gently lower the transducer and lock it in place. Using a metric tape measure, plumb bob and carpenter's level, measure the horizontal and vertical offsets from the aft benchmark (BM H) to the phase center of the transducer. The phase center is measured at the forward edge of the black insulating layer, as shown in the photos. If you have trouble locating the center, borrow a compass from the navigation department.

Notwithstanding a major accident, BM H will be outboard, aft and higher than the phase center; as such, enter all offsets as positive numbers (in cm) and the proper signs will be applied.

Once offsets have been measured, apply a digital level to the IMU to determine any pitch or roll bias in the orientation of the launch. For the purposes of this spreadsheet, a positive angle (measured in degrees) will imply the bow is higher than the stern and the port side is higher than the starboard side.

All measurements should be done in triplicate to aid in the calculation of the uncertainty (needed in the HVF). The *IMU to Phase Center* values will be calculated automatically.

| Offset Measurements (positive cm): | | | | Average |
|---|---|---|---|---|
| Bow-Stern | 8.7 | 8.7 | 8.8 | 8.7 |
| Port-Stbd | 15.9 | 15.9 | 15.8 | 15.9 |
| Up-Down | 35.5 | 35.4 | 36.0 | 35.6 |

| Angle Bias (deg): | |
|---|---|
| Bow Up | |
| Port Up | |

The measuring crew should insure there will be no yaw bias.

| Std Dev: | |
|---|---|
| Bow-Stern | 0.06 |
| Port-Stbd | 0.06 |
| Up-Down | 0.32 |

**BM H to Phase Center**
(Theodolite Coordinate System)

x 8.733 cm
y -15.867 cm
z -35.633 cm

Measured by NOAA Personnel
inserted into Offset Worksheet,
if to be used in IMU to 8101 calculation

**IMU to Phase Center (8101)**
(CARIS Coordinate System)

x 0.287 m
y -0.156 m
z 0.546 m

Calculated Value for check purposes
* see Math Explanation tab

These 2009 values were not used for the hvf offsets due to the angle bias not being entered. The 2008 values were used instead and the 2009 values were used as a check that the unit had not been displaced.

# Offsets from Aft Benchmark to Phase Center of Transducer

| 4/29/2009 | 119 | launch 1018 | Argento, Andrews, Foster, Nuckols |
|---|---|---|---|
| Date | DN | Vessel | Personnel |

4400007
Serial Number of Transducer

**Instructions:** The purpose of this measurement is to check for gross movement of the tranducer. **Fill in yellow spaces only.**

While the boat is in the cradle, connect the 8125 sled with the sonar head attached. Using a metric tape measure, plumb bob and carpenter's level, measure the horizontal and vertical offsets from the aft benchmark (BM H) to the phase center of the transducer. The phase center is measured at the center middle of the black insulating layer below the flat faced transducer, as shown in the photos. If you have trouble locating the center, borrow a compass from the navigation department.


Notwithstanding a major accident, BM H will be outboard, aft and higher than the phase center; as such, enter all offsets as positive numbers (in cm) and the proper signs will be applied.

Once offsets have been measured, apply a digital level to the IMU to determine any pitch or roll bias in the orientation of the launch. For the purposes of this spreadsheet, a positive angle (measured in degrees) will imply the bow is higher than the stern and the port side is higher than the starboard side.

All measurements should be done in triplicate to aid in the calculation of the uncertainty (needed in the HVF). The *IMU to Phase Center* values will be calculated automatically.

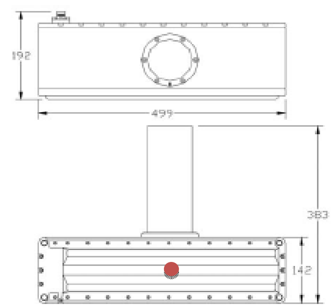



Figure 3 - Transducer array outline dimensions

| Offset Measurements (positive cm): | | | | Average |
|---|---|---|---|---|
| Bow-Stern | 123.2 | 122.0 | 122.4 | 122.5 |
| Port-Stbd | 84.2 | 84.4 | 84.1 | 84.2 |
| Up-Down | 55.7 | 56.2 | 56.5 | 56.1 |

| Angle Bias (deg): | |
|---|---|
| Bow Up | -0.5 |
| Port Up | -2.0 |

The measuring crew should insure there will be no yaw bias.

| Std Dev: | |
|---|---|
| Bow-Stern | 0.61 |
| Port-Stbd | 0.15 |
| Up-Down | 0.40 |

**BM H to Phase Center**
(Theodolite Coordinate System)

x 122.533 cm
y -84.233 cm
z -56.133 cm

**IMU to Phase Center (8125)**
(CARIS Coordinate System)

x -0.396 m
y 0.982 m
z 0.751 m

Measured by NOAA Personnel inserted into Offset Worksheet, if to be used in IMU to 8101 calculation

Calculated Value for check purposes
* see Math Explanation tab

| Measurement | IMU to 8125 | Port Ant to 8125 | RP* to Waterline | Port Ant to Stbd Ant | | IMU to Port Ant | | IMU to Heave | |
|---|---|---|---|---|---|---|---|---|---|
| aka | *SWATH1 x,y,z & MRU to Trans* | ***Nav to Trans x,y,z*** | | | | | | | |
| Coord. Sys. | Caris | Caris | Caris | | | Caris | Pos/Mv | Caris | Pos/Mv |
| x | -0.396 | 0.502 | n/a | Scaler Distance | 1.834 | -0.898 | -1.101 | 0.015 | -1.114 |
| y | 0.982 | 2.082 | n/a | | | -1.101 | -0.898 | -1.114 | 0.015 |
| z | 0.751 | 3.919 | -0.333 | | | -3.161 | -3.161 | -0.336 | -0.336 |

Vessel Offsets Horizontal, Vertical & XYZ worksheets in this spreadsheet. 2009 Measured Value

**Calculations**

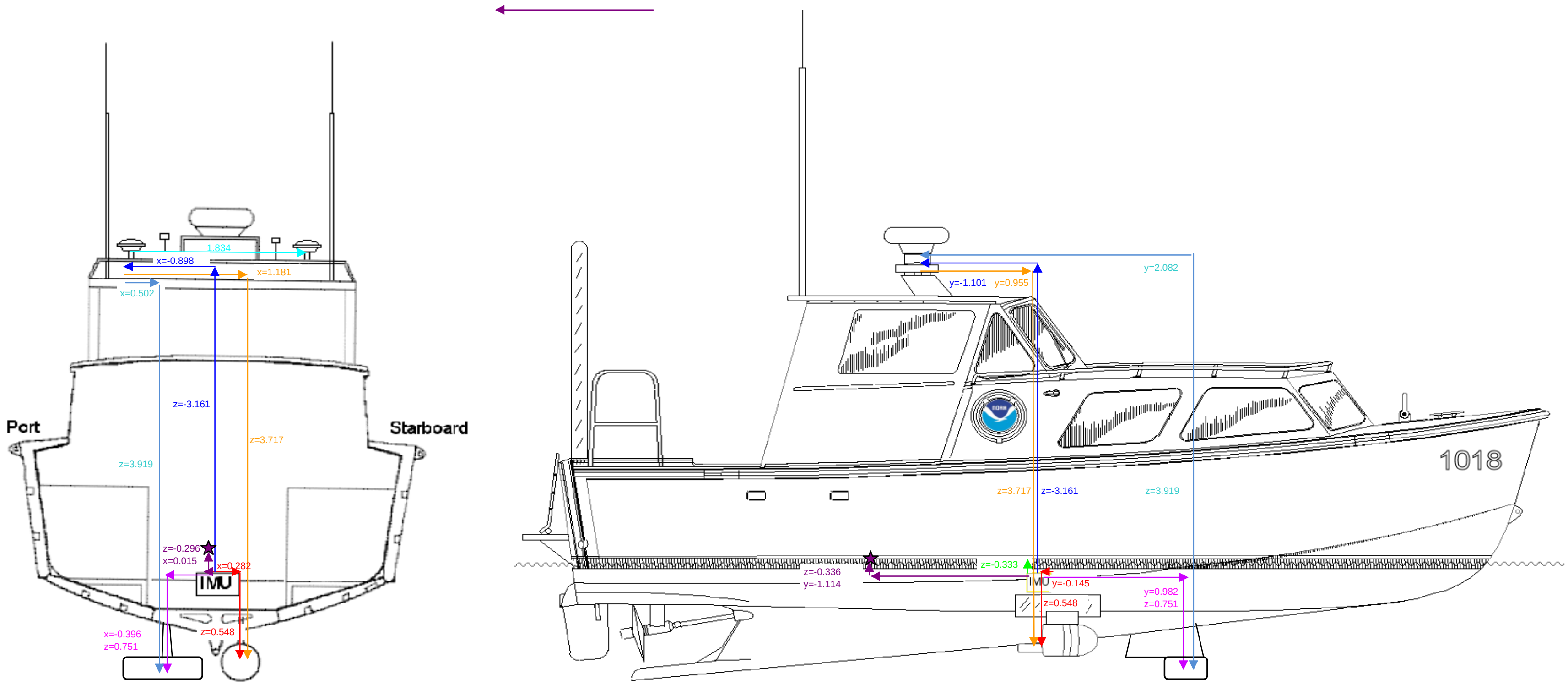
| Coord. Sys. | IMU to 8125 | | | | Port Ant to 8125 | | |
|---|---|---|---|---|---|---|---|
| **Theodolite** | IMU (m) | x | 3.54587 | | IMU (m) | x | 3.545867 |
| | | y | -0.01516 | | | y | -0.01516 |
| | | z | -0.85883 | | | z | -0.85883 |
| | BM H | x | 3.30204 | | Port Ant (m) | x | 2.445 |
| | | y | 0.43081 | | | y | -0.913 |
| | | z | -1.0485 | | | z | 2.309 |
| | IMU | x | -0.244 | | IMU to | x | -1.101 |
| | to BM H | y | 0.446 | | Port Antenna | y | -0.898 |
| | | z | -0.190 | | | z | 3.168 |
| | BM H to | x | 122.533 | | IMU to | x | 0.982 |
| | Phase Ctr (cm) | y | -84.216 | | Phase Ctr | y | -0.396 |
| | measured | z | -56.133 | | | z | -0.751 |
| | BM H to | x | 1.225 | | | | |
| | Phase Ctr (m) | y | -0.842 | | | | |
| | | z | -0.561 | | | | |

| Coord. Sys. | IMU to 8125 | | | Port Ant to 8125 | | |
|---|---|---|---|---|---|---|
| **Theodolite** | IMU to | x | 0.982 | | x | 2.082 |
| | Phase Ctr | y | -0.396 | | y | 0.502 |
| | | z | -0.751 | | z | -3.919 |
| | Coord. Sys. **CARIS** | | | Coord. Sys. **CARIS** | | |
| | | x | -0.396 | | x | 0.502 |
| | | y | 0.982 | | y | 2.082 |
| | | z | 0.751 | | z | 3.919 |

# Description of Offsets for Launch 1018

All Values Shown are in CARIS Coordinates

The Ship Reference Frame (SRF) for Launch 1018 was based from benchmark (BM) C as the 0 point.  Physical locations were measured with x,y,z offsets from this point.  These locations were used to calculate offsets of items with respect to each other, as described for each offset.



| IMU to 8101 | | |
|---|---|---|
| x | y | z |
| 0.282 | -0.145 | 0.548 |

| IMU to 8125 | | |
|---|---|---|
| x | y | z |
| -0.396 | 0.982 | 0.751 |

The physical positions of the IMU and the phase center of the 8101 with respect to the Ship Reference Frame were measured by NOAA personnel. These physical measurements were used to calculate the xyz offsets from the IMU to BM H. Measurements from BM H to the Phase Center of the 8101 were collected by NOAA personnel while the boat was secured on the pier and thought to be as level as possible. The measured offsets from BM H to the phase center were then added to the offset from the IMU to BM H. The result is the offset from the IMU to the phase center of the transducer. The values in the X and Y fields are transposed and the inverse of the Z value is used to give the offsets in CARIS coordinates.

| Port Ant to 8101 | | |
|---|---|---|
| x | y | z |
| 1.181 | 0.955 | 3.717 |

| Port Ant to 8125 | | |
|---|---|---|
| x | y | z |
| 0.502 | 2.082 | 3.919 |

NOAA personnel calculated the distance between the port antenna and the phase center of the port antenna subtracting the IMU to Port Antenna value from the IMU to Phase Center value.

| RP to Waterline | | |
|---|---|---|
| x | y | z |
| N/A | N/A | -0.333 |

The average vertical distance from BM A and B to the waterline was measured by FAIRWEATHER personnel using a steel tape and bubble level. These values were used to calculate the BM C to the waterline value. With the knowledge of the BM C height above the IMU, the waterline height above the IMU could be calculated. On launch 1018, the IMU is used as the reference point.

| Port Ant to Stbd Ant |
|---|
| Scalar Distance |
| 1.834 |

The location of the phase center of the port and starboard POS/MV antennas were measured by NOAA personnel with respect to the SRF. The scalar distance between the phase centers was then calculated.

| IMU to Port Antenna | | |
|---|---|---|
| x | y | z |
| -0.898 | -1.101 | -3.161 |

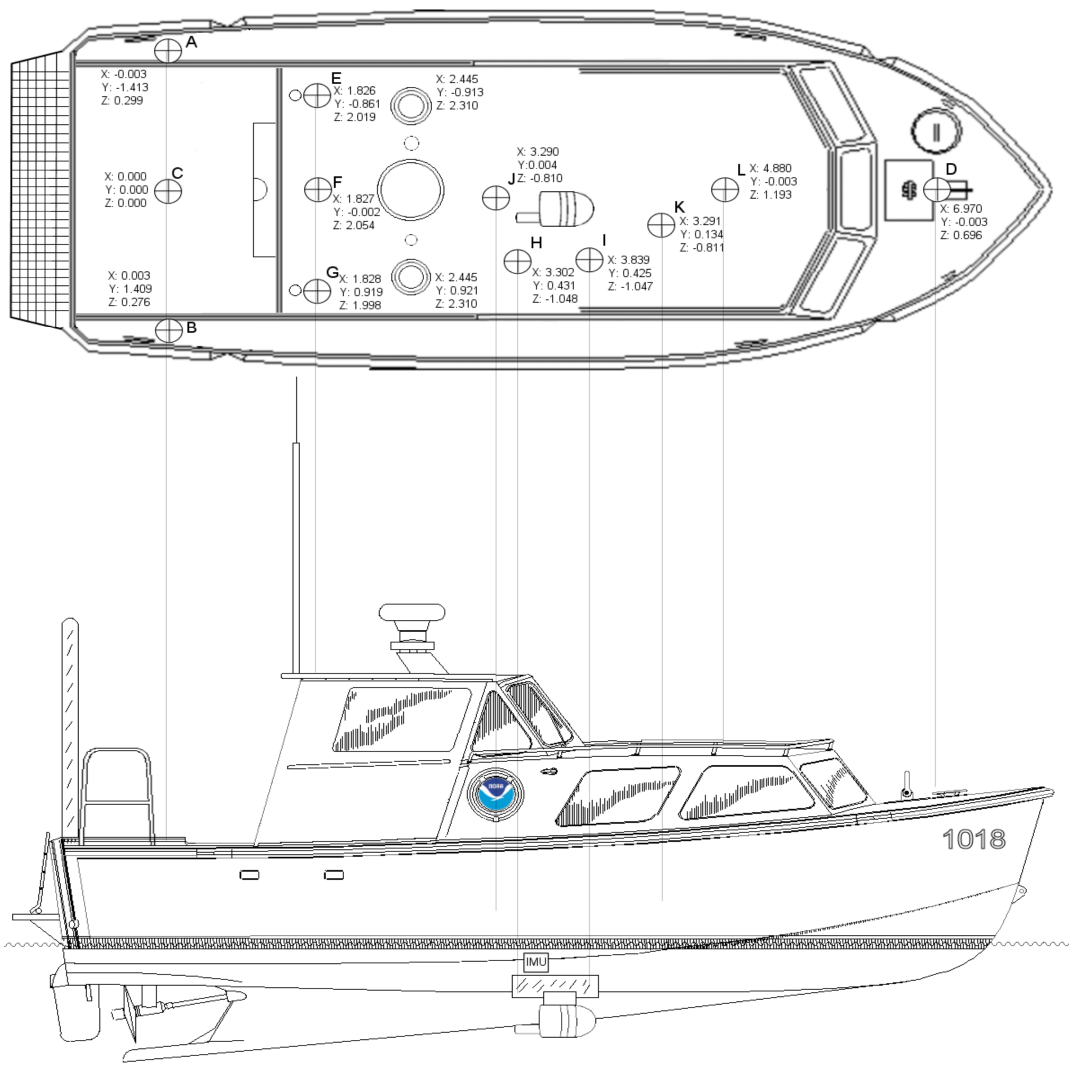
The location of the IMU and the location of the port antenna were measured by NOAA personnel with respect to the Ship Reference Frame (SRF). The xyz offsets from the IMU to the port antenna could be calculated from these physical locations.

| IMU to Heave | | |
|---|---|---|
| x | y | z |
| 0.015 | -1.114 | -0.336 |

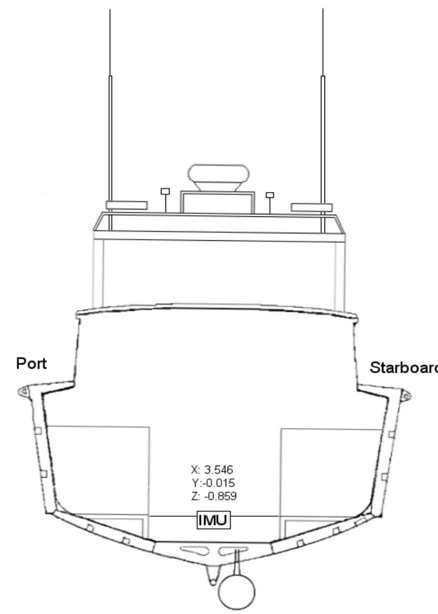
The heave point was positioned differently on each of the axes. The distance for the longitudinal axis was determined as described in the "IMU to Heave" tab in this workbook. The athwart ships axis was the vessel centerline. Lastly, the waterline was used as the height of the heave point, which was calculated earlier in 'RP to Waterline'.

# 1018 Vessel Diagram

All Values Shown are in Theodolite Coordinates




Note: Both antenna have been replaced for the POS V4. While their x-y values are not thought to have changed, the z-value has been remeasured.



**FAIRWEATHER**

**Multibeam Echosounder Calibration**

| | | |
|---|---|---|
| Vessel | **Launch 1018** | |
| Date | 4/16/2009 | |
| Dn | 106 | |
| Local Area | L. Washington | |
| Calibrating Hydrographer(s) | FOO Ringel, CST Morgan, LT Welton, ENS Morgan | |
| MBES System | 8101 | |
| MBES System Location | 1018 | |
| Date of most recent EED/Factory Check | not available | |
| Sonar Serial Number | 3102026 | |
| Processing Unit Serial Number | 34497 | |
| Sonar Mounting Configuration | Hull mounted swing arm | |
| Date of current offset measurement/verification | 03/20/2009 | |
| Description of Positioning System | POSMV v4 GPS (DGPS corrected) | |
| Date of most recent positioning system calibration | 04/15/2009 | |

**Acquisition Log**

| | |
|---|---|
| Date | 4/16/2009 |
| Dn | 106 |
| Local Area | L. Washington |
| Wx | Calm |
| Bottom Type | |
| Approximate Water Depth | 30-190 feet |
| Personnel on board | Welton, ENS Morgan, Raymond, Heiner |
| Comments | |
| TrueHeave filename | TH_1018_Patch_Test_Dn105 |

| | SV Cast filename | UTC Time | Lat | Lon | Depth | Ext. Depth |
|---|---|---|---|---|---|---|
| SV Cast #1 | 081060818 | 0:00 | | | | |
| SV Cast #2 | | | | | | |

**ROLL**

| SV Cast # | XTF Line Filename | Heading | Speed (kts) | Remarks |
| --- | --- | --- | --- | --- |
| | 005_1832.81X | 3 | 5.9 | roll |
| | 005_1838.81X | 183 | 6.0 | roll |
| | 005_1844.81X | 03 | 6.0 | roll |
| | | | | |
| | | | | |
| | | | | |

**PITCH**

| SV Cast # | XTF Line Filename | Heading | Speed (kts) | Remarks |
| --- | --- | --- | --- | --- |
| | 001_1730.81X | 274 | 5.1 | |
| | 001_1741.81X | 092 | 5.1 | |
| | 002_1751.81X | 272 | 5.2 | |
| | 002_1801.81X | 092 | 5.1 | |
| | | | | |
| | | | | |
| | | | | |

**HEADING/YAW**

| SV Cast # | XTF Line Filename | Heading | Speed (kts) | Remarks |
| --- | --- | --- | --- | --- |
| 91060818 | 001_1730.81X | 274 | 5.1 | Heading |
| | 001_1741.81X | 092 | 5.1 | Heading |
| | 002_1751.81X | 272 | 5.2 | Heading |
| | 002_1801.81X | 092 | 5.1 | Heading (1805 overtaking boat noise) |
| | | | | |
| | | | | |

**NAV TIME LATENCY**

| SV Cast # | XTF Line Filename | Heading | Speed (kts) | Remarks |
| --- | --- | --- | --- | --- |
| | 001_1811.81X | 272 | 4.8 | timing |
| | 001_1823.81X | 092 | 8.0 | timing |
| | | | | |
| | | | | |
| | 001_1741.81X | 092 | 5.1 | Heading |
| | | | | |
| | | | | |
| | | | | |

## Processing Log

| Date | Dn | Personnel |
| --- | --- | --- |
| 4/16/2009 | DN106 | ENS Morgan |

☑ **Data converted --> HDCS_Data in CARIS**

☑ **TrueHeave applied** yes

☑ **SVP applied** yes

☑ **Tide applied** zerotide.tid

**Zone file** na

**Lines merged** ☑

**Data cleaned to remove gross fliers** ☑

| Compute correctors in this order | | | |
| --- | --- | --- | --- |
| **1. Precise Timing** | **2. Pitch bias** | **3. Heading bias** | **4. Roll bias** |
| Do not enter/apply correctors until all evaluations are complete and analyzed. | | | |

## PATCH TEST RESULTS/CORRECTORS

| Evaluators | Latency (sec) | Pitch (deg) | | Roll (deg) | Yaw (deg) | |
|---|---|---|---|---|---|---|
| FOO (in progress) | -0.05 | -0.80 | | 2.88 | -0.40 | |
| CST | 0.00 | 0.30 | | 2.86 | -0.50 | |
| Nick | 0.03 | -0.94 | | 2.86 | -0.35 | |
| Bri | -0.03 | -1.06 | | 2.90 | -0.10 | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| **Averages** | -0.01 | -0.63 | | 2.88 | -0.34 | |
| **Standard Deviation** | 0.04 | 0.63 | 0.13 | 0.02 | 0.17 | 0.04 |
| **FINAL VALUES** | 0.00 | -0.63 | | 2.88 | -0.34 | |
| **Final Values based on** | CST/FOO | Averages | | Averages | Averages | |

**Resulting HVF File Name** FA_1018_Reson8101_2009

**Actual values used**

**MRU Align StdDev gyro** ~~0.17~~ Value from standard deviation of Heading offset values — 0.035 **MRU Align StdDev gyro**

**MRU Align StdDev Roll/Pitch** ~~0.32~~ Value from averaged standard deviations of pitch and roll offset values — 0.075 **MRU Align StdDev Roll/Pitch**

**NARRATIVE**

Values based on two patch tests- one performed on DN106 in Lake Washington using the bounded slope method and one performed on DN107on the Shilshole reference surface using the target method.

Initial MRU values were too high, TPU values reassessed with outliers removed.

☑ **HVF Hydrographic Vessel File created or updated with current offsets**

**Name:** Ringel, Welton, Morgan **Date:** 4/18/09

**FAIRWEATHER**

**Multibeam Echosounder Calibration**

**Launch 1018**
Vessel

| Date | Dn | Local Area |
|---|---|---|
| 6/27/2009 | 178 | Shumagin Islands, Near Northeast Harbor |

Calibrating Hydrographer(s): Welton, FOO Ringel, CST Morgan

| MBES System | MBES System Location | Date of most recent EED/Factory Check |
|---|---|---|
| 8125 | 1018 | uknown (on loan from RUDE) |

| Sonar Serial Number | Processing Unit Serial Number |
|---|---|
| 4400007 | 31562 |

| Sonar Mounting Configuration | Date of current offset measurement/verification |
|---|---|
| Sled hull mount | 4/29/2009 |

| Description of Positioning System | Date of most recent positioning system calibration |
|---|---|
| POSMV w/ DGPS correctors | 4/15/2009 |

## Acquisition Log

| Date | Dn | Local Area | Wx |
|---|---|---|---|
| 6/27/2009 | 178 | Shumagin Islands, Near Northeast Harbor | Wind lgt vrb, waves <1ft (Awesome) |

| Bottom Type | Approximate Water Depth |
|---|---|
| rock | 20-30 meters |

Personnel on board: Froelich, Francksen, Walker

Comments:

TrueHeave filename: 2009-178_1018.000

| | UTC Time | Lat | Lon | Depth | Ext. Depth |
|---|---|---|---|---|---|
| SV Cast #1 filename | | | | | |
| SV Cast #2 filename | | | | | |

## NAV TIME LATENCY

view parallel to track, one line with induced roll (outerbeam) or same lines over bounded slope or feature (nadir) [run same direction, different speed]

| SV Cast # | Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| H12702_1018_Dn1 | 2009L_1781804 | 022 | 6.0 | roll time bias method |

## PITCH

view parallel to track, same line (nadir) over feature or bounded slope [opposite direction, same speed]

| SV Cast # | Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| H12702_1018_Dn1 | 2009L_1781750 | 110 | 6.0 | |
| | 2009L_1781753 | 290 | 6.0 | |

## HEADING/YAW

view parallel to track, offset lines from feature or slope (outerbeams) [opposite direction, same speed]

| SV Cast # | Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| | 2009L_1781756 | 110 | 6.0 | |
| | 2009L_1781800 | 290 | 6.0 | |

## ROLL

view across track, same line over flat area in [opposite direction, same speed]

| SV Cast # | Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| H12702_1018_Dn1 | 2009L_1781750 | 110 | 6.0 | |
| | 2009L_1781753 | 290 | 6.0 | |

## Processing Log

| 6/27/2009 | 178 | ` |
|---|---|---|
| Date | Dn | Personnel |

☑ **Data converted --> HDCS_Data in CARIS**

☐ **TrueHeave applied**

☑ **SVP applied** Previous in Time

☑ **Tide applied**

**Zone file** predicted- Sand Point, AK

**Lines merged** ☑

**Data cleaned to remove gross fliers** ☑

**Compute correctors in this order**

**1. Precise Timing** **2. Pitch bias** **3. Heading bias** **4. Roll bias**

Do not enter/apply correctors until all evaluations are complete and analyzed.

### PATCH TEST RESULTS/CORRECTORS

| Evaluators | Latency (sec) | Pitch (deg) | Roll (deg) | Yaw (deg) |
|---|---|---|---|---|
| Welton | 0.00 | -0.90 | -1.98 | -2.20 |
| FOO | 0.00 | -0.30 | -1.95 | -1.70 |
| CST | 0.00 | -0.40 | -1.91 | -1.50 |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| **Averages** | 0.00 | -0.53 | -1.95 | -1.80 |
| **Standard Deviation** | 0.00 | 0.32 | 0.04 | 0.36 |
| **FINAL VALUES** | 0.00 | -0.53 | -1.95 | -1.80 |

**Final Values based on** Averages

**Resulting HVF File Name** added to FA_1018_Reson8125_2009

**MRU Align StdDev gyro** 0.36 Value from standard deviation of Heading offset values

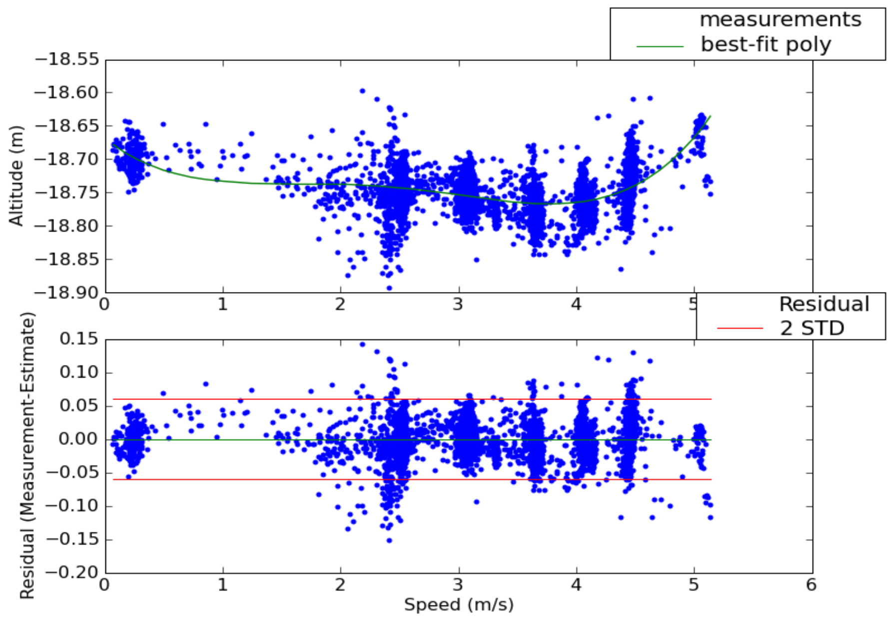
**MRU Align StdDev Roll/Pitch** 0.18 Value from averaged standard deviations of pitch and roll offset values

# Ellipsoid Referenced Dynamic Draft    Launch 1018

| 4/16/2009 | 106 | Lake Washington | Rice |
|---|---|---|---|
| Date | DN | Local Area | Processor |

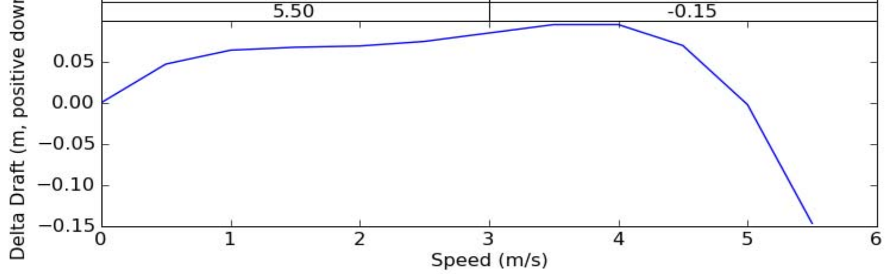
| SEAI | TH_1018_patch_test_dn105.000.002 | 1018_ERDDM.txt |
|---|---|---|
| Primary Station | POSPac File | SBET File |

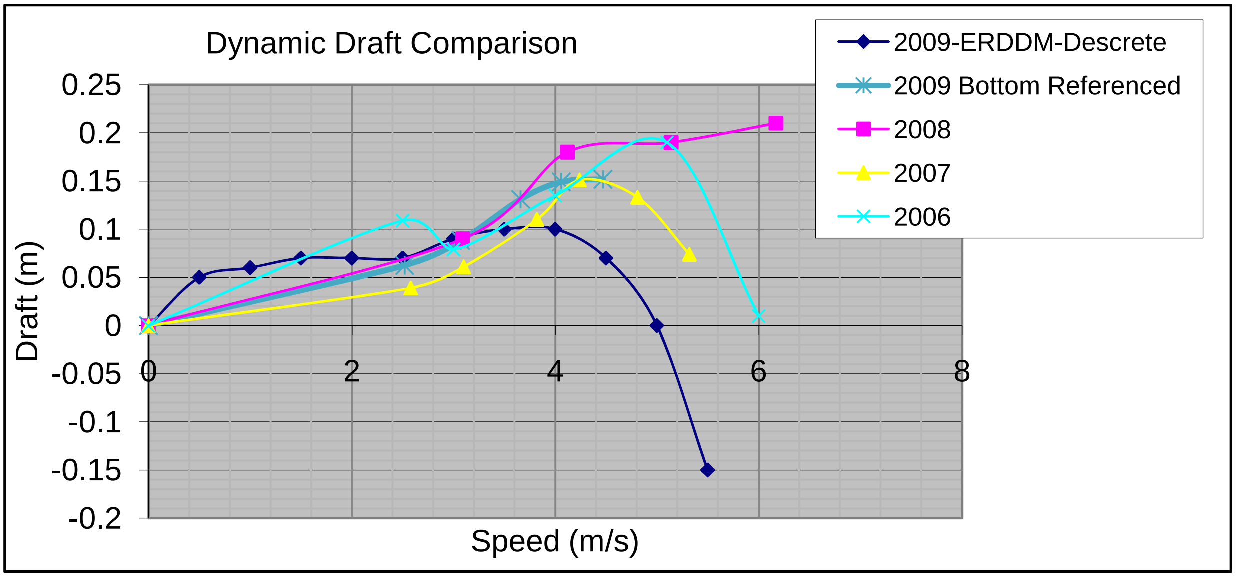
| proc_erddm.py, v0.12 | 4 |
|---|---|
| Processing Method | Coefficients |




-3.59e-003*$X^3$ +3.31e-002*$X^2$ +-1.04e-001*X

| Speed (m/s) | Delta Draft (m) |
|---|---|
| 0.00 | 0.00 |
| 0.50 | 0.05 |
| 1.00 | 0.06 |
| 1.50 | 0.07 |
| 2.00 | 0.07 |
| 2.50 | 0.07 |
| 3.00 | 0.09 |
| 3.50 | 0.10 |
| 4.00 | 0.10 |
| 4.50 | 0.07 |
| 5.00 | -0.00 |
| 5.50 | -0.15 |






## 2009 HVF Values

**2009-ERDDM-Descrete**

| speed (m/s) | draft (m) |
|---|---|
| 0 | 0 |
| 0.5 | 0.05 |
| 1 | 0.06 |
| 1.5 | 0.07 |
| 2 | 0.07 |
| 2.5 | 0.07 |
| 3 | 0.09 |
| 3.5 | 0.1 |
| 4 | 0.1 |
| 4.5 | 0.07 |
| 5 | 0 |
| 5.5 | -0.15 |

2009 Bottom Referenced

| speed (m/s) | draft (m) |
|---|---|
| 0 | 0 |
| 2.52 | 0.062 |
| 3.07 | 0.088 |
| 3.66 | 0.131 |
| 4.06 | 0.149 |
| 4.47 | 0.152 |

2008

| speed (m/s) | draft (m) |
|---|---|
| 0 | 0 |
| 3.09 | 0.09 |
| 4.12 | 0.18 |
| 5.14 | 0.19 |
| 6.17 | 0.21 |

2007

| speed (m/s) | draft (m) |
|---|---|
| 0 | 0 |
| 2.58 | 0.039 |
| 3.1 | 0.061 |
| 3.82 | 0.11 |
| 4.24 | 0.151 |
| 4.81 | 0.133 |
| 5.32 | 0.074 |

2006

| speed (m/s) | draft (m) |
|---|---|
| 0 | 0 |
| 2.5 | 0.109 |
| 3 | 0.079 |
| 4 | 0.135 |
| 5.1 | 0.19 |
| 6 | 0.01 |

# NOAA POS/MV Calibration Report

**Fill out all fields!** See previous years as an example.

**Yellow areas require screen grabs!**

**Ship:** FAIRWEATHER  **Vessel:** 1018

**Date:** 4/15/2009  **Dn:** 104

**Personnel:** Andrews, Welton, Forney, Shetler

**PCS Serial #** 2560  **IMU Serial #** 007

**IP Address:** 129.100.1.231

**Port Antenna Serial #** 60145158  **Stbd Antenna Serial #** 60130644

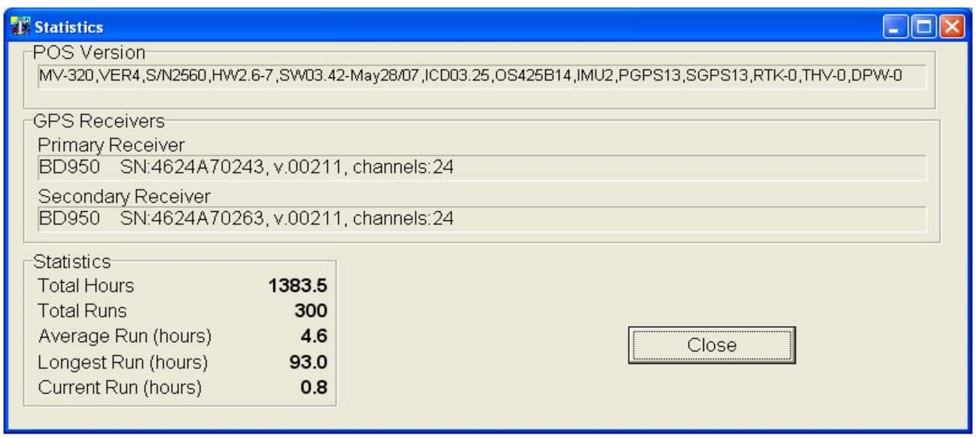
**POS controller Version (Use Menu Help > About)** 3.4.0.0

**POS Version (Use Menu View > Statistics)** MV-320,Ver 4

**GPS Receivers**

Primary Receiver Serial #: 4624A70243

Secondary Receiver Serial #: 4624A70263




## Calibration area

**Location:** Lake Washington, Seattle, WA

**Approximate Position:**

| | | | |
|---|---|---|---|
| **Lat** | 47 | 39 | 35.8 |
| **Lon** | 122 | 15 | 35.6 |

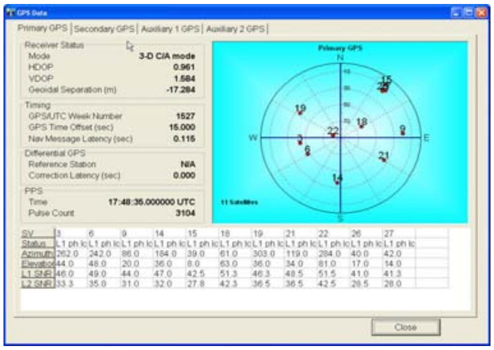
**DGPS Beacon Station:** Whidbey Island  **DGPS Receiver Serial#:** 0328-12352-0001

**Frequency:** 302

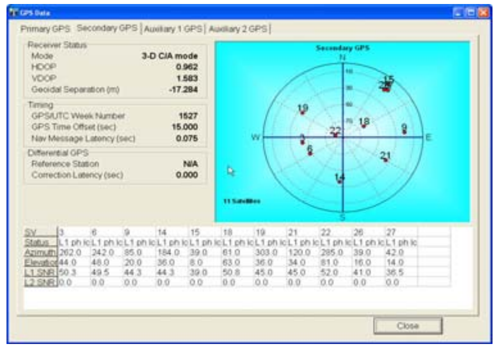
## Satellite Constellation

(Use View> GPS Data)

**Primary GPS**



**Secondary GPS**

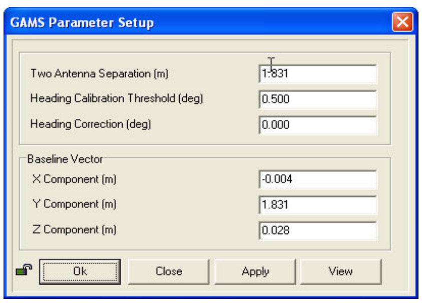


**PDOP** 1.823 (Use View> GAMS Solution)

## POS/MV Configuration

**Settings**

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




**Configuration Notes:**

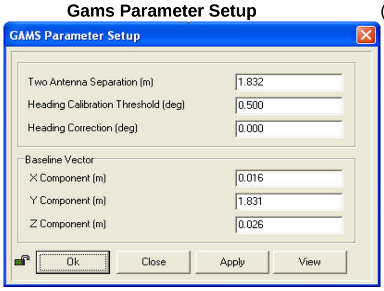
## POS/MV Calibration

**Calibration Procedure:** (Refer to POS MV V4 Installation and Operation Guide, 4-25)

Start time: 1722 UTC
End time: 1723 UTC
Heading accuracy achieved for calibration: 0.324

**Calibration Results:**

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




GAMS Status Online Ready Online
Save Settings Yes

**Calibration Notes:**

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

File Name: C:\Documents and Settings\1018acq\Desktop\POS-MV Settings\GAMS_Parameter_104_2009.nvm

## General Notes:

**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.

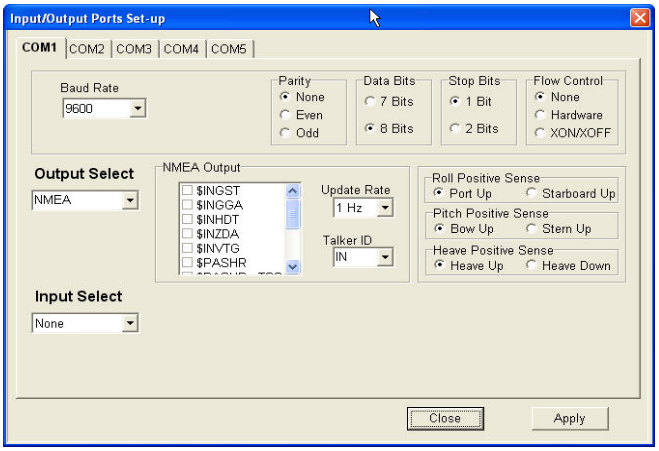
b) Pitch rotation - apply a right-hand screw rotation θy about the once-rotated y-axis to align one frame with the other.

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

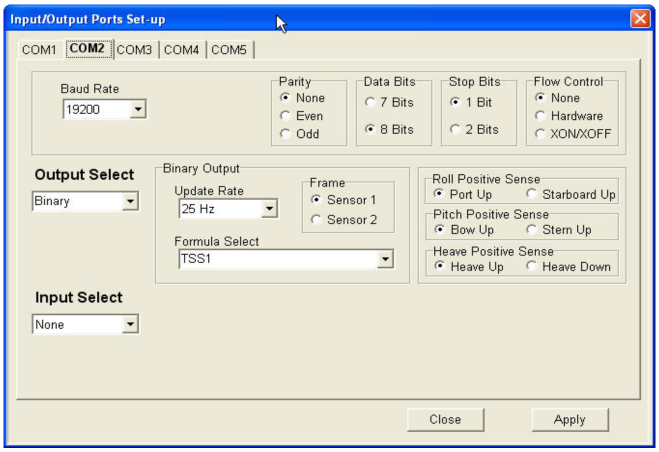
## SETTINGS

**Input/Output Ports** (Use Settings > Input/Output Ports)

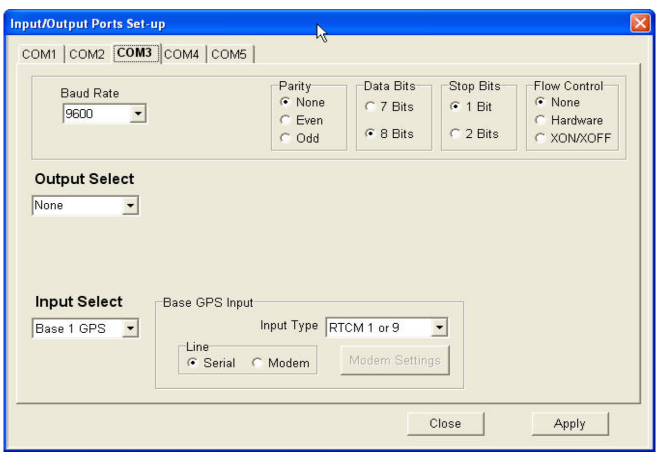
**COM1**




**COM2**

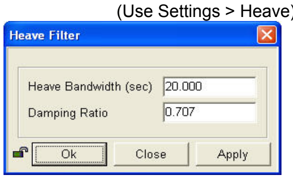



**COM3**

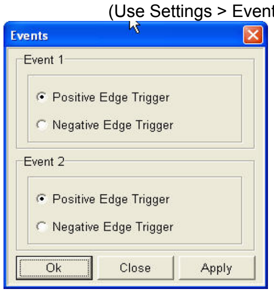


## SETTINGS Continued

**Heave Filter** (Use Settings > Heave)

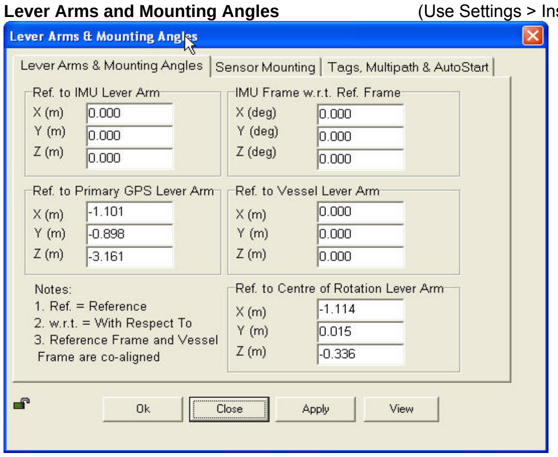



**Events** (Use Settings > Events)

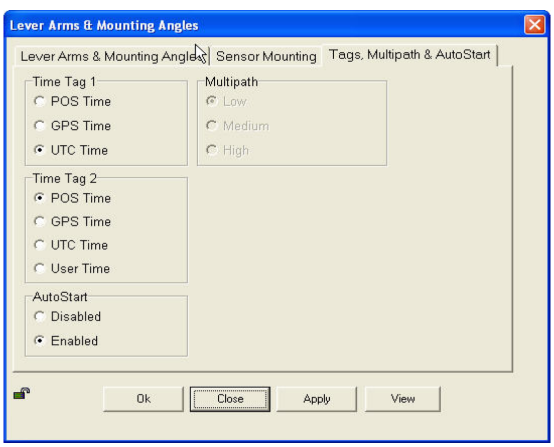



## INSTALLATION (Use Settings > Installation)

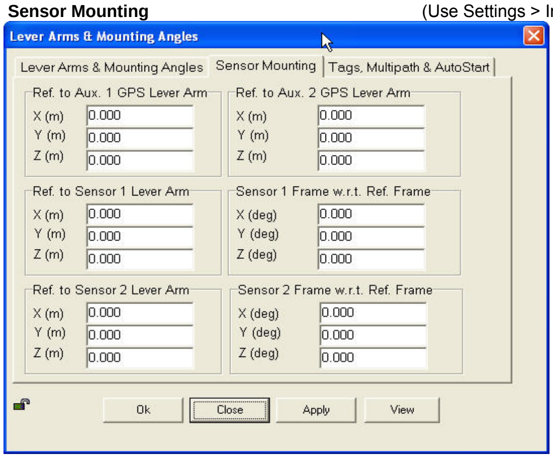
**Lever Arms and Mounting Angles** (Use Settings > Installation > Lever Arms and Offsets)



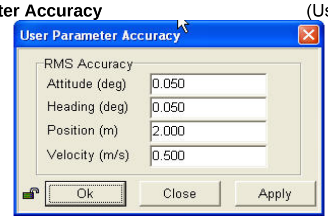

**Tags, Multipath and Auto Start** (Use Settings > Installation > Tags, Multipath and Auto Start)



**Sensor Mounting** (Use Settings > Installation > Sensor Mounting)

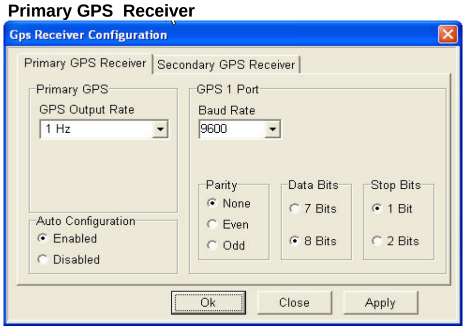



**User Parameter Accuracy** (Use Settings > Installation > User Accuracy)

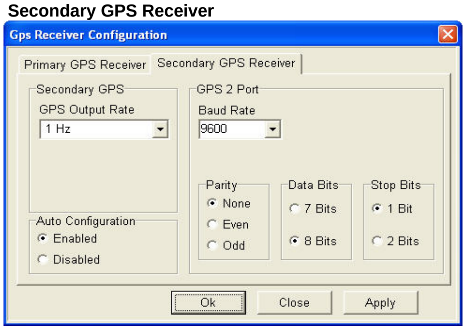


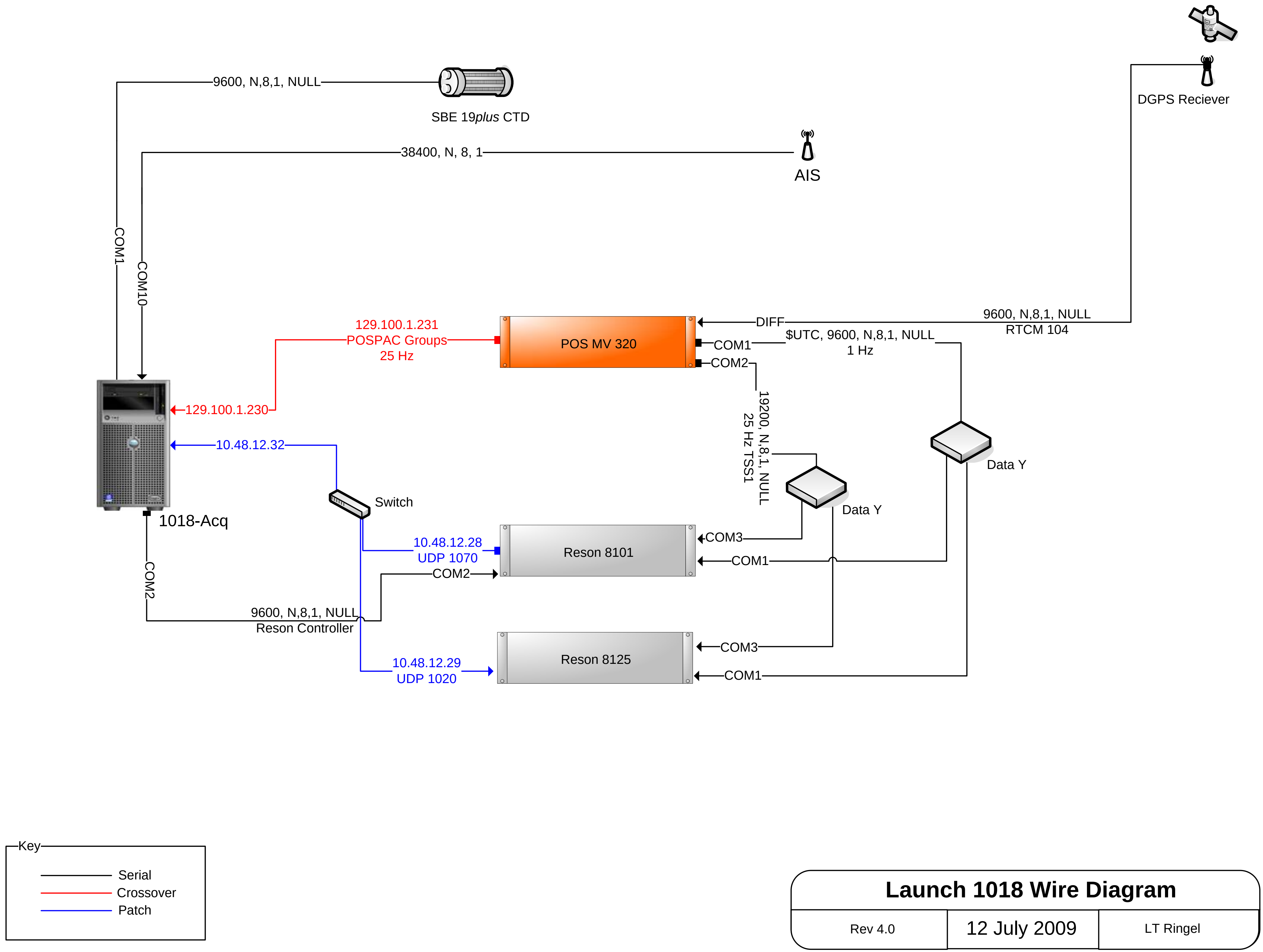

## GPS Receiver Configuration (Use Settings> Installation> GPS Receiver Configuration)

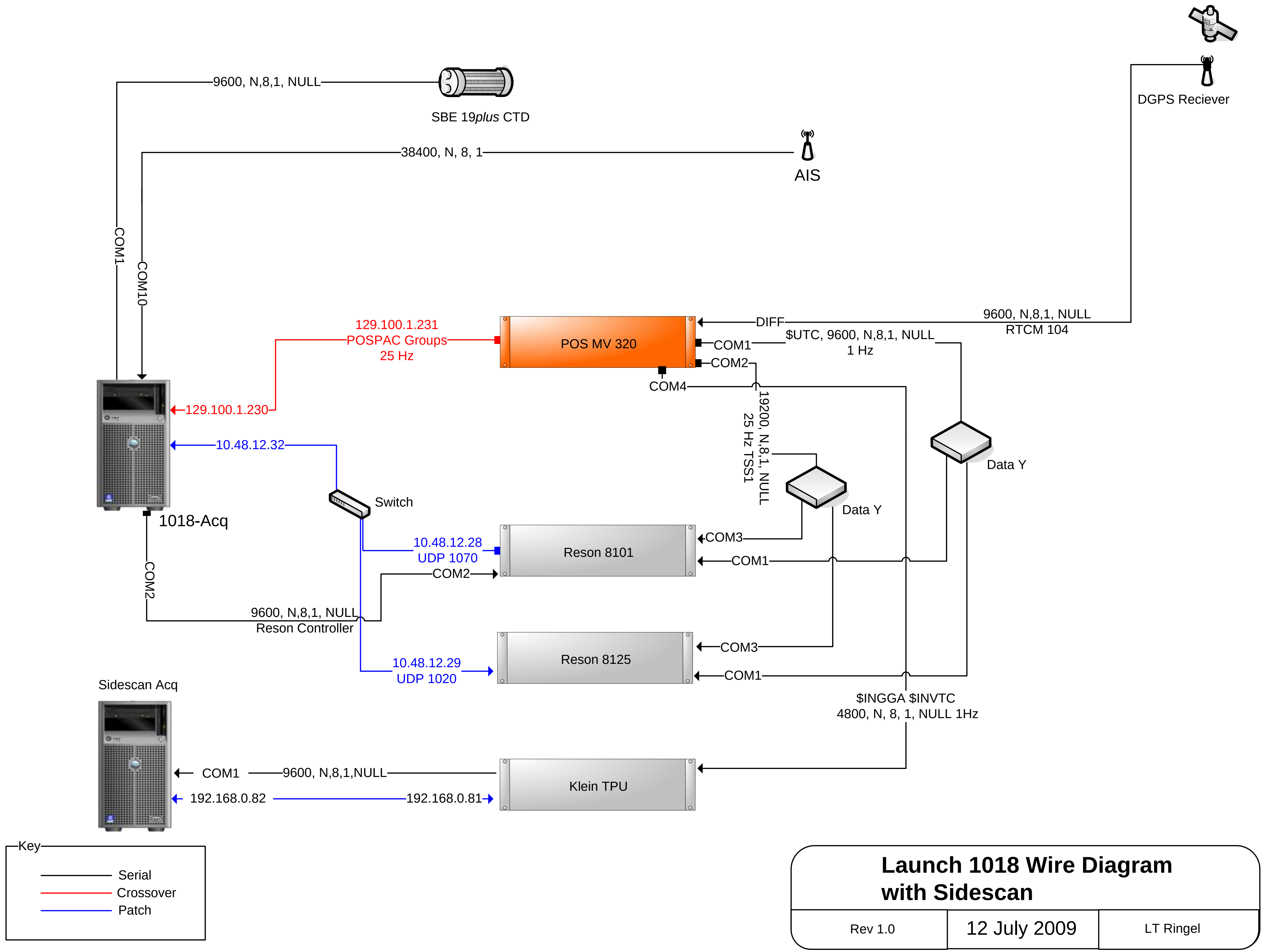
**Primary GPS Receiver**




**Secondary GPS Receiver**




9600, N,8,1, NULL
SBE 19plus CTD
38400, N, 8, 1
AIS
DGPS Reciever
COM1
COM10
129.100.1.231
POSPAC Groups
25 Hz
POS MV 320
DIFF
9600, N,8,1, NULL
RTCM 104
COM1
$UTC, 9600, N,8,1, NULL
1 Hz
COM2
19200, N,8,1, NULL
25 Hz TSS1
129.100.1.230
10.48.12.32
Data Y
Data Y
Switch
1018-Acq
10.48.12.28
UDP 1070
Reson 8101
COM3
COM1
COM2
COM2
9600, N,8,1, NULL
Reson Controller
Reson 8125
COM3
COM1
10.48.12.29
UDP 1020
Key
Serial
Crossover
Patch
Launch 1018 Wire Diagram
Rev 4.0
12 July 2009
LT Ringel


9600, N,8,1, NULL
SBE 19plus CTD
DGPS Reciever
38400, N, 8, 1
AIS
COM1
COM10
129.100.1.231
POSPAC Groups
25 Hz
POS MV 320
DIFF
9600, N,8,1, NULL
RTCM 104
$UTC, 9600, N,8,1, NULL
1 Hz
COM1
COM2
COM4
19200, N,8,1, NULL
25 Hz TSS1
129.100.1.230
10.48.12.32
Data Y
Data Y
Switch
1018-Acq
10.48.12.28
UDP 1070
Reson 8101
COM3
COM1
COM2
COM2
9600, N,8,1, NULL
Reson Controller
10.48.12.29
UDP 1020
Reson 8125
COM3
COM1
$INGGA $INVTC
4800, N, 8, 1, NULL 1Hz
Sidescan Acq
COM1
9600, N,8,1,NULL
192.168.0.82
192.168.0.81
Klein TPU
Key
Serial
Crossover
Patch
Launch 1018 Wire Diagram
with Sidescan
Rev 1.0
12 July 2009
LT Ringel

| Measurement | IMU to 8111 (MRU to Trans) | | Port Ant to 8111 (Nav to Trans) | | Waterline to RP* | | Port Ant to Stbd Ant | |
|---|---|---|---|---|---|---|---|---|
| Coord. Sys. | | Caris | | Caris | | Caris | | |
| x | | 2.868 | | 2.071 | | n/a | Scaler Distance | 1.997 |
| y | | 8.252 | | 20.144 | | n/a | | |
| z | | 4.752 | | 17.792 | | 0.014 | | |

*Top of IMU is RP (Reference Pt)

Vessel Offsets for S220_8111 are derived from Westlake-Survey-Report-NOAA-Fairweather-09-23-03.pdf and Fairweather_NGS_Report_Feb_2007.doc

2009 Measured Value

## Calculations

Coord. Sys.

### IMU to 8111

**Westlake**

| | | | |
|---|---|---|---|
| IMU | easting | | 0.000 |
| Base | northing | | 0.000 |
| (ft/m) | elevation | | 0.000 |

**Westlake**

| | | | |
|---|---|---|---|
| 8111 | easting | | 27.072 |
| (ft) | northing | | 9.410 |
| | elevation | | 15.042 |

**Westlake**

| | | | |
|---|---|---|---|
| 8111 | easting | | 8.252 |
| (m) | northing | | 2.868 |
| | elevation | | 4.585 |

**Westlake**

Base of IMU to Top of IMU

(m) elevation -0.168

### Port Ant to 8111

**NGS 2009**

| | | | |
|---|---|---|---|
| Top of Port | | x | -11.892 |
| Ant | | y | 0.797 |
| | (m) | z | 13.047 |

Top of Ant to Phase Center

(m) z 0.007

| | | | |
|---|---|---|---|
| Phase Cntr | | x | -11.892 |
| Port Ant | | y | 0.797 |
| | (m) | z | 13.040 |

CARIS

| | | | |
|---|---|---|---|
| Port | | x | 0.797 |
| Ant | | y | -11.892 |
| | (m) | z | -13.040 |

**Westlake**

| | | |
|---|---|---|
| (m) | easting | 8.252 |
| Top of IMU | northing | 2.868 |
| to 8111 | elevation | 4.752 |

CARIS

| | | | |
|---|---|---|---|
| | (m) | x | 2.868 |
| Top of IMU | | y | 8.252 |
| to 8111 | | z | 4.752 |

### Waterline to RP*

IMU Base to baseline at Keel

(ft) elevation 12.856

IMU Base to baseline at Keel

(m) elevation 3.919

Waterline to Keel

(ft) elevation 13.45

Waterline to Keel

(m) elevation 4.100

**See Ship's Draft Tab**

Top of IMU to Base of IMU

(m) elevation 0.168

Top of IMU to Keel

(m) 4.086

### Port Ant to Stbd Ant

**NGS 2009**

| | | | |
|---|---|---|---|
| Top of | | x | -11.892 |
| Port Ant | | y | 0.797 |
| | (m) | z | 13.047 |

Top of Ant to Phase Center

(m) z 0.007

**NGS 2009**

| | | | |
|---|---|---|---|
| Top of | | x | -11.886 |
| Stbd Ant | | y | 2.794 |
| | (m) | z | 13.051 |

These rows **Westlake** unless noted otherwise

### IMU to 8111

| | | |
|---|---|---|
| (m) | easting | 8.252 |
| Top of IMU | northing | 2.868 |
| to 8111 | elevation | 4.752 |

Coord Sys. CARIS

| | |
|---|---|
| x | 2.868 |
| y | 8.252 |
| z | 4.752 |

### Port Ant to 8111

CARIS

| | | |
|---|---|---|
| | x | 2.071 |
| | y | 20.144 |
| (m) | z | 17.792 |

Coord Sys. CARIS

| | |
|---|---|
| x | 2.071 |
| y | 20.144 |
| z | 17.792 |

### Waterline to RP*

| | | |
|---|---|---|
| (m) | easting | N/A |
| Waterline | northing | N/A |
| to IMU | elevation | 0.014 |

Coord. Sys. CARIS

| | |
|---|---|
| x | N/A |
| y | N/A |
| z | 0.014 |

See Description Tab

### Port Ant to Stbd Ant

Scalar Distance (m) 1.997

| IMU to Port Ant | | | IMU to Heave | | |
|---|---|---|---|---|---|
| Caris | | Pos/Mv | Caris | | Pos/Mv |
| 0.797 | | -11.892 | 1.866 | | -7.028 |
| -11.892 | | 0.797 | -7.028 | | 1.866 |
| 13.047 | | -13.047 | -2.086 | | -2.086 |

**Value in POSMV is top of antenna rather than the phase center to IMU.**

| IMU to Port Ant | | | | IMU to Heave | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NGS 2009 | | | | IMU to Bulkhd (Frame) 52 | | | | IMU Base to baseline at Keel | | | |
| IMU Top (m) | | x | 0.000 | | (ft) | easting | -11.638 | | (ft) | elevation | 12.856 |
| | | y | 0.000 | | (m) | easting | -3.547 | | (m) | elevation | 3.919 |
| | | z | 0.000 | | | | | | | | |
| NGS 2009 | | | | Frame 0 (FP) to Frame 52 | | | | Top of IMU to Base of IMU | | | |
| Top of Port | | x | -11.892 | | (m) | easting | -27.737 | | (m) | elevation | 0.168 |
| Ant | | y | 0.797 | | | | | Top of IMU to Keel | | | |
| | (m) | z | 13.047 | IMU to Frame 0 (FP) | | | | | (m) | elevation | 4.086 |
| | | | | | (m) | easting | 24.190 | | | | |
| Top of Ant to Phase Center | | | | | | | | Center of Gravity above baseline | | | |
| | (m) z | | 0.007 | Heave Pt* to Frame 0 (FP) | | | | | (ft) elevation | | 16.37 |
| | | | | | (ft) | easting | 102.42 | Mean Metacentric height | | | |
| NGS 2009 | | | | | (m) | easting | 31.218 | | (ft) | elevation | 3.88 |
| Phase Cntr | | x | -11.892 | | | | | | | | |
| Port Ant | | y | 0.797 | IMU to Centerline | | | | Heave Pt* to baseline at Keel | | | |
| | (m) | z | 13.047 | | (ft) | northing | 6.122 | | (ft) | elevation | 20.25 |
| | | | | | (m) | northing | 1.866 | | (m) | elevation | 6.172 |
| | | | | Heave Pt* to Centerline | | | | (*Heave Pt is Metacenter) | | | |
| | | | | | (m) | northing | 0 | (FP is Forward Perpendicular) | | | |

| IMU to Port Ant | | | | IMU to Heave | | | |
|---|---|---|---|---|---|---|---|
| NGS 2009 | (m) | x | -11.892 | | (m) | easting | -7.028 |
| Top of IMU | | y | 0.797 | Top of IMU | | northing | 1.866 |
| to Port Ant | | z | 13.047 | to Heave Pt* | | elevation | -2.086 |
| Coord Sys. | Pos/Mv | | | Coord. Sys. | Pos/Mv | | |
| | | x | -11.892 | | | x | -7.028 |
| | | y | 0.797 | | | y | 1.866 |
| | | z | -13.047 | | | z | -2.086 |

see Description Tab

| Measurement | IMU to 8160 (MRU to Trans) | | Port Ant to 8160 (Nav to Trans) | | Waterline to RP* | | Port Ant to Stbd Ant | | IMU to Port Ant | | IMU to Heave | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Coord. Sys. | | Caris | | Caris | | Caris | | | Caris | Pos/Mv | Caris | Pos/Mv |
| x | | 0.493 | | -0.304 | | n/a | Scaler Distance | 1.997 | 0.797 | -11.892 | 1.866 | -7.028 |
| y | | 7.665 | | 19.557 | | n/a | | | -11.892 | 0.797 | -7.028 | 1.866 |
| z | | 4.726 | | 17.766 | | 0.014 | | | 13.047 | -13.047 | -2.086 | -2.086 |

*Top of IMU is RP (Reference Pt)

Vessel Offsets for S220_8111 are derived from Westlake-Survey-Report-NOAA-Fairweather-09-23-03.pdf,
Fairweather_NGS_Report_02-07.pdf, and , FairweatherCenterlineSurvey_03-09.pdf.

## Derivations

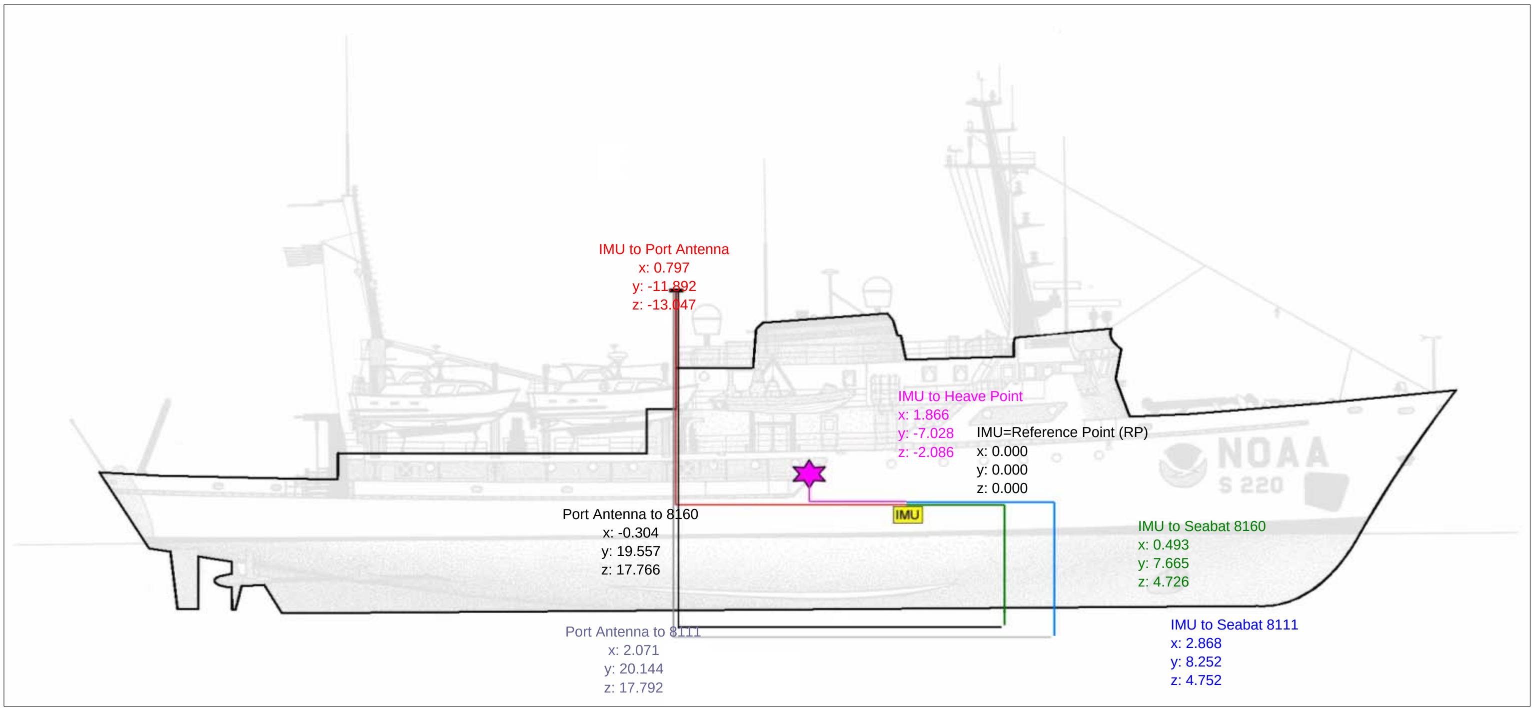
Coord. Sys.

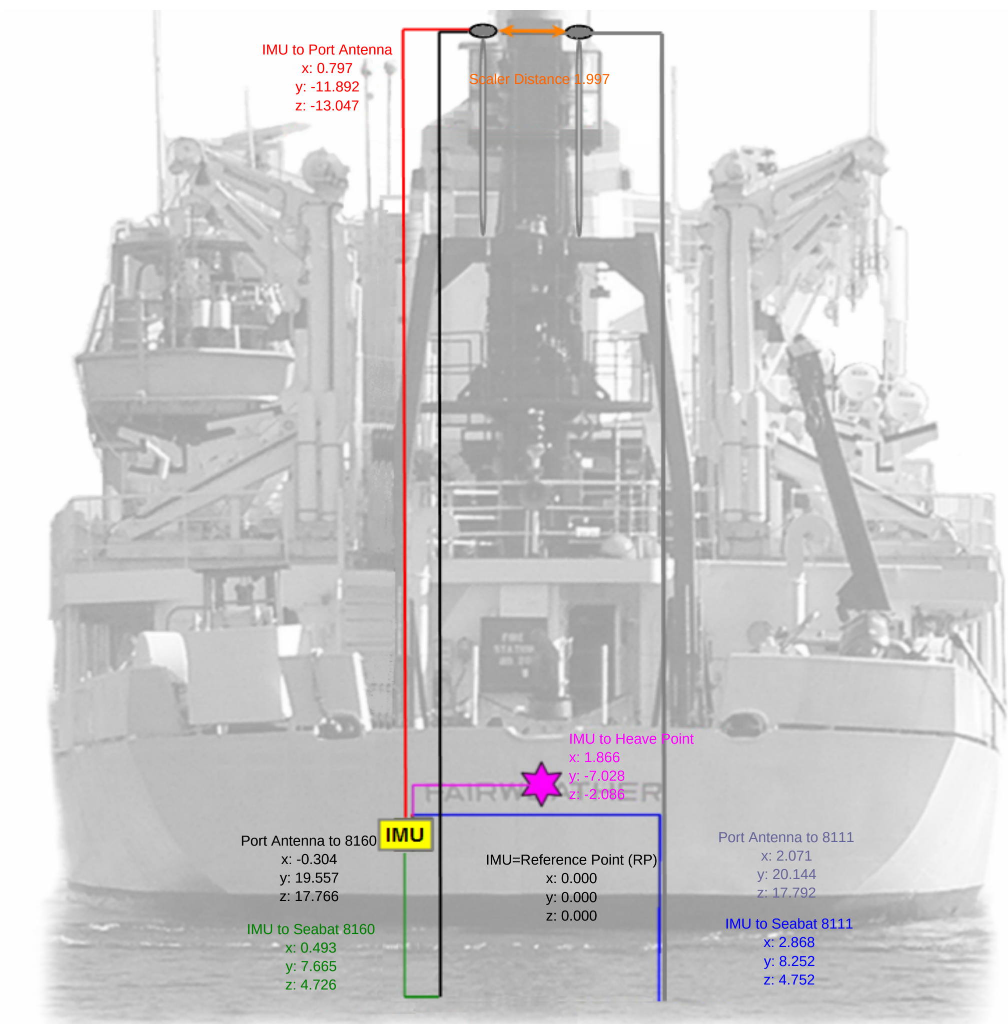
| IMU to 8160 | | | | Port Ant to 8160 | | | |
|---|---|---|---|---|---|---|---|
| **Westlake** | | | | **NGS 2009** | | | |
| IMU | | easting | 0.000 | Top of Port | | x | -11.892 |
| Base | | northing | 0.000 | Ant | | y | 0.797 |
| | (ft/m) | elevation | 0.000 | | (m) | z | 13.047 |
| **Westlake** | | | | Top of Ant to Phase Center | | | |
| 8160 | | easting | 25.149 | | (m) z | | 0.007 |
| | (ft) | northing | 1.619 | Phase Cntr | | x | -11.892 |
| | | elevation | 14.956 | Port Ant | | y | 0.797 |
| **Westlake** | | | | | (m) | z | 13.040 |
| 8160 | | easting | 7.665 | **CARIS** | | | |
| | (m) | northing | 0.493 | Port | | x | 0.797 |
| | | elevation | 4.559 | Ant | | y | -11.892 |
| | | | | | (m) | z | -13.040 |
| Base of IMU to Top of IMU | | | | **Westlake** | | | |
| | (m) | elevation | -0.168 | | (m) | easting | 7.665 |
| | | | | Top of IMU | | northing | 0.493 |
| | | | | to 8160 | | elevation | 4.726 |
| | | | | **CARIS** | | | |
| | | | | | (m) | x | 0.493 |
| | | | | Top of IMU | | y | 7.665 |
| | | | | to 8111 | | z | 4.726 |

| IMU to 8160 | | | | Port Ant to 8160 | | | |
|---|---|---|---|---|---|---|---|
| **Westlake** | | easting | 7.665 | **CARIS** | | x | -0.304 |
| Top of IMU | | northing | 0.493 | | | y | 19.557 |
| to 8160 | (m) | elevation | 4.726 | | (m) | z | 17.766 |
| Coord Sys | Caris | | | Coord Sys | Caris | | |
| | | x | 0.493 | | | x | -0.304 |
| | | y | 7.665 | | | y | 19.557 |
| | | z | 4.726 | | | z | 17.766 |

# Description of Offsets for FAIRWEATHER S-220

All Values Shown are in CARIS Coordinates



| IMU to 8111 (MRU to Trans) | | |
|---|---|---|
| x | y | z |
| 2.868 | 8.252 | 4.752 |

The lever arms between the IMU and phase center of the 8160 transducer are taken from the Westlake report with the addition of the 0.168 m offset included for the height of the IMU.

| IMU to 8160 (MRU to Trans) | | |
|---|---|---|
| x | y | z |
| 0.493 | 7.665 | 4.726 |

The lever arms between the IMU and phase center of the 8111 transducer are taken from the Westlake report with the addition of the 0.168 m offset included for the height of the IMU.

| Port Ant to 8111 (Nav to Trans) | | |
|---|---|---|
| x | y | z |
| 2.071 | 20.144 | 17.792 |

This information comes from a combination of the Westlake and NGS surveys. Subtraction of the distance between Top of Antenna and the Phase Center were included in final value determination. Relative positions obtained from Port Ant to 8111 via IMU.

| Port Ant to 8160 (Nav to Trans) | | |
|---|---|---|
| x | y | z |
| -0.304 | 19.557 | 17.766 |

This information comes from a combination of the Westlake and NGS surveys. Subtraction of the distance between Top of Antenna and the Phase Center were included in final value determination. Relative positions obtained from Port Ant to 8160 via IMU.

| Port Ant to Stbd Ant | |
|---|---|
| Scaler Distance | 1.997 |

Using the NGS 2009 survey values for the antennas, a calculated vector for antenna separation was determined. The distance from Top of Antenna to Phase Center does not affect this calculation and therefore was not included.

| IMU to Port Ant | | |
|---|---|---|
| x | y | z |
| 0.797 | -11.892 | 13.047 |

This information comes directly from the NGS 2009 survey. Subtraction of the distance between Top of Antenna and the Phase Center were included in final value determination.

| Waterline to RP* | | |
|---|---|---|
| x | y | z |
| n/a | n/a | 0.014 |

The height of the IMU above the keel comes from the Westlake survey value of 3.919 m plus the measured value of the top of the IMU to the base plate, to get an IMU height above the keel. The draft (waterline to keel) used for the FAIRWEATHER is based on observations, Ship's Draft spreadsheet. Differencing the value of IMU to keel and waterline to keel gives the waterline to RP distance.

| IMU to Heave | | |
|---|---|---|
| x | y | z |
| 1.866 | -7.028 | -2.086 |

Key points on the IMU, from the Westlake survey, are its location with respect to the ship's reference frame. It is 4.087 m (3.919 m to base line + 0.168 m for IMU height above base plate) above the keel, 1.866 m port of centerline and 3.547 m forward of frame 52. This information is needed to reference the IMU to the ship's Heave Measurement Location (Heave Point). *

**IMU to Heave**

From pg 3 of the Westlake Survey

**SUMMARY**

- IMU foundation plate is level to within +/-0.001 feet.
- IMU foundation plate is located 12.856 feet above baseline established at the keel.
- IMU is parallel to ship's centerline to within +/- 0.001 feet.
  Location of scribed centerline intersection is 6.122 feet port of ship's centerline.
- IMU foundation plate centerline is located 11.638' feet forward of bulkhead 52.

Lynn - read through and check

**IMU to Heave**

* From the Art Anderson inclination experiment the position of the metacenter was used as the position of the ship's Heave Point. (There may be a better way to determine the Heave Point, but this decision was based upon available information). The metacenter is defined by the center of buoyancy. As a vessel inclines through small angles, the center of buoyancy moves through the arc of a circle whose center is at the metacenter.

Important numbers and information determined from the Art Anderson report are the location of the metacenter and how it is positioned with respect to the vessel. The longitudinal location of the metacenter is defined as 102.42 feet (31.217 m) aft of the forward perpendicular. The height of the metacenter is 20.25 feet (6.172 m) above the keel. There is an assumption of the metacenter being on the centerline of the vessel. Similar values for the RAINIER's metacenter are 32.52 m aft of the forward perpendicular and 5.2 m above the keel. The difference in the height of the metacenter can be attributed to the difference between the FA's and RA's average draft which is 13.12 feet as opposed to approximately 14.5 feet respectively.

Referencing the metacenter (Heave Point, HP) to the IMU information requires information about the frame spacing of the vessel. From the Westlake survey, the IMU is located 3.547 m forward of frame 52. From Inclination document, the HP is 31.217 m aft of the forward perpendicular. From engineering drawings of the ship frame spacing is approximately 21 inches. The calculation for the longitudinal location of the HP with respect to frame zero, the Forward Perpendicular (FP) is as follows:

52 (frame) * 21 (inches/frame)/12(inches/ft)*.3048(m/ft)-3.547 m = 24.190 m from frame 0.

31.217 m (HP aft of FP) – 24.190 m (IMU aft of FP) = 7.027 m (HP aft of IMU)

The calculation for the vertical separation between the IMU and the HP is based on the height of the metacenter being 6.172m and the height of the IMU being 4.087 m above the keel. Differencing yields the metacenter being 2.085 m above the IMU.

The calculation for the athwartship separation is based upon the assumption that the HP is on the centerline and the knowledge that the IMU is 1.866 m to port of the centerline.

**Sources**

Offset values for the ship were derived from three sources. Two static offset surveys, an inclination experiment, and values measured or approximated by ship's personnel.

On September 23, 2003 an offset survey of the NOAA Ship FAIRWEATHER was conducted by:
Westlake Consultants, Incorporated
15115 SW Sequoia Parkway, Suite 150
Tigard, Oregon 97224
Phone (503) 684-0652

…and the relocation of the POS M/V antenna forced a partial resurvey in Feb. 2007 by Steven Breidenbach of NGS.

These values relate the physical positions of one sensor to the next with the base plate of the IMU being the point of origin. All dimensions in the document are given in feet and decimal feet.

On July 16, 2004 an inclination experiment was conducted at MOC-P by:

Art Anderson Associates
202 Pacific Avenue
Bremerton, WA 98337-1932

**Calculations**

The values for the required lever arms are listed in the S220_Offsets and Measurements spreadsheet. The reference point and the IMU are identical. Difference in documentation between Westlake and FA calculations are based off of measuring up from the IMU base (Westlake's origin) and the top of the IMU. The top center of the IMU for the POS/MV is the defined origin for the POS/MV and the origin that is being used on all FAIRWEATHER vessels. The distance from the base plate to the top of the IMU is 0.168 m, a value measured by ship's complement. Conversions factor from feet to meters is 0.3048 m/ft.

As a requirement for the TPE, the standard deviation for each position is 3 mm. This value is based upon a conversation with Elaine McDonald of Westlake and is followed up by an Email documenting that fact. The email is located at the end of this document.

US DEPARTMENT OF COMMERCE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
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GEODETIC SERVICES DIVISION
INSTRUMENTATION & METHODOLOGIES BRANCH

# NOAA SHIP FAIRWEATHER
# POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY
# FIELD REPORT

Kendall Fancher
March , 2009

**PRIMARY CONTACTS**

Glen Rice NOAA 757-615-6465

**NOAA SHIP FAIRWEATHER**
**POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY**

## PURPOSE

The primary purpose of the survey was to precisely determine the spatial relationship of various components of a POS MV navigation system aboard the NOAA ship FAIRWEATHER. Additionally, various reference points (bench marks) were re-established onboard the vessel to aid in future spatial surveys aboard the boat.

## PROJECT DETAILS

This survey was conducted while the ship was in dry dock at the Lake Union dry dock in Seattle, WA. The weather conditions over the two days required to conduct this survey were windy, cool, with intermittent rain.

## INSTRUMENTATION

The Leica TC2003 total station was used to make all measurements.

Technical Data:

Standard Deviation

| | |
|---|---|
| Horizontal angle | 0.5 seconds |
| Vertical angle | 0.5 seconds |
| Distance measurement | 0.2mm + 2ppm |

A Leica precision prism was used as a sighting target. This prism was configured to have a zero mm offset.

## PERSONNEL

Kendall Fancher NOAA/NOS/NGS/GSD/I&M BRANCH
(540) 373-1243

Dennis Lokken NOAA/NOS/NGS/GSD/I&M BRANCH
(540) 373-1243

**NOAA SHIP FAIRWEATHER**
**POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY**

## DEFINITION OF THE REFERENCE FRAME

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

## SURVEY METHODOLOGY

***02/15/2009***

Coordinates of 100.000N, 100.000E, and 100.000U were assumed for temporary control point 1. A distance and height difference were measured between temporary control points 1 and 3. These values were used to determine the coordinates at temporary control point 3. Temporary control points 1 and 3 were located along the top deck and on the north side of the dry dock vessel.

Temporary control point 1 was occupied and temporary control point 3 was observed for a backsight. After initialization, temporary control points 2 and 4(located on the top deck of the dry dock vessel), H1 (located on the bottom deck of the dry dock vessel), and BOW BM were observed in both direct and reverse.

Temporary control point 2 was occupied and temporary control point 3 was observed for a backsight. After initialization, temporary control point W1 (located on the top deck of the dry dock vessel) and D1 (located inside the ship on the D deck along the port side) were observed in both direct and reverse. Temporary control point 1 was also observed and yielded an inverse check of 0.001m horizontally and 0.001m vertically.

Temporary control point 4 was occupied and control point 1 was observed for a backsight. After initialization, temporary control point 5 (located on the south side and on the top deck of the dry dock vessel) was observed in both direct and reverse.

Temporary control point 5 was occupied and control point 4 was observed for a backsight. After initialization, temporary control point D2 (located inside the ship on the D deck along the starboard side) was observed in both direct and reverse.

Temporary control point H1 was occupied and control point 1 was observed for a backsight. After initialization, temporary control point H2 (located on the bottom deck of the dry dock vessel), and USBL BM were observed in both direct and reverse.

Temporary control point H2 was occupied and temporary control point H1 was observed for a backsight. After initialization, 8111 BM and 8160 BM were observed in both direct and reverse. Temporary control point W1 was also observed and yielded an inverse check of 0.019m horizontally and 0.033m vertically.

Temporary control point D1 was occupied and temporary control point D2 was observed for a backsight. After initialization, temporary control point D3 (located in the doorway leading to the mess hall on the D deck) was observed in both direct and reverse.

Temporary control point D3 was occupied and temporary control point D1 was observed for a backsight. After initialization, temporary control point C1 (located on the C deck near the IMU) was observed in both direct and reverse. Temporary control point D2 was also observed and yielded an inverse check of 0.026m horizontally and 0.0001m vertically.

Temporary control point C1 was occupied and temporary control point D3 was observed for a backsight. After initialization, IMU, IMU BOW PORT CORNER, IMU BOW STAR CORNER, IMU STERN STAR CORNER, and IMU STERN PORT CORNER were observed in both direct and reverse.

***02/16/2009***

Temporary control point 4 was occupied and control point 1 was observed for a backsight. After initialization, temporary control point 6 (located on the south side and on the top deck of the dry dock vessel) and BOW BM were observed in both direct and reverse. Temporary control point D2 was also observed and yielded an inverse check of 0.0004m horizontally and 0.083m vertically.

Temporary control point 6 was occupied and temporary control point 4 was observed for a backsight. After initialization, TRANSOM PIVOT POINT PORT, STERN BM, POS GPS ANT RAIL BM, POS IMU ANT DECK BM, POS GPS ANT STARBOARD, and POS GPS ANT PORT were observed in both direct and reverse.

Temporary control point 3 was occupied and temporary control point 1 was observed for a backsight. After initialization, TRANSOM PIVOT POINT STARBOARD, STERN BM, POS GPS ANT STARBOARD, and POS GPS ANT PORT were observed in both direct and reverse. Temporary control point 6 was also observed and yielded an inverse check of 0.0006m horizontally and 0.001m vertically.

The reference frame was rotated using STERN BM as the point of rotation. A zero degree azimuth was used during the rotation from STERN BM to BOW BM. The reference frame was then translated to relocate the origin of the reference frame to the IMU.

**NOAA SHIP FAIRWEATHER**
**POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY**

## INVERSE RESULTS

***Inverses were computed between the determined positions of those ship benchmarks and sensor points which were determined from two separate locations  The results of these inverses are:***

| ID | Horizontal Dist.(m) | Elevation Diff(m) |
|---|---|---|
| BOW BM | 0.0150 | 0.0240 |
| STERN BM | 0.0060 | 0.0010 |
| POS GPS ANT STARBOARD | 0.0100 | 0.0001 |
| POS GPS ANT PORT | 0.0100 | 0.0000 |

## DISCUSSION

The Fairweather was in dry dock during this survey, however, the dry dock vessel was still subject to movement due to wave action.   Conducting a survey such as this while the ship is moving requires that the automatic compensators in the survey instrument be turned off.  The survey is therefore conducted with all survey instrumentation set up relative to the mean movement of the related level vials.  While every effort was made to make the most precise measurements possible, some additional error accumulation cannot be avoided under these type observing conditions.

The POS GPS antenna coordinates were determined to the top center of the antennas.  The Z value should be corrected to the Antenna Reference Point (ARP).  In order to apply this correction, the mechanical height of the antenna should be determined and subtracted from the Z value determined during this survey for both of the POS GPS antennas.

**NOAA SHIP FAIRWEATHER**
**POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY**

## Coordinate Listing using IMU as the Reference Frame Origin

| ID | X(NORTHING)m | Y(EASTING)m | Z(UP)m |
|---|---|---|---|
| IMU CENTER | 0.000 | 0.000 | 0.000 |
| IMU STERN PORT CORNER | -0.071 | -0.089 | -0.001 |
| IMU BOW PORT CORNER | 0.070 | -0.086 | -0.001 |
| IMU BOW STARBOARD CORNER | 0.069 | 0.087 | 0.000 |
| IMU STERN STARBOARD CORNER | -0.073 | 0.086 | 0.000 |
| BOW BM | 28.378 | 1.805 | 7.796 |
| STERN BM | -40.306 | 1.805 | 2.255 |
| USBL BM | -28.354 | 1.738 | -4.204 |
| 8160 BM | 8.407 | 0.395 | -4.400 |
| 8111 BM | 8.532 | 3.002 | -4.666 |
| POS GPS ANT RAIL BM | -12.011 | 1.785 | 10.381 |
| POS IMU ANT DECK BM | -11.790 | 1.780 | 9.305 |
| POS GPS ANT STARBOARD | -11.886 | 2.794 | 13.051 |
| POS GPS ANT PORT | -11.892 | 0.797 | 13.047 |
| TRANSOM PIVOT POINT STARBOARD | -39.727 | 3.366 | 2.385 |
| TRANSOM PIVOT POINT PORT | -39.722 | 0.240 | 2.345 |

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IMU Reference Points

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POS GPS ANTENNAS

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BOW CENTERLINE REFERENCE POINT

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CENTERLINE REFERENCE POINT ON G DECK

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CENTERLINE REFERENCE POINT ON RAIL AT G DECK

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**POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY**


CENTERLINE STERN REFERENCE POINT

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TRANSOM REFERENCE POINT ON PORT SIDE


TRANSOM REFERENCE POINT ON STARBOARD SIDE

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8111 REFERENCE POINT

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8160 REFERENCE POINT

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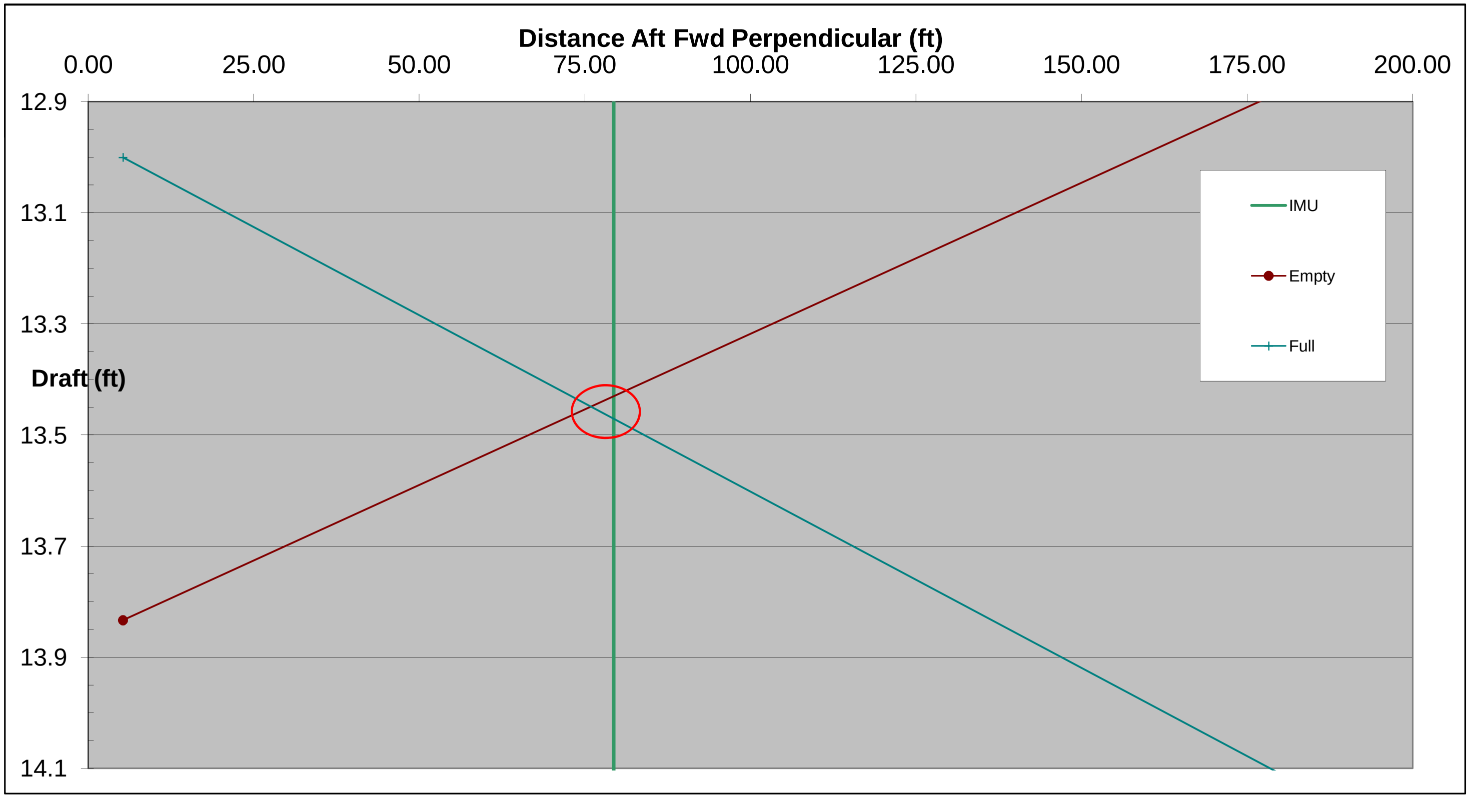
USBLE REFERENCE POINT

## *Fairweather* Draft - 2009

Immediately prior to the FA field season, the draft measurements were taken prior to fueling when the takes were very empty after shipyard (Empty) . And again after fueling and once the engineers had transferred the fuel in a satisfactory manner (Full). The waterline at the IMU was then calculated based on a linear interpolation.

| 2009 | (April) | | Fwd | | Aft | slope | IMU Depth (ft) | IMU Depth (m) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | x1 | y1 | x2 | y2 | | | | | Min | Max |
| | Empty | 5.25 | 13.83 | 189 | 12.83 | -0.00544 | 13.43 | 4.093 | | 12.83 | 14.17 |
| | Full | 5.25 | 13.00 | 189 | 14.17 | 0.00635 | 13.47 | 4.106 | | | |
| | | 5.25 | | 189 | | 0.00000 | 0.00 | 0.000 | | | |
| | | 5.25 | | 189 | | 0.00000 | 0.00 | 0.000 | | | |
| | | 5.25 | | 189 | | 0.00000 | 0.00 | 0.000 | | | |
| | | | | | | Draft at IMU (ft) | 13.45 | 4.100 | AVG | Value Used in Offsets | |
| | The IMU | x-value (ft): | 79.36 | | | | 0.029 | 0.009 | STDEV | Value used for Waterline Loading Uncertainty | |
| | | x-value (m): | 24.19 | | | | | | | | |



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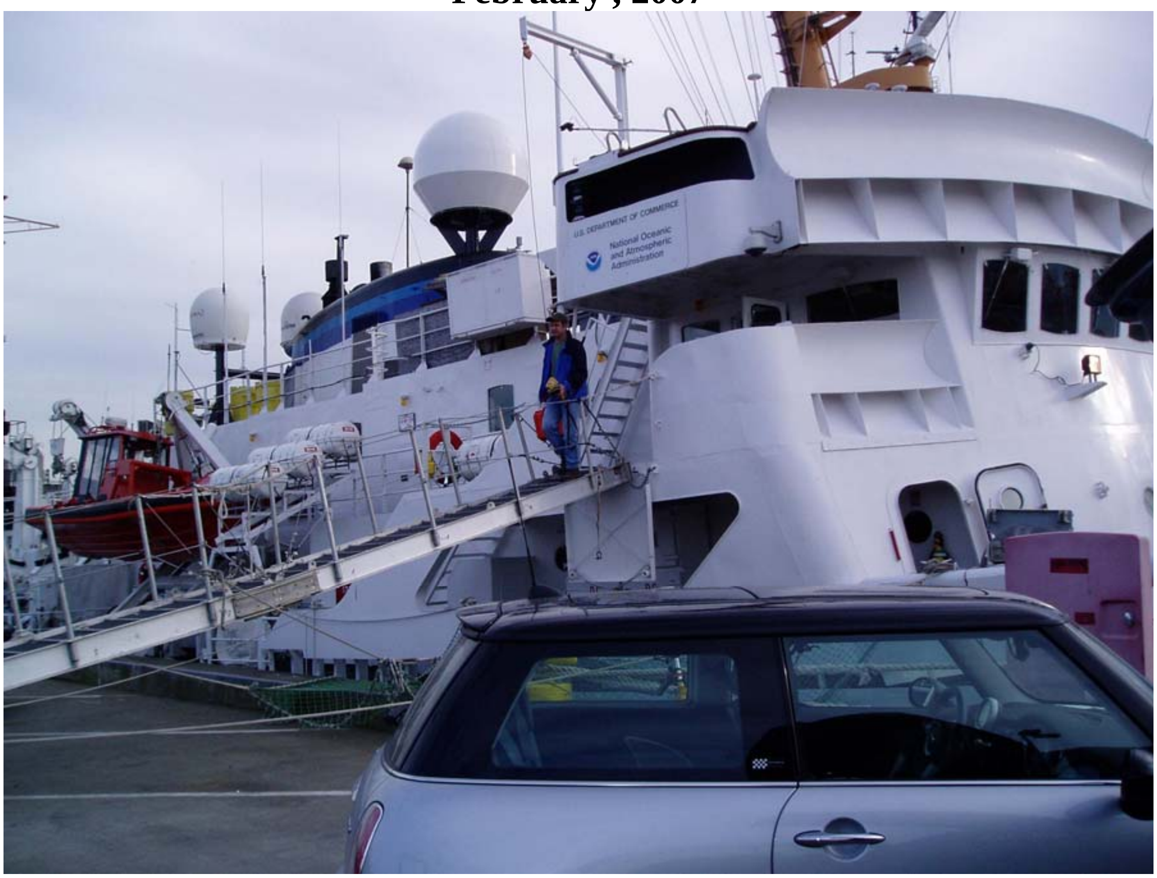
# INSTRUMENTATION & METHODOLOGIES BRANCH

## NOAA SHIP FAIRWEATHER
## POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY
## FIELD REPORT

**Steven Breidenbach**
**February , 2007**




**PRIMARY CONTACTS**
LT MARK VAN WAES NOAA (206) 526-6891

**NOAA SHIP FAIRWEATHER**
**POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY**

## PURPOSE

The primary purpose of the survey was to accurately determine the spatial relationship of various components of a POS MV navigation system aboard the NOAA ship FAIRWEATHER. Reference points were also established to determine the spatial location of differential GPS antennas, Additionally, various reference points (bench marks) were restablished onboard the vessel to aid in future spatial surveys aboard the boat.

