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NATIONAL OCEAN SERVICE

Data Acquisition & Processing Report

Type of Survey **Hydrographic**

Project No. **2010 Field Season**

Registry No.

LOCALITY

State **Washington and Alaska**

General Locality

CAPT David O. Neander, NOAA

CHIEF OF PARTY

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DATE

APPENDICES

A. INTRODUCTION

This Data Acquisition and Processing Report outlines the acquisition and processing procedures used for Hydrographic projects surveyed in 2010 by 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 2010*, the *Field Procedures Manual (FPM), April 2010*, and all active Hydrographic Surveys Technical Directives (HTD).

Any additions and changes to the following will be included with the individual Descriptive Reports or by submission of an addendum.

B. 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 is used throughout the 2010 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 maintained with reference documentation on board *Fairweather*.

1.2 Echo Sounding Equipment

1.2.1 Reson 7111 Multibeam Echosounder (MBES)

Fairweather is equipped with a Reson 7111 MBES. The system was upgraded from a Reson 8111 in October 2009, which involved replacing the dry end transceiver and processor units but leaving the wet end hull-mounted projector and receiver intact. The Reson 7111 is a 100 kHz multibeam system with swath coverage of 150°. The swath is made up of 301 discrete equidistant beams with an along-track and across-track beamwidth of 0.5°. It has a specified depth range of 3 to 1200 meters, though the typical operational depth range of the Reson 7111 on *Fairweather* is 20 to 300 meters. No calibration information was provided by the manufacturer for the system.

The Reson 7111 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 Figure 1 & Figure 2).

Various hardware and software issues have been identified with the Reson 7111 system since the initial upgrade in October 2009 which include: CARIS uncertainty modeling, real-time pitch application, several transceiver hardware failures, and bottom detection algorithms; all of which affect the system's performance capabilities and use. While *Fairweather* continues to work with Reson, NOAA, and academia to understand the cause of the issues and to resolve them, various data acquisition and processing modifications may be made based upon the current status of the Reson 7111 system. Updated information about the Reson 7111 issue is provided in the Project Correspondence folder submitted with each survey.

1.2.2 Reson 8160 Multibeam Echosounder (MBES)

Fairweather is equipped with a Reson SeaBat 8160 MBES with the snippet option. The Reson 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 Figure 3 & Figure 4).

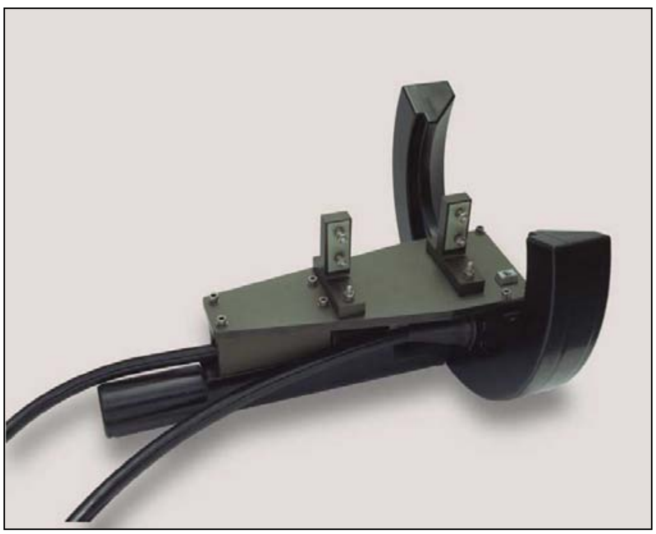


Figure 1: RESON SeaBat 7111 MBES

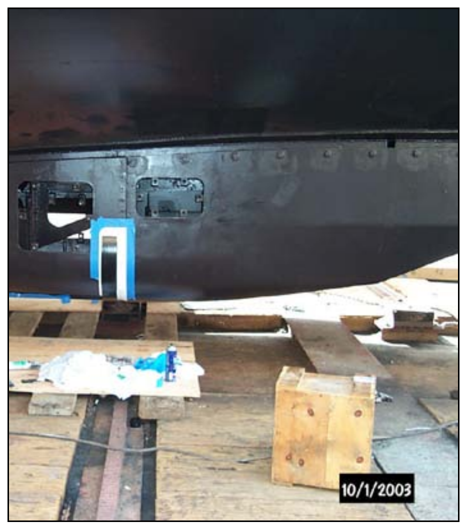


Figure 2: Installed on *Fairweather*

Figure 3: Reson SeaBat 8160

Figure 4: Installed on *Fairweather*

1.2.3 Reson 7125SV Multibeam Echosounder (MBES)

Survey launches 2805, 2806, 2807 and 2808 are each equipped with a dual frequency Reson 7125SV MBES. The Reson 7125SV has both low frequency (200kHz) and a high frequency (400kHz) head with a swath coverage of 128°. The swath is made up of 256 discrete beams for 200 kHz and 512 discrete beams for 400 kHz. The typical operational depth ranges for the Reson 7125SV operating at 200kHz is 3 to 400 meters and 3 to 100 meters operating with the 400kHz system. No calibration information was provided by the manufacturer for the system. Each system is hull mounted along the centerline (see Figure 5).

Figure 5: Reson 7125SV on a *Fairweather* Launch

1.2.4 Klein 5000 Side Scan Sonar (SSS)

The Klein Series 5000 Sonar System consists of a side scan sonar instrument-mounted towfish, 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 SIPS HDCS file format for post processing.

Testing of dual Klein 5000 SSS and Reson 7125 MBES data acquisition occurred in March 2010. The report of the test plan and results are located in Appendix II, *2010 - FA Dual SSS & MBES Acquisition*.pdf. A supplemental wiring diagram for when the launches are outfitted with Klein 5000 SSS is maintained aboard *Fairweather*. Reson 7125 MBES data acquired simultaneously with the SSS data is filtered down to 50-degrees on the side on which the SSS is mounted.

The towfish can be used in one of two configurations, hull-mounted on any one of *Fairweather's* launches (Figure 6) or towed from *Fairweather* (Figure 7). 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. If in a towed configuration, full sidescan calibration and documentation will be conducted prior to data collection and system utilization.

Figure 6: Hull-Mounted Klein 5000 Side Scan Sonar on *Fairweather* Launch

Figure 7: Towed Klein 5000 Side Scan Sonar on Fairweather

1.3 Manual Sounding Equipment

1.3.1 Lead Lines

Vessels are equipped with a lead line when appropriate. 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 March 24, 2010, and documentation is maintained aboard *Fairweather*.

1.4 Positioning, Heading, and Attitude Equipment

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

Fairweather and her launches are each equipped with a 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 mounted POS Computer System (PCS), a strap down IMU-200 Inertial Measurement Unit (IMU), and two GNSS antennas corresponding to GNSS receivers in the PCS. *Fairweather* (S220) and launches 2805, 2807, and 2808 are equipped with new Zephyr II GNSS antennas. Launch 2806 is equipped with used Zephyr I GNSS antennas. *Fairweather* (S220) and launch 2805 are equipped with BD960 PCS antenna receiver cards, and launches 2806, 2807, and 2808 are equipped with BD950 PCS antenna receiver cards. The port side antenna is designated as the primary receiver, and the starboard side antenna is the secondary receiver (see Figure 8). The POS/MV firmware version 4.22 and the controller software version 4.3.4.0 are currently the installed versions utilized. Differential correctors are supplied to the *Fairweather's* POS MV by a CSI wireless MBX-3S Automatic Differential GPS receiver and to launches 2805, 2806, 2807 and 2808 by a Hemisphere GPS MBX-4 Automatic Differential GPS receiver.

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. 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.

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.

On May 2, 2010, two new Zephyr II GNSS POS/MV antennas were installed aboard *Fairweather*, replacing the existing Zephyr I antennas mounted on the ship. The vertical coordinate for the 'primary antenna to ref entry' in the POS/MV was changed in the POS/MV controller software by roughly 2cm to account for the new antenna offsets and is incorporated into the S220 *Offsets & Measurements* spreadsheet included in Appendix II. The Nav-to-Transducer TPU values in the Reson 7111 and 8160 hvfs were also updated as well as the TPU spreadsheet in Appendix III to account for the antenna change. The serial numbers of the two new antennas are captured in the Hardware Inventory spreadsheet in Appendix I.

1.4.2 POS/MV GAMS Calibration

In the spring of 2010, GNSS Azimuth Measurement System (GAMS) calibrations were performed on each of *Fairweather's* five POS/MV units mounted to launches 2805, 2806, 2807, 2808, and *Fairweather* (S220). The GAMS calibration procedure was conducted in accordance with instructions in chapter 4 of the *POS/MV V4 Installation and Operation Guide*, 2005. Results and calibration reports are maintained with reference documentation aboard *Fairweather*. Actual calibration dates are listed in the Hardware Inventory included in Appendix I.

Figure 8: POS GNSS Antennas

1.4.3 DGPS Receivers

Fairweather is equipped with a commercial grade CSI Wireless MBX-3S DGPS Receiver on *Fairweather* (S220) and Hemisphere GPS MBX-4 DGPS receivers on launches 2805, 2806, 2807 and 2808 that are used to correct the POS/MV GPS positions used during real-time MBES 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.

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

When *Fairweather* operates in remote areas outside of DGPS range such as the Bering Sea, *Fairweather* is equipped with a NavCom receiver for utilizing the subscription-based StarFire Network, which is a global satellite based augmentation system capable of real-time decimeter position accuracy. None of *Fairweather's* launches are equipped with NavCom receivers. Launches run in course acquisition mode (CA) during real-time data acquisition, which typically results in 2-3 meter horizontal position accuracy. All individual vessel POSMV files from both the launches and ship are post processed whenever possible as described in the individual survey Descriptive Reports and project Horizontal and Vertical Control Reports.

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. Field computers currently in use are Panasonic Toughbooks; 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 (figure 9) were tested over a published benchmark. Trimble positions matched the published benchmark position within 0.6m. Test results are maintained with reference documentation on board *Fairweather*.

Figure 9: Trimble Backpack Unit

1.4.5 Hand-held Laser

The Impulse Laser Rangefinder (figure 10) and TruPulse 200 Laser Rangefinder (figure 11) 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 10: IMPULSE LR Laser Rangefinder

Figure 11: TruPulse 200 Laser Rangefinder

Data quality assurance testing was conducted in June 2010 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 maintained with reference documentation on board *Fairweather*.

1.5 Sound Speed Equipment

1.5.1 Sound Speed Profiles

1.5.1.1 SBE 19plus SEACAT Profiler

Fairweather is equipped with three SBE 19*plus* and two SBE 19*plusV2* SEACAT sound speed 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 speed profilers were calibrated by the manufacturer in early December 2009. The current calibration files are maintained with reference documentation aboard *Fairweather*.

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.

1.5.1.2 Moving Vessel Profiler 200

A Brooke Ocean Technology, Ltd. (BOT) Moving Vessel Profiler 200 (MVP 200) is mounted in the aft starboard corner of the fantail (see Figure 12). The MVP 200 system is a self contained sound speed profiling system capable of sampling water column profiles to 200 meters deep 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 data 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 with software version 2.4 is used to control the MVP system and to acquire SVP data. The 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 2) the maximum depth and 3) maximum cable out. 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.

Fairweather has three Applied Microsystems Ltd. Sound Velocity and Pressure Smart Sensors. All of the sensors were calibrated by the manufacturer during the 2009-2010 winter repair period. The resulting calibration files are maintained with reference documentation aboard *Fairweather*.

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 12: *Fairweather*'s MVP200 sound velocity system

1.5.2 Surface Sound Speed

1.5.2.1 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 13.

Figure 13: *Fairweather*'s SVP 70 sound speed unit (left) and the 8160

The sound speed is output to the Reson 7111 and Reson 8160's processing units. The transducers require sound velocity information for beam forming. The Reson 7111 and Reson 8160 are not used to acquire data without real time sound speed information.

The unit was installed during the 2009 winter drydock period in Seattle, Washington, at Lake Union Drydock Company. The last calibration of the unit was dated January 4, 2009; the calibration report is maintained with reference documentation aboard *Fairweather*.

1.5.2.2 Reson Sound Velocity Probe (SVP 71)

Survey launches 2805, 2806, 2807 and 2808 are each equipped with a Reson SVP 71. The SVP 71 measures the speed of sound near the transducer to provide real time surface sound speed values to the Reson 7125's processing unit. The 7125SV requires surface sound speed information for beam forming due to the flat faced transducer. The units are hull-mounted adjacent to the Reson 7125's transducers as shown in Figure 14.

All of the sensors were calibrated by the manufacturer and current calibration files were supplied with the units. Calibration files are maintained with reference documentation aboard *Fairweather*.

Figure 14: SVP 71 sound speed unit (right) and a Reson 7125

1.6 Vertical Control Equipment

1.6.1 Water Level Gauges

Two Sutron 8210 tide gauges and one 9210B Sutron tide gauge were provided to *Fairweather* by the Center for Operational Oceanographic Products and Services (CO-OPS) at the start of the 2010 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 *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. Three gauges underwent testing in April 2010 and results are maintained with reference documentation aboard *Fairweather*.

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. Calibration was conducted by Kuker-Ranken Inc. on February 3, 2010, and the results are maintained with reference documentation aboard *Fairweather*.

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 procedures were performed on March, 10, 2010 on all four levels, and the 2010 results are maintained with reference documentation aboard *Fairweather*.

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 in post processing kinematic (PPK) correctors.

Equipment accuracy testing of all three GPS units was performed by *Fairweather* personnel in Seattle, Washington on March 10, 2010. The Online Positioning User Service (OPUS) solutions were obtained using data acquired with all three GPS units over a local benchmark and comparing the solutions to each other and to the published data sheet for the geodetic mark used. Data compared well within the accuracy of the published position of the benchmark. The OPUS solutions are maintained with reference documentation aboard *Fairweather*.

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 mounted to *Fairweather* and her launches. 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. Horizontal control equipment serial numbers and version installation dates are located in the hardware section of Appendix I.

2.0 Software

2.1 Software Systems Inventory

An extensive software inventory with documentation of the software systems used by *Fairweather* is maintained as a survey *Software Inventory* spreadsheet on board *Fairweather*. This spreadsheet includes specifics such as software applications, versions, and hotfixes that are loaded on specific survey processing computers. Snapshot .pdf files are produced monthly. The pertinent monthly inventories are included with the Supplemental Survey Records for the individual Descriptive Reports.

2.2 Data Acquisition Software

2.2.1 Hypack® Hysweep

Fairweather uses the Hypack® Hysweep acquisition software package to log all Reson MBES data. Hysweep displays real-time MBES coverage geo-referenced against supporting background files such as charts and vector shoreline files for launch and ship helmsman to follow to acquire adequate MBES coverage. The Hypack Devices (Hysweep Interface, Applanix POS/MV Network, AIS, and MVP) and Hysweep Hardware (Hypack Navigation, Applanix POS/MV Network, and Reson) setups are set in accordance with HSTP's configuration management documentation.

Three types of files are recorded per logged line of Reson MBES data: .raw, .hsx , and .7k. The .raw file contains the raw navigation files recorded directly from the POS/MV (device 1) and from Hysweep (device 0). The .hsx files contain raw data from the Hysweep Interface (device 0), the POS/MV (device 1) and the Reson MBES (device 2). The .7k file contains all raw data that Hysweep can read from the Reson, including the Reson 7008 snippets message.

The .hsx and .raw files are converted into HDCS data in CARIS HIPS by *Fairweather* personnel. The .7k file is not post-processed by *Fairweather* personnel but is recorded for use by the Integrated Ocean and Coastal Mapping (IOCM) Center for research on backscatter processing and product development. All three raw files are submitted for archival at NGDC via the IOCM Center in accordance with the Office of Coast Survey's Backscatter Acquisition, Processing, Quality Check and Archival Pipeline Project. Additionally, the MBES sensor offsets and mounting biases are entered into the respective vessel's Hysweep Hardware device to facilitate IOCM's backscatter processing using Hypack GeoCoder. Entry of device offset values in Hysweep Hardware causes the values to be logged in the header of the .hsx only, and does not affect the data pipeline. These values are not tracked or closely monitored aboard *Fairweather* because they are part of IOCM's backscatter development project and not otherwise integral to meeting the requirements of the 2010 HSSD.

2.2.2 CARIS Notebook

CARIS Notebook™ can be used to directly collect detached shoreline positions and to 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.

2.2.3 Klein SonarPro

Klein SonarPro is a custom display and acquisition software package for use with Klein Side Scan sonar systems. *Fairweather* uses SonarPro to monitor the quality of real-time imagery and to log raw side scan files in .SDF file format while acquiring Klein 5000 Side Scan data from the sled-mounted systems configurable on any of *Fairweather's* launches. Vessel navigation data from the POS/MV is supplied to SonarPro and logged in the SDF file. The raw SDF files are converted using CARIS SIPS into HDCS files for post processing and analysis.

2.2.4 Applanix POSView

Applanix POSView is the controller software for the POS/MV. POSView is used to configure the serial and network input and output ports on the POS/MV PCS. POSView is also used to monitor real-time position and attitude data and their associated accuracies and to log POSPac .000 files. The POSPac .000 file contains the TrueHeave information that is applied to the MBES HDCS data in CARIS HIPS immediately after conversion. The POSPac .000 file is also post-processed into a PPK SBET file using Applanix's POSPac processing software.

2.3 Data Processing Software

2.3.1 CARIS

CARIS HIPS™ (Hydrographic Information Processing System) is used to process all multibeam data including data conversion, filtering, sound speed corrections, tide correction, merging and cleaning. CARIS HIPS also calculates the Total Propagated Uncertainty (TPU) used to produce Bathymetry Associated with Statistical Error (BASE) surfaces which assist the Hydrographer in data cleaning and analysis, and to produce BASE surfaces.

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, display, and edit source shoreline, shoreline updates and S-57 features that are collected directly in the field, digitized, or imported. The .hob files created in Notebook are the current shoreline deliverables.

CARIS Bathy DataBASE™ BASE Editor is used for data quality assurance checks on the BASE surface and .hob deliverables and for surface differencing and comparisons.

CARIS Plot Composer is used to create final field plots and special constituent products.

2.3.2 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.

If warranted, Fledermaus ™ can be 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.

2.3.3 Geocoder

The Hypack version of Geocoder software originally developed by Dr. Luciano Fonseca at the University of New Hampshire's Center for Coastal and Ocean Mapping (CCOM) is used occasionally by senior *Fairweather* personnel to check Reson Snippet backscatter data and to create backscatter mosaics. *Fairweather* also possesses a copy of the University of New Hampshire CCOM implementation of Geocoder for testing and comparison purposes.

2.3.4 Applanix POSPac MMS and POSGNSS

Applanix POSPac MMS and POSGNSS are used to post process POS/MV data files logged simultaneously during MBES acquisition. The Single Base PPK processing method is typically used when a single *Fairweather* or third party GPS base station is operating within approximately 20 kilometers of MBES acquisition. The SmartBase™ PPK processing method is used when a stable network of approximately 5-10 available third party GPS base stations such as those in the Continuously Operating Reference Station (CORS) system or Plate Boundary Observatory (PBO) suite of stations exists within approximately 200 kilometers of MBES acquisition. On occasion Precise Point Positioning (PPP) is used when sufficient base stations are not available for Single Base or SmartBase™ PPK. In general, *Fairweather* processing procedures follow the methods outlined in the *POSPac MMS GNSS-Intertial Tools User Guide* for each method. Processing methods specific to each project are documented in the Project Horizontal and Vertical Control Report. Processing methods specific to each survey are documented in the Descriptive Report

2.3.5 Velocipy

Velocipy is a NOAA in-house software supported by the Hydrographic Systems and Technology Program (HSTP) that is used to process raw sound velocity cast files taken with the SEACAT CTDs on the launches and the MVP from the ship. Velocipy creates CARIS format .SVP files that are applied during post processing in HIPS to MBES HDCS data to correct for sound speed. The individual CTD and MVP files are concatenated into a single vessel file by survey. Each vessel file contains the survey registry number and the time and location of each sound speed profile measured.

2.3.6 Pydro

Pydro, another NOAA program produced and maintained by HSTP, is used to produce Final Water Level Requests along with DTON Reports. In addition, Pydro is used for Tidal Constituent and Residual Interpolation *(*TCARI) tide application in conjunction with CARIS HIPS and various other macros.

3.0 Vessels

3.1 Vessel Inventory

Fairweather (S220) and her survey launches 2805, 2806, 2807, and 2808 are equipped to acquire multibeam echosounder (MBES) and sound speed profile (.svp) data. The AMBAR (2302) and SeaArk (1905) are used primarily during shoreline verification, bottom sampling, and horizontal and vertical control operations. All vessels may be used in support of dive, tide gauge, and horizontal control operations as well as for feature verification and bottom sampling. See Appendix I for the complete vessel inventory.

3.2 Noise Analysis

Fairweather sonar systems, the current Reson 8160 unit and the earlier Reson 8111ER unit, underwent noise analysis testing on October 10 and 11, 2004, respectively. Due to the change to the 7111 unit and alterations to the shaft bearings on *Fairweather* since these surveys, the results are likely out of date and are no longer followed. It is recommended that new Noise Analysis testing be conducted for both the Reson 7111 and 8160 systems.

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 section 8.1.5.2 of 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.

When possible real time DGPS positioning may later be replaced with a post processed kinematic (PPK) single best estimate of trajectory (SBET). The PPK solution is usually dependent on a local base station supported by the ship and processed in Applanix POSPac MMS software using Single Base mode. However, in areas with an adequate network of Continuously Operating Refrence Stations (CORS) or public third-party base stations, Applanix POSPac SmartBase™ mode may be used. The resulting navigation from PPK is an improvement over C/A and DGPS navigation. The details of PPK use and application for a given survey will be included in the Horizontal Control section of the project's *HVCR* or the survey's descriptive report.

4.2 Multibeam Echosounder Acquisition and Monitoring Procedures

Acquisition methods and platforms used are determined based on consideration of sonar system specifications, seafloor topography, water depth, and the capability of the acquisition platforms.

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 7125SV, Reson 7111, and Reson 8160. Adjustable parameters that are used to control the Reson include range scale, power, gain, pulse width, absorption, and spreading. These parameters are adjusted as necessary to acquire the highest quality of bathymetry and backscatter. Vessel speed is predominantly between 6-8 knots for acquisition with launch 7125SV systems. For Reson 7111 and Reson 8160 acquisition systems, vessel speeds are 6-7.5 knots. Speeds are 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 *Fairweather* while setting and utilizing the Reson systems and Hypack for data acquisition. The sensor offsets and mounting biases are entered into the Hysweep® Hardware Reson device. This information is recorded in the Hypack hsx file header for corrected backscatter mosaics created with Hypack Geocoder. These offsets do not have any effect on CARIS HIPS HDCS sounding corrections.

Navigation and motion data are acquired and monitored in POSView and logged into a POS/MV file with a .000 extension. Various position and heading accuracies, as well as satellite constellations, are monitored real-time both in POSView and Hypack Hysweep®.

Main scheme MBES acquisition lines using the Reson 7125SV, Reson 7111, and Reson 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 the required finalized BASE surface resolutions. For discrete item developments, line separation is reduced to two times the water depth to ensure least-depth determination by multibeam near-nadir beams. Hypack Hysweep® real-time coverage display is used in lieu of pre-planned line files. Hysweep® displays the acquired multibeam swath during acquisition and is monitored to ensure overlap and full bottom coverage. If coverage is not adequate, additional lines are run while still in the area.

For areas where shoreline verification is not conducted before multibeam, extra caution is taken by "half stepping" shoreward when operating near shore. Half stepping is done by driving along the edge of real time coverage to prevent the survey vessel from ever being in un-surveyed waters. Survey launch crews in the field survey to the Navigable Area Limit Line (NALL) line as defined by section 1.1.2 of the *HSSD.*

4.3 Shoreline/Feature Verification

The composite source file (CSF) in S-57/.000 format provided with the Project Instructions is the primary source for shoreline features to be verified. The original project file is imported into CARIS Notebook, converted to a .hob file, clipped to the sheet limits for the specific survey, and named H#####_Original_Composite_Source.hob to be included with the deliverables. This file is then copied and named H#####_Feature_File.hob to be utilized during field verification. Additionally, AWOIS items and other features to be investigated are provided to the field in the project reference file (PRF). These items are parsed into separate .hob files and are used for investigations and during shoreline verification.

Fairweather personnel conduct limited shoreline verification and reconnaissance at times near predicted negative tides within the survey limits, as directed by section 3.5.5.3 of the *FPM*. Detached positions (DPs) are acquired and edits to the daily field feature files are recorded in CARIS Notebook and on paper DP forms and boat sheets.

An inshore limit buffer line, offset 0.8 mm at the scale of the largest chart in the area, is provided with the Project Instructions or created by offsetting from the composite source Mean High Water (MHW) line. This inshore limit buffer line is used in the shoreline acquisition software and on the boat sheet as a reference, and utilized as described in section 1.1.2 of the *HSSD*. The NALL is determined in the field as the farthest off-shore of one of the following; the MHW inshore limit buffer specified above, the 4-meter depth contour, or the inshore limit of safe navigation as defined by the *HSSD*. All shoreline features from the CSF seaward of the NALL are verified (including an update to depth and/or position as necessary) or disproved during operations. Features off-shore of the NALL and not addressed or features of an ambiguous nature include remarks 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.

4.4 Bottom Samples

Bottom samples are acquired according to section 7.1 of the *HSSD*, any deviations from this protocol will be outlined in the individual Descriptive Report for the survey. Samples are acquired using CARIS Notebook, Hypack target files (.tgt), or by logging the latitude, longitude, and bottom characteristics manually. All samples are processed similarly to other shoreline features as outlined below in section C - 2.2 of this report. Bottom sample results are included in the Notebook .hob deliverable layer, HXXXXX_Final_Feature_File and are descriptively attributed as New.

C. QUALITY CONTROL

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 2010 *FPM*.

Estimates for the Motion Reference Unit (MRU) alignment errors are taken from the standard deviation of the values determined by multiple personnel processing the patch test data (see section C 4.0). In some instances, outlier patch test values are excluded to allow more reasonable MRU uncertainty values.

The *Fairweather* TPU Values spreadsheet located in Appendix III, 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 TPU 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 HIPS HDCS format using established and internally documented settings. After TrueHeave™, sound speed, and water level correctors are applied to all lines, the lines are merged. Once lines are merged, Total Propagated Uncertainty (TPU) is computed.

The general resolution, depth ranges, and Combined Uncertainty and Bathymetric Estimator (CUBE) parameter settings outlined in section 5.2.2.2 of the *HSSD* and section 4.2.1.1.1.1 of the *FPM* are used for surface creation and analysis. These depth range values for specific resolutions may require adjustment by sheet managers for individual surveys to address visualization gaps between finalized surfaces in areas of steep slopes. A waiver from HSD Operations is requested by project when the prescribed finalized depth ranges are not used for analysis and submission. A detailed listing of the resolutions and 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 CUBE algorithm and parameters contained in the NOAA CUBEParams_2010.xml file as provided in Appendix 4 of the *FPM* The CUBEParams_2010.xml will be included with the HIPS Vessel Files with the individual survey data. The NOAA parameter configurations for resolutions 1-32 meters are used.

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 view are also used to demonstrate coverage and to check for errors due to tides, sound speed, 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 depths less than 20 meters and deeper and in areas of navigational significance where the BASE surface does not depict the desired depth for the given area, a designated sounding is selected. Designated soundings are selected as outlined in section 5.2.1.2 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 areas of high uncertainty with respect to depth. 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. The following logic equation is used to create "IHO_1" child layers in the 1 through 8 meter finalized surfaces:

(IHO-1: ((0.5^2 +((Depth*0.013)^2))^0.5)-Uncertainty),

and an "IHO_2" child layer is created in the 8, 16 meter, and greater finalized surfaces using

(IHO-2: ((1^2 +((Depth *0.023)^2))^0.5)–Uncertainty).

It should be noted that both IHO order 1 (~80 to 100) and order 2 (100 to 176) child layers are created for the 8 meter surface since it overlaps the order 1 and order 2 boundary (order1<100 meters, order 2>100 meters). IHO surfaces are utilized during data collection and processing as an additional child layer of the finalized surfaces to indicate problem areas that need attention or discussion. Additionally, the percentage of IHO nodes passing from the combined finalized surfaces is included in the Descriptive Report for each survey. For visual depiction of localized areas that do not meet IHO standards, screen grab(s) of the individual finalized IHO child layer(s) may also be included.

The individual finalized or combined surface's IHO layers are exported from CARIS as a text file and examined to allow the Hydrographer to see the full data distribution rather than just the minimum and maximum values in the surface. These data distribution are used to assess the quality of the survey, to ensure ninety-five percent of the data meets the appropriate IHO order as specified in section 5.1.3 of the *HSSD.*

Additionally, a combined surface is reviewed in 3-D mode using one of the following programs, CARIS HIPS, CARIS Base Editor, or IVS Fledermaus, to ensure that the data are sufficiently cleaned for submission.

2.2 Shoreline/Feature Data Processing

During shoreline verification, field detached positions (DP) are acquired with CARIS Notebook or Hypack .tgt files. Tide application for features requiring tide correction is applied in CARIS Notebook when using discrete zoning and with the aid of Pydro when TCARI is used.

New features and any updates to the composite source shoreline, such as ledges or reefs, are acquired or digitized with S-57 attribution and are compiled from the field daily files into the H#####_Final_Feature_File.hob. Updates to source shoreline features primarily include a change in depth/height, position, or S-57 classification. Notebook's editing tools are used to modify source feature extents or positions.

The SORIND and SORDAT S-57 attribute fields for new features or modified source features are updated to reflect the information for the associated survey number and date (US,US,graph,H#####). All new or modified features are S-57 attributed as applicable and descriptively attributed as New or Update respectively. All unmodified source features retain their original SORIND and SORDAT values. Assigned features that are addressed but not updated are descriptively attributed as Retain and unaddressed assigned features are attributed as Not Addressed.

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, the Hydrographer may include a recommendation 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 descriptively attributed as Delete in the H#####_Final_Feature_File.hob layer. Features with the attribution of Delete retain their original SORIND and SORDAT values and include a recommendation from the Hydrographer along with an informative remark.

AWOIS investigation items are received in the Project Reference File and investigated as necessary. Shoreline features correlated to the AWOIS item are included in the H#####_Final_Feature_File.hob layer and labeled with the appropriate AWOIS number and include a remark detailing the search methods and a recommendation from the Hydrographer. Items will be attributed as AWOIS for reporting purposes. Any features that are submitted as dangers to navigation (DTON) will be attributed accordingly for reporting purposes. The status of Primary or Secondary may be attributed to aid in deconflicting multiple positions or instances of the same feature.

Photos are labeled and associated with a DP/userid number or other descriptive/unique name. They are included with the survey data and stored in the CARIS/Multimedia folder with the deliverables. References to the photos are listed with file extension and comma delimited in the Images attribute for the specific feature.

The CARIS Notebook files along with CARIS HIPS BASE surface(s) are viewed to compare MBES coverage and features simultaneously. The current NOAA object catalog will be used for CARIS Notebook processing and the version of such will be documented in the individual Descriptive Reports, along with any deviations in shoreline processing from those listed above.

Final shoreline deliverables are two Notebook HOB files, the H##### Original Composite Source and the H##### Final Feature File, included with the CARIS data. A feature listing, which includes S-57 and other attribution of items addressed by the survey, in either geography markup language (.gml) and/or as a Microsoft Excel spreadsheet or equivalent is included in Appendix II of the individual Descriptive Report.

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, H##### Data Log, is included in the Separates submitted with the individual survey data.

D. Corrections to Echo Soundings

1.0 Vessel HVFs

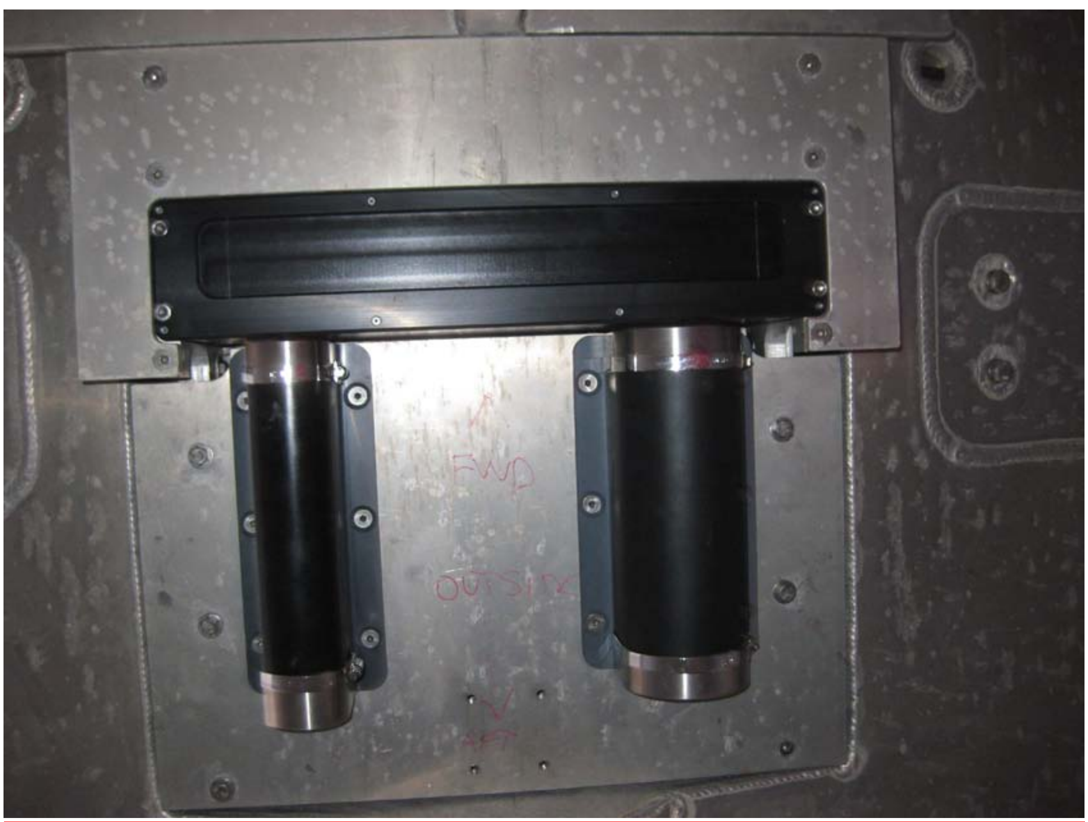
CARIS HIPS Vessel Files (HVF) are created by *Fairweather* personnel and used to define a vessel's offsets and equipment uncertainty. The HVF is used for converting and processing raw Hypack .hsx and .raw files to CARIS HIPS HDCS format. The HVFs used for a given project are included with the digital data submitted with the survey.

2.0 Vessel Offsets

Sensor offsets are measured with respect to each vessel's reference point. The reference point for *Fairweather* and her survey launches 2805, 2806, 2807, and 2808 is the top, center of the POS/MV IMU (Figure 15). The offset values from the reference point to the primary GNSS antenna are entered into Applanix's POSView POS/MV monitoring software so that all raw position data are centered at the vessel's reference point. The CARIS HVF contains the offset from the vessel's reference point to the multibeam sonar reference point.

Figure 15: Vessel Reference Point (Center of POS/MV IMU) and Primary GNSS Antenna (port side antenna).

Additionally, the Reson sonar mounting offsets measured from the center of each projector to the center of the transceiver are entered in the Reson 7125 hardware configuration with the 7K Center for both the 400 kHz and 200 kHz projectors. The measured values are used instead of Reson's default values because *Fairweather's* mounts are slightly different than of Reson's standard sonar mount (Figure 16).



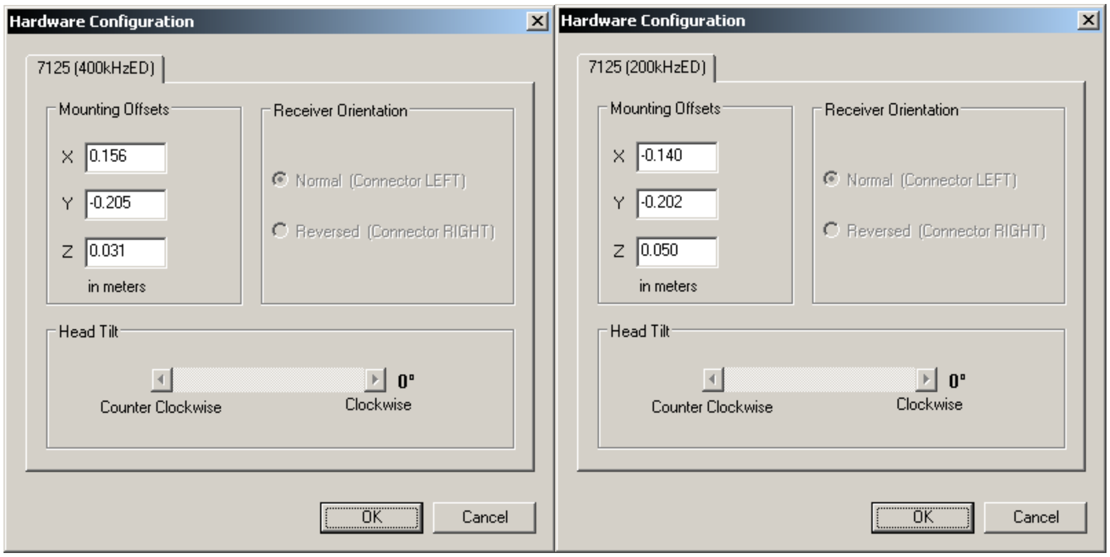


Figure 16: Reson 7125 sonar mounting with 400kHz and 200kHz offsets respectively.

