NOAA FORM 76-35A

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

Data Acquisition and Processing Report

NOAA Ship THOMAS JEFFERSON

March - June 2004

LOCALITY

Approaches to Chesapeake Bay
Dry Tortugas, FL
Flower Garden Banks National Marine Sanctuary
Approaches to Tampico and Altamira, Mexico

2004

CHIEF OF PARTY
LCDR Donald W. Haines

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DATA ACQUISITION AND PROCESSING REPORT

to accompany

PROJECTS S-K902-TJ-04, OPR-K366-TJ-04, S-H903-TJ-04, OPR-D304-TJ-04

NOAA Ship THOMAS JEFFERSON
LCDR Donald W. Haines, Commanding Officer

A. EQUIPMENT

All data were acquired by THOMAS JEFFERSON S222 and Survey Launches 1005 and 1014 in March through June, 2004. THOMAS JEFFERSON acquired side scan sonar (SSS) data, multibeam echosounder (MBES) data, vertical beam echosounder (VBES) data, and sound velocity profile (SVP) data. Launch 1005 acquired MBES data, SSS data, VBES data, and SVP data. Launch 1014 acquired MBES data, SSS data, VBES data, and SVP data. Vessel description and offset measurements are included in Appendix II of this report. Any unusual vessel configurations or problems will be addressed in survey-specific Descriptive Reports.

The methods and systems used to meet full-coverage requirements were determined by the Hydrographer and are in accordance with the Standing Letter Instructions (April, 2003), the Specifications and Deliverables (March, 2003), and the Field Procedures Manual (May, 2001). Other considerations included system performance limitations, limited time available, and ability of vessel to safely navigate a particular area.

A.1. SOUNDING EQUIPMENT

Odom Echotrac Echosounder – Vertical Beam Echosounder (VBES)

THOMAS JEFFERSON, Survey Launch 1005, and Survey Launch 1014 are each equipped with an Odom Echotrac DF3200 MKII echosounder. The Odom Echotrac is a dual-frequency digital-recording echosounder with an analog paper recorder. On THOMAS JEFFERSON, the high frequency transducer operates at 200 kHz with a circular beam footprint of 7.5° at the –6 dB point. On Survey Launch 1005 and 1014, the high frequency transducer operates at 100 kHz. The low frequency on all three platforms operates at 24 kHz with a rectangular beam of 27° (fore-aft direction) by 47° (athwartship direction) at the –6 dB point. Soundings are acquired in meters on both frequencies, with the high frequency selected for all sounding data. If MBES data are acquired, VBES data are archived in raw form, but not generally processed.

Reson Seabat 8101 - Multibeam Echosounder (MBES)

Launch 1005 is equipped with a hull-mounted Reson SeaBat 8101 multibeam echosounder (Fig. 1). The SeaBat 8101 is a 240 kHz MBES system that measures two-way sound travel times across a 150^o swath; each swath consisting of 101 individually formed 1.5^o x 1.5^o beams. This system was used to obtain full-bottom bathymetry coverage in depths generally from 5 meters to 75 meters, with range scale set between 10 meters and 150 meters, depending on water depth and across-track slope.

MBES data are monitored in real-time using the 2-D and 3-D data display windows in **Isis**, and the on-screen display for the Reson SeaBat 8101 sonar processor. Adjustable parameters used to control the Reson from the **Isis** software include range scale, power, gain, and pulse width. These parameters were adjusted as necessary to ensure best data quality. Additionally, vessel speed was adjusted as necessary, and in accordance with the NOS Specifications and Deliverables and Standing Project Instructions, to ensure the required along-track coverage for object detection.

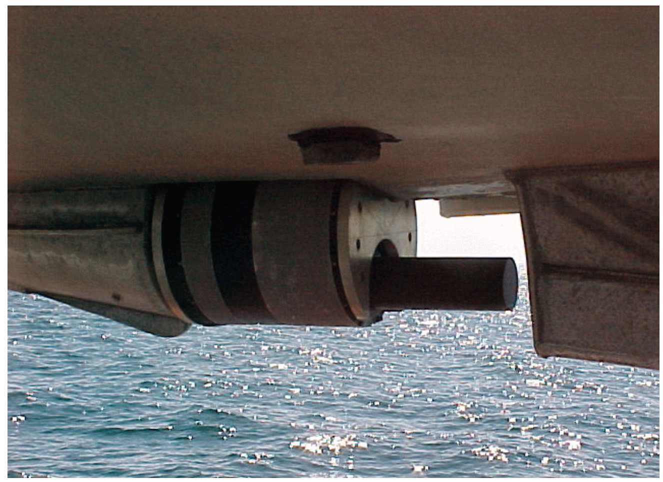


Figure 1: Reson SeaBat 8101 hull mounted in keel cut-out of Launch 1005.

Mainscheme MBES sounding lines using the Reson Seabat 8101 are generally run parallel to the contours at a line spacing approximately three to five times the water depth. Data acquired using wide line spacings such as five times the water depth were analyzed using the error estimation tools available in Caris **HIPS and SIPS 5.4**. If necessary, outer beam data were rejected and reacquired using more conservative line spacings. For discrete item developments, line spacing is often reduced to two-times water depth to ensure least-depth determination by near-nadir beams.

Reson Seabat 8125 - Multibeam Echosounder (MBES)

Launch 1014 is equipped with a hull-mounted Reson SeaBat 8125 multibeam echosounder (Fig 2). The SeaBat 8125 is a 455 kHz MBES system which measures two-way sound travel times across a 120^o swath; each swath consisting of 240 individually formed 1.0^o x 0.5^o beams. This system is used to obtain full-bottom bathymetry coverage in depths generally from 4 meters to 40 meters, with range scale set between 10 meters and 100 meters, depending on water depth and across-track slope.

Figure 2: Hull-mounted Reson 8125 transducer attached; yellow fairing facing towards the bow.

MBES data are monitored in real-time using the 2-D and 3-D data display windows in **Isis**, and the on-screen display for the Reson SeaBat 8125 sonar processor. The Reson sonar processor incorporates real time sound velocity measurements from a Digibar Pro Profiling Sound Velocimeter (section C.1). These measurements are used for initial beam forming and steering. Four adjustable parameters used to control the Reson from the **Isis** software include range scale, power, gain, and pulse width. These parameters are adjusted as necessary to ensure best bottom tracking for bathymetry. Additionally, vessel speed is adjusted as necessary, and in accordance with the NOS Specifications and Deliverables and Standing Project Instructions, to ensure the required along-track coverage for object detection.

Mainscheme MBES sounding lines using the Reson Seabat 8125 are generally run parallel to the contours at a line spacing approximately three to four times the water depth. Data acquired using wide line spacings such as four times the water depth were analyzed using the error estimation tools available in Caris **HIPS and SIPS 5.4**. If necessary, outer beam data were rejected and reacquired using more conservative line spacings. For discrete item developments, line spacing is often reduced to two-times water depth to ensure least-depth determination by near-nadir beams.

Unlike the Reson Seabat 8101, the Reson Seabat 8125 transducer is not permanently mounted to the hull. The Seabat 8125 transducer is removed for installation of the SSS towfish. A patch test or confirmation of certain biases is performed before data acquisition whenever the Seabat 8125 transducer is re-mounted to the hull.

Simrad EM 1002 - Multibeam Echosounder (MBES)

THOMAS JEFFERSON is equipped with a hull-mounted Simrad EM 1002 multibeam echo sounder. The Simrad EM 1002 is a 95 kHz multibeam system that measures two-way sound travel times across a 150^{o} swath; each swath consisting of 111 individually formed 2^{o} beams. This system was used to obtain full-bottom bathymetry coverage in depths generally from 25 meters to 300 meters.

MBES data acquisition is monitored in real-time using the EM 1002 operator station and Simrad's Merlin software. Adjustable parameters used to control the Simrad include beam angle, ping mode, spike filter strength, and beam spacing. Beam angle was set to full 75^{o} swath width. Ping mode was set to auto, enabling the system to use the appropriate mode (shallow, medium or deep) to obtain maximum coverage. Spike filter strength was set to weak. Mainscheme line beam spacing was typically set to equidistant to offer a uniform distribution of soundings.

Mainscheme MBES survey lines are generally run parallel to the contours at a line spacing approximately three to five times the water depth. Data acquired using wide line spacings such as five times the water depth were analyzed using the error estimation tools available in Caris **HIPS and SIPS 5.4**. If necessary, outer beam data were rejected and reacquired using more conservative line spacings.

Leadline

Leadlines are used for multibeam echosounder comparisons. Calibration reports for the leadlines are included in Appendix III of this report.

A.2. SIDE SCAN SONAR EQUIPMENT

General Operations

Line spacing for side scan sonar (SSS) operations is determined by the required range scale. Typically, to acquire two hundred percent coverage, 40 meter line spacing is used at the 50 m range scale, 60 meter line spacing is used at the 75 m range scale, and 80 m line spacing is used at the 100 meter range scale.

A towfish altitude of eight to twenty percent of the range scale is maintained during data acquisition. SSS altitude for towed operations is adjusted by the amount of deployed tow cable, and to a lesser degree by vessel speed.

Confidence checks are performed daily by observing changes in linear bottom features extending to the outer edges of the digital side scan image, features on the bottom in survey area, and by passing aids to navigation.

Depending on the requirements for the survey as stated in the Hydrographic Survey Letter Instructions, one of two methods can be utilized for SSS operations. The first is to acquire

100% or 200% side scan sonar coverage. All significant contacts are then selected and investigated further at the discretion of the Hydrographer. Item investigations are conducted by MBES developments. The second method, where full MBES coverage has been obtained, is to pick side scan sonar contacts only in areas of incomplete multibeam coverage, on man made features, and ambiguous features.

Klein 5500 Side Scan Sonar

The Klein System 5500 includes the Model 5250 tow fish and the T5100 Transceiver Processing Unit (TPU). The Model 5250 tow fish operates at a frequency of 455 KHz and has a vertical beam angle of 40°. The T5100 contains a network card for transmission of the sonar data to the **Isis** acquisition computer. The Klein System 5500 is unique in that each transducer simultaneously forms five dynamically focused beams per side (channel), allowing increased resolution along track (20–36 cm) and across track (7.5cm at 100 meter range scale).

There are two standard configurations for using the Klein System 5500 aboard THOMAS JEFFERSON and Launches 1014 and 1005, towed SSS and hull-mounted SSS.

Configuration 1: Klein System 5500 Towed Operations

The 5250 tow fish is deployed using a SeaMac electric-hydraulic winch spooled with approximately 200 meters of armored coaxial cable. The tow cable is lead from the winch through the stern C-frame over a snatch block with a metered sheave. The tow cable at the winch is connected to a deck cable through a slip ring assembly mounted coaxially on the winch. Cable-out is controlled remotely at the acquisition station (or locally at the winch) and is monitored on an MD-TOTCO cable counter. This sensor computes cable out by the number of revolutions of the block's sheave. The MD-TOTCO cable counter provides a serial message to the **Hypack** and **Isis** acquisition computers. The cable-out value was checked, and if necessary adjusted, for every SSS deployment.

Klein System 5500 towed operations are typically limited to seven or eight knots, speed-over-ground aboard THOMAS JEFFERSON. This is to allow an increased margin for safe navigation, to optimize vessel fuel consumption, minimize towing gear stress, and reduce "strumming" in the tow cable, which can interfere with the side scan imagery.

The SeaMac electric-hydraulic winch was replaced on March 24, 2004. The replacement winch is a DT Marine electric-hydraulic winch equipped with Klein hairy wire. The hairy fairing acts to reduce noisy vibrations along the cable and thus allows the towfish to be towed at higher speeds while improving the quality of the side scan imagery.

Configuration 2: Hull-Mounted Side Scan

This configuration is unique to Launches 1014 and 1005. The launch is outfitted with a hull-mounted sled to which the 5250 SSS is attached by a pair of omega brackets (Fig. 3). The 5250 SSS is connected to the T5100 TPU by a 10-meter lightweight Kevlar-jacketed deck cable passed through a watertight hull penetration. In this configuration, the 10-meter cable is fitted with a 6db inline attenuator to compensate for the shortened cable length.

Figure 3: Hull mounted Klein towfish under Launch 1014

The hull-mounted 5250 SSS is used primarily in shallow water (less than 20 meters) or along shore to locate shoreline features (piers, bulkheads, etc.). This configuration eliminates offset, layback, and heading errors associated with a towed system, thereby increasing the accuracy of the processed imagery. An added benefit of this configuration is its ability to avoid entanglement with lobster and crab trap floats as compared to the towed configuration.

Speed over ground in this configuration is typically limited by the launch's top speed of ten knots or prevailing sea condition. Wave heights in excess of one-half meter generally cause excessive aeration and signal quenching at the 5250 SSS transducer, consequently degrading the sonar imagery. In these cases, launch speed is reduced, or line direction reversed, to preserve image quality.

A.3. POSITIONING EQUIPMENT

Trimble DSM212L DGPS Receivers

THOMAS JEFFERSON is equipped with a Trimble DSM212L DGPS receiver for reception of U.S. Coast Guard (USCG) differential GPS (DGPS) beacons, which are used for horizontal position control. The DSM212L is an integrated 12-channel GPS receiver and dual-channel differential beacon receiver. The beacon receiver can simultaneously monitor two USCG DGPS beacon stations. The Trimble DSM212L was configured in manual mode to allow reception of only one beacon station during data acquisition. This was done in order to ensure that the proper beacon, and only that beacon, for the survey area was being received.

DSM212L parameters were configured using Trimble **TSIPTalker**. Configuration is checked frequently throughout the project period. Parameters set included number of visible satellites (4 SV's), positional dilution of precision (PDOP < 8), maximum pseudo range corrector age (30 sec), and satellite elevation mask (8°).

Position quality is monitored real time in the POS/MV controller software. The primary positional quality monitored is HDOP. Where HDOP exceeds 2.5, the data are examined during post-processing, and if necessary, positions interpolated or rejected. The **Hypack** nmea.dll configuration includes a 1000-ms update rate and a non-differential alarm in the acquisition window to alert the operator when the signal is lost.

C-NAV 2000 RM Globally Corrected Differential Global Positioning System

THOMAS JEFFERSON is equipped with a C-Nav Globally Corrected Differential Global Positioning System (GcDGPS). This system is a subscription service that uses dual L-band receivers to receive differential correctors that are broadcast worldwide via INMARSAT Geostationary Communications Satellites. These correctors are created for each GPS satellite from the raw GPS data acquired from reference receivers located around the world. The differential correctors are broadcast worldwide from 72ºN to 72ºS Latitude (the limitations of the INMARSAT Satellites) to users with C-Nav receivers.

The ship is also fitted with a Pacific Crest Radio Modem, which will broadcast the RTCM correctors to the Hydrographic Survey Launches 1005 and 1014. The RTCM corrector is used as opposed to the NMEA in order to benefit from the POS/MV heave, pitch, and roll calculations. The RTCM corrector provides slightly less accurate position information, thus decreasing the horizontal accuracy from the decimeter level to approximately 1m, which is still well within the 5m plus 5% of the water depth as specified in the NOS Hydrographic Survey Specifications and Deliverables.

The requirement to test C-Nav as per the Specifications and Deliverables standard for non-USCG Differential GPS beacons was waived by the Hydrographic Surveys Division in the Letter Instructions for S-K902-TJ-04. The C-Nav GcDGPS system was only used in Mexico for S-K902-TJ-04. For more information on the C-Nav equipment and its use during hydrographic surveys in Mexico, see the C-Nav Positioning System Report in Appendix IV.

TSS POS/MV Position and Orientation Sensor

THOMAS JEFFERSON, Launch 1005, and Launch 1014 are each equipped with a TSS POS/MV Model 320 Version 3 (Position and Orientation System for Marine Vessels) to determine position. The IMU on Launch 1014 and the PCS on Launch 1005 were replaced on March 30, 2004 (See POS/MV Configuration Note, Appendix I) The POS/MV, an aided strapdown inertial navigation system, provides a composite position solution derived from both an Inertial Measurement Unit (IMU) and dual-frequency GPS receivers. The IMU and GPS receivers are complementary sensors; data from one are used to filter and constrain errors from the other resulting in high position accuracy. On THOMAS JEFFERSON, Launch 1005, and Launch 1014, the TSS POS/MV is used for MBES, SSS, and VBES position.

Position accuracy and quality are monitored in real time during data acquisition using the POS/MV Controller software to ensure positioning accuracy requirements in the NOS Hydrographic Surveys Specifications and Deliverables are met. The POS/MV Controller software provides clear visual indications whenever accuracy thresholds are exceeded.

A.4. HEADING AND ATTITUDE EQUIPMENT

TSS POS/MV Position and Orientation System

THOMAS JEFFERSON, Launch 1005, and Launch 1014 are equipped with a TSS POS/MV Model 320 Version 3 for vessel heading and attitude determination. The POS/MV is an aided strapdown inertial navigation system (INS), consisting of an Inertial Measurement Unit (IMU) and two GPS receivers. The IMU senses linear acceleration and angular motion along the three major axes of the vessel. The POS/MV's two GPS receivers determine vessel heading using carrier-phase differential position measurements.

POS/MV Heading Computation

The POS Computer System (PCS) blends data from both the IMU and the two GPS receivers to compute highly accurate vessel heading. The IMU determines accurate heading during aggressive maneuvers and is not subject to short-period noise. However, IMU accuracy characteristically diminishes over time. The GPS receivers compute a vector between two fixed antennas and provide azimuth data using the GPS Azimuth Measurement Subsystem (GAMS). GPS heading data is accurate over time, but is affected by short-period noise. The POS/MV combines both heading measurement systems into a blended solution with accuracies greater than either system could achieve alone. On all vessels, the TSS POS/MV was used for both MBES and SSS heading.

POS/MV Heave, Pitch, and Roll Computation

Heave is computed in the POS/MV by performing a double integration of the IMU-sensed vertical accelerations. The POS/MV v3 controller heave filter is used for all data aboard THOMAS JEFFERSON, Launch 1005, and Launch 1014; a heave bandwidth between 80 and 200 seconds and heave damping ratio of 0.71 are used depending on the conditions at the time of data acquisition.

Both roll and pitch measurements are computed by the IMU after sensor alignment and leveling. The IMU mathematically simulates a gimbaled gyro platform and applies the sensed angular accelerations to this model to determine roll and pitch. On all vessels, the POS/MV was used for MBES heave, pitch, and roll.

A.5. SOFTWARE

Hypack, Inc.'s **Hypack MAX** is used for vessel navigation and line tracking during acquisition of MBES, side scan sonar, and VBES data. All VBES data are acquired in **Hypack** in the "RAW" format.

MBES data from THOMAS JEFFERSON's Simrad EM1002 unit are acquired on a SOLARIS based, Sun workstation using **Merlin**. The ship's offset configurations for the transducer and motion sensor were entered into the Caris Vessel Configuration File (VCF and HVF). Sound velocity and attitude data are not input directly at the transceiver unit, but are applied during processing.

MBES data are acquired on Survey Launch 1005 and 1014 using Triton-Elics' **Isis** software, and logged in the Extended Triton Format (*.xtf). Offset configurations for the transducer and motion sensor on each Launch were entered into the Caris Vessel Configuration File (VCF and HVF). Sound velocity and attitude data are applied during processing with Caris **HIPS and SIPS 5.4**.

On all three vessels, SSS data are acquired using Triton-Elics' **Isis** software and logged in the Extended Triton Format (*.xtf). Offset configurations for the transducer and motion sensor on each vessel were entered into the Caris Vessel Configuration File (VCF and HVF).

Side scan sonar and multibeam echosounder data are processed using Caris **HIPS and SIPS 5.4**. Due to bugs exhibited in Caris **HIPS and SIPS 5.**4, Caris **HIPS and SIPS 5.3** was used for recomputing towfish navigation and slant-range correcting sidescan imagery. Caris **HIPS and SIPS 5.4** was used during the field season for the creation of BASE (Bathymetry Associated with Statistical Error) surfaces.

All MBES soundings, and side scan and MBES features are analyzed during post-processing using **Pydro**. This program was created by the NOS Hydrographic Systems and Technology

Programs N/CS11 (HSTP) using the **Python 22** programming language to interface with the HDCS data directly.

Soundings and features are exported from **Pydro** in MIF/MID (**MapInfo** Interchange) format, and imported into **MapInfo**. **MapInfo** is used for final data analysis and for creating final plots. **Fledermaus** (IVS, Fredericton, New Brunswick), **GeoZui** (UNH, Durham, NH), and Caris **HIPS and SIPS 5.4** are used for visualization and data comparisons.

Raw sound velocity data are processed using **Velocwin,** supplied by NOAA Hydrographic Systems and Technology Program (HSTP). **Velocwin** uses raw salinity, temperature, and pressure measurements to create a sound velocity profile.

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

B. DATA PROCESSING AND QUALITY CONTROL

B.1. MULTIBEAM ECHOSOUNDER DATA

Raw XTF and Simrad multibeam data are converted to HDCS format in Caris **HIPS and SIPS 5.4**. Conversion parameters specifying the sources of the attitude and navigation data are stored in the LogFile located in each of HDCS processed line folders. After conversion, the Total Propagated Error (TPE) is calculated using the Caris **HIPS and SIPS 5.4** implementation of the multibeam error model (Hare et al., 1995) to determine the quality of the multibeam data. The TPE takes into account uncertainties in the measurements coming from each sensor (heave, pitch, roll, position, heading, sound velocity, and tide) and uncertainties in static measurements (draft and vessel offsets) to calculate the total uncertainty. Input parameters to the error model, i.e. standard deviations at one sigma for each sensor or measurement, are entered into the HVF file (HIPS Vessel File, 5.4 version of the VCF). A table of these values is provided in Appendix IV.

Traditionally, vessel heading, attitude, and navigation data are reviewed and edited line by line (viewed as time series data). However, THOMAS JEFFERSON has been moving toward a surface-based mode of editing where it is unnecessary to review each line individually. Fliers or gaps in heading, attitude, or navigation data are manually rejected. Sound velocity correction is applied in Caris **HIPS and SIPS 5.4**. Tide correction is applied to the data during merge, and dynamic draft corrections and sensor lever arms are applied in THOMAS JEFFERSON's MBES HVF. (See Appendix III).

Caris **HIPS and SIPS 5.4** uses the vertical and horizontal uncertainty from TPE to produce BASE (Bathymetry Associated with Statistical Error) surfaces. These BASE surface products (Depth, Uncertainty, Density, Standard Deviation, Mean, Shoal, and Deep) are then used to demonstrate MBES coverage, and to further check for systematic errors such as tide, sound velocity, or attitude and timing errors. Sun-illumination is used to highlight the seabed features.

Bathymetry is submitted as a collection of finalized BASE surfaces. The finalize step applies designated soundings which have been chosen by the Hydrographer in order to preserve the least depth over navigationally significant features. Designating a sounding forces the nearest BASE surface grid node to the depth of the designated sounding in the finalized BASE surface. The finalize step also allows for a depth threshold to be applied to the BASE surface, in effect cutting out just the section of the BASE surface with a specified depth range. In this way, the survey area is covered by a collection of finalized BASE surfaces, each of which preserves the highest possible resolution for the given depth range.

The actual resolution chosen for the finalized BASE surface is dependent upon the sounding density, the quality of the data, and the local "roughness". The chosen resolution must be high enough to accurately reflect the seafloor as understood by the Hydrographer, but nothing is gained by choosing a resolution higher than the data supports. There are no official standards, but the following table provides the guidelines used. See the individual Descriptive Report for more details about what resolutions were used for the submitted BASE surfaces.

Depth (in Meters)	Resolution (in Meters)
0-15	0.5
14.5-30	1
29.5-60	2
59.5-300	5

Once the BASE surfaces have been Finalized, they are inserted into **Pydro**. Bathymetry can be inserted into **Pydro** using the Insert→Caris Lines or the Insert→HIPS Weighted Grids functions. As the final product is a collection of BASE surfaces, chart comparisons and least depths on features are from the Finalized BASE surfaces, not the Caris Line bathymetry.