## PROJECT DETAILS

This survey was conducted while the ship was docked at the USCG in Seattle, WA . The weather was cool with a steady breeze.

## INSTRUMENTATION

The Topcon 3000LW total station was used to make all measurements.

Technical Data:

Angle Measurement

| | |
|---|---|
| Smallest unit in display | 0.1 seconds |

Standard Deviation

| | |
|---|---|
| Horizontal angle | 1.0 seconds |
| Vertical angle | 1.0 seconds |
| Distance measurement | 2mm + 2ppm |

A standard “peanut” prism was used as a sighting target. This prism was configured to have a zero mm offset.

## PERSONNEL

Steve Breidenbach NOAA/NOS/NGS/GSD/I&M BRANCH
(540) 373-1243

Dennis Lokken NOAA/NOS/NGS/GSD/I&M BRANCH
(540) 373-1243

**NOAA SHIP FAIRWEATHER**
**POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY**

## ESTABLISHING THE REFERENCE FRAME

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 IMU towards the bow of the boat. The Y axis is perpendicular to the centerline of the boat (X axis) and is positive from IMU towards the right, when looking at the boat from the stern. The Z axis is positive in an upward direction from the IMU. In this reference frame the IMU has the following coordinates;
X = 100.000(m)
Y = 100.000(m)
Z = 100.000(m)

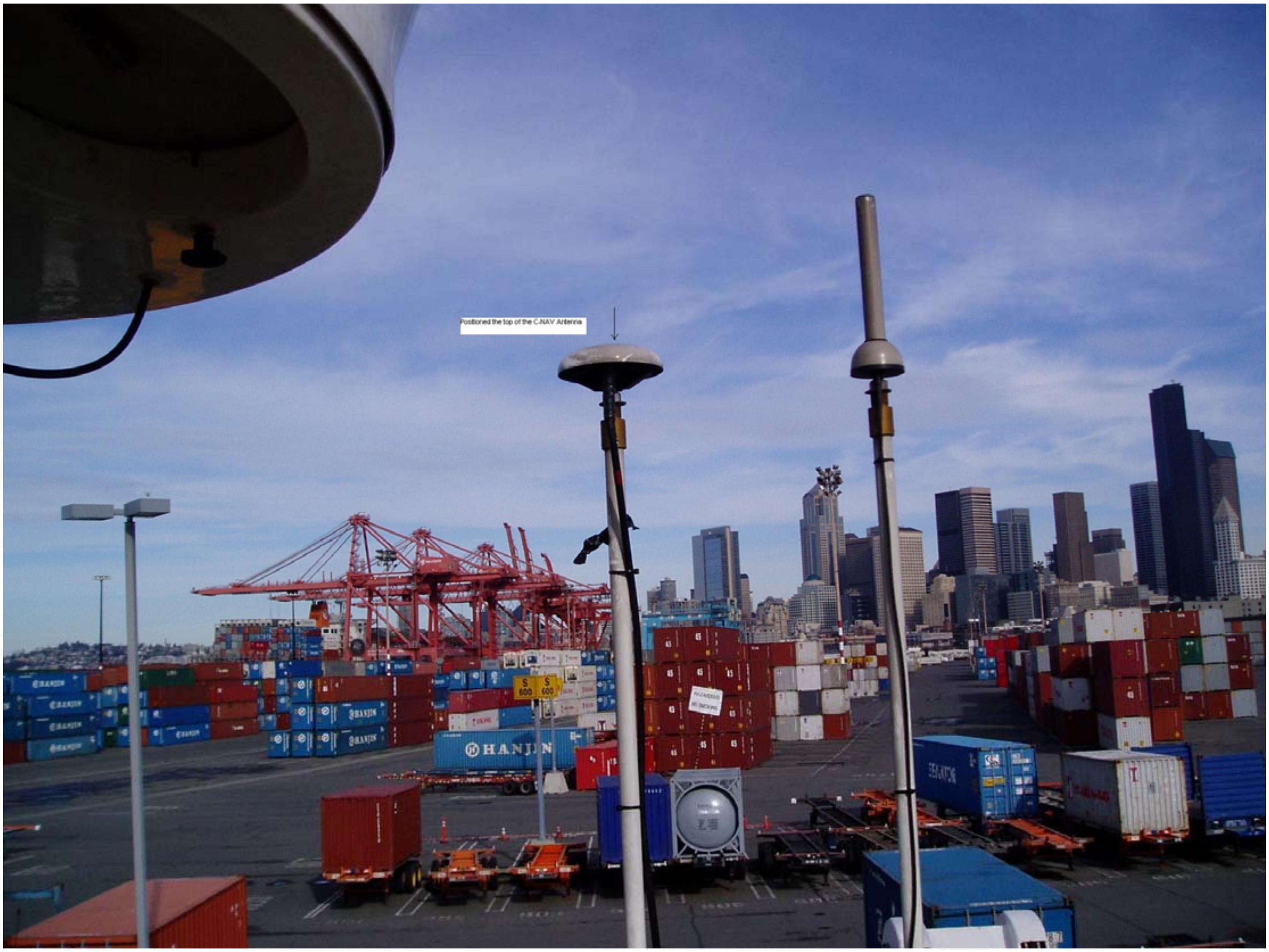
At the end of the survey all the coordinates were rotated to a right-handed coordinate system. The coordinates were translated to the IMU origin and the Granite Block origin.

## DISCUSSION

I recommend conducting the survey again, once the ship is put into dry dock. Conducting a survey such as this while the boat is in the water requires that the automatic compensators in the survey instrument be turned off. The survey is therefore conducted with all survey instrumentation set up relative to the mean movement of the related level vials. While every effort was made to make the most precise measurements possible, some additional error accumulation cannot be avoided under these type observing conditions.

The positions given for the IMU GPS antenna are to the bottom of the bolt as depicted on the photo below.

Position of the C-NAV Antenna



| Point Summary Report | | | | |
|---|---|---|---|---|
| **Name** | **Std Dev n (m)** | **Std Dev e (m)** | **Std Dev Hz (m)** | **Std Dev u (m)** |
| 10FLOOR | 0.003 | 0.003 | 0.004 | 0.002 |
| 11FLOOR | 0.003 | 0.004 | 0.005 | 0.002 |
| 1CLEAT | 0.004 | 0.018 | 0.019 | 0.002 |
| 1DECK | 0.004 | 0.018 | 0.018 | 0.002 |
| 1FLOOR | 0.000 | 0.000 | 0.000 | 0.000 |
| 1LOCKER | 0.004 | 0.004 | 0.005 | 0.003 |
| 1RAIL | 0.004 | 0.022 | 0.023 | 0.002 |
| 1WALL | 0.003 | 0.002 | 0.004 | 0.001 |
| 1WALL3 | 0.003 | 0.003 | 0.004 | 0.002 |
| 2CLEAT | 0.003 | 0.021 | 0.021 | 0.002 |
| 2CLEAT1 | 0.004 | 0.022 | 0.022 | 0.003 |
| 2FLOOR | 0.001 | 0.001 | 0.001 | 0.001 |
| 2RAIL | 0.004 | 0.022 | 0.022 | 0.002 |
| 2WALL | 0.002 | 0.003 | 0.004 | 0.002 |
| 3ANT | 0.003 | 0.006 | 0.007 | 0.003 |
| 3FLOOR | 0.002 | 0.002 | 0.003 | 0.002 |
| 3WALL | 0.003 | 0.003 | 0.005 | 0.002 |
| 4FLOOR | 0.001 | 0.001 | 0.002 | 0.003 |
| 5FLOOR | 0.002 | 0.004 | 0.005 | 0.001 |
| 6FLOOR | 0.002 | 0.002 | 0.003 | 0.003 |
| 7FLOOR | 0.005 | 0.003 | 0.006 | 0.002 |
| 8FLOOR | 0.004 | 0.004 | 0.005 | 0.002 |
| 9FLOOR | 0.002 | 0.013 | 0.013 | 0.003 |
| ABOLT | 0.003 | 0.026 | 0.026 | 0.003 |
| ANT DECK | 0.003 | 0.006 | 0.007 | 0.003 |

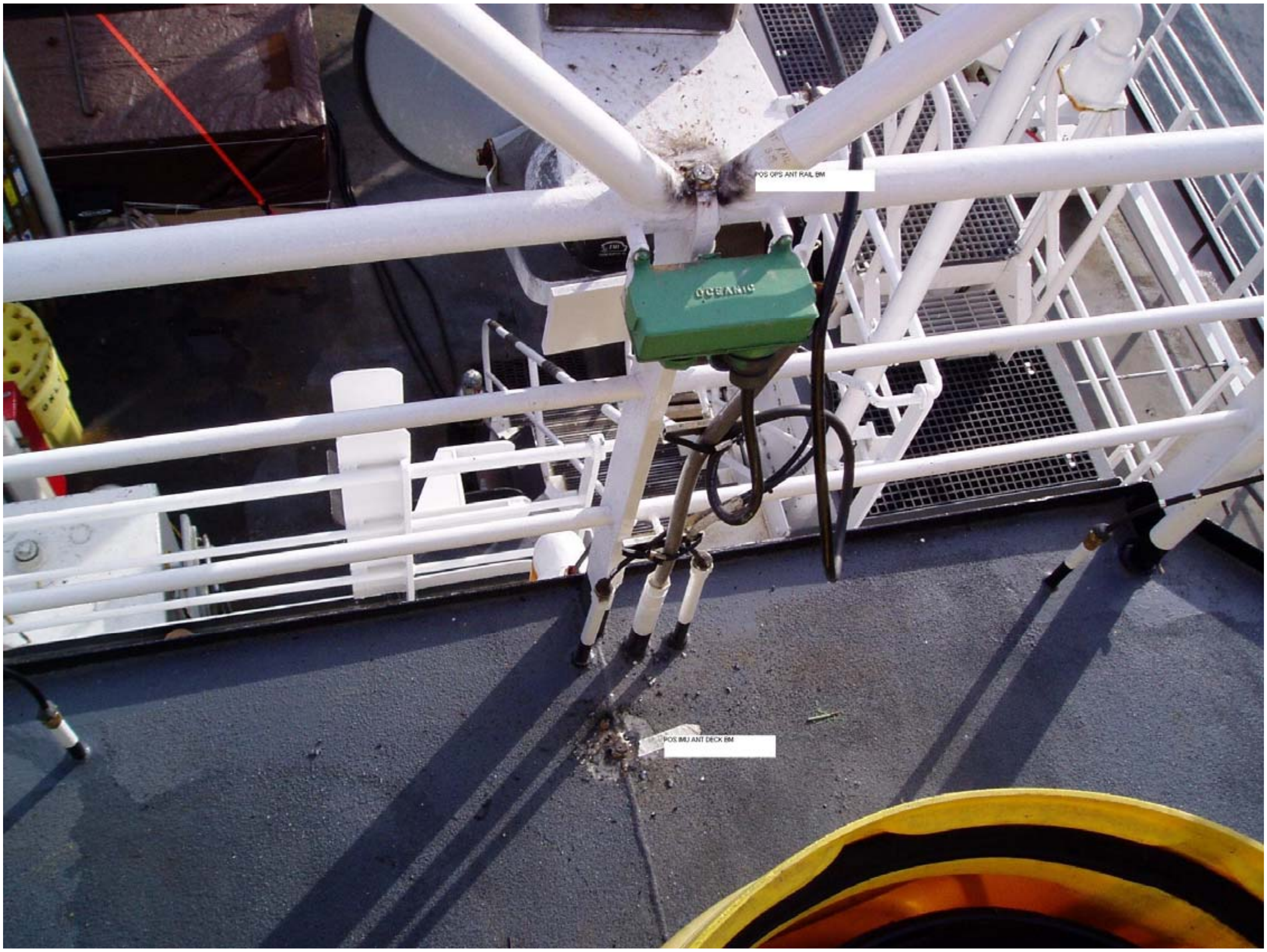
| Name | Std Dev n (m) | Std Dev e (m) | Std Dev Hz (m) | Std Dev u (m) |
|---|---|---|---|---|
| ANT DECK BM | 0.004 | 0.007 | 0.008 | 0.003 |
| ANT PORT | 0.003 | 0.007 | 0.008 | 0.003 |
| ANT RAIL | 0.004 | 0.006 | 0.007 | 0.003 |
| ANT RAIL BM | 0.003 | 0.007 | 0.007 | 0.003 |
| ANT STAR | 0.004 | 0.007 | 0.008 | 0.003 |
| BOW BM | 0.004 | 0.023 | 0.024 | 0.003 |
| BOW BM2 | 0.004 | 0.023 | 0.023 | 0.003 |
| BRIDGEPORT | 0.005 | 0.011 | 0.012 | 0.003 |
| BRIDGESTAR | 0.005 | 0.011 | 0.012 | 0.003 |
| BRIDGESTAR2 | 0.005 | 0.011 | 0.012 | 0.003 |
| DOOR | 0.001 | 0.001 | 0.002 | 0.001 |
| GRANITE BOW | 0.002 | 0.001 | 0.002 | 0.001 |
| GRANITE CENTER | 0.002 | 0.001 | 0.002 | 0.001 |
| GRANITE PORT | 0.002 | 0.001 | 0.002 | 0.001 |
| GRANITE STAR | 0.003 | 0.002 | 0.003 | 0.001 |
| GRANITE STERN | 0.002 | 0.001 | 0.002 | 0.001 |
| IMU BM | 0.003 | 0.001 | 0.003 | 0.003 |
| IMU BOW PORT | 0.002 | 0.001 | 0.002 | 0.001 |
| IMU BOW STAR | 0.002 | 0.001 | 0.002 | 0.001 |
| IMU CENTER | 0.000 | 0.000 | 0.000 | 0.000 |
| IMU STERN PORT | 0.002 | 0.001 | 0.002 | 0.001 |
| IMU STERN STAR | 0.002 | 0.001 | 0.002 | 0.001 |
| LADDER | 0.002 | 0.002 | 0.002 | 0.001 |
| MVP BM | 0.004 | 0.023 | 0.023 | 0.003 |
| RAIL STAR | 0.006 | 0.015 | 0.016 | 0.003 |
| RAIL STAR1 | 0.004 | 0.005 | 0.007 | 0.003 |
| RAILPORT | 0.005 | 0.015 | 0.016 | 0.003 |

| Name | Std Dev n (m) | Std Dev e (m) | Std Dev Hz (m) | Std Dev u (m) |
|---|---|---|---|---|
| RAILSTAR | 0.005 | 0.015 | 0.016 | 0.003 |
| STEARN BM | 0.004 | 0.024 | 0.024 | 0.003 |
| STERN BM | 0.003 | 0.024 | 0.024 | 0.002 |

## COORDINATES

| IMU Origin | | | |
|---|---|---|---|
| Right-handed Coordinate System | | | |
| | | | |
| **Name** | **Easting (x) meters** | **Northing (y) meters** | **Elevation (z) meters** |
| IMU CENTER | 0 | 0 | 0 |
| IMU BOW PORT CORNER | 0.073 | -0.084 | -0.006 |
| IMU BOW STAR CORNER | 0.071 | 0.088 | -0.004 |
| IMU STERN STAR CORNER | -0.068 | 0.089 | -0.003 |
| IMU STERN PORT CORNER | -0.065 | -0.086 | -0.006 |
| GRANITE BOW | 0.147 | 0.48 | 0.108 |
| GRANITE STAR | -0.002 | 0.574 | 0.111 |
| GRANITE STERN | -0.148 | 0.478 | 0.109 |
| GRANITE PORT | -0.003 | 0.382 | 0.106 |
| GRANITE CENTER | -0.002 | 0.477 | 0.108 |
| IMU BM | 0.034 | -0.263 | -0.496 |
| STERN BM | -40.32 | 1.927 | -2.184 |
| MVP BM | -38.721 | 5.985 | -2.018 |
| STEARN BM | -40.313 | 1.921 | -2.181 |
| POS GPS ANT STARBOARD | -11.917 | 3.171 | -12.936 |
| POS GPS ANT PORT | -11.92 | 1.177 | -12.98 |
| A FRAME BOLT | -43.019 | 1.975 | -7.142 |
| POS GPS ANT RAIL BM | -12.037 | 2.101 | -10.376 |
| POS IMU ANT DECK BM | -11.823 | 2.07 | -9.301 |
| C-NAV ANT | -10.075 | 4.131 | -11.377 |
| BOW BM | 28.346 | 2.077 | -7.853 |

| Granite Block Origin | | | |
|---|---|---|---|
| Right-handed Coordinate System | | | |
| | | | |
| **Name** | **Easting (x) meters** | **Northing (y) meters** | **Elevation (z) meters** |
| IMU CENTER | 0.002 | -0.477 | -0.108 |
| IMU BOW PORT CORNER | 0.075 | -0.561 | -0.114 |
| IMU BOW STARBOARD CORNER | 0.073 | -0.39 | -0.112 |
| IMU STERN STARBOARD CORNER | -0.065 | -0.388 | -0.111 |
| IMU STERN PORT CORNER | -0.063 | -0.563 | -0.114 |
| GRANITE BOW | 0.149 | 0.003 | 0 |
| GRANITE STAR | 0 | 0.097 | 0.003 |
| GRANITE STERN | -0.145 | 0.001 | 0.001 |
| GRANITE PORT | 0 | -0.095 | -0.002 |
| GRANITE CENTER | 0 | 0 | 0 |
| IMU BM | 0.036 | -0.74 | -0.604 |
| STERN BM | -40.317 | 1.45 | -2.292 |
| MVP BM | -38.719 | 5.508 | -2.126 |
| STEARN BM | -40.31 | 1.444 | -2.289 |
| POS GPS ANT STARBOARD | -11.915 | 2.694 | -13.044 |
| POS GPS ANT PORT | -11.918 | 0.699 | -13.088 |
| A FRAME BOLT | -43.017 | 1.498 | -7.25 |
| POS GPS ANT RAIL BM | -12.034 | 1.623 | -10.484 |
| POS IMU ANT DECK BM | -11.821 | 1.593 | -9.409 |
| C-NAV ANT | -10.073 | 3.654 | -11.485 |
| BOW BM | 28.349 | 1.6 | -7.961 |




POS GPS RAIL BM AND POS GPS DECK BM


IMU BM

TRU-STONE Technologies

*ISO 9002 Certified*

# *Certificate of Accuracy*

**Customer Name:** MCMASTER-CARR SUPPLY CO.    **Customer PO#:** TA-28173060

**Customer Address:** 200 AURORA IND. PARKWAY
AURORA,OH 44202

**Date of Calibration:** 8/23/02
**Product Description:** GRANITE SURFACE PLATE
**Size:** 8" X 12" X 2"
**Serial Number:** 36961
**Accuracy:** Actual: .000075"    Allowed: .0002"
**Repeatability:** Actual: .000055"    Allowed: .00010"
**Grade:** B
**Uncertainty of Measurement:** 5.2√D
**M.O.E.:** 7.5 x 10 6
**Laboratory Conditions:** Temperature: 69 °F    Humidity: 51%

This product was inspected under environmentally controlled conditions. The electronic and optical gauging equipment used in inspecting this item has been calibrated and is traceable to the National Institute of Standards and Technology (NIST). Our calibration system is in compliance with ISO 10012-1.

Calibration Equipment Used in the Inspection of this Product:

| *Type of Equipment* | *ID Number* | *Instrument Uncertainty* | *NIST Traceability Number* | *Cal. Due Date* |
|---|---|---|---|---|
| Autocollimator | IP 040 | ±0.5 arc sec | 821/259488-97 | 6-03 |
| .000020 Mahr Dial I | 20990 | 50 µin | 25894-1 | 6-03 |

Laboratory Manager Signature: [signature]

Donald Schirmers, Lapping Manager
Robert Golla, Accessories Supervisor

**REWORK / RECALIBRATION** *(This section is completed for recertification orders only - accuracies upon receipt)*

Date of Receipt:
Accuracy of Incoming Product:
Repeat Measurement of Incoming Product:

☐ ***Was unable to read upon receipt due to poor condition of product***

The results on this Certificate of Accuracy apply only to the item described above. This report shall not be reproduced except in full and with the written authorization of our laboratory.

*Measurement Uncertainty is expressed at a confidence level of 95% (coverage factor k=2)*

Procedure Number: QP 4.10.1

# FINAL INSPECTION REPORT

Laboratory Name

TRU-STONE Technologies

1101 Prosper Drive • Box 430
Waite Park, MN 56387
PH: 320-251-7171 • FAX: 320-259-5073

## Final Inspection

(1) **Inspection Number:** 0200851

(2) Inspection Date: 8-23-02

(3) Date of Receipt (rework items): ______

(4) Repeat Reading of Received Item: ______

(5) Accuracy of Received (rework) Item: ______

☐ Unable to Inspect – product in too poor of condition

(6) Customer Name: Mengel-Carr

(7) Serial Number: 36961

(8) P.O. Number: JA-2873060

(9) Print/Part Number: ______

(10) Description of Item: 8x12x2 OCB

(11) Granite Type: Impala

(12) Conditions at Time of Inspection: Temperature: 69 °F Humidity: 51

(13) Test Equipment:

Autocollimator Mirror Size: 3"

| Type of Equipment | Serial Number | Calibration Due Date | Uncertainty of IMTE |
|---|---|---|---|
| Autocollimator ☑ Repeat-o-meter ☑ | IP040 | 6-03 | ± 0.5 arc sec |
| Electronic Level ☐ Height Check ☐ | 2990 | 6-03 | 50 μin |
| Amp & Gauge Head ☐ Surfometer ☐ | | | |
| Penta Prism ☐ Mikrokator ☐ | | | |
| | | | |
| Other ______ | | | |

(14) Grade: **(B)** **A** **AA** **N/A**

(15) Overall Accuracy / Flatness (actual): .000075 (allowed): .0002

(16) Repeat Measurement (actual): .000055 (allowed): (.00010") B .000050" A .000025" AA N/A

(FIM: Full Indicator Movement)

(17) Final Inspector Signature: [signature]

(18) Opinion / Interpretation (if applicable): ______

(21) Thread Size, Quantity & Location to Print: Yes ______ No ______

(22) Insert / Hole / Slot Size, Quantity & Location to Print: Yes ______ No ______

19-23 Are Not Applicable – No Inserts ☑

(23) Inspector Signature: ______

Existing inserts are not inspected on reworks and/or calibration items.

The results of this inspection apply only to the item described above. This report shall not be reproduced, except in full, with the written approval of our laboratory. Measurement uncertainty is expressed at a confidence level of 95% (coverage factor k=2).

## Shipping

(19) Threaded Inserts: Yes ______ No ______ (20) Clean: Yes ✓ No ______

Packaging Conforms to Company and Customer Requirements: Yes ✓ No ______

TRU-STONE Technologies

Save **IMPORTANT DOCUMENT** Save

## Tru-Stone Technologies
## Instructions for Care of Granite Surface Plates

1. **Cleaning and Moisture:** Plates shall be cleaned thoroughly and given adequate time to dry before testing for tolerance. Water based cleansers that have not dried will cause iron parts to rust if they are left in contact with the wet surface for an extended period of time. It is recommended that plates undergo drying time in a room with less than 50 percent relative humidity. Temperature and dirt have a direct correlation with measurement accuracy. Personal cleanliness will aid in eliminating one source of contamination.
2. **Temperature Soaking Time:** Before granite surface plates are measured for work surface flatness, the granite should remain in the calibration area until it has reached room temperature, which may require 2 to 3 days. Large plates require more soak-out time than smaller ones.
3. **Scratches and Nicks**: Whenever scratches and nicks appear on granite plates, the resulting rough edges should be removed with a flat granite dressing plate. Any bump that shatters the surface raises fractured material at the rim of the crater.
4. **Rotation of Plates:** When a specific work surface area receives prolonged usage, it is suggested that the plate and stand be rotated 180 degrees on a periodic basis to increase the wear life of the plate. The production of a contour map during calibration is particularly helpful in locating the parts of the plate that should be given the most use. This can be accomplished by requesting a long form certification when ordering the new surface plate or when the plate is being sent in for recalibration.
5. **Periodic Recalibration:** Periodic recalibration of granite surface plates is recommended to determine resurfacing or replacement needs. The interval between calibrations will vary with the grade of plate and the wear resistance of the granite. TRU-STONE CONFORMS TO ISO 9000 CERTIFICATION REQUIREMENTS FOR VENDORS. Frequent monitoring of the work surface by scanning it with the repeat gage is desirable. When these results differ from those marked on the replaceable sticker, you should recalibrate the plate. In addition to measuring the overall accuracy of a surface, smaller areas can be checked for localized variations often missed by the calibrating methods. Remember precision measurements are only as accurate as the measuring tools used.
6. **Torque on THREADED Inserts:** Do not exceed the following maximum torque values when using a torque wrench to limit distorting the work surface and pulling the insert. The following torque values are the maximum level permissible by the Federal Specification GGG-P-463c.

PERMISSIBLE TORQUE CLAMPING ON THREDED INSERTS

| *Thread Size* | *Torque* |
|---|---|
| .250 inch | 7 ft. lbs. |
| .3125 inch | 15 ft. lbs. |
| .375 inch | 20 ft. lbs. |
| .500 inch | 25 ft. lbs. |

7. **Clamping Ledges on Grade AA Surface Plates:** There is danger of distorting the work surface flatness beyond tolerance when a heavy item rests on the ledge or an item is clamped to the ledge. Ledges are not only expensive, but a great cause of inaccuracy. Experimentation and research reveal that no-ledge plates retain their accuracy better than ledged plates.
8. **Supports:** There are working and loading conditions where the standard three point supports are not satisfactory. These cases should be individually engineered. When four or more supports are used, shims or adjusting screws are necessary for proper support. The supports could be spotted under the loading points and set to approximately equal the loading. Sometimes the work surface flatness can be improved by shifting support positions. Fulcrum, air and hydraulic supports are available. Whenever nonstandard supports are used, the surface plate shall be calibrated at the site for compliance to the flatness tolerance.

1101 Prosper Drive • P. O. Box 430 • Waite Park, MN 56387 • 1-800-959-0517 • PH: 320-251-7171 • Fax: 320-259-5073

9. **Care:**
    - Utilize the full surface of a plate so the wear is distributed and not concentrated in one area.
    - The surface plate should not be overloaded.
    - Use extreme care in moving the item being measured and the gages being used.
    - Place on the surface ONLY what is required.
    - Particularly avoid heavy contact with the edges.
    - Don't leave metal objects on the surface longer than necessary.
    - Clean the surface before and after use.

***Remember that the condition of this accurate plane is an integral factor in the measurement being made.***

NOTE:

Surface plate cleaner can be purchased through your local Tru-Stone distributor or directly from Tru-Stone Technologies. Call for pricing and delivery information.

When the need for recalibration or rework of your surface plates and precision granite accessories arises, contact a Tru-Stone representative or call us directly for more details on restoring your inspection item to a "like new" condition. This service comes with new certification and plate labels.

One advantage of having your granite inspection equipment recalibrated by a manufacturer is the manufacturer's ability to take the time required to ensure the proper repeatability and overall shape of the inspection surface. Tru-Stone allows the item to normalize overnight prior to taking the final readings to indicate whether it is a good enough quality to certify and return to you.

Should you have any questions, please contact our customer service representatives at 320/251-7171 or fax us at 320/259-5073.

## Important Notice

Any streaks of color in the granite are not defects. These are created by the molten lava mixing with minerals prior to evolving into the granite you see today. Black streaks or spots are the result of a magnetite (black iron oxide) concentration. White streaks or spots are areas where the granite is lacking magnetite. The levels of magnetite in granite vary considerably, however the color of the granite in no way affects the functionality or quality of it.

## Our products are UNCONDITIONALLY Guaranteed

Please refer to the Federal Specification GGG-P-463c, which is followed by NIST (National Institute of Standards & Technology) for Granite Surface Plates.

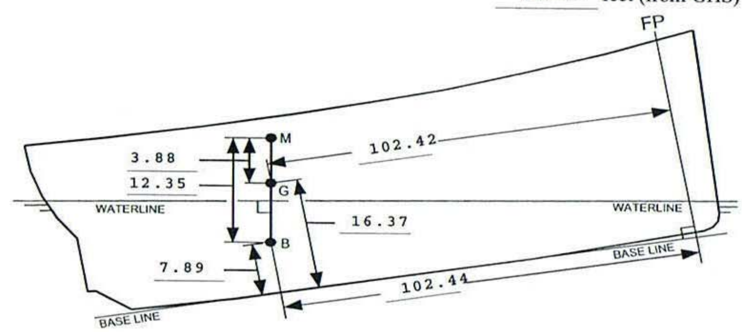
- "3.7 Seams or Color Streaks: *Seams are cause for rejection. Color streaks have no affect on the serviceability of the granite."*
- "4.5.8 Seams or Color Streaks: *Test for a seam is to wet the smooth surface of the granite where the color streak appears; then dry it off. If the streak remains wet or damp, it is a seam."*

STABILITY TEST: **NOAA Ship FAIRWEATHER (16 Jul 2004 )**

## SHIP AT TIME OF STABILITY TEST--CONDITION 0

| | | FROM HYDROSTATIC CURVES | FROM INDEPENDENT CALCULATION |
|---|---|---|---|
| Corrected diaplacement | | tons | 1638.79 tons |
| Mean virtual metacentric height obtained from plot of inclining moments versus tangents of angles of heel $\frac{\text{moment}}{\text{displacement x tangent}}$ | = 5987.252 / 1638.790 | feet | 3.65 feet |
| Correction for free surface | = 374.0 / 1638.790 | feet | 0.23 feet |
| Mean metacentric height G.M. = | | feet | 3.88 feet |
| Transverse metacenter above base line corresponding to draft at LCF (corrected for hog or sag) | | feet | |
| Transverse metacenter above base line corrected for trim, and hog or sag | | feet | |
| C.G. above base line | | feet | 16.37 feet (from figure) |
| | | | 16.36 feet (from GHS) |
| Longitudinal metacenter above C.G. | | feet | |
| Moment to alter trim 1 foot, (Long GM x Δ) / L | | ft-tons | |
| Trim by stern | | feet | |
| Trimming lever = (Trim x moment to trim) / displacement | | feet | |
| Longitudinal center of buoyancy (LCB) from origin | | feet | |
| C.G. from origin | | feet | 102.44 feet (from figure) |
| | | | 102.42 feet (from GHS) |

| | | | |
|---|---|---|---|
| Period of complete roll | | ______ | seconds |
| Apparent radius of gyration of vessel | $\alpha = \frac{T\,GM}{1.108}$ | ______ | feet |
| Rolling constant | $C = \frac{T\,GM}{B}$ | ______ | |




7/26/2004 8:05 AM

## Definitions and Basis for Dimensions/Locations

### Northings

Northings (Port - Starboard) are with reference to the IMU Foundation Plate centerline scribe.
Positive values are starboard of the IMU.
Negative values are port of the IMU.
*Calculated values are in italics.*

### Eastings

Eastings (Stern to Bow ) are with reference to the IMU Foundation Plate centerline scribe.
Positive values are forward of the IMU.
Negative values are aft of the IMU.
*Calculated values are in italics.*

### Elevations

Elevations are with reference to the IMU Foundation Plate centerline scribe = 0 elevation.
Positive values are below the IMU (toward the keel).
Negative values are toward the topside.

### Dimensions

All dimensions are in feet and decimal feet. All dimensions provided are "offsets" to IMU centerline.

### Ship's Centerline Data

At project initiation, control was established to define the ship's centerline
as a plane running from a point on the centerline of the keel at the stern through a
point on the centerline of the keel near the bow, to a point on the bow splitting the bow chock.

### IMU Referenced Data - Procedure

All data was originally referenced to the ship's geometry.
Following location of the IMU, data was transformed to the IMU as point of origin for
Northings, Eastings, and Elevation. All dimensions provided with reference to the IMU are "offsets."

## Ship's Centerline - Control Measurements

(Prior to location of IMU and referencing of data to IMU as point of origin (0,0,0)

Defined by measurements at the keel centerline

| | longitude | transverse | elevation |
|---|---|---|---|
| near the bow | 1190.674 | 1000.000 | 135.8672 |
| at the stern (point of origin) | 1000.000 | 1000.000 | 100.0000 |
| along the keel (approx 180' forward) | 1180.121 | 1000.000 | 116.6810 |

### Ship's Baseline

Defined by measurements on the keel

| | longitude | transverse | elevation |
|---|---|---|---|
| at the stern (point of origin) | 1000.000 | 1000.000 | 100.0000 |
| and approx. 129' forward of stern | 1129.120 | 999.985 | 100.0022 |

## IMU Foundation Plate

| | EASTING | NORTHING | ELEVATION |
|---|---|---|---|
| Horizontal alignment per scribed lines | | | |
| on IMU foundation plate | | **0.001** | |
| | | **0.000** | |
| Scribed lines - intersection/centerline of IMU plate | | | |
| | **0.000** | **0.000** | **0.000** |
| Elevation checks near four corners of IMU Foundation plate * | | | |
| ** elevation check adjusted for target that created 10 mm offset =.03281 feet* | | | **0.001** |
| | | | **-0.001** |
| | | | **0.000** |
| | | | **-0.001** |

**SUMMARY**

- IMU foundation plate is level to within +/-0.001 feet.
- IMU foundation plate is located 12.856 feet above baseline established at the keel.
- IMU is parallel to ship's centerline to within +/- 0.001 feet.
  Location of scribed centerline intersection is 6.122 feet port of ship's centerline.
- IMU foundation plate centerline is located 11.638' feet forward of bulkhead 52.

## Granite Block

| | EASTING | NORTHING | ELEVATION | |
|---|---|---|---|---|
| Horizontal alignment per scribed lines | | | | |
| | | **1.584** | | |
| | | **1.583** | | |
| Scribed lines - intersection/centerline of granite block | | | | |
| | **-0.003** | **1.583** | | |
| | | | | Deviation from level |
| Elevation checks near four corners of granite block | | | | |
| ** elevation check adjusted for target that created 10 mm offset = 0.03281 feet* | | | **-0.217** | -0.001 |
| | | | **-0.217** | -0.001 |
| | | | **-0.216** | 0.001 |
| | | | **-0.215** | 0.001 |

**SUMMARY**

- Granite block is level to within +/-0.001 foot
  of average elevation = -0.21632 feet
- Granite block is parallel to ship's centerline to within 0.001 foot
  Location is 4.54 feet to port of ship's centerline and 1.583 feet starboard of IMU.
- Granite block is aligned with IMU to within 0.003 feet longitudinally.

## Array Acoustical Centers - Referenced to IMU

| | EASTING | NORTHING | ELEVATION |
|---|---|---|---|
| **PORT ARRAY (81-60)** | ***25.149*** | ***1.619*** | ***14.956*** |

**Explanation of Calculations**

Acoustic center is defined as the center of the transmitter array with the elevation = 83 mm below mounting face of array.

**Easting**

Center of array is defined by the foundation plate bolt centerlines (1/2 distance between bolts)

| | |
|---|---|
| 27.008 | Forward edge of foundation as measured |
| - 0.104 | Forward edge of foundation to centerline of forward bolt hole |
| - 1.755 | Distance from bolt hole centerline to center of array |
| 25.149 | feet forward of IMU |

**Northing**

Center of array is defined as the mid-point between the bolt holes on the foundation.

| | |
|---|---|
| 1.369 | Port edge of foundation as measured |
| + 0.078 | Port edge of foundation to centerline of bolt hole - per Cascade General |
| + 0.172 | Distance from bolt hole centerline to array center |
| 1.619 | feet starboard of IMU |

**Elevation**

Per Reson drawing 2148M011_001 the elevation is 83 mm below array mounting surface

| | |
|---|---|
| 14.679 | Array foundation elevation as measured. |
| 0.005 | Isolation "shim" added between foundation and array |
| 0.272 | 83 mm below array mounting surface to acoustical center |
| 14.956 | feet below IMU |

## Array Acoustical Centers - Referenced to IMU

| | EASTING | NORTHING | ELEVATION |
|---|---|---|---|
| **STARBOARD ARRAY (81-11)** | ***27.072*** | **9.41** | ***15.042*** |

**Explanation of Calculations**

Acoustic center is defined as midpoint of the transmitter array in the longitudinal and transverse axes. The elevation is defined as the center of the receiving array.

**Easting**

Center of array is defined as 0.235' aft of the forward bolt centerlines on transmitter array foundation

| | |
|---|---|
| 28.563 | Forward edge of foundation fixture plate as measured (receiving plate forward edge) |
| 27.349 | Forward edge of transmitter array foundation as calculated |
| - 0.042 | Forward edge of foundation to centerline of forward bolt hole - per design |
| - 0.235 | Distance from bolt hole centerline to center of array - per design |
| 27.072 | feet forward of IMU |

**Northing**

Center of array is defined as the mid-point between the bolt holes on the transmitter array foundation.

| | |
|---|---|
| 9.410 | Centerline of array foundation as measured on scribe - aft section of fixture plate |
| 9.410 | feet starboard of IMU |

**Elevation**

Elevation is 0.401 feet above receiver array mounting surface

| | |
|---|---|
| 16.085 | Mounting foundation fixture plate as measured. |
| 15.447 | Receiver foundation elevation - as calculated |
| + 0.005 | Isolation "shim" added between foundation and array |
| - 0.410 | Design distance from mounting surface of array to acoustic center |
| 15.042 | feet below IMU |

## Longitudinal Array Foundation - Port Side

| | EASTING | NORTHING | ELEVATION | |
|---|---|---|---|---|
| Horizontal alignment *measured* at port edge of array foundation | | | | |
| | | **1.369** | | |
| | | **1.369** | | |
| Forward edge of array foundation - *measured* | | | | |
| | **27.008** | | | |
| Horizontal alignment - *calculated* to array centerline | | | | |
| *Foundation edge is 0.25 feet port of* | | ***1.619*** | | |
| *array centerline* | | ***1.619*** | | |
| | | | | deviation from |
| Elevation checks near four corners of array foundation | | | | level (average) |
| | | | **14.680** | 0.001 |
| | | | **14.681** | 0.002 |
| | | | **14.678** | -0.001 |
| | | | **14.677** | -0.002 |

**SUMMARY**

- Port longitudinal array foundation average elevation is 14.679 feet.
  Variation in elevation is +0.002 to -0.002 feet.
- Port longitudinal array foundation is parallel to ship's centerline and 1.369 feet starboard of IMU.
  Calculated array centerline is 1.619 feet starboard of IMU

## Longitudinal Array Foundation - Starboard Side

| | EASTING | NORTHING | ELEVATION | deviation from |
|---|---|---|---|---|
| Horizontal alignment *measured* on fixture plate scribe - | | | | *parallel* |
| *Design location is 3.292 feet* | | **9.410** | | 0.002 |
| *starboard of ship centerline* | | **9.406** | | -0.002 |
| Forward edge of array foundation fixture plate - *measured* | | | | |
| | **28.563** | | | |
| | | | | deviation from |
| Elevation checks near four corners of array foundation "fixture plate" | | | | *average* |
| | | | **16.085** | 0.000 |
| | | | **16.085** | 0.000 |
| | | | **16.084** | 0.000 |
| | | | **16.085** | 0.000 |
| *Calculated locations of longitudinal and transverse array foundations* | | | | |
| *Forward edge* | | | | |
| Receiver (transverse) | **28.563** | | | |
| *Transmitter (longitudinal)* | ***27.349*** | | | |
| *difference = 1.214* | | | | |

***NOTE:*** *On Transmitter array foundation - from forward edge to center of forward holes = 0.042'*
*On Receiver array foundation distance from forward edge to center of forward holes = 0.076'*

| | EASTING | NORTHING | ELEVATION |
|---|---|---|---|
| *Calculated elevation of longitudinal and transverse array foundations* | | | |
| *Receiver/Transverse Foundation* | | | ***15.446*** |
| *Transmitter/Longitudinal Foundation* | | | ***15.709*** |
| *difference = 0.263* | | | |

**SUMMARY**

- Starboard longitudinal array foundation (measured at fixture plate) average elevation is 16.085 feet.
  Deviation from level (average elevation) is less than 0.001 feet.
- Starboard longitudinal array foundation averages 9.408 feet starboard of IMU.
  Variation from parallel is from -0.002 feet to +0.002 feet from average.
- Starboard longitudinal array foundation forward edge is 28.563 feet forward of IMU.

## Transverse Array Foundation - Port Side

| | EASTING | NORTHING | ELEVATION | |
|---|---|---|---|---|
| Forward Edge - Transverse array foundation - *measured* | | | | |
| | **28.343** | | | |
| | **28.338** | | | |
| Port edge - Transverse array - *measured* | | | | |
| | | **-0.181** | | |
| Centerline of array - *calculated* | | | | |
| *Foundation forward edge minus* | ***28.093*** | | | |
| *0.25 feet to array centerline* | ***28.088*** | | | |
| *Port edge of foundation plus 1.806 feet* | | ***1.624*** | | |
| *to calculated array centerline* | | | | |
| | | | | deviation from |
| Elevation checks near four corners of array foundation | | | | level |
| | | | **14.679** | 0.002 |
| *0.861 feet below baseline with 0.965* | | | **14.675** | -0.001 |
| *foot offset = 98.180 feet average* | | | **14.675** | -0.001 |
| *elevation* | | | **14.677** | 0.001 |

**SUMMARY**

- Transverse array foundation average measured elevation is 14.677 feet
  below IMU (0.006 feet above design location).
  Deviation from level (average elevation) is 0.003 to -0.001 feet
- Transverse array foundation centerline (calculated) averages 28.090 feet forward of IMU.
  Variation from parallel to ship's centerline is from -0.003 to 0.003 feet (from average).
- Transverse array centerline is calculated to be 1.624 feet starboard of IMU.

## Transverse Array Foundation - Starboard Side

NOTE: Direct Measurements were not taken to the transverse array because a single "fixture plate" covered bo
transmitter and receiver foundations. The data provided here is primarily *"calculated".*

| | EASTING | NORTHING | ELEVATION |
|---|---|---|---|
| Forward edge - as measured on fixture plate | | | |
| Receiver - (transverse) | **28.563** | | |
| as measured | | | |
| *Transmitter (longitudinal)* | ***27.349*** | | |
| *difference = 1.214* | | | |
| ***NOTE:*** *On Transmitter array foundation - from forward edge to center of forward holes = 0.042'* | | | |
| *On Receiver array foundation distance from forward edge to center of forward holes = 0.076'* | | | |
| Horizontal Alignment | | **9.406** | |
| centerline scribe on fixture plate | | | |
| as measured - forward portion of plate | | | |
| (near receiver array) | | | |
| *Average of measurements on fixture plate* | | ***9.408*** | |
| *Elevation of longitudinal and transverse array foundations* | | | |
| *Receiver/Transducer Transverse Foundation* | | | ***15.446*** |
| *Transmitter/Longitudinal Foundation* | | | ***15.709*** |
| *difference = 0.263* | | | |

Based on measured elevations averaging 16.085 feet across fixture plate

**SUMMARY**

- Transverse array foundation is calculated to be 15.446 feet below IMU - calculated from measured elevation of 16.085 feet. Deviation in elevation measurements across the array fixture plate is less than 0.001 fe
- Transverse array foundation forward edge (measured) is 28.563 feet forward of IMU.
- Transverse array centerline is measured to be 9.406 feet starboard of IMU.

  Variation from parallel of the fixture plate across entire starboard array is ± 0.002 feet (from average).

## Antennae

| | EASTING | NORTHING | ELEVATION |
|---|---|---|---|
| Stbd POS MV Antenna -Location | **-35.866** | **12.925** | **-38.209** |
| Port POS MV Antenna - Location | **-35.739** | **-0.409** | **-38.283** |
| Foundation Plate Stack Antenna Alignment | | **7.677** | |
| Foundation Plate Stack Antenna Alignment | | **7.677** | |
| Port GYRO Foundation Plate Alignment | | **2.411** | |
| Port GYRO Foundation Plate Alignment | | **2.411** | |
| Stbd GYRO Foundation Plate Alignment | | **3.866** | |
| Stbd GYRO Foundation Plate Alignment | | **3.867** | |

**SUMMARY**

- Foundation plate stack antenna alignment is parallel to ship's centerline.
- Port GYRO Foundation Plate is aligned parallel to ship's centerline.
- Starboard GYRO Foundation Plate is aligned parallel to ship's centerline.

# Waterline Measurements

Fill in Yellow squares only!

Measuring Party: Rice, Argento, Campbell, Beduhn

Waterline Measurements should be Negative!

| | 1010 | |
|---|---|---|
| | Benchmark A to Waterline | Benchmark B to Waterline |
| Measure 1 | -86.2 | -88.5 |
| Measure 2 | -86.6 | -89.2 |
| Measure 3 | -87.6 | -96.0 |
| Avg (cm) | -86.80 | -91.23 |
| Avg (m) | -0.8680 | -0.9123 |
| Stdev | 0.00721 | 0.04143 |
| BM Z-value (m) | -0.02017 | -0.05283 |
| BM C to WL (m) | -0.888 | -0.965 |

| | | | |
|---|---|---|---|
| Individual measurement | | -0.88217 | -0.93783 |
| | | -0.88617 | -0.94483 |
| StDev for TPU xls (of 6 #'s) | 0.04986 | -0.89617 | -1.01283 |

Date: 4/7/2009 Dn 097

Fuel Level: .5+

Draft Tube:

Port-to-Stbd Z-difference

| Theoretical | Actual | Error |
|---|---|---|
| 0.0327 | -0.0443 | -0.0770 |

BM C to WL Average (m)

-0.927 (This value added to 1010_Offsets & Measurements_200X.xls)

utilized in Offsets and Measurements and TPU spreadsheet

This spreadsheet is designed to compute the z-values of the phase centers of the new POS M/V antenna.

**All offsets are in the Theodolite Coordinate System**

| | | |
|---|---|---|
| BM E | x | 1.665536 |
| | y | -0.892424 |
| | z | 1.612667 |
| BM F | x | 1.668082 |
| | y | -0.001217 |
| | z | 1.649000 |
| BM G | x | 1.668115 |
| | y | 0.957794 |
| | z | 1.578000 |

| | | |
|---|---|---|
| Port Ant | x | 2.316862 |
| | y | -0.886431 |
| | z | Unknown |
| Stbd Ant | x | 2.324270 |
| | y | 0.952574 |
| | z | Unknown |

POS MV V4 Installation and Operation Guide

Drawings

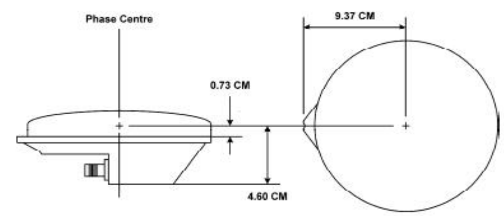



Figure 79: GPS Antenna Footprint

| **Measuring Party (fill in yellow spaces only):** | **Date:** | **Serial #- Port** | **Serial #- Stbd** |
|---|---|---|---|
| Rice, Argento, Campbell, Beduhn | 4/7/2009 | 60162863 | 60145247 |

| **Distances** | | | | | z-Values Ant. Base | Phase Center | |
|---|---|---|---|---|---|---|---|
| Port Ant to BM 'E' | 0.693 | 0.693 | 0.693 | 0.70575 | 1.884369 | 1.930369 | |
| Port Ant to BM 'F' | 1.11 | 1.11 | 1.112 | 1.1234167 | 1.888889 | 1.934889 | |
| Port Ant to BM 'G' | 1.967 | 1.97 | 1.97 | 1.98175 | 1.902489 | 1.948489 | |
| | | | | | 1.886629 | 1.932629 | AVERAGE |
| | | | | | | 0.0094 | STDEV |
| Stbd Ant to BM 'E' | 1.959 | 1.964 | 1.962 | 1.9744167 | 1.858381 | 1.904381 | |
| Stbd Ant to BM 'F' | 1.166 | 1.167 | 1.167 | 1.1794167 | 1.874221 | 1.920221 | |
| Stbd Ant to BM 'G' | 0.707 | 0.705 | 0.705 | 0.7184167 | 1.870499 | 1.916499 | |
| | | | | | 1.872360 | 1.918360 | AVERAGE |
| | | | | | | 0.0083 | STDEV |

| Antenna Post | Diameter | Radius |
|---|---|---|
| | 0.0255 | 0.01275 |

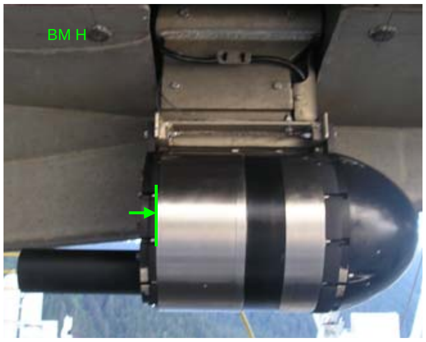
The distances from the antenna post to each benchmark was measured three times and averaged. The post offset to phase center (radius) was then added.

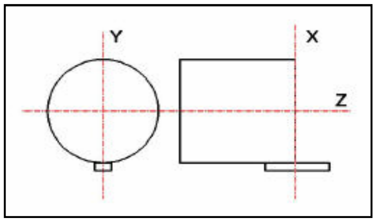
The distance is 0.046m (4.60cm) from the bottom of the antenna to the Phase center, obtained from the POSM/V v4 guide, see image above.

# Offsets from Aft Benchmark to Phase Center of Transducer

| 3/20/2009 | 79 | Launch 1010 | Campbell, Argento, Beduhn |
|---|---|---|---|
| Date | DN | Vessel | Personnel |

| 2701011 |
|---|
| Serial Number of Transducer |




**Instructions:** The purpose of this measurement is to check for gross movement of the tranducer. **Fill in yellow spaces only.**

While the boat is in the cradle, gently lower the transducer and lock it in place. Using a metric tape measure, plumb bob and carpenter's level, measure the horizontal and vertical offsets from the aft benchmark (BM H) to the phase center of the transducer. The phase center is measured at the forward edge of the black insulating layer, as shown in the photos. If you have trouble locating the center, borrow a compass from the navigation department.

Notwithstanding a major accident, BM H will be outboard, aft and higher than the phase center; as such, enter all offsets as positive numbers (in cm) and the proper signs will be applied.

Once offsets have been measured, apply a digital level to the IMU to determine any pitch or roll bias in the orientation of the launch. For the purposes of this spreadsheet, a positive angle (measured in degrees) will imply the bow is higher than the stern and the port side is higher than the starboard side.

All measurements should be done in triplicate to aid in the calculation of the uncertainty (needed in the HVF). The *IMU to Phase Center* values will be calculated automatically.

| **Offset Measurements (positive cm):** | | | | **Average** |
|---|---|---|---|---|
| Bow-Stern | 10.6 | 10.7 | 11.0 | 10.8 |
| Port-Stbd | 15.9 | 15.9 | 15.8 | 15.9 |
| Up-Down | 35.5 | 35.4 | 36.0 | 35.6 |

| **Angle Bias (deg):** | |
|---|---|
| Bow Up | |
| Port Up | |

The measuring crew should insure there will be no yaw bias.

| **Std Dev:** | |
|---|---|
| Bow-Stern | 0.16 |
| Port-Stbd | 0.05 |
| Up-Down | 0.30 |

**BM H to Phase Center**

(Theodolite Coordinate System)

x #REF! cm

y #REF! cm

z #REF! cm

Measured by NOAA Personnel
inserted into Offset Worksheet,
if to be used in IMU to 8101 calculation

**IMU to Phase Center**

(CARIS Coordinate System)

x #REF! m

y #REF! m

z #REF! m

Calculated Value for check purposes

These 2009 values were not used for the hvf offsets due to the angle bias not being entered. The 2008 values were used instead and the 2009 values were used as a check that the unit had not been displaced.

# 1010 Offsets and Measurements - Summary

| Measurement aka Coord. Sys. | IMU to RP* Caris | 8101 to RP* Caris | IMU to 8101 SWATH1 x,y,z & MRU to Trans Caris | Port Ant to 8101 Nav to Trans x,y,z Caris | RP* to Waterline Caris |
|---|---|---|---|---|---|
| x | 0.000 | 0.250 | 0.250 | 1.147 | n/a |
| y | 0.000 | -0.133 | -0.133 | 1.066 | n/a |
| z | 0.000 | 0.549 | 0.549 | 3.665 | -0.256 |

*IMU is RP (Reference Pt)

Vessel Offsets for 1010_8101 are derived from the Horizontal, Vertical & XYZ worksheets in this spreadsheet. 2008 Measured Values

## Calculations

Coord. Sys. Theodolite

8101 to RP*

| IMU to 8101 | | | Port Ant to 8101 | | | RP to Waterline | | |
|---|---|---|---|---|---|---|---|---|
| IMU (m) | x | 3.516 | IMU (m) | x | 3.516 | IMU (m) | x | 3.516 |
| | y | 0.011 | | y | 0.011 | | y | 0.011 |
| | z | -1.183 | | z | -1.183 | | z | -1.183 |
| BM H | x | 3.271447 | Port Antenna | x | 2.317 | BM C | x | 0.000 |
| | y | 0.425598 | | y | -0.886 | | y | 0.000 |
| | z | -1.37667 | | z | 1.933 | | z | 0.000 |
| IMU | x | -0.244 | IMU to | x | -1.199 | BM C to IMU | | |
| to BM H | y | 0.415 | Port Antenna | y | -0.897 | | x | n/a |
| | z | -0.194 | | z | 3.116 | | y | n/a |
| | | | | | | | z | -1.183 |
| BM H to | x | 11.10496 | IMU to | x | -0.133 | | | |
| Phase Ctr (cm) | y | -16.466 | Phase Ctr | y | 0.250 | BM C to Waterline | | |
| measured | z | -35.540 | | z | -0.549 | measured | x | n/a |
| | | | | | | | y | n/a |
| BM H to | x | 0.11105 | | | | | z | -0.927 |
| Phase Ctr (m) | y | -0.16466 | | | | | | |
| | z | -0.3554 | | | | | | |

see

Coord. Sys. Theodolite

IMU to 8101

| IMU to 8101 | | | Port Ant to 8101 | | | RP to Waterline | | |
|---|---|---|---|---|---|---|---|---|
| IMU to | x | -0.133 | | x | 1.066 | | x | n/a |
| Phase Ctr | y | 0.250 | | y | 1.147 | | y | n/a |
| | z | -0.549 | | z | -3.665 | | z | 0.256 |
| Coord. Sys. CARIS | | | Coord. Sys. CARIS | | | Coord. Sys. CARIS | | |
| | x | 0.250 | | x | 1.147 | | x | n/a |
| | y | -0.133 | | y | 1.066 | | y | n/a |
| | z | 0.549 | | z | 3.665 | | z | -0.256 |

# 1010 Offsets and Measurements - Summary

| Port Ant to Stbd Ant | | IMU to Port Antenna | | IMU to Heave | |
|---|---|---|---|---|---|
| | | Caris | Pos/Mv | Caris | Pos/Mv |
| Scalar Distance | 1.839 | -0.897 | -1.199 | -0.011 | -1.176 |
| | | -1.199 | -0.897 | -1.176 | -0.011 |
| | | -3.117 | -3.117 | -0.243 | -0.243 |

**Values in the POSMV remained as entered in 2008.**

2009 Measured Values

2007 Measured Values

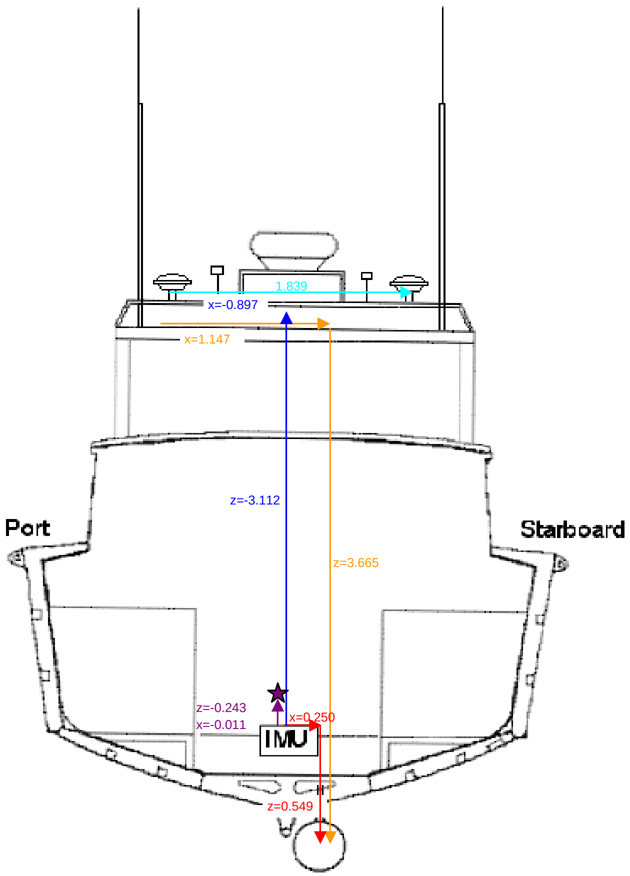
| Port Ant to Stbd Ant | | | IMU to Port Antenna | | | IMU to Heave | | |
|---|---|---|---|---|---|---|---|---|
| Port Ant (m) | x | 2.317 | IMU (m) | x | 3.516 | IMU (m) | y | 0.011 |
| | y | -0.886 | | y | 0.011 | x is n/a | z | -1.183 |
| | z | 1.933 | | z | -1.183 | | | |
| | | | | | | Heave Pt (m) | | |
| Stbd Ant (m) | x | 2.324 | Port Ant (m) | x | 2.317 | (centerline) | y | 0.000 |
| | y | 0.953 | | y | -0.886 | | | |
| | z | 1.918 | | z | 1.934 | BM C to Waterline (m) measured scalar dist | | -0.940 |
| | | | | | | BM C x&y are n/a | z | 0.000 |
| | | | | | | BM C to Waterline (m) (Heave Pt) | z | -0.940 |
| | | | | | | IMU to LCG | x | -1.176 |
| | | | | | | See IMU to Heave tab | | |

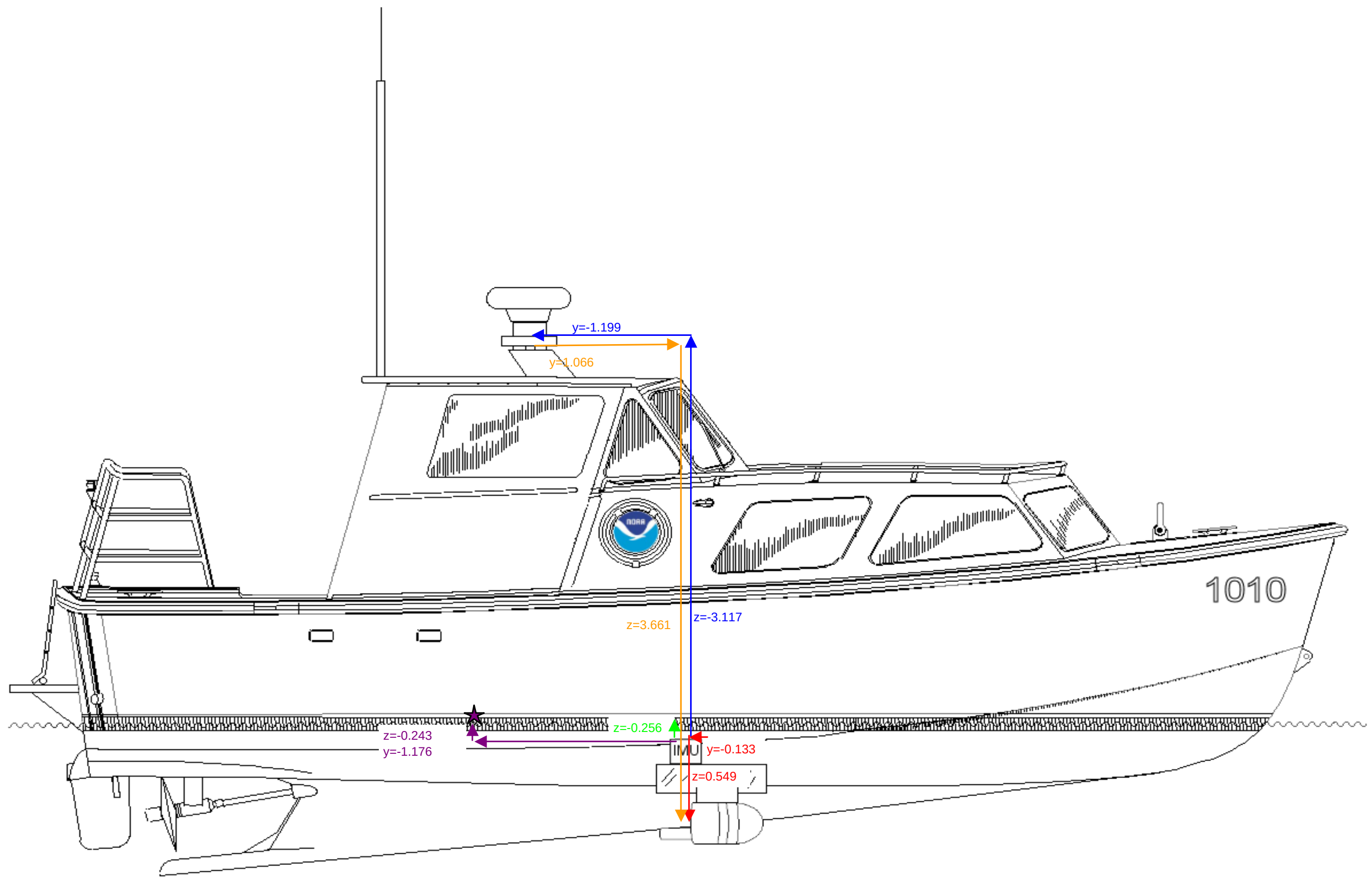
| Port Ant to Stbd Ant | | IMU to Port Antenna | | | IMU to Heave | | |
|---|---|---|---|---|---|---|---|
| | | | x | -1.199 | | x | -1.176 |
| Scalar Distance | 1.839 | | y | -0.897 | | y | -0.011 |
| | | | z | 3.117 | | z | 0.243 |
| | | Coord. Sys. Pos/Mv | | | Coord. Sys. Pos/Mv | | |
| | | | x | -1.199 | | x | -1.176 |
| | | | y | -0.897 | | y | -0.011 |
| | | | z | -3.117 | | z | -0.243 |
| | | | | | See IMU to Heave tab | | |

# Description of Offsets for Launch 1010

All Values Shown are in CARIS Coordinates

The Ship Reference Frame (SRF) for Launch 1010 was based from benchmark (BM) C as the 0 point. Physical locations were measured with x,y,z offsets from this point. These locations were used to calculate offsets of items with respect to each other, as described for each offset.



| IMU to 8101 | | |
|---|---|---|
| x | y | z |
| 0.250 | -0.133 | 0.549 |

The physical positions of the IMU and the phase center of the 8101 with respect to the Ship Reference Frame were measured by NOAA personnel. These physical measurements were used to calculate the xyz offsets from the IMU to BM H. Measurements from BM H to the Phase Center of the 8101 were collected by NOAA personnel while the boat was secured on the pier and thought to be as level as possible. The measured offsets from BM H to the phase center were then added to the offset from the IMU to BM H. The result is the offset from the IMU to the phase center of the transducer. The values in the X and Y fields are transposed and the inverse of the Z value is used to give the offsets in CARIS coordinates.

| Port Ant to 8101 | | |
|---|---|---|
| x | y | z |
| 1.147 | 1.066 | 3.665 |

NOAA personnel calculated the distance between the port antenna and the phase center of the port antenna subtracting the IMU to Port Antenna value from the IMU to Phase Center value.

| RP to Waterline | | |
|---|---|---|
| x | y | z |
| N/A | N/A | -0.256 |

The average vertical distance from BM A and B to the waterline was measured by FAIRWEATHER personnel using a steel tape and bubble level. These values were used to calculate the BM C to the waterline value. With the knowledge of the BM C height above the IMU, the waterline height above the IMU could be calculated. On launch 1010, the IMU is used as the reference point.

| Port Ant to Stbd Ant |
|---|
| Scalar Distance |
| 1.839 |

The location of the phase center of the port and starboard POS/MV antennas were measured by NOAA personnel with respect to the SRF. The scalar distance between the phase centers was then calculated.

| IMU to Port Antenna | | |
|---|---|---|
| x | y | z |
| -0.897 | -1.199 | -3.117 |

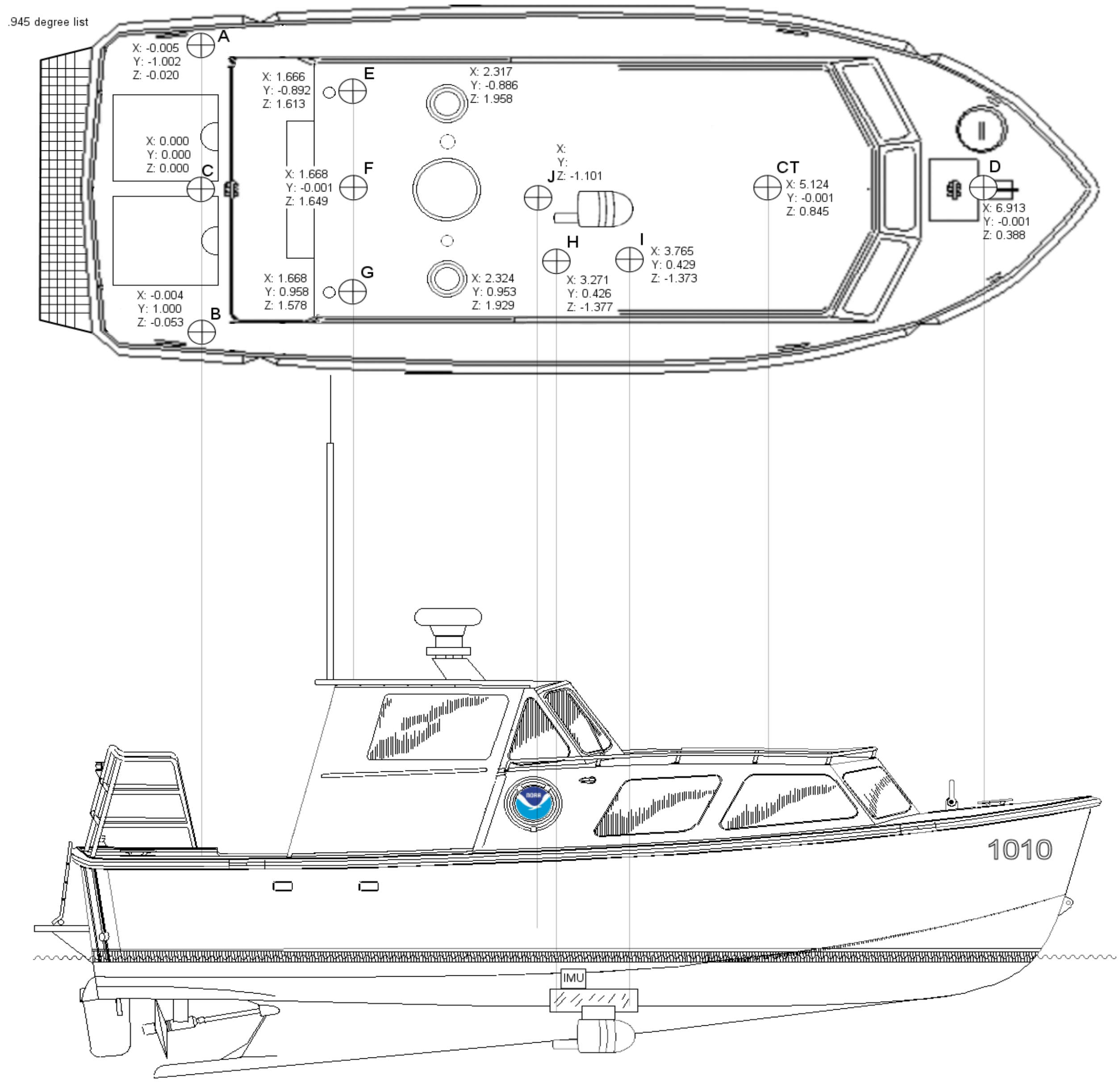
The location of the IMU and the location of the port antenna were measured by NOAA personnel with respect to the Ship Reference Frame (SRF). The xyz offsets from the IMU to the port antenna could be calculated from these physical locations.

| IMU to Heave | | |
|---|---|---|
| x | y | z |
| -0.011 | -1.176 | -0.243 |

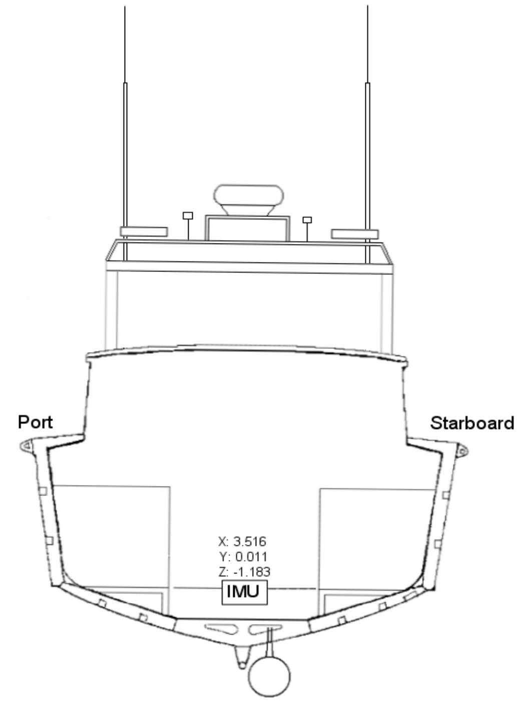
The heave point was positioned differently on each of the axes. The distance for the longitundinal axis was determined as described in the "IMU to Heave" tab in this workbook. The athwart ships axis was the vessel centerline. Lastly, the waterline was used as the height of the heave point, which was calculated earlier in 'RP to Waterline'.

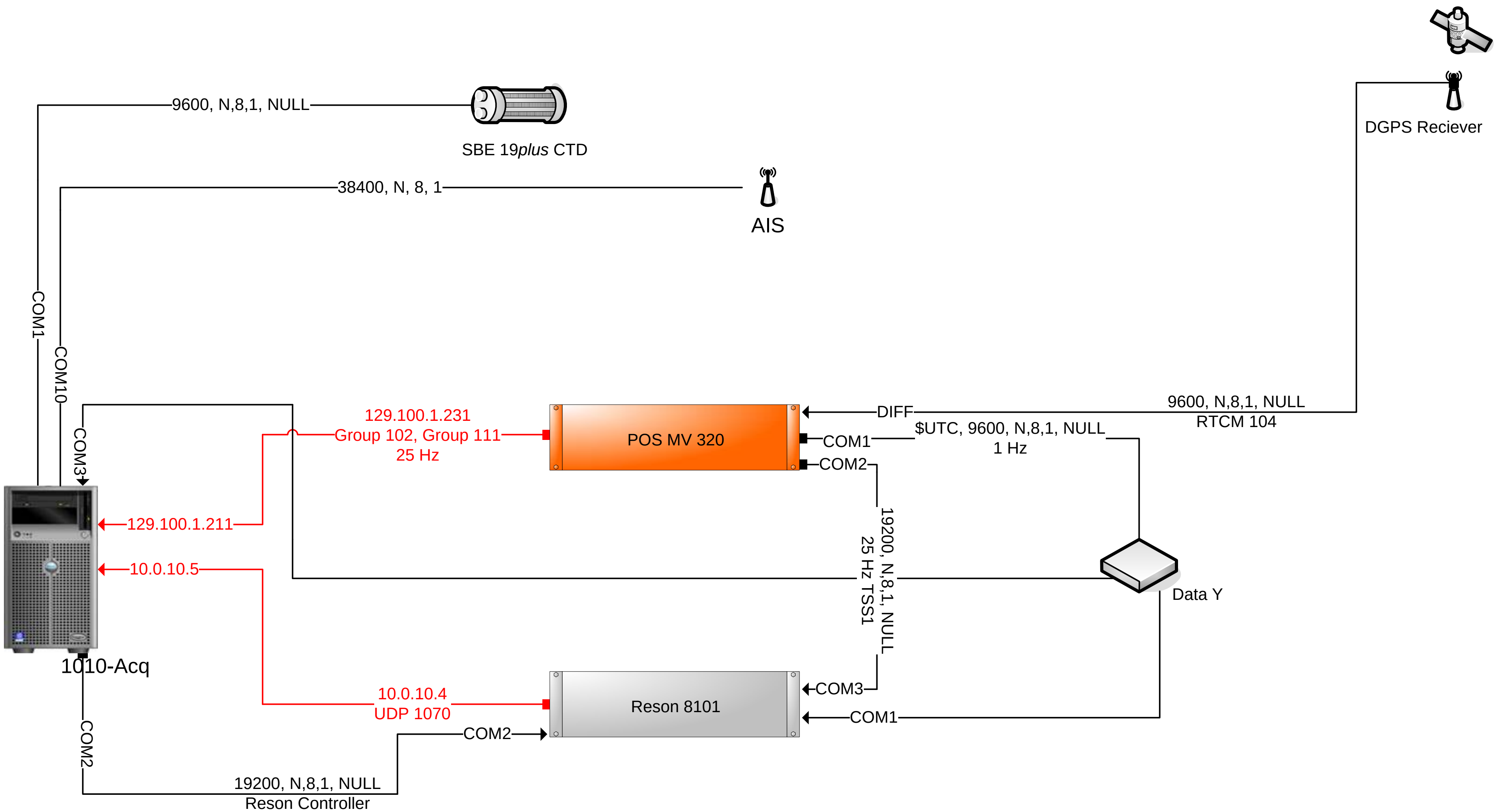
# 1010 Vessel Diagram

All Values Shown are in Theodolite Coordinates




Note: Both antenna have been replaced for the POS V4. While their x-y values are not thought to have changed, the z-value has been remeasured.






Key

- Serial
- Crossover
- Patch

## Launch 1010 Wire Diagram

| Rev 3.0 | 12 July 2009 | LT Ringel |
| --- | --- | --- |

# NOAA POS/MV Calibration Report

**Fill out all fields!** See previous years as an example.

**Yellow areas require screen grabs!**

**Ship:** **FAIRWEATHER** | **Vessel:** **1010**

**Date:** **4/15/2009** | **Dn:** **105**

**Personnel:** W Renoud, L Morgan, T Beduhn

**PCS Serial #** 2564 | **IMU Serial #** **294**

**IP Address:** **129.100.1.231**

**Port Antenna Serial #** 60162863 | **Stbd Antenna Serial #** 60145247

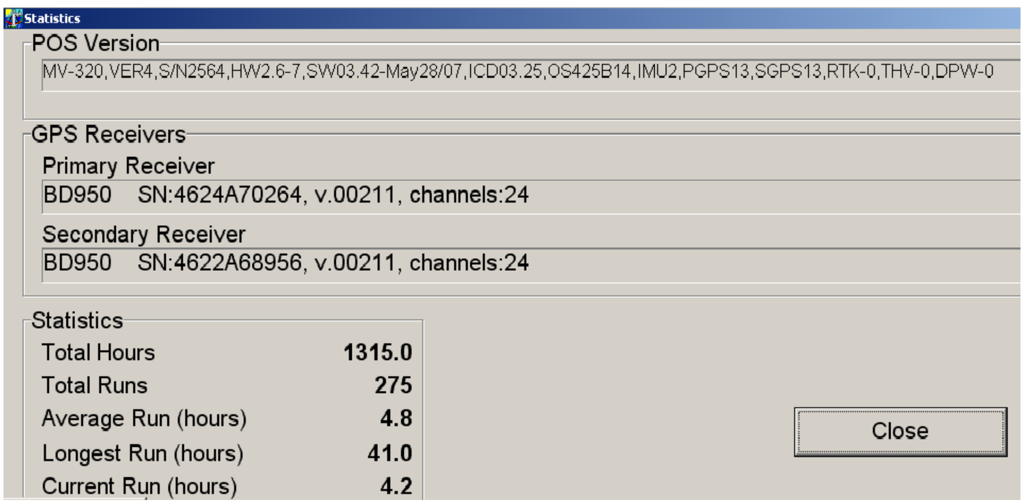
**POS controller Version (Use Menu Help > About)** 3.4.0.0

**POS Version (Use Menu View > Statistics)** MV-320,VER4,S/N2564,HW2.6-7,SW03.42-May28/07,ICD03.25, OS425B14,IMU2,PGPS13,SGPS13,RTK-0,THV-0,DPW-0

**GPS Receivers**

Primary Receiver Serial #: 4624A70264

Secondary Receiver Serial #: 4622A68956




## Calibration area

**Location:** Lake Washington, N of Sandpoint

**Approximate Position:**

| | | | |
|---|---|---|---|
| **Lat** | 47 | 43 | 41 |
| **Lon** | 122 | 16 | 30 |

**DGPS Beacon Station:** Whidbey | **DGPS Receiver Serial#:** 0331-12579-0008

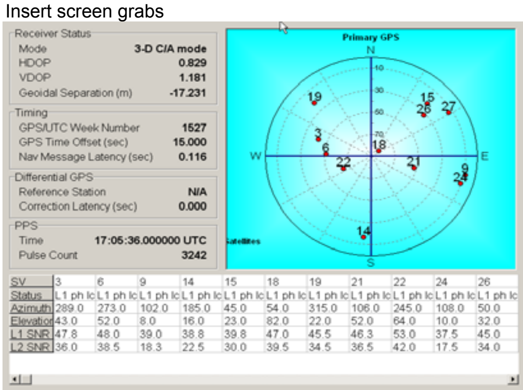
**Frequency:** 302HZ

## Satellite Constellation

(Use View> GPS Data)

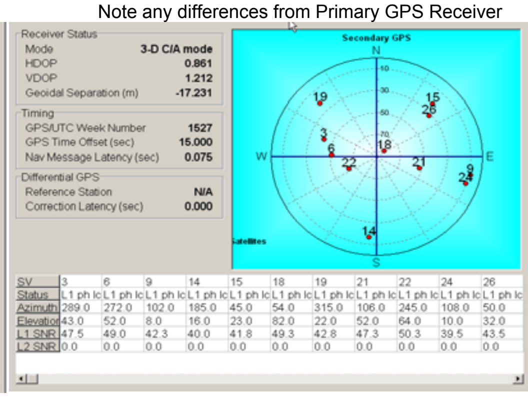
### Primary GPS

Insert screen grabs




### Secondary GPS

Note any differences from Primary GPS Receiver

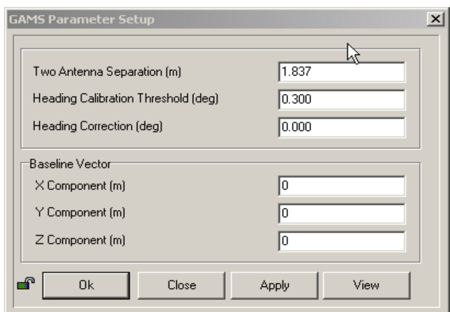



**PDOP** 1.736 (Use View> GAMS Solution)

## POS/MV Configuration

### Settings

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




**Configuration Notes:**

## POS/MV Calibration

### Calibration Procedure:

(Refer to POS MV V4 Installation and Operation Guide, 4-25)

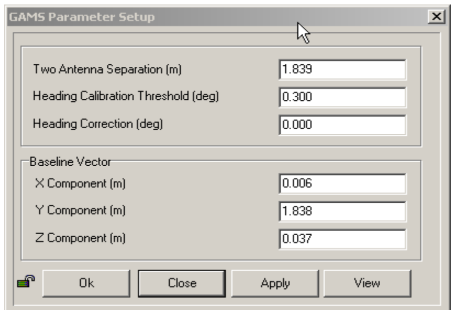
Start time: ____________________

End time: ____________________

Heading accuracy achieved for calibration: 0.091°

### Calibration Results:

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




GAMS Status Online X

Save Settings X

**Calibration Notes:**

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

File Name: 1010_Dn105_POS_Config_new.nvm

## General Notes:

**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.

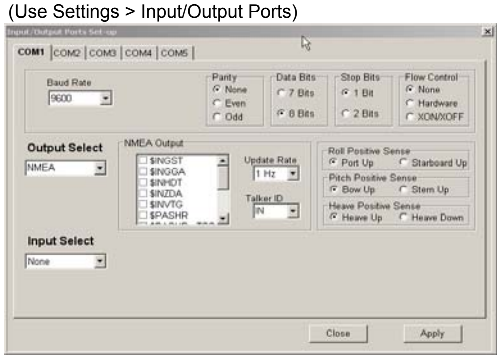
b) Pitch rotation - apply a right-hand screw rotation θy about the once-rotated y-axis to align one frame with the other.

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

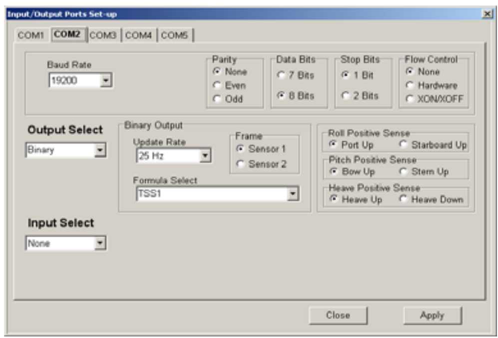
## SETTINGS

**Input/Output Ports** (Use Settings > Input/Output Ports)

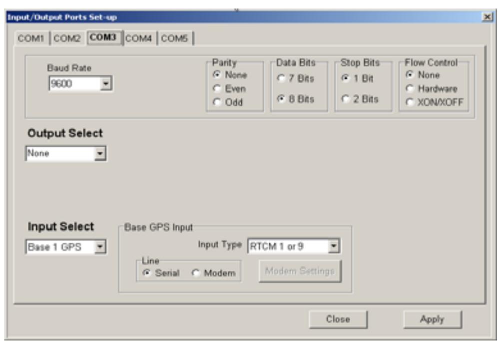
**COM1**



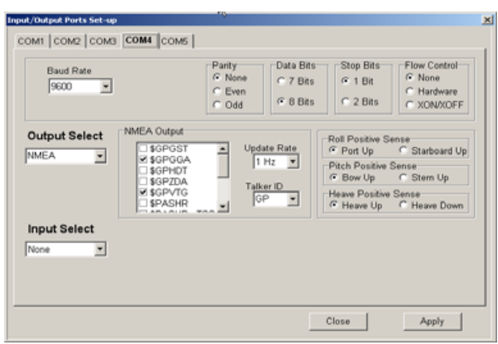

**COM2**



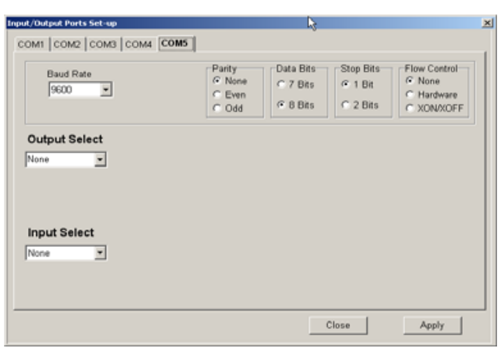

**COM3**




**COM4**

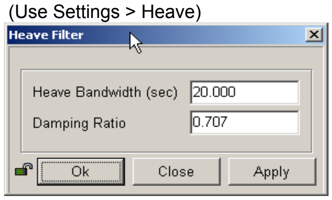



**COM5**

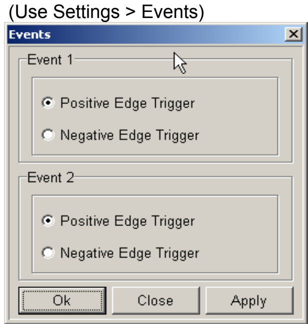


## SETTINGS Continued

**Heave Filter** (Use Settings > Heave)




**Events** (Use Settings > Events)

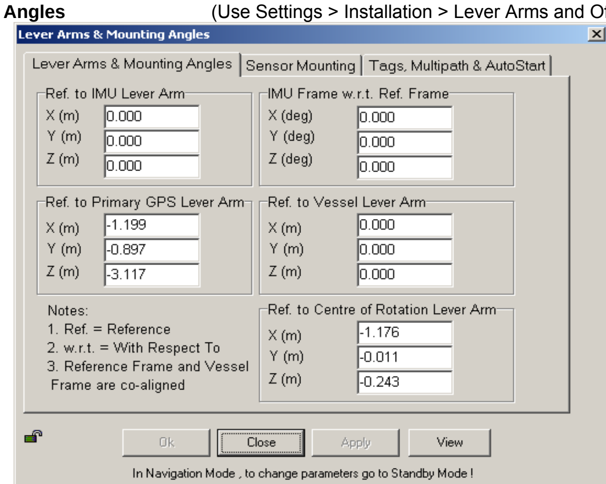



**Time Sync** (Use Settings > Time Sync)

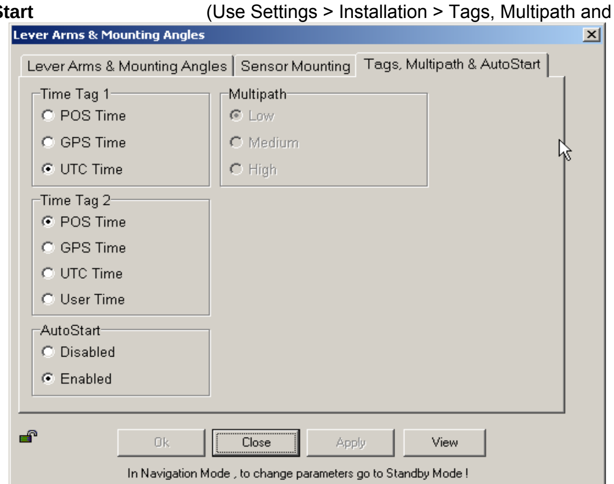
User Time Conversion (Units/Sec.)