A ship survey of *Fairweather* was completed by Westlake Consultants, Inc on September 23, 2003. A spatial relationship survey of *Fairweather* POS/MV components was conducted by NOAA's National Geodetic Survey (NGS) in February 2007, and again on February 15, 2009, while the ship was in Lake Union Drydock in Seattle, WA. The results of the Westlake, the 2009 NGS survey, and additional offset values discussed below in section D 4.0 are used to determine the offsets for the ship. The reports from each survey, whose values are used for the offset measurements, are located in Appendix II. The S220 *Offsets & Measurements* spreadsheet is also included in Appendix II, listing the final values for *Fairweather*'s offsets with explanations of how they were calculated.

Permanent control points were established on launches 2805, 2806, 2807, & 2808 during construction at All American Marine in 2009. Sensor offsets were measured by NGS in January 2010 using the methods described in the report on each launch located in Appendix II of this report. The resultant offsets, measurements, derivations, descriptions of methodology used, diagrams, and coordinate system references are included in the respective vessel's *Offsets & Measurements* spreadsheet also included in Appendix II.

3.0 Static and Dynamic Draft

The static drafts (*Waterline Height* in the HVF) for launches 2805, 2806, 2807, and 2808 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 values and calculations for static draft of the various launches are listed in the respective *Waterline Measurement* spreadsheets included in Appendix II of this report.

The static draft of *Fairweather* was measured under different loading conditions with different amounts of fuel. The bow and stern draft marks were recorded and then used to perform a linear interpolation of the static draft at *Fairweather*'s IMU. The *Ship Draft 2010* spreadsheet records the static draft values and is included with the ship offset documentation in Appendix II.

Fairweather's dynamic draft measurement was taken February, 2010 in Lake Washington while the ship was transiting from Sand Point to South Seattle. The dynamic draft of launches 2805, 2806, 2807, and 2808 were measured similarly in Lake Washington in March, 2010. 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 data on each vessel and then processing the data with local reference stations in Applanix POSPac MMS 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 NOAA personnel and implemented within Pydro. The polynomial curve was used to derive the table used in the CARIS HVF, and the standard deviation of the residuals was used to determine the associated uncertainty in the measurement. Written reports for each platform about the initial measurements carried out in February and March are provided in Appendix II of this report. The polynomial best fit curve of the ellipsoidal height differences from launches 2805, 2806, and 2808 compare well with each other. Due to IMU issues with launch 2807, the ERDDM failed several times before finally being successfully completed on May 23rd, 2010 in the Behm Canal working grounds after the faulty IMU was replaced. The values obtained during this measurement were compared to the other launches and were found to compare favorably. The dynamic draft offset values and standard deviation were then entered into the two 2807 CARIS HVFs.

4.0 Patch Tests

Patch tests were conducted on launches 2805, 2806, 2807 and 2808 for the Reson 7125SV MBES sonar systems during the month of March 2010 using the Shilshole Bay Reference Surface and Patch Test site near Seattle, WA. Additional patch tests were conducted on launch 2807 in April 2010 after the IMU failed and was replaced with a spare unit.

Patch tests were conducted for *Fairweather's* Reson 8160 and Reson 7111 MBES sonar systems during May, 2010, near Ketchikan, AK. A second roll bias test for the Reson 7111 was conducted on July 14, 2010, near Dutch Harbor, AK, and the value post-applied to all Reson 7111 data acquired in 2010. 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 II.

Also included in Appendix II is the Sounding System Comparison. This comparison includes surface differencing between all launch and ship MBES reference surfaces using CARIS Bathy Database. Since all launch reference surfaces closely agree with one another, only launch 2805 Reson 7125's reference surface was differenced with the ship's Reson 7111 and Reson 8160 reference surfaces. The results of the comparison show that the Reson 8160 data are on average 0.206 meters deeper than the launch data, and that the Reson 7111 data are on average 0.322 meters deeper than the launch data. Due to this measured offset and similarly observed offsets between launch and ship systems during the past several field seasons, the ship multibeam system HVF vertical Z-values (FA_S220_Rsn7111_301bms_2010.hvf and FA_S220_Rsn8160_5to750_2010.hvf) have been adjusted to reflect this measurement. The values are listed under 'Correction based on Reference Surface' and are included in the S220 *Offsets & Measurements* spreadsheet located in Appendix II.

5.0 Attitude and Kinematic Data

Vessel attitude is measured by the POS/MV and recorded in the Hysweep .hsx file. Roll is applied real time to Reson 8160 and Reson 7125SV data. Pitch is applied real time to Reson 7111 and Reson 8160 data. Attitude measurements not applied in real time (heave, pitch, roll, and heading) are applied during post processing in CARIS HIPS using the raw POS/MV attitude data recorded in the Hysweep .hsx file. Post processed kinematic (PPK) data from the POS/MV .000 file are applied to MBES data in CARIS HIPS in the form of SBET files once all data acquisition is complete.

The POS/MV IMU uncertainty values for heave, pitch, roll, and heading measurements were derived from the manufacturer specifications and are listed in the *Fairweather TPU Values* spreadsheet located in Appendix III of this report. When PPK data are applied, the error file associated with the SBET is applied in CARIS HIPS to include the uncertainty of the PPK data in the total propagated uncertainty estimation of each sounding. This practice is a known issue that artificially inflates the total propagated uncertainty estimation because CARIS HIPS does not remove the real-time POS/MV heave, pitch, roll, and heading values when the SBET error file is applied.

5.1 TrueHeave™

The POS/MV TrueHeave™ data is logged within the POS/MV .000 files and applied in CARIS HIPS during post processing using the "Apply TrueHeave" function. TrueHeave™ is a forward-backward filtered heave corrector as opposed to the real time heave corrector, and is fully described in Section 6 of the *POS/MV Version 4 Installation and Operation Manual*. To ensure proper application in CARIS HIPS, POS/MV files are logged for at least three to five minutes before and after all MBES files are logged.

If the POS/MV files fail to apply in CARIS HIPS during the "Apply TrueHeave" process the files are fixed using a CARIS tool called "fixTrueHeave.exe." In cases where this is necessary a new fixed file is created with the extension ".fixed" (2010-ddd-vssl.000.fixed). The new fixed TrueHeave™ file is then applied to the data in CARIS HIPS. The original corrupted file is retained along with the fixed file with the submitted Global Navigation Satellite System (GNSS) data. Occurrences of this for specific surveys are noted in the individual Descriptive Reports.

In cases where TrueHeave™ cannot be applied, real time heave correctors are used. Real time heave data are recorded and stored in the Hypack Hysweep .hsx file and are applied as the heave corrector for MBES data if TrueHeave™ files are unavailable. Data that do not have TrueHeave™ applied will be listed in the individual Descriptive Report for the survey.

5.2 Post Processed Kinematic Data

Post Processed Kinematic (PPK) data in the form of Single Best Estimate of Trajectory (SBET) files are applied to soundings to increase the accuracy of the kinematic vessel corrections and to allow the ability to reference soundings to the ellipsoid.

Standard daily data processing procedures aboard *Fairweather* include post processing of POS/MV kinematic .000 files using Applanix POSPac MMS and POSGNSS software using either Single Base or SmartBase batch processing methods as described in section B.2.3.4. After processing and quality control analysis of the post-processed SBET files is complete, the SBET and SMRMSG files are applied to the HDCS data in CARIS HIPS using the “Load Attitude/Navigation Data”, the “Load error data…”, and “Compute GPS Tide” processing tools. Ellipsoidal heights are contained within the PPK SBET files. Soundings to which SBETs have been applied can be reduced to the ellipsoid by merging the data in CARIS HIPS with “GPS Tide” applied. Data are frequently referenced to the ellipsoid during data analysis for troubleshooting unexplained vertical offsets.

Positioning of features and bottom samples is not corrected with post processed GNSS data because at this time as there is not a developed nor streamlined procedure for PPK application to features.

6.0 Sound Speed

Seabird SBE 19*plus* and SBE 19*plusV2* sound speed profilers are used regularly to collect sound speed data for the Reson 7125SV MBES systems on survey launches 2805, 2806, 2807, and 2808, and used on an as needed basis for *Fairweather*’s Reson 7111 and Reson 8160 MBES systems. The Brooke Ocean Technology Moving Vessel Profiler (MVP) is primarily used to collect sound speed data for sound speed correction of data acquired with *Fairweather*’s Reson 7111 and Reson 8160 MBES systems.

Daily sound speed profiles from the SBE 19*plus* and SBE 19*plusV2* profilers are processed with Velocipy 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 BOT_XXXX.calc, where X is the incrementally increasing cast number. The .calc file for each cast is opened with Velocipy and converted into CARIS .svp file format. The individual .svp profiles are concatenated into vessel specific .svp files for the entire survey. Individual sound speed profiles taken by the MVP are not submitted separately due to the large number of casts acquired and the way in which they are processed; however, the daily concatenated files are submitted for backup purposes and include all profiles acquired.

The concatenated sound speed files are applied to multibeam data in CARIS HIPS during data processing. CARIS HIPS uses one of four different methods to automatically apply a sound speed profile stored in a concatenated sound speed file. They are: “previous in time,” “nearest in time," "nearest in distance" and "nearest in distance within time." The method of applying sound speed for a specific day of data collection is listed in the daily logs included as Separates submitted with the individual survey data.

7.0 Water Level

Unless otherwise noted in the survey Descriptive Report, the vertical datum for all soundings and heights is Mean Lower Low Water (MLLW). Predicted, preliminary, and/or verified water level correctors from the primary tide station(s) listed in the Project 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, HydroMI in MapInfo, or the NOAA stand-alone Create HIPS Cowlis .exe.

Water level data in the .tid files are applied to HDCS 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 as noted in the individual survey's Descriptive Report.

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 12, 2010
Updated Through: August 9, 2010

SURVEY VESSELS								
Vessel Name	**FAIRWEATHER**	**Launch 2805**	**Launch 2806**	**Launch 2807**	**Launch 2808**	**Ambar 700**	**Skiff**	**FRB**
Hull Number	S 220	2805	2806	2807	2808	2302	1905	2301
Call Letters	WTEB							
Manufacturer	Aerojet-General Shipyards	All American Marine	All American Marine	All American Marine	All American Marine	Marine Silverships, Inc	SeaArk	Zodiak of North America
Year of Construction	1967	2009	2009	2009	2009	1998	2000	2004
Type of Construction	Welded steel hull - ice strengthened	Welded Aluminum	Welded Aluminum	Welded Aluminum	Welded Aluminum	RHIB (Aluminum)	Welded Aluminum	RHIB (Fiberglass)
Length Overall	70.4 m (231')	8.64 m (28' 6")	8.64 m (28' 6")	8.64 m (28' 6")	8.64 m (28' 6")	7.0 m (23')	5.79 m (19')	6.7 m (22')
Beam	12.8 m (42')	3.48 m (11' 5")	3.48 m (11' 5")	3.48 m (11' 5")	3.48 m (11' 5")	2.9 m (9' 4")	2.44 m (8')	2.6 m (8' 6")
Draft	4.7 m (15' 6")	1.12 m (3' 8")	1.12 m (3' 8")	1.12 m (3' 8")	1.12 m (3' 8")	0.4 m (1' 4")	0.66 m (26")	0.6 m (22")
Cruising Speed	12.5 knots	24 knots	24 knots	24 knots	24 knots	22 knots	25 knots	18 knots
Max Survey Speed	6 knots	8 knots	8 knots	8 knots	8 knots			
Date of Effective Full Vessel Static Offset Survey	Origninal Survey 9/23/2003 POS/MV Offsets Surveyed 2/2007 and 2/15/2009	1/26/2010	1/26/2010	1/27/2010	1/27/2010			
Organization which Conducted the Effective Full Offset Survey	Original Survey - Westlake Consultants POS/MV Spatial Surveys - NGS	NGS/GSD	NGS/GSD	NGS/GSD	NGS/GSD			
Date of Last Partial Survey or Offset Verification & Methods Used	n/a	n/a	n/a	n/a	n/a			
Date of Last Static Draft Determination & Method Used	April-2010 Draft Marks	3/8/2010	3/9/2010	2/4/2010	3/5/2010			
Date of Last Settlement and Squat/Dynamic Draft Measurements & Method Used	1/21/2010 Post Processed Kinematic (Ellipsoidally referenced)	2/20/2010 Post Processed Kinematic (Ellipsoidally referenced)	3/8/2010 Post Processed Kinematic (Ellipsoidally referenced)	5/23/2010 Post Processed Kinematic (Ellipsoidally referenced)	3/3/2010 Post Processed Kinematic (Ellipsoidally referenced)			

Hydrographic Hardware Inventory										
	Field Unit:		**FAIRWEATHER**							
	Effective Date:		**3/25/2010**						further investigation/information required in future	
	Updated Through:		**8/9/2010**							

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	Bar Code	Comments
Processor	RESON	81-P (8160)	35385	Dry: 8160-2.09-7C6D Wet: 8160-1.00-E9E1	May-2004	S220-DP1	N/A		CD0001065313	
Transducer	RESON	8160	unknown	N/A	installed in hull - April-04	S220-hull	5/8/2010	installed in hull, 2004		
Tranceiver	RESON	81-P (8160)	35028			S220-Conf Rm	N/A			P/N 85108021, RMA# 501210
Processor	RESON	71-P (7111)	2009003	TBD		S220-DP1	N/A	10/6/2009 - Reson visit	CD0001065312	P/N 85101802
Transducer	RESON	7111	unknown	N/A	installed in hull - Oct-10	S220-hull	5/24/10, 7/14/10 Roll only	replaced transducer Mar-2009		
Tranceiver	RESON	71-P (7111)				S220-Conf Rm	N/A	Feb, May & July 2010 - Reson visits		onging issues, see App IV-Corr.
Processor	RESON	7125 SV	1812028	MR 7.1.1	Jan-2010	2805	200 & 400kHz 3/8/2010		CD0001529714	cal of transducers listed under processor
Processor	RESON	7125 SV	1812027	MR 7.1.1	Jan-2010	2806	200 & 400kHz 3/9/2010		CD0001529685	P/N 85101812, cal of transducers listed under processor, vessesl with loaner unit 2010
Processor	RESON	7125 SV	1812020	MR 7.1.1	Jan-2010	2807	200 & 400kHz 4/21/2010		CD0001527818	cal of transducers listed under processor
Processor	RESON	7125 SV	1812023	MR 7.1.1	Jan-2010	2808	200kHz 3/5/10, 400 3/5/10, & 400 4/5/10 PH		CD0001529704	cal of transducers listed under processor
200 khz Projector	RESON	200kHz (2163)	2409098		Jan-2010	TBD		installed in hull, 2010		
200 khz Projector	RESON	200kHz (2163)	4408351		Jan-2010	TBD		installed in hull, 2010		
200 khz Projector	RESON	200kHz (2163)	TBD		Jan-2010	TBD		installed in hull, 2010		
200 khz Projector	RESON	200kHz (2163)	TBD		Jan-2010	TBD		installed in hull, 2010		
400 khz Projector	RESON	400kHz (2160)	2208007		Jan-2010	TBD		installed in hull, 2010		
400 khz Projector	RESON	400kHz (2160)	2308110		Jan-2010	TBD		installed in hull, 2010		
400 khz Projector	RESON	400kHz (2160)	TBD		Jan-2010	TBD		installed in hull, 2010		
400 khz Projector	RESON	400kHz (2160)	TBD		Jan-2010	TBD		installed in hull, 2010		
Receiver	RESON	7200/7216	309012		Jan-2010	TBD		installed in hull, 2010		
Receiver	RESON	7200	309019		Jan-2010	TBD		installed in hull, 2010		
Receiver	RESON	7200	TBD		Jan-2010	TBD		installed in hull, 2010		
Receiver	RESON	7200	TBD		Jan-2010	TBD		installed in hull, 2010		
Processor	RESON	81-P (8125)	31562	Dry: 8125-2.10-A50F Wet: 8125-1.08-9E98	Unknown	DP3	N/A		CD0000825308	Transferred to Mike Webb's Property (EEB)
Transducer	RESON	8125	4400007	N/A	Unknown	C02	not installed	Unknown		on loan from RUDE
Towfish	Klein	5000	260	N/A		Spare, Boat Deck				on loan from Bay Hydro til Sept-10
Towfish	Klein	5000	321			2805				
Towfish	Klein	5000	293			2808			CD0000825404	initially testing 5/14/2009

TPU	Klein 5000 TPU	5000	11937			2805			CD0001722042	PN: 12V-0320-TV05J12-P150-KA-1
TPU	Klein 5000 TPU	5000	117633			2808	Readiness testing 04/06/2010		CD0001527021	PN: 12V-0320-TV05J12-P150-KA-1
TPU	Klein 5000 TPU	5000	130144			SPARE			CD0001527022	PN: 12V-0320-TV05J12-P150-KA-1
Processor	Odom Hydrographic Systems	Echotrac CVM-A	26034	Version 4.01		o lab		new unit, May-2007	CD0001703210	ChartView Dongle (100.001.001.098)
Transducer (2)	Odom Hydrographic Systems	SMBB200-4A	TR5162/TR5159	N/A	N/A	o lab	N/A	N/A		Two 4 degree (large)
Transducer (2)	Odom Hydrographic Systems	SMBB200_9	TR5138/TR5139	N/A	N/A	o lab	N/A	N/A		Two 9 degree (small)
Divers Least Depth Gaug	PTC	MODIII	68337	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		no bar code	
Lead Line	FA Personnel	Traditional	10_02_05	N/A	N/A	any	4/20/2009		no bar code	
Lead Line	FA Personnel	Traditional	20_01_05	N/A	N/A	any	4/28/2009		no bar code	
Lead Line	FA Personnel	Traditional	20_02_05	N/A	N/A	any	4/28/2009		no bar code	
Lead Line	FA Personnel	Traditional	20_03_05	N/A	N/A	any	4/28/2009		no bar code	
Lead Line	FA Personnel	Traditional	30_01_05	N/A	N/A	any	4/28/2009		no bar code	
Lead Line	FA Personnel	V-100/Non-Traditional	10_05_09	N/A	N/A	any	4/28/2009		no bar code	
Lead Line	FA Personnel	V-100/Non-Traditional	10_06_09	N/A	N/A	any			no bar code	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**	**Bar Code**	**Comments**
POS/MV PCS	Applanix	POS MV 320 V4	3627	HW4.1-7, SW04.22 POS Cntrlr v. 4.3.4.0	Jun-2008	S220 IP:129.100.1.231	5/28/10		CD0001697462	Auth. No. 811025-00534537
POS/MV IMU	Applanix	LN200	292	N/A	Apr-2004	S220			CD0001696450	
POS MV Port Antenna	Trimble	Zephyr II	1440904133		May-10	S220				P/N 57970-00 DC 4911 On permanent loan from Rainer
POS MV Stbd Antenna	Trimble	Zephyr II	31180200		May-10	S220				P/N 57970-00 DC 4845 On permanent loan from Rainer
POS/MV PCS	Applanix	POS MV 320 V4	3628	HW4.1-7, SW04.22 POS Cntrlr v. 4.3.4.0		2805	2/20/10		CD0001527796	Part # PCS-29
POS/MV IMU	Applanix	LN200	294	N/A	Jul-2003	2805		2/1/2010	CD0001696449	part # 10001506-4
POS MV Port Antenna	Trimble	Zephyr II	31171727			2805	Mar-09		no bar code	P/N: 57970-00 DC4905
POS MV Stbd Antenna	Trimble	Zephyr II	31185275			2805	Feb-09		no bar code	P.N 57970-00 DC4905
POS/MV PCS	Applanix	POS MV 320 V4	2564	HW2.6-7, SW04.22 POS Cntrlr v. 4.3.4.0		2806	3/8/10		CD0001601275	no part no
POS/MV IMU	Applanix	LN200	324	N/A	Feb-2007	2806		2/2/2010	CD0001722041	part # 10001506-4
POS MV Port Antenna	Trimble	Zephyr I	30130644			2806			no bar code	P/N: 39105-00 DC4804
POS MV Stbd Antenna	Trimble	Zephyr I	60078644			2806			no bar code	P/N 39105-00 DC4521
POS/MV PCS	Applanix	POS MV 320 V4	2560	HW2.6-7, SW04.22 POS Cntrlr v. 4.3.4.0		2807	4/21/10		CD0001601274	no p/n
POS/MV IMU	Applanix	LN200	037			2807		TT 2007 (3/1/1998)	CD0000832907	part # 10000978
POS MV Port Antenna	Trimble	Zephyr II	1440904832			2807	Aug-09		no bar code	P/N: 57970-00 DC4911
POS MV Stbd Antenna	Trimble	Zephyr II	1440912566			2807	Aug-09		no bar code	P/N 57970-00 DC4920
POS/MV PCS	Applanix	POS MV 320 V4	2411	HW2.9-7, SW04.22 POS Cntrlr v.4.3.4.0		2808	3/4/10		CD0001697462	no p/n
POS/MV IMU	Applanix	LN200	007			2808		TT 2007 (7/1996)	CD0000825306	part # 10,000,978
POS MV Port Antenna	Trimble	Zephyr II	1440925095			2808	Mar-09		no bar code	P/N: 39105-00 DC4604
POS MV Stbd Antenna	Trimble	Zephyr II	31171272			2808	Mar-09		no bar code	P/N: 57970-00 DC4845

POS/MV IMU	Applanix	LN200	047						CD0000825306	removed from 2807 in April 2010 -assumed to be bad
POS/MV Port Antenna	Applanix	OEM2 3151R	60103854	HW1	Feb-2007	spare			no bar code	ETs have as spares P/N 39105-00 DC 4602
POS/MV Stbd Antenna	Applanix	OEM2 3151R	60125191	HW1	Feb-2007	spare			no bar code	ETs have as spares P/N 39105-00 DC 4602
POS/MV Stbd Antenna	Applanix	OEM2 3151R	60145247	HW1	Mar-2007	spare				removed from 1010 on 8/22/09
POS/MV Port Antenna	Trimble	OEM2 3151R	60145158	N/A	Feb-2007	spare			39105-00 DC 4618	
POS/MV Port Antenna	Trimble	39105-00	60268090	N/A	Aug-2009	spare				From new batch of 20 spares to be purchased by Larry Lowen- sent by Olivia
DGPS Receiver	CSI Wireless	MBX-3S	0324-11969-0002	N/A	Jul-2004	S220			CD0001065375	
DGPS Antenna	CSI Wireless	MGL3	9824-1779-0002	N/A	Apr-2004	S220			no bar code	
DGPS Receiver	Hemisphere	MBX-4	0927-9567-0001	CDP004433		2805			no bar code	P/N 801-3012-000#
DGPS Antenna	Hemisphere	MA40	0924-9488-0046			2805			no bar code	P/N 804-3029-000#
DGPS Receiver	Hemisphere	MBX-4	0923-9416-0005	CDP004432		2806			no bar code	P/N 801-3012-000#
DGPS Antenna	Hemisphere	MA40	0923-9416-0005			2806			no bar code	P/N 801-3012-000#C
DGPS Receiver	Hemisphere	MBX-4	0923-9416-0007			2807			no bar code	P/N 801-3012-000#
DGPS Antenna	Hemisphere	MA40	0919-9231-0191			2807			no bar code	P/N 804-3029-000#
DGPS Receiver	Hemisphere	MBX-4	09249498-007	CDP004425		2808			no bar code	P/N 801-3012-000#
DGPS Antenna	Hemisphere	MA40	0924-9488-0040			2808			no bar code	P/N 804-3029-000#
DGPS Receiver	CSI Wireless	MBX-3S	0328-12362-0001	N/A	Jul-2004	ET Stores			10652291	
DGPS Antenna	CSI Wireless	MGL3	0328-12352-0002	N/A	Jul-2004	ET Stores				
StarFire GPS Receiver	NavCom	SF-2050R	5012		Jul-2008	Plot Rm		9/1/08	CD0001697402	P/N 92-310059, Net 1&2 capable only
StarFire GPS Receiver	NavCom	SF-2050R	5086			stored in O-lab			CD0001699203	thought to be Net 1 capable only
Trimble Backpack 1	Trimble	Pathfinder Pro XRS	0224078543	Firmware v1.96 RevA	Mar-2008	S220			CD0001269835	
Trimble Backpack 1: Antenna	Trimble	33580-50	0220341062	N/A	N/A	S220			CD0001269835	
Trimble Backpack 2	Trimble	Pathfinder Pro XRS	0224090101	Firmware v1.96 RevA	Mar-2008	S220			CD0001269836	
Trimble Backpack 2: Antenna	Trimble	33580-50	0220321059	N/A	N/A	S220				
Handheld data collector	Trimble	TSCe	37318	N/A	N/A	S220			no bar code	PN 45268-50
Antenna cable	Trimble					S220			no bar code	P/N22628
Camcorder Batteries	Trimble					S220			no bar code	P/N17466
NMEA/RTCM cable	Trimble					S220			no bar code	P/N30232-00
data/power cable	Trimble					S220			no bar code	P/N30231-00
dual battery cable	Trimble					S220			no bar code	P/N24333
GPS Pathfinder field device cable	Trimble					S220			no bar code	P/N45052
Laser	Laser Tech Inc.	Impulse Laser Rangefinder	i09290	N/A	N/A	S220			CD0001269812	
Laser	Laser Tech Inc.	TruPulse 200 Laser Rangefinder	001481	N/A	N/A	S220			no bar code	no Bar Code
Laser	Laser Tech Inc.	TruPulse 200 Laser Rangefinder	000676	N/A	N/A	S220			no bar code	no Bar Code

SOUND SPEED MEASUREMENT EQUIPMENT										
Equipment Type	**Brooke Ocean Technology Inc.**	**Model**	**Serial Number**	**Firmware and/or Software Version**	**Version Install Date**	**Location**	**Date of last Field Cal/Testing**	**Date of last Manufacturer Cal/Service**	**Bar Code**	**Comments**
Moving Vessel Profiler winch	Brooke Ocean Technology Inc.	MVP-200-5	10328			S220	N/A	Apr-2009	no bar code	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	no bar code	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	no bar code	Visit by BOT tech Darrell Groom, spare fish
Moving Vessel Profiler sensor	Applied Micro Systems Ltd.	AML Smart SV +P	4986			stored in server room	DQAs weekly if in service	3/2/2010		spare
Moving Vessel Profiler sensor	Applied Micro Systems	AML Smart SV +P	5229			S220	DQAs weekly	1/7/2010		installed in primary fish
Moving Vessel Profiler sensor	Applied Micro Systems Ltd.	AML Smart SV +P	5466			stored in server room	DQAs weekly if in service	3/2/2010		spare
SEACAT Profiler	Sea-Bird	SBE 19plus	19P36026-4585	1.4D		S220	DQAs weekly	12/7/2009	CD0001697254	CON file: 4585.con
SEACAT Profiler	Sea-Bird	SBE 19plus	19P36026-4616	1.4D		2805	DQAs weekly	12/7/2009	CD0001697264	CON file: 4616.con
SEACAT Profiler	Sea-Bird	SBE 19plus	19P36026-4617	1.4D		2806	DQAs weekly	12/7/2009	CD0001697251	CON file: 4617.con
SEACAT Profiler	Sea-Bird	SBE 19plus V2	19P50959-6121	2.1		2807	DQAs weekly	12/3/2009	CD0001527777	CON file: 6121.con
SEACAT Profiler	Sea-Bird	SBE 19plus V2	19P50959-6122	2.1		2808	DQAs weekly	12/7/2009	CD0001527778	CON file: 6122.con
Sound Velocity Probe	RESON	SVP-71	2008027		Jan-2010	2805	DQAs weekly	installed in hull, 2010		
Sound Velocity Probe	RESON	SVP-71	2008024		Jan-2010	2806	DQAs weekly	installed in hull, 11/30/2009		
Sound Velocity Probe	RESON	SVP-71	2008038		Jan-2010	2807	DQAs weekly	installed in hull, 2010		
Sound Velocity Probe	RESON	SVP-71	2008017		Jan-2010	2808	DQAs weekly	installed in hull, 10/09/2009		
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/ DB 1200	98207	SW 1.11		Goes with 8125 Loc. in C02	DQAs weekly	4/16/2009		Previous S/N listed: 98013-041609

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**	**Bar Code**	**Comments**
Level	Carl Zeiss	N12 333	100056	N/A	N/A	stored in O-lab, when not in field	Mar-2009	Mar-2008	no bar code	
Level	Carl Zeiss	N12 333	103267	N/A	N/A	stored in O-lab, when not in field	Mar-2009	Mar-2008	no bar code	
Level	Leica	NA2 100	5332739	N/A	N/A	stored in O-lab			no bar code	Spare
Level	Lecia	NA2 100	5332747	N/A	N/A	stored in O-lab			no bar code	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**	**Bar Code**	**Comments**
GPS Reciever	Trimble	NetR5	4910K61066	4.03	Apr-2009	stored O-lab	Apr-2009	obtained Apr-2009	CD0001526972	used in field
GPS Antenna	Trimble	Zephyr Geodetic 2	30767996			stored O-lab	Apr-2009	obtained Apr-2009	no Bar Code	used in field
GPS Reciever	Trimble	NetR5	4910K61054	4.03	Apr-2009	stored O-lab	Apr-2009	obtained Apr-2009	CD0001526973	used in field
GPS Antenna	Trimble	Zephyr Geodetic 2	30767941			stored O-lab	Apr-2009	obtained Apr-2009	no Bar Code	used in field
GPS Receiver	Ashtech	Z-Xtreme	ZE1200339016	ZE21	Mar-2008	stored O-lab	Apr-2009	obtained Apr-2004	CD0001062363	used in field
GPS Antenna	Ashtech	Geodetic 4	8365			stored O-lab	Apr-2009	obtained Apr-2004	No Barcode	used in field
UHF Radio	FreeWave	HTP-900RE	884-8978	2.17	Mar-2009	S220		obtained Mar-2009	CD0001526970	
UHF Radio	FreeWave	HTP-900RE	884-9190	2.17	Mar-2009	S220		obtained Mar-2009	CD0001526971	
UHF Radio	FreeWave	HTP-900RE	884-9511	2.17	May-2009	S220		obtained May-2009	no Bar Code	
UHF Radio	FreeWave	HTP-900RE	884-9301	2.17	May-2009	S220		obtained May-2009	no Bar Code	
UHF Radio	FreeWave	HTP-900RE	885-8740	6.5P		2805				
UHF Radio	FreeWave	HTP-900RE	885-8156	6.5P		2806				
UHF Radio	FreeWave	HTP-900RE	885-8689	6.5P		2807				
UHF Radio	FreeWave	HTP-900RE	885-8141	6.5P		2808				
UHF Antenna	PCTEL	MAX9053				S220		obtained May-2009	no Bar Code	
UHF Antenna	PCTEL	MAX9053				stored O-lab		obtained May-2009	no Bar Code	used in field
UHF Antenna	PCTEL	MAX9053				stored O-lab		obtained May-2009	no Bar Code	used in field
UHF Antenna	PCTEL	MAX9053				stored O-lab		obtained May-2009	no Bar Code	spare
Solar Charger	PWM	EPRC5				stored O-lab		obtained May-2009	no Bar Code	used in field
Solar Charger	PWM	EPRC5				stored O-lab		obtained May-2009	no Bar Code	used in field
Solar Charger	PWM	EPRC5				stored O-lab		obtained May-2009	no Bar Code	spare
Solar Panel	Uni-Solar	FLX-32	USF-32-14639	N/A	N/A	stored O-lab			no Bar Code	used in field
Solar Panel	Uni-Solar	FLX-32	USF-32-14634	N/A	N/A	stored O-lab			no Bar Code	used in field
Solar Panel	Uni-Solar	FLX-32	USF-32-14633	N/A	N/A	stored O-lab			no Bar Code	used in field
Solar Panel	Uni-Solar	FLX-32	USF-32-14529	N/A	N/A	stored O-lab			no Bar Code	used in field
Solar Panel	Uni-Solar	FLX-32	USF-32-14631	N/A	N/A	stored O-lab			no Bar Code	used in field
Solar Panel	Uni-Solar	FLX-32	USF-32-14625	N/A	N/A	stored O-lab			no Bar Code	used in field
Solar Panel	Uni-Solar	MBC-525	525-011590	N/A	N/A	stored O-lab			CD000684513	used in field
Solar Panel	Uni-Solar	MBC-526	525-011093	N/A	N/A	stored O-lab			CD000684507	used in field
Solar Panel	Uni-Solar	MBC-527	525-011589	N/A	N/A	stored O-lab			CD000684510	used in field
Solar Panel	Uni-Solar	MBC-528	525-011607	N/A	N/A	stored O-lab			CD000684512	used in field
Solar Panel	Uni-Solar	MBC-529	525-011587	N/A	N/A	stored O-lab			CD000684511	used in field
Solar Panel	GE Energy	GEPV-030-MNA	C30G200506210062	N/A	N/A	stored O-lab			no Bar Code	used in field
Solar Panel	GE Energy	GEPV-030-MNA	C30G200506210063	N/A	N/A	stored O-lab			no Bar Code	used in field
Solar Panel	GE Energy	GEPV-030-MNA	C30G200506210075	N/A	N/A	stored O-lab			no Bar Code	used in field
Solar Panel	GE Energy	GEPV-030-MNA	C30G200506210076	N/A	N/A	stored O-lab			no Bar Code	used in field
Solar Panel	Uni-Solar	FLX-32	USF-32-14645	N/A	N/A	destroyed			no Bar Code	gone- eaten by bear
Solutions Dongles	Ashtech	600586 (A)	KEB2083	N/A	N/A	stored S220			no Bar Code	
Solutions Dongles	Ashtech	600586 (A)	KEB2077	N/A	N/A	stored 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	Bar Code	Comments
GPS RTK Receiver	Trimble	DSM-232	225111661	3.57	Mar-2008	C02			CD0001697439	RTK capable
GPS Receiver	Trimble	DSM-232RS	225111655	3.57	Mar-2008	C02			CDCD0001697422	not upgradable
DGPS Antenna	Trimble	33580-00	220395038	N/A	N/A	C02			no Bar Code	
GPS Antenna	Trimble	Zephyr Geodetic Antenna	30325441	N/A	N/A	C02			no Bar Code	
GPS Antenna	Trimble	SPS MSK	5876	N/A	N/A	C02			no Bar Code	
GPS RTK Reciver	Trimble	MS 750	220339262			C02			CD 0001478898	RTK capable
GPS Antenna	Trimble	Trimble Micro Centered L1/L2	220298707	N/A	N/A	C02			no Bar Code	NOAA Launch Barcode A2008
Position Data Link High Powered Base Unit	Pacific Crest	PDL 4135	0424 0171	2.40	Apr-2004	C02	5/3/2007	obtained Apr-2004	CD0001269910	
Position Data Link Rover	Pacific Crest	PDL 4100	04240154	2.4	Apr-2004	C02	5/3/2007	obtained Apr-2004	CD0001269896	
Position Data Link Rover	Pacific Crest	PDL 4100	03473047	2.32	Apr-2004	C02	5/3/2007	obtained Apr-2004	CD0001269912	
Position Data Link Rover	Pacific Crest	PDL 4100	04240155	2.4	Apr-2004	C02	5/3/2007	obtained Apr-2004	CD0001269911	
Position Data Link Rover	Pacific Crest	PDL 4101	07095939			C02			no Bar Code	

OTHER 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	Bar Code	Comments
8-Port Gigabit Switch	Lynksys	SRW2008	RMQ00J700285			2805			P004422	
8-Port Gigabit Switch	Lynksys	SRW2008	RMQ00J700115			2806			P004421	
8-Port Gigabit Switch	Lynksys	SRW2008				2807			no bar code	
8-Port Gigabit Switch	Lynksys	SRW2008	RMQ00J700119			2808			P004424	
Hard Drive Dock	Nexstar					2805			no bar code	
Hard Drive Dock	Nexstar					2806			no bar code	
Hard Drive Dock	Nexstar					2807			no bar code	
Hard Drive Dock	Nexstar					2808			no bar code	
Penetrometer	Brooke Ocean Technology Inc.	FFCPT-35-2	10416			S220				
Penetrometer sensor	Brooke Ocean Technology Inc.	AML SV +P	191-3			S220				
Micro Thermosalinograph	Sea-Bird	SBE 45 (TSG)	4536628-0117	N/A	N/A	S220	Jul-2009	1/8/2008		P/N 4536628
GPS Antenna	Furno	GPA-019S	21299	N/A		S220			no bar code	for bridge equipment?
Processor	Klein	Sonar Workstation		Sonar Pro 11.3		ET stores			CD0000825155	not being utilized
Processor	Klein	Sonar Workstation				ET stores			CD0000825148	not being utilized