B.2. VERTICAL-BEAM ECHOSOUNDER DATA

Vertical-beam echosounder (VBES) data are acquired concurrently with both MBES data and SSS data. When VBES data are not the primary source of bathymetry, i.e. MBES data are also acquired, VBES data are not routinely processed, but may be used for troubleshooting or confidence check purposes. In this case, the raw **Hypack** VBES data are submitted for archival purposes only. These data should not be used for the creation of any product.

When VBES data are the primary source of bathymetry, i.e. acquired concurrently with SSS data, VBES data are processed, passed through quality control, and submitted for the purposes of product creation. Following acquisition, VBES data are converted from **Hypack** “Raw” format to HDCS using Caris **HIPS and SIPS 5.4**. After examining navigation and attitude data, each line’s observed depths are viewed in Caris **HIPS and SIPS 5.4** Single Beam Editor.

When the primary source of bathymetry is VBES data, analog paper VBES data are acquired and scanned along with the digital VBES data. After review and cleaning, Caris **HIPS and SIPS 5.4** is used to merge depth, position, and attitude data with sound velocity, tide, vessel offset, and dynamic draft correctors to compute the corrected depth and position of each sounding. All soundings are reviewed again in Caris **HIPS and SIPS 5.4** Subset Mode. Data are compared with adjacent lines and crosslines for systematic errors such as tide or sound velocity errors.

Vertical-beam echosounder data were incorporated into the BASE surface pipeline used for MBES data, thus creating BASE surfaces with soundings from both MBES and VBES. Thus all bathymetric data could be submitted in one model, or collection of BASE surfaces. In order to add any sounding data to a BASE surface it must first have TPE values calculated. Caris did not implement TPE calculation for VBES in **HIPS and SIPS 5.4**. By treating the VBES as a MBES with a single beam at nadir, the HIPS vessel file and the Caris

DeviceModels.xml file were modified to allow the calculation of TPE for VBES data. For more information about this modification, see the VBES note in Appendix I.

B.3. SIDE SCAN SONAR DATA

Side scan sonar data are converted from *.xtf (**Isis** raw format) to HDCS**.** Side scan data are processed using Caris **HIPS and SIPS**.

Processing side scan data includes examining and editing fish height, vessel heading (gyro), and vessel navigation records. Fish navigation is recalculated using Caris **HIPS and SIPS 5.3**. Tow point offsets (C-frame and cable out), fish depth, fish attitude, and water depth are used to calculate horizontal layback.

After fish navigation is recalculated, side scan imagery data are slant-range corrected to 0.1m with beam pattern correction. The slant-range corrected side scan imagery data are closely examined for any targets. Targets-of-interest are evaluated as potential contacts based upon apparent shadow length and appearance; particularly targets which do not appear to be natural in origin. Contacts are selected and saved to a contact file for each line of SSS data. Contact selection includes measuring apparent height, selecting contact position, and creating a contact snapshot (*.tif) image.

Side scan sonar coverage is determined by using mosaics generated in Caris **HIPS and SIPS 5.4** and imported into **MapInfo**. If any deficiencies in the side scan sonar data are found, a holiday line file is created from the mosaics, and additional lines of SSS are acquired, in order to meet the requirements set forth in the Hydrographic Surveys Letter Instructions.

All contacts are imported into **Pydro** using the “Insert Caris Line Features” tool. Contacts are arranged by day and line and can be selected in the data “Tree” window. Information concerning a specific contact is reviewed in **Pydro**’s “Editor Notebook Window” including contact position, AWOIS item positions, surrounding depths, contact cross references, and charting recommendations. Each contact is reviewed, and information flags are set accordingly. The available flags are “Resolved”, “Rejected”, “Primary Hit”, “Significant”, “Chart”, and “DTON”. “Resolved” is chosen after the contact has been reviewed by the Sheet OIC. If the contact is significant, then the “Significant” flag is chosen. If there are multiple contacts for a single feature, the one providing the best SSS image of the feature is chosen as the “Primary Hit”. Any items that are to be addressed in the Item Investigation section of the Descriptive Report are flagged as “Chart”. Items which have the “Chart” flag set could also be further designated for inclusion in the Danger To Navigation Report by choosing the “DTON” flag. “Snapshots” of contacts are displayed in **Pydro**’s “Image Notebook Editor”. Contacts appearing significant are further investigated by multibeam. Final positioning and least depth determination of significant items is accomplished using multibeam echosounders.

C. CORRECTIONS TO ECHO SOUNDINGS

C.1. SOUND VELOCITY

SBE19 Conductivity, Temperature, and Depth (CTD) profilers

Sound velocity profiles are acquired with Sea-Bird Electronics SeaCat SBE19 CTD profilers. Raw conductivity, temperature, and pressure data are processed using the program **Velocwin** which generates sound velocity profiles for Caris **HIPS and SIPS 5.4**. Sound velocity correctors are applied to MBES and VBES soundings in Caris **HIPS and SIPS 5.4** during post processing only. Calibration reports for the SBE19 CTD profilers are included in Appendix III of this report. A CTD and hydrometer comparison was performed on March 16, 2004, the results of which are in Appendix III.

The speed of sound through water is determined by a minimum of one cast every four to six hours of MBES acquisition, in accordance with the Standing Letter Instructions and NOS Specifications and Deliverables for Hydrographic Surveys. Casts were conducted more frequently when changing survey areas, or when it was felt that conditions, such as a change in weather, tide, or current, would warrant additional sound velocity profiles.

The sound velocity casts are extended in **Velocwin** and applied to the Simrad MBES and Reson MBES data in Caris **HIPS and SIPS 5.4** during post processing.

Kongsberg Simrad Surface Sound Velocity System

THOMAS JEFFERSON is equipped with a Kongsberg Simrad Surface Sound Velocity System (SSVS). The SSVS uses an Applied Microsystems Limited Sound Velocity and Temperature Smart Sensor to measure sound velocity and temperature at the depth of the Simrad EM 1002 transducer. Mounted in THOMAS JEFFERSON's transducer void, the smart sensor samples water pumped through insulated stainless steel pipes passing through the void. This unit calculates and outputs temperature and sound velocity ten times per second to the EM1002 Sun operator workstation for real-time beam-steering at the transducer head. These values are averaged by Simrad before application by 3 seconds. This averaging mitigates the effects of erroneous measurements.

Reson 8125 Surface Sound Velocity System

Launch 1014 is equipped with a Seabird Digibar Pro surface sound velocity sensor. The sensor is used to measure sound velocity at the depth of the Reson 8125 transducer. This data is used for real-time beem-steering at the transducer head. The sensor is mounted next to the transducer on the hull mounted equipment sled.

C.2. VESSEL OFFSETS AND DYNAMIC DRAFT CORRECTORS

The following table lists each HIPS Vessel File.

HVF NAME	SURVEY SYSTEM
S222_vb	THOMAS JEFFERSON Odom VBES
S222_mb	THOMAS JEFFERSON EM 1002 Multibeam
S222_100	THOMAS JEFFERSON Towed Klein SSS 100% Coverage
S222_200	THOMAS JEFFERSON Towed Klein SSS 200% Coverage
1005_vb	Launch 1005 Odom VBES
1005_mb	Launch 1005 Reson 8101Multibeam
1005_100	Launch 1005 Hull-Mounted Klein Side Scan Sonar 100% Coverage
1005_200	Launch 1005 Hull-Mounted Klein Side Scan Sonar 200% Coverage
1014_vb	Launch 1014 Odom VBES
1014_mb	Launch 1014 Reson 8125 Mulitbeam
1014_100	Launch 1014 Hull-Mounted Klein Side Scan Sonar 100% Coverage
1014_200	Launch 1014 Hull_mounted Klein Side Scan Sonar 200% Coverage

THOMAS JEFFERSON Offsets and Dynamic Draft

Static draft corrections for THOMAS JEFFERSON were measured on March 16, 2004 and can be found in Appendix II.

Dynamic draft measurements were made on THOMAS JEFFERSON on March 16, 2004. The procedure and results are in Appendix II. Dynamic draft measurements were made again in June, 2004. The procedure and results are also in Appendix II.

Vessel offset measurements were made on THOMAS JEFFERSON while in drydock at Atlantic Drydock Corp. in Jacksonville, FL on February 9, 2004. The measurements made in drydock confirmed previous measurements to .083 meters. The procedure and results are in the Offset Confirmation Report found in Appendix II.

The Simrad EM1002 sensor and vessel offsets are stored in the Vessel Configuration File (S222_MB) and are applied during post processing to data acquired with NOAA Ship THOMAS JEFFERSON. All offsets and biases are duplicated in the Caris **HIPS and SIPS 5.4** HIPS Vessel File (HVF).

THOMAS JEFFERSON performed a side scan sonar verification during the shakedown March 16 - 18. See the NOAA Ship THOMAS JEFFERSON Side Scan Sonar Verification in Appendix IV for more information. The Klein side scan sonar sensor offsets are stored in the Vessel Configuration Files (duplicated in the HVF) and are applied to side scan data during processing in Caris **HIPS and SIPS**.

Launch 1005 Offsets and Dynamic Draft

Vessel offset measurements were made on Launch 1005 on March 26, 2004 at Marine Operations Center - Atlantic. The measurements confirmed previous measurements made in 2003.

An attempt to measure dynamic draft on Launch 1005 was made on March 29, 2004. The procedure was incomplete and this remains an outstanding item to be completed. For more information, see the report in Appendix II.

The Reson Seabat 8101 sensor offsets are stored in the Vessel Configuration File (1005_MB) and are applied to MBES data acquired with Launch 1005. All offsets and biases are duplicated in the Caris **HIPS and SIPS 5.4** HIPS Vessel File (HVF).

Launch 1014 Offsets and Dynamic Draft

Vessel offset measurements were made on Launch 1014 on March 31, 2004 at Old Point Comfort, VA. The measurements confirmed previous measurements made in 2003.

Static draft corrections for Launch 1014 were measured on April 26, 2004 and can be found in Appendix II.

Dynamic draft measurements were made on Launch 1014 on March 31, 2004. The procedure and results are in Appendix II.

The Reson Seabat 8125 sensor offsets are stored in the Vessel Configuration File (1014_MB) and are applied to MBES data acquired with Launch 1014. All offsets and biases are duplicated in the Caris **HIPS and SIPS 5.4** HIPS Vessel File (HVF).

Vessel offset diagrams and dynamic draft tables are included in Appendix II of this report. The Vessel Configuration Files themselves are included with the digital data.

C.3. HEAVE, PITCH, ROLL AND HEADING, INCLUDING BIASES AND NAVIGATION TIMING ERRORS

Heave, pitch, roll, and navigation latency biases for Survey Launch 1005's Reson 8101 were not determined prior to the start of the projects covered by this DAPR. The safety stand-down that halted launch operations prevented a patch test being done after the start of the field season. The MBES system bias values contained in the HIPS Vessel Configuration Files (VCFs and HVFs) are from bias tests done the previous year. The 8101 is rigidly mounted to the hull of Launch 1005. As such, the system's biases are not expected to change appreciably. Launch 1005 was used primarily as a side scan sonar platform, only acquiring MBES data during Project OPR-K366-TJ-04, which was in deep, offshore waters. These offsets and biases are applied to the sounding data during processing in Caris **HIPS and SIPS 5.4**. The VCFs and HVFs are included with the digital data.

Heave, pitch, roll, and navigation latency biases for Survey Launch 1014's Reson 8125 were determined during patch tests conducted on April 2, 2004 near Old Point Comfort, VA**.** MBES vessel offsets, dynamic draft correctors, and system bias values are contained in **HIPS** Vessel Configuration Files (VCFs and HVFs). These offsets and biases are applied to the sounding data during processing in Caris **HIPS and SIPS**. The VCFs, HVFs and Patch Test data are included with the digital data. The Patch Test Report for Launch 1014 can be found in Appendix IV. A Patch Test or verification of certain biases is also performed at the start of each project before acquiring MBES data in the new area.

Heave, pitch, roll, and navigation latency biases for NOAA Ship THOMAS JEFFERSON's EM1002 were determined during a patch test conducted on March 16 and 17, 2004 approximately 3 nautical miles west of Cape Charles City in Chesapeake Bay. The results of the patch test were saved in the VCF and HVF. A detailed report on the patch test can be found in Appendix IV. A Patch Test or verification of certain biases is also performed at the start of each project before acquiring MBES data in the new area.

C.4. WATER LEVEL CORRECTORS

Soundings are reduced to Mean Lower-Low Water (MLLW) using verified tide data from the local, primary tide gauge obtained from the Center for Operational Oceanographic Products and Services (CO-OPS) web site. For all projects, a simple predicted tide table is applied to MBES data in Caris **HIPS and SIPS** during the Merge process. A zone-corrected verified tide file is supplied by CO-OPS, which is then reapplied to all MBES data using Caris **HIPS and SIPS 5.4**.

D. APPROVAL

As Chief of Party, I have ensured that standard field surveying and processing procedures were adhered to during this project in accordance with the Hydrographic Manual, Fourth Edition; Hydrographic Survey Guidelines; Field Procedures Manual, and the NOS Hydrographic Surveys Specifications and Deliverables, as updated for March, 2003.

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

Submitted:

____
ENS Matthew Ringel, NOAA
Junior Officer

Approved and Forwarded:

____
LTjg Marc Moser, NOAA
Field Operations Officer

____
LCDR Donald W. Haines, NOAA
Commanding Officer

APPENDIX I

- Software Versions
- Hardware Serial Numbers
- VBES Software Note

S222 Acquisition/Processing Software		
Software	**Version**	**Installed**
Acquisition		
Hypack Max	2.12	1/03
ISIS	6.20	7/03
Simrad EM1002	5.1v25B	6/03
Horizontal Control		
TSIP Talker	2.0	
POS/MV Controller	1.3	5/03
Sound Velocity		
Velocwin	8.5	3/22/04
Processing		
Pydro	4.3.beta	
	4.5.2	5/25/04
MapInfo	6.5	
MapBasic	5.0	
Vertical Mapper	3.0	5/03
Fledermaus	6.0	12/19/03
GeoZui	3.4	8/03
Grid Manipulator	Shepware	8/03
CARIS GIS	4.4a 3.0	7/03
	4.4a 3.0 HF1-18	10/27/03
	4.4a 3.0 HF20-23	11/17/03
	4.4a 3.0 HF 19,25	11/28/03
CARIS HIPS & SIPS	5.3.3 HF1-2	10/23/03
	5.3.3 HF4,5,8,9	11/14/03
	5.3.3 HF 10	11/17/03
	5.3.3 HF 11,13	12/10/03
	5.4 HF 14	5/4/04
Utilities		
KapConv	3.4.1	7/03
HydroMI	3.12.3g	
Tides and Currents	2.56	
Cygwin		10/31/03
WorldReg	1.0	
NOAA Chart Reprojector	2.0.4	2/03

Equipment Serial Numbers

Equipment	Serial Number(s)	Updated
Odom Echotrac DF3200 MKII Echosounder	Launch 1014 - 9644	
	Launch 1005 - 9708	
	TJ - 9643	
Simrad EM1002 Multibeam Echosounder	Transducer 267	
	Transeiver 222	
Reson 8101 Mutibeam Echosounder	Processor 13976	
	Transducer ?	
Reson 8125 Multibeam Echosounder	Processor 31381	
	Transducer 1501014	
Klein 5500 high speed, high resolution, multiple beam, side scan sonar processor	Launch 1005 - 91184	
	Launch 1014 - 91566	
	TJ - 91182	
Klein 5500 high speed, high resolution, multiple beam, side scan sonar towfish	276	
	278	
	279	
	292	
Trimble DSM212L	Launch 1005 - 0220168291	
	Launch 1014 - 0220157923	
	TJ - 0020159721	
	TJ - 0220159716	
TSS Position & Orientation System POS/MV	Launch 1005 PCS - 402	30 March, 2004
	Launch 1005 IMU - 103	30 March, 2004
	Launch 1014 PCS - 207	30 March, 2004
	Launch 1014 IMU - 30	30 March, 2004
	TJ PCS - 226	
	TJ IMU - 780	
Trimble GPS Pathfinder Pro XRS Receiver	224025052	
Diver Least Depth Gauges	68338	
	68339	
Seabird SBE 19 Sound Velocity Profiler	285	22 March, 2004
Seabird SBE 19 Plus Sound Velocity Profiler	4486	22 March, 2004
Seabird SBE 19 Plus Sound Velocity Profiler	4487	22 March, 2004
Odom DIGIBAR-Pro Profiling Sound Velocimeter	98130-0124403	
Applied Microsystems Smart SV & Temperature probe	4823	3 January, 2004
C-Nav	DU (Processor) 8462-13	2 April, 2004
	2000 RM (Antenna) 268586	2 April, 2004
Pacific Crest PDL Radiomodem	TJ - 03380655	2 April, 2004
	1005 - 03380623	2 April, 2004
	1014 - 03380621	2 April, 2004

THOMAS JEFFERSON S222
VBES Software Note

ST Helen Stewart

Background:

To compute TPE values for vertical-beam echosounder data, modifications to the DeviceModels.xml file and to the Vessel Configuration file were made. The DeviceModels.xml file contains information on the following properties of each sonar system used by CARIS HIPS and SIPS:

- Type of sonar (side-scan, multibeam, vertical beam)
- Number of Beams
- Operating frequency (or frequencies)
- Maximum angle from nadir
- Beam width across track and along track
- Pulse length and ping frequency
- Hull mounting properties (e.g. towed, pole-mount)

Procedure:

Values for operating frequencies, optimal pulse length, and optimal ping rate were determined from the ODOM Echotrak MK II manual and inserted into the DeviceModels.xml file used by Caris. As the ODOM is a vertical-beam system, number of beams is assumed to be 1 and maximum angle from nadir is assumed to be 5 degrees from nadir (allowing for beam spread in deeper water).

The following section was inserted into the DeviceModels.xml file.

```
<SonarModel label="ODOM Echotrak Mk II" key="odom">
  <Max_Num_Beams value="1"/>
  <Operating_Frequency_1 value="200.0"/>
  <Operating_Frequency_2 value="24.0"/>
  <Max_Angle value="5.0"/>
  <Beam_Width_Across value="1.5"/>
  <Beam_Width_Along value="1.5"/>
  <Steering_Angle value="0.0"/>
  <Range_Sampling_Frequency value="20000.0"/>
  <Range_Sampling_Distance value="0.06"/>
  <Min_Pulse_Length value="0.07"/>
  <Rates>
   <Repitition value="10"/>
   <Bathy value="10"/>
   <Attitude value="0"/>
   <Imagery value="0"/>
  </Rates>
  <Density>
   <Bathy value="1"/>
   <Attitude value="0"/>
   <Imagery value="0"/>
  </Density>
  <DeviceProperties>
```

<Multibeam value="Yes"/>
<SideScan value="No"/>
<Towed value="No"/>
<Calibrated value="No"/>
<DualFrequency value="Yes"/>
<HasAccuracy value="No"/>
<Steered value="No"/>
<Splithead value="Yes"/>
<Bathymetric value="Yes"/>
<Imagery value="No"/>
<Attitude value="Yes"/>
</DeviceProperties>
</SonarModel>

After completing changes to the DeviceModels.xml file, the following xml paragraph was added to the HIPS Vessel File (HVF).

<TimeStamp value="2002-001 00:00:00">
<Latency value="0.000000"/>
<SensorClass value="Swath"/>
<TransducerEntries>
<Transducer Number="1" StartBeam="1" Model="odom">
<Offsets X="0.640000" Y="-0.110000" Z="0.300000" Latency="0.000000"/>
<MountAngle Pitch="0.000000" Roll="0.000000" Azimuth="0.000000"/>
</Transducer>
</TransducerEntries>
</TimeStamp>

The DeviceModels.xml file and the HIPS Vessel Files are included with the digital data.

APPENDIX II

- NOAA Ship THOMAS JEFFERSON Static Draft Determination
- NOAA Ship THOMAS JEFFERSON Dynamic Draft Determination - 24 March, 2004
- NOAA Ship THOMAS JEFFERSON Dynamic Draft Determination - 6 June , 2004
- NOAA Ship THOMAS JEFFERSON Offset Confirmation Report
- Launch 1005 Static Draft Determination
- Launch 1005 Dynamic Draft Determination
- Launch 1014 Static Draft Determination
- Launch 1014 Dynamic Draft Determination

S222 Static Draft Determination
SST Peter Lewit

NOAA Ship *THOMAS JEFFERSON* 2004 DN 076

Background

The purpose of a static draft measurement is to correct for the difference in distance from the waterline to the transducer face. It also accounts for the long-term differences in loading due to fuel, water and supplies. In our current software the term draft is not used. The Z value (the z-axis being vertical) of the transducer below the Inertial Motion Unit (IMU) and the waterline will give the surveying draft of the ship. The term waterline is the distance from the waterline to the IMU. The current confirmed value of the distance from the IMU to the multibeam echosounder transducer is 5.15 meters

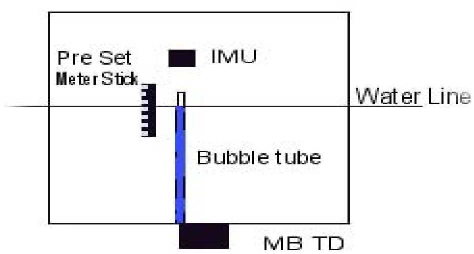
The current configuration for the ship has the origin of the ship's reference frame at the IMU. The offsets for SVP pole and waterline are entered in reference to the IMU.

Location

Static draft measurements were performed at the following location by SST Peter Lewit.

March 16, 2004 (DN076) Chesapeake Bay, VA

Procedure



The method used is to read a bubble tube installed from the sound speed velocimeter to a point near the IMU. It is located under the cargo hatch that leads from the electronic stores to survey stores. A level was run from the IMU down to a mark and a meter stick attached to the bulkhead inline with the level mark. The bubble tube was then attached next to meter stick. The valves are opened from the SSV tank and the pump is turned off. By reading the water level in the tube against the meter stick an insitu reading of waterline can be made.

It is recommended that all readings be taken after ballasting. Constants for various tests including Static draft and lead line checks are based on the recent bubble tube data and are accurate for future use.

Once the distance from the IMU to the waterline is known, it becomes a matter of measuring the distance between the IMU and the transducer in the z direction. This is difficult to measure directly, and therefore a reference point (RP) or notch mark on the hull is surveyed into position to aid the measurement. The distance from the RP to the transducer can be measured directly, as well as the distance from the RP to the IMU.

The constants are as follows

RP(notch) to IMU= **7.72m** RP to TD = **12.873** IMU to TD(transducer**)= 5.153**

Results

The following table shows the waterline and draft measurements at the time of survey and the adjustments to be made according to the type of system configuration

INSITU Static Readings and Aquisition Entry's

YR	DN	VCF DN	Method	MB Static Draft	Pos MV Z	Simrad Z	Simrad Waterlevel
2003	239	239	Bubble	4.593	5.153	5.150	0.56
2004	076	111	Bubble	4.613	5.153	5.150	0.54

Preliminary VCF Draft Waterline Entries

	DN Draft	VCF	Adjustments	Swath offsets Z	SVP pole Bot Z offsets	Apply Flag	Velocity Applied	Caris Waterline/Projected
2003	*239	*239	N/A	0	5.150	y	y	0.56
2004	076	076	N/A	0	5.153	y	y	0.54

.The following Drafts are provided for Velocity and Leadline comparison

VB Draft 200kHz	4.440
VB Draft 24 kHz	4.123
MB Draft	4.613
Waterline MB and VB (should be same)	0.540

Recommendations for Use:

These results are adequate for correcting soundings for hydrographic surveys.