## INSTALLATION (Use Settings > Installation)

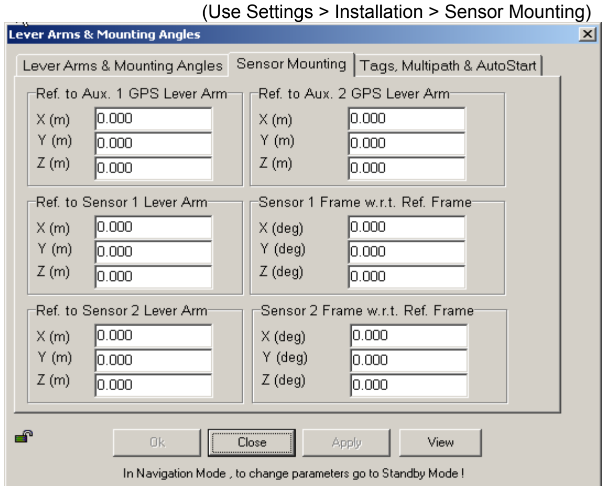
**Lever Arms and Mounting Angles** (Use Settings > Installation > Lever Arms and Offsets)



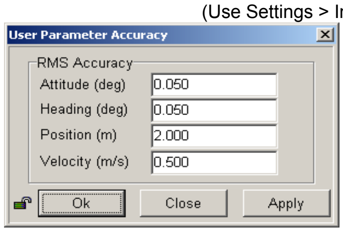

**Tags, Multipath and Auto Start** (Use Settings > Installation > Tags, Multipath and Auto Start)



**Sensor Mounting** (Use Settings > Installation > Sensor Mounting)




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




**Frame Control** (Use Tools > Config)

User Frame
IMU Frame

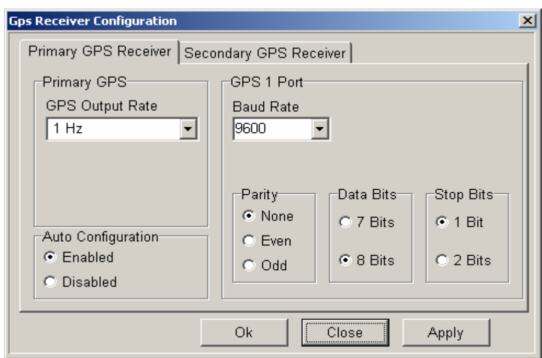
Primary GPS Measurement
Auxiliary GPS Measurement

**Use GAMS enabled**

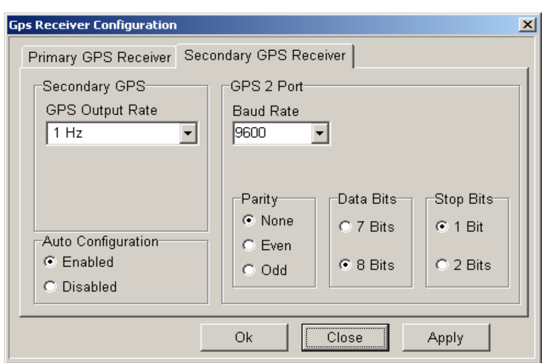
## GPS Receiver Configuration

(Use Settings> Installation> GPS Receiver Configuration)

**Primary GPS Receiver**




**Secondary GPS Receiver**



**FAIRWEATHER**

**Multibeam Echosounder Calibration**

| Launch 1010 |
|---|
| Vessel |

| 4/17/2009 | 107 | Lake Washington, Seattle, Washington |
|---|---|---|
| Date | Dn | Local Area |

| Rice, Beduhn, Forney, Marcum |
|---|
| Calibrating Hydrographer(s) |

| Reson 8101 | Swing Arm-Hull Mount | not available |
|---|---|---|
| MBES System | MBES System Location | Date of most recent EED/Factory Check |

| 2701011 | 35737 |
|---|---|
| Sonar Serial Number | Processing Unit Serial Number |

| Swing Arm | 3/20/2009 |
|---|---|
| Sonar Mounting Configuration | Date of current offset measurement/verification |

| DGPS - Woodby Island | 4/15/2009 |
|---|---|
| Description of Positioning System | Date of most recent positioning system calibration |

**Acquisition Log**

| 4/17/2009 | 107 | Lake Washington | 5-10kt, >1ft |
|---|---|---|---|
| Date | Dn | Local Area | Wx |

| | 10m-80m |
|---|---|
| Bottom Type | Approximate Water Depth |

| Marcum, Rice, Forney, Beduhn |
|---|
| Personnel on board |

| Beacon: 302 Hz Whidbey, MBES lines 2009__1071850_1 through 2009__1072047_5, 24 lines collected |
|---|
| Comments |

| TH_1010_107 |
|---|
| TrueHeave filename |

| | UTC Time | Lat | Lon | Depth | Ext. Depth |
|---|---|---|---|---|---|
| SV Cast #1 filename: 09107175_4616.5nv | 0:00 | 47/39/01.97 | 122/16/17.32 | 51 | |
| SV Cast #2 filename: 09107202.3nv | 0:00 | 47/39/15.82 | 122/15/31.53 | 51 | |
| SV Cast #3 filename: 09107210.0nv | 0:00 | 47/39/08.84 | 122/14/06.18 | 15 | 20 |

## NAV TIME LATENCY

view parallel to track, one line with induced roll (outerbeam) or same lines bounded slope (nadir) [same direction, different speed]

| SV Cast # | XTF Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| 1 | 2009_1071923_1 | 271 | 5.4 | |
| 1 | 2009_1071925_1 | 093 | 5.1 | |
| 1 | 2009_1071927_1 | 272 | 5.0 | |
| 1 | 2009_1071929_1 | 091 | 5.0 | |
| 1 | 2009_1071914_1 | 272 | 2.9 | |
| 1 | 2009_1071917_1 | 090 | 2.7 | |
| 1 | 2009_1071931_1 | 272 | 2.5 | |
| | | | | |

## PITCH

view parallel to track, same line (at nadir) [opposite direction, same speed]

| SV Cast # | XTF Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| 1 | 2009__1071850_1 | 272 | 4 | |
| 1 | 2009__1071910_1 | 92 | 4 | |
| 1 | 2009__1071905_1 | 93 | 4 | |
| 1 | 2009__1071907_1 | 271 | 4 | |
| 1 | 2009__1071903_1 | 270 | 4 | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

## HEADING/YAW

view parallel to track, offset lines (outerbeams) [opposite direction, same speed]

| SV Cast # | XTF Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| 1 | 2009__1071945_4 | 272 | 4 | N |
| 1 | 2009__1071938_4 | 272 | 4 | N |
| 1 | 2009__1071935_4 | 94 | 4 | N |
| 1 | 2009__1071941_4 | 93 | 4 | N |
| 1 | 2009__1071955_2 | 092 | 4 | S |
| 1 | 2009__1071959_2 | 272 | 4 | S |
| 1 | 2009__1071949_2 | 092 | 4 | S |
| 1 | 2009__1071952_2 | 272 | 4 | S |

## ROLL

view across track, same line [opposite direction, same speed]

| SV Cast # | XTF Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| 2 | 2009__1072043_5 | 04 | 3.8 | |
| 2 | 2009__1072039_5 | 183 | 3.5 | |
| 2 | 2009__1072047_5 | 184 | 3.5 | |
| 2 | 2009__1072035_5 | 03 | 3.9 | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

## Processing Log

| 4/18/2009 | 108 | Welton |
|---|---|---|
| Date | Dn | Personnel |

☑ **Data converted --> HDCS_Data in CARIS**

☑ **TrueHeave applied**

☑ **SVP applied**

☑ **Tide applied**

**Zone file** na

**Lines merged** ☑

**Data cleaned to remove gross fliers** ☐

| Compute correctors in this order | | | |
|---|---|---|---|
| **1. Precise Timing** | **2. Pitch bias** | **3. Heading bias** | **4. Roll bias** |
| Do not enter/apply correctors until all evaluations are complete and analyzed. | | | |

### PATCH TEST RESULTS/CORRECTORS

| Evaluators | Latency (sec) | Pitch (deg) | | Roll (deg) | Yaw (deg) | |
|---|---|---|---|---|---|---|
| FOO Ringel | -0.05 | 0.20 | | 1.50 | 0.50 | |
| B. Welton | 0.02 | -0.35 | | 1.50 | 0.35 | |
| G. Rice | 0.01 | 0.43 | | 1.48 | 0.28 | |
| N.Morgan | 0.06 | | | 1.48 | | |
| A. Raymond | 0.02 | 0.00 | | 1.46 | 0.20 | |
| CST Morgan | 0.00 | -0.40 | | 1.48 | 0.60 | |
| | | | | | | |
| | | | | | | |
| **Averages** | 0.01 | -0.02 | | 1.48 | 0.39 | |
| **Standard Deviation** | 0.04 | 0.36 | 0.04 | 0.02 | 0.16 | 0.08 |
| **FINAL VALUES** | 0.00 | -0.02 | | 1.48 | 0.39 | |

**Final Values based on** averages with outliers removed

**Resulting HVF File Name** FA_1010_Reson8101_2009.hvf

| | | | Actual values used | |
|---|---|---|---|---|
| **MRU Align StdDev gyro** | ~~0.16~~ | Value from standard deviation of Heading offset values | 0.075 | **MRU Align StdDev gyro** |
| **MRU Align StdDev Roll/Pitch** | ~~0.19~~ | Value from averaged standard deviations of pitch and roll offset values | 0.025 | **MRU Align StdDev Roll/Pitch** |

**NARRATIVE**

Lines from Dn108 (2009_1081822_11 through 2009_1082211_2) were also utilized to assess patch test values.
Dn108 did not have True Heave applied as the Pos file was not logged, therefore a full patch write-up was not conducted.

Removed N. Morgan pitch (-1.6 deg) and yaw (1.62) values from the averages as outliers.

Initial MRU values were too high, TPU values reassessed with outliers removed.

☑ **HVF Hydrographic Vessel File created or updated with current offsets**

**Name:** CST/FOO/Welton **Date:** 04/24/09

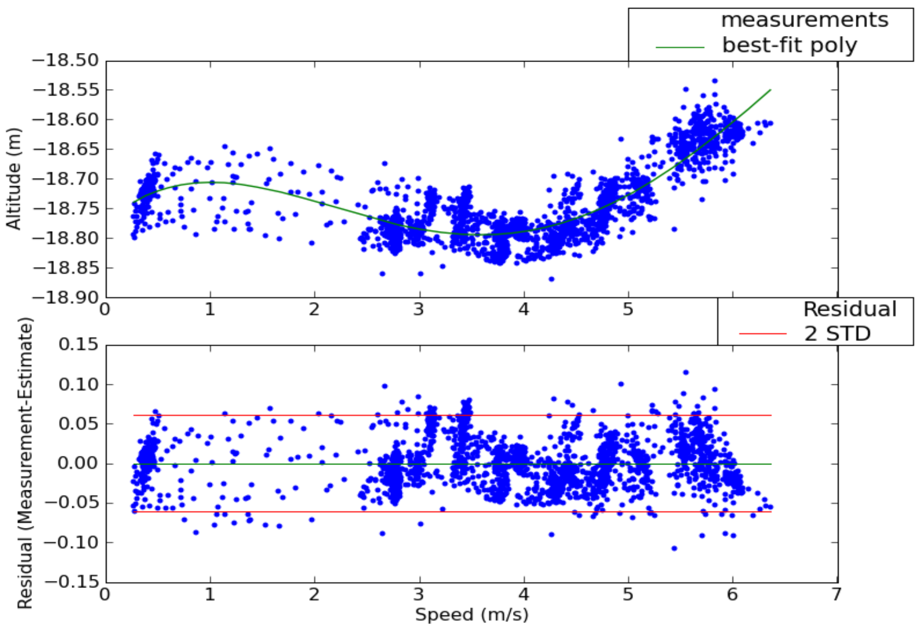
## Ellipsoid Referenced Dynamic Draft

## Launch 1010

| 4/17/2009 | 107 | Lake Washington | Rice |
|---|---|---|---|
| Date | DN | Local Area | Processor |

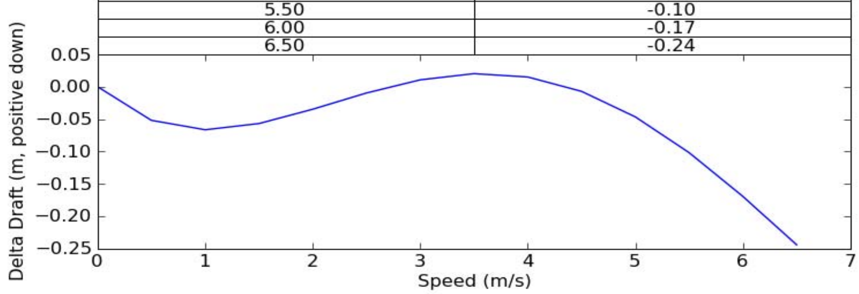
| SEAI | TH_1010_107.000.002 | 1018_ERDDM.txt |
|---|---|---|
| Primary Station | POSPac File | SBET File |

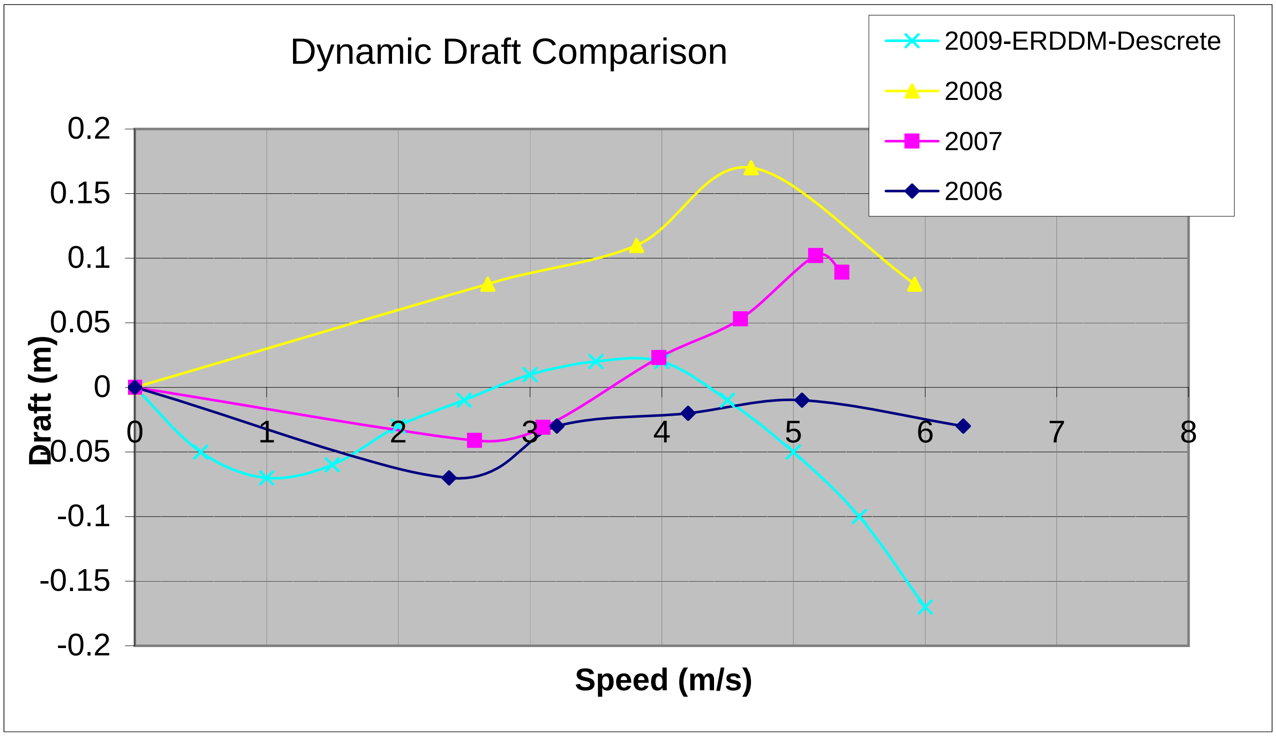
| proc_erddm.py, v0.12 | 4 |
|---|---|
| Processing Method | Coefficients |




1.24e-003*$X^3$ +-2.15e-002*$X^2$ +1.05e-001*X

| Speed (m/s) | Delta Draft (m) |
|---|---|
| 0.00 | 0.00 |
| 0.50 | -0.05 |
| 1.00 | -0.07 |
| 1.50 | -0.06 |
| 2.00 | -0.03 |
| 2.50 | -0.01 |
| 3.00 | 0.01 |
| 3.50 | 0.02 |
| 4.00 | 0.02 |
| 4.50 | -0.01 |
| 5.00 | -0.05 |
| 5.50 | -0.10 |
| 6.00 | -0.17 |
| 6.50 | -0.24 |






**2009 HVF Values**

**2009-ERDDM-Descrete**

| speed (m/s) | draft (m) |
|---|---|
| 0 | 0 |
| 0.5 | -0.05 |
| 1 | -0.07 |
| 1.5 | -0.06 |
| 2 | -0.03 |
| 2.5 | -0.01 |
| 3 | 0.01 |
| 3.5 | 0.02 |
| 4 | 0.02 |
| 4.5 | -0.01 |
| 5 | -0.05 |
| 5.5 | -0.1 |
| 6 | -0.17 |

2008

| speed (m/s) | draft (m) |
|---|---|
| 0 | 0 |
| 2.68 | 0.08 |
| 3.81 | 0.11 |
| 4.68 | 0.17 |
| 5.92 | 0.08 |

2007

| speed (m/s) | draft |
|---|---|
| 0 | 0 |
| 2.58 | -0.041 |
| 3.1 | -0.031 |
| 3.98 | 0.023 |
| 4.6 | 0.053 |
| 5.17 | 0.102 |
| 5.37 | 0.089 |

2006

| speed (m/s) | draft |
|---|---|
| 0 | 0 |
| 2.385 | -0.07 |
| 3.205 | -0.03 |
| 4.2 | -0.02 |
| 5.065 | -0.01 |
| 6.29 | -0.03 |

## Reference Surface Acquisition Log

| Launch 1010 |
|---|
| Vessel |

| 4/18/2009 | 108 | Shilshole Reference Surface | <1ft, <5kts |
|---|---|---|---|
| Date | Dn | Local Area | Wx |

| Andrews, Rice, Beduhn, Raymond |
|---|
| Personnel |

| |
|---|
| Comments |

| 09108172.7nv | 1727 | 47/40/27.300 | 122/25/35.70 | 34 | 44.2 |
|---|---|---|---|---|---|
| SV Cast #1 filename | UTC Time | Lat | Lon | Depth | Ext. Depth |

| 09108211.0nv | 2110 | 47/40/30.96 | 122/25/31.12 | 37.1 | 48.2 |
|---|---|---|---|---|---|
| SV Cast #2 filename | UTC Time | Lat | Lon | Depth | Ext. Depth |

| **SV Cast #** | **XTF Line Filename** | **Heading** | **Line Type** | **Remarks** |
|---|---|---|---|---|
| 2110 | 2009_1082123_3 | 240 | ref | east-west |
| | 2009_1082126_7 | 061 | ref | east-west |
| | 2009_1082128_8 | 240 | ref | east-west |
| | 2009_1082130_5 | 061 | ref | east-west |
| | 2009_1082132_4 | 240 | ref | east-west |
| | 2009_1082135_9 | 061 | ref | east-west |
| | 2009_1082137_9 | | ref | north-south |
| | 2009_1082139_10 | | ref | north-south |
| | 2009_1082142_11 | | ref | north-south |
| | 2009_1082146_12 | | ref | north_south |
| | 2009_1082149_13 | 150 | ref | north-south |
| | 2009_1082151_1 | 345 | ref | north-south |
| | 2153 | 155 | ref | north-south |
| | 2155 | 345 | ref | north-south |
| | 2158 | 161 | ref | north-south |
| | 2009_1082207_1 | 132 | Heading | |
| | 2009_1082208_1 | 312 | Heading | |
| | 2009_1082210_2 | 132 | Heading | |
| | 2009_1082211_2 | 312 | Heading | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

| Measurement | IMU to 8125 | Port Ant to 8125 | RP* to Waterline | Port Ant to Stbd Ant | | IMU to Port Ant | | IMU to Heave | |
|---|---|---|---|---|---|---|---|---|---|
| aka | *SWATH1 x,y,z & MRU to Trans* | ***Nav to Trans x,y,z*** | | | | | | | |
| Coord. Sys. | Caris | Caris | Caris | | | Caris | Pos/Mv | Caris | Pos/Mv |
| x | -0.396 | 0.502 | n/a | Scaler Distance | 1.834 | -0.898 | -1.101 | 0.015 | -1.114 |
| y | 0.982 | 2.082 | n/a | | | -1.101 | -0.898 | -1.114 | 0.015 |
| z | 0.751 | 3.919 | -0.333 | | | -3.161 | -3.161 | -0.336 | -0.336 |

Vessel Offsets Horizontal, Vertical & XYZ worksheets in this spreadsheet.

2009 Measured Value

**Calculations**

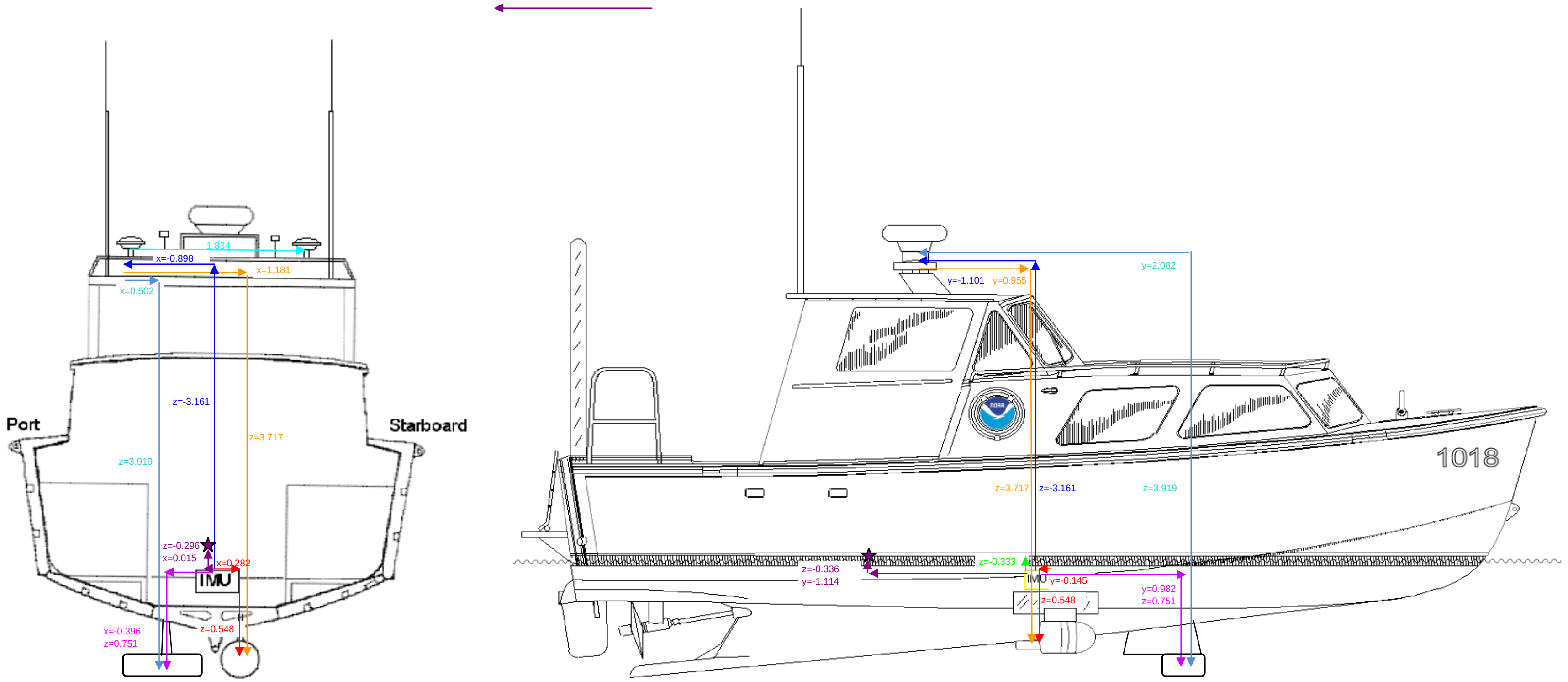
| Coord. Sys. | IMU to 8125 | | | | Port Ant to 8125 | | | |
|---|---|---|---|---|---|---|---|---|
| **Theodolite** | IMU (m) | | x | 3.54587 | IMU (m) | | x | 3.545867 |
| | | | y | -0.01516 | | | y | -0.01516 |
| | | | z | -0.85883 | | | z | -0.85883 |
| | BM H | | x | 3.30204 | Port Ant (m) | | x | 2.445 |
| | | | y | 0.43081 | | | y | -0.913 |
| | | | z | -1.0485 | | | z | 2.309 |
| | IMU | | x | -0.244 | IMU to | | x | -1.101 |
| | to BM H | | y | 0.446 | Port Antenna | | y | -0.898 |
| | | | z | -0.190 | | | z | 3.168 |
| | BM H to | | x | 122.533 | IMU to | | x | 0.982 |
| | Phase Ctr | (cm) | y | -84.216 | Phase Ctr | | y | -0.396 |
| | measured | | z | -56.133 | | | z | -0.751 |
| | BM H to | | x | 1.225 | | | | |
| | Phase Ctr | (m) | y | -0.842 | | | | |
| | | | z | -0.561 | | | | |

| Coord. Sys. | IMU to 8125 | | | | Port Ant to 8125 | | | |
|---|---|---|---|---|---|---|---|---|
| **Theodolite** | IMU to | | x | 0.982 | | | x | 2.082 |
| | Phase Ctr | | y | -0.396 | | | y | 0.502 |
| | | | z | -0.751 | | | z | -3.919 |
| | Coord. Sys. | **CARIS** | | | Coord. Sys. | **CARIS** | | |
| | | | x | -0.396 | | | x | 0.502 |
| | | | y | 0.982 | | | y | 2.082 |
| | | | z | 0.751 | | | z | 3.919 |

# Description of Offsets for Launch 1018

All Values Shown are in CARIS Coordinates

The Ship Reference Frame (SRF) for Launch 1018 was based from benchmark (BM) C as the 0 point. Physical locations were measured with x,y,z offsets from this point. These locations were used to calculate offsets of items with respect to each other, as described for each offset.



| IMU to 8101 | | |
|---|---|---|
| x | y | z |
| 0.282 | -0.145 | 0.548 |

| IMU to 8125 | | |
|---|---|---|
| x | y | z |
| -0.396 | 0.982 | 0.751 |

The physical positions of the IMU and the phase center of the 8101 with respect to the Ship Reference Frame were measured by NOAA personnel. These physical measurements were used to calculate the xyz offsets from the IMU to BM H. Measurements from BM H to the Phase Center of the 8101 were collected by NOAA personnel while the boat was secured on the pier and thought to be as level as possible. The measured offsets from BM H to the phase center were then added to the offset from the IMU to BM H. The result is the offset from the IMU to the phase center of the transducer. The values in the X and Y fields are transposed and the inverse of the Z value is used to give the offsets in CARIS coordinates.

| Port Ant to 8101 | | |
|---|---|---|
| x | y | z |
| 1.181 | 0.955 | 3.717 |

| Port Ant to 8125 | | |
|---|---|---|
| x | y | z |
| 0.502 | 2.082 | 3.919 |

NOAA personnel calculated the distance between the port antenna and the phase center of the port antenna subtracting the IMU to Port Antenna value from the IMU to Phase Center value.

| RP to Waterline | | |
|---|---|---|
| x | y | z |
| N/A | N/A | -0.333 |

The average vertical distance from BM A and B to the waterline was measured by FAIRWEATHER personnel using a steel tape and bubble level. These values were used to calculate the BM C to the waterline value. With the knowledge of the BM C height above the IMU, the waterline height above the IMU could be calculated. On launch 1018, the IMU is used as the reference point.

| Port Ant to Stbd Ant |
|---|
| Scalar Distance |
| 1.834 |

The location of the phase center of the port and starboard POS/MV antennas were measured by NOAA personnel with respect to the SRF. The scalar distance between the phase centers was then calculated.

| IMU to Port Antenna | | |
|---|---|---|
| x | y | z |
| -0.898 | -1.101 | -3.161 |

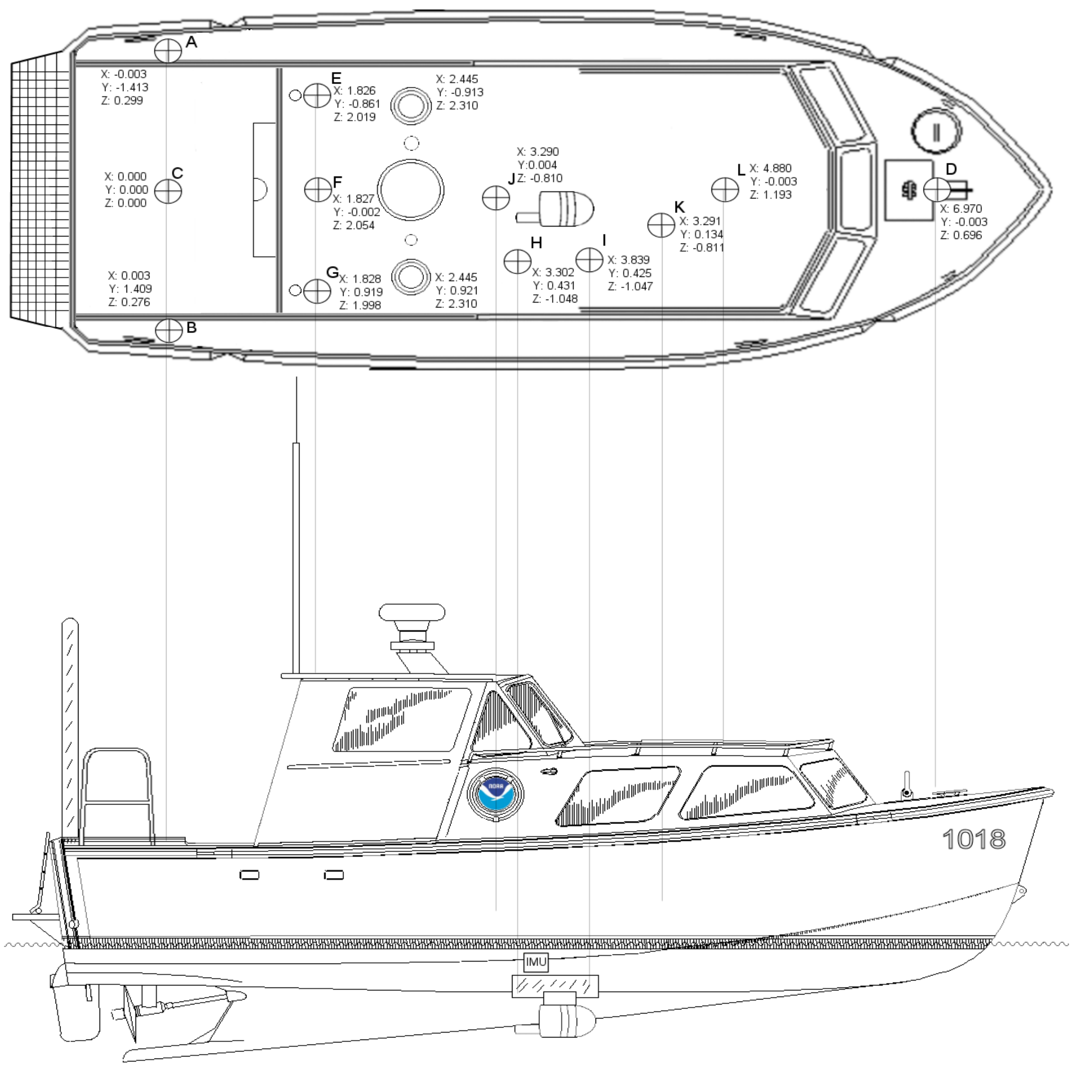
The location of the IMU and the location of the port antenna were measured by NOAA personnel with respect to the Ship Reference Frame (SRF). The xyz offsets from the IMU to the port antenna could be calculated from these physical locations.

| IMU to Heave | | |
|---|---|---|
| x | y | z |
| 0.015 | -1.114 | -0.336 |

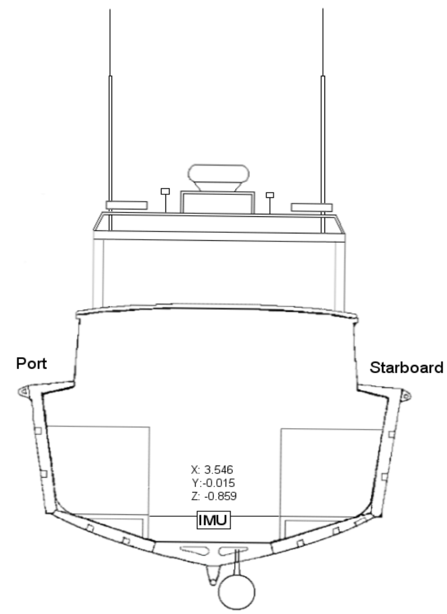
The heave point was positioned differently on each of the axes. The distance for the longitudinal axis was determined as described in the "IMU to Heave" tab in this workbook. The athwart ships axis was the vessel centerline. Lastly, the waterline was used as the height of the heave point, which was calculated earlier in 'RP to Waterline'.

# 1018 Vessel Diagram

All Values Shown are in Theodolite Coordinates




Note: Both antenna have been replaced for the POS V4. While their x-y values are not thought to have changed, the z-value has been remeasured.



## Waterline Measurements

**Fill in Yellow squares only!**

Measuring Party: Rice, Argento, Campbell, Beduhn

Waterline measurements should be negative!

Date: 4/7/2009
Fuel Level: 0.75
Draft Tube:

| | 1018 | |
|---|---|---|
| | Benchmark A to Waterline | Benchmark B to Waterline |
| Measure 1 | -80.8 | -81.0 |
| Measure 2 | -81.3 | -82.1 |
| Measure 3 | -81.1 | -81.9 |
| Avg (cm) | -81.07 | -81.67 |
| Avg (m) | -0.8107 | -0.8167 |
| Stdev | 0.00252 | 0.00586 |
| BM Z-value (m) | 0.29933 | 0.27567 |
| BM C to WL (m) | -0.511 | -0.541 |

Port-to-Stbd Z-difference

| Theoretical | Actual | Error |
|---|---|---|
| 0.0237 | -0.0060 | -0.0297 |

BM C to WL Average (m)

-0.526 (Add this value to 1018_Offsets & Measurements_200X.xls)

| | | |
|---|---|---|
| Individual measurement StdEv for TPU xls (of 6 #'s) | -0.50867 | -0.53433 |
| | -0.51367 | -0.54533 |
| 0.016742 | -0.51167 | -0.54333 |

utilized in Offsets and Measurements and TPU spreadsheet

Measuring Party: Raymond, Welton

Date: 4/16/2009
Fuel Level: half full
Draft Tube: na

| | 1018 | |
|---|---|---|
| | Benchmark A to Waterline | Benchmark B to Waterline |
| Measure 1 | -82.4 | -82.2 |
| Measure 2 | -82.3 | -82.2 |
| Measure 3 | -82.0 | -81.1 |
| Avg (cm) | -82.23 | -81.83 |
| Avg (m) | -0.8223 | -0.8183 |
| Stdev | 0.00208 | 0.00635 |
| BM Z-value (m) | 0.29933 | 0.27567 |
| BM C to WL (m) | -0.523 | -0.543 |

Port-to-Stbd Z-difference

| Theoretical | Actual | Error |
|---|---|---|
| 0.0237 | 0.0040 | -0.0197 |

BM C to WL Average (m)

-0.533 (or add this value to 1018_Offsets & Measurements_2008)

| | | |
|---|---|---|
| Individual measurement StdEv for TPU xls (of 6 #'s) | -0.52467 | -0.54633 |
| | -0.52367 | -0.54633 |
| 0.011572 | -0.52067 | -0.53533 |

This spreadsheet is designed to compute the z-values of the phase centers of the new POS M/V antenna.

**All offsets are in the Theodolite Coordinate System**

| | | | | | |
|---|---|---|---|---|---|
| BM E | x | 1.825761 | Port Ant | x | 2.445325 |
| | y | -0.861405 | | y | -0.913449 |
| | z | 2.018667 | | z | Unknown |
| BM F | x | 1.826865 | Stbd Ant | x | 2.444676 |
| | y | -0.002043 | | y | 0.920569 |
| | z | 2.054333 | | z | Unknown |
| BM G | x | 1.828354 | | | |
| | y | 0.918931 | | | |
| | z | 1.998333 | | | |

POS MV V4 Installation and Operation Guide

Drawings

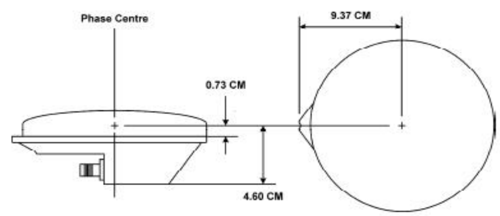



Figure 79: GPS Antenna Footprint

| Measuring Party (fill in yellow spaces only): | Date: | Serial #- Port | Serial #- Stbd |
|---|---|---|---|
| Rice, Argento, Campbell, Beduhn | 4/7/2009 | 60145158 | 60130644 |

| Distances | | | | | z-Values Ant. Base | Phase Center | |
|---|---|---|---|---|---|---|---|
| Port Ant to BM 'E' | 0.652 | 0.652 | 0.653 | 0.665083 | 2.254818 | 2.300818 | |
| Port Ant to BM 'F' | 1.109 | 1.11 | 1.111 | 1.12275 | 2.272081 | 2.318081 | |
| Port Ant to BM 'G' | 1.941 | 1.945 | 1.943 | 1.95575 | 2.292759 | 2.338759 | |
| | | | | | 2.263449 | 2.309449 | AVERAGE |
| | | | | | | 0.019 | STDEV |
| Stbd Ant to BM 'E' | 1.884 | 1.882 | 1.889 | 1.89775 | 2.225956 | 2.271956 | |
| Stbd Ant to BM 'F' | 1.111 | 1.112 | 1.113 | 1.12475 | 2.233664 | 2.279664 | |
| Stbd Ant to BM 'G' | 0.648 | 0.647 | 0.647 | 0.660083 | 2.234669 | 2.280669 | |
| | | | | | 2.234166 | 2.280166 | AVERAGE |
| | | | | | | 0.005 | STDEV |

| Antenna Post | Diameter | Radius |
|---|---|---|
| | 0.0255 | 0.01275 |

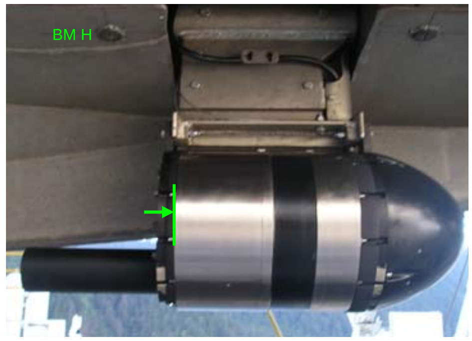
The distances from the antenna post to each benchmark was measured three times and averaged. The post offset to phase center (radius) was then added.

The distance is 0.046m (4.60cm) from the bottom of the antenna to the Phase center, obtained from the POSM/V v4 guide, see image above.

# Offsets from Aft Benchmark to Phase Center of Transducer

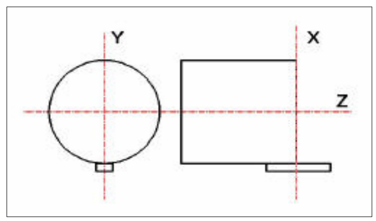
| Date | DN | Vessel | Personnel |
|---|---|---|---|
| 3/20/2009 | 79 | launch 1018 | Campbell, Argento, Rice, Beduhn |

3102026
Serial Number of Transducer




**Instructions:** The purpose of this measurement is to check for gross movement of the tranducer. **Fill in yellow spaces only.**

While the boat is in the cradle, gently lower the transducer and lock it in place. Using a metric tape measure, plumb bob and carpenter's level, measure the horizontal and vertical offsets from the aft benchmark (BM H) to the phase center of the transducer. The phase center is measured at the forward edge of the black insulating layer, as shown in the photos. If you have trouble locating the center, borrow a compass from the navigation department.




Notwithstanding a major accident, BM H will be outboard, aft and higher than the phase center; as such, enter all offsets as positive numbers (in cm) and the proper signs will be applied.

Once offsets have been measured, apply a digital level to the IMU to determine any pitch or roll bias in the orientation of the launch. For the purposes of this spreadsheet, a positive angle (measured in degrees) will imply the bow is higher than the stern and the port side is higher than the starboard side.

All measurements should be done in triplicate to aid in the calculation of the uncertainty (needed in the HVF). The *IMU to Phase Center* values will be calculated automatically.

| Offset Measurements (positive cm): | | | | Average |
|---|---|---|---|---|
| Bow-Stern | 8.7 | 8.7 | 8.8 | 8.7 |
| Port-Stbd | 15.9 | 15.9 | 15.8 | 15.9 |
| Up-Down | 35.5 | 35.4 | 36.0 | 35.6 |

| Angle Bias (deg): | |
|---|---|
| Bow Up | |
| Port Up | |

The measuring crew should insure there will be no yaw bias.

| Std Dev: | |
|---|---|
| Bow-Stern | 0.06 |
| Port-Stbd | 0.06 |
| Up-Down | 0.32 |

**BM H to Phase Center**
(Theodolite Coordinate System)

x 8.733 cm

y -15.867 cm

z -35.633 cm

Measured by NOAA Personnel
inserted into Offset Worksheet,
if to be used in IMU to 8101 calculation

**IMU to Phase Center (8101)**
(CARIS Coordinate System)

x 0.287 m

y -0.156 m

z 0.546 m

Calculated Value for check purposes
* see Math Explanation tab

These 2009 values were not used for the hvf offsets due to the angle bias not being entered. The 2008 values were used instead and the 2009 values were used as a check that the unit had not been displaced.

# Offsets from Aft Benchmark to Phase Center of Transducer

| 4/29/2009 | 119 | launch 1018 | Argento, Andrews, Foster, Nuckols |
|---|---|---|---|
| Date | DN | Vessel | Personnel |

4400007
Serial Number of Transducer

**Instructions:** The purpose of this measurement is to check for gross movement of the tranducer. **Fill in yellow spaces only.**

While the boat is in the cradle, connect the 8125 sled with the sonar head attached. Using a metric tape measure, plumb bob and carpenter's level, measure the horizontal and vertical offsets from the aft benchmark (BM H) to the phase center of the transducer. The phase center is measured at the center middle of the black insulating layer below the flat faced transducer, as shown in the photos. If you have trouble locating the center, borrow a compass from the navigation department.


Notwithstanding a major accident, BM H will be outboard, aft and higher than the phase center; as such, enter all offsets as positive numbers (in cm) and the proper signs will be applied.

Once offsets have been measured, apply a digital level to the IMU to determine any pitch or roll bias in the orientation of the launch. For the purposes of this spreadsheet, a positive angle (measured in degrees) will imply the bow is higher than the stern and the port side is higher than the starboard side.

All measurements should be done in triplicate to aid in the calculation of the uncertainty (needed in the HVF). The *IMU to Phase Center* values will be calculated automatically.

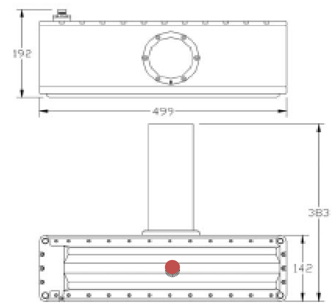



Figure 3 - Transducer array outline dimensions

| Offset Measurements (positive cm): | | | | Average |
|---|---|---|---|---|
| Bow-Stern | 123.2 | 122.0 | 122.4 | 122.5 |
| Port-Stbd | 84.2 | 84.4 | 84.1 | 84.2 |
| Up-Down | 55.7 | 56.2 | 56.5 | 56.1 |

| Angle Bias (deg): | |
|---|---|
| Bow Up | -0.5 |
| Port Up | -2.0 |

The measuring crew should insure there will be no yaw bias.

| Std Dev: | |
|---|---|
| Bow-Stern | 0.61 |
| Port-Stbd | 0.15 |
| Up-Down | 0.40 |

**BM H to Phase Center**
(Theodolite Coordinate System)

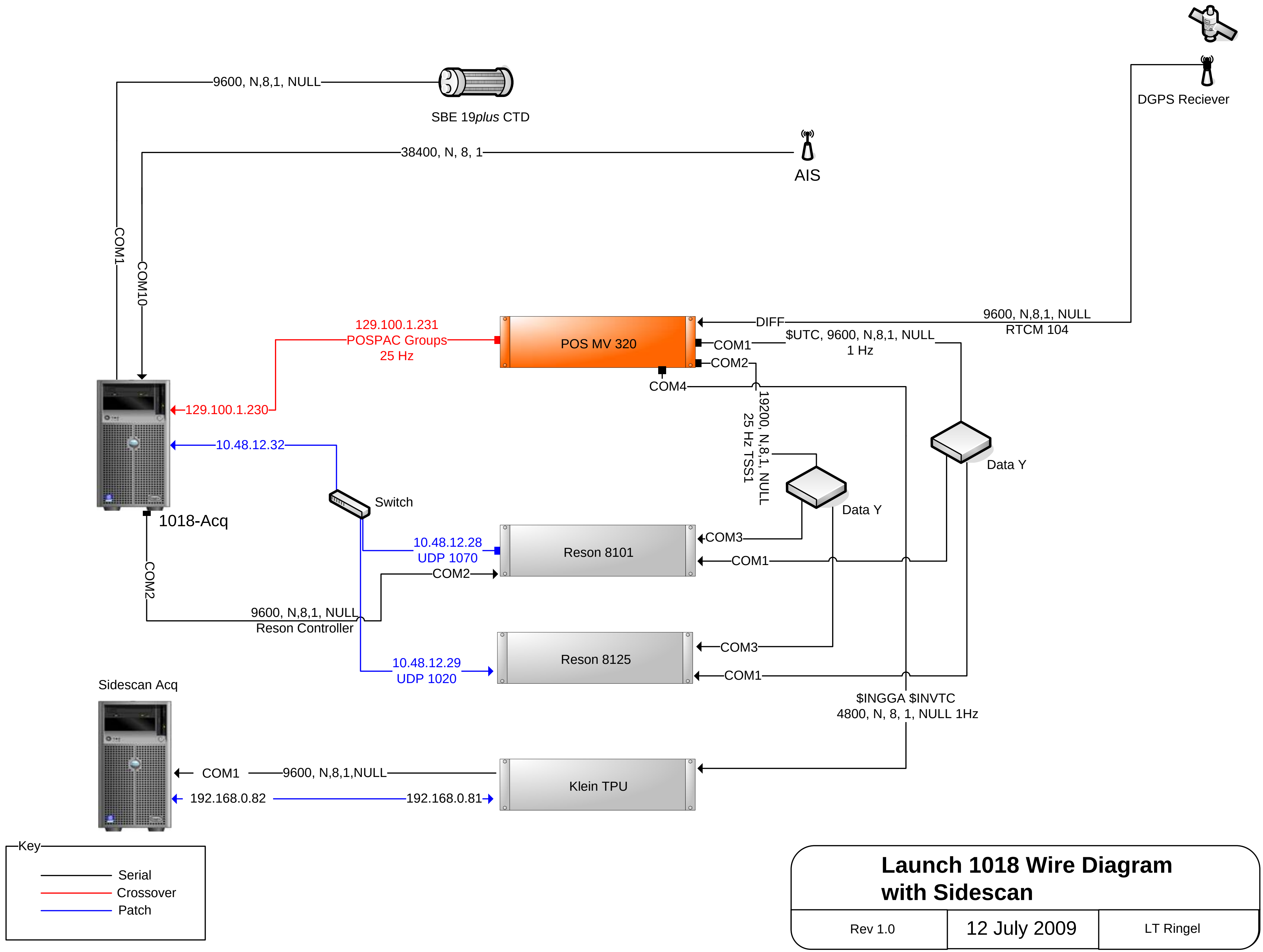
x 122.533 cm
y -84.233 cm
z -56.133 cm

Measured by NOAA Personnel
inserted into Offset Worksheet,
if to be used in IMU to 8101 calculation

**IMU to Phase Center (8125)**
(CARIS Coordinate System)

x -0.396 m
y 0.982 m
z 0.751 m

Calculated Value for check purposes
* see Math Explanation tab


9600, N,8,1, NULL
SBE 19*plus* CTD
DGPS Reciever
38400, N, 8, 1
AIS
COM1
COM10
129.100.1.231
POSPAC Groups
25 Hz
POS MV 320
DIFF
9600, N,8,1, NULL
RTCM 104
COM1
$UTC, 9600, N,8,1, NULL
1 Hz
COM2
COM4
19200, N,8,1, NULL
25 Hz TSS1
129.100.1.230
10.48.12.32
Switch
Data Y
Data Y
1018-Acq
10.48.12.28
UDP 1070
Reson 8101
COM3
COM1
COM2
COM2
9600, N,8,1, NULL
Reson Controller
10.48.12.29
UDP 1020
Reson 8125
COM3
COM1
$INGGA $INVTC
4800, N, 8, 1, NULL 1Hz
Sidescan Acq
COM1
9600, N,8,1,NULL
Klein TPU
192.168.0.82
192.168.0.81
Key
Serial
Crossover
Patch
Launch 1018 Wire Diagram
with Sidescan
Rev 1.0
12 July 2009
LT Ringel

# NOAA POS/MV Calibration Report

**Fill out all fields!** See previous years as an example.

**Yellow areas require screen grabs!**

**Ship:** FAIRWEATHER **Vessel:** 1018

**Date:** 4/15/2009 **Dn:** 104

**Personnel:** Andrews, Welton, Forney, Shetler

**PCS Serial #** 2560 **IMU Serial #** 007

**IP Address:** 129.100.1.231

**Port Antenna Serial #** 60145158 **Stbd Antenna Serial #** 60130644

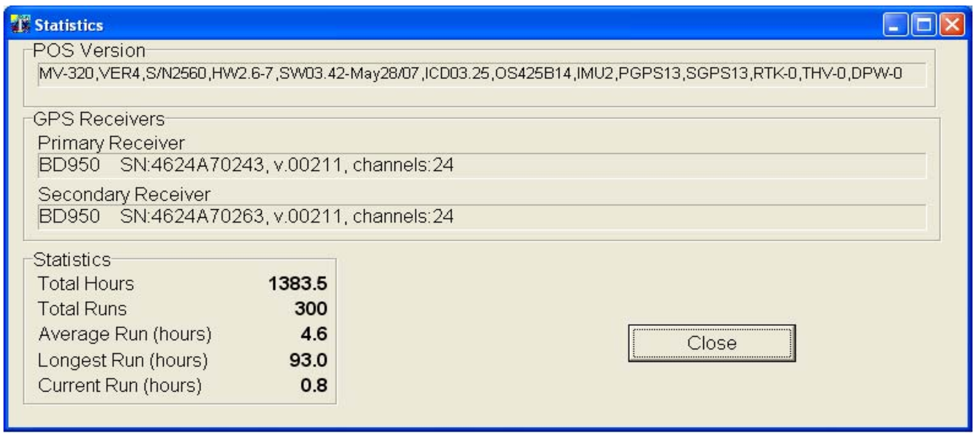
**POS controller Version (Use Menu Help > About)** 3.4.0.0

**POS Version (Use Menu View > Statistics)** MV-320,Ver 4

**GPS Receivers**

Primary Receiver Serial #: 4624A70243

Secondary Receiver Serial #: 4624A70263




## Calibration area

**Location:** Lake Washington, Seattle, WA

**Approximate Position:**

| | | | |
|---|---|---|---|
| **Lat** | 47 | 39 | 35.8 |
| **Lon** | 122 | 15 | 35.6 |

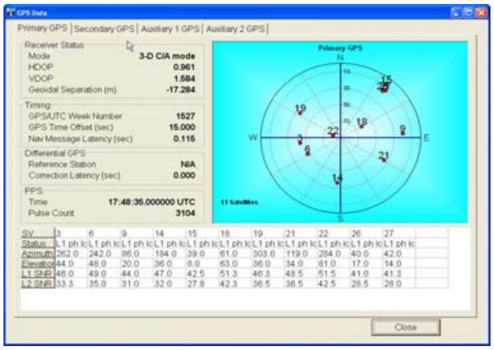
**DGPS Beacon Station:** Whidbey Island **DGPS Receiver Serial#:** 0328-12352-0001

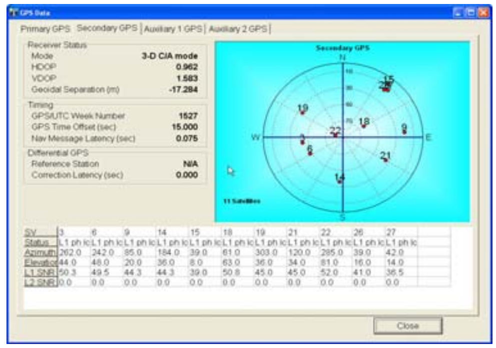
**Frequency:** 302

## Satellite Constellation

(Use View> GPS Data)

**Primary GPS** **Secondary GPS**



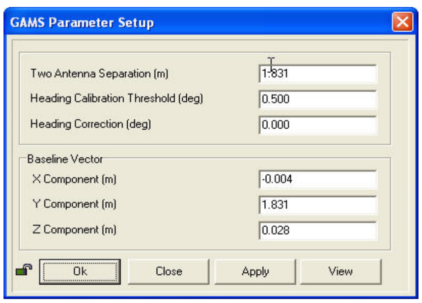


**PDOP** 1.823 (Use View> GAMS Solution)

## POS/MV Configuration

### Settings

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




**Configuration Notes:**

## POS/MV Calibration

### Calibration Procedure:

(Refer to POS MV V4 Installation and Operation Guide, 4-25)

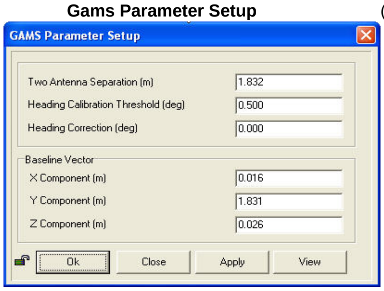
Start time: 1722 UTC

End time: 1723 UTC

Heading accuracy achieved for calibration: 0.324

### Calibration Results:

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




GAMS Status Online Ready Online

Save Settings Yes

**Calibration Notes:**

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

File Name: C:\Documents and Settings\1018acq\Desktop\POS-MV Settings\GAMS_Parameter_104_2009.nvm

## General Notes:

**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 $\theta z$ about the z-axis to align one frame with the other.

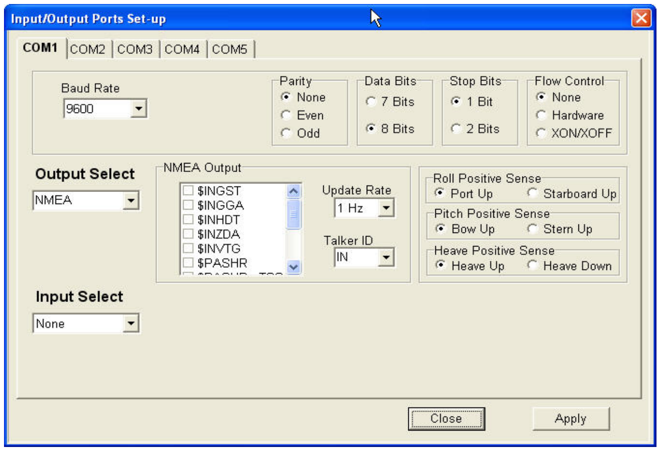
b) Pitch rotation - apply a right-hand screw rotation $\theta y$ about the once-rotated y-axis to align one frame with the other.

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

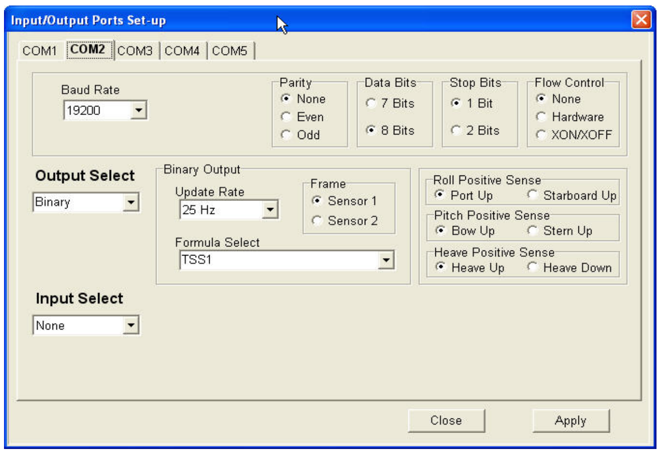
## SETTINGS

**Input/Output Ports** (Use Settings > Input/Output Ports)

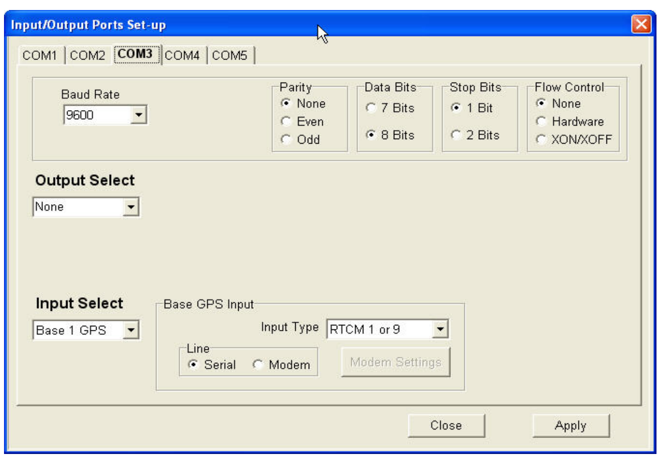
**COM1**




**COM2**

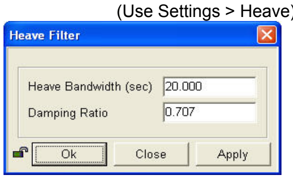



**COM3**

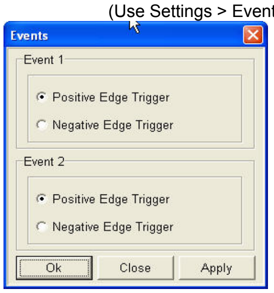


## SETTINGS Continued

**Heave Filter** (Use Settings > Heave)

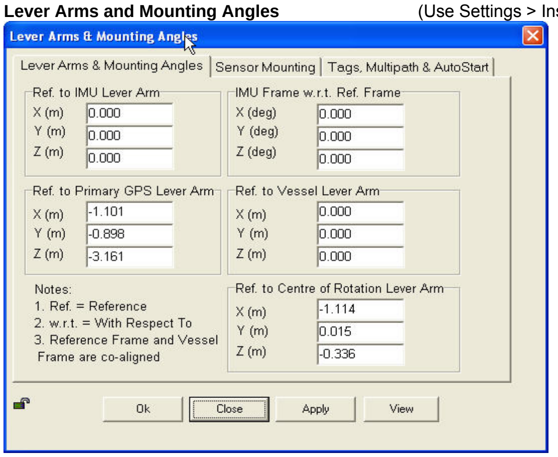



**Events** (Use Settings > Events)

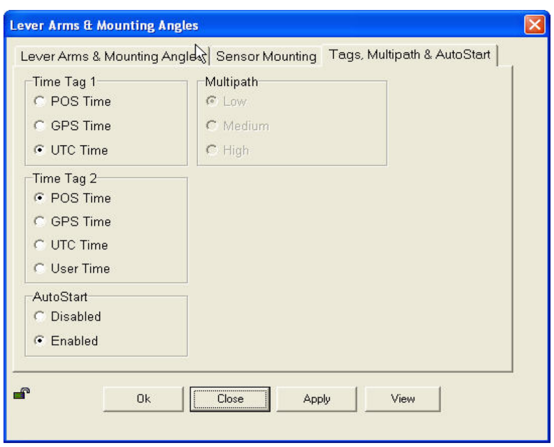



## INSTALLATION (Use Settings > Installation)

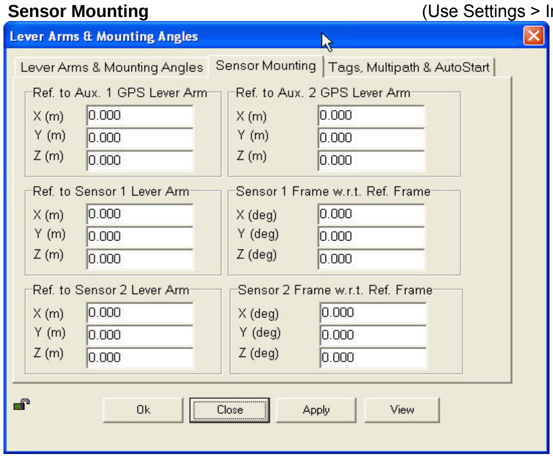
**Lever Arms and Mounting Angles** (Use Settings > Installation > Lever Arms and Offsets)



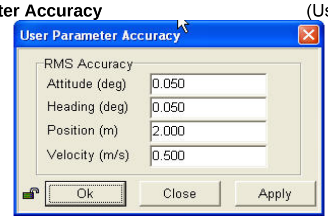

**Tags, Multipath and Auto Start** (Use Settings > Installation > Tags, Multipath and Auto Start)



**Sensor Mounting** (Use Settings > Installation > Sensor Mounting)



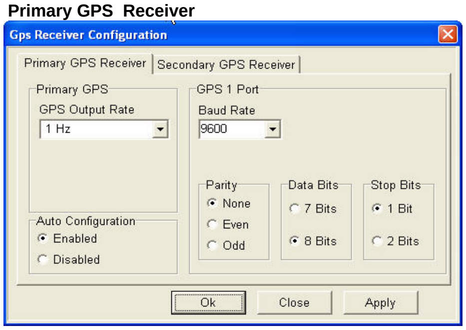

**User Parameter Accuracy** (Use Settings > Installation > User Accuracy)



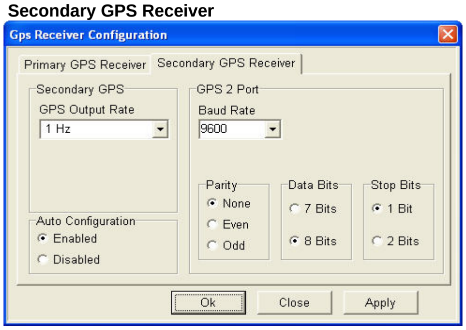

## GPS Receiver Configuration

(Use Settings> Installation> GPS Receiver Configuration)

**Primary GPS Receiver**




**Secondary GPS Receiver**



**FAIRWEATHER**

**Multibeam Echosounder Calibration**

**Launch 1018**
Vessel

| | | |
|---|---|---|
| 4/16/2009 | 106 | L. Washington |
| Date | Dn | Local Area |

FOO Ringel, CST Morgan, LT Welton, ENS Morgan
Calibrating Hydrographer(s)

| | | |
|---|---|---|
| 8101 | 1018 | not available |
| MBES System | MBES System Location | Date of most recent EED/Factory Check |
| 3102026 | | 34497 |
| Sonar Serial Number | | Processing Unit Serial Number |
| Hull mounted swing arm | | 03/20/2009 |
| Sonar Mounting Configuration | | Date of current offset measurement/verification |
| POSMV v4 GPS (DGPS corrected) | | 04/15/2009 |
| Description of Positioning System | | Date of most recent positioning system calibration |

**Acquisition Log**

| | | | |
|---|---|---|---|
| 4/16/2009 | 106 | L. Washington | Calm |
| Date | Dn | Local Area | Wx |
| | | | 30-190 feet |
| Bottom Type | | | Approximate Water Depth |

Welton, ENS Morgan, Raymond, Heiner
Personnel on board

Comments

TH_1018_Patch_Test_Dn105
TrueHeave filename

| | | | | | |
|---|---|---|---|---|---|
| 081060818 | 0:00 | | | | |
| SV Cast #1 filename | UTC Time | Lat | Lon | Depth | Ext. Depth |
| | | | | | |
| SV Cast #2 filename | UTC Time | Lat | Lon | Depth | Ext. Depth |

**ROLL**

| SV Cast # | XTF Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| | 005_1832.81X | 3 | 5.9 | roll |
| | 005_1838.81X | 183 | 6.0 | roll |
| | 005_1844.81X | 03 | 6.0 | roll |
| | | | | |
| | | | | |
| | | | | |

**PITCH**

| SV Cast # | XTF Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| | 001_1730.81X | 274 | 5.1 | |
| | 001_1741.81X | 092 | 5.1 | |
| | 002_1751.81X | 272 | 5.2 | |
| | 002_1801.81X | 092 | 5.1 | |
| | | | | |
| | | | | |
| | | | | |

**HEADING/YAW**

| SV Cast # | XTF Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| 91060818 | 001_1730.81X | 274 | 5.1 | Heading |
| | 001_1741.81X | 092 | 5.1 | Heading |
| | 002_1751.81X | 272 | 5.2 | Heading |
| | 002_1801.81X | 092 | 5.1 | Heading (1805 overtaking boat noise) |
| | | | | |
| | | | | |

**NAV TIME LATENCY**

| SV Cast # | XTF Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| | 001_1811.81X | 272 | 4.8 | timing |
| | 001_1823.81X | 092 | 8.0 | timing |
| | | | | |
| | | | | |
| | 001_1741.81X | 092 | 5.1 | Heading |
| | | | | |
| | | | | |
| | | | | |

## Processing Log

| 4/16/2009 | DN106 | ENS Morgan |
|---|---|---|
| Date | Dn | Personnel |

☑ **Data converted --> HDCS_Data in CARIS**

☑ **TrueHeave applied** yes

☑ **SVP applied** yes

☑ **Tide applied** zerotide.tid

**Zone file** na

**Lines merged** ☑

**Data cleaned to remove gross fliers** ☑

| Compute correctors in this order | | | |
|---|---|---|---|
| **1. Precise Timing** | **2. Pitch bias** | **3. Heading bias** | **4. Roll bias** |
| Do not enter/apply correctors until all evaluations are complete and analyzed. | | | |

**PATCH TEST RESULTS/CORRECTORS**

| Evaluators | Latency (sec) | Pitch (deg) | | Roll (deg) | Yaw (deg) | |
|---|---|---|---|---|---|---|
| FOO (in progress) | -0.05 | -0.80 | | 2.88 | -0.40 | |
| CST | 0.00 | 0.30 | | 2.86 | -0.50 | |
| Nick | 0.03 | -0.94 | | 2.86 | -0.35 | |
| Bri | -0.03 | -1.06 | | 2.90 | -0.10 | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| **Averages** | -0.01 | -0.63 | | 2.88 | -0.34 | |
| **Standard Deviation** | 0.04 | 0.63 | 0.13 | 0.02 | 0.17 | 0.04 |
| **FINAL VALUES** | 0.00 | -0.63 | | 2.88 | -0.34 | |
| **Final Values based on** | CST/FOO | Averages | | Averages | Averages | |

**Resulting HVF File Name** FA_1018_Reson8101_2009

**Actual values used**

| | | | | |
|---|---|---|---|---|
| **MRU Align StdDev gyro** | ~~0.17~~ | Value from standard deviation of Heading offset values | 0.035 | **MRU Align StdDev gyro** |
| **MRU Align StdDev Roll/Pitch** | ~~0.32~~ | Value from averaged standard deviations of pitch and roll offset values | 0.075 | **MRU Align StdDev Roll/Pitch** |

**NARRATIVE**

Values based on two patch tests- one performed on DN106 in Lake Washington using the bounded slope method and one performed on DN107on the Shilshole reference surface using the target method.

Initial MRU values were too high, TPU values reassessed with outliers removed.

☑ **HVF Hydrographic Vessel File created or updated with current offsets**

**Name:** Ringel, Welton, Morgan

**Date:** 4/18/09

**FAIRWEATHER**

**Multibeam Echosounder Calibration**

| | |
|---|---|
| **Launch 1018** | |
| Vessel | |

| Date | Dn | Local Area |
|---|---|---|
| 6/27/2009 | 178 | Shumagin Islands, Near Northeast Harbor |

Calibrating Hydrographer(s): Welton, FOO Ringel, CST Morgan

| MBES System | MBES System Location | Date of most recent EED/Factory Check |
|---|---|---|
| 8125 | 1018 | uknown (on loan from RUDE) |

| Sonar Serial Number | Processing Unit Serial Number |
|---|---|
| 4400007 | 31562 |

| Sonar Mounting Configuration | Date of current offset measurement/verification |
|---|---|
| Sled hull mount | 4/29/2009 |

| Description of Positioning System | Date of most recent positioning system calibration |
|---|---|
| POSMV w/ DGPS correctors | 4/15/2009 |

## Acquisition Log

| Date | Dn | Local Area | Wx |
|---|---|---|---|
| 6/27/2009 | 178 | Shumagin Islands, Near Northeast Harbor | Wind lgt vrb, waves <1ft (Awesome) |

| Bottom Type | Approximate Water Depth |
|---|---|
| rock | 20-30 meters |

Personnel on board: Froelich, Francksen, Walker

Comments:

TrueHeave filename: 2009-178_1018.000

| SV Cast #1 filename | UTC Time | Lat | Lon | Depth | Ext. Depth |
|---|---|---|---|---|---|
| | | | | | |

| SV Cast #2 filename | UTC Time | Lat | Lon | Depth | Ext. Depth |
|---|---|---|---|---|---|
| | | | | | |

**NAV TIME LATENCY** view parallel to track, one line with induced roll (outerbeam) or same lines over bounded slope or feature (nadir) [run same direction, different speed]

| SV Cast # | Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| H12702_1018_Dn1 | 2009L_1781804 | 022 | 6.0 | roll time bias method |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

**PITCH** view parallel to track, same line (nadir) over feature or bounded slope [opposite direction, same speed]

| SV Cast # | Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| H12702_1018_Dn1 | 2009L_1781750 | 110 | 6.0 | |
| | 2009L_1781753 | 290 | 6.0 | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

**HEADING/YAW** view parallel to track, offset lines from feature or slope (outerbeams) [opposite direction, same speed]

| SV Cast # | Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| | 2009L_1781756 | 110 | 6.0 | |
| | 2009L_1781800 | 290 | 6.0 | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

**ROLL** view across track, same line over flat area in [opposite direction, same speed]

| SV Cast # | Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| H12702_1018_Dn1 | 2009L_1781750 | 110 | 6.0 | |
| | 2009L_1781753 | 290 | 6.0 | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

## Processing Log

| 6/27/2009 | 178 | ` |
|---|---|---|
| Date | Dn | Personnel |

☑ **Data converted --> HDCS_Data in CARIS**

☐ **TrueHeave applied**

☑ **SVP applied** Previous in Time

☑ **Tide applied**

**Zone file** predicted- Sand Point, AK

**Lines merged** ☑

**Data cleaned to remove gross fliers** ☑

**Compute correctors in this order**

**1. Precise Timing** **2. Pitch bias** **3. Heading bias** **4. Roll bias**

Do not enter/apply correctors until all evaluations are complete and analyzed.

### PATCH TEST RESULTS/CORRECTORS

| Evaluators | Latency (sec) | Pitch (deg) | Roll (deg) | Yaw (deg) |
|---|---|---|---|---|
| Welton | 0.00 | -0.90 | -1.98 | -2.20 |
| FOO | 0.00 | -0.30 | -1.95 | -1.70 |
| CST | 0.00 | -0.40 | -1.91 | -1.50 |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| **Averages** | 0.00 | -0.53 | -1.95 | -1.80 |
| **Standard Deviation** | 0.00 | 0.32 | 0.04 | 0.36 |
| **FINAL VALUES** | 0.00 | -0.53 | -1.95 | -1.80 |

**Final Values based on** Averages

**Resulting HVF File Name** added to FA_1018_Reson8125_2009

| | | |
|---|---|---|
| **MRU Align StdDev gyro** | 0.36 | Value from standard deviation of Heading offset values |
| **MRU Align StdDev Roll/Pitch** | 0.18 | Value from averaged standard deviations of pitch and roll offset values |

# Launch DDSSM DATA ACQUISITION FORM

Date 4/16/2009
Vessel # 1018
Average Depth 30m

DN 105
Location L. Wash
Personnel Welton, Morgan, Raymond, Heiner

Wind calm
Seas calm

| RPM | Speed | Az | Hypack Line Name | Acquisition Comments |
|---|---|---|---|---|
| 650 | 4.9 | 90 | 007_1923.81X | forgot to let truheave settle prior to running into the line |
| 850 | 5.9 | 270 | 007_1930.81X | forgot to let truheave settle prior to running into the line |
| 650 | 4.9 | 90 | 007_1942.81X | |
| 850 | 5.9 | 270 | 007_1952.81X | |
| 1050 | 7 | 90 | 007_2001.81X | |
| 1250 | 7.9 | 270 | 007_2008.81X | |
| 1450 | 8.7 | 90 | 007_2016.81X | |
| Stop1 | 0 | - | 007_2023.81X | |
| Stop2 | 0 | - | 007_2025.81X | |
| Stop3 | 0 | - | 007_2028.81X | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

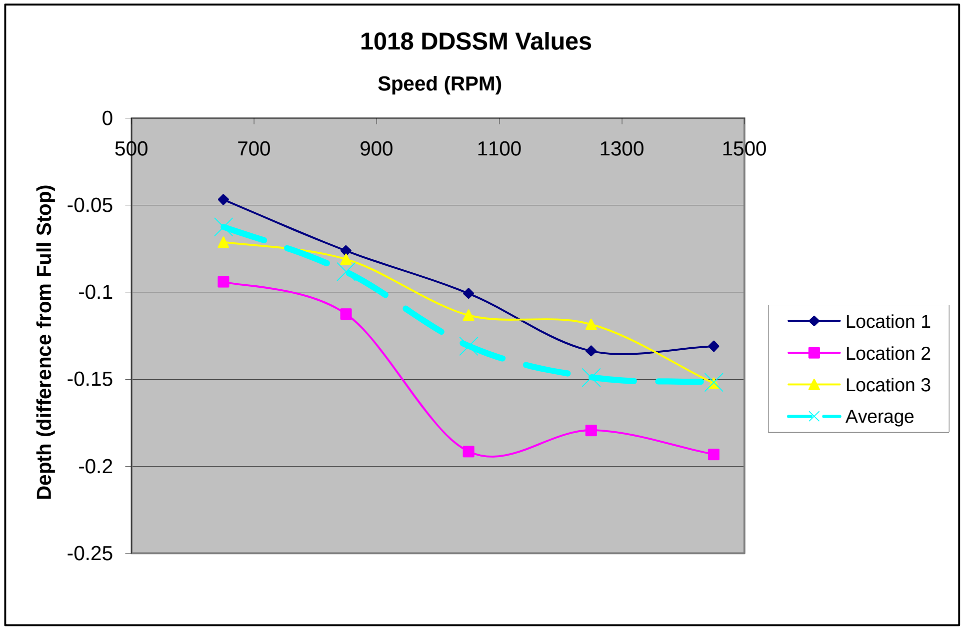
# DDSSM DATA PROCESSING AND RESULTS FORM

Date 4/18/2009 DN 106 Wind calm
Vessel # 1018 Location Lk Washington Seas calm
Average Depth ______ Personnel ______

SVP file loaded ______

Tide file loaded ______

| Speed (m/s) | Speed (Kts) | Speed (RPM) | Hypack Line Name | CARIS Line Name | Depth Loc 1 | Diff Loc 1 | Depth Loc 2 | Diff Loc 2 | Depth Loc 3 | Diff Loc 3 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | | | 27.6557457 | | 25.9568637 | | 29.8462362 | | |
| 2.52 | 4.9 | 650 | 007_1942.81X | 007_1942 | 27.6090035 | -0.0467422 | 25.8629032 | -0.0939605 | 29.7750175 | -0.0712187 | -0.0624817 |
| 3.07 | 5.9 | 850 | 007_1952.81X | 007_1952 | 27.5795859 | -0.0761598 | 25.844337 | -0.1125267 | 29.7651968 | -0.0810394 | -0.0882821 |
| 3.66 | 7 | 1050 | 007_2001.81X | 007_2001 | 27.5550541 | -0.1006916 | 25.7653247 | -0.191539 | 29.7330816 | -0.1131546 | -0.130974 |
| 4.06 | 7.9 | 1250 | 007_2008.81X | 007_2008 | 27.5219777 | -0.133768 | 25.7774865 | -0.1793773 | 29.7278022 | -0.118434 | -0.1489711 |
| 4.47 | 8.7 | 1450 | 007_2016.81X | 007_2016 | 27.5246716 | -0.1310741 | 25.7636516 | -0.1932122 | 29.6939714 | -0.1522648 | -0.1517868 |



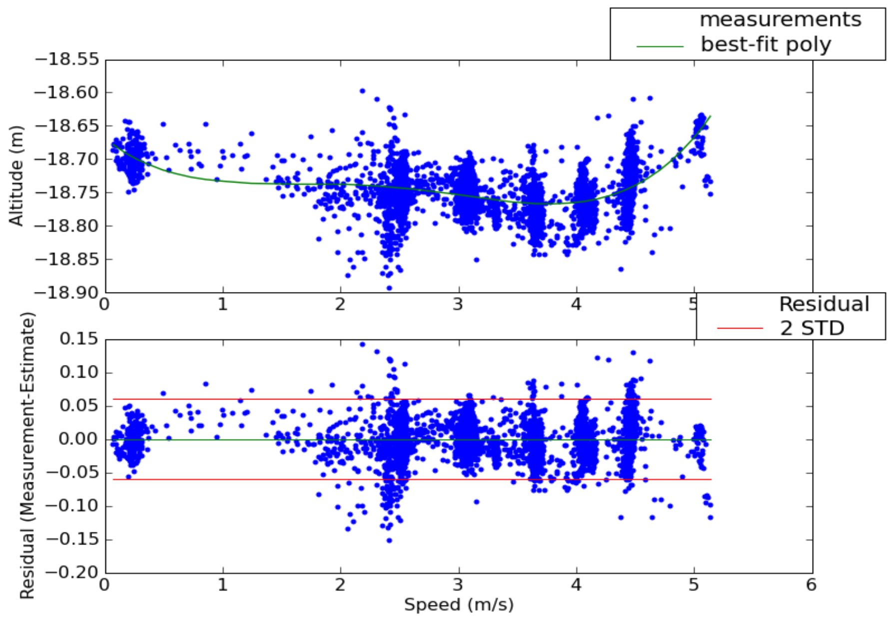
# Ellipsoid Referenced Dynamic Draft

Launch 1018

| 4/16/2009 | 106 | Lake Washington | Rice |
|---|---|---|---|
| Date | DN | Local Area | Processor |

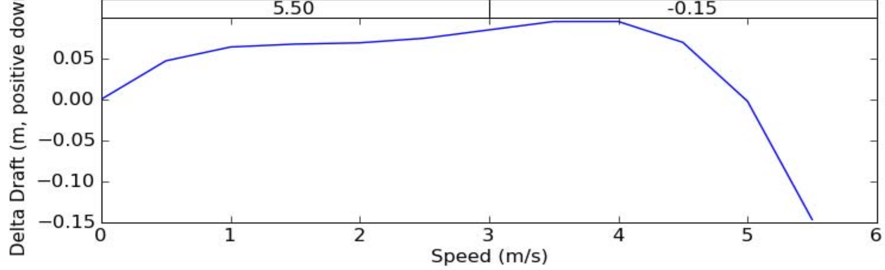
| SEAI | TH_1018_patch_test_dn105.000.002 | 1018_ERDDM.txt |
|---|---|---|
| Primary Station | POSPac File | SBET File |

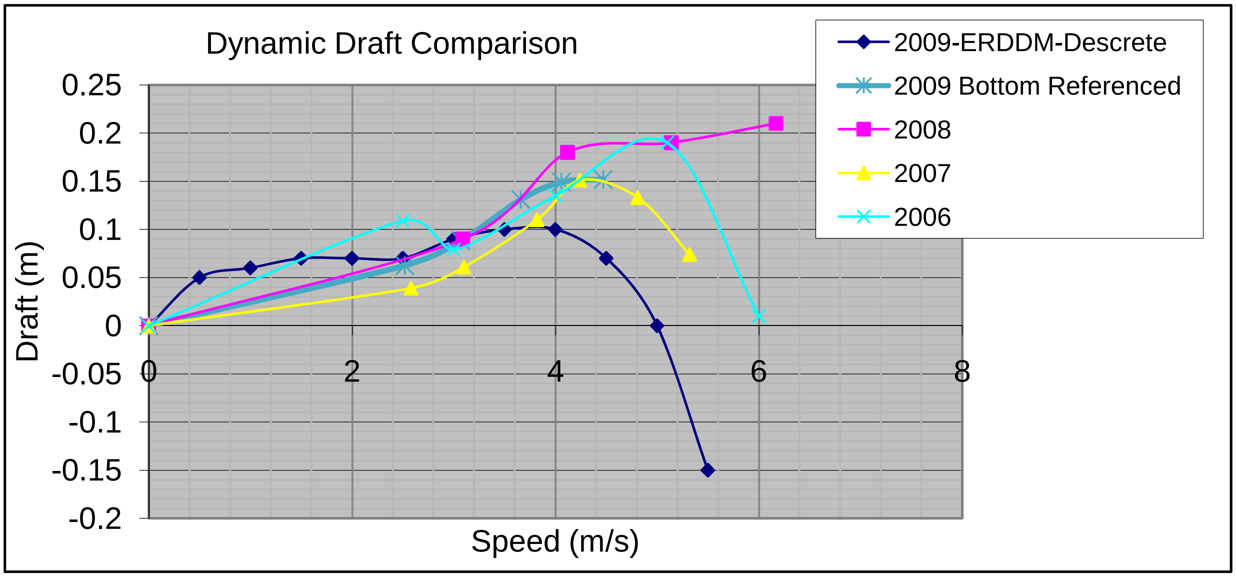
| proc_erddm.py, v0.12 | 4 |
|---|---|
| Processing Method | Coefficients |




$-3.59e-003*X^3 +3.31e-002*X^2 +-1.04e-001*X$

| Speed (m/s) | Delta Draft (m) |
|---|---|
| 0.00 | 0.00 |
| 0.50 | 0.05 |
| 1.00 | 0.06 |
| 1.50 | 0.07 |
| 2.00 | 0.07 |
| 2.50 | 0.07 |
| 3.00 | 0.09 |
| 3.50 | 0.10 |
| 4.00 | 0.10 |
| 4.50 | 0.07 |
| 5.00 | -0.00 |
| 5.50 | -0.15 |






## 2009 HVF Values

**2009-ERDDM-Descrete**

| speed (m/s) | draft (m) |
|---|---|
| 0 | 0 |
| 0.5 | 0.05 |
| 1 | 0.06 |
| 1.5 | 0.07 |
| 2 | 0.07 |
| 2.5 | 0.07 |
| 3 | 0.09 |
| 3.5 | 0.1 |
| 4 | 0.1 |
| 4.5 | 0.07 |
| 5 | 0 |
| 5.5 | -0.15 |

2009 Bottom Referenced

| speed (m/s) | draft (m) |
|---|---|
| 0 | 0 |
| 2.52 | 0.062 |
| 3.07 | 0.088 |
| 3.66 | 0.131 |
| 4.06 | 0.149 |
| 4.47 | 0.152 |

2008

| speed (m/s) | draft (m) |
|---|---|
| 0 | 0 |
| 3.09 | 0.09 |
| 4.12 | 0.18 |
| 5.14 | 0.19 |
| 6.17 | 0.21 |

2007

| speed (m/s) | draft (m) |
|---|---|
| 0 | 0 |
| 2.58 | 0.039 |
| 3.1 | 0.061 |
| 3.82 | 0.11 |
| 4.24 | 0.151 |
| 4.81 | 0.133 |
| 5.32 | 0.074 |

2006

| speed (m/s) | draft (m) |
|---|---|
| 0 | 0 |
| 2.5 | 0.109 |
| 3 | 0.079 |
| 4 | 0.135 |
| 5.1 | 0.19 |
| 6 | 0.01 |

# DDSSM DATA PROCESSING AND RESULTS FORM

***NOTE: Conducted with sled-mounted 8125.***

Date 4/18/2009
Vessel # 1018
Average Depth 16 meters

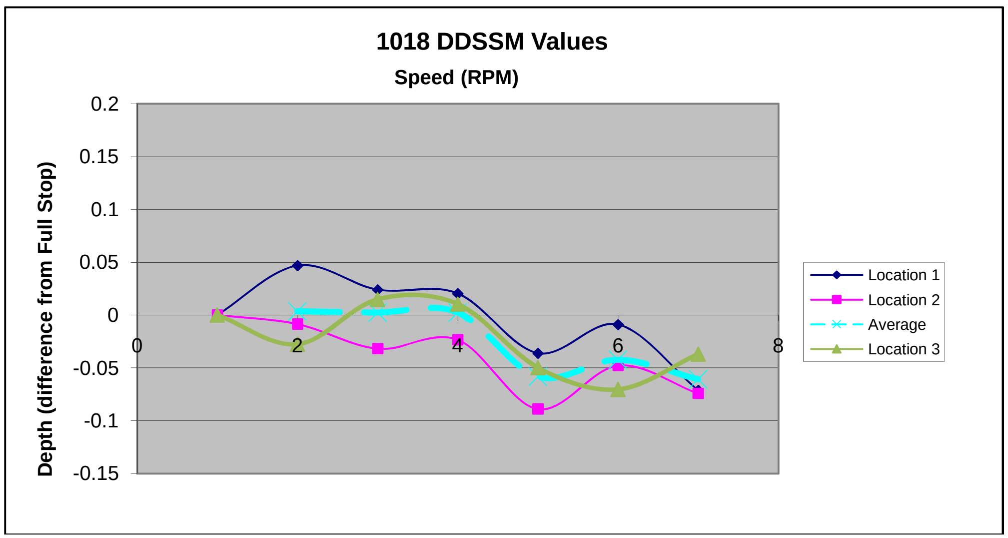
DN 219
Location Dutch Harbor, AK
Personnel Welton, Rice, Beduhn

Wind calm
Seas calm

SVP file loaded 092192151.svp

Tide file loaded 946-2620 9462620.tid

| Speed (m/s) | Speed (Kts) | Speed (RPM) | Hypack Line Name | Depth Loc 1 | Diff Loc 1 | Depth Loc 2 | Diff Loc 2 | Depth Loc 3 | Diff Loc 3 | Average |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 2142 | 17.5421699 | 0 | **16.9987276** | 0 | 16.87650376 | 0 | |
| | 5 | 650 | 2050/2055 | 17.58894816 | 0.046778256 | 16.99016 | -0.008567602 | 16.84873958 | -0.027764188 | 0.003482155 |
| | 5.5 | 774 | 2123/2128 | 17.56613327 | 0.023963362 | 16.96695 | -0.031777602 | 16.89124567 | 0.014741905 | 0.002309222 |
| | 6.3 | 890 | 2101/2105 | 17.56247363 | 0.020303723 | 16.97538 | -0.023347602 | 16.88678976 | 0.010285998 | 0.00241404 |
| | 7.1/7.2 | 1060 | 2133/2136 | 17.50604808 | -0.036121821 | 16.9098 | -0.088927602 | 16.82672642 | -0.049777349 | -0.058275591 |
| | 7.4/7.5 | 1120 | 2109/2112 | 17.53315974 | -0.009010164 | 16.951 | -0.047727602 | 16.80605949 | -0.070444274 | -0.042394013 |
| | 8.4/8.5 | 1425 | 2116/2119 | 17.51770889 | -0.07123927 | 16.916 | -0.07416 | 16.8116773 | -0.037062276 | -0.060820515 |



## Reference Surface Acquisition Log

**Launch 1018**
Vessel

| Date | Dn | Local Area | Wx |
|---|---|---|---|
| 4/17/2009 | 107 | Shilshole Bay | Clear, wind up to 10kts |

Personnel: Argento, Andrews, Renoud, Welton

Comments:

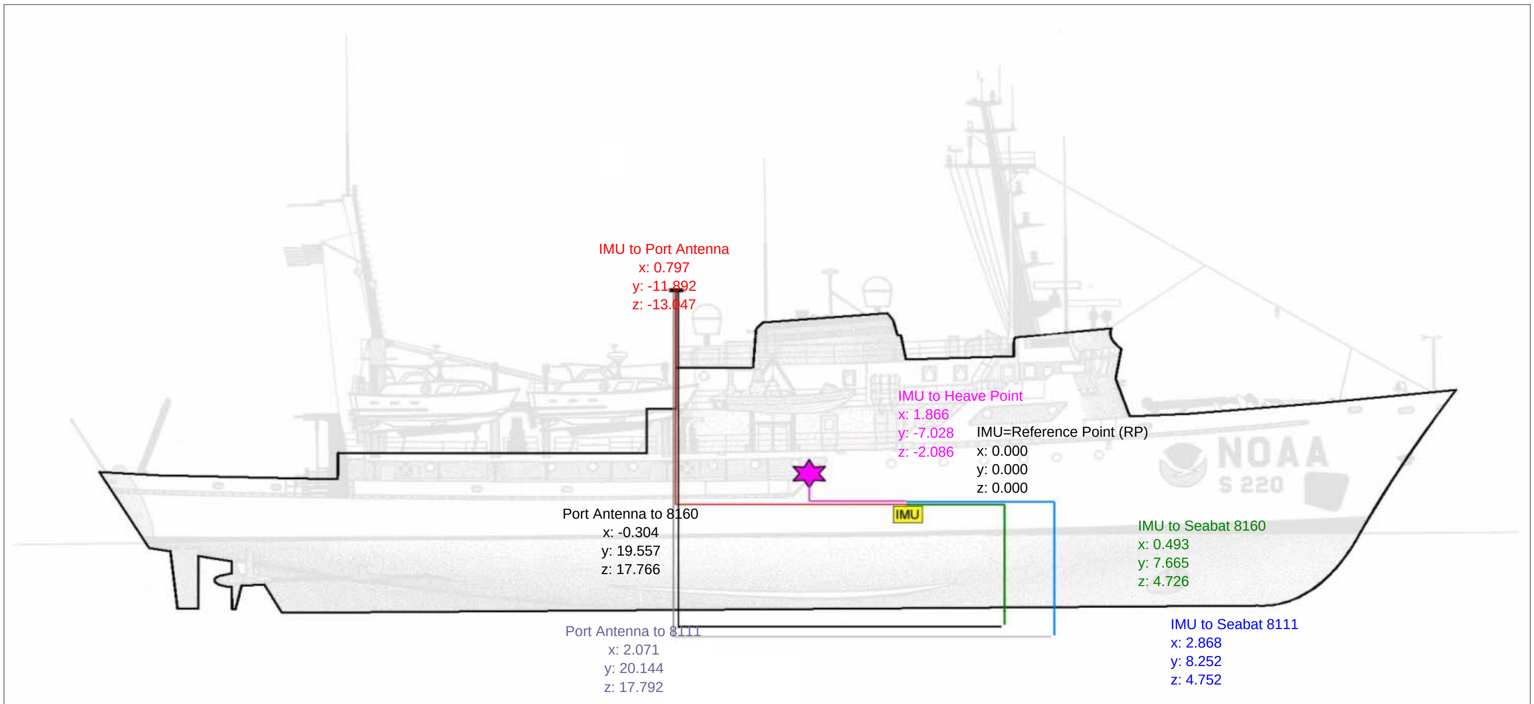
| SV Cast #1 filename | UTC Time | Lat | Lon | Depth | Ext. Depth |
|---|---|---|---|---|---|
| 09107094.4nv | 0944 | 47/40/26 | 122/25/27 | 38.8 | |

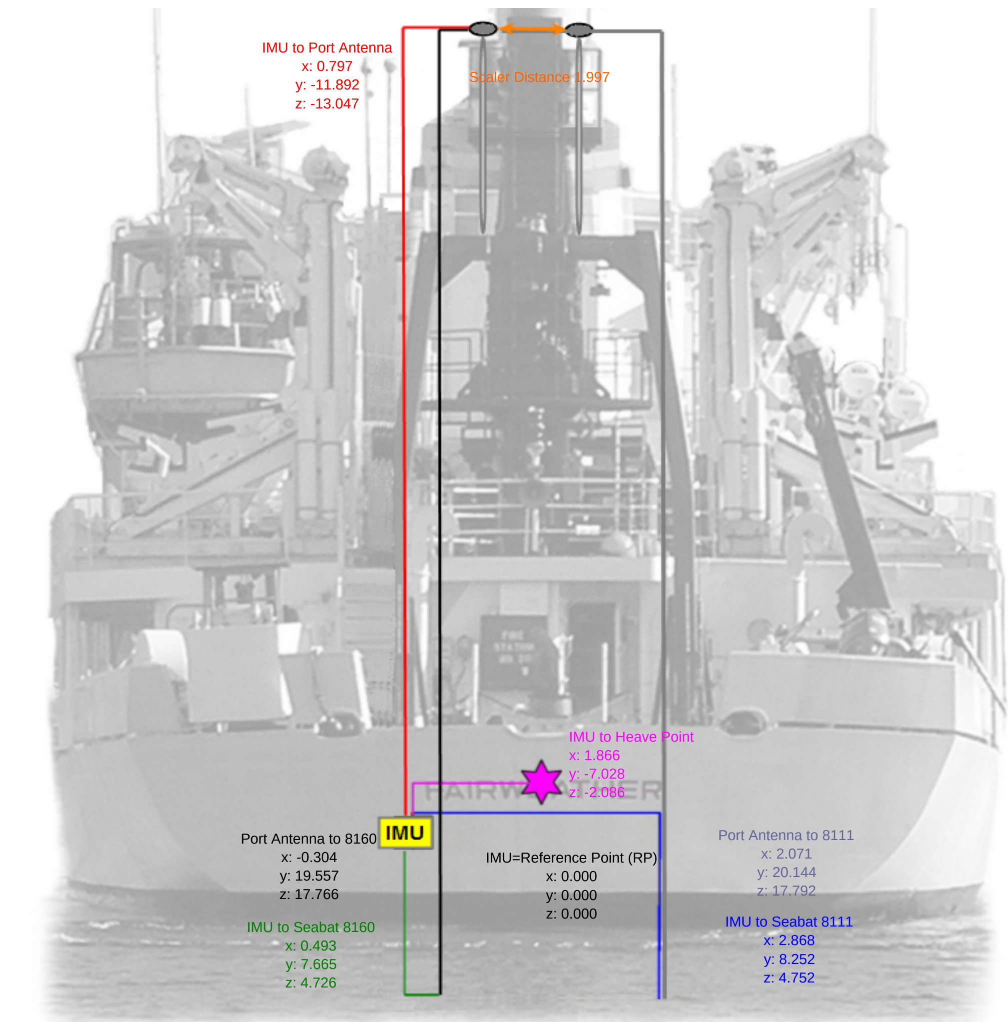
| SV Cast #2 filename | UTC Time | Lat | Lon | Depth | Ext. Depth |
|---|---|---|---|---|---|
| | | | | | |

| Project | Vessel | Day | Line | Min Time | Max Time | Total Time | Merged | Outdated | Sr Corrected | Line Reject | Line Class | Heading | Length (m) | Speed (n |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1018_HSRR_2 | FA_1018_Res | 2009-107 | 002_1819 | 2009-04-17 1 | 2009-04-17 1 | 01:47.921 | Yes | No | No | No | N/A | 330.46837204 | 397.60476283 | 3.6842205 |
| 1018_HSRR_2 | FA_1018_Res | 2009-107 | 005_1807 | 2009-04-17 1 | 2009-04-17 1 | 01:54.640 | Yes | No | No | No | N/A | 240.98222111 | 422.65786607 | 3.6868271 |
| 1018_HSRR_2 | FA_1018_Res | 2009-107 | 007_1832 | 2009-04-17 1 | 2009-04-17 1 | 02:07.520 | Yes | No | No | No | N/A | 150.11034297 | 430.78281106 | 3.3781588 |
| 1018_HSRR_2 | FA_1018_Res | 2009-107 | 003_1930 | 2009-04-17 1 | 2009-04-17 1 | 01:57.241 | Yes | No | No | No | N/A | 239.90304509 | 391.50376162 | 3.3393075 |
| 1018_HSRR_2 | FA_1018_Res | 2009-107 | 006_1804 | 2009-04-17 1 | 2009-04-17 1 | 02:02.361 | Yes | No | No | No | N/A | 62.214888907 | 433.37597276 | 3.5417818 |
| 1018_HSRR_2 | FA_1018_Res | 2009-107 | 007_1801 | 2009-04-17 1 | 2009-04-17 1 | 01:46.800 | Yes | No | No | No | N/A | 239.99611762 | 392.36713316 | 3.6738495 |
| 1018_HSRR_2 | FA_1018_Res | 2009-107 | 007_1834 | 2009-04-17 1 | 2009-04-17 1 | 04.200 | Yes | No | No | No | N/A | 146.34218827 | 14.457033584 | 3.4421508 |
| 1018_HSRR_2 | FA_1018_Res | 2009-107 | 009_1814 | 2009-04-17 1 | 2009-04-17 1 | 01:38.201 | Yes | No | No | No | N/A | 60.697567590 | 362.44868852 | 3.6908859 |
| 1018_HSRR_2 | FA_1018_Res | 2009-107 | 008_1812 | 2009-04-17 1 | 2009-04-17 1 | 01:52.720 | Yes | No | No | No | N/A | 241.42584894 | 409.60399673 | 3.6338182 |
| 1018_HSRR_2 | FA_1018_Res | 2009-107 | 004_1824 | 2009-04-17 1 | 2009-04-17 1 | 01:57.681 | Yes | No | No | No | N/A | 330.88975106 | 432.27878893 | 3.6733099 |
| 1018_HSRR_2 | FA_1018_Res | 2009-107 | 005_1826 | 2009-04-17 1 | 2009-04-17 1 | 02:12.760 | Yes | No | No | No | N/A | 150.59129913 | 447.14063149 | 3.3680372 |
| 1018_HSRR_2 | FA_1018_Res | 2009-107 | 003_1758 | 2009-04-17 1 | 2009-04-17 1 | 02:07.721 | Yes | No | No | No | N/A | 61.539851955 | 437.69002170 | 3.4269229 |
| 1018_HSRR_2 | FA_1018_Res | 2009-107 | 003_1821 | 2009-04-17 1 | 2009-04-17 1 | 01:47.360 | Yes | No | No | No | N/A | 149.47814582 | 364.91138722 | 3.3989510 |
| 1018_HSRR_2 | FA_1018_Res | 2009-107 | 004_1809 | 2009-04-17 1 | 2009-04-17 1 | 01:43.561 | Yes | No | No | No | N/A | 60.265994504 | 371.11739483 | 3.5835632 |
| 1018_HSRR_2 | FA_1018_Res | 2009-107 | 006_1829 | 2009-04-17 1 | 2009-04-17 1 | 01:56.681 | Yes | No | No | No | N/A | 331.31979816 | 430.67186877 | 3.6910196 |

# Description of Offsets for FAIRWEATHER S-220

All Values Shown are in CARIS Coordinates



## *Fairweather* Draft - 2009

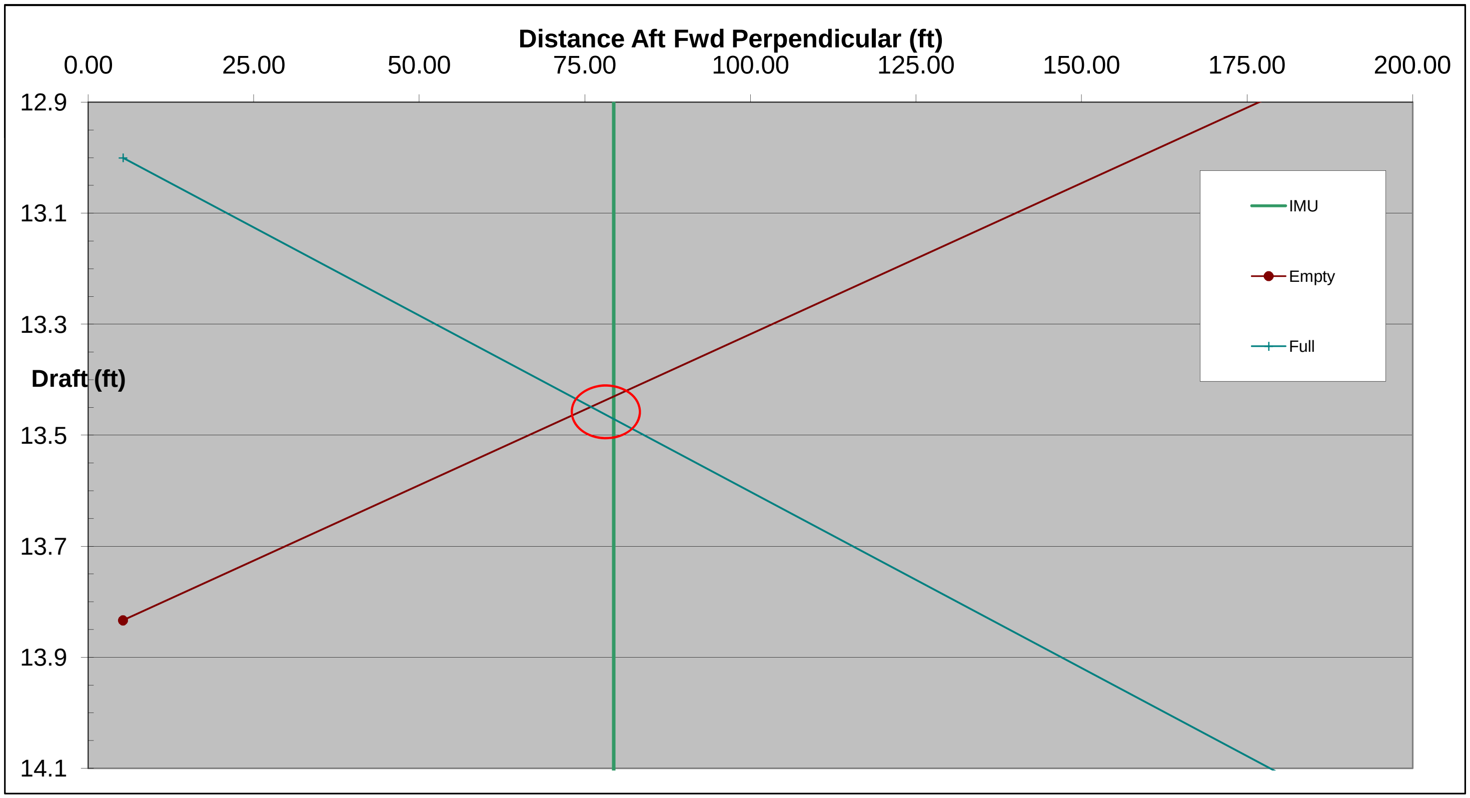
Immediately prior to the FA field season, the draft measurements were taken prior to fueling when the takes were very empty after shipyard (Empty) . And again after fueling and once the engineers had transferred the fuel in a satisfactory manner (Full). The waterline at the IMU was then calculated based on a linear interpolation.

| 2009 | (April) | x1 | Fwd y1 | x2 | Aft y2 | slope | IMU Depth (ft) | IMU Depth (m) |
|---|---|---|---|---|---|---|---|---|
| | Empty | 5.25 | 13.83 | 189 | 12.83 | -0.00544 | 13.43 | 4.093 |
| | Full | 5.25 | 13.00 | 189 | 14.17 | 0.00635 | 13.47 | 4.106 |
| | | 5.25 | | 189 | | 0.00000 | 0.00 | 0.000 |
| | | 5.25 | | 189 | | 0.00000 | 0.00 | 0.000 |
| | | 5.25 | | 189 | | 0.00000 | 0.00 | 0.000 |

| Min | Max |
|---|---|
| 12.83 | 14.17 |

| | | | | |
|---|---|---|---|---|
| Draft at IMU (ft) | 13.45 | 4.100 | AVG | Value Used in Offsets |
| | 0.029 | 0.009 | STDEV | Value used for Waterline Loading Uncertainty |

The IMU x-value (ft): 79.36
x-value (m): 24.19

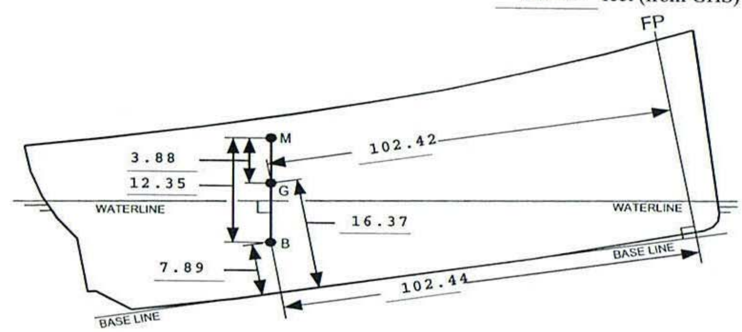


STABILITY TEST: **NOAA Ship FAIRWEATHER (16 Jul 2004 )**

## SHIP AT TIME OF STABILITY TEST--CONDITION 0

| | | FROM HYDROSTATIC CURVES | FROM INDEPENDENT CALCULATION |
|---|---|---|---|
| Corrected diaplacement | | tons | 1638.79 tons |
| Mean virtual metacentric height obtained from plot of inclining moments versus tangents of angles of heel | $\frac{\text{moment}}{\text{displacement x tangent}}$ = 5987.252 / 1638.790 | feet | 3.65 feet |
| Correction for free surface | = 374.0 / 1638.790 | feet | 0.23 feet |
| Mean metacentric height G.M. = | | feet | 3.88 feet |
| Transverse metacenter above base line corresponding to draft at LCF (corrected for hog or sag) | | feet | |
| Transverse metacenter above base line corrected for trim, and hog or sag | | feet | |
| C.G. above base line | | feet | 16.37 feet (from figure) |
| | | | 16.36 feet (from GHS) |
| Longitudinal metacenter above C.G. | | feet | |
| Moment to alter trim 1 foot, (Long GM x Δ) / L | | ft-tons | |
| Trim by stern | | feet | |
| Trimming lever = (Trim x moment to trim) / displacement | | feet | |
| Longitudinal center of buoyancy (LCB) from origin | | feet | |
| C.G. from origin | | feet | 102.44 feet (from figure) |
| | | | 102.42 feet (from GHS) |

| | | | |
|---|---|---|---|
| Period of complete roll | | ______ | seconds |
| Apparent radius of gyration of vessel | $\alpha = \frac{T\,GM}{1.108}$ | ______ | feet |
| Rolling constant | $C = \frac{T\,GM}{B}$ | ______ | |



## Definitions and Basis for Dimensions/Locations

### Northings

Northings (Port - Starboard) are with reference to the IMU Foundation Plate centerline scribe.
Positive values are starboard of the IMU.
Negative values are port of the IMU.
*Calculated values are in italics.*

### Eastings

Eastings (Stern to Bow ) are with reference to the IMU Foundation Plate centerline scribe.
Positive values are forward of the IMU.
Negative values are aft of the IMU.
*Calculated values are in italics.*

### Elevations

Elevations are with reference to the IMU Foundation Plate centerline scribe = 0 elevation.
Positive values are below the IMU (toward the keel).
Negative values are toward the topside.