FAIRWEATHER Computers

Machine Name	Location	Make/Model	Operating System	Date Purchased	Date of Last Rebuild	Processor Speed	RAM (original)	RAM (checked on date)	Number of Video Outputs	Video RAM	Service Tag	Barcode	Comments
FA_Proc_1	Plot Room	Dell Precision T3400	XP Pro 2002 SP3	Summer-09		3.33 GHz	3 GB		2	512 MB	HG7LWK1	CD0001766763	New Dell desktop installed March 2010
FA_Proc_2	Plot Room	Dell Precision T3400	XP Pro 2002 SP3	Summer-09		3.33 GHz	3 GB		2	512 MB	DJKBZK1	CD0001766913	New Dell desktop installed March 2010
FA_Proc_3	Plot Room	Dell Precision T3400	XP Pro 2002 SP3	Summer-09		3.33 GHz	3 GB		2	512 MB	7G7CWK1	CD0001766754	New Dell desktop installed March 2010
FA_Proc_4	Plot Room	Dell Precision T3400	XP Pro 2002 SP3	Summer-09		3.33 GHz	3 GB		2	512 MB	GZ55K1	CD0001766791	New Dell desktop installed March 2010
FA_Proc_5	Plot Room	Dell Precision 490	XP Pro 2002 SP3	Nov-07		2.66 GHz	3 GB		2	256 MB	3MP1PD1	CD0001615381	Dell deskptop installed week of 12/4/07
FA_Proc_6	Plot Room	Dell Precision T3400	XP Pro 2002 SP3	Summer-09		3.33 GHz	3 GB		2	512 MB	JG7CWK1	CD0001766764	New Dell desktop installed March 2010
FA_Proc_7	Plot Room	Dell Precision T3400	XP Pro 2002 SP3	Summer-09		3.33 GHz	3 GB		2	512 MB	1H7CWK1	CD0001766765	New Dell desktop installed March 2010
FA_Proc_8	Plot Room	Dell Precision T3400	XP Pro 2002 SP3	Apr-08		3.0 GHz	3 GB		2	512 MB	5JKCZF1	CD0001615467	Dell desktop installed week of 04/14/08
FA_Proc_9	Plot Room	Dell Precision T3400	XP Pro 2002 SP3	Apr-08		3.0 GHz	3 GB		2	512 MB	3JKCZF1	CD0001615472	Dell desktop installed week of 04/06/08
FA_Proc_10	Plot Room	Dell Precision T3400	XP Pro 2002 SP3	Apr-08		3.0 GHz	3 GB		2	512 MB	TJKCZF1	CD0001615471	Dell desktop installed week of 04/06/08, Not installed as of 6/3/10
FA_CST	Field Office	Dell Precision T3400	XP Pro 2002 SP3	Apr-08		3.0 GHz	3 GB		2	512 MB	4JKCZF1	CD0001615469	Dell desktop installed week of 04/06/08
FA_FOO	Field Office	Dell Precision T3400	XP Pro 2002 SP3	Apr-08		3.0 GHz	3 GB		2	512 MB	DHKCZF1	CD0001615470	Dell desktop installed week of 04/06/08
FA_O-Lab	O-Lab	Dell Precision 490	XP Pro 2002 SP3	Nov-07		2.66 GHz	3 GB		2	256 MB	2NP1PD1	CD0001615380	Dell desktop installed week of 12/4/07, Moved 03/2010
FA_P2_Proc_1	Plot Room 2	Dell Precision T3400	XP Pro 2002 SP3	Apr-08		3.0 GHz	3 GB		2	512 MB	JHKCZF1	CD0001615468	Dell desktop installed week of 04/06/08
FA_P3_Proc_1	Plot Room 3	Dell Precision T3400	XP Pro 2002 SP3	Summer-09		3.33 GHz	3 GB		2	512 MB	FJKBZK1	CD0001766914	New Dell desktop installed March 2010
FA_P3_Proc_2	Plot Room 3	Dell Precision 490	XP Pro 2002 SP3	Nov-07		2.66 GHz	3 GB		2	256 MB	8MP1PD1	CD0001615384	Dell desktop installed week of 12/4/07, Moved 03/2010
FA_P3_Proc_3	Plot Room 3	Dell Precision 490	XP Pro 2002 SP3	Nov-07		2.66 GHz	3 GB		2	256 MB	9MP1PD1	CD0001615385	Refreshed 02/2010, 12/4/07, Moved 03/2010
FA_P3_Proc_4	Plot Room 3	Dell Precision T3400	XP Pro 2002 SP3	Summer-09		3.33 GHz	3 GB		2	512 MB	HZ55ZK1	CD0001766792	New Dell desktop installed March 2010
Toughbook 1	Laptop	Panasonic CF-18	XP Pro 2002 SP2	~ March 2004	~ July 2006	1.1 GHz	2.5 GB		1	64 MB	4HKSA59499	CD0001269860	*rebuilt after crash July 2006 -, whereabouts unknown
Toughbook 2	Laptop	Panasonic CF-18	XP Pro 2002 SP2	~ March 2004	~ September 2005	1.1 GHz	2.5 GB		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		1	64 MB	4GKSA55049	CD0001269859	transferred to Engineering dept, April 2010
Toughbook 3	Laptop	Panasonic CF-29	XP Pro 2002 SP2	March 2006		1.6 GHz	2.5 GB		1	128 MB	6AKSB06863	CD0001698251	
Toughbook 4	Laptop	Panasonic CF-30	XP Pro 2002 SP3	March 2009		1.7 GHz	1 Gb		0	384 MB	8HKSB80630	CD0001447100	
Toughbook 6	Laptop	Panasonic CF-30	XP Pro 2002 SP3	March 2009		1.7 GHz	1 Gb		0	384 MB	8HKSB80631	CD0001447101	
Toughbook 5	Laptop	Panasonic CF-19	XP Pro 2002 SP3	March 2009		1.1 GHz	1 Gb		1	384 MB	9AKSB43281	CD0001696424	Previously listed as CD0001698316
Survey Mobile Workstation	Laptop	Dell Precision M4400	XP Pro 2002 SP3			3.0 GHz	3.5 Gb		1	512 MB	8L56ZK1	CD0001766841	
2805_ACQ	Launch 2805	Cybertron PC ACP-4000	XP Pro 2002 SP3			2.0 GHz	3 GB		2	1024 MB	40001000160709	CD0001703148	P/N ACP-4000MB-00XE
2806_ACQ	Launch 2806	Cybertron PC ACP-4000	XP Pro 2002 SP3			2.0 GHz	3 GB		2	1024 MB	40001000160707	CD0001703147	P/N ACP-4000MB-00XE
2807_ACQ	Launch 2807	Cybertron PC ACP-4000	XP Pro 2002 SP3			2.0 GHz	3 GB		2	1024 MB	40001000160711	CD0001703146	P/N ACP-4000MB-00XE
2808_ACQ	Launch 2808	Cybertron PC ACP-4000	XP Pro 2002 SP3			2.0 GHz	3 GB		2	1024 MB	4000100016078	CD0001703149	P/N ACP-4000MB-00XE
S220_ACQ	Plot Room	Dell Precision T3400	XP Pro 2002 SP2	Mar-08		3.0 GHz	3 GB		3	512 MB	CSH8NF1	CD0001269854	
FA_MVP200	Plot Room	MVP-C1-2001	2000 SP4	~ March 2004	~ September 2005	2.4 GHz	230 MB		1	64 MB	SN: 10330		(CD# Not found) Listed previously as S220_ACQ CD#. CD0001615444?) 11/18

Appendix II

Vessel Reports, Offsets, and Diagrams

Launch 2805

1. Offsets
2. Patch Test
3. Dynamic Draft

Launch 2806

1. Offsets
2. Patch Test
3. Dynamic Draft

Launch 2807

1. Offsets
2. Patch Test
3. Dynamic Draft

Launch 2808

1. Offsets
2. Patch Test
3. Dynamic Draft

S220

1. Offsets
2. Patch Test
3. Dynamic Draft

Coordinate Systems Utilized in Vessel Offsets

Reference Surface Comparison

SSS and MBES Dual Acquisition Report

2805 Offsets and Measurements - Summary

Measurement aka Coord. Sys.	IMU to RP*	IMU to 7125 (SWATH1 x,y,z & MRU to Trans)	Port Ant to 7125 (Nav to Trans x,y,z)	RP* to Waterline	Port Ant to Stbd Ant		IMU to Port Ant		IMU to Heave	
	Caris	Caris	Caris	Caris			Caris	Pos/Mv	Caris	Pos/Mv
x	0.000	0.004	0.686	n/a	Scaler Distance	1.447	-0.682	-0.806	0.000	0.000
y	0.000	0.245	1.051	n/a			-0.806	-0.682	0.000	0.000
z	0.000	0.482	3.656	-0.111			-3.174	-3.174	0.000	0.000

*IMU is Reference Point

Vessel Offsets for 2805 7125 are derived from the NGS Survey, January 2010, Trimble Equipment Specs, a 2010 Measured Values.

Calculations

Coord. Sys./ Source
NGS

IMU to 7125

IMU (m)	x	0.00000
	y	0.00000
	z	0.00000
MBES RP Rcvr - Phase Center (m)	x	0.00401
	y	0.24503
	z	-0.48191

Port Ant to 7125

IMU to Port Ant (m) (calculated)	x	-0.68217
	y	-0.80598
	z	3.17407
IMU to 7125 Phase Ctr (calculated)	x	0.00401
	y	0.24503
	z	-0.48191

RP to Waterline

RP to Waterline (m) (waterline worksheet)	z	0.111

Port Ant to Stbd Ant

IMU to Port Ant (m) (calculated)	x	-0.68217
	y	-0.80598
	z	3.17407
IMU (m)	x, y, z	0.00000
Top of Stbd Ant (m)	x	0.76454
	y	-0.80778
	z	3.14528
Base to top of Stbd Ant (eqp spec) (m)	z	0.073
Bottom of Stbd Ant (calculated) (m)	z	3.07228
Base to Phase Cntr of Stbd Ant (eqp spc) (m)	z	0.0843

IMU to Port Ant

IMU (m)	x	0.00000
	y	0.00000
	z	0.00000
Top of Port Ant (m)	x	-0.68217
	y	-0.80598
	z	3.16277
Base to top of Port Ant (eqp spec) (m)	z	0.073
Bottom of Port Ant (calculated) (m)	z	3.08977
Base to Phase Cntr of Port Ant (eqp spc) (m)	z	0.0843

IMU to Heave

IMU (m)	x	0.00000
	y	0.00000
	z	0.00000
Heave Pt (m) (by design)	x	0.00000
	y	0.00000
	z	0.00000

Coord. Sys.
NGS

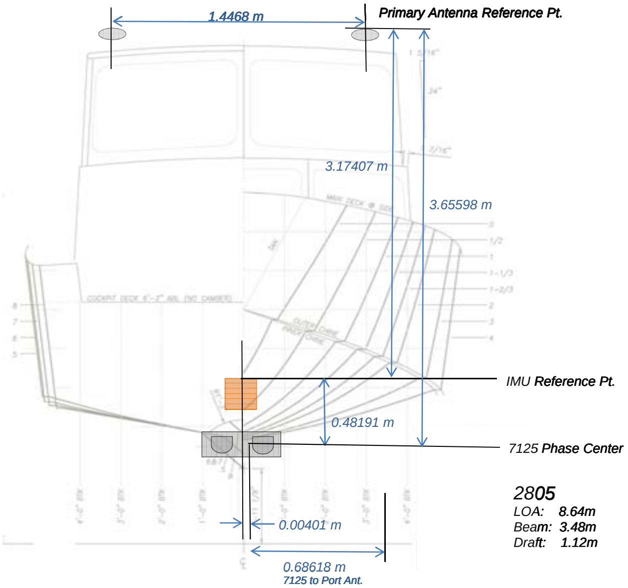
	IMU to 7125	Port Ant to 7125	RP to Waterline	Port Ant to Stbd Ant	IMU to Port Ant	IMU to Heave
x	0.00401 (IMU to 7125 Phase Ctr)	0.68618	n/a	Scalar Distance 1.4468	-0.68217	0.00000
y	0.24503	1.05101	n/a		-0.80598	0.00000
z	-0.48191	-3.65598	0.111		3.17407	0.00000

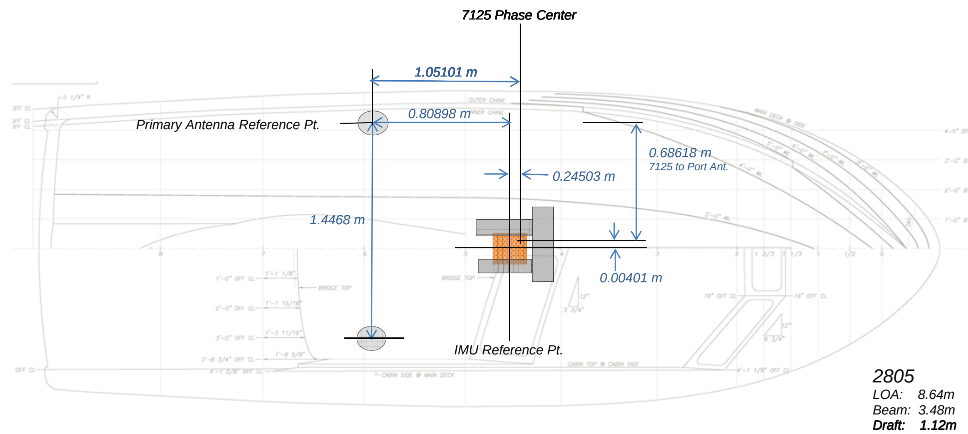
	IMU to 7125 (Coord. Sys. CARIS)	Port Ant to 7125 (Coord. Sys. CARIS)	RP to Waterline (Coord. Sys. CARIS)	IMU to Port Ant (Coord. Sys. Pos/Mv)	IMU to Heave (Coord. Sys. Pos/Mv)
x	0.00401	0.68618	n/a	-0.80598	0.00000
y	0.24503	1.05101	n/a	-0.68217	0.00000
z	0.48191	3.65598	-0.111	-3.17407	0.00000

Description of Offsets for Launch 2805

All Values Shown are in CARIS Coordinates

The Ship Reference Frame (SRF) for Launch 2805 was based from the IMU reference point as the 0,0,0 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 7125		
x	y	z
0.004	0.245	0.482

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 7125		
x	y	z
0.686	1.051	3.656

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	-0.111

The average vertical distance from Port Benchmark to waterline and the Starboard Benchmark to the waterline were measured by FAIRWEATHER personnel using a steel tape and bubble level. These values were combined with the Z value of the Benchmarks to the RP/IMU to get an average for the waterline to RP. The Waterline Measurement value is in NGS coordinates initially and is converted to CARIS coordinates.

Port Ant to Stbd Ant
Scalar Distance
1.447

The location of the phase center of the port and starboard POS/MV antennas were surveyed by NGS. The z-values were adjusted to the phase center. Then the scalar distance between the phase centers was calculated.

IMU to Port Antenna		
x	y	z
-0.682	-0.806	-3.174

The location of the IMU and the location of the top of port antenna were surveyed by NGS. The z-value of the antenna was calculated by subtracting the height of the antenna and then adding the value from the base of the antenna to the phase center of the antenna. The calculation results were then transposed from the NGS to the CARIS coordinate system.

IMU to Heave		
x	y	z
0.000	0.000	0.000

The Heave Point is assumed to coincide with the IMU location.

Waterline Measurements

Fill in Yellow squares only!

Measuring Party: Beduhn, Loy, Floyd, Brooks

2805

Waterline measurements should be negative and cm!

	2805	
	Port Benchmark to Waterline	Stbd Benchmark to Waterline
Measure 1	-95.0	-94.9
Measure 2	-94.8	-94.8
Measure 3	-94.8	-94.3
Avg (cm)	-94.87	-94.67
Avg (m)	-0.9487	-0.9467
Stdev	0.00115	0.00321
BM Z-value (m)*	1.07535	1.04250
BM to WL (m)	0.127	0.096

Date: 3/8/2010
Fuel Level: 5/8 Full
Draft Tube:

Port-to-Stbd Z-difference

Theoretical	Actual	Error
0.0329	0.0020	-0.0309

RP to WL Average (m)
0.111 NGS Coordinate System (do not enter into CARIS directly)
(Add this value to VSSL_Offsets & Measurements_20XX.xls)

Individual measurement StDev for TPU xls (of 6 #'s)		Port	Stbd
	0.017035	0.12535	0.09350
		0.12735	0.09450
		0.12735	0.09950

utilized in Offsets and Measurements and TPU spreadsheet

Measuring Party: Floyd, Loy, Brooks, Beduhn

Waterline measurements should be negative and cm!

	2805	
	Port Benchmark to Waterline	Stbd Benchmark to Waterline
Measure 1	-96.0	97.9
Measure 2	-96.5	-97.3
Measure 3	-94.1	-97.2
Avg (cm)	-95.53	-32.20
Avg (m)	-0.9553	-0.3220
Stdev	0.01266	1.12670
BM Z-value (m)	1.07535	1.04250
BM to WL (m)	0.120016667	0.721

Date: 3/9/2010
Fuel Level: 1/2 Full
Draft Tube:

Port-to-Stbd Z-difference

Theoretical	Actual	Error
0.0329	0.6333	0.6005

RP to WL Average (m)
0.420 NGS Coordinate System (do not enter into CARIS directly)
(or add this value to VSSL_Offsets & Measurements_20XX)

Individual measurement StDev for TPU xls (of 6 #'s)		Port	Stbd
	0.784869	0.11535	2.02150
		0.11035	0.06950
		0.13435	0.07050

Measuring Party: Jaskoski, Loy, Nardi, Andvick

Waterline measurements should be negative and cm!

	2805	
	Port Benchmark to Waterline	Stbd Benchmark to Waterline
Measure 1	-97.0	-97.7
Measure 2	-97.2	-97.9
Measure 3	-97.2	-98.2
Avg (cm)	-97.13	-97.93
Avg (m)	-0.9713	-0.9793
Stdev	0.00115	0.00252
BM Z-value (m)	1.07535	1.04250
BM to WL (m)	0.104	0.063

Date: 4/1/2010
Fuel Level: 1/3 full 43.4 gal
Draft Tube:

Port-to-Stbd Z-difference

Theoretical	Actual	Error
0.0329	-0.0080	-0.0409

RP to WL Average (m)
0.084 NGS Coordinate System (do not enter into CARIS directly)
(or add this value to VSSL_Offsets & Measurements_20XX)

Individual measurement StDev for TPU xls (of 6 #'s)		Port	Stbd
	0.022443	0.10535	0.06550
		0.10335	0.06350
		0.10335	0.06050

US DEPARTMENT OF COMMERCE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE
NATIONAL GEODETIC SURVEY
GEODETIC SERVICES DIVISION
INSTRUMENTATION & METHODOLOGIES BRANCH

NOAA SURVEY VESSEL 2805
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY
FIELD REPORT

Kendall L. Fancher
January, 2010

NOAA SURVEY VESSEL 2805
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY

PURPOSE

The primary purpose of the survey was to precisely determine the spatial relationship between various hydrographic surveying sensors, launch bench marks and the components of a POS MV navigation system aboard the NOAA survey vessel 2805.

PROJECT DETAILS

This survey was conducted in Seattle, WA at the NOAA Western Center on the 26th of January, 2010. The weather was sunny early then cloudy with temperatures in the 40s to 50s. For this survey, the vessel was on blocks, supported by boat jacks. The vessel was reported to have been leveled relative to the IMU.

INSTRUMENTATION

A Leica TDA5005 precision total station was used to make all measurements.
Technical Data:

Standard Deviation

Horizontal angle	0.5 seconds
Vertical angle	0.5 seconds
Distance measurement	1mm + 1ppm

Leica precision prisms were used as sighting targets. Prisms were configured to have a zero mm offset.

PERSONNEL

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NOAA SURVEY VESSEL 2805
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY

DEFINITION OF THE REFERENCE FRAME

For this survey, data was collected in a 3-D right handed Cartesian coordinate system. The origin of this coordinate system is defined as the center of the IMU target. The Y (Northing) axis is parallel to the centerline of the launch and is positive towards the bow of the launch. The X (Easting) axis is perpendicular to the Y axis and is positive towards the starboard side of the launch. The Z (Elevation) axis is perpendicular to the XY plane and is positive towards the top of the launch. The coordinates of the points established this survey are reported in this coordinate system and are provided in Appendix A.

SURVEY METHODOLOGY

Four temporary control points, (1, 2, 3, and 4), were established around the vessel such that every point to be positioned on the launch could be observed from at least two separate locations.

Coordinates of 100.000N, 100.000E, and 100.000U were assumed for temporary control point 1. A distance and height difference were measured between control points 1 and 2. Temporary control point 2 was assumed to have an Easting of 100.000. The measured distance between these two points was used to determine the Northing for temporary control point 2. The height difference between the two points was used to determine the Up component for control point 2.

Control point 1 was occupied and control point 2 was observed to initialize the instrument. After initialization, control point 4 and all visible points to be observed on the launch were observed in both direct and reverse. The stability of the instrument setup was checked at conclusion of the data set collection by checking back to temporary control point 2.

Control point 2 was occupied and control point 1 was observed to initialize the instrument. After initialization, control point 3 and all visible points to be observed on the launch were observed in both direct and reverse. The stability of the instrument setup was checked at conclusion of the data set collection by checking back to temporary control point 1.

Control point 3 was occupied and control point 2 was observed to initialize the instrument. After initialization, control point 4 and all visible points to be observed on the launch were observed in both direct and reverse. The stability of the instrument setup was checked at conclusion of the data set collection by checking back to temporary control point 2.

NOAA SURVEY VESSEL 2805
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY

Control point 4 was occupied and control point 3 was observed to initialize the instrument. After initialization, all visible points to be observed on the launch were observed in both direct and reverse. Control point 1 was also observed in order to evaluate the accuracy of the traverse. Inverse computations between the original and observed control point yielded a horizontal accuracy, or traverse closure of of 0.000m and a vertical accuracy of 0.000m. The stability of the instrument setup was checked at conclusion of the data set collection by checking back to temporary control point 2.

Inverses were computed between the two positions determined for all points surveyed to evaluate their accuracy relative to the temporary control network. Inverse reports are included in appendix B.

The reference frame was rotated using CENTERLINE STERN BM (CLS) as the point of rotation. A zero degree azimuth was used during the rotation from CLS to CENTERLINE BOW BM (BMB). The reference frame was then translated to relocate the origin of the reference frame to the IMU.

DISCUSSION

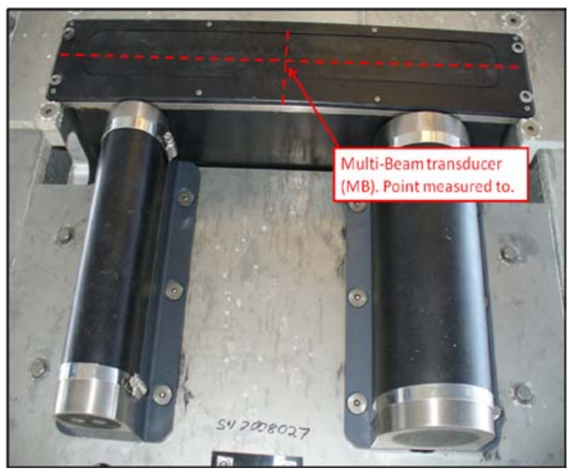
The positions given for the POS GPS antennas (Zephyr Model II p/n 57970-00) are to the top center of the antenna. To correct the Z value provided in this report for each antenna to the electronic phase center, I recommend the following steps be taken;

1) Determine the physical height of the GPS antenna. This information is probably located on the antenna or with equipment documentation.
2) Investigate to find the electronic phase center offset of the antenna. This information is probably located on the antenna or with equipment documentation. This value may also be available at the NGS website for antenna modeling.
3) Subtract the total height of the antenna from the Z value for each antenna. This will give you a Z value for the antenna ARP (antenna reference point)
4) Then add to this value the electronic phase center offset value appropriate for the antenna model.

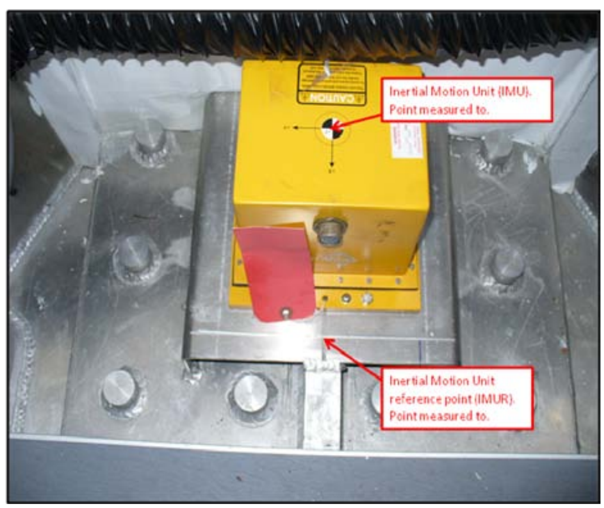
NOAA SURVEY VESSEL 2805
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY

Two reference points (MBF and MBA) were positioned in order to facilitate future measurements to the Multi-Beam sensor by launch personnel. These reference points are punch marks set along the center of the keel, at the locations described in the image at right.

A point on the Multi-Beam transducer (MB) was measured directly this survey. The measured point was at the center of the bottom of the transducer. No mark was left to indicate the measured point.



The point positioned for the Inertial Motion Unit (IMU) this survey was the center of the target affixed to the top of the unit. Additionally, a reference mark (IMUR) was established on the plate the IMU is attached to at a point where two scribed lines intersect, forward of the IMU.



NOAA SURVEY VESSEL 2805
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY

STATION LISTING

BMB-	CENTERLINE BOW BM The center of a cross mark inscribed into the top of a square metal flange, welded to the deck, along the centerline and near the bow of the launch.
CLS-	CENTERLINE STERN BM The center of a cross mark inscribed into the top of a square metal flange, welded to the deck, along the centerline and near the stern of the launch.
BMC-	CENTERLINE CAB BM The center of a cross mark inscribed into the top of a square metal flange, welded to the top of the cab, along the centerline of the launch.
BMP-	PORT SIDE BM The center of a cross mark inscribed into the top of a square metal flange, welded to the top of the deck, near the middle of and along the port side of the launch.
BMS-	STARBOARD SIDE BM The center of a cross mark inscribed into the top of a square metal flange, welded to the top of the deck, near the middle of and along the starboard side of the launch.
MBF-	KEEL BM A punch mark set along the bottom center of the keel, fore of the multi-beam transducer, 0.030 m from a point where the keel makes a 90 degree angle upwards.
MBA-	KEEL BM A punch mark set along the bottom center of the keel, aft of the multi-beam transducer, 0.030 m from a point where the keel makes a 90 degree angle upwards.
IMU-	IMU TARGET Center of a target affixed to the top of the IMU housing.
IMUR-	IMU REFERENCE BM The intersection of two scribed lines atop a metal support plate for the IMU and forward of the IMU.
GPSP-	PORT SIDE GPS ANTENNA REFERENCE POINT The top center of the port side GPS antenna for the POS system.
GPSS-	STARBOARD GPS ANTENNA REFERENCE POINT The top center of the starboard side GPS antenna for the POS system.
MB-	MULTI-BEAM REFERENCE POINT The physical bottom center of the Multi-Beam transducer.

Appendix A

Coordinate Report Launch 2805

Pt Name	***North(Y)***	***East(X)***	***Elev.(Z)***	***ID***
IMU Target	0.00000	0.00000	0.00000	IMU
IMU Reference BM	0.13270	-0.00348	-0.16937	IMUR
Centerline Stern BM	-4.04803	0.01735	0.67574	CLS
Centerline Bow BM	3.46914	0.01735	1.39751	BMB
Portside GPS Ant. Ref. Point	-0.80598	-0.68217	3.16277	GPSP
Starboard GPS Ant. Ref. Point	-0.80778	0.76454	3.14528	GPSS
Multi-Beam Ref.Point	0.24503	0.00401	-0.48191	MB
Keel BM	0.44007	-0.00202	-0.61410	MBF
Keel BM	-0.22895	-0.00227	-0.53363	MBA
Port Side BM	0.10603	-1.42637	1.07535	BMP
Starboard Side BM	0.10926	1.45859	1.04250	BMS
Centerline Cab BM	-0.19024	0.03192	2.65903	BMC

Units = meters

Appendix B

Point to Point Inverse Launch 2805

Pt. 1	*Pt. 2*	*Dist.*	*Northing*	*Easting*	*Elevation*	*ID*
18	31	0.004	-0.003	0.003	-0.00141	BMC
9	29	0.001	0.001	- 0.001	0.00051	BMP
39	49	0.003	-0.003	0.001	-0.00063	BMS
8	48	0.001	-0.001	-0.001	0.00016	CLS
10	30	0.002	-0.001	0.002	0.00033	GPSP
11	41	0.000	0.000	0.000	0.00034	GPSS
16	53	0.001	0.000	0.001	0.00024	IMU
17	54	0.002	0.000	0.002	0.00029	IMUR
4	46	0.006	0.005	0.002	-0.00018	MB
5	47	0.001	0.000	0.001	0.00016	MBA
3	45	0.002	0.001	0.001	-0.00017	MBF

Units = meters

FAIRWEATHER

Multibeam Echosounder Calibration

Launch 2805 200kHz	
Vessel	

SST Beduhn, AST Moehl, CST Morgan, LT Welton, LTjg Arnold
Calibrating Hydrographer(s)

Reson 7125 200kHz	Launch 2805	01/01/2010
MBES System	MBES System Location	Date of most recent EED/Factory Check
TBD		CD0001529714
Sonar Serial Number		Processing Unit Serial Number
Plate mounted on hull		01/26/2010
Sonar Mounting Configuration		Date of current offset measurement/verification
DGPS Beacon 323, POSMV V4		02/20/2010
Description of Positioning System		Date of most recent positioning system calibration

Acquisition Log

3/8/2010	067	Shilshole	
Date	Dn	Local Area	Wx
Bottom Type			Approximate Water Depth

Loy, Floyd, Brooks, Beduhn
Personnel on board

all speeds six knots unless otherwise noted
Comments

2010_067_2805.000
TrueHeave filename

100671857	18:44:00 PM	47 40 34.89	122 25 22.26	40	47.7
SV Cast #1 filename	UTC Time	Lat	Lon	Depth	Ext. Depth
100672227	22:27	47 40 31.25	122 25 27.03	40	46.3
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 bounded slope (nadir) [same direction, different speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	1959	239	6ish	line 1
	2001	063		induced

PITCH

view parallel to track, same line (at nadir) [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	2005	138		103
	2006	312		
	2007	137		
	2009	316		

HEADING/YAW

view parallel to track, offset lines (outerbeams) [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	2011	126		104
	2012	318		101
	2013	125		101
	2015	310		104

ROLL

view across track, same line [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	2017	237		
	2019	060		
	2022	240		
	2024	060		

Processing Log

Date	Dn	Personnel
3/10/2010		Beduhn

☑ **Data converted --> HDCS_Data in CARIS**

☑ **TrueHeave applied** 2009_064_2808.000

☑ **SVP applied** 2010_064_2808.000

☑ **Tide applied** N395RA2009.tc predicted

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)
SST Beduhn	0.00	-0.89	-0.49	0.85
AST Moehl	0.00	-0.75	-0.47	0.75
CST Morgan	0.00	-0.85	-0.47	0.80
LT Welton	0.00	-0.80	-0.48	1.10
LTjg Arnold	0.00	-0.68	-0.43	1.03
Averages	0.00	-0.79	-0.47	0.91
Standard Deviation	0.00	0.08	0.02	0.15
FINAL VALUES	0.00	-0.79	-0.47	0.91

Final Values based on Averages

Resulting HVF File Name FA_2805_200kHz_Rsn7125_256bms_2010

MRU Align StdDev gyro 0.15 Value from standard deviation of Heading offset values
MRU Align StdDev Roll/Pitch 0.05 Value from averaged standard deviations of pitch and roll offset value

NARRATIVE

☑ **HVF Hydrographic Vessel File created or updated with current offsets**

Name: CST/FOO **Date:** 3/30/2010

FAIRWEATHER

Multibeam Echosounder Calibration

Launch 2805 400kHz
Vessel

CST Morgan, LT Welton, SST Beduhn, Ltjg Arnold
Calibrating Hydrographer(s)

Reson 7125 400kHz	Launch 2805	01/01/2010
MBES System	MBES System Location	Date of most recent EED/Factory Check

TBD	CD0001529714
Sonar Serial Number	Processing Unit Serial Number
Plate mounted on hull	01/26/2010
Sonar Mounting Configuration	Date of current offset measurement/verification
DGPS Beacon 323, POSMV V4	2/20/2010
Description of Positioning System	Date of most recent positioning system calibration

Acquisition Log

3/8/2010	067	Shilshole	
Date	Dn	Local Area	Wx

Bottom Type	Approximate Water Depth

Loy, Floyd, Brooks, Beduhn
Personnel on board

All lines run 6-6.5 kts unless otherwise noted
Comments

2010_067_2805.000
TrueHeave filename

100671857	1	47 40 34.89	122 25 22.26	40	47.7
SV Cast #1 filename	U	Lat	Lon	Depth	Ext. Depth
100672227		47 40 31.25	122 25 27.03	40	46.3
SV Cast #2 filename	U	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
	2153	235	6ish	Line 1, induced roll
	2155	060		induced roll

PITCH view parallel to track, same line (at nadir) [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	2159	135		Line # 103
	2201	317		
	2202	138		
	2204	316		

HEADING/YAW view parallel to track, offset lines (outerbeams) [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	2205	129		
	2206	311		
	2207	126		
	2208	305		

ROLL view across track, same line [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	2210	057		
	2213	237		
	2215	060		
	2218	240		
	2221	061	7ish	Roll Stab Off
	2223	235		Roll Stab Off

Processing Log

3/10/2010		Beduhn
Date	Dn	Personnel

☑ **Data converted --> HDCS_Data in CARIS**

☑ **TrueHeave applied** 2009_064_2808.000

☑ **SVP applied** 2010_064_2808.000

☑ **Tide applied** N395RA2009.tc predicted

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	0.00	-1.00	-0.27	0.90
LT Welton	0.00	-1.04	-0.29	0.97
SST Beduhn	0.00	-1.00	-0.27	0.94
LT(jg) Arnold	0.00	-1.00	-0.20	0.93
Averages	0.00	-1.01	-0.26	0.94
Standard Deviation	0.00	0.02	0.04	0.03
FINAL VALUES	0.00	-1.01	-0.26	0.94

Final Values based on Averages

Resulting HVF File Name FA_2805_400kHz_Rsn7125_512bms_2010

MRU Align StdDev gyro 0.03 Value from standard deviation of Heading offset values

MRU Align StdDev Roll/Pitch 0.03 Value from averaged standard deviations of pitch and roll offset values

NARRATIVE

☑ **HVF Hydrographic Vessel File created or updated with current offsets**

Name: CST/FOO **Date:** 03/30/2010

Fairweather Launch 2805 Dynamic Draft Measurement
Lake Washington, 20 February 2010

LTjg Caryn Arnold, HSTP West Coast Field Support Liaison

On Saturday, 20 February 2010 (DN 051), *Fairweather* Launch 2805 conducted a dynamic draft measurement (DDM) on Lake Washington using post processed kinematic GPS data. The vessel sat at rest for approximately 5 minutes, then ran in the North direction at approximate speeds of 4, 6, 8 and 10 knots, holding each speed for about 4 minutes. The vessel then turned around and ran in the South direction at approximate speeds of 10, 8, 6 and 4 knots, again holding each speed for about 4 minutes and resting for approximately 5 minutes at the end. The POS/MV recorded a POSPac file the entire time from beginning rest to finish rest.

The POSPac file was processed with POSPac MMS Software using the GNSS-Inertial Processing Single Base Station Mode. The single CORS station SEAI (1 Hz) was chosen as the base station. The Lever Arm Standard Deviation was set to <3cm and then the GNSS-Inertial Processor in the Forward, Backward and Combine mode was Run.

The file was then exported out from the POSPac MMS software with an output rate of 1 sec and run through the Python Script written by LTjg Glen Rice, which includes the fourth order polynomial curve. The following graphs were generated.