Performed by:
Peter Lewit
Senior Survey Technician
NOAA Ship THOMAS JEFFERSON

Dynamic Draft Determination

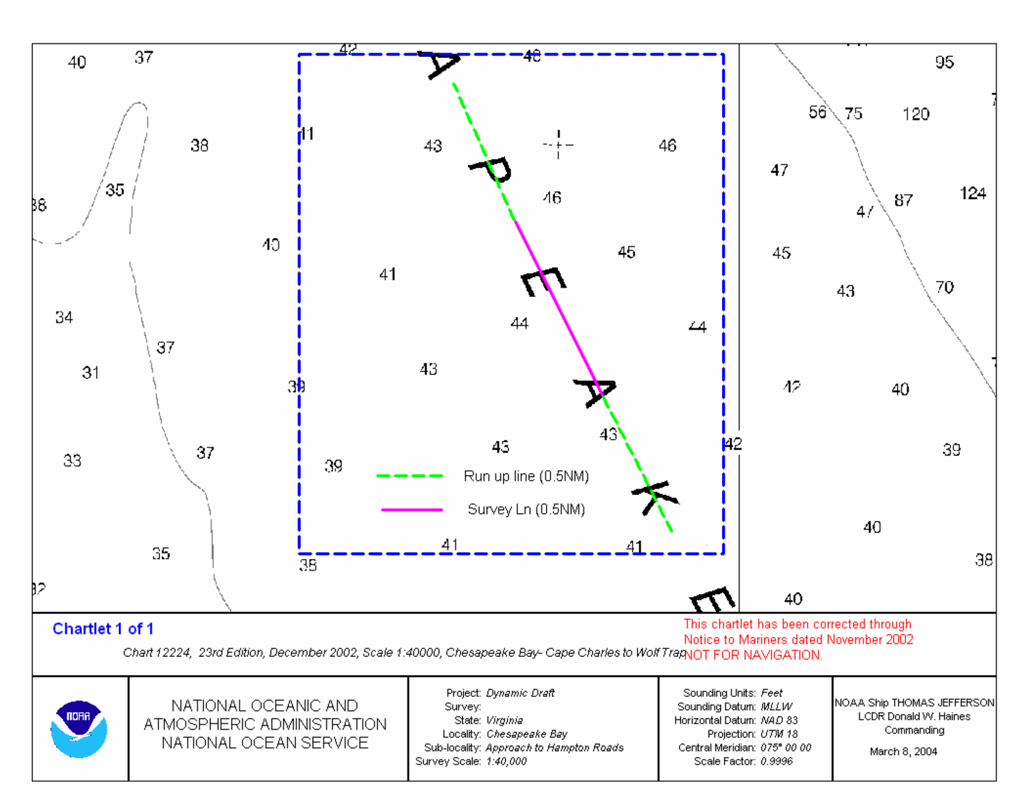
ENS Jasper Schaer

Background:

This method of determining the dynamic draft of a vessel is adapted from an older practice where successive lines were run over a flat bottom at different RPMs. At the time of this trial, no GPS equipment was available for GPS dynamic draft and it was not deemed practical to use a level and rod on a large ship in restricted waters.

Location and Date:

The trial was conducted in southern Chesapeake Bay on a broad, flat area of seafloor approximately 4 NM west of Cape Charles City, VA on 24 March, 2004 (DN 084).

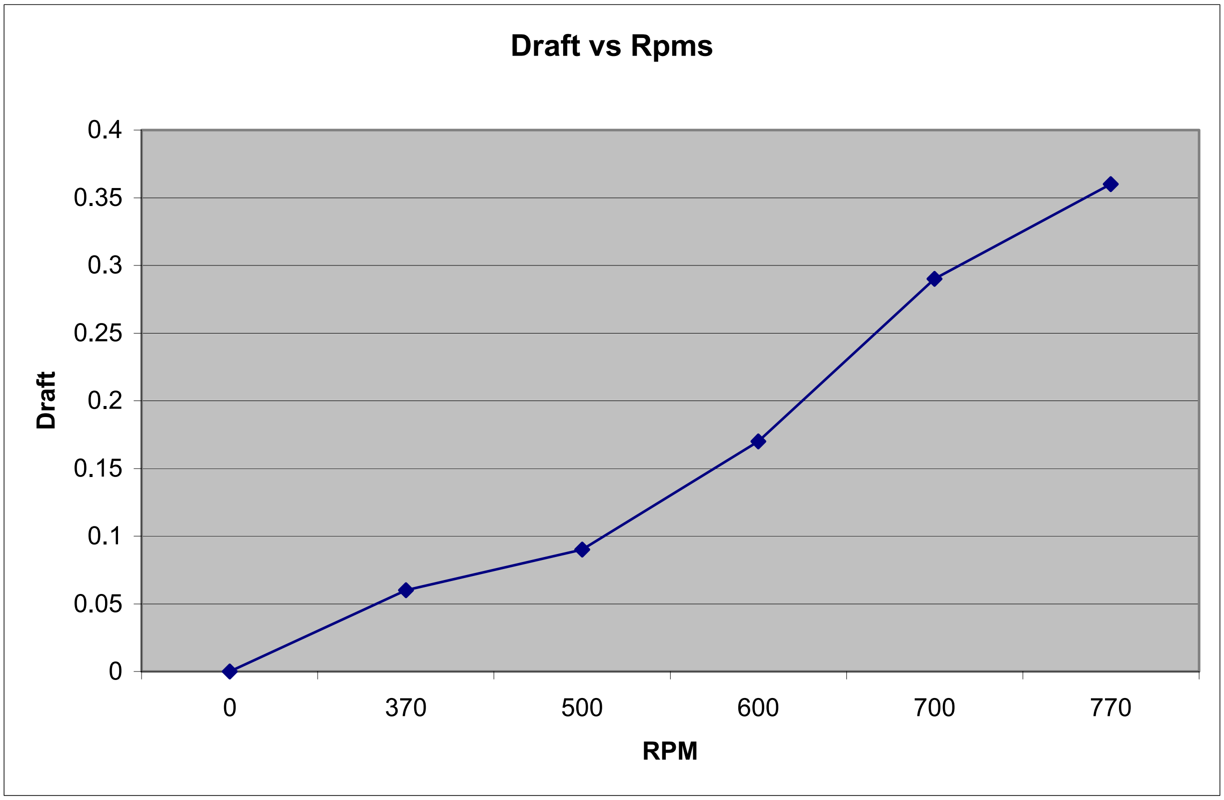


Procedure:

Lines were run northwest-southeast over a central area of interest with ½ mile runups at each end for the ship to settle into steady state motion. Each line was run in each direction at the same RPMs.

All MBES data was fully processed using standard procedures in Caris HIPS and SIPS 5.3, except that no dynamic draft was applied. Preliminary tides were applied. The average depth measured in the area for each line was computed and summarized in a spreadsheet. The depths and RPMs for each setting were averaged and the results summarized in the table below. These results compared relatively close to last years dynamic draft calculations.

Results:



RPM	Draft
0	0
370	0.06
500	0.09
600	0.17
700	0.29
770	0.36

Recommendations:

These results are adequate for correcting soundings for hydrographic surveys. Hydrographer recommends using these values for this 2004 field season.

Dynamic Draft Determination

NOAA Ship THOMAS JEFFERSON
June 2004

Purpose

The draft of a vessel changes with its speed. It is important to characterize this change, so that appropriate correctors can be applied to sounding data. By running a survey line over a relatively flat area at various RPM's, the dynamic draft of the vessel can be determined.

Procedure

Hydrographic data were acquired by the THOMAS JEFFERSON along a 0.5 nm long survey line in the area near Chesapeake Bay, along a 60' isobath. The ship acquired data at a single RPM in both directions along this line, for several different RPM's. Data was also acquired at the center of the line with the ship dead in the water at both the beginning and end of the trial.

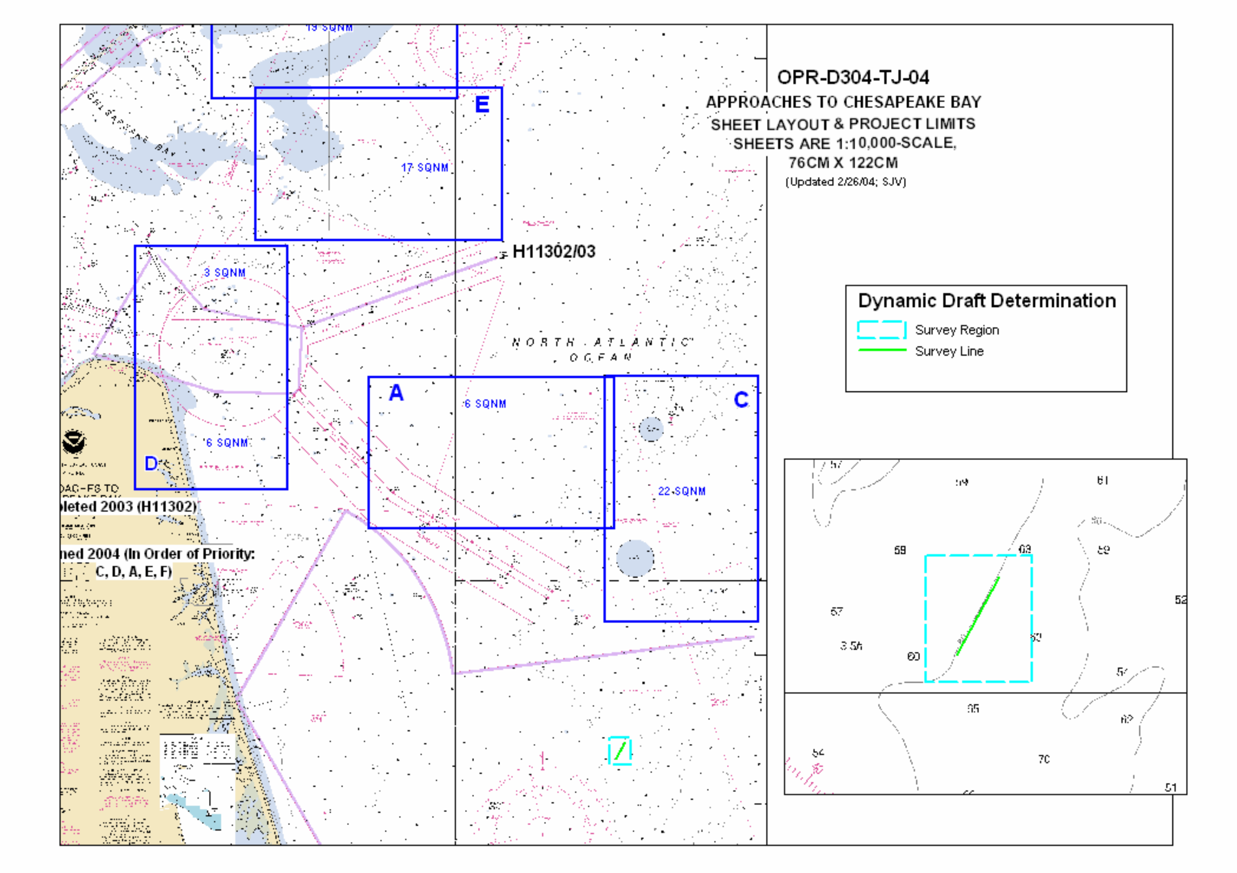


Figure 1: Dynamic Draft Line Plan

All data were processed in Caris HIPS & SIPS v.5.4. Preliminary tides were applied, but the dynamic draft correction in the vessel editor was turned off before merging the data. A field sheet was created for the area, as well as individual BASE surfaces for each RPM value. All of the BASE surface depth layers were overlaid and the depths were queried at ten different points along the line.

Created by: AST Keene

Results

The measured depth at a point for a given RPM was subtracted from the DIW depth at that point. The resulting value corresponded to the change in the draft of the vessel. The results, averaged over ten data points, are shown in Table 1 below. The values for the dynamic draft determined in March 2004 are also displayed in the table. Figure 2 is a plot of the dynamic draft for both data sets versus vessel speed.

RPM	*Speed (kts)*	*June 2004 Dynamic Draft (m)*	*March 2004 Dynamic Draft (m)*
360	5.7	0.28	0.06
500	7.75	0.35	0.09
600	9.4	0.36	0.17
700	10.9	0.45	0.29
760	11.15	0.47	0.36

Table 1: Comparison of Dynamic Draft Values

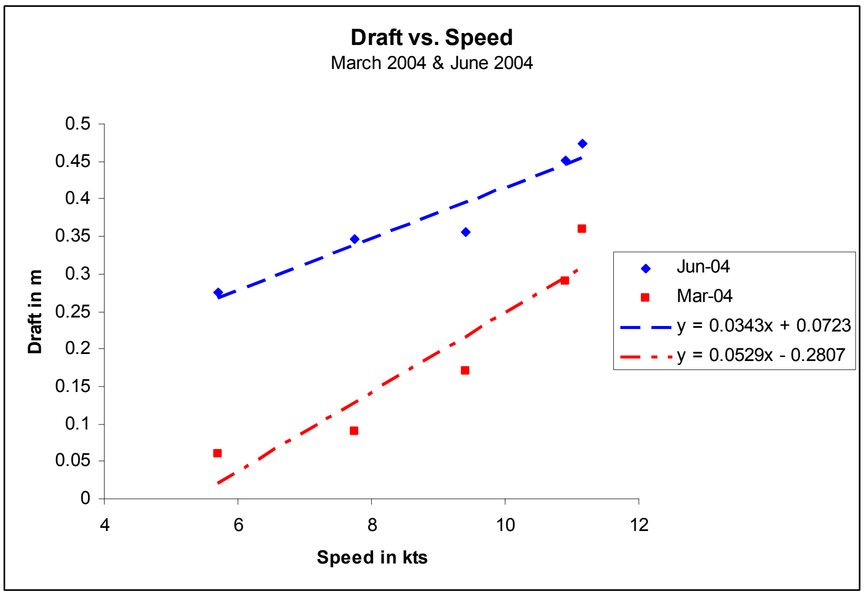


Figure 2: Change in Vessel Draft vs. Speed

Discussion

The change in vessel draft due to speed determined in the June 2004 calculations follows the same trend as the data from March 2004. The overall offset in values is likely due to the methods used in calculation. For the March data set, there were no DIW data, so the draft at zero RPM had to be extrapolated. This may have introduced an offset error into that data. The results of the June 2004 computations are believed to be accurate and should be applied as corrections to future hydrographic data acquired by the THOMAS JEFFERSON.

It should be noted that the dynamic draft of a vessel is highly dependent on many factors, including weight distribution and fuel consumption of the ship, as well as characteristics of the water, such as temperature, density and salinity. This test will need to be repeated and the dynamic draft recalculated whenever there is a change to any of the contributing factors.

Offset Confirmation Report

NOAA Ship THOMAS JEFFERSON 2004

SST Peter Lewit

On Feb 9 2004 while Thomas Jefferson was in drydock, Jacksonville Florida. Offsets were measured to confirm the NASA and NGS Measurements recorded in 2003. ENS Jasper Schaer and SST Peter Lewit conducted the survey. The ship had a 0.5-degree list to starboard, on average, and nothing perceptible fore and aft. Prior information obtained from marine engineering was helpful in conducting the survey.

1. The frames for the ship are not necessarily evenly spaced 24-25inches avg.
2. The frame with the number does not necessarily have to continue straight up
3. The frames that have watertight bulkheads or more specifically, that have watertight sliding doors must be continuous and the frame number does correspond.
4. Frames are welded on the inside <u>only</u>. Look for the double burn mark on the outside.
5. The Skin is welded on either or both sides. But never in close proximity to the frames.
6. The bulkhead between the survey room and the main passage way on the main deck is on the centerline.
7. There are two bench marks with a center punch on the keel near frame 20 and 79
8. There are two benchmarks (with a line inscribed fore and aft) on the port side under the ships bottom near frame 33 and 55.

While waiting for an opportunity to run levels preparation was made to check horizontal offsets. From the IMU location, frame 22, 34 and Centerline were measured. Identifying marks such as a steel square weld in the SSSV room that could be seen inside and outside the ship were used to establish the frame line under the hull. Frame 34 was established as well as the centerline and measurements taken to Simrad and 200 kHz transducers as well as the benchmarks.

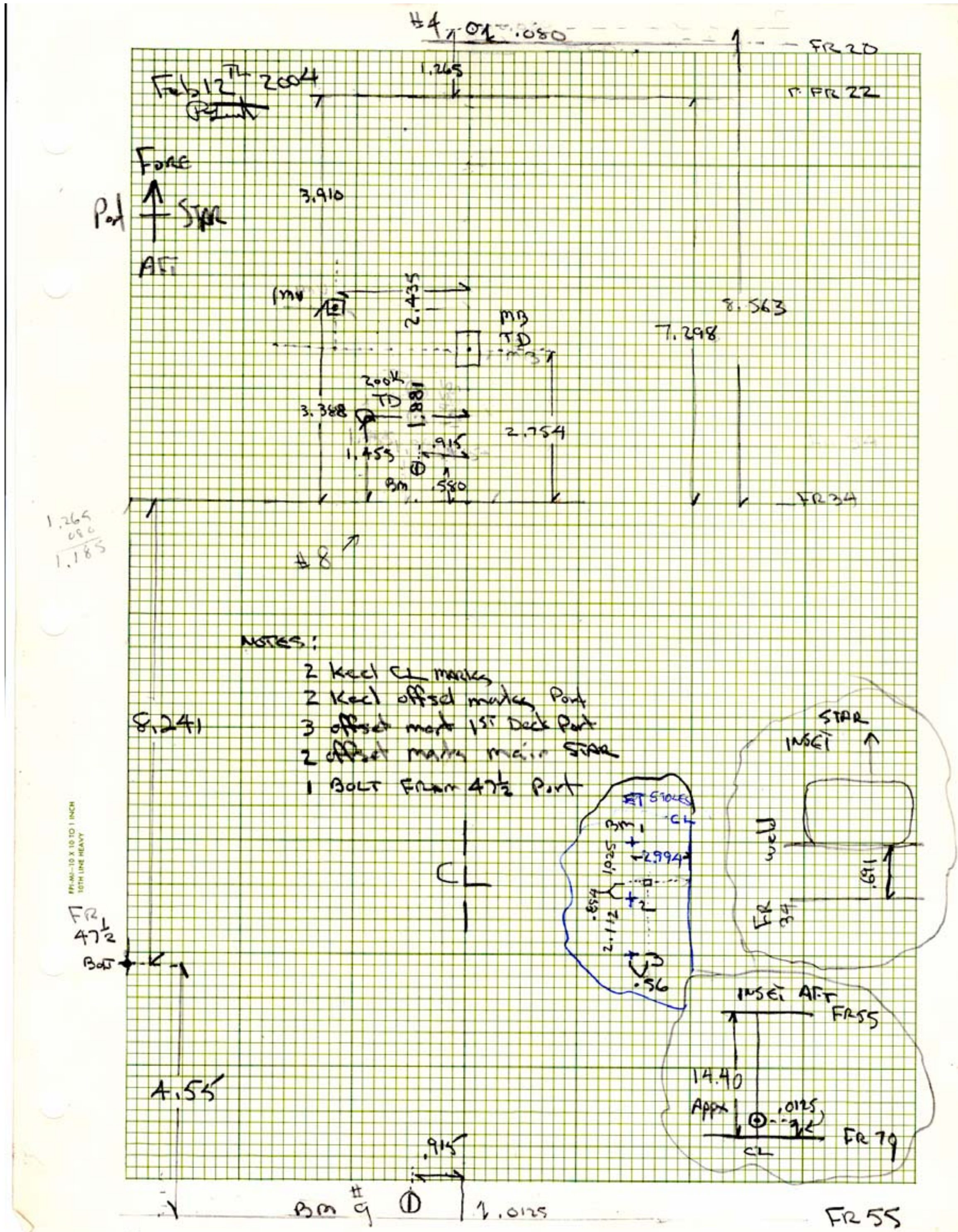
The second part of the survey was to establish vertical distance of the transducers (both the EM 1002 and the Odom transducers) to the IMU, using the reference point notches as an intermediary step in the measurement. A Leitz level and Philadelphia rod were used. The heights were brought to a point on the starboard side near the high point of a scupper. Then a tape was dropped plumb to a point on the drydock. From there the level was used again taking down shots to the two transducers and a benchmark. From there they were taken back to the scupper and up to the two notches. The bottom of the V notch was used as reference. At that point surveying ceased because of various ship work on the ship and near the IMU. One forward run was accomplished and differences in elevations were computed.

The results were compared to the original offset table and the horizontal and vertical differences for the key marks were less than or equal to .083 of a meter. The following tables and drawings define those results. This survey only confirms that no major changes have occurred. It was determined that the NASA survey used superior methods such as laser levels or total stations. The current offsets should remain in place with the exception of draft and waterline.

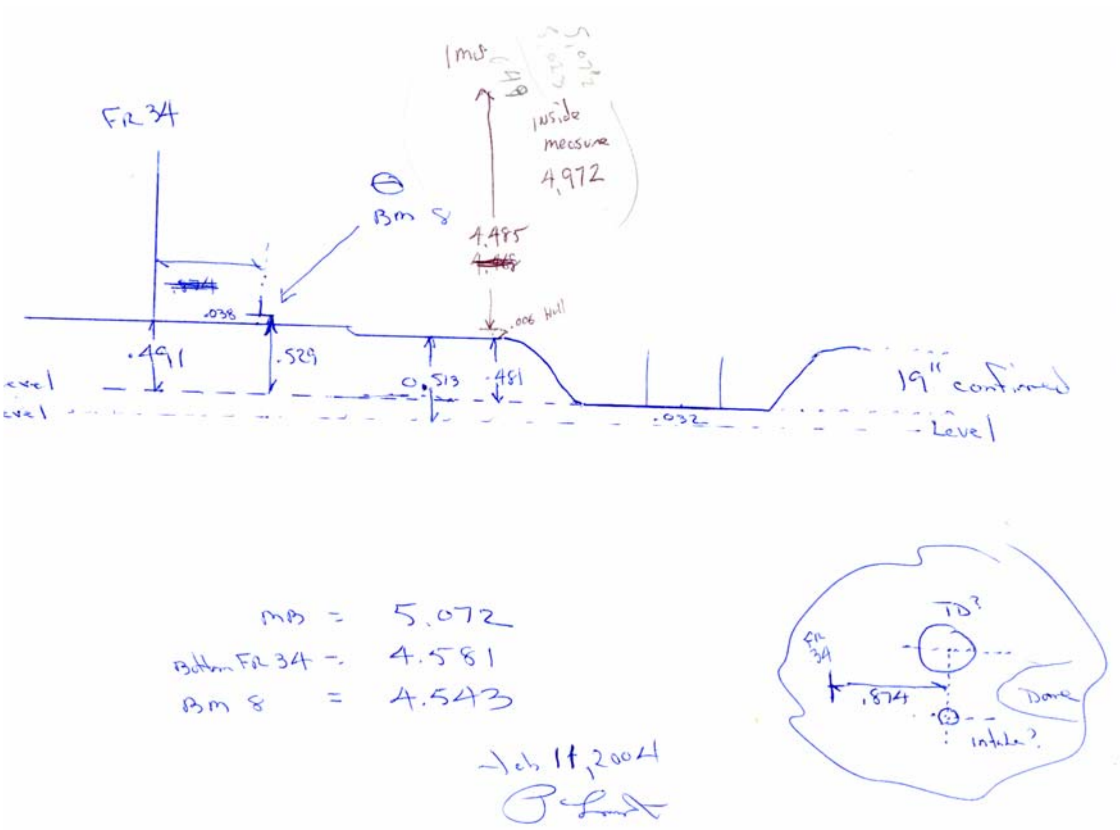
Visual inspection of Antennas and SSS block revealed no movement. Accessibility was a determining factor for tight measurements. The ship was not trim. Centimeter accuracy was not required for the block and was measured by tape. For the POS/MV antennas, a plumb line was dropped from the starboard antenna as well as a metric tape. The point was then measured to the centerline and the "IMU to CL" measurement added. The distance to the starboard notch was measured and that "IMU to notch" distance added. The port Antenna was on a 5 pointed star platform on the spoke perpendicular to the centerline. The starboard antenna was on the 2nd spoke clockwise from the Port antenna. The distance between the two antennas was measured at 1.5m and the Port Antenna position was computed using geometry. If antennas are upgraded a more detailed inspection will be required.

