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

Data Acquisition & Processing Report

Type of Survey *Multibeam and Side Scan Sonar*

Project No.
OPR-E350-TJ-11, OPR-D304-TJ-11,
OPR-B363-TJ-11 and OPR-SA916-TJ-11

Time Frame: *2011 Fieldseason*

LOCALITY

State:
Virginia, Rhode Island, Connecticut,
New York, and Maine

General Locality:
Southern Chesapeake Bay, Approaches to Chesapeake Bay,
Block Island Sound, and Boone Island, ME

2011

CHIEF OF PARTY

CDR Lawrence T. Krepp

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DATE__________________________________

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Data Acquisition and Processing Report

NOAA Ship *Thomas Jefferson*
Chief of Party: CDR Lawrence T. Krepp
Year: 2011
Version: 1.0
Publish Date: 2011-09-01

A Equipment

A.1 Survey Vessels

A.1.1 NOAA Ship THOMAS JEFFERSON

<table>
<tr><td>Name</td><td>NOAA Ship THOMAS JEFFERSON</td></tr>
<tr><td>Hull Number</td><td>S222</td></tr>
<tr><td>Description</td><td>Hydrographic Survey vessel designed and built by Halter Marine, Inc., Moss Point, MS. Home Port: Norfolk, VA</td></tr>
<tr><td>Utilization</td><td>NOAA Ship THOMAS JEFFERSON's primary mission is to acquire hydrographic survey data to update NOAA Nautical Charts in support of maritime commerce and safety of navigation. Other missions include Integrated Ocean and Coastal Mapping missions in support of missions such as benthic habitat mapping, wreck surveys, and other research oriented survey operations. The ship is also occasionally employed in buoy deployment and recovery operations.</td></tr>
<tr><td>Dimensions</td><td><table>
<tr><td>LOA</td><td>208 feet</td></tr>
<tr><td>Beam</td><td>45 feet</td></tr>
<tr><td>Max Draft</td><td>16.3 feet</td></tr>
</table></td></tr>
<tr><td>Most Recent Full Static Survey</td><td><table>
<tr><td>Date</td><td>2003-05-07</td></tr>
<tr><td>Performed By</td><td>National Geodetic Survey (NGS)</td></tr>
<tr><td>Discussion</td><td>NGS performed a full, static survey during which they surveyed the distance from IMU to the Notch Reference Point and updated the transducer to Notch Reference Point distance.</td></tr>
</table></td></tr>
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<table>
<tr><td rowspan="3">Most Recent Partial Static Survey</td><td>Date</td><td>2005-03-10</td></tr>
<tr><td>Performed By</td><td>National Geodetic Survey (NGS)</td></tr>
<tr><td>Discussion</td><td>A partial re-survey of THOMAS JEFFERSON vessel offsets was conducted by NGS personnel, and no physical changes in offsets have occurred since then.</td></tr>
<tr><td>Most Recent Full Offset Verification</td><td colspan="2">Full offset verification was not performed.</td></tr>
</table>

Most Recent Partial Offset Verification	*Date*	2010-10-01
	Method Used	Confidence check
	Discussion	The THOMAS JEFFERSON verified NGS measurements and found one z-value offset of 20 cm on S222 Reson 7125, which appears to have been the z-value for the port transducer instead of the starboard transducer. As a result of ERS processing on survey H12180 during the fall of 2010, it was determined that the 2005 partial survey did not adequately take into account the alignment of the POS antennas with respect to vessel reference frame. This was evident in the Calibrated Installation Parameters report generated by the GNSS processor in POS MMS 5.3. X, Y, and Z offsets were settling in on values that differed from the installation parameter values entered in MV/POSView based on the 2005 NGS survey. The differences in offsets are insignificant for surveys reduced to MLLW via traditional tides application because the vertical offset of the antenna does not affect survey depths. Only horizontal positioning is affected by the inaccuracies of the antenna offsets. Since the horizontal offsets determined for the antennas is significantly smaller than the horizontal positioning requirement for IHO Order 1 surveys, no reprocessing is necessary for surveys submitted via traditional discrete zoning. For ERS surveys, the antenna heights do affect the final survey depths because the soundings are referenced to the ellipsoid based on the 3-D positioning determined by the GNSS processing of POSPac data, which are then reduced to MLLW via a SEP model, which is a grid of the difference between the ellipsoid and MLLW for a given area. Through an iterative process by which calibrated installation parameters were applied and the SBET re-processed using the GNSS processor, precise values for the antenna positions with respect to the IMU were determined.

Most Recent Static Draft Determination	*Date*	2011-06-06
	Method Used	Waterline measurements
	Discussion	Preliminary static draft measurements are made at the beginning of each leg and as necessary thereafter, typically every 2 - 3 days and before and after any transfers of ballast, fuel, and black and gray water. Static draft for THOMAS JEFFERSON is measured using a sight tube located in lower survey stores in the vicinity of frame 33. Lower survey stores is not vented to the atmosphere, and as a result, air pressure inside the ship can introduce an error in static draft measurements. As a result, a value of 0.1m was entered into the CARIS HVF as the uncertainty for static draft for the ship. Standard practice is to open hatches in survey that provide access to lower survey stores to reduce the effects of differential air pressure on the waterline measurements.
Most Recent Dynamic Draft Determination	*Date*	2011-03-25
	Method Used	Ellipsoidally Referenced Dynamic Draft Measurement (ERDDM)
	Discussion	For the 2011 field season, the THOMAS JEFFERSON used an inertially-aided post-processed kinematic approach (IAPPK) to determine the dynamic draft (settlement and squat) for the ship (S222). This method is called an ellipsoid-referenced dynamic draft measurement (ERDDM). The initial test for the ship occurred on March 30, 2011, in the Chesapeake Bay, in the vicinity of Cape Charles City, east of York Spit Channel. Environmental conditions (current) led to questionable results. The ERDDM method was tried again on May 26, 2011. These results were entered into the ship's HVF as DN089 and have been used for the entire 2011 field season.

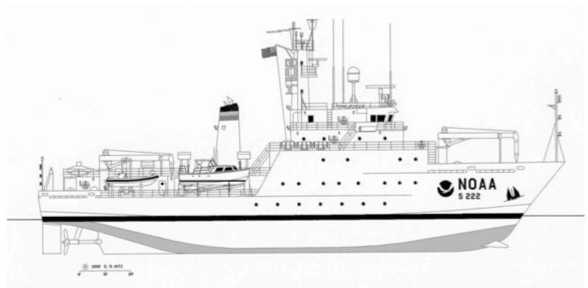

Figure 1: NOAA Ship THOMAS JEFFERSON

A.1.2 Hydrographic Survey Launch 3101

Name	Hydrographic Survey Launch 3101	
Hull Number	3101	
Description	NOAA Ship THOMAS JEFFERSON Hydrographic Survey Launch 1 of 2	
Utilization	shallow water hydrographic data collection	
Dimensions	*LOA*	31 feet
	Beam	10.667 feet
	Max Draft	5.167 feet
Most Recent Full Static Survey	*Date*	2010-01-13
	Performed By	National Geodetic Survey (NGS)
	Discussion	Vessel offset measurements were conducted for HSL 3101 by NGS personnel. The NGS survey measured from established benchmarks on the vessel back to the reference point, specifically the cross hairs on top of the IMU. From the surveyed benchmarks, the new RESON 7125SV, SSVS, and Odom CV200 installation offsets were measured using a steel tape. The Klein 5000 side scan was surveyed in a similar manner and offsets for the "heavy-weight" and "light-weight" systems were recorded.

Most Recent Partial Static Survey	*Date*	2011-02-09
	Performed By	NGS
	Discussion	NGS performed a partial resurvey of launches 3101 and 3102 to survey new POS/MV antenna's with respect to the vessel reference point. The launches were in the cradles onboard the ship at the time of the NGS survey, which reduced the accuracy and precision of the measurements. Calibrated Installation Parameters as calculated by the POS/MV indicate that the NGS measurements are within 8cm of the calculated values.
Most Recent Full Offset Verification	*Date*	2011-03-08
	Method Used	Steel tape to previously established reference marks on the vessel's hull
	Discussion	During the 2010 NGS survey, reference marks were established at various locations along the keel and hull of the launches to facilitate offsets verification. A steel tape was used to measure from reference point of each transducer to one of the previously established reference marks. This procedure was used to verify prior results.
Most Recent Partial Offset Verification	Partial offset verification was not performed.	
Most Recent Static Draft Determination	*Date*	2011-02-14
	Method Used	Waterline measurement
	Discussion	Static draft measurements for HSL 3101 and HSL 3102 are determined using a sight tube to measure the waterline with respect to the reference point on the top of the IMU. These measurements are made at the beginning and end of each working day while the vessel is dead in the water.

Most Recent Dynamic Draft Determination	*Date*	2011-03-25
	Method Used	Ellipsoidally Referenced Dynamic Draft Measurement (ERDDM)
	Discussion	For the 2011 field season, NOAA Ship THOMAS JEFFERSON used an inertially-aided post-processed kinematic approach (IAPPK) to determine the dynamic draft (settlement and squat) for 3101 and 3102. This method is called an ellipsoid-referenced dynamic draft measurement (ERDDM). This method was used to determine the dynamic draft for HSL 3101 as a part of the 2011 Hydrographic Systems Readiness Review which occurred on March 25, 2011 in the Elizabeth River.

Figure 2: Hydrographic Survey Launch 3101/3102

A.1.3 Hydrographic Survey Launch 3102

Name	Hydrographic Survey Launch 3102
Hull Number	3102
Description	NOAA Ship THOMAS JEFFERSON Hydrographic Survey Launch 2 of 2
Utilization	shallow water hydrographic data collection

Dimensions	*LOA*	31 feet
	Beam	10.667 feet
	Max Draft	5.167 feet
Most Recent Full Static Survey	*Date*	2010-01-13
	Performed By	National Geodetic Survey (NGS)
	Discussion	Vessel offset measurements were conducted for HSL 3102 by NGS personnel. The NGS survey measured from established benchmarks on the vessel back to the reference point on top of the IMU in the same manner as the survey of HSL 3101. From the surveyed benchmarks, the new RESON 7125SV, SSVS, and Odom CV200 installation offsets were measured using a steel tape. The Klein 5000 side scan was surveyed in a similar manner and offsets for the “heavy-weight” and “light-weight” systems were recorded.
Most Recent Partial Static Survey	*Date*	2011-02-09
	Performed By	NGS
	Discussion	NGS performed a partial resurvey of launches 3101 and 3102 to survey new POS/MV antenna's with respect to the vessel reference point. The launches were in the cradles onboard the ship at the time of the NGS survey, which reduced the accuracy and precision of the measurements. Calibrated Installation Parameters as calculated by the POS/MV indicate that the NGS measurements are within 10cm of the calculated values.

Most Recent Full Offset Verification	*Date*	2011-03-08
	Method Used	Steel tape to previously established reference marks
	Discussion	During the 2010 NGS survey, reference marks were established at various locations along the keel and hull of the launches to facilitate offsets verification. A steel tape was used to measure from phase center of each transducer to one of the previously established reference marks. This procedure was used to verify prior results.
Most Recent Partial Offset Verification	Partial offset verification was not performed.	
Most Recent Static Draft Determination	*Date*	2011-02-14
	Method Used	Waterline Measurement
	Discussion	Static draft measurements for HSL 3101 and HSL 3102 are determined using a sight tube to measure the waterline with respect to the reference point on the top of the IMU. These measurements are made at the beginning and end of each working day while the vessel is dead in the water.

Most Recent Dynamic Draft Determination	*Date*	2011-03-25
	Method Used	Ellipsoidally Referenced Dynamic Draft Measurement (ERDDM)
	Discussion	For the 2011 field season, NOAA Ship THOMAS JEFFERSON used an inertially-aided post-processed kinematic approach (IAPPK) to determine the dynamic draft (settlement and squat) for 3102. This method is called an ellipsoid-referenced dynamic draft measurement (ERDDM). The draft values were not updated in the HVF for 3102 in a timely manner, and therefore dynamic draft values from the 2010 season were retained for the 2011 season. Subsequent analysis showed that 2010 values agreed with the 2011 ERDDM values within 3cm for the entire range of survey speed, and therefore it was determined that the values retained from the 2010 season were adequate and additional processing with updated values from the ERDDM test were not warranted.

Figure 3: Hydrographic Survey Launch 3101/3102

A.2 Echo Sounding Equipment

A.2.1 Side Scan Sonars

A.2.1.1 Klein 5000

Manufacturer	Klein
Model	5000
Description	High speed, high resolution side scan sonar towfish (exclusively towed):The KLEIN 5000 high speed, high-resolution side-scan sonar (SSS) system is a beam-forming acoustic imagery device with an operating frequency of 455 kHz and vertical beam angle of 40°. The KLEIN 5000 system consists of a KLEIN 5500 towfish, a Transceiver/Processing Unit (TPU), and a computer for user interface. Stern-towed units also include a tow cable telemetry assembly. There are two configurations for data acquisition using the KLEIN 5000 system: stern-towed and hull-mounted. S-222 uses exclusively towed SSS, HSL 3101 is a hull-mount configuration, HSL 3102 can be converted from hull-mounted to towed as required. The KLEIN 5000 system is distinct from other commercially-available side scan sonars in that it forms 5 simultaneous, dynamically-focused receiver beams per transducer face. This improves along-track resolution to approximately 20cm at the 100m range scale, even when acquiring data at up to 10 knots. Across-track resolution is typically 7.5cm at the 100m range scale. The achievable 20cm resolution meets the NOAA Hydrographic Surveys Specifications and Deliverables Manual (HSSDM) requirements for object detection. Digital data from the KLEIN 5000 TPU is sent directly to the acquisition computer for display and logging by KLEIN SonarPro software. Raw digital side scan data from the KLEIN 5000 is collected in SDF file format and maintained at full resolution with no conversion or down sampling techniques applied. These files are archived to the raw data storage drives at the end of each line for initial processing and quality control review Towfish positioning with respect to the vessel reference point is provided by CARIS HIPS using cable-out values recorded in the Sonar Pro SDF files. HIPS uses cable-out and towfish depth to compute towfish positions. The towfish position is calculated from the position of the tow point using the cable-out value received by SonarPro from the cable-payout meter, the towfish pressure depth (sent via a serial interface from the KLEIN 5000 computer TPU to the SonarPro software), and the Course Made Good (CMG) of the vessel. This method assumes that the cable is in a straight line therefore no catenary algorithm is applied at the time of acquisition. During processing, CARIS SIPS applies a 0.9 coefficient to account for the catenary. When in the towed configuration, the north and east velocity vectors are filtered to calculate the ship's CMG. The CMG is used to determine the azimuth from the tow-block to the side-scan towfish. The position for the side-scan towfish is computed based on the vessel's

	heading, the reference position (POS/MV IMU), the measured offsets (X, Y, and Z) to the tow point, height of the tow point above the water, Course Made Good, and cable-out. This calculated towfish position is sent to the sonar data collection system in the form of a GGA (NMEA-183, National Marine Electronics Association, Global Positioning System Fix Data String) message where it is merged with the sonar data file. Cable adjustments are made using a remote winch controller located in acquisition in order to maintain acceptable towfish altitudes and sonar record quality. Changes to the amount of cable-out are automatically saved to the SonarPro SDF. Towfish altitude is maintained between 8% and 20% of the range scale in use (e.g. 4m-10m @ 50m range scale), when conditions permit. For equipment and personnel safety as well as safe vessel maneuverability, data may have been collected at towfish altitudes outside the 8% to 20% of the range over shoal areas and in the vicinity of charted obstructions or wrecks. In some regions of the survey areas, the presence of a significant density layer required that the altitude of the towfish be maintained outside the 8% to 20 % of the range to avoid refraction in the sonar data that would mask small targets in the outer sonar swath range. When the towfish altitude was either greater than 20% or less than 8%, periodic confidence checks on linear features (e.g. trawl scars) or geological features (e.g. sand waves or sediment boundaries) were made to verify the quality of the sonar data. Confidence checks ensure the ability to detect one-meter high objects across the full sonar record range. Another feature that affects the towfish altitude is the use of a K-wing depressor. The K-wing depressor is attached directly to the towfish and serves to keep it below the vessel wake, even in shallow, near-shore waters at slow survey speeds. The use of the K-wing reduces the amount of cable payout, which in turn reduces the positioning error of the towfish. Another benefit to less cable out is increased maneuverability of the ship in shallow water. Less cable out reduces the need to recover cable prior to turning for the next survey line, permitting tighter turns and increased survey efficiency. Side scan data files break automatically every 15 minutes and manually at the completion of a survey line. Each line is given a unique file name based on the time acquisition began on each line. Klein TPUs are interchangeable on the ship and launches. TPUs are occasionally swapped from one platform to another for troubleshooting or as necessary when factory maintenance is required. Klein 5000 light-weight and heavy-weight towfish are also interchangeable on all platforms. The standard configuration is to hull mount the light weight towfish on the launches and to tow the heavy weight towfish from the ship.
Serial Numbers	*Vessel Installed On*: S222 *TPU s/n*: 135/136/137 *Towfish s/n*: 280

Specifications	*Frequency*	455 kilohertz	
	Along Track Resolution	*Resolution*	20 centimeters
		Min Range	50 meters
		Max Range	150 meters
	Across Track Resolution	7.5 centimeters	
	Max Range Scale	150 meters	
Manufacturer Calibrations	Manufacturer calibration was not performed.		

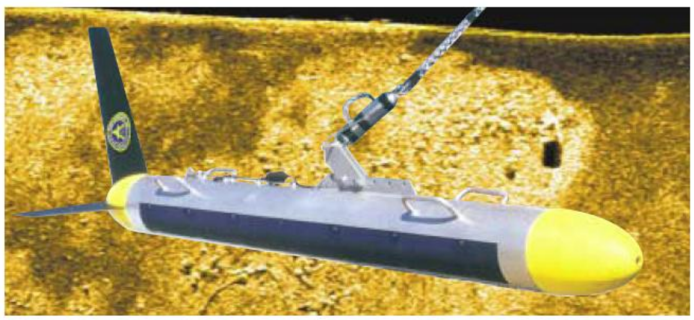

Figure 4: Klein 5000

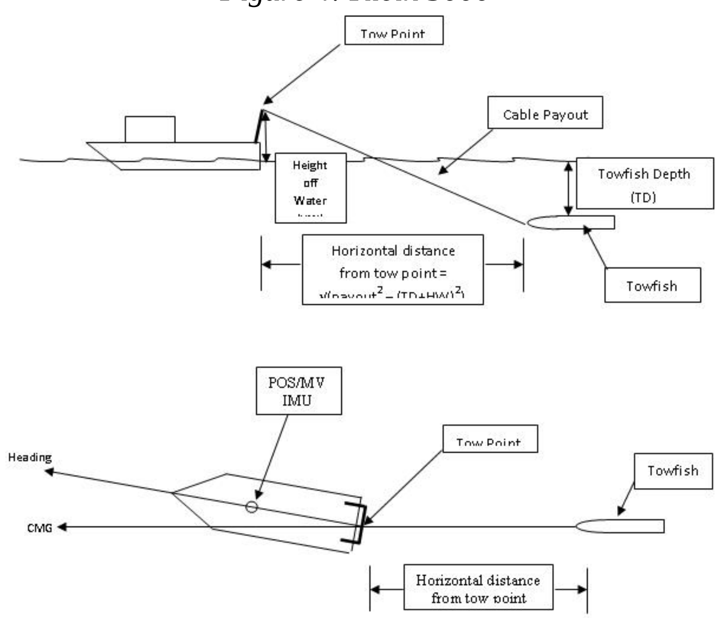

Figure 5: Side Scan Towfish Position Calculations

A.2.1.2 Klein 5000 Light-weight

Manufacturer	Klein		
Model	5000 Light-weight		
Description	High speed, high resolution side scan sonar towfish (hull mounted): Aboard both survey launches, the lightweight or heavyweight Klein 5500 towfish can be mounted to an aluminum sled using omega brackets. Positioning of the hull mounted towfish is determined by entering the X, Y, Z position of the towfish as the towpoint and a layback value of zero. Otherwise, the system is processed the same as the towed configuration. The hull-mounted configuration is normally used in depths of twenty meters or less, per the HSSDM. Aboard Launch 3101 and 3102, sidescan may be collected concurrently with ODOM Echotrac CV-200 vertical beam bathymetry or with Reson 7125-SV multibeam bathymetry with the addition of a BNC to BNC coax cable from the Klein TPU Trigger 1 Out to the Reson Trigger In. When SSS/MBES acquisition is in use, the ping rate for both systems is determined by the range scale in use on the Klein 5000. SSS/MBES acquisition will be discussed further in the Reson 7125-SV section. Launch acquisition of SSS with concurrent MBES bathymetry only occurred during OPR-B363-TJ-11 on H122296 and H12298 during the 2011 field season. Logging SSS with concurrent MBES on the launches frequently resulted in timing errors. The volume of data arriving at the acquisition computer from each of the survey components exceeded the acquisition computer's ability to process the data, resulting in dropped data packets. The dropped data packets manifests as a mismatch between bathymetry and the vessel motion. For this reason, SSS with concurrent bathymetry is not a standard mode of operation on the launches.		
Serial Numbers	*Vessel Installed On*		3101/3102
	TPU s/n		135/136/137
	Towfish s/n		322/319
Specifications	*Frequency*		455 kilohertz
	Along Track Resolution	*Resolution*	20 centimeters
		Min Range	50 meters
		Max Range	
	Across Track Resolution		7.5 centimeters
	Max Range Scale		150 meters
Manufacturer Calibrations	Manufacturer calibration was not performed.		

Figure 6: Side Scan Hull Mounted on 3101/3102

A.2.2 Multibeam Echosounders

A.2.2.1 RESON 7125-ROV

Manufacturer	RESON
Model	7125-ROV
Description	Shallow water multibeam sonar: The RESON 7125 forms 256 beams and can be set to interpolate to 512 beams. The RESON 7125 can also be set to acquire equi-distant or equi-angular beam spacing. Each beam in the receive array has a 0.5° across-track resolution and 1° along-track resolution. The RESON 7125 has a maximum ping rate of 50 Hz and can achieve a full swath width to a depth of ~100m. Standard operating procedure on THOMAS JEFFERSON is to acquire 512 beam, equi-distant bathymetry. Adaptive gates are used to assist in filtering noise from the water column. Adaptive gates are usually set at 10% of the nadir depth and nadir search gates are used to help eliminate surface noise and deep fliers in the data. Range scale is either adjusted manually or by "autopilot" settings that are tuned specifically for each survey area. Autopilot settings can control power, gain, range scale, absorption, spreading, and pulse length. The sonar contribution to the total propagated error is computed using parameters provided by the manufacturer and distributed with Caris HIPS. The RESON 7125 performs active beam steering to correct for sound velocity at the transducer head using an Applied Microsystems LTD Sound Velocity and Temperature

<table>
<tr><td></td><td colspan="3">Smart Sensor. This sensor will be discussed in more detail in the Sound Velocity Equipment Section.</td></tr>
<tr><td rowspan="7">Serial Numbers</td><td colspan="2">Vessel Installed On</td><td>S222</td></tr>
<tr><td colspan="2">Processor s/n</td><td>50357</td></tr>
<tr><td colspan="2">Transceiver s/n</td><td>61206</td></tr>
<tr><td colspan="2">Transducer s/n</td><td>1908203</td></tr>
<tr><td colspan="2">Receiver s/n</td><td>808042</td></tr>
<tr><td colspan="2">Projector 1 s/n</td><td>TC 2160</td></tr>
<tr><td colspan="2">Projector 2 s/n</td><td>None</td></tr>
<tr><td rowspan="10">Specifications</td><td colspan="2">Frequency</td><td>400 kilohertz</td></tr>
<tr><td rowspan="2">Beamwidth</td><td>Along Track</td><td>1 degrees</td></tr>
<tr><td>Across Track</td><td>0.5 degrees</td></tr>
<tr><td colspan="2">Max Ping Rate</td><td>50 hertz</td></tr>
<tr><td rowspan="2">Beam Spacing</td><td>Beam Spacing Mode</td><td>N/A</td></tr>
<tr><td>Number of Beams</td><td>512</td></tr>
<tr><td colspan="2">Max Swath Width</td><td>128 degrees</td></tr>
<tr><td colspan="2">Depth Resolution</td><td>5 millimeters</td></tr>
<tr><td rowspan="2">Depth Rating</td><td>Manufacturer Specified</td><td>200 meters</td></tr>
<tr><td>Ship Usage</td><td>100 meters</td></tr>
<tr><td>Manufacturer Calibrations</td><td colspan="3">Manufacturer calibration was not performed.</td></tr>
<tr><td rowspan="3">System Accuracy Tests</td><td>Vessel Installed On</td><td>S222</td><td>S222</td></tr>
<tr><td>Methods</td><td>Patch Test</td><td>Patch Test</td></tr>
<tr><td>Results</td><td>Patch test results for DN 090 can be found in Appendix A.2.1.</td><td>Patch test results for DN232 can be found in Appendix A.2.2.</td></tr>
<tr><td>Snippets</td><td colspan="3">Sonar has snippets logging capability.</td></tr>
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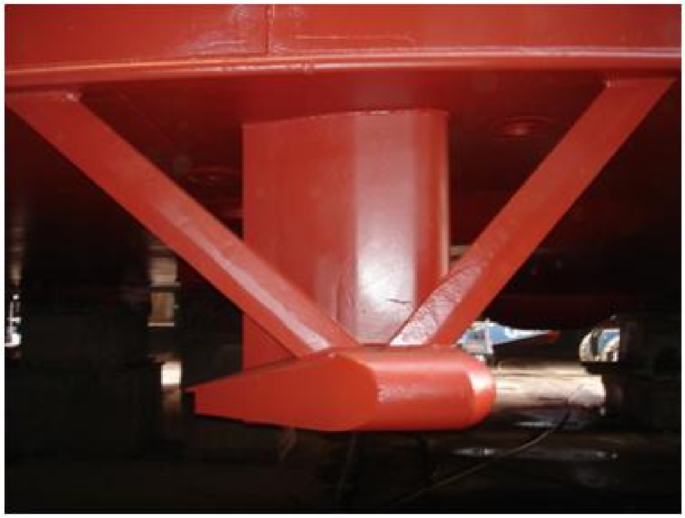

Figure 7: 7125 Transducer Mount on THOMAS JEFFERSON

A.2.2.2 RESON 7125-SV1

Manufacturer	RESON
Model	7125-SV1
Description	Dual Frequency multibeam echo sounder: The RESON 7125-SV system aboard Launches 3101, 3102 are installed on a RESON Seabat 7125 mounting bracket deployed on a retractable arm from the hull. The RESON 7125-SV forms 256 beams and can be set to interpolate to 512 beams in the receive array and can be set to acquire equi-distant or equi-angular beam spacing. Standard operating procedure on THOMAS JEFFERSON is to acquire 512 beam, equi-distant bathymetry. The 400 kHz frequency has a 0.54° across-track resolution and 1° along-track resolution. The 200 kHz frequency has a 1.1° across-track resolution and 2.2° along-track resolution. The RESON 7125-SV has a maximum ping rate of 50 pings and can maintain a full swath width in depths of 1-75 m for the 400 kHz, and 1-150 m for the 200 kHz systems. Adaptive gates are used to assist in filtering noise from the water column. Adaptive gates are usually set at 10% of the nadir depth and nadir search gates are used to help eliminate surface noise and deep fliers in the data. Range scale is either adjusted manually or by "autopilot" settings that are tuned specifically for each survey area. Autopilot settings can control power, gain, range scale, absorption, spreading, and pulse length. The sonar contribution to the total propagated error is computed using parameters provided by the manufacturer and distributed with Caris HIPS.

<table>
<tr><td></td><td>The RESON 7125-SV performs active beam steering to correct for sound velocity at the transducer head using a RESON Sound Velocity Probe (SVP) 70. This sensor will be discussed in more detail in the Sound Velocity Equipment Section.

The RESON 7125-SV can be configured for roll stabilization. In roll-stabilized mode, the sonar can operate in environments with up to +/- 10 degrees of roll without degrading system performance. Standard operating procedure on THOMAS JEFFERSON is to acquire data in the roll-stabilized mode.

Notable RESON7125-SV equipment changes: The Reson 7125-SV units on 3101 and 3102 were new equipment installations for 2010 field season; new .hvf files were created. Over the course of the 2011 season, receiver cables for the new Reson7125-SV units have failed on three separate occasions due to micro-fractures in the wires. These receiver cables have been replaced by a newer design which has endured the rotational stresses of a pivot mount significantly better than previous designs.

Components from the RESON 7125-SV units are interchangeable and both units have been deployed on each launch at least once during the 2011 field season. Patch tests are acquired anytime a receiver or projector are removed and replaced on a launch.</td></tr>
<tr><td>Serial Numbers</td><td>
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<tr><td>Vessel Installed On</td><td>3101</td><td>3102</td></tr>
<tr><td>Processor s/n</td><td>1812018</td><td>1812031</td></tr>
<tr><td>Transceiver s/n</td><td>1812018</td><td>1812031</td></tr>
<tr><td>Transducer s/n</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Receiver s/n</td><td>1409071/0309006</td><td>1409071/0309006</td></tr>
<tr><td>Projector 1 s/n</td><td>2308097/2208005</td><td>2308097/2208005</td></tr>
<tr><td>Projector 2 s/n</td><td>4408356/2909185</td><td>4408356/2909185</td></tr>
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<tr><td>Specifications</td><td>
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<tr><td>Frequency</td><td colspan="2">400 kilohertz</td><td colspan="2">200 kilohertz</td></tr>
<tr><td rowspan="2">Beamwidth</td><td>Along Track</td><td>1.1 degrees</td><td>Along Track</td><td>2.2 degrees</td></tr>
<tr><td>Across Track</td><td>0.54 degrees</td><td>Across Track</td><td>1.1 degrees</td></tr>
<tr><td>Max Ping Rate</td><td colspan="2">50 hertz</td><td colspan="2">50 hertz</td></tr>
<tr><td rowspan="2">Beam Spacing</td><td>Beam Spacing Mode</td><td>Equiangular</td><td>Beam Spacing Mode</td><td>Equidistant</td></tr>
<tr><td>Number of Beams</td><td>512</td><td>Number of Beams</td><td>256</td></tr>
<tr><td>Max Swath Width</td><td colspan="2">140 degrees</td><td colspan="2">140 degrees</td></tr>
<tr><td>Depth Resolution</td><td colspan="2">6 millimeters</td><td colspan="2">6 millimeters</td></tr>
<tr><td rowspan="2">Depth Rating</td><td>Manufacturer Specified</td><td>200 meters</td><td>Manufacturer Specified</td><td>300 meters</td></tr>
<tr><td>Ship Usage</td><td>100 meters</td><td>Ship Usage</td><td>250 feet</td></tr>
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<tr><td>Manufacturer Calibrations</td><td>Manufacturer calibration was not performed.</td></tr>
<tr><td>System Accuracy Tests</td><td>
<table>
<tr><td>Vessel Installed On</td><td>3101</td><td>3101</td><td>3102</td><td>3102</td></tr>
<tr><td>Methods</td><td>Patch Test on DN059</td><td>Patch Test on DN 232</td><td>Patch test on DN 056</td><td>Past test on DN 233</td></tr>
<tr><td>Results</td><td>Patch test results can be found in Appendix A.2.3. - Retained patch values from 2010 field season because the 2011 Patch results did not resolve the biases any better than the 2010 values. Retaining the 2010 values until a more suitable patch area is available.</td><td>See HVF for patch test results - Values applied to the HVF and used for OPR-B363-TJ-11</td><td>Patch test results can be found in Appendix A.2.4.- Retained patch values from 2010 field season because the 2011 Patch results did not resolve the biases any better than the 2010 values. Retaining the 2010 values until a more suitable patch area is available.</td><td>Patch test results can be found in A.2.5. - Values applied to the HVF and used for OPR-B363-TJ-11</td></tr>
</table>
</td></tr>
<tr><td>Snippets</td><td>Sonar has snippets logging capability.</td></tr>
</table>

Figure 8: 7125-SV1 Housing on Launch 3101/3102

A.2.2.3 Kongsberg Simrad EM 1002

Manufacturer	Kongsberg		
Model	Simrad EM 1002		
Description	S222, Multibeam Echosounder, Processor, Transducer		
Serial Numbers	*Vessel Installed On*	S222	
	Processor s/n	227	
	Transceiver s/n	382	
	Transducer s/n	267	
	Receiver s/n	N/A	
	Projector 1 s/n	N/A	
	Projector 2 s/n	N/A	
Specifications	*Frequency*	95 kilohertz	
	Beamwidth	*Along Track*	1.5 degrees
		Across Track	2 degrees
	Max Ping Rate	10 hertz	
	Beam Spacing	*Beam Spacing Mode*	Equidistant
		Number of Beams	111
	Max Swath Width	150 degrees	
	Depth Resolution	8 centimeters	
	Depth Rating	*Manufacturer Specified*	1000 meters
		Ship Usage	1000 meters
Manufacturer Calibrations	Manufacturer calibration was not performed.		
System Accuracy Tests	System accuracy test was not performed.		
Snippets	Sonar has snippets logging capability.		

A.2.3 Single Beam Echosounders

A.2.3.1 Odom Echotrac CV-200

<table>
<tr><td>Manufacturer</td><td>Odom</td></tr>
<tr><td>Model</td><td>Echotrac CV-200</td></tr>
<tr><td>Description</td><td>Shallow water single beam echo sounder: The Echotrac CV-200 is a dual-frequency digital-recording echosounder system with a digital recorder. The systems high-frequency setting is 200 kHz; low-frequency is 24 kHz. It is hull-mounted on HSL 3101and 3102.