-9.41e-004*X^4+1.83e-003*X^3+2.50e-002*X^2+-5.22e-002*X

Speed (m/s)	Delta Draft (m)
0.00	0.00
0.50	-0.02
1.00	-0.03
1.50	-0.02
2.00	-0.00
2.50	0.02
3.00	0.04
3.50	0.06
4.00	0.07
4.50	0.05
5.00	0.00
5.50	-0.09

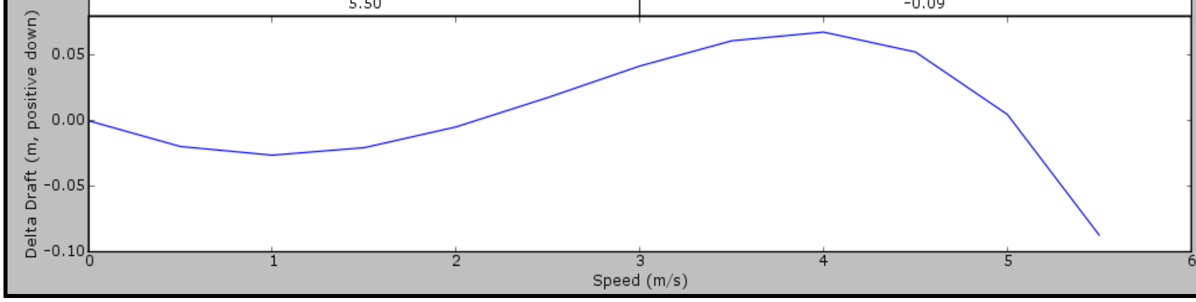


Figure 1. *Fairweather* Launch 2805 Inverted Dynamic Draft Curve & Computed Dynamic Draft Table for Caris

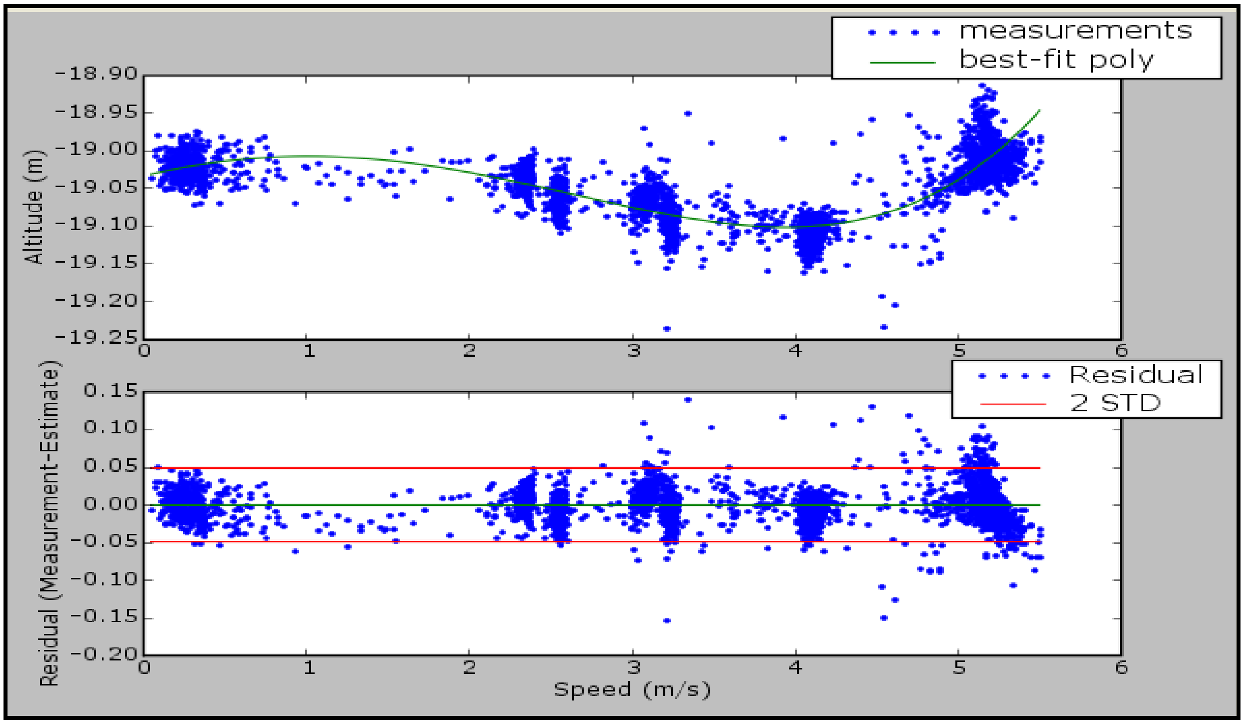


Figure 2. *Fairweather* Launch 2805 Dynamic Draft Curve with Data Points

2806 Offsets and Measurements - Summary

Measurement aka Coord. Sys.	IMU to RP* (Caris)	IMU to 7125 (Receiver) *SWATH1 x,y,z & MRU to Trans* (Caris)	Port Ant to 7125 *Nav to Trans x,y,z* (Caris)	RP* to Waterline (Caris)	Port Ant to Stbd Ant	IMU to Port Ant (Caris)	IMU to Port Ant (Pos/Mv)	IMU to Heave (Caris)	IMU to Heave (Pos/Mv)
x	0.000	-0.013	0.624	n/a	Scaler Distance 1.448	-0.637	-0.832	0.000	0.000
y	0.000	0.254	1.087	n/a		-0.832	-0.637	0.000	0.000
z	0.000	0.481	3.617	-0.105		-3.136	-3.136	0.000	0.000

*IMU is Reference Point

Vessel Offsets for 2808 7125 are derived from the NGS Survey, January 2010, Trimble Equipment Specs, 2010 Measured Values.

Calculations

Coord. Sys./ Source **NGS**

IMU to 7125

IMU (m)	x	0.00000
	y	0.00000
	z	0.00000
MBES RP Rcvr - Phase Center (m)	x	-0.01284
	y	0.25447
	z	-0.48083

Port Ant to 7125

IMU to Port Ant (m) (calculated)	x	-0.63695
	y	-0.83249
	z	3.13638
IMU to Phase Ctr (calculated)	x	-0.01284
	y	0.25447
	z	-0.48083

RP to Waterline

RP to Waterline (m) (waterline worksheet)	z	0.105

Port Ant to Stbd Ant

IMU to Port Ant (m) (calculated)	x	-0.63695
	y	-0.83249
	z	3.13638
IMU (m)	x, y, z	0.00000
Top of Stbd Ant (m)	x	0.81062
	y	-0.82526
	z	3.10821
Base to top of Stbd Ant (measured) (m)	z	0.059
Bottom of Stbd Ant (calculated) (m)	z	3.04921
Base to Phase Cntr of Stbd Ant (eqp spc) (m)	z	0.046

IMU to Port Ant

IMU (m)	x	0.00000
	y	0.00000
	z	0.00000
Top of Port Ant (m)	x	-0.63695
	y	-0.83249
	z	3.14938
Base to top of Port Ant (measured) (m)	z	0.059
Bottom of Port Ant (calculated) (m)	z	3.09038
Base to Phase Cntr of Port Ant (eqp spc) (m)	z	0.046

IMU to Heave

IMU (m)	x	0.00000
	y	0.00000
	z	0.00000
Heave Pt m) (by design)	x	0.00000
	y	0.00000
	z	0.00000

Coord. Sys. **NGS**

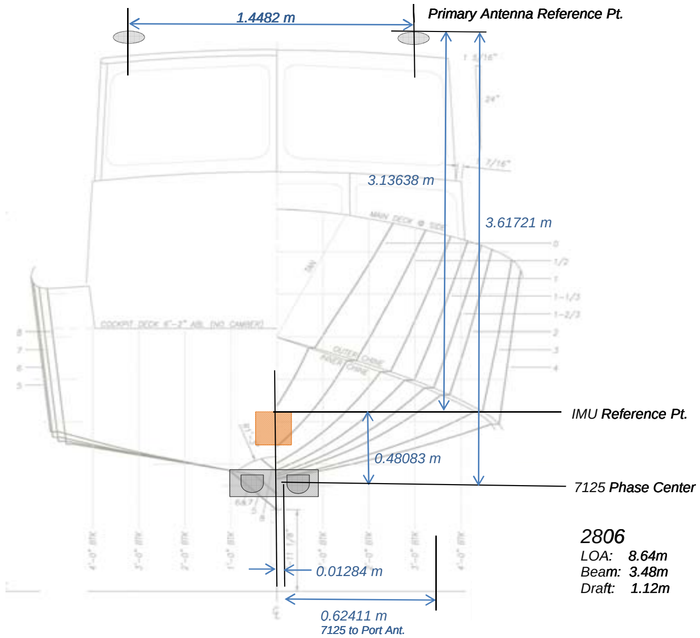
	IMU to 7125 (IMU to Phase Ctr)	Port Ant to 7125	RP to Waterline	Port Ant to Stbd Ant	IMU to Port Ant	IMU to Heave
x	-0.01284	0.62411	n/a		-0.63695	0.00000
y	0.25447	1.08696	n/a	Scalar Distance 1.4482	-0.83249	0.00000
z	-0.48083	-3.61721	0.105		3.13638	0.00000

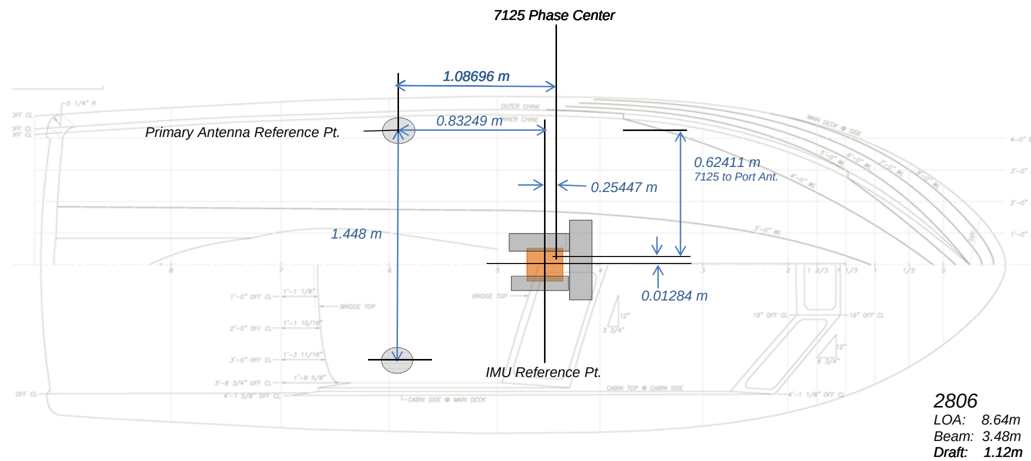
	IMU to 7125 (Coord. Sys. CARIS)	Port Ant to 7125 (Coord. Sys. CARIS)	RP to Waterline (Coord. Sys. CARIS)	IMU to Port Ant (Coord. Sys. Pos/Mv)	IMU to Heave (Coord. Sys. Pos/Mv)
x	-0.01284	0.62411	n/a	-0.83249	0.00000
y	0.25447	1.08696	n/a	-0.63695	0.00000
z	0.48083	3.61721	-0.105	-3.13638	0.00000

Description of Offsets for Launch 2806

All Values Shown are in CARIS Coordinates

The Ship Reference Frame (SRF) for Launch 2806 was based from the IMU reference point as the 0,0,0 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 7125		
x	y	z
-0.013	1.087	3.617

The physical positions of the IMU and the receiver phase center of the 7125 were measured during the NGS survey. These physical measurements were taken while the launch was secured on the pier and thought to be as level as possible. The measured values for the IMU and MB were taken directly for the report. The difference is the offset from the IMU to the phase center of the 7125 which was then transposed from the NGS to the CARIS coordinate system.

Port Ant to 7125		
x	y	z
0.624	1.087	3.617

The values were calculated by subtracting the of the Port Antenna to the IMU x, y, z values from the respective values of the IMU to the 7125. The calculated values were then transposed from the NGS to the CARIS coordinate system.

RP to Waterline		
x	y	z
n/a	n/a	-0.105

The average vertical distance from Port Benchmark to waterline and the Starboard Benchmark to the waterline were measured by FAIRWEATHER personnel using a steel tape and bubble level. These values were combined with the Z value of the Benchmarks to the RP/IMU to get an average for the waterline to RP. The Waterline Measurement value is in NGS coordinates initially and is converted to CARIS coordinates.

Port Ant to Stbd Ant
Scalar Distance
1.448

The location of the phase center of the port and starboard POS/MV antennas were surveyed by NGS. The z-values were adjusted to the phase center. Then the scalar distance between the phase centers was

IMU to Port Antenna		
x	y	z
-0.637	-0.832	-3.136

The location of the IMU and the location of the top of port antenna were surveyed by NGS. The z-value of the antenna was calculated by subtracting the height of the antenna and then adding the value from the base of the antenna to the phase center of the antenna. The calculation results were then transposed from the NGS to the CARIS coordinate system.

IMU to Heave		
x	y	z
0.000	0.000	0.000

The Heave Point is assumed to coincide with the IMU location.

Waterline Measurements

Fill in Yellow squares only!

Measuring Party: Beduhn, Wozumi, Phunt, Allen

2806

Waterline measurements should be negative and cm!

	2806	
	Port Benchmark to Waterline	Stbd Benchmark to Waterline
Measure 1	-90.4	-94.4
Measure 2	-93.4	-96.0
Measure 3	-92.6	-93.2
Avg (cm)	-92.13	-94.53
Avg (m)	-0.9213	-0.9453
Stdev	0.01553	0.01405
BM Z-value (m)*	1.09615	1.01777
BM to WL (m)	0.175	0.072

Individual measurement StDev for TPU xls (of 6 #'s)	0.057619	0.19215	0.07377
		0.16215	0.05777
		0.17015	0.08577

Date: 3/9/2010
Fuel Level: Full
Draft Tube:

Port-to-Stbd Z-difference

Theoretical	Actual	Error
0.0784	-0.0240	-0.1024

RP to WL Average (m)
0.124 NGS Coordinate System (do not enter in CARIS directly)
(Add this value to VSSL_Offsets & Measurements_20XX.xls)

utilized in Offsets and Measurements and TPU spreadsheet

Measuring Party: Beduhn, Wozumi, Phunt, Allen

Waterline measurements should be negative and cm!

	2806	
	Port Benchmark to Waterline	Stbd Benchmark to Waterline
Measure 1	-96.2	-95.2
Measure 2	-96.0	-95.0
Measure 3	-94.2	-94.8
Avg (cm)	-95.47	-95.00
Avg (m)	-0.9547	-0.9500
Stdev	0.01102	0.00200
BM Z-value (m)	1.09615	1.01777
BM to WL (m)	0.141483333	0.068

Individual measurement StDev for TPU xls (of 6 #'s)	0.040991	0.13415	0.06577
		0.13615	0.06777
		0.15415	0.06977

Date: 3/9/2010
Fuel Level: 3/4 Full
Draft Tube:

Port-to-Stbd Z-difference

Theoretical	Actual	Error
0.0784	0.0047	-0.0737

RP to WL Average (m)
0.105 NGS Coordinate System (do not enter in CARIS directly)
(or add this value to VSSL_Offsets & Measurements_20XX)

utilized in Offsets and Measurements and TPU spreadsheet

Measuring Party:

Waterline measurements should be negative and cm!

	2806	
	Port Benchmark to Waterline	Stbd Benchmark to Waterline
Measure 1	-98.4	-97.7
Measure 2	-97.5	-97.8
Measure 3	-97.3	-98.7
Avg (cm)	-97.73	-98.07
Avg (m)	-0.9773	-0.9807
Stdev	0.00586	0.00551
BM Z-value (m)	1.09615	1.01777
BM to WL (m)	0.119	0.037

Individual measurement StDev for TPU xls (of 6 #'s)	0.045044	0.11215	0.04077
		0.12115	0.03977
		0.12315	0.03077

Date: 4/1/2010
Fuel Level: 3/10 Full 35.2 Gal
Draft Tube:

Port-to-Stbd Z-difference

Theoretical	Actual	Error
0.0784	-0.0033	-0.0817

RP to WL Average (m)
0.078 NGS Coordinate System (do not enter into CARIS directly
(or add this value to VSSL_Offsets & Measurements_20XX)

US DEPARTMENT OF COMMERCE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE
NATIONAL GEODETIC SURVEY
GEODETIC SERVICES DIVISION
INSTRUMENTATION & METHODOLOGIES BRANCH

NOAA SURVEY VESSEL 2806
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY
FIELD REPORT

Kendall L. Fancher

January, 2010

NOAA SURVEY VESSEL 2806
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY

PURPOSE

The primary purpose of the survey was to precisely determine the spatial relationship between various hydrographic surveying sensors, launch bench marks and the components of a POS MV navigation system aboard the NOAA survey vessel 2806.

PROJECT DETAILS

This survey was conducted in Seattle, WA at the NOAA Western Center on the 26th of January, 2010. The weather was sunny then cloudy with temperatures in the 40s to 50s. For this survey, the vessel was on blocks, supported by boat jacks. The vessel was reported to have been leveled relative to the IMU.

INSTRUMENTATION

A Leica TDA5005 precision total station was used to make all measurements.
Technical Data:

Standard Deviation

Horizontal angle	0.5 seconds
Vertical angle	0.5 seconds
Distance measurement	1mm + 1ppm

Leica precision prisms were used as sighting targets. Prisms were configured to have a zero mm offset.

PERSONNEL

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NOAA SURVEY VESSEL 2806
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY

DEFINITION OF THE REFERENCE FRAME

For this survey, data was collected in a 3-D right handed Cartesian coordinate system. The origin of this coordinate system is defined as the center of the IMU target. The Y (Northing) axis is parallel to the centerline of the launch and is positive towards the bow of the launch. The X (Easting) axis is perpendicular to the Y axis and is positive towards the starboard side of the launch. The Z (Elevation) axis is perpendicular to the XY plane and is positive towards the top of the launch. The coordinates of the points established this survey are reported in this coordinate system and are provided in Appendix A.

SURVEY METHODOLOGY

Four temporary control points, (1, 2, 3, and 4), were established around the vessel such that every point to be positioned on the launch could be observed from at least two separate locations.

Coordinates of 100.000N, 100.000E, and 100.000U were assumed for temporary control point 1. A distance and height difference were measured between control points 1 and 2. Temporary control point 2 was assumed to have an Easting of 100.000. The measured distance between these two points was used to determine the Northing for temporary control point 2. The height difference between the two points was used to determine the Up component for control point 2.

Control point 1 was occupied and control point 2 was observed to initialize the instrument. After initialization, control point 4 and all visible points to be observed on the launch were observed in both direct and reverse. The stability of the instrument setup was checked at conclusion of the data set collection by checking back to temporary control point 2.

Control point 2 was occupied and control point 1 was observed to initialize the instrument. After initialization, control point 3 and all visible points to be observed on the launch were observed in both direct and reverse. The stability of the instrument setup was checked at conclusion of the data set collection by checking back to temporary control point 1.

Control point 3 was occupied and control point 2 was observed to initialize the instrument. After initialization, control point 4 and all visible points to be observed on the launch were observed in both direct and reverse. The stability of the instrument setup was checked at conclusion of the data set collection by checking back to temporary control point 2.

NOAA SURVEY VESSEL 2806
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY

Control point 4 was occupied and control point 3 was observed to initialize the instrument. After initialization, all visible points to be observed on the launch were observed in both direct and reverse. Control point 1 was also observed in order to evaluate the accuracy of the traverse. Inverse computations between the original and observed control point yielded a horizontal accuracy, or traverse closure of of 0.000m and a vertical accuracy of 0.000m. The stability of the instrument setup was checked at conclusion of the data set collection by checking back to temporary control point 2.

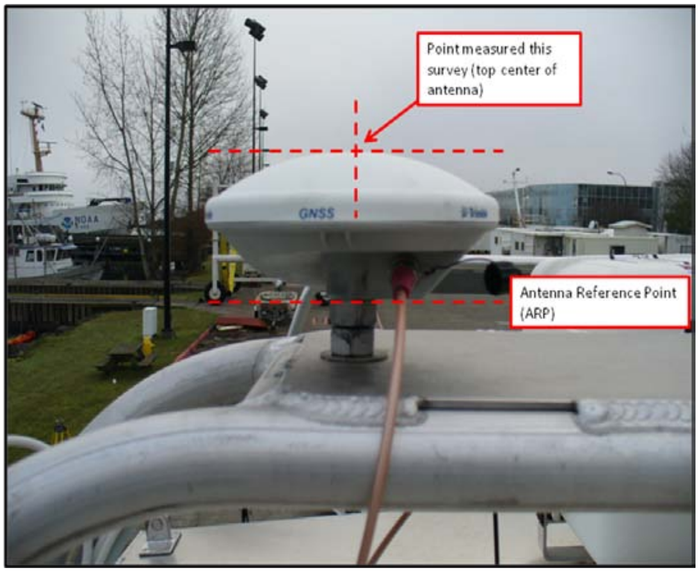
Inverses were computed between the two positions determined for all points surveyed to evaluate their accuracy relative to the temporary control network. Inverse reports are included in appendix B.

The reference frame was rotated using CENTERLINE STERN BM (CLS) as the point of rotation. A zero degree azimuth was used during the rotation from CLS to CENTERLINE BOW BM (BMB). The reference frame was then translated to relocate the origin of the reference frame to the IMU. The resulting coordinates are reported in appendix A.

<u>DISCUSSION</u>

The positions given for the POS GPS antennas (Zephyr p/n 39105-00) are to the top center of the antenna. To correct the Z value provided in this report for each antenna to the electronic phase center, I recommend the following steps be taken;

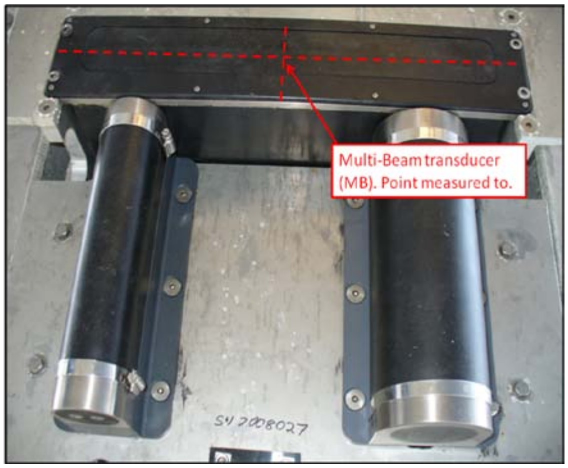
1) Determine the physical height of the GPS antenna. This information is probably located on the antenna or with equipment documentation.
2) Investigate to find the electronic phase center offset of the antenna. This information is probably located on the antenna or with equipment documentation. This value may also be available at the NGS website for antenna modeling.
3) Subtract the total height of the antenna from the Z value for each antenna. This will give you a Z value for the antenna ARP (antenna reference point)
4) Then add to this value the electronic phase center offset value appropriate for the antenna model.



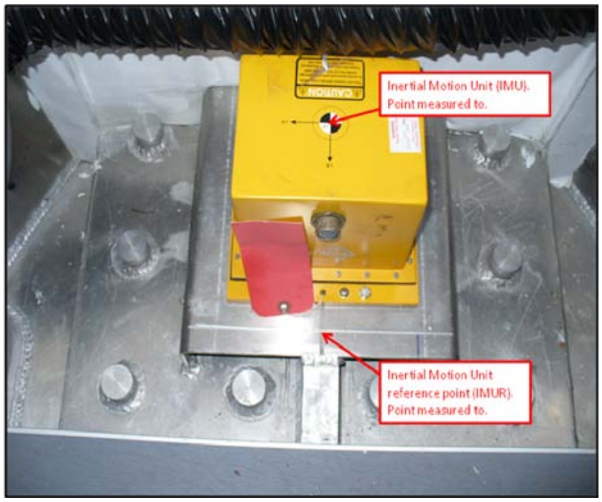
NOAA SURVEY VESSEL 2806
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY

Two reference points (MBF and MBA) were positioned in order to facilitate future measurements to the Multi-Beam sensor by launch personnel. These reference points are punch marks set along the center of the keel, at the locations described in the image at right.

A point on the Multi-Beam transducer (MB) was measured directly this survey. The measured point was at the center of the bottom of the transducer. No mark was left to indicate the measured point.



The point positioned for the Inertial Motion Unit (IMU) this survey was the center of the target affixed to the top of the unit. Additionally, a reference mark (IMUR) was established on the plate the IMU is attached to at a point where two scribed lines intersect, forward of the IMU.



NOAA SURVEY VESSEL 2806
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY

STATION LISTING

BMB-	CENTERLINE BOW BM The center of a cross mark inscribed into the top of a square metal flange, welded to the deck, along the centerline and near the bow of the launch.
CLS-	CENTERLINE STERN BM The center of a cross mark inscribed into the top of a square metal flange, welded to the deck, along the centerline and near the stern of the launch.
BMC-	CENTERLINE CAB BM The center of a cross mark inscribed into the top of a square metal flange, welded to the top of the cab, along the centerline of the launch.
BMP-	PORT SIDE BM The center of a cross mark inscribed into the top of a square metal flange, welded to the top of the deck, near the middle of and along the port side of the launch.
BMS-	STARBOARD SIDE BM The center of a cross mark inscribed into the top of a square metal flange, welded to the top of the deck, near the middle of and along the starboard side of the launch.
MBF-	KEEL BM A punch mark set along the bottom center of the keel, fore of the multi-beam transducer, 0.030 m from a point where the keel makes a 90 degree angle upwards.
MBA-	KEEL BM A punch mark set along the bottom center of the keel, aft of the multi-beam transducer, 0.030 m from a point where the keel makes a 90 degree angle upwards.
IMU-	IMU TARGET Center of a target affixed to the top of the IMU housing.
IMUR-	IMU REFERENCE BM The intersection of two scribed lines atop a metal support plate for the IMU and forward of the IMU.
GPSP-	PORT SIDE GPS ANTENNA REFERENCE POINT The top center of the port side GPS antenna for the POS system.
GPSS-	STARBOARD GPS ANTENNA REFERENCE POINT The top center of the starboard side GPS antenna for the POS system.
MB-	MULTI-BEAM REFERENCE POINT The physical bottom center of the Multi-Beam transducer.

Appendix A

Coordinate Report Launch 2806

Pt Name	***North(Y)***	***East(X)***	***UP(Z)***	***ID***
IMU Target	0.00000	0.00000	0.00000	IMU
IMU Reference BM	0.13142	-0.01122	-0.16986	IMUR
Centerline Stern BM	-4.08215	0.02583	0.62671	CLS
Centerline Bow BM	3.44035	0.02583	1.42590	BMB
Portside GPS Ant. Ref. Point	-0.83249	-0.63695	3.14938	GPSP
Starboard GPS Ant. Ref. Point	-0.82526	0.81062	3.10821	GPSS
Multi-Beam Ref.Point	0.25447	-0.01284	-0.48083	MB
Keel BM	0.44302	-0.02150	-0.61052	MBF
Keel BM	-0.22767	-0.01641	-0.53926	MBA
Port Side BM	0.08725	-1.41542	1.09615	BMP
Starboard Side BM	0.09859	1.46945	1.01777	BMS
Centerline Cab BM	-0.21255	0.06840	2.64944	BMC

Units = meters

Appendix B

Point to Point Inverse Launch 2806

Pt. 1	*Pt. 2*	*Dist.*	*Northing*	*Easting*	*Elevation*	*ID*
24	42	0.001	0.000	-0.001	0.00012	SBF
6	22	0.000	0.000	0.000	0.00025	SBA
7	23	0.001	0.001	-0.001	0.00048	SB
33	35	0.004	0.003	0.001	0.00015	IMUR
36	32	0.004	-0.002	-0.004	0.00010	IMU
37	25	0.002	0.001	0.001	0.00013	CLS
12	26	0.002	-0.001	-0.002	0.00054	BMS
38	50	0.002	-0.002	0.000	0.00010	BMP
52	20	0.006	0.006	-0.003	0.00045	BMB
51	15	0.002	0.001	0.002	0.00011	BMC
13	27	0.003	0.003	-0.001	0.00080	GPSS
28	14	0.000	0.000	0.000	0.00023	GPSP

Units = meters

FAIRWEATHER

Multibeam Echosounder Calibration

Launch 2806 200kHz
Vessel

Reson 7125 200kHz	Launch 2806	11/30/2009
MBES System	MBES System Location	Date of most recent EED/Factory Check

TBD	CD0001529685
Sonar Serial Number	Processing Unit Serial Number
Plate mounted on hull	1/26/2010
Sonar Mounting Configuration	Date of current offset measurement/verification
DGPS Beacon 323, POSMV V4	3/08/2010
Description of Positioning System	Date of most recent positioning system calibration

Acquisition Log

3/9/2010	068		
Date	Dn	Local Area	Wx

Bottom Type	Approximate Water Depth

Pfundt, Wozumi, Beduhn, Akken
Personnel on board

Comments

2010_068_2806.000
TrueHeave filename

1856		47 40 35.67	122 25 22.10		51.7
SV Cast #1 filename	U	Lat	Lon	Depth	Ext. Depth
2038		47/40/32.13	122/25/18.83		44.7
SV Cast #2 filename	U	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	1947	240		roll
1	1949	060		roll
	1953			bad line

PITCH view parallel to track, same line (at nadir) [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
1	1954	320	6.5	
1	1955	142	6.5	
1	1956	313	7.0	
1	1958	150	6.4	

HEADING/YAW view parallel to track, offset lines (outerbeams) [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
1	1959	313		line 104
1	2000	137		line 101
1	2001A	307		line 101
1	2003	128		line 104

ROLL view across track, same line [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
1	2005	246		
1	2008	053		
1	2010	234		
1	2013	056		

Processing Log

Date	Dn	Personnel
3/10/2010		Beduhn

☑ **Data converted --> HDCS_Data in CARIS**

☑ **TrueHeave applied** 2009_064_2808.000

☑ **SVP applied** 2010_064_2808.000

☑ **Tide applied** N395RA2009.tc predicted

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)
AST Francksen	0.00	-1.57	-0.24	0.30
LT Welton	0.00	-1.50	-0.25	0.38
PS Wozumi	0.00	-1.56	-0.23	0.43
SST Beduhn	0.00	-1.47	-0.25	0.38
Averages	0.00	-1.53	-0.24	0.37
Standard Deviation	0.00	0.05	0.01	0.05
FINAL VALUES	0.00	-1.53	-0.24	0.37

Final Values based on Averages

Resulting HVF File Name FA_2806_200kHz_rsn7125_256bms_2010

MRU Align StdDev gyro 0.05 Value from standard deviation of Heading offset values

MRU Align StdDev Roll/Pitch 0.03 Value from averaged standard deviations of pitch and roll offset values

NARRATIVE

☑ **HVF Hydrographic Vessel File created or updated with current offsets**

Name: CST/FOO **Date:** 03/30/2010

FAIRWEATHER

Multibeam Echosounder Calibration

Launch 2806 400kHz
Vessel

CST Morgan, LT Welton, SST Beduhn, PS Wozumi
Calibrating Hydrographer(s)

Reson 7125 400kHz	Launch 2806	11/30/2009
MBES System	MBES System Location	Date of most recent EED/Factory Check
		CD0001529685
Sonar Serial Number		Processing Unit Serial Number
Plate mounted on hull		1/26/2010
Sonar Mounting Configuration		Date of current offset measurement/verification
DGPS Beacon 323, POSMV V4		3/08/2010
Description of Positioning System		Date of most recent positioning system calibration

Acquisition Log

3/9/2010	068		
Date	Dn	Local Area	Wx
Bottom Type			Approximate Water Depth

Pfundt, Wozumi, Beduhn, Allen
Personnel on board

all lines run at 6-6.5 knots unless otherwise
Comments

2010_068_2806.000
TrueHeave filename

1856		47 40 35.67	122 25 22.10		51.7
SV Cast #1 filename	U	Lat	Lon	Depth	Ext. Depth
2038		47/40/32.13	122/25/18.83		44.7
SV Cast #2 filename	U	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
2	2015			
2	2017			

PITCH view parallel to track, same line (at nadir) [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
2	2121	120		103
2	2122	327		103
2	2124	139		103 bad line?
2	2125	325		103

HEADING/YAW view parallel to track, offset lines (outerbeams) [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
2	2126	128		104 questionable?
2	2127	320		101
2	2128	135		101
2	2129	316		104
2	2131	132		104

ROLL view across track, same line [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
2	2134	060		slow speed due to sailboat
2	2136	232		
2	2140	064		
2	2143	230		

Processing Log

3/10/2010		Beduhn
Date	Dn	Personnel

☑ **Data converted --> HDCS_Data in CARIS**

☑ **TrueHeave applied** 2009_064_2808.000

☑ **SVP applied** 2010_064_2808.000

☑ **Tide applied** N395RA2009.tc predicted

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	0.00	-1.80	-0.09	0.60
LT Welton	0.00	-1.14	-0.10	-0.25
SST Beduhn	0.00	-1.98	-0.08	0.62
	0.00	-1.79	-0.09	0.57
Averages	0.00	-1.86	-0.09	0.60
Standard Deviation	0.00	0.11	0.01	0.03
FINAL VALUES	0.00	-1.86	-0.09	0.60

Final Values based on averages, with outliers removed

Resulting HVF File Name FA_2806_400kHz_Rsn7125_512bms_2010

MRU Align StdDev gyro 0.03 Value from standard deviation of Heading offset values*
MRU Align StdDev Roll/Pitch 0.06 Value from averaged standard deviations of pitch and roll offset values
*Std Dev calculations did not include outliers.

NARRATIVE

☑ **HVF Hydrographic Vessel File created or updated with current offsets**

Name: CST/FOO **Date:** 03/30/2010

Fairweather Launch 2806 Dynamic Draft Measurement
Lake Washington, 08 March 2010

LTjg Caryn Arnold, HSTP West Coast Field Support Liaison

On Monday, 08 March 2010 (DN 067), *Fairweather* Launch 2806 conducted a dynamic draft measurement (DDM) on Lake Washington using post processed kinematic GPS data. The vessel sat at rest for approximately 5 minutes, then ran in the South direction at approximate speeds of 4, 6, 8 and 10 knots, holding each speed for about 4 minutes. The vessel then turned around and ran in the North direction at approximate speeds of 10, 8, 6 and 4 knots, again holding each speed for about 4 minutes and resting for approximately 5 minutes at the end. The POS/MV recorded a POSPac file the entire time from beginning rest to finish rest.

The POSPac file was processed with POSPac MMS Software using the GNSS-Inertial Processing Single Base Station Mode. The single CORS station SEAI (1 Hz) was chosen as the base station. The Lever Arm Standard Deviation was set to <3cm and then the GNSS-Inertial Processor in the Forward, Backward and Combine mode was Run.

The file was then exported out from the POSPac MMS software with an output rate of 1 sec and run through the Python Script written by LTjg Glen Rice, which includes the fourth order polynomial curve. The following graphs were generated.

-1.35e-003*X^4+7.53e-003*X^3+9.06e-004*X^2+-1.80e-002*X

Speed (m/s)	Delta Draft (m)
0.00	0.00
0.50	-0.01
1.00	-0.01
1.50	-0.01
2.00	0.01
2.50	0.03
3.00	0.05
3.50	0.07
4.00	0.08
4.50	0.07
5.00	0.03
5.50	-0.05
6.00	-0.20

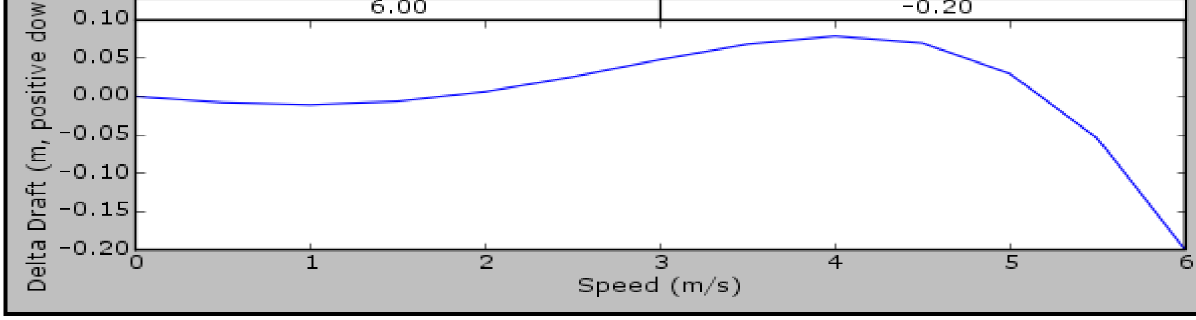


Figure 1. *Fairweather* Launch 2806 Inverted Dynamic Draft Curve & Computed Dynamic Draft Table for Caris

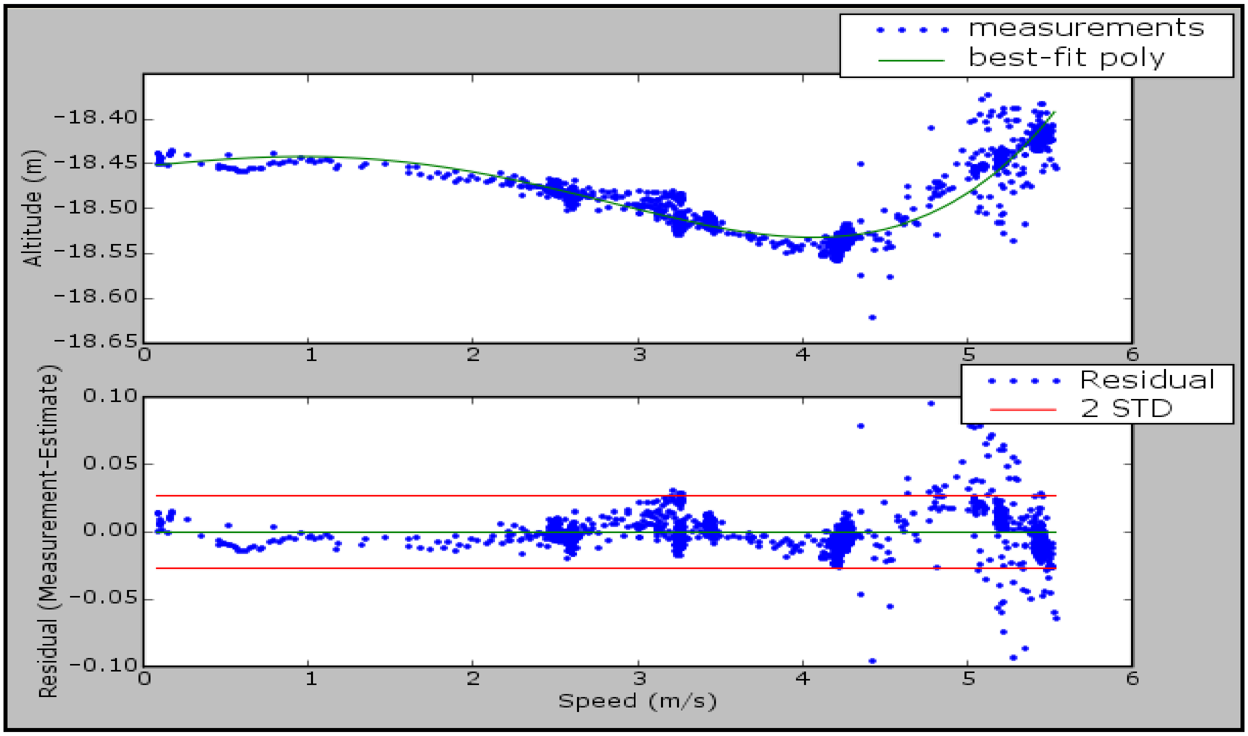


Figure 2. *Fairweather* Launch 2806 Dynamic Draft Curve with Data Points

2807 Offsets and Measurements - Summary

Measurement aka Coord. Sys.	IMU to RP*	IMU to 7125 (Receiver) *SWATH1 x,y,z & MRU to Trans*	Port Ant to 7125 *Nav to Trans x,y,z*	RP* to Waterline	Port Ant to Stbd Ant		IMU to Port Ant		IMU to Heave	
	Caris	Caris	Caris	Caris			Caris	Pos/Mv	Caris	Pos/Mv
x	0.000	0.019	0.804	n/a	Scaler Distance	1.440	-0.786	-0.812	0.000	0.000
y	0.000	0.244	1.056	n/a			-0.812	-0.786	0.000	0.000
z	0.000	0.481	3.628	-0.130			-3.147	-3.147	0.000	0.000

*IMU is Reference Point

Vessel Offsets for 2808 7125 are derived from the NGS Survey, January 2010, Trimble Equipment Specs, a 2010 Measured Values.