Items mentioned	NASA/NGS	TJ-04	Difference
EM 1002 TRANSDUCER	X= -0.56 Y= 2.384 Z= 5.153	X= - 0.632 Y= 2.435 Z= 5.072	-0.072 -0.051 0.081
200 kHz TRANSDUCER (IN EA 600 POD)	X= -1.902 Y= 0.494 Z= 4.980	X= -1.935 Y= 0.554 Z= 4.900	-0.033 -0.060 0.080
BENCHMARK # 2 (INTR. SCIENTIFIC STOREROOM)	X= -1.118 Y= -0.600 Z= 0.305	N/A N/A Z= 0.298	0.007
star Freeboard RP to imu	X= -0.357 Y= 8.925 Z= -7.720	N/A N/A Z= -7.681	0.039
port Freeboard RP to imu	X= -0.449 Y= -4.184 Z= -7.720	N/A N/A Z= -7.736	-0.016
Avg Freeboard to imu	Z= -7.720	Z= -7.708	0.012
Avg Freeboard RP to MB (ABS)	Z= 12.873	Z= 12.790	0.083
Avg Freeboard RP to VB 200 kHz (ABS)	Z= 12.700	Z= 12.618	0.082
SSS block Rough	X= -42.553 Y= 6.374 Z= - 4.797	X= -42.700 Y= 6.702 Z= - 5.145	-0.147 -0.328 -0.348
Tasman 1 Port Rough	X= -9.397 Y= 3.347 Z= -25.728	X= -9.671 Y= 3.640 Z= -25.454	0.397 -0.266 0.274
Tasman 2 Star Rough	X= -8.894 Y= 4.764 Z= -25.731	X= -8.790 Y= 4.840 Z= -25.454	0.104 -0.076 0.277

Work sheet notes



CloseUP EM1002 TRANSDUCER



1005 Static Draft Determination
SST Peter Lewit

NOAA Ship *THOMAS JEFFERSON* 2004 DN 86

Background

The purpose of a static draft measurement is to correct for the difference in distance from the waterline to the transducer face. It also accounts for the long-term differences in loading due to fuel, water and supplies. In our current software the term draft is not used. The Z value of the transducer below the Inertial Motion Unit (IMU) and the waterline will give the surveying draft of the vessel. The term waterline is the distance from the waterline to the IMU.

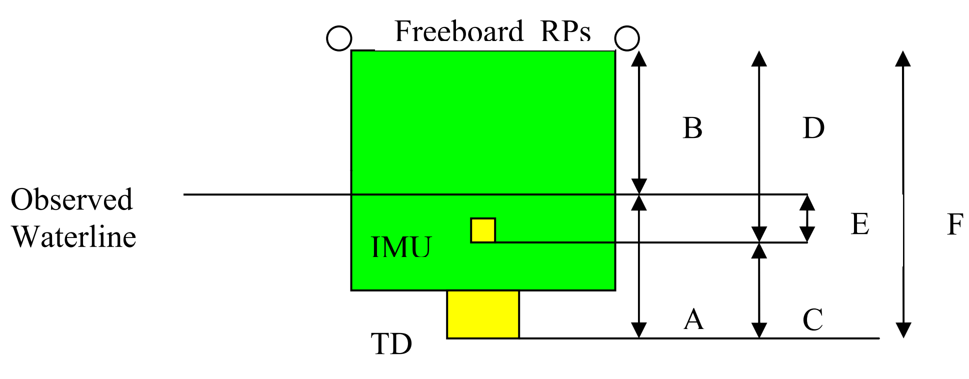
The current configuration for the ship has the Position at the IMU. The offsets for SVP pole to waterline are entered. The following diagram displays one set of distances, the measured Freeboard Reference Points (RP's), Observed Waterline, IMU, and the transducer (TD). The values will change depending on which transducer, MBES or VBES, is used. The values of C, D and F are known constants from the offset table. When the unknown B is found the sought values of A, the draft, and E, the Caris Waterline, can be found. The Caris Waterline is the same for Vertical beam and Multibeam as the Transducer to IMU offsets are known.

Location

Static draft measurements were performed at the following location.

March 26, 2004 (DN086) Chesapeake Bay, VA.

Procedure



The method used is to take simultaneous readings of the distance from the freeboard RPs to the observed waterline. This value can be entered into the offset table and the Static draft form. The formula for Caris Waterline is

E = D – (Port RP reading + Star RP Reading/2)

The formula for MB and VB Draft is

A = F - B

The constants are as follows

RP(notch) to IMU= **1.22** RP to TD **= 1.56** IMU to TD(transducer)= **0.34**

Results

The following table shows the waterline and draft measurements at the time of survey and the adjustments to be made according to the type of system configuration

Static Readings and Aquisition Entry's

YR	DN	VCF DN	Method	MB Static Draft	Pos MV Z	Reson 8101 Z	Reson Waterlevel
2004	086	086	leadline	0.34	-0.34	0.34	-0.32

Preliminary VCF Draft Waterline Entries

	DN Draft	VCF	Adjustments	Swath offsets Z	Apply Flag	Velocity Applied	Caris Waterline/Projected
2004	086	076	N/A	0	y	y	-0.32

.The following Drafts are provided for Velocity and Leadline comparison

VB Draft 200kHz	0.32
VB Draft 24 kHz	0.32
MB Draft	0.34
Waterline MB and VB (should be same)	-0.32

Recommendations for Use:

These results are adequate for correcting soundings for hydrographic surveys.
Performed by:
Peter Lewit
Senior Survey Technician
NOAA Ship THOMAS JEFFERSON

NOAA SHIP THOMAS JEFFERSON

Survey Launch 1005
Dynamic Draft Determination

ENS Jasper Schaer

Background:

This method of determining the dynamic draft of a vessel involves running successive lines over a flat bottom at different RPM. At the time of this trial, no Real Time Kinematic GPS equipment was available for dynamic draft and it was not deemed practical to use a level rod.

Location, Date, and Personnel:

The trial was conducted in southern Chesapeake Bay-Elizabeth River Channel on a broad, flat area of seafloor approximately one-half NM south of Lambert's Point Norfolk, VA on 29 March, 2004 (DN 089) by ENS Jasper Schaer.

Procedure:

Lines were run northwest-southeast over a central area of interest with DIW at the start of the line then brought up to a specified RPM. Each line was run in each direction at the same RPM.

Results:

Launch 1005 had problems with the POS/MV on DN089. Launch 1005 was unable to complete the dynamic draft determination before the end of the day, once the POS/MV started working.

Recommendations:

The Hydrographer recommends using the dynamic draft values from 2002 until a dynamic draft determination on Launch 1005 can be performed properly.

1014 Static Draft VB Determination
ENS Jasper Schaer
AST Jennifer Keene

NOAA Ship *THOMAS JEFFERSON* 2004 DN 117

Background

The purpose of a static draft measurement is to correct for the difference in distance from the waterline to the transducer face. It also accounts for the long-term differences in loading due to fuel, water and supplies. In our current software the term draft is not used. The Z value of the transducer below the Inertial Motion Unit (IMU) and the waterline will give the surveying draft of the vessel. The term waterline is the distance from the waterline to the IMU.

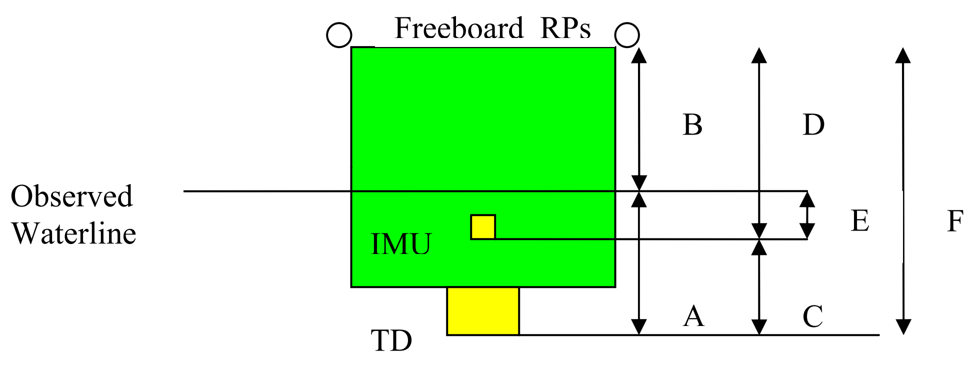
The current configuration for the ship has the Position at the IMU. The offsets for SVP pole to waterline are entered. The following diagram displays one set of distances, the measured Freeboard Reference Points (RP's), Observed Waterline, IMU, and the transducer (TD). The values will change depending on which transducer, MBES or VBES, is used. The values of C, D and F are known constants from the offset table. When the unknown B is found the sought values of A, the draft, and E, the Caris Waterline, can be found. The Caris Waterline is the same for Vertical beam and Multibeam as the Transducer to IMU offsets are known.

Location

Static draft measurements were performed at the following location.

April 26, 2004 (DN117) Altamira, Mexico.

Procedure



The method used is to take simultaneous readings of the distance from the freeboard RPs to the observed waterline. The formula for Caris Waterline is

$$E = D - (\text{Port RP reading} + \text{Star RP Reading}/2)$$

The formula for MB and VB Draft is

$$A = F - B$$

The constants are as follows

RP(notch) to IMU (D) = **1.21** RP to TD (F) **= 1.69** IMU to TD(C)= **0.48**

Results

The following values shows the waterline and draft measurements at the time of survey.

Static Readings and Aquisition Entry's

YR	DN	VCF DN	Method	MB Static Draft	Pos MV Z	Reson 8125 Z	Reson 8125 Waterlevel
2004	117	117	leadline	0.48	-0.48	0.48	-0.41

Recommendations for Use:

These results are adequate for correcting soundings for hydrographic surveys.

Survey Launch 1014
Dynamic Draft Determination

ENS Jasper Schaer

Background:

The draft of a vessel changes with its speed. It is important to characterize this change, so that appropriate correctors can be applied to sounding data. By running a survey line over a relatively flat area at various RPM's, the dynamic draft of the vessel can be determined.

Location, Date, and Personnel:

The trial was conducted in southern Chesapeake Bay-Elizabeth River Channel approximately one-half NM south of Lambert's Point Norfolk, VA on 31 March, 2004 (DN 089) by ENS Jasper Schaer.

Procedure:

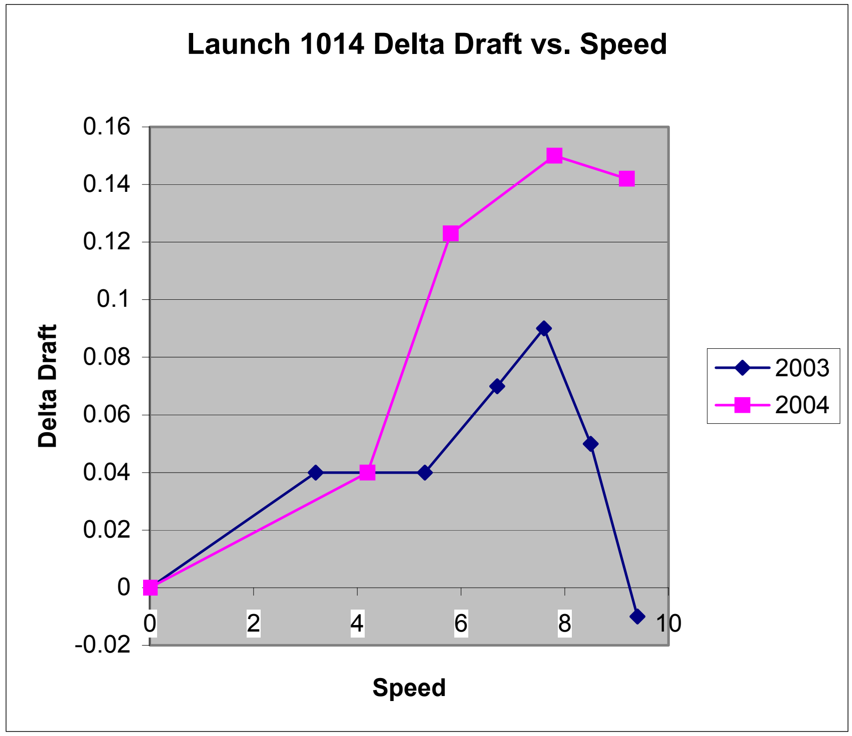
Hydrographic data were acquired by Launch 1014 along a survey line on a broad, flat area of seafloor. The launch acquired data at a single RPM in both directions along this line, for several different RPM's. Data was also acquired with the launch dead in the water at both the beginning and end of the trial.

All data were processed in Caris HIPS & SIPS v.5.4. Preliminary tides were applied, but the dynamic draft correction in the vessel editor was turned off before merging the data. A field sheet was created for the area, as well as individual BASE surfaces for each RPM value. All of the BASE surface depth layers were overlaid and the depths were queried at ten different points along the line.

The measured depth at a point for a given RPM was subtracted from the DIW depth at that point. The resulting value corresponded to the change in the draft of the vessel. The results, averaged over ten data points, are shown in the table below. The following plot compares the values obtained from this year with those obtained in 2003.

Results:

RPM	draft
0	0
750	.04
1000	.123
1500	.15
2000	.142



Recommendations:

The 2003 dynamic results are of unknown origin but were most likely done optically via level rod. These 2004 dynamic draft values supercede the previous dynamic draft values obtained. These results should be used until such an event warrants a new calibration.

APPENDIX III

- NOAA Ship THOMAS JEFFERSON Sensor Calibration Report 2004
- Odom Digibar Calibration Report
- Applied Microsystems Smart Sound Velocity & Temperature Probe Calibration
- Seabird SBE 19 0285 Calibration Report
- Seabird SBE 19 plus 4486 Calibration Report
- Seabird SBE 19 plus 4487 Calibration Report
- Leadline Calibration Reports

NOAA Ship THOMAS JEFFERSON
Sensor Calibration Report 2004

Model	Serial number	Last Date Calibrated
Odom Digibar Pro Surface Sound Velocity Sensor	98130-120403	12/4/2003
AML Smart SV and Temperature Surface Sound Velocity Sensor	4823	12/5/2003
Seabird SBE 19	0285	12/3/2003
SBE 19 Seacat Plus CTD	4486	9/10/2003
SBE 19 Seacat Plus CTD	4487	9/19/2003

odom
HYDROGRAPHIC SYSTEMS

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

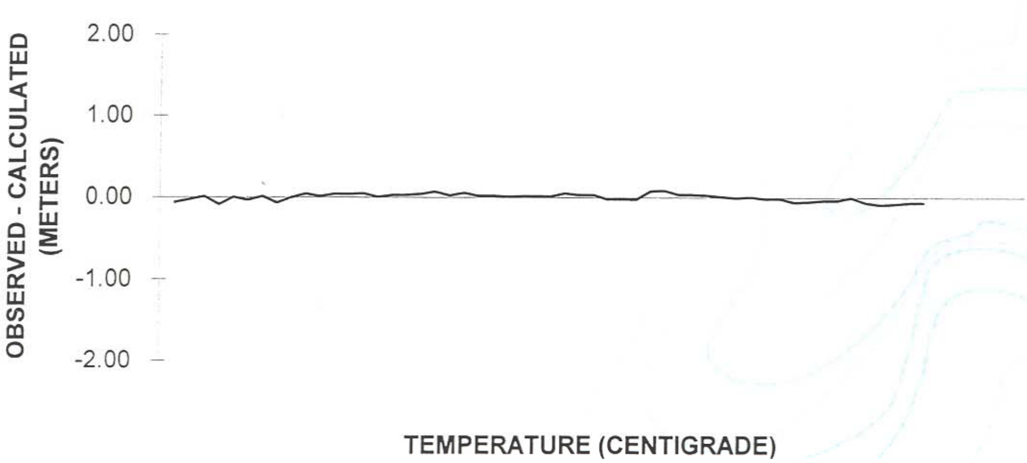
12/4/2003 STANDARD DEL GROSSO H2O SERIAL# 98130-120403

TEMP	VELOCITY	MEASURED FREQUENCY	RES VEL	OBS-CAL
4.0	1421.62	5546.9	1421.6	-0.06
4.5	1423.90	5555.9	1423.9	-0.03
5.0	1426.15	5564.9	1426.2	0.01
5.5	1428.38	5573.2	1428.3	-0.09
6.0	1430.58	5582.1	1430.6	0.00
6.5	1432.75	5590.4	1432.7	-0.03
7.0	1434.90	5599.0	1434.9	0.01
7.5	1437.02	5607.0	1437.0	-0.06
8.0	1439.12	5615.4	1439.1	0.00
8.5	1441.19	5623.7	1441.2	0.05
9.0	1443.23	5631.5	1443.2	0.01
9.5	1445.25	5639.5	1445.3	0.04
10.0	1447.25	5647.3	1447.3	0.04
10.5	1449.22	5655.0	1449.3	0.05
11.0	1451.17	5662.5	1451.2	0.01
11.5	1453.09	5670.1	1453.1	0.03
12.0	1454.99	5677.5	1455.0	0.03
12.5	1456.87	5684.8	1456.9	0.04
13.0	1458.72	5692.2	1458.8	0.07
13.5	1460.55	5699.1	1460.6	0.03
14.0	1462.36	5706.3	1462.4	0.06
14.5	1464.14	5713.1	1464.2	0.02
15.0	1465.91	5720.0	1465.9	0.03
15.5	1467.65	5726.7	1467.7	0.01
16.0	1469.36	5733.5	1469.4	0.02
16.5	1471.06	5740.1	1471.1	0.02
17.0	1472.73	5746.6	1472.7	0.02

TEMP	VELOCITY	MEASURED FREQUENCY	RES VEL	OBS-CAL
17.5	1474.38	5753.2	1474.4	0.05
18.0	1476.01	5759.5	1476.0	0.03
18.5	1477.62	5765.8	1477.7	0.04
19.0	1479.21	5771.7	1479.2	-0.02
19.5	1480.77	5777.9	1480.8	-0.02
20.0	1482.32	5783.9	1482.3	-0.02
20.5	1483.84	5790.2	1483.9	0.08
21.0	1485.35	5796.1	1485.4	0.09
21.5	1486.83	5801.7	1486.9	0.03
22.0	1488.29	5807.4	1488.3	0.04
22.5	1489.74	5813.0	1489.8	0.03
23.0	1491.16	5818.5	1491.2	0.01
23.5	1492.56	5823.9	1492.6	0.00
24.0	1493.95	5829.4	1494.0	0.01
24.5	1495.32	5834.6	1495.3	-0.01
25.0	1496.66	5839.9	1496.6	-0.01
25.5	1497.99	5844.9	1497.9	-0.06
26.0	1499.30	5850.0	1499.2	-0.05
26.5	1500.59	5855.1	1500.6	-0.04
27.0	1501.86	5860.1	1501.8	-0.04
27.5	1503.11	5865.1	1503.1	0.00
28.0	1504.35	5869.7	1504.3	-0.06
28.5	1505.56	5874.3	1505.5	-0.09
29.0	1506.76	5879.0	1506.7	-0.07
29.5	1507.94	5883.7	1507.9	-0.06
30.0	1509.10	5888.2	1509.0	-0.06

constants: 3281 1

CALIBRATION GRAPH



APPLIED MICROSYSTEMS Because it's not just H_2O

Certificate of Calibration

Customer: NOAA

Reference: Job#: 3991 PO#: Credit Card

Part No: Smart SV & Temperature

Serial No: 4823

Comments: This unit has been fitted with a new SV sensor and a full calibration.

Alan Roblin

Date: Dec 5 2003

Alan Roblin

Technologist

APPLIED MICROSYSTEMS LTD. CERTIFIES THAT THE ABOVE DESCRIBED EQUIPMENT HAS BEEN CALIBRATED WITH EQUIPMENT REFERENCED TO TRACEABLE STANDARDS. ANY REPAIRS/CALIBRATIONS PERFORMED ON THIS INSTRUMENT WERE APPROVED BY THE CONTRACT/PURCHASE ORDER NAMED ABOVE.

Calibration Coefficients
Smart SV & Temperature 4823

12-05-2003

NOAA

NOTE: This instrument has been re-calibrated. Please update your records and any post-processing software you may be using.

Applied Microsystems Ltd.

2071 Malaview Ave. West, Sidney, British Columbia, Canada V8L 5X6

Phone: (250) 656-0771   Fax: (250) 655-3655

Canada & USA: 800-663-8721

Email: info@AppliedMicroSystems.com Web: http://www.aml.bc.ca

Smart SV & Temperature 4823

Smart SV Calibration

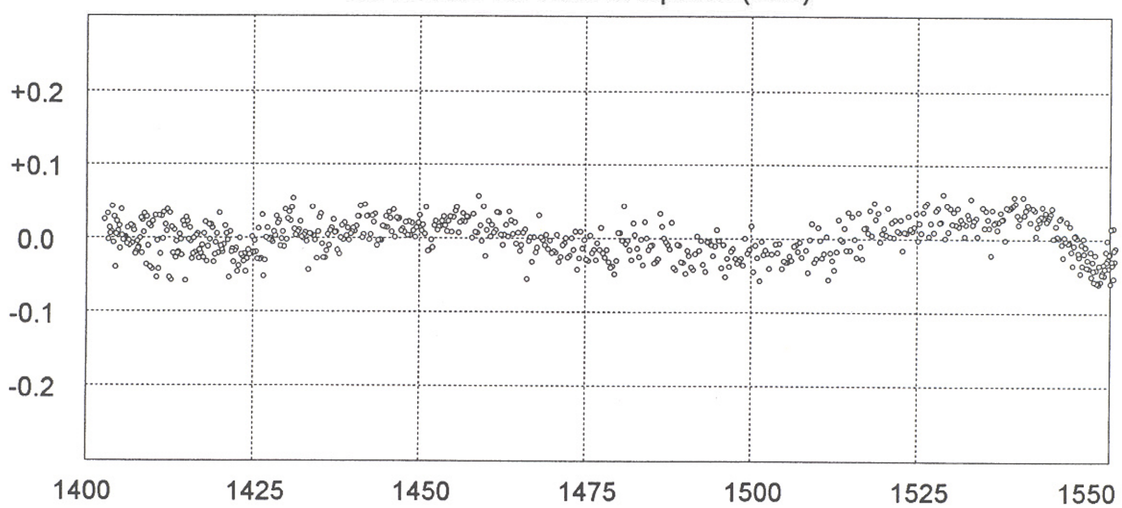
Job Information

Date	12-04-2003
Job Number	3991
Customer	NOAA

Sensor Information

Manufacturer	AML
Model Number	Time of Flight
Serial Number	152-9
Range	1400 to 1570 m/s
Channel	2
Calibrated By	AR
Standards	Smart T 9998

Deviation vs. Sound Speed (m/s)



Delgrosso Pure Water Sound Speed (m/s)

Coefficients

A = 1.525900E+03
B = -1.072045E+02
C = 9.117854E+00
D = -1.165074E+00

=A+B*((N-NL)/(NH-NL))+C*((N-NL)/(NH-NL))^2+D*((N-NL)/(NH-NL))^3

RMS = 0.0253

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Smart SV & Temperature 4823

Smart Temperature Calibration

Job Information

Date	12-03-2003
Job Number	3991
Customer	NOAA

Sensor Information

Manufacturer	YSI/AML
Model Number	Type E
Serial Number	125-1
Range	-2 to +45 Deg C
Channel	1
Calibrated By	AR
Standards	Hart/T2128

Calibration Data

Raw	Standard
52072	45.052
49502	40.060
46614	35.034
43471	30.049
40082	25.038
36524	20.023
32877	15.043
29219	10.055
25591	4.974
22266	0.097
21744	-0.712

Coefficients

A = -4.893039E+01
B = 3.146134E-03
C = -5.488447E-08
D = 5.589575E-13

=A+B*Raw+C*Raw^2+D*Raw^3

RMS = 0.0358

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APPLIED MICROSYSTEMS

Because it's not just H_2O

Diagnostics Summary

Date	11/24/2003	***Customer***	Kongsberg Simrad Inc. --- Lynnwoo
Instrument	Smart SV & Temperatu	***Last Calibration***	3/25/2003
Serial Number	4823	***Checked By***	AR
Job #	3991		

Reasons for return Diagnostics

General Condition Fair

Visual Inspection

Case Parts	OK	***Plugs***	N/A	***Conductivity***	N/A
Zincs	FAIL	***Bulkhead Conn.***	OK	***Pressure***	N/A
O-Rings	OK	***Cables***	N/A	***Temperature***	OK
Sound Velocity	OK	***Battery Pack***	N/A	***Conductance - Zincs***	OK
Cond. - Electronics	OK	***Electronics***	OK	***Battery Charger***	N/A
Blue Box	N/A				

Operational Tests

Battery Voltage		***Communication***	OK	***Cable Connections***	OK
Sensors	OK	***Charger***	N/A	***BlueBox***	N/A
Calibration Check	OK				

Temperature	15.0402	15.095	0.055	***Deg C***
Conductivity			0.000	***mS/cm***
Sound Vel.	1470.73	1470.1	-0.58	***m/s***
Pressure			0.00	

Summary

Unit is in good working order.