### Dimensions

All dimensions are in feet and decimal feet. All dimensions provided are "offsets" to IMU centerline.

### Ship's Centerline Data

At project initiation, control was established to define the ship's centerline
as a plane running from a point on the centerline of the keel at the stern through a
point on the centerline of the keel near the bow, to a point on the bow splitting the bow chock.

### IMU Referenced Data - Procedure

All data was originally referenced to the ship's geometry.
Following location of the IMU, data was transformed to the IMU as point of origin for
Northings, Eastings, and Elevation. All dimensions provided with reference to the IMU are "offsets."

## Ship's Centerline - Control Measurements

(Prior to location of IMU and referencing of data to IMU as point of origin (0,0,0)

Defined by measurements at the keel centerline

| | longitude | transverse | elevation |
|---|---|---|---|
| near the bow | 1190.674 | 1000.000 | 135.8672 |
| at the stern (point of origin) | 1000.000 | 1000.000 | 100.0000 |
| along the keel (approx 180' forward) | 1180.121 | 1000.000 | 116.6810 |

### Ship's Baseline

Defined by measurements on the keel

| | longitude | transverse | elevation |
|---|---|---|---|
| at the stern (point of origin) | 1000.000 | 1000.000 | 100.0000 |
| and approx. 129' forward of stern | 1129.120 | 999.985 | 100.0022 |

## IMU Foundation Plate

| | EASTING | NORTHING | ELEVATION |
|---|---|---|---|
| Horizontal alignment per scribed lines on IMU foundation plate | | 0.001 | |
| | | 0.000 | |
| Scribed lines - intersection/centerline of IMU plate | 0.000 | 0.000 | 0.000 |
| Elevation checks near four corners of IMU Foundation plate * | | | |
| ** elevation check adjusted for target that created 10 mm offset =.03281 feet* | | | 0.001 |
| | | | -0.001 |
| | | | 0.000 |
| | | | -0.001 |

**SUMMARY**

- IMU foundation plate is level to within +/-0.001 feet.
- IMU foundation plate is located 12.856 feet above baseline established at the keel.
- IMU is parallel to ship's centerline to within +/- 0.001 feet.
  Location of scribed centerline intersection is 6.122 feet port of ship's centerline.
- IMU foundation plate centerline is located 11.638' feet forward of bulkhead 52.

## Granite Block

| | EASTING | NORTHING | ELEVATION | |
|---|---|---|---|---|
| Horizontal alignment per scribed lines | | | | |
| | | **1.584** | | |
| | | **1.583** | | |
| Scribed lines - intersection/centerline of granite block | | | | |
| | **-0.003** | **1.583** | | |
| | | | | Deviation from level |
| Elevation checks near four corners of granite block | | | | |
| ** elevation check adjusted for target that created 10 mm offset = 0.03281 feet* | | | **-0.217** | -0.001 |
| | | | **-0.217** | -0.001 |
| | | | **-0.216** | 0.001 |
| | | | **-0.215** | 0.001 |

**SUMMARY**

- Granite block is level to within +/-0.001 foot
  of average elevation = -0.21632 feet
- Granite block is parallel to ship's centerline to within 0.001 foot
  Location is 4.54 feet to port of ship's centerline and 1.583 feet starboard of IMU.
- Granite block is aligned with IMU to within 0.003 feet longitudinally.

## Array Acoustical Centers - Referenced to IMU

| | EASTING | NORTHING | ELEVATION |
|---|---|---|---|
| **PORT ARRAY (81-60)** | ***25.149*** | ***1.619*** | ***14.956*** |

**Explanation of Calculations**

Acoustic center is defined as the center of the transmitter array with the elevation = 83 mm below mounting face of array.

**Easting**

Center of array is defined by the foundation plate bolt centerlines (1/2 distance between bolts)

| | |
|---|---|
| 27.008 | Forward edge of foundation as measured |
| - 0.104 | Forward edge of foundation to centerline of forward bolt hole |
| - 1.755 | Distance from bolt hole centerline to center of array |
| 25.149 | feet forward of IMU |

**Northing**

Center of array is defined as the mid-point between the bolt holes on the foundation.

| | |
|---|---|
| 1.369 | Port edge of foundation as measured |
| + 0.078 | Port edge of foundation to centerline of bolt hole - per Cascade General |
| + 0.172 | Distance from bolt hole centerline to array center |
| 1.619 | feet starboard of IMU |

**Elevation**

Per Reson drawing 2148M011_001 the elevation is 83 mm below array mounting surface

| | |
|---|---|
| 14.679 | Array foundation elevation as measured. |
| 0.005 | Isolation "shim" added between foundation and array |
| 0.272 | 83 mm below array mounting surface to acoustical center |
| 14.956 | feet below IMU |

## Array Acoustical Centers - Referenced to IMU

| | EASTING | NORTHING | ELEVATION |
|---|---|---|---|
| **STARBOARD ARRAY (81-11)** | ***27.072*** | **9.41** | ***15.042*** |

**Explanation of Calculations**

Acoustic center is defined as midpoint of the transmitter array in the longitudinal and transverse axes.
The elevation is defined as the center of the receiving array.

**Easting**

Center of array is defined as 0.235' aft of the forward bolt centerlines on transmitter array foundation

| | |
|---|---|
| 28.563 | Forward edge of foundation fixture plate as measured (receiving plate forward edge) |
| 27.349 | Forward edge of transmitter array foundation as calculated |
| - 0.042 | Forward edge of foundation to centerline of forward bolt hole - per design |
| - 0.235 | Distance from bolt hole centerline to center of array - per design |
| 27.072 | feet forward of IMU |

**Northing**

Center of array is defined as the mid-point between the bolt holes on the transmitter array foundation.

| | |
|---|---|
| 9.410 | Centerline of array foundation as measured on scribe - aft section of fixture plate |
| 9.410 | feet starboard of IMU |

**Elevation**

Elevation is 0.401 feet above receiver array mounting surface

| | |
|---|---|
| 16.085 | Mounting foundation fixture plate as measured. |
| 15.447 | Receiver foundation elevation - as calculated |
| + 0.005 | Isolation "shim" added between foundation and array |
| - 0.410 | Design distance from mounting surface of array to acoustic center |
| 15.042 | feet below IMU |

## Longitudinal Array Foundation - Port Side

| | EASTING | NORTHING | ELEVATION | |
|---|---|---|---|---|
| Horizontal alignment *measured* at port edge of array foundation | | | | |
| | | **1.369** | | |
| | | **1.369** | | |
| Forward edge of array foundation - *measured* | | | | |
| | **27.008** | | | |
| Horizontal alignment - *calculated* to array centerline | | | | |
| *Foundation edge is 0.25 feet port of* | | ***1.619*** | | |
| *array centerline* | | ***1.619*** | | |
| | | | | deviation from |
| Elevation checks near four corners of array foundation | | | | level (average) |
| | | | **14.680** | 0.001 |
| | | | **14.681** | 0.002 |
| | | | **14.678** | -0.001 |
| | | | **14.677** | -0.002 |

**SUMMARY**

- Port longitudinal array foundation average elevation is 14.679 feet.
  Variation in elevation is +0.002 to -0.002 feet.
- Port longitudinal array foundation is parallel to ship's centerline and 1.369 feet starboard of IMU.
  Calculated array centerline is 1.619 feet starboard of IMU

## Longitudinal Array Foundation - Starboard Side

| | EASTING | NORTHING | ELEVATION | deviation from |
|---|---|---|---|---|
| Horizontal alignment *measured* on fixture plate scribe - | | | | *parallel* |
| *Design location is 3.292 feet* | | **9.410** | | 0.002 |
| *starboard of ship centerline* | | **9.406** | | -0.002 |
| Forward edge of array foundation fixture plate - *measured* | | | | |
| | **28.563** | | | |
| | | | | deviation from |
| Elevation checks near four corners of array foundation "fixture plate" | | | | *average* |
| | | | **16.085** | 0.000 |
| | | | **16.085** | 0.000 |
| | | | **16.084** | 0.000 |
| | | | **16.085** | 0.000 |
| *Calculated locations of longitudinal and transverse array foundations* | | | | |
| *Forward edge* | | | | |
| Receiver (transverse) | **28.563** | | | |
| *Transmitter (longitudinal)* | ***27.349*** | | | |
| *difference = 1.214* | | | | |

***NOTE:*** *On Transmitter array foundation - from forward edge to center of forward holes = 0.042'*
*On Receiver array foundation distance from forward edge to center of forward holes = 0.076'*

| | ELEVATION |
|---|---|
| *Calculated elevation of longitudinal and transverse array foundations* | |
| *Receiver/Transverse Foundation* | ***15.446*** |
| *Transmitter/Longitudinal Foundation* | ***15.709*** |
| *difference = 0.263* | |

**SUMMARY**

- Starboard longitudinal array foundation (measured at fixture plate) average elevation is 16.085 feet.
  Deviation from level (average elevation) is less than 0.001 feet.
- Starboard longitudinal array foundation averages 9.408 feet starboard of IMU.
  Variation from parallel is from -0.002 feet to +0.002 feet from average.
- Starboard longitudinal array foundation forward edge is 28.563 feet forward of IMU.

## Transverse Array Foundation - Port Side

| | EASTING | NORTHING | ELEVATION | |
|---|---|---|---|---|
| Forward Edge - Transverse array foundation - *measured* | | | | |
| | **28.343** | | | |
| | **28.338** | | | |
| Port edge - Transverse array - *measured* | | | | |
| | | **-0.181** | | |
| Centerline of array - *calculated* | | | | |
| *Foundation forward edge minus* | ***28.093*** | | | |
| *0.25 feet to array centerline* | ***28.088*** | | | |
| *Port edge of foundation plus 1.806 feet* | | ***1.624*** | | |
| *to calculated array centerline* | | | | |
| | | | | deviation from |
| Elevation checks near four corners of array foundation | | | | level |
| | | | **14.679** | 0.002 |
| *0.861 feet below baseline with 0.965* | | | **14.675** | -0.001 |
| *foot offset = 98.180 feet average* | | | **14.675** | -0.001 |
| *elevation* | | | **14.677** | 0.001 |

**SUMMARY**

- Transverse array foundation average measured elevation is 14.677 feet
  below IMU (0.006 feet above design location).
  Deviation from level (average elevation) is 0.003 to -0.001 feet
- Transverse array foundation centerline (calculated) averages 28.090 feet forward of IMU.
  Variation from parallel to ship's centerline is from -0.003 to 0.003 feet (from average).
- Transverse array centerline is calculated to be 1.624 feet starboard of IMU.

## Transverse Array Foundation - Starboard Side

NOTE: Direct Measurements were not taken to the transverse array because a single "fixture plate" covered bo
transmitter and receiver foundations. The data provided here is primarily *"calculated".*

| | EASTING | NORTHING | ELEVATION |
|---|---|---|---|
| Forward edge - as measured on fixture plate | | | |
| Receiver - (transverse) | **28.563** | | |
| as measured | | | |
| *Transmitter (longitudinal)* | ***27.349*** | | |
| *difference = 1.214* | | | |
| ***NOTE:*** *On Transmitter array foundation - from forward edge to center of forward holes = 0.042'* | | | |
| *On Receiver array foundation distance from forward edge to center of forward holes = 0.076'* | | | |
| Horizontal Alignment | | **9.406** | |
| centerline scribe on fixture plate | | | |
| as measured - forward portion of plate | | | |
| (near receiver array) | | | |
| *Average of measurements on fixture plate* | | ***9.408*** | |
| *Elevation of longitudinal and transverse array foundations* | | | |
| *Receiver/Transducer Transverse Foundation* | | | ***15.446*** |
| *Transmitter/Longitudinal Foundation* | | | ***15.709*** |
| *difference = 0.263* | | | |
| Based on measured elevations averaging 16.085 feet across fixture plate | | | |

**SUMMARY**

- Transverse array foundation is calculated to be 15.446 feet below IMU - calculated from measured elevation of 16.085 feet. Deviation in elevation measurements across the array fixture plate is less than 0.001 fe
- Transverse array foundation forward edge (measured) is 28.563 feet forward of IMU.
- Transverse array centerline is measured to be 9.406 feet starboard of IMU.

  Variation from parallel of the fixture plate across entire starboard array is ± 0.002 feet (from average).

## Antennae

| | EASTING | NORTHING | ELEVATION |
|---|---|---|---|
| Stbd POS MV Antenna -Location | **-35.866** | **12.925** | **-38.209** |
| Port POS MV Antenna - Location | **-35.739** | **-0.409** | **-38.283** |
| Foundation Plate Stack Antenna Alignment | | **7.677** | |
| Foundation Plate Stack Antenna Alignment | | **7.677** | |
| Port GYRO Foundation Plate Alignment | | **2.411** | |
| Port GYRO Foundation Plate Alignment | | **2.411** | |
| Stbd GYRO Foundation Plate Alignment | | **3.866** | |
| Stbd GYRO Foundation Plate Alignment | | **3.867** | |

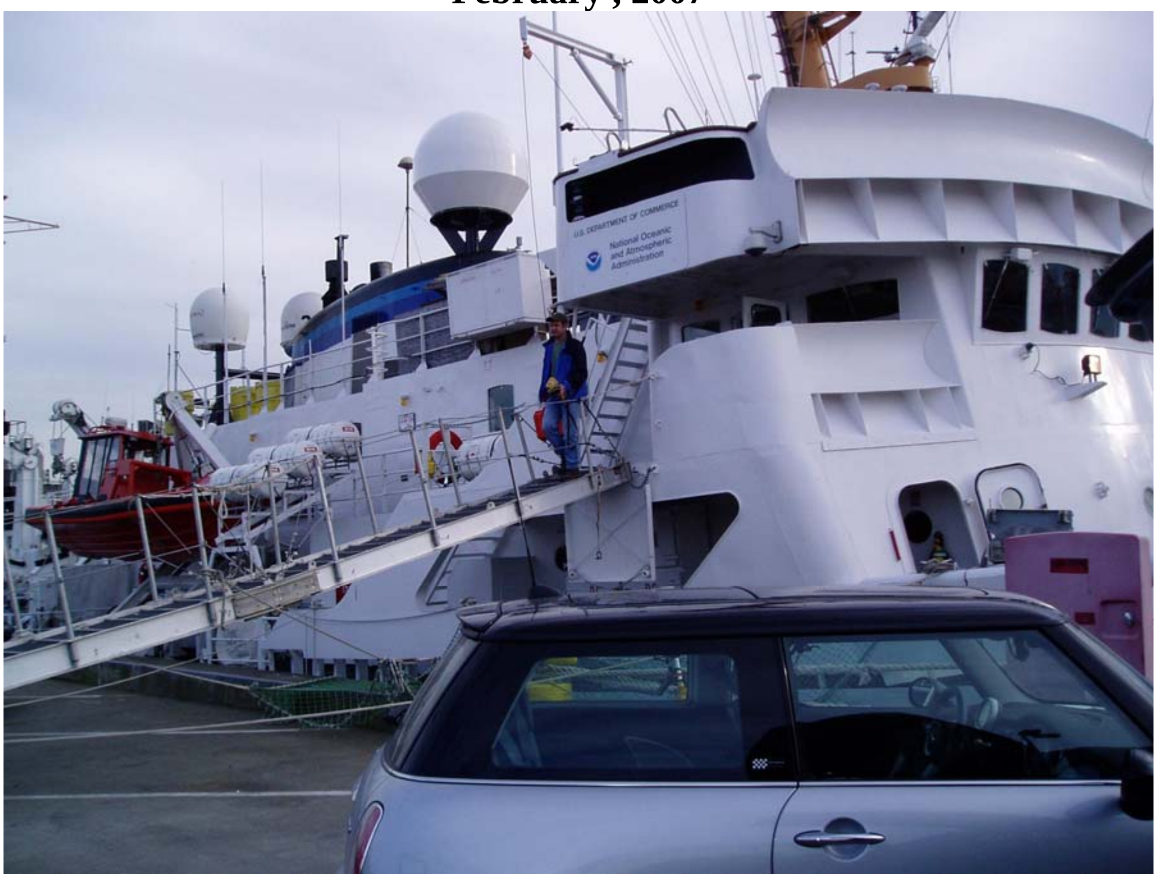
**SUMMARY**

- Foundation plate stack antenna alignment is parallel to ship's centerline.
- Port GYRO Foundation Plate is aligned parallel to ship's centerline.
- Starboard GYRO Foundation Plate is aligned parallel to ship's centerline.

# US DEPARTMENT OF COMMERCE
# NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
# NATIONAL OCEAN SERVICE
# NATIONAL GEODETIC SURVEY
# GEODETIC SERVICES DIVISION
# INSTRUMENTATION & METHODOLOGIES BRANCH

## NOAA SHIP FAIRWEATHER
## POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY
## FIELD REPORT

**Steven Breidenbach**
**February , 2007**



**PRIMARY CONTACTS**
LT MARK VAN WAES NOAA (206) 526-6891

**NOAA SHIP FAIRWEATHER**
**POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY**

## PURPOSE

The primary purpose of the survey was to accurately determine the spatial relationship of various components of a POS MV navigation system aboard the NOAA ship FAIRWEATHER. Reference points were also established to determine the spatial location of differential GPS antennas, Additionally, various reference points (bench marks) were restablished onboard the vessel to aid in future spatial surveys aboard the boat.

## PROJECT DETAILS

This survey was conducted while the ship was docked at the USCG in Seattle, WA . The weather was cool with a steady breeze.

## INSTRUMENTATION

The Topcon 3000LW total station was used to make all measurements.

Technical Data:

Angle Measurement

| | |
|---|---|
| Smallest unit in display | 0.1 seconds |

Standard Deviation

| | |
|---|---|
| Horizontal angle | 1.0 seconds |
| Vertical angle | 1.0 seconds |
| Distance measurement | 2mm + 2ppm |

A standard “peanut” prism was used as a sighting target. This prism was configured to have a zero mm offset.

## PERSONNEL

Steve Breidenbach NOAA/NOS/NGS/GSD/I&M BRANCH
(540) 373-1243

Dennis Lokken NOAA/NOS/NGS/GSD/I&M BRANCH
(540) 373-1243

**NOAA SHIP FAIRWEATHER**
**POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY**

## ESTABLISHING THE REFERENCE FRAME

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 IMU towards the bow of the boat. The Y axis is perpendicular to the centerline of the boat (X axis) and is positive from IMU towards the right, when looking at the boat from the stern. The Z axis is positive in an upward direction from the IMU. In this reference frame the IMU has the following coordinates;
X = 100.000(m)
Y = 100.000(m)
Z = 100.000(m)

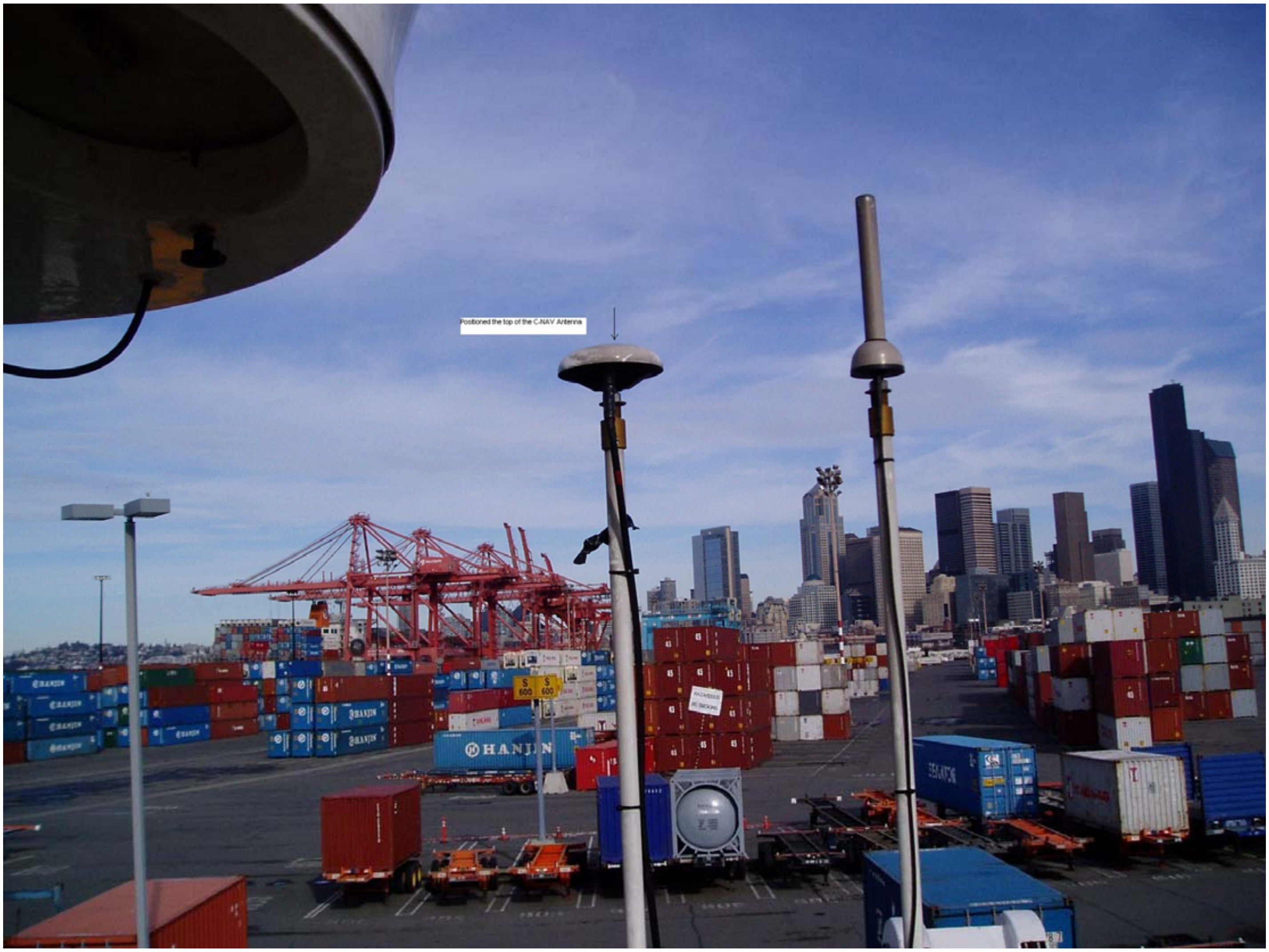
At the end of the survey all the coordinates were rotated to a right-handed coordinate system. The coordinates were translated to the IMU origin and the Granite Block origin.

## DISCUSSION

I recommend conducting the survey again, once the ship is put into dry dock. Conducting a survey such as this while the boat is in the water requires that the automatic compensators in the survey instrument be turned off. The survey is therefore conducted with all survey instrumentation set up relative to the mean movement of the related level vials. While every effort was made to make the most precise measurements possible, some additional error accumulation cannot be avoided under these type observing conditions.

The positions given for the IMU GPS antenna are to the bottom of the bolt as depicted on the photo below.

Position of the C-NAV Antenna



| Point Summary Report | | | | |
|---|---|---|---|---|
| **Name** | **Std Dev n (m)** | **Std Dev e (m)** | **Std Dev Hz (m)** | **Std Dev u (m)** |
| 10FLOOR | 0.003 | 0.003 | 0.004 | 0.002 |
| 11FLOOR | 0.003 | 0.004 | 0.005 | 0.002 |
| 1CLEAT | 0.004 | 0.018 | 0.019 | 0.002 |
| 1DECK | 0.004 | 0.018 | 0.018 | 0.002 |
| 1FLOOR | 0.000 | 0.000 | 0.000 | 0.000 |
| 1LOCKER | 0.004 | 0.004 | 0.005 | 0.003 |
| 1RAIL | 0.004 | 0.022 | 0.023 | 0.002 |
| 1WALL | 0.003 | 0.002 | 0.004 | 0.001 |
| 1WALL3 | 0.003 | 0.003 | 0.004 | 0.002 |
| 2CLEAT | 0.003 | 0.021 | 0.021 | 0.002 |
| 2CLEAT1 | 0.004 | 0.022 | 0.022 | 0.003 |
| 2FLOOR | 0.001 | 0.001 | 0.001 | 0.001 |
| 2RAIL | 0.004 | 0.022 | 0.022 | 0.002 |
| 2WALL | 0.002 | 0.003 | 0.004 | 0.002 |
| 3ANT | 0.003 | 0.006 | 0.007 | 0.003 |
| 3FLOOR | 0.002 | 0.002 | 0.003 | 0.002 |
| 3WALL | 0.003 | 0.003 | 0.005 | 0.002 |
| 4FLOOR | 0.001 | 0.001 | 0.002 | 0.003 |
| 5FLOOR | 0.002 | 0.004 | 0.005 | 0.001 |
| 6FLOOR | 0.002 | 0.002 | 0.003 | 0.003 |
| 7FLOOR | 0.005 | 0.003 | 0.006 | 0.002 |
| 8FLOOR | 0.004 | 0.004 | 0.005 | 0.002 |
| 9FLOOR | 0.002 | 0.013 | 0.013 | 0.003 |
| ABOLT | 0.003 | 0.026 | 0.026 | 0.003 |
| ANT DECK | 0.003 | 0.006 | 0.007 | 0.003 |

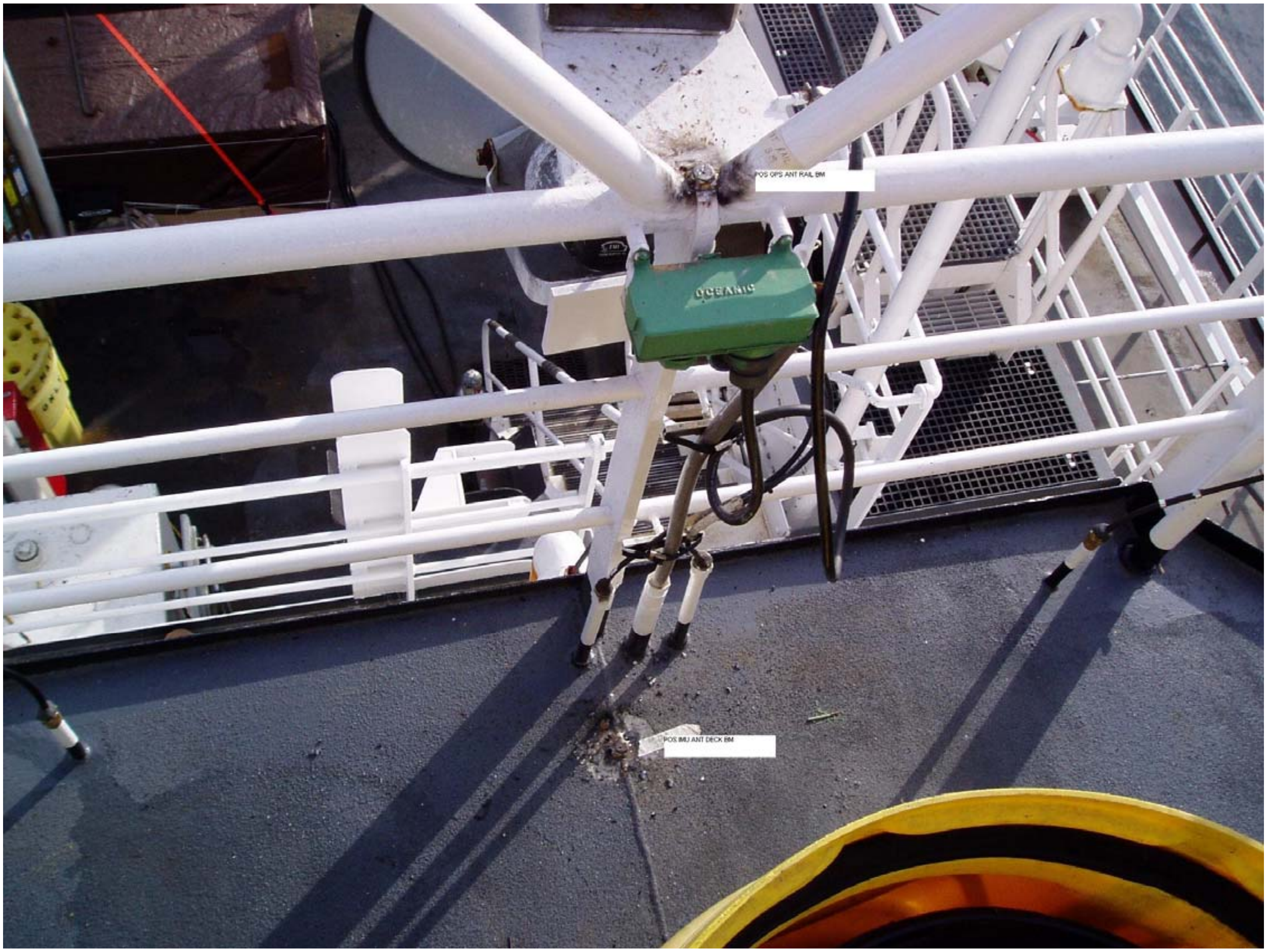
| Name | Std Dev n (m) | Std Dev e (m) | Std Dev Hz (m) | Std Dev u (m) |
|---|---|---|---|---|
| ANT DECK BM | 0.004 | 0.007 | 0.008 | 0.003 |
| ANT PORT | 0.003 | 0.007 | 0.008 | 0.003 |
| ANT RAIL | 0.004 | 0.006 | 0.007 | 0.003 |
| ANT RAIL BM | 0.003 | 0.007 | 0.007 | 0.003 |
| ANT STAR | 0.004 | 0.007 | 0.008 | 0.003 |
| BOW BM | 0.004 | 0.023 | 0.024 | 0.003 |
| BOW BM2 | 0.004 | 0.023 | 0.023 | 0.003 |
| BRIDGEPORT | 0.005 | 0.011 | 0.012 | 0.003 |
| BRIDGESTAR | 0.005 | 0.011 | 0.012 | 0.003 |
| BRIDGESTAR2 | 0.005 | 0.011 | 0.012 | 0.003 |
| DOOR | 0.001 | 0.001 | 0.002 | 0.001 |
| GRANITE BOW | 0.002 | 0.001 | 0.002 | 0.001 |
| GRANITE CENTER | 0.002 | 0.001 | 0.002 | 0.001 |
| GRANITE PORT | 0.002 | 0.001 | 0.002 | 0.001 |
| GRANITE STAR | 0.003 | 0.002 | 0.003 | 0.001 |
| GRANITE STERN | 0.002 | 0.001 | 0.002 | 0.001 |
| IMU BM | 0.003 | 0.001 | 0.003 | 0.003 |
| IMU BOW PORT | 0.002 | 0.001 | 0.002 | 0.001 |
| IMU BOW STAR | 0.002 | 0.001 | 0.002 | 0.001 |
| IMU CENTER | 0.000 | 0.000 | 0.000 | 0.000 |
| IMU STERN PORT | 0.002 | 0.001 | 0.002 | 0.001 |
| IMU STERN STAR | 0.002 | 0.001 | 0.002 | 0.001 |
| LADDER | 0.002 | 0.002 | 0.002 | 0.001 |
| MVP BM | 0.004 | 0.023 | 0.023 | 0.003 |
| RAIL STAR | 0.006 | 0.015 | 0.016 | 0.003 |
| RAIL STAR1 | 0.004 | 0.005 | 0.007 | 0.003 |
| RAILPORT | 0.005 | 0.015 | 0.016 | 0.003 |

| Name | Std Dev n (m) | Std Dev e (m) | Std Dev Hz (m) | Std Dev u (m) |
|---|---|---|---|---|
| RAILSTAR | 0.005 | 0.015 | 0.016 | 0.003 |
| STEARN BM | 0.004 | 0.024 | 0.024 | 0.003 |
| STERN BM | 0.003 | 0.024 | 0.024 | 0.002 |

## COORDINATES

| IMU Origin | | | |
|---|---|---|---|
| Right-handed Coordinate System | | | |
| | | | |
| **Name** | **Easting (x) meters** | **Northing (y) meters** | **Elevation (z) meters** |
| IMU CENTER | 0 | 0 | 0 |
| IMU BOW PORT CORNER | 0.073 | -0.084 | -0.006 |
| IMU BOW STAR CORNER | 0.071 | 0.088 | -0.004 |
| IMU STERN STAR CORNER | -0.068 | 0.089 | -0.003 |
| IMU STERN PORT CORNER | -0.065 | -0.086 | -0.006 |
| GRANITE BOW | 0.147 | 0.48 | 0.108 |
| GRANITE STAR | -0.002 | 0.574 | 0.111 |
| GRANITE STERN | -0.148 | 0.478 | 0.109 |
| GRANITE PORT | -0.003 | 0.382 | 0.106 |
| GRANITE CENTER | -0.002 | 0.477 | 0.108 |
| IMU BM | 0.034 | -0.263 | -0.496 |
| STERN BM | -40.32 | 1.927 | -2.184 |
| MVP BM | -38.721 | 5.985 | -2.018 |
| STEARN BM | -40.313 | 1.921 | -2.181 |
| POS GPS ANT STARBOARD | -11.917 | 3.171 | -12.936 |
| POS GPS ANT PORT | -11.92 | 1.177 | -12.98 |
| A FRAME BOLT | -43.019 | 1.975 | -7.142 |
| POS GPS ANT RAIL BM | -12.037 | 2.101 | -10.376 |
| POS IMU ANT DECK BM | -11.823 | 2.07 | -9.301 |
| C-NAV ANT | -10.075 | 4.131 | -11.377 |
| BOW BM | 28.346 | 2.077 | -7.853 |

| Granite Block Origin | | | |
|---|---|---|---|
| Right-handed Coordinate System | | | |
| | | | |
| **Name** | **Easting (x) meters** | **Northing (y) meters** | **Elevation (z) meters** |
| IMU CENTER | 0.002 | -0.477 | -0.108 |
| IMU BOW PORT CORNER | 0.075 | -0.561 | -0.114 |
| IMU BOW STARBOARD CORNER | 0.073 | -0.39 | -0.112 |
| IMU STERN STARBOARD CORNER | -0.065 | -0.388 | -0.111 |
| IMU STERN PORT CORNER | -0.063 | -0.563 | -0.114 |
| GRANITE BOW | 0.149 | 0.003 | 0 |
| GRANITE STAR | 0 | 0.097 | 0.003 |
| GRANITE STERN | -0.145 | 0.001 | 0.001 |
| GRANITE PORT | 0 | -0.095 | -0.002 |
| GRANITE CENTER | 0 | 0 | 0 |
| IMU BM | 0.036 | -0.74 | -0.604 |
| STERN BM | -40.317 | 1.45 | -2.292 |
| MVP BM | -38.719 | 5.508 | -2.126 |
| STEARN BM | -40.31 | 1.444 | -2.289 |
| POS GPS ANT STARBOARD | -11.915 | 2.694 | -13.044 |
| POS GPS ANT PORT | -11.918 | 0.699 | -13.088 |
| A FRAME BOLT | -43.017 | 1.498 | -7.25 |
| POS GPS ANT RAIL BM | -12.034 | 1.623 | -10.484 |
| POS IMU ANT DECK BM | -11.821 | 1.593 | -9.409 |
| C-NAV ANT | -10.073 | 3.654 | -11.485 |
| BOW BM | 28.349 | 1.6 | -7.961 |




POS GPS RAIL BM AND POS GPS DECK BM


IMU BM

US DEPARTMENT OF COMMERCE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE
NATIONAL GEODETIC SURVEY
GEODETIC SERVICES DIVISION
INSTRUMENTATION & METHODOLOGIES BRANCH

# NOAA SHIP FAIRWEATHER
# POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY
# FIELD REPORT

Kendall Fancher
March , 2009

**PRIMARY CONTACTS**

Glen Rice NOAA 757-615-6465

**NOAA SHIP FAIRWEATHER**
**POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY**

## PURPOSE

The primary purpose of the survey was to precisely determine the spatial relationship of various components of a POS MV navigation system aboard the NOAA ship FAIRWEATHER. Additionally, various reference points (bench marks) were re-established onboard the vessel to aid in future spatial surveys aboard the boat.

## PROJECT DETAILS

This survey was conducted while the ship was in dry dock at the Lake Union dry dock in Seattle, WA. The weather conditions over the two days required to conduct this survey were windy, cool, with intermittent rain.

## INSTRUMENTATION

The Leica TC2003 total station was used to make all measurements.

Technical Data:

Standard Deviation

| | |
|---|---|
| Horizontal angle | 0.5 seconds |
| Vertical angle | 0.5 seconds |
| Distance measurement | 0.2mm + 2ppm |

A Leica precision prism was used as a sighting target. This prism was configured to have a zero mm offset.

## PERSONNEL

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Dennis Lokken NOAA/NOS/NGS/GSD/I&M BRANCH
(540) 373-1243

**NOAA SHIP FAIRWEATHER**
**POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY**

## DEFINITION OF THE REFERENCE FRAME

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

## SURVEY METHODOLOGY

***02/15/2009***

Coordinates of 100.000N, 100.000E, and 100.000U were assumed for temporary control point 1. A distance and height difference were measured between temporary control points 1 and 3. These values were used to determine the coordinates at temporary control point 3. Temporary control points 1 and 3 were located along the top deck and on the north side of the dry dock vessel.

Temporary control point 1 was occupied and temporary control point 3 was observed for a backsight. After initialization, temporary control points 2 and 4(located on the top deck of the dry dock vessel), H1 (located on the bottom deck of the dry dock vessel), and BOW BM were observed in both direct and reverse.

Temporary control point 2 was occupied and temporary control point 3 was observed for a backsight. After initialization, temporary control point W1 (located on the top deck of the dry dock vessel) and D1 (located inside the ship on the D deck along the port side) were observed in both direct and reverse. Temporary control point 1 was also observed and yielded an inverse check of 0.001m horizontally and 0.001m vertically.

Temporary control point 4 was occupied and control point 1 was observed for a backsight. After initialization, temporary control point 5 (located on the south side and on the top deck of the dry dock vessel) was observed in both direct and reverse.

Temporary control point 5 was occupied and control point 4 was observed for a backsight. After initialization, temporary control point D2 (located inside the ship on the D deck along the starboard side) was observed in both direct and reverse.

Temporary control point H1 was occupied and control point 1 was observed for a backsight. After initialization, temporary control point H2 (located on the bottom deck of the dry dock vessel), and USBL BM were observed in both direct and reverse.

Temporary control point H2 was occupied and temporary control point H1 was observed for a backsight. After initialization, 8111 BM and 8160 BM were observed in both direct and reverse. Temporary control point W1 was also observed and yielded an inverse check of 0.019m horizontally and 0.033m vertically.

Temporary control point D1 was occupied and temporary control point D2 was observed for a backsight. After initialization, temporary control point D3 (located in the doorway leading to the mess hall on the D deck) was observed in both direct and reverse.

Temporary control point D3 was occupied and temporary control point D1 was observed for a backsight. After initialization, temporary control point C1 (located on the C deck near the IMU) was observed in both direct and reverse. Temporary control point D2 was also observed and yielded an inverse check of 0.026m horizontally and 0.0001m vertically.

Temporary control point C1 was occupied and temporary control point D3 was observed for a backsight. After initialization, IMU, IMU BOW PORT CORNER, IMU BOW STAR CORNER, IMU STERN STAR CORNER, and IMU STERN PORT CORNER were observed in both direct and reverse.

***02/16/2009***

Temporary control point 4 was occupied and control point 1 was observed for a backsight. After initialization, temporary control point 6 (located on the south side and on the top deck of the dry dock vessel) and BOW BM were observed in both direct and reverse. Temporary control point D2 was also observed and yielded an inverse check of 0.0004m horizontally and 0.083m vertically.

Temporary control point 6 was occupied and temporary control point 4 was observed for a backsight. After initialization, TRANSOM PIVOT POINT PORT, STERN BM, POS GPS ANT RAIL BM, POS IMU ANT DECK BM, POS GPS ANT STARBOARD, and POS GPS ANT PORT were observed in both direct and reverse.

Temporary control point 3 was occupied and temporary control point 1 was observed for a backsight. After initialization, TRANSOM PIVOT POINT STARBOARD, STERN BM, POS GPS ANT STARBOARD, and POS GPS ANT PORT were observed in both direct and reverse. Temporary control point 6 was also observed and yielded an inverse check of 0.0006m horizontally and 0.001m vertically.

The reference frame was rotated using STERN BM as the point of rotation. A zero degree azimuth was used during the rotation from STERN BM to BOW BM. The reference frame was then translated to relocate the origin of the reference frame to the IMU.

**NOAA SHIP FAIRWEATHER**
**POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY**

## INVERSE RESULTS

***Inverses were computed between the determined positions of those ship benchmarks and sensor points which were determined from two separate locations  The results of these inverses are:***

| ID | Horizontal Dist.(m) | Elevation Diff(m) |
|---|---|---|
| BOW BM | 0.0150 | 0.0240 |
| STERN BM | 0.0060 | 0.0010 |
| POS GPS ANT STARBOARD | 0.0100 | 0.0001 |
| POS GPS ANT PORT | 0.0100 | 0.0000 |

## DISCUSSION

The Fairweather was in dry dock during this survey, however, the dry dock vessel was still subject to movement due to wave action.   Conducting a survey such as this while the ship is moving requires that the automatic compensators in the survey instrument be turned off.  The survey is therefore conducted with all survey instrumentation set up relative to the mean movement of the related level vials.  While every effort was made to make the most precise measurements possible, some additional error accumulation cannot be avoided under these type observing conditions.

The POS GPS antenna coordinates were determined to the top center of the antennas.  The Z value should be corrected to the Antenna Reference Point (ARP).  In order to apply this correction, the mechanical height of the antenna should be determined and subtracted from the Z value determined during this survey for both of the POS GPS antennas.

**NOAA SHIP FAIRWEATHER**
**POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY**

**Coordinate Listing using IMU as the Reference Frame Origin**

| ID | X(NORTHING)m | Y(EASTING)m | Z(UP)m |
|---|---|---|---|
| IMU CENTER | 0.000 | 0.000 | 0.000 |
| IMU STERN PORT CORNER | -0.071 | -0.089 | -0.001 |
| IMU BOW PORT CORNER | 0.070 | -0.086 | -0.001 |
| IMU BOW STARBOARD CORNER | 0.069 | 0.087 | 0.000 |
| IMU STERN STARBOARD CORNER | -0.073 | 0.086 | 0.000 |
| BOW BM | 28.378 | 1.805 | 7.796 |
| STERN BM | -40.306 | 1.805 | 2.255 |
| USBL BM | -28.354 | 1.738 | -4.204 |
| 8160 BM | 8.407 | 0.395 | -4.400 |
| 8111 BM | 8.532 | 3.002 | -4.666 |
| POS GPS ANT RAIL BM | -12.011 | 1.785 | 10.381 |
| POS IMU ANT DECK BM | -11.790 | 1.780 | 9.305 |
| POS GPS ANT STARBOARD | -11.886 | 2.794 | 13.051 |
| POS GPS ANT PORT | -11.892 | 0.797 | 13.047 |
| TRANSOM PIVOT POINT STARBOARD | -39.727 | 3.366 | 2.385 |
| TRANSOM PIVOT POINT PORT | -39.722 | 0.240 | 2.345 |

**NOAA SHIP FAIRWEATHER**
**POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY**


IMU Reference Points

**NOAA SHIP FAIRWEATHER**
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POS GPS ANTENNAS

**NOAA SHIP FAIRWEATHER**
**POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY**


BOW CENTERLINE REFERENCE POINT

**NOAA SHIP FAIRWEATHER**
**POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY**


CENTERLINE REFERENCE POINT ON G DECK

**NOAA SHIP FAIRWEATHER**
**POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY**


CENTERLINE REFERENCE POINT ON RAIL AT G DECK

**NOAA SHIP FAIRWEATHER**
**POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY**


CENTERLINE STERN REFERENCE POINT

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**POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY**


TRANSOM REFERENCE POINT ON PORT SIDE


TRANSOM REFERENCE POINT ON STARBOARD SIDE

**NOAA SHIP FAIRWEATHER**
**POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY**


8111 REFERENCE POINT

**NOAA SHIP FAIRWEATHER**
**POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY**


8160 REFERENCE POINT

**NOAA SHIP FAIRWEATHER**
**POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY**


USBLE REFERENCE POINT

TRU-STONE Technologies

*ISO 9002 Certified*

# *Certificate of Accuracy*

**Customer Name:** MCMASTER-CARR SUPPLY CO. **Customer PO#:** TA-28173060

**Customer Address:** 200 AURORA IND. PARKWAY
AURORA,OH 44202

**Date of Calibration:** 8/23/02
**Product Description:** GRANITE SURFACE PLATE
**Size:** 8" X 12" X 2"
**Serial Number:** 36961
**Accuracy:** Actual: .000075" Allowed: .0002"
**Repeatability:** Actual: .000055" Allowed: .00010"
**Grade:** B
**Uncertainty of Measurement:** 5.2√D
**M.O.E.:** 7.5 x 10 6
**Laboratory Conditions:** Temperature: 69 °F Humidity: 51%

This product was inspected under environmentally controlled conditions. The electronic and optical gauging equipment used in inspecting this item has been calibrated and is traceable to the National Institute of Standards and Technology (NIST). Our calibration system is in compliance with ISO 10012-1.

Calibration Equipment Used in the Inspection of this Product:

| *Type of Equipment* | *ID Number* | *Instrument Uncertainty* | *NIST Traceability Number* | *Cal. Due Date* |
|---|---|---|---|---|
| Autocollimator | IP 040 | ±0.5 arc sec | 821/259488-97 | 6-03 |
| .000020 Mahr Dial I | 20990 | 50 µin | 25894-1 | 6-03 |

Laboratory Manager Signature: [signature]

Donald Schirmers, Lapping Manager
Robert Golla, Accessories Supervisor

**REWORK / RECALIBRATION** *(This section is completed for recertification orders only - accuracies upon receipt)*

Date of Receipt:
Accuracy of Incoming Product:
Repeat Measurement of Incoming Product:

☐ ***Was unable to read upon receipt due to poor condition of product***

The results on this Certificate of Accuracy apply only to the item described above. This report shall not be reproduced except in full and with the written authorization of our laboratory.

*Measurement Uncertainty is expressed at a confidence level of 95% (coverage factor k=2)*

Procedure Number: QP 4.10.1

# FINAL INSPECTION REPORT

Laboratory Name

TRU-STONE Technologies
1101 Prosper Drive • Box 430
Waite Park, MN 56387
PH: 320-251-7171 • FAX: 320-259-5073

## Final Inspection

(1) Inspection Number: 0200851

(2) Inspection Date: 8-23-02

(3) Date of Receipt (rework items): ______

(4) Repeat Reading of Received Item: ______

(5) Accuracy of Received (rework) Item: ______

☐ Unable to Inspect – product in too poor of condition

(6) Customer Name: [illegible]

(7) Serial Number: 36961

(8) P.O. Number: JA-2813060

(9) Print/Part Number: ______

(10) Description of Item: 8x12x2 CLB

(11) Granite Type: Impala

(12) Conditions at Time of Inspection: Temperature: 69 °F Humidity: 51

(13) Test Equipment:

Autocollimator Mirror Size: 3"

| Type of Equipment | Serial Number | Calibration Due Date | Uncertainty of IMTE |
|---|---|---|---|
| Autocollimator ☑ Repeat-o-meter ☑ | IP040 | 6-03 | ± 0.5 arc sec |
| Electronic Level ☐ Height Check ☐ | 2990 | 6-03 | 50 µin |
| Amp & Gauge Head ☐ Surfometer ☐ | | | |
| Penta Prism ☐ Mikrokator ☐ | | | |
| Other | | | |

(14) Grade: **(B)** A AA N/A

(15) Overall Accuracy / Flatness (actual): .000075 (allowed): .0002

(16) Repeat Measurement (actual): .000055 (allowed): (.00010") B .000050" A .000025" AA N/A

(FIM: Full Indicator Movement)

(17) Final Inspector Signature: [signature]

(18) Opinion / Interpretation (if applicable): ______

(21) Thread Size, Quantity & Location to Print: Yes ______ No ______

(22) Insert / Hole / Slot Size, Quantity & Location to Print: Yes ______ No ______

19-23 Are Not Applicable – No Inserts ☑

(23) Inspector Signature: ______

Existing inserts are not inspected on reworks and/or calibration items.

The results of this inspection apply only to the item described above. This report shall not be reproduced, except in full, with the written approval of our laboratory. Measurement uncertainty is expressed at a confidence level of 95% (coverage factor k=2).

## Shipping

(19) Threaded Inserts: Yes ______ No ______ (20) Clean: Yes ✓ No ______

Packaging Conforms to Company and Customer Requirements: Yes ✓ No ______

TRU-STONE Technologies

Save IMPORTANT DOCUMENT Save

# Tru-Stone Technologies
## Instructions for Care of Granite Surface Plates

1. **Cleaning and Moisture:** Plates shall be cleaned thoroughly and given adequate time to dry before testing for tolerance. Water based cleansers that have not dried will cause iron parts to rust if they are left in contact with the wet surface for an extended period of time. It is recommended that plates undergo drying time in a room with less than 50 percent relative humidity. Temperature and dirt have a direct correlation with measurement accuracy. Personal cleanliness will aid in eliminating one source of contamination.
2. **Temperature Soaking Time:** Before granite surface plates are measured for work surface flatness, the granite should remain in the calibration area until it has reached room temperature, which may require 2 to 3 days. Large plates require more soak-out time than smaller ones.
3. **Scratches and Nicks**: Whenever scratches and nicks appear on granite plates, the resulting rough edges should be removed with a flat granite dressing plate. Any bump that shatters the surface raises fractured material at the rim of the crater.
4. **Rotation of Plates:** When a specific work surface area receives prolonged usage, it is suggested that the plate and stand be rotated 180 degrees on a periodic basis to increase the wear life of the plate. The production of a contour map during calibration is particularly helpful in locating the parts of the plate that should be given the most use. This can be accomplished by requesting a long form certification when ordering the new surface plate or when the plate is being sent in for recalibration.
5. **Periodic Recalibration:** Periodic recalibration of granite surface plates is recommended to determine resurfacing or replacement needs. The interval between calibrations will vary with the grade of plate and the wear resistance of the granite. TRU-STONE CONFORMS TO ISO 9000 CERTIFICATION REQUIREMENTS FOR VENDORS. Frequent monitoring of the work surface by scanning it with the repeat gage is desirable. When these results differ from those marked on the replaceable sticker, you should recalibrate the plate. In addition to measuring the overall accuracy of a surface, smaller areas can be checked for localized variations often missed by the calibrating methods. Remember precision measurements are only as accurate as the measuring tools used.
6. **Torque on THREADED Inserts:** Do not exceed the following maximum torque values when using a torque wrench to limit distorting the work surface and pulling the insert. The following torque values are the maximum level permissible by the Federal Specification GGG-P-463c.

PERMISSIBLE TORQUE CLAMPING ON THREDED INSERTS

| *Thread Size* | *Torque* |
|---|---|
| .250 inch | 7 ft. lbs. |
| .3125 inch | 15 ft. lbs. |
| .375 inch | 20 ft. lbs. |
| .500 inch | 25 ft. lbs. |

7. **Clamping Ledges on Grade AA Surface Plates:** There is danger of distorting the work surface flatness beyond tolerance when a heavy item rests on the ledge or an item is clamped to the ledge. Ledges are not only expensive, but a great cause of inaccuracy. Experimentation and research reveal that no-ledge plates retain their accuracy better than ledged plates.
8. **Supports:** There are working and loading conditions where the standard three point supports are not satisfactory. These cases should be individually engineered. When four or more supports are used, shims or adjusting screws are necessary for proper support. The supports could be spotted under the loading points and set to approximately equal the loading. Sometimes the work surface flatness can be improved by shifting support positions. Fulcrum, air and hydraulic supports are available. Whenever nonstandard supports are used, the surface plate shall be calibrated at the site for compliance to the flatness tolerance.

1101 Prosper Drive • P. O. Box 430 • Waite Park, MN 56387 • 1-800-959-0517 • PH: 320-251-7171 • Fax: 320-259-5073

9. **Care:**
   - Utilize the full surface of a plate so the wear is distributed and not concentrated in one area.
   - The surface plate should not be overloaded.
   - Use extreme care in moving the item being measured and the gages being used.
   - Place on the surface ONLY what is required.
   - Particularly avoid heavy contact with the edges.
   - Don't leave metal objects on the surface longer than necessary.
   - Clean the surface before and after use.

***Remember that the condition of this accurate plane is an integral factor in the measurement being made.***

NOTE:

Surface plate cleaner can be purchased through your local Tru-Stone distributor or directly from Tru-Stone Technologies. Call for pricing and delivery information.

When the need for recalibration or rework of your surface plates and precision granite accessories arises, contact a Tru-Stone representative or call us directly for more details on restoring your inspection item to a "like new" condition. This service comes with new certification and plate labels.

One advantage of having your granite inspection equipment recalibrated by a manufacturer is the manufacturer's ability to take the time required to ensure the proper repeatability and overall shape of the inspection surface. Tru-Stone allows the item to normalize overnight prior to taking the final readings to indicate whether it is a good enough quality to certify and return to you.

Should you have any questions, please contact our customer service representatives at 320/251-7171 or fax us at 320/259-5073.

## Important Notice

Any streaks of color in the granite are not defects. These are created by the molten lava mixing with minerals prior to evolving into the granite you see today. Black streaks or spots are the result of a magnetite (black iron oxide) concentration. White streaks or spots are areas where the granite is lacking magnetite. The levels of magnetite in granite vary considerably, however the color of the granite in no way affects the functionality or quality of it.

## Our products are UNCONDITIONALLY Guaranteed

Please refer to the Federal Specification GGG-P-463c, which is followed by NIST (National Institute of Standards & Technology) for Granite Surface Plates.

- "3.7 Seams or Color Streaks: *Seams are cause for rejection. Color streaks have no affect on the serviceability of the granite."*
- "4.5.8 Seams or Color Streaks: *Test for a seam is to wet the smooth surface of the granite where the color streak appears; then dry it off. If the streak remains wet or damp, it is a seam."*

| Measurement | IMU to 8111 (MRU to Trans) | | Port Ant to 8111 (Nav to Trans) | | Waterline to RP* | | Port Ant to Stbd Ant | |
|---|---|---|---|---|---|---|---|---|
| Coord. Sys. | | Caris | | Caris | | Caris | | |
| x | | 2.868 | | 2.071 | | n/a | Scaler Distance | 1.997 |
| y | | 8.252 | | 20.144 | | n/a | | |
| z | | 4.752 | | 17.792 | | 0.014 | | |

*Top of IMU is RP (Reference Pt)

Vessel Offsets for S220_8111 are derived from Westlake-Survey-Report-NOAA-Fairweather-09-23-03.pdf and Fairweather_NGS_Report_Feb_2007.doc

2009 Measured Value

## Calculations

**IMU to 8111**

Coord. Sys. **Westlake**

| | | |
|---|---|---|
| IMU | easting | 0.000 |
| Base | northing | 0.000 |
| (ft/m) | elevation | 0.000 |

**Westlake**

| | | |
|---|---|---|
| 8111 | easting | 27.072 |
| (ft) | northing | 9.410 |
| | elevation | 15.042 |

**Westlake**

| | | |
|---|---|---|
| 8111 | easting | 8.252 |
| (m) | northing | 2.868 |
| | elevation | 4.585 |

**Westlake**

Base of IMU to Top of IMU

(m) elevation -0.168

**Port Ant to 8111**

**NGS 2009**

| | | |
|---|---|---|
| Top of Port | x | -11.892 |
| Ant | y | 0.797 |
| (m) | z | 13.047 |

Top of Ant to Phase Center

(m) z 0.007

| | | |
|---|---|---|
| Phase Cntr | x | -11.892 |
| Port Ant | y | 0.797 |
| (m) | z | 13.040 |

**CARIS**

| | | |
|---|---|---|
| Port | x | 0.797 |
| Ant | y | -11.892 |
| (m) | z | -13.040 |

**Westlake**

| | | |
|---|---|---|
| (m) | easting | 8.252 |
| Top of IMU | northing | 2.868 |
| to 8111 | elevation | 4.752 |

**CARIS**

| | | |
|---|---|---|
| (m) | x | 2.868 |
| Top of IMU | y | 8.252 |
| to 8111 | z | 4.752 |

**Waterline to RP***

IMU Base to baseline at Keel

(ft) elevation 12.856

IMU Base to baseline at Keel

(m) elevation 3.919

Waterline to Keel

(ft) elevation 13.45

Waterline to Keel

(m) elevation 4.100

**See Ship's Draft Tab**

Top of IMU to Base of IMU

(m) elevation 0.168

Top of IMU to Keel

(m) 4.086

**Port Ant to Stbd Ant**

**NGS 2009**

| | | |
|---|---|---|
| Top of | x | -11.892 |
| Port Ant | y | 0.797 |
| (m) | z | 13.047 |

Top of Ant to Phase Center

(m) z 0.007

**NGS 2009**

| | | |
|---|---|---|
| Top of | x | -11.886 |
| Stbd Ant | y | 2.794 |
| (m) | z | 13.051 |

These rows **Westlake** unless noted otherwise

| IMU to 8111 | | | Port Ant to 8111 | | | Waterline to RP* | | | Port Ant to Stbd Ant | |
|---|---|---|---|---|---|---|---|---|---|---|
| (m) | easting | 8.252 | CARIS | x | 2.071 | (m) | easting | N/A | | |
| Top of IMU | northing | 2.868 | | y | 20.144 | Waterline | northing | N/A | Scalar Distance (m) | 1.997 |
| to 8111 | elevation | 4.752 | (m) | z | 17.792 | to IMU | elevation | 0.014 | | |

| Coord Sys. CARIS | | Coord Sys. CARIS | | Coord. Sys. CARIS | |
|---|---|---|---|---|---|
| x | 2.868 | x | 2.071 | x | N/A |
| y | 8.252 | y | 20.144 | y | N/A |
| z | 4.752 | z | 17.792 | z | 0.014 |

See Description Tab

| IMU to Port Ant | | IMU to Heave | |
|---|---|---|---|
| Caris | Pos/Mv | Caris | Pos/Mv |
| 0.797 | -11.892 | 1.866 | -7.028 |
| -11.892 | 0.797 | -7.028 | 1.866 |
| 13.047 | -13.047 | -2.086 | -2.086 |

**Value in POSMV is top of antenna rather than the phase center to IMU.**

| IMU to Port Ant | | |
|---|---|---|
| **NGS 2009** | | |
| IMU Top (m) | x | 0.000 |
| | y | 0.000 |
| | z | 0.000 |
| **NGS 2009** | | |
| Top of Port | x | -11.892 |
| Ant | y | 0.797 |
| (m) | z | 13.047 |
| Top of Ant to Phase Center | | |
| (m) z | | 0.007 |
| **NGS 2009** | | |
| Phase Cntr | x | -11.892 |
| Port Ant | y | 0.797 |
| (m) | z | 13.047 |

**IMU to Heave**

| | | | | | | |
|---|---|---|---|---|---|---|
| IMU to Bulkhd (Frame) 52 | | | IMU Base to baseline at Keel | | | |
| (ft) | easting | -11.638 | (ft) | elevation | 12.856 | |
| (m) | easting | -3.547 | (m) | elevation | 3.919 | |
| Frame 0 (FP) to Frame 52 | | | Top of IMU to Base of IMU | | | |
| (m) | easting | -27.737 | (m) | elevation | 0.168 | |
| | | | Top of IMU to Keel | | | |
| IMU to Frame 0 (FP) | | | (m) | elevation | 4.086 | |
| (m) | easting | 24.190 | | | | |
| | | | Center of Gravity above baseline | | | |
| Heave Pt* to Frame 0 (FP) | | | (ft) | elevation | 16.37 | |
| (ft) | easting | 102.42 | Mean Metacentric height | | | |
| (m) | easting | 31.218 | (ft) | elevation | 3.88 | |
| IMU to Centerline | | | Heave Pt* to baseline at Keel | | | |
| (ft) | northing | 6.122 | (ft) | elevation | 20.25 | |
| (m) | northing | 1.866 | (m) | elevation | 6.172 | |
| Heave Pt* to Centerline | | | (*Heave Pt is Metacenter) | | | |
| (m) | northing | 0 | (FP is Forward Perpendicular) | | | |

| IMU to Port Ant | | | | IMU to Heave | | |
|---|---|---|---|---|---|---|
| **NGS 2009** (m) | x | -11.892 | | (m) | easting | -7.028 |
| Top of IMU | y | 0.797 | | Top of IMU | northing | 1.866 |
| to Port Ant | z | 13.047 | | to Heave Pt* | elevation | -2.086 |
| Coord Sys. **Pos/Mv** | | | | Coord. Sys. **Pos/Mv** | | |
| | x | -11.892 | | | x | -7.028 |
| | y | 0.797 | | | y | 1.866 |
| | z | -13.047 | | | z | -2.086 |

see Description Tab

| Measurement | IMU to 8160 (MRU to Trans) | Port Ant to 8160 (Nav to Trans) | Waterline to RP* | Port Ant to Stbd Ant | | IMU to Port Ant | | IMU to Heave | |
|---|---|---|---|---|---|---|---|---|---|
| Coord. Sys. | Caris | Caris | Caris | | | Caris | Pos/Mv | Caris | Pos/Mv |
| x | 0.493 | -0.304 | n/a | Scaler Distance | 1.997 | 0.797 | -11.892 | 1.866 | -7.028 |
| y | 7.665 | 19.557 | n/a | | | -11.892 | 0.797 | -7.028 | 1.866 |
| z | 4.726 | 17.766 | 0.014 | | | 13.047 | -13.047 | -2.086 | -2.086 |

*Top of IMU is RP (Reference Pt)

Vessel Offsets for S220_8111 are derived from Westlake-Survey-Report-NOAA-Fairweather-09-23-03.pdf, Fairweather_NGS_Report_02-07.pdf, and , FairweatherCenterlineSurvey_03-09.pdf.

## Derivations

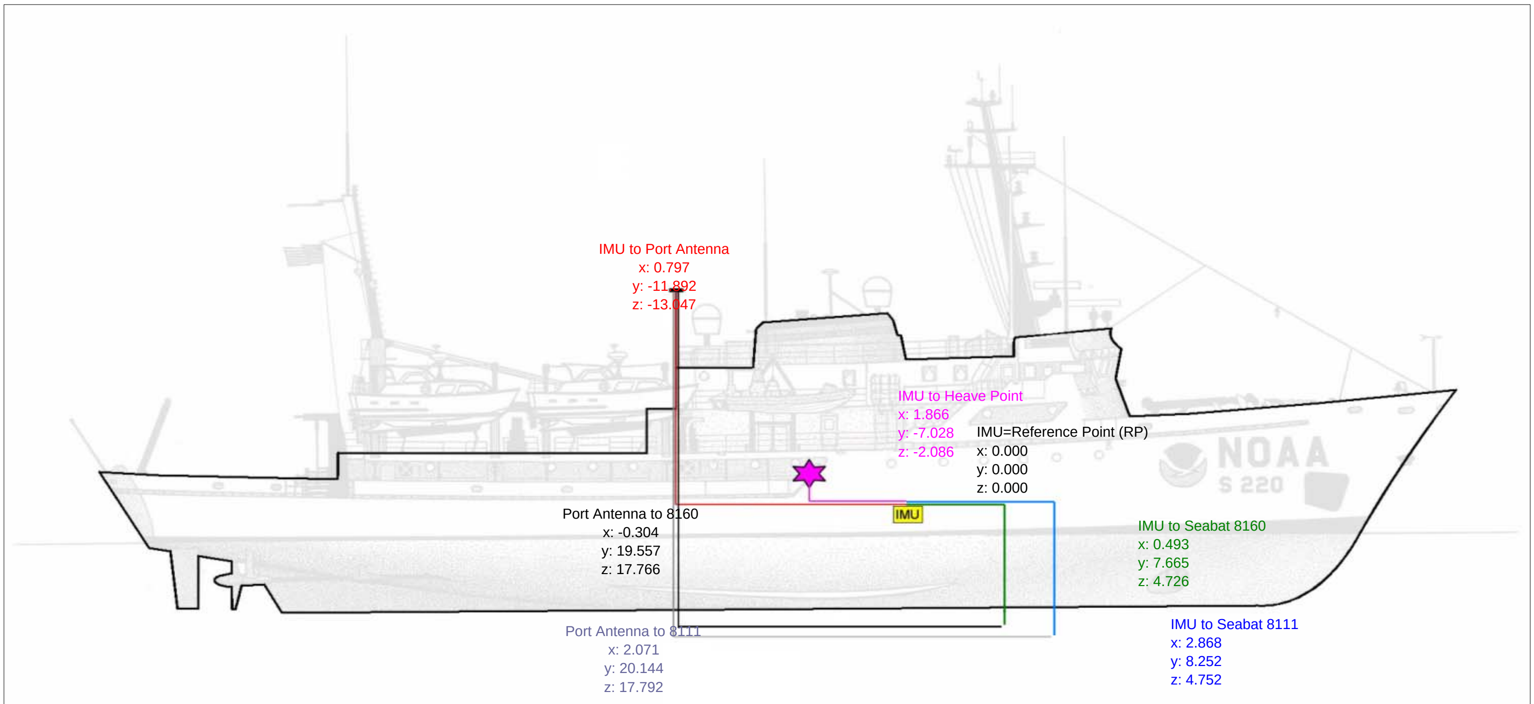
Coord. Sys.

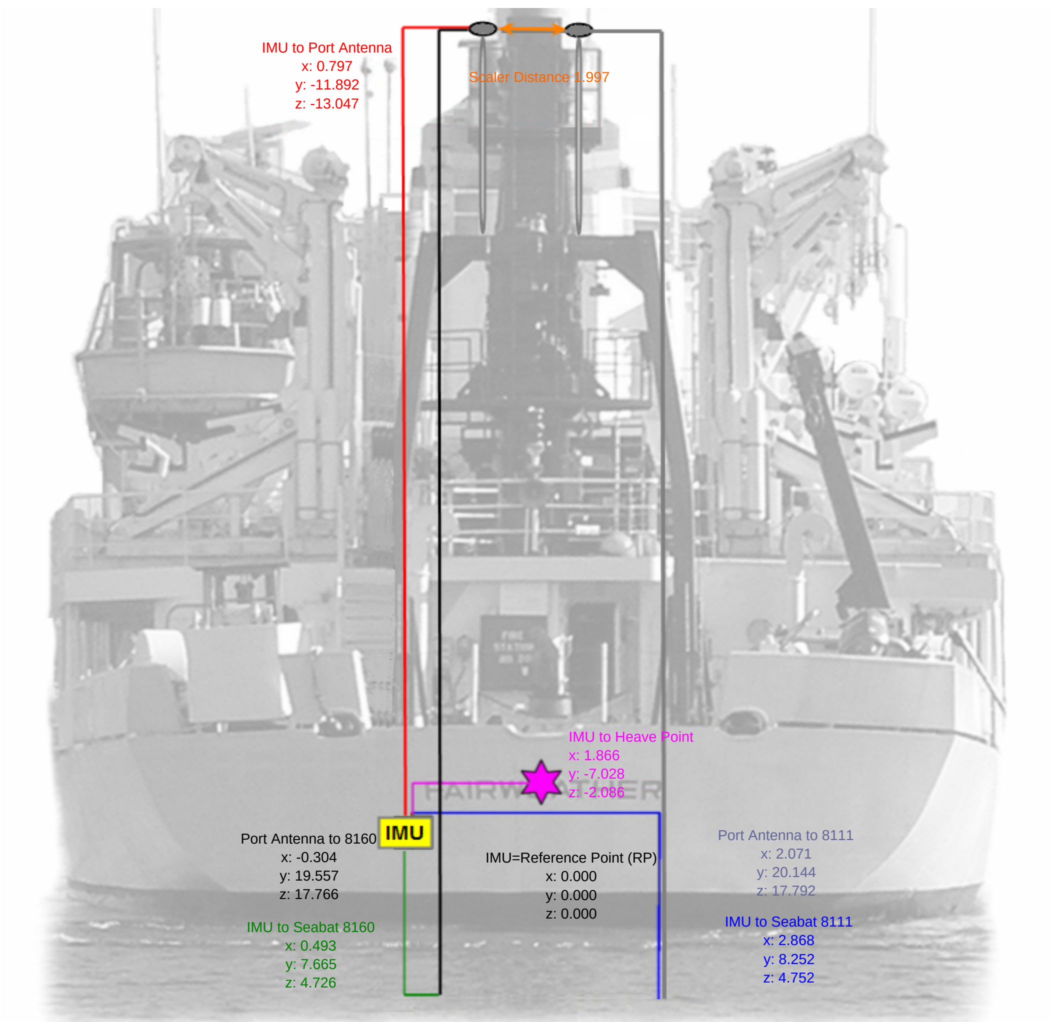
| IMU to 8160 | | | Port Ant to 8160 | | |
|---|---|---|---|---|---|
| **Westlake** | | | **NGS 2009** | | |
| IMU | easting | 0.000 | Top of Port | x | -11.892 |
| Base | northing | 0.000 | Ant | y | 0.797 |
| (ft/m) | elevation | 0.000 | (m) | z | 13.047 |
| **Westlake** | | | Top of Ant to Phase Center | | |
| 8160 | easting | 25.149 | (m) z | | 0.007 |
| (ft) | northing | 1.619 | Phase Cntr | x | -11.892 |
| | elevation | 14.956 | Port Ant | y | 0.797 |
| **Westlake** | | | (m) | z | 13.040 |
| 8160 | easting | 7.665 | **CARIS** | | |
| (m) | northing | 0.493 | Port | x | 0.797 |
| | elevation | 4.559 | Ant | y | -11.892 |
| | | | (m) | z | -13.040 |
| Base of IMU to Top of IMU | | | **Westlake** | | |
| (m) | elevation | -0.168 | (m) | easting | 7.665 |
| | | | Top of IMU | northing | 0.493 |
| | | | to 8160 | elevation | 4.726 |
| | | | **CARIS** | | |
| | | | (m) | x | 0.493 |
| | | | Top of IMU | y | 7.665 |
| | | | to 8111 | z | 4.726 |

| IMU to 8160 | | | Port Ant to 8160 | | |
|---|---|---|---|---|---|
| **Westlake** | easting | 7.665 | **CARIS** | x | -0.304 |
| Top of IMU | northing | 0.493 | | y | 19.557 |
| to 8160 (m) | elevation | 4.726 | (m) | z | 17.766 |
| Coord Sys | Caris | | Coord Sys | Caris | |
| | x | 0.493 | | x | -0.304 |
| | y | 7.665 | | y | 19.557 |
| | z | 4.726 | | z | 17.766 |

# Description of Offsets for FAIRWEATHER S-220

All Values Shown are in CARIS Coordinates



**IMU to 8111 (MRU to Trans)**

| x | y | z |
|---|---|---|
| 2.868 | 8.252 | 4.752 |

The lever arms between the IMU and phase center of the 8160 transducer are taken from the Westlake report with the addition of the 0.168 m offset included for the height of the IMU.

**IMU to 8160 (MRU to Trans)**

| x | y | z |
|---|---|---|
| 0.493 | 7.665 | 4.726 |

The lever arms between the IMU and phase center of the 8111 transducer are taken from the Westlake report with the addition of the 0.168 m offset included for the height of the IMU.

**Port Ant to 8111 (Nav to Trans)**

| x | y | z |
|---|---|---|
| 2.071 | 20.144 | 17.792 |

This information comes from a combination of the Westlake and NGS surveys. Subtraction of the distance between Top of Antenna and the Phase Center were included in final value determination. Relative positions obtained from Port Ant to 8111 via IMU.

**Port Ant to 8160 (Nav to Trans)**

| x | y | z |
|---|---|---|
| -0.304 | 19.557 | 17.766 |

This information comes from a combination of the Westlake and NGS surveys. Subtraction of the distance between Top of Antenna and the Phase Center were included in final value determination. Relative positions obtained from Port Ant to 8160 via IMU.

**Port Ant to Stbd Ant**

| | |
|---|---|
| Scaler Distance | 1.997 |

Using the NGS 2009 survey values for the antennas, a calculated vector for antenna separation was determined. The distance from Top of Antenna to Phase Center does not affect this calculation and therefore was not included.

**IMU to Port Ant**

| x | y | z |
|---|---|---|
| 0.797 | -11.892 | 13.047 |

This information comes directly from the NGS 2009 survey. Subtraction of the distance between Top of Antenna and the Phase Center were included in final value determination.

**Waterline to RP***

| x | y | z |
|---|---|---|
| n/a | n/a | 0.014 |

The height of the IMU above the keel comes from the Westlake survey value of 3.919 m plus the measured value of the top of the IMU to the base plate, to get an IMU height above the keel. The draft (waterline to keel) used for the FAIRWEATHER is based on observations, Ship's Draft spreadsheet. Differencing the value of IMU to keel and waterline to keel gives the waterline to RP distance.

**IMU to Heave**

| x | y | z |
|---|---|---|
| 1.866 | -7.028 | -2.086 |

Key points on the IMU, from the Westlake survey, are its location with respect to the ship's reference frame. It is 4.087 m (3.919 m to base line + 0.168 m for IMU height above base plate) above the keel, 1.866 m port of centerline and 3.547 m forward of frame 52. This information is needed to reference the IMU to the ship's Heave Measurement Location (Heave Point). *

**IMU to Heave**

From pg 3 of the Westlake Survey

**SUMMARY**

- IMU foundation plate is level to within +/-0.001 feet.
- IMU foundation plate is located 12.856 feet above baseline established at the keel.
- IMU is parallel to ship's centerline to within +/- 0.001 feet.
  Location of scribed centerline intersection is 6.122 feet port of ship's centerline.
- IMU foundation plate centerline is located 11.638' feet forward of bulkhead 52.

Lynn - read through and check

**IMU to Heave**

* From the Art Anderson inclination experiment the position of the metacenter was used as the position of the ship's Heave Point. (There may be a better way to determine the Heave Point, but this decision was based upon available information). The metacenter is defined by the center of buoyancy. As a vessel inclines through small angles, the center of buoyancy moves through the arc of a circle whose center is at the metacenter.

Important numbers and information determined from the Art Anderson report are the location of the metacenter and how it is positioned with respect to the vessel. The longitudinal location of the metacenter is defined as 102.42 feet (31.217 m) aft of the forward perpendicular. The height of the metacenter is 20.25 feet (6.172 m) above the keel. There is an assumption of the metacenter being on the centerline of the vessel. Similar values for the RAINIER's metacenter are 32.52 m aft of the forward perpendicular and 5.2 m above the keel. The difference in the height of the metacenter can be attributed to the difference between the FA's and RA's average draft which is 13.12 feet as opposed to approximately 14.5 feet respectively.

Referencing the metacenter (Heave Point, HP) to the IMU information requires information about the frame spacing of the vessel. From the Westlake survey, the IMU is located 3.547 m forward of frame 52. From Inclination document, the HP is 31.217 m aft of the forward perpendicular. From engineering drawings of the ship frame spacing is approximately 21 inches. The calculation for the longitudinal location of the HP with respect to frame zero, the Forward Perpendicular (FP) is as follows:

52 (frame) * 21 (inches/frame)/12(inches/ft)*.3048(m/ft)-3.547 m = 24.190 m from frame 0.

31.217 m (HP aft of FP) – 24.190 m (IMU aft of FP) = 7.027 m (HP aft of IMU)

The calculation for the vertical separation between the IMU and the HP is based on the height of the metacenter being 6.172m and the height of the IMU being 4.087 m above the keel. Differencing yields the metacenter being 2.085 m above the IMU.

The calculation for the athwartship separation is based upon the assumption that the HP is on the centerline and the knowledge that the IMU is 1.866 m to port of the centerline.

**Sources**

Offset values for the ship were derived from three sources. Two static offset surveys, an inclination experiment, and values measured or approximated by ship's personnel.

On September 23, 2003 an offset survey of the NOAA Ship FAIRWEATHER was conducted by:
Westlake Consultants, Incorporated
15115 SW Sequoia Parkway, Suite 150
Tigard, Oregon 97224
Phone (503) 684-0652

…and the relocation of the POS M/V antenna forced a partial resurvey in Feb. 2007 by Steven Breidenbach of NGS.

These values relate the physical positions of one sensor to the next with the base plate of the IMU being the point of origin. All dimensions in the document are given in feet and decimal feet.

On July 16, 2004 an inclination experiment was conducted at MOC-P by:

Art Anderson Associates
202 Pacific Avenue
Bremerton, WA 98337-1932

**Calculations**

The values for the required lever arms are listed in the S220_Offsets and Measurements spreadsheet. The reference point and the IMU are identical. Difference in documentation between Westlake and FA calculations are based off of measuring up from the IMU base (Westlake's origin) and the top of the IMU. The top center of the IMU for the POS/MV is the defined origin for the POS/MV and the origin that is being used on all FAIRWEATHER vessels. The distance from the base plate to the top of the IMU is 0.168 m, a value measured by ship's complement. Conversions factor from feet to meters is 0.3048 m/ft.

As a requirement for the TPE, the standard deviation for each position is 3 mm. This value is based upon a conversation with Elaine McDonald of Westlake and is followed up by an Email documenting that fact. The email is located at the end of this document.