On Launches 3101 and 3102, the transducer is mounted on the port side forward of the retractable arm that accommodates the RESON 7125-SV. The installation of the Odom on Launch 3101 and 3102 allows simultaneous acquisition of KLEIN 5000 side-scan with general survey-grade bathymetry when the ODOM is operated in either low- or high-frequency mode.</td></tr>
<tr><td>Serial Numbers</td><td><table>
<tr><td>Vessel</td><td>3101</td><td>3102</td></tr>
<tr><td>Processor s/n</td><td>003260</td><td>002917</td></tr>
<tr><td>Transducer s/n</td><td>xxxxxxxx</td><td>xxxxxxxx</td></tr>
</table></td></tr>
<tr><td>Specifications</td><td><table>
<tr><td>Frequency</td><td colspan="2">200 kilohertz</td><td colspan="2">24 kilohertz</td></tr>
<tr><td rowspan="2">Beamwidth</td><td>Along Track</td><td>4 degrees</td><td>Along Track</td><td>20 degrees</td></tr>
<tr><td>Across Track</td><td>4 degrees</td><td>Across Track</td><td>20 degrees</td></tr>
<tr><td>Max Ping Rate</td><td colspan="2">20 hertz</td><td colspan="2">20 hertz</td></tr>
<tr><td>Depth Resolution</td><td colspan="2">1 centimeters</td><td colspan="2">1 centimeters</td></tr>
<tr><td rowspan="2">Depth Rating</td><td>Manufacturer Specified</td><td>200 meters</td><td>Manufacturer Specified</td><td>1500 meters</td></tr>
<tr><td>Ship Usage</td><td>150 meters</td><td>Ship Usage</td><td>1000 meters</td></tr>
</table></td></tr>
<tr><td>Manufacturer Calibrations</td><td>Manufacturer calibration was not performed.</td></tr>
<tr><td>System Accuracy Tests</td><td><table>
<tr><td>Vessel Installed On</td><td>3101</td><td>3101</td><td>3102</td><td>3102</td></tr>
<tr><td>Methods</td><td>Bar Check</td><td>Reference surface</td><td>Bar Check</td><td>Reference Surface</td></tr>
<tr><td>Results</td><td>Meets IHO Order 1</td><td>Meets IHO Order 1</td><td>Meets IHO Order 1</td><td>Meets IHO Order 1</td></tr>
</table></td></tr>
</table>

Figure 9: Odom Vertical Beam on 3101 / 3102

A.2.4 Phase Measuring Bathymetric Sonars

No phase measuring bathymetric sonars were utilized for data acquisition.

A.2.5 Other Echosounders

No additional echosounders were utilized for data acquisition.

Additional Discussion

An Applanix Landmark Marine laser scanner was used during OPR-E350-TJ-11 on survey H12282. The system is a Class I laser product with a maximum range of 1500m. The system has a raw range accuracy of 7mm@100m and raw positional accuracy of 8mm@100m. The system is coupled with an Applanix Pos/MV 420 ver 4 GNSS inertial navigation system. The components were mounted to an aluminum mounting bracket and all offsets for the components were surveyed to the reference point for the unit. With this modular design the system can mobilize and commence surveying in a matter of hours. The Landmark Marine system was used to acquired high resolution x,y,z plus intensity laser data on shoreline features to support a 1:10,000 scale chart product of Norfolk Harbor. Positioning was obtained by post-processing the GNSS data with Applanix In-Fusion Smart Base processing. The resulting SBETs were parsed with the raw laser data to create processed x,y,z + Intensity files referenced to the ellipsoid using a proprietary data parser provided by the manufacturer. In Caris BDB, the ellipsoid-referenced point cloud data were shifted to MLLW using a VDATUM separation model provided with the Project Instructions for OPR-E350-TJ-11. The point cloud data were then used to confirm or disprove charted shoreline features. The Landmark Marine system is not discussed further in other sections of this DAPR. No additional systems accuracy checks were made aside from comparing the features from the laser data to orthoimagery provided with the project instructions and with sonar data from H12282.

Figure 10: Landmark Marine Laser Scanner System - image courtesy of geoconnexion.com

A.3 Manual Sounding Equipment

A.3.1 Diver Depth Gauges

No diver depth gauges were utilized for data acquisition.

A.3.2 Lead Lines

Manufacturer	Lead Line fabricated by ship's force
Model	N/A
Description	Standard Lead Line
Serial Numbers	WH-4

Calibrations	*Serial Number*: WH-4 *Date*: 2011-03-02 *Procedures*: The lead line was calibrated against a steel tape in the parking lot of the NOAA Marine Operations Center - Atlantic, Norfolk, VA 23510 on March 2, 2011. The calibration/accuracy check was performed by SST Lewit and ST Glomb.
Accuracy Checks	No accuracy checks were performed.
Correctors	From 0m - 15m, no corrections are needed, at 16m, a -1 cm corrector must be applied. The lead line does not extend beyond 16m.
Non-Standard Procedures	Non-standard procedures were not utilized.

A.3.3 Sounding Poles

No sounding poles were utilized for data acquisition.

A.3.4 Other Manual Sounding Equipment

No additional manual sounding equipment was utilized for data acquisition.

A.4 Positioning and Attitude Equipment

A.4.1 Applanix POS/MV

Manufacturer	Applanix
Model	POS/MV Model 320 v.4.
Description	The POS/MV 320 system includes dual GPS antennas, an inertial measurement unit (IMU), and data processor (PCS). The IMU measures linear and angular accelerations corresponding to the major motions of the vessel (heave, pitch, roll, yaw) and inputs this data to the PCS, where it is combined with a GPS position determined by carrier-phase differential measurements to give the final position solution. GPS positions are subject to short-period noise, but are stable over time and do not drift. IMU data is not subject to short-period noise, but will drift over time. The POS/MV uses a tightly-coupled solution which uses the IMU data to buffer the short-period noise from the GPS solutions and utilizes the GPS solutions to prevent IMU drift over time. The result of this tightly-coupled solution is attitude data (Pitch, Roll, and Yaw) with accuracies of 0.02° and horizontal positioning accuracy of 2m or better.

PCS	*Manufacturer*	Applanix
	Model	POS/MV 320 v.4
	Description	The POS Computer System (PCS) receives data from the GPS antennas and IMU and processes the information into a tightly-coupled solution. The PCS then outputs a variety of data streams to other devices via Ethernet, serial communication, and coaxial cable.
	Firmware Version	S222 - 2.8-7; 3101 - 2.8-7; 3102 - 2.5-7
	Software Version	S222 - 3.42; 3101 - 5.01; 3102 - 5.03
	Serial Numbers	*Vessel Installed On*: S222, 3101, 3102 *PCS s/n*: PCS-2321, PCS-2320, PCS-2562
IMU	*Manufacturer*	Applanix
	Model	POS M/V 320 v.4
	Description	Survey-grade Inertial Measurement Unit. The IMU measures linear and angular accelerations corresponding to the major motions of the vessel (heave, pitch, roll, yaw) and inputs this data to the PCS, where it is combined with a GPS position determined by carrier-phase differential measurements to give the final position solution. The POS/MV position solution is not sensitive to short-period noise, but its accuracy may decay rapidly over time.
	Serial Numbers	*Vessel Installed On*: S222, 3101, 3102 *IMU s/n*: IMU-146, IMU-352, IMU-356
	Certification	*IMU s/n*: IMU-146, IMU-352, IMU-356 *Certification Date*: 2010-02-02, 2010-02-02, 2010-02-02

Antennas	*Manufacturer*	Trimble Navigation LTD			
	Model	Zephyr			
	Description	L1/L2 carrier-phase antennas			
	Serial Numbers	*Vessel Installed On*	S222	3101	3102
		Antenna s/n	4526A59117	4526A59093	4617A68061
		Port or Starboard	Port	Port	Port
		Primary or Secondary	Primary	Primary	Primary
	Manufacturer	Trimble Navigation LTD			
	Model	Zephyr			
	Description	L1/L2 carrier-phase antennas			
	Serial Numbers	*Vessel Installed On*	S222	3101	3102
		Antenna s/n	44526A59133	4533A59352	4624A70252
		Port or Starboard	Starboard	Starboard	Starboard
		Primary or Secondary	Secondary	Secondary	Secondary
GAMS Calibration	*Vessel*	S222	3101	3102	
	Calibration Date	2011-03-30	2011-02-28	2011-02-25	
Configuration Reports	*Vessel*	S222	3101	3102	
	Report Date	2011-09-20	2011-10-21	2011-10-21	

Figure 11: POS M/V 320 v.4

A.4.2 DGPS

<table>
<tr><td>Description</td><td colspan="2">THOMAS JEFFERSON, Survey Launch 3101, and Survey Launch 3102 are each equipped with Trimble DSM212L DGPS receivers. The DSM212L includes a 12-channel GPS receiver capable of receiving external RTCM correctors from a shore-based reference station. The DSM212L receivers are used to receive differential correctors only and not used for actual positioning.</td></tr>
<tr><td rowspan="4">Antennas</td><td>Manufacturer</td><td>Trimble Navigation Limited</td></tr>
<tr><td>Model</td><td>MSK H-field loop</td></tr>
<tr><td>Description</td><td>Differential Radio Beacon Receiver</td></tr>
<tr><td>Serial Numbers</td><td><table><tr><td>Vessel Installed On</td><td>S222</td><td>S222</td><td>3101</td><td>3102</td></tr><tr><td>Antenna s/n</td><td>0220227516</td><td>0220159716</td><td>0220243252</td><td>0220168291</td></tr></table></td></tr>
<tr><td rowspan="5">Receivers</td><td>Manufacturer</td><td>Trimble Navigation LTD</td></tr>
<tr><td>Model</td><td>DSM212L</td></tr>
<tr><td>Description</td><td>12-channel GPS receiver capable of receiving external RTCM correctors from a shore-based reference station. The DSM212L receivers are used to receive differential correctors only and not used for actual positioning.</td></tr>
<tr><td>Firmware Version</td><td>2.0</td></tr>
<tr><td>Serial Numbers</td><td><table><tr><td>Vessel Installed On</td><td>S222</td><td>S222</td><td>3101</td><td>3102</td></tr><tr><td>Antenna s/n</td><td>0220227516</td><td>0220159716</td><td>0220243252</td><td>0220168291</td></tr></table></td></tr>
</table>

A.4.3 Trimble Backpacks

Trimble backpack equipment was not utilized for data acquisition.

A.4.4 Laser Rangefinders

No laser rangefinders were utilized for data acquisition.

A.4.5 Other Positioning and Attitude Equipment

No additional positioning and attitude equipment was utilized for data acquisition.

A.5 Sound Speed Equipment

A.5.1 Sound Speed Profiles

A.5.1.1 CTD Profilers

A.5.1.1.1 Sea Bird Electronics SBE19/19+ CTD Profilers

Manufacturer	Sea Bird Electronics
Model	SBE19/19+ CTD Profilers
Description	There are four Seabird Electronics CTDs aboard the THOMAS JEFFERSON. The ship has a SBE19 and a SBE19+V2, and launches 3101 and 3102 have a SBE 19+ models. The SBE19 is designed to measure conductivity, temperature, and pressure in marine or fresh water environments. It can operate in Profiling mode or Moored mode. Profiling mode is used exclusively aboard the ship. The system is configured for a sampling rate of 0.5 seconds. The SBE 19 is powered by 9 D-size alkaline batteries. The on-board memory is 1024 kilobytes CMOS static RAM, which can record 24 hrs of conductivity, temperature, and pressure data at the 0.5 second sample rate. The SBE19 is capable of CTD profiling at depths from 0-3,400m. Post-calibration drift is expected to be 0.02 °C yr-1, 0.012S m-1 yr-1, and 4.5 psia yr-1 for temperature, conductivity, and pressure, respectively. The SBE19 is deployed by hand or by using the DT Marine Oceanographic winch for ship-based acquisition. During the 2011 field season, the SBE19 was only used for CTD comparisons aboard the ship and was not used to acquire profiles for corrections to echosounder data.

	Seabird Electronics SBE-19 CTD+ units were used to collect sound speed profile (SSP) data from Launches 3101 and 3102.
Serial Numbers	*Vessel Installed On*: S222 - SBE-19 / S222 - SBE - 19+ V2 / 3101 - SBE 19+ / 3102 - SBE 19+; *CTD s/n*: 285 / 6667 / 4486 / 4487
Calibrations	see below

Serial Numbers

Vessel Installed On	S222 - SBE-19	S222 - SBE - 19+ V2	3101 - SBE 19+	3102 - SBE 19+
CTD s/n	285	6667	4486	4487

Calibrations

CTD s/n	285	6667	4486	4487
Date	2011-09-10	2011-09-20	2011-09-20	2011-09-20
Procedures	Manufacturer Calibration	Manufacturer Calibration	Manufacturer Calibration	Manufacturer Calibration

A.5.1.2 Sound Speed Profilers

A.5.1.2.1 Brooke Ocean Technology MVP 100

Manufacturer	Brooke Ocean Technology
Model	MVP 100
Description	A Brooke Ocean Technology Moving Vessel Profiler (MVP) with an Applied Microsystems Smart Sound Velocity and Pressure (SV&P) sensor or a Seabird Electronics SBE-19 CTD were used to collect sound speed profile (SSP) data from THOMAS JEFFERSON. The Moving Vessel Profiler (MVP) is a self-contained profiling system capable of sampling water-column profiles to 100m depth. MVP-100 was mounted to the port quarter. The MVP consists of a computer-controlled high-speed hydraulic winch, a cable metering, over-boarding and docking system, a conductor cable and a streamlined free-fall fish (FFF) housing an Applied Microsystems "time of flight" SV&P Smart Sensor (see SV&P below) . The system as configured aboard the THOMAS JEFFERSON collects vertical profiles of sound velocity data while the ship is underway at survey speed. The unit is located on the fantail and controlled remotely from the ship's acquisition room. The MVP is capable of importing its data directly into the Kongsberg SIMRAD EM 1002 multi-beam echosounder (MBES) at the time of acquisition. When using MVP casts in conjunction with the RESON 7125 MBES, sound velocity data is processed using Velocwin software, then applied in CARIS HIPS during post processing.

Serial Numbers

Vessel Installed On	S222	S222	S222
Sound Speed Profiler s/n	4988	5340	7591

Calibrations	*Sound Speed Profiler s/n*	4988	5340	7591
	Date	2011-01-26	2011-01-26	2011-04-28
	Procedures	Manufacturer Calibration	Manufacturer Calibration	Manufacturer Calibration

Figure 12: MVP 100 on S-222

A.5.2 Surface Sound Speed

A.5.2.1 AML AML Smart SV&T Probe

Manufacturer	AML
Model	AML Smart SV&T Probe
Description	The AML Smart SV&T Probe is a real-time time-of-flight sound velocimeter and thermistor sensor. The manufacturer-specified sound velocity accuracy is 0.02 m/s and temperature accuracy is 0.03 °C. Empirical observations of drift show a sound velocity drift of approximately 0.5 m/s/yr and temperature drift of approximately

	0.05 °C/yr. Aboard THOMAS JEFFERSON, the AML Smart SV&T probe is mounted in an insulated sea chest in the sonar void. Sea surface temperature and sound velocity values are output in real-time to the SIMRAD EM1002 and RESON 7125 systems at a rate of 10 Hz and are recorded in the raw Hypack .hsx files.

Serial Numbers

Vessel Installed On	S222	S222
Sound Speed Sensor s/n	4823	5649

Calibrations

Sound Speed Sensor s/n	4823	5649
Date	2011-09-10	2011-11-23
Procedures	Manufacturer Calibration	Manufacturer Calibration

A.5.2.2 Reson SV-71

Manufacturer	Reson
Model	SV-71
Description	

Serial Numbers

Vessel Installed On	3101	3102
Sound Speed Sensor s/n	2008044	2008027

Calibrations

Sound Speed Sensor s/n	2008044	2008027
Date	2010-11-24	2011-03-03
Procedures	Three data-point, side-by-side comparisons to known calibrated lab instruments.	Three data-point, side-by-side comparisons to known calibrated lab instruments.

A.6 Horizontal and Vertical Control Equipment

A.6.1 Horizontal Control Equipment

No horizontal control equipment was utilized for data acquisition.

A.6.2 Vertical Control Equipment

A.6.2.1 Water Level Gauges

No water level gauges were utilized for data acquisition.

A.6.2.2 Leveling Equipment

Manufacturer	Lietz / Sokkisha
Model	B1 Automatic Level
Description	TIDES & LEVELING EQUIPMENT
Serial Numbers	7423
Calibrations	No calibrations were performed.
Kukkamaki	No Kukkamaki procedures were performed.

Manufacturer	Carl Zeiss
Model	Ni 2 Level
Description	TIDES & LEVELING EQUIPMENT
Serial Numbers	20606
Calibrations	No calibrations were performed.
Kukkamaki	No Kukkamaki procedures were performed.

A.7 Computer Hardware and Software

A.7.1 Computer Hardware

Manufacturer	Kongsberg	
Model	EM HWS 10	
Description	Survey, rack mounted	
Serial Numbers	*Computer s/n*	227
	Operating System	Windows XP Profesional 2002
	Use	Acquisition

Manufacturer	Dell
Model	Precision T3400
Description	CARIS Survey Software, rack mounted-PC

Serial Numbers	*Computer s/n*	6705VK1
	Operating System	Windows XP Profesional 2002
	Use	Acquisition

Manufacturer	RESON	
Model	7K V 2.11.3.1	
Description	STBD 7125, Rack-PC S222 Acquisition Monitor	
Serial Numbers	*Computer s/n*	50357
	Operating System	Windows XP Professional 2002
	Use	Acquisition and Processing

Manufacturer	Dell	
Model	Precision T3400	
Description	Klein Back-up (SSS ISIS)	
Serial Numbers	*Computer s/n*	GQG2VK1
	Operating System	Windows XP Professional 2002
	Use	Acquisition

Manufacturer	Industrial Computer Inc.	
Model	4UX-208-X7DAL-E	
Description	Survey 3101, used for Hypack & Hysweep	
Serial Numbers	*Computer s/n*	NM8AS31197
	Operating System	Windows XP Professional 2002
	Use	Acquisition

Manufacturer	Dell	
Model	4U X-208-X7DAL-E	
Description	Survey 3102, used for Hypack & Hysweep	
Serial Numbers	*Computer s/n*	OM86S45147
	Operating System	Windows XP Professional 2002
	Use	Acquisition

Manufacturer	Dell
Model	Workstation PWS 650
Description	Processor Survey Chief, plot room

Serial Numbers	*Computer s/n*	4DVFZF1
	Operating System	Windows XP Professional 2002
	Use	Processing

Manufacturer	DELL	
Model	Workstation PWS 650	
Description	Processor 6, plot room	
Serial Numbers	*Computer s/n*	4JKBZK1
	Operating System	Windows XP Professional 2002
	Use	Processing

Manufacturer	Dell	
Model	Workstation PWS 650	
Description	Processor 7, plot room	
Serial Numbers	*Computer s/n*	6JKBZK1
	Operating System	Windows XP Professional 2002
	Use	Processing

Manufacturer	Dell	
Model	Precision T3400	
Description	Survey -4, plot room	
Serial Numbers	*Computer s/n*	8JKBZK1
	Operating System	Windows XP Professional 2003
	Use	Processing

Manufacturer	Dell	
Model	Precision T3400	
Description	Survey -3, plot room	
Serial Numbers	*Computer s/n*	CJKBZK1
	Operating System	Windows XP Professional 2003
	Use	Processing

Manufacturer	Dell
Model	Precision T3400
Description	Survey -2, plot room

Serial Numbers	*Computer s/n*	9JKBZK1
	Operating System	Windows XP 2002
	Use	Processing

Manufacturer	Dell	
Model	Precision T3400	
Description	Survey-1, plot room	
Serial Numbers	*Computer s/n*	DDVFZF1
	Operating System	Windows XP Professional 2003
	Use	Processing

Manufacturer	Dell	
Model	Percision T3400	
Description	FOO Desktop	
Serial Numbers	*Computer s/n*	CD#0001766903
	Operating System	Windows XP 2002 sp3
	Use	Processing

Manufacturer	Dell	
Model	Latitude D800	
Description	FOO Laptop	
Serial Numbers	*Computer s/n*	CD#0000398722
	Operating System	Windows XP 2002
	Use	Processing

A.7.2 Computer Software

Manufacturer	Caris
Software Name	Bathy Database
Version	3.2
Service Pack	
Hotfix	
Installation Date	2011-09-14
Use	Processing

Description	Base Editor is used for feature preparation and compilation, surface review, and chart comparison.

Manufacturer	Caris
Software Name	HIPS & SIPS
Version	7.0
Service Pack	
Hotfix	
Installation Date	2011-09-14
Use	Processing
Description	CARIS HIPS (Hydrographic Information Processing System) is used for all initial processing of multibeam and vertical beam echosounder bathymetry data, including tide, sound velocity, and vessel offset correction and data cleaning. CARIS HIPS uses statistical modeling to create Bathymetry with Associated Statistical Error (BASE) surfaces in one of three ways: swath-angle weighted grids, uncertainty-weighted grids, and Combined Uncertainty and Bathymetry Estimator (CUBE) algorithm grids. Creation of grids as bathymetric products is discussed in section B of this report. CARIS SIPS (Side-scan Information Processing System) is used for all processing of side-scan sonar imagery, including cable layback correction, slant range correction, contact selection, towpoint entry, and mosaic generation.

Manufacturer	HSTP
Software Name	Pydro
Version	11.9
Service Pack	
Hotfix	
Installation Date	2011-09-14
Use	Processing
Description	HSTP PYDRO is a program for the correlation and classification of side-scan sonar and multibeam bathymetry features and for the creation of preliminary smooth sheets. Multibeam features (designated soundings), side-scan sonar contacts, and detached positions are analyzed, grouped, and assigned S-57 classifications. High resolution BASE surface data is entered into the program and excessed to survey scale. The final product is a Preliminary Smooth Sheet file (PSS), which is delivered to the Atlantic Hydrographic Branch as part of the final submission package. Pydro Versions 7.3 and later have functionality for TCARI installed. TCARI is described in detail in the section "Corrections to Echo Soundings, Tides and Water Levels". The TCARI file for the area (when applicable) is received from NOS and loaded into Pydro along with the predicted, observed, or verified tide files for the corresponding stations. The use of TCARI is specified in the Project Instructions. Pydro is also used for chart comparisons, generation of chartlets, generation of Danger to Navigation

	reports, generation of appendices to the Descriptive Report, compilation of survey statistics, and generation of standard NOAA forms such as the Descriptive Report cover sheet.

Manufacturer	MapInfo
Software Name	MI Professional
Version	10
Service Pack	
Hotfix	
Installation Date	2011-09-14
Use	Processing
Description	MapInfo Professional is the Geographic Information System (GIS) software package used aboard THOMAS JEFFERSON. MapInfo is used for sheet management, line planning, final data analysis, and creating end-user plots.

Manufacturer	IVS
Software Name	Fledermaus
Version	
Service Pack	
Hotfix	
Installation Date	2011-09-14
Use	Processing
Description	Fledermaus is used for processing water column, or "midwater" multibeam data.

Manufacturer	HSTP
Software Name	Velocipy
Version	11.10
Service Pack	
Hotfix	
Installation Date	2011-09-14
Use	Processing
Description	HSTP Velocwin is a program for the processing of sound velocity casts. This program uses Sea-Bird Electronics SeaSoft software to convert hexadecimal SeaCat data into ASCII conductivity-temperature-depth data, and then converts the ASCII data into a depth-binned sound velocity file. Velocwin software is also used to process Moving Vessel Profiler (MVP) sound velocity data into a CARIS compatible format. Velocwin allows for batch processing of the numerous .calc files generated by the MVP during multibeam echosounder acquisition. The resulting .svp files are

	applied in CARIS HIPS during post-processing to correct for sound velocity variation within the water column. These sound velocity files are applied to the data in CARIS HIPS. Velocwin is also used to check the accuracy of sound velocity casts and to archive sound velocity information for the National Oceanographic Data Center.

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

A.8.1.1 Kahlsico Mud Snapper 214WA100

Manufacturer	Kahlsico Mud Snapper
Model	214WA100
Description	Deployed by one person by hand and is best used for shallow-water bottom samples acquired on the survey launches. It is a foot-trip model, capable of fitting through a 15 cm (6") diameter ice-hole, and fabricated from sturdy bronze and stainless steel materials to assure long-time, trouble-free service. The Snapper has a long threaded post with a strong compression spring surrounding it which presses against the jaws at one end and is seated inside a cap at its upper end. By turning the threaded cap, spring-tension adjustment is effected on the closing jaws which are easily cocked open by the attached foot-trip assembly. The post may be fastened to a long, hand-held rod for shallow-water use, to a sounding weight for intermediate-water sampling or to a lowering line for free-fall to the bed of a lake, estuary, reservoir, etc. Upon impact with the bottom, the foot-trip is pushed up, disengaging the pivoted locking arm and allowing the spring-tensioned, hinged jaws to snap shut.

Figure 13: Kahlsico Mud Snapper

A.8.1.2 Ponar Wildco # 1728

Manufacturer	Ponar Wildco
Model	# 1728
Description	The Ponar Wildco Model # 1728 sampler may be deployed by one person by hand and is sometimes used with the DT Marine Oceanographic winch for ship-based bottom sample acquisition. The Ponar Grab is a self-closing sampler using a patented spring-loaded Pinch-Pin™ system that releases when the sampler impacts the bottom and the lowering cable or line becomes slack. A Safety-Pin replaces the Pinch-Pin when sampling to prevent unexpected closing of the scoops and protects the operator from injury by sudden closing of the scoops. Self-closing scoops have center pivot closing action. When the scoops contact the bottom, they obtain good penetration with very little sample disturbance. An underlip, attached to the scoops, wipes clean most pebbles and small cobble that would prevent the scoops from closing completely. Removable side plates prevent the lateral loss of sample when scoops are closing

Figure 14: Ponar Wildco Model # 1728

B Quality Control

B.1 Data Acquisition

B.1.1 Bathymetry

B.1.1.1 Multibeam Echosounder

During multibeam data collection, watch-standers continuously monitor the Reson acquisition system. On THOMAS JEFFERSON, MBES data acquisition is controlled via Hypack/Hysweep software. Thresholds set in Hypack/Hysweep, as well as POSView and the RESON I/O Module alert the watch-stander by displaying alarm messages when error thresholds or tolerances are exceeded. These alarms, displayed as they occur, are reviewed and acknowledged on a case-by-case basis. Alarm conditions that may compromise survey data quality are corrected and then noted in acquisition log. Warning messages such as the temporary loss of differential GPS, loss of external clock data (timing from POS/MV), loss of sound speed from the surface sound velocimeter, or excessive cross-track error are addressed by the watch-stander and corrected before further data acquisition occurs.

Along-track data density is managed by controlling vessel speed-over-ground and sonar ping rate. Vessel speed during MBES operations can range between 0 and10 kts depending on density requirements and environmental conditions at the time of acquisition. Vessel speeds during MBES acquisition are nominally 8.5 kts for the launches and 9.5 kts for the ship.

Ping rate is usually set between 14 and 20 pings per second. As the range scale increases, the ping rate achievable by the sonar system decreases. If the ping rate is set significantly higher than the ping rate that the sonar can achieve, then buffer overflow is possible. Buffer overflow can result in system instability and can introduce timing latency into the data. Therefore, it is important for the sonar operator to monitor the ping rate frequently during acquisition.

The Reson 7125 SV sonars have the option for roll stabilization. This utilizes active beam steering to remove the affects of roll-motion during ping transmission. Roll-stabilized systems reduce the likelihood of holidays between adjacent lines due to inadequate line overlap. It is standard operating procedure to operate the Reson 7125 SV sonars in roll-stabilized mode. Roll stabilization is not available for the RESON 7125 ROV system installed on the ship.

Another feature of the Reson 7125 systems (ROV and SV) is an auto-pilot setting. User-configured parameters such as power, gain, ping rate, absorption, and spreading can be optimized for a particular survey area and then saved to a configuration file. When beginning survey operations in a new survey area, it is standard practice to create one or more configuration files that properly tune the sonar for the area. During acquisition, the watch-stander operates the sonar in the "Auto-Pilot" mode and monitors the quality of the sonar data. If the auto-pilot settings are not performing adequately, the watch-stander must switch to manual control and either modify the auto-pilot setting and return to auto-pilot control, or continue to operate the sonar in manual control.

B.1.1.2 Single Beam Echosounder

During vertical beam data collection, watch-standers continuously monitor the Odom acquisition system. Thresholds set in Hypack and POSView alert the watch-stander by displaying alarm messages when error thresholds or tolerances are exceeded, and any issues are addressed by the watch-stander and corrected before further data acquisition occurs.

The Odom Echotrac CV200 sonar system is controlled via the E-Chart software provided with the system. E-chart software's standard operating procedure is to configure the VBES sonar such that the primary channel is configured for 200kHz (high frequency) and the secondary channel is configured for 24 kHz (low frequency). As part of the standard operating procedure, auto power and auto gain settings are used to tune the VBES. Occasionally, environmental conditions necessitate manual control of the power or gain.

It is important for sonar operators to open a raw VBES data file at the beginning of the survey day and periodically throughout the day to determine if timing latency issues are present. When timing issues are observed, a complete re-start of all acquisition systems often resolves the issue.

B.1.1.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar bathymetry was not acquired.

B.1.2 Imagery

B.1.2.1 Side Scan Sonar

During side-scan data collection, watch-standers continuously monitor the Klein acquisition system. Thresholds set in SonarPro and POSView alert the watch-stander by displaying alarm messages when error thresholds or tolerances are exceeded, and any issues are addressed by the watch-stander and corrected before further data acquisition occurs.

Standard operating configurations for the Klein 5000 are: 50 micro-second chirp and 20cm resolution (along track). Digital data from the KLEIN 5000 TPU is sent directly to the acquisition computer for display and logging by KLEIN SonarPro software. Raw digital side-scan data from the KLEIN 5000 is collected in (SDF) and maintained at full resolution, with no conversion or down-sampling techniques applied. These files are archived to the raw data storage drives at the end of each line for initial processing and quality control review.

The sonar operator monitors the image quality in real-time, looking for signs of refraction that could make height estimates on features inaccurate. When refraction is encountered there are a few options available. For towed systems, the cable-out can be adjusted to get the sonar above or below the layer causing the refraction. It is preferable to get the sonar below the refraction layer if safety and operational conditions permit. For hull mounted systems, the vessel must relocate to an area without refraction, must change the mode of survey operations (such as Object Detection MBES), or must cease operations until the water column is more conducive for surveying.

B.1.2.2 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar imagery was not acquired.

B.1.3 Sound Speed

B.1.3.1 Sound Speed Profiles

A Brooke Ocean Technology Moving Vessel Profiler (MVP) with an Applied Microsystems Smart Sound Velocity and Pressure (SV&P) sensor or a Seabird Electronics SBE-19 CTD were used to collect sound speed profile (SSP) data from THOMAS JEFFERSON. Seabird Electronics SBE-19 CTD+ units were used to collect sound speed profile (SSP) data from Launches 3101 and 3102. SSP data were obtained at intervals frequent enough to reduce sound speed errors. The frequency of casts was based on observed sound speed changes from previously collected profiles and time elapsed since the previous cast. The ship acquired casts at 15 – 30 minute intervals while acquiring cross-lines at the beginning of each project to determine the variability in sound speed in the survey area. Subsequent casts were made based on the observed trend of sound speed changes. As the sound speed profiles change, cast frequency and location are modified accordingly. Confidence checks of the sound speed profile casts are conducted weekly by comparing simultaneous casts taken with all sound speed determining devices on the ship and each launch.

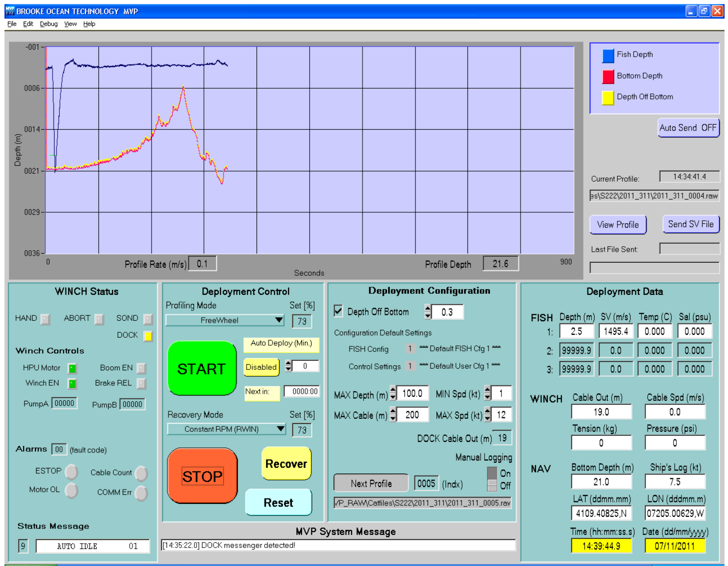


Figure 15: MVP Cast

B.1.3.2 Surface Sound Speed

Sound speed uncertainty for THOMAS JEFFERSON is calculated for each project area. Because the intake for the SSVS on the ship is not located at the transducer, it is necessary to account for the difference in sound speed due to the vertical offset of the transducer with respect to the intake, the effects of roll due to the athwartship offset between the transducer and intake, and the time delay between water entering the intake and the SSVS unit registering the change.

On DN 203 (2010) a test was designed to measure the latency associated with the AML Smart SV&T arrangement. The experiment determined that it takes approximately 3 minutes for the SSVS in the sea chest to register a change in sound speed from the intake. Based on the latency value of approximately 3 minutes and based on the athwartship and vertical offsets between the sea chest intake and the Reson 7125 transducer on the ship, uncertainty values for the speed of sound are calculated for each project. These uncertainty values are compared to the default value of 0.2m/s, and when deemed significant, are applied during TPU processing in CARIS Hips and Sips. The calculated values for surface sound speed are derived from the following equation:

Uncertaintyssv = Square Root of [(#sv/tlatency)]^2 +[(#sv/#z)^2 + ((#sv/(#y)tan#roll)^2]

Where (#sv/tlatency) is the change in sound speed along-track due to the approximately 3 minute lag time associate with the plumbing of the SSVS and the sea chest configuration on the ship; (#sv/#z) is the difference in sound speed due to the static vertical offset between the intake and the transducer as observed in sound speed profiles of the water column; and ([(#sv/(#y)tan#roll) is the change in sound speed attributable to roll of the ship with regard to the athwartship offset when compared to sound speed profiles of the water column.