Recommendations

full calibration and new zinc

In-Situ Real-Time Detection Measurement

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EMAIL **sales@appliedmicrosystems.com**
**VISIT OUR WEBSITE AT:http://www.appliedmicrosystems.com

SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

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

SENSOR SERIAL NUMBER: 0285
CALIBRATION DATE: 03-Dec-03

SBE19 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Seimens/meter

GHIJ COEFFICIENTS

```
g =  -4.07176800e+000
h =   4.85945520e-001
i =   1.12104725e-003
j =  -1.71446693e-005
CPcor =  -9.5700e-008  (nominal)
CTcor =   3.2500e-006  (nominal)
```

ABCDM COEFFICIENTS

```
a =   4.99108391e-003
b =   4.79541339e-001
c =  -4.06130242e+000
d =  -9.25431384e-005
m =   2.5
CPcor =  -9.5700e-008  (nominal)
```

BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2.88550	0.00000	0.00000
1.0000	34.8510	2.97865	8.27829	2.97855	-0.00010
4.5000	34.8297	3.28586	8.64335	3.28597	0.00011
15.0000	34.7856	4.26825	9.71682	4.26831	0.00007
18.5000	34.7764	4.61365	10.06644	4.61354	-0.00011
24.0000	34.7667	5.17206	10.60727	5.17209	0.00002
29.0000	34.7620	5.69443	11.08874	5.69441	-0.00002
32.5000	34.7612	6.06747	11.41998	6.06748	0.00002

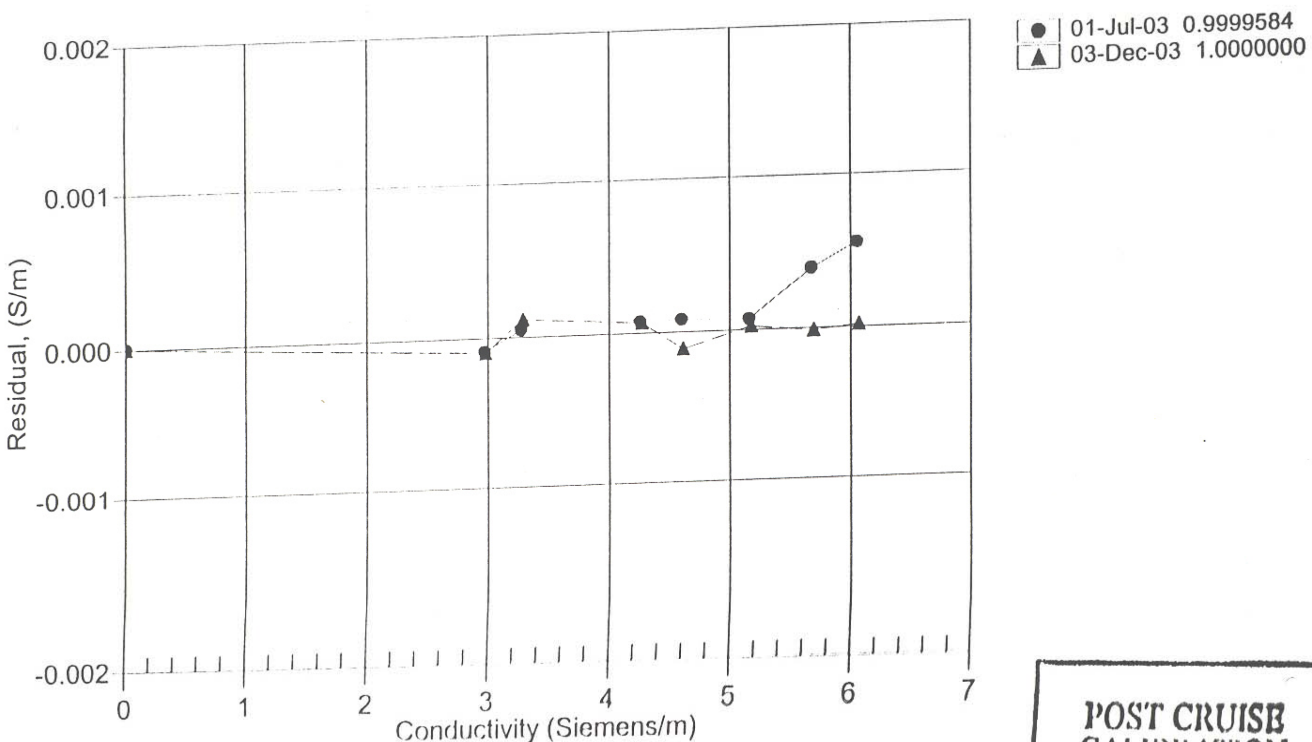
Conductivity = $(g + hf^2 + if^3 + jf^4) / 10(1 + \delta t + \epsilon p)$ Siemens/meter

Conductivity = $(af^m + bf^2 + c + dt) / [10 (1 + \epsilon p)$ Siemens/meter

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

Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients

Date, Slope Correction



POST CRUISE CALIBRATION

SBE SEA-BIRD ELECTRONICS, INC.
1808 - 136th Place Northeast, Bellevue, Washington 98005 USA
Phone: (425) 643-9866 Fax: (425) 643-9954 www.seabird.com

Conductivity Calibration Report

Customer:	Atlantic Marine Center		
Job Number:	34295	**Date of Report:**	12/3/2003
Model Number	SBE 19	**Serial Number:**	192472-0285

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

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

'AS RECEIVED CALIBRATION' ☑ Performed ☐ Not Performed

Date: 12/3/2003 Drift since last cal: -.00020 PSU/month*

Comments:

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

Date: Drift since Last cal: PSU/month*

Comments:

**Measured at 3.0 S/m*

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

SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0285
CALIBRATION DATE: 03-Dec-03

SBE19 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPRATURE SCALE

ITS-90 COEFFICIENTS

```
g =   4.12407283e-003
h =   5.72551828e-004
i = -3.35898943e-006
j = -3.82789231e-006
f0 = 1000.0
```

ITS-68 COEFFICIENTS

```
a =   3.64764822e-003
b =   5.70329124e-004
c =   6.21709422e-006
d = -3.82799637e-006
f0 = 2297.659
```

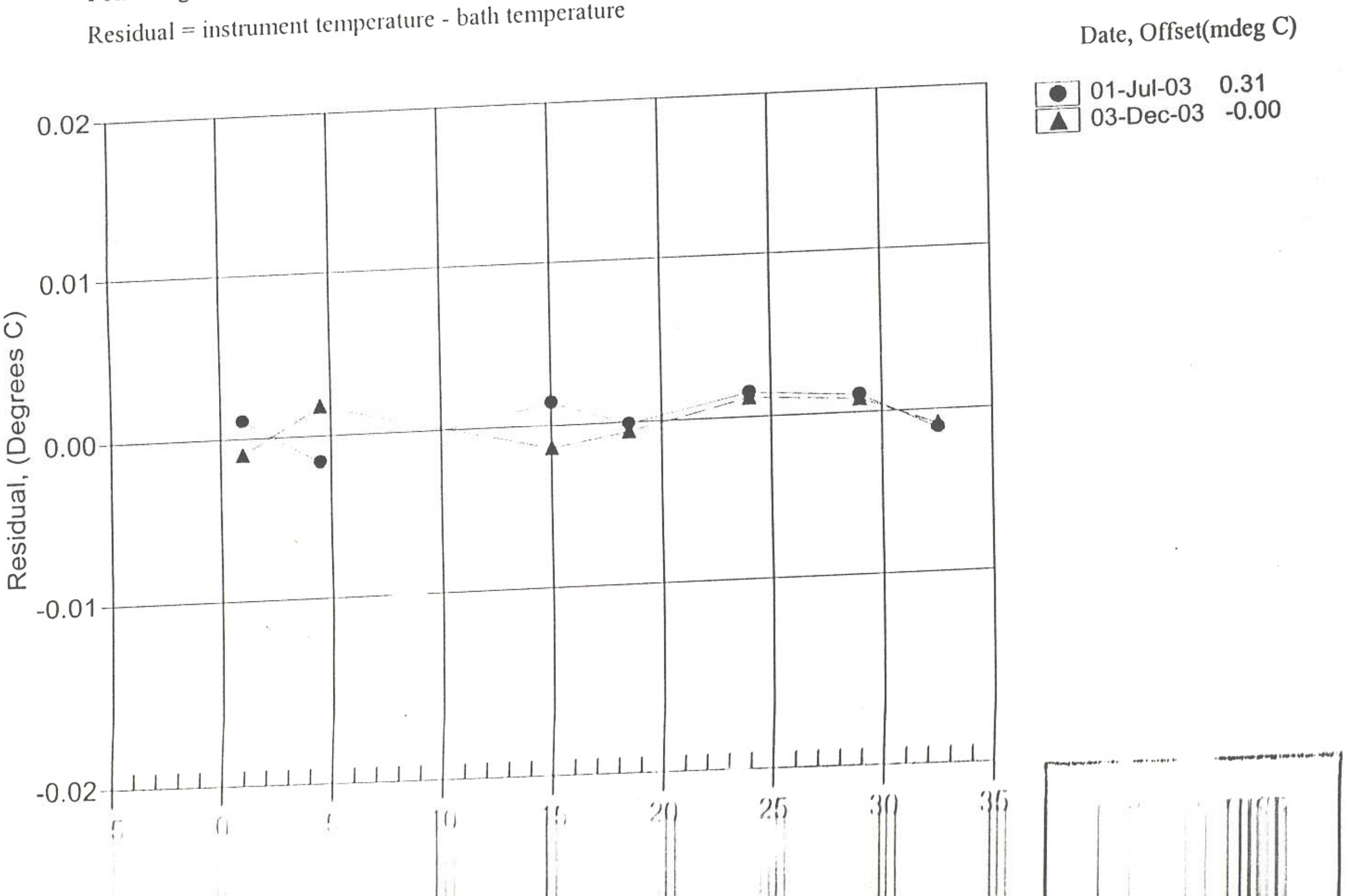
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	2297.659	0.9990	-0.00100
4.5000	2490.969	4.5018	0.00183
15.0000	3139.173	14.9986	-0.00140
18.5000	3379.605	18.4994	-0.00059
24.0000	3783.419	24.0012	0.00118
29.0000	4179.022	29.0008	0.00083
32.5000	4472.694	32.4991	-0.00086

Temperature ITS-90 = $1/\{g + h[ln(f_0/f)] + i[ln^2(f_0/f)] + j[ln^3(f_0/f)]\} - 273.15$ (°C)

Temperature ITS-68 = $1/\{a + b[ln(f_0/f)] + c[ln^2(f_0/f)] + d[ln^3(f_0/f)]\} - 273.15$ (°C)

Following the recommendation of JPOTS: T_{68} is assumed to be 1.00024 * T_{90} (-2 to 35 °C)

Residual = instrument temperature - bath temperature



SBE SEA-BIRD ELECTRONICS, INC.
1808 - 136th Place Northeast, Bellevue, Washington 98005 USA
Phone: (425) 643-9866 Fax: (425) 643-9954 www.seabird.com

Temperature Calibration Report

Customer:	Atlantic Marine Center		
Job Number:	34295	Date of Report:	12/3/2003
Model Number	SBE 19	Serial Number:	192472-0285

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

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

'AS RECEIVED CALIBRATION'

☑ Performed ☐ Not Performed

Date: 12/3/2003

Drift since last cal: -.00073 Degrees Celsius/year

Comments:

'CALIBRATION AFTER REPAIR'

☐ Performed ☑ Not Performed

Date:

Drift since Last cal: Degrees Celsius/year

Comments:

SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0285
CALIBRATION DATE: 08-Dec-03

SBE19 PRESSURE CALIBRATION DATA
5000 psia S/N 133807 TCV: -121

QUADRATIC COEFFICIENTS:
PA0 = 2.492570e+003
PA1 = -6.503588e-001
PA2 = -6.635612e-008

STRAIGHT LINE FIT:
M = -6.503540e-001
B = 2.492112e+003

PRESSURE PSIA	INST OUTPUT(n)	COMPUTED PSIA	ERROR %FS	LINEAR PSIA	ERROR %FS
14.71	3807.2	15.55	0.02	16.07	0.03
1014.88	2272.2	1014.50	-0.01	1014.40	-0.01
2015.06	735.8	2014.01	-0.02	2013.59	-0.03
3015.11	-803.2	3014.91	-0.00	3014.49	-0.01
4015.31	-2341.7	4015.17	-0.00	4015.06	-0.00
5015.41	-3880.2	5015.10	-0.01	5015.62	0.00
5015.41	-3880.2	5015.10	-0.01	5015.62	0.00
4015.24	-2343.1	4016.03	0.02	4015.92	0.01
3015.10	-805.8	3016.55	0.03	3016.14	0.02
2015.05	734.9	2014.59	-0.01	2014.17	-0.02
1014.85	2271.5	1014.96	0.00	1014.86	0.00
14.67	3809.1	14.31	-0.01	14.84	0.00

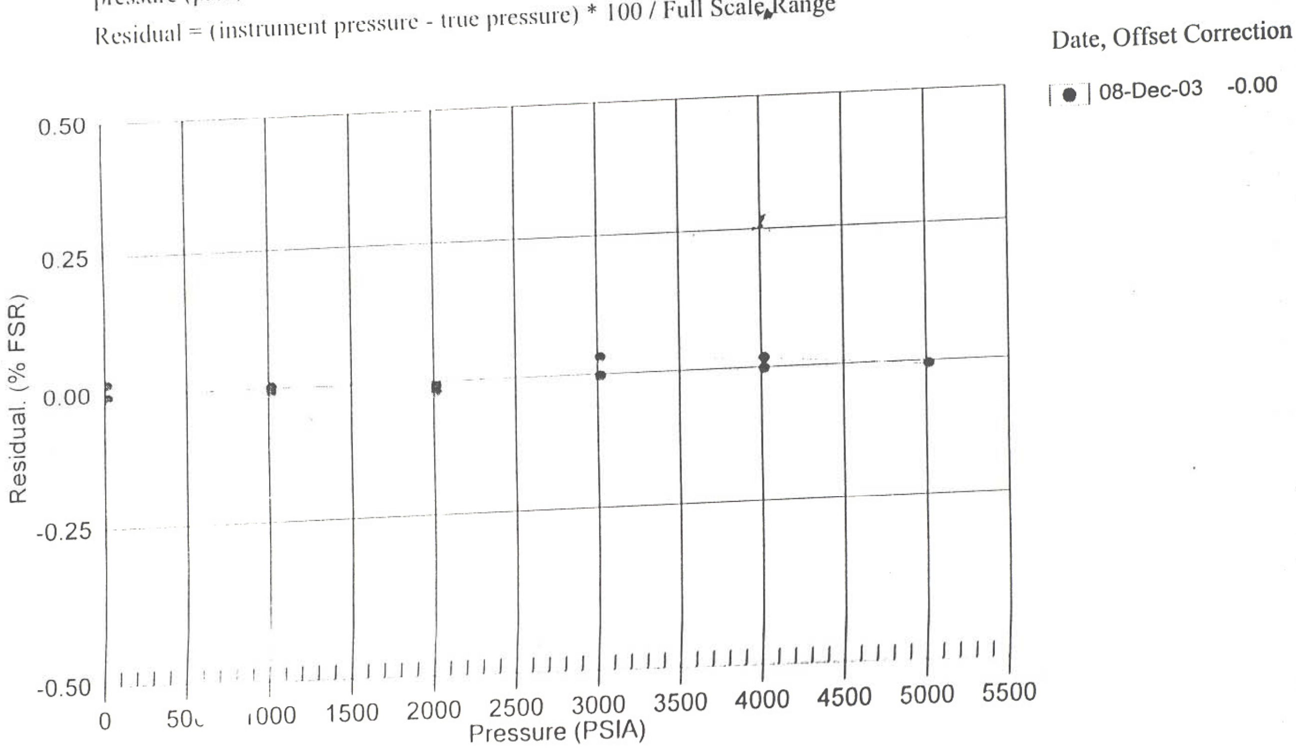
Straight Line Fit:

Pressure (psia) = M * N + B (N = binary output)

Quadratic Fit:

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

Residual = (instrument pressure - true pressure) * 100 / Full Scale Range



SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

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

SENSOR SERIAL NUMBER: 4486
CALIBRATION DATE: 10-Sep-03

SBE19plus PRESSURE CALIBRATION DATA
508 psia S/N 2799

COEFFICIENTS:

PA0 = 4.343834e-003
PA1 = 1.547740e-003
PA2 = 6.820772e-012
PTEMPA0 = -7.441230e+001
PTEMPA1 = 4.735896e+001
PTEMPA2 = 2.388068e-002

PTCA0 = 5.248572e+005
PTCA1 = 9.376601e-001
PTCA2 = -3.909727e-002
PTCB0 = 2.468737e+001
PTCB1 = -7.250000e-004
PTCB2 = 0.000000e+000

PRESSURE SPAN CALIBRATION

PRESSURE PSIA	INST OUTPUT	THERMISTOR OUTPUT	COMPUTED PRESSURE	ERROR %FSR
14.65	534278.0	2.0	14.59	-0.01
99.69	589177.0	2.0	99.65	-0.01
199.67	653674.0	2.0	199.62	-0.01
299.65	718159.0	2.0	299.63	-0.00
404.63	785812.0	2.0	404.62	-0.00
504.62	850211.0	2.0	504.62	-0.00
504.62	850211.0	2.0	504.62	-0.00
404.63	785830.0	2.0	404.65	0.00
299.64	718179.0	2.0	299.67	0.00
199.64	653709.0	2.0	199.68	0.01
99.65	589204.0	2.0	99.69	0.01
14.55	534292.0	2.0	14.61	0.01

THERMAL CORRECTION

TEMP ITS90	THERMISTOR OUTPUT	INST OUTPUT
32.50	2.25	534432.43
29.00	2.18	534434.28
24.00	2.08	534444.93
18.50	1.96	534440.94
15.00	1.89	534450.93
4.50	1.67	534446.26
1.00	1.59	534442.25

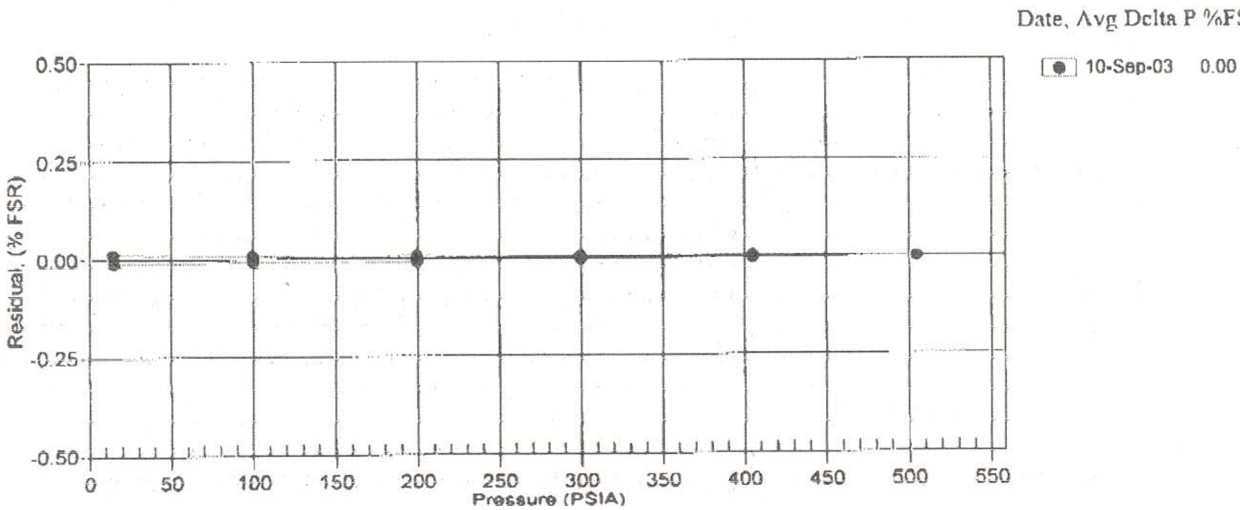
TEMP (ITS90)	SPAN (mV)
-5.00	24.69
35.00	24.66

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

$x = \text{pressure output} - PTCA0 - PTCA1 * t - PTCA2 * t^2$

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

$\text{pressure (psia)} = PA0 + PA1 * n + PA2 * n^2$



SEA-BIRD ELECTRONICS, INC.