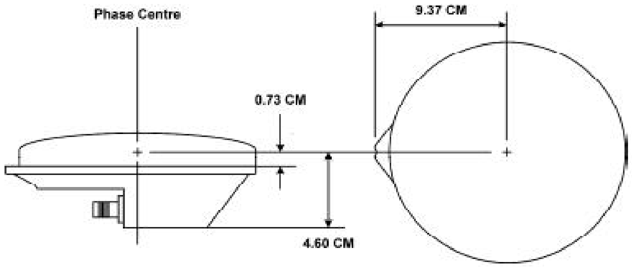



Figure 79: GPS Antenna Footprint



# Appendix E

# Drawings

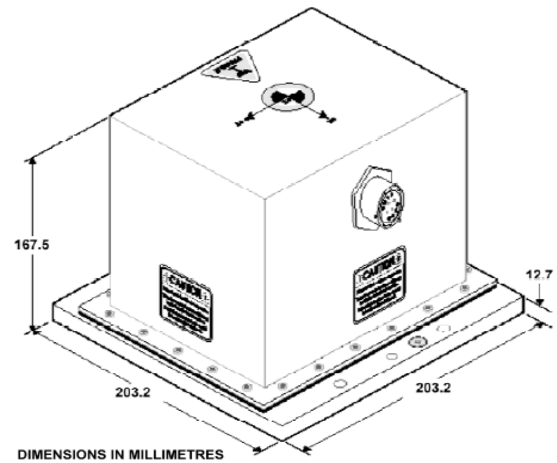
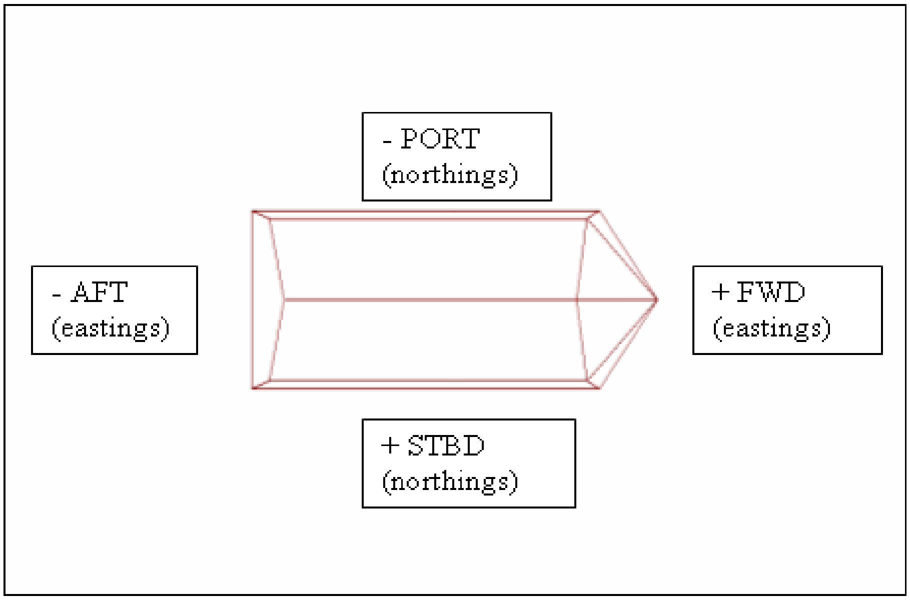
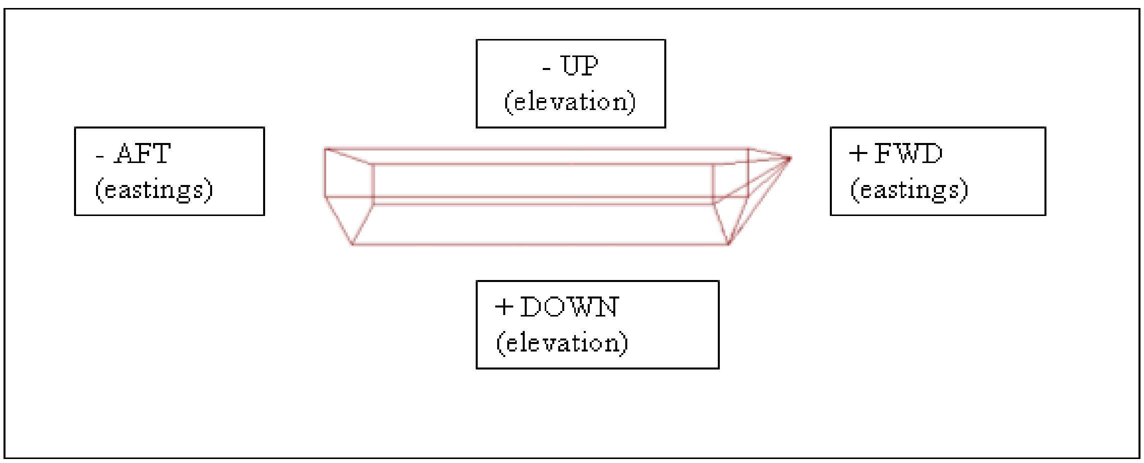
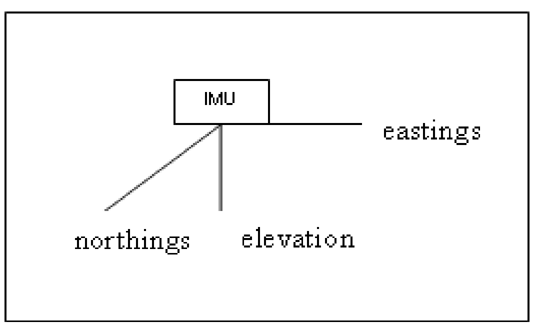



Figure 77: IMU Footprint

**WESTLAKE Coordinate System**

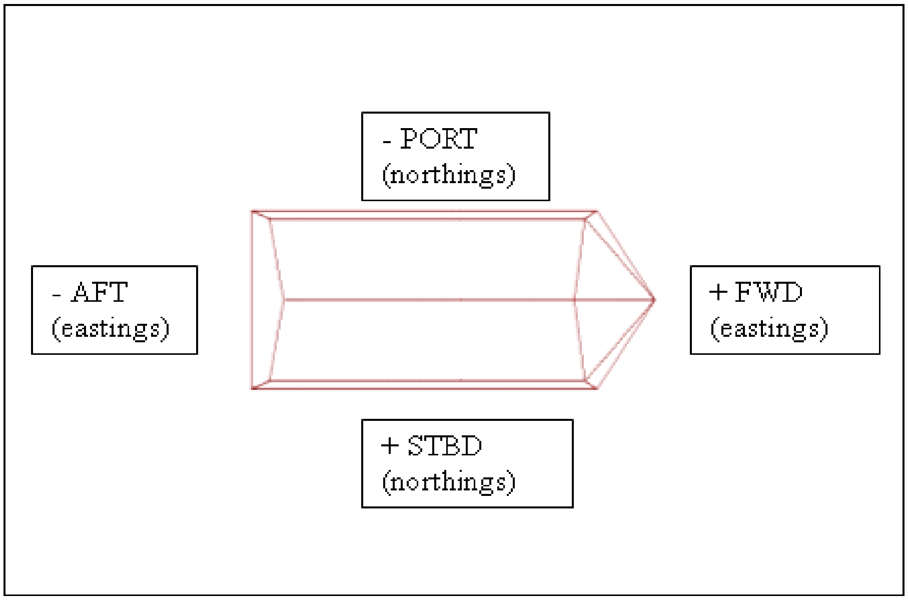


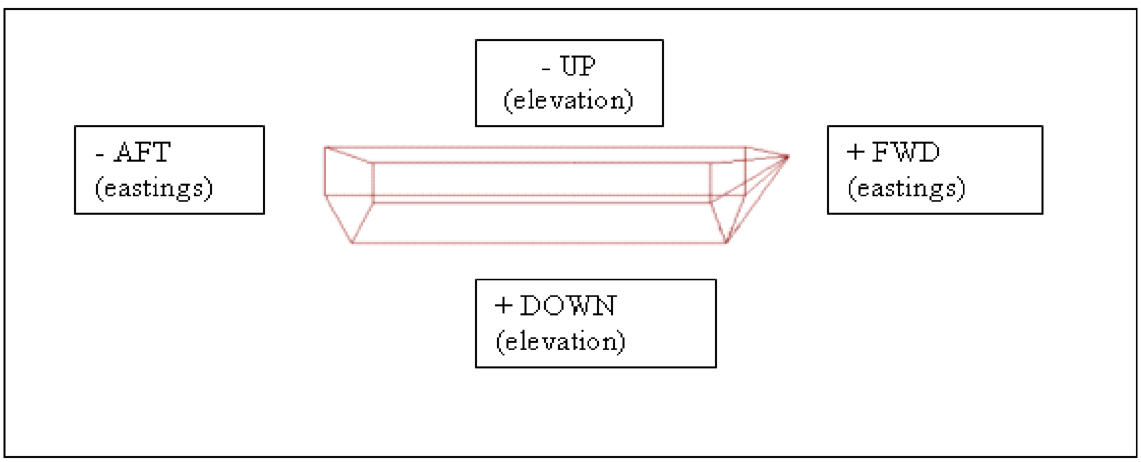



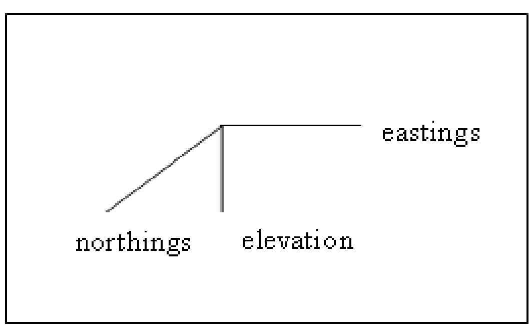




Bottom Center of IMU is origin of Westlake Coordinate System

## NGS Coordinate System

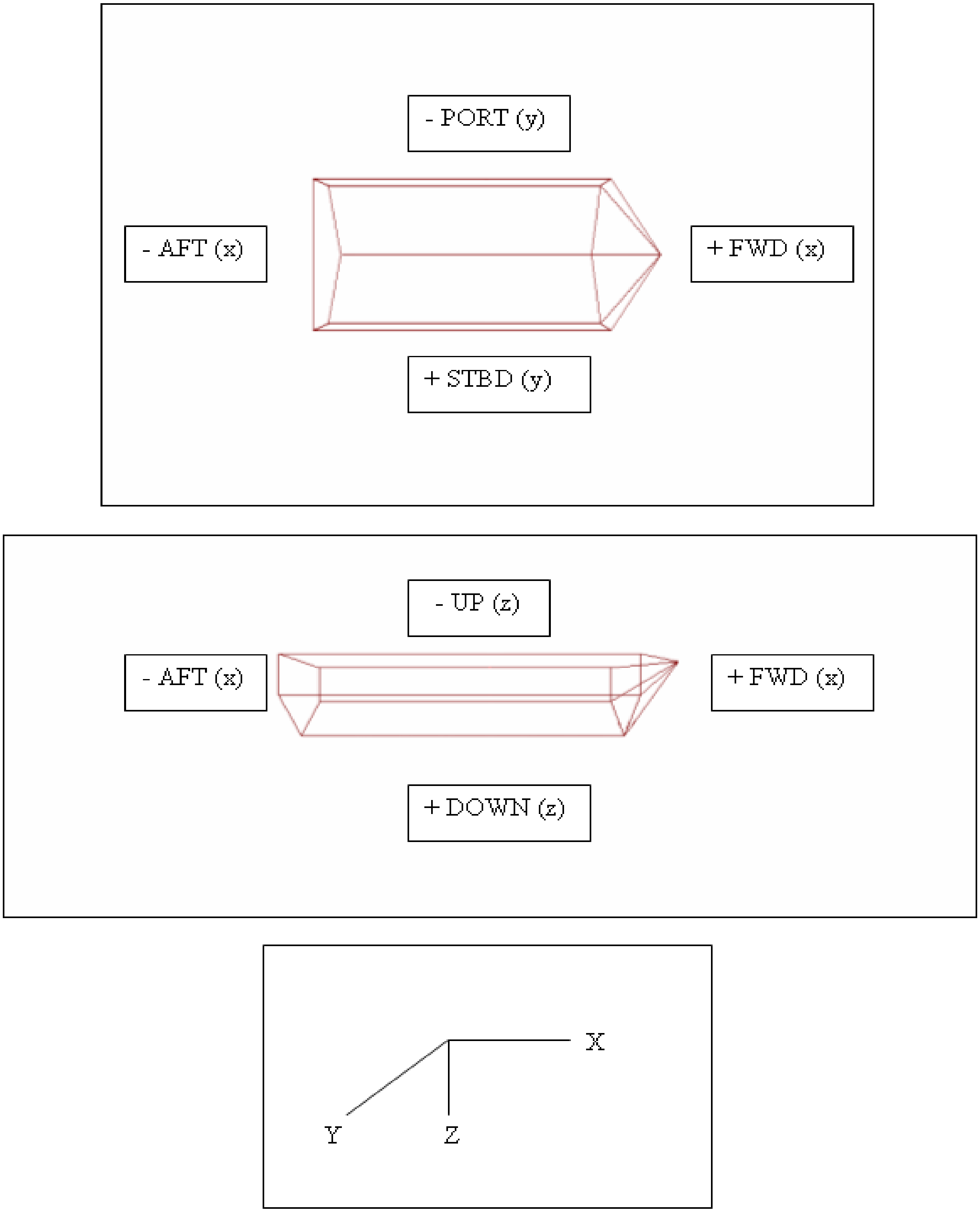


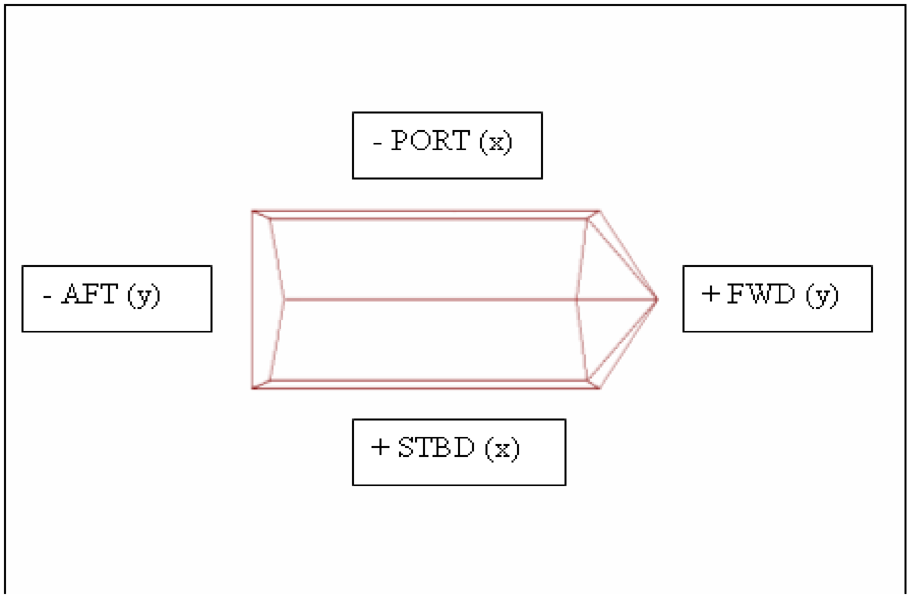

*Top Center of IMU is origin of NGS Coordinate System*

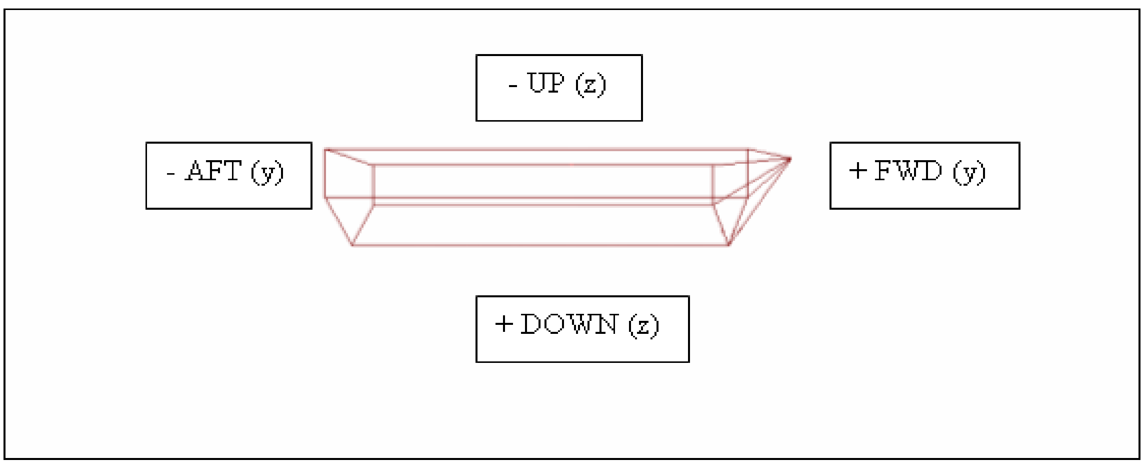
## POS/MV Coordinate System

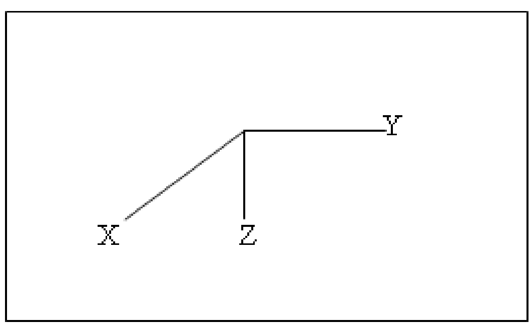



Top Center of IMU is origin of POS/MV Coordinate System

**CARIS Coordinate System**




Top Center of IMU is origin of CARIS Coordinate System

**IMU to 8111 (MRU to Trans)**

| x | y | z |
|---|---|---|
| 2.868 | 8.252 | 4.752 |

The lever arms between the IMU and phase center of the 8160 transducer are taken from the Westlake report with the addition of the 0.168 m offset included for the height of the IMU.

**IMU to 8160 (MRU to Trans)**

| x | y | z |
|---|---|---|
| 0.493 | 7.665 | 4.726 |

The lever arms between the IMU and phase center of the 8111 transducer are taken from the Westlake report with the addition of the 0.168 m offset included for the height of the IMU.

**Port Ant to 8111 (Nav to Trans)**

| x | y | z |
|---|---|---|
| 2.071 | 20.144 | 17.792 |

This information comes from a combination of the Westlake and NGS surveys. Subtraction of the distance between Top of Antenna and the Phase Center were included in final value determination. Relative positions obtained from Port Ant to 8111 via IMU.

**Port Ant to 8160 (Nav to Trans)**

| x | y | z |
|---|---|---|
| -0.304 | 19.557 | 17.766 |

This information comes from a combination of the Westlake and NGS surveys. Subtraction of the distance between Top of Antenna and the Phase Center were included in final value determination. Relative positions obtained from Port Ant to 8160 via IMU.

**Port Ant to Stbd Ant**

| | |
|---|---|
| Scaler Distance | 1.997 |

Using the NGS 2009 survey values for the antennas, a calculated vector for antenna separation was determined. The distance from Top of Antenna to Phase Center does not affect this calculation and therefore was not included.

**IMU to Port Ant**

| x | y | z |
|---|---|---|
| 0.797 | -11.892 | 13.047 |

This information comes directly from the NGS 2009 survey. Subtraction of the distance between Top of Antenna and the Phase Center were included in final value determination.

**Waterline to RP***

| x | y | z |
|---|---|---|
| n/a | n/a | 0.014 |

The height of the IMU above the keel comes from the Westlake survey value of 3.919 m plus the measured value of the top of the IMU to the base plate, to get an IMU height above the keel. The draft (waterline to keel) used for the FAIRWEATHER is based on observations, Ship's Draft spreadsheet. Differencing the value of IMU to keel and waterline to keel gives the waterline to RP distance.

**IMU to Heave**

| x | y | z |
|---|---|---|
| 1.866 | -7.028 | -2.086 |

Key points on the IMU, from the Westlake survey, are its location with respect to the ship's reference frame. It is 4.087 m (3.919 m to base line + 0.168 m for IMU height above base plate) above the keel, 1.866 m port of centerline and 3.547 m forward of frame 52. This information is needed to reference the IMU to the ship's Heave Measurement Location (Heave Point). *

**IMU to Heave**

From pg 3 of the Westlake Survey

**SUMMARY**

- IMU foundation plate is level to within +/-0.001 feet.
- IMU foundation plate is located 12.856 feet above baseline established at the keel.
- IMU is parallel to ship's centerline to within +/- 0.001 feet.
  Location of scribed centerline intersection is 6.122 feet port of ship's centerline.
- IMU foundation plate centerline is located 11.638' feet forward of bulkhead 52.

Lynn - read through and check

**IMU to Heave**

* From the Art Anderson inclination experiment the position of the metacenter was used as the position of the ship's Heave Point. (There may be a better way to determine the Heave Point, but this decision was based upon available information). The metacenter is defined by the center of buoyancy. As a vessel inclines through small angles, the center of buoyancy moves through the arc of a circle whose center is at the metacenter.

Important numbers and information determined from the Art Anderson report are the location of the metacenter and how it is positioned with respect to the vessel. The longitudinal location of the metacenter is defined as 102.42 feet (31.217 m) aft of the forward perpendicular. The height of the metacenter is 20.25 feet (6.172 m) above the keel. There is an assumption of the metacenter being on the centerline of the vessel. Similar values for the RAINIER's metacenter are 32.52 m aft of the forward perpendicular and 5.2 m above the keel. The difference in the height of the metacenter can be attributed to the difference between the FA's and RA's average draft which is 13.12 feet as opposed to approximately 14.5 feet respectively.

Referencing the metacenter (Heave Point, HP) to the IMU information requires information about the frame spacing of the vessel. From the Westlake survey, the IMU is located 3.547 m forward of frame 52. From Inclination document, the HP is 31.217 m aft of the forward perpendicular. From engineering drawings of the ship frame spacing is approximately 21 inches. The calculation for the longitudinal location of the HP with respect to frame zero, the Forward Perpendicular (FP) is as follows:

52 (frame) * 21 (inches/frame)/12(inches/ft)*.3048(m/ft)-3.547 m = 24.190 m from frame 0.

31.217 m (HP aft of FP) – 24.190 m (IMU aft of FP) = 7.027 m (HP aft of IMU)

The calculation for the vertical separation between the IMU and the HP is based on the height of the metacenter being 6.172m and the height of the IMU being 4.087 m above the keel. Differencing yields the metacenter being 2.085 m above the IMU.

The calculation for the athwartship separation is based upon the assumption that the HP is on the centerline and the knowledge that the IMU is 1.866 m to port of the centerline.

**Sources**

Offset values for the ship were derived from three sources. Two static offset surveys, an inclination experiment, and values measured or approximated by ship's personnel.

On September 23, 2003 an offset survey of the NOAA Ship FAIRWEATHER was conducted by:
Westlake Consultants, Incorporated
15115 SW Sequoia Parkway, Suite 150
Tigard, Oregon 97224
Phone (503) 684-0652

…and the relocation of the POS M/V antenna forced a partial resurvey in Feb. 2007 by Steven Breidenbach of NGS.

These values relate the physical positions of one sensor to the next with the base plate of the IMU being the point of origin. All dimensions in the document are given in feet and decimal feet.

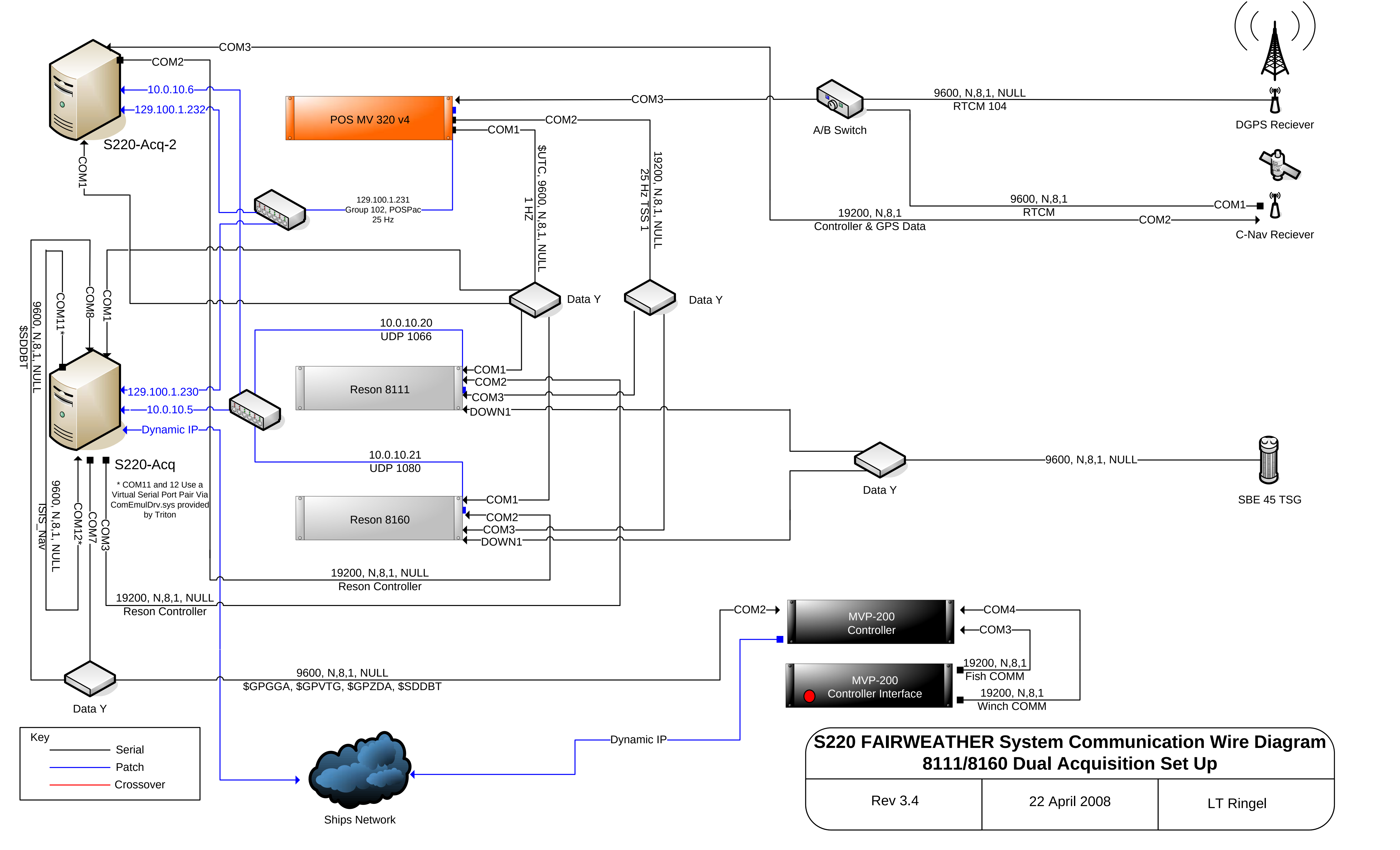
On July 16, 2004 an inclination experiment was conducted at MOC-P by:

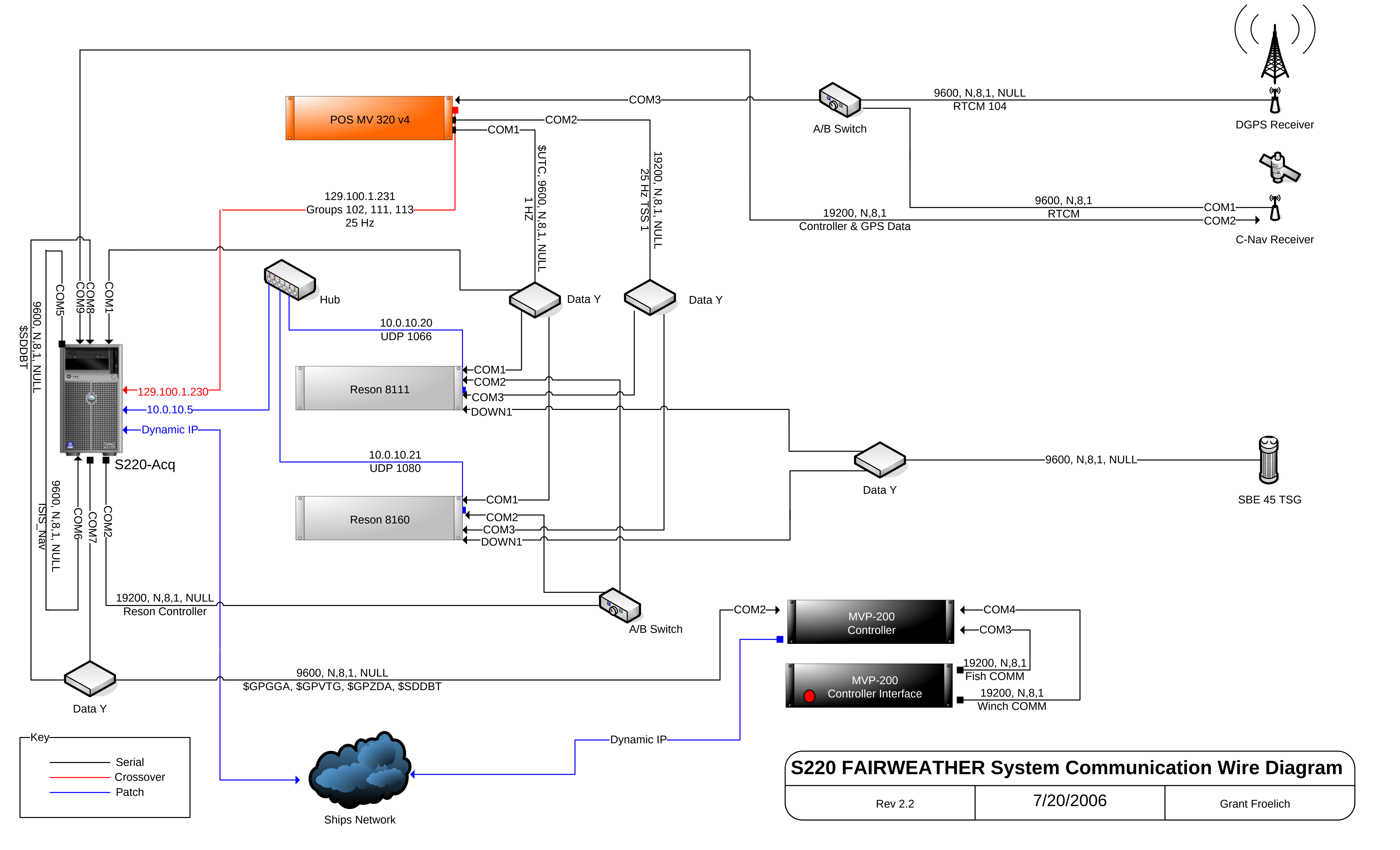
Art Anderson Associates
202 Pacific Avenue
Bremerton, WA 98337-1932

**Calculations**

The values for the required lever arms are listed in the S220_Offsets and Measurements spreadsheet. The reference point and the IMU are identical. Difference in documentation between Westlake and FA calculations are based off of measuring up from the IMU base (Westlake's origin) and the top of the IMU. The top center of the IMU for the POS/MV is the defined origin for the POS/MV and the origin that is being used on all FAIRWEATHER vessels. The distance from the base plate to the top of the IMU is 0.168 m, a value measured by ship's complement. Conversions factor from feet to meters is 0.3048 m/ft.

As a requirement for the TPE, the standard deviation for each position is 3 mm. This value is based upon a conversation with Elaine McDonald of Westlake and is followed up by an Email documenting that fact. The email is located at the end of this document.


S220 FAIRWEATHER System Communication Wire Diagram
8111/8160 Dual Acquisition Set Up
Rev 3.4
22 April 2008
LT Ringel
S220-Acq-2
S220-Acq
POS MV 320 v4
Reson 8111
Reson 8160
A/B Switch
DGPS Reciever
C-Nav Reciever
SBE 45 TSG
MVP-200 Controller
MVP-200 Controller Interface
Ships Network
Data Y
COM1
COM2
COM3
COM7
COM8
COM11*
COM12*
COM4
DOWN1
10.0.10.6
129.100.1.232
129.100.1.230
10.0.10.5
Dynamic IP
129.100.1.231
Group 102, POSPac
25 Hz
$UTC, 9600, N,8,1, NULL
1 HZ
19200, N,8,1, NULL
25 Hz TSS 1
9600, N,8,1, NULL
RTCM 104
9600, N,8,1
RTCM
19200, N,8,1
Controller & GPS Data
10.0.10.20
UDP 1066
10.0.10.21
UDP 1080
19200, N,8,1, NULL
Reson Controller
9600, N,8,1, NULL
$GPGGA, $GPVTG, $GPZDA, $SDDBT
9600, N,8,1, NULL
$SDDBT
9600, N,8,1, NULL
ISIS_Nav
* COM11 and 12 Use a Virtual Serial Port Pair Via ComEmulDrv.sys provided by Triton
19200, N,8,1
Fish COMM
19200, N,8,1
Winch COMM
Key
Serial
Patch
Crossover


POS MV 320 v4
COM3
COM2
COM1
129.100.1.231
Groups 102, 111, 113
25 Hz
$UTC, 9600, N,8,1, NULL
1 HZ
19200, N,8,1, NULL
25 Hz TSS 1
A/B Switch
9600, N,8,1, NULL
RTCM 104
DGPS Receiver
9600, N,8,1
RTCM
19200, N,8,1
Controller & GPS Data
COM1
COM2
C-Nav Receiver
Hub
Data Y
Data Y
10.0.10.20
UDP 1066
Reson 8111
COM1
COM2
COM3
DOWN1
COM5
COM9
COM8
COM1
9600, N,8,1, NULL
$SDDBT
S220-Acq
129.100.1.230
10.0.10.5
Dynamic IP
10.0.10.21
UDP 1080
Reson 8160
COM1
COM2
COM3
DOWN1
Data Y
9600, N,8,1, NULL
SBE 45 TSG
9600, N,8,1, NULL
ISIS_Nav
COM6
COM7
COM2
19200, N,8,1, NULL
Reson Controller
A/B Switch
COM2
MVP-200
Controller
COM4
COM3
MVP-200
Controller Interface
19200, N,8,1
Fish COMM
19200, N,8,1
Winch COMM
Data Y
9600, N,8,1, NULL
$GPGGA, $GPVTG, $GPZDA, $SDDBT
Key
Serial
Crossover
Patch
Dynamic IP
Ships Network
S220 FAIRWEATHER System Communication Wire Diagram
Rev 2.2
7/20/2006
Grant Froelich

# NOAA POS/MV Calibration Report

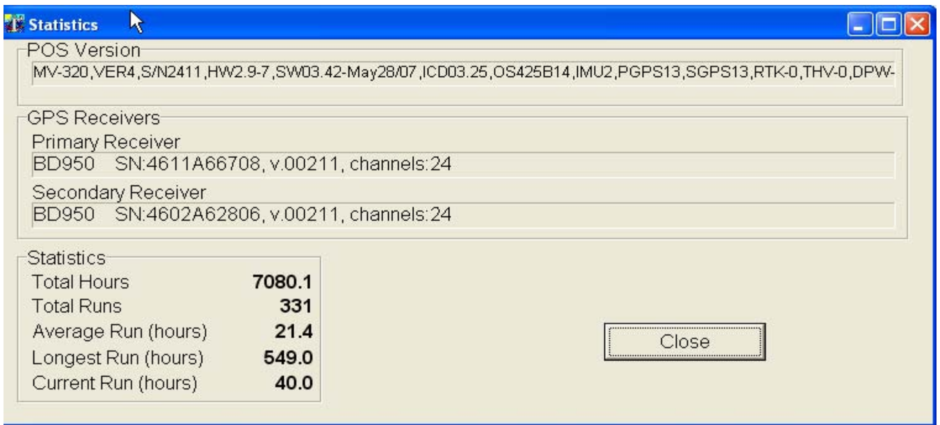
**Ship:** FAIRWEATHER **Vessel:** S220
**Date:** 4/27/2009 **Dn:** 117
**Personnel:** Campbell, Rice

**PCS Serial #** 2411 **IMU Serial #** 292
**IP Address:** 129.100.1.231

**Port Antenna Serial #** 60103854 **Stbd Antenna Serial #** 60125191

**POS controller Version (Use Menu Help > About)** 4.0.2.0

**POS Version (Use Menu View > Statistics)** 320 Version 4
**GPS Receivers**
Primary Receiver BD950 SN:4611A66708 v.00211
Secondary Receiver BD950 SN:4602A62806 v.00211




## Calibration area

**Location:** Central Fitz Hugh Sound, BC, Canada
**Approximate Position:**

| | | | |
|---|---|---|---|
| **Lat** | | | |
| **Lon** | | | |

**DGPS Beacon Station:** Alert Bay
**Frequency:** 309

## Satellite Constellation

(Use View> GPS Data)

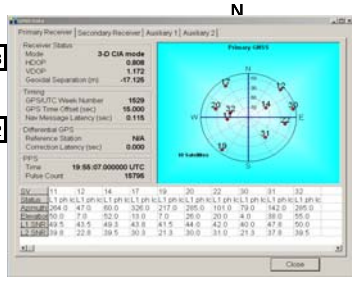
### Primary GPS

Sketch general SV configuration or insert screen grabs

N

**HDOP** 0.808

**VDOP** 1.172



**Sattelites in use:** 10

**L1 SNR >** 30 35 40

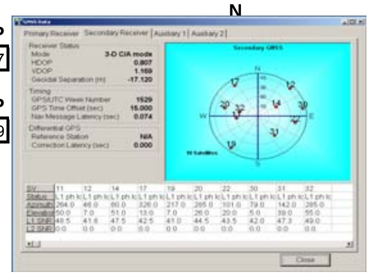
### Secondary GPS

Note any differences from Primary GPS Receiver

N

**HDOP** 0.807

**VDOP** 1.169



**Sattelites in use:** 10

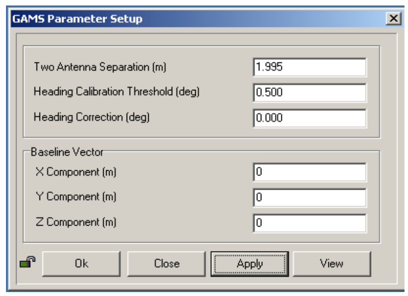
**L1 SNR >** 30 35 40

**PDOP** ____________ (Use View> GAMS Solution)

## POS/MV Configuration

### Settings

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



GAMS Parameter Setup

| | |
|---|---|
| Two Antenna Separation (m) | 1.995 |
| Heading Calibration Threshold (deg) | 0.500 |
| Heading Correction (deg) | 0.000 |

Baseline Vector

| | |
|---|---|
| X Component (m) | 0 |
| Y Component (m) | 0 |
| Z Component (m) | 0 |

Ok | Close | Apply | View

**Configuration Notes:** Antenna separation based on 2007 survey.

## POS/MV Calibration

### Calibration Procedure:

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

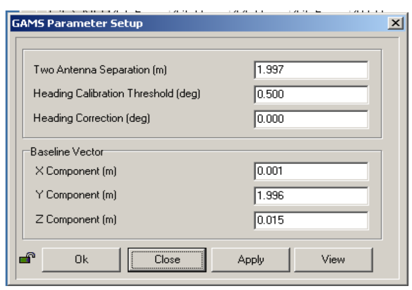
Start time: 19:59:38

End time: 20:34:44

Heading accuracy achieved for calibration: 0.253

### Calibration Results:

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



GAMS Parameter Setup

| | |
|---|---|
| Two Antenna Separation (m) | 1.997 |
| Heading Calibration Threshold (deg) | 0.500 |
| Heading Correction (deg) | 0.000 |

Baseline Vector

| | |
|---|---|
| X Component (m) | 0.001 |
| Y Component (m) | 1.996 |
| Z Component (m) | 0.015 |

Ok | Close | Apply | View

GAMS Status Online Yes

Save Settings ____________

**Calibration Notes:** ____________

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

File Name: ____________

## General Notes:

**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.

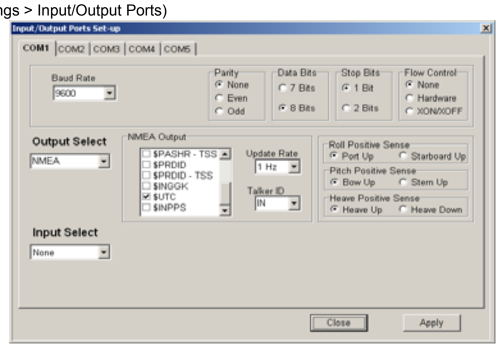
b) Pitch rotation - apply a right-hand screw rotation θy about the once-rotated y-axis to align one frame with the other.

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

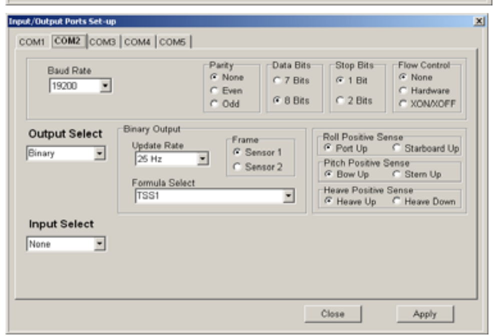
## SETTINGS

**Input/Output Ports** (Use Settings > Input/Output Ports)

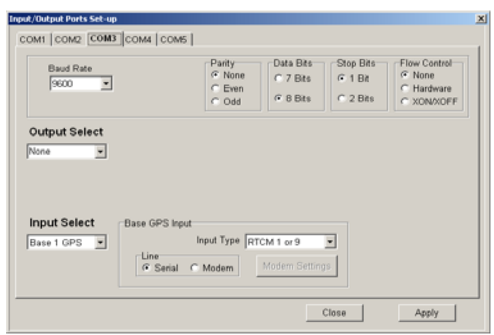
**COM1**



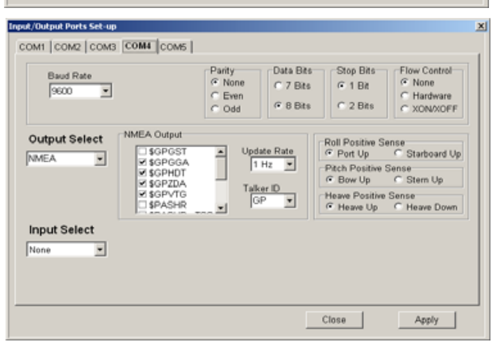

**COM2**



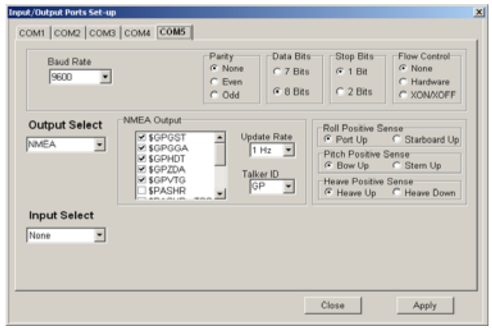

**COM3**



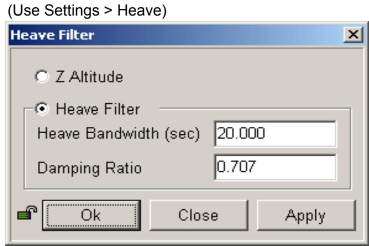

**COM4**



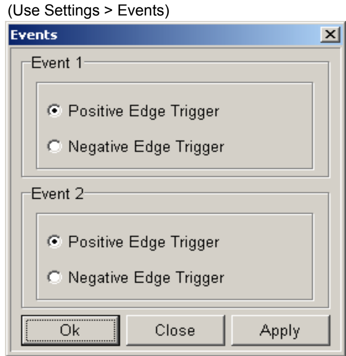
**SETTINGS Continued** **COM5**




**Heave Filter** (Use Settings > Heave)



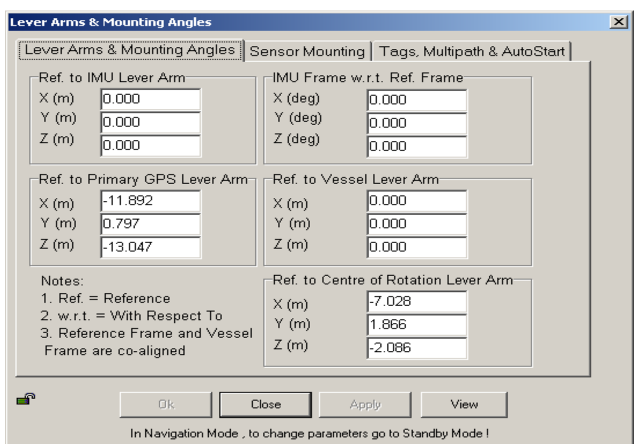

**Events** (Use Settings > Events)




## INSTALLATION

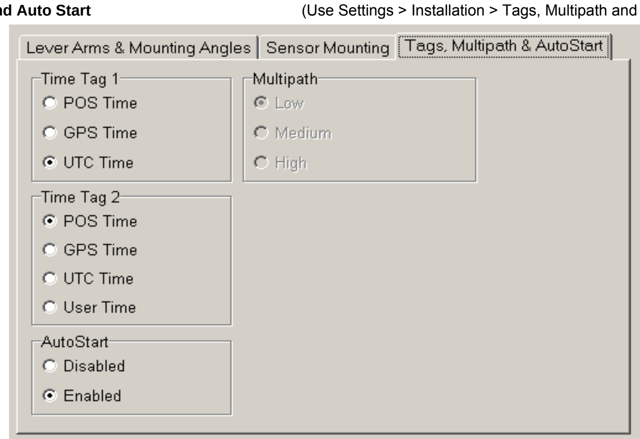
(Use Settings > Installation)

**Lever Arms and Mounting Angles** (Use Settings > Installation > Lever Arms and Offsets)

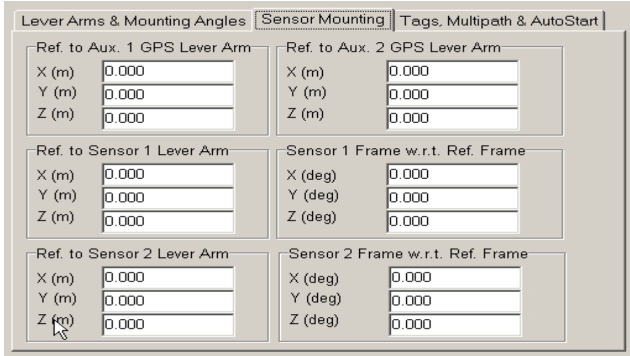



## INSTALLATION Continued

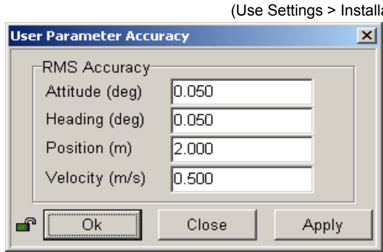
**Tags, Multipath and Auto Start** (Use Settings > Installation > Tags, Multipath and Auto Start)



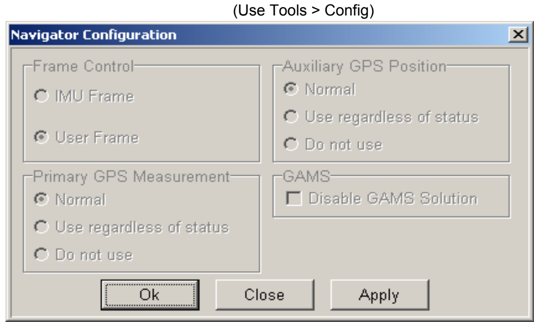
**Sensor Mounting** (Use Settings > Installation > Sensor Mounting)




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



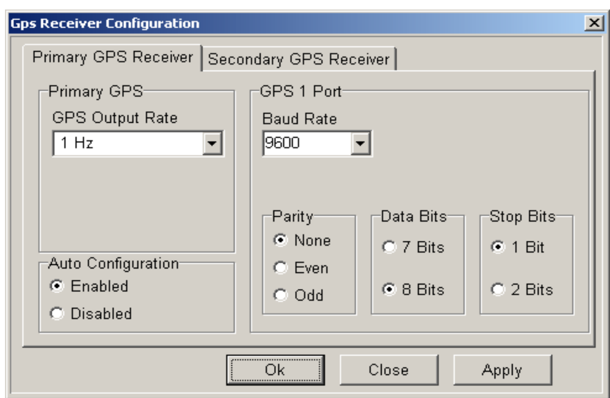

**Frame Control** (Use Tools > Config)



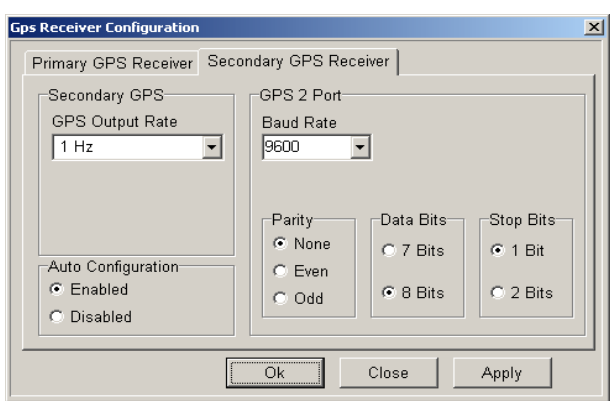

(Use Settings> Installation> GPS Receiver Configuration)

## GPS Receiver Configuration

**Primary GPS Receiver**




**Secondary GPS Receiver**



**FAIRWEATHER**

**Multibeam Echosounder Calibration**

**S220 8111**
Vessel

| | | |
|---|---|---|
| 4/28/2009 | 118 | Moira Rock |
| Date | Dn | Local Area |

Morgan, Welton, Raymond, Stuart, Ringel
Calibrating Hydrographer(s)

| | | |
|---|---|---|
| Reson 8111 | Fairweather | Mar-2009 |
| MBES System | MBES System Location | Date of most recent EED/Factory Check |

| | |
|---|---|
| Unknown | 35652 |
| Sonar Serial Number | Processing Unit Serial Number |
| Hull, curved transducer | 2/15/2009 |
| Sonar Mounting Configuration | Date of current offset measurement/verification |
| Applanix Pos MV | 4/27/2009 |
| Description of Positioning System | Date of most recent positioning system calibration |

**Acquisition Log**

| | | | |
|---|---|---|---|
| 4/29/2009 | 119 | Moira Rock | Ptly cloudy, cool, |
| Date | Dn | Local Area | Wx |

| | |
|---|---|
| | |
| Bottom Type | Approximate Water Depth |

Personnel on board

Back time cast number BOT_005
Comments

TrueHeave filename

| | | | | | |
|---|---|---|---|---|---|
| BOT_0004 | | | | | |
| SV Cast #1 filename | UTC Time | Lat | Lon | Depth | Ext. Depth |
| BOT_0005 | | 55\04\48.48 | 131\58\23.30 | | |
| SV Cast #2 filename | UTC Time | Lat | Lon | Depth | Ext. Depth |

## NAV TIME LATENCY

view parallel to track, one line with induced roll (outerbeam) or same lines target or slope (nadir) [same direction, different speed]

| SV Cast # | XTF Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| BOT_0005 | 2009_1190714 | 206 | 3.7 | 10m port over target |
| BOT_0005 | 2009_1190732 | 033 | 3.8 | 8m starboard over target |
| BOT_0005 | 2009_1190749 | 207 | 9.0 | 30m port over target redo:do not use for patch |
| BOT_0005 | 2009_1190800 | 034 | 8.7 | 7m stb over tgt |
| BOT_0005 | 2009_1190811 | 207 | 9.0 | 30m stb over target redo:do not use for patch |
| BOT_0006 | 2009_1190857 | 206 | 9.1 | 5m port over target |
| | | | | |
| | | | | |

## PITCH

view parallel to track, same line (at nadir) [opposite direction, same speed]

| SV Cast # | XTF Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| BOT_0005 | 2009__1190608 | 207 | 6.5 | back time cast 0605 |
| BOT_0005 | 2009__1190633 | 033 | 6.5 | good line held true |
| BOT_0005 | 2009__1190645 | 210 | 6.2 | started to starboard, straightened smartly |
| BOT_0005 | 2009_1190658 | 033 | 7.2 | 15m starboard over target |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

## HEADING/YAW

view parallel to track, offset lines (outerbeams) [opposite direction, same speed]

| SV Cast # | XTF Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| BOT_0005 | 2009__1190827 | 031 | 6.5 | Line 3:good line held true |
| BOT_0006 | 2009__1190911 | 031 | 6.5 | Line4: good line held true |
| BOT_0006 | 2009__1190937 | 208 | 6.5 | Line 3:good line held true |
| BOT_0006 | 2009__1191002 | 207 | 6.6 | Line 4: good line held true |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

## ROLL

view across track, same line [opposite direction, same speed]

| SV Cast # | XTF Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| BOT_0004 | 2009__1190503 | 270 | 5.3 | good line |
| | 2009__1190519 | 086 | 5.4 | Off line to Starboard 20ish meters at start |
| | 2009__1190534 | 268 | 5.4 | mostly good line, 10m off at start |
| | 2009__1190548 | 091 | 5.7 | mostly good line, 20m off Starboard at start |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

## Processing Log

| Date | Dn | Personnel |
|---|---|---|
| 4/29/2009 | 119 | Stuart |

☑ **Data converted --> HDCS_Data in CARIS**

☑ **TrueHeave applied** PosPac_S220_118.005

☑ **SVP applied** Moira_Rock_S220_SV.svp

☑ **Tide applied** zerotide.tid

**Zone file**

**Lines merged** ☑

**Data cleaned to remove gross fliers** ☐

| Compute correctors in this order | | | |
|---|---|---|---|
| **1. Precise Timing** | **2. Pitch bias** | **3. Heading bias** | **4. Roll bias** |
| Do not enter/apply correctors until all evaluations are complete and analyzed. | | | |

### PATCH TEST RESULTS/CORRECTORS

| Evaluators | Latency (sec) | Pitch (deg) | | Roll (deg) | Yaw (deg) | |
|---|---|---|---|---|---|---|
| B. Welton | -0.05 | 0.30 | | 0.00 | -0.30 | |
| A. Raymond | 0.04 | -0.40 | | 0.00 | -0.40 | |
| L. Stuart | -0.07 | 0.25 | | 0.02 | -0.70 | |
| CST Morgan | 0.00 | -0.20 | | -0.02 | -0.30 | |
| FOO | 0.04 | -0.30 | | 0.00 | -0.20 | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| **Averages** | -0.01 | -0.07 | | 0.00 | -0.38 | |
| **Standard Deviation** | 0.05 | 0.32 | 0.10 | 0.01 | 0.19 | 0.08 |
| **FINAL VALUES** | 0.00 | -0.07 | | 0.00 | -0.38 | |

**Final Values based on** CST/FOO Average of all results

**Resulting HVF File Name** FA_S220_Reson8111_2009.hvf

**Actual values used**

**MRU Align StdDev gyro** ~~0.19~~ Value from standard deviation of Heading offset values — 0.082 **MRU Align StdDev gyro**

**MRU Align StdDev Roll/Pitch** ~~0.17~~ Value from averaged standard deviations of pitch and roll offset values — 0.057 **MRU Align StdDev Roll/Pitch**

**NARRATIVE**

Initial MRU values were too high, TPU values reassessed with outliers removed.

☑ **HVF Hydrographic Vessel File created or updated with current offsets**

**Name:** CST Morgan **Date:** 05/06/09

**FAIRWEATHER**

**Multibeam Echosounder Calibration**

| | |
|---|---|
| **S220 8160** | |
| Vessel | |

| | | |
|---|---|---|
| 4/28/2009 | 118 | Moira Rock |
| Date | Dn | Local Area |

| |
|---|
| Morgan, Welton, Raymond, Campbell, Ringel |
| Calibrating Hydrographer(s) |

| | | |
|---|---|---|
| Reson 8160 | *Fairweather* - S220 | 2004 |
| MBES System | MBES System Location | Date of most recent EED/Factory Check |

| | |
|---|---|
| Unknown | 35385 |
| Sonar Serial Number | Processing Unit Serial Number |
| Hull, flat faced | 2/15/2009 |
| Sonar Mounting Configuration | Date of current offset measurement/verification |
| Applanix Pos MV | 4/27/2009 |
| Description of Positioning System | Date of most recent positioning system calibration |

## Acquisition Log

| | | | |
|---|---|---|---|
| 4/28-29/2009 | 01 | Moira Rock | Clear, cool, 2 foot chop, 10-12 kts NNW |
| Date | Dn | Local Area | Wx |

| | |
|---|---|
| | |
| Bottom Type | Approximate Water Depth |

| |
|---|
| |
| Personnel on board |
| NMEA Output was not run during SV Cast resulting in no positions, an approximate position for Cast #3 is entered below |
| Comments |
| PosPac_S220_118 |
| TrueHeave filename |

| | | | | | |
|---|---|---|---|---|---|
| BOT_0001 | | | | | |
| SV Cast #1 filename | UTC Time | Lat | Lon | Depth | Ext. Depth |
| BOT_0002 | | | | | |
| SV Cast #2 filename | UTC Time | Lat | Lon | Depth | Ext. Depth |
| BOT_0003 | | 55/05.9346 | 131/56.5637 | | |
| SV Cast #3 filename | UTC Time | Lat | Lon | Depth | Ext. Depth |

## NAV TIME LATENCY

view parallel to track, one line with induced roll (outerbeam) or same lines bounded slope (nadir) [same direction, different speed]

| SV Cast # | XTF Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| BOT_0001 | 2009_1182317 | 032 | 6.6 | Also good Pitch line |
| | 2009_1182347 | 033 | 4.4 | |
| | 2009_1182332 | 207 | 7.0 | Good pitch line |
| | | | | |
| | 2009_1190007 | 207 | 4.3 | Latency |
| | 2009_1190023 | 032 | 9.6 | Latency |
| | 2009_1190034 | 207 | 9.2 | Latency |
| | | | | |

## PITCH

view parallel to track, same line (at nadir) [opposite direction, same speed]

| SV Cast # | HSX Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| BOT_0001 | 2009_1182240 | 033 | 6.5 | First line!! |
| | 2009_1182305 | 207 | 6.4 | Pretty good line. |
| | 2009_1182317 | 032 | 6.6 | good line |
| | 2009_1182332 | 207 | 7.0 | good line |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

## HEADING/YAW

view parallel to track, offset lines (outerbeams) [opposite direction, same speed]

| SV Cast # | XTF Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| BOT_0002 | 2009_1190112 | 024 | 5.5 | NW line, good outer beam overlap with feature. |
| | 2009_1190131 | 213 | 5.5 | SE Good line |
| | 2009_1190147 | 027 | 5.5 | NW inboard and better overlap |
| | 2009_1190203 | 213 | 5.6 | SE |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

## ROLL

view across track, same line [opposite direction, same speed]

| SV Cast # | XTF Line Filename | Heading | Speed (kts) | Remarks |
|---|---|---|---|---|
| BOT_0003 | 2009__1190307 | 270 | 6.2 | 80m to port at beginning of line |
| | 2009__1190323 | 090 | 6.3 | lost bottom track mid line |
| | 2009__1190338 | 270 | 5.0 | poor line tracking |
| | 2009__1190353 | 090 | 6.8 | good line |
| | 2009__1190408 | 270 | 6.3 | good line |
| | 2009__1190426 | 090 | 6.0 | good line |
| | | | | |
| | | | | |

## Processing Log

| Date | Dn | Personnel |
|---|---|---|
| 4/29/2009 | 119 | Stuart |

☑ **Data converted --> HDCS_Data in CARIS**

☑ **TrueHeave applied** PosPac_S220_118.000

☑ **SVP applied** Moira_Rock_S220_SV.svp

☑ **Tide applied** zerotide.tid

**Zone file**

**Lines merged** ☑

**Data cleaned to remove gross fliers** ☐

| Compute correctors in this order | | | |
|---|---|---|---|
| **1. Precise Timing** | **2. Pitch bias** | **3. Heading bias** | **4. Roll bias** |
| Do not enter/apply correctors until all evaluations are complete and analyzed. | | | |

### PATCH TEST RESULTS/CORRECTORS

| Evaluators | Latency (sec) | Pitch (deg) | | Roll (deg) | Yaw (deg) | |
|---|---|---|---|---|---|---|
| CST Morgan | 0.04 | -0.40 | | -0.04 | -0.40 | |
| B. Welton | 0.00 | -0.35 | | -0.07 | 0.60 | |
| A. Raymond | 0.05 | -0.16 | | -0.04 | 0.55 | |
| B. Campbell | 0.01 | -0.35 | | -0.04 | 0.60 | |
| FOO | 0.00 | -0.10 | | -0.05 | 0.50 | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| **Averages** | 0.02 | -0.27 | | -0.05 | 0.37 | |
| **Standard Deviation** | 0.02 | 0.13 | 0.029 | 0.01 | 0.43 | 0.05 |
| **FINAL VALUES** | 0.00 | -0.27 | | -0.50 | 0.37 | |

**Final Values based on**

**Resulting HVF File Name**

| | | | Actual values used | |
|---|---|---|---|---|
| **MRU Align StdDev gyro** | ~~0.43~~ | Value from standard deviation of Heading offset values | 0.048 | **MRU Align StdDev gyro** |
| **MRU Align StdDev Roll/Pitch** | ~~0.07~~ | Value from averaged standard deviations of pitch and roll offset values | 0.021 | **MRU Align StdDev Roll/Pitch** |

**NARRATIVE**
Data analyzed was collected on Dn 118 and 119.

Initial MRU values were too high, TPU values reassessed with outliers removed.

☑ **HVF Hydrographic Vessel File created or updated with current offsets**

**Name:** CST Morgan **Date:** 5/6/2009

G.Rice

2/26/09

# *Fairweather* Elipsoidally Referenced Dynamic Draft Measurement

## *Lake Washington, February 23rd 2009*

On Feb 23rd, 2009 the NOAA Ship *Fairweather* conducted a dynamic draft measurement (DDM) on Lake Washington using post processed kinematics (PPK). A standard operating procedure was defined before the test and is included as Appendix A. The plan was to determine the how much, at different speeds, the vessel's draft changes with reference to ellipsoidal height. During the test, *Fairweather* stopped between speeds to allow for a static height measurement. Due to time constraints this test was only run with approximate speeds of 4 knots, 6 knots, 8 knots, and 10 knots.

Because this DDM was conducted on Lake Washington, any change in water level was assumed to be negligible. Since it was further assumed there was no current, speed through the water was determined using over-ground speed (GPS). Wind was from the North at approximately 10 knots. The ship was light on fuel, without launches, and drawing two feet less in the stern than would normally be expected during survey operations.

POSPac file recording from the POS/MV began before getting underway, approximately an hour before the DDM was performed. After the test, the data were imported into POSPac processing software and reference stations were uploaded using the "smart select" option. Six stations were selected, three from CORS and three from SOPAC. The Smart Base Quality Check was run and it identified one position to be adjusted and two that could be set to control; these changes were accepted. Applanix Smart Base was run to generate a local virtual reference station. Processors then ran the GNSS-Inertial Processor, using the SmartBase GNSS Mode with a zero initialization for Roll, Pitch and Heading. Lever Arms and Mounting Arms were set to be in the 10cm uncertainty range.

A coordinate system of UTM zone 10 with the GEOID03 (Conus) was used while processing the data. Figure 1 is a screen grab of the network. Reference station distance from the working area ranged from 1500 meters to 35 kilometers.

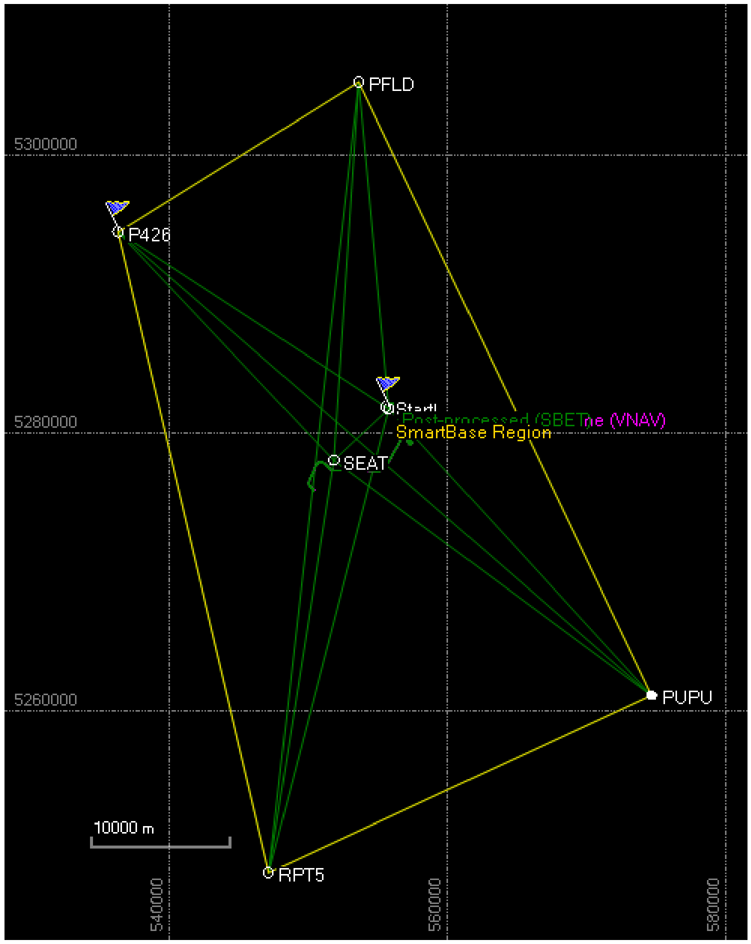



**Figure 1 – The network used consisting of six reference stations.**

Once processed in POSPac the Display Plots were reviewed. No problems were found. The X, Y and Z Reference-Primary GPS Lever Arms varied by as much as 0.2 meters over the course of the exercise, although the Z Lever Arm agreed to within 3cm with the typical values found during the Ernest Sound Project. The Altitude SBET and the associated RMS values can be found in Figure 2 and Figure 3 respectively.

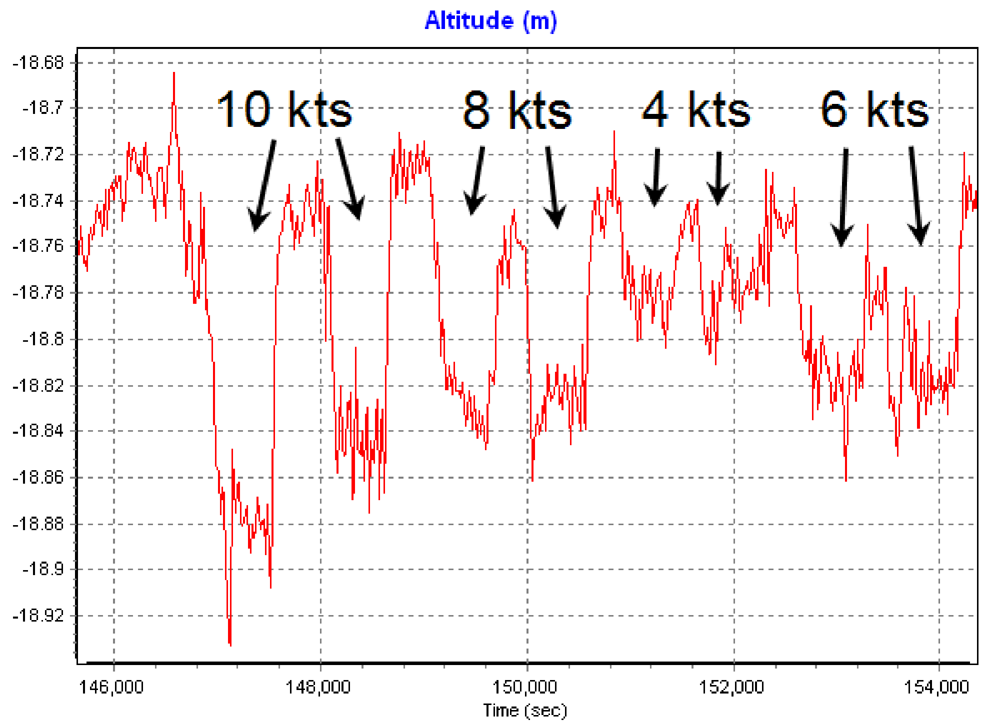



**Figure 2 – The altitude time series during this test as seen in POSPac.**

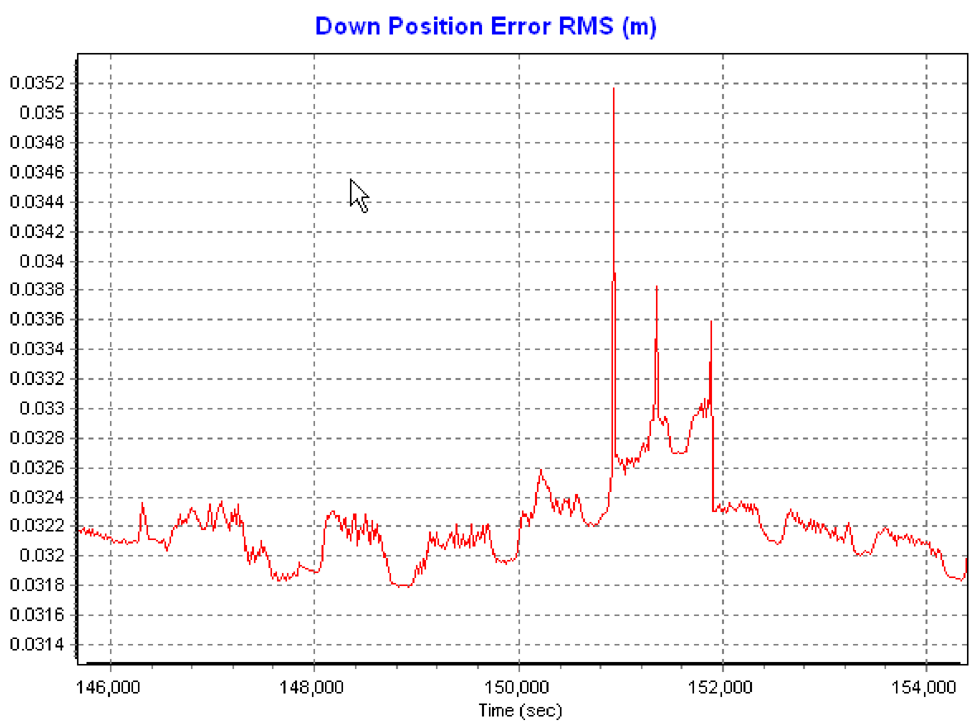



**Figure 3 – The estimated vertical error time series from POSPac.**

Because the noise associated with altitude readings (Figure 2) is within the uncertainty shown in Figure 3, this noise is not considered significant. Two approaches were considered for determining authentic draft measurement from within the noise. The first approach selects specific sections of data that have relatively small changes in speed and average them for both speed and ellipsoidal height. The draft, then, is the result of subtracting the average ellipsoidal height recorded at rest from the averaged ellipsoidal height at speed. The second method plots a best-fit polynomial curve to the distribution of all data on a speed vs ellipsoidal height axis (Figure 4). This is more robust and just as accurate as the first approach. Consider that survey vessels are often making changes to speed or course during operations, changes for which typical DDM tests do not account. The second method described was used here.

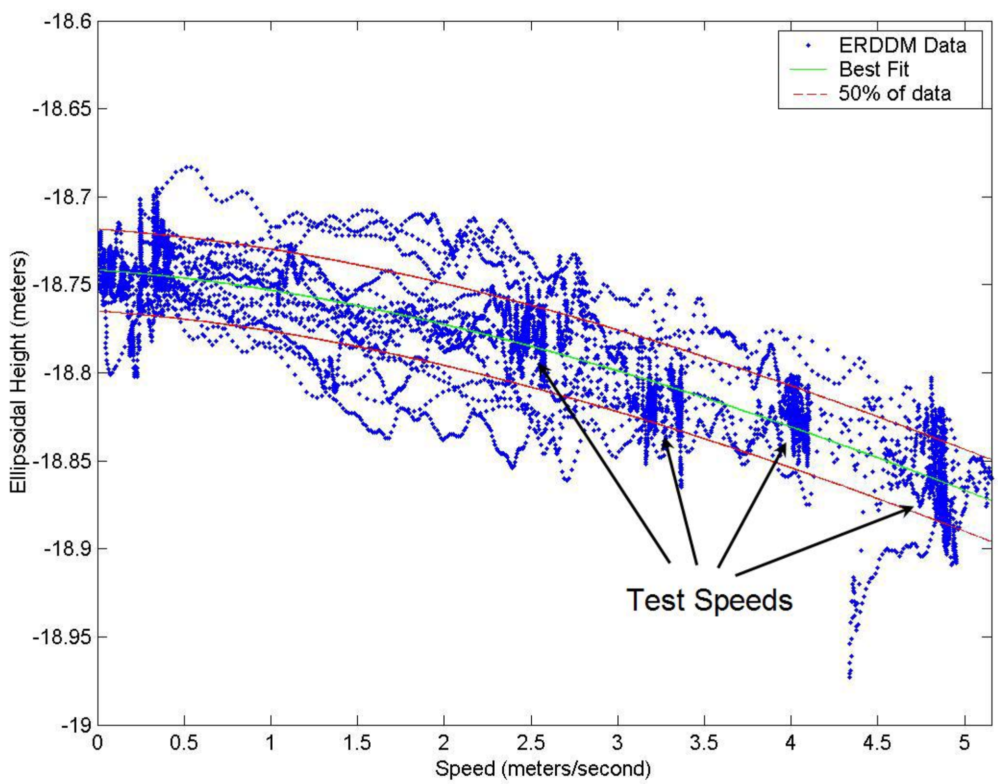



**Figure 4 – Ellipsoidal Height data as a function of the Speed with the best-fit curve.**

Figure 4 shows the data clusters at each of the target speeds. These clusters of data weight the best-fit curve to the correct shape. Data points from speed changes demonstrate the variation likely during survey operations and are an indicator of the uncertainty for DDM. While the best-fit curve does not pass through each cluster, its proximity is within the vertical uncertainty for these measurements.

The equation for the best-fit curve can be used to give the delta draft table needed by Caris. By simply plugging in different speeds the change in draft is given when the ellipsoidal offset at rest is subtracted from the equation, resulting in a zero y intercept. This is accomplished here by using the y intercept derived by the polynomial fit. If insufficient data from at rest is supplied to the best-fit process or the fit is poor this can result in a vertical offset. Since the table in Caris assumes down is positive the equation will also need to be multiplied by (-1). Equation 1 was derived using the described process and was used to populate Table 1.

$$\Delta Draft = (-2.15 * Speed^3 + 46.93 * Speed^2 + 69.41 * Speed) * 10^{-4} \quad \textbf{(1)}$$

**Table 1 The computed Dynamic Draft Table for Caris**

| Speed (m/s) | Delta Draft (m) |
|---|---|
| 0 | 0 |
| 0.5 | 0.005 |
| 1.0 | 0.011 |
| 1.5 | 0.020 |
| 2.0 | 0.031 |
| 2.5 | 0.043 |
| 3.0 | 0.057 |
| 3.5 | 0.072 |
| 4.0 | 0.089 |
| 4.5 | 0.107 |
| 5.0 | 0.125 |
| 5.5 | 0.144 |
| 6.0 | 0.164 |

While the number of terms in Equation 1 might be excessive it was deemed prudent to have too many rather than too few coefficients.

Past dynamic draft values for *Fairweather* have varied and have had mixed success. The values used from the 2006 season have generally been accepted to work best and were used for 2008 when the 2008 values proved to be insufficient. Figure 5 allows for a visual comparison of these values.

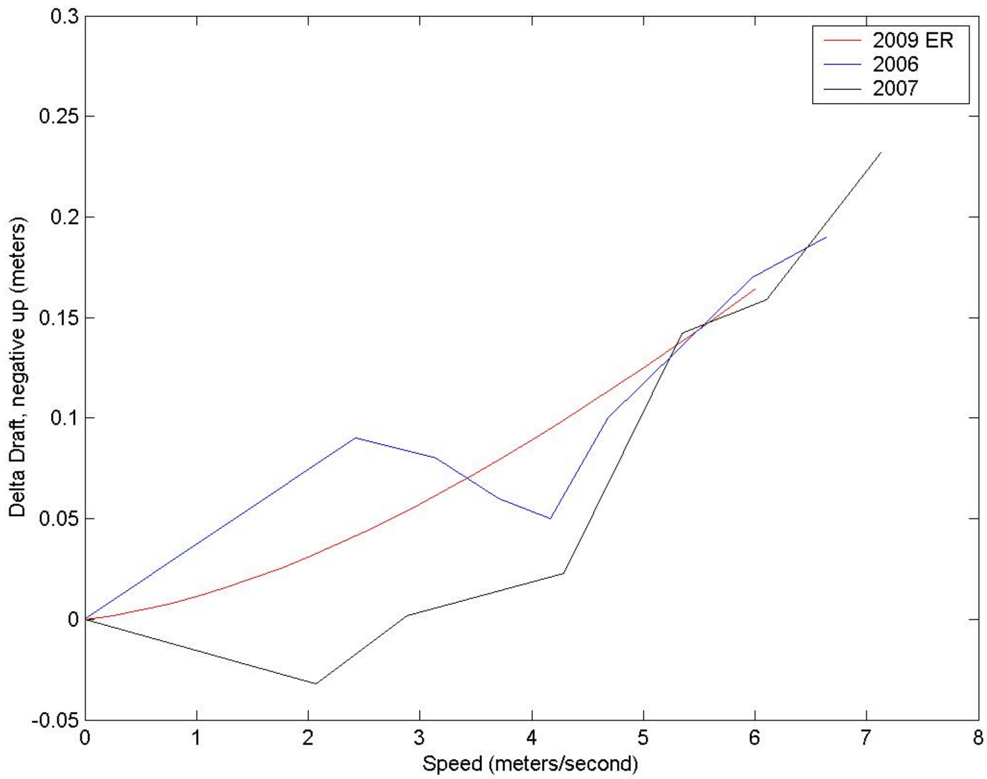



**Figure 5 – A comparison of the 2009 ellipsoidally referenced measurements to those from previous years.**

The best-fit polynomial curve can be evaluated by subtracting its values from all test data. Calculating the standard deviation for these residual values give an estimate of the uncertainty in the estimate from the best-fit curve (Figure 6).

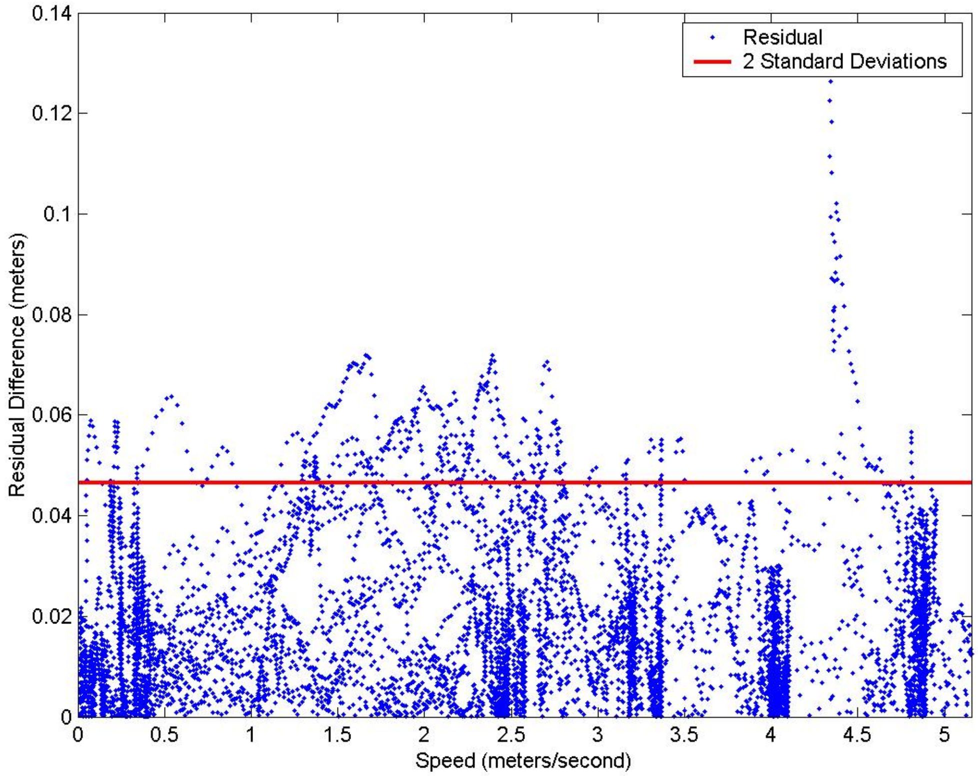



**Figure 6 – The residual difference between the measurement data and the best-ft curve.**

Two standard deviations for the residual difference was calculated to be 4.7cm. While this is accurate for this test it is not accurate to say this depicts the uncertainty for dynamic draft in general. The changes in draft while changing speed was captured by this method but the further uncertainty caused by currents is not. It is standard for the vessel speed through the water to be approximated by the speed over ground on many NOAA vessels. Since this impacts how Caris implements the dynamic draft table it also impacts the delta draft used.

In conclusion, this method for estimating the dynamic draft appears reliable from the comparison with previous year's results as well as robust because of its inclusion of many measurements. Due to time constraints this test was limited to four speeds at 10 minutes each. More time at each speed and at more speeds would add to the reliability of the estimates. Differences between the best-fit curves for the geoid verse the ellipsoid varied by as much as 4 mm and was not considered significant.

# Appendix A

G. Rice

2/3/08

## Dynamic Draft Measurements Using POSPac

### 1. Scope:

This document is for the initial attempt to use POSPac to measure dynamic draft relative to the ellipsoid aboard the NOAA Ship FAIRWEATHER. This process is only a preliminary and should be updated with lessons learned after the initial attempt.

### 2. Background:

This process is for a body of water with a static water level over short time periods, such as a lake. Tides will not be taken into account and it is assumed that currents are negligible. The ellipsoid is assumed to be relatively parallel to the water level over the area of this test. Time periods of static vessel settlement at the end of each line will help to confirm this assumption. V-datum does exist for the area of Lake Washington (where this test will be performed) so if needed the navigation information can be converted to the geoid. Since vertical data will only be referenced internally (at rest compared to underway) the datum does not matter as long as it is parallel to the water level plane. Because of the availability of reference stations for an established network the data will be processed to the ITRF ellipsoid.

### 3. Data Collection:

The POS/MV should be turned on and logging POSPac for 30 minutes before the beginning of the evolution. If time allows log the status of water and fuel tanks, which small boats are aboard and what the draft marks read. Once on location for the test sit static for 2 minutes and then again in between every line and again at the end of the test. Each line should be driven at speed for 5 minutes in each direction. The two minute rest can occur before or after turning around to begin the next line. Speed estimates are to ensure proper space is available for each line only. Maintaining the same shaft RPM and propeller pitch for both directions is more important than having the same speed. Line speeds are as follows:

| Line 1 Start/End | Line 2 Start/End | Approximate speed (kts) | Shaft RPM | Propeller Pitch | Comments |
|---|---|---|---|---|---|
| | | 2<br>4 | 120<br>130 | 30<br>40 | |
| | | 6<br>8 | 140<br>150 | 50<br>60 | |
| | | 10<br>12 | 160<br>170 | 70<br>80 | |

Record the start and end time for each line according to the time in the POS Controller.

## 4. Data Processing:

The data will be processed through POSPac using either a Virtual Reference Station in a network or a single station. Output will likely be examined in either Python or Matlab to estimate actual Dynamic Draft Measurements.

# SeaBat 8160 Noise Analysis

## 1.0 Overview

For mid and deep water sonar systems, noise emanating from the vessel on which the sonar is mounted is a major determinant in the performance of the sonar. In addition to sources such as echosounders and other acoustic devices, such as doppler logs, mechanical noise from the engines and drive trains, and flow noise will also affect performance, with the magnitude of the noise varying with vessel speed.

This document describes the noise analysis test done on the RESON SeaBat 8160 installed on the NOAA S/V Fairweather, on 10 October 2004.

## 2.0 Test Conduct

The following is a description of the system setup and test protocol used to test the SeaBat 8160 multibeam sonar.

### *2.1 Sonar Setup*

To determine the amount of in-band noise seen by the sonar, the system was configured as follows:

| Setting | Value |
|---|---|
| Power | Off |
| Gain | Manual Fixed 20 |
| Range | 100 meters |

Data collection was done using a RESON engineering utility, which collects the full amplitude and phase time series data from the sonar. Figure 1 shows a sample screen capture, in this case one of the data sets taken at six knots, with a shaft speed of 140 RPM. At least ten (10) collections were done for each test case, and the results for first 10 measurements each test case were averaged for the report.

### *2.2 Vessel Operation*

Normal survey speed for the vessel is approximately 10 knots. To bracket this range, and to check at possible lower survey speeds, the test was defined to cover the range of 2 to 12 knots, in 2 knot steps. The initial tests were at a shaft speed of 130 RPM, with the speed adjusted by changing the pitch on the propellers. Additional tests were run at shaft speeds of 140 and 150 RPM, with the pitch adjusted to achieve speeds of 6, 8 and 10 knots. A log of data collections for the tests is provided in Appendix A.

All the underway data collections were done in water depths of 200 to 300 meters.  The zero speed data collections were done at anchor, in water depths of about 30 meters.

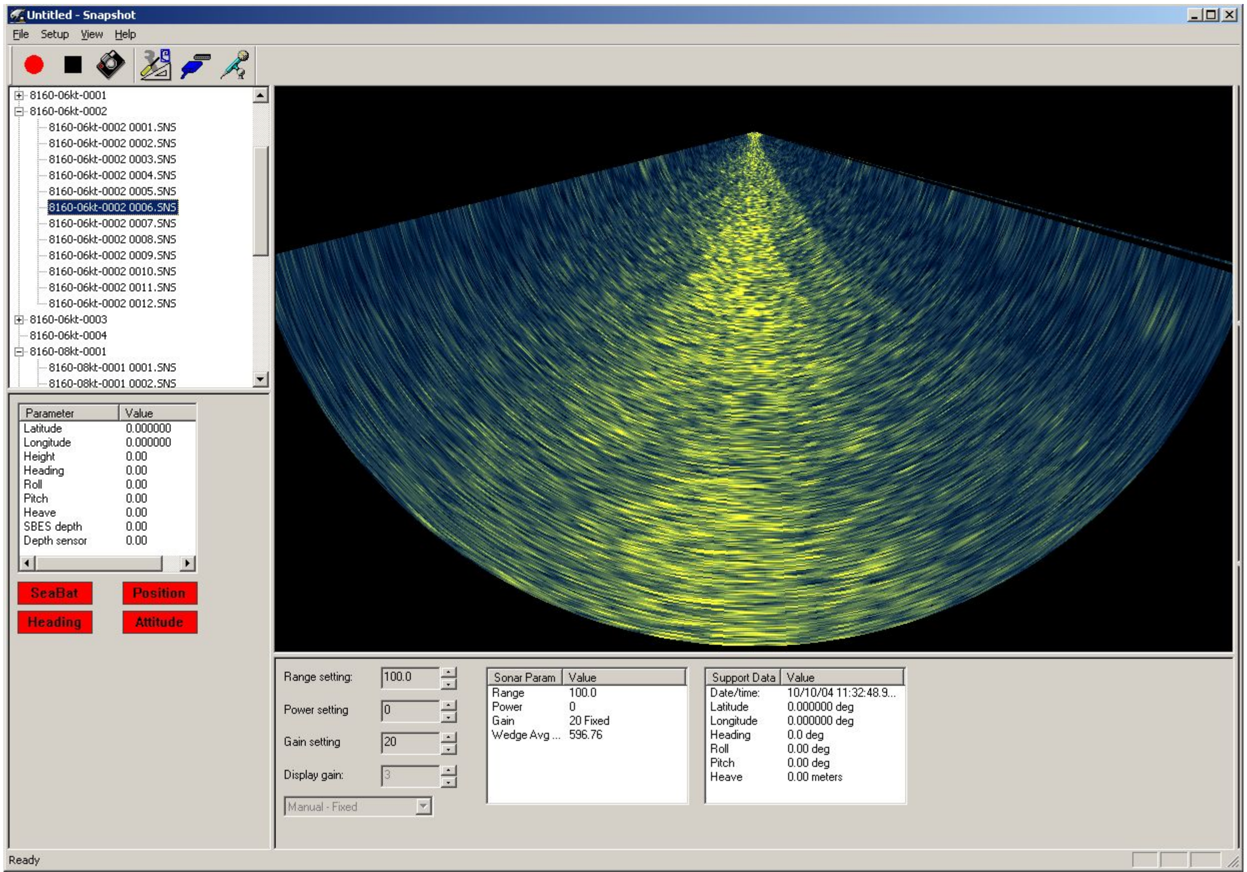



**Figure 1 - Snapshot Utility Screen Capture**

## *2.3 Data Analysis*

The data from each of the test cases were collated in an Excel spreadsheet, shown in Appendix B.  A graph of the measured noise levels, as a function of vessel speed and shaft RPM is shown in Figure 2.  The noise level is a unitless value that represents the average of all the amplitude samples, from all the beams for the sampled sonar ping.  This value represents a combination of the electrical noise in the sonar, and the response to all acoustic energy, within the bandwidth of the sonar, impinging on the receive array.

For each the 130, 140 and 150 RPM tests, the plot shows the noise level as a function of vessel speed.  Only one sample was taken at 160 RPM, since to achieve the 12 knot speed, it was necessary to run at that RPM, with the pitch set to maximum test value of 10 feet.

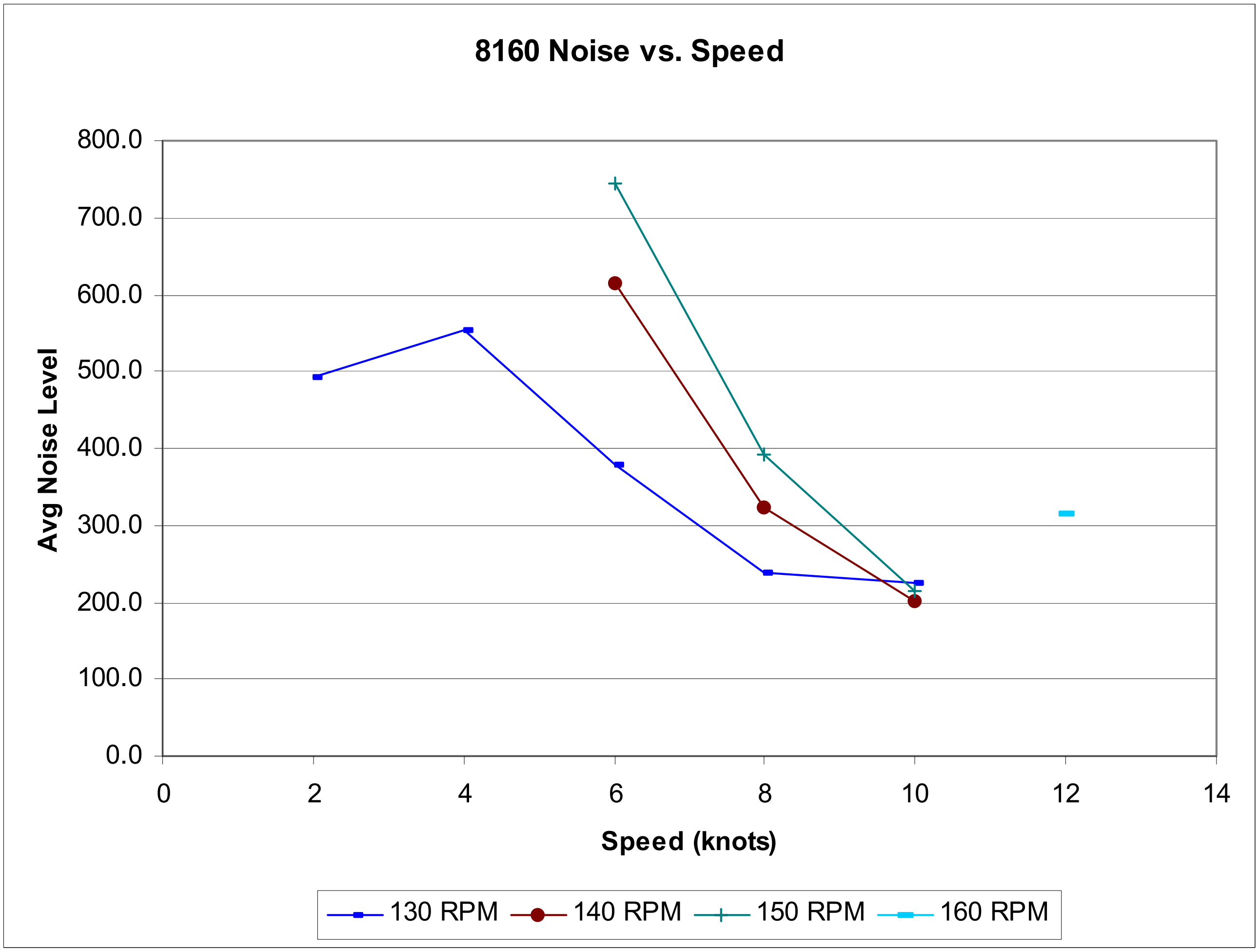



**Figure 2 - Noise Plot**

# 3.0 Conclusions

a. It appears that the best survey speed, from a noise perspective, is at approximately 10 knots. Both lower and higher speeds correlate with higher noise levels.
b. For lower survey speeds, it would be desirable to use a lower shaft RPM, combined with a higher pitch setting, to minimize the noise level seen by the sonar.
c. The reason for the higher noise levels seen in the zero speed, at anchor collections is undetermined, by may be a result of the much shallower operating depth, and increased reverberation of vessel mechanical noise reflected off the bottom.

# Appendix A – Test Log

RESON Inc.

| | | | | | |
|---|---|---|---|---|---|
| **Date:** | 10/10/2004 | **Survey Area:** | Rudyerd Bay, AK | **Page / Pages:** | |
| **Survey Name:** | 8160 Noise Test | **Surveyors:** | B Bridge | **TimeZone:** | -9 |
| **Survey Vessel:** | NOAA Fairweather | **Client:** | NOAA | | |

**Offset Information**

| | X | Y | Z | Latency | Roll | Pitch | Yaw |
|---|---|---|---|---|---|---|---|
| *Sounder* | | | | | | | |
| *DGPS* | | | | | | | |
| *Motion Sensor* | | | | | | | |
| *Other* | | | | | | | |

**SVP File:**
**Tide File**
**Date of Patch Test**
Total Pole
minus Dry Pole
**Draft (Z)**

| Start | Stop | Line | Dir. | Speed | COMMENTS |
|---|---|---|---|---|---|
| | | 8160-00kt-0002 | | 0 | At anchor, engines off - Gain Fixed 20, Pwr Off Rng100 |
| | | 8160-00kt-eng_on0001 | | 0 | Engines turned on |
| | | 8160-02kt-0001 | | 2 | sog 2.5 stw 1.7 rpm 130@1.5 feet pitch |
| | | 8160-04kt-0001 | | 4 | sog 4.0 stw 3.0 rpm 130@4.0 feet pitch |
| | | 8160-06kt-0001 | | 6 | sog 6.0 stw 5.0 rpm 130@6.0 feet pitch |
| | | 8160-08kt-0001 | | 8 | sog 8.0 stw 7.0 rpm 130@8.0 feet pitch |
| | | 8160-10kt-0001 | | 10 | sog 10.0 stw 8.5 rpm 130@10.0 feet pitch |
| | | 8160-12kt-0001 | | 12 | sog 12.0 stw 10.5 rpm 160@10.0 feet pitch |
| | | 8160-06kt-0002 | | 6.5 | sog 6.0 stw 5.0 rpm 140@5.0 feet pitch |
| | | 8160-08kt-0002 | | 8 | sog 8.0 stw 7.0 rpm 140@7.0 feet pitch |
| | | 8160-10kt-0002 | | 10 | sog 10.0 stw 8.5 rpm 140@9.5 feet pitch |
| | | 8160-10kt-0003 | | 10 | sog 10.0 stw 8.5 rpm 150@9.0 feet pitch |
| | | 8160-08kt-0003 | | 8 | sog 8.0 stw 7.0 rpm 150@6.5 feet pitch |
| | | 8160-06kt-0003 | | 6 | sog 6.0 stw 5.0 rpm 150@4.5 feet pitch |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| | | | |
|---|---|---|---|
| Survey Manager: | | Client Representative: | |
| Signature: | | Signature: | |

# Appendix B – Noise Analysis Spreadsheet

8160 Noise Test Results.xls

| | A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 8160 Noise Test Results | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | |
| 3 | Speed | Pitch (ft) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Average |
| 4 | Eng Off | | | | | | | | | | | | |
| 5 | 0 | | 407.4 | 409.7 | 406.2 | 414.0 | 414.5 | 416.3 | 417.4 | 418.6 | 417.4 | 417.8 | 413.9 |
| 6 | Eng On | | | | | | | | | | | | |
| 7 | 0 | | 1449.6 | 1363.7 | 1373.6 | 1393.3 | 1495.8 | 1656.9 | 1714.9 | 1597.3 | 1606.3 | 1829.4 | 1548.1 |
| 8 | | | | | | | | | | | | | |
| 9 | 130 RPM | | | | | | | | | | | | |
| 10 | 2 | 1.5 | 500.6 | 519.0 | 486.3 | 540.0 | 490.3 | 459.0 | 482.3 | 456.7 | 531.7 | 473.2 | 493.9 |
| 11 | 4 | 4 | 594.5 | 648.2 | 624.9 | 552.5 | 633.4 | 623.7 | 624.4 | 577.4 | 612.2 | 58.2 | 554.9 |
| 12 | 6 | 6 | 395.0 | 407.6 | 355.7 | 385.4 | 357.1 | 386.7 | 381.0 | 354.0 | 404.2 | 361.1 | 378.8 |
| 13 | 8 | 8 | 231.2 | 233.3 | 230.2 | 233.2 | 240.3 | 233.7 | 241.2 | 240.3 | 238.6 | 262.9 | 238.5 |
| 14 | 10 | 10 | 233.8 | 221.1 | 223.3 | 222.0 | 222.8 | 225.6 | 224.1 | 223.4 | 225.5 | 237.3 | 225.9 |
| 16 | | | | | | | | | | | | | |
| 17 | RPM 140 | | | | | | | | | | | | |
| 18 | 6 | 5 | 650.8 | 686.4 | 648.0 | 628.3 | 608.1 | 596.8 | 614.1 | 589.9 | 572.8 | 560.5 | 615.6 |
| 19 | 8 | 7 | 330.4 | 334.9 | 309.92 | 330.7 | 338.5 | 308.9 | 308.3 | 314.5 | 350.2 | 312.5 | 323.9 |
| 20 | 10 | 9.5 | 211.0 | 202.0 | 201.4 | 201.0 | 198.3 | 196.9 | 202.3 | 199.9 | 198.1 | 197.1 | 200.8 |
| 21 | | | | | | | | | | | | | |
| 22 | RPM 150 | | | | | | | | | | | | |
| 23 | 6 | 4.5 | 729.8 | 638.1 | 769.8 | 898.7 | 740.0 | 782.7 | 787.7 | 687.2 | 657.8 | 747.0 | 743.9 |
| 24 | 8 | 6.5 | 428.7 | 396.0 | 396.3 | 391.6 | 473.6 | 380.3 | 432.0 | 309.7 | 375.5 | 336.3 | 392.0 |
| 25 | 10 | 9 | 212.1 | 214.0 | 216.5 | 213.6 | 217.5 | 214.2 | 216.6 | 216.9 | 210.3 | 207.2 | 213.9 |
| 26 | | | | | | | | | | | | | |
| 27 | 160 RPM | 10 | | | | | | | | | | | |
| 28 | 12 | 10 | 324.8 | 317.1 | 324.5 | 308.2 | 313.3 | 346.6 | 315.8 | 304.7 | 301.4 | 303.5 | 316.0 |
| 29 | | | | | | | | | | | | | |

Sheet1 / Sheet2 / Sheet3

# SeaBat 8111 Noise Analysis

## 1.0 Overview

For mid and deep water sonar systems, noise emanating from the vessel on which the sonar is mounted is a major determinant in the performance of the sonar. In addition to sources such as echosounders and other acoustic devices, such as doppler logs, mechanical noise from the engines and drive trains, and flow noise will also affect performance, with the magnitude of the noise varying with vessel speed.