Calculations

Coord. Sys./ Source **NGS**

IMU to 7125

IMU (m)	x	0.00000
	y	0.00000
	z	0.00000
MBES RP Rcvr - Phase Center (m)	x	0.01867
	y	0.24441
	z	-0.48063

Port Ant to 7125

IMU to Port Ant (m) (calculated)	x	-0.78576
	y	-0.81181
	z	3.14689
IMU to Phase Ctr (calculated)	x	0.01867
	y	0.24441
	z	-0.48063

RP to Waterline

RP to Waterline (m) (waterline worksheet)	z	0.130

Port Ant to Stbd Ant

IMU to Port Ant (m) (calculated)	x	-0.78576
	y	-0.81181
	z	3.14689
IMU (m)	x, y, z	0.00000
Top of Stbd Ant (m)	x	0.65423
	y	-0.81691
	z	3.16283
Base to top of Stbd Ant (eqp spec) (m)	z	0.073
Bottom of Stbd Ant (calculated) (m)	z	3.08983
Base to Phase Cntr of Stbd Ant (eqp spc) (m)	z	0.0843

IMU to Port Ant

IMU (m)	x	0.00000
	y	0.00000
	z	0.00000
Top of Port Ant (m)	x	-0.78576
	y	-0.81181
	z	3.13559
Base to top of Port Ant (measured) (m)	z	0.073
Bottom of Port Ant (calculated) (m)	z	3.06259
Base to Phase Cntr of Port Ant (eqp spc) (m)	z	0.0843

IMU to Heave

IMU (m)	x	0.00000
	y	0.00000
	z	0.00000
Heave Pt (m) (by design)	x	0.00000
	y	0.00000
	z	0.00000

Coord. Sys. **NGS**

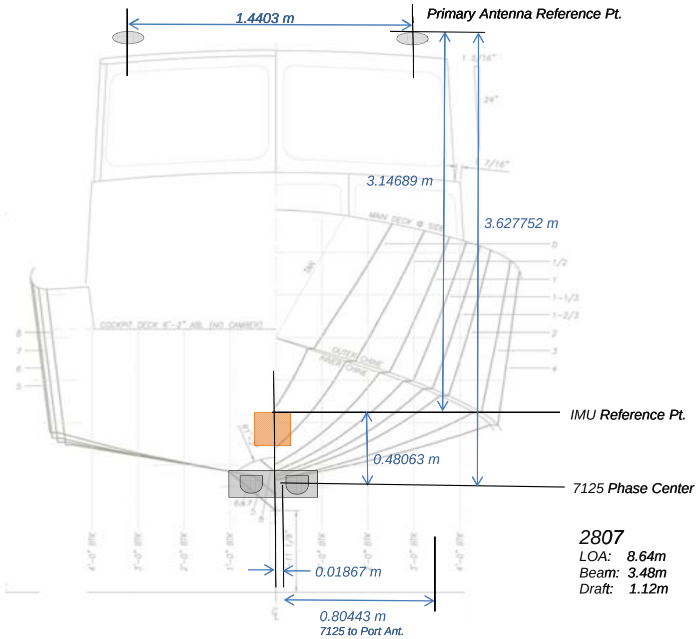
	IMU to 7125		Port Ant to 7125		RP to Waterline		Port Ant to Stbd Ant		IMU to Port Ant		IMU to Heave
IMU to Phase Ctr	x	0.01867	x	0.80443	x	n/a			x	-0.78576	x	0.00000
	y	0.24441	y	1.05622	y	n/a	Scalar Distance	1.4403	y	-0.81181	y	0.00000
	z	-0.48063	z	-3.62752	z	0.130			z	3.14689	z	0.00000

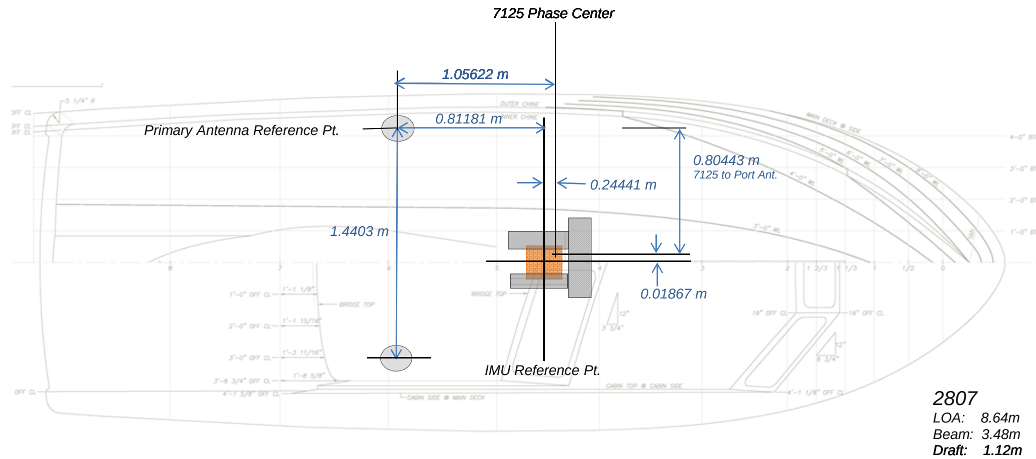
	IMU to 7125		Port Ant to 7125		RP to Waterline		IMU to Port Ant		IMU to Heave	
	Coord. Sys. **CARIS**		Coord. Sys. **CARIS**		Coord. Sys. **CARIS**		Coord. Sys. **Pos/Mv**		Coord. Sys. **Pos/Mv**	
	x	0.01867	x	0.80443	x	n/a	x	-0.81181	x	0.00000
	y	0.24441	y	1.05622	y	n/a	y	-0.78576	y	0.00000
	z	0.48063	z	3.62752	z	-0.130	z	-3.14689	z	0.00000

Description of Offsets for Launch 2807

All Values Shown are in CARIS Coordinates

The Ship Reference Frame (SRF) for Launch 2807 was based from IMU Reference Point as the 0,0,0 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 7125		
x	y	z
0.019	0.244	0.481

The physical positions of the IMU and the receiver phase center of the 7125 were measured during the NGS survey. These physical measurements were taken while the launch was secured on the pier and thought to be as level as possible. The measured values for the IMU and MB were taken directly for the report. The difference is the offset from the IMU to the phase center of the 7125 which was then transposed from the NGS to the CARIS coordinate system.

Port Ant to 7125		
x	y	z
0.804	1.056	3.628

The values were calculated by subtracting the of the Port Antenna to the IMU x, y, z values from the respective values of the IMU to the 7125. The calculated values were then transposed from the NGS to the CARIS coordinate system.

RP to Waterline		
x	y	z
N/A	N/A	-0.130

The average vertical distance from Port Benchmark to waterline and the Starboard Benchmark to the waterline were measured by FAIRWEATHER personnel using a steel tape and bubble level. These values were combined with the Z value of the Benchmarks to the RP/IMU to get an average for the waterline to RP. The Waterline Measurement value is in NGS coordinates initially and is converted to CARIS coordinates.

Port Ant to Stbd Ant
Scalar Distance
1.440

The location of the phase center of the port and starboard POS/MV antennas were surveyed by NGS. The z-values were adjusted to the phase center. Then the scalar distance between the phase centers was

IMU to Port Antenna		
x	y	z
-0.786	-0.812	-3.147

The location of the IMU and the location of the top of port antenna were surveyed by NGS. The z-value of the antenna was calculated by subtracting the height of the antenna and then adding the value from the base of the antenna to the phase center of the antenna. The calculation results were then transposed from the NGS to the CARIS coordinate system.

IMU to Heave		
x	y	z
0.000	0.000	0.000

The Heave Point is assumed to coincide with the IMU location.

Waterline Measurements

Fill in Yellow squares only!

Measuring Party: Beduhn, Wilson, Marcum, Jaskoski

2807

Waterline measurements should be negative and cm!

	2807	
	Port Benchmark to Waterline	Stbd Benchmark to Waterline
Measure 1	-92.2	-93.2
Measure 2	-93.1	-92.9
Measure 3	-93.2	-94.0
Avg (cm)	-92.84	-93.36
Avg (m)	-0.9284	-0.9336
Stdev	0.00529	0.00577
BM Z-value (m)*	1.03292	1.08830
BM to WL (m)	0.105	0.155

Individual		0.11062		0.15630
measurement		0.10212		0.15950
StDev for TPU xls	0.027909	0.10092		0.14830
(of 6 #'s)				

Date: 2/4/2010 63

Fuel Level: 2/3 full

Draft Tube:

Port-to-Stbd Z-difference

Theoretical	Actual	Error
-0.0554	-0.0052	0.0501

RP to WL Average (m)

0.130 NGS Coordinate System (do not enter into CARIS directly)

(Add this value to VSSL_Offsets & Measurements_20XX.xls)

utilized in Offsets and Measurements and TPU spreadsheet

US DEPARTMENT OF COMMERCE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE
NATIONAL GEODETIC SURVEY
GEODETIC SERVICES DIVISION
INSTRUMENTATION & METHODOLOGIES BRANCH

NOAA SURVEY VESSEL 2807
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY
FIELD REPORT

Kendall L. Fancher
January, 2010

NOAA SURVEY VESSEL 2807
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY

PURPOSE

The primary purpose of the survey was to precisely determine the spatial relationship between various hydrographic surveying sensors, launch bench marks and the components of a POS MV navigation system aboard the NOAA survey vessel 2807.

PROJECT DETAILS

This survey was conducted in Seattle, WA at the NOAA Western Center on the 27th of January, 2010. The weather was foggy early then sunny with temperatures in the 40s to 50s. For this survey, the vessel was on blocks, supported by boat jacks. The vessel was reported to have been leveled relative to the IMU.

INSTRUMENTATION

A Leica TDA5005 precision total station was used to make all measurements.
Technical Data:

Standard Deviation

Horizontal angle	0.5 seconds
Vertical angle	0.5 seconds
Distance measurement	1mm + 1ppm

Leica precision prisms were used as sighting targets. Prisms were configured to have a zero mm offset.

PERSONNEL

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DEFINITION OF THE REFERENCE FRAME

For this survey, data was collected in a 3-D right handed Cartesian coordinate system. The origin of this coordinate system is defined as the center of the IMU target. The Y (Northing) axis is parallel to the centerline of the launch and is positive towards the bow of the launch. The X (Easting) axis is perpendicular to the Y axis and is positive towards the starboard side of the launch. The Z (Elevation) axis is perpendicular to the XY plane and is positive towards the top of the launch. The coordinates of the points established this survey are reported in this coordinate system and are provided in Appendix A.

SURVEY METHODOLOGY

Four temporary control points, (1, 2, 3, and 4), were established around the vessel such that every point to be positioned on the launch could be observed from at least two separate locations.

Coordinates of 100.000N, 100.000E, and 100.000U were assumed for temporary control point 1. A distance and height difference were measured between control points 1 and 2. Temporary control point 2 was assumed to have an Easting of 100.000. The measured distance between these two points was used to determine the Northing for temporary control point 2. The height difference between the two points was used to determine the Up component for control point 2.

Control point 1 was occupied and control point 2 was observed to initialize the instrument. After initialization, control point 4 and all visible points to be observed on the launch were observed in both direct and reverse. The stability of the instrument setup was checked at conclusion of the data set collection by checking back to temporary control point 2.

Control point 2 was occupied and control point 1 was observed to initialize the instrument. After initialization, control point 3 and all visible points to be observed on the launch were observed in both direct and reverse. The stability of the instrument setup was checked at conclusion of the data set collection by checking back to temporary control point 1.

Control point 3 was occupied and control point 2 was observed to initialize the instrument. After initialization, control point 4 and all visible points to be observed on the launch were observed in both direct and reverse. The stability of the instrument setup was checked at conclusion of the data set collection by checking back to temporary control point 2.

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Control point 4 was occupied and control point 3 was observed to initialize the instrument. After initialization, all visible points to be observed on the launch were observed in both direct and reverse. Control point 1 was also observed in order to evaluate the accuracy of the traverse. Inverse computations between the original and observed control point yielded a horizontal accuracy, or traverse closure of of 0.001 m and a vertical accuracy of 0.000 m. The stability of the instrument setup was checked at conclusion of the data set collection by checking back to temporary control point 2.

Inverses were computed between the two positions determined for all points surveyed to evaluate their accuracy relative to the temporary control network. Inverse reports are included in appendix B.

The reference frame was rotated using CENTERLINE STERN BM (CLS) as the point of rotation. A zero degree azimuth was used during the rotation from CLS to CENTERLINE BOW BM (BMB). The reference frame was then translated to relocate the origin of the reference frame to the IMU. The resulting coordinates are reported in appendix A.

DISCUSSION

The positions given for the POS GPS antennas (Zephyr Model II p/n 57970-00) are to the top center of the antenna. To correct the Z value provided in this report for each antenna to the electronic phase center, I recommend the following steps be taken;

1) Determine the physical height of the GPS antenna. This information is probably located on the antenna or with equipment documentation.
2) Investigate to find the electronic phase center offset of the antenna. This information is probably located on the antenna or with equipment documentation. This value may also be available at the NGS website for antenna modeling.
3) Subtract the total height of the antenna from the Z value for each antenna. This will give you a Z value for the antenna ARP (antenna reference point)
4) Then add to this value the electronic phase center offset value appropriate for the antenna model.

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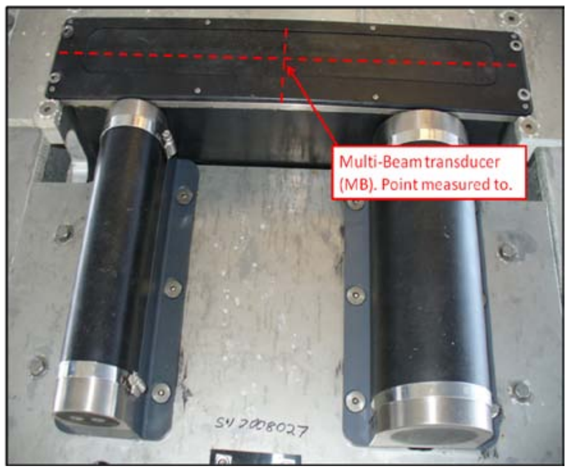
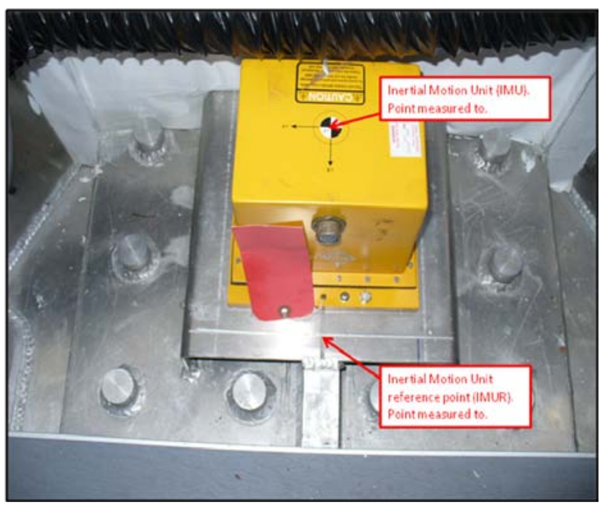
Two reference points (MBF and MBA) were positioned in order to facilitate future measurements to the Multi-Beam sensor by launch personnel. These reference points are punch marks set along the center of the keel, at the locations described in the image at right.

A point on the Multi-Beam transducer (MB) was measured directly this survey. The measured point was at the center of the bottom of the transducer. No mark was left to indicate the measured point.



The point positioned for the Inertial Motion Unit (IMU) this survey was the center of the target affixed to the top of the unit. Additionally, a reference mark (IMUR) was established on the plate the IMU is attached to at a point where two scribed lines intersect, forward of the IMU.



NOAA SURVEY VESSEL 2807
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY

STATION LISTING

BMB-	CENTERLINE BOW BM The center of a cross mark inscribed into the top of a square metal flange, welded to the deck, along the centerline and near the bow of the launch.
CLS-	CENTERLINE STERN BM The center of a cross mark inscribed into the top of a square metal flange, welded to the deck, along the centerline and near the stern of the launch.
BMC-	CENTERLINE CAB BM The center of a cross mark inscribed into the top of a square metal flange, welded to the top of the cab, along the centerline of the launch.
BMP-	PORT SIDE BM The center of a cross mark inscribed into the top of a square metal flange, welded to the top of the deck, near the middle of and along the port side of the launch.
BMS-	STARBOARD SIDE BM The center of a cross mark inscribed into the top of a square metal flange, welded to the top of the deck, near the middle of and along the starboard side of the launch.
MBF-	KEEL BM A punch mark set along the bottom center of the keel, fore of the multi-beam transducer, 0.030 m from a point where the keel makes a 90 degree angle upwards.
MBA-	KEEL BM A punch mark set along the bottom center of the keel, aft of the multi-beam transducer, 0.030 m from a point where the keel makes a 90 degree angle upwards.
IMU-	IMU TARGET Center of a target affixed to the top of the IMU housing.
IMUR-	IMU REFERENCE BM The intersection of two scribed lines atop a metal support plate for the IMU and forward of the IMU.
GPSP-	PORT SIDE GPS ANTENNA REFERENCE POINT The top center of the port side GPS antenna for the POS system.
GPSS-	STARBOARD GPS ANTENNA REFERENCE POINT The top center of the starboard side GPS antenna for the POS system.
MB-	MULTI-BEAM REFERENCE POINT The physical bottom center of the Multi-Beam transducer.

Appendix A

Coordinate Report Launch 2807

Pt Name	***North(Y)***	***East(X)***	***UP(Z)***	***ID***
IMU Target	0.00000	0.00000	0.00000	IMU
IMU Reference BM	0.13111	0.00714	-0.16724	IMUR
Centerline Stern BM	-4.06155	-0.02156	0.64902	CLS
Centerline Bow BM	3.44775	-0.02156	1.41160	BMB
Portside GPS Ant. Ref. Point	-0.81181	-0.78576	3.13559	GPSP
Starboard GPS Ant. Ref. Point	-0.81691	0.65423	3.16283	GPSS
Multi-Beam Ref.Point	0.24441	0.01867	-0.48063	MB
Keel BM	0.43114	0.01129	-0.61049	MBF
Keel BM	-0.23560	0.00988	-0.53203	MBA
Port Side BM	0.09979	-1.46918	1.03292	BMP
Starboard Side BM	0.08626	1.42671	1.08830	BMS
Centerline Cab BM	-0.21841	-0.05358	2.65245	BMC

Units = meters

Appendix B

Point to Point Inverse Launch 2807

Pt. 1	*Pt. 2*	*Dist.*	*Northing*	*Easting*	*Elevation*	*ID*
18	37	0.002	-0.002	0.000	0.00024	MBF
35	39	0.001	-0.001	-0.001	0.00027	MBA
19	36	0.004	0.001	0.004	0.00043	MB
29	27	0.006	0.001	0.006	0.00023	IMUR
26	30	0.006	0.005	0.004	0.00012	IMU
20	31	0.001	-0.001	-0.001	0.00038	CLS
32	45	0.000	0.000	0.000	0.00005	BMP
21	9	0.000	0.000	0.000	0.00057	BMS
49	16	0.007	0.007	0.000	0.00076	BMB
12	46	0.001	-0.001	0.000	0.00044	BMC
11	47	0.003	-0.002	0.001	0.00094	GPSP
10	48	0.002	-0.002	0.001	0.00068	GPSS

Units = meters

FAIRWEATHER

Multibeam Echosounder Calibration

Launch 2807 200kHz
Vessel

Date	Dn	Local Area
4/21/2010	111	Ketchikan, AK

Calibrating Hydrographer(s): Wozumi, Welton, Froelich

MBES System	MBES System Location	Date of most recent EED/Factory Check
7125 200kHz ED	2807	01/01/2010

Sonar Serial Number	Processing Unit Serial Number
TBD	CD0001527818

Sonar Mounting Configuration	Date of current offset measurement/verification
Plate mounted on hull	1/27/2010

Description of Positioning System	Date of most recent positioning system calibration
DGPS Beacon 323, POSMV V4	3/3/2010

Acquisition Log

Date	Dn	Local Area	Wx
4/21/2010	111	Tongass NARROWS	ovc,

Bottom Type	Approximate Water Depth

Personnel on board: Nardi, Wozumi, Forney

Comments: DGPS- 323, ED

TrueHeave filename: 2010_111_2807.000

		Lat	Lon	Depth	Ext. Depth
SV Cast #1 filename	2010_111_193713.HEX	55/20/00.25N	131/37/57.50W	46.7	
SV Cast #2 filename					
SV Cast #3 filename					

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 #	HSX Line Filename	Heading	Speed (kts)	Remarks
1	2010_T1112101.HSX	SE		

PITCH

view parallel to track, same line (at nadir) [opposite direction, same speed]

SV Cast #	HSX Line Filename	Heading	Speed (kts)	Remarks
1	2010_T1112033.HSX	SE	4.0	
1	2010_T1112036.HSX	NW	4.0	
1	2010_T1112038.HSX	SE	4.0	
1	2010_T1112040.HSX	NW	4.0	

HEADING/YAW

view parallel to track, offset lines (outerbeams) [opposite direction, same speed]

SV Cast #	HSX Line Filename	Heading	Speed (kts)	Remarks
1	2010_T1112043.HSX	SE	4.0	Line 5
1	2010_T1112046.HSX	NW	4.0	Line 5
1	2010_T1112048.HSX	SE	4.0	Line 4
1	2010_T1112051.HSX	NW	4.0	Line 4

ROLL

view across track, same line [opposite direction, same speed]

SV Cast #	HSX Line Filename	Heading	Speed (kts)	Remarks
1	2010_T1112054.HSX	SE	4.0	Ad Hoc
1	2010_T1112057.HSX	NW	4.0	Ad Hoc

Processing Log

Date	Dn	Personnel
4/22/2010	112	Wozumi

☑ **Data converted --> HDCS_Data in CARIS**

☑ **TrueHeave applied** 2010_111_2807.000

☑ **SVP applied** 2010_111_193713

☐ **Tide applied**

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)
Wozumi		-1.60	0.10	0.20
Hypack (GF)	0.00	-2.20	-0.30	4.50
Welton	0.00	-1.10	0.10	0.45
Froelich		-1.40	0.09	0.51
Averages	0.00	-1.58	0.10	1.42
Standard Deviation	0.00	0.25	0.01	0.16
FINAL VALUES	0.00	-1.37	0.10	0.39

Final Values based on Wozumi, Welton, Froelich

Resulting HVF File Name FA_2807_200kHz_Rsn7125_256bms_2010.hvf

MRU Align StdDev gyro 0.16 Value from standard deviation of Heading offset values

MRU Align StdDev Roll/Pitch 0.13 Value from averaged standard deviations of pitch and roll offset values

NARRATIVE

SBET was applied to data

Added to hvf under Dn 091

☑ **HVF Hydrographic Vessel File created or updated with current offsets**

Name: FA_2807_200kHz_Rsn7125_256bms_2010.hvf **Date:** 5/21/2010

FAIRWEATHER

Multibeam Echosounder Calibration

Launch 2807 400kHz
Vessel

4/21/2010	111	Tongass Narrow
Date	Dn	Local Area

Wozumi, Welton, Froelich
Calibrating Hydrographer(s)

Reson 7125sv	2807	01/01/2010
MBES System	MBES System Location	Date of most recent EED/Factory Check

TBD	CD0001527818
Sonar Serial Number	Processing Unit Serial Number
Plate mounted on hull	1/27/2010
Sonar Mounting Configuration	Date of current offset measurement/verification
DGPS Beacon 323, POSMV V4	3/3/2010
Description of Positioning System	Date of most recent positioning system calibration

Acquisition Log

4/21/2010	111	Tongass Narrows	Cloudy and rainy
Date	Dn	Local Area	Wx

Bottom Type	Approximate Water Depth

Nardi, Wozumi, Forney
Personnel on board

Comments

2010_111_2807.000
TrueHeave filename

2010_111_193713.HEX		55/20/00.25N	131/37/57.50W	46.7	
SV Cast #1 filename	U	Lat	Lon	Depth	Ext. Depth
SV Cast #2 filename	U	Lat	Lon	Depth	Ext. Depth
SV Cast #3 filename	U	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 #	HSX Line Filename	Heading	Speed (kts)	Remarks
1	2010_T1112026	NW		

PITCH view parallel to track, same line (at nadir) [opposite direction, same speed]

SV Cast #	HSX Line Filename	Heading	Speed (kts)	Remarks
1	2010_T1111956	SE	5.0	Line 1
1	2010_T1112003	NW		Line 1
1	2010_T1112012	NW		Line 1
1	2010_T1112016	SE		Line 1

HEADING/YAW view parallel to track, offset lines (outerbeams) [opposite direction, same speed]

SV Cast #	HSX Line Filename	Heading	Speed (kts)	Remarks
1	2010_T1111958	NW	5.0	Line 5
1	2010_T1112001	SE		Line 5
1	2010_T1112005	SE		Line 4
1	2010_T1112008	NW		Line 4

ROLL view across track, same line [opposite direction, same speed]

SV Cast #	HSX Line Filename	Heading	Speed (kts)	Remarks
1	2010_T1112020	NW	4.8	
1	2010_T1112023	SE		

Processing Log

Date	Dn	Personnel
4/22/2010	112	Wozumi

- [x] **Data converted --> HDCS_Data in CARIS**
- [x] **TrueHeave applied**
- [x] **SVP applied** 2010_111_2807.000 / 2010_111_193713
- [ ] **Tide applied**

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)
Wozumi		-1.23	0.13	0.23
Hypack (GF)	0.00	-1.60	-0.30	3.60
Welton	0.00	-1.10	0.10	0.39
Froelich	0.00	-1.20	0.10	0.50
Jaskoski	0.00	-1.15	0.11	0.60
Averages	0.00	-1.26	0.03	1.06
Standard Deviation	0.00	0.06	0.01	0.16
FINAL VALUES	0.00	-1.17	0.11	0.43

Final Values based on Wozumi, Welton, Froelich, and Jaskoski averages

Resulting HVF File Name 2807_400kHz_MBES_Cal_2010.xls

MRU Align StdDev gyro 0.16 Value from standard deviation of Heading offset values

MRU Align StdDev Roll/Pitch 0.04 Value from averaged standard deviations of pitch and roll offset values

NARRATIVE

SBET was applied to data

- [x] **HVF Hydrographic Vessel File created or updated with current offsets**

Name: Briana Welton **Date:** 5/21/10

Fairweather Launch 2807 Dynamic Draft Measurement
Custom House Cove, AK, 23 May 2010

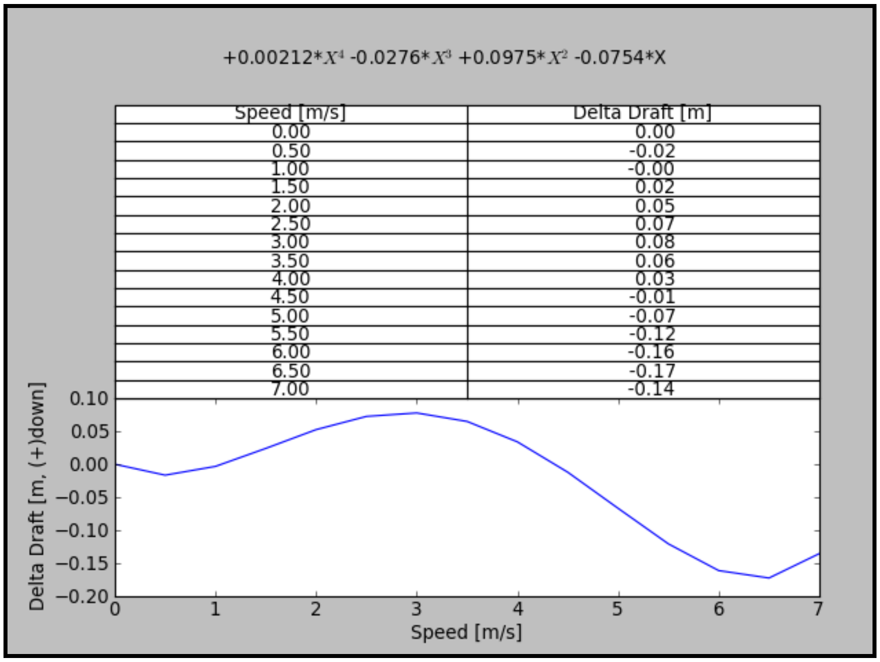
Grant Froelich, Physical Scientist- Pacific Hydrographic Branch

On Sunday, 23 May 2010 (DN 143), *Fairweather* Launch 2807 conducted a dynamic draft measurement (DDM) in Custom House Cove, AK using post processed kinematic GPS data. The vessel sat at rest for approximately 5 minutes, then ran in the South-West direction at approximate speeds of 4, 6, 8, 10and 12 knots, holding each speed for about 4 minutes. The vessel then turned around and ran in the North-East direction at approximate speeds of 4,6,8,10 and 12 knots, again holding each speed for about 4 minutes and resting for approximately 5 minutes at the end. The POS MV recorded a POSPac file the entire time from beginning rest to finish rest.

The POSPac file was processed with POSPac MMS Software using the GNSS-Inertial Processing Single Base Station Mode. The single *Fairweather* base station SOUTH TWIN (1 Hz) was chosen as the base station. The Lever Arm Standard Deviation was set to <3cm and then the GNSS-Inertial Processor in the Forward, Backward and Combine mode was Run.

The file was then exported out from the POSPac MMS software with an output rate of 1 sec and run through the Pydro script, which includes the fourth order polynomial curve. The following graphs were generated.

Due to the unusually high standard deviation value for 2807 from this run in comparison to the three other *Fairweather* launches, another SBET file was created limiting the speeds examined to 1.0 m/s to 6.6 m/s. This was done to remove the high variation of ellipsoid height data between 0.0 m/s and 1.0 m/s as seen in Figure 2, which occurred for unknown reasons. This speed-clipped file was then run through the Pydro script from GPS seconds of the week 63600 to 64981 to encompass the times of the actual dynamic draft measurement. This produced another set of graphs which included a more reasonable standard deviation value. Because of the missing “at rest” data (0.0 m/s to 1.0 m/s) the best fit equation of the line for this new run varied greatly from the previous run. Based on the results from the other *Fairweather* launches this new run equation of the line was determined to be erroneous due to the lack of “at rest” data which the script is trying to incorporate. The standard deviation plot (Figure 3) does not appear to be affected by this and so the value from this graph (2 STD value of 0.07) was used to update the Delta Draft TPU value in the CARIS HVF on 08/10/2010 but is back dated for use from beginning of the field season.



$+0.00212*X^4 -0.0276*X^3 +0.0975*X^2 -0.0754*X$

Speed [m/s]	Delta Draft [m]
0.00	0.00
0.50	-0.02
1.00	-0.00
1.50	0.02
2.00	0.05
2.50	0.07
3.00	0.08
3.50	0.06
4.00	0.03
4.50	-0.01
5.00	-0.07
5.50	-0.12
6.00	-0.16
6.50	-0.17
7.00	-0.14

Figure 1. *Fairweather* Launch 2807 Inverted Dynamic Draft Curve & Computed Dynamic Draft Table for CARIS

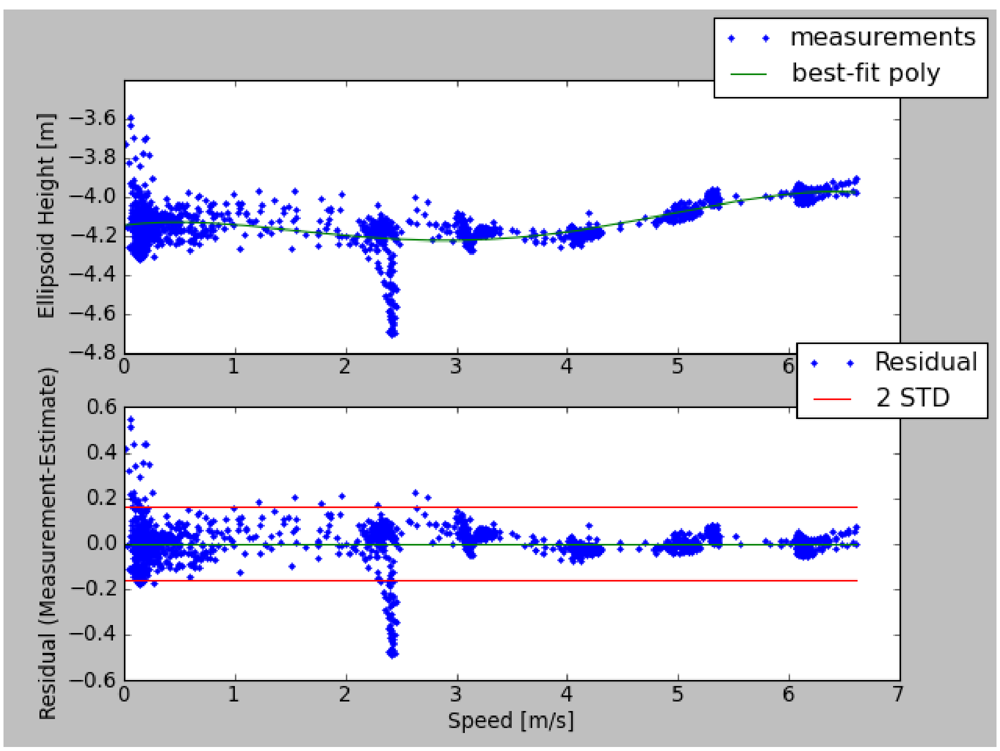


Figure 2. *Fairweather* Launch 2807 Dynamic Draft Curve with Data Points

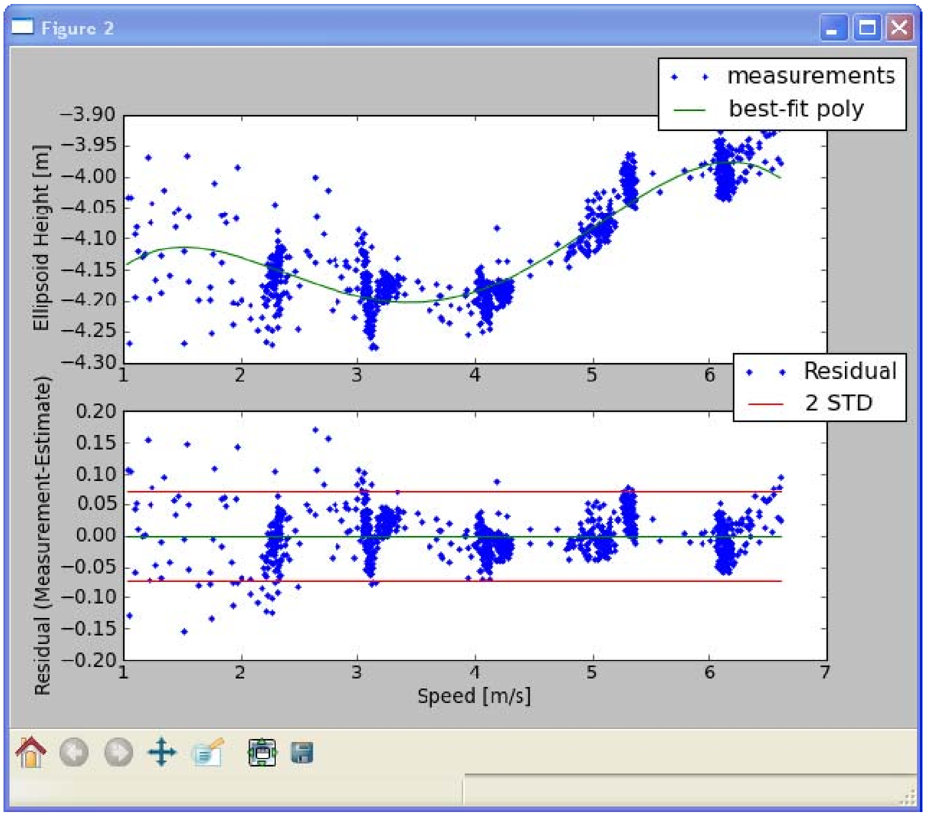


Figure 3. *Fairweather* Launch 2807 Dynamic Draft Curve with Data Points from clipped run

2808 Offsets and Measurements - Summary

Measurement aka Coord. Sys.	IMU to RP* (Caris)	IMU to 7125 (Receiver) *SWATH1 x,y,z & MRU to Trans* (Caris)	Port Ant to 7125 *Nav to Trans x,y,z* (Caris)	RP* to Waterline (Caris)	IMU to Port Ant (Caris)	IMU to Port Ant (Pos/Mv)	IMU to Heave (Caris)	IMU to Heave (Pos/Mv)
x	0.000	0.004	0.685	n/a	-0.682	-0.837	0.000	0.000
y	0.000	0.250	1.086	n/a	-0.837	-0.682	0.000	0.000
z	0.000	0.477	3.637	-0.123	-3.160	-3.160	0.000	0.000

Port Ant to Stbd Ant: Scaler Distance 1.453

*IMU is Reference Point

Vessel Offsets for 2808 7125 are derived from the NGS Survey, January 2010, Trimble Equipment Specs, 2010 Measured Values.