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SENSOR SERIAL NUMBER: 4486
CALIBRATION DATE: 03-Aug-03

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

COEFFICIENTS:

g = -1.028879e+000
h = 1.435249e-001
i = -2.694713e-004
j = 4.038569e-005

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

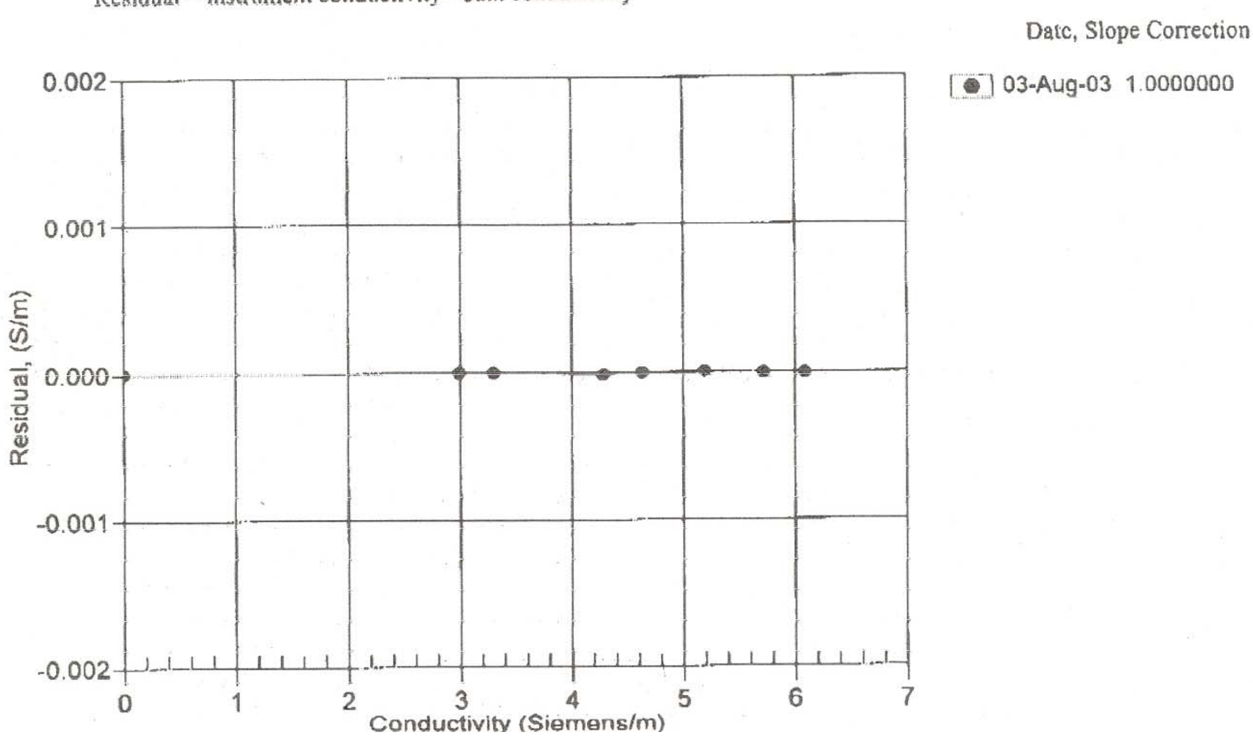
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2681.47	-0.0000	-0.00000
1.0000	34.9769	2.98838	5296.00	2.9884	0.00000
4.4999	34.9567	3.29665	5494.83	3.2967	0.00000
15.0000	34.9132	4.28224	6086.33	4.2822	-0.00001
18.5000	34.9041	4.62876	6280.80	4.6288	0.00000
24.0000	34.8942	5.18893	6582.72	5.1889	0.00001
29.0001	34.8894	5.71295	6852.78	5.7129	-0.00000
32.5001	34.8878	6.08706	7039.05	6.0871	-0.00000

f = INST FREQ / 1000.0

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

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

Residual = instrument conductivity - bath conductivity



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

SENSOR SERIAL NUMBER: 4486
CALIBRATION DATE: 03-Aug-03

SBE19plus TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

a0 = 1.272221e-003
a1 = 2.604990e-004
a2 = 1.993979e-007
a3 = 1.428064e-007

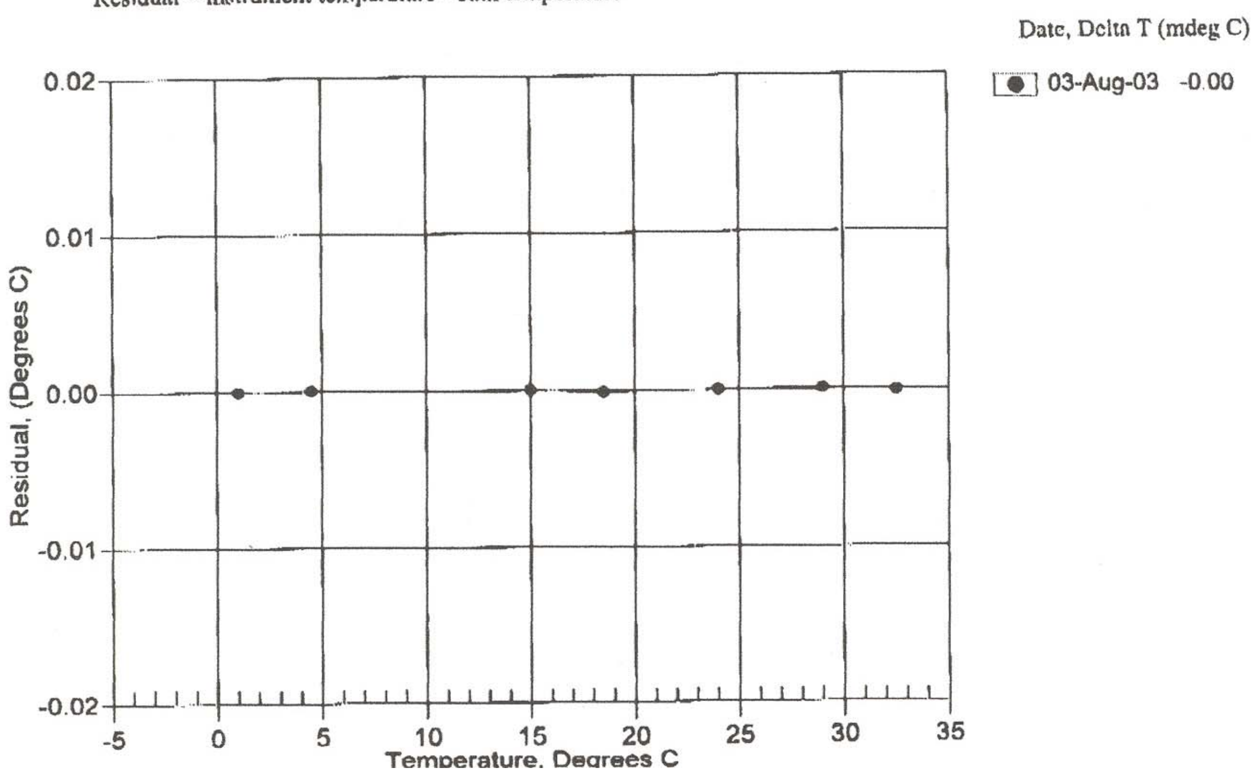
BATH TEMP (ITS-90)	INSTRUMENT OUTPUT(n)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	604347.342	1.0000	-0.0000
4.4999	535777.456	4.4999	0.0000
15.0000	366315.723	15.0000	0.0000
18.5000	320996.852	18.4999	-0.0001
24.0000	259595.240	24.0000	0.0000
29.0001	212957.298	29.0002	0.0001
32.5001	184833.650	32.5000	-0.0001

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

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

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

Residual = instrument temperature - bath temperature



ConReport.txt

Date: 03/19/2004

ASCII file: C:\velocity\CONFIG\4486.con

```
Configuration report for SBE 19 Seacat plus CTD
-----------------------------------------------

Pressure sensor type      : Strain Gauge
External voltage channels : 0
Mode                      : Profile
Scans to average          : 1
Surface PAR voltage added : No
NMEA position data added  : No

1) Frequency channel 0, Temperature, V2

   Serial number : 4486
   Calibrated on : 03-Aug-03
   A0            : 1.27222100e-003
   A1            : 2.60499000e-004
   A2            : 1.99397900e-007
   A3            : 1.42806400e-007
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency channel 1, Conductivity

   Serial number : 4486
   Calibrated on : 03-Aug-03
   G             : -1.02887900e+000
   H             : 1.43524900e-001
   I             : -2.69471300e-004
   J             : 4.03856900e-005
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00000000
   Offset        : 0.00000

3) Frequency channel 2, Pressure, Strain Gauge

   Serial number : 4486
   Calibrated on : 10-Sep-03
   PA0           : 4.34383400e-003
   PA1           : 1.54774000e-003
   PA2           : 6.82077200e-012
   PTEMPA0       : -7.44123000e+001
   PTEMPA1       : 4.73589600e+001
   PTEMPA2       : 2.38806800e-002
   PTCA0         : 5.24857200e+005
   PTCA1         : 9.37660100e-001
   PTCA2         : -3.90972700e-002
   PTCB0         : 2.46873700e+001
   PTCB1         : -7.25000000e-004
   PTCB2         : 0.00000000e+000
   Offset        : 0.000000
```

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SENSOR SERIAL NUMBER: 4487
CALIBRATION DATE: 19-Sep-03

SBE19plus PRESSURE CALIBRATION DATA
508 psia S/N 2837

COEFFICIENTS:

PA0 = -1.370901e-002	PTCA0 = 5.245787e+005
PA1 = 1.552263e-003	PTCA1 = 2.562214e+000
PA2 = 6.514945e-012	PTCA2 = -1.414790e-001
PTEMPA0 = -7.442045e+001	PTCB0 = 2.498675e+001
PTEMPA1 = 4.936629e+001	PTCB1 = -5.000000e-005
PTEMPA2 = -4.451470e-001	PTCB2 = 0.000000e+000

PRESSURE SPAN CALIBRATION

PRESSURE PSIA	INST OUTPUT	THERMISTOR OUTPUT	COMPUTED PRESSURE	ERROR %FSR
14.64	534017.0	2.0	14.65	0.00
99.76	588809.0	2.0	99.73	-0.01
199.76	653185.0	2.0	199.75	-0.00
299.76	717510.0	2.0	299.74	-0.00
404.75	785027.0	2.0	404.74	-0.00
504.74	849284.0	2.0	504.74	-0.00
504.74	849284.0	2.0	504.74	-0.00
404.75	785045.0	2.0	404.77	0.00
299.76	717540.0	2.0	299.78	0.00
199.76	653205.0	2.0	199.78	0.00
99.77	588838.0	2.0	99.78	0.00
14.66	534024.0	2.0	14.66	0.00

THERMAL CORRECTION

TEMP ITS90	THERMISTOR OUTPUT	INST OUTPUT
32.50	2.21	534238.73
29.00	2.14	534255.97
24.00	2.03	534268.57
18.50	1.92	534281.04
15.00	1.84	534329.91
4.50	1.62	534312.42
1.00	1.55	534295.31

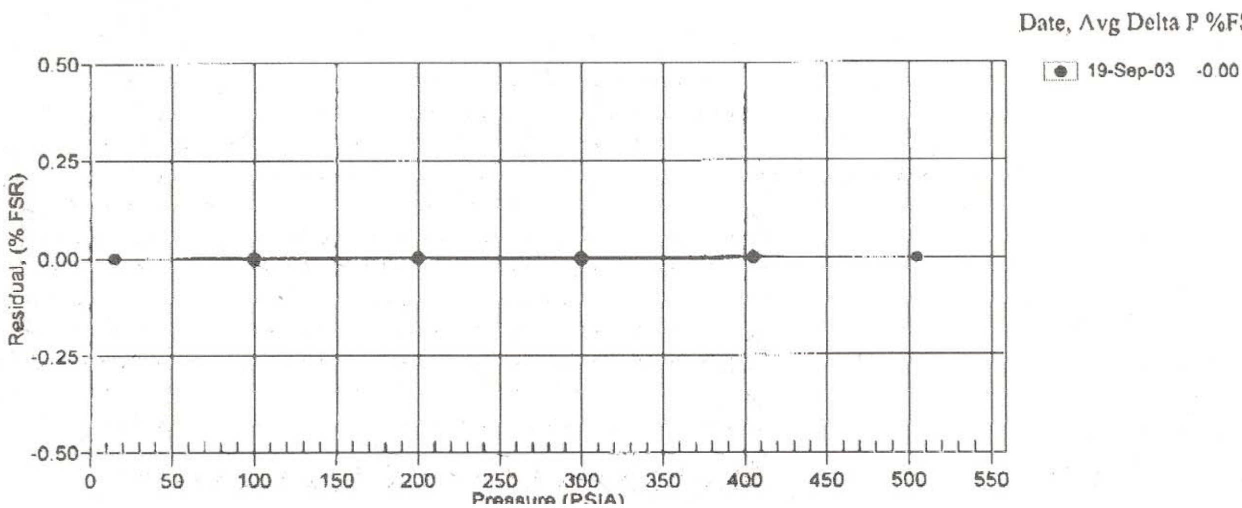
TEMP (ITS90)	SPAN (mV)
-5.00	24.99
35.00	24.98

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

$x = \text{pressure output} - PTCA0 - PTCA1 * t - PTCA2 * t^2$

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

$\text{pressure (psia)} = PA0 + PA1 * n + PA2 * n^2$



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SENSOR SERIAL NUMBER: 4487
CALIBRATION DATE: 12-Sep-03

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

COEFFICIENTS:

g = -1.024010e+000
h = 1.402295e-001
i = -3.672909e-004
j = 4.798552e-005

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

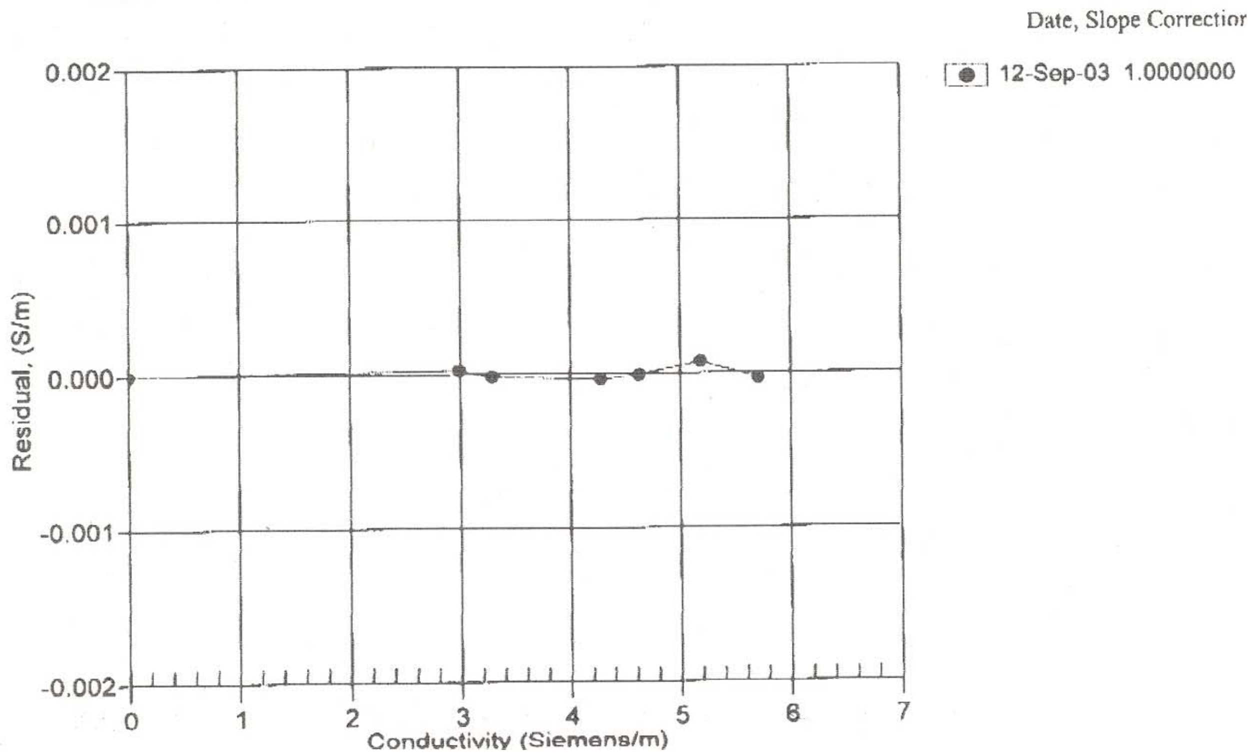
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2708.51	-0.0000	-0.00000
1.0000	34.9400	2.98553	5358.52	2.9856	0.00002
4.5000	34.9191	3.29346	5559.86	3.2934	-0.00002
15.0000	34.8751	4.27806	6158.79	4.2780	-0.00004
18.4999	34.8645	4.62406	6355.57	4.6241	-0.00001
23.9999	34.8546	5.18368	6661.22	5.1838	0.00007
29.0000	34.8500	5.70722	6934.49	5.7072	-0.00003

f = INST FREQ / 1000.0

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

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

Residual = instrument conductivity - bath conductivity



SEA-BIRD ELECTRONICS, INC.

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

SENSOR SERIAL NUMBER: 4487
CALIBRATION DATE: 12-Sep-03

SBE19plus TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

a0 = 1.211715e-003
a1 = 2.620729e-004
a2 = -1.400150e-007
a3 = 1.505172e-007

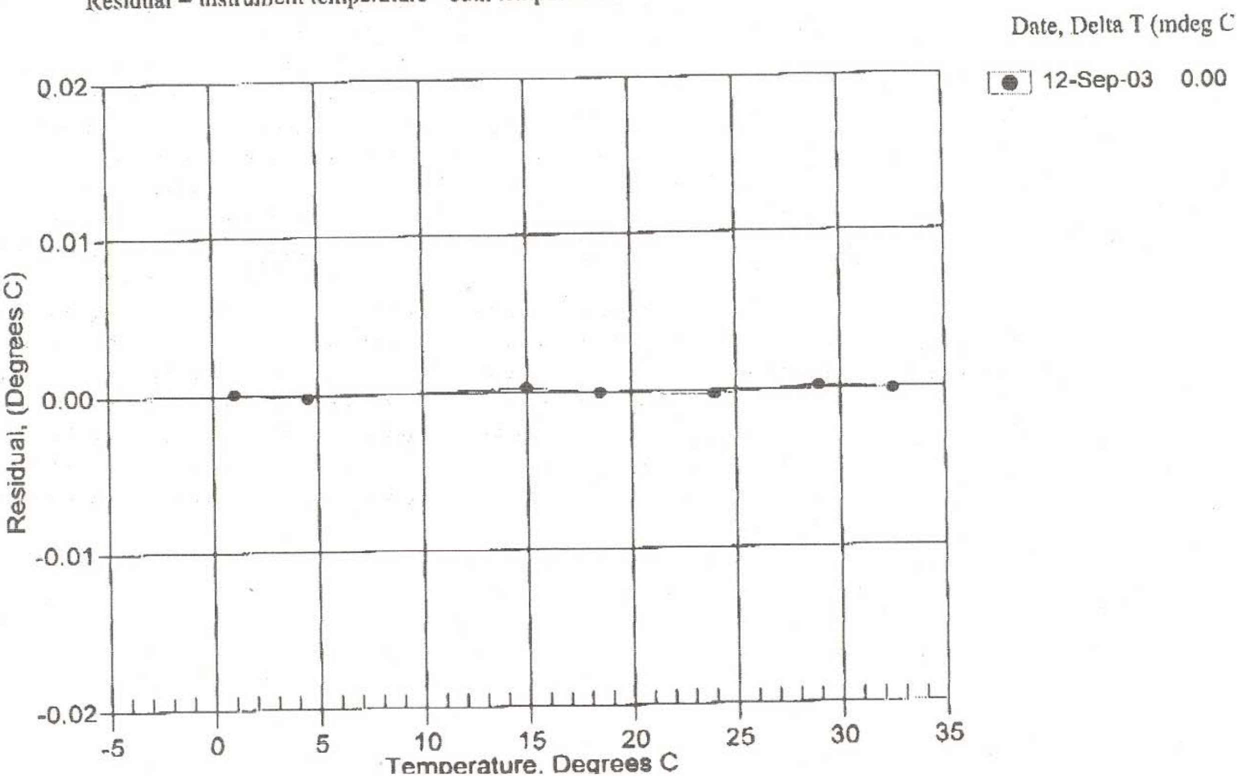
BATH TEMP (ITS-90)	INSTRUMENT OUTPUT(n)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	713419.313	1.0001	0.0001
4.5000	638109.571	4.4998	-0.0002
15.0000	447121.706	15.0003	0.0003
18.4999	394857.896	18.4998	-0.0001
23.9999	323224.156	23.9996	-0.0003
29.0000	268171.319	29.0002	0.0002
32.5000	234710.863	32.5000	-0.0000

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

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

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

Residual = instrument temperature - bath temperature



```
Date: 03/19/2004

ASCII file: C:\velocity\CONFIG\4487.con

Configuration report for SBE 19 Seacat plus CTD
-----------------------------------------------

Pressure sensor type      : Strain Gauge
External voltage channels : 0
Mode                      : Profile
Scans to average          : 1
Surface PAR voltage added : No
NMEA position data added  : No

1) Frequency channel 0, Temperature, V2

   Serial number : 4487
   Calibrated on : 12-Sep-03
   A0            : 1.21171500e-003
   A1            : 2.62072900e-004
   A2            : -1.40015000e-007
   A3            : 1.50517200e-007
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency channel 1, Conductivity

   Serial number : 4487
   Calibrated on : 12-Sep-03
   G             : -1.02401000e+000
   H             : 1.40229500e-001
   I             : -3.67290900e-004
   J             : 4.79855200e-005
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00000000
   Offset        : 0.00000

3) Frequency channel 2, Pressure, Strain Gauge

   Serial number : 4487
   Calibrated on : 19-Sep-03
   PA0           : -1.37090100e-002
   PA1           : 1.55226300e-003
   PA2           : 6.51494500e-012
   PTEMPA0       : -7.44204500e+001
   PTEMPA1       : 4.93662900e+001
   PTEMPA2       : -4.45147000e-001
   PTCA0         : 5.24578700e+005
   PTCA1         : 2.56221400e+000
   PTCA2         : -1.41479000e-001
   PTCB0         : 2.49867500e+001
   PTCB1         : -5.00000000e-005
   PTCB2         : 0.00000000e+000
   Offset        : 0.000000
```

X

LEAD LINE / BAR LINE CALIBRATION

Lead-line Calibration **Bar Line Calibration**

Lead / Bar Line Identifier WH01 **DN** **Date** 3/11/02

Leadline / Stbd Bar Line			Port Bar line		
Steel Tape (M)	Mark (M)	Correction (M)	Steel Tape (M)	Mark (M)	Correction (M)
A	B	C = A - B	A	B	C = A - B
1	1.00	0	* 21	20.95	0.05
2	2.00	0	* 22	21.96	0.04
3	3.00	0	* 23	22.95	0.05
4	4.00	0	* 24	23.94	0.06
5	5.00	0	* 25	24.94	0.06
6	6.00	0	* 26	25.94	0.06
7	7.00	0	* 27	26.94	0.06
8	8.00	0	* 28	27.92	0.08
9	8.99	0.01	* 29	28.90	0.10
10	9.99	0.01	* 30	29.89	0.11
11	10.99	0.01	31		
12	11.98	0.02	12		
13	12.97	0.03	13		
14	13.97	0.03	14		
15	14.96	0.04	15		
16	15.96	0.04	16		
17	16.96	0.04	17		
18	17.96	0.04	18		
19	18.96	0.04	19		
20	19.96	0.04	20		
	Sum			**Sum**	
	Mean			**Mean**	

Read and record the steel tape readings to the nearest centimeter. If correction exceeds 0.1m, the line must be remarked.

* 21-30 have been corrected*

Measured by:
Checked by:

~~Extend 10m, th from lead to 1m~~ rack

Done

LEAD LINE / BAR LINE CALIBRATION

Lead-line Calibration

Bar Line Calibration

Lead / Bar Line Identifier WH02

DN **Date** 3/11/02

Leadline / Stbd Bar Line			**Port Bar line**		
Steel Tape (M)	Mark (M)	Correction (M)	Steel Tape (M)	Mark (M)	Correction (M)
A	B	C = A - B	A	B	C = A - B
1	1.00		21	20.99	
2	2.00		22	21.99	
3	3.00		23	22.99	
4	4.00		24	23.99	
5	5.00		25	24.99	
6	6.00		26	25.99	
7	7.00		27	26.99	
8	8.00		28	27.99	
9	9.00		29	28.99	
10	10.00		30	29.99	
11	11.00		11		
12	12.00		12		
13	13.00		13		
14	14.00		14		
15	15.00		15		
16	16.00		16		
17	17.00		17		
18	18.00		18		
19	19.00		19		
20	20.00		20		
	Sum			**Sum**	
	Mean			**Mean**	

Read and record the steel tape readings to the nearest centimeter. If correction exceeds 0.1m, the line must be remarked.