This document describes the noise analysis test done on the RESON SeaBat 8111 installed on the NOAA S/V Fairweather, on 11 October 2004.

## 2.0 Test Conduct

The following is a description of the system setup and test protocol used to test the SeaBat 8111 multibeam sonar.

### *2.1 Sonar Setup*

To determine the amount of in-band noise seen by the sonar, the system was configured as follows:

| Setting | Value |
|---|---|
| Power | Off |
| Gain | Manual Fixed 20 |
| Range | 100 meters |

Data collection was done using a RESON engineering utility, which collects the full amplitude and phase time series data from the sonar. Figure 1 shows a sample screen capture, in this case one of the data sets taken at six knots, with a shaft speed of 140 RPM. At least ten (10) collections were done for each test case, and the results for first 10 measurements each test case were averaged for the report.

### *2.2 Vessel Operation*

Normal survey speed for the vessel is approximately 10 knots. To bracket this range, and to check at possible lower survey speeds, the test protocol was defined to cover the range of 2 to 12 knots, in 2 knot steps. The tests were conducted at shaft speeds of 120 to 170 RPM, in 10 RPM steps, with the speed adjusted by changing the pitch on the propellers. For each RPM value, the speeds that could be achieved at that shaft speed were tested. A log of data collections for the tests is provided in Appendix A.

All the underway data collections were done in water depths of 120 to 160 fathoms. The zero speed data collections, with the engines on, were done at anchor in about 30 meters of water, and out in the bay, at water depths of about 130 fathoms.

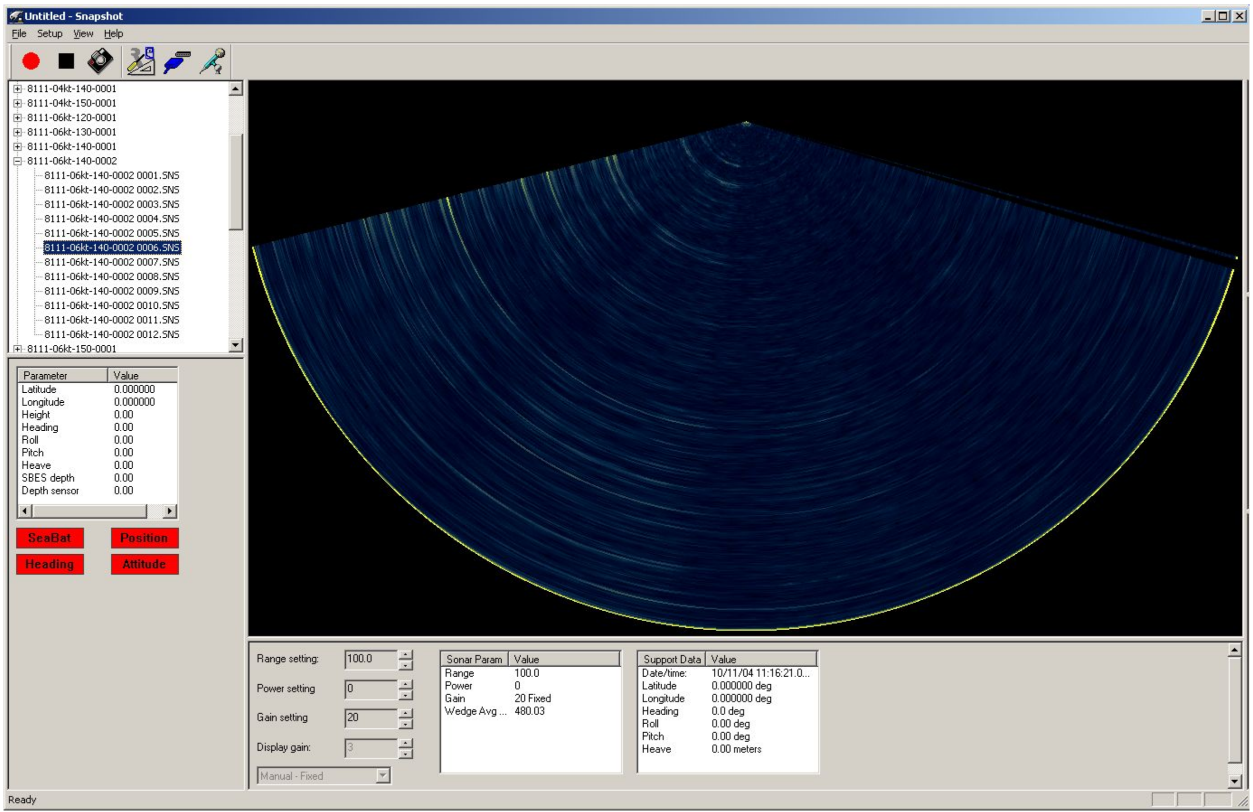



**Figure 1 - Snapshot Utility Screen Capture**

## 2.3 Data Analysis

The data from each of the test cases were collated in an Excel spreadsheet, shown in Appendix B. A graph of the measured noise levels, as a function of vessel speed and shaft RPM is shown in Figure 2. The noise level is a unitless value that represents the average of all the amplitude samples, from all the beams for the sampled sonar ping. This value represents a combination of the electrical noise in the sonar, and the response to all acoustic energy, within the bandwidth of the sonar, impinging on the receive array.

For each the tests, the plot shows the noise level as a function of vessel speed. Again, the tests were run at the speeds that could be achieved at the selected shaft RPM.

In an effort to resolve the cause of the high noise levels at anchor seen in the 8160 tests, noise tests with the engines at idle (110 shaft RPM, 0 pitch) in both shallow and deep water. In deeper water, much lower noise levels were observed, apparently due to the greater attenuation of the noise from the various acoustic sources on the ship over the greater range.

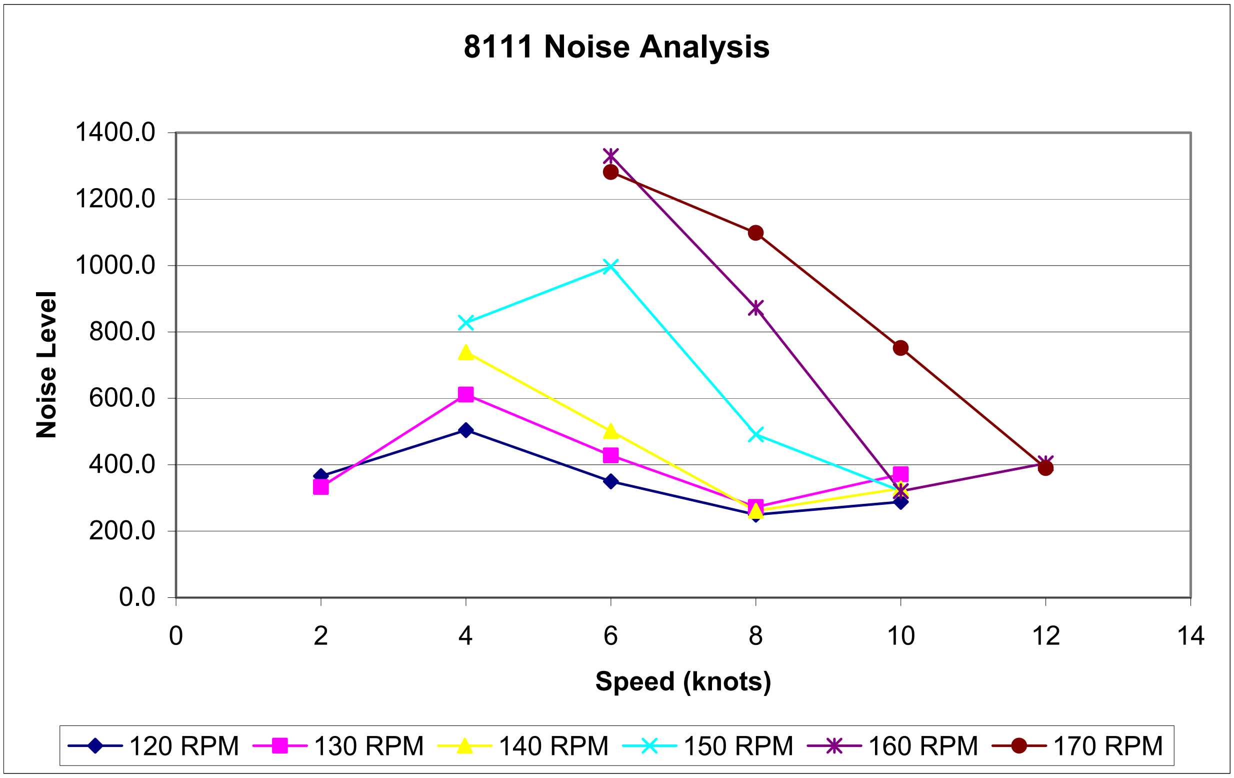



**Figure 2 - Noise Plot**

## 3.0 Conclusions

a. It appears that the best survey speed for the 8111, from a noise perspective, is in the range of 8 to 10 knots. Both lower and higher speeds correlate with higher noise levels.
b. It would be desirable to use shaft speeds of 140 RPM, or lower, to minimize the noise level seen by the sonar.
c. Significantly increased levels of reverberation from acoustic sources on the vessel are seen in shallower water. If this causes any degradation in the quality of the soundings in the 8111, increased power levels, higher than those recommended in the sonar settings guide, should be used to compensate.

# Appendix A – Test Logs

Survey Log - 8111 Noise Test.xls

**RESON Inc.**

| | | | |
|---|---|---|---|
| **Date:** | 10/11/2004 | **Survey Area:** | Rudyerd Bay, AK |
| **Page / Pages:** | 1 of 2 | | |
| **Survey Name:** | 8111 Noise Test | **Surveyors:** | B Bridge |
| **TimeZone:** | -9 | | |
| **Survey Vessel:** | NOAA Fairweather | **Client:** | NOAA |

**Offset Information**

| | X | Y | Z | Latency | Roll | Pitch | Yaw |
|---|---|---|---|---|---|---|---|
| *Sounder* | | | | | | | |
| *DGPS* | | | | | | | |
| *Motion Sensor* | | | | | | | |
| *Other* | | | | | | | |

**Date of Patch Test**

**SVP File:**

**Tide File**

Total Pole minus Dry Pole

**Draft (Z)**

| Start | Stop | Line | Dir. | Speed | COMMENTS |
|---|---|---|---|---|---|
| | | 8111-00kt-EngOn-0001 | | 0 | Gain MF20, Power 0, Range 100, at anchor, 110 RPM |
| | | 8111-00kt-0001 | | 0 | 110 RPM 0 Pitch |
| | | 8111-02kt-120-0001 | | 2 | 120 RPM 1.0 Pitch 0.4 Doppler |
| | | 8111-04kt-120-0001 | | 4 | 120 RPM 3.0 Pitch 2.8 Doppler |
| | | 8111-06kt-120-0001 | | 6 | 120 RPM 6.0 Pitch 4.6 Doppler |
| | | 8111-08kt-120-0001 | | 8 | 120 RPM 8.5 Pitch 6.7 Doppler |
| | | 8111-10kt-120-0001 | | 9 | 120 RPM 10.0 Pitch 7.2 Doppler |
| | | 8111-10kt-130-0001 | | 10 | 130 RPM 10.0 Pitch 8.2 Doppler |
| | | 8111-08kt-130-0001 | | 8 | 130 RPM 7.0 Pitch 6.2 Doppler |
| | | 8111-06kt-130-0001 | | 6 | 130 RPM 5.0 Pitch 4.5 Doppler |
| | | 8111-04kt-130-0001 | | 4 | 130 RPM 3.0 Pitch 2.2 Doppler |
| | | 8111-02kt-130-0001 | | 2 | 130 RPM 1.5 Pitch 0.5 Doppler |
| | | 8111-04kt-140-0001 | | 4 | 140 RPM 2.5 Pitch 2.5 Doppler |
| | | 8111-06kt-140-0001 | | 6 | 140 RPM 4.75 Pitch 4.3 Doppler Too Shallow |
| | | 8111-06kt-140-0002 | | 6 | 140 RPM 5.3 Pitch 5.2 Doppler |
| | | 8111-08kt-140-0001 | | 8 | 140 RPM 7.4 Pitch 6.5 Doppler |
| | | 8111-10kt-140-0001 | | 10 | 140 RPM 9.0 Pitch 8.5 Doppler |
| | | | | | |
| | | | | | |

Survey Manager: Client Representative:

Signature: Signature:

Sheet1 / Sheet2 / Sheet3

Survey Log - 8111 Noise Test Pg2.xls

# RESON Inc.

| | | | | | |
|---|---|---|---|---|---|
| **Date:** | 10/11/2004 | **Survey Area:** | Rudyerd Bay, AK | **Page / Pages:** | 2 of 2 |
| **Survey Name:** | 8111 Noise Test | **Surveyors:** | B Bridge | **TimeZone:** | -9 |
| **Survey Vessel:** | NOAA Fairweather | **Client:** | NOAA | | |

## Offset Information

| | X | Y | Z | Latency | Roll | Pitch | Yaw |
|---|---|---|---|---|---|---|---|
| ***Sounder*** | | | | | | | |
| ***DGPS*** | | | | | | | |
| ***Motion Sensor*** | | | | | | | |
| ***Other*** | | | | | | | |

**SVP File:**

**Tide File**

**Date of Patch Test**

Total Pole
minus Dry Pole
**Draft (Z)**

| Start | Stop | Line | Dir. | Speed | COMMENTS |
|---|---|---|---|---|---|
| | | 8111-10kt-150-0001 | | 10 | Gain MF20, Power 0, Range 100, 150, 8.2, 7.4 |
| | | 8111-08kt-150-0002 | | 8 | 150 RPM 6.1 Pitch 6.3 Doppler |
| | | 8111-06kt-150-0001 | | 6 | 150 RPM 4.3 Pitch 4.4 Doppler |
| | | 8111-04kt-150-0001 | | 4 | 150 RPM 3.0 Pitch 2.8 Doppler |
| | | 8111-06kt-160-0001 | | 6 | 160 RPM 4.0 Pitch 5.2 Doppler |
| | | 8111-08kt-160-0001 | | 8 | 160 RPM 6.1 Pitch 6.5 Doppler |
| | | 8111-10kt-160-0001 | | 10 | 160 RPM 8.2 Pitch 8.8 Doppler |
| | | 8111-12kt-160-0001 | | 11.7 | 160 RPM 10. Pitch 9.9 Doppler |
| | | 8111-12kt-170-0001 | | 12 | 170 RPM 9.0 Pitch 10.4 Doppler |
| | | 8111-06kt-170-0001 | | 6 | 170 RPM 4.0 Pitch 4.8 Doppler |
| | | 8111-08kt-170-0001 | | 8 | 170 RPM 5.9 Pitch 6.8 Doppler |
| | | 8111-10kt-170-0001 | | 10 | 170 RPM 7.0 Pitch 8.3 Doppler |

Survey Manager: Client Representative:

Signature: Signature:

Sheet1 / Sheet2 / Sheet3

# Appendix B – Noise Analysis Spreadsheet

8111 Noise Test Results

| Test Condition | Speed | Pitch (ft) | Test Case | | | | | | | | | | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
| Eng On Shallow | 0 | 0 | 707.5 | 740.2 | 754.1 | 711.4 | 728.1 | 710.6 | 691.5 | 747.9 | 813.7 | 722.1 | 732.7 |
| Eng On Deep | 0 | 0 | 209.0 | 208.4 | 208.6 | 207.2 | 205.6 | 211.2 | 206.3 | 208.8 | 210.9 | 210.0 | 208.6 |
| 120 RPM | 2.0 | 1.0 | 382.8 | 363.0 | 363.6 | 330.6 | 447.5 | 315.2 | 389.0 | 322.1 | 371.9 | 371.1 | 365.7 |
| | 4.0 | 3.0 | 552.7 | 431.0 | 555.9 | 480.0 | 517.9 | 448.0 | 472.8 | 500.7 | 583.6 | 499.2 | 504.2 |
| | 6.0 | 6.0 | 325.5 | 332.9 | 302.5 | 322.9 | 324.8 | 364.2 | 325.8 | 384.3 | 409.1 | 407.4 | 349.9 |
| | 8.0 | 8.5 | 253.8 | 244.0 | 250.3 | 253.0 | 248.4 | 241.0 | 241.7 | 252.4 | 253.5 | 259.1 | 249.7 |
| | 9.0 | 10.0 | 298.8 | 296.8 | 277.4 | 306.1 | 284.1 | 274.0 | 274.1 | 290.1 | 287.5 | 291.9 | 288.1 |
| 130 RPM | 2.0 | 1.5 | 316.9 | 363.0 | 366.1 | 429.6 | 317.1 | 313.9 | 303.7 | 315.5 | 315.5 | 289.4 | 333.1 |
| | 4.0 | 3.0 | 671.0 | 657.4 | 700.4 | 632.7 | 602.6 | 631.0 | 552.5 | 605.8 | 537.9 | 523.7 | 611.5 |
| | 6.0 | 5.0 | 488.2 | 471.1 | 410.9 | 497.2 | 387.7 | 390.9 | 431.0 | 448.9 | 361.3 | 393.5 | 428.1 |
| | 8.0 | 7.0 | 285.2 | 279.1 | 276.7 | 266.2 | 287.8 | 268.3 | 271.0 | 262.5 | 283.4 | 249.9 | 273.0 |
| | 10.0 | 10.0 | 362.8 | 396.1 | 378.8 | 378.2 | 370.2 | 391.7 | 354.6 | 369.9 | 334.3 | 374.0 | 371.1 |
| RPM 140 | 4 | 2.5 | 763.9 | 725.6 | 669.0 | 723.3 | 759.5 | 751.5 | 773.5 | 750.6 | 689.0 | 785.7 | 739.2 |
| | 6 | 5.3 | 487.1 | 551.5 | 605.3 | 596.4 | 444.3 | 480.0 | 416.2 | 500.0 | 452.6 | 478.9 | 501.2 |
| | 8 | 7.4 | 261.5 | 257.6 | 260.7 | 273.1 | 259.8 | 274.8 | 255.0 | 252.1 | 248.7 | 270.6 | 261.4 |
| | 10 | 9.0 | 301.5 | 365.3 | 328.4 | 360.1 | 359.9 | 328.4 | 326.2 | 315.0 | 302.7 | 300.4 | 328.8 |
| RPM 150 | 4 | 3.0 | 775.2 | 766.3 | 916.9 | 809.7 | 815.4 | 860.6 | 710.5 | 801.1 | 892.1 | 928.6 | 827.6 |
| | 6 | 4.3 | 1058.7 | 926.7 | 737.5 | 1015.6 | 1028.1 | 1086.3 | 1048.8 | 1133.8 | 997.3 | 931.8 | 996.5 |
| | 8 | 6.1 | 507.8 | 567.2 | 535.4 | 486.4 | 507.3 | 443.4 | 460.9 | 537.6 | 461.0 | 406.4 | 491.3 |
| | 10 | 8.2 | 299.2 | 294.1 | 315.8 | 306.5 | 308.4 | 323.2 | 348.8 | 336.8 | 332.8 | 344.5 | 321.0 |
| 160 RPM | 6 | 4.0 | 1488.4 | 1551.6 | 1328.3 | 1454.8 | 1456.9 | 1518.9 | 1256.4 | 1146.3 | 1089.5 | 1005.8 | 1329.7 |
| | 8 | 6.1 | 740.7 | 777.4 | 926.5 | 904.7 | 851.6 | 817.7 | 886.5 | 801.0 | 1005.7 | 1015.9 | 872.8 |
| | 10 | 8.2 | 339.9 | 330.9 | 335.0 | 329.4 | 300.6 | 326.7 | 316.9 | 311.6 | 313.7 | 300.9 | 320.6 |
| | 12 | 10.0 | 581.4 | 396.6 | 351.5 | 360.6 | 344.6 | 410.5 | 466.2 | 357.1 | 389.6 | 386.4 | 404.5 |
| 170 RPM | 6 | 4.0 | 1240.1 | 1173.3 | 1016.2 | 1346.1 | 1301.8 | 1391.5 | 1520.2 | 1327.6 | 1320.2 | 1176.3 | 1281.3 |
| | 8 | 5.9 | 961.9 | 1096.9 | 1229.4 | 1017.2 | 1041.2 | 1168.9 | 1176.6 | 1060.5 | 1117.9 | 1112.2 | 1098.3 |
| | 10 | 7.0 | 756.2 | 751.3 | 747.9 | 640.1 | 769.5 | 844.8 | 714.6 | 795.6 | 787.4 | 709.4 | 751.7 |
| | 12 | 9.0 | 396.2 | 360.1 | 552.7 | 339.9 | 348.5 | 339.3 | 352.6 | 356.5 | 502.1 | 351.7 | 390.0 |

# Appendix IV

## Total Propagated Error (TPE)

- **Fairweather TPE Values**
- **Tide TPE Values**

| | | | | |
|---|---|---|---|---|
| | FAIRWEATHER SURVEY | | *Appendix IV* | *Process Owner* Survey |
| | *Documents Title* **FA_TPE_Values_2009** | *Last update* July 18, 2009 | *Version* 2009.3 | *Approval Date* July 18, 2009 |

## Offsets

| | | | | | | |
|---|---|---|---|---|---|---|
| | Vessel | **FAIRWEATHER-S220** | **FAIRWEATHER-S220** | **1010** | **1018** | **1018** |
| | Sonar System | **Reson 8111** | **Reson 8160** | **Reson 8101** | **Reson 8101** | **Reson 8125** |
| | Positioning System | **POS/MV Model 320** | **POS/MV Model 320** | **POS/MV Model 320** | **POS/MV Model 320** | **POS/MV Model 320** |
| **Offsets** | MRU to Trans X | 2.868 | 0.493 | 0.250 | 0.282 | -0.396 |
| | MRU to Trans Y | 8.252 | 7.665 | -0.133 | -0.145 | 0.982 |
| | MRU to Trans Z | 4.752 | 4.726 | 0.549 | 0.548 | 0.751 |
| | Nav to Trans X | 2.071 | -0.304 | 1.147 | 1.181 | 0.502 |
| | Nav to Trans Y | 20.144 | 19.557 | 1.066 | 0.955 | 2.082 |
| | Nav to Trans Z | 17.792 | 17.766 | 3.665 | 3.717 | 3.919 |
| | Trans Roll | 0.00 | 0.00 | 0.000 | 0.00 | 0.00 |

## Standard Deviation

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Vessel | **FAIRWEATHER-S220** | **FAIRWEATHER-S220** | **1010** | **1018** | **1018** | | |
| | Sonar System | **Reson 8111** | **Reson 8160** | **Reson 8101** | **Reson 8101** | **Reson 8101** | | |
| | Positioning System | **POS/MV Model 320 V4** | **POS/MV Model 320 V4** | **POS/MV Model 320 V3** | **POS/MV Model 320 V3** | **POS/MV Model 320 V3** | | **Status** |
| **Motion Sensor** | Motion Gyro (deg) | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | **Vessel Configuration File** | Finalized |
| | Heave% Amp | 5 | 5 | 5 | 5 | 5 | | Finalized |
| | Heave (m) | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | | Finalized |
| | Roll (deg) | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | | Finalized |
| | Pitch (deg) | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | | Finalized |
| | Position Nav (m) | 0.5* | 0.5 | 0.5 | 0.5 | 0.5 | | Finalized |
| | Vessel Speed (m/s) | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | | Finalized |
| **Latency** | Timing Trans (s) | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | | Finalized |
| | Nav Timing (s) | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | | Finalized |
| | Gyro Timing (s) | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | | Finalized |
| | Heave Timing (s) | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | | Finalized |
| | Pitch Timing (s) | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | | Finalized |
| | Roll Timing (s) | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | | Finalized |
| **Vessel Offsets** | Offset X (m) | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | | Finalized |
| | Offset Y (m) | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | | Finalized |
| | Offset Z (m) | 0.008 | 0.008 | 0.007 | 0.007 | 0.007 | | Finalized |
| **Waterline** | Loading | 0.01 | 0.01 | 0.050 | 0.017 | 0.017 | | Finalized |
| | Draft (m) | 0.014 | 0.014 | 0.035 | 0.035 | 0.035 | | Finalized |
| | DeltaDraft (m) | 0.050 | 0.050 | 0.060 | 0.060 | 0.060 | | Finalized |
| **MRU Alignment** | MRU alignStdev gyro | 0.082 | 0.048 | 0.075 | 0.035 | 0.036 | | Finalized, 8125-P183^ |
| | MRU align roll/pitch | 0.057 | 0.021 | 0.025 | 0.075 | 0.180 | | Finalized, 8125-P183^ |
| **Tides** | Tide Meas (m) | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **Compute TPE Dialog Box** | Project Dependent** |
| | Tide Zoning (m) | Project Dependent | Project Dependent | Project Dependent | Project Dependent | Project Dependent | | Project Dependent** |
| **Sound Velocity** | SV Meas (m/s) | 0.5 | 0.5 | 1.0 | 1.0 | 1.0 | | Defaults, Project Dependent** |
| | Surface SV (m/s) | 0.5 | 0.5 | 1.0 | 1.0 | 1.0 | | Defaults, Project Dependent** |

*Position Nav adjusted in the HVF to 5m when acquiring in Coarse Acquisition mode, additional information will be submitted in the DAPR and/or the DR.
**Default values listed, descriptive report will list actual values applied if supplied with Project Instructions or calculated with the Sound speed estimator.
^MRU values for 1018 8125 may change as new patch test values are used.

| Project | H# | Tide Measurement (Use in Caris) | Tide Zoning 95% (Provided by CO-OPS) | Tide Zoning 1-sigma (Use in Caris) | | | SV Msrd (m/s) (Use in Caris) | Surface SV (m/s) (Use in Caris) |
|---|---|---|---|---|---|---|---|---|
| OPR-O119-FA-09 | | | | | | 8101 | 1.00 | 1.00 |
| Ernest Sound | | 0.00 | 0.14 | 0.07 | | 8125 | 1.00 | 0.50 |
| | | | | | | 8111/8160 | 0.50 | 0.50 |
| OPR-P183-FA-09 | | | | | | 8101 | 1.00 | 1.00 |
| Shumagin Islands | | 0.00 | 0.00 | 0.00 | | 8125 | 1.00 | 0.50 |
| and Vicinity | | (TCARI is a special case, see FOO for more info) | | | | 8111/8160 | 0.50 | 0.50 |
| OPR-P357-FA-09 | | | | | | 8101 | 1.00 | 1.00 |
| Kachemak bay | | 0.00 | 0.00 | 0.00 | | 8125 | 1.00 | 0.50 |
| | | (TCARI is a special case, see FOO for more info) | | | | 8111/8160 | 0.50 | 0.50 |
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# Appendix V

## Additional Calibration Reports

- **Control**
- **Diver Least Depth Gauge**
- **Laser Level**
- **Leadlines**
- **Sound Velocity**
- **Total Stations**

**Vertical Control Equipment Test**
**April 2009**

The 2009 test of the *Fairweathers'* vertical control equipment included testing five 8210 Sutron "bubbler" Tide Gauges that were provided by the Center for Operational Oceanographic Products and Services (CO-OPS). The gauges are equipped with Paros Scientific Sensors (SDI-12) for measuring pressure. Each year, the gauges are checked by the CO-OPS Field Operations Center to ensure their accuracy.

CO-OPS does not provide calibration or quality assurance documentation to the FAIRWEATHER. FAIRWEATHER personnel are responsible for installation and removal of the water level gauges. CO-OPS is responsible for delivering final approved vertical correctors to the FAIRWEATHER for application to the hydrographic data set. As FAIRWEATHER receives new gauges, data quality assurance checks will be conducted in a similar manner as the procedures listed below to ensure full functionality prior to deployment.

Five tide gauges: #10 (3344973C), #12 (3344B1D0), #13 (3344C740), #14 (3344D436) and #17 (3351E1F2) were set up and tested by ship personnel at the Sand Point Pier in Seattle, WA from April 1st through April 17$^{th}$, 2009. Each gauge was tested for at least 48 hours to insure proper data collection. The orifice was placed just off the pier by the gauge in approximately 10 meters of water. The GPS antenna was facing open sky to the South-Southwest. The set-up was periodically checked to insure proper transmission and to check for any leaks in the system. Table #1 below lists pertinent information for the five gauges tested at Sand Point.

CO-OPS was able to verify that all the above gauges had strong transmissions to the GOES satellite, and were collecting accurate tide curves.

| Gauge # | PAROS Ser# | GOES Channel | Plat ID | Tx Time |
|---|---|---|---|---|
| 10 | 97043 | 116 | 3344973C | 0:37:32 |
| 12 | 85173 | 116 | 3344B1D0 | 0:17:02 |
| 13 | 85220 | 116 | 3344C740 | 0:20:02 |
| 14 | 86002 | 116 | 3344D436 | 0:23:32 |
| 17 | 79049 | 116 | 3351E1F2 | 0:18:02 |

**Table 1: 2009 Gauge information**

**Kukkamake February 26, 2009 (Dn 057)**

On February 26, 2009 (Dn 057) SST Campbell, ENS Forney, AST Renoud and AST Beduhn performed a Kukkamaki on both Carl Zeiss N12 (Stadia:333) levels (S/N 100056 and S/N 103267). The Kukkamaki were performed in conjunction with the Tides Training portion of Hydroschool 2009 at Sand Point.

The Kukkamaki course was set up in the parking lot on Lake Washington behind the Dive Building. The weather was sunny and cold with moderate wind. A 40 meter straight line was measured on level ground and divided into 10 meter intervals. The level was then set on the 30 meter mark and a backsight and forsight were shot to the 20 and 40 meter marks respectively. Next the level was set up at the 0 meter mark, and a backsight and foresight were shot to the 20 and 40 meter marks, respectively. (See Fig. 1)

The Carl Zeiss level, S/N 100056 had a collimation error of 0.026, and Zeiss level S/N 103267 also had a collimation error of 0.026. Error values for both Zeiss levels fall within the +/- 0.05 tolerance requirements of the *Field Procedures Manual, May 2008.*

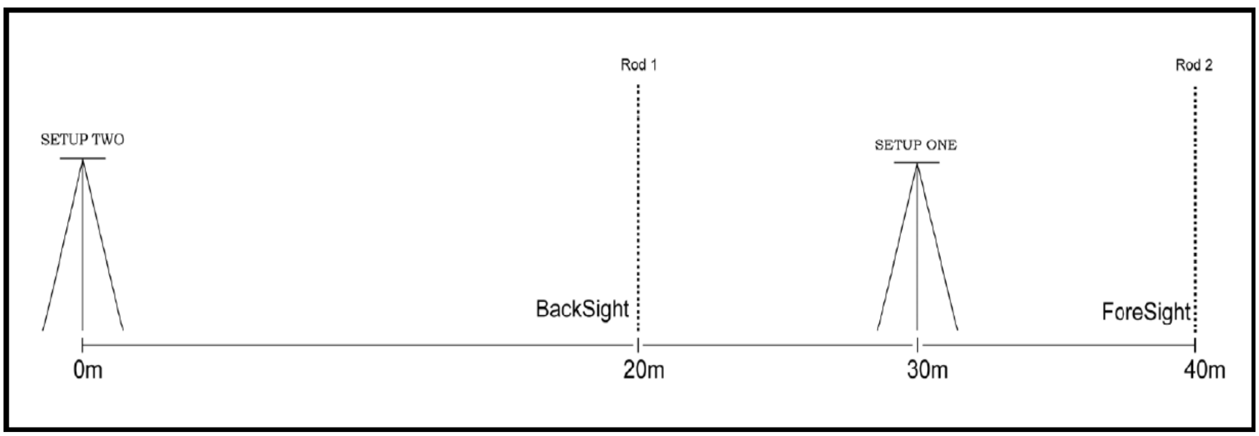



***Fig 1. Diagram of Kukkamaki setup***

NOAA FORM 75-29 (12-75) | **U.S. DEPARTMENT OF COMMERCE** NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION | HSRR | 103267 | SHEET | OF

## PRECISE LEVELING

*THREE-WIRE*

FROM B.M. | TO B.M.

**Kukkamaki**

9:30 | DATE: Dn 057, Feb. 26, 2009

WEATHER Sunny, cool

**FORWARD RUN** *(See reverse for BACKWARD RUN)*

| | BACKSIGHTS | | | | | FORESIGHTS | | | | ___3___ ORDER, CLASS ___1___ | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Setup | THREAD READING | MEAN | THREAD INTERVAL | SUM OF INTERVALS | ROD TEMP | THREAD READING | MEAN | THREAD INTERVAL | SUM OF INTERVALS | REMARKS | |
| | 1548 | BS1 | | | | 1499 | FS1 | | | C = (Δh1 - Δ2) - 0.2mm | |
| 1 | 1532 | 1532.33 | | | | 1484 | 1483.67 | | | 20 m | |
| | 1517 | | | | | 1468 | | | | where BS1 - FS1 = Δh1 | |
| | 4597 | | | | | 4451 | | | | BS2 - FS2 = Δh2 | |
| | | | | | | | | | | | |
| | 1411 | 20mS | | | | 1393 | 40mS | | | Δh1- | 48.67 |
| 2 | 1381 | 1380.67 | | | | 1331 | 1331.67 | | | Δh2 | 49 |
| | 1350 | | | | | 1271 | | | | Δh1-Δh2 = | -0.33 |
| | 4142 | | | | | 3995 | | | | - 0.2 (CR) | -0.53 |
| | | | | | | | | | | ÷20m | -0.02666667 |
| | | | | | | | | | | C = | -0.02666667 |

**Fill in YELLOW shaded cells.**

"C" must be < + 0.05mm/m

Instrument SN: 103267

Rod SN: B

Party Chief: Baird

Observer: SST Campbell

Recorder: ENS Forney

Rod Person: AST Renoud

| NOAA FORM 75-29 (12-75) | U.S. DEPARTMENT OF COMMERCE<br>NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION | HSRR | 100056 | SHEET | OF |
|---|---|---|---|---|---|

| | | |
|---|---|---|
| **PRECISE LEVELING**<br>*THREE-WIRE* | FROM B.M.<br>**Kukkamaki** | TO B.M.<br>10:45 |
| **FORWARD RUN** *(See reverse for BACKWARD RUN)* | WEATHER Sunny, cool | DATE: Dn 057, Feb. 26, 2009 |

| | BACKSIGHTS | | | | | FORESIGHTS | | | | __3__ ORDER, CLASS __1__ | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Setup | THREAD READING | MEAN | THREAD INTERVAL | SUM OF INTERVALS | ROD TEMP | THREAD READING | MEAN | THREAD INTERVAL | SUM OF INTERVALS | REMARKS | |
| | 1528 | BS1 | | | | 1471 | FS1 | | | C = (Δh1 - Δ2) - 0.2mm | |
| 1 | 1513 | 1513 | | | | 1456 | 1456.33 | | | 20 m | |
| | 1498 | | | | | 1442 | | | | where BS1 - FS1 = Δh1 | |
| | 4539 | | | | | 4369 | | | | BS2 - FS2 = Δh2 | |
| | | | | | | | | | | | |
| | 1567 | 20mS | | | | 1540 | 40mS | | | Δh1- | 56.67 |
| 2 | 1537 | 1537 | | | | 1480 | 1480 | | | Δh2 | 57 |
| | 1507 | | | | | 1420 | | | | Δh1-Δh2 = | -0.33 |
| | 4611 | | | | | 4440 | | | | - 0.2 (CR) | -0.53 |
| | | | | | | | | | | ÷20m | -0.02666667 |
| | | | | | | | | | | C = | -0.02666667 |

**Fill in YELLOW shaded cells.**

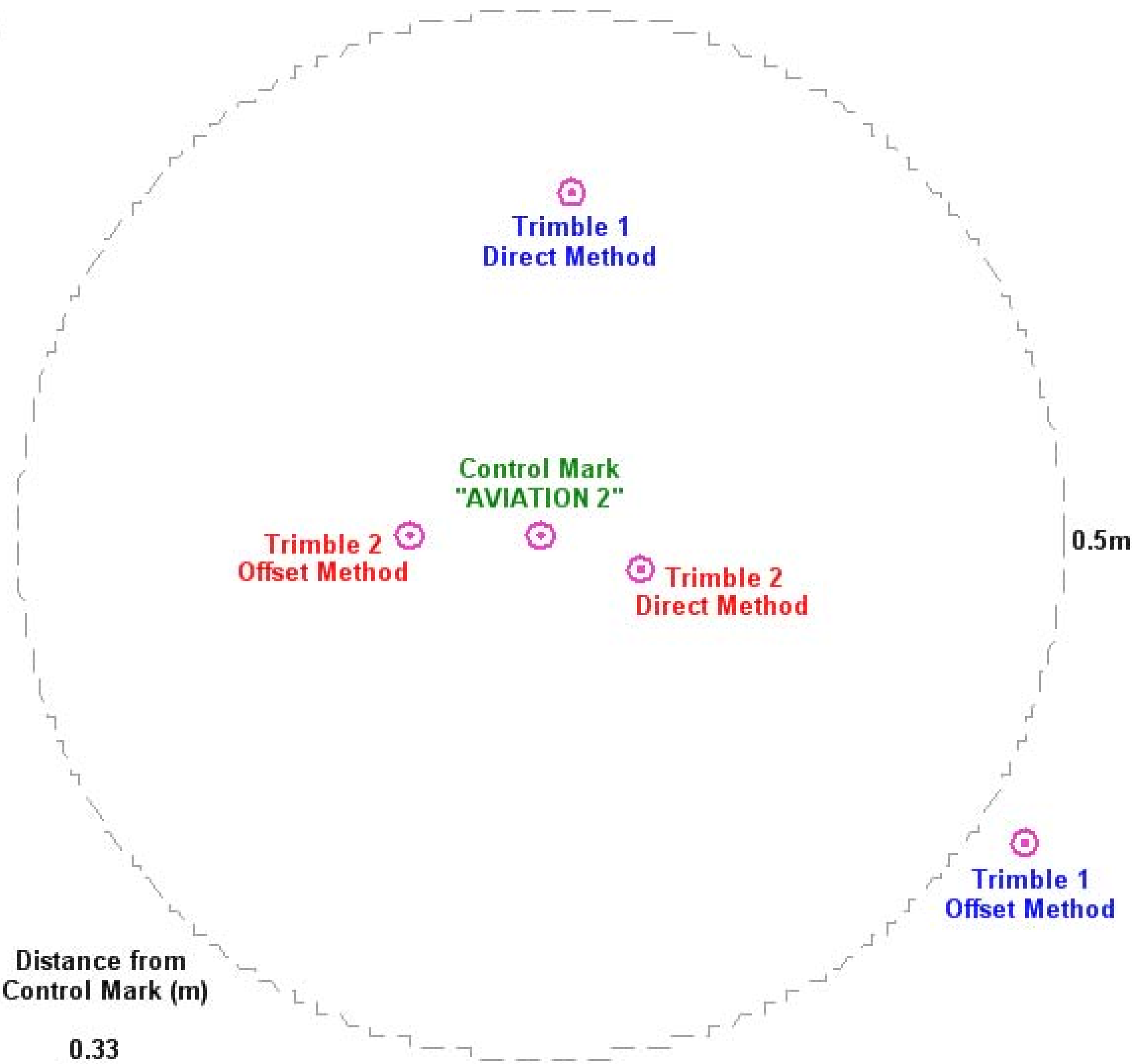
"C" must be < + 0.05mm/m

Instrument SN: 100056
Rod SN: B
Party Chief: Baird
Observer: ENS Forney
Recorder: SST Campbell
Rod Person: AST Beduhn

**NOAA Ship FAIRWEATHER**

**Trimble Backpack Data Quality Assurance Testing**

**April 2009**




| | Distance from Control Mark (m) |
|---|---|
| Trimble 1 Direct | 0.33 |
| Trimble 1 Offset | 0.56 |
| Trimble 2 Direct | 0.10 |
| Trimble 2 Offset | 0.13 |

# SURVEY DATASHEET (Version 1.0)

**PID:** BBBK46
**Designation:** VIXEN HBR 2009
**Stamping:** VIXEN HBR 2009
**Stability:**
**Setting:** In rock outcrop or ledge
**Description:** A modified 3.5 inch bronze NOS disk is cemented into a rock outcrop on the West Side of Magnetic Point on the eastern side of Ernest Sound. The mark is approximately 10 feet above the high water mark on the south side of the westward of two humps, and it protrudes south out of a wooded area and is nearly surrounded at high water. This mark was leveled as part of a series of NOS benchmarks for a tide station originally designated as Vixen Harbor.
**Observed:** 2009-05-20T08:00:00Z
**Source:** OPUS - page5 0810.20

**Close-up View**

| REF_FRAME: | EPOCH: | SOURCE: | UNITS: | SET PROFILE | DETAILS |
|---|---|---|---|---|---|
| NAD_83(CORS96) | 2003.0000 | NAVD88 (Computed using GEOID06) | m | | |

| | | | |
|---|---|---|---|
| **LAT:** | 55° 47' 18.23740" | ± 0.005 | m |
| **LON:** | -132° 11' 27.06511" | ± 0.010 | m |
| **ELL HT:** | 1.331 | ± 0.015 | m |
| **X:** | -2413974.145 | ± 0.004 | m |
| **Y:** | -2663096.964 | ± 0.015 | m |
| **Z:** | 5251232.937 | ± 0.011 | m |
| **ORTHO HT:** | 5.768 | ± 0.121 | m |

| | **UTM** 8 | **SPC** 5001(AK 1 ) |
|---|---|---|
| **NORTHING:** | 6186101.208m | 441196.443m |
| **EASTING:** | 676130.571m | 911250.506m |
| **CONVERGENCE:** | 2.32366467° | 1.22996338° |
| **POINT SCALE:** | 0.99998052 | 0.99990050 |
| **COMBINED FACTOR:** | 0.99998032 | 0.00000000 |

**CONTRIBUTED BY**

glen.rice
National Oceanic and Atmospheric Administration

**Horizon View**


The numerical values for this position solution have satisfied the quality control criteria of the National Geodetic Survey. The contributor has verified that the information submitted is accurate and complete.

```
 FILE: VIXE1201.09O 000038260

                              NGS OPUS SOLUTION REPORT
                              ========================

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: www.ngs.noaa.gov/OPUS/Using_OPUS.html#accuracy

      USER: weston.renoud@noaa.gov                    DATE: May 06, 2009
RINEX FILE: vixe120s.09o                              TIME: 06:03:36 UTC


  SOFTWARE: page5  0810.20 master11.pl 081023      START: 2009/04/30  18:28:00
 EPHEMERIS: igr15294.eph [rapid]                    STOP: 2009/05/01  02:35:00
  NAV FILE: brdc1200.09n                        OBS USED: 14778 / 16367   :  90%
  ANT NAME: ASH701975.01AGP NONE             # FIXED AMB:    97 /   102   :  95%
ARP HEIGHT: 1.3                              OVERALL RMS: 0.016(m)


 REF FRAME: NAD_83(CORS96)(EPOCH:2003.0000)           ITRF00 (EPOCH:2009.3286)

         X:     -2413974.164(m)   0.036(m)          -2413975.012(m)   0.036(m)
         Y:     -2663096.982(m)   0.041(m)          -2663095.882(m)   0.041(m)
         Z:      5251232.967(m)   0.060(m)           5251233.143(m)   0.060(m)

       LAT:   55 47 18.23725      0.011(m)        55 47 18.24701      0.011(m)
     E LON:  227 48 32.93477      0.009(m)       227 48 32.85632      0.009(m)
     W LON:  132 11 27.06523      0.009(m)       132 11 27.14368      0.009(m)
    EL HGT:            1.371(m)   0.080(m)                 1.378(m)   0.080(m)
 ORTHO HGT:            5.808(m)   0.144(m) [NAVD88 (Computed using GEOID06)]

                        UTM COORDINATES    STATE PLANE COORDINATES
                         UTM (Zone 08)         SPC (5001 AK 1)
Northing (Y) [meters]     6186101.204           441196.438
Easting (X)  [meters]      676130.569           911250.504
Convergence  [degrees]     2.32366465           1.22996336
Point Scale                0.99998052           0.99990050
Combined Factor            0.99998031           0.00000000

US NATIONAL GRID DESIGNATOR:  8UPG7613186101(NAD 83)



                              BASE STATIONS USED
PID       DESIGNATION                        LATITUDE    LONGITUDE DISTANCE(m)
DK6423 BIS5 BIORKA ISLAND 5 CORS ARP       N565116.162 W1353221.387  238727.4
DJ3035 LEV6 LEVEL ISLAND 6 CORS ARP        N562756.364 W1330532.511   93963.3
DK6482 AIS5 ANNETTE ISLAND 5 CORS ARP      N550408.647 W1313558.255   88401.3

                 NEAREST NGS PUBLISHED CONTROL POINT
UV5996      LOOK 1916                      N554728.961 W1321123.951     336.0
```

BASE STATION INFORMATION

```
STATION NAME: bis5  a    2 (Biorka Island 5; Biorka Island, Alaska  USA)
 MONUMENT: NO DOMES NUMBER
XYZ  -2494921.0833  -2448390.9914   5317113.6533  MON @ 1997.0000 (M)
XYZ        -0.0164         0.0037         0.0005  VEL (M/YR)
NEU         0.0000         0.0000         0.0000  MON TO ARP (M)
NEU        -0.0034        -0.0019         0.0813  ARP TO L1 PHASE CENTER (M)
NEU        -0.0037        -0.0015         0.0689  ARP TO L2 PHASE CENTER (M)
XYZ        -0.2022         0.0456         0.0062  VEL TIMES 12.3286 YRS
XYZ         0.0000         0.0000         0.0000  MON TO ARP
XYZ        -0.0351        -0.0318         0.0662  ARP TO L1 PHASE CENTER
XYZ  -2494921.3206  -2448390.9776   5317113.7257  L1 PHS CEN @ 2009.3286
XYZ         0.0000         0.0001         0.0001  + XYZ ADJUSTMENTS
XYZ  -2494921.3205  -2448390.9775   5317113.7257  NEW L1 PHS CEN @ 2009.3286
XYZ  -2494921.2855  -2448390.9457   5317113.6595  NEW ARP @ 2009.3286
XYZ  -2494921.2855  -2448390.9457   5317113.6595  NEW MON @ 2009.3286
LLH  56 51 16.17152  224 27 38.53076     66.8349  NEW L1 PHS CEN @ 2009.3286
LLH  56 51 16.17163  224 27 38.53088     66.7536  NEW ARP @ 2009.3286
LLH  56 51 16.17163  224 27 38.53088     66.7536  NEW MON @ 2009.3286

STATION NAME: lev6  a    2 (Level Island 6; Level Island, Alaska  USA)
 MONUMENT: NO DOMES NUMBER
XYZ  -2412812.0457  -2579074.2577   5293282.2476  MON @ 1997.0000 (M)
XYZ        -0.0190         0.0003        -0.0044  VEL (M/YR)
NEU         0.0000         0.0000         0.0000  MON TO ARP (M)
NEU        -0.0034        -0.0019         0.0813  ARP TO L1 PHASE CENTER (M)
NEU        -0.0037        -0.0015         0.0689  ARP TO L2 PHASE CENTER (M)
XYZ        -0.2342         0.0037        -0.0542  VEL TIMES 12.3286 YRS
XYZ         0.0000         0.0000         0.0000  MON TO ARP
XYZ        -0.0340        -0.0336         0.0659  ARP TO L1 PHASE CENTER
XYZ  -2412812.3140  -2579074.2876   5293282.2592  L1 PHS CEN @ 2009.3286
XYZ        -0.0000         0.0000         0.0000  + XYZ ADJUSTMENTS
XYZ  -2412812.3140  -2579074.2875   5293282.2593  NEW L1 PHS CEN @ 2009.3286
XYZ  -2412812.2799  -2579074.2540   5293282.1934  NEW ARP @ 2009.3286
XYZ  -2412812.2799  -2579074.2540   5293282.1934  NEW MON @ 2009.3286
LLH  56 27 56.37385  226 54 27.40784     25.4801  NEW L1 PHS CEN @ 2009.3286
LLH  56 27 56.37396  226 54 27.40796     25.3988  NEW ARP @ 2009.3286
LLH  56 27 56.37396  226 54 27.40796     25.3988  NEW MON @ 2009.3286

STATION NAME: ais5  a    2 (Annette Island 5; Annette Island, Alaska  USA)
 MONUMENT: NO DOMES NUMBER
XYZ  -2430153.8469  -2737192.9494   5205816.7670  MON @ 1997.0000 (M)
XYZ        -0.0147        -0.0013        -0.0087  VEL (M/YR)
NEU         0.0000         0.0000         0.0000  MON TO ARP (M)
NEU        -0.0034        -0.0019         0.0813  ARP TO L1 PHASE CENTER (M)
NEU        -0.0037        -0.0015         0.0689  ARP TO L2 PHASE CENTER (M)
XYZ        -0.1812        -0.0160        -0.1073  VEL TIMES 12.3286 YRS
XYZ         0.0000         0.0000         0.0000  MON TO ARP
XYZ        -0.0342        -0.0356         0.0647  ARP TO L1 PHASE CENTER
XYZ  -2430154.0623  -2737193.0011   5205816.7244  L1 PHS CEN @ 2009.3286
XYZ         0.0000        -0.0000        -0.0000  + XYZ ADJUSTMENTS
XYZ  -2430154.0623  -2737193.0011   5205816.7244  NEW L1 PHS CEN @ 2009.3286
XYZ  -2430154.0281  -2737192.9654   5205816.6597  NEW ARP @ 2009.3286
XYZ  -2430154.0281  -2737192.9654   5205816.6597  NEW MON @ 2009.3286
LLH  55  4  8.65794  228 24  1.66886     32.4119  NEW L1 PHS CEN @ 2009.3286
LLH  55  4  8.65805  228 24  1.66897     32.3306  NEW ARP @ 2009.3286
LLH  55  4  8.65805  228 24  1.66897     32.3306  NEW MON @ 2009.3286
```

## REMOTE STATION INFORMATION

```
 STATION NAME: vixe       1
  MONUMENT: NO DOMES NUMBER
 XYZ  -2413975.4955  -2663095.9246   5251234.3436  MON @ 2009.3281 (M)
 NEU         0.0025         0.0026         1.3000  MON TO ARP (M)
 NEU        -0.0025        -0.0026         0.0637  ARP TO L1 PHASE CENTER (M)
 NEU        -0.0012         0.0008         0.0440  ARP TO L2 PHASE CENTER (M)
 XYZ        -0.4876        -0.5418         1.0765  MON TO ARP
 XYZ        -0.0274        -0.0263         0.0513  ARP TO L1 PHASE CENTER
 XYZ  -2413976.0104  -2663096.4927   5251235.4713  L1 PHS CEN @ 2009.3286

 BASELINE NAME:   bis5  vixe
 XYZ         0.4944         0.0601        -1.2254  + XYZ ADJUSTMENTS
 XYZ  -2413975.5160  -2663096.4326   5251234.2459  NEW L1 PHS CEN @ 2009.3286
 XYZ  -2413975.4887  -2663096.4063   5251234.1947  NEW ARP @ 2009.3286
 XYZ  -2413975.0011  -2663095.8645   5251233.1182  NEW MON @ 2009.3286
 LLH  55 47 18.24711  227 48 32.85611      2.7099  NEW L1 PHS CEN @ 2009.3286
 LLH  55 47 18.24719  227 48 32.85626      2.6462  NEW ARP @ 2009.3286
 LLH  55 47 18.24711  227 48 32.85611      1.3462  NEW MON @ 2009.3286

 BASELINE NAME:   lev6  vixe
 XYZ         0.4956         0.0484        -1.2118  + XYZ ADJUSTMENTS
 XYZ  -2413975.5149  -2663096.4443   5251234.2595  NEW L1 PHS CEN @ 2009.3286
 XYZ  -2413975.4875  -2663096.4180   5251234.2082  NEW ARP @ 2009.3286
 XYZ  -2413974.9999  -2663095.8762   5251233.1318  NEW MON @ 2009.3286
 LLH  55 47 18.24714  227 48 32.85661      2.7255  NEW L1 PHS CEN @ 2009.3286
 LLH  55 47 18.24722  227 48 32.85676      2.6618  NEW ARP @ 2009.3286
 LLH  55 47 18.24714  227 48 32.85661      1.3618  NEW MON @ 2009.3286

 BASELINE NAME:   ais5  vixe
 XYZ         0.4596         0.0195        -1.1652  + XYZ ADJUSTMENTS
 XYZ  -2413975.5509  -2663096.4732   5251234.3062  NEW L1 PHS CEN @ 2009.3286
 XYZ  -2413975.5235  -2663096.4468   5251234.2549  NEW ARP @ 2009.3286
 XYZ  -2413975.0359  -2663095.9051   5251233.1784  NEW MON @ 2009.3286
 LLH  55 47 18.24677  227 48 32.85619      2.7897  NEW L1 PHS CEN @ 2009.3286
 LLH  55 47 18.24685  227 48 32.85634      2.7260  NEW ARP @ 2009.3286
 LLH  55 47 18.24677  227 48 32.85619      1.4260  NEW MON @ 2009.3286
```

## G-FILES

```
Axx2009 430   9 5 1
B2009 4301828   9 5 1 235 1 page5 v0810.20IGS     226 1 2 27NGS   2009 5 6IFDDFX
Iant_info.003        NGS   20090501
C00090001 -809462844   24 2147049188   30  658805413   33 X1209AVIXEX1209ABIS5
D  1  2  4808077  1  3 -9110619  2  3 -5412684

Axx2009 430   9 5 1
B2009 4301828   9 5 1 235 1 page5 v0810.20IGS     226 1 2 27NGS   2009 5 6IFDDFX
Iant_info.003        NGS   20090501
C00090002   11627200   25  840216222   34  420490616   38 X1209AVIXEX1209ALEV6
D  1  2  6906117  1  3 -8609405  2  3 -3610684

Axx2009 430   9 5 1
B2009 4301828   9 5 1 235 1 page5 v0810.20IGS     226 1 2 27NGS   2009 5 6IFDDFX
Iant_info.003        NGS   20090501
C00090003 -161789922   38 -740970604   54 -454165187   57 X1209AVIXEX1209AAIS5
D  1  2  7937919  1  3 -6704252  2  3 -1704411
```

POST-FIT RMS BY SATELLITE VS. BASELINE

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | OVERALL | 02 | 03 | 04 | 06 | 07 | 08 | 09 | 10 |
| bis5-vixe | 0.015 | 0.022 | 0.059 | 0.016 | ... | 0.015 | 0.014 | ... | 0.018 |
| | 11 | 12 | 13 | 14 | 16 | 17 | 18 | 19 | 20 |
| bis5-vixe | 0.011 | ... | 0.017 | 0.014 | 0.018 | 0.017 | ... | 0.017 | 0.014 |
| | 22 | 23 | 24 | 25 | 28 | 30 | 31 | 32 | |
| bis5-vixe | 0.018 | 0.013 | ... | 0.015 | 0.022 | ... | 0.018 | 0.020 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | OVERALL | 01 | 02 | 03 | 04 | 06 | 07 | 08 | 09 |
| lev6-vixe | 0.015 | ... | 0.018 | 0.001 | 0.016 | ... | 0.015 | 0.014 | ... |
| | 10 | 11 | 12 | 13 | 14 | 16 | 17 | 18 | 19 |
| lev6-vixe | 0.018 | 0.012 | ... | 0.016 | 0.014 | 0.013 | 0.018 | ... | 0.019 |
| | 20 | 22 | 23 | 24 | 25 | 28 | 30 | 31 | 32 |
| lev6-vixe | 0.014 | 0.019 | 0.014 | ... | 0.015 | ... | ... | 0.019 | ... |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | OVERALL | 02 | 03 | 04 | 06 | 07 | 08 | 09 | 10 |
| ais5-vixe | 0.017 | 0.025 | 0.008 | 0.021 | ... | 0.014 | 0.016 | ... | 0.020 |
| | 11 | 12 | 13 | 14 | 16 | 17 | 18 | 19 | 20 |
| ais5-vixe | 0.013 | ... | 0.021 | 0.015 | 0.012 | 0.022 | ... | 0.019 | 0.022 |
| | 22 | 23 | 24 | 25 | 28 | 30 | 31 | 32 | |
| ais5-vixe | 0.021 | 0.016 | ... | 0.015 | 0.022 | ... | 0.017 | 0.019 | |

OBS BY SATELLITE VS. BASELINE

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | OVERALL | 02 | 03 | 04 | 06 | 07 | 08 | 09 | 10 |
| bis5-vixe | 5152 | 289 | 1 | 375 | ... | 421 | 269 | ... | 246 |
| | 11 | 12 | 13 | 14 | 16 | 17 | 18 | 19 | 20 |
| bis5-vixe | 389 | ... | 191 | 220 | 9 | 247 | ... | 139 | 608 |
| | 22 | 23 | 24 | 25 | 28 | 30 | 31 | 32 | |
| bis5-vixe | 110 | 642 | ... | 531 | 61 | ... | 385 | 19 | |
| | OVERALL | 01 | 02 | 03 | 04 | 06 | 07 | 08 | 09 |
| lev6-vixe | 4998 | ... | 252 | 1 | 380 | ... | 427 | 254 | ... |
| | 10 | 11 | 12 | 13 | 14 | 16 | 17 | 18 | 19 |
| lev6-vixe | 234 | 399 | ... | 196 | 221 | 8 | 262 | ... | 137 |
| | 20 | 22 | 23 | 24 | 25 | 28 | 30 | 31 | 32 |
| lev6-vixe | 584 | 110 | 612 | ... | 523 | ... | ... | 398 | ... |
| | OVERALL | 02 | 03 | 04 | 06 | 07 | 08 | 09 | 10 |
| ais5-vixe | 4628 | 151 | 1 | 314 | ... | 411 | 234 | ... | 209 |
| | 11 | 12 | 13 | 14 | 16 | 17 | 18 | 19 | 20 |
| ais5-vixe | 384 | ... | 163 | 221 | 8 | 151 | ... | 108 | 566 |
| | 22 | 23 | 24 | 25 | 28 | 30 | 31 | 32 | |
| ais5-vixe | 112 | 616 | ... | 523 | 48 | ... | 390 | 18 | |

Covariance Matrix for the xyz OPUS Position (meters2).

| | | |
|---|---|---|
| 0.0000058778 | 0.0000005693 | -0.0000006648 |
| 0.0000005693 | 0.0000110489 | -0.0000003393 |
| -0.0000006648 | -0.0000003393 | 0.0000128489 |

Covariance Matrix for the enu OPUS Position (meters2).

| | | |
|---|---|---|
| 0.0000076436 | -0.0000022269 | 0.0000012035 |
| -0.0000022269 | 0.0000097701 | 0.0000014095 |
| 0.0000012035 | 0.0000014095 | 0.0000123618 |

Horizontal network accuracy = 0.00730 meters.
Vertical network accuracy = 0.00689 meters.

Derivation of NAD 83 vector components

Position of reference station ARP in NAD_83(CORS96)(EPOCH:2003.0000).

| | Xa(m) | Ya(m) | Za(m) | |
|---|---|---|---|---|
| BIS5 | -2494920.44060 | -2448392.05858 | 5317113.38841 | 2003.00 |
| LEV6 | -2412811.42529 | -2579075.35282 | 5293281.97185 | 2003.00 |
| AIS5 | -2430153.20716 | -2737194.06415 | 5205816.48535 | 2003.00 |

Position of reference station monument in NAD_83(CORS96)(EPOCH:2003.0000).

| | Xr(m) | Yr(m) | Zr(m) | |
|---|---|---|---|---|
| BIS5 | -2494920.44060 | -2448392.05858 | 5317113.38841 | 2003.00 |
| LEV6 | -2412811.42529 | -2579075.35282 | 5293281.97185 | 2003.00 |
| AIS5 | -2430153.20716 | -2737194.06415 | 5205816.48535 | 2003.00 |

Velocity of reference station monument in NAD_83(CORS96)(EPOCH:2003.0000).

| | Vx (m/yr) | Vy (m/yr) | Vz (m/yr) |
|---|---|---|---|
| BIS5 | 0.00490 | 0.00450 | 0.00990 |
| LEV6 | 0.00220 | 0.00120 | 0.00480 |
| AIS5 | 0.00620 | -0.00040 | 0.00060 |

Vectors from unknown station monument to reference station monument
in NAD_83(CORS96)(EPOCH:2003.0000).

| | Xr-X= DX(m) | Yr-Y= DY(m) | Zr-Z= DZ(m) | |
|---|---|---|---|---|
| BIS5 | -80946.27660 | 214704.92342 | 65880.42141 | 2003.00 |
| LEV6 | 1162.73871 | 84021.62918 | 42049.00485 | 2003.00 |
| AIS5 | -16179.04316 | -74097.08215 | -45416.48165 | 2003.00 |

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

# The NGS Data Sheet

**See file dsdata.txt for more information about the datasheet.**

```
DATABASE =  ,PROGRAM = datasheet, VERSION = 7.67
1        National Geodetic Survey,   Retrieval Date = AUGUST  4, 2009
 AI4914 ***********************************************************************
 AI4914  DESIGNATION -  BM NO 37
 AI4914  PID         -  AI4914
 AI4914  STATE/COUNTY-  AK/KETCHIKAN GATEWAY BOROUGH
 AI4914  USGS QUAD   -  KETCHIKAN B-5
 AI4914
 AI4914                        *CURRENT SURVEY CONTROL
 AI4914  ___________________________________________________________________
 AI4914* NAD 83(2007)-  55 19 58.66141(N)    131 37 31.81957(W)     ADJUSTED
 AI4914* LOCAL TIDAL -         8.25   (meters)      27.1    (feet)  LEVELING
 AI4914  ___________________________________________________________________
 AI4914  EPOCH DATE  -        2007.00
 AI4914  X           -  -2,415,358.879 (meters)                     COMP
 AI4914  Y           -  -2,718,046.174 (meters)                     COMP
 AI4914  Z           -   5,222,559.311 (meters)                     COMP
 AI4914  LAPLACE CORR-          -0.13  (seconds)                    DEFLEC99
 AI4914  ELLIP HEIGHT-           3.778 (meters)          (02/10/07) ADJUSTED
 AI4914  GEOID HEIGHT-          -5.88  (meters)                     GEOID06
 AI4914
 AI4914  ------- Accuracy Estimates (at 95% Confidence Level in cm) --------
 AI4914  Type    PID    Designation                      North   East  Ellip
 AI4914  -------------------------------------------------------------------
 AI4914  NETWORK AI4914 BM NO 37                          0.63    0.45   1.57
 AI4914  -------------------------------------------------------------------
 AI4914  VERT ORDER  -  THIRD ?
 AI4914
 AI4914.The horizontal coordinates were established by GPS observations
 AI4914.and adjusted by the National Geodetic Survey in February 2007.
 AI4914
 AI4914.The datum tag of NAD 83(2007) is equivalent to NAD 83(NSRS2007).
 AI4914.See National Readjustment for more information.
 AI4914.The horizontal coordinates are valid at the epoch date displayed above.
 AI4914.The epoch date for horizontal control is a decimal equivalence
 AI4914.of Year/Month/Day.
 AI4914
 AI4914.The orthometric height was determined by differential leveling.
 AI4914.The vertical network tie was performed by a horz. field party for horz.
 AI4914.obs reductions. Reset procedures were used to establish the elevation.
 AI4914
 AI4914.Photographs are available for this station.
 AI4914
 AI4914.The X, Y, and Z were computed from the position and the ellipsoidal ht.
 AI4914
 AI4914.The Laplace correction was computed from DEFLEC99 derived deflections.
 AI4914
 AI4914.The ellipsoidal height was determined by GPS observations
 AI4914.and is referenced to NAD 83.
 AI4914
 AI4914.The geoid height was determined by GEOID06.
 AI4914
 AI4914;                   North         East     Units Scale Factor Converg.
 AI4914;SPC AK 1     -   391,423.859   948,202.671   MT  0.99990058   +1 41 48.4
 AI4914;UTM  09      - 6,134,983.224   333,464.473   MT  0.99994023   -2 09 35.6
```

```
AI4914
AI4914!            -  Elev Factor  x  Scale Factor =   Combined Factor
AI4914!SPC AK 1    -   0.99999941  x   0.99990058  =   0.99989999
AI4914!UTM  09     -   0.99999941  x   0.99994023  =   0.99993964
AI4914
AI4914                          SUPERSEDED SURVEY CONTROL
AI4914
AI4914  NAD 83(1992)-  55 19 58.65991(N)    131 37 31.82053(W) AD(       ) B
AI4914  ELLIP H (04/28/00)    3.819  (m)                       GP(       ) 4 1
AI4914
AI4914.Superseded values are not recommended for survey control.
AI4914.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
AI4914.See file dsdata.txt to determine how the superseded data were derived.
AI4914
AI4914_U.S. NATIONAL GRID SPATIAL ADDRESS:  9UUB3346434983(NAD 83)
AI4914_MARKER: DB = BENCH MARK DISK
AI4914_SETTING: 32 = SET IN A RETAINING WALL OR CONCRETE LEDGE
AI4914_SP_SET: RETAINING WALL
AI4914_STAMPING: NO 37 1956
AI4914_MARK LOGO: CGS
AI4914_MAGNETIC: O = OTHER; SEE DESCRIPTION
AI4914_STABILITY: B = PROBABLY HOLD POSITION/ELEVATION WELL
AI4914_SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR
AI4914+SATELLITE: SATELLITE OBSERVATIONS - January 04, 2007
AI4914
AI4914  HISTORY     - Date     Condition        Report By
AI4914  HISTORY     - 1956     MONUMENTED       CGS
AI4914  HISTORY     - 20050420 GOOD             NGS
AI4914  HISTORY     - 20070104 GOOD             INDIV
AI4914
AI4914                          STATION DESCRIPTION
AI4914
AI4914'DESCRIBED BY COAST AND GEODETIC SURVEY 1956
AI4914'DESCRIBED BY R+M CONSULTANTS 1999 (RHB) .  THE STATION IS LOCATED
AI4914'APPROXIMATELY 1.6 KM (1.00 MI) SOUTHEASTERLY OF DOWNTOWN KETCHIKAN
AI4914'ALASKA AT THE KETCHIKAN COAST GUARD BASE.  OWNERSHIP-- UNITED STATES
AI4914'COAST GUARD, C/O PCC CHUCK SHAFFER I.S.C.  KETCHIKAN, 1300 STEDMAN
AI4914'STREET, KETCHIKAN ALASKA 99901, PHONE NUMBER 907-228-0380, FAX NUMBER
AI4914'907-228-0314, ACCESS IS RESTRICTED.  CONTACT THE CHIEF PETTY OFFICER
AI4914'AT LEAST 48 HOURS PRIOR TO ENTRY.
AI4914'TO REACH THE STATION FROM THE INTERSECTION OF STEDMAN STREET AND
AI4914'DEERMOUNT STREET, AT THE SOUTHEASTERLY END OF KETCHIKAN, PROCEED
AI4914'SOUTHEAST 1.0 KM (0.60 MI) ALONG STEDMAN STREET TO THE COAST GUARD
AI4914'BASE AND THE STATION ON THE RIGHT.
AI4914'THE STATION IS A STANDARD USCGS BRASS BENCH MARK DISK STAMPED --NO 37
AI4914'1956-- AND SET FLUSH WITH A CONCRETE RETAINING WALL IN FRONT OF THE
AI4914'COAST GUARD ADMINISTRATION BUILDING.  THE STATION IS LOCATED 26.5 M
AI4914'(86.9 FT) 351 DEGREES MAGNETIC AZIMUTH FROM THE NORTHEAST CORNER OF
AI4914'THE COAST GUARD ADMINISTRATION BUILDING, 3.0 M (9.8 FT) 134 DEGREES
AI4914'MAGNETIC AZIMUTH FROM THE NORTH END OF A GUARD RAIL, AND 42.2 M (138.5
AI4914'FT) 95 DEGREES MAGNETIC AZIMUTH FROM A FIRE HYDRANT.
AI4914
AI4914                          STATION RECOVERY (2005)
AI4914
AI4914'RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 2005 (RA)
AI4914'RECOVERED IN GOOD CONDITION.
AI4914
AI4914                          STATION RECOVERY (2007)
AI4914
AI4914'RECOVERY NOTE BY INDIVIDUAL CONTRIBUTORS 2007 (JPP)
AI4914'RECOVERED AS DESCRIBED

*** retrieval complete.
Elapsed Time = 00:00:00
```

```
 FILE: USCG1212.09O 000038225

                              NGS OPUS SOLUTION REPORT
                              ========================

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: www.ngs.noaa.gov/OPUS/Using_OPUS.html#accuracy

      USER: weston.renoud@noaa.gov                     DATE: May 06, 2009
RINEX FILE: uscg121u.09o                               TIME: 01:51:09 UTC


  SOFTWARE: page5  0810.20 master30.pl 081023      START: 2009/05/01  20:56:00
 EPHEMERIS: igr15295.eph [rapid]                    STOP: 2009/05/01  23:05:00
  NAV FILE: brdc1210.09n                        OBS USED:  4299 /  4471   :  96%
  ANT NAME: ASH701975.01AGP NONE             # FIXED AMB:    25 /    28   :  89%
ARP HEIGHT: 1.5                              OVERALL RMS: 0.016(m)


 REF FRAME: NAD_83(CORS96)(EPOCH:2003.0000)           ITRF00 (EPOCH:2009.3313)

         X:     -2415358.948(m)   0.060(m)         -2415359.797(m)   0.060(m)
         Y:     -2718046.293(m)   0.089(m)         -2718045.189(m)   0.089(m)
         Z:      5222559.332(m)   0.048(m)          5222559.513(m)   0.048(m)

       LAT:   55 19 58.65822      0.078(m)       55 19 58.66849      0.078(m)
     E LON:  228 22 28.18196      0.066(m)      228 22 28.10437      0.066(m)
     W LON:  131 37 31.81804      0.066(m)      131 37 31.89563      0.066(m)
    EL HGT:            3.872(m)   0.058(m)                3.872(m)   0.058(m)
 ORTHO HGT:            9.747(m)   0.133(m) [NAVD88 (Computed using GEOID06)]

                        UTM COORDINATES    STATE PLANE COORDINATES
                         UTM (Zone 09)         SPC (5001 AK 1)
Northing (Y) [meters]     6134983.124           391423.761
Easting (X)  [meters]      333464.496           948202.701
Convergence  [degrees]    -2.15989498           1.69678539
Point Scale                0.99994023           0.99990058
Combined Factor            0.99993962           0.00000000

US NATIONAL GRID DESIGNATOR:  9UUB3346434983(NAD 83)



                              BASE STATIONS USED
PID       DESIGNATION                        LATITUDE    LONGITUDE DISTANCE(m)
DK6423 BIS5 BIORKA ISLAND 5 CORS ARP       N565116.162 W1353221.387  296620.9
DJ3035 LEV6 LEVEL ISLAND 6 CORS ARP        N562756.364 W1330532.511  155952.3
DK6482 AIS5 ANNETTE ISLAND 5 CORS ARP      N550408.647 W1313558.255   29425.0

                 NEAREST NGS PUBLISHED CONTROL POINT
AI4914      BM NO 37                       N551958.661 W1313731.819       0.0
```

BASE STATION INFORMATION

```
STATION NAME: bis5  a    2 (Biorka Island 5; Biorka Island, Alaska  USA)
 MONUMENT: NO DOMES NUMBER
XYZ  -2494921.0833  -2448390.9914   5317113.6533  MON @ 1997.0000 (M)
XYZ        -0.0164         0.0037         0.0005  VEL (M/YR)
NEU         0.0000         0.0000         0.0000  MON TO ARP (M)
NEU        -0.0034        -0.0019         0.0813  ARP TO L1 PHASE CENTER (M)
NEU        -0.0037        -0.0015         0.0689  ARP TO L2 PHASE CENTER (M)
XYZ        -0.2022         0.0456         0.0062  VEL TIMES 12.3313 YRS
XYZ         0.0000         0.0000         0.0000  MON TO ARP
XYZ        -0.0351        -0.0318         0.0662  ARP TO L1 PHASE CENTER
XYZ  -2494921.3206  -2448390.9775   5317113.7257  L1 PHS CEN @ 2009.3313
XYZ        -0.0000        -0.0000        -0.0000  + XYZ ADJUSTMENTS
XYZ  -2494921.3206  -2448390.9776   5317113.7257  NEW L1 PHS CEN @ 2009.3313
XYZ  -2494921.2855  -2448390.9458   5317113.6595  NEW ARP @ 2009.3313
XYZ  -2494921.2855  -2448390.9458   5317113.6595  NEW MON @ 2009.3313
LLH  56 51 16.17151  224 27 38.53076     66.8349  NEW L1 PHS CEN @ 2009.3313
LLH  56 51 16.17162  224 27 38.53087     66.7536  NEW ARP @ 2009.3313
LLH  56 51 16.17162  224 27 38.53087     66.7536  NEW MON @ 2009.3313

STATION NAME: lev6  a    2 (Level Island 6; Level Island, Alaska  USA)
 MONUMENT: NO DOMES NUMBER
XYZ  -2412812.0457  -2579074.2577   5293282.2476  MON @ 1997.0000 (M)
XYZ        -0.0190         0.0003        -0.0044  VEL (M/YR)
NEU         0.0000         0.0000         0.0000  MON TO ARP (M)
NEU        -0.0034        -0.0019         0.0813  ARP TO L1 PHASE CENTER (M)
NEU        -0.0037        -0.0015         0.0689  ARP TO L2 PHASE CENTER (M)
XYZ        -0.2343         0.0037        -0.0543  VEL TIMES 12.3313 YRS
XYZ         0.0000         0.0000         0.0000  MON TO ARP
XYZ        -0.0340        -0.0336         0.0659  ARP TO L1 PHASE CENTER
XYZ  -2412812.3140  -2579074.2876   5293282.2592  L1 PHS CEN @ 2009.3313
XYZ        -0.0000         0.0000        -0.0000  + XYZ ADJUSTMENTS
XYZ  -2412812.3140  -2579074.2876   5293282.2592  NEW L1 PHS CEN @ 2009.3313
XYZ  -2412812.2800  -2579074.2540   5293282.1933  NEW ARP @ 2009.3313
XYZ  -2412812.2800  -2579074.2540   5293282.1933  NEW MON @ 2009.3313
LLH  56 27 56.37384  226 54 27.40784     25.4801  NEW L1 PHS CEN @ 2009.3313
LLH  56 27 56.37395  226 54 27.40796     25.3988  NEW ARP @ 2009.3313
LLH  56 27 56.37395  226 54 27.40796     25.3988  NEW MON @ 2009.3313

STATION NAME: ais5  a    2 (Annette Island 5; Annette Island, Alaska  USA)
 MONUMENT: NO DOMES NUMBER
XYZ  -2430153.8469  -2737192.9494   5205816.7670  MON @ 1997.0000 (M)
XYZ        -0.0147        -0.0013        -0.0087  VEL (M/YR)
NEU         0.0000         0.0000         0.0000  MON TO ARP (M)
NEU        -0.0034        -0.0019         0.0813  ARP TO L1 PHASE CENTER (M)
NEU        -0.0037        -0.0015         0.0689  ARP TO L2 PHASE CENTER (M)
XYZ        -0.1813        -0.0160        -0.1073  VEL TIMES 12.3313 YRS
XYZ         0.0000         0.0000         0.0000  MON TO ARP
XYZ        -0.0342        -0.0356         0.0647  ARP TO L1 PHASE CENTER
XYZ  -2430154.0623  -2737193.0011   5205816.7244  L1 PHS CEN @ 2009.3313
XYZ        -0.0000         0.0000        -0.0000  + XYZ ADJUSTMENTS
XYZ  -2430154.0623  -2737193.0011   5205816.7244  NEW L1 PHS CEN @ 2009.3313
XYZ  -2430154.0282  -2737192.9654   5205816.6597  NEW ARP @ 2009.3313
XYZ  -2430154.0282  -2737192.9654   5205816.6597  NEW MON @ 2009.3313
LLH  55  4  8.65794  228 24  1.66886     32.4119  NEW L1 PHS CEN @ 2009.3313
LLH  55  4  8.65805  228 24  1.66897     32.3306  NEW ARP @ 2009.3313
LLH  55  4  8.65805  228 24  1.66897     32.3306  NEW MON @ 2009.3313
```

## REMOTE STATION INFORMATION

```
 STATION NAME: uscg       1
  MONUMENT: NO DOMES NUMBER
 XYZ  -2415360.6791  -2718045.9236   5222561.0525  MON @ 2009.3312 (M)
 NEU        0.0025         0.0026         1.5000  MON TO ARP (M)
 NEU       -0.0025        -0.0026         0.0637  ARP TO L1 PHASE CENTER (M)
 NEU       -0.0012         0.0008         0.0440  ARP TO L2 PHASE CENTER (M)
 XYZ       -0.5634        -0.6380         1.2351  MON TO ARP
 XYZ       -0.0274        -0.0269         0.0510  ARP TO L1 PHASE CENTER
 XYZ  -2415361.2699  -2718046.5885   5222562.3386  L1 PHS CEN @ 2009.3313

 BASELINE NAME:   bis5  uscg
 XYZ        0.9053         0.7027        -1.5713  + XYZ ADJUSTMENTS
 XYZ  -2415360.3646  -2718045.8858   5222560.7673  NEW L1 PHS CEN @ 2009.3313
 XYZ  -2415360.3372  -2718045.8589   5222560.7163  NEW ARP @ 2009.3313
 XYZ  -2415359.7738  -2718045.2209   5222559.4812  NEW MON @ 2009.3313
 LLH  55 19 58.66769  228 22 28.10655      5.4148  NEW L1 PHS CEN @ 2009.3313
 LLH  55 19 58.66777  228 22 28.10670      5.3511  NEW ARP @ 2009.3313
 LLH  55 19 58.66769  228 22 28.10655      3.8511  NEW MON @ 2009.3313

 BASELINE NAME:   lev6  uscg
 XYZ        0.8455         0.7092        -1.5248  + XYZ ADJUSTMENTS
 XYZ  -2415360.4245  -2718045.8793   5222560.8138  NEW L1 PHS CEN @ 2009.3313
 XYZ  -2415360.3971  -2718045.8524   5222560.7628  NEW ARP @ 2009.3313
 XYZ  -2415359.8336  -2718045.2144   5222559.5277  NEW MON @ 2009.3313
 LLH  55 19 58.66761  228 22 28.10377      5.4730  NEW L1 PHS CEN @ 2009.3313
 LLH  55 19 58.66769  228 22 28.10392      5.4093  NEW ARP @ 2009.3313
 LLH  55 19 58.66761  228 22 28.10377      3.9093  NEW MON @ 2009.3313

 BASELINE NAME:   ais5  uscg
 XYZ        0.8950         0.7912        -1.5237  + XYZ ADJUSTMENTS
 XYZ  -2415360.3749  -2718045.7973   5222560.8149  NEW L1 PHS CEN @ 2009.3313
 XYZ  -2415360.3476  -2718045.7704   5222560.7639  NEW ARP @ 2009.3313
 XYZ  -2415359.7841  -2718045.1324   5222559.5288  NEW MON @ 2009.3313
 LLH  55 19 58.67014  228 22 28.10278      5.4202  NEW L1 PHS CEN @ 2009.3313
 LLH  55 19 58.67022  228 22 28.10293      5.3565  NEW ARP @ 2009.3313
 LLH  55 19 58.67014  228 22 28.10278      3.8565  NEW MON @ 2009.3313
```

## G-FILES

```
Axx2009 5 1   9 5 1
B2009 5 12056   9 5 123 5 1 page5 v0810.20IGS     226 1 2 27NGS   2009 5 5IFDDFX
Iant_info.003        NGS   20090501
C00090001 -795615118   66 2696542751   78  945541782   67 X1219AUSCGX1219ABIS5
D  1  2  2500896  1  3 -8353636  2  3 -3886207

Axx2009 5 1   9 5 1
B2009 5 12056   9 5 123 5 1 page5 v0810.20IGS     226 1 2 27NGS   2009 5 5IFDDFX
Iant_info.003        NGS   20090501
C00090002   25475536   48 1389709604   61  707226656   63 X1219AUSCGX1219ALEV6
D  1  2  4114541  1  3 -8151359  2  3 -1359443

Axx2009 5 1   9 5 1
B2009 5 12056   9 5 123 5 1 page5 v0810.20IGS     226 1 2 27NGS   2009 5 5IFDDFX
Iant_info.003        NGS   20090501
C00090003 -147942441   83 -191478330   77 -167428691   87 X1219AUSCGX1219AAIS5
D  1  2  9292636  1  3 -1168614  2  3    -2618
```

## POST-FIT RMS BY SATELLITE VS. BASELINE

| | OVERALL | 02 | 04 | 07 | 11 | 13 | 14 | 16 | 17 | 20 | 23 | 25 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| bis5-uscg\| | 0.020 | 0.025 | 0.019 | ... | 0.017 | 0.025 | ... | 0.028 | ... | ... | 0.019 | 0.028 | ... | 0.016 | 0.018 |
| lev6-uscg\| | 0.012 | 0.022 | 0.015 | ... | 0.014 | 0.012 | ... | 0.029 | ... | ... | 0.011 | 0.013 | ... | 0.010 | 0.010 |
| ais5-uscg\| | 0.015 | 0.026 | 0.019 | ... | 0.016 | 0.020 | ... | 0.024 | ... | ... | 0.012 | 0.018 | ... | 0.012 | 0.012 |

## OBS BY SATELLITE VS. BASELINE

| | OVERALL | 02 | 04 | 07 | 11 | 13 | 14 | 16 | 17 | 20 | 23 | 25 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| bis5-uscg\| | 1428 | 40 | 217 | ... | 85 | 166 | ... | 106 | ... | ... | 256 | 91 | ... | 211 | 256 |
| lev6-uscg\| | 1441 | 27 | 221 | ... | 85 | 166 | ... | 131 | ... | ... | 252 | 91 | ... | 212 | 256 |
| ais5-uscg\| | 1430 | 40 | 198 | ... | 79 | 159 | ... | 141 | ... | ... | 256 | 89 | ... | 212 | 256 |

Covariance Matrix for the xyz OPUS Position (meters2).

| | | |
|---|---|---|
| 0.0000301089 | 0.0000018736 | -0.0000015562 |
| 0.0000018736 | 0.0000349644 | -0.0000005678 |
| -0.0000015562 | -0.0000005678 | 0.0000356156 |

Covariance Matrix for the enu OPUS Position (meters2).

| | | |
|---|---|---|
| 0.0000303908 | -0.0000022471 | 0.0000006067 |
| -0.0000022471 | 0.0000336197 | -0.0000000685 |
| 0.0000006067 | -0.0000000685 | 0.0000366785 |

Horizontal network accuracy = 0.01384 meters.
Vertical network accuracy = 0.01188 meters.

Derivation of NAD 83 vector components

Position of reference station ARP in NAD_83(CORS96)(EPOCH:2003.0000).

| | Xa(m) | Ya(m) | Za(m) | |
|---|---|---|---|---|
| BIS5 | -2494920.44060 | -2448392.05858 | 5317113.38841 | 2003.00 |
| LEV6 | -2412811.42529 | -2579075.35282 | 5293281.97185 | 2003.00 |
| AIS5 | -2430153.20716 | -2737194.06415 | 5205816.48535 | 2003.00 |

Position of reference station monument in NAD_83(CORS96)(EPOCH:2003.0000).

| | Xr(m) | Yr(m) | Zr(m) | |
|---|---|---|---|---|
| BIS5 | -2494920.44060 | -2448392.05858 | 5317113.38841 | 2003.00 |
| LEV6 | -2412811.42529 | -2579075.35282 | 5293281.97185 | 2003.00 |
| AIS5 | -2430153.20716 | -2737194.06415 | 5205816.48535 | 2003.00 |

Velocity of reference station monument in NAD_83(CORS96)(EPOCH:2003.0000).

| | Vx (m/yr) | Vy (m/yr) | Vz (m/yr) |
|---|---|---|---|
| BIS5 | 0.00490 | 0.00450 | 0.00990 |
| LEV6 | 0.00220 | 0.00120 | 0.00480 |
| AIS5 | 0.00620 | -0.00040 | 0.00060 |

Vectors from unknown station monument to reference station monument
in NAD_83(CORS96)(EPOCH:2003.0000).

| | Xr-X= DX(m) | Yr-Y= DY(m) | Zr-Z= DZ(m) | |
|---|---|---|---|---|
| BIS5 | -79561.49260 | 269654.23442 | 94554.05641 | 2003.00 |
| LEV6 | 2547.52271 | 138970.94018 | 70722.63985 | 2003.00 |
| AIS5 | -14794.25916 | -19147.77115 | -16742.84665 | 2003.00 |

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

```
FILE: 10541220.09o 000038259

                              NGS OPUS SOLUTION REPORT
                              ========================

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: www.ngs.noaa.gov/OPUS/Using_OPUS.html#accuracy

      USER: weston.renoud@noaa.gov                     DATE: May 06, 2009
RINEX FILE: 1054122b.09o                               TIME: 05:56:23 UTC


  SOFTWARE: page5  0810.20 master11.pl 081023      START: 2009/05/02  01:31:00
 EPHEMERIS: igr15296.eph [rapid]                    STOP: 2009/05/02  03:27:30
  NAV FILE: brdc1220.09n                        OBS USED:  4571 /  4715   :  97%
  ANT NAME: TRM55971.00     NONE             # FIXED AMB:    28 /    29   :  97%
ARP HEIGHT: 1.5                              OVERALL RMS: 0.012(m)


 REF FRAME: NAD_83(CORS96)(EPOCH:2003.0000)            ITRF00 (EPOCH:2009.3318)

         X:     -2415358.872(m)   0.005(m)          -2415359.721(m)   0.005(m)
         Y:     -2718046.148(m)   0.053(m)          -2718045.044(m)   0.053(m)
         Z:      5222559.317(m)   0.036(m)           5222559.498(m)   0.036(m)

       LAT:   55 19 58.66217      0.038(m)        55 19 58.67244      0.038(m)
     E LON:  228 22 28.17972      0.033(m)       228 22 28.10212      0.033(m)
     W LON:  131 37 31.82028      0.033(m)       131 37 31.89788      0.033(m)
    EL HGT:            3.770(m)   0.037(m)                 3.770(m)   0.037(m)
 ORTHO HGT:            9.645(m)   0.125(m) [NAVD88 (Computed using GEOID06)]

                        UTM COORDINATES    STATE PLANE COORDINATES
                         UTM (Zone 09)         SPC (5001 AK 1)
Northing (Y) [meters]     6134983.248           391423.882
Easting (X)  [meters]      333464.461           948202.658
Convergence  [degrees]    -2.15989552           1.69678487
Point Scale                0.99994023           0.99990058
Combined Factor            0.99993964           0.00000000

US NATIONAL GRID DESIGNATOR:  9UUB3346434983(NAD 83)



                              BASE STATIONS USED
PID       DESIGNATION                        LATITUDE    LONGITUDE DISTANCE(m)
DK6423 BIS5 BIORKA ISLAND 5 CORS ARP      N565116.162 W1353221.387  296620.7
DJ3035 LEV6 LEVEL ISLAND 6 CORS ARP       N562756.364 W1330532.511  155952.1
DK6482 AIS5 ANNETTE ISLAND 5 CORS ARP     N550408.647 W1313558.255   29425.1

                 NEAREST NGS PUBLISHED CONTROL POINT
AI4914      BM NO 37                      N551958.661 W1313731.819       0.0
```

BASE STATION INFORMATION

```
STATION NAME: bis5  a    2 (Biorka Island 5; Biorka Island, Alaska  USA)
 MONUMENT: NO DOMES NUMBER
XYZ  -2494921.0833  -2448390.9914   5317113.6533  MON @ 1997.0000 (M)
XYZ        -0.0164         0.0037         0.0005  VEL (M/YR)
NEU         0.0000         0.0000         0.0000  MON TO ARP (M)
NEU        -0.0034        -0.0019         0.0813  ARP TO L1 PHASE CENTER (M)
NEU        -0.0037        -0.0015         0.0689  ARP TO L2 PHASE CENTER (M)
XYZ        -0.2022         0.0456         0.0062  VEL TIMES 12.3318 YRS
XYZ         0.0000         0.0000         0.0000  MON TO ARP
XYZ        -0.0351        -0.0318         0.0662  ARP TO L1 PHASE CENTER
XYZ  -2494921.3206  -2448390.9775   5317113.7257  L1 PHS CEN @ 2009.3318
XYZ        -0.0000        -0.0000         0.0000  + XYZ ADJUSTMENTS
XYZ  -2494921.3206  -2448390.9775   5317113.7257  NEW L1 PHS CEN @ 2009.3318
XYZ  -2494921.2855  -2448390.9458   5317113.6595  NEW ARP @ 2009.3318
XYZ  -2494921.2855  -2448390.9458   5317113.6595  NEW MON @ 2009.3318
LLH  56 51 16.17151  224 27 38.53076     66.8349  NEW L1 PHS CEN @ 2009.3318
LLH  56 51 16.17162  224 27 38.53087     66.7536  NEW ARP @ 2009.3318
LLH  56 51 16.17162  224 27 38.53087     66.7536  NEW MON @ 2009.3318

STATION NAME: lev6  a    2 (Level Island 6; Level Island, Alaska  USA)
 MONUMENT: NO DOMES NUMBER
XYZ  -2412812.0457  -2579074.2577   5293282.2476  MON @ 1997.0000 (M)
XYZ        -0.0190         0.0003        -0.0044  VEL (M/YR)
NEU         0.0000         0.0000         0.0000  MON TO ARP (M)
NEU        -0.0034        -0.0019         0.0813  ARP TO L1 PHASE CENTER (M)
NEU        -0.0037        -0.0015         0.0689  ARP TO L2 PHASE CENTER (M)
XYZ        -0.2343         0.0037        -0.0543  VEL TIMES 12.3318 YRS
XYZ         0.0000         0.0000         0.0000  MON TO ARP
XYZ        -0.0340        -0.0336         0.0659  ARP TO L1 PHASE CENTER
XYZ  -2412812.3140  -2579074.2876   5293282.2592  L1 PHS CEN @ 2009.3318
XYZ        -0.0000         0.0000         0.0000  + XYZ ADJUSTMENTS
XYZ  -2412812.3140  -2579074.2876   5293282.2592  NEW L1 PHS CEN @ 2009.3318
XYZ  -2412812.2800  -2579074.2540   5293282.1933  NEW ARP @ 2009.3318
XYZ  -2412812.2800  -2579074.2540   5293282.1933  NEW MON @ 2009.3318
LLH  56 27 56.37384  226 54 27.40784     25.4801  NEW L1 PHS CEN @ 2009.3318
LLH  56 27 56.37395  226 54 27.40796     25.3988  NEW ARP @ 2009.3318
LLH  56 27 56.37395  226 54 27.40796     25.3988  NEW MON @ 2009.3318

STATION NAME: ais5  a    2 (Annette Island 5; Annette Island, Alaska  USA)
 MONUMENT: NO DOMES NUMBER
XYZ  -2430153.8469  -2737192.9494   5205816.7670  MON @ 1997.0000 (M)
XYZ        -0.0147        -0.0013        -0.0087  VEL (M/YR)
NEU         0.0000         0.0000         0.0000  MON TO ARP (M)
NEU        -0.0034        -0.0019         0.0813  ARP TO L1 PHASE CENTER (M)
NEU        -0.0037        -0.0015         0.0689  ARP TO L2 PHASE CENTER (M)
XYZ        -0.1813        -0.0160        -0.1073  VEL TIMES 12.3318 YRS
XYZ         0.0000         0.0000         0.0000  MON TO ARP
XYZ        -0.0342        -0.0356         0.0647  ARP TO L1 PHASE CENTER
XYZ  -2430154.0624  -2737193.0011   5205816.7244  L1 PHS CEN @ 2009.3318
XYZ         0.0000         0.0000         0.0000  + XYZ ADJUSTMENTS
XYZ  -2430154.0624  -2737193.0011   5205816.7244  NEW L1 PHS CEN @ 2009.3318
XYZ  -2430154.0282  -2737192.9654   5205816.6597  NEW ARP @ 2009.3318
XYZ  -2430154.0282  -2737192.9654   5205816.6597  NEW MON @ 2009.3318
LLH  55  4  8.65794  228 24  1.66886     32.4119  NEW L1 PHS CEN @ 2009.3318
LLH  55  4  8.65805  228 24  1.66897     32.3306  NEW ARP @ 2009.3318
LLH  55  4  8.65805  228 24  1.66897     32.3306  NEW MON @ 2009.3318
```

## REMOTE STATION INFORMATION

```
 STATION NAME: 1054       1
  MONUMENT: NO DOMES NUMBER
 XYZ  -2415360.1829  -2718045.5883   5222560.7616  MON @ 2009.3317 (M)
 NEU        -0.0016        -0.0007         1.5000  MON TO ARP (M)
 NEU         0.0016         0.0007         0.0850  ARP TO L1 PHASE CENTER (M)
 NEU         0.0008         0.0012         0.0701  ARP TO L2 PHASE CENTER (M)
 XYZ        -0.5681        -0.6383         1.2328  MON TO ARP
 XYZ        -0.0307        -0.0356         0.0708  ARP TO L1 PHASE CENTER
 XYZ  -2415360.7818  -2718046.2622   5222562.0652  L1 PHS CEN @ 2009.3318

 BASELINE NAME:   bis5  1054
 XYZ         0.4618         0.5681        -1.2792  + XYZ ADJUSTMENTS
 XYZ  -2415360.3200  -2718045.6941   5222560.7861  NEW L1 PHS CEN @ 2009.3318
 XYZ  -2415360.2893  -2718045.6585   5222560.7152  NEW ARP @ 2009.3318
 XYZ  -2415359.7211  -2718045.0202   5222559.4824  NEW MON @ 2009.3318
 LLH  55 19 58.67263  228 22 28.10122      5.3319  NEW L1 PHS CEN @ 2009.3318
 LLH  55 19 58.67258  228 22 28.10118      5.2469  NEW ARP @ 2009.3318
 LLH  55 19 58.67263  228 22 28.10122      3.7469  NEW MON @ 2009.3318

 BASELINE NAME:   lev6  1054
 XYZ         0.4650         0.5483        -1.2431  + XYZ ADJUSTMENTS
 XYZ  -2415360.3167  -2718045.7139   5222560.8221  NEW L1 PHS CEN @ 2009.3318
 XYZ  -2415360.2860  -2718045.6783   5222560.7513  NEW ARP @ 2009.3318
 XYZ  -2415359.7179  -2718045.0400   5222559.5185  NEW MON @ 2009.3318
 LLH  55 19 58.67296  228 22 28.10211      5.3687  NEW L1 PHS CEN @ 2009.3318
 LLH  55 19 58.67290  228 22 28.10207      5.2837  NEW ARP @ 2009.3318
 LLH  55 19 58.67296  228 22 28.10211      3.7837  NEW MON @ 2009.3318

 BASELINE NAME:   ais5  1054
 XYZ         0.4596         0.5153        -1.2692  + XYZ ADJUSTMENTS
 XYZ  -2415360.3222  -2718045.7469   5222560.7960  NEW L1 PHS CEN @ 2009.3318
 XYZ  -2415360.2915  -2718045.7113   5222560.7252  NEW ARP @ 2009.3318
 XYZ  -2415359.7233  -2718045.0730   5222559.4924  NEW MON @ 2009.3318
 LLH  55 19 58.67172  228 22 28.10312      5.3634  NEW L1 PHS CEN @ 2009.3318
 LLH  55 19 58.67167  228 22 28.10308      5.2784  NEW ARP @ 2009.3318
 LLH  55 19 58.67172  228 22 28.10312      3.7784  NEW MON @ 2009.3318
```

## G-FILES

```
Axx2009 5 2   9 5 2
B2009 5 2 130   9 5 2 327 1 page5 v0810.20IGS     226 1 2 27NGS   2009 5 6IFDDFX
Iant_info.003        NGS   20090501
C00090001 -795615644   35 2696540744   64  945541770   54 X1229A1054X1229ABIS5
D  1  2  5925660  1  3 -7873734  2  3 -3932368

Axx2009 5 2   9 5 2
B2009 5 2 130   9 5 2 327 1 page5 v0810.20IGS     226 1 2 27NGS   2009 5 6IFDDFX
Iant_info.003        NGS   20090501
C00090002   25474379   48 1389707860  105  707226749   74 X1229A1054X1229ALEV6
D  1  2  8548113  1  3 -6918825  2  3 -5342543

Axx2009 5 2   9 5 2
B2009 5 2 130   9 5 2 327 1 page5 v0810.20IGS     226 1 2 27NGS   2009 5 6IFDDFX
Iant_info.003        NGS   20090501
C00090003 -147943048   35 -191478924   46 -167428327   63 X1229A1054X1229AAIS5
D  1  2  8769931  1  3 -7728950  2  3 -8819178
```

## POST-FIT RMS BY SATELLITE VS. BASELINE

| | OVERALL | 03 | 06 | 07 | 08 | 10 | 13 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|
| bis5-1054\| | 0.012 | 0.012 | ... | ... | 0.007 | 0.012 | 0.011 | 0.013 | ... |
| | 19 | 23 | 24 | 25 | 28 | | | | |
| bis5-1054\| | 0.014 | 0.013 | ... | 0.010 | 0.011 | | | | |

| | OVERALL | 03 | 06 | 07 | 08 | 10 | 13 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|
| lev6-1054\| | 0.012 | 0.014 | ... | ... | 0.007 | 0.011 | 0.012 | 0.017 | ... |
| | 19 | 23 | 24 | 25 | 28 | | | | |
| lev6-1054\| | 0.016 | 0.011 | ... | 0.010 | 0.010 | | | | |

| | OVERALL | 03 | 06 | 07 | 08 | 10 | 13 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|
| ais5-1054\| | 0.012 | 0.013 | ... | ... | 0.008 | 0.012 | 0.013 | 0.015 | ... |
| | 19 | 23 | 25 | 28 | | | | | |
| ais5-1054\| | 0.015 | 0.013 | 0.010 | 0.012 | | | | | |

## OBS BY SATELLITE VS. BASELINE

| | OVERALL | 03 | 06 | 07 | 08 | 10 | 13 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|
| bis5-1054\| | 1534 | 165 | ... | ... | 233 | 224 | 190 | 62 | ... |
| | 19 | 23 | 24 | 25 | 28 | | | | |
| bis5-1054\| | 204 | 50 | ... | 233 | 173 | | | | |
| | OVERALL | 03 | 06 | 07 | 08 | 10 | 13 | 15 | 16 |
| lev6-1054\| | 1486 | 165 | ... | ... | 233 | 215 | 193 | 62 | ... |
| | 19 | 23 | 24 | 25 | 28 | | | | |
| lev6-1054\| | 202 | 50 | ... | 233 | 133 | | | | |
| | OVERALL | 03 | 06 | 07 | 08 | 10 | 13 | 15 | 16 |
| ais5-1054\| | 1551 | 164 | ... | ... | 233 | 217 | 202 | 62 | ... |
| | 19 | 23 | 25 | 28 | | | | | |
| ais5-1054\| | 221 | 51 | 233 | 168 | | | | | |

Covariance Matrix for the xyz OPUS Position (meters2).

| | | |
|---|---|---|
| 0.0000105644 | 0.0000015661 | -0.0000012555 |
| 0.0000015661 | 0.0000383044 | -0.0000017924 |
| -0.0000012555 | -0.0000017924 | 0.0000274689 |

Covariance Matrix for the enu OPUS Position (meters2).

| | | |
|---|---|---|
| 0.0000212492 | -0.0000110088 | 0.0000079720 |
| -0.0000110088 | 0.0000255317 | -0.0000008251 |
| 0.0000079720 | -0.0000008251 | 0.0000295569 |

Horizontal network accuracy = 0.01224 meters.
Vertical network accuracy = 0.01066 meters.