TPU Parameters for sound speed uncertainties are documented in each survey's Descriptive Report.

B.1.4 Horizontal and Vertical Control

B.1.4.1 Horizontal Control

The Horizontal Datum for survey operations is the North American Datum of 1983 (NAD83). 2011 surveys were either in UTM zone 18 (OPR-E350-TJ-11 and OPR-D304-TJ-11) or UTM Zone 19 (OPR-B363-TJ-11 and S-A916-TJ-11). Horizontal control for survey operations is primarily derived from Differentially-corrected GPS, using USCG differential correctors. Differential beacons are chosen based on their proximity to the survey grounds and the signal-to-noise ratio of the beacons if more than one beacon is near the survey grounds. For surveys in the vicinity of Norfolk, the Driver, VA beacon is the primary beacon. The beacon at New Bern, NC was used during temporary outages at the Driver, VA site. For surveys in the Block Island Sound (BIS) area, the beacons at Moriches and Acushnet were used.

Other tools are available for horizontal control, namely Smooth Best Estimate Trajectory (SBET) files processed from Applanix POSPac files. POSPac files are acquired daily on each vessel during normal survey operations. These POSPac files provide for a post-processed heave solution called TrueHeave. Further processing of the POSPac file using Applanix POS MMS 5.4 creates an SBET file which can be used for both horizontal and vertical control. From the perspective of data acquisition there are few changes necessary to acquire a POSPac file that will be used to create an SBET as opposed to a POSPac file that will be used for TrueHeave only. In order to acquire a POSPac file for use in creating an SBET file, the watch-stander must monitor the number of satellites and PDOP. If the number of satellites, or space vehicles (SVs) drops below 5, or the PDOP increases above 6, then acquisition should be stopped until SV geometry improves and the numbers return to acceptable values.

No additional horizontal control methods or tools were used during the 2011 field season.

B.1.4.2 Vertical Control

Vertical Datum for surveys is Mean Lower Low Water (MLLW). For each project, the project instructions include the method(s) approved for vertical control. Typically, vertical control is based on one or more NWLON stations operated by CO-OPS. Co-range and co-phase measurements from the NWLON stations are used to derive discrete tide zones for a project area in the form of a zone definition file (*.zdf). Sometimes, it is necessary to install temporary, tertiary tide stations to supplement data from existing NWLON stations in order to adequately model tides.

Tidal Constituents and Residuals Interpolator (TCARI) is an alternative to discrete zoning. TCARI uses the shoreline to generate a Triangulated Irregular Network (TIN) surface that encompasses the survey area.

Water levels and residuals from tide stations in the area are used to populate each cell in the TIN, resulting in a smoother tide solution than can be achieved by discrete zoning.

Both discrete zoning and TCARI are based on the MLLW tidal datum. Observed tides are downloaded from the CO-OPS website, www.tidesandcurrents.noaa.gov on a daily basis via an in-house software program called FetchTides. Once CO-OPS have verified the observed data from a tide station and corrected any fliers in the data, a verified tide file for each tide station is made available for download.

An alternative to discrete zoning and TCARI, is Ellipsoid-Referenced Surveying (ERS). ERS utilizes a completely different approach to vertical control. ERS surveys utilize inertially-aided, post-processed kinematic (IAPPK) GPS solutions and reference the Ellipsoid as the vertical datum. DGPS measurements recorded by a rover aboard the survey vessel are post-processed with ephemeris correctors and clock correctors from Continuously Operating Reference Stations (CORS). ERS vertical control data is acquired in the form of a POSPac file in the same manner as discussed in the previous section on horizontal control. Processing of ERS data will be discussed further in the data processing section of vertical control.

B.1.5 Feature Verification

Features may be verified by utilizing a variety of tools based on the type of feature and its disposition with respect to MLLW:

Bearing features that are already depicted on the chart may be verified using various sources of aerial imagery, whether included in the project instructions or viewed online with GoogleEarth. When feasible, NGS may fly tide-coordinated ortho-imagery to update the national shoreline. These data sets are included in the project instructions when available. In 2011, a horizontal scanning laser was used to identify bearing features during H12282, but this technology has not been adopted as standard operating procedure.

Submerged features are investigated with side-scan sonar, multibeam, or both. When investigating a feature with side-scan, the vessel is positioned to acquire lines adjacent to the feature at a distance approximately 30%-70% of the range scale in use, in order to get the highest quality imagery. At times it may be necessary to acquire imagery from multiple directions to obtain sufficient detail to identify the feature. When investigating a feature with multibeam, the vessel is positioned directly above the feature or as near to directly above the feature as safety permits. In accordance with the 2011 HSSD - 6.3.2, least depths on features must be selected from beams within 30° of nadir unless multiple passes are made over the feature.

While not a common technique aboard THOMAS JEFFERSON, DGPS "backpack" positioning is also an approved method for verifying features. A backpack rover unit is positioned over the feature and the site is occupied for a duration of time which can range from as little as 15 seconds to as long as 4 hrs depending on the required positional accuracy.

Detached Positions (DPs) and Lines of Position (LOPs) are yet another method which may be utilized to verify the position of features. For DPs, the survey vessel is positioned against or adjacent to the feature and a target is created in Hypack using the F5 key. Distance and azimuth from the vessel's reference point

(RP) are recorded in the target file so the position can be properly corrected in post processing. A variation of using DPs to verify feature position is the LOP. With LOPs, multiple DPs (with azimuth recorded) are acquired from various angles around the feature. When the position and azimuth for each DP are plotted, the lines intersect at the position of the feature, similar to the way mariners take visual fixes on navigational aides. The LOP approach is particularly useful in positioning features ashore or inshore where water depth limits access by the survey vessel.

When feasible, digital images and notes are taken for each feature verified. These images and notes aid in feature attribution when the feature report is created.

B.1.6 Bottom Sampling

Recommended bottom sample locations are supplied to the field by HSD OPS. These recommended bottom sample sites are compared to the charted density and current survey data to optimize the final density and locations for bottom samples sites. Once locations have been determined, a target file is loaded into the survey acquisition software. The vessel (ship or launch) is positioned directly above or up current/wind of the target to facilitate sampling over the proper location.

B.1.7 Backscatter

THOMAS JEFFERSON and launches 3101 and 3102 acquire MBES Snippet Backscatter data with their RESON 7125 and 7125-SV systems when project instructions specify this type of data as a requirement. During acquisition, the power is set to maximum power (220 dB). Range Scale and Gain are adjusted as necessary during acquisition to keep the sonar tuned properly and to prevent intensity value saturation. Settings such as Absorption and Spreading are adjusted prior to the beginning of acquisition and are not changed. RESON Autopilot is configured to manage the various settings during acquisition. RESON systems are configured to send snippet data to the acquisition computer during all MBES operations. HYPACK/HYSWEEP is the software used to acquire MBES and Snippet Backscatter data on the acquisition computer. HYSWEEP logs data to HSX format, and when configured to log Snippet Backscatter data, logs data to an additional format called ".7k". The .7k files contain the intensity values from the Snippet Backscatter data. The HYSWEEP Hardware initialization file can be modified to acquire Snippets at different sampling rates. Standard operating procedure for THOMAS JEFFERSON is to log Datagram Version 1 at 25 snippet samples per beam.

B.1.8 Other

No additional data were acquired.

B.2 Data Processing

B.2.1 Bathymetry

B.2.1.1 Multibeam Echosounder

Raw bathymetry data, (Simrad .all, Hypack .raw and .hsx) are converted into CARIS HDCS data format upon completion of daily acquisition. Conversion parameters vary for each data format, and are stored in the Log File of each HDCS processed line folder. After data conversion, attitude and navigation are reviewed for outliers, and true heave, water level, and sound velocity are applied. Bathymetry lines are then merged. Following merge, Total Propagated Uncertainty (TPU) is calculated for each sounding. For a more detailed explanation of TPU calculation of multibeam and vertical beam echo sounder data, refer to Section 4.2.3.8 of the 2011 NOAA Field Procedures Manual.

MBES bathymetry are processed using Combined Uncertainty Bathymetric Estimator (CUBE) surfaces with resolution determined by the depth range and coverage type in accordance with Section 5.2.2 of the 2011 NOS Hydrographic Survey Specifications and Deliverables (HSSD). CUBE surfaces are described in detail in Section 4.2.1.1.1 of the 2011 NOS Field Procedures Manual and the CARIS HIPS/SIPS Users Manual.

Once surfaces have been created, data are cleaned of fliers and least depths on submerged features are designated. A child layer for "IHOness" is then created to demonstrate where the survey meets the assigned IHO Order. Areas that do not meet the assigned IHO Order are further investigated and resolved.

Once the surfaces are cleaned appropriately, and least depths have been designated on all significant features, the CUBE surface is "Finalized". When a surface is finalized, the surface is forced up to honor the designated soundings over survey features. Also, the uncertainty for each node in the grid is re-assigned based on the "greater of the two" between the node values for Standard Deviation and Uncertainty.

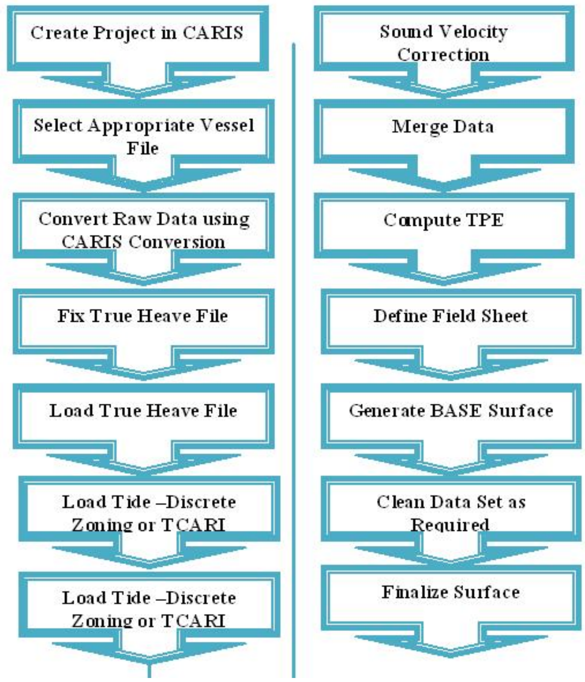


Figure 16: MBES Data Processing Flow Chart

B.2.1.2 Single Beam Echosounder

Raw vertical beam data is converted into CARIS HDCS data format upon completion of daily acquisition. Conversion parameters are stored in the Log File of each HDCS processed line folder. After data conversion, VBES data are cleaned for fliers using the .bin file to aide in data cleaning decisions. After the data has been cleaned, attitude and navigation are reviewed for outliers, and true heave, water level, and sound velocity are applied. Vertical beam lines are then merged. Following merge, Total Propagated Uncertainty (TPU) is calculated for each sounding. For a more detailed explanation of TPU calculation of multibeam and vertical beam echo sounder data, refer to Section 4.2.3.8 of the 2011 NOAA Field Procedures Manuals. The vertical beam lines are then gridded as an Uncertainty BASE surface, typically at 4m resolution.

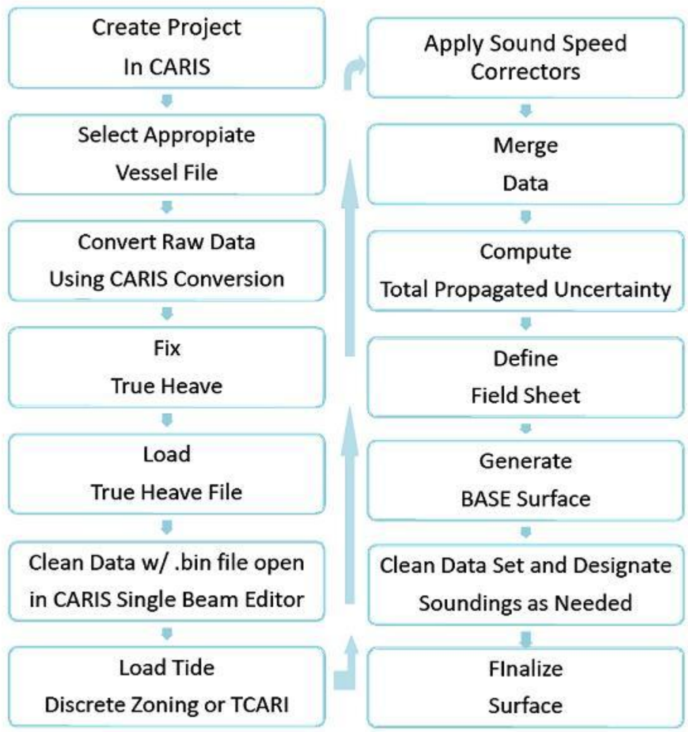


Figure 17: Single Beam Processing Workflow

B.2.1.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar bathymetry was not processed.

B.2.1.4 Specific Data Processing Methods

B.2.1.4.1 Methods Used to Maintain Data Integrity

Please refer to the Quality Management section.

B.2.1.4.2 Methods Used to Generate Bathymetric Grids

When the primary source of bathymetry for a survey area is a combination of VBES with MBES developments over features, a collection of finalized uncertainty-weighted mean bathymetric surfaces is generated as the product of the survey. CUBE is not permitted for set line spacing VBES mainscheme. When the primary source of bathymetry for this type of survey is set line spacing MBES data (also known as “skunk-stripe”), CUBE shall be used. The use of CUBE in this situation is required to guarantee proper nodal propagation distances as described in section 5.2.1, Gridded Data Specifications, of the 2011 HSSD. HSSD requires that 95% of the nodes in a CUBE grid contain a minimum of 5 soundings/node.

When Complete or Object Detection (OD) MB is the primary source of bathymetry, data are processed using CUBE grids. The use of CUBE is mandatory to ensure compliance with the specification described in the paragraph above.

Each resolution has its own CUBE parameter settings, and the hydrographer uses the appropriate resolution-based CUBE parameters settings when computing each grid. CUBE parameters were distributed with the project instructions for each survey.

B.2.1.4.3 Methods Used to Derive Final Depths

Methods Used	Cleaning Filters Gridding Parameters Surface Computation Algorithms
Description	There are a number of methods available to assist in deriving final depths. The following sections detail each method. Cleaning filters are tools that are available to address systematic errors in bathymetry data. Cleaning filters are seldom used aboard THOMAS JEFFERSON and are not part of the standard operating procedures. Cleaning filters are most often used to clean bad data resulting from refraction issues or from poor beam-forming caused by a bad element. While there are a number of options available when setting filters, filtering by beam number and by beam angle are the options most commonly used. Final survey depths are taken from statistical surfaces. These surfaces are created using the Combined Uncertainty Bathymetry Estimator (CUBE) algorithm or the CARIS Bathymetry and Associated Statistical Error (BASE) algorithm. CUBE was developed by Brian Calder at the University of New Hampshire (UNH), Joint Hydrographic Center (JHC), Center for Coast and Ocean Mapping (CCOM). NOAA has developed standardized CUBE parameters. These parameters are distributed to the field units and have been used exclusively for the creation of all CUBE surfaces during the 2011 field season. CUBE parameters are chosen based on the type of survey. For object detection multibeam, the IHO Order 1a option is used. For general bathymetry, the IHO Order 1b option is used. Grid resolution is in accordance with NOS HSSD unless specifically noted otherwise in a survey's descriptive report. BASE surfaces are uncertainty-weighted grids and are primarily used aboard THOMAS JEFFERSON for griding vertical beam data where the data density is insufficient for the CUBE algorithm.

B.2.2 Imagery

B.2.2.1 Side Scan Sonar

Side-scan sonar data are converted from *.sdf (SonarPro raw format) to CARIS HDCS. Processing side-scan data includes examining and editing fish height, vessel heading (gyro), and vessel navigation records. When side-scan sonar is towed, fish navigation is recalculated using CARIS SIPS. Tow point offsets (C-frame and cable-out), fish depth, fish attitude, and water depth are used to calculate horizontal layback.

After towfish navigation is recalculated, side-scan imagery data are slant-range corrected to 0.1m and beam pattern correction is applied. The slant-range corrected side-scan imagery data are closely examined for significant contacts. Points-of-interest are evaluated as potential contacts based upon apparent shadow height and appearance. Contacts are selected and saved to a contact file located in each line of SSS data. Contact selection includes measuring apparent height and width, selecting contact position, entering notes, and creating a contact image.

Side-scan sonar coverage is determined by creating mosaics using Mosaic Editor in CARIS SIPS. Mosaic Editor uses the accurately modeled backscatter correction algorithms of the Geocoder engine to process source data. This processed imagery data is stored in SIPS as Georeferenced Backscatter Rasters, or GeoBaRs. GeoBaRs are the basis for all mosaics created in SIPS. From the GeoBaRs, mosaics are created which can be examined and edited in Mosaic Editor. Once imagery has been corrected, a full mosaic is created for each 100% coverage.

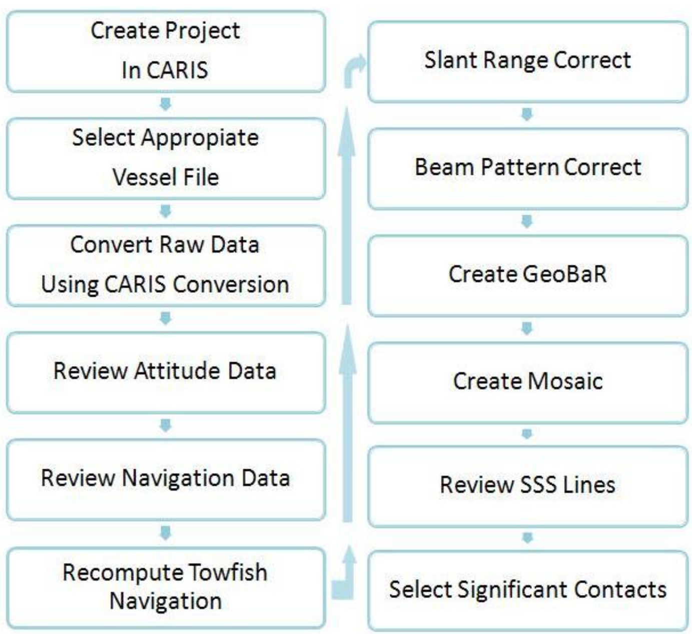


Figure 18: Side-Scan Imagery Processing Diagram

B.2.2.2 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar imagery was not processed.

B.2.2.3 Specific Data Processing Methods

B.2.2.3.1 Methods Used to Maintain Data Integrity

Please refer to the Quality Management section.

B.2.2.3.2 Methods Used to Achieve Object Detection and Accuracy Requirements

Object detection from side-scan imagery is obtained by acquiring the entire survey area two times, with survey lines in the second coverage offset halfway between the lines from the first coverage. This results in 200% Side-Scan Coverage with line spacing based on 80% of the range scale.

To ensure positional accuracy, a side-scan certification test is performed. Multiple passes are made on a discrete feature (1m cube when possible) that ensonifies the feature with each transducer at a distance approximately 15%, 50%, and 80% of the range scale in use. A total of 12 passes are made and the feature must be detected in at least 10 of the 12 pass. All survey lines are then processed and a contact created for the feature. Contact positions are plotted and compared to the actual position of the feature. The contacts must be within 5m of the actual position for hull-mounted systems and 10m for towed systems.

B.2.2.3.3 Methods Used to Verify Swath Coverage

Side-scan sonar coverage is determined by creating mosaics using Mosaic Editor in CARIS SIPS. Each 100% of coverage is evaluated independently for gaps in coverage. Any holidays noted in the mosaics must be re-acquired in a manner that will ensonify the area from the same incidence angle as originally intended.

B.2.2.3.4 Criteria Used for Contact Selection

For water depths less than 20m, contact heights of 1m or greater are considered significant. For water depths 20m or greater, contact heights of 10% of the water depth are considered significant. A feature is created for each significant contact.

B.2.2.3.5 Compression Methods Used for Reviewing Imagery

No compression methods were used for reviewing imagery.

B.2.3 Sound Speed

B.2.3.1 Sound Speed Profiles

Sound speed profiles are acquired by two types of devices: CTD and MVP. Sound speed casts from a CTD are downloaded to a computer designated to process sound speed casts. On the launches, the acquisition computers are used, on the ship, a processing computer in survey is used. Sound speed casts acquired using the MVP are processed on the acquisition computer that controls the MVP. In each case, the sound speed profiles are processed using Velocipy. Velocipy is an in-house software application written in the Python programming language and distributed with the in-house program Pydro.

Once a cast has been downloaded, the position of the cast and other metadata are entered. Next, the SV tab is reviewed and the watch-stander must determine if it is necessary to extend the cast based on the trend of the SV profile near the bottom. In most cases, it is unnecessary to extend a cast because Caris automatically uses the last value in a SV profile for all depths beyond the last profile value. However, if there is a significant change in the SV profile near the last data point in the cast, then it may be necessary to extend the cast using the most probable slope option.

Profiles are then exported to concatenated Caris SVP files.

B.2.3.1.1 Specific Data Processing Methods

B.2.3.1.1.1 Caris SVP File Concatenation Methods

SVP files are concatenated by day to create an SVP day file for each vessel. The SVP text files for each vessel day are then manually concatenated into Master SVP files for each vessel per survey.

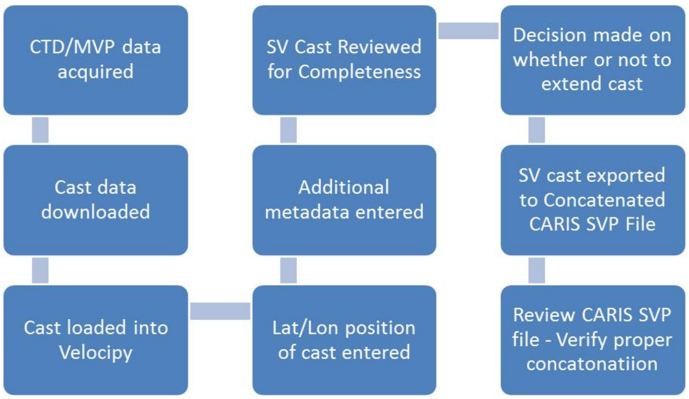


Figure 19: SVP Processing Diagram

B.2.3.2 Surface Sound Speed

Unlike CTD profilers, surface sound velocity sensors (SSVS) calculate sound velocity (sound speed) in water using the measured two-way travel time. The typical SSVS consists of a transducer and a reflector at a known distance from the transducer. A pulse of known frequency is emitted, reflects at the reflector surface, and returns. The two-way travel time is measured, and sound velocity is derived (distance divided by time). SSVS are required for flat faced multibeam systems and systems that perform active beam steering at the transducer head. The RESON 7125 ROV and RESON 7125-SV systems both require SSVS data, as does the Klein HydroChart 5000.

Surface sound velocity (speed) is input directly into the RESON 7125 Transceiver Processing Unit (TPU). The RESON I/O module receives the message string and saves it to the raw data being logged. A surface sound speed value is recorded along with each ping and is used to correct for the launch and receive angles as the sound wave passes between the ceramics of the transducer and the water, allowing for proper ray-tracing during processing.

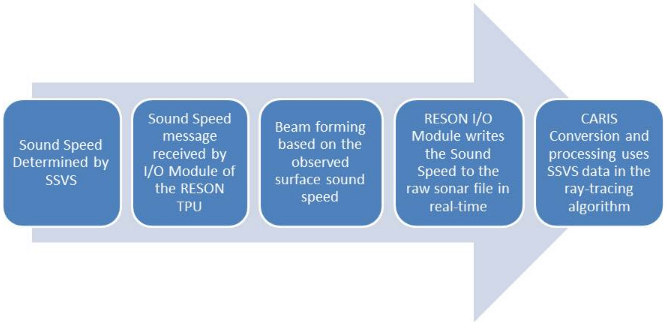


Figure 20: Surface Sound Velocity (Speed) Processing

B.2.4 Horizontal and Vertical Control

B.2.4.1 Horizontal Control

Horizontal control data comes in the form of a POSPac file, or in the case of GPS base stations, from the RINEX file. During 2011, the field unit did not use a GPS Base Station, so the procedures to process base station data is not discussed in this report.

POSPac files were processed into Smoothed Best Estimate Trajectory files using Applanix POS MMS 5.4. All data were processed in the ITRF2000 reference system until the SBET is exported as a Custom Smoothed BET in NAD83. To process a POSPac file, it must first be loaded into POS MMS 5.4. This is done by dragging and dropping the .000 POSPac file into the Plan View window. Next, base stations are selected, and clock and ephemeris data are downloaded and the raw data is imported. Next, the data is QC'ed by running the Smart Base Quality Check feature. If there is a problem with the data quality, then a different control station may need to be chosen, one of the other base stations may need to be disabled, and/or data from another station may be necessary. Once any data quality problems are resolved, the Applanix SmartBase processor is used to create the SmartBase region. Next, the GNSS-Inertial Processor is used to create the SBET. Applanix Infusion SmartBase is used to process SBET files unless specifically noted otherwise in a survey's descriptive report. Once the SBET has been created, the message log is reviewed for quality control. Finally, the SBET is exported to a Custom SBET in the NAD83 datum with UTM projection.

PDOP should be less than 6 for the entire SBET file or there will be high RMS-Error values. Additionally, the number of space vehicles is required to be 5 or more.

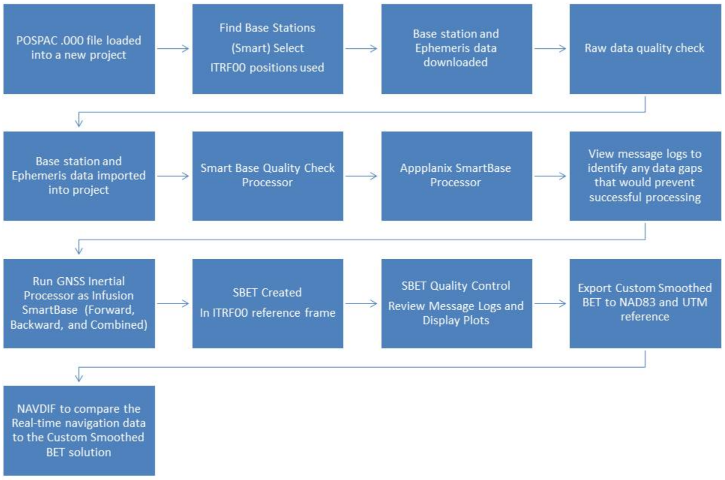


Figure 21: Steps to create a Smoothed Best Estimate Trajectory (SBET)

B.2.4.2 Vertical Control

Vertical control is achieved via tide measurements or via processed SBET files. Tide station data is processed by CO-OPS and is available for download using the FetchTides application developed by HSTP. No field processing of tide station data occurs. Vertical control from SBET files is processed as discussed in the horizontal control section above. Vertical data for all surveys is Mean Lower Low Water (MLLW) unless specifically stated otherwise a survey's descriptive report.

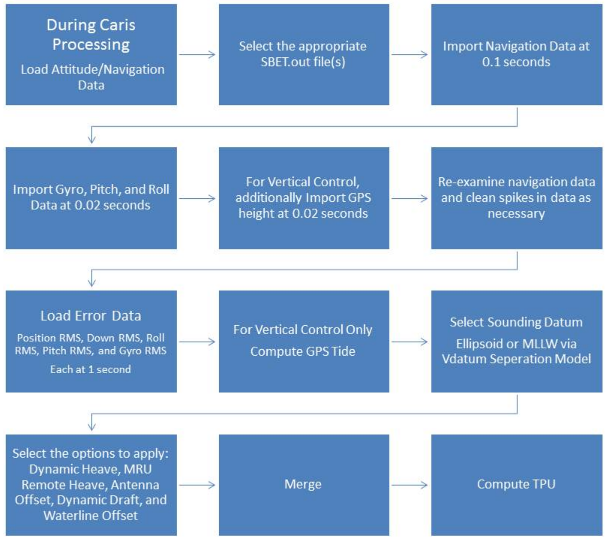


Figure 22: CARIS processing utilizing SBET files for Horizontal and Vertical Control

B.2.5 Feature Verification

Least depths of navigationally significant features are flagged as “designated soundings,” which both identifies the object as a navigationally significant object for import into Pydro and forces the depth of the grid to match the least depth of the feature.

Following data cleaning in CARIS HIPS, designated soundings and side-scan contacts are inserted into a PYDRO Preliminary Smooth Sheet (PSS). DP and GP features are inserted using the “Generic Data Parser” tool. Images of contacts exported from CARIS are displayed in the Image Notebook Editor in PYDRO. Contacts are arranged by day and line and can be selected in the data “Tree” window. Information concerning a specific contact is reviewed in the Editor Notebook Window in PYDRO. This information includes contact positions, AWOIS item positions, contact cross references, and charting recommendations.

Contacts are classified according to type of contact (e.g. MBES, SSS, DP, etc), confidence, and proximity to other contacts. Although this will vary from survey to survey, the following general rules apply for classification of contacts:

• MBES contacts will be classified as primary contacts over SSS, DP, and GP contacts;

• If there are two or more MBES contacts for the same feature, the MBES contact of least depth is classified as the primary contact;

• If there is no bathymetry contact for a feature, then the SSS position will be classified as primary contact over DP and GP contacts;

• If there are two or more SSS contacts for the same feature, then the SSS contact that best represents the feature is classified as the primary contact;

• If there are no bathymetry or imagery contacts, then the DP contact that best represents the feature is classified as the primary contact.

Multiple representations of one distinct feature (e.g. contacts from two or more SSS lines on a known wreck) may be grouped. For a group of features, one representation is selected as the primary contact, and all others are selected as secondary contacts with respect to the primary contact.

Significant features are defined by the Hydrographic Survey Specifications and Deliverables as an object rising more than 1m above the sea floor in water depths of 0-20m, and an object rising 10% of depth above the sea floor in water depths greater than 20m. Either echosounder least depth or side-scan sonar acoustic shadow height may be used to determine height of an object off the water bottom.

Contacts appearing significant are further investigated with a MBES system capable of meeting NOAA object detection specifications. If there is no known least depth of good confidence on a significant feature, then the feature will be flagged as “Investigate”. Features with such a tag must be further developed, in order of preference, with multibeam echosounder, diver least depth gauge, or vertical beam echosounder.

Any items that are to be addressed in the Feature Report (Appendix II) of the Descriptive Report are flagged as “Report”. Examples of Report items include positions of new or repositioned Aids to Navigation, permanent man-made features which do not pose a danger to surface navigation, or dynamic sedimentary bed forms.

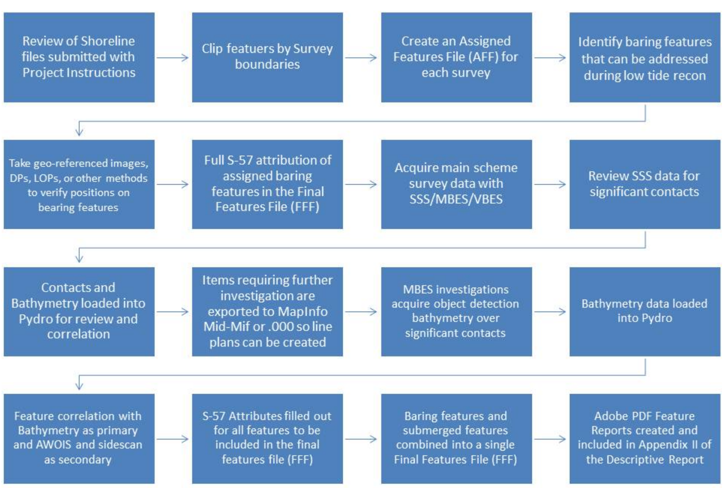


Figure 23: Features Management Workflow

B.2.6 Backscatter

Once data has been acquired, the MBES Snippet Backscatter data is processed in three major steps. First, the .HSX multibeam data is processed as normal in CARIS HIPS. Once the data has been processed through the TPU step, each .HSX line can be exported to .GSF format using CARIS HIPS Export Wizard. The second step is to convert the HYPACK .7k files into the RESON .s7k format. This is accomplished by running a Python script from NOAA's in-house Feature Management software PYDRO. The script 7k2s7k.exe does exactly what its name suggests, it converts the header file for each line from the .7k format of HYPACK\HYSWEEP into the .s7k format native to RESON. The final step utilizes IVS Fledermaus FMGT. This tool is IVS's implementation of the Geocoder processing tool originally developed at the University of New Hampshire, Joint Hydrographic Center, Center for Coastal and Ocean Mapping (UNH, JHC-CCOM). Fledermaus utilizes the .GSF files to extract the navigation information for each survey line and the backscatter intensity data from the .s7k files to generate a processed backscatter mosaic.

Backscatter processing in the field is primarily for quality assurance only. Raw Snippet Backscatter data is the only field deliverable.

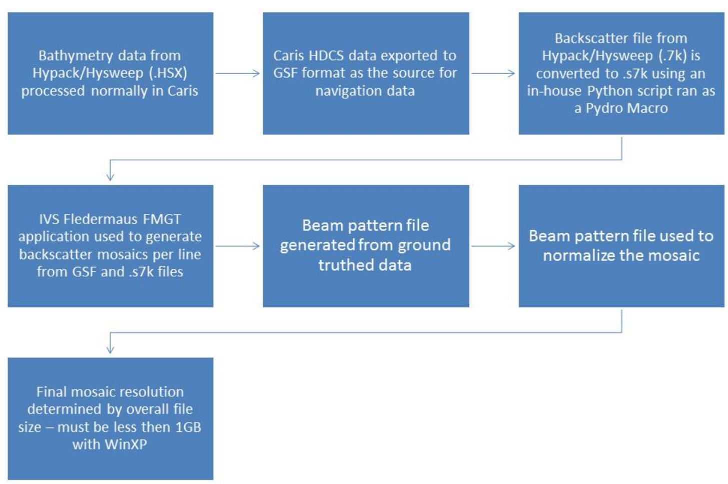


Figure 24: MBES Backscatter Processing Workflow

B.2.7 Other

No additional data were processed.