Calculations

Coord. Sys./ Source: **NGS**

IMU to 7125

IMU (m)	x	0.00000
	y	0.00000
	z	0.00000
MBES RP Rcvr - Phase Center (m)	x	0.00351
	y	0.24969
	z	-0.47677

Port Ant to 7125

IMU to Port Ant (m) (calculated)	x	-0.68151
	y	-0.83666
	z	3.15974
IMU to Phase Ctr (calculated)	x	0.00351
	y	0.24969
	z	-0.47677

RP to Waterline

RP to Waterline (m) (waterline worksheet)	z	0.123

Port Ant to Stbd Ant

IMU to Port Ant (m) (calculated)	x	-0.68151
	y	-0.83666
	z	3.15974
IMU (m)	x, y, z	0.00000
Top of Stbd Ant (m)	x	0.77098
	y	-0.83402
	z	3.13235
Base to top of Stbd Ant (eqp spec) (m)	z	0.073
Bottom of Stbd Ant (calculated) (m)	z	3.05935
Base to Phase Cntr of Stbd Ant (eqp spc) (m)	z	0.0843

IMU to Port Ant

IMU (m)	x	0.00000
	y	0.00000
	z	0.00000
Top of Port Ant (m)	x	-0.68151
	y	-0.83666
	z	3.14844
Base to top of Port Ant (measured) (m)	z	0.073
Bottom of Port Ant (calculated) (m)	z	3.07544
Base to Phase Cntr of Port Ant (eqp spc) (m)	z	0.0843

IMU to Heave

IMU (m)	x	0.00000
	y	0.00000
	z	0.00000
Heave Pt m) (by design)	x	0.00000
	y	0.00000
	z	0.00000

Coord. Sys. **NGS**

	IMU to 7125 (IMU to Phase Ctr)	Port Ant to 7125	RP to Waterline	IMU to Port Ant	IMU to Heave
x	0.00351	0.68502	n/a	-0.68151	0.00000
y	0.24969	1.08635	n/a	-0.83666	0.00000
z	-0.47677	-3.63651	0.123	3.15974	0.00000

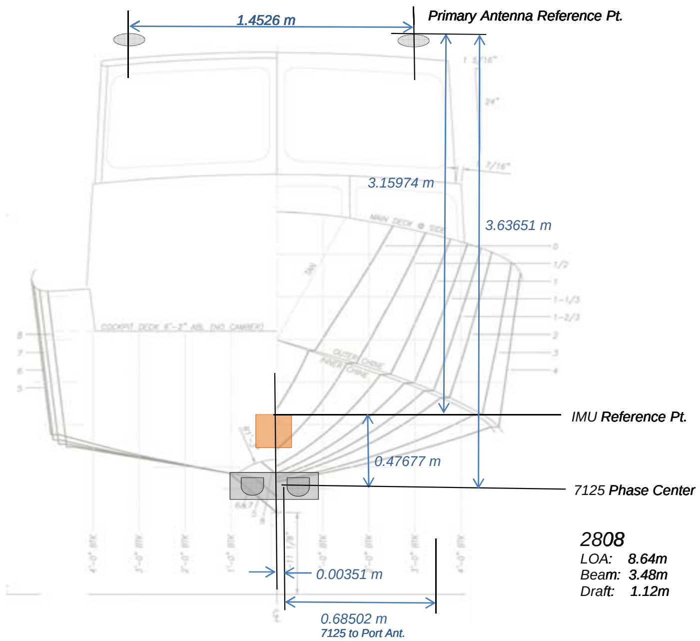
Port Ant to Stbd Ant: Scalar Distance 1.4526

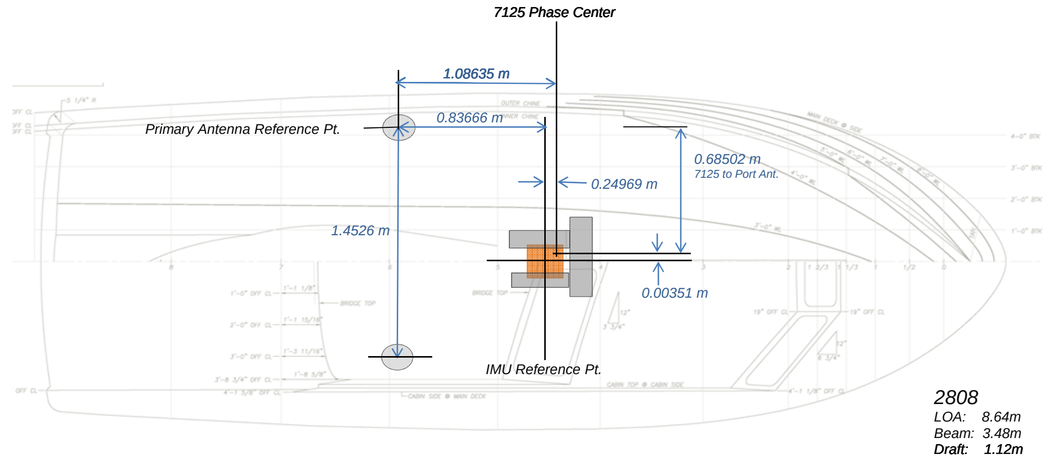
	IMU to 7125 (Coord. Sys. CARIS)	Port Ant to 7125 (Coord. Sys. CARIS)	RP to Waterline (Coord. Sys. CARIS)	IMU to Port Ant (Coord. Sys. Pos/Mv)	IMU to Heave (Coord. Sys. Pos/Mv)
x	0.00351	0.68502	n/a	-0.83666	0.00000
y	0.24969	1.08635	n/a	-0.68151	0.00000
z	0.47677	3.63651	-0.123	-3.15974	0.00000

Description of Offsets for Launch 2808

All Values Shown are in CARIS Coordinates

The Ship Reference Frame (SRF) for Launch 2808 was based from the IMU reference point as the 0,0,0 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 7125		
x	y	z
0.004	0.250	0.477

The physical positions of the IMU and the receiver phase center of the 7125 were measured during the NGS survey. These physical measurements were taken while the launch was secured on the pier and thought to be as level as possible. The measured values for the IMU and MB were taken directly for the report. The difference is the offset from the IMU to the phase center of the 7125 which was then transposed from the NGS to the CARIS coordinate system.

Port Ant to 7125		
x	y	z
0.685	1.086	3.637

The values were calculated by subtracting the of the Port Antenna to the IMU x, y, z values from the respective values of the IMU to the 7125. The calculated values were then transposed from the NGS to the CARIS coordinate system.

RP to Waterline		
x	y	z
n/a	n/a	-0.123

The average vertical distance from Port Benchmark to waterline and the Starboard Benchmark to the waterline were measured by FAIRWEATHER personnel using a steel tape and bubble level. These values were combined with the Z value of the Benchmarks to the RP/IMU to get an average for the waterline to RP. The Waterline Measurement value is in NGS coordinates initially and is converted to CARIS coordinates.

Port Ant to Stbd Ant
Scalar Distance
1.453

The location of the phase center of the port and starboard POS/MV antennas were surveyed by NGS. The z-values were adjusted to the phase center. Then the scalar distance between the phase centers was

IMU to Port Antenna		
x	y	z
-0.682	-0.837	-3.160

The location of the IMU and the location of the top of port antenna were surveyed by NGS. The z-value of the antenna was calculated by subtracting the height of the antenna and then adding the value from the base of the antenna to the phase center of the antenna. The calculation results were then transposed from the NGS to the CARIS coordinate system.

IMU to Heave		
x	y	z
0.000	0.000	0.000

The Heave Point is assumed to coincide with the IMU location.

Waterline Measurements

Fill in Yellow squares only!

Measuring Party: Beduhn, Francksen, Froelich

2808

Waterline measurements should be negative and cm!

Date: 3/5/2010
Fuel Level: 3/4 Full
Draft Tube:

	2808	
	Port Benchmark to Waterline	Stbd Benchmark to Waterline
Measure 1	-93.4	-95.2
Measure 2	-93.2	-92.2
Measure 3	-92.9	-95.2
Avg (cm)	-93.17	-94.20
Avg (m)	-0.9317	-0.9420
Stdev	0.00252	0.01732
BM Z-value (m)*	1.07600	1.04444
BM to WL (m)	0.144	0.102

Port-to-Stbd Z-difference

Theoretical	Actual	Error
0.0316	-0.0103	-0.0419

RP to WL Average (m)
0.123 NGS Coordinate System (do not enter into CARIS directly)
(Add this value to VSSL_Offsets & Measurements_20XX.xls)

		Port	Stbd
Individual measurement		0.14200	0.09244
		0.14400	0.12244
StDev for TPU xls (of 6 #'s)	0.025476	0.14700	0.09244

utilized in Offsets and Measurements and TPU spreadsheet

Measuring Party: Beduhn, Francksen, Froelich

Waterline measurements should be negative and cm!

Date: 3/5/2010
Fuel Level: 1/2 port ~1/2 star
Draft Tube:

	2808	
	Port Benchmark to Waterline	Stbd Benchmark to Waterline
Measure 1	-92.2	-93.1
Measure 2	-93.8	-91.0
Measure 3	-93.4	-92.5
Avg (cm)	-93.13	-92.20
Avg (m)	-0.9313	-0.9220
Stdev	0.00833	0.01082
BM Z-value (m)	1.07600	1.04444
BM to WL (m)	0.144666667	0.122

Port-to-Stbd Z-difference

Theoretical	Actual	Error
0.0316	0.0093	-0.0222

RP to WL Average (m)
0.134 NGS Coordinate System (do not enter into CARIS directly)
(or add this value to VSSL_Offsets & Measurements_20XX)

		Port	Stbd
Individual measurement		0.15400	0.11344
		0.13800	0.13444
StDev for TPU xls (of 6 #'s)	0.014925	0.14200	0.11944

US DEPARTMENT OF COMMERCE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE
NATIONAL GEODETIC SURVEY
GEODETIC SERVICES DIVISION
INSTRUMENTATION & METHODOLOGIES BRANCH

NOAA SURVEY VESSEL 2808
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY
FIELD REPORT

Kendall L. Fancher
January, 2010

NOAA SURVEY VESSEL 2808
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY

PURPOSE

The primary purpose of the survey was to precisely determine the spatial relationship between various hydrographic surveying sensors, launch bench marks and the components of a POS MV navigation system aboard the NOAA survey vessel 2808.

PROJECT DETAILS

This survey was conducted in Seattle, WA at the NOAA Western Center on the 27^{th} of January, 2010. The weather was foggy then sunny with temperatures in the 40s to 50s. For this survey, the vessel was on blocks, supported by boat jacks. The vessel was reported to have been leveled relative to the IMU.

INSTRUMENTATION

A Leica TDA5005 precision total station was used to make all measurements.
Technical Data:

Standard Deviation

Horizontal angle	0.5 seconds
Vertical angle	0.5 seconds
Distance measurement	1mm + 1ppm

Leica precision prisms were used as sighting targets. Prisms were configured to have a zero mm offset.

PERSONNEL

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NOAA SURVEY VESSEL 2808
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY

DEFINITION OF THE REFERENCE FRAME

For this survey, data was collected in a 3-D right handed Cartesian coordinate system. The origin of this coordinate system is defined as the center of the IMU target. The Y (Northing) axis is parallel to the centerline of the launch and is positive towards the bow of the launch. The X (Easting) axis is perpendicular to the Y axis and is positive towards the starboard side of the launch. The Z (Elevation) axis is perpendicular to the XY plane and is positive towards the top of the launch. The coordinates of the points established this survey are reported in this coordinate system and are provided in Appendix A.

SURVEY METHODOLOGY

Four temporary control points, (1, 2, 3, and 4), were established around the vessel such that every point to be positioned on the launch could be observed from at least two separate locations.

Coordinates of 100.000N, 100.000E, and 100.000U were assumed for temporary control point 1. A distance and height difference were measured between control points 1 and 2. Temporary control point 2 was assumed to have an Easting of 100.000. The measured distance between these two points was used to determine the Northing for temporary control point 2. The height difference between the two points was used to determine the Up component for control point 2.

Control point 1 was occupied and control point 2 was observed to initialize the instrument. After initialization, control point 4 and all visible points to be observed on the launch were observed in both direct and reverse. The stability of the instrument setup was checked at conclusion of the data set collection by checking back to temporary control point 2.

Control point 2 was occupied and control point 1 was observed to initialize the instrument. After initialization, control point 3 and all visible points to be observed on the launch were observed in both direct and reverse. The stability of the instrument setup was checked at conclusion of the data set collection by checking back to temporary control point 1.

Control point 3 was occupied and control point 2 was observed to initialize the instrument. After initialization, control point 4 and all visible points to be observed on the launch were observed in both direct and reverse. The stability of the instrument setup was checked at conclusion of the data set collection by checking back to temporary control point 2.

NOAA SURVEY VESSEL 2808
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY

Control point 4 was occupied and control point 3 was observed to initialize the instrument. After initialization, all visible points to be observed on the launch were observed in both direct and reverse. Control point 1 was also observed in order to evaluate the accuracy of the traverse. Inverse computations between the original and observed control point yielded a horizontal accuracy, or traverse closure of of 0.001m and a vertical accuracy of 0.000m. The stability of the instrument setup was checked at conclusion of the data set collection by checking back to temporary control point 2.

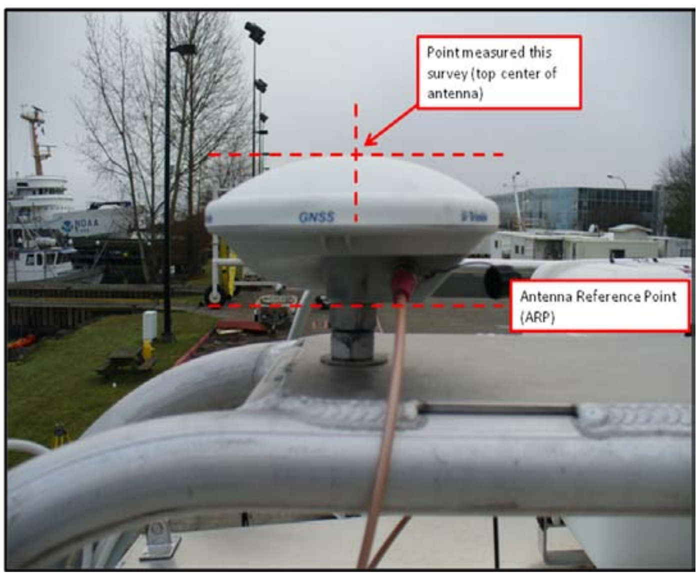
Inverses were computed between the two positions determined for all points surveyed to evaluate their accuracy relative to the temporary control network. Inverse reports are included in appendix B.

The reference frame was rotated using CENTERLINE STERN BM (CLS) as the point of rotation. A zero degree azimuth was used during the rotation from CLS to CENTERLINE BOW BM (BMB). The reference frame was then translated to relocate the origin of the reference frame to the IMU. The resulting coordinates are reported in appendix A.

DISCUSSION

The positions given for the POS GPS antennas (Zephyr Model II p/n 57970-00) are to the top center of the antenna. To correct the Z value provided in this report for each antenna to the electronic phase center, I recommend the following steps be taken;

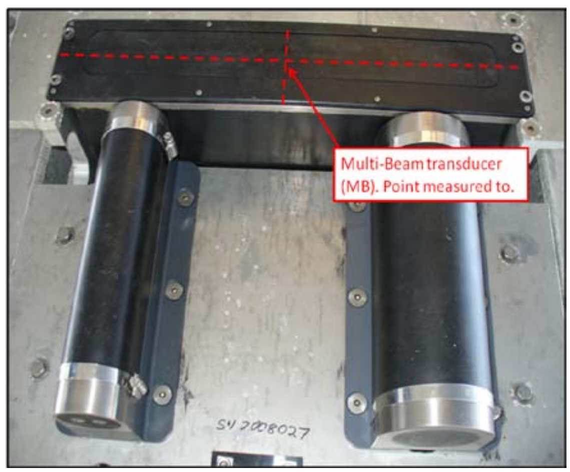
1) Determine the physical height of the GPS antenna. This information is probably located on the antenna or with equipment documentation.
2) Investigate to find the electronic phase center offset of the antenna. This information is probably located on the antenna or with equipment documentation. This value may also be available at the NGS website for antenna modeling.
3) Subtract the total height of the antenna from the Z value for each antenna. This will give you a Z value for the antenna ARP (antenna reference point)
4) Then add to this value the electronic phase center offset value appropriate for the antenna model.



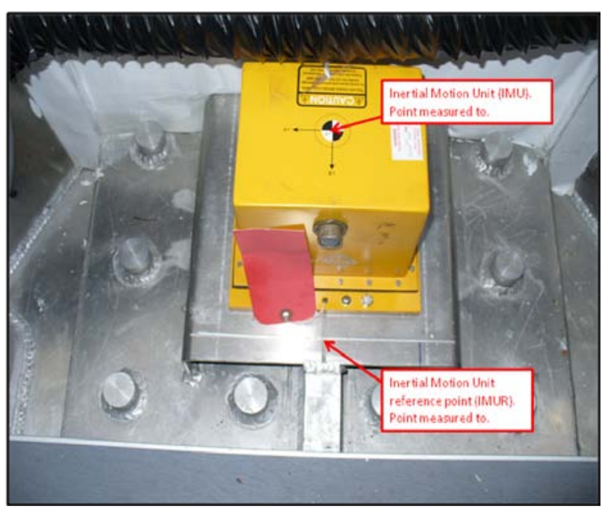
NOAA SURVEY VESSEL 2808
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY

Two reference points (MBF and MBA) were positioned in order to facilitate future measurements to the Multi-Beam sensor by launch personnel. These reference points are punch marks set along the center of the keel, at the locations described in the image at right.

A point on the Multi-Beam transducer (MB) was measured directly this survey. The measured point was at the center of the bottom of the transducer. No mark was left to indicate the measured point.



The point positioned for the Inertial Motion Unit (IMU) this survey was the center of the target affixed to the top of the unit. Additionally, a reference mark (IMUR) was established on the plate the IMU is attached to at a point where two scribed lines intersect, forward of the IMU.



NOAA SURVEY VESSEL 2808
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY

STATION LISTING

BMB- CENTERLINE BOW BM
The center of a cross mark inscribed into the top of a square metal flange, welded to the deck, along the centerline and near the bow of the launch.

CLS- CENTERLINE STERN BM
The center of a cross mark inscribed into the top of a square metal flange, welded to the deck, along the centerline and near the stern of the launch.

BMP- PORT SIDE BM
The center of a cross mark inscribed into the top of a square metal flange, welded to the top of the deck, near the middle of and along the port side of the launch.

BMS- STARBOARD SIDE BM
The center of a cross mark inscribed into the top of a square metal flange, welded to the top of the deck, near the middle of and along the starboard side of the launch.

MBF- KEEL BM
A punch mark set along the bottom center of the keel, fore of the multi-beam transducer, 0.030 m from a point where the keel makes a 90 degree angle upwards.

MBA- KEEL BM
A punch mark set along the bottom center of the keel, aft of the multi-beam transducer, 0.030 m from a point where the keel makes a 90 degree angle upwards.

IMU- IMU TARGET
Center of a target affixed to the top of the IMU housing.

IMUR- IMU REFERENCE BM
The intersection of two scribed lines atop a metal support plate for the IMU and forward of the IMU.

GPSP- PORT SIDE GPS ANTENNA REFERENCE POINT
The top center of the port side GPS antenna for the POS system.

GPSS- STARBOARD GPS ANTENNA REFERENCE POINT
The top center of the starboard side GPS antenna for the POS system.

MB- MULTI-BEAM REFERENCE POINT
The physical bottom center of the Multi-Beam transducer.

Appendix A

Coordinate Report Launch 2808

Pt Name	***North(Y)***	***East(X)***	***UP(Z)***	***ID***
IMU Target	0.00000	0.00000	0.00000	IMU
IMU Reference BM	0.13282	-0.00186	-0.16518	IMUR
Centerline Stern BM	-4.07730	0.01391	0.61506	CLS
Centerline Bow BM	3.44544	0.01391	1.44047	BMB
Portside GPS Ant. Ref. Point	-0.83666	-0.68151	3.14844	GPSP
Starboard GPS Ant. Ref. Point	-0.83402	0.77098	3.13235	GPSS
Multi-Beam Ref.Point	0.24969	0.00351	-0.47677	MB
Keel BM	0.44021	-0.00126	-0.60545	MBF
Keel BM	-0.22600	0.00192	-0.53583	MBA
Port Side BM	0.08204	-1.42963	1.07600	BMP
Starboard Side BM	0.08324	1.46250	1.04444	BMS

Units = meters

Appendix B

Point to Point Inverse Launch 2808

Pt. 1	*Pt. 2*	*Dist.*	*Northing*	*Easting*	*Elevation*	*ID*
3	40	0.001	-0.001	0.000	0.00026	MBF
5	42	0.003	-0.002	-0.001	0.00013	MBA
4	41	0.002	-0.001	-0.002	0.00062	MB
14	55	0.006	-0.005	0.004	0.00049	IMUR
13	56	0.006	-0.004	0.004	0.00055	IMU
43	6	0.001	0.000	0.001	0.00048	CLS
33	44	0.000	0.000	0.000	0.00006	BMS
8	22	0.001	-0.001	0.000	0.00039	BMP
17	25	0.005	0.000	0.005	0.00011	BMB
24	34	0.001	0.000	0.000	0.00049	GPSS
23	7	0.000	0.000	0.000	0.00022	GPSP

Units = meters

FAIRWEATHER

Multibeam Echosounder Calibration

Launch 2808 200kHz
Vessel

Froelich, Francksen, Beduhn, Brooks
Calibrating Hydrographer(s)

Reson 7125	Launch 2808	10/09/2009
MBES System	MBES System Location	Date of most recent EED/Factory Check

TBD	CD0001529704
Sonar Serial Number	Processing Unit Serial Number
Plate mounted on hull	1/27/2010
Sonar Mounting Configuration	Date of current offset measurement/verification
DGPS Beacon 323, POSMV V4	3/4/2010
Description of Positioning System	Date of most recent positioning system calibration

Acquisition Log

3/5/2010	064	Shilshole Bay, WA	Clear, Calm
Date	Dn	Local Area	Wx

Mixed	15m
Bottom Type	Approximate Water Depth

Froelich, Francksen, Beduhn, Brooks
Personnel on board

Comments

2009_064_2808.000
TrueHeave filename

10064181.4ex		47 40 32.34	122 25 23.33			
SV Cast #1 filename	U	Lat	Lon	Depth	Ext. Depth	
10064205.2ex		47 40 30.5603	122 25 24.75			
SV Cast #2 filename	U	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	2010_0641859	240	6.0	Good line
	1901	240		not enough roll delete line
	1903a	240		
	1905	068		Good line

PITCH view parallel to track, same line (at nadir) [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
1	2010_0641909	132	6.0	line 103
	1910	312		
	1911	132		
	1912	312		

HEADING/YAW view parallel to track, offset lines (outerbeams) [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
1	2010_0641914	132	6.0	line 104
	1915	312		line 101
	1916	132		101 questionable
	1917	312		line 104

ROLL view across track, same line [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
1	2010_0641919	060	6.0	line 1
	1922	240		
	1924	060		
	1927	240		

Processing Log

Date	Dn	Personnel
3/10/2010		Beduhn

- [x] **Data converted --> HDCS_Data in CARIS**
- [x] **TrueHeave applied** 2009_064_2808.000
- [x] **SVP applied** 2010_064_2808.000
- [x] **Tide applied** N395RA2009.tc predicted

Zone file

Lines merged [x]

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)**
SST Beduhn	0.00	-2.10	0.23	0.60
AST Mallory	0.00	-2.10	0.27	0.85
LT Welton	0.00	-1.95	0.27	0.90
PS Froelich	0.00	-2.20	0.34	0.90
Averages	0.00	-2.09	0.28	0.81
Standard Deviation	0.00	0.10	0.05	0.14
FINAL VALUES	0.00	-2.09	0.28	0.81

Final Values based on Averages

Resulting HVF File Name FA_2808_200kHz_Rsn7125_256bms

MRU Align StdDev gyro 0.14 Value from standard deviation of Heading offset values

MRU Align StdDev Roll/Pitch 0.07 Value from averaged standard deviations of pitch and roll offset values

NARRATIVE

- [x] **HVF Hydrographic Vessel File created or updated with current offsets**

Name: CST/FOO **Date:** 03/30/2010

FAIRWEATHER

Multibeam Echosounder Calibration

Launch 2808 400kHz
Vessel

3/5/2010	064	Shilshoal Bay, WA
Date	Dn	Local Area

Froelich, Francksen, Beduhn, Brooks
Calibrating Hydrographer(s)

Reson 7125 400kHz	Launch 2808	
MBES System	MBES System Location	Date of most recent EED/Factory Check

	CD0001529704
Sonar Serial Number	Processing Unit Serial Number

Plate mounted on hull	
Sonar Mounting Configuration	Date of current offset measurement/verification

DGPS Beacon 323, POSMV V4	
Description of Positioning System	Date of most recent positioning system calibration

Acquisition Log

3/5/2010	064	Shilshoal	Clear, Calm
Date	Dn	Local Area	Wx

Mixed	15m
Bottom Type	Approximate Water Depth

Froelich, Francksen, Beduhn, Brooks
Personnel on board

All lines were collected at 6-6.5 kts unless otherwise noted
Comments

2009_064_2808.000
TrueHeave filename

10064181.4ex		47 40 32.34	122 25 23.33		
SV Cast #1 filename	U	Lat	Lon	Depth	Ext. Depth
10064205.2ex		47 40 30.5603	122 25 24.75		
SV Cast #2 filename	U	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	2010_0642026	060	6.0	induced roll
	2028	240	6.0	induced roll

PITCH

view parallel to track, same line (at nadir) [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
1	2010_0642031	125	6.0	line 103
	2032	312	6.0	
	2033	125	6.0	
	2034	312	6.0	

HEADING/YAW

view parallel to track, offset lines (outerbeams) [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
1	2010_0642036	132	6.0	line 104
	2037	312	6.0	line 101
	2038	132	6.0	line 101, better line
	2039	312	6.0	line 104, better line

ROLL

view across track, same line [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
1	2010_0642040	060	6.0	line 1
	2044	240	6.0	
	2046	060	6.0	
	2049	240	6.0	

Processing Log

Date	Dn	Personnel
3/10/2010		Beduhn, Welton

☑ **Data converted --> HDCS_Data in CARIS**

☑ **TrueHeave applied** 2009_064_2808.000

☑ **SVP applied** 2010_064_2808.000

☑ **Tide applied** N395RA2009.tc predicted

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)
SST Beduhn	0.00	-1.20	0.38	-0.16
CST Morgan	0.00	-2.24	0.40	1.00
LT Welton	0.00	-1.50	0.36	? +/- .4
PS Froelich	0.00	-2.20	0.38	-0.50
Averages	0.00	-1.79	0.38	0.11
Standard Deviation	0.00	0.52	0.02	0.79
FINAL VALUES				

Final Values based on averages, questionable range value not included

Resulting HVF File Name FA_2808_400kHz_Rsn7125_512bms_2010

MRU Align StdDev gyro	0.79	Value from standard deviation of Heading offset values
MRU Align StdDev Roll/Pitch	0.27	Value from averaged standard deviations of pitch and roll offset values

NARRATIVE

☐ **HVF Hydrographic Vessel File created or updated with current offsets**

Name: **Date:**

FAIRWEATHER

Multibeam Echosounder Calibration

Launch 2808 400kHz	
Vessel	

4/5/2010	095	Shilshoal Bay, WA
Date	Dn	Local Area

Beduhn, Hedgepeth, Allen
Calibrating Hydrographer(s)

Reson 7125 400kHz	Launch 2808	10/09/2009
MBES System	MBES System Location	Date of most recent EED/Factory Check

TBD	CD0001529704
Sonar Serial Number	Processing Unit Serial Number

Plate mounted on hull	1/27/2010
Sonar Mounting Configuration	Date of current offset measurement/verification

DGPS Beacon 323, POSMV V4	3/4/2010
Description of Positioning System	Date of most recent positioning system calibration

Acquisition Log

4/5/2010	095	Shilshoal	Clear, Calm
Date	Dn	Local Area	Wx

Mixed	15m
Bottom Type	Approximate Water Depth

Beduhn, Hedgepeth, Allen
Personnel on board

Clear < 1' chop
Comments

2009_095_2808.000
TrueHeave filename

100641814.svp	1814	47:40:32.34	-122:25:23.33	35	
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 bounded slope (nadir) [same direction, different speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
1				

PITCH

view parallel to track, same line (at nadir) [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
1	0951656	134		
1	0951657	315		
1	0951659	134		
1	0951701	315		
1	0951702	134		
1	0951703	315		

HEADING/YAW

view parallel to track, offset lines (outerbeams) [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
1	0951705	132		
1	0951706	312		
1	0951708	132		
1	0951709	312		
1	0951711	132		
1	0951712	312		
1	0951714	132		
1	0951716	312		

ROLL

view across track, same line [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
1				

Processing Log

4/5/2010	095	Wilson
Date	Dn	Personnel

☑ **Data converted --> HDCS_Data in CARIS**

☑ **TrueHeave applied** 2009_095_2808.000

☑ **SVP applied** NIDWT 3hrs

☑ **Tide applied** N395RA2009.tc predicted

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)
SST Beduhn		-1.88		0.22
CST Morgan		-1.89		0.21
LT Welton		-1.82		0.24
PS Wozumi		-1.84		0.32
HST Wilson		-1.85		0.23
	Values from Dn 64		Values from Dn 64	
Averages	0.00	-1.86	0.38	0.24
Standard Deviation	0.00	0.03	0.02	0.04
FINAL VALUES	0.00	-1.86	0.38	0.24

Final Values based on Final values based on averages from Dn 64 and Dn 95.

Resulting HVF File Name FA_2808_400kHz_Rsn7125_512bms_2010

MRU Align StdDev gyro 0.04 Value from standard deviation of Heading offset values

MRU Align StdDev Roll/Pitch 0.02 Value from averaged standard deviations of pitch and roll offset values

NARRATIVE

Values to be dated to start of the season.

☑ **HVF Hydrographic Vessel File created or updated with current offsets**

Name: CST Morgan **Date:** 04/11/2010

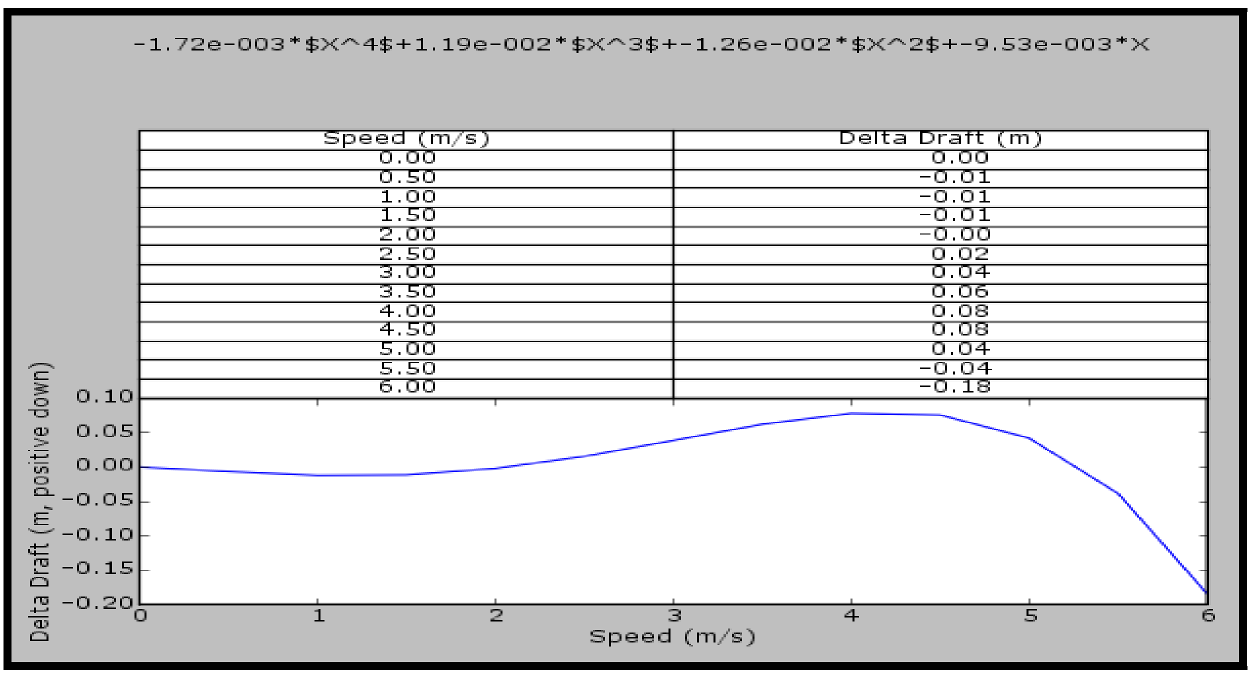
Fairweather Launch 2808 Dynamic Draft Measurement
Lake Washington, 03 March 2010

LTjg Caryn Arnold, HSTP West Coast Field Support Liaison

On Wednesday, 03 March 2010 (DN 063), *Fairweather* Launch 2808 conducted a dynamic draft measurement (DDM) on Lake Washington using post processed kinematic GPS data. The vessel sat at rest for approximately 5 minutes, then ran in the South direction at approximate speeds of 4, 6, 8 and 10 knots, holding each speed for about 4 minutes. The vessel then turned around and ran in the North direction at approximate speeds of 10, 8, 6 and 4 knots, again holding each speed for about 4 minutes and resting for approximately 5 minutes at the end. The POS/MV recorded a POSPac file the entire time from beginning rest to finish rest.

The POSPac file was processed with POSPac MMS Software using the GNSS-Inertial Processing Single Base Station Mode. The single CORS station SEAI (1 Hz) was chosen as the base station. The Lever Arm Standard Deviation was set to <3cm and then the GNSS-Inertial Processor in the Forward, Backward and Combine mode was Run.

The file was then exported out from the POSPac MMS software with an output rate of 1 sec and run through the Python Script written by LTjg Glen Rice, which includes the fourth order polynomial curve. The following graphs were generated.