## Derivation of NAD 83 vector components

Position of reference station ARP in NAD_83(CORS96)(EPOCH:2003.0000).

| | Xa(m) | Ya(m) | Za(m) | |
|---|---|---|---|---|
| BIS5 | -2494920.44060 | -2448392.05858 | 5317113.38841 | 2003.00 |
| LEV6 | -2412811.42529 | -2579075.35282 | 5293281.97185 | 2003.00 |
| AIS5 | -2430153.20716 | -2737194.06415 | 5205816.48535 | 2003.00 |

Position of reference station monument in NAD_83(CORS96)(EPOCH:2003.0000).

| | Xr(m) | Yr(m) | Zr(m) | |
|---|---|---|---|---|
| BIS5 | -2494920.44060 | -2448392.05858 | 5317113.38841 | 2003.00 |
| LEV6 | -2412811.42529 | -2579075.35282 | 5293281.97185 | 2003.00 |
| AIS5 | -2430153.20716 | -2737194.06415 | 5205816.48535 | 2003.00 |

Velocity of reference station monument in NAD_83(CORS96)(EPOCH:2003.0000).

| | Vx (m/yr) | Vy (m/yr) | Vz (m/yr) |
|---|---|---|---|
| BIS5 | 0.00490 | 0.00450 | 0.00990 |
| LEV6 | 0.00220 | 0.00120 | 0.00480 |
| AIS5 | 0.00620 | -0.00040 | 0.00060 |

Vectors from unknown station monument to reference station monument
in NAD_83(CORS96)(EPOCH:2003.0000).

| | Xr-X= DX(m) | Yr-Y= DY(m) | Zr-Z= DZ(m) | |
|---|---|---|---|---|
| BIS5 | -79561.56860 | 269654.08942 | 94554.07141 | 2003.00 |
| LEV6 | 2547.44671 | 138970.79518 | 70722.65485 | 2003.00 |
| AIS5 | -14794.33516 | -19147.91615 | -16742.83165 | 2003.00 |

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

```
 FILE: 10661210.09o 000038258

                              NGS OPUS SOLUTION REPORT
                              ========================

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: www.ngs.noaa.gov/OPUS/Using_OPUS.html#accuracy

      USER: weston.renoud@noaa.gov                     DATE: May 06, 2009
RINEX FILE: 1066121x.09o                               TIME: 05:55:21 UTC


  SOFTWARE: page5  0810.20 master29.pl 081023      START: 2009/05/01  23:15:00
 EPHEMERIS: igr15295.eph [rapid]                    STOP: 2009/05/02  01:23:00
  NAV FILE: brdc1210.09n                        OBS USED:  4958 /  5204   :  95%
  ANT NAME: TRM55971.00     NONE             # FIXED AMB:    31 /    37   :  84%
ARP HEIGHT: 1.5                              OVERALL RMS: 0.013(m)


 REF FRAME: NAD_83(CORS96)(EPOCH:2003.0000)           ITRF00 (EPOCH:2009.3315)

         X:     -2415358.876(m)   0.004(m)          -2415359.725(m)   0.004(m)
         Y:     -2718046.200(m)   0.072(m)          -2718045.096(m)   0.072(m)
         Z:      5222559.312(m)   0.019(m)           5222559.493(m)   0.019(m)

       LAT:   55 19 58.66097      0.058(m)        55 19 58.67125      0.058(m)
     E LON:  228 22 28.18151      0.045(m)       228 22 28.10391      0.045(m)
     W LON:  131 37 31.81849      0.045(m)       131 37 31.89609      0.045(m)
    EL HGT:            3.789(m)   0.017(m)                 3.789(m)   0.017(m)
 ORTHO HGT:            9.664(m)   0.121(m) [NAVD88 (Computed using GEOID06)]

                        UTM COORDINATES    STATE PLANE COORDINATES
                         UTM (Zone 09)         SPC (5001 AK 1)
Northing (Y) [meters]     6134983.210           391423.846
Easting (X)  [meters]      333464.491           948202.691
Convergence  [degrees]    -2.15989510           1.69678528
Point Scale                0.99994023           0.99990058
Combined Factor            0.99993963           0.00000000

US NATIONAL GRID DESIGNATOR:  9UUB3346434983(NAD 83)



                              BASE STATIONS USED
PID       DESIGNATION                        LATITUDE    LONGITUDE DISTANCE(m)
DK6423 BIS5 BIORKA ISLAND 5 CORS ARP       N565116.162 W1353221.387  296620.8
DJ3035 LEV6 LEVEL ISLAND 6 CORS ARP        N562756.364 W1330532.511  155952.2
DK6482 AIS5 ANNETTE ISLAND 5 CORS ARP      N550408.647 W1313558.255   29425.1

                 NEAREST NGS PUBLISHED CONTROL POINT
AI4914      BM NO 37                       N551958.661 W1313731.819       0.0
```

BASE STATION INFORMATION

```
STATION NAME: bis5  a    2 (Biorka Island 5; Biorka Island, Alaska  USA)
 MONUMENT: NO DOMES NUMBER
XYZ  -2494921.0833  -2448390.9914   5317113.6533  MON @ 1997.0000 (M)
XYZ        -0.0164         0.0037         0.0005  VEL (M/YR)
NEU         0.0000         0.0000         0.0000  MON TO ARP (M)
NEU        -0.0034        -0.0019         0.0813  ARP TO L1 PHASE CENTER (M)
NEU        -0.0037        -0.0015         0.0689  ARP TO L2 PHASE CENTER (M)
XYZ        -0.2022         0.0456         0.0062  VEL TIMES 12.3316 YRS
XYZ         0.0000         0.0000         0.0000  MON TO ARP
XYZ        -0.0351        -0.0318         0.0662  ARP TO L1 PHASE CENTER
XYZ  -2494921.3206  -2448390.9775   5317113.7257  L1 PHS CEN @ 2009.3315
XYZ         0.0000        -0.0000        -0.0000  + XYZ ADJUSTMENTS
XYZ  -2494921.3206  -2448390.9776   5317113.7257  NEW L1 PHS CEN @ 2009.3315
XYZ  -2494921.2855  -2448390.9458   5317113.6595  NEW ARP @ 2009.3315
XYZ  -2494921.2855  -2448390.9458   5317113.6595  NEW MON @ 2009.3315
LLH  56 51 16.17151  224 27 38.53076     66.8349  NEW L1 PHS CEN @ 2009.3315
LLH  56 51 16.17162  224 27 38.53087     66.7536  NEW ARP @ 2009.3315
LLH  56 51 16.17162  224 27 38.53087     66.7536  NEW MON @ 2009.3315
```

```
STATION NAME: lev6  a    2 (Level Island 6; Level Island, Alaska  USA)
 MONUMENT: NO DOMES NUMBER
XYZ  -2412812.0457  -2579074.2577   5293282.2476  MON @ 1997.0000 (M)
XYZ        -0.0190         0.0003        -0.0044  VEL (M/YR)
NEU         0.0000         0.0000         0.0000  MON TO ARP (M)
NEU        -0.0034        -0.0019         0.0813  ARP TO L1 PHASE CENTER (M)
NEU        -0.0037        -0.0015         0.0689  ARP TO L2 PHASE CENTER (M)
XYZ        -0.2343         0.0037        -0.0543  VEL TIMES 12.3316 YRS
XYZ         0.0000         0.0000         0.0000  MON TO ARP
XYZ        -0.0340        -0.0336         0.0659  ARP TO L1 PHASE CENTER
XYZ  -2412812.3140  -2579074.2876   5293282.2592  L1 PHS CEN @ 2009.3315
XYZ         0.0000        -0.0000        -0.0000  + XYZ ADJUSTMENTS
XYZ  -2412812.3140  -2579074.2876   5293282.2592  NEW L1 PHS CEN @ 2009.3315
XYZ  -2412812.2800  -2579074.2540   5293282.1933  NEW ARP @ 2009.3315
XYZ  -2412812.2800  -2579074.2540   5293282.1933  NEW MON @ 2009.3315
LLH  56 27 56.37384  226 54 27.40784     25.4801  NEW L1 PHS CEN @ 2009.3315
LLH  56 27 56.37395  226 54 27.40796     25.3988  NEW ARP @ 2009.3315
LLH  56 27 56.37395  226 54 27.40796     25.3988  NEW MON @ 2009.3315
```

```
STATION NAME: ais5  a    2 (Annette Island 5; Annette Island, Alaska  USA)
 MONUMENT: NO DOMES NUMBER
XYZ  -2430153.8469  -2737192.9494   5205816.7670  MON @ 1997.0000 (M)
XYZ        -0.0147        -0.0013        -0.0087  VEL (M/YR)
NEU         0.0000         0.0000         0.0000  MON TO ARP (M)
NEU        -0.0034        -0.0019         0.0813  ARP TO L1 PHASE CENTER (M)
NEU        -0.0037        -0.0015         0.0689  ARP TO L2 PHASE CENTER (M)
XYZ        -0.1813        -0.0160        -0.1073  VEL TIMES 12.3316 YRS
XYZ         0.0000         0.0000         0.0000  MON TO ARP
XYZ        -0.0342        -0.0356         0.0647  ARP TO L1 PHASE CENTER
XYZ  -2430154.0624  -2737193.0011   5205816.7244  L1 PHS CEN @ 2009.3315
XYZ         0.0000        -0.0000         0.0000  + XYZ ADJUSTMENTS
XYZ  -2430154.0624  -2737193.0011   5205816.7244  NEW L1 PHS CEN @ 2009.3315
XYZ  -2430154.0282  -2737192.9654   5205816.6597  NEW ARP @ 2009.3315
XYZ  -2430154.0282  -2737192.9654   5205816.6597  NEW MON @ 2009.3315
LLH  55  4  8.65794  228 24  1.66886     32.4119  NEW L1 PHS CEN @ 2009.3315
LLH  55  4  8.65805  228 24  1.66897     32.3306  NEW ARP @ 2009.3315
LLH  55  4  8.65805  228 24  1.66897     32.3306  NEW MON @ 2009.3315
```

## REMOTE STATION INFORMATION

```
 STATION NAME: 1066       1
  MONUMENT: NO DOMES NUMBER
 XYZ  -2415360.3732  -2718045.6145   5222560.7825  MON @ 2009.3314 (M)
 NEU        -0.0016        -0.0007         1.5000  MON TO ARP (M)
 NEU         0.0016         0.0007         0.0850  ARP TO L1 PHASE CENTER (M)
 NEU         0.0008         0.0012         0.0701  ARP TO L2 PHASE CENTER (M)
 XYZ        -0.5681        -0.6383         1.2328  MON TO ARP
 XYZ        -0.0307        -0.0356         0.0708  ARP TO L1 PHASE CENTER
 XYZ  -2415360.9721  -2718046.2884   5222562.0861  L1 PHS CEN @ 2009.3315

 BASELINE NAME:   bis5  1066
 XYZ         0.6505         0.5484        -1.2812  + XYZ ADJUSTMENTS
 XYZ  -2415360.3216  -2718045.7400   5222560.8049  NEW L1 PHS CEN @ 2009.3315
 XYZ  -2415360.2908  -2718045.7043   5222560.7341  NEW ARP @ 2009.3315
 XYZ  -2415359.7227  -2718045.0661   5222559.5013  NEW MON @ 2009.3315
 LLH  55 19 58.67204  228 22 28.10288      5.3675  NEW L1 PHS CEN @ 2009.3315
 LLH  55 19 58.67198  228 22 28.10284      5.2825  NEW ARP @ 2009.3315
 LLH  55 19 58.67204  228 22 28.10288      3.7825  NEW MON @ 2009.3315

 BASELINE NAME:   lev6  1066
 XYZ         0.6466         0.4762        -1.3003  + XYZ ADJUSTMENTS
 XYZ  -2415360.3255  -2718045.8122   5222560.7858  NEW L1 PHS CEN @ 2009.3315
 XYZ  -2415360.2948  -2718045.7766   5222560.7150  NEW ARP @ 2009.3315
 XYZ  -2415359.7266  -2718045.1383   5222559.4822  NEW MON @ 2009.3315
 LLH  55 19 58.67018  228 22 28.10544      5.3840  NEW L1 PHS CEN @ 2009.3315
 LLH  55 19 58.67013  228 22 28.10540      5.2990  NEW ARP @ 2009.3315
 LLH  55 19 58.67018  228 22 28.10544      3.7990  NEW MON @ 2009.3315

 BASELINE NAME:   ais5  1066
 XYZ         0.6477         0.5316        -1.2860  + XYZ ADJUSTMENTS
 XYZ  -2415360.3244  -2718045.7568   5222560.8001  NEW L1 PHS CEN @ 2009.3315
 XYZ  -2415360.2937  -2718045.7212   5222560.7293  NEW ARP @ 2009.3315
 XYZ  -2415359.7255  -2718045.0829   5222559.4965  NEW MON @ 2009.3315
 LLH  55 19 58.67156  228 22 28.10340      5.3718  NEW L1 PHS CEN @ 2009.3315
 LLH  55 19 58.67151  228 22 28.10336      5.2868  NEW ARP @ 2009.3315
 LLH  55 19 58.67156  228 22 28.10340      3.7868  NEW MON @ 2009.3315
```

## G-FILES

```
Axx2009 5 1   9 5 2
B2009 5 12315   9 5 2 123 1 page5 v0810.20IGS     226 1 2 27NGS   2009 5 6IFDDFX
Iant_info.003        NGS   20090501
C00090001 -795615628   39 2696541203   52  945541582   57 X1219A1066X1219ABIS5
D  1  2  5936586  1  3 -9007484  2  3 -5245597

Axx2009 5 1   9 5 2
B2009 5 12315   9 5 2 123 1 page5 v0810.20IGS     226 1 2 27NGS   2009 5 6IFDDFX
Iant_info.003        NGS   20090501
C00090002   25474467   53 1389708843   69  707227111   69 X1219A1066X1219ALEV6
D  1  2  7879129  1  3 -8769746  2  3 -5475035

Axx2009 5 1   9 5 2
B2009 5 12315   9 5 2 123 1 page5 v0810.20IGS     226 1 2 27NGS   2009 5 6IFDDFX
Iant_info.003        NGS   20090501
C00090003 -147943027   41 -191478825   47 -167428368   50 X1219A1066X1219AAIS5
D  1  2  9402615  1  3 -8031189  2  3 -8318564
```

```
                    POST-FIT RMS BY SATELLITE VS. BASELINE

           OVERALL     02     03     04     06     07     08     10     13
bis5-1066|  0.013  0.017  0.022  0.012    ...  0.011  0.018  0.015    ...
               16     20     23     24     25     31     32
bis5-1066|  0.013  0.011  0.010    ...  0.007    ...  0.026

           OVERALL     02     03     04     06     07     08     10     13
lev6-1066|  0.012  0.016  0.021  0.012    ...  0.010  0.015  0.015    ...
               16     20     23     24     25     31     32
lev6-1066|  0.014  0.013  0.009    ...  0.007    ...  0.027

           OVERALL     02     03     04     06     07     08     10     13
ais5-1066|  0.012  0.018  0.019  0.015    ...  0.009  0.017  0.017    ...
               16     20     23     25     31     32
ais5-1066|  0.013  0.014  0.009  0.008    ...    ...

                         OBS BY SATELLITE VS. BASELINE

           OVERALL     02     03     04     06     07     08     10     13
bis5-1066|   1700    197     54    111    ...    254    105     92    ...
               16     20     23     24     25     31     32
bis5-1066|    244    118    254    ...    254    ...     17
           OVERALL     02     03     04     06     07     08     10     13
lev6-1066|   1702    197     35    111    ...    254    105     95    ...
               16     20     23     24     25     31     32
lev6-1066|    245    129    251    ...    254    ...     26
           OVERALL     02     03     04     06     07     08     10     13
ais5-1066|   1556     70     67     98    ...    254    104     77    ...
               16     20     23     25     31     32
ais5-1066|    245    133    254    254    ...    ...


Covariance Matrix for the xyz OPUS Position (meters2).
   0.0000133578     0.0000013105    -0.0000015235
   0.0000013105     0.0000214978    -0.0000013592
  -0.0000015235    -0.0000013592     0.0000233556

Covariance Matrix for the enu OPUS Position (meters2).
   0.0000156481    -0.0000033255     0.0000020278
  -0.0000033255     0.0000186598     0.0000012414
   0.0000020278     0.0000012414     0.0000239032

Horizontal network accuracy =    0.01018 meters.
Vertical network accuracy   =    0.00959 meters.
```

## Derivation of NAD 83 vector components

Position of reference station ARP in NAD_83(CORS96)(EPOCH:2003.0000).

| | Xa(m) | Ya(m) | Za(m) | |
|---|---|---|---|---|
| BIS5 | -2494920.44060 | -2448392.05858 | 5317113.38841 | 2003.00 |
| LEV6 | -2412811.42529 | -2579075.35282 | 5293281.97185 | 2003.00 |
| AIS5 | -2430153.20716 | -2737194.06415 | 5205816.48535 | 2003.00 |

Position of reference station monument in NAD_83(CORS96)(EPOCH:2003.0000).

| | Xr(m) | Yr(m) | Zr(m) | |
|---|---|---|---|---|
| BIS5 | -2494920.44060 | -2448392.05858 | 5317113.38841 | 2003.00 |
| LEV6 | -2412811.42529 | -2579075.35282 | 5293281.97185 | 2003.00 |
| AIS5 | -2430153.20716 | -2737194.06415 | 5205816.48535 | 2003.00 |

Velocity of reference station monument in NAD_83(CORS96)(EPOCH:2003.0000).

| | Vx (m/yr) | Vy (m/yr) | Vz (m/yr) |
|---|---|---|---|
| BIS5 | 0.00490 | 0.00450 | 0.00990 |
| LEV6 | 0.00220 | 0.00120 | 0.00480 |
| AIS5 | 0.00620 | -0.00040 | 0.00060 |

Vectors from unknown station monument to reference station monument in NAD_83(CORS96)(EPOCH:2003.0000).

| | Xr-X= DX(m) | Yr-Y= DY(m) | Zr-Z= DZ(m) | |
|---|---|---|---|---|
| BIS5 | -79561.56460 | 269654.14142 | 94554.07641 | 2003.00 |
| LEV6 | 2547.45071 | 138970.84718 | 70722.65985 | 2003.00 |
| AIS5 | -14794.33116 | -19147.86415 | -16742.82665 | 2003.00 |

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

# Divers Least Depth Gauge Report

Dive Completed: April 22, 2009 (DN112)

Location: Lake Washington, Seattle, Washington

Latitude - 47/39/01.97N Longitude - 22/16/17.32W

Divers: ENS Glen Rice, ENS Mark Andrews, SST Adam Argento & LTjg Caryn Arnold

DLDG S/N: 68337

CTD S/N: 4616

Surface Pressure (mb): 1021

Surface Gauge Reading (psia): 14.78

| Lead Line (M) | 1st DLDG reading (psia) | 2nd DLDG reading (psia) | Average (psia) | Computed Depth (M) |
|---|---|---|---|---|
| 1 | 16.04 | 16.23 | **16.14** | **1.03** |
| 2 | 17.57 | 17.64 | **17.61** | **2.06** |
| 3 | 19.02 | 19.08 | **19.05** | **3.07** |
| 4 | 20.43 | 20.48 | **20.46** | **4.07** |
| 5 | 21.86 | 21.90 | **21.88** | **5.06** |
| 6 | 23.25 | - | **23.25** | **6.02** |

Notes:

The dive was completed on DN112 and the cast used for this report was from DN107. *(SVP file 09107175)*

Report Prepared by: LTjg Arnold

# PTC Electronics Incorporated

PO Box 72, Wyckoff, NJ 07481 Phone: (201) 847-0500 • Fax: (201) 847-1394 • URL: www.PTCElectronics.com

| | | |
|---|---|---|
| DATE | 04/02/2008 | |
| TRANSDUCER TYPE | Digital Pressure Gage-D2000 | |
| SERIAL NUMBER | 68337 | |
| PRESSURE RANGE/ACC'Y | 0-100psia | 0.1% fs. |
| EXCITATION VOLTAGE | NA | |
| PRESSURE STANDARD USED | DRUCK DPI 600 | |
| SPECIFIED ACCURACY | 0.03% | |
| CALIBRATION PERIOD | Bi-annual | |
| LAST CALIBRATED | 06/01/06 | |
| READOUT | Digital | |
| DATA TAKEN BY | John C. Kicks | |

CALIBRATION CONDITIONS:

| | |
|---|---|
| BAROMETRIC PRESSURE | 14.64 psia |
| AMBIENT TEMPERATURE | 72°F |
| PRESSURE MEDIA | Air |

| PRESSURE APPLIED | REFERENCE PRESSURE | OUTPUT (UNITS) psia Increasing | Decreasing |
|---|---|---|---|
| -1.00 | 13.64 | 13.47 | 13.47 |
| 0.00 | 14.64 | 14.48 | 14.47 |
| 1.00 | 15.64 | 15.48 | 15.48 |
| 2.00 | 16.64 | 16.48 | 16.48 |
| 3.00 | 17.64 | 17.48 | 17.48 |
| 4.00 | 18.64 | 18.48 | 18.49 |
| 5.00 | 19.64 | 19.48 | 19.48 |
| 6.00 | 20.64 | 20.48 | 20.49 |
| 7.00 | 21.64 | 21.48 | 21.48 |
| 12.00 | 26.64 | 26.49 | 26.49 |
| 17.00 | 31.64 | 31.48 | 31.48 |
| 22.00 | 36.64 | 36.49 | 36.50 |
| 27.00 | 41.64 | 41.47 | 41.47 |
| 32.00 | 46.64 | 46.48 | |

APPROVED by

Alan F. Kicks, Q.A. Manager

**NOAA Ship FAIRWEATHER**
**LASER RANGEFINDER Accuracy test**

Testing date: 04/13/2009, 04/22/2009
Testing personnel: Mark Andrews, Matthew Andring, Annie Raymond, Patricia Raymond, Glen Rice

| Trial | Actual Distance | LR 001481 Distance | LR 000676 Distance | Actual Height | LR 001481 Height | LR 000676 Height |
|---|---|---|---|---|---|---|
| 1 | 10 | 10.1 | 10.1 | 2.0 | 2.1 | 2.0 |
| 2 | 10 | 10.0 | 10.0 | 2.0 | 2.0 | 2.0 |
| 3 | 10 | 10.0 | 10.0 | 2.0 | 2.0 | 2.0 |
| 4 | 20 | 20.1 | 20.2 | 2.0 | 2.1 | 2.1 |
| 5 | 20 | 20.1 | 20.1 | 2.0 | 2.0 | 2.0 |
| 6 | 20 | 20.1 | 20.1 | 2.0 | 2.1 | 2.1 |
| 7 | 50 | 50.0 | 50.1 | 2.0 | 2.0 | 1.8 |
| 8 | 50 | 50.1 | 50.1 | 2.0 | 2.1 | 1.9 |
| 9 | 50 | 50.1 | 50.0 | 2.0 | 1.8 | 1.9 |
| 10 | 100 | 100.1 | 100.2 | 2.0 | 2.0 | 2.1 |
| 11 | 100 | 100.0 | 100.1 | 2.0 | 2.0 | 2.0 |
| 12 | 100 | 100.2 | 100.1 | 2.0 | 1.8 | 1.7 |

| Trial | Actual Distance | LR i0929 Distance | Actual Height | LR i0929 Height |
|---|---|---|---|---|
| 1 | 10 | 9.94 | 1.0 | 1.10 |
| 2 | 10 | 9.93 | 1.0 | 0.98 |
| 3 | 10 | 9.95 | 1.0 | 1.06 |
| 4 | 20 | 19.91 | 1.0 | 1.07 |
| 5 | 20 | 19.90 | 1.0 | 1.11 |
| 6 | 20 | 19.88 | 1.0 | 0.96 |
| 7 | 50 | 49.92 | 1.0 | 0.94 |
| 8 | 50 | 49.90 | 1.0 | 0.93 |
| 9 | 50 | 49.88 | 1.0 | 1.04 |
| 10 | 100 | 99.90 | 1.0 | 1.19 |
| 11 | 100 | 99.89 | 1.0 | 1.06 |
| 12 | 100 | 99.89 | 1.0 | 1.08 |

LR = Laser Rangefinder
All distances are measured in meters.

# Lead Line & Sounding Pole Calibration Report

**Field unit: FA**

**Lead Line / Sounding Pole Identification Number:**
**Line 10-01-05 w/ lead 20-05**

**Date of Calibration: 4/20/09**

**Method of Calibration:** **x Steel tape** **Permanent graduation marks**
**Other**

**Location: Seattle, WA**

**Chief of Party: CDR Baird**

**Lead Line / Sounding Pole Unit of Measure:** Meters (measured from bottom of lead to bottom of mark)

| Measured by: AR/LS | Recorded by: AR | Checked by: AR |
|---|---|---|
| **Graduated Marking (a)** | **Calibration Measurement (b)** | **Lead Line Corrector (c = b - a)** |
| 1 | 0.992 | -0.008 |
| 2 | 1.992 | -0.008 |
| 3 | 2.992 | -0.008 |
| 4 | 3.99 | -0.01 |
| 5 | 4.987 | -0.013 |
| 6 | 5.985 | -0.015 |
| 7 | 6.984 | -0.016 |
| 8 | 7.983 | -0.017 |
| 9 | 8.982 | -0.018 |
| 10 | 9.98 | -0.02 |
| | Average Correction | -0.0133 |
| | Standard Deviation | 0.004547282 |
| | | |

# Lead Line & Sounding Pole Calibration Report

**Field unit: FA**

**Lead Line / Sounding Pole Identification Number: 10_5_09**

**Date of Calibration: 4/27/09**

**Method of Calibration: x Steel tape Permanent graduation marks Other**

**Location: Seattle, WA**

**Chief of Party: CDR Baird**

**Lead Line / Sounding Pole Unit of Measure:** Meters (measured from bottom of lead to bottom of mark)

| **Measured by:DF/BN** | **Recorded by: DF** | **Checked by: DF** |
|---|---|---|
| **Graduated Marking (a)** | **Calibration Measurement (b)** | **Lead Line Corrector (c = b - a)** |
| 1 | 1 | 0 |
| 2 | 1.995 | -0.005 |
| 3 | 2.99 | -0.01 |
| 4 | 3.885 | -0.115 |
| 5 | 4.882 | -0.118 |
| 6 | 5.74 | -0.26 |
| 7 | 6.967 | -0.033 |
| 8 | 7.962 | -0.038 |
| 9 | 8.955 | -0.045 |
| 10 | 9.946 | -0.054 |
| | Average Correction | -0.0678 |
| | Standard Deviation | 0.079147963 |
| | | |
| | | |

# Lead Line & Sounding Pole Calibration Report

**Field unit: FA**

**Lead Line / Sounding Pole Identification Number:**
**Line 10-02-05 w/ lead 10-02-04**

**Date of Calibration: 4/20/09**

**Method of Calibration:** **x Steel tape** **Permanent graduation marks**
**Other**

**Location: Seattle, WA**

**Chief of Party: CDR Baird**

**Lead Line / Sounding Pole Unit of Measure:** Meters (measured from bottom of lead to bottom of mark)

| **Measured by: AR/LS** | **Recorded by: AR** | **Checked by: AR** |
|---|---|---|
| **Graduated Marking (a)** | **Calibration Measurement (b)** | **Lead Line Corrector (c = b - a)** |
| 1 | 1 | 0 |
| 2 | 1.99 | -0.01 |
| 3 | 2.89 | -0.11 |
| 4 | 3.976 | -0.024 |
| 5 | 4.97 | -0.03 |
| 6 | 5.965 | -0.035 |
| 7 | 6.955 | -0.045 |
| 8 | 7.95 | -0.05 |
| 9 | 8.945 | -0.055 |
| 10 | 9.94 | -0.06 |
| | Average Correction | -0.0419 |
| | Standard Deviation | 0.030722594 |
| | | |
| | | |

# Lead Line & Sounding Pole Calibration Report

**Field unit: FA**

**Lead Line / Sounding Pole Identification Number:**
**20_01_05 (Lead 10_02_04)**

**Date of Calibration: 4/28/2009**

**Method of Calibration:** **x Steel tape** **Permanent graduation marks** **Other**

**Location: Seattle, WA**

**Chief of Party: CDR Baird**

**Lead Line / Sounding Pole Unit of Measure:** Meters (measured from bottom of lead to bottom of mark)

| Measured by: DF/BN | Recorded by: DF | Checked by: |
|---|---|---|
| **Graduated Marking (a)** | **Calibration Measurement (b)** | **Lead Line Corrector (c = b - a)** |
| 1 | 1.021 | 0.021 |
| 2 | 2.002 | 0.002 |
| 3 | 2.993 | -0.007 |
| 4 | 3.988 | -0.012 |
| 5 | 4.991 | -0.009 |
| 6 | 5.998 | -0.002 |
| 7 | 6.994 | -0.006 |
| 8 | 7.995 | -0.005 |
| 9 | 8.994 | -0.006 |
| 10 | 9.991 | -0.009 |
| 11 | 10.993 | -0.007 |
| 12 | 11.992 | -0.008 |
| 13 | 12.988 | -0.012 |
| 14 | 13.986 | -0.014 |
| 15 | 14.984 | -0.016 |
| 16 | 15.983 | -0.017 |
| 17 | 16.982 | -0.018 |
| 18 | 17.986 | -0.014 |
| 19 | 18.981 | -0.019 |
| 20 | 19.986 | -0.014 |
| | Average Correction | -0.0086 |
| | Standard Deviation | 0.008875751 |
| | | |

# Lead Line & Sounding Pole Calibration Report

**Field unit: FA**

**Lead Line / Sounding Pole Identification Number: 20_02_05**

**Date of Calibration:04/28/2009**

**Method of Calibration:** **x Steel tape** **Permanent graduation marks** **Other**

**Location: Seattle, WA**

**Chief of Party: CDR Baird**

**Lead Line / Sounding Pole Unit of Measure:** Meters (measured from bottom of lead to bottom of mark)

| Measured by: DF/BN/JL | Recorded by: DF | Checked by: |
|---|---|---|
| **Graduated Marking (a)** | **Calibration Measurement (b)** | **Lead Line Corrector (c = b - a)** |
| 1 | 1.004 | 0.004 |
| 2 | 1.998 | -0.002 |
| 3 | 2.992 | -0.008 |
| 4 | 3.988 | -0.012 |
| 5 | 4.98 | -0.02 |
| 6 | 5.974 | -0.026 |
| 7 | 6.97 | -0.03 |
| 8 | 7.967 | -0.033 |
| 9 | 8.962 | -0.038 |
| 10 | 9.955 | -0.045 |
| 11 | 10.9887 | -0.0113 |
| 12 | 11.989 | -0.011 |
| 13 | 12.985 | -0.015 |
| 14 | 13.985 | -0.015 |
| 15 | 14.987 | -0.013 |
| 16 | 15.985 | -0.015 |
| 17 | 16.985 | -0.015 |
| 18 | 17.987 | -0.013 |
| 19 | 18.99 | -0.01 |
| 20 | 19.99 | -0.01 |
| | Average Correction | -0.016915 |
| | Standard Deviation | 0.011978809 |
| | | |

# Lead Line & Sounding Pole Calibration Report

**Field unit: FA**

**Lead Line / Sounding Pole Identification Number: 30_01_03 (Lead 10_02_04)**

**Date of Calibration: 04/28/2009**

**Method of Calibration: x Steel tape Permanent graduation marks Other**

**Location: Seattle, WA**

**Chief of Party: CDR Baird**

**Lead Line / Sounding Pole Unit of Measure:** Meters (measured from bottom of lead to bottom of mark)

| **Measured by: DF/BN/MA** | **Recorded by: DF** | **Checked by:** |
|---|---|---|
| **Graduated Marking (a)** | **Calibration Measurement (b)** | **Lead Line Corrector (c = b - a)** |
| 1 | 0.998 | -0.002 |
| 2 | 1.975 | -0.025 |
| 3 | 2.973 | -0.027 |
| 4 | 3.996 | -0.004 |
| 5 | 4.965 | -0.035 |
| 6 | 5.961 | -0.039 |
| 7 | 6.966 | -0.034 |
| 8 | 7.959 | -0.041 |
| 9 | 8.955 | -0.045 |
| 10 | 9.952 | -0.048 |
| 11 | 10.958 | -0.042 |
| 12 | 11.953 | -0.047 |
| 13 | 12.954 | -0.046 |
| 14 | 13.949 | -0.051 |
| 15 | 14.949 | -0.051 |
| 16 | 15.95 | -0.05 |
| 17 | 16.948 | -0.052 |
| 18 | 17.951 | -0.049 |
| 19 | 18.968 | -0.032 |
| 20 | 19.974 | -0.026 |
| 21 | 20.976 | -0.024 |
| 22 | 21.953 | -0.047 |
| 23 | 22.956 | -0.044 |
| 24 | 23.965 | -0.035 |
| 25 | 24.955 | -0.045 |
| 26 | 25.953 | -0.047 |
| 27 | 26.95 | -0.05 |
| 28 | 27.956 | -0.044 |
| 29 | 28.951 | -0.049 |
| 30 | 29.957 | -0.043 |
| | Average Correction | -0.03 |
| | Standard Deviation | 0.015937377 |
| | | |

# SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 4585
CALIBRATION DATE: 24-Dec-08

SBE19plus TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS
a0 = 1.152958e-003
a1 = 2.769577e-004
a2 = -1.238595e-006
a3 = 1.923712e-007

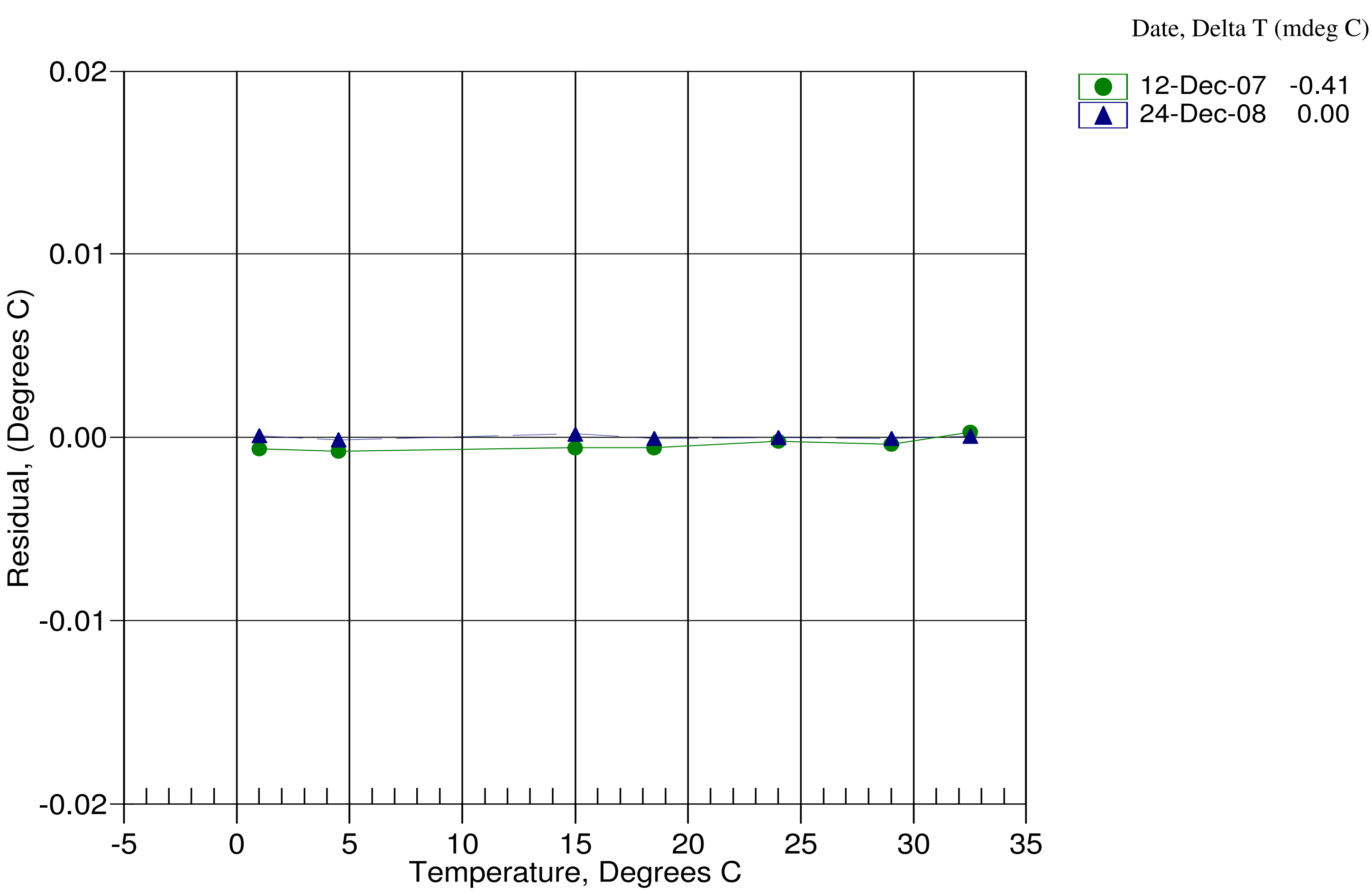
| BATH TEMP (ITS-90) | INSTRUMENT OUTPUT(n) | INST TEMP (ITS-90) | RESIDUAL (ITS-90) |
|---|---|---|---|
| 1.0000 | 686671.898 | 1.0001 | 0.0001 |
| 4.5000 | 613990.153 | 4.4999 | -0.0001 |
| 15.0000 | 430449.356 | 15.0002 | 0.0002 |
| 18.5000 | 380356.864 | 18.4999 | -0.0001 |
| 24.0000 | 311746.237 | 24.0000 | -0.0000 |
| 29.0001 | 259029.610 | 29.0000 | -0.0001 |
| 32.5000 | 226970.136 | 32.5001 | 0.0001 |

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



**SEA-BIRD ELECTRONICS, INC.**
1808 136th Place N.E., Bellevue, Washington, 98005 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 4585
CALIBRATION DATE: 24-Dec-08

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

COEFFICIENTS:

g = -1.030096e+000
h = 1.490529e-001
i = -1.755436e-004
j = 3.495131e-005

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

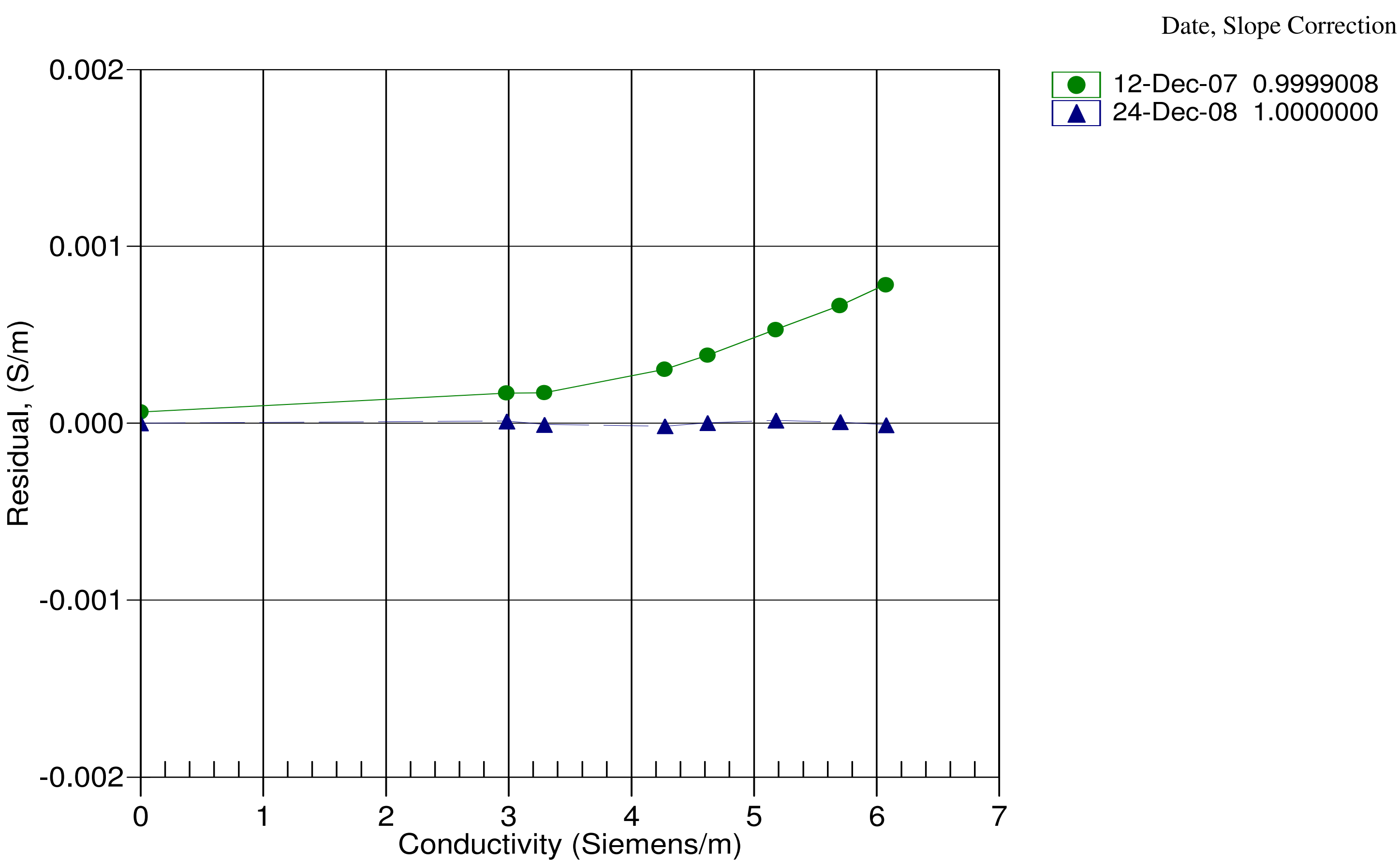
| BATH TEMP (ITS-90) | BATH SAL (PSU) | BATH COND (Siemens/m) | INST FREQ (Hz) | INST COND (Siemens/m) | RESIDUAL (Siemens/m) |
|---|---|---|---|---|---|
| 22.0000 | 0.0000 | 0.00000 | 2630.81 | 0.0000 | 0.00000 |
| 1.0000 | 34.9056 | 2.98287 | 5188.24 | 2.9829 | 0.00001 |
| 4.5000 | 34.8856 | 3.29062 | 5382.83 | 3.2906 | -0.00001 |
| 15.0000 | 34.8424 | 4.27448 | 5961.81 | 4.2745 | -0.00002 |
| 18.5000 | 34.8329 | 4.62033 | 6152.16 | 4.6203 | 0.00000 |
| 24.0000 | 34.8221 | 5.17939 | 6447.70 | 5.1794 | 0.00002 |
| 29.0001 | 34.8149 | 5.70213 | 6711.97 | 5.7021 | 0.00001 |
| 32.5000 | 34.8105 | 6.07509 | 6894.15 | 6.0751 | -0.00001 |

f = INST FREQ / 1000.0

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

t = temperature[°C)]; p = pressure[decibars]; $\delta$ = CTcor; $\epsilon$ = CPcor;

Residual = instrument conductivity - bath conductivity



# SEA-BIRD ELECTRONICS, INC.

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


SENSOR SERIAL NUMBER: 4585
CALIBRATION DATE: 29-Dec-08

SBE19plus PRESSURE CALIBRATION DATA
5076 psia S/N 5433

COEFFICIENTS:

| | |
|---|---|
| PA0 = 5.029148e-001 | PTCA0 = 5.087931e+005 |
| PA1 = 1.546002e-002 | PTCA1 = -1.387413e+000 |
| PA2 = -6.698233e-010 | PTCA2 = 1.147553e-001 |
| PTEMPA0 = -6.561551e+001 | PTCB0 = 2.398063e+001 |
| PTEMPA1 = 5.126876e+001 | PTCB1 = -2.075000e-003 |
| PTEMPA2 = -2.271790e-001 | PTCB2 = 0.000000e+000 |

PRESSURE SPAN CALIBRATION

| PRESSURE PSIA | INST OUTPUT | THERMISTOR OUTPUT | COMPUTED PRESSURE | ERROR %FSR |
|---|---|---|---|---|
| 14.43 | 509698.5 | 1.6 | 14.38 | -0.00 |
| 1026.03 | 575213.9 | 1.6 | 1025.77 | -0.01 |
| 2037.81 | 641125.8 | 1.6 | 2037.49 | -0.01 |
| 3049.21 | 707405.4 | 1.6 | 3049.00 | -0.00 |
| 4061.89 | 774171.3 | 1.6 | 4061.98 | 0.00 |
| 5073.45 | 841224.4 | 1.6 | 5073.30 | -0.00 |
| 4060.64 | 774087.2 | 1.6 | 4060.79 | 0.00 |
| 3049.89 | 707478.4 | 1.6 | 3050.21 | 0.01 |
| 2037.97 | 641159.4 | 1.6 | 2038.09 | 0.00 |
| 1026.00 | 575237.5 | 1.6 | 1026.17 | 0.00 |
| 14.44 | 509714.6 | 1.6 | 14.59 | 0.00 |

THERMAL CORRECTION

| TEMP ITS90 | THERMISTOR OUTPUT | INST OUTPUT |
|---|---|---|
| 32.50 | 1.93 | 509770.31 |
| 29.00 | 1.86 | 509746.37 |
| 24.00 | 1.76 | 509720.20 |
| 18.50 | 1.65 | 509705.55 |
| 15.00 | 1.58 | 509700.64 |
| 4.50 | 1.38 | 509686.80 |
| 1.00 | 1.31 | 509690.08 |

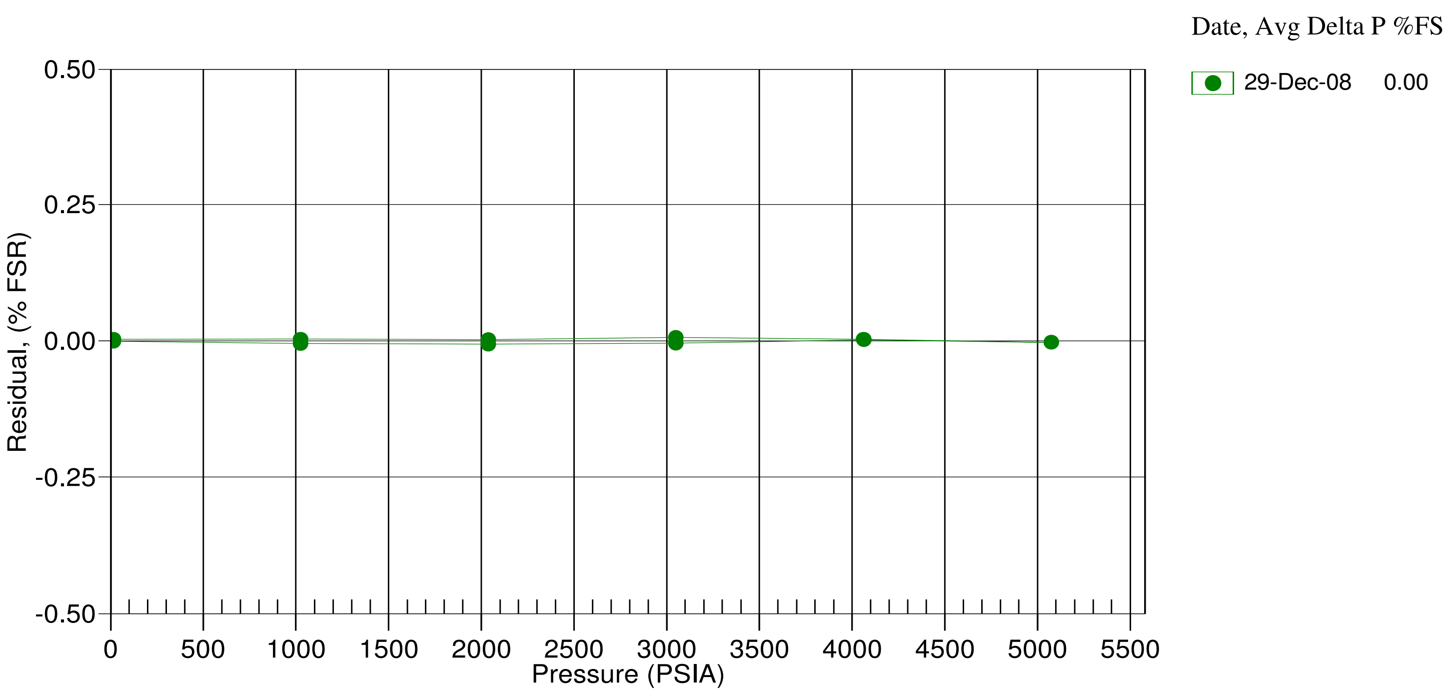
| TEMP(ITS90) | SPAN(mV) |
|---|---|
| -5.00 | 23.99 |
| 35.00 | 23.91 |

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

$x = \text{pressure output} - PTCA0 - PTCA1 * t - PTCA2 * t^2$

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

$\text{pressure (psia)} = PA0 + PA1 * n + PA2 * n^2$



SBE
# SEA-BIRD ELECTRONICS, INC.
1808 - 136th Place Northeast, Bellevue, Washington 98005 USA
Phone: (425) 643-9866 Fax: (425) 643-9954 www.seabird.com

## Conductivity Calibration Report

| | |
|---|---|
| **Customer:** | Pacific Marine Center / NOAA |

| | | | |
|---|---|---|---|
| **Job Number:** | 53036 | **Date of Report:** | 12/29/2008 |
| **Model Number** | SBE 19Plus | **Serial Number:** | 19P36026-4585 |

*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: 12/24/2008 Drift since last cal: -0.00020 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.*

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# *Temperature Calibration Report*

| | | | |
|---|---|---|---|
| **Customer:** | Pacific Marine Center / NOAA | | |
| **Job Number:** | 53036 | **Date of Report:** | 12/29/2008 |
| **Model Number** | SBE 19Plus | **Serial Number:** | 19P36026-4585 |

***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: 12/24/2008 Drift since last cal: +0.00040 **Degrees Celsius/year**

Comments:

**'CALIBRATION AFTER REPAIR'** ☐ Performed ☑ Not Performed

Date: Drift since Last cal: **Degrees Celsius/year**

Comments:

# SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 4616
CALIBRATION DATE: 30-Dec-08

SBE19plus TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

a0 = 1.281404e-003
a1 = 2.533926e-004
a2 = 1.063479e-006
a3 = 1.058343e-007

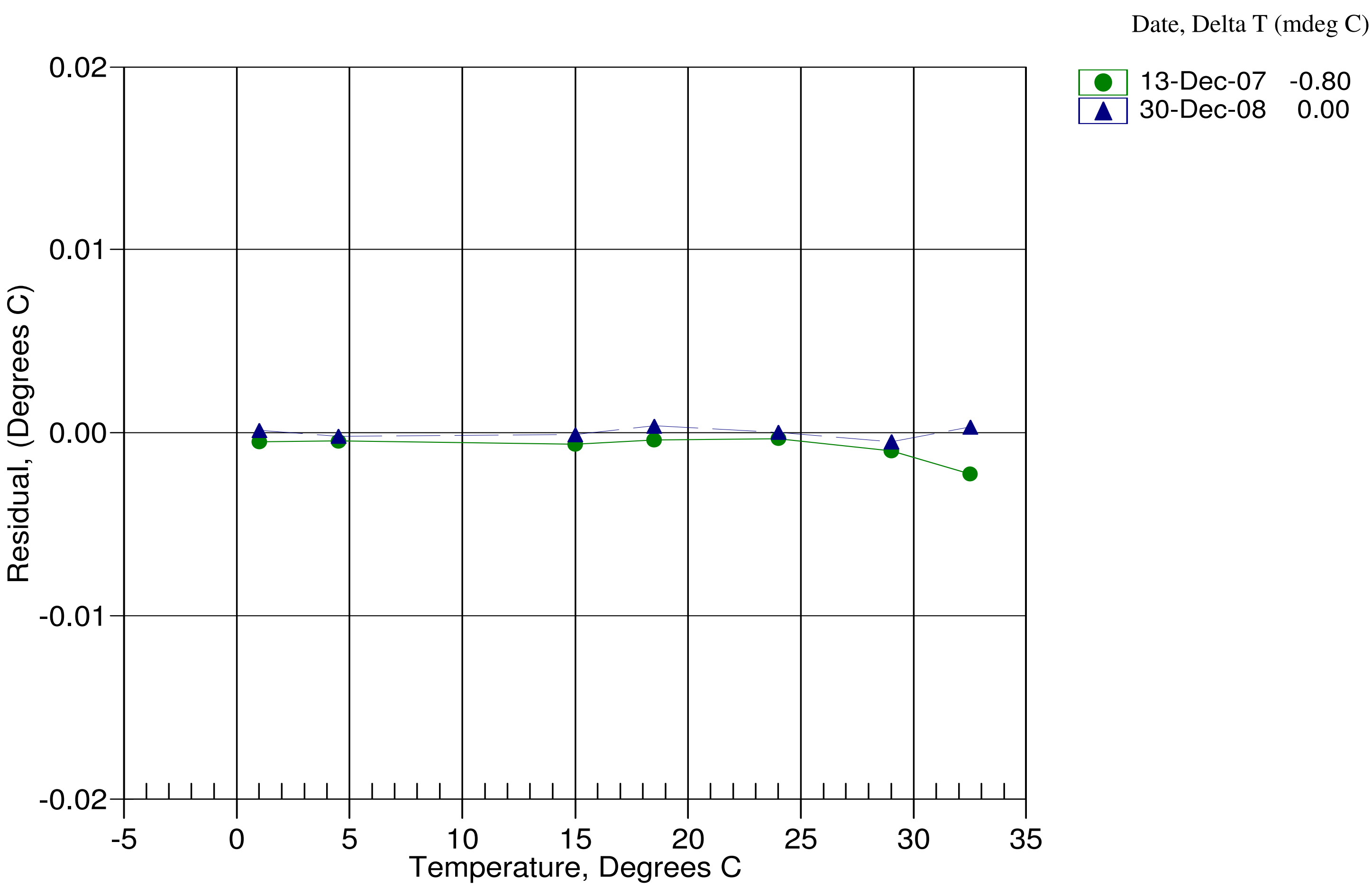
| BATH TEMP (ITS-90) | INSTRUMENT OUTPUT(n) | INST TEMP (ITS-90) | RESIDUAL (ITS-90) |
|---|---|---|---|
| 1.0000 | 622339.390 | 1.0001 | 0.0001 |
| 4.5000 | 552555.458 | 4.4998 | -0.0002 |
| 15.0000 | 379373.339 | 14.9999 | -0.0001 |
| 18.5000 | 332879.949 | 18.5004 | 0.0004 |
| 24.0000 | 269786.136 | 24.0000 | 0.0000 |
| 29.0000 | 221773.322 | 28.9995 | -0.0005 |
| 32.5001 | 192769.169 | 32.5004 | 0.0003 |

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



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SENSOR SERIAL NUMBER: 4616
CALIBRATION DATE: 30-Dec-08

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

COEFFICIENTS:

g = -1.045676e+000
h = 1.453624e-001
i = -2.792262e-004
j = 4.047864e-005

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

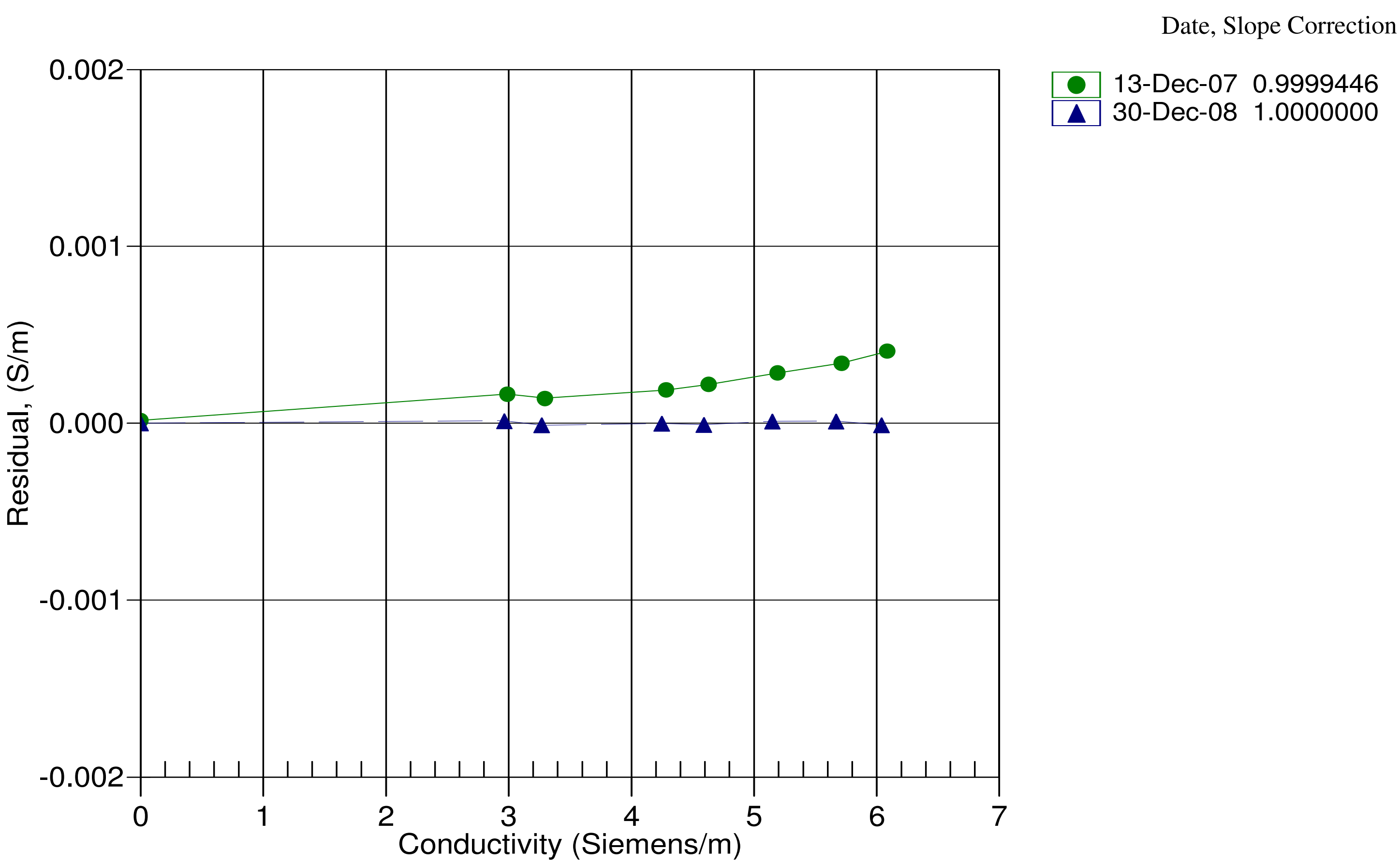
| BATH TEMP (ITS-90) | BATH SAL (PSU) | BATH COND (Siemens/m) | INST FREQ (Hz) | INST COND (Siemens/m) | RESIDUAL (Siemens/m) |
|---|---|---|---|---|---|
| 22.0000 | 0.0000 | 0.00000 | 2686.32 | 0.0000 | 0.00000 |
| 1.0000 | 34.6635 | 2.96415 | 5258.47 | 2.9642 | 0.00001 |
| 4.5000 | 34.6435 | 3.27002 | 5454.79 | 3.2700 | -0.00001 |
| 15.0000 | 34.6004 | 4.24792 | 6039.09 | 4.2479 | -0.00000 |
| 18.5000 | 34.5912 | 4.59172 | 6231.25 | 4.5917 | -0.00001 |
| 24.0000 | 34.5806 | 5.14743 | 6529.62 | 5.1474 | 0.00001 |
| 29.0000 | 34.5733 | 5.66698 | 6796.43 | 5.6670 | 0.00001 |
| 32.5001 | 34.5689 | 6.03772 | 6980.38 | 6.0377 | -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]; $\delta$ = CTcor; $\varepsilon$ = CPcor;

Residual = instrument conductivity - bath conductivity



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

SENSOR SERIAL NUMBER: 4616
CALIBRATION DATE: 23-Dec-08

SBE19plus PRESSURE CALIBRATION DATA
1450 psia S/N 5512

COEFFICIENTS:

PA0 = 8.151393e-001
PA1 = 4.427036e-003
PA2 = -1.489407e-011
PTEMPA0 = -7.628063e+001
PTEMPA1 = 4.917975e+001
PTEMPA2 = -2.452670e-001

PTCA0 = 5.204151e+005
PTCA1 = 1.499910e+001
PTCA2 = -2.797969e-001
PTCB0 = 2.473825e+001
PTCB1 = 5.000000e-005
PTCB2 = 0.000000e+000

PRESSURE SPAN CALIBRATION

| PRESSURE PSIA | INST OUTPUT | THERMISTOR OUTPUT | COMPUTED PRESSURE | ERROR %FSR |
|---|---|---|---|---|
| 14.56 | 523716.6 | 2.0 | 14.62 | 0.00 |
| 300.91 | 588379.6 | 2.0 | 300.80 | -0.01 |
| 587.28 | 653125.0 | 2.0 | 587.23 | -0.00 |
| 873.71 | 717921.0 | 2.0 | 873.75 | 0.00 |
| 1160.12 | 782709.1 | 2.0 | 1160.11 | -0.00 |
| 1446.59 | 847531.7 | 2.0 | 1446.51 | -0.01 |
| 1160.83 | 782900.4 | 2.0 | 1160.96 | 0.01 |
| 587.26 | 653145.1 | 2.0 | 587.32 | 0.00 |
| 300.86 | 588375.3 | 2.0 | 300.78 | -0.01 |
| 14.56 | 523715.6 | 2.0 | 14.61 | 0.00 |

THERMAL CORRECTION

| TEMP ITS90 | THERMISTOR OUTPUT | INST OUTPUT |
|---|---|---|
| 32.50 | 2.24 | 523831.27 |
| 29.00 | 2.16 | 523832.41 |
| 24.00 | 2.06 | 523825.60 |
| 18.50 | 1.95 | 523815.10 |
| 15.00 | 1.87 | 523797.80 |
| 4.50 | 1.66 | 523711.29 |
| 1.00 | 1.58 | 523637.33 |

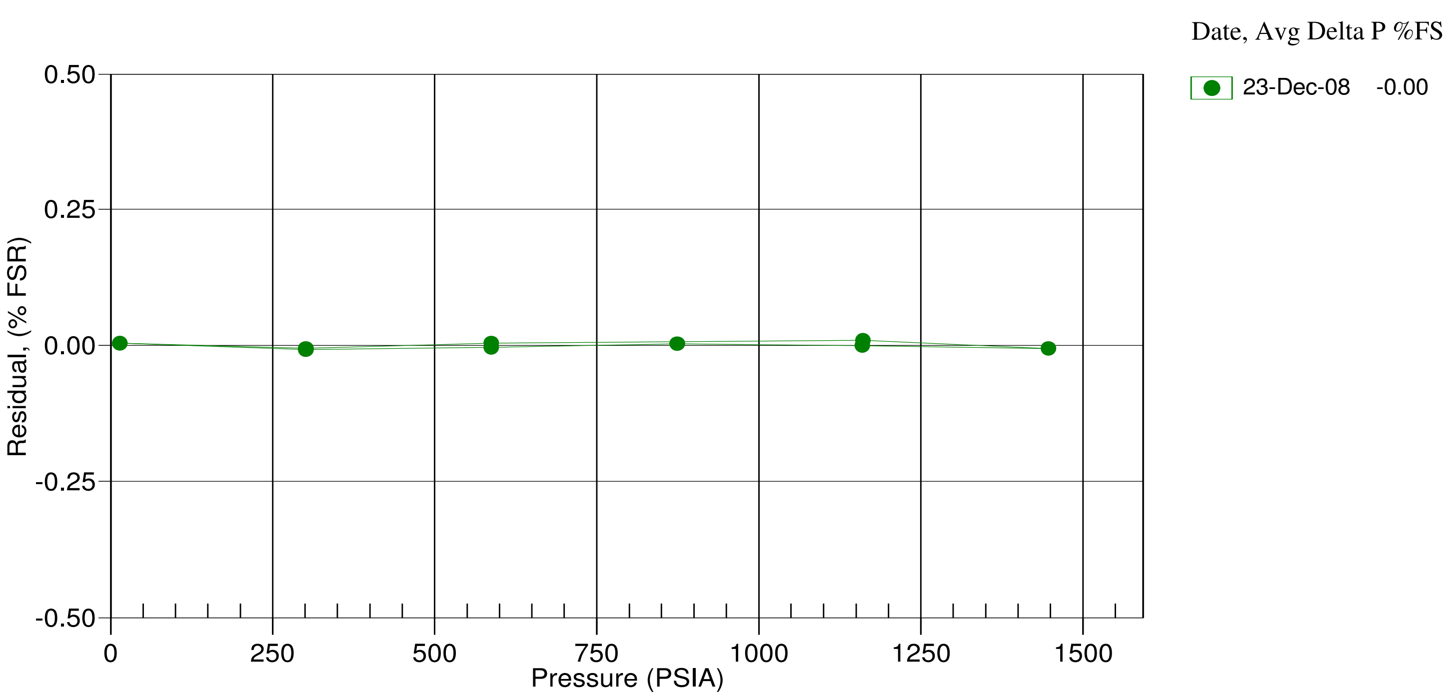
| TEMP(ITS90) | SPAN(mV) |
|---|---|
| -5.00 | 24.74 |
| 35.00 | 24.74 |

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

$x = \text{pressure output} - PTCA0 - PTCA1 * t - PTCA2 * t^2$

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

$\text{pressure (psia)} = PA0 + PA1 * n + PA2 * n^2$



SBE **SEA-BIRD ELECTRONICS, INC.**
**1808 - 136th Place Northeast, Bellevue, Washington 98005 USA**
**Phone: (425) 643-9866   Fax: (425) 643-9954  www.seabird.com**

# *Temperature Calibration Report*

| | | | |
|---|---|---|---|
| **Customer:** | Pacific Marine Center / NOAA | | |
| **Job Number:** | 53036 | **Date of Report:** | 12/30/2008 |
| **Model Number** | SBE 19Plus | **Serial Number:** | 19P36026-4616 |

***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: 12/30/2008 Drift since last cal: +0.00077 **Degrees Celsius/year**

Comments:

**'CALIBRATION AFTER REPAIR'** ☐ Performed ☑ Not Performed

Date: Drift since Last cal: **Degrees Celsius/year**

Comments:

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**Phone: (425) 643-9866 Fax: (425) 643-9954 www.seabird.com**

# *Conductivity Calibration Report*

| | | | |
|---|---|---|---|
| **Customer:** | Pacific Marine Center / NOAA | | |
| **Job Number:** | 53036 | **Date of Report:** | 12/30/2008 |
| **Model Number** | SBE 19Plus | **Serial Number:** | 19P36026-4616 |

***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: 12/30/2008 Drift since last cal: +0.00010 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.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

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


SENSOR SERIAL NUMBER: 4617
CALIBRATION DATE: 20-Dec-08

SBE19plus TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

a0 = 1.246846e-003
a1 = 2.697109e-004
a2 = -7.052860e-007
a3 = 1.823959e-007

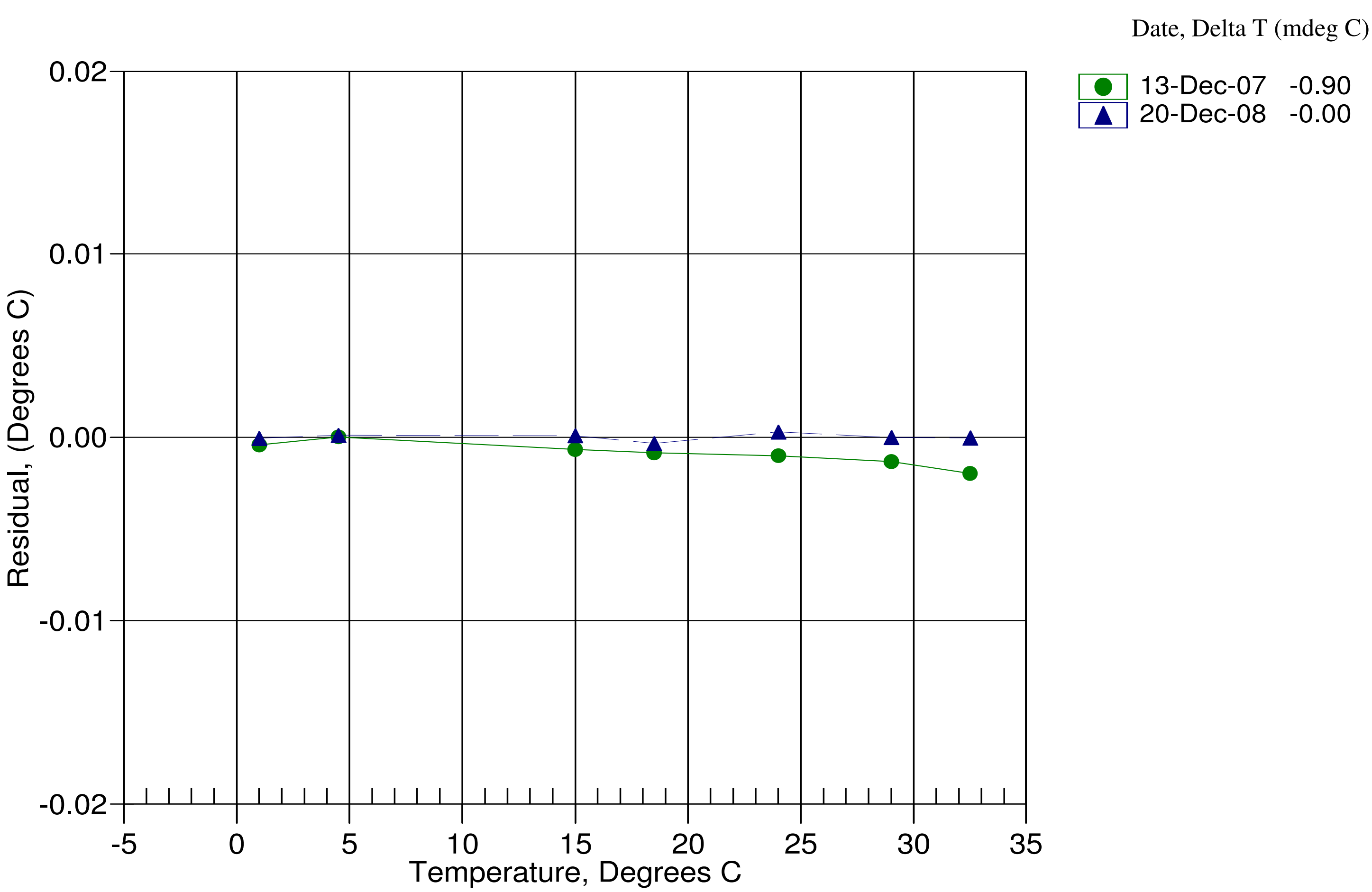
| BATH TEMP (ITS-90) | INSTRUMENT OUTPUT(n) | INST TEMP (ITS-90) | RESIDUAL (ITS-90) |
|---|---|---|---|
| 1.0000 | 585630.424 | 0.9999 | -0.0001 |
| 4.5000 | 518793.136 | 4.5001 | 0.0001 |
| 15.0000 | 354138.373 | 15.0001 | 0.0001 |
| 18.5000 | 310211.898 | 18.4997 | -0.0003 |
| 24.0000 | 250739.695 | 24.0003 | 0.0003 |
| 29.0000 | 205606.492 | 29.0000 | -0.0000 |
| 32.5000 | 178394.119 | 32.5000 | -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



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


SENSOR SERIAL NUMBER: 4617
CALIBRATION DATE: 20-Dec-08

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

COEFFICIENTS:

g = -1.000141e+000
h = 1.279500e-001
i = -2.981125e-004
j = 3.615456e-005

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

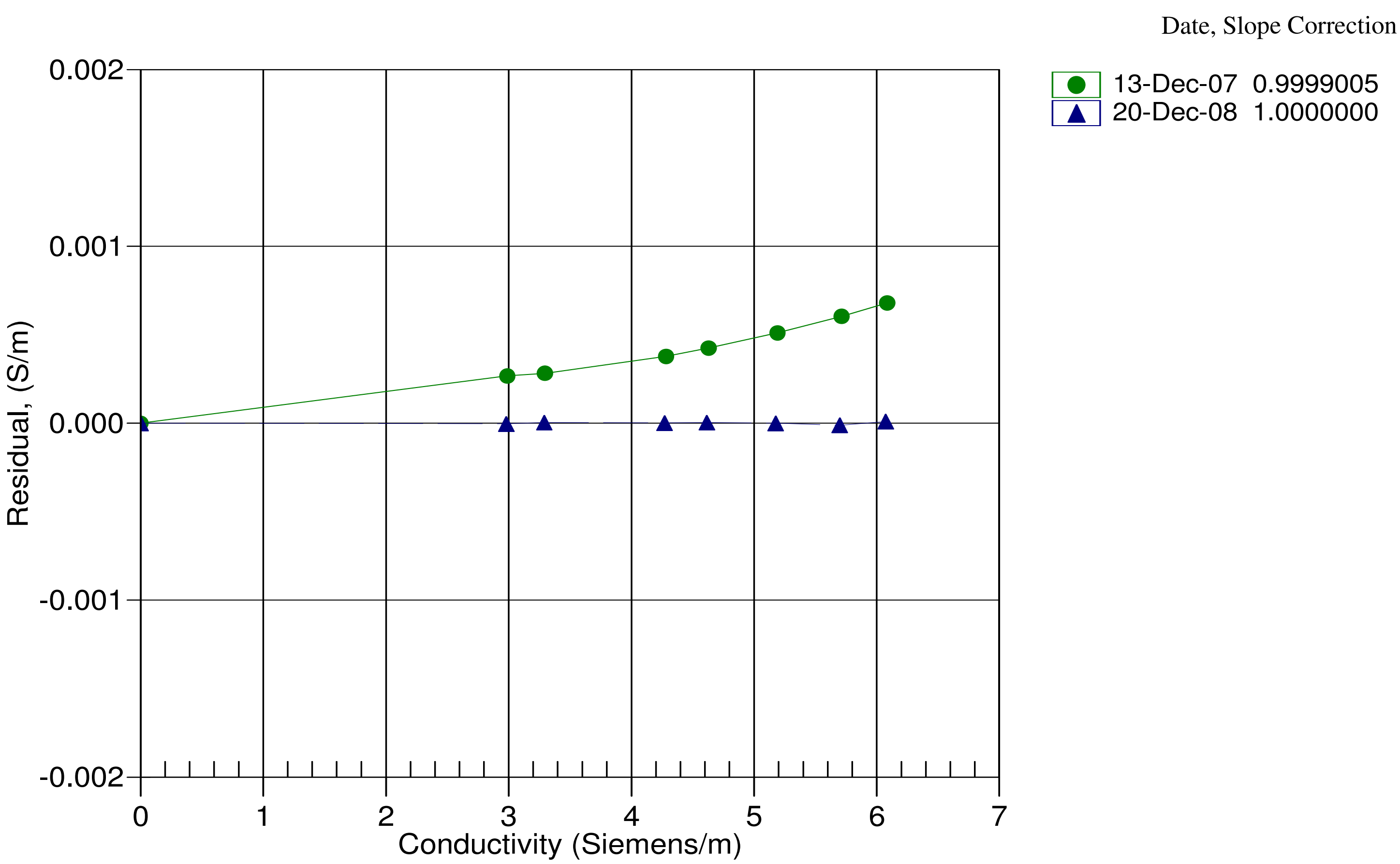
| BATH TEMP (ITS-90) | BATH SAL (PSU) | BATH COND (Siemens/m) | INST FREQ (Hz) | INST COND (Siemens/m) | RESIDUAL (Siemens/m) |
|---|---|---|---|---|---|
| 22.0000 | 0.0000 | 0.00000 | 2801.87 | 0.0000 | 0.00000 |
| 1.0000 | 34.8741 | 2.98043 | 5589.41 | 2.9804 | -0.00000 |
| 4.5000 | 34.8541 | 3.28794 | 5800.77 | 3.2879 | 0.00000 |
| 15.0000 | 34.8109 | 4.27102 | 6429.24 | 4.2710 | 0.00000 |
| 18.5000 | 34.8011 | 4.61657 | 6635.72 | 4.6166 | 0.00000 |
| 24.0000 | 34.7896 | 5.17509 | 6956.19 | 5.1751 | -0.00000 |
| 29.0000 | 34.7810 | 5.69719 | 7242.59 | 5.6972 | -0.00001 |
| 32.5000 | 34.7748 | 6.06957 | 7439.93 | 6.0696 | 0.00001 |

f = INST FREQ / 1000.0

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

t = temperature[°C)]; p = pressure[decibars]; $\delta$ = CTcor; $\epsilon$ = CPcor;

Residual = instrument conductivity - bath conductivity



# SEA-BIRD ELECTRONICS, INC.

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SENSOR SERIAL NUMBER: 4617
CALIBRATION DATE: 23-Dec-08

SBE19plus PRESSURE CALIBRATION DATA
1450 psia S/N 5513

COEFFICIENTS:

PA0 = -6.055955e-001
PA1 = 4.445261e-003
PA2 = -1.492962e-011
PTEMPA0 = -7.890859e+001
PTEMPA1 = 4.909915e+001
PTEMPA2 = -3.861224e-001

PTCA0 = 5.192474e+005
PTCA1 = -1.257329e+001
PTCA2 = 2.871586e-001
PTCB0 = 2.460838e+001
PTCB1 = 6.750000e-004
PTCB2 = 0.000000e+000

PRESSURE SPAN CALIBRATION

| PRESSURE PSIA | INST OUTPUT | THERMISTOR OUTPUT | COMPUTED PRESSURE | ERROR %FSR |
|---|---|---|---|---|
| 14.56 | 522528.9 | 2.0 | 14.57 | 0.00 |
| 300.91 | 586983.0 | 2.0 | 300.87 | -0.00 |
| 587.28 | 651477.4 | 2.0 | 587.23 | -0.00 |
| 873.71 | 716034.6 | 2.0 | 873.74 | 0.00 |
| 1160.12 | 780599.0 | 2.0 | 1160.16 | 0.00 |
| 1446.59 | 845193.3 | 2.0 | 1446.58 | -0.00 |
| 1160.83 | 780743.0 | 2.0 | 1160.80 | -0.00 |
| 587.26 | 651494.2 | 2.0 | 587.30 | 0.00 |
| 300.86 | 586980.7 | 2.0 | 300.86 | 0.00 |
| 14.56 | 522528.9 | 2.0 | 14.57 | 0.00 |

THERMAL CORRECTION

| TEMP ITS90 | THERMISTOR OUTPUT | INST OUTPUT |
|---|---|---|
| 32.50 | 2.31 | 522669.88 |
| 29.00 | 2.24 | 522666.19 |
| 24.00 | 2.13 | 522662.57 |
| 18.50 | 2.02 | 522651.21 |
| 15.00 | 1.94 | 522650.29 |
| 4.50 | 1.72 | 522724.31 |
| 1.00 | 1.65 | 522781.82 |

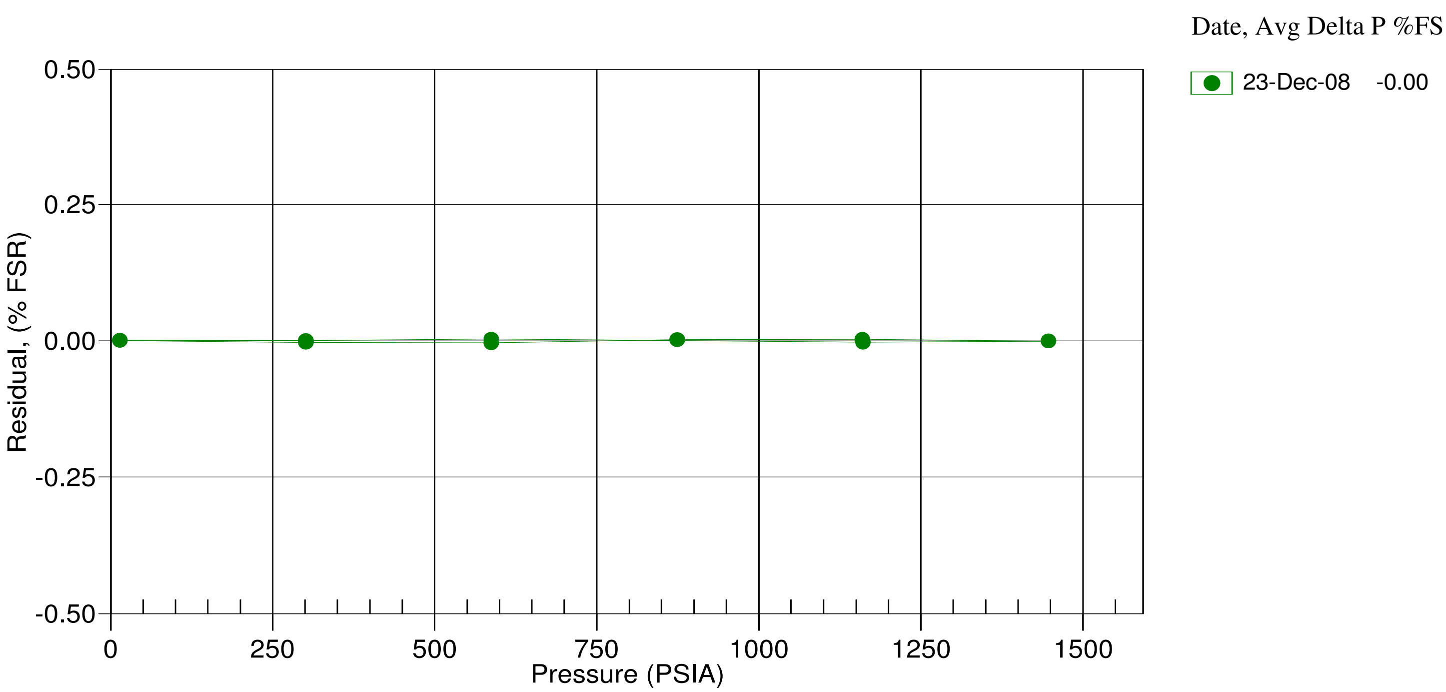
| TEMP(ITS90) | SPAN(mV) |
|---|---|
| -5.00 | 24.61 |
| 35.00 | 24.63 |

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

$x = \text{pressure output} - PTCA0 - PTCA1 * t - PTCA2 * t^2$

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

$\text{pressure (psia)} = PA0 + PA1 * n + PA2 * n^2$



SBE

SEA-BIRD ELECTRONICS, INC.