Measured by:
Checked by:

LEAD LINE / BAR LINE CALIBRATION

Lead-line Calibration **Bar Line Calibration** ✓

Lead / Bar Line Identifier WH 4 WH 5 **DN** **Date** 3/11/02

Leadline / Stbd Bar Line WH 5			Port Bar line WH 4		
Steel Tape (M)	Mark (M)	Correction (M)	Steel Tape (M)	Mark (M)	Correction (M)
A	B	C = A - B	A	B	C = A - B
1	1.00		1	1.00	
2	2.00		2	2.00	
3	3.00		3	3.00	
4	4.00		4	4.00	
5	5.00		5	5.00	
6	6.00		6	6.00	
7	7.01		7	7.00	
8	8.01		8	8.00	
9	9.01		9	9.00	
10	10.01		10	10.00	
11	11.02		11	11.00	
12	12.02		12	12.0[illegible]	
13	13.02		13	13.00	
14	13.02		14	14.0[illegible]	
15	15.01		15	15.0[illegible]	
16	16.01		16	16.0[illegible]	
17	17.02		17		
18			18		
19			19		
20			20		
	Sum			**Sum**	
	Mean			**Mean**	

Read and record the steel tape readings to the nearest centimeter. If correction exceeds 0.1m, the line must be remarked.

Measured by:
Checked by:

APPENDIX IV

- NOAA Ship THOMAS JEFFERSON EM1002 Calibration Report
- NOAA Ship THOMAS JEFFERSON Side Scan Sonar Calibration Report
- Launch 1005 Reson 8101 Calibration Report
- Launch 1005 Reson 8101 Calibration Report, DN 303, 2003
- Launch 1014 Reson 8125 Calibration Report
- Launch 1014 Reson 8125 Roll Calibration Report
- C-NAV Global Differential Corrected GPS Report
- Sensor Error Report

NOAA SHIP THOMAS JEFFERSON

THOMAS JEFFERSON S222
PATCH TEST REPORT

March 18, 2004

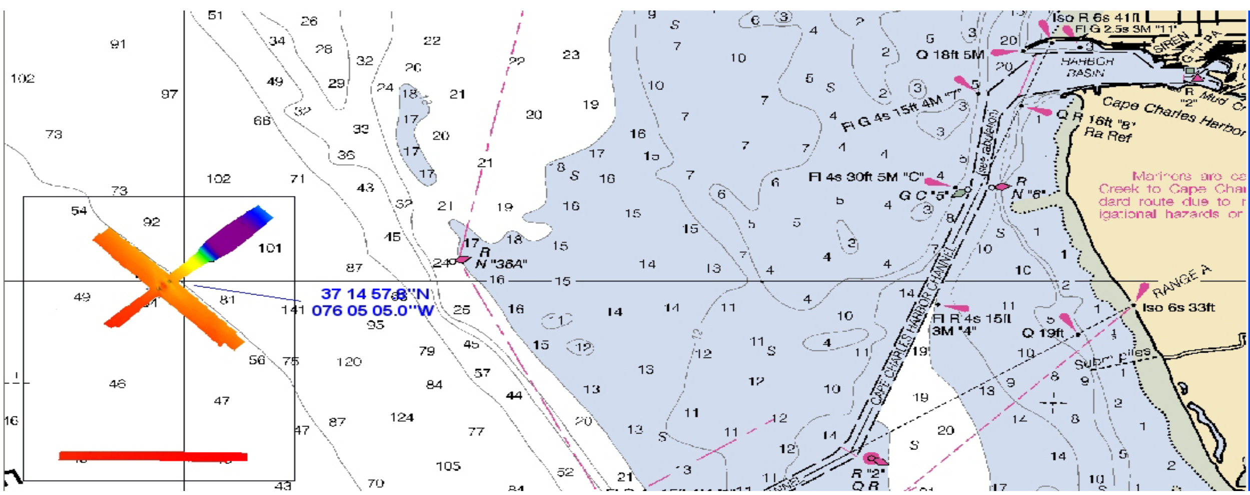
SST Peter Lewit

Background:

NOAA Ship THOMAS JEFFERSON is equipped with a SIMRAD EM1002. The transducer array is permanently mounted to the forward keel of the ship and encased in a fiberglass blister. It has a ping rate of more than 10 Hz. The systems nominal frequency is 95 khz. There are 111 beams with a 2 degree beamwidth, and electronic roll stabilization. Residual biases due to misalignment of the sonar were assessed in CARIS HIPS and entered in the CARIS vessel configuration file S222_MB.VCF and the Simrad installation parameters. The system configuration used on DN 78 has lever arm Position of the sounding at IMU.

Location, Date, and Personnel:

Preliminary tests For HAT, SAT and POS/MV antenna calibration were performed April 23-24, 2004. A Calibration test was performed off shore of Cape Charles Harbor, VA and approaches to Chesapeake Bay (see graphic below) on March 18, 2004 (DN 078) by ST Abrams, AST Glomb, LTJG Moser. The patch test processing log is filed in the S222_MB offsets folder.



Equipment:

Simrad EM1002 multibeam echo-sounder
TSS POS/MV 3 Inertial Motion sensor
Trimble DSM 212L DGPS receiver
Novetel GPS Antennas
Seacat SBE19 sound velocity profiler

Procedure:

Navigation Time delay: two pair of coincident lines, run at different speeds and same direction. One pair up slope and one down slope, each line within a pair run at 4.5 and 8.5 knots over a 6% slope. Each pair of lines were reviewed in CARIS calibration mode for an average along track displacement of soundings.

Pitch: two pair of coincident lines, run at same speed and different direction. One pair up slope and one down slope, each line run at 5 knots over a 6% slope. Each pair of lines were reviewed in CARIS calibration mode for an average along track displacement of soundings.

Roll: one pair of coincident lines, run at same speed and different direction in depths of 22 to 27 meters. One checkline run perpendicular to the pair of lines at the same speed for outer beam comparison. The pair of lines were reviewed in CARIS calibration mode for an average across track displacement of soundings. The checkline was reviewed with the pair of coincident lines and averaged with the overall roll bias.

Yaw- one pair of lines offset approximately 15 meters to either side of a charted wreck, run at same speed in opposite direction. The pair of lines were reviewed in CARIS calibration mode for an average along track displacement of soundings.

A notice from Simrad indicated their documentation had the incorrect sign for outer beam offset. An additional calibration was performed on September 18, 2003 and a new offset of +0.56 was obtained. On Dn077, 2004, two lines were used from the base surface test located at 37 12 19,N 076 03 44.0W to check the outer beam roll coefficient. The results showed an insignificant amount of change. The current roll coefficient of +0.56 should be retained in the Simrad installation parameters until such a time or event warrants a new calibration. This roll coefficient is checked every time the ship moves to new working grounds, as predominantly warmer, colder, salty, or brackish water can have a large impact on its value.

System configuration, Correction	2003 POS/MV Sounding Position at IMU DN 224	2003 Outer beam offset Correction DN 261	2004 Dn77,78 POS/MV Sounding Position at IMU
Navigation Time Error	0.00	0.00	0.10
Pitch bias	0.00	0.00	-0.475
Roll bias	-0.06	-0.06	-0.05
Yaw bias	0.00	0.00	0.00
Outer beam Roll	-0.07	0.56	0.56

Recommendations

These calibration results should be used from March 17, 2004 (DN 077) and should be used until such a time or event warrants a new calibration

NOAA SHIP THOMAS JEFFERSON

THOMAS JEFFERSON S222
PRELIMINARY CALIBRATION REPORT

June 10, 2004

SST Lewit

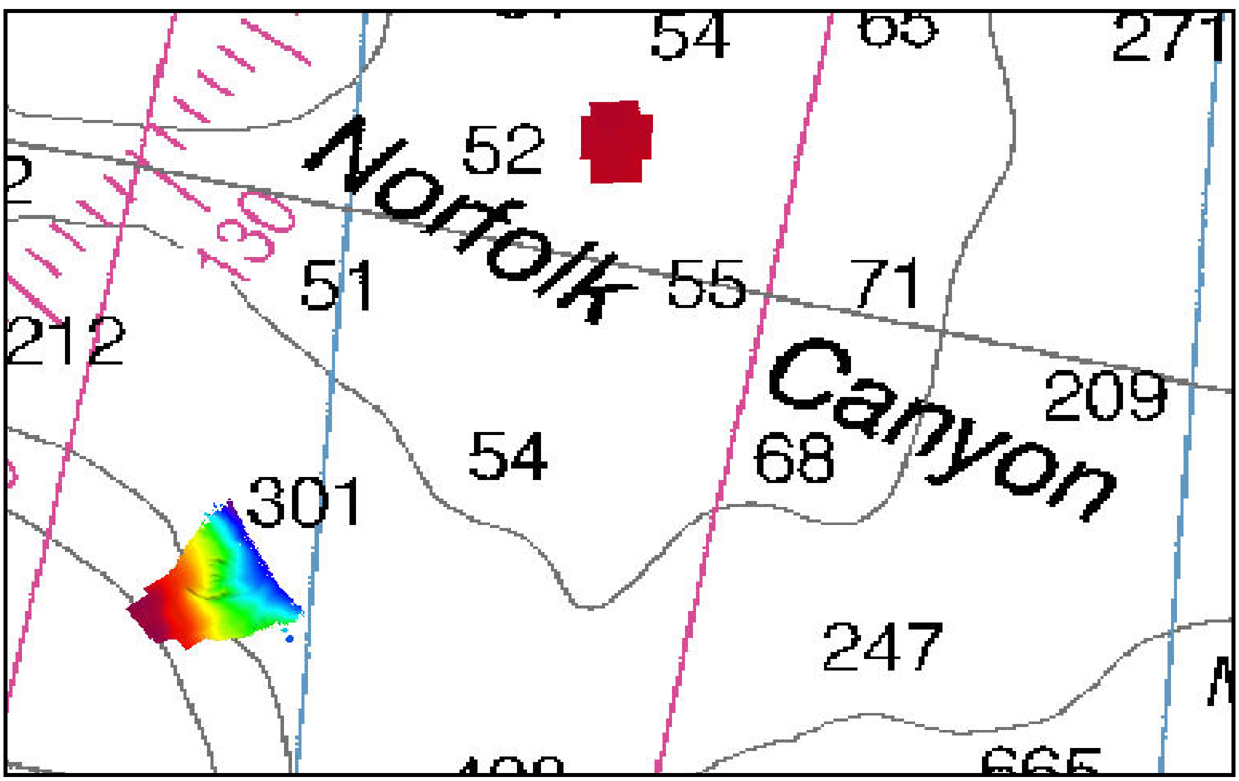
Background:

THOMAS JEFFERSON is equipped with a hull-mounted SIMRAD EM1002 multibeam echosounder system. The transducer array is permanently mounted to the forward keel of the ship and encased in a fiberglass blister. The SIMRAD EM1002 system has a nominal frequency of 95 kHz and a minimum ping rate of 10Hz. The system produces 111 beams each of which has a 2 degree beamwidth at a swath width of 150°. The system also features electronic roll stabilization.

The purpose of this patch test is to check how the SIMRAD system responds to the conditions immediately offshore the Chesapeake Bay mouth. Residual biases due to misalignment of the sonar were assessed in CARIS HIPS and entered in the CARIS vessel configuration file S222_MB.VCF and the SIMRAD installation parameters.

Location, Date, and Personnel:

Time latency error, pitch error, and roll error tests were performed in Norfolk Canyon, approximately 58nm northeast of Chesapeake Light, North Atlantic Ocean, on June 10 (DN 162). Yaw bias error test lines were not acquired as of 15 June 2004. Acquisition of patch test data was performed by the crew of THOMAS JEFFERSON. Processing of the calibration data was performed by ST Stewart and SST Lewit. Outer beam roll bias coefficient data processing was performed by ST Stewart and SST Forfinski. The patch test processing log is filed in the S222_MB Patch Test Log.



Equipment:

Simrad EM1002 multibeam echo-sounder
TSS POS/MV 320 GPS-Aided inertial navigation system
Trimble DSM 212L DGPS receiver
Novetel GPS Antennas
Seacat SBE19 CTD sound velocity profiler

Procedure:

Navigation Time delay: two pair of coincident lines, run at different speeds and same direction. One pair up slope and one down slope, each line within a pair run at clutch ahead (approximately 5 knots) and full ahead (approximately 10 knots) over a 6% slope. Each pair of lines were reviewed in CARIS calibration mode for an average along track displacement of soundings.

Pitch: two pair of coincident lines, run at 6 knots and reciprocal direction were run over a 6% slope. Each pair of lines were reviewed in CARIS calibration mode for an average along track displacement of soundings.

Roll: one pair of coincident lines were run at 10.5 knots in reciprocal directions in approximately 120 meters of water. One checkline was run perpendicular to the pair of lines at the same speed for outer beam roll bias comparison. The pair of reciprocal lines were reviewed in CARIS calibration mode to determine an average across track displacement of soundings. The checkline was reviewed with the pair of coincident lines and averaged with the overall roll bias.

Yaw- one pair of lines offset approximately 15 meters to either side of a charted wreck, run at same speed in reciprocal directions. The pair of lines were reviewed in CARIS calibration mode for an average along track displacement of soundings.

Outer beam coefficient- The outer beam roll coefficient test was performed to correct, in part, errors caused by physical differences at the transducer head that are related to the properties of the water body. Lines were run with an outer beam coefficient of -0.01. Lines used for the roll calibration test were also used for the outer beam roll coefficient test. For each test, one line and one crossline were entered into CARIS calibration mode and observed for presence of a frown or a smile (determining the polarity of the final corrector). The outer beam wing of the test line had a corrector applied to it such that the angle of the wing was parallel to the nadir line (crossline). The wing on the port side begins about half the distance from nadir of the test line to the outermost beam of the port side, and vice versa. The average value of correctors for both port and starboard side correctors was determined. As a frown was observed in the data, the sign of the corrector was determined to be positive. The calculated value was loaded into SIMRAD, and observed to cause the data to smile. As a result, the calculated value was halved and reloaded into SIMRAD. This value appeared correct.

System configuration, Correction	2004 DN 162 Pos/MV Sounding Position at IMU
Navigation Time Error Pitch bias Roll bias Yaw bias Outer beam Roll	0.255 -0.285 -0.055 N/A 0.30

Recommendations

These calibration results should be used from June 13, 2004 (DN 162) until such a time or event warrants a new calibration.

NB: These results are preliminary. A bug in CARIS HIPS 5.4 calibration mode causes pitch and roll values to be reversed in the .hvf file. In addition, a value entered into the .hvf while in calibration mode will not be applied to data in calibration mode. Between these two program bugs, it is impossible for the processor to tell precisely which values are applied to the data at the time of calibration. However, these values are both reasonable and similar to previous calibration values.

NOAA SHIP THOMAS JEFFERSON

Klein System 5500 Side-Scan Sonar Verification

ENS MICHAEL C. DAVIDSON

BACKGROUND

The NOAA Ship THOMAS JEFFERSON S-222 is a multiplatform survey ship equipped with an ECHOTRAC Vertical Beam Echo Sounder (VBES), SIMRAD 1002 Shallow Water Multibeam Sonar (SWMB), and a Klein System 5500 Side-Scan Sonar (SSS).

PURPOSE

In order to validate the data that will be collected aboard the NOAA Ship THOMAS JEFFERSON S-222 during the 2004 field season, calibration and/or confidence checks were performed on all the survey systems during a shakedown cruise conducted March 16 -18. This section specifically addresses the "Object Detection" abilities of the Klein System 5500 as currently configured aboard the NOAA Ship THOMAS JEFFERSON S-222. In addition, the horizontal positional accuracy of the object investigated during the SSS certification will be addressed. All though no specific standards are currently in place in the Specifications and Deliverables regarding the horizontal positional accuracy of objects in SSS imagery, its use in "Skunk Stripe" surveying to identify features that need further multibeam development creates the need to have a rough estimate of the horizontal positional accuracy that can be expected for SSS detected features.

LOCATION

The buoy anchor block for the Y"B" buoy, approximately 10 nm east of Cape Henry and approximately 2.2nm west-northwest of the Chesapeake Light, was chosen as the location to test the Klein System 5500 SSS (see figure 1). This area was chosen due to the relatively flat, sandy conditions in the area. The buoy was expected to provide a single, easily identifiable target with dimensions approximately equal to the 1m X 1m X 1m specified in the Specifications and Deliverables.

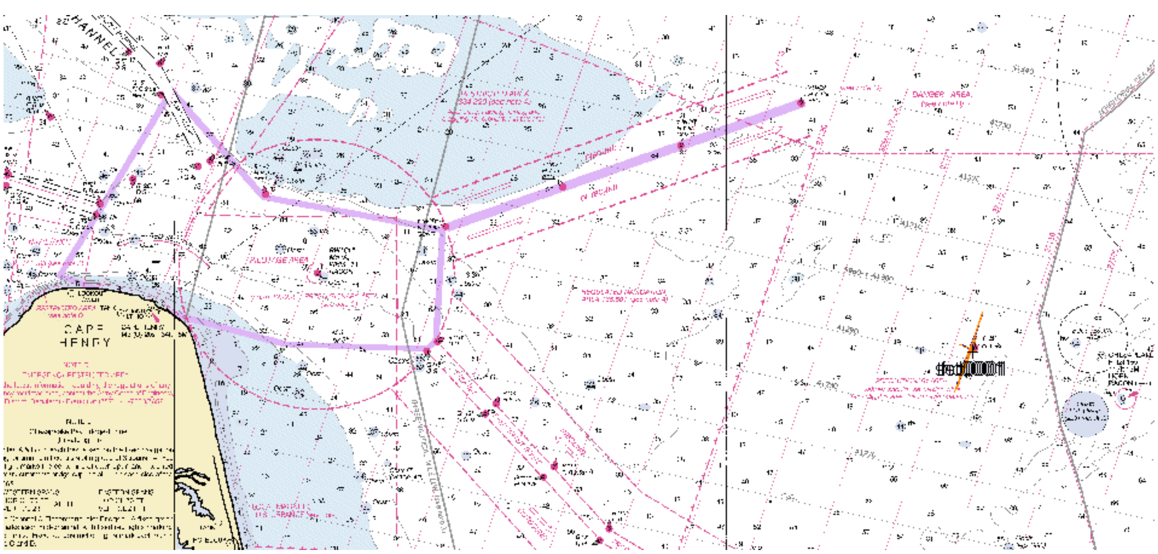


Figure 1 – Survey lines approximately 10nm east of Cape Henry, VA and 2.2 nm WNW of Chesapeake Light

PROCEDURE

Side-scan sonar survey lines were laid out in MapInfo for the area near the Y"B" buoy. The lines followed the general headings of 020˚T and 200˚T and 110˚T and 290˚T at ranges of 30m, 60m, and 80m from the buoy. The lines were converted into Hypack prior to sailing on 16 March 2004.

SSS data was collected on the evening of 17 March 2004. As the Y"B" buoy is an unlighted aide to navigation, and dusk was approaching, lines were run along the 020˚T heading at 30m and 80m and the 200˚T heading at 60m, and a single cross line on a heading of 110˚T at approximately 30m, in order to finish the side-scan survey before nightfall. The lines actually ran provided for orthogonal coverage on the starboard channel on the 50m range scale (30m from the buoy), single coverage in the port channel on the 75m range scale (60m from the buoy), and single coverage in the starboard channel on the 100m range scale (80m from the buoy).

The SSS data was recorded in XTF format in ISIS and stored locally at G:\Patch_Calibration_04\s222_100\2004_077. A vessel configuration file was created in Caris HIPS/SIPS with "0" entered into the X, Y, and Z for the Navigation, Heave, Pitch, and Roll inputs. A water line value of 0.540 was used, and zero layback error was assumed (this will be discussed further in the conclusion section). The Vessel Configuration file used is saved locally at H:\HDCS_DATA\VesselConfig\S222_100.

The XTF files were converted into Caris SIPS using the conversion parameters from 19 September 2003, except gyro data from the ship was used instead of from the attitude packet. In the current configuration, no attitude packet was being created and lines converted with that as an input deviated drastically from the ship's actual course made good, rendering the recomputed towfish navigation virtually useless. Fish height, vessel heading, and other navigational information was examined and cleaned where necessary, and the towfish navigation was recomputed. Slant range correction was applied assuming a sound velocity of 1500 m/s. Each line was examined and the Y"B" anchor block was identified and labeled as a contact.

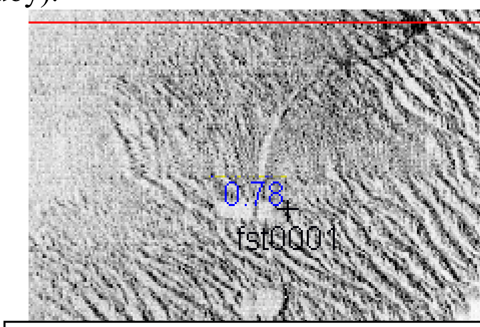


Figure 2 – Target measures 0.78m

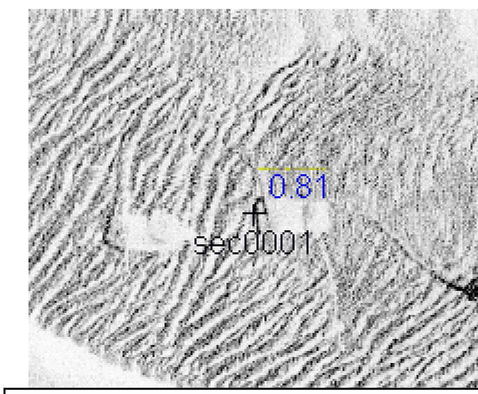


Figure 3 – Target measures 0.81m

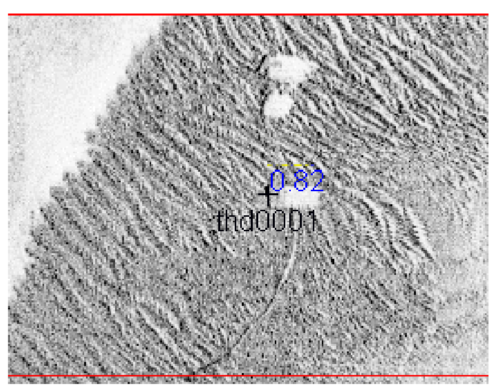


Figure 4 – Target measures 0.82m

CONCLUSION

While the lines for the SSS verification differed from the lines originally laid out in MapInfo (due to time constraints experienced during the shakedown cruise), the results have been promising. The Specifications and Deliverables require that the side-scan sonar used for hydrographic survey operations be able to detect an object with 1m X 1m X 1m dimensions. The Y"B" buoy anchor block used as the target object for the certification consistently measured approximately 0.8m (See figures 2, 3, and 4). Thus, the Klein System 5500 as currently configured aboard the NOAA Ship THOMAS JEFFERSON meets or exceeds the expectations laid forth in the Specifications and Deliverables.

The initial horizontal positional accuracy of the SSS imagery collected near the Y"B" buoy resulted in a positional error radius of approximately 10m (see figure5). However, there were a few sources of errors that have been identified by ST Forfinski and SST Lewit.

The first source is the depth sensor on the towfish. The sensor configuration appears to have gotten corrupted; resulting in an error of approximately 10m (the towfish thinks it is deeper than it actually is). The error resulting from the faulty depth causes Caris to compute a shorter layback than actually exists (by approximately 5m for the area surveyed near the Y"B" buoy). By correcting for this, the horizontal positional error radius decreases to less than 5m.

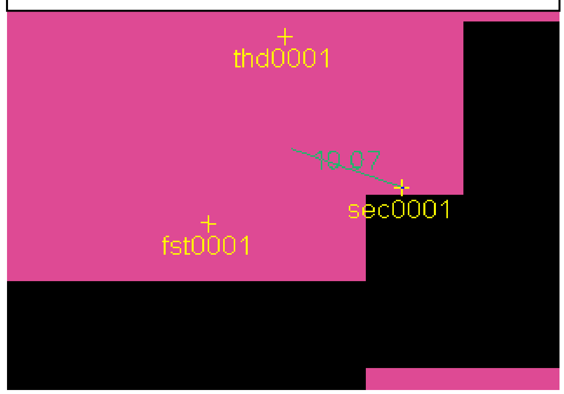


Figure 5 – Object position within a 10m radius

The second source of error pertains to the reference point from which the towpoint for the towfish is calculated. While the towpoint is referenced to the POS/MV, the POS/MV is sending out the position of the multibeam transducer. This exact difference in position and the manner in which it affects the horizontal accuracy of the side-scan imagery is yet to be fully determined. This error, however, is small in comparison to the error associated with the depth sensor on the towfish.