Speed (m/s)	Delta Draft (m)
0.00	0.00
0.50	-0.01
1.00	-0.01
1.50	-0.01
2.00	-0.00
2.50	0.02
3.00	0.04
3.50	0.06
4.00	0.08
4.50	0.08
5.00	0.04
5.50	-0.04
6.00	-0.18

Figure 1. *Fairweather* Launch 2808 Inverted Dynamic Draft Curve & Computed Dynamic Draft Table for Caris

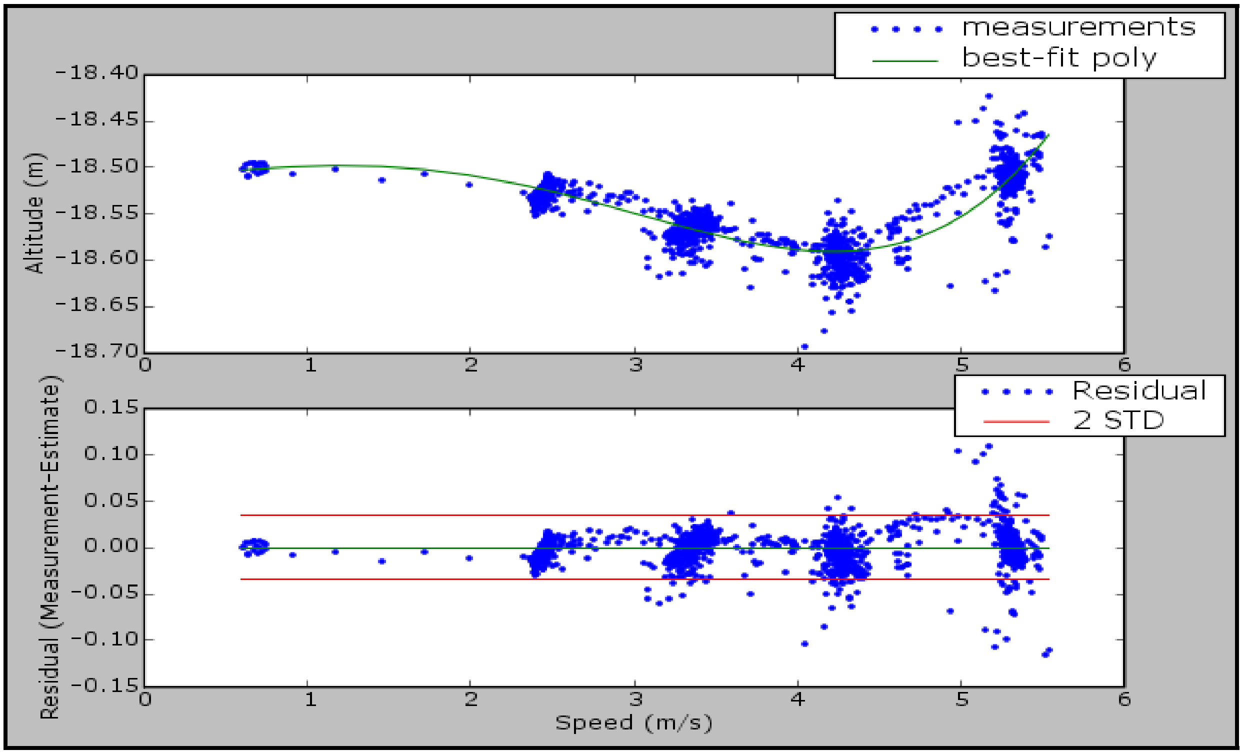


Figure 2. *Fairweather* Launch 2808 Dynamic Draft Curve with Data Points

S220 Offsets and Measurements - Summary

Measurement	IMU to 7/8111 (MRU to Trans)	Port Ant to 7/8111 (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	2.868	2.071	n/a	Scaler Distance	1.997	0.797	-11.892	1.866	-7.028
y	8.252	20.144	n/a			-11.892	0.797	-7.028	1.866
z	4.430	17.499	0.014			13.068	-13.068	-2.086	-2.086

*Top of IMU is RP (Reference Pt)

2010 Measured Value

Vessel Offsets for S220 7111 are derived from Westlake Survey Report NOAA Fairweather 09-23-03, Fairweather Centerline Survey (NGS) Report March 2009, and measurements by FA personne

Calculations

Coordinate Systems used as listed

IMU to 7/8111 — Westlake

IMU	easting		0.000
Base	northing		0.000
(ft/m)	elevation		0.000
8111 (from IMU Base to sensor)			
	easting		27.072
(ft)	northing		9.410
	elevation		15.042
8111 (from IMU Base to sensor)			
	easting		8.252
(m)	northing		2.868
	elevation		4.585
Base of IMU to Top of IMU			
(m)	elevation		-0.168
Correction based on Ref Surface			
(m)	elevation		-0.322

Port Ant to 7/8111

NGS			
Top of IMU		x	-11.892
to Port Ant		y	0.797
	(m)	z	13.068
CARIS			
Port		x	0.797
Ant		y	-11.892
	(m)	z	-13.068
Westlake			
	(m)	easting	8.252
Top of IMU		northing	2.868
to 8111		elevation	4.430
CARIS			
	(m)	x	2.868
Top of IMU		y	8.252
to 8111		z	4.430

Waterline to RP* — Westlake

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 Spreadsheet		
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

Phase Center		x	-11.892
Port Ant		y	0.797
	(m)	z	13.068
Top of old Stbd		x	-11.886
Ant (pre-2010)		y	2.794
	(m)	z	13.051
Top to Base of Old (pre-2010) Ant			
measured	(in)	z	2.477
	(m)	z	0.0629
Top of Stbd		x	-11.886
Ant Post		y	2.794
	(m)	z	12.988
Base to Phase Ctr New(2010) Ant			
listed on Ant	(m)	z	0.0843

IMU to Port Ant — NGS

IMU Top (m)		x	0.000
		y	0.000
		z	0.000
Top of old Port		x	-11.892
Ant (pre-2010)		y	0.797
	(m)	z	13.047
Top to Base of Old (pre-2010) Ant			
measured	(in)	z	2.477
	(m)	z	0.0629
Top of Port		x	-11.892
Ant Post		y	0.797
	(m)	z	12.984
Base to Phase Ctr New(2010) Ant			
listed on Ant	(m)	z	0.0843

IMU to Heave — Westlake

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	
IMU to Frame 0 (FP)				Top of IMU to Keel			
(m)	easting	24.190		(m)	elevation	4.086	
Heave Pt* to Frame 0 (FP)				Center of Gravity above baseline			
(ft)	easting	102.42		(ft)	elevation	16.37	
(m)	easting	31.218		Mean Metacentric height			
				(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 7/8111

Westlake	easting	8.252
Top-IMU	northing	2.868
to 8111 (m)	elevation	4.430
Coord Sys. CARIS		
	x	2.868
	y	8.252
	z	4.430

Port Ant to 7/8111

CARIS	x	2.071
	y	20.144
(m)	z	17.499
Coord Sys. CARIS		
	x	2.071
	y	20.144
	z	17.499

Waterline to RP*

Westlake	easting	N/A
Waterline	northing	N/A
to IMU (m)	elevation	0.014
Coord. Sys CARIS		
	x	N/A
	y	N/A
	z	0.014

Stbd Antenna

NGS	(m)	x	-11.886
Top of IMU		y	2.794
to Stbd Ant		z	13.072
(aka Stbd Ant Phase Center)			

Port Ant to Stbd Ant

Scalar Distance (m) 1.997

IMU to Port Ant

NGS	(m)	x	-11.892
Top of IMU		y	0.797
to Port Ant		z	13.068
(aka Port Ant Phase Center)			
Coord Sys. POS/MV			
		x	-11.892
		y	0.797
		z	-13.068

IMU to Heave

Westlake	easting	-7.028
Top-IMU to	northing	1.866
Heave Pt* (m	elevation	-2.086
*(*see Description Tab)*		
Coord. Sys. POS/MV		
	x	-7.028
	y	1.866
	z	-2.086

S220 Offsets and Measurements - Summary

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		4.520		17.588		0.014			13.068	-13.068	-2.086	-2.086

*Top of IMU is RP (Reference Pt)

Vessel Offsets for S220 8160 are derived from Westlake Survey Report NOAA Fairweather 09-23-03, Fairweather Centerline Survey (NGS) Report March 2009, and measurements by FA personnel.

Derivations

Coord. Sys.

IMU to 8160			Port Ant to 8160		
Westlake			**NGS 2009**		
IMU	easting	0.000	Top of IMU	x	-11.892
Base	northing	0.000	to Port Ant	y	0.797
(ft/m)	elevation	0.000	(m)	z	13.068
8160 (from IMU Base to sensor)			CARIS		
	easting	25.149	Port	x	0.797
(ft)	northing	1.619	Ant	y	-11.892
	elevation	14.956	(m)	z	-13.068
8160 (from IMU Base to sensor)			**Westlake**		
	easting	7.665	(m)	easting	7.665
(m)	northing	0.493	Top of IMU	northing	0.493
	elevation	4.559	to 8160	elevation	4.520
Base of IMU to Top of IMU			CARIS		
(m)	elevation	-0.168	(m)	x	0.493
			Top of IMU	y	7.665
Correction based on Ref Surface			to 8160	z	4.520
(m)	elevation	-0.206			

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	4.520	(m)	z	17.588
Coord Sys CARIS			Coord Sys CARIS		
	x	0.493		x	-0.304
	y	7.665		y	19.557
	z	4.520		z	17.588

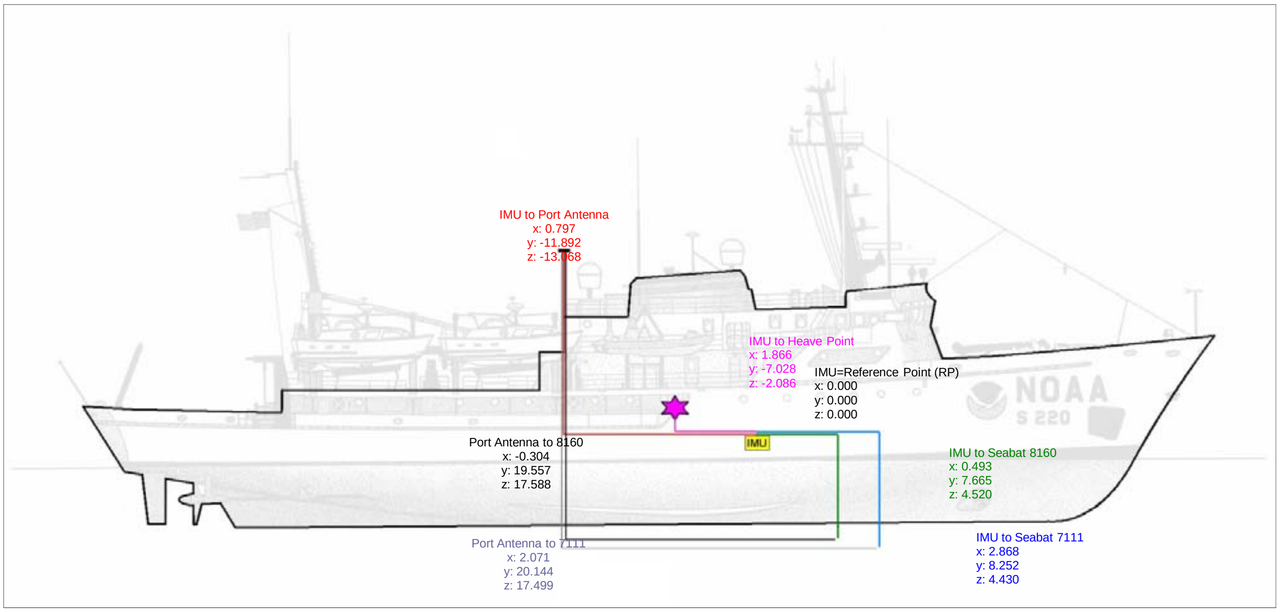
Measurement	IMU to Port Ant			Port Ant to K5K Towpoint		
Coord. Sys.	Caris		Pos/Mv	Caris		Pos/Mv
x	0.797		2.868	0.797		
y	-11.892		8.252	-11.892		
z	13.047		4.430	13.047		

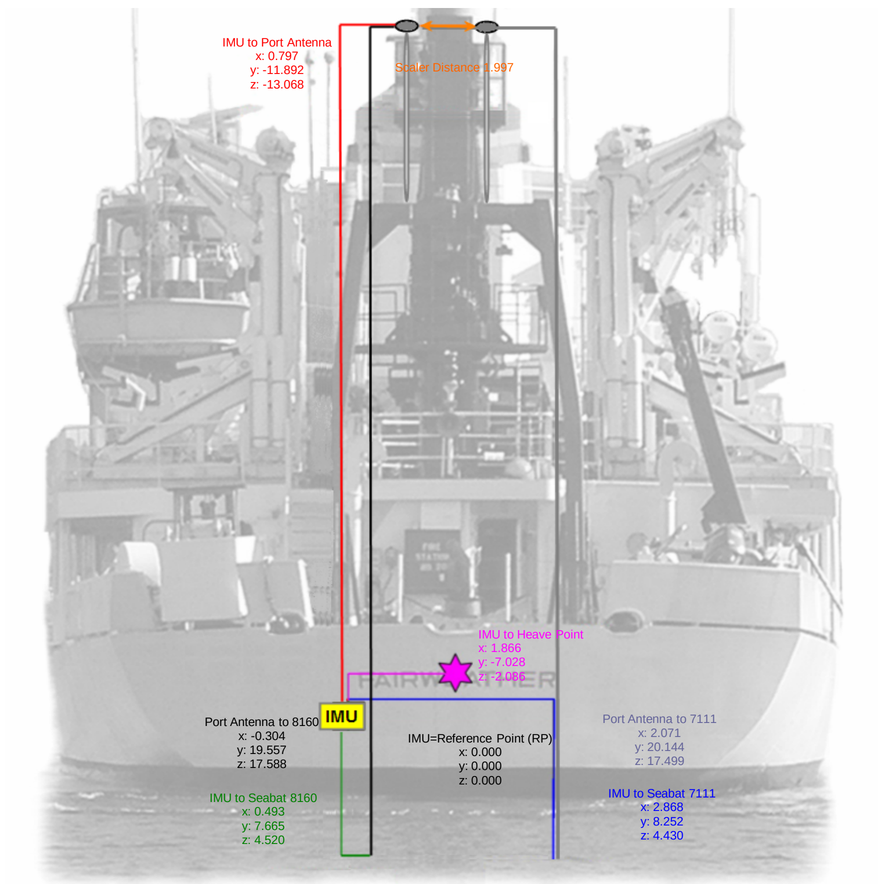
Derivations

Coord. Sys.	IMU to K5K Towpoint		Port Ant to K5K Towpoint	
	Coord Sys CARIS		Coord Sys CARIS	
	x	1.866	x	1.866
	y	-42.642	y	-30.370
	z	7.402	z	5.645

Description of Offsets for FAIRWEATHER S-220

All Values Shown are in CARIS Coordinates





IMU to 7/8111 (MRU to Trans)

x	y	z
2.868	8.252	4.430

The lever arms between the IMU and phase center of the 7111 transducer are taken from the Westlake report along with the the -0.168 m offset included for the height of the IMU. An additional correction based on 2010 reference surface comparisons of -0.322 is applied.

IMU to 8160 (MRU to Trans)

x	y	z
0.493	7.665	4.520

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. An additional correction based on 2010 reference surface comparisons of -0.206 is applied.

Port Ant to 7/8111 (Nav to Trans)

x	y	z
2.071	20.144	17.499

Relative positions obtained from Port Ant to 7/8111 via IMU.

Port Ant to 8160 (Nav to Trans)

x	y	z
-0.304	19.557	17.588

Relative positions obtained from Port Ant to 7/8111 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	13.068

This information comes from a combination of the Westlake, NGS surveys, and measurements by FA personnel. The NGS 2009 survey was to the top of the antenna, that distance (z-value) was measured in 2010 and subtracted to get the xyz of the antenna post. Then the distance (z-value) up to the phase center to the new 2010 antanna was added to obtain the xyz of the phase center of the newly installed (May2010) antenna.

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.

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. Three 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

The relocation of the POS M/V antenna forced a partial resurvey in Feb. 2007 by Steven Breidenbach of NGS (values no longer utilized).

While in drydock, another NGS (Centerline) survey was conducted March, 2009.

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.

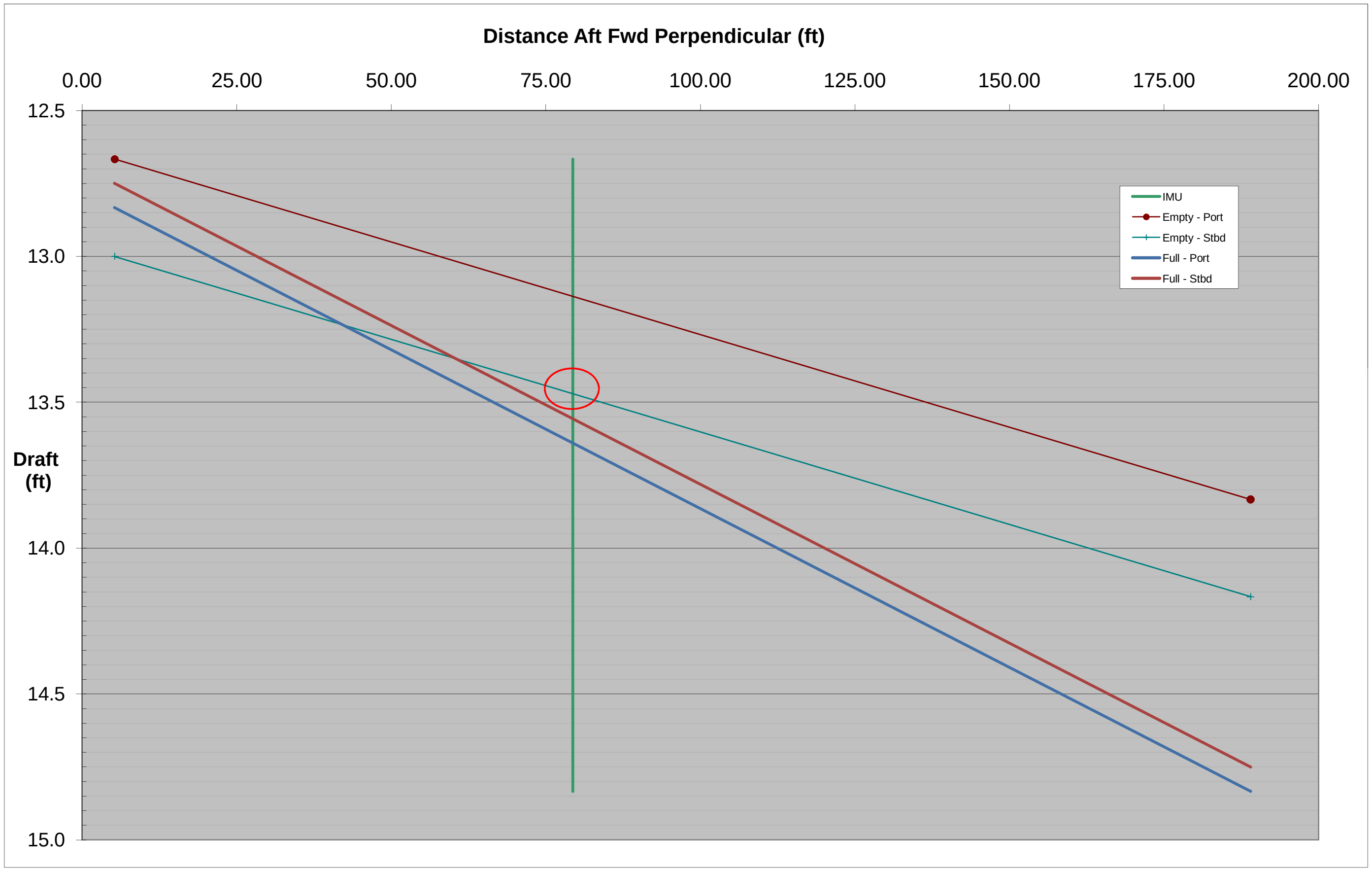
As a requirement for the TPU, the standard deviation for each position is 3 mm. This value is based upon a conversation with Elaine McDonald of Westlake and is followed up by an Email documenting that fact. The email is located at the end of this document.

Fairweather Draft - 2010

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.

2010	April		Fwd		Aft	slope	IMU Depth (ft)	IMU Depth (m)		Min	Max
		x1	y1	x2	y2						
	Empty - Port	5.25	12.67	189	13.83	0.00635	13.14	4.004		12.67	14.83
	Empty - Stbd	5.25	13.00	189	14.17	0.00635	13.47	4.106			
	Full - Port	5.25	12.83	189	14.83	0.01088	13.64	4.157			
	Full - Stbd	5.25	12.75	189	14.75	0.01088	13.56	4.132			
	Description (ie empty, full)	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		0.220	0.067	STDEV	Value used for Waterline Loading Uncertainty
	x-value (m): 24.19					



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

<u>PRIMARY CONTACTS</u>

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

NOAA SHIP FAIRWEATHER
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY

IMU Reference Points

NOAA SHIP FAIRWEATHER
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY

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

NOAA SHIP FAIRWEATHER
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

STABILITY TEST: NOAA Ship FAIRWEATHER (16 Jul 2004)

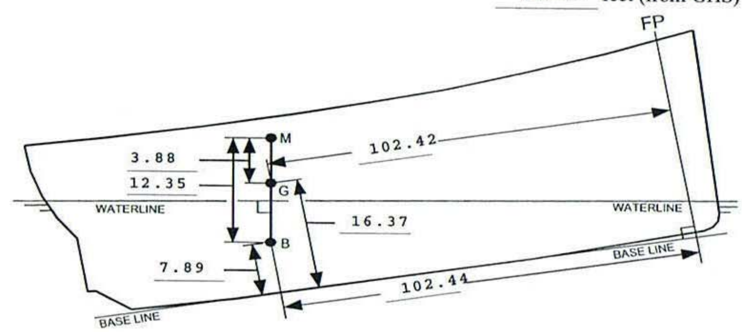
SHIP AT TIME OF STABILITY TEST--CONDITION 0

		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 8:06 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'

			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'

	EASTING	NORTHING	ELEVATION
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.

FAIRWEATHER

Multibeam Echosounder Calibration

S220 7111
Vessel

5/24/2010	144	Revillagigedo Channel
Date	Dn	Local Area

Campbell
Calibrating Hydrographer(s)

Reson 7111	S220	TPU installed Oct 2009, Sonar installed Mar 2009
MBES System	MBES System Location	Date of most recent EED/Factory Check

Unknown	S/N 2009003
Sonar Serial Number	Processing Unit Serial Number
Hull Mounted	5/2/2010
Sonar Mounting Configuration	Date of current offset measurement/verification
POS/MV v.4	5/4/2010
Description of Positioning System	Date of most recent positioning system calibration

Acquisition Log

5/24/2010	144	Revillagigedo Channel	grey, rain, light breeze, low chop
Date	Dn	Local Area	Wx

Bottom Type	Approximate Water Depth

Campbell, Loy
Personnel on board

Pos file logged to Ketchikan_Patch GNSS folder.
Comments

2010-144-S220
TrueHeave filename

BOT_0001					
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 bounded slope (nadir) [same direction, different speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks

PITCH view parallel to track, same line (at nadir) [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
BOT_0001	2010P_1441002	047	6.1	A little off on SW end.
	2010P_1441019	219	6.0	

HEADING/YAW view parallel to track, offset lines (outerbeams) [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
BOT_0001	1441038	045	5.9	right on line.run sw-ne
	1441122	221	7.3	not a good line. Off and too fast. Run ne-sw
	1441137	042	6.0	good south. off North. run sw-ne
	1441159	224	6.4	on line. NE to SW
	1441242	316	6.5	not a good line. NE to SW
	1441325	136	5.5	on line. NE to SW
	1441339	320	5.5	On line, SW to NE
	1441355	138	5.8	On line NE to SW

ROLL view across track, same line [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	1441257	133	5.5	on line. NE to SW
	1441312	326	5.6	on line. SW to NE

Processing Log

Date	Dn	Personnel
5/24/2010	144	Campbell

☑ **Data converted --> HDCS_Data in CARIS**

☐ **TrueHeave applied** True heave would not apply, fixed or otherwise.

☑ **SVP applied** 2010_Patch_Dn144

☑ **Tide applied** Predicted

Zone file O193FA2010CORP_Rev2

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)
Campbell	0.00	-0.50	0.08	-0.70
Froelich	0.00	-0.80	0.08	0.08
Welton	0.00	-0.70	0.08	0.00
Averages	0.00	-0.67	0.08	-0.21
Standard Deviation	0.00	0.15	0.00	0.06
FINAL VALUES	0.00	-0.67	0.08	0.04

Final Values based on All three reviewers with the exception of Campbell's yaw

Resulting HVF File Name FA_S220_Rsn7111_301bms_2010.hvf

MRU Align StdDev gyro 0.06 Value from standard deviation of Heading offset values

MRU Align StdDev Roll/Pitch 0.08 Value from averaged standard deviations of pitch and roll offset values

NARRATIVE

Entered on Dn 122 in hvf.

☑ **HVF Hydrographic Vessel File created or updated with current offsets**

Name: CST Morgan **Date:** 7/18/10

FAIRWEATHER

Multibeam Echosounder Calibration

S220 7111
Vessel

Date	Dn	Local Area
7/14/2010	195	

Weston, Renoud, Mike Keeler
Calibrating Hydrographer(s)

MBES System	MBES System Location	Date of most recent EED/Factory Check
Reson 7111	S220	TPU installed Oct 2009, Sonar installed Mar 2009

Sonar Serial Number	Processing Unit Serial Number
Unknown	S/N 2009003

Sonar Mounting Configuration	Date of current offset measurement/verification
Hull Mounted	5/2/2010

Description of Positioning System	Date of most recent positioning system calibration
POS/MV v.4	5/4/2010

Acquisition Log

Date	Dn	Local Area	Wx
7/14/2010	195	Dutch Harbor	Overcast

Bottom Type	Approximate Water Depth
	30m

FA Crew
Personnel on board

Comments

2010_195_S220.000
TrueHeave filename

	UTC Time	Lat	Lon	Depth	Ext. Depth
SV Cast #1 filename: BOT_0001					
SV Cast #2 filename					

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

PITCH — view parallel to track, same line (at nadir) [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks

HEADING/YAW — view parallel to track, offset lines (outerbeams) [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks

ROLL — view across track, same line [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
1	1951319A	027		
1	1951358	029		
1	1951408	208		
1	1951456	207		

Processing Log

Date	Dn	Personnel
		Renoud

☑ **Data converted --> HDCS_Data in CARIS**

☑ **TrueHeave applied** 2010_195_S220.000

☑ **SVP applied** Previous in time

☐ **Tide applied** Zero_Tides

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				-0.10	
SST Beduhn				-0.12	
LT Welton				-0.10	
SST Renoud				-0.12	
Averages	#DIV/0!	#DIV/0!		-0.11	#DIV/0!
Standard Deviation	#DIV/0!	0.15	*from 144	0.01	#DIV/0!
FINAL VALUES					

Final Values based on Roll only, based on averages

Resulting HVF File Name FA_S220_Rsn7111_301bms_2010.hvf

MRU Align StdDev gyro #DIV/0! Value from standard deviation of Heading offset values
MRU Align StdDev Roll/Pitch 0.08 Value from averaged standard deviations of pitch and roll offset values

NARRATIVE

Roll value adjusted after 7111 testing lines run in Dutch Harbor.

Value to be used instead of Dn 144 Roll value. MRU values remain as for listed in Dn144, roll/pitch is same as shown above.

☑ **HVF Hydrographic Vessel File created or updated with current offsets**

Name: CST Morgan **Date:** 7/18/10

FAIRWEATHER

Multibeam Echosounder Calibration

S220 8160
Vessel

5/8/2010	128	Revillagigedo Channel
Date	Dn	Local Area

Campbell, Moehl
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	5/2/2010
Sonar Mounting Configuration	Date of current offset measurement/verification
Applanix Pos MV	5/4/2010
Description of Positioning System	Date of most recent positioning system calibration

Acquisition Log

5/8/2010	128	Revilla Channel	Sunny, warm, lite breeze and chop
Date	Dn	Local Area	Wx

rock, sand, gravel	80 to 300
Bottom Type	Approximate Water Depth

Campbell, Moehl
Personnel on board

Comments

2010-128-S220
TrueHeave filename

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 bounded slope (nadir) [same direction, different speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
BOT_0000				

PITCH

view parallel to track, same line (at nadir) [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
BOT_0000	1282006	226	4.9	
	1282026	041	3.8	Broke line early due to channel traffic
	1282047	046	4.1	
	1282108	222	6.6	
	1282122	042	6.5	

HEADING/YAW

view parallel to track, offset lines (outerbeams) [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
BOT_0001	1282157	227	6.1	Reson was not well adjusted while going over the feature
	1282219	042	5.3	
	1282237	226	6.1	
	1282252	042	6.3	
	1282314	324	4.9	
	1282326	134	6.8	

ROLL

view across track, same line [opposite direction, same speed]

SV Cast #	XTF Line Filename	Heading	Speed (kts)	Remarks
	1282347	318	4.9	
	1290002	142	5.6	

Processing Log

Date	Dn	Personnel
5/8/2010	128	Campbell

☑ **Data converted --> HDCS_Data in CARIS**

☑ **TrueHeave applied**

☑ **SVP applied**

☑ **Tide applied**

Zone file 0193FA2010CORP_Rev.zdf

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)
Campbell	0.00	0.20	-0.04	-0.32
Froelich	0.00	-0.12	-0.09	0.67
Morgan	0.00	0.10	-0.09	0.10
Jaskoski	0.00	0.12	-0.07	-0.21
Averages	0.00	0.08	-0.07	0.06
Standard Deviation	0.00	0.14	0.02	0.44
FINAL VALUES	0.00	0.08	-0.07	0.06

Final Values based on Averages

Resulting HVF File Name FA_S220_Rsn8160_5to750_2010

MRU Align StdDev gyro 0.44 Value from standard deviation of Heading offset values

MRU Align StdDev Roll/Pitch 0.08 Value from averaged standard deviations of pitch and roll offset values

NARRATIVE

Entered on Dn 122 in hvf

☑ **HVF Hydrographic Vessel File created or updated with current offsets**

Name: CST Morgan **Date:** 5/10/2010

Checked again on 7/18/2010

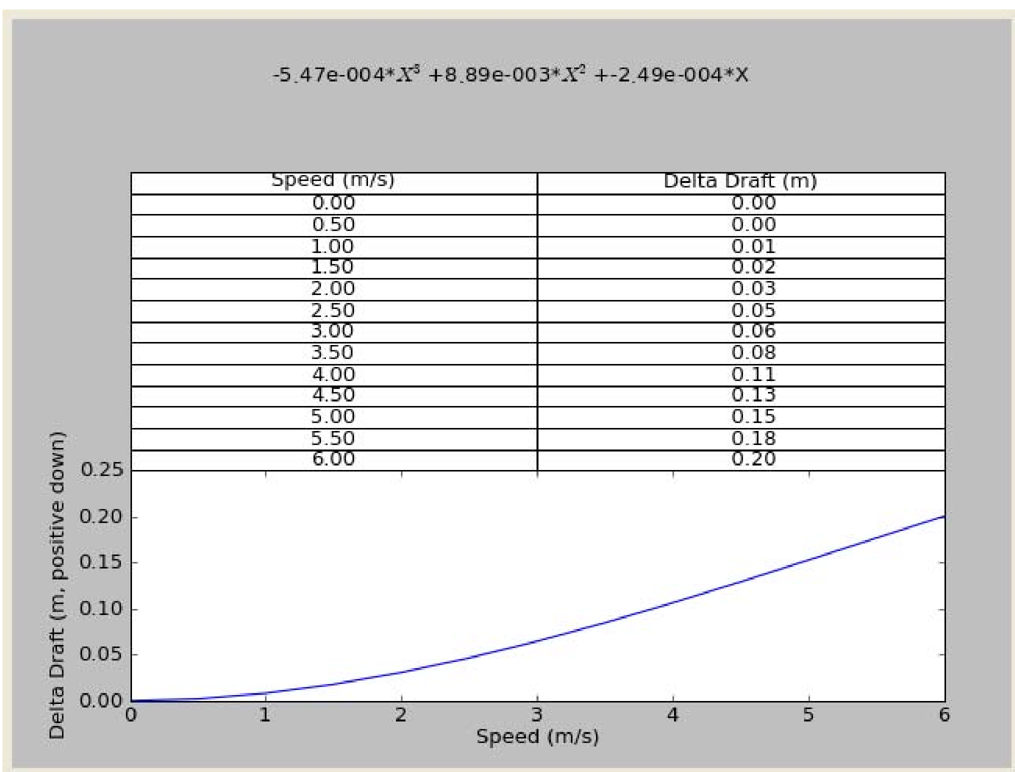
Fairweather (S220) Dynamic Draft Measurement
Lake Washington, 21 January 2010

SST Tami Beduhn & PS Grant Froelich

On Thursday, 21 January 2010 (DN 021), *Fairweather* conducted a dynamic draft measurement (DDM) on Lake Washington using post processed kinematic GPS data. The vessel sat at rest alongside the pier, then ran in the North direction at approximate speeds of 4, 6, 8 and 10 knots, holding each speed for about 4 minutes. The vessel then turned around and ran in the South direction at approximate speeds of 10, 8, 6 and 4 knots, again holding each speed for about 4 minutes and resting for approximately 5 minutes at the end. The POS/MV recorded a POSPac file the entire time from beginning rest to finish rest.

The POSPac file was processed with POSPac MMS Software using the GNSS-Inertial Processing Single Base Station Mode. The single CORS station SEAI (1 Hz) was chosen as the base station. The Lever Arm Standard Deviation was set to <3cm and then the GNSS-Inertial Processor in the Forward, Backward and Combine mode was Run.

The file was then exported out from the POSPac MMS software with an output rate of 1 sec and run through the Python Script written by LTjg Glen Rice, which includes the third order polynomial curve. The following graphs were generated.