1808 - 136th Place Northeast, Bellevue, Washington 98005 USA

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

# Temperature Calibration Report

| | | | |
|---|---|---|---|
| **Customer:** | Pacific Marine Center / NOAA | | |
| **Job Number:** | 53036 | **Date of Report:** | 12/22/2008 |
| **Model Number** | SBE 19Plus | **Serial Number:** | 19P36026-4617 |

*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: 12/20/2008 Drift since last cal: +0.00088 **Degrees Celsius/year**

Comments:

**'CALIBRATION AFTER REPAIR'** ☐ Performed ☑ Not Performed

Date: Drift since Last cal: **Degrees Celsius/year**

Comments:

**SEA-BIRD ELECTRONICS, INC.**
**1808 - 136th Place Northeast, Bellevue, Washington 98005 USA**
**Phone: (425) 643-9866 Fax: (425) 643-9954 www.seabird.com**

# *Conductivity Calibration Report*

| | | | |
|---|---|---|---|
| **Customer:** | Pacific Marine Center / NOAA | | |
| **Job Number:** | 53036 | **Date of Report:** | 12/22/2008 |
| **Model Number** | SBE 19Plus | **Serial Number:** | 19P36026-4617 |

***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: 12/20/2008 Drift since last cal: -0.00020 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.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

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


SENSOR SERIAL NUMBER: 6121
CALIBRATION DATE: 28-Aug-08

SBE19plus TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

a0 = 1.289081e-003
a1 = 2.567873e-004
a2 = 1.103918e-007
a3 = 1.347008e-007

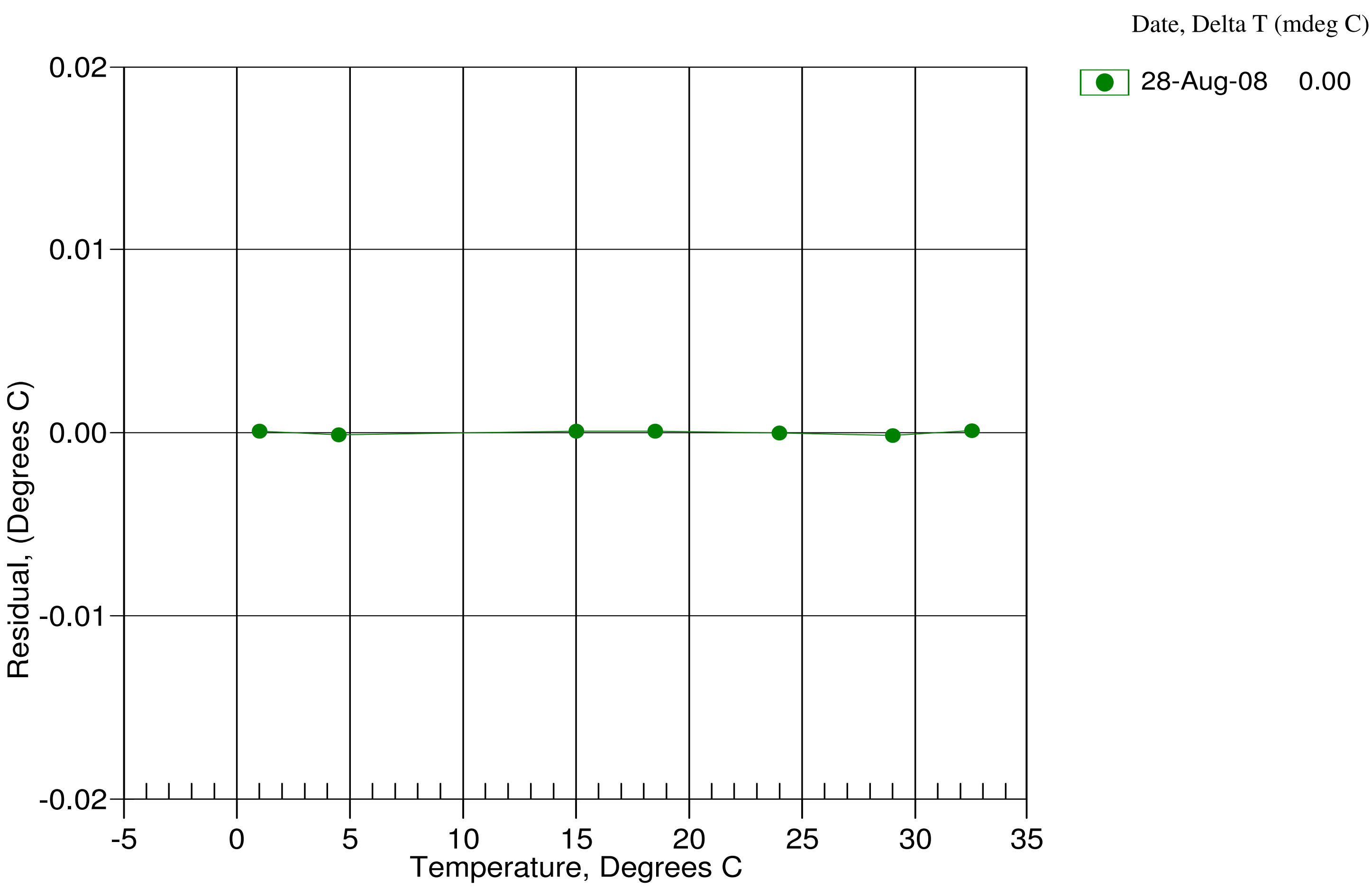
| BATH TEMP (ITS-90) | INSTRUMENT OUTPUT(n) | INST TEMP (ITS-90) | RESIDUAL (ITS-90) |
|---|---|---|---|
| 1.0000 | 648503.186 | 1.0001 | 0.0001 |
| 4.5000 | 575581.220 | 4.4999 | -0.0001 |
| 15.0000 | 394150.390 | 15.0001 | 0.0001 |
| 18.5000 | 345412.610 | 18.5001 | 0.0001 |
| 24.0000 | 279302.814 | 24.0000 | -0.0000 |
| 29.0001 | 229064.831 | 28.9999 | -0.0002 |
| 32.5000 | 198774.661 | 32.5001 | 0.0001 |

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



# SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

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


SENSOR SERIAL NUMBER: 6121
CALIBRATION DATE: 28-Aug-08

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

COEFFICIENTS:

g = -1.002097e+000
h = 1.438184e-001
i = -5.214257e-004
j = 5.901932e-005

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

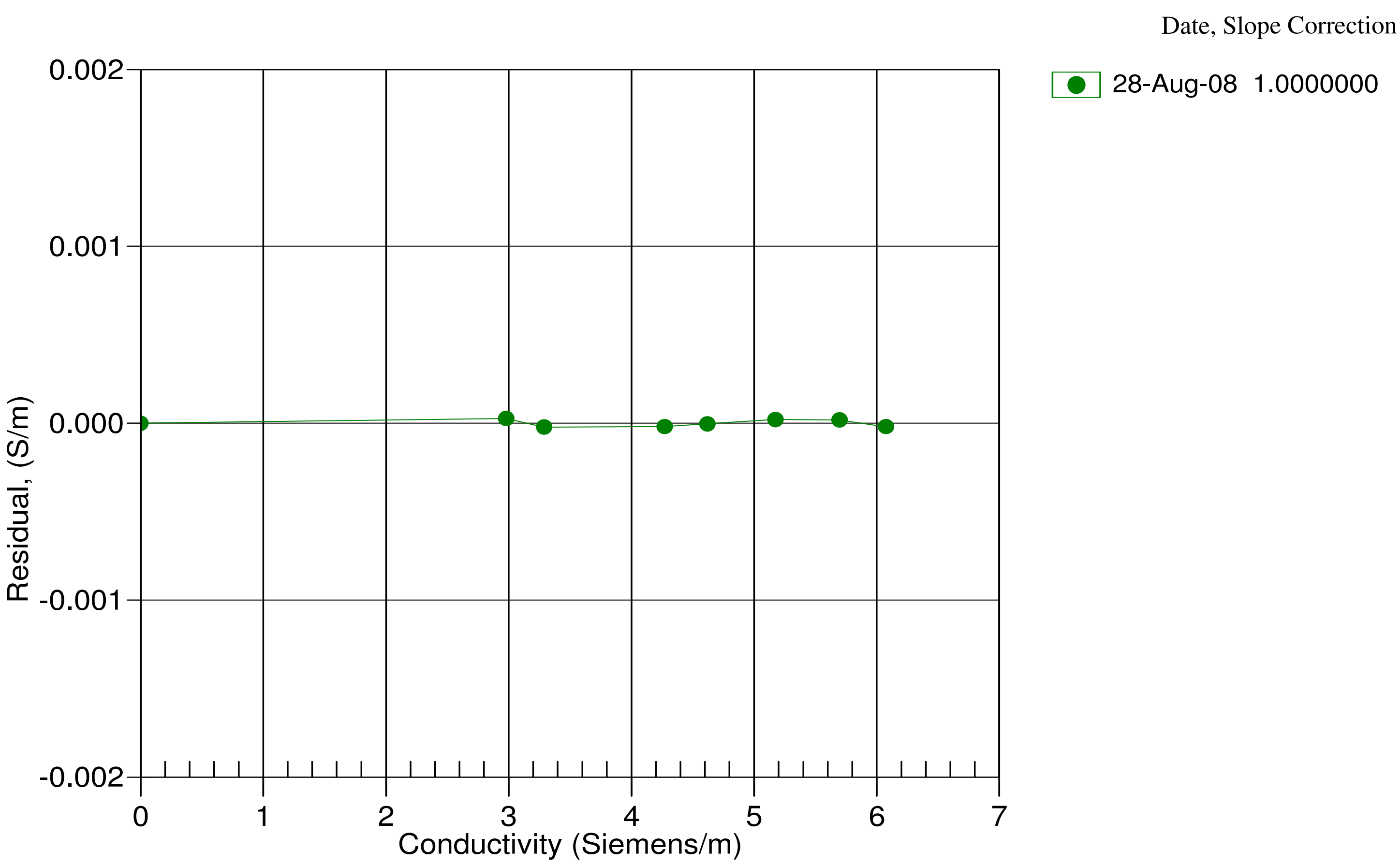
| BATH TEMP (ITS-90) | BATH SAL (PSU) | BATH COND (Siemens/m) | INST FREQ (Hz) | INST COND (Siemens/m) | RESIDUAL (Siemens/m) |
|---|---|---|---|---|---|
| 22.0000 | 0.0000 | 0.00000 | 2648.58 | 0.0000 | 0.00000 |
| 1.0000 | 34.8850 | 2.98128 | 5283.22 | 2.9813 | 0.00003 |
| 4.5000 | 34.8648 | 3.28885 | 5482.95 | 3.2888 | -0.00002 |
| 15.0000 | 34.8213 | 4.27216 | 6076.87 | 4.2721 | -0.00002 |
| 18.5000 | 34.8119 | 4.61785 | 6272.01 | 4.6178 | -0.00000 |
| 24.0000 | 34.8011 | 5.17661 | 6574.84 | 5.1766 | 0.00002 |
| 29.0001 | 34.7946 | 5.69917 | 6845.52 | 5.6992 | 0.00002 |
| 32.5000 | 34.7904 | 6.07198 | 7032.01 | 6.0720 | -0.00002 |

f = INST FREQ / 1000.0

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

t = temperature[°C)]; p = pressure[decibars]; $\delta$ = CTcor; $\epsilon$ = CPcor;

Residual = instrument conductivity - bath conductivity



# SEA-BIRD ELECTRONICS, INC.

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


SENSOR SERIAL NUMBER: 6121
CALIBRATION DATE: 26-Aug-08

SBE19plus PRESSURE CALIBRATION DATA
870 psia S/N 2752079

COEFFICIENTS:

```
PA0 =   -6.478769e-001          PTCA0 =  5.247839e+005
PA1 =    2.639452e-003          PTCA1 = -1.748425e+001
PA2 =    1.757831e-011          PTCA2 =  2.632259e-001
PTEMPA0 = -6.128910e+001        PTCB0 =  2.511463e+001
PTEMPA1 =  5.471751e+001        PTCB1 = -1.075000e-003
PTEMPA2 = -5.689142e-001        PTCB2 =  0.000000e+000
```

PRESSURE SPAN CALIBRATION

| PRESSURE PSIA | INST OUTPUT | THERMISTOR OUTPUT | COMPUTED PRESSURE | ERROR %FSR |
|---|---|---|---|---|
| 14.68 | 530344.0 | 1.5 | 14.69 | 0.00 |
| 179.95 | 592865.0 | 1.5 | 179.94 | -0.00 |
| 359.94 | 660894.0 | 1.5 | 359.90 | -0.00 |
| 539.94 | 728875.0 | 1.5 | 539.90 | -0.00 |
| 719.93 | 796800.0 | 1.5 | 719.91 | -0.00 |
| 874.90 | 855228.0 | 1.5 | 874.89 | -0.00 |
| 719.95 | 796828.0 | 1.5 | 719.99 | 0.00 |
| 539.97 | 728912.0 | 1.5 | 540.00 | 0.00 |
| 359.97 | 660927.0 | 1.5 | 359.99 | 0.00 |
| 179.96 | 592874.0 | 1.5 | 179.97 | 0.00 |
| 14.69 | 530337.0 | 1.5 | 14.68 | -0.00 |

THERMAL CORRECTION

| TEMP ITS90 | THERMISTOR OUTPUT | INST OUTPUT |
|---|---|---|
| 32.50 | 1.75 | 530426.41 |
| 29.00 | 1.68 | 530439.09 |
| 24.00 | 1.59 | 530454.71 |
| 18.50 | 1.48 | 530483.73 |
| 15.00 | 1.42 | 530518.13 |
| 4.50 | 1.22 | 530644.39 |
| 1.00 | 1.15 | 530705.47 |

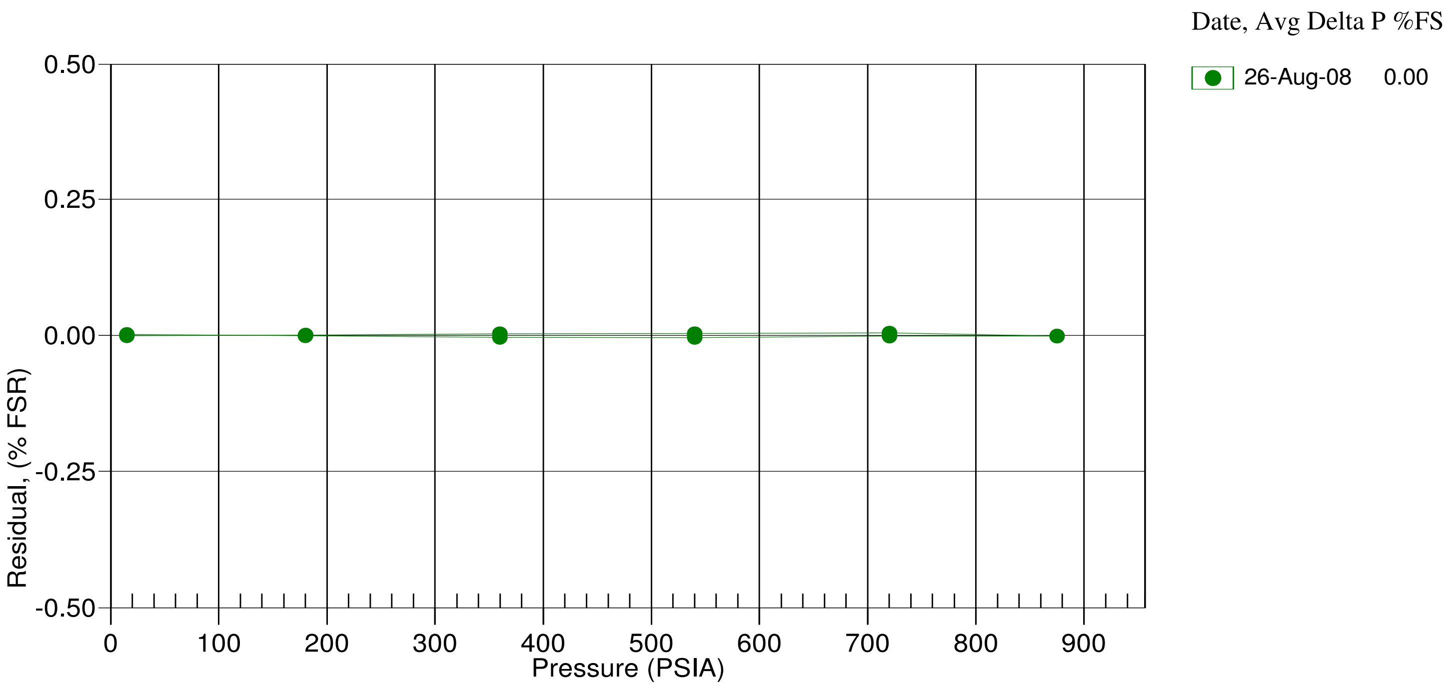
| TEMP(ITS90) | SPAN(mV) |
|---|---|
| -5.00 | 25.12 |
| 35.00 | 25.08 |

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

$x = \text{pressure output} - PTCA0 - PTCA1 * t - PTCA2 * t^2$

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

$\text{pressure (psia)} = PA0 + PA1 * n + PA2 * n^2$



# SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

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


SENSOR SERIAL NUMBER: 6122
CALIBRATION DATE: 28-Aug-08

SBE19plus TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

a0 = 1.310924e-003
a1 = 2.514962e-004
a2 = 7.231185e-007
a3 = 1.086082e-007

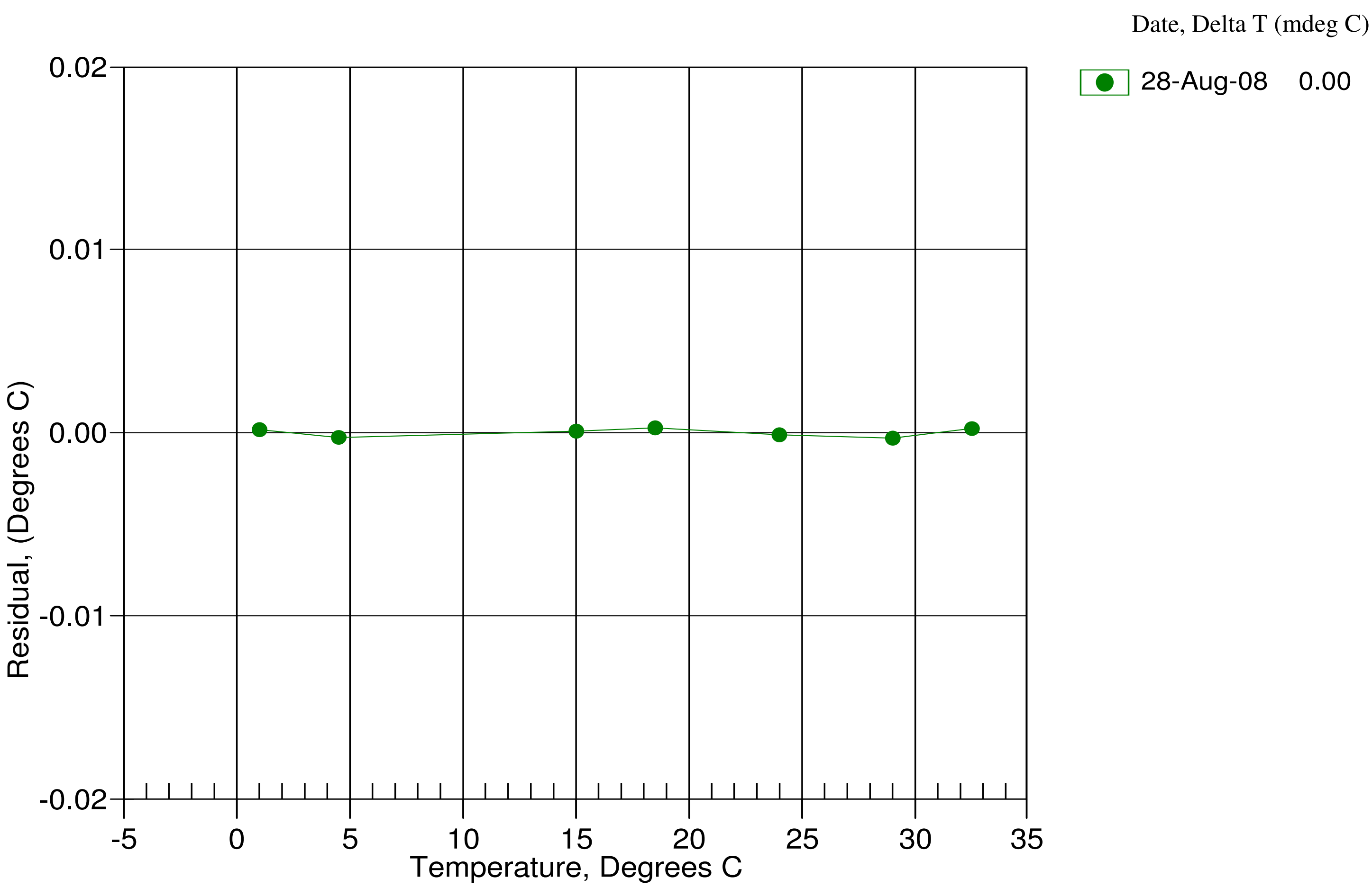
| BATH TEMP (ITS-90) | INSTRUMENT OUTPUT(n) | INST TEMP (ITS-90) | RESIDUAL (ITS-90) |
|---|---|---|---|
| 1.0000 | 640421.220 | 1.0002 | 0.0002 |
| 4.5000 | 567849.949 | 4.4997 | -0.0003 |
| 15.0000 | 387722.085 | 15.0001 | 0.0001 |
| 18.5000 | 339446.305 | 18.5003 | 0.0003 |
| 24.0000 | 274051.763 | 23.9999 | -0.0001 |
| 29.0001 | 224421.051 | 28.9998 | -0.0003 |
| 32.5000 | 194523.508 | 32.5002 | 0.0002 |

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



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SENSOR SERIAL NUMBER: 6122
CALIBRATION DATE: 28-Aug-08

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

COEFFICIENTS:

g = -9.949806e-001
h = 1.571158e-001
i = -4.874166e-004
j = 6.173091e-005

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

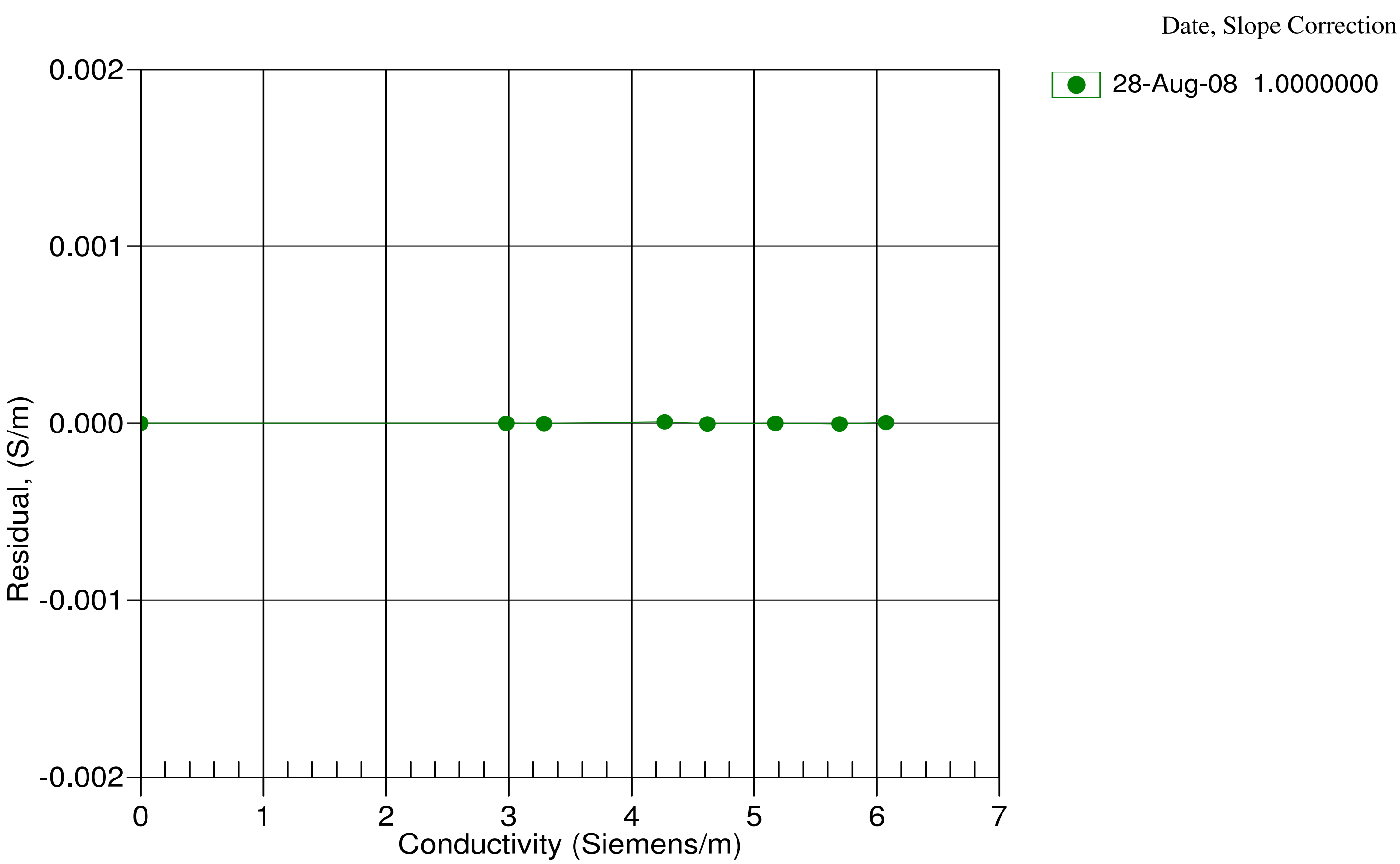
| BATH TEMP (ITS-90) | BATH SAL (PSU) | BATH COND (Siemens/m) | INST FREQ (Hz) | INST COND (Siemens/m) | RESIDUAL (Siemens/m) |
|---|---|---|---|---|---|
| 22.0000 | 0.0000 | 0.00000 | 2523.23 | 0.0000 | 0.00000 |
| 1.0000 | 34.8850 | 2.98128 | 5044.97 | 2.9813 | -0.00000 |
| 4.5000 | 34.8648 | 3.28885 | 5236.00 | 3.2888 | -0.00000 |
| 15.0000 | 34.8213 | 4.27216 | 5803.96 | 4.2722 | 0.00001 |
| 18.5000 | 34.8119 | 4.61785 | 5990.56 | 4.6178 | -0.00000 |
| 24.0000 | 34.8011 | 5.17661 | 6280.15 | 5.1766 | 0.00000 |
| 29.0001 | 34.7946 | 5.69917 | 6539.03 | 5.6992 | -0.00000 |
| 32.5000 | 34.7904 | 6.07198 | 6717.42 | 6.0720 | 0.00000 |

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]; $\delta$ = CTcor; $\varepsilon$ = CPcor;

Residual = instrument conductivity - bath conductivity



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SENSOR SERIAL NUMBER: 6122
CALIBRATION DATE: 26-Aug-08

SBE19plus PRESSURE CALIBRATION DATA
870 psia S/N 2752080

COEFFICIENTS:

| | |
|---|---|
| PA0 = -1.047938e-001 | PTCA0 = 5.243776e+005 |
| PA1 = 2.635617e-003 | PTCA1 = 1.680541e-001 |
| PA2 = 2.031440e-011 | PTCA2 = -1.070257e-001 |
| PTEMPA0 = -6.085315e+001 | PTCB0 = 2.507825e+001 |
| PTEMPA1 = 5.350080e+001 | PTCB1 = -5.500000e-004 |
| PTEMPA2 = -1.784269e-001 | PTCB2 = 0.000000e+000 |

PRESSURE SPAN CALIBRATION

| PRESSURE PSIA | INST OUTPUT | THERMISTOR OUTPUT | COMPUTED PRESSURE | ERROR %FSR |
|---|---|---|---|---|
| 14.68 | 529945.0 | 1.5 | 14.68 | 0.00 |
| 179.95 | 592575.0 | 1.5 | 179.92 | -0.00 |
| 359.94 | 660723.0 | 1.5 | 359.90 | -0.00 |
| 539.94 | 728813.0 | 1.5 | 539.91 | -0.00 |
| 719.93 | 796824.0 | 1.5 | 719.90 | -0.00 |
| 874.90 | 855331.0 | 1.5 | 874.89 | -0.00 |
| 719.95 | 796862.0 | 1.5 | 720.00 | 0.01 |
| 539.97 | 728851.0 | 1.5 | 540.01 | 0.00 |
| 359.97 | 660760.0 | 1.5 | 359.99 | 0.00 |
| 179.96 | 592598.0 | 1.5 | 179.98 | 0.00 |
| 14.69 | 529948.0 | 1.5 | 14.69 | 0.00 |

THERMAL CORRECTION

| TEMP ITS90 | THERMISTOR OUTPUT | INST OUTPUT |
|---|---|---|
| 32.50 | 1.75 | 530023.07 |
| 29.00 | 1.69 | 530041.09 |
| 24.00 | 1.60 | 530065.44 |
| 18.50 | 1.49 | 530093.22 |
| 15.00 | 1.43 | 530105.65 |
| 4.50 | 1.23 | 530137.68 |
| 1.00 | 1.16 | 530118.67 |

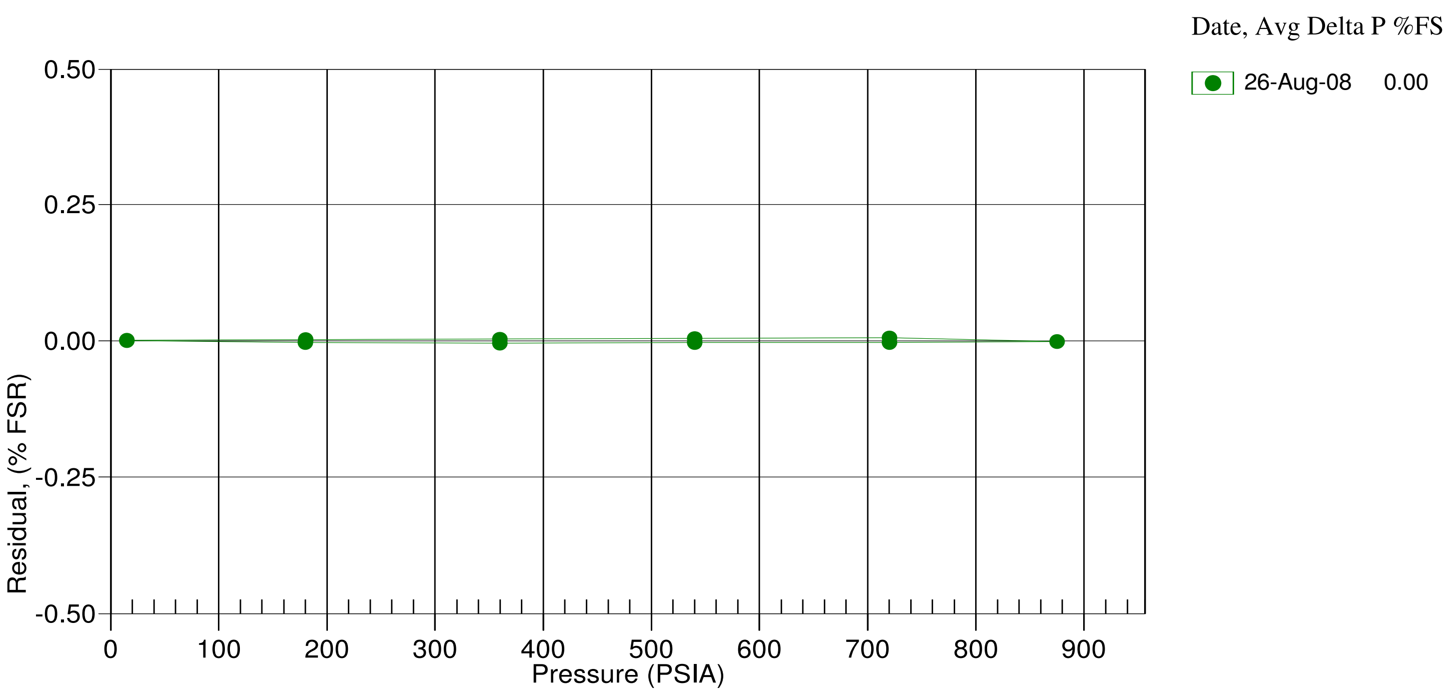
| TEMP(ITS90) | SPAN(mV) |
|---|---|
| -5.00 | 25.08 |
| 35.00 | 25.06 |

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

$x = \text{pressure output} - PTCA0 - PTCA1 * t - PTCA2 * t^2$

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

$\text{pressure (psia)} = PA0 + PA1 * n + PA2 * n^2$



APPLIED MICROSYSTEMS

# 004986 Certificate of Calibration

| | |
|---|---|
| Customer: | NOAA - Pacific Marine Center |
| Asset Serial Number: | 004986 |
| Asset Type: | 004986 (Smart SV&P) |
| Calibrated Pressure Range: | 1000 dBar |

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| | |
|---|---|
| Certification Date: | 02/10/2008 (dd/mm/yyyy) |
| Certified By: | |

Applied Microsystems Ltd.

Robert Haydock,
President
Applied Microsystems

Applied Microsystems certifies that the equipment described above has been calibrated with equipment referenced to traceable standards. Any repairs / calibrations completed on this instrument were approved by the instrument owner under purchase order.

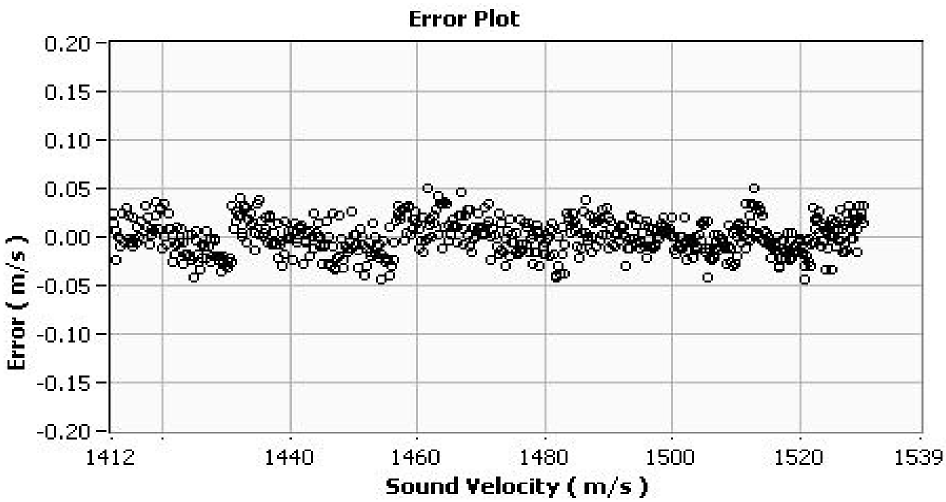
This instrument has been recalibrated. Please be sure to update your records. Please also ensure that you update the instrument's coefficient values in any post-processing software (ie. Smart Talk) that you use. Instrument configuration files are available at our Client Service & Support Portal (see web address below).

For a complete service history of this instrument, please consult our on-line Client Service & Support Portal at http://www.appliedmicrosystems.com/customers/index.htm

Applied Microsystems
2071 Malaview Avenue
Sidney, B.C. V8L 5X6 CANADA
Tel: +1-250-656-0771 Fax: +1-250-655-3655

# Sound Velocity Calibration

| | | | |
|---|---|---|---|
| **Date:** | 9/23/2008 | **RMS Error:** | 0.018 |
| **Instrument SN:** | 004986 | **Range:** | 1400 to 1550 m/s |
| **Calibrator:** | Les Woodland | | |




m/s=A+B*((NH-N)/(NH-NL))+C*((NH-N)/(NH-NL))^2+D*((NH-N)/(NH-NL))^3

## Coefficients

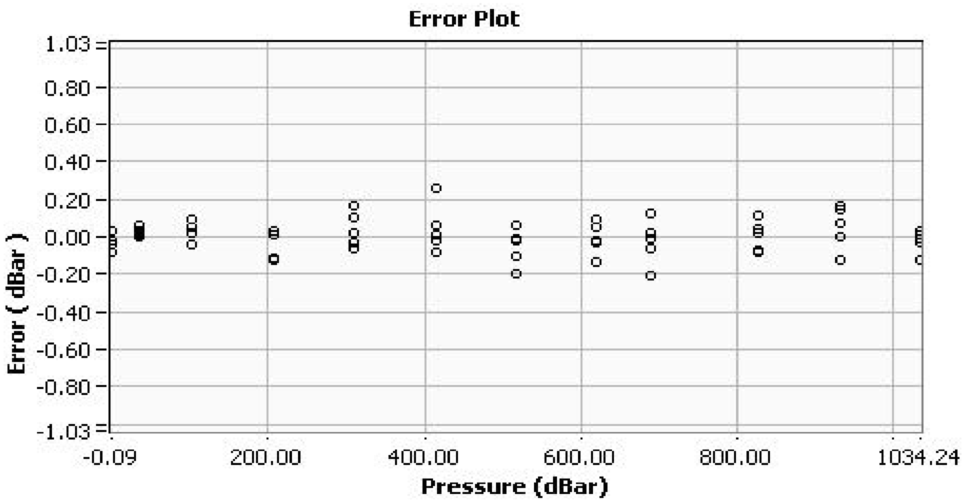
**A=1.521719E+3**
**B=-1.065195E+2**
**C=8.413916E+0**
**D=-7.328216E-1**


APPLIED MICROSYSTEMS Because it's not just H2O

2071 Malaview Ave West, Sidney, British Columbia, Canada V8L 5X6
Phone: (250) 656-0771 Fax: (250) 655-3655
Canada & USA: 800-663-8721
Email: info@AppliedMicrosystems.com Web: http://www.aml.bc.ca

# Pressure Calibration

| | | | |
|---|---|---|---|
| **Date ( mm/dd/yy ):** | 09/30/08 | **RMS Error:** | 0.086 |
| **Instrument SN:** | 004986 | **Range:** | 1000 dBar |
| **Calibrator:** | Les Woodland | | |




$$dBar=A+B*T+C*T^2+D*T^3+(E+F*T+G*T^2+H*T^3)*Raw+(I+J*T+K*T^2+L*T^3)*Raw^2$$

### Coefficients

**A=-1.774596E+3  G=-3.214595E-7**
**B=9.062190E-2  H=9.150362E-9**
**C=2.005744E-2  I=-1.404551E-8**
**D=-3.298937E-4  J=3.282178E-10**
**E=5.909598E-2  K=-4.517941E-12**
**F=-7.414152E-6  L=-5.695738E-14**


APPLIED MICROSYSTEMS Because it's not just $H_2O$

2071 Malaview Ave West, Sidney, British Columbia, Canada V8L 5X6
Phone: (250) 656-0771 Fax: (250) 655-3655
Canada & USA: 800-663-8721
Email: info@AppliedMicrosystems.com Web: http://www.aml.bc.ca

APPLIED MICROSYSTEMS Because it's not just $H_2O$

# 5229 Certificate of Calibration

| | |
|---|---|
| Customer: | NOAA - Pacific Marine Center |
| Instrument Serial Number: | INS-05229 |
| Instrument Type: | Smart SV&P |
| Instrument Description: | Real-time instrument with sound velocity (invar) and pressure |
| Calibrated Pressure Range: | 1000 dBar |

---

Certification Date: 08/02/2008 (dd/mm/yyyy)

Certified By:

Robert Haydock,
General Manager
Applied Microsystems

Applied Microsystems certifies that the equipment described above has been calibrated with equipment referenced to traceable standards. Any repairs / calibrations completed on this instrument were approved by the instrument owner under purchase order.

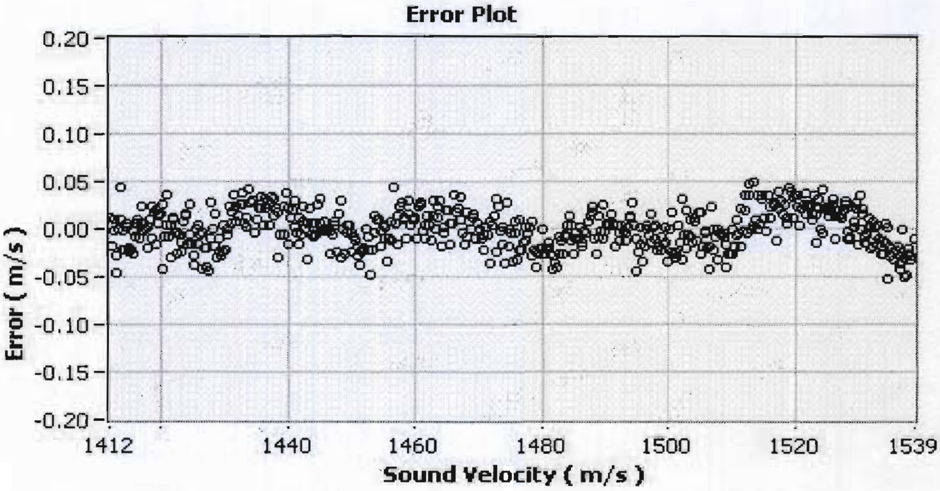
This instrument has been recalibrated. Please be sure to update your records. Please also ensure that you update the instrument's coefficient values in any post-processing software (ie. Smart Talk) that you use. Instrument configuration files are available at our Client Service & Support Portal (see web address below).

For a complete service history of this instrument, please consult our on-line Client Service & Support Portal at http://www.appliedmicrosystems.com/customers/index.htm

Applied Microsystems
2071 Malaview Avenue
Sidney, B.C. V8L 5X6 CANADA
Tel: +1-250-656-0771 Fax: +1-250-655-3655

# Sound Velocity Calibration

| | | | |
|---|---|---|---|
| **Date:** | 2/8/2008 | **RMS Error:** | 0.020 |
| **Instrument SN:** | 005229 | **Range:** | 1400 to 1550 m/s |
| **Calibrator:** | Matt Tradewell | | |




m/s=A+B*((NH-N)/(NH-NL))+C*((NH-N)/(NH-NL))^2+D*((NH-N)/(NH-NL))^3

**Coefficients**

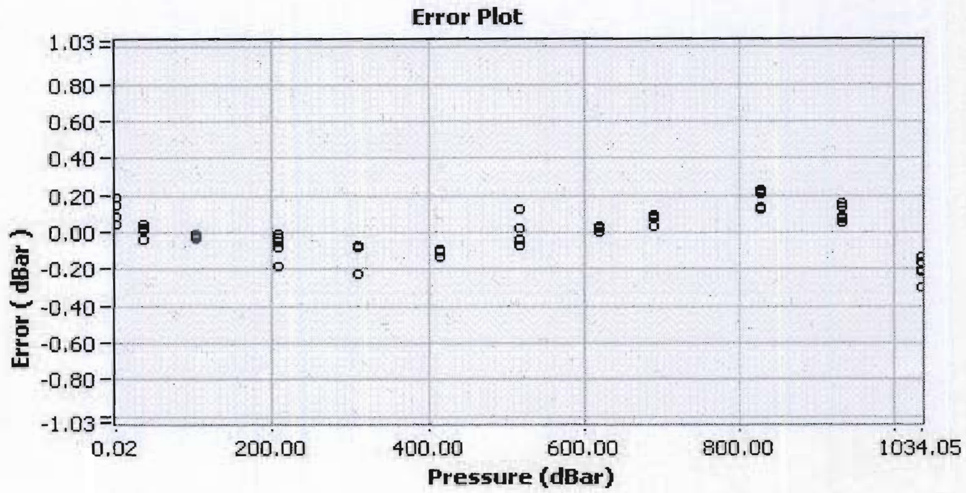
**A=1.521988E+3**
**B=-1.067986E+2**
**C=8.820610E+0**
**D=-9.938356E-1**


APPLIED MICROSYSTEMS Because it's not just $H_2O$

2071 Malaview Ave West, Sidney, British Columbia, Canada V8L 5X6
Phone: (250) 656-0771 Fax: (250) 655-3655
Canada & USA: 800-663-8721
Email: info@AppliedMicrosystems.com Web: http://www.aml.bc.ca

# Pressure Calibration

| | | | |
|---|---|---|---|
| **Date:** | 2/6/2008 | **RMS Error:** | 0.1141 |
| **Instrument SN:** | 005229 | **Range:** | 1000 dBar |
| **Calibrator:** | Matt Tradewell | | |




dBar=A+B*T+C*T^2+D*T^3+(E+F*T+G*T^2+H*T^3)*Raw+(I+J*T+K*T^2+L*T^3)*Raw^2

## Coefficients

**A=-1.468823E+3 G=2.642032E-7**
**B=-4.145866E-1 H=-1.446059E-8**
**C=-1.325764E-3 I=-1.195644E-9**
**D=2.944354E-4 J=-5.100709E-13**
**E=4.653640E-2 K=-5.746673E-12**
**F=1.484535E-5 L=1.502744E-13**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APPLIED MICROSYSTEMS

# 005466 Certificate of Conformity

| | |
|---|---|
| Customer: | NOAA Ship Fairweather |
| Our Reference: | Project 14065 NOAA Ship Fairweather; Smart SV&P-MVP (Sept-08) |
| Customer Purchase Order: | Phone Order |
| Asset Serial Number: | 005466 |
| Asset Type: | 005466 (Smart SV&P for Brooke MVP) |
| Calibrated Pressure Range: | 1000 dBar |
| Additional Description: | RS 485 communication at 19200 baud |

---

Certification Date: 30/10/2008 (dd/mm/yyyy)

Certified By:

Applied Microsystems Ltd.

Robert Haydock,
President
Applied Microsystems

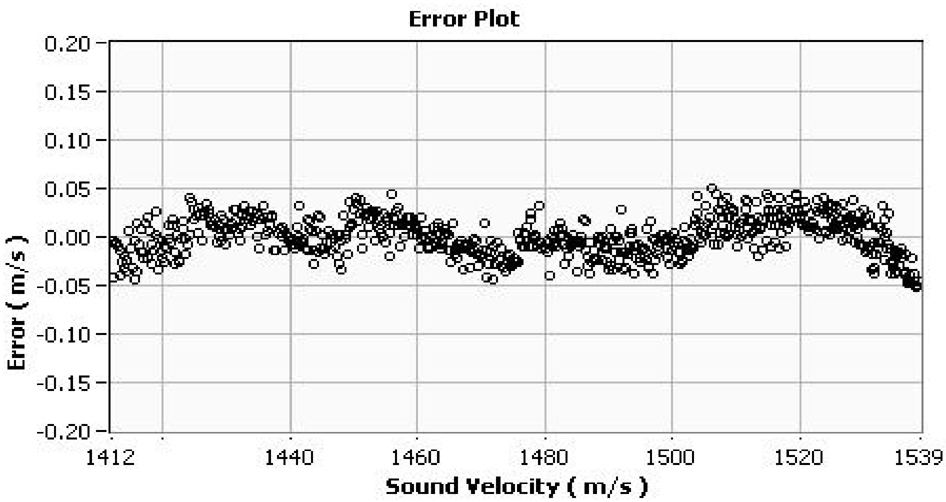
Applied Microsystems certifies that the above described equipment has been tested in accordance with the product's technical specifications, brochures, and / or relevant drawings. Applied Microsystems certifies that calibrations on this instrument have been completed with equipment reference to traceable standards.

Instrument configuration files and soft copy certificates are available at Applied Microsystems Client Service and Support Portal at http://www.appliedmicrosystems.com/customers/index.htm

Applied Microsystems
2071 Malaview Avenue
Sidney, B.C. V8L 5X6 CANADA
Tel: +1-250-656-0771 Fax: +1-250-655-3655

# Sound Velocity Calibration

| | | | |
|---|---|---|---|
| **Date (mm/dd/yy):** | 30/10/08 | **RMS Error:** | 0.020 |
| **Instrument SN:** | 005466 | **Range:** | 1400 to 1550 m/s |
| **Calibrator:** | Matt Tradewell | | |




m/s=A+B*((NH-N)/(NH-NL))+C*((NH-N)/(NH-NL))^2+D*((NH-N)/(NH-NL))^3

**Coefficients**

**A=1.533131E+3**
**B=-1.137455E+2**
**C=1.040759E+1**
**D=-1.332106E+0**

APPLIED MICROSYSTEMS Because it's not just $H_2O$

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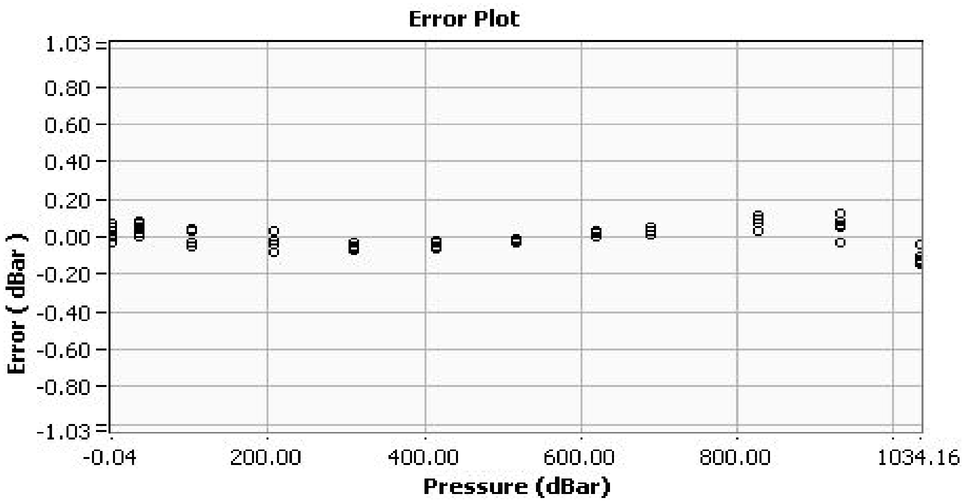
# Pressure Calibration

| | | | |
|---|---|---|---|
| **Date:** | 10/23/2008 | **RMS Error:** | 0.0604 |
| **Instrument SN:** | 005466 | **Range:** | 1000 dBar |
| **Calibrator:** | Matt Tradewell | | |




dBar=A+B*T+C*T^2+D*T^3+(E+F*T+G*T^2+H*T^3)*Raw+(I+J*T+K*T^2+L*T^3)*Raw^2

**Coefficients**

**A=-1.238729E+3  G=-1.128182E-6**
**B=-3.145002E-1  H=1.415759E-8**
**C=3.012141E-2  I=-4.262089E-9**
**D=-3.571170E-4  J=-1.925685E-10**
**E=4.398952E-2  K=1.080000E-11**
**F=2.278661E-5  L=-1.832266E-13**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AML Calibration Equipment

Temperature Calibrations

Performed using either of two Hart Scientific "Black Stack" Model 1560 Power Bases with attached Hart Scientific Model 2563 Thermistor Modules connected to a Thermometrics AS125 4 Wire Thermistor Standard

1: Hart Scientfic Power Base 1560 S/N 79263 / Thermistor Module 2563 S/N 79039 / Thermometrics AS125 4 Wire Thermistor Standard S/N 2131
2: Hart Scientfic power Base 1560 S/N A05690 / Thermistor Module 2563 S/N A05693 / Thermometrics AS125 4 Wire Thermistor Standard S/N 2128

Temperature calibration equipment is calibrated yearly and verified bi-monthly as per Applied Microsystems Ltd. Calibration Schedule T11.2 utilizing a Hart Scientific Model 5901 Triple Point of Water Cell. All temperature calibrations and verifications are ITS-90 and NIST traceable

Pressure Calibrations

Performed using a Budenburg Model 380D S/N 18564 Range 0-8000 psi Deadweight Tester. Calibrations and verifications are implemented as per Applied Microsystems Ltd. Calibration Schedule T11.2. All pressure calibrations and verifications are NIST traceable.

Conductivity Calibrations

Performed using either of two Guildline 8400B S/N 59251 or Guildline 8400 S/N 43385 Autosals. Both Conductivity Calibrators are calibrated and verified using Ocean Scientific International IAPSO Standard Seawater as per Applied Microsystems ltd. Calibration Schedule T11.2. All Conductivity Calibrations and verifications are NIST traceable

Battery Channel Calibrations

Performed using a Precision Fluke Model 45 Multimeter S/N 4720162. Calibrations and verifications are implemented as per Applied Microsystems Ltd. Calibration Schedule T11.2 All calibrations and verifications are NIST traceable.

Sound Velocity Calibrations

Performed using an Applied Microsystems Ltd Temperature Standard S/N 9998 in distilled water, <5 ppm TDS, and sound velocity reference is Del Grosso and Mader's Pure Water Equation. Calibrations and verifications are implemented as per Applied Microsystems Ltd. Calibration Schedule T11.2 All temperature calibrations and verifications are ITS-90 and NIST traceable.

# SVP Test and Calibration certificate

| | | | |
|---|---|---|---|
| SVP Type : | SVP70 | Date of issue : | 01-04-2009 |
| SVP Serial No. | 4008077 | | |

**Functionality Test :** Sign : ______________________________

| | |
|---|---|
| **Temperature Calibration :** | **Hart 1504 s/n A6B554 & Thermistor s/n 3014** |
| **Point 1:** | 4.6 ℃ |
| **Point 2:** | 16.5 ℃ |
| **Point 3:** | 25.5 ℃ |
| **Pressure Calibration :** | **Custom Built Tank (TestUnit ASF150 Ser# 41-10-0007-R03)** |
| **Point 1:** | 0 Bar |
| **Point 2:** | 301.7 Bar |
| **Point 3:** | 603.6 Bar |

| | RMS Speed of Sound Errors |
|---|---|
| **Temperature Validation :** | **0.0033 m/s** |
| **Pressure Validation :** | **0.0845 m/s** |

**Calibration Completed :** Sign : ______________________________

**Final Function Test :** Sign : ______________________________

**QA Signature :** Inits : ________________

# SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

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

SENSOR SERIAL NUMBER: 0117
CALIBRATION DATE: 08-Jan-08

SBE 45 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -1.031942e+000
h = 1.269033e-001
i = -2.218276e-004
j = 3.318496e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006
WBOTC = -3.1803e-006

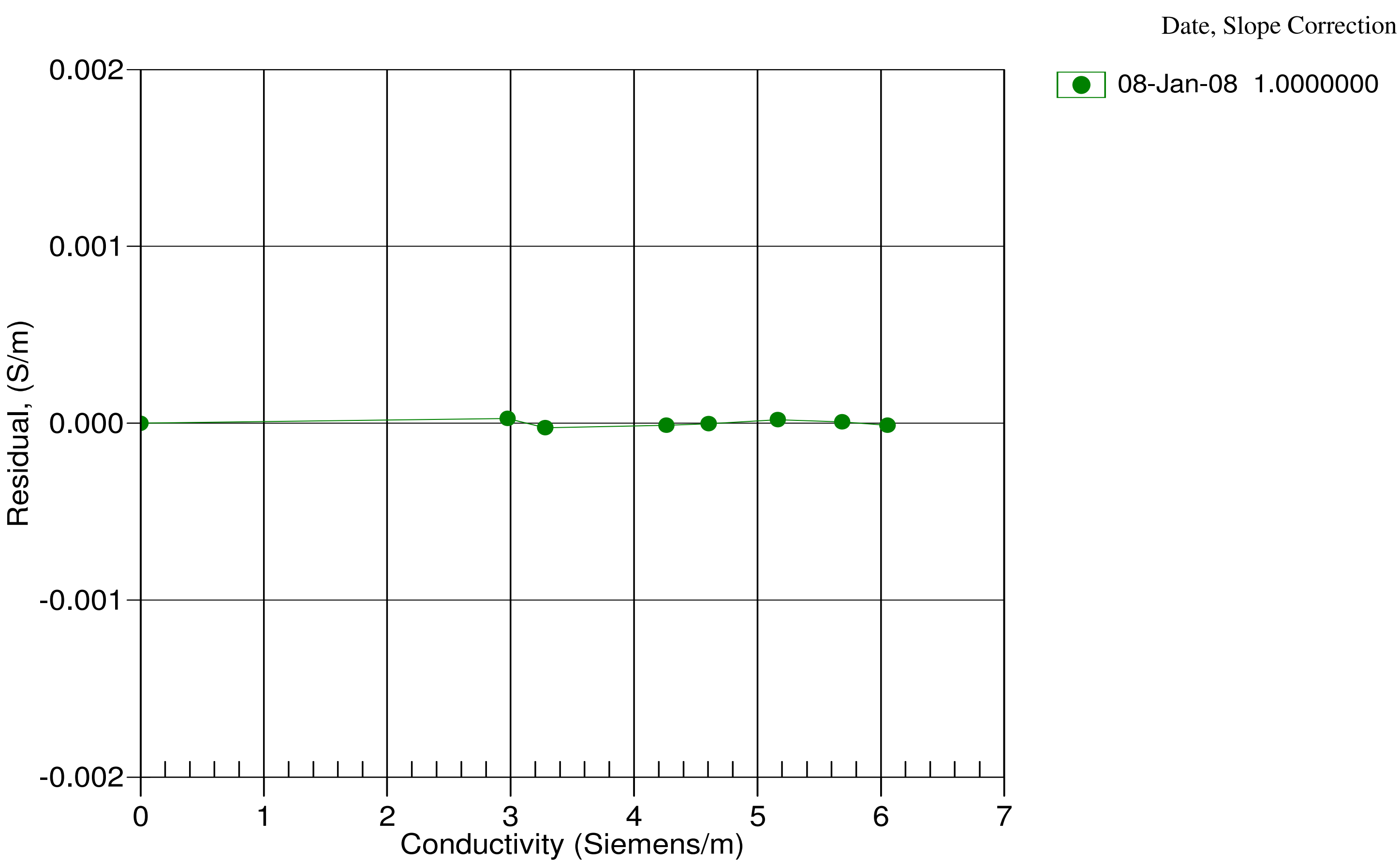
| BATH TEMP (ITS-90) | BATH SAL (PSU) | BATH COND (Siemens/m) | INST FREQ (Hz) | INST COND (Siemens/m) | RESIDUAL (Siemens/m) |
|---|---|---|---|---|---|
| 22.0000 | 0.0000 | 0.00000 | 2855.80 | 0.00000 | 0.00000 |
| 1.0000 | 34.7807 | 2.97321 | 5622.31 | 2.97324 | 0.00003 |
| 4.4999 | 34.7610 | 3.28001 | 5832.94 | 3.27999 | -0.00003 |
| 14.9999 | 34.7176 | 4.26078 | 6459.57 | 4.26076 | -0.00001 |
| 18.5000 | 34.7080 | 4.60555 | 6665.57 | 4.60555 | -0.00000 |
| 24.0000 | 34.6969 | 5.16282 | 6985.35 | 5.16285 | 0.00002 |
| 29.0000 | 34.6902 | 5.68399 | 7271.30 | 5.68399 | 0.00001 |
| 32.4999 | 34.6851 | 6.05568 | 7468.33 | 6.05567 | -0.00001 |

f = INST FREQ * sqrt(1.0 + WBOTC * t) / 1000.0

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

t = temperature[°C)]; p = pressure[decibars]; $\delta$ = CTcor; $\varepsilon$ = CPcor;

Residual = instrument conductivity - bath conductivity



# SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

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

SENSOR SERIAL NUMBER: 0117
CALIBRATION DATE: 11-Dec-07

SBE 45 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -1.029836e+000
h = 1.264890e-001
i = -1.244736e-004
j = 2.698268e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006
WBOTC = -3.1803e-006

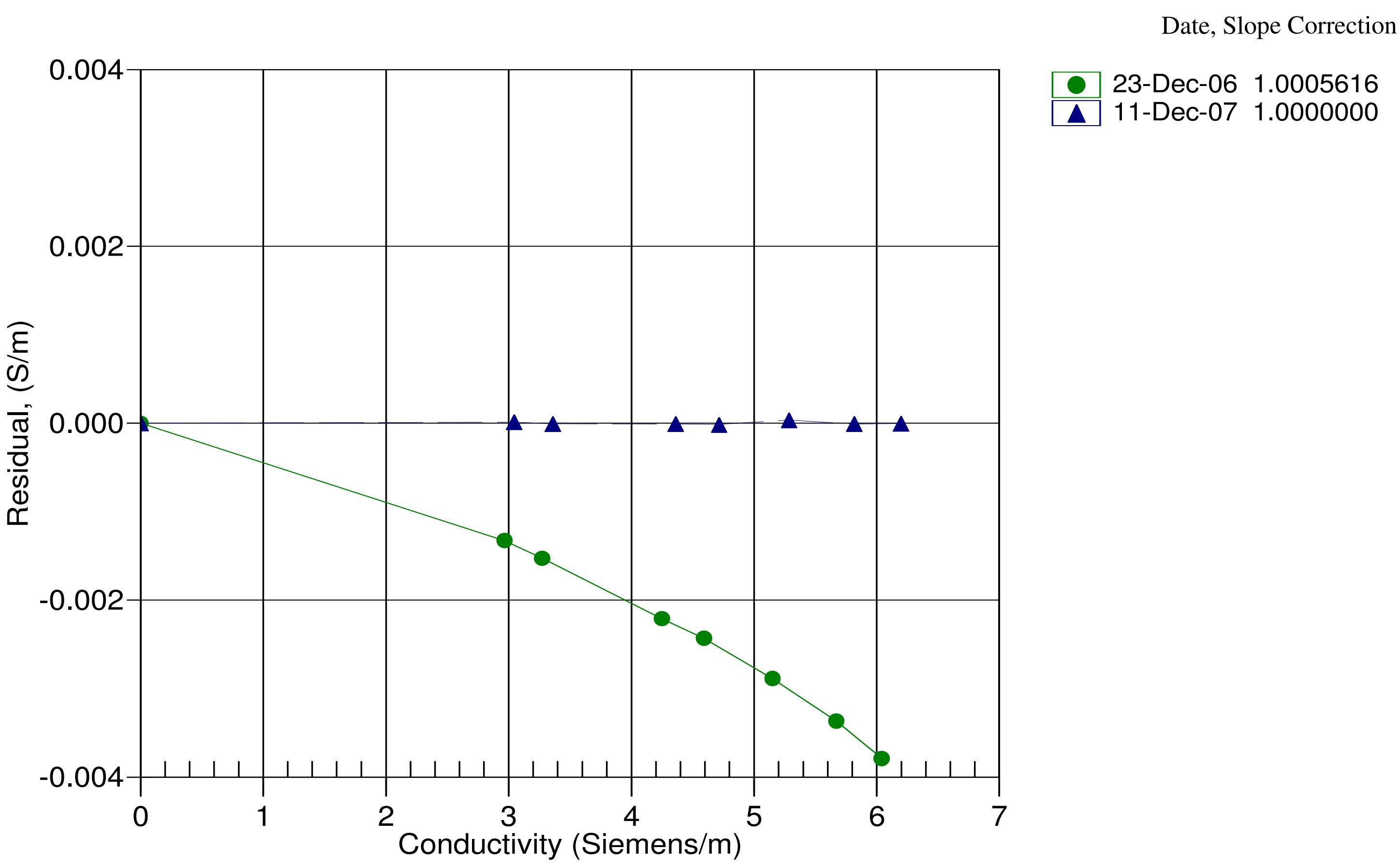
| BATH TEMP (ITS-90) | BATH SAL (PSU) | BATH COND (Siemens/m) | INST FREQ (Hz) | INST COND (Siemens/m) | RESIDUAL (Siemens/m) |
|---|---|---|---|---|---|
| 22.0000 | 0.0000 | 0.00000 | 2854.99 | 0.00000 | 0.00000 |
| 1.0000 | 35.7009 | 3.04425 | 5671.69 | 3.04426 | 0.00001 |
| 4.5000 | 35.6792 | 3.35798 | 5885.14 | 3.35797 | -0.00001 |
| 15.0000 | 35.6327 | 4.36100 | 6519.96 | 4.36099 | -0.00001 |
| 18.5000 | 35.6226 | 4.71361 | 6728.60 | 4.71359 | -0.00002 |
| 23.9999 | 35.6111 | 5.28357 | 7052.48 | 5.28361 | 0.00003 |
| 29.0000 | 35.6023 | 5.81635 | 7341.91 | 5.81634 | -0.00001 |
| 32.5001 | 35.5947 | 6.19615 | 7541.26 | 6.19615 | -0.00000 |

f = INST FREQ * sqrt(1.0 + WBOTC * t) / 1000.0

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

t = temperature[°C)]; p = pressure[decibars]; $\delta$ = CTcor; $\varepsilon$ = CPcor;

Residual = instrument conductivity - bath conductivity



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

SENSOR SERIAL NUMBER: 0117
CALIBRATION DATE: 08-Jan-08

SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

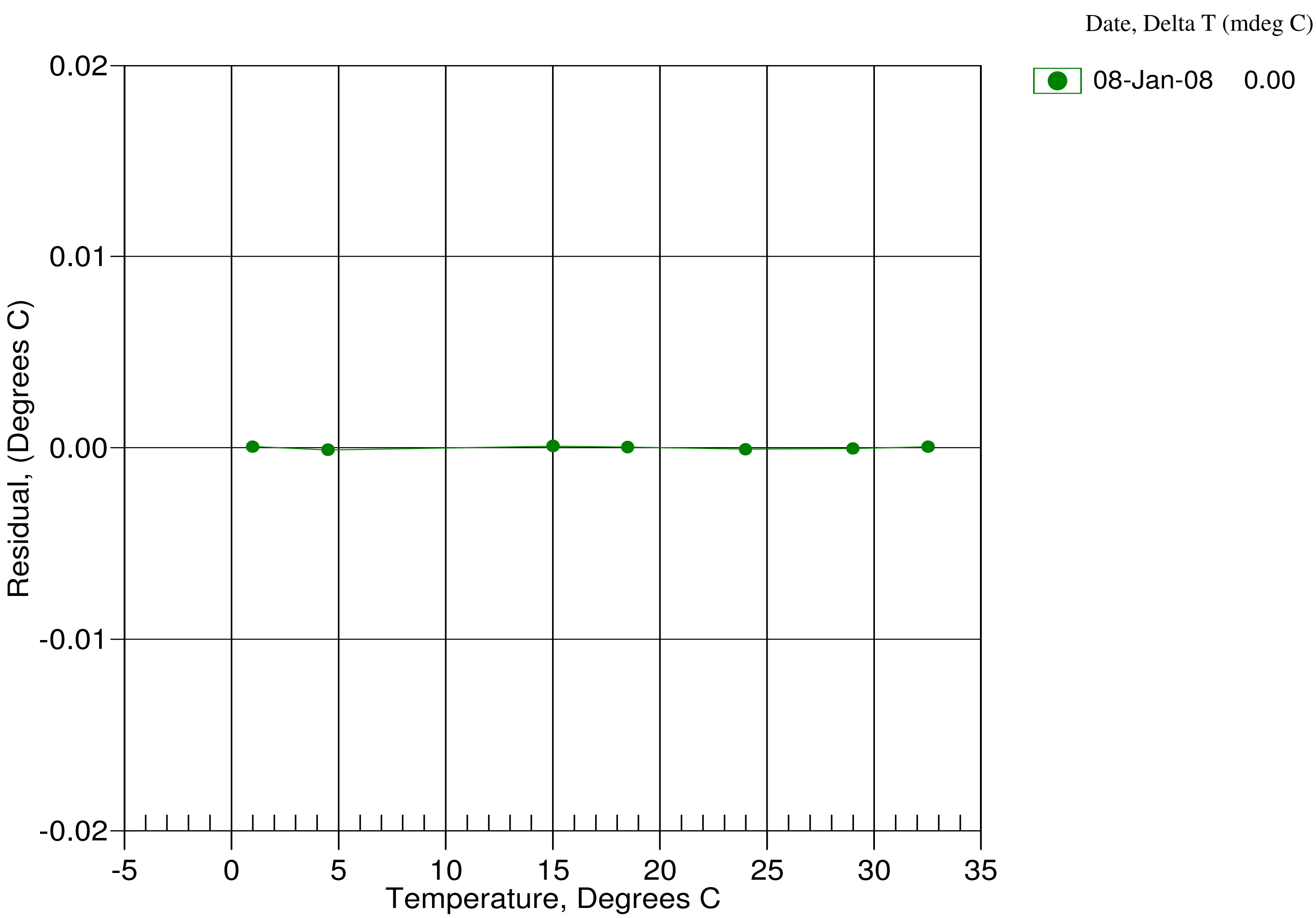
ITS-90 COEFFICIENTS

a0 = -2.444687e-004
a1 = 3.101067e-004
a2 = -4.608202e-006
a3 = 2.066460e-007

| BATH TEMP (ITS-90) | INSTRUMENT OUTPUT | INST TEMP (ITS-90) | RESIDUAL (ITS-90) |
|---|---|---|---|
| 1.0000 | 825687.0 | 1.0001 | 0.0001 |
| 4.4999 | 708009.0 | 4.4998 | -0.0001 |
| 14.9999 | 455003.1 | 15.0000 | 0.0001 |
| 18.5000 | 395051.1 | 18.5000 | 0.0000 |
| 24.0000 | 318250.6 | 23.9999 | -0.0001 |
| 29.0000 | 263033.5 | 29.0000 | -0.0000 |
| 32.4999 | 230938.9 | 32.4999 | 0.0000 |

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

Residual = instrument temperature - bath temperature



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SENSOR SERIAL NUMBER: 0117
CALIBRATION DATE: 11-Dec-07

SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

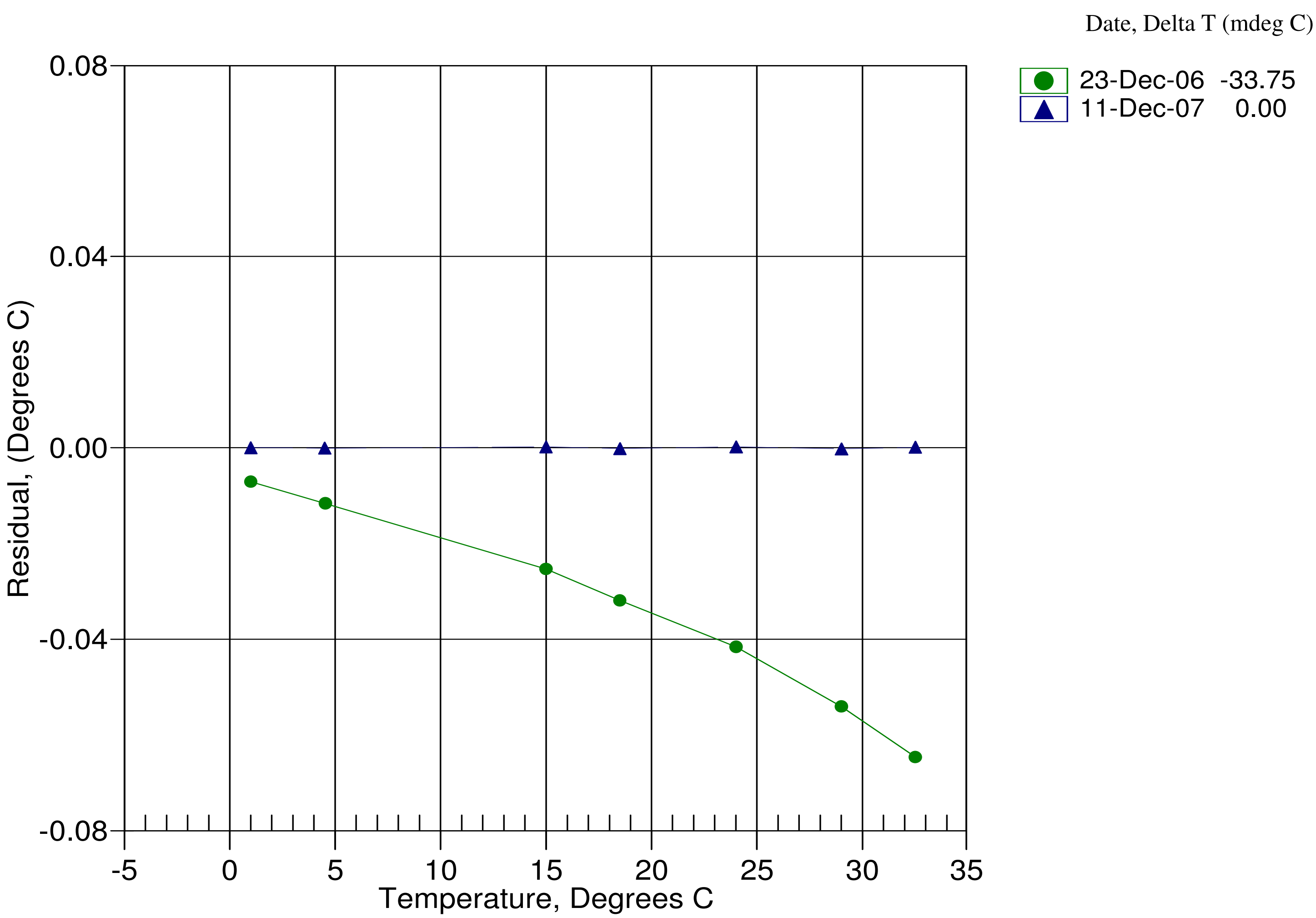
ITS-90 COEFFICIENTS

a0 = -1.865866e-004
a1 = 2.970047e-004
a2 = -3.621420e-006
a3 = 1.819198e-007

| BATH TEMP (ITS-90) | INSTRUMENT OUTPUT | INST TEMP (ITS-90) | RESIDUAL (ITS-90) |
|---|---|---|---|
| 1.0000 | 825650.8 | 1.0001 | 0.0001 |
| 4.5000 | 707981.6 | 4.4999 | -0.0001 |
| 15.0000 | 455000.0 | 15.0002 | 0.0002 |
| 18.5000 | 395058.3 | 18.4998 | -0.0002 |
| 23.9999 | 318252.4 | 24.0001 | 0.0002 |
| 29.0000 | 263036.0 | 28.9998 | -0.0002 |
| 32.5001 | 230933.8 | 32.5002 | 0.0001 |

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

Residual = instrument temperature - bath temperature



SBE
SEA-BIRD ELECTRONICS, INC.
1808 - 136th Place Northeast, Bellevue, Washington 98005 USA
Phone: (425) 643-9866 Fax: (425) 643-9954 www.seabird.com

# Conductivity Calibration Report

| | | | |
|---|---|---|---|
| **Customer:** | Pacific Marine Center / NOAA | | |
| **Job Number:** | 48749 | **Date of Report:** | 1/8/2008 |
| **Model Number** | SBE 45 | **Serial Number:** | 4536628-0117 |

***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: 12/11/2007 Drift since last cal: +0.00150 PSU/month*

Comments:

**'CALIBRATION AFTER REPAIR'** ☑ Performed ☐ Not Performed

Date: 1/8/2008 Drift since Last cal: N/A 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.***

SBE
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1808 - 136th Place Northeast, Bellevue, Washington 98005 USA
Phone: (425) 643-9866   Fax: (425) 643-9954  www.seabird.com

# *Temperature Calibration Report*

| | | | |
|---|---|---|---|
| **Customer:** | Pacific Marine Center / NOAA | | |
| **Job Number:** | 48749 | **Date of Report:** | 1/8/2008 |
| **Model Number** | SBE 45 | **Serial Number:** | 4536628-0117 |

***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: 12/11/2007 Drift since last cal: +0.03490 **Degrees Celsius/year**

Comments:

**'CALIBRATION AFTER REPAIR'** ☑ Performed ☐ Not Performed

Date: 1/8/2008 Drift since Last cal: N/A **Degrees Celsius/year**

Comments:

**Date:**
Apr 16, 2009

**Serial #:**
98013-041609

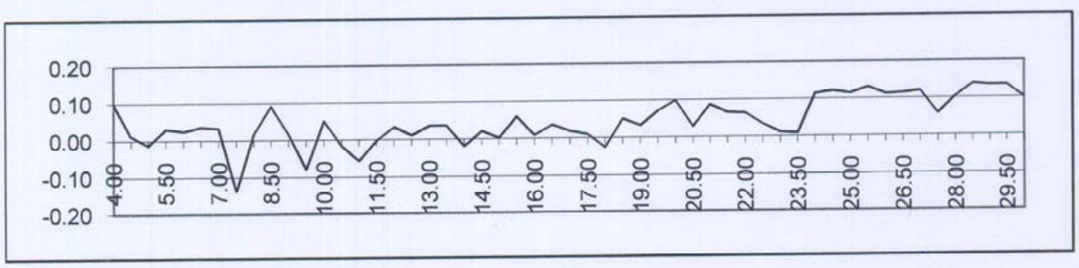
# DIGIBAR CALIBRATION REPORT

version 1.0 (c) 2004

ODOM HYDROGRAPHIC SYSTEMS, Inc.

## STANDARD DEL GROSSO $H^2O$

| TEMP | VELOCITY | MEASURED FREQUENCY | RES_VEL | OBS-CAL | TEMP | VELOCITY | MEASURED FREQUENCY | RES_VEL | OBS-CAL |
|---|---|---|---|---|---|---|---|---|---|
| 4.00 | 1421.62 | 5555.38 | 1421.72 | 0.10 | 17.50 | 1474.38 | 5754.23 | 1474.39 | 0.01 |
| 4.50 | 1423.90 | 5563.65 | 1423.91 | 0.01 | 18.00 | 1476.01 | 5760.25 | 1475.98 | -0.03 |
| 5.00 | 1426.15 | 5572.06 | 1426.14 | -0.01 | 18.50 | 1477.62 | 5766.61 | 1477.67 | 0.05 |
| 5.50 | 1428.38 | 5580.63 | 1428.41 | 0.03 | 19.00 | 1479.21 | 5772.53 | 1479.24 | 0.03 |
| 6.00 | 1430.58 | 5588.91 | 1430.60 | 0.02 | 19.50 | 1480.77 | 5778.59 | 1480.84 | 0.07 |
| 6.50 | 1432.75 | 5597.16 | 1432.79 | 0.04 | 20.00 | 1482.32 | 5784.53 | 1482.42 | 0.10 |
| 7.00 | 1434.90 | 5605.25 | 1434.93 | 0.03 | 20.50 | 1483.84 | 5790.02 | 1483.87 | 0.03 |
| 7.50 | 1437.02 | 5612.62 | 1436.88 | -0.14 | 21.00 | 1485.35 | 5795.92 | 1485.43 | 0.09 |
| 8.00 | 1439.12 | 5621.12 | 1439.13 | 0.02 | 21.50 | 1486.83 | 5801.44 | 1486.89 | 0.07 |
| 8.50 | 1441.19 | 5629.22 | 1441.28 | 0.09 | 22.00 | 1488.29 | 5806.96 | 1488.36 | 0.06 |
| 9.00 | 1443.23 | 5636.66 | 1443.25 | 0.02 | 22.50 | 1489.74 | 5812.30 | 1489.77 | 0.03 |
| 9.50 | 1445.25 | 5643.93 | 1445.18 | -0.08 | 23.00 | 1491.16 | 5817.59 | 1491.17 | 0.01 |
| 10.00 | 1447.25 | 5651.96 | 1447.30 | 0.05 | 23.50 | 1492.56 | 5822.88 | 1492.57 | 0.01 |
| 10.50 | 1449.22 | 5659.15 | 1449.21 | -0.02 | 24.00 | 1493.95 | 5828.51 | 1494.06 | 0.11 |
| 11.00 | 1451.17 | 5666.35 | 1451.11 | -0.06 | 24.50 | 1495.32 | 5833.69 | 1495.44 | 0.12 |
| 11.50 | 1453.09 | 5673.82 | 1453.09 | 0.00 | 25.00 | 1496.66 | 5838.75 | 1496.78 | 0.11 |
| 12.00 | 1454.99 | 5681.13 | 1455.03 | 0.03 | 25.50 | 1497.99 | 5843.82 | 1498.12 | 0.13 |
| 12.50 | 1456.87 | 5688.13 | 1456.88 | 0.01 | 26.00 | 1499.30 | 5848.69 | 1499.41 | 0.11 |
| 13.00 | 1458.72 | 5695.22 | 1458.76 | 0.04 | 26.50 | 1500.59 | 5853.57 | 1500.70 | 0.11 |
| 13.50 | 1460.55 | 5702.13 | 1460.59 | 0.04 | 27.00 | 1501.86 | 5858.39 | 1501.98 | 0.12 |
| 14.00 | 1462.36 | 5708.74 | 1462.34 | -0.02 | 27.50 | 1503.11 | 5862.89 | 1503.17 | 0.06 |
| 14.50 | 1464.14 | 5715.63 | 1464.17 | 0.02 | 28.00 | 1504.35 | 5867.72 | 1504.45 | 0.10 |
| 15.00 | 1465.91 | 5722.21 | 1465.91 | 0.00 | 28.50 | 1505.56 | 5872.44 | 1505.70 | 0.14 |
| 15.50 | 1467.65 | 5728.99 | 1467.70 | 0.06 | 29.00 | 1506.76 | 5876.95 | 1506.89 | 0.13 |
| 16.00 | 1469.36 | 5735.28 | 1469.37 | 0.01 | 29.50 | 1507.94 | 5881.41 | 1508.08 | 0.13 |
| 16.50 | 1471.06 | 5741.78 | 1471.09 | 0.04 | 30.00 | 1509.10 | 5885.67 | 1509.20 | 0.10 |
| 17.00 | 1472.73 | 5748.03 | 1472.75 | 0.02 | | | | | |




**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:**
Apr 16, 2009

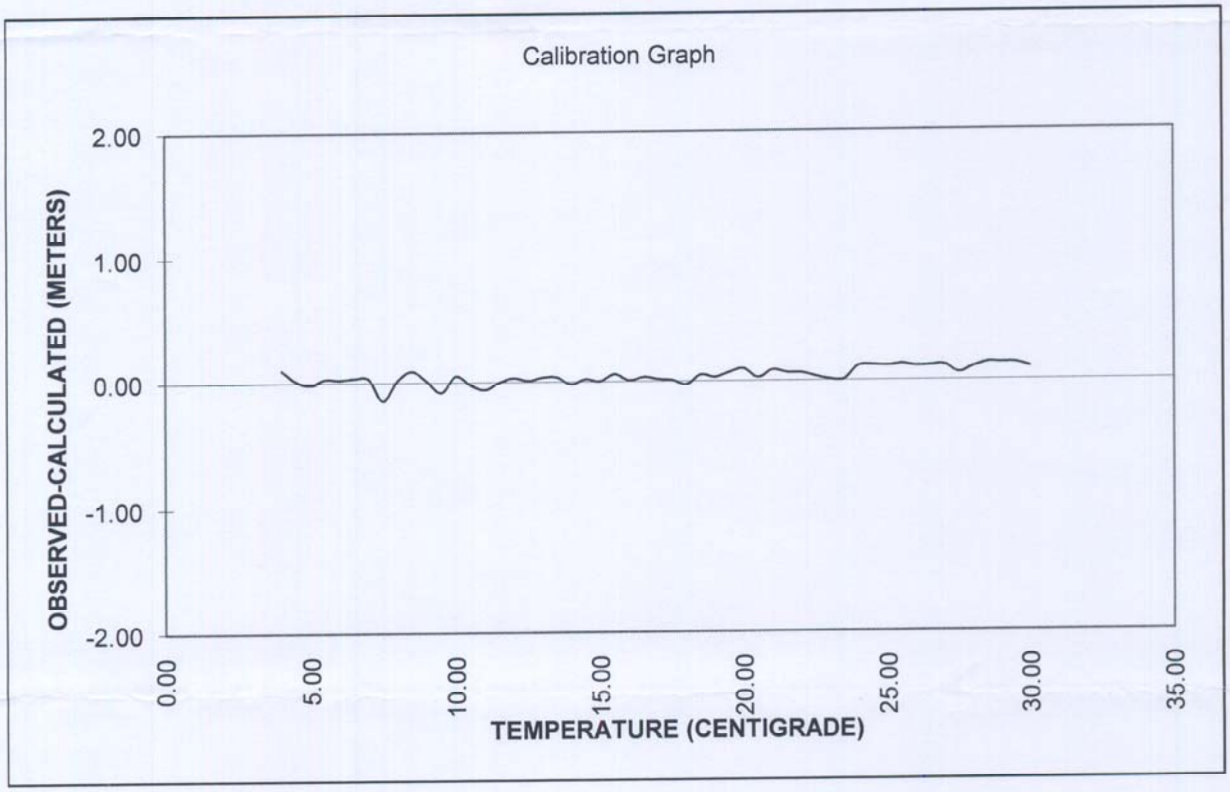
**Serial #:**
98013-041609

# DIGIBAR CALIBRATION REPORT

version 1.0 (c) 2004

ODOM HYDROGRAPHIC SYSTEMS, Inc.

| | | |
|---|---|---|
| Burn these numbers to EPROM: | Gradient | **3391** |
| | Intercept | **497** |




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

***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

TELEDYNE ODOM HYDROGRAPHIC
A Teledyne Technologies Company

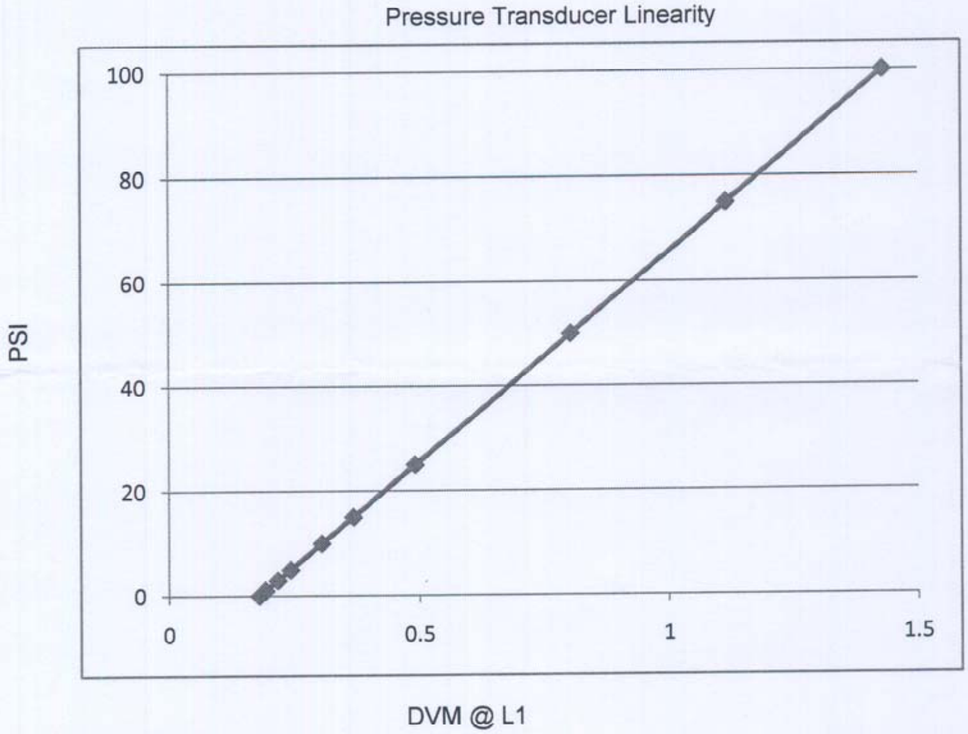
# Digibar

| | |
|---|---|
| Date | 4/17/2009 |
| Serial # | 98013 |
| SW Version | 1.11 |
| Cable Length | 20 meters |

| Board Identification | Serial # |
|---|---|
| Power Supply | |
| Control PCB | |
| LCD | |
| Probe Sensor | |
| Probe Controller | |
| Airmar Transducer | 853906 |

| | |
|---|---|
| Press Transducer | 79842 |
| Zero Voltage | .18 |
| Span Volage | 2.68 |
| Mid-Scale Voltage | 1.43 |
| R5 | 3.9K |
| R9 | 10K |
| Gradient | 3391 |
| Intercept | 497 |

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




| 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 |

# Certificate of Calibration

Model: Nikon DTM310

Serial Number: 842575

This certifies that the above instrument has been inspected and calibrated by the GeoLine Positioning Systems Inc. Service Department. At the time of completion of this service, GeoLine Positioning Systems, Inc. certifies that the above stated product meets all factory specifications and tolerances for product parameters and performance of this product model.

All product calibration and specification parameters were tested and/or adjusted using applicable factory calibration jigs, precision optical collimation systems and electronic test equipment. All collimation systems have been properly checked and calibrated according to industry standard practices. All electronic test equipment used have had current calibration.

Date of Calibration: 6/28/04

Next Recommended Calibration Date: 12/28/04

Signed: Sean Valer Date: 6/28/04

Title: Service Technician

**GeoLine Positioning Systems, Inc.**
1331 118th Avenue SE, Suite 400
Bellevue, WA 98005
425.452.2711 • 425.452.2703 fax

# Certificate of Calibration

Model: Sokkia SET 5F

Serial Number: 16288

This certifies that the above instrument has been inspected and calibrated by the GeoLine Positioning Systems Inc. Service Department. At the time of completion of this service, GeoLine Positioning Systems, Inc. certifies that the above stated product meets all factory specifications and tolerances for product parameters and performance of this product model.

All product calibration and specification parameters were tested and/or adjusted using applicable factory calibration jigs, precision optical collimation systems and electronic test equipment. All collimation systems have been properly checked and calibrated according to industry standard practices. All electronic test equipment used have had current calibration.

Date of Calibration: 7/19/04

Next Recommended Calibration Date: 7/19/05

Signed: Sean Vale Date: 7/19/04

Title: Service Technician

**GeoLine Positioning Systems, Inc.**
1331 118th Avenue SE, Suite 400
Bellevue, WA 98005
425.452.2711 • 425.452.2703 fax

# Appendix VI

## Correspondence

- **PPK DDSSM Permission**
- **FA Hydrographic Resolution Waiver Request**
- **FA Hydrographic Resolution Waiver Acceptance**

----- Original Message -----
From        Briana.Welton@noaa.gov
Date        Thu, 23 Apr 2009 17:06:02 -0700
To    CO.Fairweather@noaa.gov, XO.Fairweather@noaa.gov
Subject     Fwd: Re: Dynamic draft using PPK

----- Original Message -----
From        Olivia.Hauser@noaa.gov
Date        Thu, 23 Apr 2009 09:14:31 -0700
To    Olivia Hauser <Olivia.Hauser@noaa.gov>
Cc    Edward.J.Vandenameele@noaa.gov, "Jack L. Riley"
<Jack.Riley@noaa.gov>, Glen Rice <Glen.Rice@noaa.gov>, Grant Froelich
<Grant.Froelich@noaa.gov>, Steve Brodet <Steve.Brodet@noaa.gov>,
FOO.Thomas.Jefferson@noaa.gov, FOO Rainier <FOO.Rainier@noaa.gov>,
FOO.Fairweather@noaa.gov, Briana Welton <Briana.Welton@noaa.gov>, 'Corey
Allen' <Corey.Allen@noaa.gov>
Subject     Re: Dynamic draft using PPK

Hello All,

I spoke with EJ who conferred with Jeff Ferguson and they both agreed that if you decide to use the PPK method to determine dynamic draft on your vessel, include it in the HSRRs with the following information and they will be approved. Please include a statement that it is a deviation from the FPM, what you did to get your values and a comparison to either previous dynamic draft tables or one obtained concurrently using an approved method. (Basically the write-ups you already have). The HSRRs will be approved with the deviation, and we'll work on getting the FPM updated for next year.

V/R, Olivia

----- Original Message -----
From: Olivia Hauser <olivia.hauser@noaa.gov>
Date: Tuesday, April 21, 2009 12:08 pm
Subject: Dynamic draft using PPK
To: edward.j.vandenameele@noaa.gov, "Jack L. Riley"
<Jack.Riley@noaa.gov>,  Glen Rice <Glen.Rice@noaa.gov>, Grant Froelich
<Grant.Froelich@noaa.gov>,  Steve Brodet <Steve.Brodet@noaa.gov>,
foo.thomas.jefferson@noaa.gov, FOO Rainier <FOO.Rainier@noaa.gov>,
foo.fairweather@noaa.gov, Briana Welton <Briana.Welton@noaa.gov>,
'Corey Allen' <Corey.Allen@noaa.gov>

> LCDR van den Ameele,
>
>  This is a follow-up to our phone conversation the other day. Both FA
> and
>  RA have tested the use of PPK to determine the dynamic draft for
> their
>  vessels with positive results. Currently the FPM states that this is
> not
>  a valid method to determine dynamic draft. Can we change that? I have
>
>  attached the two write ups/reports that were created from these
> tests.
>  The only major item of concern here is the removal of tide. Both of
> the
>  test cases were conducted in areas where tide is negligible which

> made
>  the use of this data easy. It may noe be as simple in areas with
> large
>  tidal fluctuations. Is there a way we can remove tide from the SBET
>  (Jack or Steve)? Also, ENS Rice wrote the python script that created
> the
>  final curves and graphs in both reports. It might be in our best
>  interest to include these in pydro or provide them in another form to
>
>  all the field units if they decide to use this method.
>
>  I recommend that we change the FPM to include this method as an
>  acceptable method to calculate dynamic draft.
>
>  V/R, Olivia
>
>  --
>  LTJG Olivia Hauser
>  NOAA HSTP Field Support Liaison, East
>  439 W. York Street, Norfolk, VA 23510
>  Voice: 757-441-6319 x 105
>  Fax: 757-441-6601
>  Cell: 302-229-3368
>  olivia.hauser@noaa.gov
>

**UNITED STATES DEPARTMENT OF COMMERCE**
National Oceanic and Atmospheric Administration
NOAA Marine and Aviation Operations
NOAA Ship *Fairweather* S-220
1010 Stedman Street
Ketchikan, AK 99901

May 8, 2009

MEMORANDUM FOR: Jeffery Ferguson
Chief, Hydrographic Surveys Division

FROM: CDR Douglas D. Baird, Jr., NOAA
Commanding Officer, NOAA Ship *Fairweather*

SUBJECT: Waiver from HTD 2009-02 specifications

*Fairweather* personnel have examined 2009 reference surface and project related data with the Hydrographic Technical Directive 2009-02 CUBE criteria and specifications in mind, and have determined that adhering to those specifications would be an onerous task.

In order to meet the HTD 2009-02 criteria for complete coverage surveys for the 2, 4, & 8 meter grid resolutions the survey launches would have to clutch-in and clutch-out of gear to move slowly enough and the ship would be reduced to bare steerage and significantly reduced swath coverages.

I am willing to slow the platforms down to six knots speed over ground – this is just a touch over clutch-in speed on Fairweather's two survey launches, and allows the ship to maintain positive control for most conditions. And we will reduce the swath coverage to 50º off nadir to both port and starboard.

I propose the following grid resolutions for the 2009 calendar year projects, using at least 5 soundings per node, at 6 knots, displaying 50º off nadir:

0 to 23 meters …………. 1 meter grid resolution
18 to 40 meters …........... 2 meter grid resolution
35 to 80 meters ………... 4 meter grid resolution
75 to 160 meters ..……… 8 meter grid resolution
155+ meters ………… 16 meter grid resolution

Since it is very rare for *Fairweather* to be required to conduct object detection surveys, this waiver request is strictly for complete coverage multibeam surveys.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
Office of Coast Survey
Silver Spring, Maryland 20910-3282

19 May 2009

MEMORANDUM FOR: Commander Douglas D. Baird Jr., NOAA
Commanding Officer, NOAA Ship *Fairweather*

FROM: Jeffrey Ferguson
Chief, Hydrographic Surveys Division

SUBJECT: Waiver from HTD 2009-02 Specifications

The NOAA Ship *Fairweather's* waiver, dated May 8, 2009, requesting a departure from the grid resolution requirements specified in Hydrographic Technical Directive 2009-02 is approved.

The NOAA Ship *Fairweather* will use the following grid resolutions for complete coverage multibeam on 2009 calendar year surveys, obtaining at least 5 soundings per node:

0 to 23 meters…………………1 meter grid resolution
18 to 40 meters………………..2 meter grid resolution
35 to 80 meters………………..4 meter grid resolution
75 to 160 meters………………8 meter grid resolution
155+ meters………………….16 meter grid resolution

cc Chiefs; OPS, PHB, AHB