B.3 Quality Management

A systematic approach to Quality Management has been instituted aboard the THOMAS JEFFERSON, starting well before the field season begins, through to the final packaging of Survey Deliverables and delivery to AHB.

Clear and concise communication is critical at all stages of the survey, and is established between all relevant parties at the earliest stage of the process. Figure 1 represents the parties involved at all stages of the Quality Management process.

In the Review Project Requirements stage, the final project instructions are reviewed for specific criteria. Some of these are:

- Is the Survey fit for the Purpose?
- Are all charted features and AWOIS in the Composite Source File (CSF)?
- Are there any extraneous or unassigned features in CSF?
- Is the Survey a reasonable size (2 weeks)?
- Does the work assigned fit within allowed time period?
- Are the resources available for the job?
- Do we have the right equipment, spares, qualified staff, OT, software and specs?
- Are there any special requirements from HSD OPS?

If any of these elements are found to be in question, dialog is opened with HSD OPS, in order to resolve them. Once these questions have been answered, the Acquisition manager can prepare the survey plan. This would include the following requirements:

- Line plans/Polygons, Crossline plans, Bottom Sample plan
- Feature requirements as addressed in the Composite Source File (CSF) or ENC.
- Safety of Operations, i.e. where we can and cannot go.
- The plan's effectiveness and efficiency.
- Proper or maximum platform utilization.
- Survey Specific Sensor configurations, staffing plans, line plans, target files, etc.

All aspects of the survey plan are carefully reviewed by the CST, FOO and CO for any required changes initiated by the Acquisition manager before survey begins.

A weekly progress review of all planned and open surveys is conducted to evaluate and incorporate the following factors into the acquisition and deliverables schedule:

- Ship schedule (imports/transits)
- Completion rate, estimated survey end date
- Weather factors
- Equipment failures
- Processing backlog (if any)

The goal is to continuously manage multiple surveys and to establish a projected survey shipment date which accurately reflects all known factors. If processing is not keeping pace with acquisition, then additional resources can be deployed to reduce backlogs. This in turn allows for better quality assessment of collected data.

A Progress review of the survey occurs shortly before completion, with the following goals:

- Review remaining work

• Evaluate density coverage (5 Pings per grid node?)
• Confirm that all assigned features have coverage
• Prioritize remaining work for time remaining
• Adjust personnel and platform schedules as necessary
• Evaluate grids for systematic errors (Std Dev, Uncertainty)
• Review initial field sheet layout

After acquisition is complete and the Deliverables manager has applied final tides to all data, a Content Review is performed on the initial results of the survey, primarily surfaces and feature reports. Some of the particular items addressed are:
• Systematic errors evident in the child layers of the grids (Density, Std Dev, Hypothesis Count) that need to be addressed in the DR.
• Review feature report and advise changes or revisions.
• Consider any feature candidates for DtoN's.
• Determine any unusual acquisition or processing issues that need to be discussed in DR.

The final stage of the Quality Management system is a multiple review of the deliverables, by the CST, FOO and CO, each ensuring that all Specs have been met and that any revisions or changes identified in the Content Review have been made. These checks include:
• Examine finalized/thresholded grids for flyers or unresolved systematic issues. Are they discussed in the DR?
• Final check of feature report inclusions, relevance, S-57 attribution, image quality and general completeness.
• Vetting of the final DR. Does it reflect the Content Review discussion?
• Housekeeping – are all the ancillary reports, documents and data included and in the proper place?

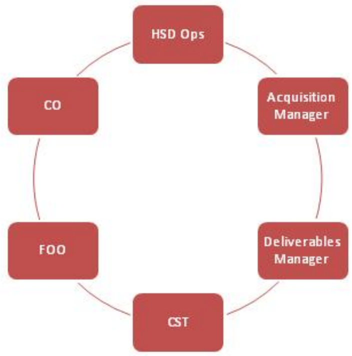


Figure 25: Quality Management Loop

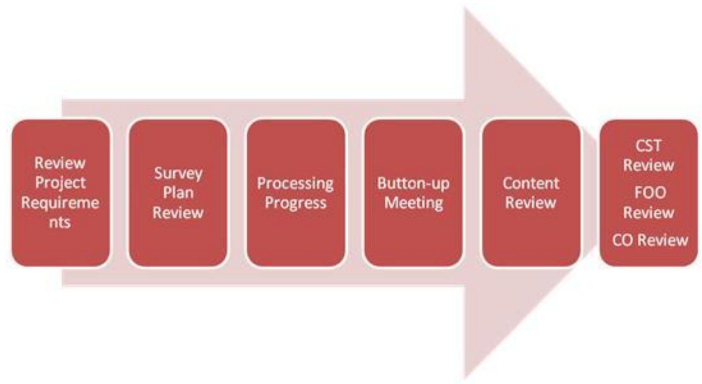


Figure 26: Quality Review Stages

B.4 Uncertainty and Error Management

This section still needs to be filled.

B.4.1 Total Propagated Uncertainty (TPU)

B.4.1.1 TPU Calculation Methods

TPU is calculated by CARIS HIPS during the TPU step in processing. CARIS uses a root sum squared method to calculate the vertical uncertainty of each node in a statistical surface.

B.4.1.2 Source of TPU Values

The majority of values entered into each vessel's HVF come from published values from the sensor manufacturer. X,Y,Z offset uncertainties are based on the conditions during the NGS offset measurements for each vessel. Other uncertainly values are derived from observations by the field unit during survey operations. Each vessel's CARIS HIPS/SIPS HVF TPU values and user defined uncertainty parameters are applied during the TPU step in processing.

B.4.1.3 TPU Values

Vessel	S222
Echosounder	Reson 7125 400 kilohertz

TPU Standard Deviation Values	*Motion*	*Gyro*	0.02 degrees
		Heave	5 % Amplitude
			0.05 meters
		Pitch	0.05 degrees
		Roll	0.05 degrees
	Navigation Position	0.8 meters	
	Timing	*Transducer*	0.005 seconds
		Navigation	0.005 seconds
		Gyro	0.005 seconds
		Heave	0.005 seconds
		Pitch	0.005 seconds
		Roll	0.005 seconds
	Offsets	*x*	0.05 meters
		y	0.05 meters
		z	0.05 meters
	MRU Alignment	*Gyro*	0.1 degrees
		Pitch	0.1 degrees
		Roll	0.1 degrees
	Vessel	*Speed*	0.53 meters/second
		Loading	0.05 meters
		Draft	0.1 meters
		Delta Draft	0.05 meters
Vessel	3101		
Echosounder	Reson 7125-SV 400 kilohertz		
TPU Standard Deviation Values	*Motion*	*Gyro*	0.02 degrees
		Heave	5 % Amplitude
			0.5 meters
		Pitch	0.02 degrees
		Roll	0.02 degrees
	Navigation Position	0.8 meters	

	Timing	*Transducer*	0.005 seconds
		Navigation	0.005 seconds
		Gyro	0.005 seconds
		Heave	0.005 seconds
		Pitch	0.005 seconds
		Roll	0.005 seconds
	Offsets	*x*	0.05 meters
		y	0.05 meters
		z	0.05 meters
	MRU Alignment	*Gyro*	0.1 degrees
		Pitch	0.1 degrees
		Roll	0.1 degrees
	Vessel	*Speed*	0.53 meters/second
		Loading	0.02 meters
		Draft	0.02 meters
		Delta Draft	0.02 meters
Vessel	3101		
Echosounder	Reson 7125 200 kilohertz		
TPU Standard Deviation Values	*Motion*	*Gyro*	0.02 degrees
		Heave	5 % Amplitude
			0.05 meters
		Pitch	0.02 degrees
		Roll	0.02 degrees
	Navigation Position	0.800 meters	
	Timing	*Transducer*	0.005 seconds
		Navigation	0.005 seconds
		Gyro	0.005 seconds
		Heave	0.005 seconds
		Pitch	0.005 seconds
		Roll	0.005 seconds
	Offsets	*x*	0.05 meters
		y	0.05 meters
		z	0.05 meters

	MRU Alignment	*Gyro*	0.100 degrees
		Pitch	0.100 degrees
		Roll	0.100 degrees
	Vessel	*Speed*	0.530 meters/second
		Loading	0.020 meters
		Draft	0.020 meters
		Delta Draft	0.020 meters
Vessel	3101		
Echosounder	Odom CV200 200 kilohertz		
TPU Standard Deviation Values	*Motion*	*Gyro*	0.02 degrees
		Heave	5 % Amplitude 0.05 meters
		Pitch	0.02 degrees
		Roll	0.02 degrees
	Navigation Position	0.8 meters	
	Timing	*Transducer*	0.005 seconds
		Navigation	0.005 seconds
		Gyro	0.005 seconds
		Heave	0.005 seconds
		Pitch	0.005 seconds
		Roll	0.005 seconds
	Offsets	*x*	0.05 meters
		y	0.05 meters
		z	0.05 meters
	MRU Alignment	*Gyro*	0 degrees
		Pitch	0 degrees
		Roll	0 degrees
	Vessel	*Speed*	0.530 meters/second
		Loading	0.02 meters
		Draft	0.02 meters
		Delta Draft	0.02 meters
Vessel	3102		
Echosounder	Reson 7125 400 kilohertz		

TPU Standard Deviation Values	*Motion*	*Gyro*	0.020 degrees
		Heave	5 % Amplitude
			0.05 meters
		Pitch	0.020 degrees
		Roll	0.02 degrees
	Navigation Position	0.800 meters	
	Timing	*Transducer*	0.005 seconds
		Navigation	0.005 seconds
		Gyro	0.005 seconds
		Heave	0.005 seconds
		Pitch	0.005 seconds
		Roll	0.005 seconds
	Offsets	*x*	0.050 meters
		y	0.050 meters
		z	0.050 meters
	MRU Alignment	*Gyro*	0.100 degrees
		Pitch	0.100 degrees
		Roll	0.100 degrees
	Vessel	*Speed*	0.530 meters/second
		Loading	0.020 meters
		Draft	0.020 meters
		Delta Draft	0.020 meters
Vessel	3102		
Echosounder	Reson 7125 200 kilohertz		
TPU Standard Deviation Values	*Motion*	*Gyro*	0.020 degrees
		Heave	5 % Amplitude
			0.050 meters
		Pitch	0.02 degrees
		Roll	0.02 degrees
	Navigation Position	0.500 meters	

	Timing	*Transducer*	0.005 seconds
		Navigation	0.005 seconds
		Gyro	0.005 seconds
		Heave	0.005 seconds
		Pitch	0.005 seconds
		Roll	0.005 seconds
	Offsets	*x*	0.05 meters
		y	0.05 meters
		z	0.05 meters
	MRU Alignment	*Gyro*	0.100 degrees
		Pitch	0.100 degrees
		Roll	0.100 degrees
	Vessel	*Speed*	0.530 meters/second
		Loading	0.02 meters
		Draft	0.02 meters
		Delta Draft	0.02 miles
Vessel	3102		
Echosounder	ODOM ETCV200 200 kilohertz		
TPU Standard Deviation Values	*Motion*	*Gyro*	0.02 degrees
		Heave	5 % Amplitude 0.050 meters
		Pitch	0.02 degrees
		Roll	0.02 degrees
	Navigation Position	0.500 meters	
	Timing	*Transducer*	0.005 seconds
		Navigation	0.005 seconds
		Gyro	0.005 seconds
		Heave	0.005 seconds
		Pitch	0.005 seconds
		Roll	0.005 seconds
	Offsets	*x*	0.05 meters
		y	0.05 meters
		z	0.05 meters

	MRU Alignment	*Gyro*	0 degrees
		Pitch	0 degrees
		Roll	0 degrees
	Vessel	*Speed*	0.530 meters/second
		Loading	0.020 meters
		Draft	0.020 meters
		Delta Draft	0.020 meters

B.4.2 Deviations

There were no deviations from the requirement to compute total propagated uncertainty.

Additional Discussion

For ERS surveys, there is currently no dedicated location to enter the VDatum model uncertainty value. In order to account for VDatum uncertainty in the overall total propagated uncertainty (TPU) for gridded bathymetry data, the VDatum uncertainty values are entered into the measured tidal uncertainty section of the "Compute TPU" step that follows Merge in CARIS HIPS. See Figure 27 for a typical example of the Compute TPU step in MBES processing when surveying to the ellipsoid and using VDatum to reduce to chart datum (MLLW).

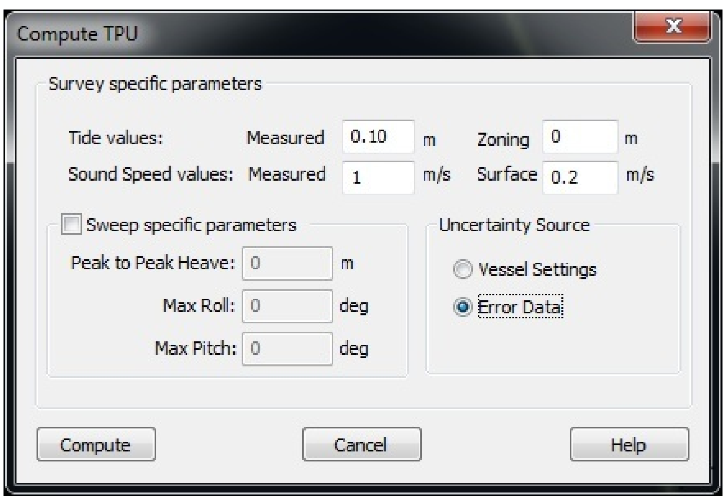


Figure 27: Typical TPU values for an ERS survey - note 0.10m for the Measured Tide value is the VDatum model uncertainty

C Corrections To Echo Soundings

C.1 Vessel Offsets and Layback

C.1.1 Vessel Offsets

C.1.1.1 Description of Correctors

Vessel offsets have been determined by a NGS survey of sensors and permanently installed benchmarks throughout the ship. Offsets between GPS antennas, IMU, and various transducers have been installed into each vessels' corresponding CARIS HIPS Vessel File (HVF). Offsets are applied to data during the SVP and/or Merge steps in processing of bathymetry data, and the Compute Towfish Navigation step in side-scan processing. Discussion of vessel surveys are included in Section A - Survey Vessels.

C.1.1.2 Methods and Procedures

Please refer to Section A - Survey Vessels.

C.1.1.3 Vessel Offset Correctors

Vessel	3101		
Echosounder	Reson 7125 SV1 400 kilohertz		
Date	2010-03-08		
Offsets	*MRU to Transducer*	*x*	-0.472 meters
		y	0.072 meters
		z	0.541 meters
		x2	
		y2	
		z2	
	Nav to Transducer	*x*	0.201 meters
		y	0.944 meters
		z	4.343 meters
		x2	
		y2	
		z2	
	Transducer Roll	*Roll*	0.000 degrees
		Roll2	
Vessel	3101		
Echosounder	Odom Echotrac CV 200 200 kilohertz		

Date	2010-03-08		
Offsets	*MRU to Transducer*	*x*	-1.030 meters
		y	0.947 meters
		z	0.198 meters
		x2	
		y2	
		z2	
	Nav to Transducer	*x*	0.239 meters
		y	1.682 meters
		z	3.952 meters
		x2	
		y2	
		z2	
	Transducer Roll	*Roll*	0.000 degrees
		Roll2	0.000 degrees
Vessel	3102		
Echosounder	Reson 7125 SV1 400 kilohertz		
Date	2011-10-03		
Offsets	*MRU to Transducer*	*x*	-0.522 meters
		y	-0.033 meters
		z	0.545 meters
		x2	
		y2	
		z2	
	Nav to Transducer	*x*	0.299 meters
		y	0.958 meters
		z	4.342 meters
		x2	
		y2	
		z2	
	Transducer Roll	*Roll*	0.00 degrees
		Roll2	
Vessel	3102		
Echosounder	ODOM Echotrac CV-200 200 kilohertz		
Date	2011-10-03		

Offsets	*MRU to Transducer*	*x*	-1.004 meters
		y	0.867 meters
		z	0.140 meters
		x2	
		y2	
		z2	
	Nav to Transducer	*x*	-0.035 meters
		y	1.709 meters
		z	3.954 meters
		x2	
		y2	
		z2	
	Transducer Roll	*Roll*	0.00 degrees
		Roll2	
Vessel	S222		
Echosounder	Reson 7125 ROV 400 kilohertz		
Date	2011-10-03		
Offsets	*MRU to Transducer*	*x*	8.499 meters
		y	-2.364 meters
		z	5.062 meters
		x2	
		y2	
		z2	
	Nav to Transducer	*x*	7.663 meters
		y	7.084 meters
		z	27.444 meters
		x2	
		y2	
		z2	
	Transducer Roll	*Roll*	0.00 degrees
		Roll2	

C.1.2 Layback

C.1.2.1 Description of Correctors

Towfish positioning is provided to CARIS HIPS using cable-out values registered by the Totco cable counter and recorded in the Sonar Pro SDF files. SonarPro uses Payout and Towfish Depth to compute towfish positions. The towfish position is calculated from the position of the tow point using the cable-out value received by SonarPro from the cable payout meter, the towfish pressure depth (sent via a serial interface from the KLEIN 5000 TPU to the SonarPro software), and the Course Made Good (CMG) of the vessel. This method assumes that the cable is in a straight line. Therefore, no catenary algorithm is applied at the time of acquisition, but in processing, CARIS SIPS applies a 0.9 coefficient to account for the catenary.

C.1.2.2 Methods and Procedures

Layback error is calculated by running a side-scan certification test. This test consists of running parallel to a known feature at varying ranges from nadir to ensonify the target in the near-field (approx 15% of range scale in use), mid-field (approx 50 % of range scale in use), and far-field (approx 85% of the range scale in use). The test requires that each side of the sonar ensonify the feature at each of these areas in the swath. Then the test is repeated in a direction that is orthogonal to the original set of lines such that the feature is ensonified a total of 12 times. A successful test will detect the feature in at least 10 of the 12 passes. For hull-mounted systems, the selected contact positions must be within 5m; for towed systems, the contact positions must be within 10m. Layback error is the amount of correction that must be applied to minimize the distance between contact positions.

C.1.2.3 Layback Correctors

<table>
<tr><td>Vessel</td><td colspan="3">S222</td></tr>
<tr><td>Echosounder</td><td colspan="3">Klein 5000 455 kilohertz</td></tr>
<tr><td>Date</td><td colspan="3">2011-03-01</td></tr>
<tr><td rowspan="4">Layback</td><td rowspan="3">Towpoint</td><td>x</td><td>6.37 meters</td></tr>
<tr><td>y</td><td>-42.55 meters</td></tr>
<tr><td>z</td><td>-4.80 meters</td></tr>
<tr><td>Layback Error</td><td colspan="2">-2.25 meters</td></tr>
<tr><td>Vessel</td><td colspan="3">3101</td></tr>
<tr><td>Echosounder</td><td colspan="3">Klein 5000 Light weight 455 kilohertz</td></tr>
<tr><td>Date</td><td colspan="3">2011-03-01</td></tr>
<tr><td rowspan="4">Layback</td><td rowspan="3">Towpoint</td><td>x</td><td>0.494 meters</td></tr>
<tr><td>y</td><td>0.054 meters</td></tr>
<tr><td>z</td><td>-0.832 meters</td></tr>
<tr><td>Layback Error</td><td colspan="2">0 meters</td></tr>
<tr><td>Vessel</td><td colspan="3">3102</td></tr>
<tr><td>Echosounder</td><td colspan="3">Klein 5000 Light Weight 455 kilohertz</td></tr>
<tr><td>Date</td><td colspan="3">2011-03-01</td></tr>
</table>

Layback	*Towpoint*	*x*	0.463 meters
		y	-0.02 meters
		z	-0.852 meters
	Layback Error	0.0 meters	

C.2 Static and Dynamic Draft

C.2.1 Static Draft

C.2.1.1 Description of Correctors

Static draft for each vessel is measured via a sight tube. For the ship, a system of marks have been surveyed into the ship's reference point. A steel ruler is used to measure from one of these marks and the waterline height is calculated. A common waterline for the ship when fully loaded with fuel and ballasted normally is approximately 35cm below the reference point of the ship, but the waterline may change by as much as +/- 30cm over the course of a field season. On the launches, the waterline is measured by placing a steel ruler directly on the reference mark and measuring directly from the sight tube. The waterline is almost constant on the launches despite fuel levels or normal loading. The normal range for waterline on each launch is 22.5 cm to 23.5 cm above the reference point.

C.2.1.2 Methods and Procedures

Waterline measurements are recorded daily at the beginning and end of the day on the launches because the process only takes a few seconds. The process takes considerably longer on the ship, and therefore, the waterline is measured at least weekly. When feasible, waterline measurements are taken before and after fueling or ballasting of the ship. The values are kept in a static draft log and periodically updated in the HVF. Once applied in the HVF, all affected lines have SVP re-applied and are then merged so that the updated waterline measurements will be applied.

C.2.2 Dynamic Draft

C.2.2.1 Description of Correctors

Dynamic draft during the 2011 field season was determined by the Ellipsoid Referenced Dynamic Draft Method (ERDDM). This method removes much of the subjectiveness of the traditional dynamic draft determination methods such observations of a level rod or sonar reference surfaces. Due to formatting issues with the XML DAPR, Dynamic draft tables are not included in the main body of the report. The Dynamic Draft report for each vessel is manually attached to the end of the DAPR document. *Note - 3102 retained dynamic draft values from the 2010 field season. The 2011 ERDDM derived values were not validated by the field unit early enough in the field season to warrant reprocessing survey data with the previous values applied. The difference between the 2011 ERDDM values and the values retained from the 2010 season were less than 3cm across the range of survey speeds.

C.2.2.2 Methods and Procedures

The first step in acquiring ERDDM is to log an Applanix POSPac file through the duration of the step that follow. Next, the vessel should begin transiting from dead in the water, increasing speed in small increments and maintaining speed at each speed interval for at least 1 - 2 minutes so the vessel will reach a hydrodynamic equilibrium at the new speed. Speed should be increased in the manner described until the vessel has exceeded maximum surveying speed. Next, the vessel should stop remaining DIW for approximately 5 minutes to provide a clear reference point between the first run and the second run. After the DIW period is complete, the vessel should repeat the previously described transit in the opposite direction increasing speed in intervals as before, followed by another period of DIW. ERDDM provides the most consistent results when performed in an area with no currents or tidal influence. If such an area is not available, then the experiment should be planned for slack water to minimize the difference between speed over ground (SOG) and speed through the water (STW).

C.2.2.3 Dynamic Draft Correctors

<table>
<tr><td>Vessel</td><td>Due to formatting issues with the XML DAPR, Dynanic Draft Tables are not included in this section and have been attached to the end of this report.</td></tr>
<tr><td>Date</td><td>2011-03-30</td></tr>
<tr><td>Dynamic Draft Table</td><td><table><tr><td>Speed</td><td>0.0 meters/second</td><td></td></tr><tr><td>Draft</td><td>0.0 meters</td><td></td></tr></table></td></tr>
</table>

C.3 System Alignment

C.3.1 Description of Correctors

Patch tests are used for assessing the mounting biases of multibeam sonar systems.

C.3.2 Methods and Procedures

Heave, pitch, roll, yaw, and navigation latency biases for each vessel are corrected during a multibeam bias calibration test, or "patch test". MBES vessel offsets, dynamic draft correctors, and system bias values are contained in HIPS Vessel Files (HVFs). These offsets and biases are applied to the sounding data during processing in CARIS HIPS. A Patch Test or verification of certain biases is typically performed at the start of each field season and re-verified for each project before acquiring MBES data in the new survey area. Calibration reports are generated for initial calibrations at the beginning of the field season, but reports are not necessarily generated for each project when values are re-verified. Small changes in the roll bias are common, but also are not necessarily documented by official reports. Changes in HVFs not accompanied by full calibration reports are instead documented in the comments column of the HVF entry by the date in which the change took effect.

C.3.3 System Alignment Correctors

Vessel	TJ_S222_RESON7125_STBD.hvf	
Echosounder	Reson 7125 ROV 400 kilohertz	
Date	2011-03-29	
Patch Test Values	*Navigation Time Correction*	0 seconds
	Pitch	0.3 degrees
	Roll	0.18 degrees
	Yaw	-0.05 degrees
	Pitch Time Correction	0 seconds
	Roll Time Correction	0 seconds
	Yaw Time Correction	0 seconds
	Heave Time Correction	0 seconds
Vessel	TJ_S222_RESON7125_STBD.hvf	
Echosounder	Reson 7125 ROV 400 kilohertz	
Date	2011-06-01	
Patch Test Values	*Navigation Time Correction*	0 seconds
	Pitch	0.30 degrees
	Roll	-0.02 degrees
	Yaw	-0.05 degrees
	Pitch Time Correction	0 seconds
	Roll Time Correction	0 seconds
	Yaw Time Correction	0 seconds
	Heave Time Correction	0 seconds
Vessel	TJ_S222_RESON7125_STBD.hvf	
Echosounder	Reson 7125 ROV 400 kilohertz	
Date	2011-06-03	
Patch Test Values	*Navigation Time Correction*	0 seconds
	Pitch	0.3 degrees
	Roll	0.08 degrees
	Yaw	-0.05 degrees
	Pitch Time Correction	0 seconds
	Roll Time Correction	0 seconds
	Yaw Time Correction	0 seconds
	Heave Time Correction	0 seconds

Vessel	TJ_S222_RESON7125_STBD.hvf	
Echosounder	Reson 7125 ROV 400 kilohertz	
Date	2011-08-20	
Patch Test Values	*Navigation Time Correction*	0 seconds
	Pitch	-0.06 degrees
	Roll	0.12 degrees
	Yaw	-0.67 degrees
	Pitch Time Correction	0 seconds
	Roll Time Correction	0 seconds
	Yaw Time Correction	0 seconds
	Heave Time Correction	0 seconds
Vessel	TJ_3101_Reson7125_400KHZ.hvf	
Echosounder	Reson 7125 SV1 400 kilohertz	
Date	2011-02-28	
Patch Test Values	*Navigation Time Correction*	0 seconds
	Pitch	1.567 degrees
	Roll	-0.418 degrees
	Yaw	1.033 degrees
	Pitch Time Correction	0 seconds
	Roll Time Correction	0 seconds
	Yaw Time Correction	0 seconds
	Heave Time Correction	0 seconds
Vessel	TJ_3101_Reson7125_400KHZ.hvf	
Echosounder	Reson 7125 SV1 400 kilohertz	
Date	2011-08-20	
Patch Test Values	*Navigation Time Correction*	0 seconds
	Pitch	1.28 degrees
	Roll	-0.46 degrees
	Yaw	1.15 degrees
	Pitch Time Correction	0 seconds
	Roll Time Correction	0 seconds
	Yaw Time Correction	0 seconds
	Heave Time Correction	0 seconds
Vessel	TJ_3102_Reson7125_400KHZ.hvf	
Echosounder	Reson 7125 SV1 400 kilohertz	

Date	2011-02-25	
Patch Test Values	*Navigation Time Correction*	0 seconds
	Pitch	1.80 degrees
	Roll	-0.92 degrees
	Yaw	-0.897 degrees
	Pitch Time Correction	0 seconds
	Roll Time Correction	0 seconds
	Yaw Time Correction	0 seconds
	Heave Time Correction	0 seconds
Vessel	TJ_3102_Reson7125_400KHZ.hvf	
Echosounder	Reson 7125 SV1 400 kilohertz	
Date	2011-08-20	
Patch Test Values	*Navigation Time Correction*	0 seconds
	Pitch	0.28 degrees
	Roll	-0.88 degrees
	Yaw	-1.50 degrees
	Pitch Time Correction	0 seconds
	Roll Time Correction	0 seconds
	Yaw Time Correction	0 seconds
	Heave Time Correction	0 seconds

C.4 Positioning and Attitude

C.4.1 Description of Correctors

C.4.2 Methods and Procedures

The THOMAS JEFFERSON uses inertial positioning and orientation sensors and U.S. Coast Guard Differential GPS (DGPS) for a highly accurate blended position and orientation solution. The 2010 Field Procedures Manual recommends a horizontal positional uncertainty value in the range of 0.5m – 2.0m based on the quality of differential correctors. Surveys covered by this DAPR were acquired within approximately 50nm of USCG differential beacons. Because of this relatively short distance to the differential beacons, horizontal positioning errors of 0.5m were used in Caris HVFs for all platforms during the surveys covered by this DAPR. Processing of SBET data during the ERS component of H12180 indicated that a value of 0.7m would have been more appropriate. No changes to the HVF were made after this discovery due to the additional time that would have been required to reprocess surveys. Since the areas surveyed are relatively flat with gentle slopes, the underestimation of horizontal position uncertainty has little effect on the overall uncertainty that would be reported at any given node and does not negate the validity of survey soundings.

Positioning for data acquired by the launches and the ship are achieved by writing differentially corrected GPS positions output from the POS/MV to the raw sonar data in real time. Upon conversion in CARIS, the positional information in the raw sonar data is used to create vessel track lines for the processed data. In addition, all platforms (except for 1701) have True Heave (a long-period recording of vessel heave used to detect longer period sea swells that may not be detected during short-period heave calculations) applied in Caris as a post-processed heave solution.

During normal survey operations, no further processing of positional information is required. However, beginning in 2010, OCS has begun adding additional positioning requirements to certain projects in an effort to build the internal capabilities necessary to conduct Ellipsoid Referenced Surveys (ERS).

When assigned, the additional positioning requirements involve logging full POSPac data from the POS/MV and utilizing POSPac MMS to derive Smoothed Best Estimate Trajectory (SBET) files. POSPac MMS requires ephemeris and clock data for the GPS constellation and data downloaded from Continually Operating Reference Stations (CORS) or other base stations to correct for atmospheric effects in the GPS data. SBET files are extremely accurate measurements of the 3-D position, speed, and motion of a vessel and can be used to apply higher quality navigation information to the processed data in Caris. Inertially Aided Post Processed Kinematic (IAPPK) navigation may be applied in Caris during the SVP step in the processing workflow. For OPR-E350-TJ-10, H12180, vertical and horizontal positioning was derived from IAPPK methods. IAPPK methods were not utilized for OPR-K380-TJ-10, OPR -H355-TJ-10 or OPR-D304-TJ-10.

C.5 Tides and Water Levels

C.5.1 Description of Correctors

C.5.2 Methods and Procedures

Discrete tidal zoning is a methodology used by the National Ocean Service (NOS) to provide tide reducers for hydrographic surveys. Analyses of historical tide data, models, and other research are used to describe the tidal characteristics of a given survey area. Co-tidal charts are constructed to define GIS maps of co-range and co-time lines. The co-tidal maps are used to construct a discrete tidal zoning scheme. Survey areas are divided up into geographic zones or areas which have defined times of tide and ranges of tide. The number of zones for a particular survey depends upon the complexity of the tide in the area. Each zone is described by a range ratio or a time correction to a tide station in operation during the survey. Tide reducers are compiled by applying the appropriate time and range corrections to the observed data relative to Mean Lower Low Water (MLLW).

Soundings are initially reduced to Mean Lower-Low Water (MLLW) using preliminary (observed) water level data. Data may be obtained from the primary tide gauge through the Center for Operational Oceanographic Products and Services (CO-OPS) website. Observed water level files are converted to CARIS tide files (.tid) and/or text files and applied to all sounding data using either discrete tidal zoning in CARIS HIPS or the TCARI module in Pydro. The type of water level correction used in a survey is specified in the Water Level Instructions, provided by CO-OPS.

When discrete tidal zoning is specified in the Tide Note, THOMAS JEFFERSON personnel use verified water levels and final tidal zoning from the Zone Definition File (ZDF) provided by CO-OPS for hydrographic product generation.

TCARI works by separating the astronomic tide, residual, and datum difference components and treating them differently. First, the method spatially interpolates each tidal constituent's amplitude and phase throughout the region, based on data at the water level stations and makes a tidal prediction. The amplitude and phase of constituents at water level stations must have been previously determined by analysis of historical records. This predicted tide is then added to the residual component, which is computed by spatially interpolating the non-tidal values observed at the water level stations at the time of the survey. Finally, the datum offset, or difference between MSL and MLLW based on historical data, is interpolated throughout the region and added to the prediction.

Tidal Constituents and Residuals Interpolator (TCARI) grid files, when applicable, are submitted to THOMAS JEFFERSON as part of the Project Instruction package. A TCARI grid is computed using the shoreline, a limiting boundary, and the positions of two or more water level gauges. Harmonic constants, residual water levels, and gauge weights are interpolated for each grid point, using the data from the water level gauges as control points. Water level corrections are applied in Pydro using the TCARI tools found in Pydro 7.3 and beyond. When using TCARI for datum reduction, water level corrections are not applied to echosounder data in CARIS. Following TCARI water level correction in Pydro, data is merged and processed.

C.6 Sound Speed

C.6.1 Sound Speed Profiles

C.6.1.1 Description of Correctors

C.6.1.2 Methods and Procedures

CTD Profiles

Sound velocity profiles for the THOMAS JEFFERSON and for Launches 3101 and 3102 are processed using the program HSTP Velocwin version 8.96 which generates sound velocity profiles for CARIS HIPS. Sound velocity correctors are applied to MBES and VBES soundings in CARIS HIPS during post processing only. The speed of sound through water is determined by a minimum of one cast per week (although one per day is usually acquired) for VBES acquisition and one cast every three to four hours of MBES acquisition, in accordance with the NOS Hydrographic Surveys Specifications and Deliverables (HSSD). Casts are conducted more frequently when changing survey areas, or when environmental conditions such as changes in weather, tide, current, or significant spatial and/or temporal variation in the speed of sound is observed in the survey area that would warrant additional sound velocity profiles. The sound velocity casts are extended in HSTP Velocwin and applied to all bathymetric data in CARIS HIPS during post processing.