Speed (m/s)	Delta Draft (m)
0.00	0.00
0.50	0.00
1.00	0.01
1.50	0.02
2.00	0.03
2.50	0.05
3.00	0.06
3.50	0.08
4.00	0.11
4.50	0.13
5.00	0.15
5.50	0.18
6.00	0.20

Figure 1. *Fairweather* Inverted Dynamic Draft Curve & Computed Dynamic Draft Table for Caris

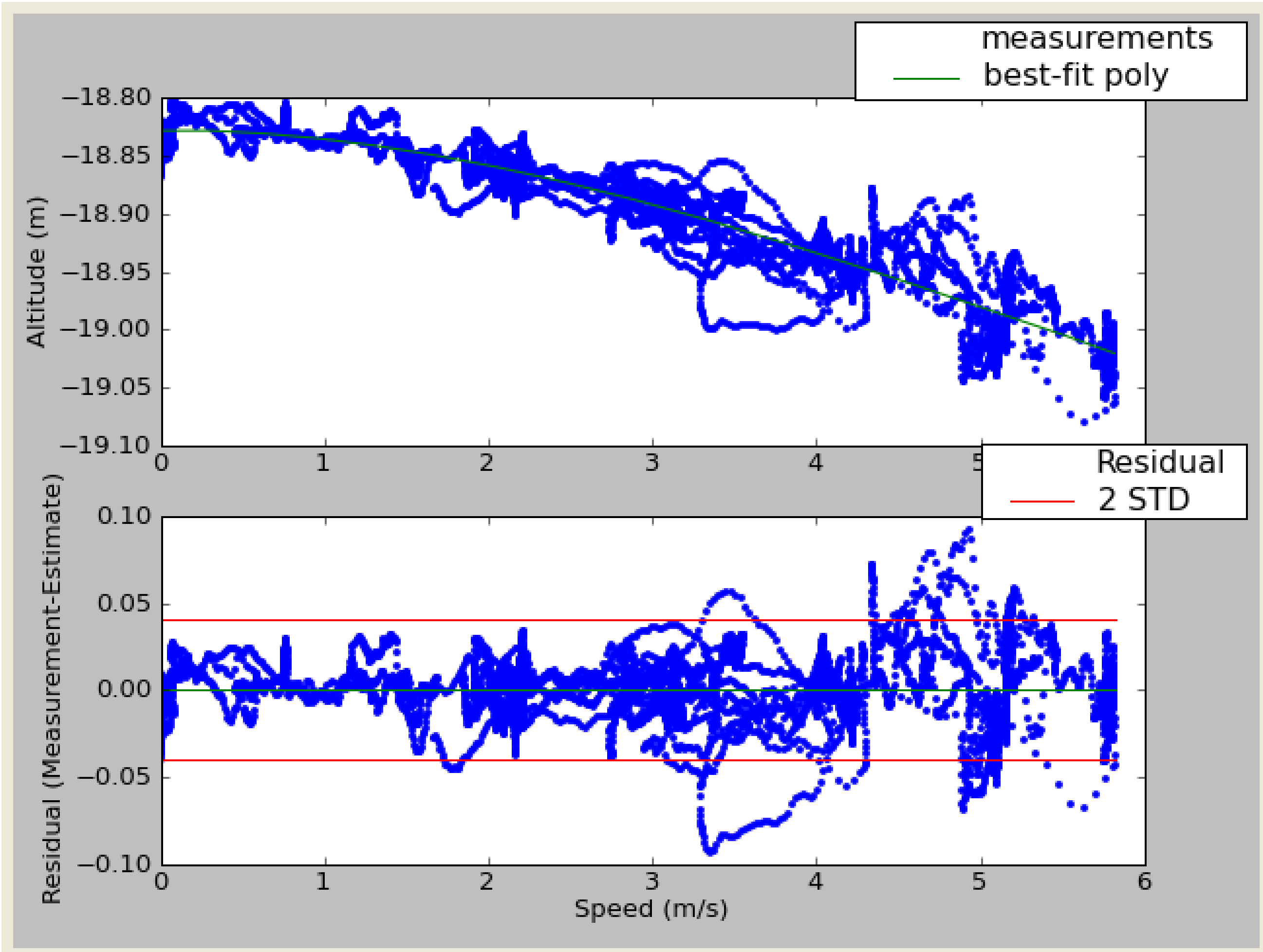
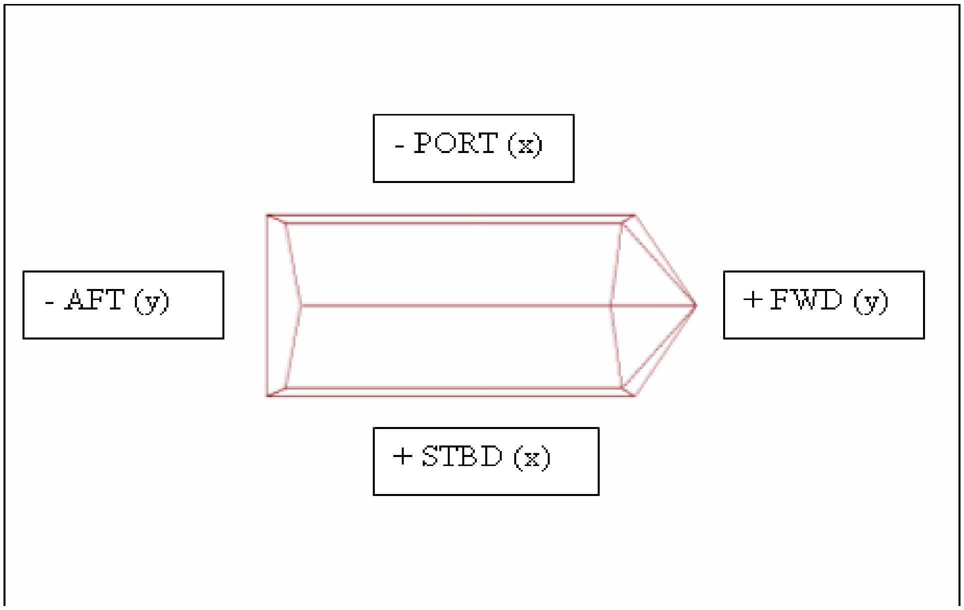
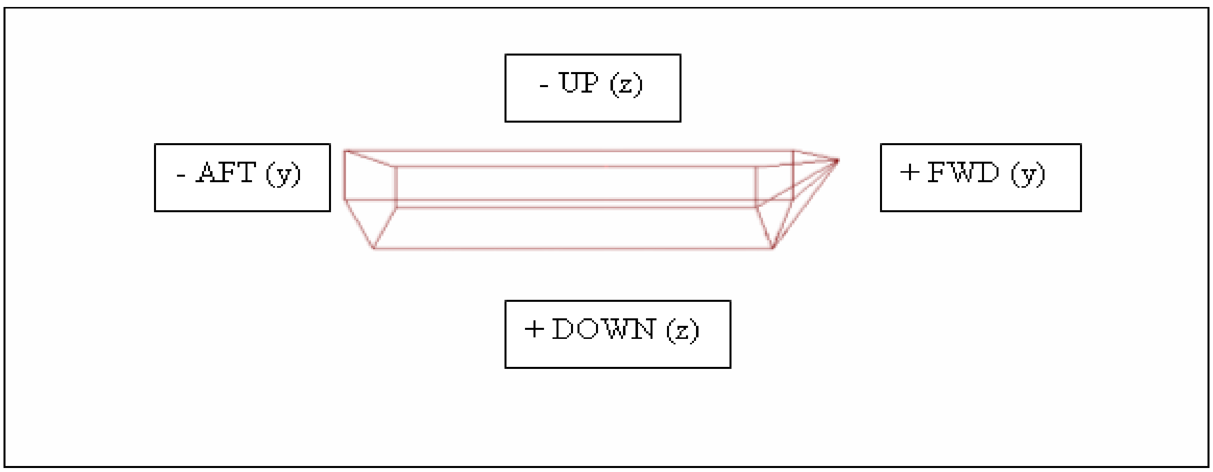
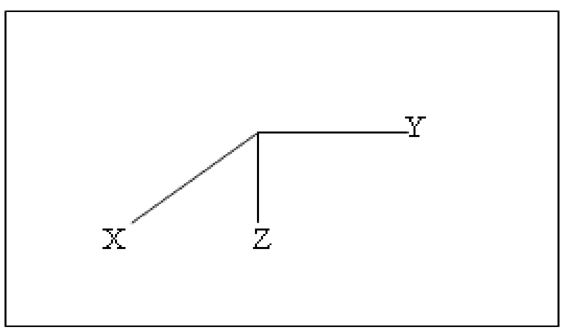


Figure 2. *Fairweather* Dynamic Draft Curve with Data Points

CARIS Coordinate System

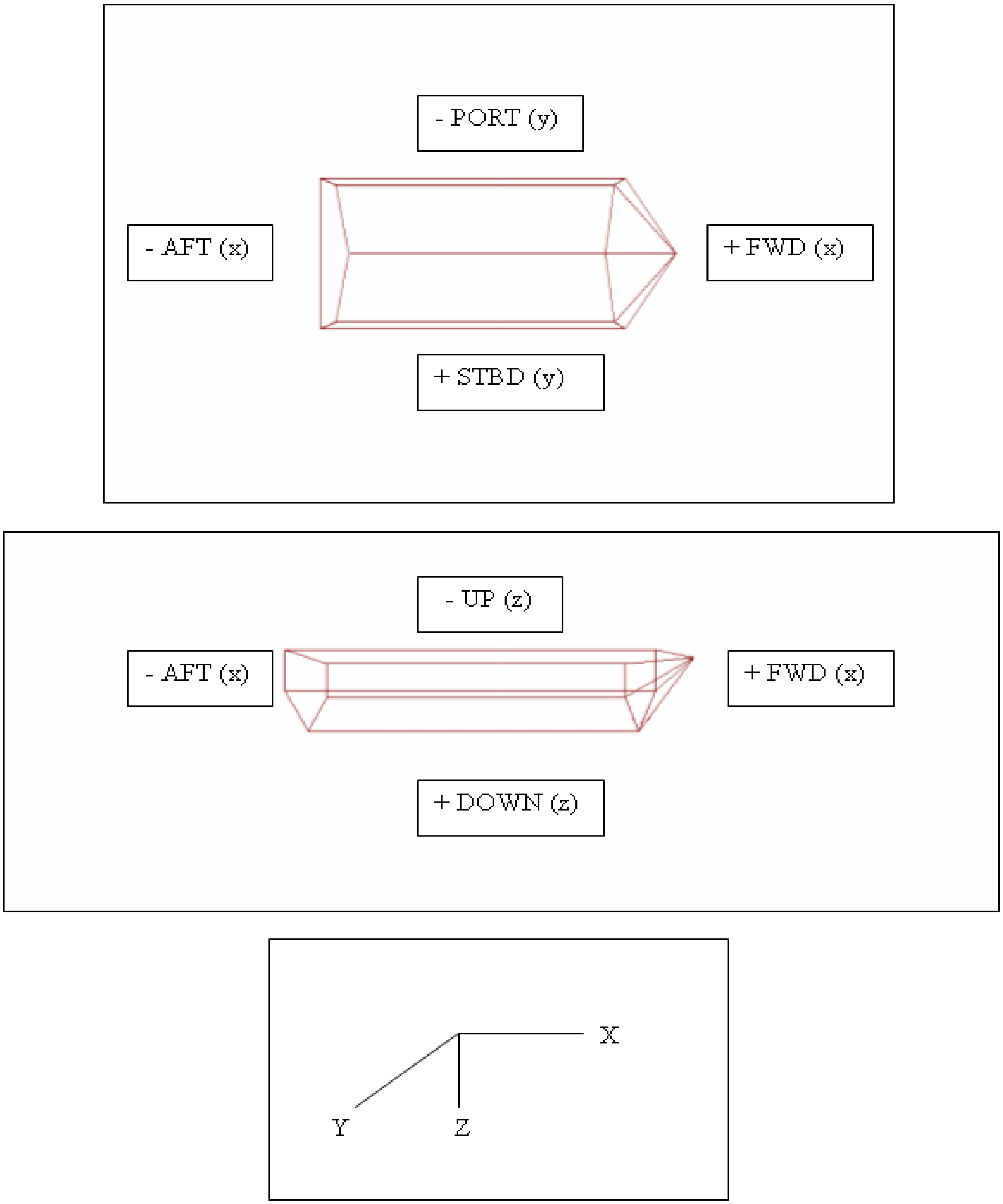






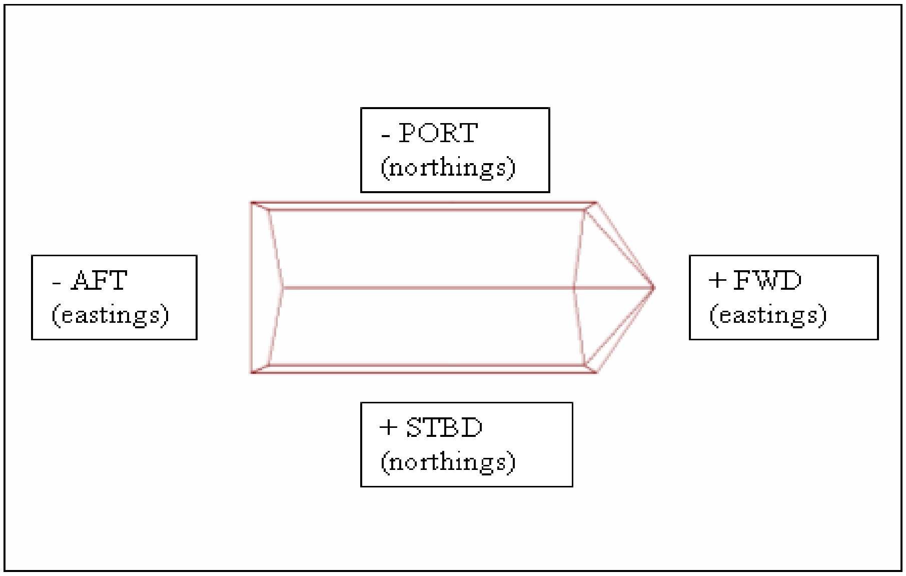
Top Center of IMU is origin of CARIS Coordinate System

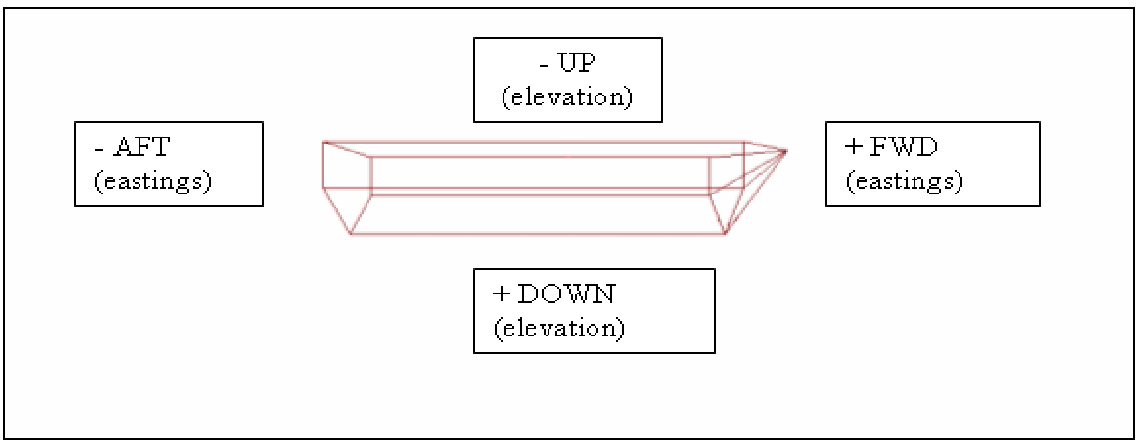
POS/MV Coordinate System

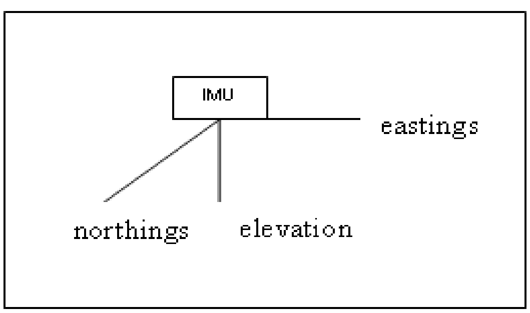


Top Center of IMU is origin of POS/MV Coordinate System

WESTLAKE Coordinate System

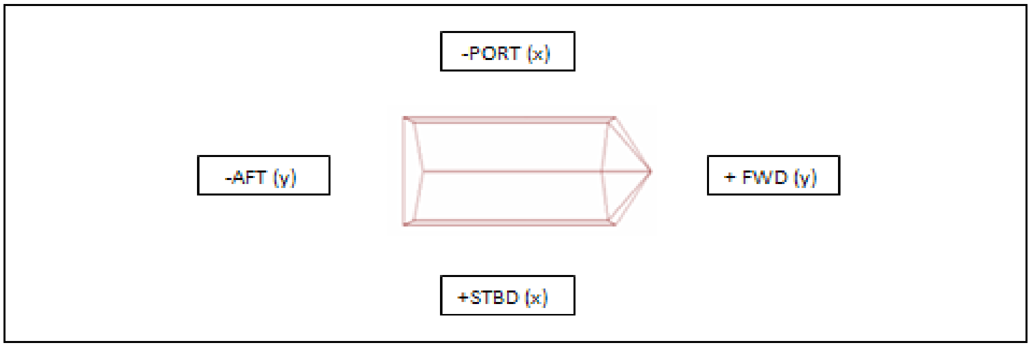


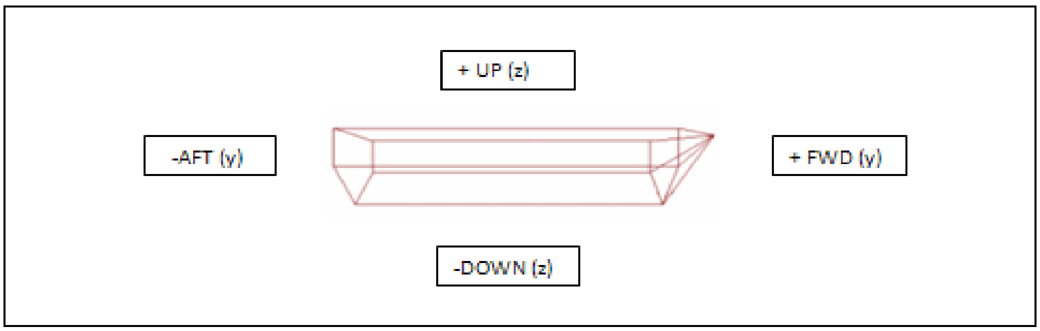


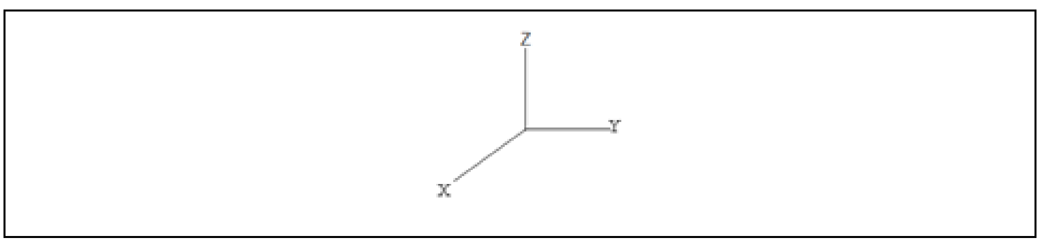


Bottom Center of IMU is origin of Westlake Coordinate System

NGS/ RESON Coordinate System

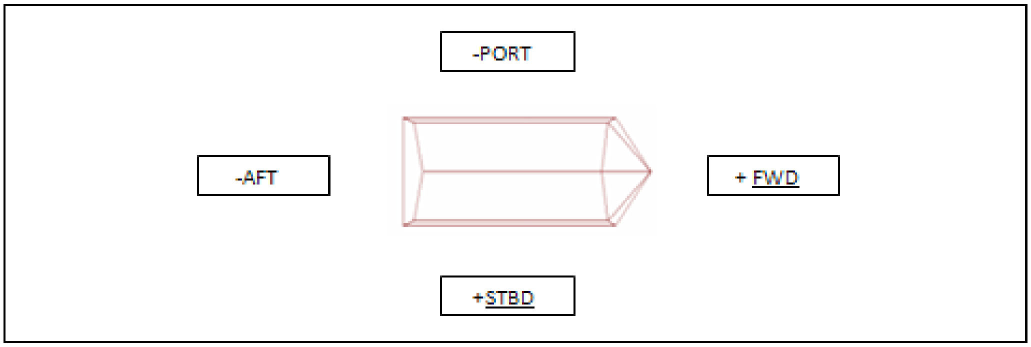


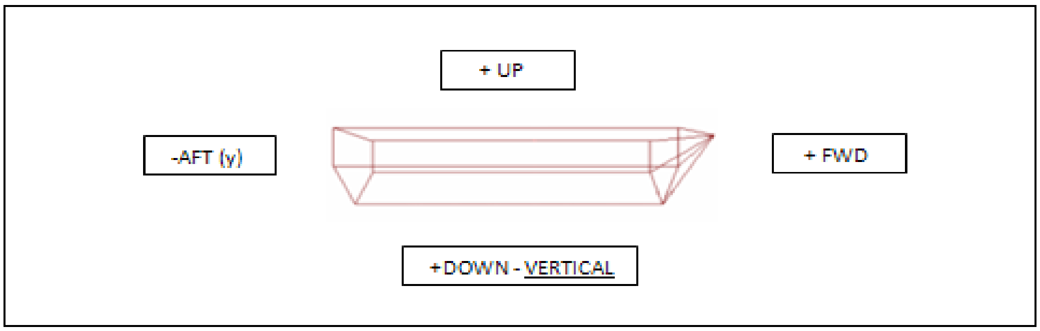


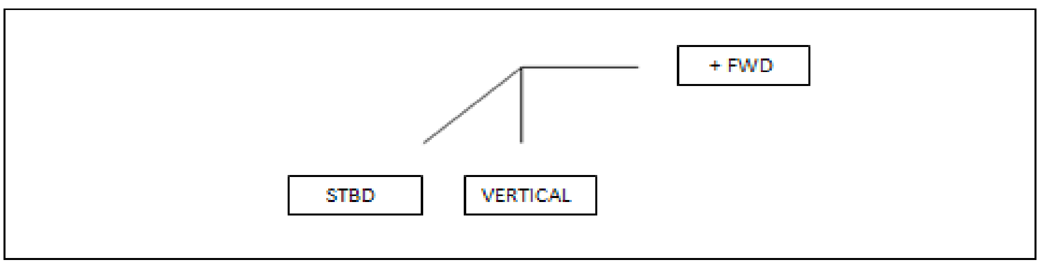


The Center of IMU is origin of NGS/ Reson System

Hypack Coordinate System







Top Center of IMU is origin of Hypack Coordinate System

Reference Surface Comparison

Frequency: 200 kHz
Resolution: 1 m
Surface Difference = Surface1 - Surface2

Average Surface Difference (m)		Surface 2: 2805	2806	2807	2808(DN064)	8160	7111
Surface 1	2805		0.008	0.033	0.019	-0.206	-0.322
	2806			0.026	0.012		
	2807				-0.009		

Standard Deviation		Surface 2: 2805	2806	2807	2808	8160	7111
Surface 1	2805		0.113	0.14	0.213	0.987	0.956
	2806			0.121	0.224		
	2807				0.556		

Frequency: 400 kHz
Resolution: 1 m
Surface Difference = Surface1 - Surface2

Average Surface Difference (m)		Surface 2: 2805	2806	2807	2808(DN095)	2808(DN064)
Surface 1	2805		-0.078	-0.044	-0.312	-0.05
	2806			0.035	-0.236	0.026
	2807				-0.27	-0.007

Standard Deviation		Surface 2: 2805	2806	2807	2808	2808
Surface 1	2805		0.128	0.123	0.304	
	2806			0.11	0.309	
	2807				0.281	

200 kHz to 400 kHz comparison
Resolution: 1 m
Surface Difference = Surface1 - Surface2

Average Surface Difference (m)		Surface 2 400kHz: 2805	2806	2807	2808(DN095)	2808(DN064)
Surface 1 200KHz	2805	0.104				
	2806		0.017			
	2807			0.032		
	2808(DN095)				-0.23	
	2808(DN064)					0.031

Standard Deviation		Surface 2 400 kHz: 2805	2806	2807	2808(DN095)	2808(DN064)
Surface 1 200KHz	2805	0.125957				
	2806		0.11			
	2807			0.525		
	2808(DN095)				0.364	
	2808(DN064)					0.362

Dual Side Scan Sonar and Multibeam Acquisition
SYSTEM READINESS REPORT 2010

Vessel: 2808
Sonars: Reson 7125 MBES
Klein 5000 SSS
Written By: LT Jaskoski
Report Date: 06-APR-2010

Background:

Fairweather 2010 planned operations call for dual acquisition of hull mounted Klein System 5000 side scan sonar data (SSS) and Reson 7125sv multibeam echosounder data (MBES). Several acquisition methods (variables: ping triggering, SSS pulse length, beam spacing and MBES frequency) were investigated to determine best practices for such operations.

Calibration Location, Date, and Personnel:

The dual acquisition methods were performed at the entrance to Juanita Bay in Lake Washington, WA (figure 1). The area was chosen for several reasons. First, the area is bisected by a cable area this provided the opportunity to determine the ability of each setting to resolve linear objects across both port and starboard returns in the SSS trace. Second, the relatively shallow, flat area was chosen as a mimic of the bathymetry expected in the project areas where SSS will be the primary mode of hydrography. The shallow area was also intended to test the interference effects of increased MBES ping rate on the SSS trace. The slope area was chosen to determine the effects of changing MBES range scale on the SSS trace.

Personnel: SST Beduhn, LT Jaskoski
Coxwain: AB Marcum
Location: Lake Washington, WA
Date: 01-MAR-2010; DN 060

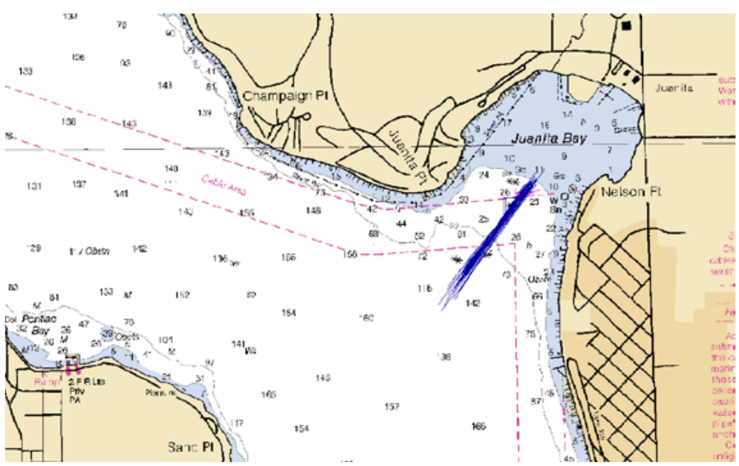


Figure 1: Location of dual system acquisition practices investigation, Chart 18447

Procedure for dual acquisition practices investigation:

Imagery and bathymetry data were simultaneously acquired over a single survey line. User controlled settings were manipulated by the hydrographer. Each setting configuration was used for one inshore and one offshore line to determine the effects of changing range scale and ping rate in both the up-slope and down-slope direction. The settings manipulated in the MBES were range scale (as needed/depth dependent), frequency (200kHz/400kHz) number of beams (256/512), beam spacing (equi-distant and equi-angular) and Trigger input (on or off). Settings manipulated in the SSS were pulse length (50µs/100µs), SSS range was set at 100m. Imagery data were reviewed in Caris SIPS to determine the extent of interference on the trace and bottom track capabilities, and the resultant effect on the operator's ability to determine significant point and linear contacts

Results:

For all settings linear contacts could be determined by the operator across port and starboard returns in the processed data.

Interference was given the values of "very light", "light" and "substantial." Interference was considered to be very light if it did not impinge upon the operator's ability to determine a $1m^3$ object in the outer beams and had no effect on bottom track (figure 2). Interference was considered light if it did not impinge upon the operator's ability to determine a $1m^3$ object in the outer beams, but had a negative effect on bottom track (figure 3). Substantial interference was deemed to be present if it impinged upon the operator's ability to determine a 1m tall object in the outer beams (figure 4). For all settings in which external triggering was disabled in the MBES substantial interference was noted in the line. Bottom track ability was degraded less by interference with a SSS pulse length of 100µs than 50µs.

Lightest interference was noted with the following settings: 400kHz frequency, 512 beams, equi-angular beam spacing, triggering input on, and SSS pulse length set to 100µs.

The nominal ping rate of a Klein 5000 SSS is 7Hz, if triggering is enabled the resultant max ping rate of the MBES will also be 7Hz. At typical survey speeds (appx 6-9 knots) the along-track ping density at 7Hz can be expected to be between 2.2-1.5 pings per meter, this is adequate ping density for use in this application.

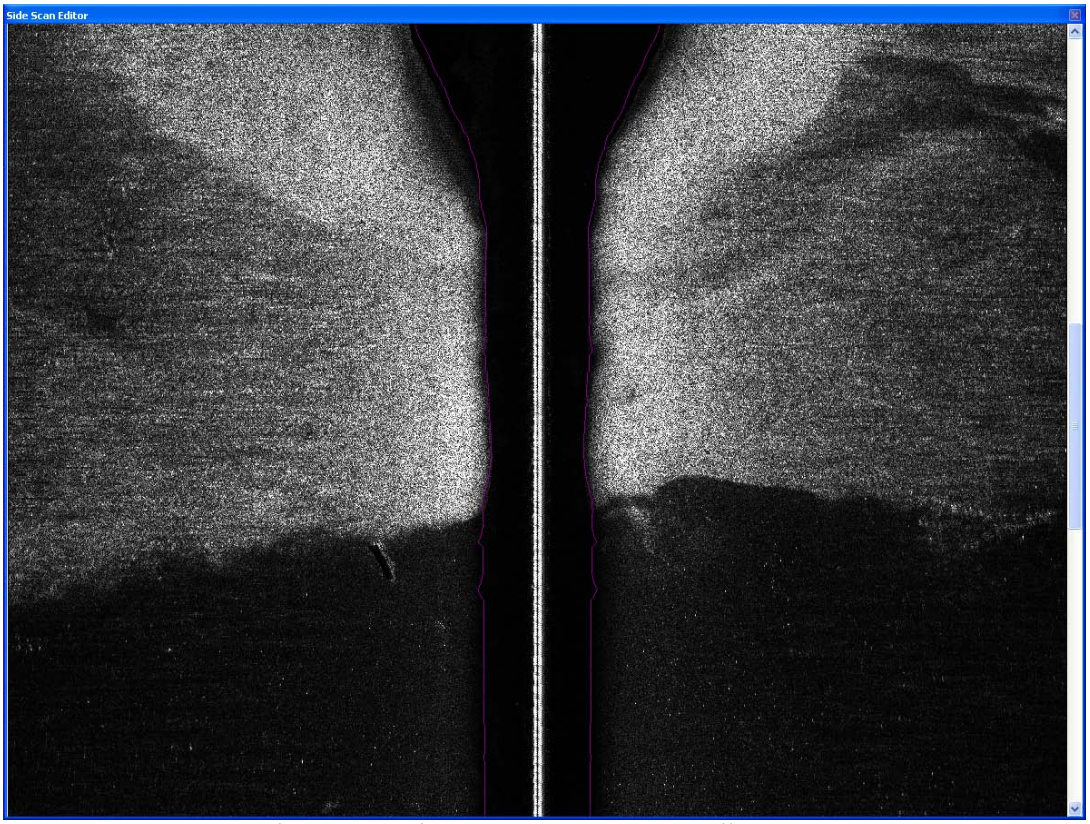


Figure 2: Very light interference, interference will not negatively affect processing SSS data

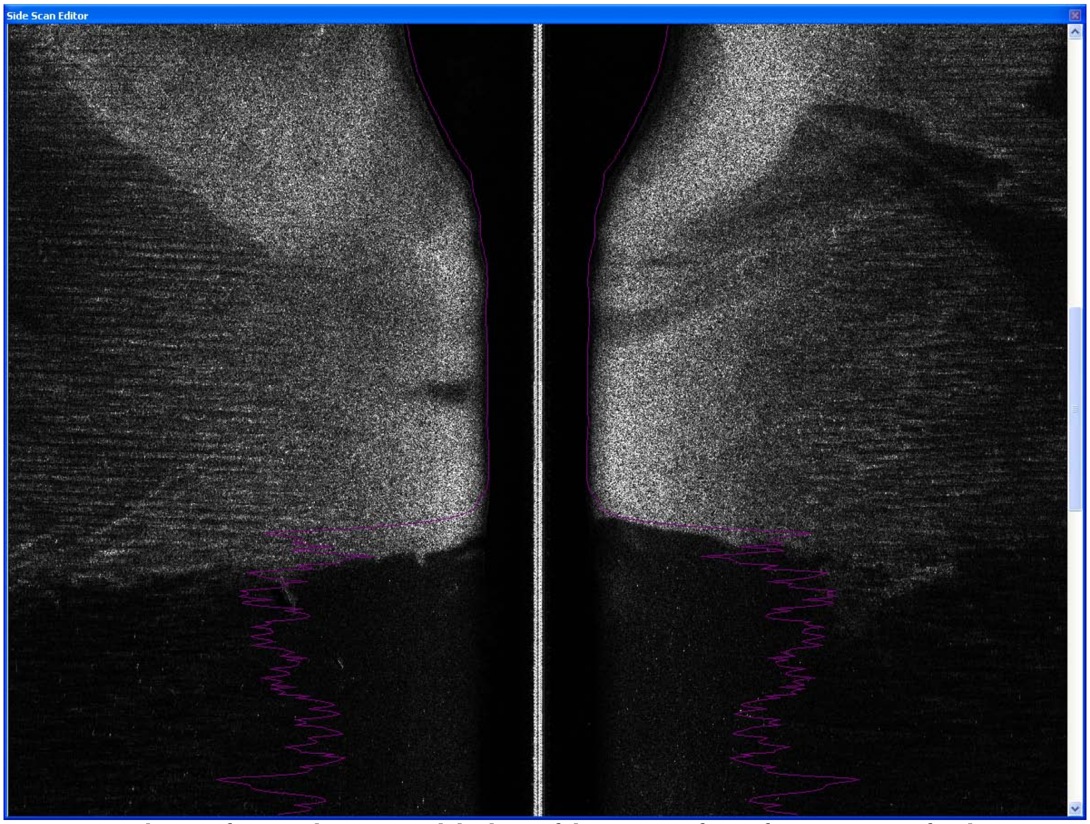


Figure 3: Light interference, bottom track locks on false return of interference over softer bottom type.

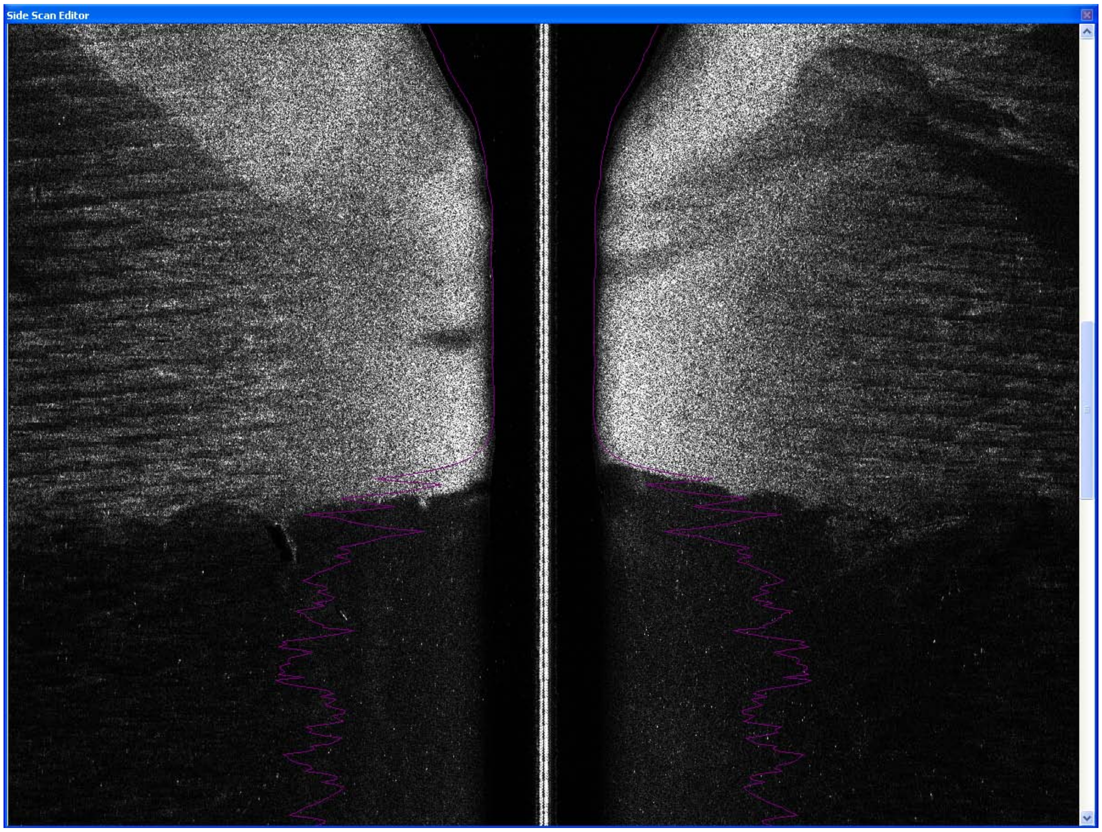


Figure 4: Substantial interference, operator unable to reliably determine significant contacts in outer beams .

Recommendations

It is the recommendation that the best practices for acquiring simultaneous hull mounted SSS and MBES data be the following:

Klein SSS	100µs pulse length Triggering enabled
Reson 7125	400kHz, 512 beams, Equi-angular spacing External triggering enabled

It is also recommended that the MBES pulse length be limited to less than one half of the SSS pulse length (>50µs)

Appendix III

Total Propagated Uncertainty (TPU)

Fairweather TPU Values

	FAIRWEATHER SURVEY		*Appendix III*	*Process Owner* Survey
	Documents Title **FA_TPU_Values_2010**	*Last update* August 9, 2010	*Version* 2010.1	*Approval Date* August 9, 2010

Offsets

	Vessel	**FAIRWEATHER-S220**	**FAIRWEATHER-S220**	**2805**	**2806**	**2807**	**2808**
	Sonar System	**Reson 7/8111**	**Reson 8160**	**Reson 7125**	**Reson 7125**	**Reson 7125**	**Reson 7125**
	Frequency			**200kHz / 400kHz**	**200kHz / 400kHz**	**200kHz / 400kHz**	**200kHz / 400kHz**
	Positioning System	**POS/MV Model 320 V4**	**POS/MV Model 320 V4**	**POS/MV Model 320 V4**	**POS/MV Model 320 V4**	**POS/MV Model 320 V4**	**POS/MV Model 320 V4**
Offsets	MRU to Trans X	2.868	0.493	0.004	-0.013	0.019	0.004
	MRU to Trans Y	8.252	7.665	0.245	0.254	0.244	0.250
	MRU to Trans Z	4.430	4.520	0.482	0.481	0.481	0.477
	Nav to Trans X	2.071	-0.304	0.686	0.624	0.804	0.685
	Nav to Trans Y	20.144	19.557	1.051	1.087	1.056	1.086
	Nav to Trans Z	17.499	17.588	3.656	3.617	3.628	3.637
	Trans Roll	0.00	0.00	0.000	0.000	0.000	0.000

Standard Deviation

	Vessel	**FAIRWEATHER-S220**	**FAIRWEATHER-S220**	**2805**		**2806**		**2807**		**2808**			
	Sonar System	**Reson 7111**	**Reson 8160**	**Reson 7125**		**Reson 7125**		**Reson 7125**		**Reson 7125**			
	Frequency			**200kHz**	**400kHz**	**200kHz**	**400kHz**	**200kHz**	**400kHz**	**200kHz**	**400kHz**		
	Positioning System	**POS/MV Model 320 V4**	**POS/MV Model 320 V4**	**POS/MV Model 320 V4**		**POS/MV Model 320 V4**		**POS/MV Model 320 V4**		**POS/MV Model 320 V4**			**Status**
Motion Sensor	Motion Gyro (deg)	0.02	0.02	0.02		0.02		0.02		0.02		**Vessel Configuration File**	Finalized
	Heave% Amp	5	5	5		5		5		5			Finalized
	Heave (m)	0.05	0.05	0.05		0.05		0.05		0.05			Finalized
	Roll (deg)	0.02	0.02	0.02		0.02		0.02		0.02			Finalized
	Pitch (deg)	0.02	0.02	0.02		0.02		0.02		0.02			Finalized
	Position Nav (m)	0.5*	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		0.03			Finalized
Latency	Timing Trans (s)	0.005	0.005	0.005		0.005		0.005		0.005			Finalized
	Nav Timing (s)	0.005	0.005	0.005		0.005		0.005		0.005			Finalized
	Gyro Timing (s)	0.005	0.005	0.005		0.005		0.005		0.005			Finalized
	Heave Timing (s)	0.005	0.005	0.005		0.005		0.005		0.005			Finalized
	Pitch Timing (s)	0.005	0.005	0.005		0.005		0.005		0.005			Finalized
	Roll Timing (s)	0.005	0.005	0.005		0.005		0.005		0.005			Finalized
Vessel Offsets	Offset X (m)	0.007	0.007	0.006		0.004		0.007		0.006			Finalized
	Offset Y (m)	0.007	0.007	0.006		0.004		0.007		0.006			Finalized
	Offset Z (m)	0.008	0.008	0.006		0.004		0.007		0.006			Finalized
Waterline	Loading	0.067	0.067	0.017		0.041		0.028		0.025			Finalized
	Draft (m)	0.068	0.068	0.018		0.041		0.028		0.026			Finalized
	DeltaDraft (m)	0.04	0.04	0.05		0.03		0.07		0.04			Finalized
MRU Alignment	MRU alignStdev gyro	0.060	0.440	0.15	0.03	0.05	0.03	0.16	0.16	0.14	0.04		Finalized
	MRU align roll/pitch	0.080	0.080	0.05	0.03	0.03	0.06	0.13	0.04	0.07	0.02		Finalized
Tides	Tide Meas (m)	0.01	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			Default=0.2, Project Dependent**
Sound Velocity	SV Meas (m/s)	0.5	0.5	1.0		1.0		1.0		1.0			Defaults, Project Dependent**
	Surface SV (m/s)	0.5	0.5	0.5		0.5		0.5		0.5			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 may change if new patch test values are used.