A final source of error during the 17 March 2004 SSS verification survey stems from an improperly marked towfish cable which made it difficult to see the 10m mark which is used to calibrate the cable-out counter. This issue was corrected when the new side-scan winch was installed on March 24, 2004. The resulting error caused by the missing 10m was unlikely to have a major effect on the horizontal positional accuracy in the verification survey.

The horizontal positional accuracy of the multibeam sonar is 5m plus 5% of the depth of the water, according to the Specifications and Deliverables. The results from the survey near the Y"B" buoy for the Klein System 5500 Side-Scan Sonar verification show that under the right conditions, a high degree of horizontal positional accuracy can be achieved. Once corrections are made to the known sources of error, SSS sonar can be used to locate features with a relatively high degree of horizontal accuracy. However, since the sonar is towed behind the ship and its exact heading at any specific time is impossible to determine, horizontal positions for the SSS can only be determined by running orthogonal lines and processing the data.

CORRECTIVE ACTIONS

In order to improve the use of the Klein System 5500 SSS aboard the NOAA Ship THOMAS JEFFERSON, the following changes were made: Gyro input into the Attitude Packet is recorded in order to provide accurate towfish navigation regardless of which method gets selected from the XTF Conversion Wizard; The POS/MV reference point offsets which were outputting the reference position relative to the transducer were corrected; and the new SSS winch cable was properly marked to prevent ambiguity in the exact amount of cable out.

SURVEY LAUNCH 1005
CALIBRATION REPORT 2004

AST Helen Stewart

Background:

Launch 1005 is a multi-purpose survey vessel capable of acquiring either multibeam bathymetry or high-resolution side scans sonar depending on which system is mounted. Multibeam bathymetry data is acquired using a RESON 8101 shallow-water multibeam echosounder rigidly mounted to the keel of the vessel. The RESON 8101 has a nominal frequency of 240 kHz, with a ping rate of 10-40 Hz and maximum range of approximately 50m. Residual biases due to misalignment of the sonar were assessed in CARIS HIPS and entered in the CARIS vessel configuration file "1005_mb".

Location, Date, and Personnel:

The initial calibration survey data was collected near Charles City South Chesapeake Bay (see graphic below) on March 26, 2004 (DN 086) by AST Helen Stewart. The patch test processing log is filed in the 1005 offsets folder.

Equipment:

Reson 8101 multibeam echo sounder
TSS POS/MV 2
Trimble DSM 212L DGPS receiver

Procedure:

Navigation Time delay: two pair of coincident lines, run at different RPMs and same direction. One pair up slope and one down slope, each line within a pair run at 900 RPMs and 1800 RPMs over a well defined slope. These pairs of lines were reviewed in CARIS calibration mode for an average along track displacement of soundings.

Pitch: two pair of coincident lines were run at the same RPMs and different direction. Each line was run at 900 & 1800 RPMs over a well-defined slope. The lines were reviewed in CARIS calibration mode for an average along track displacement of soundings.

Roll: one pair of coincident lines, run at same RPMs and different direction with one running perpendicular for outer beam comparison. They are run at the same speed and on a flat area. The pair of lines was reviewed in CARIS calibration mode for an average across track displacement of soundings. The checkline was reviewed with the pair of coincident lines and averaged with the overall roll bias.

Yaw- one pair of lines offset approximately 15 meters to either side of a known item, run at same RPMs in opposite direction. These pairs of lines were reviewed in CARIS calibration mode for an average along track displacement of soundings.

Results:

The following parameters were determined by ENS Schaer and AST Stewart:

Navigation Time Error	0.30
Pitch bias	0.45
Roll bias	-0.50
Yaw bias	0.00

Owing to several factors, the results of this patch test were unsatisfactory:

- The lines were run in an area of strong current. In order to keep on the line, the coxswain was forced to crab against the current resulting in skewing of the transducer with respect to the line. This was most obvious in the yaw bias calibration, but also notable in other bias calibrations. Yaw bias data acquired was completely useless for calibration purposes because of this crabbing.
- The POS/MV mounted on survey launch 1005 had been experiencing problems the day before and morning of the patch test. While the POS/MV operated within user specified tolerances during the patch test acquisition, the actual attitude and navigation data quality was poor. Despite the bad navigation and attitude data, the bathymetry data was processed, cleaned, merged, and run through the usual patch calibration process to obtain the biases above.

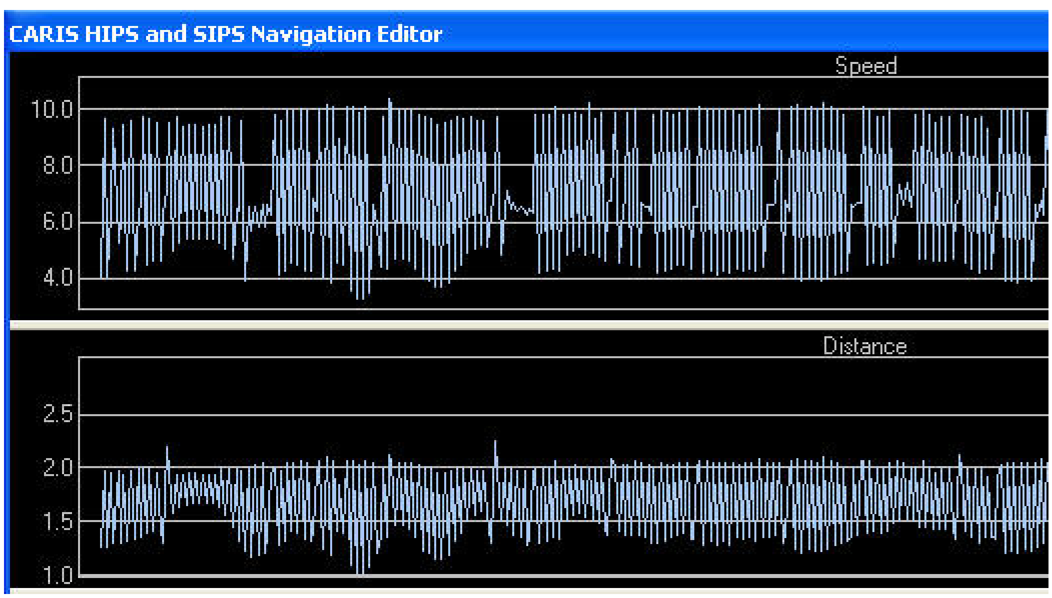


Figure 1: Line 003_1725

- Following the patch test, a new POS/MV system was installed on launch 1005. Although the GPS, CNAV, and Trimble antennae were not moved, the POS/MV PCS version 2 was replaced by POS/MV version 3.

Recommendations:

In light of these systematic problems, the Hydrographer recommends conducting a second, independent patch calibration test in the Tampico survey region. Recognizing that the RESON 8101 is rigidly mounted to the keel of Launch 1005 and that the antenna placement has not changed since the last patch calibration report, the October 2003 calibration report should suffice until a new patch test has been completed. Until that point, the Hydrographer recommends using the patch test results from October 2003 for acquisition with the understanding that after repatching, any data be remerged in CARIS HIPS with the appropriate results of the patch test in the vessel configuration file.

NOAA SHIP THOMAS JEFFERSON

SURVEY LAUNCH 1005
PATCH TEST REPORT 2003
DN 303

ENS Héctor Casanova

Background: On October 30 (DN 303) a closing Patch test was performed for project OPR-B370-TJ-03.

Location, Date, and Personnel: The test for DN 303 was also near Gull Island and was performed by SST Peter Lewit and ENS Héctor Casanova.

Procedure:

Navigation Time delay: two pair of coincident lines, run at different speeds and same direction. One pair up slope and one down slope, each line within a pair run at 4.5 and 8.5 knots over a well defined slope. The pair of lines were reviewed in CARIS calibration mode for an average along track displacement of soundings.

Pitch: two pair of coincident lines, run at same speed and different direction. Each line was run at 5 knots over a well-defined slope. The lines were reviewed in CARIS calibration mode for an average along track displacement of soundings.

Roll: one pair of coincident lines, run at same speed and different direction with one running perpendicular for outer beam comparison. They are run at the same speed and on a flat area. The pair of lines was reviewed in CARIS calibration mode for an average across track displacement of soundings. The checkline was reviewed with the pair of coincident lines and averaged with the overall roll bias.

Yaw- one pair of lines offset approximately 15 meters to either side of a known item, run at same speed in opposite direction. The pair of lines were reviewed in CARIS calibration mode for an average along track displacement of soundings.

Results:

1005 Test	DN 303
Navigation Time Error	0.0
Pitch bias	1.25
Roll bias	-0.63
Yaw bias	.08

Recommendations:

These calibration results should be used from daynumber 303 indicated in the vessel configuration file and should be used until such a time or event warrants a new calibration. Subsequent confidence checks for roll and yaw confirmed the original bias and no adjustments were made.

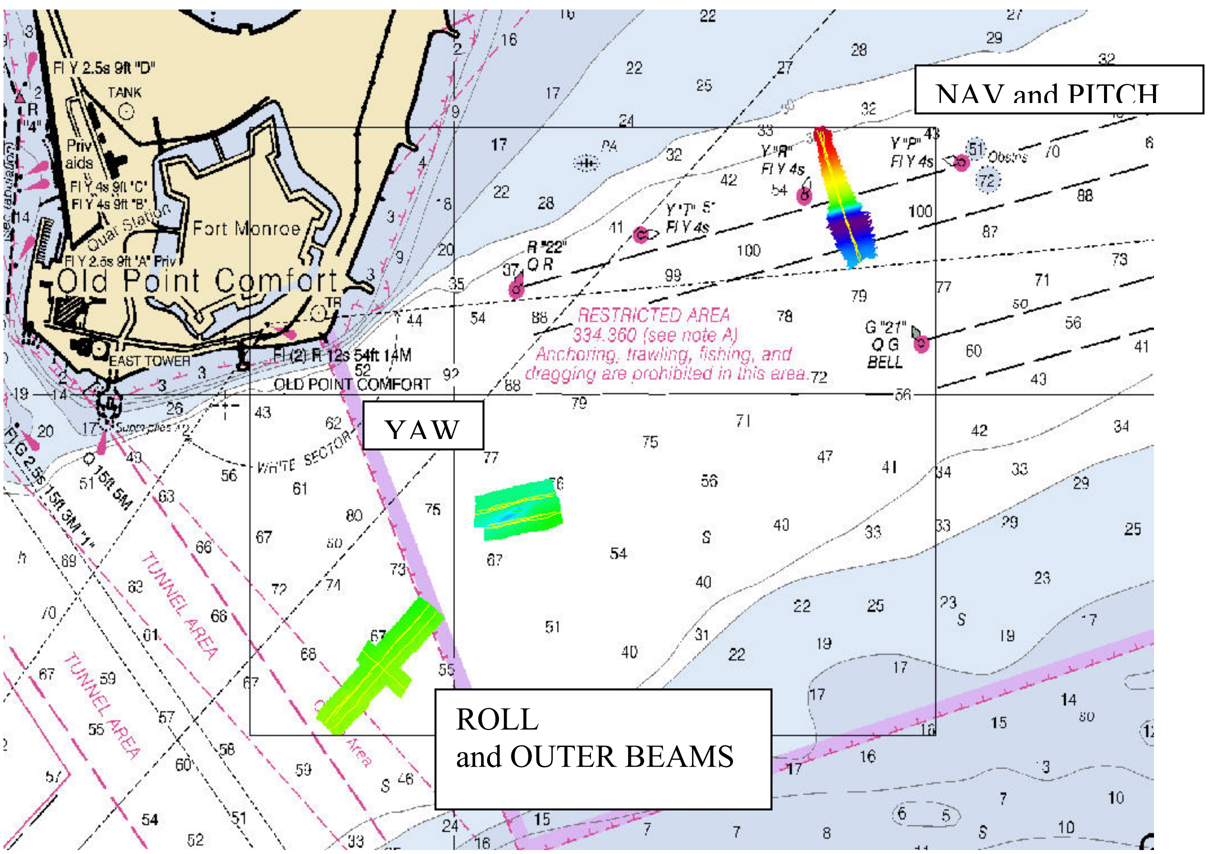
SURVEY LAUNCH 1014
CALIBRATION REPORT 2004
ENS Hector Casanova

Background:

Launch 1014 is a multi-purpose survey vessel capable of acquiring either multibeam bathymetry or high-resolution side scan sonar depending on which system is mounted. The sonar mounting is a rigid aluminum sled bolted to the hull of the vessel and designed for the interchangeability of a Reson 8125 shallow-water multibeam system or a Klein System 5500 high-speed high-resolution side scan sonar. The launch is currently equipped with the Reson 8125. Residual biases due to misalignment of the sonar were assessed in CARIS HIPS and entered in the CARIS vessel configuration file "1014_mb".

Location, Date, and Personnel:

The initial calibration survey data was collected near Old Point Comfort, VA (see graphic below) on April 2, 2004 (DN 091) by SST Peter Lewit and PS Kim Sampadian. Subsequent data has not been collected yet.



Equipment:

Reson 8125 multibeam echo-sounder
TSS POS/MV 3
Trimble DSM 212L DGPS receiver
Seacat SBE19 sound velocity profiler

Procedure:

Navigation Time delay: Run two pair of coincident lines at different speeds and same direction. One pair up slope and one down slope, each line within a pair run at 4.5 and 8.5 knots over a 10º slope. Each pair of lines will be reviewed in CARIS calibration mode.

Pitch: Run two pair of coincident lines at same speed and different direction. One pair up slope and one down slope, each line run at 5 knots over a 10º slope. Each pair of lines will be reviewed in CARIS calibration mode.

Roll: Run one pair of coincident lines at same speed and different direction in depths of 18 to 21 meters. Run one checkline perpendicular to the pair of lines at the same speed for outer beam comparison. The pair of lines will be reviewed in CARIS calibration mode.

Yaw: Run one pair of lines offset approximately 15 meters to either side of a charted wreck (18.7m) at same speed in opposite direction. The pair of lines will be reviewed in CARIS calibration mode.

Results and Recommendations:

Navigation Time Error	-0.17
Pitch bias	-0.25
Roll bias	-0.2
Yaw bias	2.5

These calibration results should be used from April 2, 2004 (DN 091) until such a time or event that warrants a new calibration. Subsequent confidence checks for roll and yaw confirmed the original bias and no adjustments were made.

NOAA SHIP THOMAS JEFFERSON

Survey Launch 1014
Roll Calibration Report

April 28, 2004

ENS Jasper Schaer

Background:

Launch 1014 is a multi-purpose survey vessel capable of acquiring either multibeam bathymetry or high-resolution side scan sonar, depending on which system is installed. The sonar mount to a rigid aluminum sled bolted to the hull of the vessel, designed for the interchangeability of a Reson 8125 multibeam system or a Klein System 5500 side scan sonar. The launch is currently equipped with the Reson 8125 multibeam echosounder. Residual biases due to misalignment of the sonar were previously assessed in CARIS HIPS and entered in the HIPS vessel configuration file *1014_mb*. The purpose of this roll calibration test is to determine the biases associated with roll after remounting the Reson 8125 MBES onto the hull of Survey Launch 1014.

Location, Date, and Personnel:

Roll Bias calibration took place in Tampico, Mexico on DN 119 (April 28, 2004), on Sheet B. Three MBES lines were acquired for this calibration. Data was evaluated in CARIS 5.4.

Procedure:

Acquisition

The survey crew aboard the launch was given a line plan with the following instructions:

> **Roll**: Run one pair of coincident lines in a flat area at the same speed, in different directions. Run one checkline perpendicular to the pair of lines, at the same speed, for outer beam comparison.

Results:

The following table lists the results from this patch test, along with the results of several previous calibrations.

Calibration	2004 DN 119	2004 DN 091	2003 DN 303
Roll Bias	-0.10	-0.20	-0.26

Table 1: Results of Current and Previous Patch Tests

Recommendations

These results are adequate to supercede any previous results and should be used until such a time or event warrants a new calibration.

NOAA Ship THOMAS JEFFERSON
C-Nav Positioning System Report

Prepared by ENS Michael C. Davidson

The NOAA Ship THOMAS JEFFERSON is equipped with a C-Nav Globally Corrected Differential Global Positioning System GcDGPS. This system is a subscription service which uses dual L-band receivers to receive differential correctors that are broadcast worldwide via INMARSAT Geostationary Communications Satellites. The differential correctors are calculated using a differential processing technique developed by C-Nav based on NASA JPL Real-Time GYPSY (RTG), resulting in precise error models which account for atomic clock errors, GPS constellation ephemeris errors, ionospheric effect errors, and troposheric effect errors. These correctors are created for each GPS satellite from the raw GPS data collected from reference receivers located around the world. The raw data is sent to the processing hubs located in Torrance CA, and Moline, IL, via terrestrial communication links. The correctors are then transmitted to Land Earth Stations (LES) for uplink to the INMARSAT Geostationary Satellites. The differential correctors are then broadcast worldwide from 72ºN to 72ºS Latitude (the limitations of the INMARSAT Satellites) to users with C-Nav receivers.

The C-Nav receiver in use aboard the NOAA Ship THOMAS JEFFERSON is the C-Nav 2000 RM, which provides decimeter horizontal accuracy at 1 or 5 updates per second, using the NMEA string. The 2000 RM receivers feature 10 channels for continuous GPS satellite tracking, two channels for Satellite Based Augmentation System (SBAS), and an L-band demodulator for receiving correctors from the C-Nav service. The sensor can output raw data as fast as 50HZ and Position Velocity Time (PVT) data as fast as 25 Hz through two 115kbps RS232 serial ports. The ship is also fitted with a Pacific Crest Radio Modem, which will broadcast the RTCM correctors to the Hydrographic Survey Launches 1005 and 1014. The RTCM corrector is used as opposed to the NMEA in order to benefit from the POS/MV heave, pitch, and roll calculations. The RTCM corrector provides slightly less accurate position information, thus decreasing the horizontal accuracy from the decimeter level to approximately 1m, which is still well within the 5m plus 5% of the water depth as specified in the NOS Hydrographic Survey Specifications and Deliverables.

The C-Nav system can output a subset of NMEA 0183 messages which provide QA/QC information. This NMEA string will be monitored to ensure that positional information provided by the C-Nav service remains within the limit specified in the NOS Hydrographic Survey Specifications and Deliverables.

NOAA SHIP THOMAS JEFFERSON

THOMAS JEFFERSON S222
SENSOR ERROR REPORT

15 August, 2004

ENS Matthew Ringel

Background:

With the release of **HIPS and SIPS 5.4**, Caris implemented an error model that calculates the predicted horizontal and vertical error for each sounding. The model uses a user-given one sigma error for each sensor and computes the cumulative effect of each sensor's given error on the position of each sounding, returning this error as a vertical and horizontal component known as TPE, or Total Propagated Error. This model depends upon having reasonably accurate predictions of each sensor's error. The following values are those used in the current implementation's Hydrographic Vessel File (HVF).

Sensor	error (one sigma)	
Motion Gyro	0.05	Based on manufacturers specification for the POS/MV.
Heave % Amp	5	
Heave	0.05	POS/MV Heave error is given as 0.05 meters + 5% of heave. The Caris implementation is Heave or Heave % Amp, whichever is greater. Thus 0.06 is used as a compromise.
Roll	0.05	Based on manufacturers specification for the POS/MV.
Pitch	0.05	Based on manufacturers specification for the POS/MV.
Position Nav	0.5	Based on manufacturers specification for the POS/MV.
Timing Trans	0	Not known.
Nav Timing	0.1	Based on calibration samples done during Patch Test.
Gyro Timing	0.01	Based on manufacturers specification for the POS/MV.
Heave Timing	0.01	Based on manufacturers specification for the POS/MV.
Pitch Timing	0.01	Based on manufacturers specification for the POS/MV.
Roll Timing	0.01	Based on manufacturers specification for the POS/MV.
Sound Velocity Measured	0.5	Based on accuracy limit of SeaBird instrument.
Sound Velocity Surface	0.6	Instrument accuracy = 0.5, plus 0.1 to take into account water being piped to SSV sensor.
Tide Measured	0.01	Error estimate from smooth tide file, determined by CO-OPS
Tide Zoning	0.1	Largest error estimate for any tide zone from CO-OPS. Current implementation does not allow this to change dynamically.
Offset X	0.02	Limit of offset measuring methods.
Offset Y	0.02	Limit of offset measuring methods.
Offset Z	0.02	Limit of offset measuring methods.
Vessel Speed	0.25	Allows our average speed to be different from our instantaneous speed by .5 knots.
Loading	0	Currently not using this error. Further investigation required.
Draft	0.03	Limit of draft measuring methods.
Delta Draft	0	Currently not using this error. Further investigation required.
MRU Align StdDev gyro	0	Currently not using this error. Further investigation required.
MRU Align StdDev Roll/Pitch	0	Currently not using this error. Further investigation required.

Recommendations

These error values are based on our current understanding of our systems and their integration. Further investigation over time needs to be done to figure realistic values for the fields currently not used. Until then, these values should be used to calculate TPE for all soundings acquired by NOAA Ship THOMAS JEFFERSON.

Most of these values hold true for Survey Launch 1005 and 1014, as they share many of the same sources of error that NOAA Ship THOMAS JEFFERSON has. For example, all three platforms have a TSS POS/MV for attitude and position, data from all three platforms is tide corrected in the same fashion, and all have offsets measured in similar fashions. As such, these same values, with minor modifications, can be used to calculate TPE for Launch 1005 and 1014.

The following is quoted directly from the “Caris HIPS and SIPS User’s Guide” dated 16 July 2004. It is their explanation for what each of the error fields entered in the HVF describes.

CARIS HIPS & SIPS User’s Guide

• *Gyro*: The measurement standard deviation of the heading data in degrees.

• *Heave % Amplitude*: An additional heave standard deviation component that is the percentage of the instantaneous heave.

• *Heave*: The measurement for standard deviation of the heave data in meters. Most heave manufacturers quote heave error as being determined from StaticHeave or PercentageOfHeave depending on which value is larger.

• *Roll*: The measurement standard deviation of the roll data in degrees.

• *Pitch*: The measurement standard deviation of the pitch data in degrees. HIPS Vessel Files: Edit Sensor Configuration

• *Navigation*: The standard deviation associated with the measurement of positions for the vessel in meters. This is usually the error of the GPS sensor being used.

• *Timing Transducer*: Standard deviation in transducer time stamp measurement.

• *Navigation Timing*: Standard deviation in navigation time stamp measurement.

• *Gyro Timing*: Standard deviation in gyro time stamp measurement.

• *Heave Timing*: Standard deviation in heave time stamp measurement.

• *Pitch Timing*: Standard deviation in pitch time stamp measurement.

• *Roll Timing*: Standard deviation in roll time stamp measurement.

• *Sound Velocity Measured*: The standard deviation in the measurement of Sound Velocity readings in meters/second.

• *Surface*: The standard deviation in the measurement of Surface Sound velocity in meters/second.

• *Tide Measured*: The standard deviation in the measured tide values in meters.

• *Tide Zoning*: The standard deviation in the tide values associated with zoning in meters.

• *Offset X*: Standard deviation for the X measured offset on the vessel in meters.

• *Offset Y*: Standard deviation for the Y measured offset on the vessel in meters.

• *Offset Z*: Standard deviation for Z measured offset on the vessel in meters.

• *Vessel Speed*: The standard deviation for the vessel speed measurements in meters/second.

• *Loading*: Vertical changes during the survey because of fuel consumption, etc.

• *Draft*: The standard deviation in the vessel draft measurements in meters.

• *Delta Draft*: The standard deviation in the dynamic vessel draft measurements in meters.