Brooke Ocean MVP

The SV data acquired by the MVP is transmitted to a raw SV file folder, where the hydrographer conducts a basic check of the data for correct day number, sound velocity data, and file format/integrity. The SV cast may also be graphically viewed and compared with other casts using the Sound Velocity vs. Depth graph in the MVP controller software. Like CTD casts, MVP casts are processed and/or extended for use in CARIS HIPS using HSTP Velocwin.

C.6.2 Surface Sound Speed

C.6.2.1 Description of Correctors

C.6.2.2 Methods and Procedures

Sound Velocity

Sound speed data acquired by the surface sound velocity sensors on THOMAS JEFFERSON and Survey Launch 3101/3102 are recorded in the raw Hypack .hsx files and are used to calculate launch and receive angles for the ray tracing algorithm. The surface sound velocity sensors are discussed in Section A and will not be discussed further in this section.

D. APPROVAL SHEET

This Data Acquisition and Processing Report is respectfully submitted for the following projects:

OPR-E350-TJ-11 Southern Chesapeake Bay, VA

OPR-D304-TJ-11 Approaches to Chesapeake Bay, VA

OPR-B363-TJ-11 Block Island Sound

OPR-S-A916-TJ-11 Boone Island, ME

As Chief of Party, I have ensured that standard field surveying and processing procedures were adhered to during these projects in accordance with the Hydrographic Surveys Specifications and Deliverables (2011), Hydrographic Survey Technical Directives **HTD 2011-03**, and the Field Procedures Manual for Hydrographic Surveying (2011,).

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

This DAPR applies to all surveys completed in 2011 for the projects listed above.

Approved and Forwarded:

Michael C. Davidson
2012.03.29 18:26:56
-04'00'

___________________________________ ___________________________________

LT Michael C. Davidson, NOAA CDR Lawrence T. Krepp, NOAA

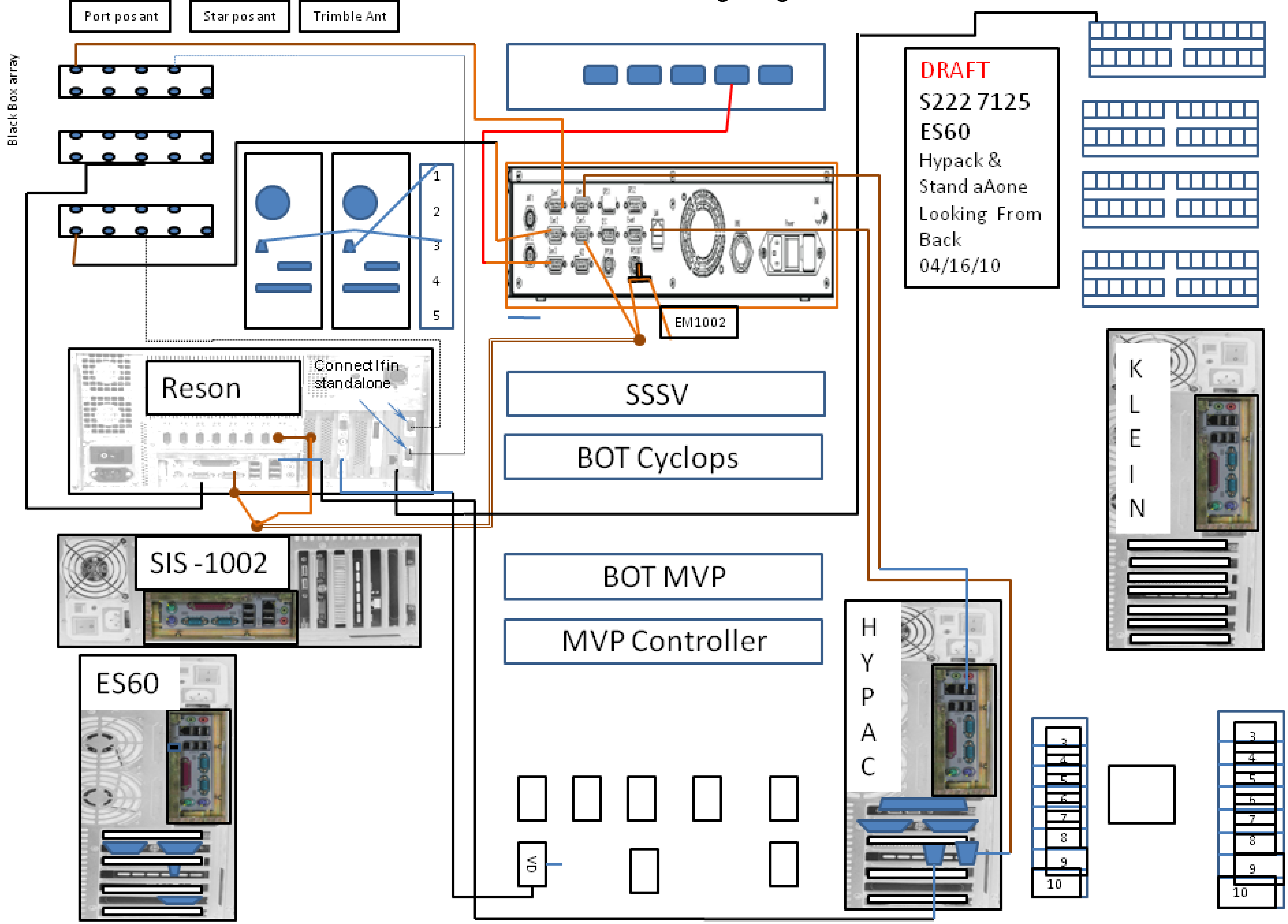
Operations Officer Commanding Officer

Contents

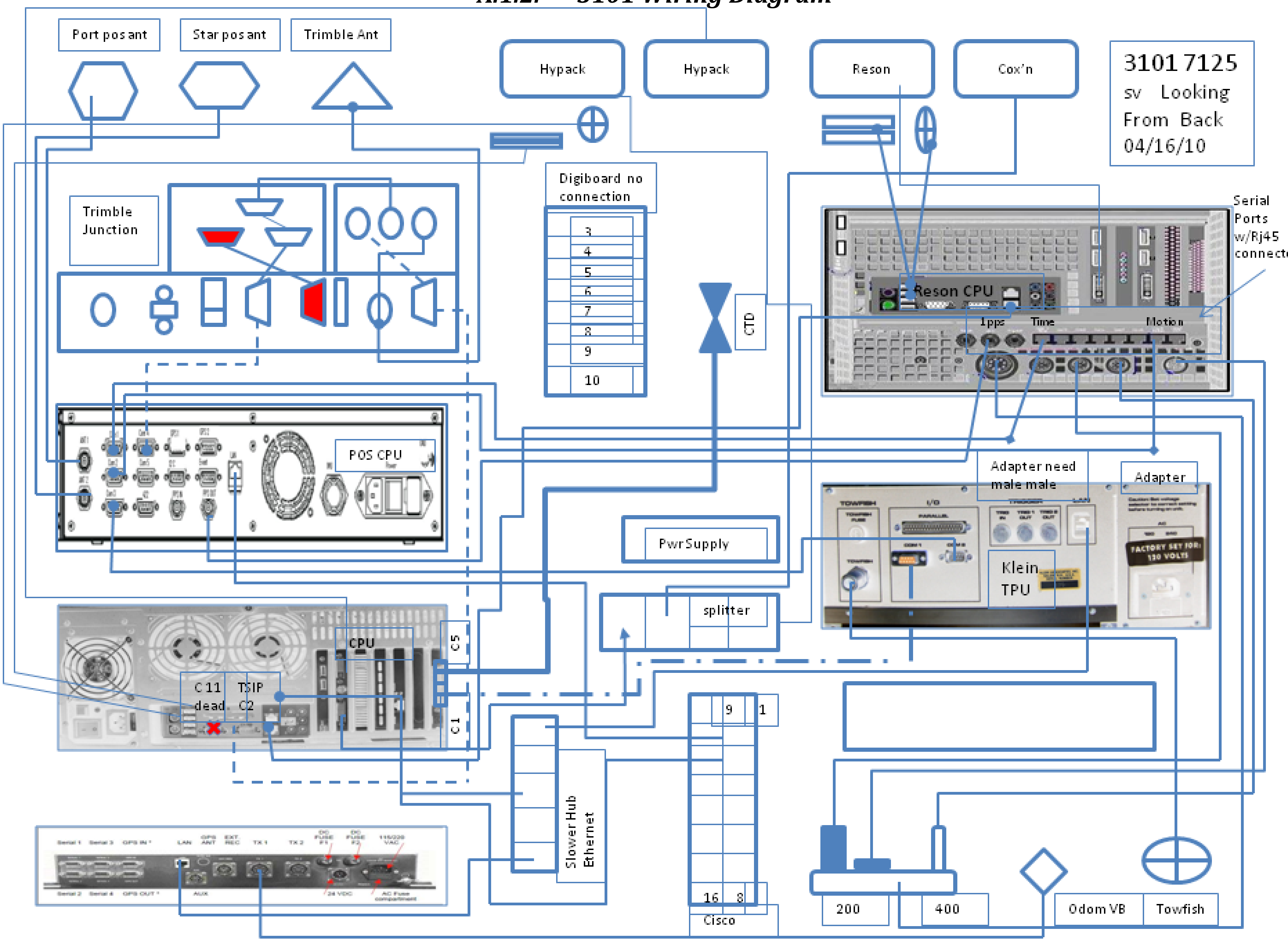
Appendix A

A.1. Survey Vessels

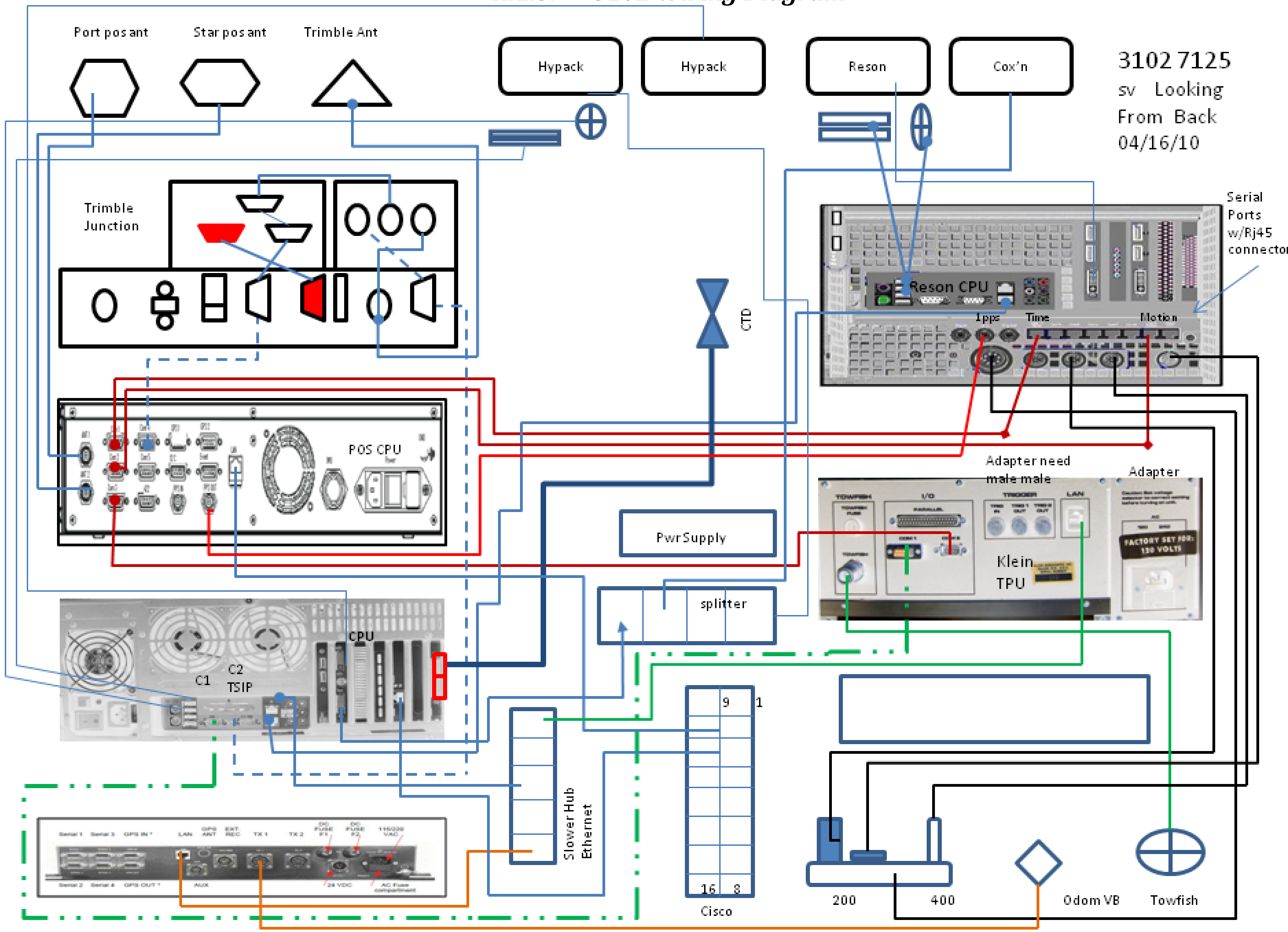
A.1.1. S222 Wiring Diagram



A.1.2. 3101 Wiring Diagram



A.1.3. 3102 Wiring Diagram



A.2. Multibeam Echosounders

A.2.1. S222- DN090 7125 Patch Test Results

Multibeam Echosounder Calibration

Field Unit: NOAA Ship Thomas Jefferson

Date of Test: 2011 DN 090

Calibrating Hydrographer(s):

MULTIBEAM SYSTEM INFORMATION

Multibeam Echosounder System: Reson 7125 400kHz

System Location: Hull mounted on stdb side

Sonar Serial Number: 61206

Processing Unit Serial Number: 50357

Date of Most Recent EED / Factory Checkout:

VESSEL INFORMATION

Sonar Mounting Configuration: hull mounted on stbd side

Date of Current Vessel Offset Measurement / Verification:

Description of Positioning System: POS/MV version 4 w/ Precise Timing

Date of Most Recent Positioning System Calibration: Tumble tested winter 2009/2010

TEST INFORMATION

Test Date(s) / DN(s): 2011 DN090

System Operator(s): According to survey watch schedule

Wind / Seas / Sky: 15 kts, seas 3 ft

Locality: Chesapeake Bay

Sub-Locality: Vicinity of CBBT and Pilot area north of Cape Henry, VA

Bottom Type: sandy

Approximate Average Water Depth: variable

DATA ACQUISITION INFORMATION

Line Number	Heading	Speed
400_0739	145°	~9kts SOG
401_0730	325°	~8kts SOG
402_1655	020°	~9.5kts SOG
402_1705	200°	~9.5kts SOG
402_1758	020°	~5kts SOG
403_1915	280°	~7kts SOG
403_1934	100°	11.5kts COG

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TEST RESULTS

Navigation Timing Error: 0.00 seconds

Pitch Timing Error: 0.00 seconds

Roll Timing Error: 0.00 seconds

Pitch Bias: +0.30

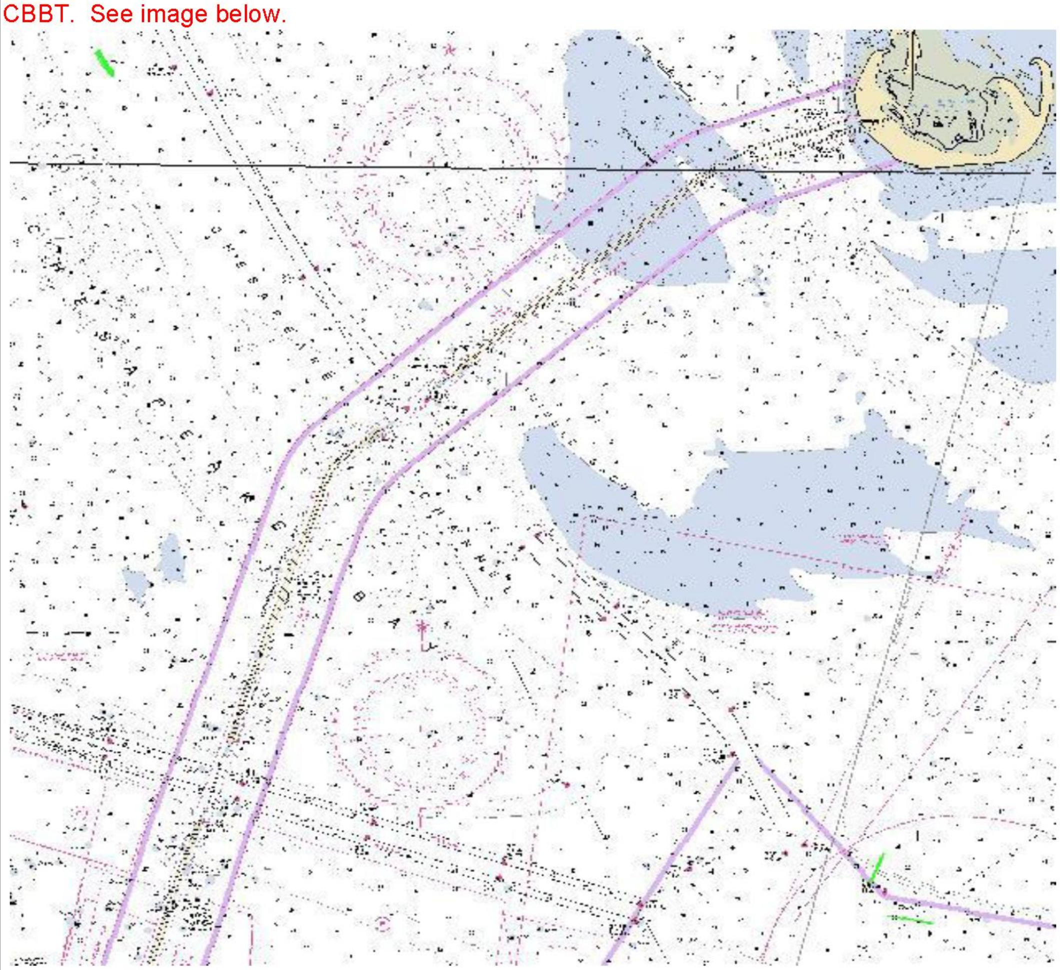
Roll Bias: +0.18

Heading Bias: -0.05

Resulting CARIS HIPS HVF File Name: TJ_S222_Reson7125_STBD.hvf

NARRATIVE

The 2011 HSRR patch test for the Thomas Jefferson's Reson 7125 took place in southern Chesapeake Bay in the vicinity of Cheseapeake Channel and the pilot area north of Cape Henry, VA. Pitch and Nav lines were acquried along a steep slope along the northern boundary of the pilot area. Roll lines were acquried in a relatively deep and flat area in the northern part of the pilot area. Yaw lines were acquired over a charted obstruction south and east of Chesapeake Channel, approximately 4nm northwest of the CBBT. See image below.



A.2.2. S222- DN232 7125 Patch Test Results

Multibeam Echosounder Calibration

Field Unit: Thomas Jefferson S222

Date of Test: 20 AUG 2011

Calibrating Hydrographer(s): LT Davidson

MULTIBEAM SYSTEM INFORMATION

Multibeam Echosounder System: 7125 400Khz 512 beams

System Location: STBD Sonar Strut

Sonar Serial Number:

Processing Unit Serial Number:

Date of Most Recent EED / Factory Checkout:

VESSEL INFORMATION

Sonar Mounting Configuration: hull mounted

Date of Current Vessel Offset Measurement / Verification:

Description of Positioning System: POS/MV version 4 w/ Precise Timing

Date of Most Recent Positioning System Calibration: Winter '09 - '10

TEST INFORMATION

Test Date(s) / DN(s): 232

System Operator(s):

Wind / Seas / Sky:

Locality: Block Island Sound

Sub-Locality: Vicinity of Southwest Ledge

Bottom Type: variable

Approximate Average Water Depth: 12m - 70m

DATA ACQUISITION INFORMATION

Line Number	Heading	Speed
101_1419 (Pitch)	275°	5.2 kts
101_1506 (Pitch and Nav Time)	095°	4.9 kts
101_1557 (Nav Time)	095°	9.5 kts
010_1804 (Roll)	340°	10.1 kts
010_1813 (Roll)	160°	8.9 kts
012_1846 (Yaw)	181°	9.6 kts
102_1858 (Yaw)	181°	9.5 kts

TEST RESULTS

Navigation Timing Error: 0.00

Pitch Timing Error: N/A

Roll Timing Error: N/A

Pitch Bias: -0.06

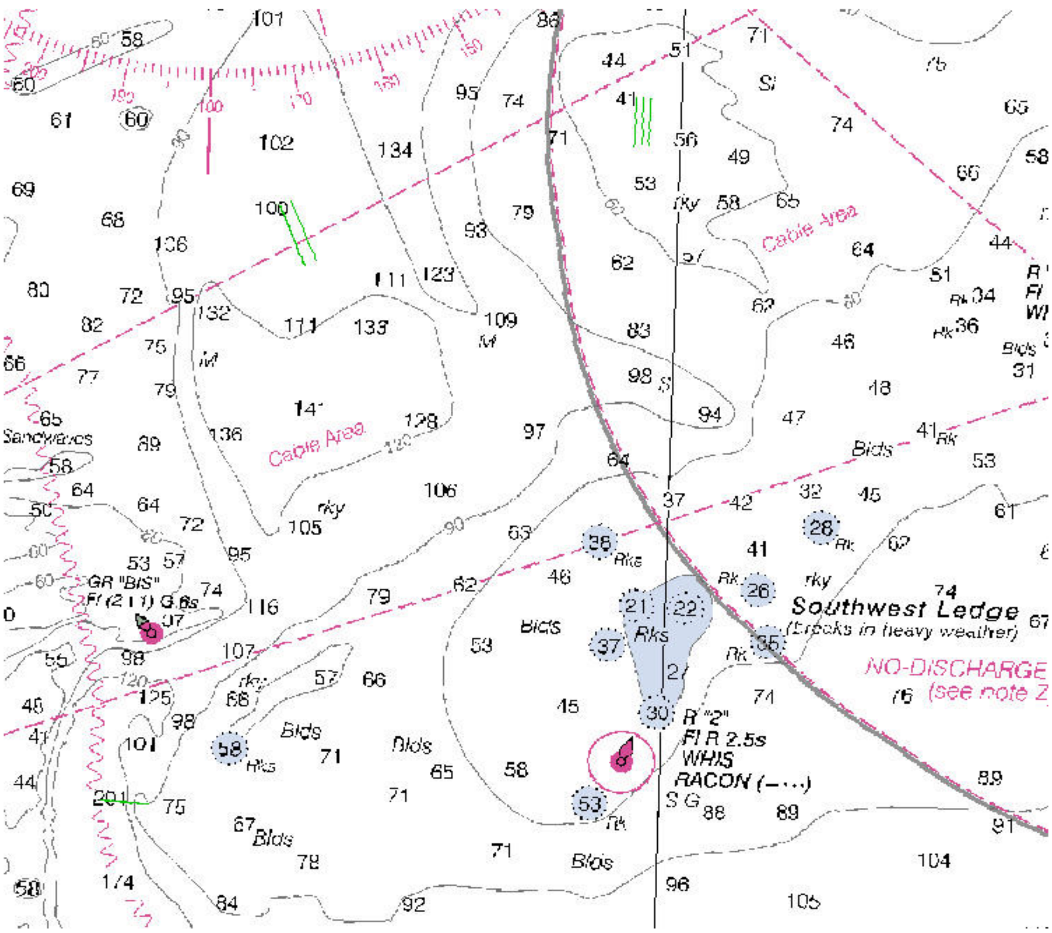
Roll Bias: +0.12

Heading Bias: -0.67

Resulting CARIS HIPS HVF File Name: TJ_S222_RESON7125_STBD.hvf

NARRATIVE

Patch test for S222 Reson 7125 ROV 400kHz in Block Island Sound in the vicinity of Southwest Ledge. Nav and Pitch lines along a steep, bounded slope. Roll lines are in a deep, flat, featureless area. Yaw lines were acquired in a flat rocky area with many isolated rocks in an otherwise flat sandy bottom.



A.2.3. 3101- DN059 7125 Patch Test Results

Multibeam Echosounder Calibration

Field Unit: Thomas Jefferson Launch 3101

Date of Test: 28 Feb 2011 and March 2 2011

Calibrating Hydrographer(s): SST Lewit

MULTIBEAM SYSTEM INFORMATION

Multibeam Echosounder System: 7125 400Khz 512 beams

System Location:

Sonar Serial Number:

Processing Unit Serial Number:

Date of Most Recent EED / Factory Checkout:

VESSEL INFORMATION

Sonar Mounting Configuration: pole-mount on port side of vessel

Date of Current Vessel Offset Measurement / Verification: Jan 2011 Antennas Only

Description of Positioning System: POS/MV version 4 w/ Precise Timing

Date of Most Recent Positioning System Calibration:

TEST INFORMATION

Test Date(s) / DN(s): 059 and 61

Acquired by:ST Wood

Wind / Seas / Sky: Wind SW @ 25kts 2ft

Locality: Elizabeth River VA

Sub-Locality: Maersk terminal

Bottom Type: sandy

Approximate Average Water Depth: 8-20 meters

DATA ACQUISITION INFORMATION

Line Number	Heading	Speed
001-1808	South	clutch ahead NAV
001-1812	South	9.5 kts NAV
002_1419	West	7.0 kts ROLL
002_1425	East	7.0 kts Roll
003_1511	South	7.0 kts Pitch
003_1521	North	7.0 kts Pitch
004_1525	South	7.0 kts Yaw
005_1530	South	7.0 kts Yaw

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TEST RESULTS	
Navigation Timing Error:	**0**
Pitch Timing Error: N/A	**N/A**
Roll Timing Error: N/A	**N/A**
Pitch Bias:	**1.28 (+1.567 entered into 2011 hvf)**
Roll Bias:	**"-0.62 (-0.418 entered into 2011 hvf)"**
Heading Bias:	**"-0.34 (+1.033 entered into 2011 hvf)"**
Resulting CARIS HIPS HVF File Name:	**TJ_3101_Reson7125_400khz.hvf**

NARRATIVE

Analysis of the 2011 HSRR did not indicate that biases were better resolved than the values from 2010. Therefore, the 2010 values are retained for the beginning of the 2011 season.

A.2.4. 3102- DN056 7125 Patch Test Results

Multibeam Echosounder Calibration

Field Unit: **Thomas Jefferson Launch 3102**

Date of Test: **25 Feb 2011**

Calibrating Hydrographer(s): **SST Lewit (Final values - LT Davidson)**

MULTIBEAM SYSTEM INFORMATION

Multibeam Echosounder System: **7125 400Khz 512 beams**

System Location:

Sonar Serial Number:

Processing Unit Serial Number:

Date of Most Recent EED / Factory Checkout:

VESSEL INFORMATION

Sonar Mounting Configuration: pole-mount on port side of vessel

Date of Current Vessel Offset Measurement / Verification: **Jan 2011 Antennas Only**

Description of Positioning System: POS/MV version 4 w/ Precise Timing

Date of Most Recent Positioning System Calibration:

TEST INFORMATION

Test Date(s) / DN(s): **056**

System Operator(s): **SST Lewit**

Wind / Seas / Sky: **Wind SW @ 25kts 2ft**

Locality: Elizabeth River VA

Sub-Locality: Maersk terminal

Bottom Type: sandy

Approximate Average Water Depth: **8-20** meters

DATA ACQUISITION INFORMATION

Line Number	Heading	Speed
001-1743	**South**	clutch ahead NAV
001-1748	**South**	9.5 kts NAV
002-1753	**West**	8.5 kts ROLL
002-1755	**East**	8.5 kts Roll
003-1758	**South**	8.5 kts Pitch
003-1800	**North**	8.5 kts Pitch
004-1804	**South**	8.5 kts Yaw
005-1808	**South**	8.5 kts Yaw

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TEST RESULTS
Navigation Timing Error: 0.00
Pitch Timing Error: N/A
Roll Timing Error: N/A
Pitch Bias: -0.10 (+1.80 entered into 2011 DAPR)
Roll Bias: -0.99 (-0.92 entered into 2011 DAPR)
Heading Bias: -1.04 (-0.897 entered into 2011 DAPR)
Resulting CARIS HIPS HVF File Name: TJ_3102_Reson7125_400khz.hvf
NARRATIVE
Analysis of the 2011 HSRR did not indicate that biases were better resolved than the values from 2010. Therefore, the 2010 values are retained for the beginning of the 2011 season.

A.2.5. 3102- DN233 7125 Patch Test Results

Multibeam Echosounder Calibration

Field Unit: Thomas Jefferson Launch 3102

Date of Test: 21 AUG 2011

Calibrating Hydrographer(s): LT Davidson

MULTIBEAM SYSTEM INFORMATION

Multibeam Echosounder System: 7125 400Khz 512 beams

System Location:

Sonar Serial Number:

Processing Unit Serial Number:

Date of Most Recent EED / Factory Checkout:

VESSEL INFORMATION

Sonar Mounting Configuration: hull mounted with rotating deployment config

Date of Current Vessel Offset Measurement / Verification: Jan 2011 Antennas Only

Description of Positioning System: POS/MV version 4 w/ Precise Timing

Date of Most Recent Positioning System Calibration: Winter '09 - '10

TEST INFORMATION

Test Date(s) / DN(s): 233

System Operator(s): SST Lewit

Wind / Seas / Sky:

Locality: Block Island Sound

Sub-Locality: Vicinity of Southwest Ledge

Bottom Type: variable

Approximate Average Water Depth: 12m - 70m

DATA ACQUISITION INFORMATION

Line Number	Heading	Speed
101_1846 (Pitch)	275°	~6.5kts
101_1849 (Nav) (Pitch)	095°	~6.5kts
101_1852	275°	~10.5kts
101_1855 (Nav)	095°	~10kts
100_1815 (Roll)	160°T	7kts
100_1819 (Roll)	340°	8.5kts

TEST RESULTS

Navigation Timing Error: 0.00

Pitch Timing Error: N/A

Roll Timing Error: N/A

Pitch Bias: +0.28

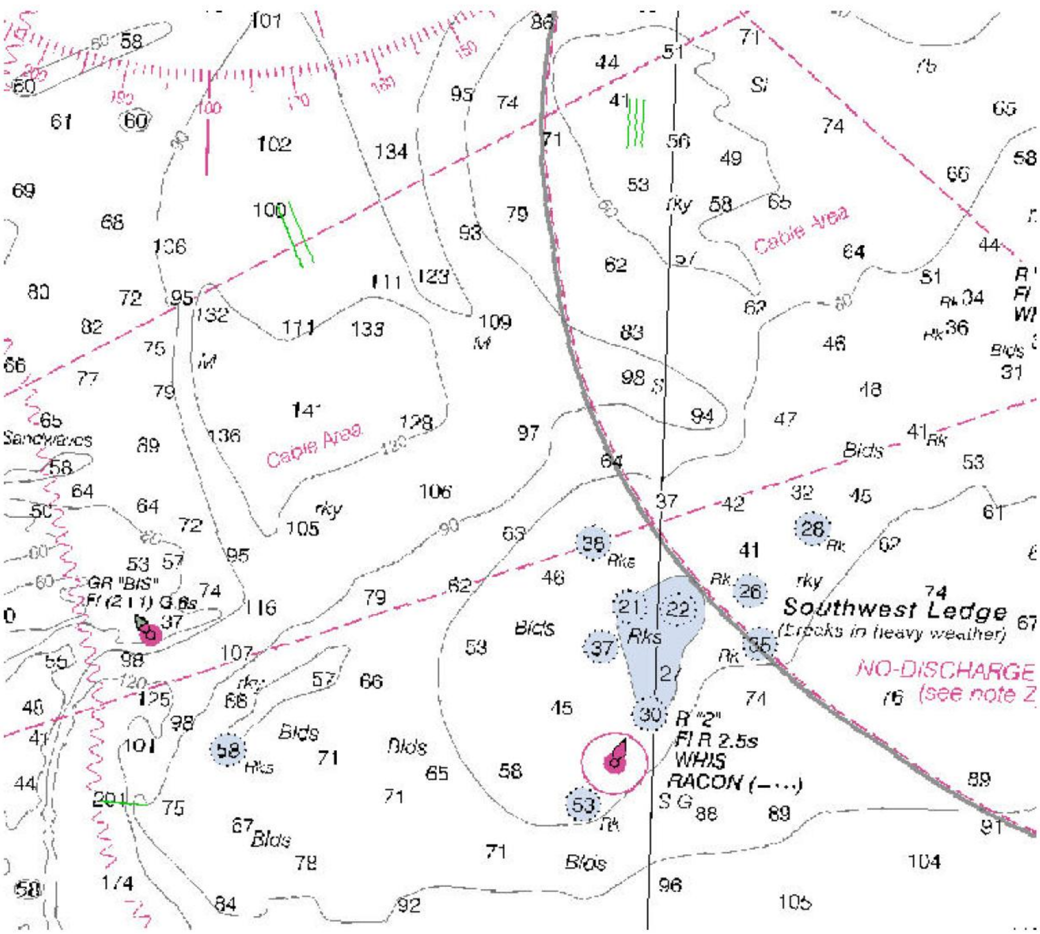
Roll Bias: -0.88

Heading Bias: -1.50

Resulting CARIS HIPS HVF File Name: TJ_3102_Reson7125_400khz.hvf

NARRATIVE

Patch test for 3102 Reson 7125SV 400kHz in Block Island Sound in the vicinity of Southwest Ledge. Nav and Pitch lines along a steep, bounded slope. Roll lines are in a deep, flat, featureless area. Yaw lines were acquired in a flat rocky area with many isolated rocks in an otherwise flat sandy bottom.



A.3. Positioning & Attitude

A.3.1. Applanix Pos/MV IMU 146 Certification

applanix
A TRIMBLE COMPANY

Certificate of Conformance

Applanix Corporation certifies that the material listed below has been tested in accordance with approved test procedures and was found to meet or exceed published specifications.

1)	Description:	**IMU LN200**
	Applanix Part Number:	**10000770**
	IMU Serial Number:	**402952 (Top Hat # 146)**

Return Material Authorization #: L09-051

Customer: NOAA
Atlantic Branch at MOC

Bruce A Francis

2 February, 2010

Certified By:
Bruce Francis
Customer Support Engineer

Date:

A.3.2. Applanix Pos/MV IMU 352 Certification

applanix
A TRIMBLE COMPANY

Certificate of Conformance

Applanix Corporation certifies that the material listed below has been tested in accordance with approved test procedures and was found to meet or exceed published specifications.

1) Description: **IMU LN200**
Applanix Part Number: **10002416**
IMU Serial Number: **410461 (Top Hat # 352)**

Return Material Authorization #: L09-051

Customer: NOAA
Atlantic Branch at MOC

2 February, 2010

Certified By:
Bruce Francis
Customer Support Engineer

Date:

A.3.3. Applanix Pos/MV IMU 356 Certification

applanix
A TRIMBLE COMPANY

Certificate of Conformance

Applanix Corporation certifies that the material listed below has been tested in accordance with approved test procedures and was found to meet or exceed published specifications.

1)	Description:	**IMU LN200**
	Applanix Part Number:	**10002416**
	IMU Serial Number:	**407301 (Top Hat # 356)**

Return Material Authorization #: L09-051

Customer: NOAA
Atlantic Branch at MOC

2 February, 2010

Certified By:
Bruce Francis
Customer Support Engineer

Date:

A.3.4. Applanix Pos/MV GAMS Calibration S222

POS/MV Calibration Report

Field Unit: Thomas Jefferson

SYSTEM INFORMATION

Vessel: NOAA Ship Thomas Jefferson S222

Date: 3/30/2011 Dn: 89

Personnel: SST Lewit

PCS Serial # 2321

IP Address: 129.100.1.231

POS controller Version (Use Menu Help > About) 4.3.4.0

POS Version (Use Menu View > Statistics) MV320 Ver4

GPS Receivers

Primary Receiver SGN 45226A59117

Secondary Receiver SGN 4526A59133

CALIBRATION AREA

Location: Chesapeake Bay

Approximate Position:

	D	M	S
Lat	37	5	4.91
Lon	76	7	5.39

DGPS Beacon Station: Driver, VA

Frequency: 289 kHZ

Satellite Constellation (Use View> GPS Data)

Primary GPS (Port Antenna)

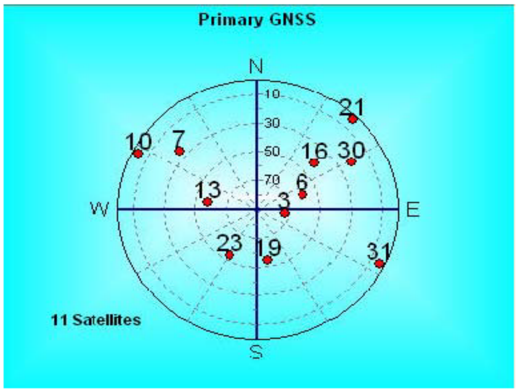
HDOP: 0.949

VDOP: 1.031

Sattelites in Use: 11

10,7,13,23,19,31,3,6,16,30,21

PDOP 2.716 (Use View> GAMS Solution)



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

POS/MV CONFIGURATION

Settings

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

User Entries, Pre-Calibration

2.209	Two Antenna Separation (m)
0.50	Heading Calibration Threshold
0	Heading Correction

Baseline Vector

0.052	X Component (m)
2.207	YComponent (m)
-0.076	Z Component (m)

Configuration Notes:

POS/MV CALIBRATION

Calibration Procedure:

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

Start time: 01:36 UTC

End time: 01:44 UTC

Heading accuracy achieved for calibration: 0.25

Calibration Results:

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

POS/MV Post-Calibration Values

2.211	Two Antenna Separation (m)
0.500	Heading Calibration Threshold
0	Heading Correction

Baseline Vector

0.032	X Component (m)
2.209	YComponent (m)
-0.081	Z Component (m)

GAMS Status Online? X

Save Settings? X

Calibration Notes:

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

File Name: S222_PosConfig_gams_033011.NVM

A.3.5. Applanix POS/MV 3101 GAMS Calibration

POS/MV Calibration Report

Field Unit: Thomas Jefferson

SYSTEM INFORMATION

Vessel: NOAA Launch 3101

Date: 2/28/2011 Dn: 59

Personnel: SST wood

PCS Serial # 2320

IP Address: 1.29.100.1.231

POS controller Version (Use Menu Help > About) 4.3.4.0

POS Version (Use Menu View > Statistics) MV320 Ver4

GPS Receivers

Primary Receiver SGN 4526A59093

Secondary Receiver SGN 4533A59352

CALIBRATION AREA

Location: Norfolk, VA

Approximate Position:

	D	M	S
Lat	36	52	4
Lon	76	19	33

DGPS Beacon Station: Driver, VA

Frequency: 289 kHZ

Satellite Constellation (Use View> GNSS Data)

Primary GPS (Port Antenna)

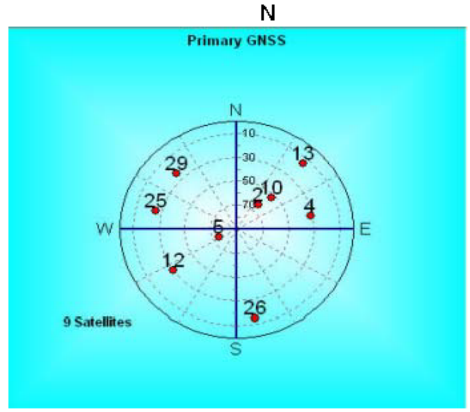
HDOP: 0.878

VDOP: 1.355

Sattelites in Use: 9

PDOP Not recorded (Use View> GAMS Solution)

N



Note:

POS/MV CONFIGURATION

Settings

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

User Entries, Pre-Calibration

Value	Parameter
1.291	Two Antenna Separation (m)
0.50	Heading Calibration Threshold
0	Heading Correction

Baseline Vector

Value	Component
0	X Component (m)
0	YComponent (m)
0	Z Component (m)

Configuration Notes:

POS/MV CALIBRATION

Calibration Procedure:

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

Start time: 1348

End time: 1350

Heading accuracy achieved for calibration: 0.032

Calibration Results:

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

POS/MV Post-Calibration Values

Value	Parameter
1.296	Two Antenna Separation (m)
0.500	Heading Calibration Threshold
0	Heading Correction

Baseline Vector

Value	Component
-0.005	X Component (m)
1.296	YComponent (m)
-0.021	Z Component (m)

GAMS Status Online? X

Save Settings? X

Calibration Notes:

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

File Name: PosConfig_3101_28Feb-2011.nvm

A.3.6. Applanix POS/MV 3102 GAMS Calibration

POS/MV Calibration Report

Field Unit:

SYSTEM INFORMATION

Vessel: **NOAA Launch 3102**

Date: **2/25/2011** Dn: **56**

Personnel: **SST Lewit CB Pooser**

PCS Serial # 2562

IP Address: 129.100.0.231

POS controller Version (Use Menu Help > About) 5.1.0.2

POS Version (Use Menu View > Statistics) MV320 Ver4

GPS Receivers

Primary Receiver SGN 4617A68061

Secondary Receiver SGN 4624A70252

CALIBRATION AREA

Location: Norfolk, VA

Approximate Position:

	D	M	S
Lat	36	52	15
Lon	76	19	46

DGPS Beacon Station: Driver, VA

Frequency: 289 kHZ

Satellite Constellation (Use View> GNSS Data)

Primary GPS (Port Antenna)

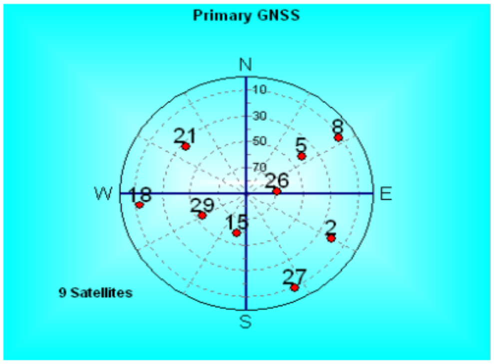
N

HDOP: 0.833

VDOP: 1.171

Sattelites in Use: 9

PDOP 1.559 (Use View> GAMS Solution)



Note:

POS/MV CONFIGURATION

Settings

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

User Entries, Pre-Calibration		Baseline Vector	
	Two Antenna Separation (m)		X Component (m)
	Heading Calibration Threshold		YComponent (m)
	Heading Correction		Z Component (m)

Configuration Notes: The original values were not recorded

POS/MV CALIBRATION

Calibration Procedure:

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

Start time: This was not recorded

End time: This was not recorded

Heading accuracy achieved for calibration: This was not recorded

Calibration Results:

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

POS/MV Post-Calibration Values		Baseline Vector	
1.531	Two Antenna Separation (m)	**0.009**	X Component (m)
0.500	Heading Calibration Threshold	**1.531**	YComponent (m)
0	Heading Correction	**-0.025**	Z Component (m)

GAMS Status Online? X

Save Settings? X

Calibration Notes:

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

File Name: Posconfig_3102_25Feb2011.NVM

A.4. Sound Speed

A.4.1. SBE 19+ SN285

A.4.1.1. Conductivity Calibration Report

SEA-BIRD ELECTRONICS, INC.

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

Conductivity Calibration Report

Customer:	Atlantic Marine Center		
Job Number:	61820	**Date of Report:**	11/11/2010
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: 11/11/2010 Drift since last cal: +0.00060 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.

A.4.1.2. Conductivity Calibration Data

SEA-BIRD ELECTRONICS, INC.

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

SENSOR SERIAL NUMBER: 0285
CALIBRATION DATE: 11-Nov-10

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

GHIJ COEFFICIENTS
```
g = -4.07944976e+000
h =  4.86633541e-001
i =  1.21190759e-003
j = -2.29868736e-005
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

ABCDM COEFFICIENTS
```
a =  1.29103349e-002
b =  4.70521285e-001
c = -4.06331630e+000
d = -9.32582862e-005
m =  2.3
CPcor = -9.5700e-008 (nominal)
```

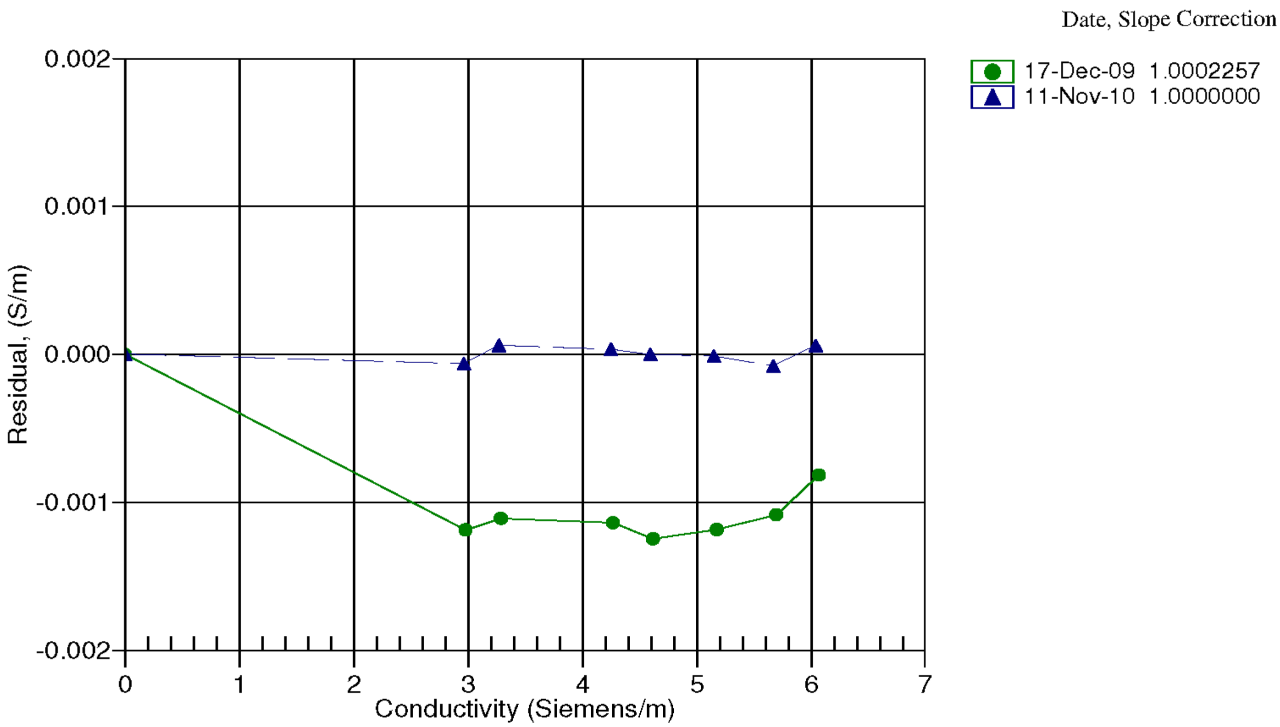
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2.88556	0.00000	0.00000
1.0000	34.6461	2.96280	8.25139	2.96274	-0.00006
4.5000	34.6263	3.26856	8.61509	3.26862	0.00006
15.0000	34.5830	4.24601	9.68473	4.24604	0.00003
18.5000	34.5731	4.58957	10.03319	4.58957	-0.00000
24.0000	34.5619	5.14495	10.57184	5.14494	-0.00001
29.0000	34.5543	5.66422	11.05131	5.66414	-0.00008
32.5000	34.5479	6.03446	11.38081	6.03452	0.00006

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

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

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

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



A.4.1.3. Pressure Calibration Data

SEA-BIRD ELECTRONICS, INC.

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

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

SENSOR SERIAL NUMBER: 0285
CALIBRATION DATE: 16-Nov-10

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

QUADRATIC COEFFICIENTS:

PA0 = 2.492113e+003
PA1 = -6.502899e-001
PA2 = -4.326982e-008

STRAIGHT LINE FIT:

M = -6.503083e-001
B = 2.491853e+003

PRESSURE PSIA	INST OUTPUT(N)	COMPUTED PSIA	ERROR %FS	LINEAR PSIA	ERROR %FS
14.66	3809.0	14.53	-0.00	14.83	0.00
1014.92	2272.0	1014.43	-0.01	1014.35	-0.01
2015.13	735.0	2014.13	-0.02	2013.88	-0.03
3015.06	-804.0	3014.92	-0.00	3014.70	-0.01
4015.08	-2342.0	4014.86	-0.00	4014.87	-0.00
5015.02	-3880.0	5014.59	-0.01	5015.05	0.00
4014.93	-2343.0	4015.51	0.01	4015.53	0.01
3014.96	-806.0	3016.22	0.03	3016.00	0.02
2014.95	734.0	2014.78	-0.00	2014.53	-0.01
1014.85	2271.0	1015.08	0.00	1015.00	0.00
14.66	3808.0	15.18	0.01	15.48	0.02

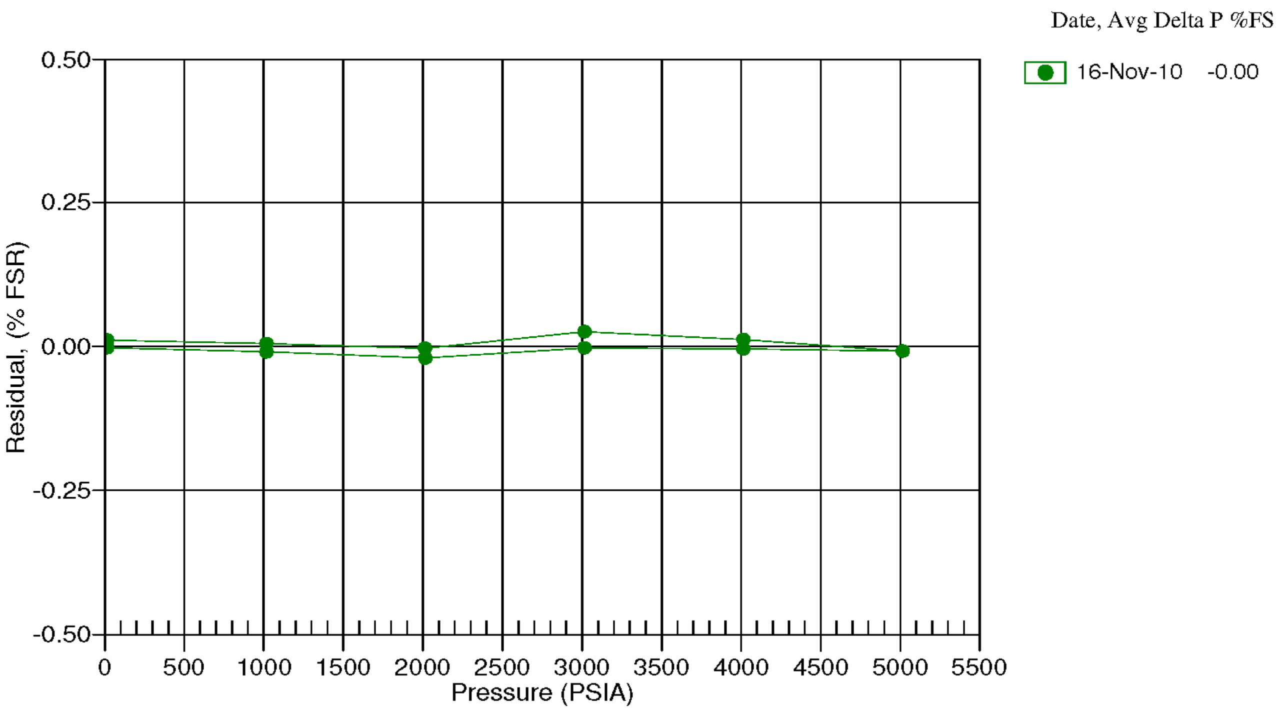
Straight Line Fit:

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



A.4.1.4. Temperature Calibration Report

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

Temperature Calibration Report

Customer:	Atlantic Marine Center		
Job Number:	61820	**Date of Report:**	11/11/2010
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: 11/11/2010 Drift since last cal: +0.00057 Degrees Celsius/year

Comments:

'CALIBRATION AFTER REPAIR' ☐ Performed ☑ Not Performed

Date: Drift since Last cal: Degrees Celsius/year

Comments:

A.4.1.5. Temperature Calibration Data

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

SENSOR SERIAL NUMBER: 0285
CALIBRATION DATE: 11-Nov-10

SBE19 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

g = 4.12504156e-003
h = 5.75337354e-004
i = -8.04668896e-007
j = -3.07104747e-006
f0 = 1000.0

IPTS-68 COEFFICIENTS

a = 3.64764210e-003
b = 5.70436400e-004
c = 6.88256027e-006
d = -3.07098183e-006
f0 = 2297.617

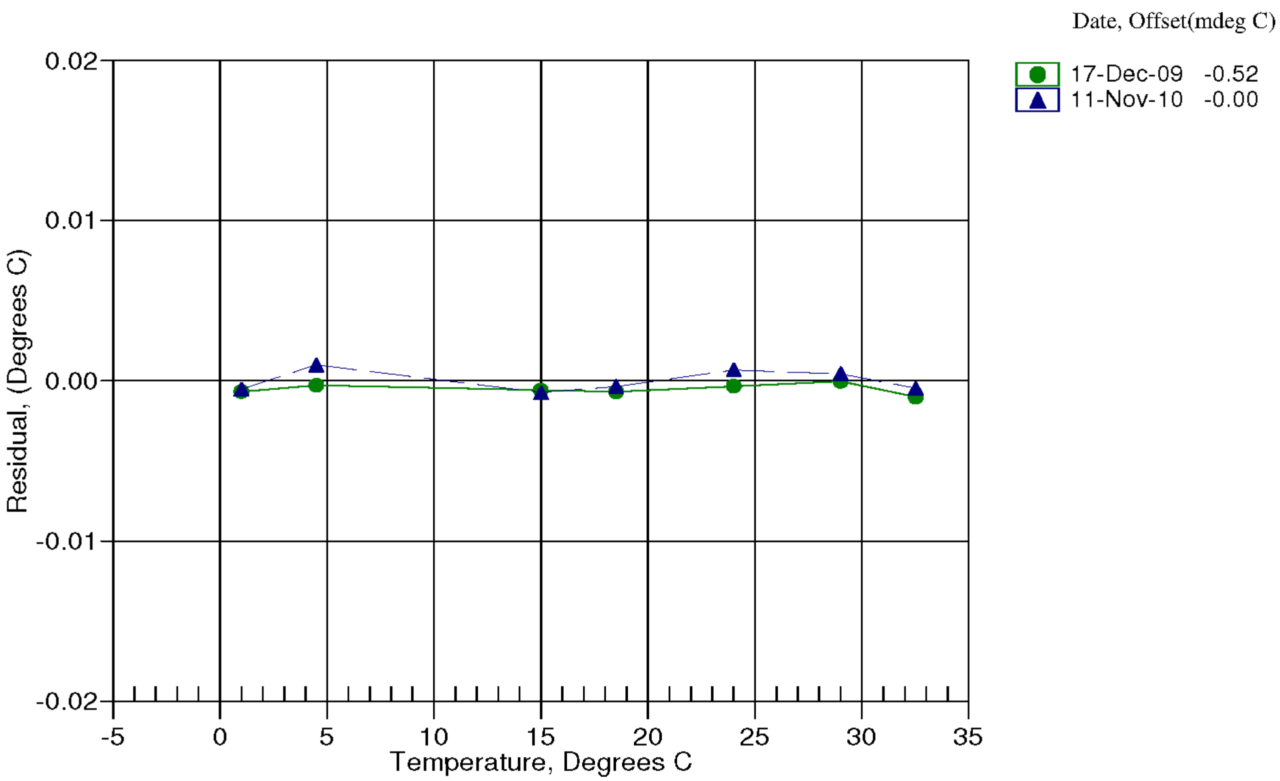
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	2297.617	0.9995	-0.00054
4.5000	2490.828	4.5010	0.00098
15.0000	3139.173	14.9993	-0.00072
18.5000	3379.607	18.4996	-0.00037
24.0000	3783.392	24.0007	0.00067
29.0000	4178.956	29.0004	0.00043
32.5000	4472.598	32.4995	-0.00046

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 IPTS-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



A.4.2. SBE 19+ SN 4486

A.4.2.1. Conductivity Calibration Report

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

Conductivity Calibration Report

Customer:	Atlantic Marine Center		
Job Number:	61820	**Date of Report:**	11/10/2010
Model Number	SBE 19Plus	**Serial Number:**	19P33589-4486

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: 11/10/2010 Drift since last cal: -0.00040 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.

A.4.2.2. Conductivity Calibration Data

SEA-BIRD ELECTRONICS, INC.

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

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

SENSOR SERIAL NUMBER: 4486
CALIBRATION DATE: 10-Nov-10

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

COEFFICIENTS:

g = -1.029462e+000
h = 1.435105e-001
i = -2.257815e-004
j = 3.785683e-005

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

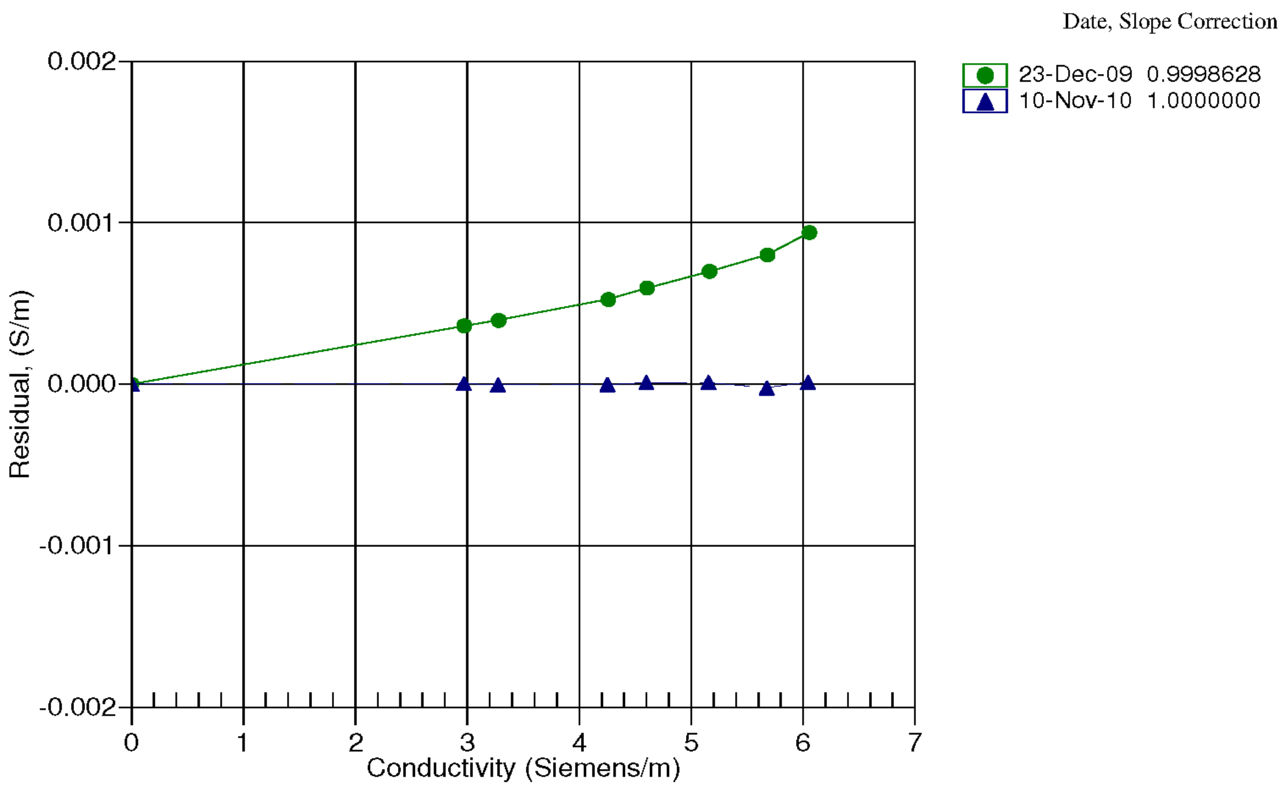
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2681.44	0.0000	0.00000
0.9999	34.7063	2.96745	5279.93	2.9675	0.00000
4.5000	34.6861	3.27365	5477.77	3.2736	-0.00001
14.9999	34.6425	4.25253	6066.39	4.2525	-0.00000
18.5000	34.6326	4.59662	6259.88	4.5966	0.00001
24.0000	34.6213	5.15282	6560.29	5.1528	0.00001
29.0000	34.6139	5.67289	6828.89	5.6729	-0.00002
32.5000	34.6084	6.04382	7014.02	6.0438	0.00001

f = INST FREQ / 1000.0

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

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

Residual = instrument conductivity - bath conductivity



A.4.2.3. Pressure Calibration Data

SEA-BIRD ELECTRONICS, INC.

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

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

SENSOR SERIAL NUMBER: 4486
CALIBRATION DATE: 08-Nov-10

SBE19plus PRESSURE CALIBRATION DATA
508 psia S/N 2799

COEFFICIENTS:

```
PA0 =     3.191141e-002          PTCA0 =  5.246486e+005
PA1 =     1.549863e-003          PTCA1 =  2.809928e+000
PA2 =     6.518813e-012          PTCA2 = -9.180600e-002
PTEMPA0 = -7.532420e+001         PTCB0 =  2.468737e+001
PTEMPA1 =  4.817492e+001         PTCB1 = -7.250000e-004
PTEMPA2 = -2.155322e-001         PTCB2 =  0.000000e+000
```

PRESSURE SPAN CALIBRATION

PRESSURE PSIA	INST OUTPUT	THERMISTOR OUTPUT	COMPUTED PRESSURE	ERROR %FSR
14.65	534090.0	2.0	14.64	-0.00
104.90	592268.0	2.0	104.89	-0.00
204.93	656703.0	2.0	204.90	-0.01
304.93	721106.0	2.0	304.92	-0.00
404.94	785475.0	2.0	404.93	-0.00
504.94	849804.0	2.0	504.94	-0.00
404.95	785494.0	2.0	404.96	0.00
304.95	721144.0	2.0	304.98	0.01
204.95	656736.0	2.0	204.96	0.00
104.94	592302.0	2.0	104.95	0.00
14.65	534094.0	2.0	14.65	0.00

THERMAL CORRECTION

TEMP ITS90	THERMISTOR OUTPUT	INST OUTPUT
32.50	2.26	534165.16
29.00	2.19	534174.11
24.00	2.08	534182.30
18.50	1.97	534190.51
15.00	1.89	534194.09
4.50	1.67	534178.92
1.00	1.60	534173.52

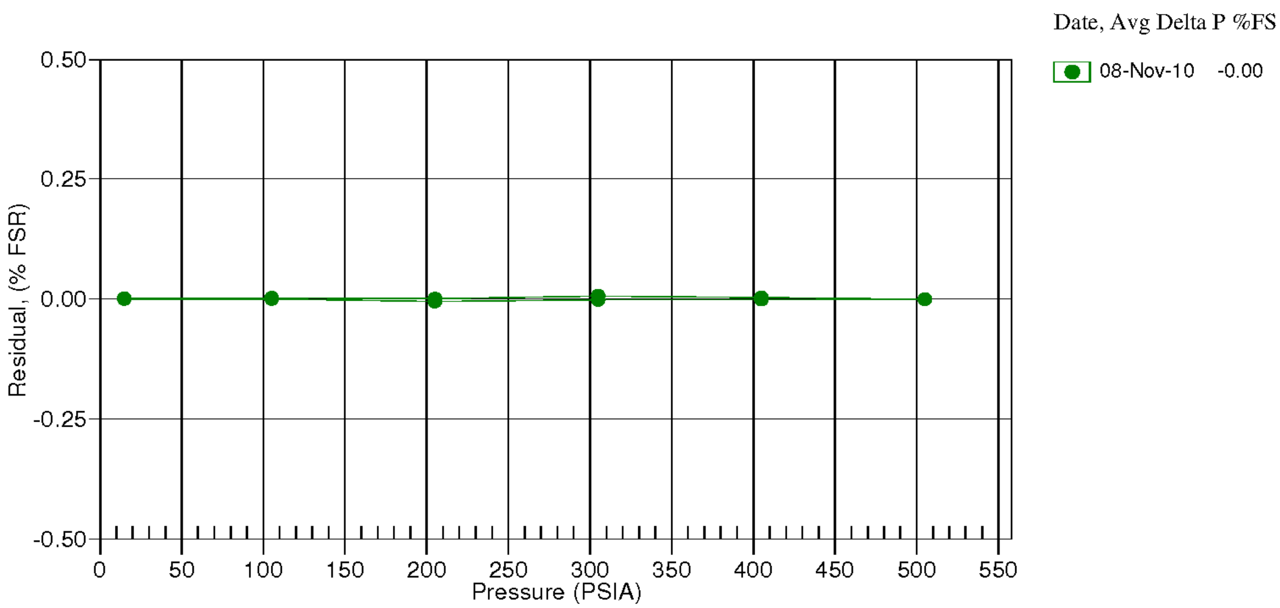
TEMP(ITS90)	SPAN(mV)
-5.00	24.69
35.00	24.66

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

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

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

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



A.4.2.4. Temperature Calibration Report

SEA-BIRD ELECTRONICS, INC.

13431 NE 20th St. Bellevue, Washington 98005 USA

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

Temperature Calibration Report

Customer:	Atlantic Marine Center		
Job Number:	61820	**Date of Report:**	11/10/2010
Model Number	SBE 19Plus	**Serial Number:**	19P33589-4486

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: 11/10/2010 Drift since last cal: +0.00109 Degrees Celsius/year

Comments:

'CALIBRATION AFTER REPAIR' ☐ Performed ☑ Not Performed

Date: Drift since Last cal: Degrees Celsius/year

Comments:

A.4.2.5. Temperature Calibration Data

SEA-BIRD ELECTRONICS, INC.

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

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

SENSOR SERIAL NUMBER: 4486
CALIBRATION DATE: 10-Nov-10

SBE19plus TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

a0 = 1.285758e-003
a1 = 2.555140e-004
a2 = 8.098471e-007
a3 = 1.179498e-007

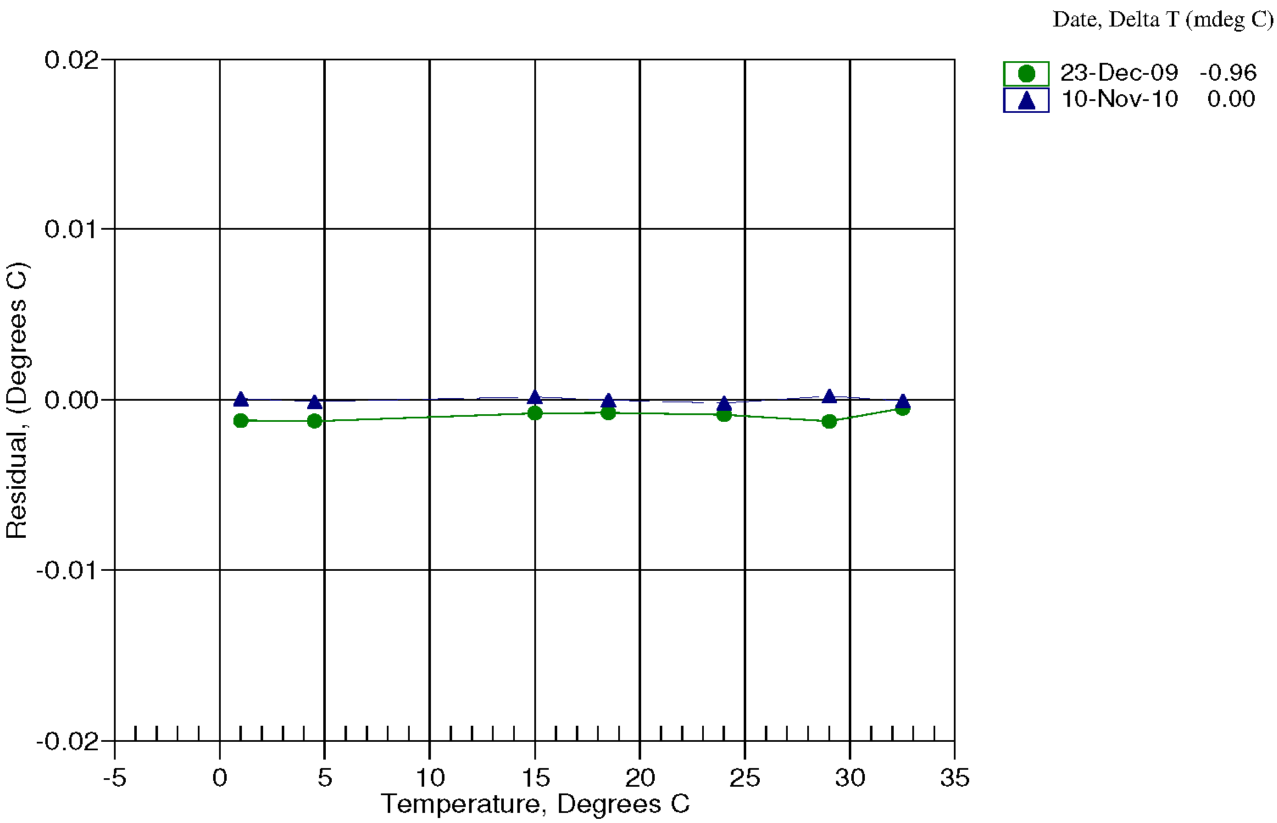
BATH TEMP (ITS-90)	INSTRUMENT OUTPUT(n)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
0.9999	604341.109	0.9999	0.0000
4.5000	535771.484	4.4999	-0.0001
14.9999	366314.953	15.0001	0.0002
18.5000	320997.094	18.5000	-0.0000
24.0000	259599.188	23.9998	-0.0002
29.0000	212957.047	29.0002	0.0002
32.5000	184831.953	32.4999	-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



A.4.3. SBE 19+ SN 4487

A.4.3.1. Conductivity Calibration Report

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

Conductivity Calibration Report

Customer:	Atlantic Marine Center		
Job Number:	61820	**Date of Report:**	11/10/2010
Model Number	SBE 19Plus	**Serial Number:**	19P33589-4487

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: 11/10/2010 Drift since last cal: -0.00020 **PSU/month***

Comments:

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

Date: Drift since Last cal: **PSU/month***

Comments:

****Measured at 3.0 S/m***

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

A.4.3.2. Conductivity Calibration Data

SEA-BIRD ELECTRONICS, INC.

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

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

SENSOR SERIAL NUMBER: 4487
CALIBRATION DATE: 10-Nov-10

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

COEFFICIENTS:

g = -1.021473e+000
h = 1.394711e-001
i = -1.760513e-004
j = 3.330787e-005

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

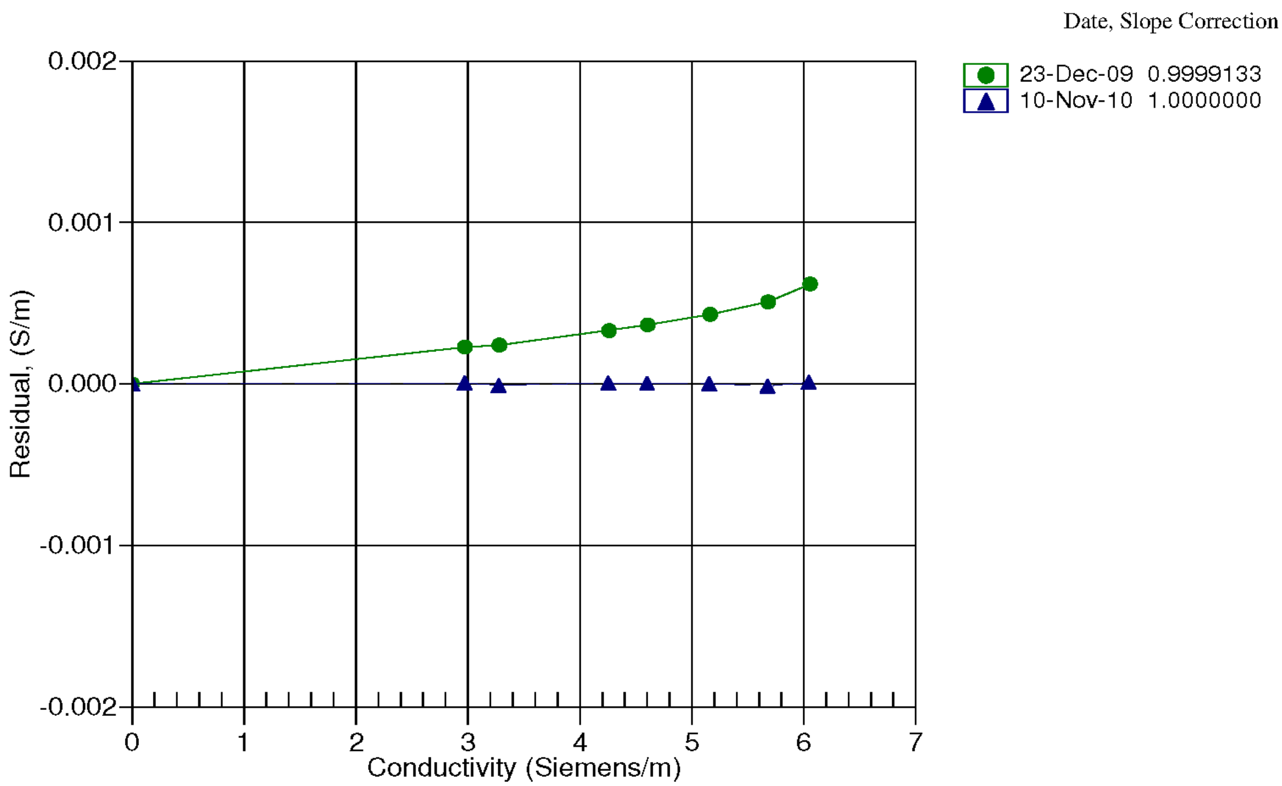
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2708.53	0.0000	0.00000
0.9999	34.7063	2.96745	5347.73	2.9675	0.00000
4.5000	34.6861	3.27365	5548.45	3.2736	-0.00001
14.9999	34.6425	4.25253	6145.58	4.2525	0.00000
18.5000	34.6326	4.59662	6341.85	4.5966	0.00000
24.0000	34.6213	5.15282	6646.56	5.1528	0.00000
29.0000	34.6139	5.67289	6919.01	5.6729	-0.00001
32.5000	34.6084	6.04382	7106.78	6.0438	0.00001

f = INST FREQ / 1000.0

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

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

Residual = instrument conductivity - bath conductivity



A.4.3.3. Pressure Calibration Data

SEA-BIRD ELECTRONICS, INC.

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

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

SENSOR SERIAL NUMBER: 4487
CALIBRATION DATE: 08-Nov-10

SBE19plus PRESSURE CALIBRATION DATA
508 psia S/N 2837

COEFFICIENTS:

PA0 =	6.679933e-002	PTCA0 =	5.244274e+005
PA1 =	1.555865e-003	PTCA1 =	4.143632e+000
PA2 =	6.564530e-012	PTCA2 =	-1.000848e-001
PTEMPA0 =	-7.455275e+001	PTCB0 =	2.498675e+001
PTEMPA1 =	4.916832e+001	PTCB1 =	-5.000000e-005
PTEMPA2 =	-3.918811e-001	PTCB2 =	0.000000e+000

PRESSURE SPAN CALIBRATION

PRESSURE PSIA	INST OUTPUT	THERMISTOR OUTPUT	COMPUTED PRESSURE	ERROR %FSR
14.65	533835.0	2.0	14.64	-0.00
104.90	591833.0	2.0	104.91	0.00
204.93	656046.0	2.0	204.90	-0.01
304.93	720235.0	2.0	304.91	-0.00
404.94	784395.0	2.0	404.93	-0.00
504.94	848510.0	2.0	504.94	-0.00
404.95	784414.0	2.0	404.96	0.00
304.95	720270.0	2.0	304.97	0.00
204.95	656079.0	2.0	204.95	0.00
104.94	591859.0	2.0	104.95	0.00
14.65	533842.0	2.0	14.65	0.00

THERMAL CORRECTION

TEMP ITS90	THERMISTOR OUTPUT	INST OUTPUT
32.50	2.22	533927.31
29.00	2.14	533933.29
24.00	2.04	533935.02
18.50	1.92	533936.32
15.00	1.85	533942.22
4.50	1.63	533913.75
1.00	1.56	533899.87

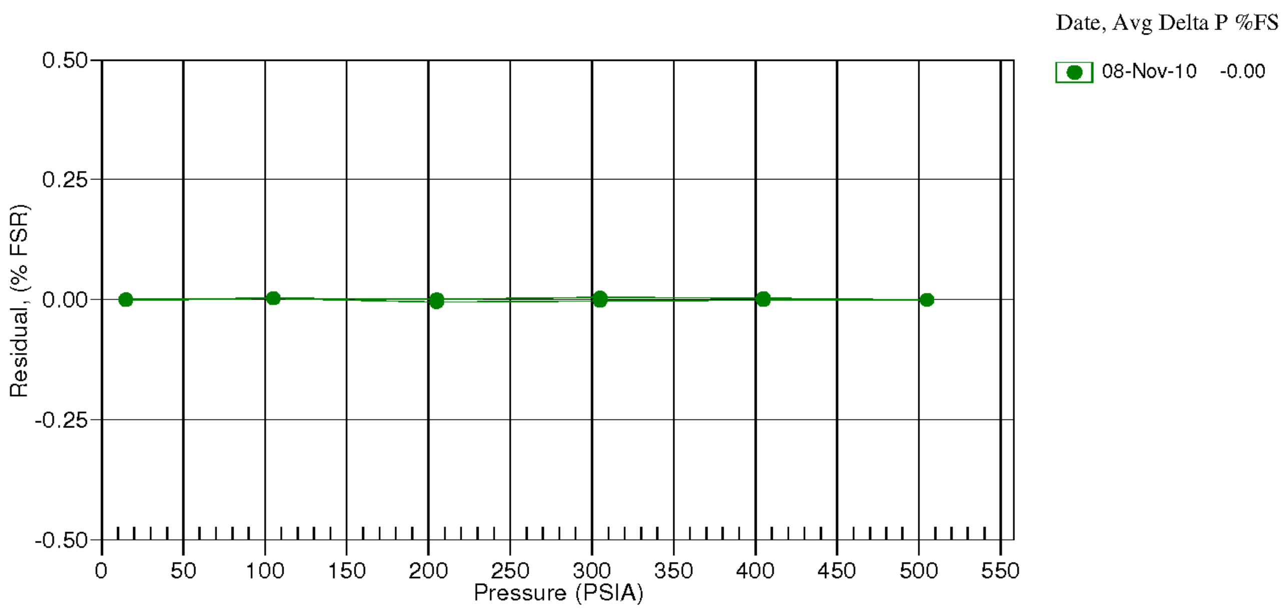
TEMP(ITS90)	SPAN(mV)
-5.00	24.99
35.00	24.98

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

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

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

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



A.4.3.4. Temperature Calibration Report

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

Temperature Calibration Report

Customer:	Atlantic Marine Center		
Job Number:	61820	**Date of Report:**	11/10/2010
Model Number	SBE 19Plus	**Serial Number:**	19P33589-4487

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: 11/10/2010 Drift since last cal: +0.00065 Degrees Celsius/year

Comments:

'CALIBRATION AFTER REPAIR' ☐ Performed ☑ Not Performed

Date: Drift since Last cal: Degrees Celsius/year

Comments:

A.4.3.5. Temperature Calibration Data

SEA-BIRD ELECTRONICS, INC.

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

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

SENSOR SERIAL NUMBER: 4487
CALIBRATION DATE: 10-Nov-10

SBE19plus TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

a0 = 1.222783e-003
a1 = 2.580636e-004
a2 = 3.403966e-007
a3 = 1.314272e-007

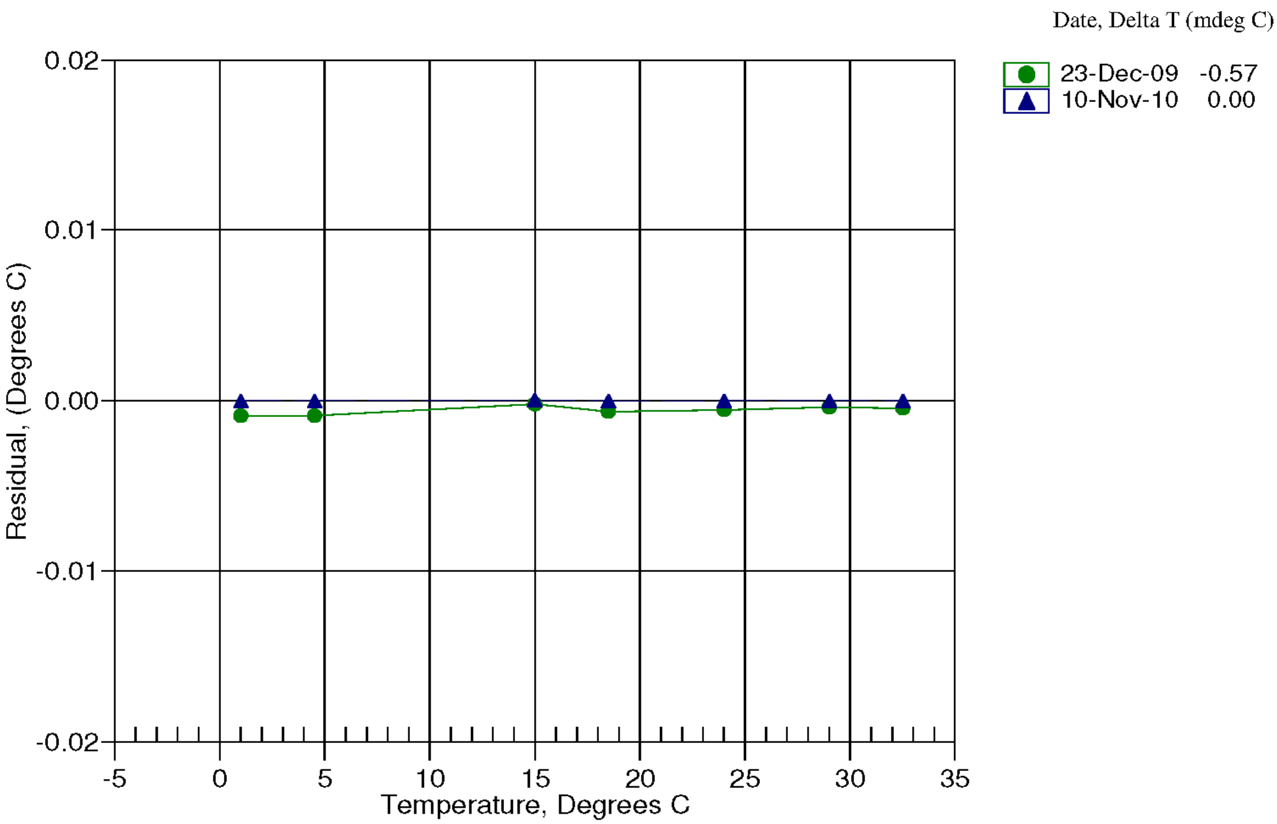
BATH TEMP (ITS-90)	INSTRUMENT OUTPUT(n)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
0.9999	713456.770	0.9999	0.0000
4.5000	638138.984	4.5000	-0.0000
14.9999	447165.426	14.9999	0.0000
18.5000	394894.164	18.5000	-0.0000
24.0000	323256.656	24.0000	-0.0000
29.0000	268206.672	29.0000	0.0000
32.5000	234740.016	32.5000	-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



A.4.4. MVP-100 SN 4988

A.4.4.1. Pressure Calibration Certificate

OCEANOGRAPHIC
Xchange your old ideas

Certificate of Calibration

Customer:	NOAA - Marine Operations Center Atlantic
Asset Serial Number:	004988 Smart SV&P for Brooke MVP - PDC-A0200-OEM-Brooke
Asset Product Type:	Smart SV&P for Brooke MVP - PDC-A0200-OEM-Brooke
Calibration Type:	Pressure
Calibration Range:	1000 dBar
Calibration RMS Error:	.0353
Calibration ID:	004988 021407 0XE111 260111 130048
Installed On:	004988 Smart SV&P for Brooke MVP - PDC-A0200-OEM-Brooke

Coefficient A:	-1.569447E+3	Coefficient G:	-7.050158E-8
Coefficient B:	-8.337370E-1	Coefficient H:	-5.412054E-9
Coefficient C:	2.784933E-3	Coefficient I:	8.759462E-9
Coefficient D:	1.651412E-4	Coefficient J:	-2.154370E-11
Coefficient E:	4.767409E-2	Coefficient K:	-1.798432E-12
Coefficient F:	2.482477E-5	Coefficient L:	3.779060E-14
		Coefficient M:	

Calibration Date: 26/1/2011

Certified By:

AML Oceanographic

Robert Haydock
President, AML Oceanographic

AML Oceanographic certifies that the asset described above has been calibrated or recalibrated with equipment referenced to traceable standards. Please note that Xchange™ sensor-heads may be installed on assets other than the one listed above; this calibration certificate will still be valid when used on other such assets. If this instrument or sensor has been recalibrated, please be sure to update your records. Please also ensure that you update the instrument's coefficient values in any post-processing software that you use, if necessary. Older generation instruments may require configuration files, which are available for download at our Customer Centre at www.AMLoceanographic.com/support

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A.4.4.2. Sound Velocity Calibration Certificate

AML OCEANOGRAPHIC
Xchange your old ideas

Certificate of Calibration

Customer:	NOAA - Marine Operations Center Atlantic
Asset Serial Number:	004988 Smart SV&P for Brooke MVP - PDC-A0200-OEM-Brooke
Asset Product Type:	Smart SV&P for Brooke MVP - PDC-A0200-OEM-Brooke
Calibration Type:	Sound Velocity
Calibration Range:	1400 to 1550 m/s
Calibration RMS Error:	.0182
Calibration ID:	004988 011712 139859 170111 221816
Installed On:	004988 Smart SV&P for Brooke MVP - PDC-A0200-OEM-Brooke

---

Coefficient A:	1.529664E+3	Coefficient G:	0.000000E+0
Coefficient B:	-1.120304E+2	Coefficient H:	0.000000E+0
Coefficient C:	8.985080E+0	Coefficient I:	0.000000E+0
Coefficient D:	-7.303128E-1	Coefficient J:	0.000000E+0
Coefficient E:	0.000000E+0	Coefficient K:	0.000000E+0
Coefficient F:	0.000000E+0	Coefficient L:	0.000000E+0
		Coefficient M:	

Calibration Date: 18/1/2011

Certified By:

AML Oceanographic

Robert Haydock

President, AML Oceanographic

AML Oceanographic certifies that the asset described above has been calibrated or recalibrated with equipment referenced to traceable standards. Please note that Xchange™ sensor-heads may be installed on assets other than the one listed above; this calibration certificate will still be valid when used on other such assets. If this instrument or sensor has been recalibrated, please be sure to update your records. Please also ensure that you update the instrument's coefficient values in any post-processing software that you use, if necessary. Older generation instruments may require configuration files, which are available for download at our Customer Centre at www.AMLoceanographic.com/support

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A.4.5. MVP-100 SN 5340

A.4.5.1. Pressure Calibration Certificate

AML OCEANOGRAPHIC
Xchange your old ideas

Certificate of Calibration

Customer:	NOAA - Marine Operations Center Atlantic
Asset Serial Number:	005340 Smart SV&P for Brooke MVP - PDC-A0200-OEM-Brooke
Asset Product Type:	Smart SV&P for Brooke MVP - PDC-A0200-OEM-Brooke
Calibration Type:	Pressure
Calibration Range:	1000 dBar
Calibration RMS Error:	.0255
Calibration ID:	005340 127028 0ZE092 260111 142138
Installed On:	005340 Smart SV&P for Brooke MVP - PDC-A0200-OEM-Brooke

Coefficient A:	-1.918104E+3	Coefficient G:	-9.419392E-7
Coefficient B:	-1.399663E+0	Coefficient H:	1.044152E-8
Coefficient C:	2.217375E-2	Coefficient I:	1.235858E-8
Coefficient D:	-1.520440E-4	Coefficient J:	-1.508418E-10
Coefficient E:	5.847678E-2	Coefficient K:	8.793572E-12
Coefficient F:	4.658058E-5	Coefficient L:	-1.896560E-13
		Coefficient M:	

Calibration Date: 26/1/2011

Certified By:

Robert Haydock

Robert Haydock
President, AML Oceanographic

AML Oceanographic certifies that the asset described above has been calibrated or recalibrated with equipment referenced to traceable standards. Please note that Xchange™ sensor-heads may be installed on assets other than the one listed above; this calibration certificate will still be valid when used on other such assets. If this instrument or sensor has been recalibrated, please be sure to update your records. Please also ensure that you update the instrument's coefficient values in any post-processing software that you use, if necessary. Older generation instruments may require configuration files, which are available for download at our Customer Centre at www.AMLoceanographic.com/support

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A.4.5.2. Sound Velocity Calibration Certificate

AML OCEANOGRAPHIC
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Certificate of Calibration

Customer:	NOAA - Marine Operations Center Atlantic
Asset Serial Number:	005340 Smart SV&P for Brooke MVP - PDC-A0200-OEM-Brooke
Asset Product Type:	Smart SV&P for Brooke MVP - PDC-A0200-OEM-Brooke
Calibration Type:	Sound Velocity
Calibration Range:	1400 to 1550 m/s
Calibration RMS Error:	.0169
Calibration ID:	005340 126551 127004 170111 221816
Installed On:	005340 Smart SV&P for Brooke MVP - PDC-A0200-OEM-Brooke

Coefficient A:	1.532143E+3	Coefficient G:	0.000000E+0
Coefficient B:	-1.071905E+2	Coefficient H:	0.000000E+0
Coefficient C:	7.531091E+0	Coefficient I:	0.000000E+0
Coefficient D:	-3.418192E-1	Coefficient J:	0.000000E+0
Coefficient E:	0.000000E+0	Coefficient K:	0.000000E+0
Coefficient F:	0.000000E+0	Coefficient L:	0.000000E+0
		Coefficient M:	

Calibration Date: 18/1/2011

Certified By:

AML Oceanographic

Robert Haydock

President, AML Oceanographic

AML Oceanographic certifies that the asset described above has been calibrated or recalibrated with equipment referenced to traceable standards. Please note that Xchange™ sensor-heads may be installed on assets other than the one listed above; this calibration certificate will still be valid when used on other such assets. If this instrument or sensor has been recalibrated, please be sure to update your records. Please also ensure that you update the instrument's coefficient values in any post-processing software that you use, if necessary. Older generation instruments may require configuration files, which are available for download at our Customer Centre at www.AMLoceanographic.com/support

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A.4.6. MVP-100 SN 7591

A.4.6.1. Pressure Calibration Certificate

AML OCEANOGRAPHIC
Xchange your old ideas

Certificate of Calibration

Customer:	Rolls-Royce Canada Limited, Naval Marine
Asset Serial Number:	007591
Asset Product Type:	Micro SV&P for Brooke MVP - PDC-A1300-OEM-Brooke
Calibration Type:	Pressure
Calibration Range:	1000 dBar
Calibration RMS Error:	.0482
Calibration ID:	007591 129146 0TE599 280411 100126
Installed On:	

Coefficient A:	-2.576150E+3	Coefficient G:	8.071607E-10
Coefficient B:	1.820538E-1	Coefficient H:	-5.916234E-15
Coefficient C:	-4.133096E-6	Coefficient I:	-1.762715E-5
Coefficient D:	2.932489E-11	Coefficient J:	1.123850E-9
Coefficient E:	5.711748E-1	Coefficient K:	-2.388330E-14
Coefficient F:	-3.660197E-5	Coefficient L:	1.691618E-19
		Coefficient M:	

Calibration Date (dd/mm/yyyy): 28/4/2011

Certified By:

AML Oceanographic

Robert Haydock
President, AML Oceanographic

AML Oceanographic certifies that the asset described above has been calibrated or recalibrated with equipment referenced to traceable standards. Please note that Xchange™ sensor-heads may be installed on assets other than the one listed above; this calibration certificate will still be valid when used on other such assets. If this instrument or sensor has been recalibrated, please be sure to update your records. Please also ensure that you update the instrument's coefficient values in any post-processing software that you use, if necessary. Older generation instruments may require configuration files, which are available for download at our Customer Centre at www.AMLoceanographic.com/support

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A.4.6.2. Sound Velocity Calibration Certificate

AML OCEANOGRAPHIC
Xchange your old ideas

Certificate of Calibration

Customer:	Rolls-Royce Canada Limited, Naval Marine
Asset Serial Number:	007591
Asset Product Type:	Micro SV&P for Brooke MVP - PDC-A1300-OEM-Brooke
Calibration Type:	Sound Velocity
Calibration Range:	1400 to 1600 m/s
Calibration RMS Error:	.0154
Calibration ID:	007591 131945 135084 260411 233702
Installed On:	

Coefficient A:	7.186609E-4	Coefficient G:	0.000000E+0
Coefficient B:	-7.408975E-5	Coefficient H:	0.000000E+0
Coefficient C:	7.368149E-7	Coefficient I:	0.000000E+0
Coefficient D:	-4.088703E-7	Coefficient J:	0.000000E+0
Coefficient E:	0.000000E+0	Coefficient K:	0.000000E+0
Coefficient F:	0.000000E+0	Coefficient L:	0.000000E+0
		Coefficient M:	

Calibration Date (dd/mm/yyyy): 28/4/2011

Certified By:

AML Oceanographic

Robert Haydock
President, AML Oceanographic

AML Oceanographic certifies that the asset described above has been calibrated or recalibrated with equipment referenced to traceable standards. Please note that Xchange™ sensor-heads may be installed on assets other than the one listed above; this calibration certificate will still be valid when used on other such assets. If this instrument or sensor has been recalibrated, please be sure to update your records. Please also ensure that you update the instrument's coefficient values in any post-processing software that you use, if necessary. Older generation instruments may require configuration files, which are available for download at our Customer Centre at www.AMLoceanographic.com/support

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A.4.7. Reson SV-1 SN 2008044 Calibration Certificate

RESON

SVP Test and Calibration certificate

SVP Type :	SVP71
SVP Serial No.	2008044

Date of issue :	24-11-2010

Functionality Test : Sign : Ford Petersen

Temperature Calibration :	Hart 1504 s/n A6B554 & Thermistor s/n 3014
Point 1:	4.6 °C
Point 2:	16.5 °C
Point 3:	25.5 °C
Pressure Calibration :	Custom Built Tank (TestUnit ASF150 Ser# 41-10-0007-R03)
Point 1:	0 Bar
Point 2:	101.1 Bar
Point 3:	205.4 Bar

	RMS Speed of Sound Errors
Temperature Validation :	0.0295 m/s
Pressure Validation :	0.0092 m/s

Calibration Completed : Sign : Ford Petersen

Final Function Test : Sign : Ford Petersen

QA Signature : Inits : ______________

RESON

RESON A/S, Fabriksvangen 13, DK-3550 Slangerup
Fax: +45 4738 0066, Phone: +45 4738 0022

A.4.7.1. Reson SV-1 SN 2008027 Calibration Certificate

RESON

SVP Test and Calibration certificate

SVP Type :	SVP71
SVP Serial No.	2008027

Date of issue : 16-03-2011

Temperature Calibration :	Hart 1504 s/n A6B554 & Thermistor s/n 3014
Point 1:	4.6 °C
Point 2:	16.5 °C
Point 3:	25.5 °C
Pressure Calibration :	Custom Built Tank (TestUnit ASF150 Ser# 41-10-0007-R03)
Point 1:	0 Bar
Point 2:	101.4 Bar
Point 3:	203.9 Bar

	RMS Speed of Sound Errors
Temperature Validation :	0.0208 m/s
Pressure Validation :	0.0287 m/s

Calibration & Final Function Test : Sign : Finn Petersen

QA Signature : Inits : ____________

RESON

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A.5. Static and Dynamic Draft

A.5.1. *Dynamic Draft- S222 DN089*

Draft (m)	Speed (m/s)
0.00	0.5
0.01	1
0.02	1.5
0.03	2
0.05	2.5
0.08	3
0.11	3.5
0.15	4
0.19	4.5
0.25	5
0.31	5.5
0.39	6
0.39	10

A.5.2. *Dynamic Draft- 3101 DN059*

Draft (m)	Speed (m/s)
0.052	2.294
0.084	3.497
0.036	4.380
-0.042	5.299
-0.042	10.289

A.5.3. *Dynamic Draft- 3101 DN232*

Draft (m)	Speed (m/s)
0.00	0.5
0.01	1
0.02	1.5
0.03	2
0.05	2.5
0.06	3
0.08	3.5
0.09	4
0.09	4.5
0.08	5
0.07	5.5
0.04	6
0	10

A.5.4. Dynamic Draft- 3101 ERDDM Documentation

Introduction

As a vessel increases speed through the water a high pressure area is generated at the bow and a low pressure area is generated at the stern. This causes the vessel to rise at the bow and settle at the stern, a phenomenon called settlement and squat, or dynamic draft. As speed increases, the bow will continue to rise and the stern will continue to squat until the vessel exceeds the threshold called planing speed, at which point the vessel ceases to push through the water and rises up on top of the water and more or less trims out onto a level plane. It is important to note than many vessels have displacement hulls, which means that they cannot reach planing speed, and are therefore continuously operating in their dynamic range of settlement and squat.

For hydrographic survey vessels, it is critical to accurately measure the amount of settlement and squat (dynamic draft) in order to accurately account for the effects of settlement and squat in the bathymetry. Many methods exist to attempt to measure the settlement and squat of a vessel. For the 2011 fieldseason, NOAA Ship Thomas Jefferson utilized an Inertially-aided post-processed kinematic approach (IAPPK) to determine the settlement and squat for the ship and two hydrographic survey launches (HSL). This method is called an ellipsoid referenced dynamic draft measurement (ERDDM). The method utilized for the 2011 Hydrographic Systems Readiness Review on HSL 3101 is described below.

Method

On March 25, 2011 (DN084), HSL 3101 conducted an Ellipsoid Reference Dynamic Draft Measurement (ERDDM) mission in the Elizabeth River, in the vicinity of Lambert Bend to Pinner Point (See figure 1).

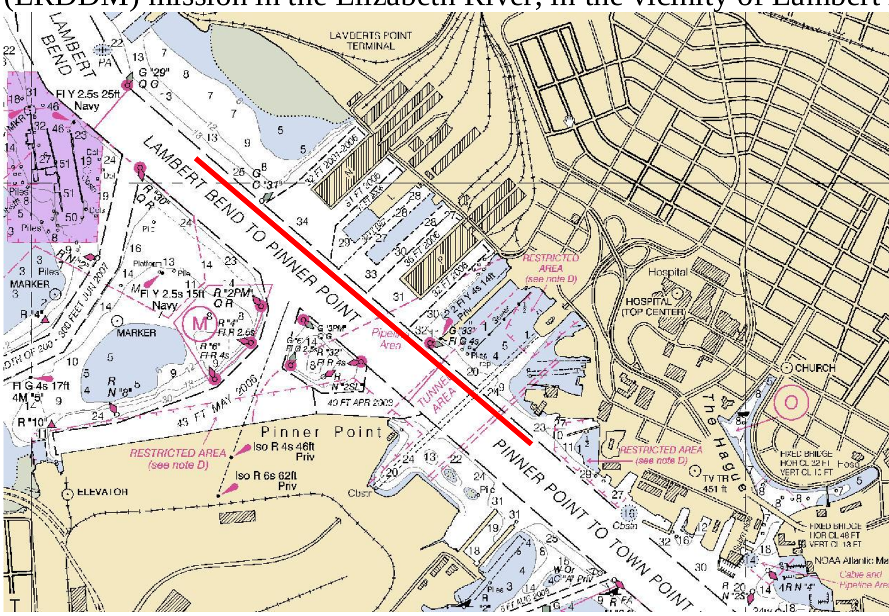


Figure 1 – Subset of NOAA Chart 12253. The red line indicates the approximate area where the ERDDM mission occurred.

The survey line indicated in Figure 1 was ran a total of 3 times beginning with a 2 minute dead-in-the-water (DIW) period to establish the zero point for the ERDDM procedure. After the 2 minute DIW, HSL 3101 began transiting the at low-idle clutch ahead. This speed was maintained for approximately 1 minutes, and then the speed was increased to regular-idle clutch ahead for 1 minute. Next, the engine RPMs were increased by 200 and maintained for 1 minute. This step was repeated until the engine was at maximum speed. At the end of the top speed run, the vessel stopped and began another 2 minute DIW period to conclude the first run. The steps mentioned above were repeated until three complete runs were achieved. Figure 2 illustrates the speeds achieved during the mission.

Figure 2 – Speed vs Time graph illustrating all 3 runs acquired during the ERDDM mission. The spike farthest to the right is the transit back to the ship.

During the steps mentioned above, IAPPK data was logged using the Applanix POS/MV POSPAC file format. The POSPac file logged for the day was processed using Applanix POSMMS 5.4 GNSS SmartBase Processing. Nearby Continuously Operating Reference Stations (CORS) were used as control stations for the mission, see figure 3. These stations are used to derive very accurate and precise measurements of errors associated with ephemeris and clock data from the global navigation satellite system (GNSS), making it possible to derive positions and altitudes to within a few centimeters of accuracy.

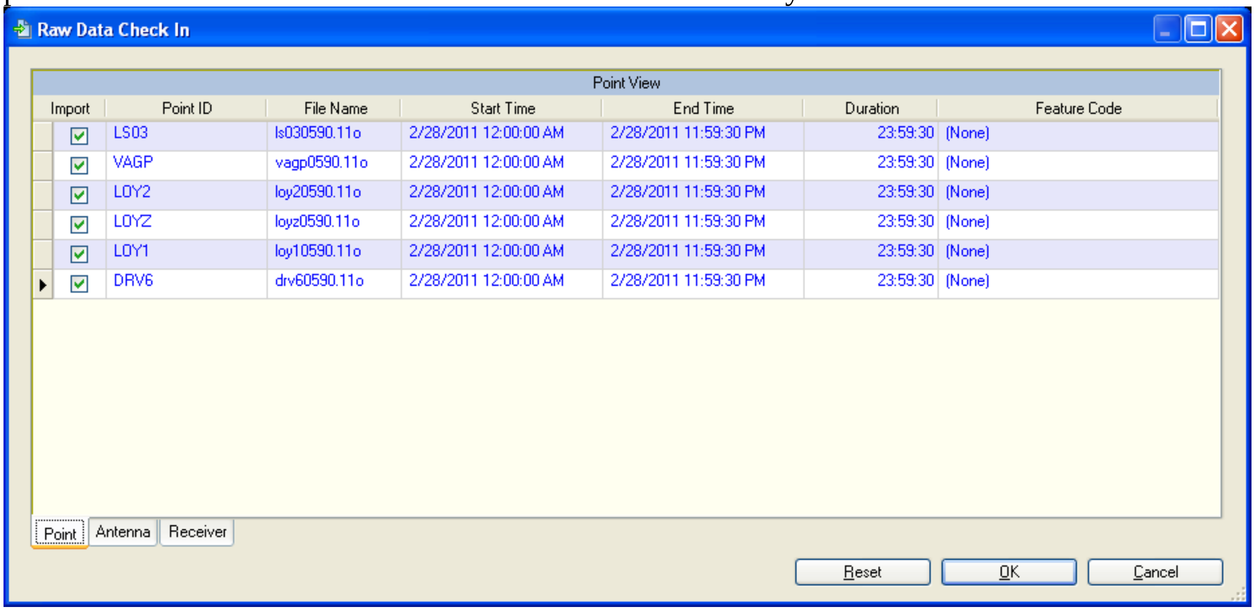


Figure 3 – CORS used during the mission to provide a triangulated network for processing IAPPK data.

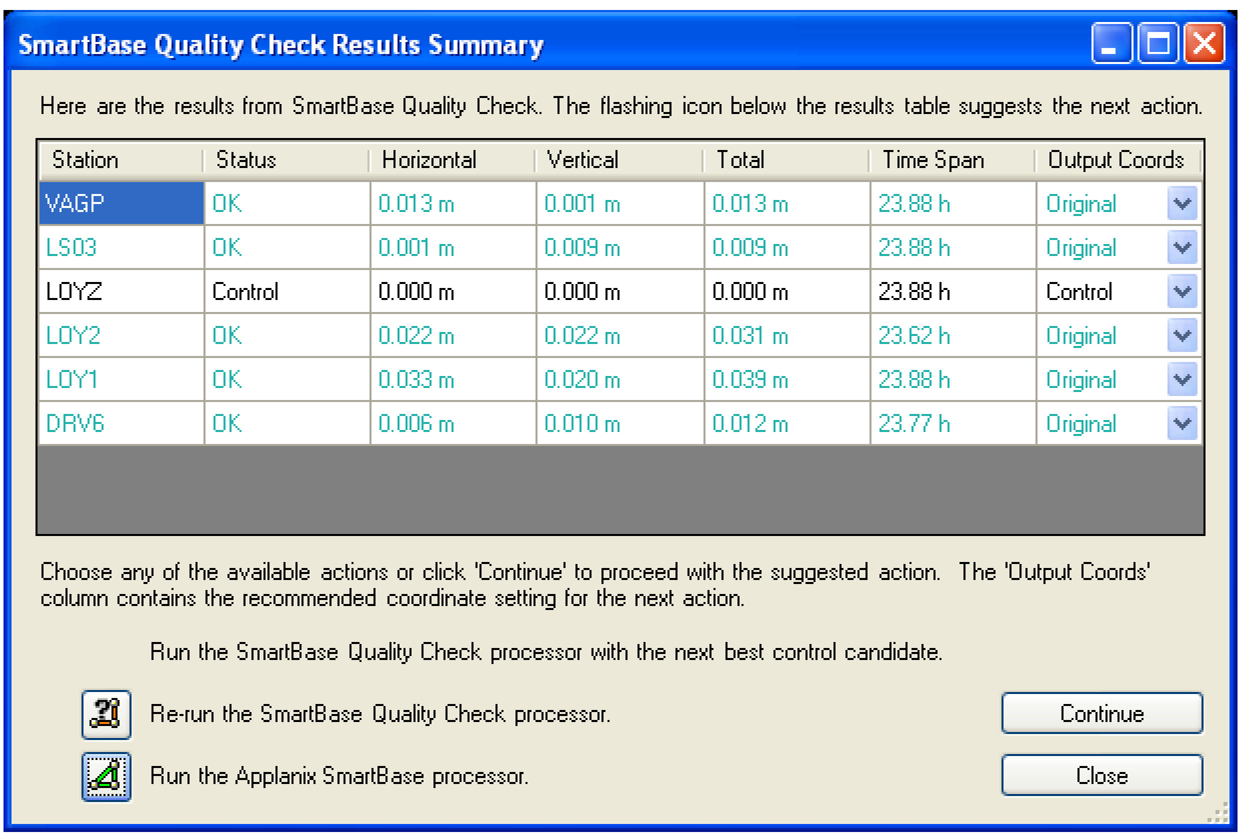


Figure 4 – Quality Check of CORS data during Applanix POSMMS 5.4 SmartBase processing of IAPPK data. All stations passed the Quality Check and LOYZ was selected by the software as the Control Station for the mission.

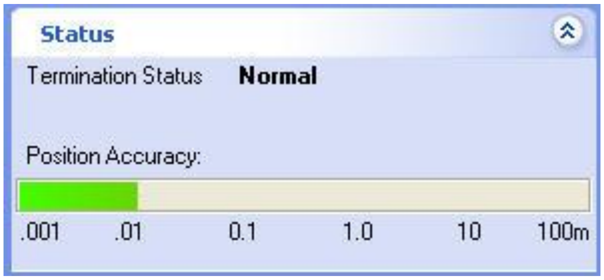


Figure 5 – Termination Status and Positional Accuracy of the processed SBET indicating a positional accuracy of approximately 1cm.

Forward and Backward processing terminated normally, creating a Smoothed Best Estimate Trajectory (SBET) file with reported positional accuracy of approximately 1cm in the horizontal and approximately 3cm in the vertical. PDOP was less than 3 for the duration of the mission. There were 7 or more SV's in the solution for the duration of the mission. The SBET generated for this mission was free of any anomalies or errors that would degrade the results of the ERDDM.

The SBET file was processed keeping all the coordinates in ITRF00 until the Export step. In Export, a Custom Smoothed BET was created which transformed the positions into UTM Zone 18N with NAD83 as the Datum. See figures 6 and 7.

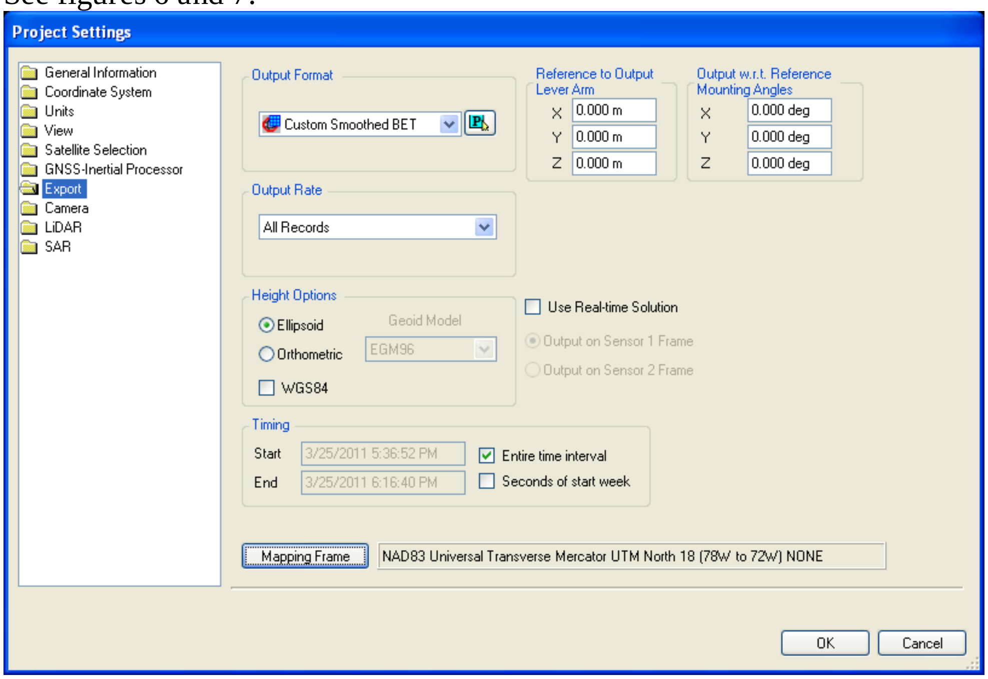


Figure 6 – Settings for SBET export to a Custom Smoothed Best Estimate Trajectory during which, the mapping frame was transformed from ITRF00 with WGS84 datum to UTM zone 18N with NAD83 datum (NOAA hydrographic data is delivered in UTM projection with NAD83 as the datum).

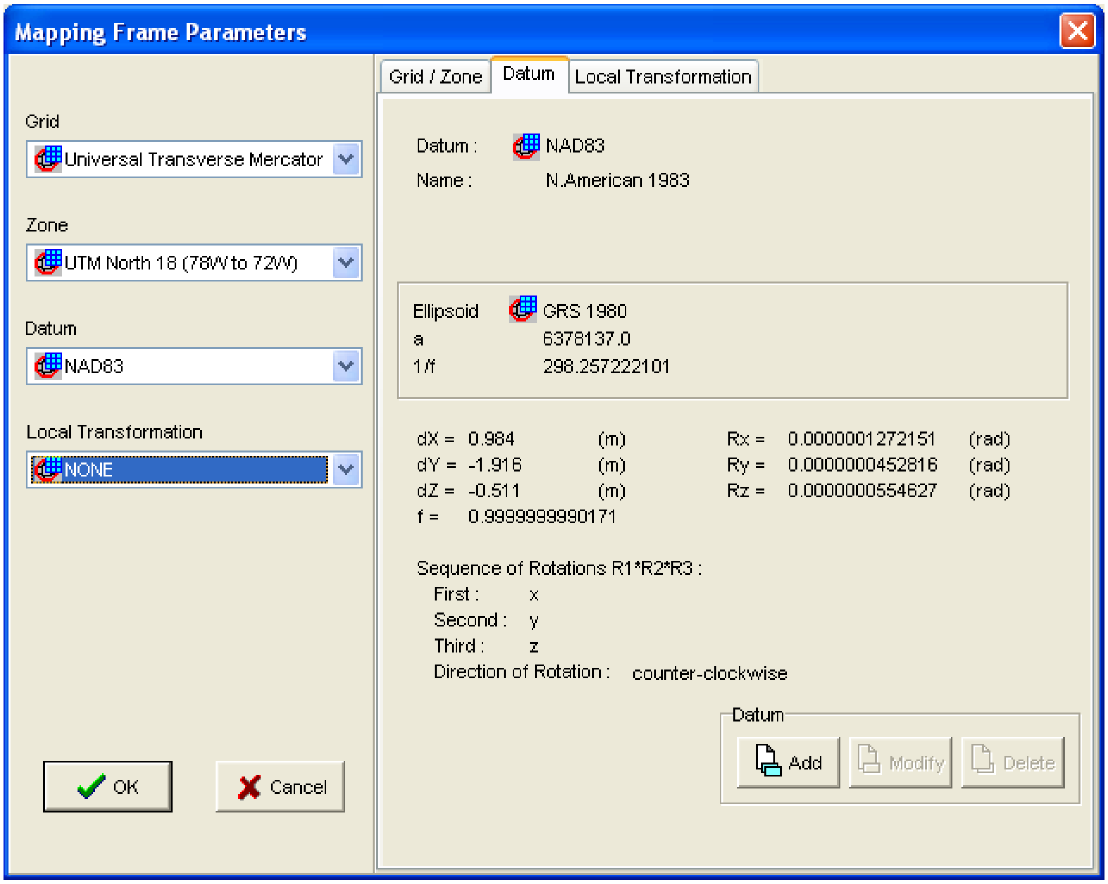


Figure 7 – Mapping Frame Parameters

Once all export parameters were set, the message in figure 8 (below) was displayed to notify the use that transformation occurred from WGS84 to NAD83, but no orientation was performed. This is not relevant for the purposes of the ERDDM mission. “Yes” was selected and the export was completed.

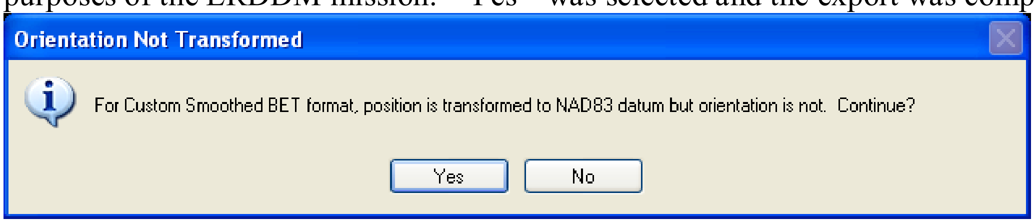


Figure 8 – Orientation Not Transformed warning is not an issue for ERDDM – “Yes” chosen

Pydro is an in-house software application used primarily for survey feature management and report generation. However, Pydro is also used to execute many customized macros designed to perform specific tasks as necessitated by the NOAA survey mission. One particular macro was designed to read an SBET and derive a dynamic draft table for the vessel used to acquired the POSPac data. The macro is:

ProcSBETDynamicDraft.py

and ProcSBETDynamicDraft.py macro is found in:

C:\Program Files\Pydro\Lib\site-packages\HSTP\Pydro\Macros\ProcSBETDynamicDraft.py

The script can be called directly from the location listed above, or by opening the Pydro application and chooseing: Misc/Run Macro

The macro prompts the user for the ERDDM POSProc SBET file in either the binary “.out” or ASCII “.txt” format. For this mission, the Customized Smoothed BET that was exported into UTM 18N, NAD83 was selected in binary format - see Figure 9.

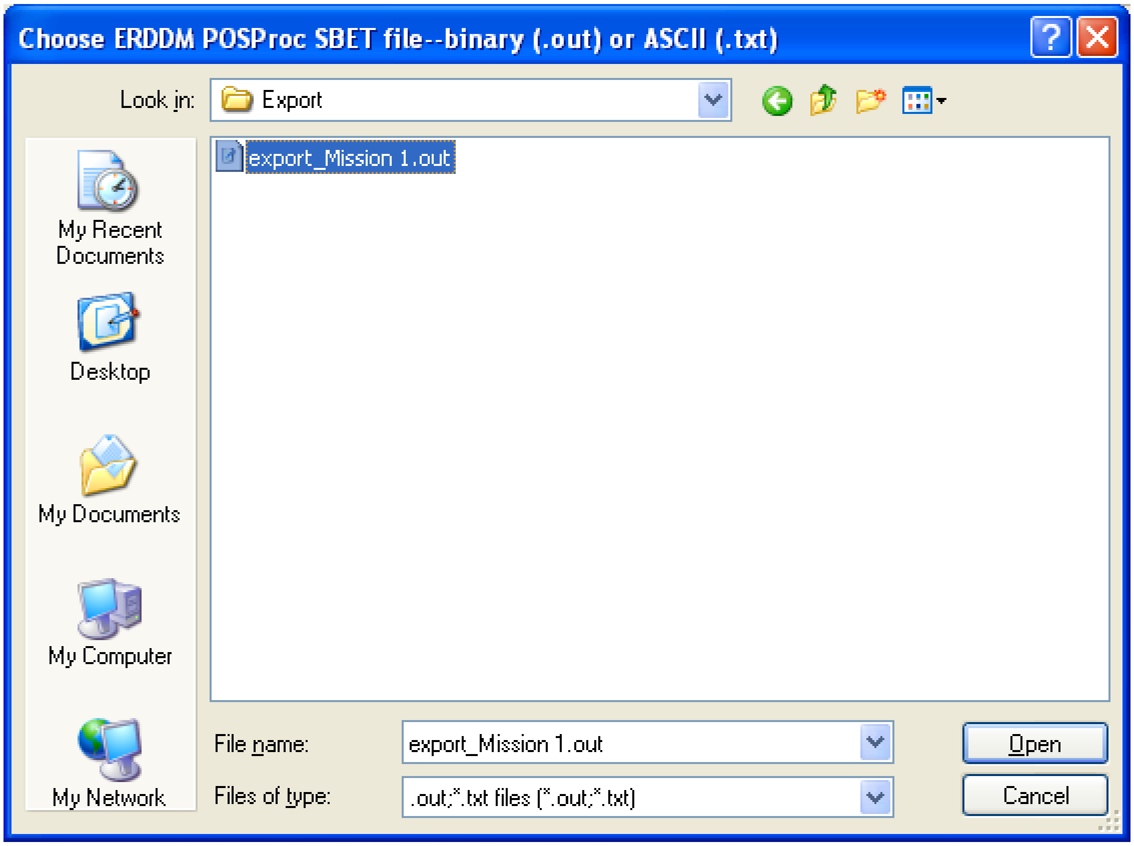


Figure 9 – Binary format for the Customized Smoothed BET created during the previous steps was selected for use by the ERDDM macro.

Once the SBET file has been selected, the macro prompts the user for the data in YYYY-DOY format – Figure 10.

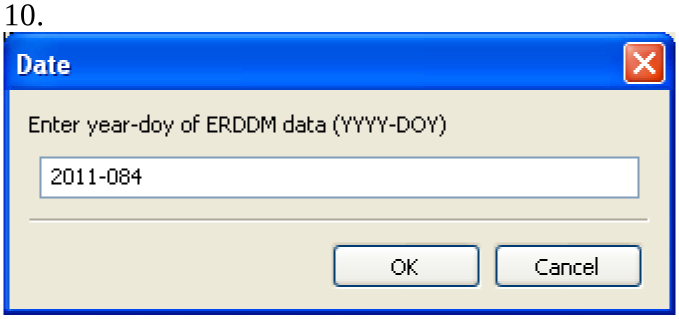


Figure 10 – Date format for the ERDDM macro

Once the date has been entered in the proper format, the macro prompts the user to select the order of polynomial best fit line to be used. Experience has shown that the 3rd order polynomial more accurately represents the actually dynamic draft of the vessel. 4th order polynomial lines tend to indicate a lift at very slow speeds with a squat at the very high speeds. These lifts and squats are not indicative of the actual behavior of the vessel at these speeds, but are controlled by the behavior of the 4th order polynomial equations. 3rd order polynomial equations do not exhibit the same behavior at the extreme high and low speeds, and are therefore considered to be more accurate for the purposes of ERDDM. For this mission, the 3rd order was used. See figure 11.

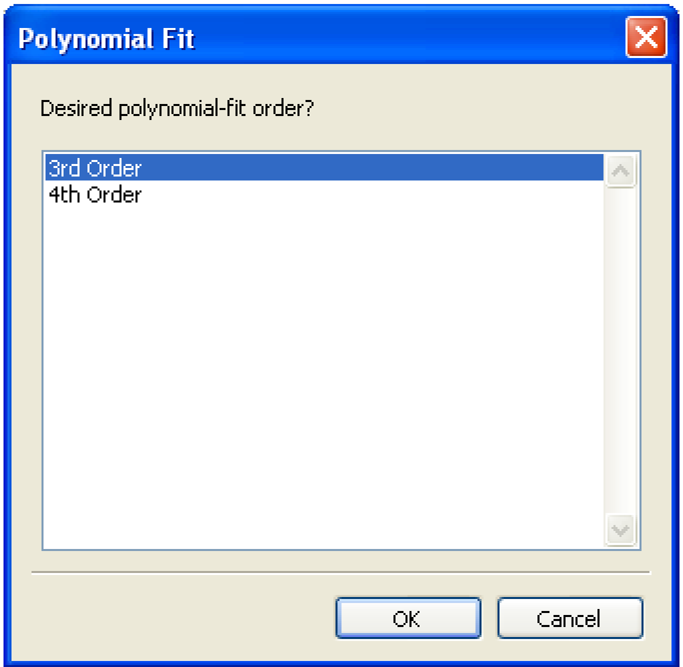


Figure 11 – 3rd Order Polynomial best fit line was selected for this ERDDM mission.
Next, the macro prompts the user to specify a time range to use. The SBET may include an entire day's worth of data, but only the portion during the ERDDM acquisition is necessary. The entire SBET can be used, and the macro will utilize the speed and altitude data to determine the ERDDM, however, a longer time range increases the likelihood of a tidal anomaly to skew the data. For the purposes of this mission, a unique POSPac file was logged just prior to the start of ERDDM acquisition, and was ended shortly after the acquisition was completed. Therefore, the entire time range of the Customized Smoothed BET was used for this particular mission (Figure 12). By limiting the mission to approximately 40 minutes, the effect of tide was virtually eliminated from the process. Water levels were not loaded as indicated by the error message (Figure 13). The effect of tides during this mission was negligible and therefore tides were not applied. Additionally, TCARI tides were the only option available for this area. When attempts were made to apply TCARI tides to the data, it crashed the ERDDM script.

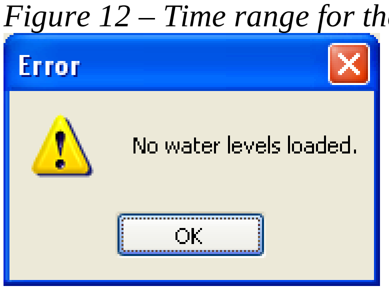
Figure 12 – Time range for the ERDDM mission.


Figure 13 – Error message seen if water levels are not loaded prior to executing the ERDDM macro.
Pydro creates a series of graphs that document the output of the ERDDM macro. The first graph shows ellipsoid height and the associated uncertainties vs time as recorded in the POSPac data (figure 14). The second graph shows ellipsoid height vs speed and the residuals from the measurements to 2 standard deviations (figure 15). The third graph (figure 16) is the speed vs delta draft table with the 3rd order polynomial best fit line, which will be used in the CARIS HIPS and SIPS, HIPS vessel file (HVF).

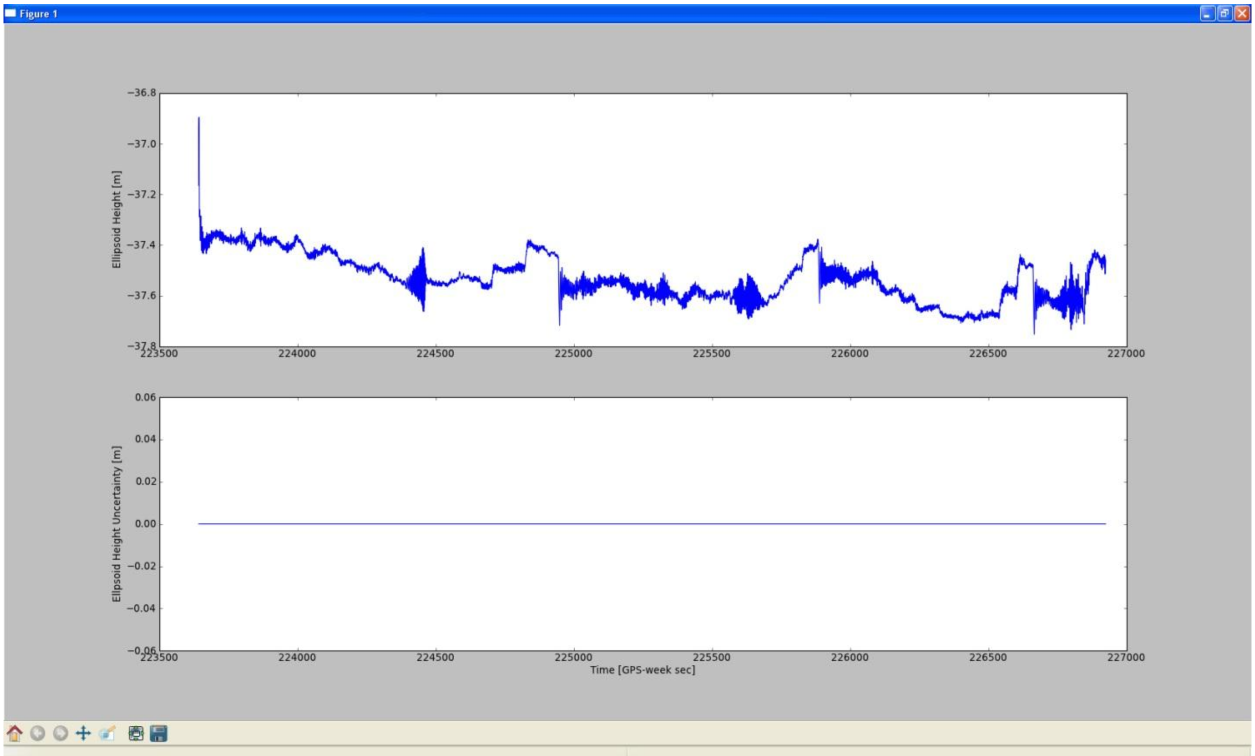


Figure 14 – Ellipsoid Height vs Time and the associated uncertainty

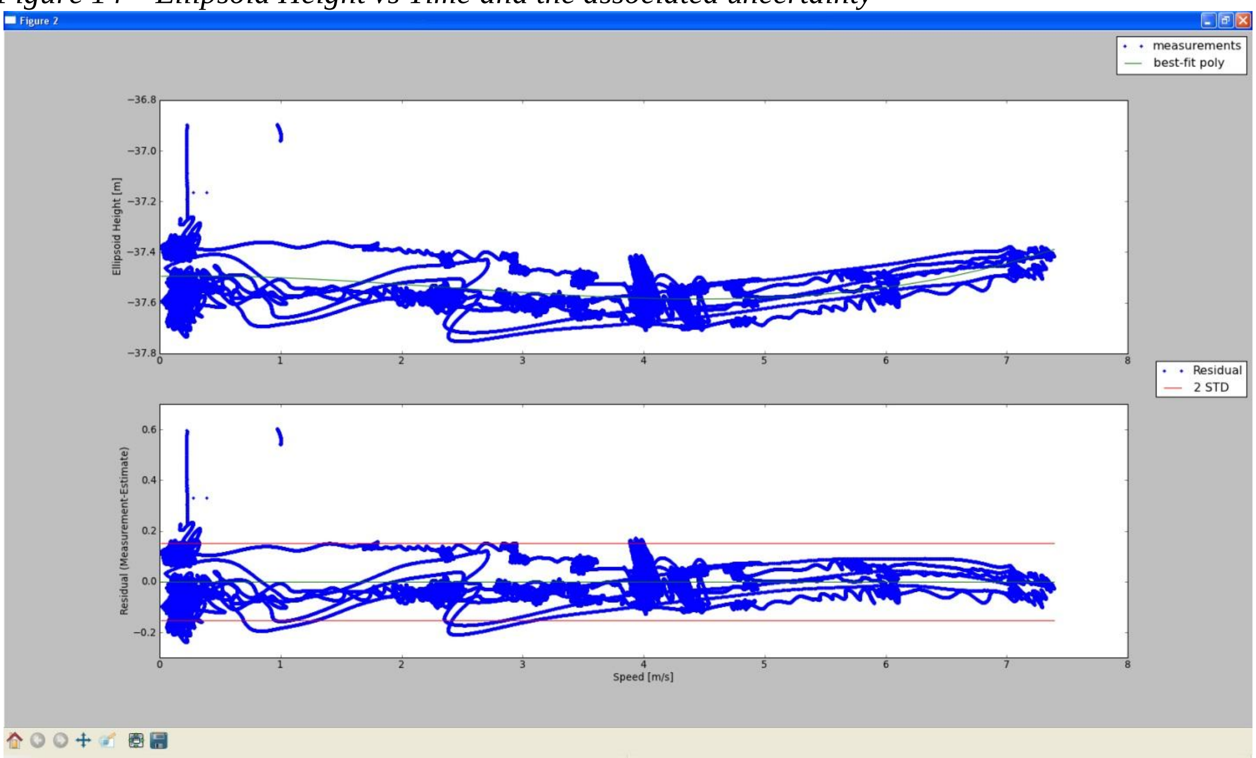
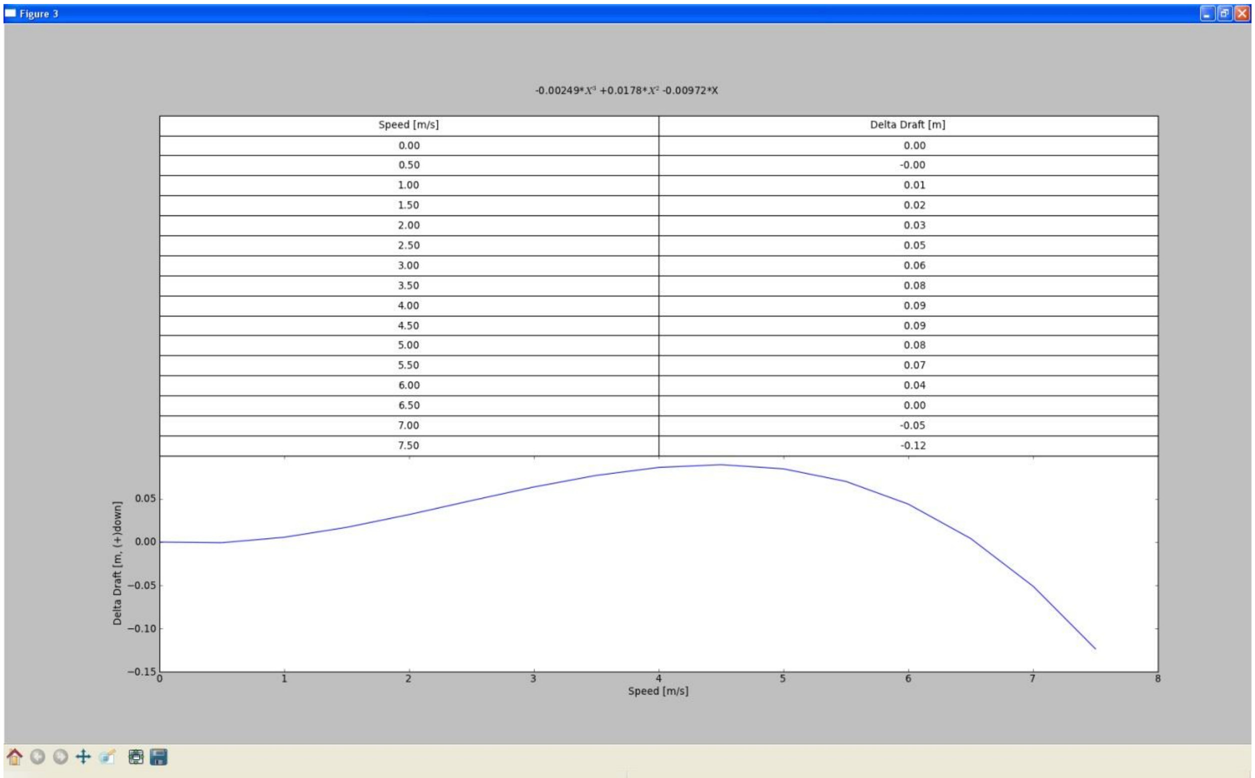


Figure 15 – Ellipsoid Height vs Speed and the residuals to 2 standard deviations



Speed [m/s]	Delta Draft [m]
0.00	0.00
0.50	-0.00
1.00	0.01
1.50	0.02
2.00	0.03
2.50	0.05
3.00	0.06
3.50	0.08
4.00	0.09
4.50	0.09
5.00	0.08
5.50	0.07
6.00	0.04
6.50	0.00
7.00	-0.05
7.50	-0.12

*Figure 16 – Speed vs Delta Draft to be entered into the CARIS HIPS and SIPS, HIPS HVF. *Note – the values in the graph are positive down values.*

Results

The values derived from the ERDDM procedure for HSL 3101 match closely to the best estimates available by any other method in the past. The statistical robustness of the ERDDM approach and the fact that all subjectivity is removed from the process makes this approach more desirable than the reference surface approach or the optical level approach.

The values listed in Figure 16 are used for the Draft section of the HVF for HSL 3101 beginning on DN232 for the 2011 fieldseason. These values were not applied to the beginning because surveys were already processed prior to successful ERDDM were determined.

A.5.5. Dynamic Draft- 3102 DN 056

Draft (m)	Speed (m/s)
0.018	2.200
0.093	3.473
0.087	4.314
0.024	5.386
0.024	10.289